National *Semiconductor*

PC87309 SuperI/O Plug and Play Compatible Chip in Compact 100-Pin VLJ Packaging

Highlights

General Description

The PC87309 is a single-chip solution to the most commonly used ISA, EISA and MicroChannel® peripherals in a compact, 100-pin VLJ packaging. This fully Plug and Play (PnP) and PC97 compatible chip conforms to the *Plug and Play ISA Specification* Version 1.0a, May 5, 1994, and meets specifications defined in the *PC97 Hardware Design Guide*.

The PC87309 incorporates: a Floppy Disk Controller (FDC), a Mouse and Keyboard Controller (KBC), two enhanced UARTs, one of which is with Infrared (IR) support, a full IEEE 1284 parallel port and support for Power Management (PM). The chip also provides a separate configuration register set for each module.

The Infrared (IR) interface complies with the HP-SIR and SHARP-IR standards, and supports all four basic protocols for Consumer Remote Control circuitry (RC-5, RC-6, NEC, RCA and RECS 80).

For flexible UART and IR support, the PC87309 offers two operation modes:

- Mode 1: Full-IR Mode
  UART1 works as UART; UART2 works as fully IR-compliant device

- Mode 2: Two-UART Mode
  Either both UARTs work as UARTs, or UART1 works as UART and UART2 works as partially IR-compliant device, providing only IRRX and IRTX support

Outstanding Features

- Full SuperI/O functionality in compact, cost-effective 100-pin VLJ packaging

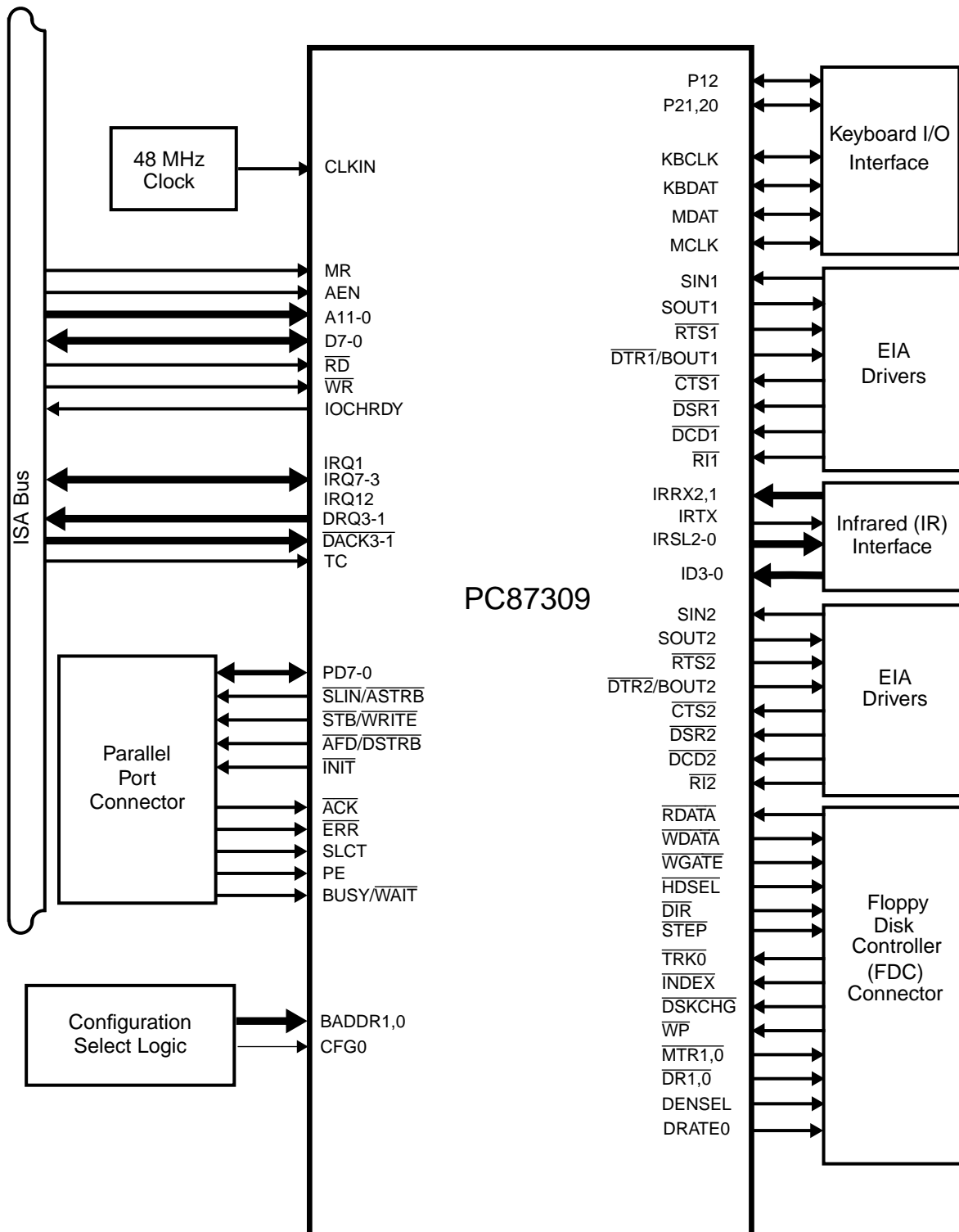- PC97 compliant

PC87309 Block Diagram
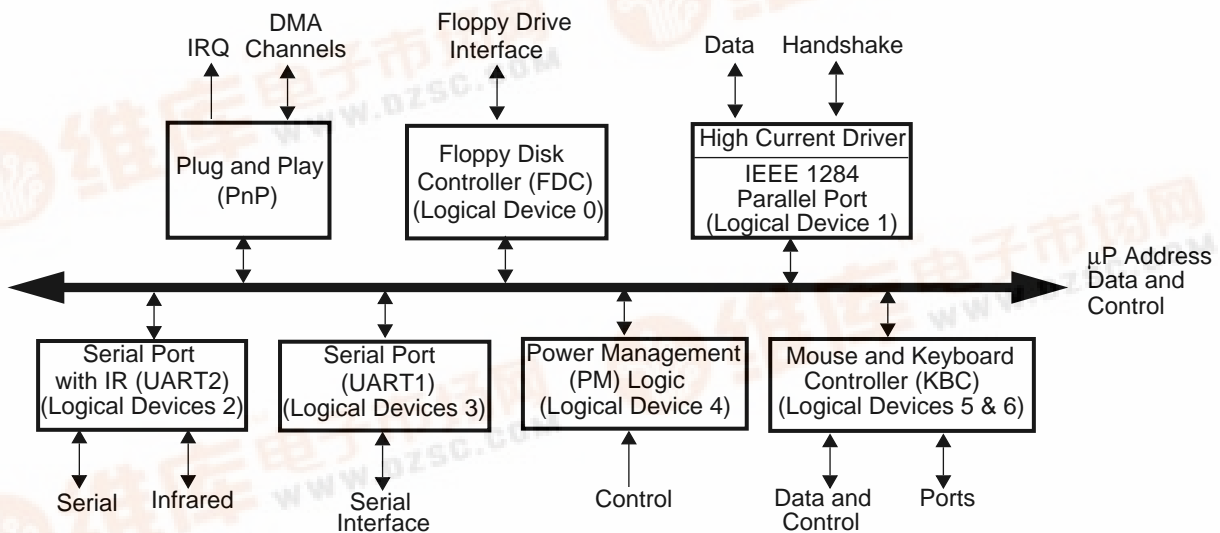
Features

- 100% compatibility with PnP requirements specified in the "*Plug and Play ISA Specification*", PC97, ISA, EISA, and MicroChannel architectures

- A special PnP module that includes:
  - Flexible IRQs, DMAs and base addresses that meet the PnP requirements specified by Microsoft® in their 1995 hardware design guide for Windows® and PnP ISA Revision 1.0A
  - PnP ISA mode (with isolation mechanism – Wait for Key state Motherboard PnP mode

- A Floppy Disk Controller (FDC) that provides:
  - A relocatable address that is referenced by an 11-bit programmable register
  - Software compatibility with the PC8477, which contains a superset of the floppy disk controller functions in the μDP8473, the NEC μPD765A and the N82077
  - 7 IRQ channel options
  - Three 8-bit DMA channel options
  - 16-byte FIFO
  - Burst and non-burst modes
  - A new high-performance, on-chip, digital data separator that does not require any external filter components
  - Support for standard 5.25" and 3.5" floppy disk drives
  - Perpendicular recording drive support
  - Three-mode Floppy Disk Drive (FDD) support
  - Full support for the IBM Tape Drive Register (TDR) implementation of AT and PS/2 drive types

- A Keyboard and mouse Controller (KBC) with:
  - A relocatable address that is referenced by an 11-bit programmable register, reported as a fixed address in resource data
  - 7 IRQ options for the keyboard controller
  - 7 IRQ options for the mouse controller
  - An 8-bit microcontroller
  - Software compatibility with the 8042AH and PC87911 microcontrollers
  - 2 KB of custom-designed program ROM
  - 256 bytes of RAM for data
  - Three programmable dedicated open drain I/O lines for keyboard controller applications
  - Asynchronous access to two data registers and one status register during normal operation
  - Support for both interrupt and polling
  - 93 instructions
  - An 8-bit timer/counter
  - Support for binary and BCD arithmetic
  - Operation at 8 MHz,12 MHz or 16 MHz (programmable option)
  - Customizing by using the PC87323VUL, which includes a RAM-based KBC, as a development platform for keyboard controller code for the PC87309

- Two UARTs that provide:
  - Software compatibility with the 16550A and the 16450
  - A relocatable address that is referenced by an 11-bit programmable register
  - 7 IRQ channel options
  - Shadow register support for write-only bit monitoring
  - UART data rates up to 1.5 Mbaud

- An enhanced UART and Infrared (IR) interface on the UART2 that supports:
  - HP-SIR
  - ASK-IR option of SHARP-IR
  - DASK-IR option of SHARP-IR
  - Consumer Remote Control circuitry
  - A PnP compatible external transceiver
  - Three 8-bit DMA options for the UART with Slow Infrared support (UART2)

- A bidirectional parallel port that includes:
  - A relocatable address that is referenced by an 11-bit programmable register
  - Software or hardware control
  - 7 IRQ channel options
  - Three 8-bit DMA channel options
  - Demand mode DMA support
  - An Enhanced Parallel Port (EPP) that is compatible with the new version EPP 1.9, and is IEEE 1284 compliant
  - An Enhanced Parallel Port (EPP) that also supports version EPP 1.7 of the Xircom specification.
  - Support for an Enhanced Parallel Port (EPP) as mode 4 of the Extended Capabilities Port (ECP)
  - An Extended Capabilities Port (ECP) that is IEEE 1284 compliant, including level 2
  - Selection of internal pull-up or pull-down resistor for Paper End (PE) pin
  - Reduction of PCI bus utilization by supporting a demand DMA mode mechanism and a DMA fairness mechanism
  - A protection circuit that prevents damage to the parallel port when a printer connected to it powers up or is operated at high voltages
  - Output buffers that can sink and source 14 mA

- Enhanced Power Management (PM), including:
  - Reduced current leakage from pins
  - Low-power CMOS technology
  - Ability to shut off clocks to all modules

- Clock source:
  - Source is a 48 MHz clock input signal.

- General features include:
  - Access to all configuration registers is through an Index and a Data register, which can be relocated within the ISA I/O address space
  - 100-pin Plastic Quad Flatpack (PQFP) package

Basic Configuration

48 MHz Clock	CLKIN	

PC87309

ISA Bus

MR
AEN
A11-0
D7-0
RD
WR
IOCHRDY

IRQ1
IRQ7-3
IRQ12
DRQ3-1
DACK3-1
TC

Parallel Port Connector

PD7-0
SLIN/ASTRB
STB/WRITE
AFD/DSTRB
INIT

ACK
ERR
SLCT
PE
BUSY/WAIT

Configuration Select Logic

BADDR1,0
CFG0

P12
P21,20
KBCLK
KBDAT
MDAT
MCLK

Keyboard I/O Interface

SIN1
SOUT1
RTS1
DTR1/BOUT1
CTS1
DSR1
DCD1
RI1

EIA Drivers

IRRX2,1
IRTX
IRSL2-0
ID3-0

Infrared (IR) Interface

SIN2
SOUT2
RTS2
DTR2/BOUT2
CTS2
DSR2
DCD2
RI2

EIA Drivers

RDATA
WDATA
WGATE
HDSEL
DIR
STEP
TRK0
INDEX
DSKCHG
WP
MTR1,0
DR1,0
DENSEL
DRATE0

Floppy Disk Controller (FDC) Connector

Table of Contents

4.0   Parallel Port (Logical Device 1)

1.0 Signal/Pin Connection and Description

1.1 CONNECTION DIAGRAM

Top pins (80–51):
PD5, PD4, PD3, PD2, PD1, PD0, AFD/DSTRB, SLIN/ASTRB, INIT, ERR, PE, SLCT, ACK, STB/WRITE, BUSY/WAIT, VSS, P21, P20, MDAT, MCLK, KBDAT, KBCLK, DSKCHG, WP, INDEX, TRK0, RDATA, WGATE, HDSEL, STEP

Left pins:
81 PD6
82 PD7
83 CTS1
84 DCD1
85 DSR1
86 BOUT1/DTR1/BADDR0
87 RI1
88 RTS1/BADDR1
89 SIN1
90 VDD
91 VSS
92 SOUT1/CGF0
93 CTS2/A11
94 DCD2/P12
95 DSR2/DRATE0
96 BOUT2/DTR2/IRSL2/ID2
97 RI2/DENSEL
98 RTS2/IRSL1/ID1
99 SIN2/ID3
100 SOUT2/IRSL0/IRRX2/ID0

PC87309VLJ

Right pins:
50 DIR
49 WDATA
48 DR1/DENSEL
47 DR0
46 MTR1/P12
45 MTR0/DRATE0
44 IRTX/DENSEL
43 IRRX1/P12/DRATE0
42 DACK3
41 VDD
40 VSS
39 DACK2
38 DACK1
37 DRQ3
36 DRQ2
35 DRQ1
34 MR
33 CLKIN
32 IRQ12
31 IRQ7

Bottom pins (1–30):
D0, D1, D2, D3, D4, D5, D6, D7, A0, A1, A2, A3, A4, A5, VSS, A6, A7, A8, A9, A10, AEN, IOCHRDY, IORD, IOWR, TC, IRQ1, IRQ3, IRQ4, IRQ5, IRQ6

1.2 SIGNAL/PIN DESCRIPTIONS

TABLE 1-1 lists the signals of the PC87309 in alphabetical order and shows the pin(s) associated with each. TABLE 1-2 on page 18 lists the signals that are multiplexed in Full-IR and Two-UART modes. TABLE 1-3 on page 18 lists the pins that have strap functions during reset.

The Module column indicates the functional module that is associated with these pins. In this column, the System label indicates internal functions that are common to more than one module. The I/O and Group # column describes whether the pin is an input, output, or bidirectional pin (marked as Input, Output or I/O, respectively).

TABLE 1-1. Signal/Pin Description Table

Signal/Pin Name	Pin Number	Module	I/O and Group #	Function
A11-0	93, 20-16, 14-9	ISA-Bus	Input Group 1	**ISA-Bus Address –** A11-0 are used for address decoding on any access except DMA accesses, on the condition that the AEN signal is low. A11 is multiplexed with $\overline{CTS2}$ on pin 93 and available in Full-IR mode only. Since A11 is required to support full ISA PnP mode (for decoding A79h), this mode is not available in Two-UART mode. See Section 2.2.2.
$\overline{ACK}$	68	Parallel Port	Input Group 3	**Acknowledge –** This input signal is pulsed low by the printer to indicate that it has received data from the parallel port. This pin is internally connected to an internal weak pull-up.
$\overline{AFD}$	74	Parallel Port	I/O Group 8	**Automatic Feed –** When this signal is low the printer should automatically feed a line after printing each line. This pin is in TRI-STATE after a 0 is loaded into the corresponding control register bit. An external 4.7 KΩ pull-up resistor should be attached to this pin. This signal is multiplexed with $\overline{DSTRB}$. See TABLE 4-12 on page 101 for more information.
AEN	21	ISA-Bus	Input Group 1	**DMA Address Enable –** This input signal disables function selection via A11-0 when it is high. Access during DMA transfer is not affected by this signal. This pin is used for external decoding of A11-15 in Two-UART mode or A15-12 in Full-IR mode.
$\overline{ASTRB}$	73	Parallel Port	Output Group 8	**Address Strobe (EPP) –** This signal is used in EPP mode as an address strobe. It is active low. This signal is multiplexed with $\overline{SLIN}$. See TABLE 4-12 on page 101 for more information.
BADDR1,0	88,86	Configuration	Input Group 4	**Base Address Strap Pins 0 and 1 –** These pins determine the base addresses of the Index and Data registers, the value of the Plug and Play ISA Serial Identifier and the configuration state immediately after reset. These pins are pulled down by internal 30 KΩ resistors. External 10 KΩ pull-up resistors to V_{DD} should be employed. BADDR1 is multiplexed with $\overline{RTS1}$. BADDR0 is multiplexed with $\overline{DTR1}$ and BOUT1. See TABLE 2-1 and Section 2.1.
BOUT2,1	96,86	UART1, UART2	Output Group 12	**Baud Output –** This multi-function pin provides the associated serial channel Baud Rate generator output signal if test mode is selected, i.e., bit 7 of the EXCR1 register is set. See "Bit 7 - Baud Generator Test (BTEST)" on page 121. After Master Reset this pin provides the DTR function. BOUT2 is multiplexed with DTR2, IRSL2 and ID2. BOUT1 is multiplexed with DRT1 and BADDR0.
BUSY	66	Parallel Port	Input Group 2	**Busy –** This pin is set high by the printer when it cannot accept another character. It is internally connected to a weak pull-down resistor. This signal is multiplexed with $\overline{WAIT}$. See TABLE 4-12 on page 101 for more information.

Signal/Pin Name	Pin Number	Module	I/O and Group #	Function
CFG0	92	Configuration	Input Group 4	This pin selects between Full-IR and Two-UART mode as the default configuration upon power up. It is pulled down by internal 30 KΩ resistors. External 10 KΩ pull-up resistors to V_{DD} should be employed. This signal is multiplexed with SOUT1. See TABLE 2-1 and Section 2.1.
CLKIN	33	Clock	Input Group 1	**Clock In –** A TTL or CMOS compatible 48 MHz clock.
$\overline{CTS2,1}$	93,83	UART1, UART2	Input Group 1	**UART1 and UART2 Clear to Send –** When low, these signals indicate that the modem or other data transfer device is ready to exchange data. $\overline{CTS2}$ is multiplexed with A11, and available only in Two-UART mode.
D7-0	8-1	ISA-Bus	I/O Group 5	**ISA-Bus Data –** Bidirectional data lines to the microprocessor. D0 is the LSB and D7 is the MSB. These signals have 24 mA (sink) buffered outputs.
$\overline{DACK3}$ $\overline{DACK2,1}$	42 39,38	ISA-Bus	Input Group 1	**DMA Acknowledge 1,2 and 3 –** These active low input signals acknowledge a request for DMA services and enable the $\overline{IOWR}$ and $\overline{IORD}$ input signals during a DMA transfer. These DMA signals can be mapped to the following logical devices: FDC, UART or Parallel Port.
$\overline{DCD2,1}$	94,84	UART1, UART2	Input Group 1	**UART1 and UART2 Data Carrier Detected –** When low, this signal indicates that the modem or other data transfer device has detected the data carrier. $\overline{DCD2}$ is multiplexed with P12 and available only in Two-UART mode.
DENSEL	97, 48 or 44	FDC	Output Group 11	**Density Select –** Indicates that a high FDC density data rate (500 Kbps or 1 Mbps) or a low density data rate (250 or 300 Kbps) is selected. DENSEL polarity is controlled by bit 5 of the SuperI/O FDC Configuration register as described in Section 2.5.1. This signal is multiplexed with: IRTX, , $\overline{DR1}$, or $\overline{R12}$.
$\overline{DIR}$	50	FDC	Output Group 11	**Direction –** This output signal determines the direction of the Floppy Disk Drive (FDD) head movement (active = step in, inactive = step out) during a seek operation. During reads or writes, $\overline{DIR}$ is inactive.
$\overline{DR1,0}$	48, 47	FDC	Output Group 11	**Drive Select 0 and 1 –** These active low output signals are the decoded drive select output signals. $\overline{DR0}$ and $\overline{DR1}$ are controlled by Digital Output Register (DOR) bits 0 and 1. They are encoded with information to control four FDDs when bit 7 of the SuperI/O FDC Configuration register is 1, as described in Section 2.5.1. $\overline{DR0}$ can optionally become a logical OR of $\overline{DR0}$ and $\overline{MTR0}$ when $\overline{MTR0}$/DRATE0 is used as DRATE0. $\overline{DR1}$ is multiplexed with DENSEL and is available only in Two-UART mode. Optionally, it can become a logical OR of $\overline{DR1}$ and $\overline{MTR1}$ when $\overline{MTR1}$/P12 is used as P12. See $\overline{MTR0,1}$ for more information.
DRATE0	95, 45 or 43	FDC	Output Group 14	**Data Rate 0 –** This output signal reflects the value of bit 0 of the Configuration Control Register (CCR) or the Data Rate Select Register (DSR), whichever was written to last. Output from the pin is totem-pole buffered (6 mA sink, 6 mA source). This signal is multiplexed with IRRX1/P12, $\overline{MTR0}$ or $\overline{DSR2}$
DRQ3-1	37-35	ISA-Bus	Output Group 13	**DMA Request 1, 2 and 3 –** These active high output signals inform the DMA controller that a data transfer is needed. These DMA signals can be mapped to the following logical devices: Floppy Disk Controller (FDC), UART or parallel port.
$\overline{DSKCHG}$	58	FDC	Input Group 1	**Disk Change –** This input signal indicates whether or not the drive door has been opened. The state of this pin is available from the Digital Input Register (DIR). This pin can also be configured as the RGATE data separator diagnostic input signal via the MODE command. See the MODE command in Section 3.7.7.

Signal/Pin Name	Pin Number	Module	I/O and Group #	Function
$\overline{DSR2,1}$	95,85	UART1, UART2	Input Group 1	**Data Set Ready –** When low, this signal indicates that the data transfer device, e.g., modem, is ready to establish a communications link. $\overline{DSR2}$ is multiplexed with DRATE0 and available only in Two-UART mode.
$\overline{DSTRB}$	74	Parallel Port	Output Group 8	**Data Strobe –** This signal is used in EPP mode as a data strobe. It is active low. $\overline{DSTRB}$ is multiplexed with $\overline{AFD}$. See TABLE 4-12 on page 101 for more information.
$\overline{DTR2,1}$	96,86	UART1, UART2	Output Group 12	**Data Terminal Ready –** When low, this output signal indicates to the modem or other data transfer device that the UART1 or UART2 is ready to establish a communications link. A Master Reset (MR) deactivates this signal high, and loopback operation holds this signal inactive. $\overline{DTR1}$ is multiplexed with BADDR0 and with BOUT1. $\overline{DTR2}$ is multiplexed with IRSL2/ID2/BOUT2 and is available only in Two-UART mode. (BOUT2 is multiplexed implicitly and controlled by UART2.)
$\overline{ERR}$	71	Parallel Port	Input Group 3	**Error –** This input signal is set active low by the printer when it has detected an error. This pin is internally connected to an internal weak pull-up.
$\overline{HDSEL}$	52	FDC	Output Group 11	**Head Select –** This output signal determines which side of the FDD is accessed. Active low selects side 1, inactive selects side 0.
ID3 ID2 ID1 ID0	99 96 98 100	UART2	Input Group 1	**Identification –** These ID signals identify the infrared transceiver for Plug and Play support. These pins are read after reset. ID0,1,2 are multiplexed implicitly with IRSL0,1,2 respectively by the UART2 cell. ID3 is multiplexed with SIN2. ID2 is multiplexed with BOUT2, $\overline{DTR2}$, IRSL2. ID1 is multiplexed with $\overline{RTS2}$, IRSL1 ID0 is multiplexed with SOUT2,IRSL0, IRRX2
$\overline{INDEX}$	56	FDC	Input Group 1	**Index –** This input signal indicates the beginning of an FDD track.
$\overline{INIT}$	72	Parallel Port	I/O Group 8	**Initialize –** When this signal is active low, it causes the printer to be initialized. This signal is in TRI-STATE after a 1 is loaded into the corresponding control register bit. An external 4.7 KΩ pull-up resistor should be employed.
IOCHRDY	22	ISA-Bus	Output Group 15	**I/O Channel Ready –** This is the I/O channel ready open drain output signal. When IOCHRDY is driven low, the EPP extends the host cycle.
$\overline{IORD}$	23	ISA-Bus	Input Group 1	**I/O Read –** An active low $\overline{RD}$ input signal indicates that the microprocessor has read data.
$\overline{IOWR}$	24	ISA-Bus	Input Group 1	**I/O Write –** $\overline{WR}$ is an active low input signal that indicates a write operation from the microprocessor to the controller.
IRQ1 IRQ7-3 IRQ12	26 31-27 32	ISA-Bus	I/O Group 10	**Interrupt Requests 1, 3, 4, 5, 6, 7 and 12 –** IRQ polarity and push-pull or open-drain output selection is software configurable by the logical device mapped to the IRQ line. Keyboard Controller (KBC) or Mouse interrupts can be configured by the Interrupt Request Type Select 0 register (index 71h) as either edge or level.
IRRX2,1	100,43	UART2	Input Group 18	**Infrared Reception 1 and 2 –** Infrared serial input data. IRRX1 is multiplexed with P12/DRATE0 and is available only in Two-UART mode. IRRX2 is multiplexed with SOUT2/IRSL0/ID0 and is available only in Full-IR mode.

Signal/Pin Name	Pin Number	Module	I/O and Group #	Function
IRSL0 IRSL1 IRSL2	100 98 96	UART2	Output Group 12	**Infrared Control Signals 0, 1 and 2 –** These signals control the Infrared analog front end. The pins on which these signals are driven is determined by the SuperI/O Configuration 2 register (index 22h). SeeTABLE 1-2 for more information. IRSL0 is multiplexed on pin 100 with SOUT2, IRRX2 and ID0, and is available only in Full-IR mode. IRSL1 is multiplexed on pin 98 with RTS2 and ID1, and is available only in Full-IR mode. IRSL2 is multiplexed on pin 96 with DTR2, BOUT2 and ID2, and is available only in Full-IR mode.
IRTX	44	UART2	Output Group 12	**Infrared Transmit –** Infrared serial output data. This signal is multiplexed with DENSEL only in Two-UART mode.
KBCLK	59	KBC	I/O Group 6	**Keyboard Clock –** This I/O pin transfers the keyboard clock between the SuperI/O chip and the external keyboard using the PS/2 protocol. This pin is connected internally to the internal TO signal of the KBC.
KBDAT	60	KBC	I/O Group 6	**Keyboard Data –** This I/O pin transfers the keyboard data between the SuperI/O chip and the external keyboard using the PS/2 protocol. This pin is connected internally to KBC's P10.
MCLK	61	KBC	I/O Group 6	**Mouse Clock –** This I/O pin transfers the mouse clock between the SuperI/O chip and the external keyboard using the PS/2 protocol. This pin is connected internally to KBC's T1.
MDAT	62	KBC	I/O Group 6	**Mouse Data –** This I/O pin transfers the mouse data between the SuperI/O chip and the external keyboard using the PS/2 protocol. This pin is connected internally to KBC's P11.
MR	34	ISA-Bus	Input Group 1	**Master Reset –** An active high MR input signal resets the controller to the idle state, and resets all disk interface output signals to their inactive states. MR also clears the DOR, DSR and CCR registers, and resets the MODE command, CONFIGURE command, and LOCK command parameters to their default values. MR does not affect the SPECIFY command parameters. MR sets the configuration registers to their selected default values.
MTR1,0	46,45	FDC	Output Group 11	**Motor Select 1,0 –** These motor enable lines for drives 0 and 1 are controlled by bits D7-4 of the Digital Output Register (DOR). They are output signals that are active when they are low. They are encoded with information to control four FDDs when bit 7 of the SuperI/O FDC Configuration register is set See TABLE 1-2 for more information. See DR1,0. MTR0 is multiplexed with DRATE0 only in Two-UART mode. MTR1 is multiplexed with P12 only in Two-UART mode.
P12	94, 46 or 43	KBC	I/O Group 7	**I/O Port –** KBC quasi-bidirectional port for general purpose input and output. P12 is multiplexed on pin 43 with IRRX1 and DRATE0, on pin 46 with MTR1, and on pin 94 with DCD2.
P21,P20	64,63	KBC	I/O Group 7	**I/O Port –** KBC open-drain signals for general purpose input and output. These signals are controlled by KBC firmware.
PD7-0	82-75	Parallel Port	I/O Group 9	**Parallel Port Data –** These bidirectional signals transfer data to and from the peripheral data bus and the appropriate parallel port data register. These signals have a high current drive capability. See Section 10.1.
PE	70	Parallel Port	Input Group 2 Group 3	**Paper End –** This input signal is set high by the printer when it is out of paper. This pin has an internal weak pull-up or pull-down resistor.
RDATA	54	FDC	Input Group 1	**Read Data –** This input signal holds raw serial data read from the Floppy Disk Drive (FDD).

Signal/Pin Name	Pin Number	Module	I/O and Group #	Function
$\overline{RI2,1}$	97,87	UART1	Input Group 1	**Ring Indicators (Modem) –** When low, this signal indicates that a telephone ring signal has been received by the modem. The $\overline{RI1}$ and $\overline{RI2}$ pins have schmitt-trigger input buffers. $\overline{RI2}$ is multiplexed with DENSEL and available only in Two-UART mode.
$\overline{RTS2,1}$	98,88	UART1, UART2	Output Group 12	**Request to Send –** When low, these output signals indicate to the modem or other data transfer device that the corresponding UART1 or UART2 is ready to exchange data. A Master Reset (MR) sets $\overline{RTS}$ to inactive high. Loopback operation holds it inactive. $\overline{RTS2}$ is multiplexed on pin 98 with IRSL1 and ID1, and available only in Two-UART mode. $\overline{RTS1}$ is multiplexed on pin 88 with BADDR1.
SIN2,1	99,89	UART1, UART2	Input Group 1	**Serial Input –** This input signal receives composite serial data from the communications link (peripheral device, modem or other data transfer device). SIN2 is multiplexed on pin 99 with ID3 and available only in Two-UART mode.
SLCT	69	Parallel Port	Input Group 2	**Select –** This input signal is set active high by the printer when the printer is selected. This pin is internally connected to a nominal 25 KΩ pull-down resistor.
$\overline{SLIN}$	73	Parallel Port	I/O Group 8	**Select Input –** When this signal is active low it selects the printer. This signal is in TRI-STATE after a 0 is loaded into the corresponding control register bit. Use an external 4.7 KΩ pull-up resistor. This signal is multiplexed with $\overline{ASTRB}$.
SOUT2,1	100,92	UART1, UART2	Output Group 12	**Serial Output –** This output signal sends composite serial data to the communications link (peripheral device, modem or other data transfer device). The SOUT2,1 signals are set active high after a Master Reset (MR). SOUT2 is multiplexed on pin 100 with IRRX2, IRSL0 and ID0, and is available only in Two-UART mode. SOUT1 is multiplexed on pin 92 with CFG0.
$\overline{STB}$	67	Parallel Port	I/O Group 8	**Data Strobe –** This output signal indicates to the printer that valid data is available at the printer port. This signal is in TRI-STATE after a 0 is loaded into the corresponding control register bit. An external 4.7 KΩ pull-up resistor should be employed. For Input mode see bit 5, described in Section 4.5.16. This signal is multiplexed with $\overline{WRITE}$.
$\overline{STEP}$	51	FDC	Output Group 11	**Step –** This output signal issues pulses to the disk drive at a software programmable rate to move the head during a seek operation.
TC	25	ISA-Bus	Input Group 1	**DMA Terminal Count –** The DMA controller issues TC to indicate the termination of a DMA transfer. TC is accepted only when a $\overline{DACK}$ signal is active. TC is active high in PC-AT mode, and active low in PS/2 mode.
$\overline{TRK0}$	55	FDC	Input Group 1	**Track 0 –** This input signal indicates to the controller that the head of the selected floppy disk drive is at track 0.
V_{DD}	90,41	Power Supply	Input	**Main 5 V Power Supply –** This signal is the 5 V supply voltage for the digital circuitry.
V_{SS}	91,65,40,15	Power Supply	Output	**Ground –** This signal provides the ground for the digital circuitry.
$\overline{WAIT}$	66	Parallel Port	Input Group 2	**Wait –** In EPP mode, the parallel port device uses this signal to extend its access cycle. $\overline{WAIT}$ is active low. This signal is multiplexed with BUSY. See TABLE 4-12 on page 101 for more information.

Signal/Pin Name	Pin Number	Module	I/O and Group #	Function
$\overline{\text{WDATA}}$	49	FDC	Output Group 11	**Write Data (FDC) –** This output signal holds the write precompensated serial data that is written to the selected floppy disk drive. Precompensation is software selectable.
$\overline{\text{WGATE}}$	53	FDC	Output Group 11	**Write Gate (FDC) –** This output signal enables the write circuitry of the selected disk drive. $\overline{\text{WGATE}}$ is designed to prevent glitches during power up and power down. This prevents writing to the disk when power is cycled.
$\overline{\text{WP}}$	57	FDC	Input Group 1	**Write Protected –** This input signal indicates that the disk in the selected drive is write protected.
$\overline{\text{WRITE}}$	67	Parallel Port	Output Group 8	**Write Strobe –** In EPP mode, this active low signal is a write strobe. This signal is multiplexed with $\overline{\text{STB}}$. See TABLE 4-12 on page 101 for more information.

TABLE 1-2. Multiplexed Pins in Full-IR and Two-UART Modes

Pin	Full-IR Mode CFG0 = 0		Two-UART Mode CFG0 = 1	
	Signal/Pin Name	Direction	Signal/Pin Name	Direction
93	A11	I	$\overline{\text{CTS2}}$	I
94	$\overline{\text{P12}}$	I/O	$\overline{\text{DCD2}}$	I
95	DRATE0	O	$\overline{\text{DSR2}}$	I
96	IRSL2/ID2	I/O	$\overline{\text{DTR2}}$/BOUT2	O
97	DENSEL	I/O	$\overline{\text{RI2}}$	I
98	IRSL1/ID1	I/O	$\overline{\text{RTS2}}$	O
99	ID3	I	SIN2	I
100	IRRX2/IRSL0/ID0	I/O	SOUT2	O
43[1]	IRRX1	I	IRRX1/P12/DRATE0	I/O
44[1]	IRTX	O	IRTX/DENSEL	O
45[1]	$\overline{\text{MTR0}}$	O	$\overline{\text{MTR0}}$/DRATE0	O
46[1]	$\overline{\text{MTR1}}$	O	$\overline{\text{MTR1}}$/P12	I/O
48[1]	$\overline{\text{DR1}}$	O	$\overline{\text{DR1}}$/DENSEL	O

1. These pins have additional multiplexing options in Two-UART mode, controlled by a configuration register. They do not automatically change functions.

TABLE 1-3. Pins with a Strap Function During Reset

Function	Pin	Symbols
BADDR0	86	$\overline{\text{DTR1}}$/BOUT1/BADDR0
BADDR1	88	$\overline{\text{RTS1}}$/BADDR1
CFG0	92	SOUT1/CFG0

2.0 Configuration

The PC87309VLJ is partially configured by hardware, during reset. The configuration can also be changed by software, by changing the values of the configuration registers.

The configuration registers are accessed using an Index register and a Data register. During reset, hardware strapping options define the addresses of the configuration registers. See Section 2.1.2 "The Index and Data Register Pair".

After the Index and Data register pair have determined the addresses of the configuration registers, the addresses of the Index and Data registers can be changed within the ISA I/O address space, and a 11-bit programmable register controls references to their addresses and to the addresses of the other registers.

This chapter describes the hardware and software configuration processes. For each, it describes configuration of the Index and Data register pair first. See Sections 2.1 "HARDWARE CONFIGURATION" and 2.2 "SOFTWARE CONFIGURATION" on page 20.

Section 2.3 "THE CONFIGURATION REGISTERS" on page 21 presents an overview of the configuration registers of the PC87309VLJ and describes each in detail.

2.1 HARDWARE CONFIGURATION

The PC87309VLJ Hardware Cofiguration is based on three strap-pins: BADDR0, BADDR1 and CFG0.

The PC87309VLJ wakes up with the KBC active (enabled) and all the other logical devices wake up inactive (disabled). This is always true and is not affected by strapping.

Clock source is 48MHz, fed via CLKIN.

2.1.1 Wake Up Options

The PC87309VLJ supports three available Wake Up Options:

- Full PnP ISA with Full-IR mode.

- PnP Motherboard with Full-IR mode.

- PnP Motherboard with Two-UART mode.

TABLE 2-1 "Strap Pins and Base Addresses" on page 20 shows the strap pins and their applicable wake up options.

The three available wake up options are a combination of the four basic modes which are determined by three strapping pins during reset:

BADDR0 and BADDR1 strap-pins select one of two basic modes.

- Full PnP ISA mode – System wakes up in Wait for Key state. (Not available when in Two-UART mode - see CFG0 in TABLE 2-1).

    Index and Data register addresses are as defined in the *"Plug and Play ISA Specification, Version 1.0a, May 5, 1994."*

- PnP Motherboard mode – system wakes up in Config state.

    The BIOS configures the PC87309VLJ. Index and Data register addresses are different from the addresses of the PnP Index and Data registers. Configuration registers can be accessed as if the serial isolation procedure had already been done, and the PC87309VLJ is selected.

    The BIOS may switch the addresses of the Index and Data registers to the PnP ISA addresses of the Index and Data registers, by using software to modify the base address bits, as shown in Section 2.4.3 on page 29.

CFG0 strap-pin selects between the following two modes:

- Mode 1: Full-IR Mode
  UART1 works as UART; UART2 works as fully IR-compliant device

- Mode 2: Two-UART Mode
  Either both UART1 and UART2 work as UARTs, or UART 1 works as UART and UART2 works as partially IR-compliant device, providing only IRRX and IRTX support

2.1.2 The Index and Data Register Pair

During reset, a hardware strapping option on the BADDR0 and BADDR1 pins defines an address for the Index and Data Register pair.

TABLE 2-1 "Strap Pins and Base Addresses" shows the base addresses for the Index and Data registers that hardware sets for each combination of values of the Base Address strap pins (BADDR0 and BADDR1). You can access and change the content of the configuration registers at any time, as long as the base addresses of the Index and Data registers are defined.

When BADDR1 is low (0), the PnP protocol defines the addresses of the Index and Data register, and the system wakes up from reset in the Wait for Key state.

When BADDR1 is high (1), the addresses of the Index and Data register are according to TABLE 2-1 "Strap Pins and Base Addresses", and the system wakes up from reset in the Config state.

This configures the PC87309VLJ with default values, automatically, without software intervention. After reset, use software as described in Section 2.2 "SOFTWARE CONFIGURATION" on page 20 to modify the selected base address of the Index and Data register pair, and the defaults for configuration registers.

The PnP soft reset has no effect on the logical devices, except for the effect of the Activate registers (index 30h) in each logical device.

TABLE 2-1. Strap Pins and Base Addresses

CFG0	BADDR1	BADDR0	Address		Configuration Type
			Index Register	Data Register	
0	0	x	0279h Write Only	Write: 0A79h Read: RD_DATA Port	Full PnP ISA mode Full-IR mode
0	1	0	015Ch Read/Write	015Dh Read/Write	PnP Motherboard mode Full-IR mode
0	1	1	002Eh Read/Write	002Fh Read/Write	PnP Motherboard mode Full-IR mode
1	x	0	015Ch Read/Write	015Dh Read/Write	PnP Motherboard mode Two-UART mode
1	x	1	002Eh Read/Write	002Fh Read/Write	PnP Motherboard mode Two-UART mode

2.2 SOFTWARE CONFIGURATION

2.2.1 Accessing the Configuration Registers

Only two system I/O addresses are required to access any of the configuration registers. The Index and Data register pair is used to access registers for all read and write operations.

In a write operation, the target configuration register is identified, based on a value that is loaded into the Index register. Then, the data to be written into the configuration register is transferred via the Data register.

Similarly, for a read operation, first the source configuration register is identified, based on a value that is loaded into the Index register. Then, the data to be read is transferred via the Data register.

Reading the Index register returns the last value loaded into the Index register. Reading the Data register returns the data in the configuration register pointed to by the Index register.

If, during reset, the Base Address 1 (BADDR1) signal is low (0), the Index and Data registers are not accessible immediately after reset. As a result, all configuration registers of the PC87309VLJ are also not accessible at this time. To access these registers, you must apply the PnP ISA protocol.

If during reset, the Base Address 1 (BADDR1) signal is high (1), all configuration registers are accessible immediately after reset.

It is up to the configuration software to guarantee no conflicts between the registers of the active (enabled) logical devices, between IRQ signals and between DMA channels. If conflicts of this type occur, the results are unpredictable.

To maintain compatibility with other SuperI/O's, the value of reserved bits may not be altered. Use read-modify-write.

2.2.2 Address Decoding

The address decoding of all logical devices, as well as the configuration registers, consists of 11 non-zero address bits (A10-0) and AEN. The supported I/O range is 0 to 3FFh. The only non-zero A11 address decoding is the PnP WRITEA_DATA port at ISA address A79h, when working in full PnP mode.

In full PnP mode, the addresses of the Index and Data registers that access the Configuration Registers are decoded using pins A10-0, according to the ISA PnP specification.

In PnP Motherboard mode, the addresses of the Index and Data registers that access the Configuration Registers are decoded using pins A10-1. Pin A0 distinguishes between these two registers.

KBC and mouse register addresses are decoded using pins A1,0 and A10-3. Pin A2 distinguishes between the device registers.

Power Management (PM) register addresses are decoded using pins A10-1.

FDC and UART register addresses are decoded using pins A10-3.

Parallel Port (PP) modes determine which pins are used for register addresses. TABLE 2-2 shows which address pins are used to decode base address and which address pins are used to distinguish between registers in each mode.

TABLE 2-2. Address Pins Used for Parallel Port

PP Mode	Pins Used to Decode Base Address	Pins Used to Distinguish between Registers
SPP	A10-2	A1,0
ECP	A9-2	A1,0 and A10
EPP	A10-3	A2-0

NOTE: When working with the Parallel Port in ECP mode and enabling the registers at base (address)+403h, base+404h, base+405h (the default state) both the Parallel Port base address and the ECP registers are 8 byte aligned and take 8 bytes of the I/O space.

TABLE 2-3. Parallel Port Address Range Allocation

Parallel Port Mode	SuperI/O Parallel Port Configuration Register Bits	Decoded Range [a]
	7 6 5 4	
SPP	0 0 x x	Three registers, from base (address) to base + 02h
EPP (Non IEEE1284 Mode 4)	0 1 x x	Eight registers, from base to base + 07h
IEEE1284, No Mode 4, No Internal Configuration	1 0 0 0	Six registers, from base to base + 02h and from base + 400h to base + 402h
IEEE1284 with Mode 4, No Internal Configuration	1 1 1 0	11 registers, from base to base + 07h and from base + 400h to base + 402h
IEEE1284 with Mode 4, Configuration within Parallel Port	1 0 0 1 or 1 1 1 1	16 registers, from base to base + 07h and from base + 400h to base + 407h

a. The SuperI/O processor does not decode the Parallel Port outside this range.

A15-11 are read only 0 in all base address registers. To ensure full 16-bit decoding as required by PC95/PC97, you must externally decode A15-11 (in Two-UART mode) or A15-12 (in Full-IR mode), and drive them via AEN as shown below:

- In Two-UART mode (A11 not available)
  AEN<=(AEN|A11|A12|A13|A14|A15)
  where | = logical OR

- In Full-IR mode (A11 available on pin 93)
  AEN<=(AEN|A12|A13|A14|A15)
  where | = logical OR

2.3 THE CONFIGURATION REGISTERS

The configuration registers control the setup of the PC87309VLJ. Their major functions are to:

- Identify the chip

- Enable major functions (such as, the Keyboard Controller (KBC) for the keyboard and the mouse, the Floppy Disc Controller (FDC), UARTs, parallel and general purpose ports, power management and pin functionality)

- Define the I/O addresses of these functions

- Define the status of these functions upon reset

Section 2.3.2 "Configuration Register Summary" on page 25 summarizes information for each register of each function. In addition, the following non-standard, or card control, registers are described in detail, in Section 2.4 "CARD CONTROL REGISTERS" on page 28.

- Card Control Registers
  — SID Register
  — SuperI/O Configuration 1 Register (SIOCF1)
  — SuperI/O Configuration 2 Register (SIOCF2)
  — SRID Register
  — NSC-Test Register

- FDC Configuration Registers (Logical Device 0)
  — SuperI/O FDC Configuration Register
  — Drive ID Register

- SuperI/O Parallel Port Configuration Register (Logical Device 1)

- SuperI/O UART2 and Infrared Configuration Register (Logical Device 2)

- SuperI/O UART1 Configuration Register (Logical Device 3)

- SuperI/O KBC Configuration Register (Logical Device 6)

2.3.1 Standard Plug and Play (PnP) Register Definitions

TABLES 2-4 through 2-9 describe the standard PnP registers. For more detailed information on these registers, refer the *"Plug and Play ISA Specification, Version 1.0a, May 5, 1994"*

TABLE 2-4. Plug and Play (PnP) Standard Control Registers

Index	Name	Description
00h	Set RD_DATA Port	Writing to this location modifies the address of the port used for reading from the PnP ISA cards. Data bits 7-0 are loaded into I/O read port address bits 9-2. Reads from this register are ignored. Bits1 and 0 are fixed at the value 11.
01h	Serial Isolation	Reading this register causes a PnP card in the Isolation state to compare one bit of the ID of the board. This register is read only.
02h	Config Control	This register is write-only. The values are not sticky, that is, hardware automatically clears the bits and there is no need for software to do so. Bit 0 - Reset Writing this bit resets all logical devices (except the KBC, Logical Device 6) and restores the contents of configuration registers to their power-up (default) values. In addition, all the logical devices enter their default state and the CSN is preserved. Bit 1 - Return to the Wait for Key state. Writing this bit puts the device in the Wait for Key state, with CSN preserved and logical devices not affected. This bit is ignored in Motherboard PnP mode. Bit 2 - Reset CSN to 0.
03h	Wake[CSN]	A write to this port causes all cards that have a CSN that matches the write data in bits 7-0 to go from the Sleep state to either the Isolation state, if the write data for this command is zero, or the Config state, if the write data is not zero. It also resets the pointer to the byte-serial device. This register is write-only.
04h	Resource Data	This address holds the next byte of resource information. The Status register must be polled until bit 0 of this register is set to 1 before this register can be read. This register is read-only.
005	Status	When bit 0 of this register is set to 1, the next data byte is available for reading from the Resource Data register. This register is read-only.
06h	Card Select Number (CSN)	Writing to this port assigns a CSN to a card. The CSN is a value uniquely assigned to each ISA card after the serial identification process so that each card may be individually selected during a Wake[CSN] command. This register is read/write.
07h	Logical Device Number	This register selects the current logical device. All reads and writes of memory, I/O, interrupt and DMA configuration information access the registers of the logical device written here. In addition, the I/O Range Check and Activate commands operate only on the selected logical device. This register is read/write.
20h - 2Fh	Card Level, Vendor Defined	Vendor defined registers.

TABLE 2-5. Plug and Play (PnP) Logical Device Control Registers

Index	Name	Definition
0030h	Activate	For each logical device there is one Activate register that controls whether or not the logical device is active on the ISA bus. This is a read/write register. Before a logical device is activated, I/O Range Check must be disabled. Bit 0 - Logical Device Activation Control 0: Do not activate the logical device. 1: Activate the logical device. Bits 7-1 - Reserved These bits are reserved and return 0 on reads.
0031h	I/O Range Check	This register is used to perform a conflict check on the I/O port range programmed for use by a logical device. This register is read/write. Bit 0 - I/O Range Check control 0: The logical device drives 00AAh. 1: The logical device responds to I/O reads of the logical device's assigned I/O range with a 0055h when I/O Range Check is enabled. Bit 1 - Enable I/O Range Check 0: I/O Range Check is disabled. 1: I/O Range Check is enabled. (I/O Range Check is valid only when the logical device is inactive). Bits 7-2 - Reserved These bits are reserved and return 0 on reads.

TABLE 2-6. Plug and Play (PnP) I/O Space Configuration Registers

Index	Name	Definition
60h	I/O Port Base Address Bits (15-8) Descriptor 0	Read/write value indicating the selected I/O lower limit address bits 15-8 for I/O descriptor 0. Bits 7-3 (for A15-11) are read only 00000b.
61h	I/O Port Base Address Bits (7-0) Descriptor 0	Read/write value indicating the selected I/O lower limit address bits 7-0 for I/O descriptor 0.
62h	I/O Port Base Address Bits (15-8) Descriptor 1	Read/write value indicating the selected I/O lower limit address bits 15-8 for I/O descriptor 1. Bits 7-3 (for A15-11) are ready only 00000b.
63h	I/O Port Base Address Bits (7-0) Descriptor 1	Read/write value indicating the selected I/O lower limit address bits 7-0 for I/O descriptor 1.

TABLE 2-7. Plug and Play (PnP) Interrupt Configuration Registers

Index	Name	Definition
70h	Interrupt Request Level Select 0	Read/write value indicating selected interrupt level. Bits3-0 select the interrupt level used for interrupt 0. A value of 1 selects IRQL 1, a value of 15 selects IRQL 15. IRQL 0 is not a valid interrupt selection and (represents no interrupt selection.
71h	Interrupt Request Type Select 0	Read/write value that indicates the type and level of the interrupt request level selected in the previous register. If a card supports only one type of interrupt, this register may be read-only. Bit 0 - Type of the interrupt request selected in the previous register. 0: Edge 1: Level Bit1 - Level of the interrupt request selected in the previous register. (See also Section 9.1). 0: Low polarity. (Implies open-drain output with strong pull-up for a short time, followed by weak pull-up). 1: High polarity. (Implies push-pull output).

TABLE 2-8. Plug and Play (PnP) DMA Configuration Registers

Index	Name	Definition
74h	DMA Channel Select 0	Read/write value indicating selected DMA channel for DMA 0. Bits 2-0 select the DMA channel for DMA 0. A value of 0 selects DMA channel 0; a value of 7 selects DMA channel 7. Selecting DMA channel 4, the cascade channel, indicates that no DMA channel is active.
75h	DMA Channel Select 1	Read/write value indicating selected DMA channel for DMA 1 Bits 2-0 select the DMA channel for DMA 1. A value of 0 selects DMA channel 0; a value of 7 selects DMA channel 7. Selecting DMA channel 4, the cascade channel, indicates that no DMA channel is active.

TABLE 2-9. Plug and Play (PnP) Logical Device Configuration Registers

Index	Name	Definition
F0h-FEh	Logical Device Configuration Vendor Defined	Vendor defined.

2.3.2 Configuration Register Summary

The tables in this section specify the Index, type (read/write), reset values and configuration register or action that controls each register associated with each function.

When the reset value is not fixed, the table indicates what controls the value or points to another section that provides this information.

Soft reset is related to a reset executed by utilizing the reset bit (bit 0) of the Configuration Control Register. (See TABLE 2-4 "Plug and Play (PnP) Standard Control Registers" on page 22.

Access to the KBC Configuration Registers for Logical Device 6 (see TABLE 2-17 "KBC Configuration Registers for Keyboard - Logical Device 6" on page 28) is controlled by bit 4 of the SIOCF1 Register. Setting this bit to 1 locks the KBC Configuration Registers and disables access to Logical Device 6. All writes are ignored and all reads return 0 when you attempt to access the locked registers. However, locking the KBC configuration registers does not affect access to the KBC Command Data and Status Registers.

TABLE 2-10. Card Control Registers

Index	Type	Hard Reset	Soft Reset	Configuration Register or Action
00h	W	00h	PnP ISA	Set RD_DATA Port.
01h	R			Serial Isolation.
02h	W	PnP ISA	PnP ISA	Configuration Control.
03h	W	00h	PnP ISA	Wake[CSN].
04h	R			Resource Data.
05h	R			Status.
06h	R/W	00h	PnP ISA	Card Select Number (CSN).
07h	R/W	00h	PnP ISA	Logical Device Number.
20h	R	E0h	E0h	Read only SID Register. Bits 2-0 - Revision ID Bit 7-3 - Chip ID
21h	R/W	See Section 2.4.2.	No Effect	SuperI/O Configuration 1 Register (SIOCF1).
22h	R/W	See Section 2.4.3.	No Effect	SuperI/O Configuration 2 Register (SIOCF2).
27h	R	xx	xx	SRID Register. Bits 7-0 - Revision ID
2Eh		xx	xx	Reserved for National Semiconductor use only.

TABLE 2-11. FDC Configuration Registers - Logical Device 0

Index	R/W	Hard Reset	Soft Reset	Configuration Register or Action
30h	R/W	00h or 01h See CFG0 in Section 2.1.1.	00h or 01h See CFG0 in Section 2.1.1.	Activate. See also FER1 of the Power Management device (Logical Device 4).
31h	R/W	00h	00h	I/O Range Check.
60h	R/W	03h	03h	Base Address MSB Register. Bits 7-3 (for A15-11) are read only, 00000b.
61h	R/W	F2h	F2h	Base Address LSB Register. Bits 2 and 0 (for A2 and A0) are read only, 0,0.
70h	R/W	06h	06h	Interrupt Select.
71h	R/W	03h	03h	Interrupt Type. Bit 1 is read/write; other bits are read only.
74h	R/W	02h	02h	DMA Channel Select.
75h	R	04h	04h	Report no DMA assignment.
F0h	R/W	See Section 2.5.1.	No Effect	SuperI/O FDC Configuration Register.
F1h	R/W	See Section 2.5.2.	No Effect	Drive ID Register.

TABLE 2-12. Parallel Port Configuration Registers - Logical Device 1

Index	R/W	Hard Reset	Soft Reset	Configuration Register or Action
30h	R/W	00h	00h	Activate. See also FER1 of the Power Management device (Logical Device 4).
31h	R/W	00h	00h	I/O Range Check.
60h	R/W	02h	02h	Base Address MSB register. Bits 7-3 (for A15-11) are read only, 00000b.
61h	R/W	78h	78h	Base Address LSB register. Bits 1,0 (for A1,0) are read only, 00b. See Section 2.2.2 on page 20.
70h	R/W	07h	07h	Interrupt Select.
71h	R/W	00h	00h	Interrupt Type. Bit 0 is read only. It reflects the interrupt type dictated by the Parallel Port operation mode and configured by the SuperI/O Parallel Port Configuration register. This bit is set to 1 (level interrupt) in Extended Mode and cleared (edge interrupt) in all other modes. Bit 1 is a read/write bit. Bits 7-2 are read only.
74h	R/W	04h	04h	DMA Channel Select.
75h	R	04h	04h	Report no DMA assignment.
F0h	R/W	See Section 2.6	No Effect	SuperI/O Parallel Port Configuration register.

TABLE 2-13. UART2 and Infrared Configuration Registers - Logical Device 2

Index	R/W	Hard Reset	Soft Reset	Configuration Register or Action
30h	R/W	00h	00	Activate. See also FER1 of the Power Management device (Logical Device 4).
31h	R/W	00h	00h	I/O Range Check.
60h	R/W	02h	02h	Base Address MSB register. Bits 7-3 (for A15-11) are read only, 00000b.
61h	R/W	F8h	F8h	Base Address LSB register. Bit 2-0 (for A2-0) are read only, 000b.
70h	R/W	03h	03h	Interrupt Select.
71h	R/W	03h	03h	Interrupt Type. Bit 1 is R/W; other bits are read only.
74h	R/W	04h	04h	DMA Channel Select 0 (RX_DMA).
75h	R/W	04h	04h	DMA Channel Select 1 (TX_DMA).
F0h	R/W	See Section 2.7	No Effect	SuperI/O UART2 Configuration register.

TABLE 2-14. UART1 Configuration Registers - Logical Device 3

Index	R/W	Hard Reset	Soft Reset	Configuration Register or Action
30h	R/W	00h	00h	Activate. See also FER1 of the Power Management device (Logical Device 4).
31h	R/W	00h	00h	I/O Range Check.
60h	R/W	03h	03h	Base Address MSB Register. Bits 7-3 (for A15-11) are read only, 00000b.
61h	R/W	F8h	F8h	Base Address LSB Register. Bits 2-0 (for A2-0) are read only as 000b.
70h	R/W	04h	04h	Interrupt Select.
71h	R/W	03h	03h	Interrupt Type. Bit 1 is read/write. Other bits are read only.
74h	R	04h	04h	Report no DMA Assignment.
75h	R	04h	04h	Report no DMA Assignment.
F0h	R/W	See Section 2.8	No Effect	SuperI/O UART 1 Configuration register.

TABLE 2-15. Power Management Configuration Registers - Logical Device 4

Index	R/W	Hard Reset	Soft Reset	Configuration Register or Action
30h	R/W	00	00	Activate. When bit 0 is cleared, the registers of this logical device are not accessible. The registers are maintained.
31h	R/W	00h	00h	I/O Range Check.
60h	R/W	00h	00h	Base Address MSB register. Bits 7-3 (for A15-11) are read only, 00000b.
61h	R/W	00h	00h	Base Address LSB Register. Bit 0 (for A0) is read only 0.
74h	R	04h	04h	Report no DMA assignment.
75h	R	04h	04h	Report no DMA assignment.

TABLE 2-16. KBC Configuration Registers for Mouse - Logical Device 5

Index	R/W	Hard Reset	Soft Reset	Configuration Register or Action
30h	R/W	00h	00h	Activate. When the mouse of the KBC mouse is inactive, the IRQ selected by the Mouse Interrupt Select Register (index 70h) is not asserted. This register has no effect on host KBC commands handling the PS/2 mouse.
70h	R/W	0Ch	0Ch	Mouse Interrupt (KBC IRQ12 pin) Select.
71h	R/W	02h	02h	Mouse Interrupt Type. Bits 1,0 are read/write; other bits are read only.
74h	R	04h	04h	Report no DMA assignment.
75h	R	04h	04h	Report no DMA assignment.

TABLE 2-17. KBC Configuration Registers for Keyboard - Logical Device 6

Index	R/W	Hard Reset	Soft Reset	Configuration Register or Action
30h	R/W	01h	No Effect	Activate. See also FER1 of Power Management device (Logical Device 4).
31h	R/W	00h	No Effect	I/O Range Check.
60h	R/W	00h	No Effect	Base Address MSB Register. Bits 7-3 (for A15-11) are read only, 00000b.
61h	R/W	60h	No Effect	Base Address LSB Register. Bits 2-0 are read only 000b.
62h	R/W	00h	No Effect	Command Base Address MSB Register. Bits 7-3 (for A15-11) are read only, 00000b.
63h	R/W	64h	No Effect	Command Base Address LSB. Bits 2-0 are read only 100b.
70h	R/W	01h	No Effect	KBC Interrupt (KBC IRQ1 pin) Select.
71h	RW	02h	No Effect	KBC Interrupt Type. Bits 1,0 are read/write; others are read only.
74h	R	04h	No Effect	Report no DMA assignment.
75h	R	04h	No Effect	Report no DMA assignment.
F0h	R/W	See Section 2.9.	No Effect	SuperI/O KBC Configuration Register.

2.4 CARD CONTROL REGISTERS

This section describes the registers at first level indexes in the range 20h - 2Fh.

2.4.1 SID Register

This read-only register contains the identity number of the chip. The PC87309VLJ is identified by the value E0h in this register.

SID Register, Index 20h

2.4.2 SuperI/O Configuration 1 Register (SIOCF1)

This register can be read or written. It is reset by hardware according to the BADDRs and the CFG0 strap pins see TABLE 2-1 "Strap Pins and Base Addresses" on page 20.
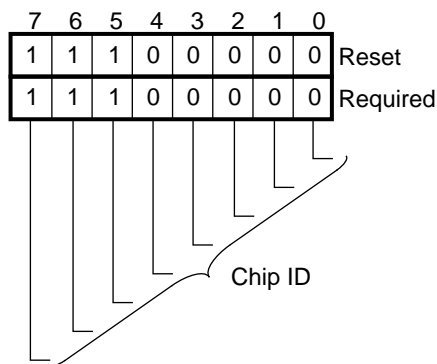
SuperI/O Configuration 1 Register (SIOCF1), Index 21h
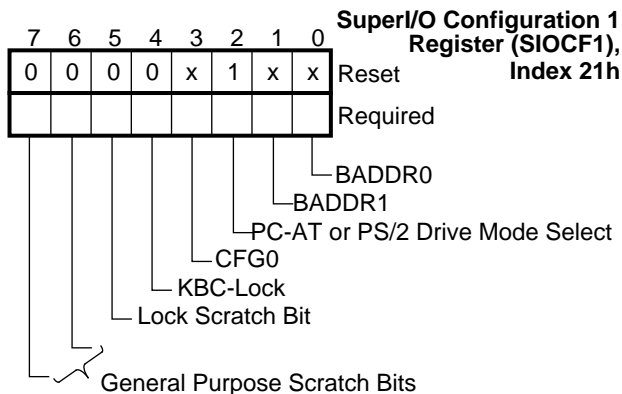
Bit 1,0 - BADDR1 and BADDR0

Initialized on reset by BADDR1 and BADDR0 strap pins (BADDR0 on bit 0). These bits select the addresses of the configuration Index and Data registers and the PnP ISA Serial Identifier. See TABLE 2-1 "Strap Pins and Base Addresses" on page 20.

Bit 2 - PC-AT or PS/2 Drive Mode Select

0: PS/2 drive mode.

1: PC-AT drive mode. (Default)

Bit 3 - CFG0 Bit

Initialized on reset by CFG0 strap pin. This read-only bit selects between Full-IR and Two-UART modes.

0: Full-IR mode.

1: Two-UART mode.

Bit 4 - KBC-Lock

This bit Locks the access to the configuration registers of the KBC, Logical Device 6.

0: Access is enabled.

1: Access is disabled. Writes are ignored and reads returns 0 upon access to Logical Device 6.

Bit 5 - Lock Scratch Bit

This bit controls bits 7 and 6 of this register. Once this bit is set to 1 by software, it can be cleared to 0 only by a hardware reset.

0: Bits 7 and 6 of this register are read/write bits.

1: Bits 7 and 6 of this register are read only bits.

Bits 7,6 - General Purpose Scratch Bits

When bit 5 is set to 1, these bits are read only. After reset they can be read or written. Once changed to read-only, they can be changed back to be read/write bits only by a hardware reset.

2.4.3   SuperI/O Configuration 2 Register (SIOCF2)

This is a read/write register in Two-UART mode only. (In Full-IR mode, it is a read only 00h register and cannot be modified.) It controls the function multiplexing of the following pins:

- Pin 43 - IRRX/P12/DRATE0
- Pin 44 - IRTX/DENSEL
- Pin 45 - $\overline{MTR0}$/DRATE0
- Pin 46 - $\overline{MTR1}$/P12
- Pin 48 - $\overline{DR1}$/DENSEL

In addition, it controls the function of $\overline{DR0,1}$ pins when $\overline{MTR0,1}$ are de-selected.

Configuring the same function by software on more than one pin is illegal, and may cause unpredictable results.

SuperI/O Configuration 2 Register (SIOCF2), Index 22h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

$\overline{MTR0}$/DRATE0 Select
$\overline{MTR1}$/P12 Select
$\overline{DR0,1}$ Function
$\overline{DR1}$/DENSEL Select
IRRX1/P12/DRATE0 Select
IRTX/DENSEL Select
Reserved
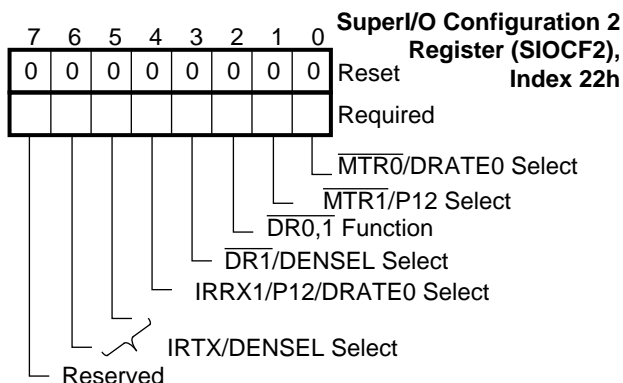
Bit 0 - $\overline{MTR0}$/DRATE0 Select

0: Pin 45 is $\overline{MTR0}$

1: Pin 45 is DRATE0 (with $\overline{MTR0}$ DC characteristics)

Bit 1 - $\overline{MTR1}$/P12 Select

0: Pin 46 is $\overline{MTR1}$

1: Pin 46 is P12 (open drain with $\overline{MTR1}$ current sink characteristics)

Bit 2 - $\overline{DR0,1}$ Function

$\overline{DR0}$ and $\overline{DR1}$ function in a single, motor-drive-select operation. $\overline{DR0}$ is affected only when $\overline{MTR0}$ is de-selected (bit 0 is set to 1); $\overline{DR1}$ is affected only when $\overline{MTR1}$ is de-selected (bit 1 is set to 1).

0: No change in DR0,1 function

1: $\overline{DR0,1}$ become a logical OR of $\overline{DR0,1}$ and $\overline{MTR0,1}$ when bits 0,1 are set to 1, respectively.

Bit 3 - $\overline{DR1}$/DENSEL Select

0: Pin 48 is $\overline{DR1}$

1: Pin 48 is DENSEL

Bits 5,4 - IRRX/P12/DRATE0 Select

X0: Pin 43 is IRRX1

01: Pin 43 is P12

11: Pin 43 is DRATE0

Bit 6 - IRTX/DENSEL Select

0: Pin 44 is IRTX

1: Pin 44 is DENSEL (with IRTX DC characteristics)

Bit 7 - Reserved

This is read only 0.

2.4.4   SRID Register

This read-only register contains the identity number of the chip revision. SRID is incremented on each revision.

SRID Register, Index 27h

7	6	5	4	3	2	1	0	
x	x	x	x	x	x	x	x	Reset
								Required

Chip Revision ID
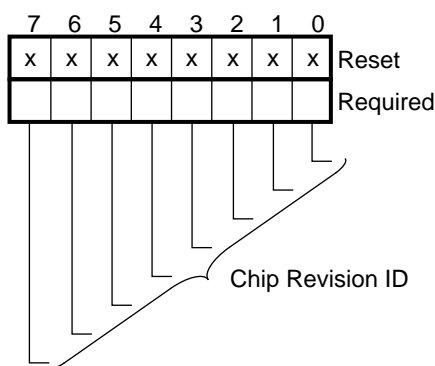
2.5 FDC CONFIGURATION REGISTERS (LOGICAL DEVICE 0)

2.5.1 SuperI/O FDC Configuration Register

This read/write register is reset by hardware to 20h.

7	6	5	4	3	2	1	0	
0	0	1	0	0	0	0	0	Reset
								Required

Super I/O FDC Configuration Register, Index F0h

- TRI-STATE Control
- Reserved
- DENSEL Polarity Control
- TDR Register Mode
- Four Drive Control
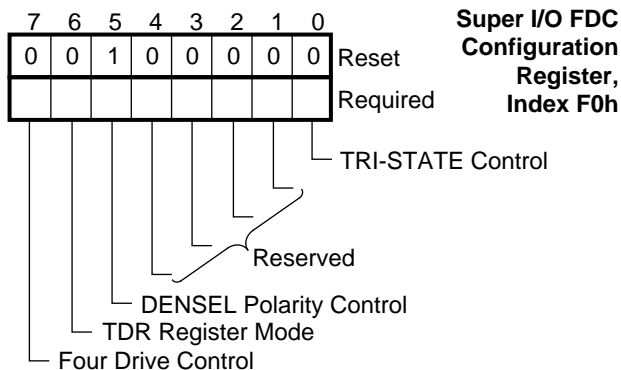
Bit 0 - TRI-STATE Control

When set, this bit causes the FDC pins to be in TRI-STATE (except the IRQ and DMA pins) when the FDC is inactive (disabled).

This bit is ORed with a bit of PMC1 register of Logical Device 4.

0: FDC pins are not put in TRI-STATE.

1: FDC pins are put in TRI-STATE.

Bits 4-1 - Reserved

Bit 5 - DENSEL Polarity Control

0: DENSEL is active low for 500 Kbps or 1 Mbps data rates.

1: DENSEL is active high for 500 Kbps or 1 Mbps data rates. (Default)

Bit 6 - TDR Register Mode

0: PC-AT Compatible drive mode (bits 7 through 2 of TDR are not driven).

1: Enhanced drive mode (bits 7 through 2 of TDR are driven on TDR read).

Bit 7 - Four Drive Control

0: Two floppy drives are directly controlled by $\overline{DR1\text{-}0}$, $\overline{MTR1\text{-}0}$.

1: Four floppy drives are controlled with the aid of an external decoder.

2.5.2 Drive ID Register

This read/write register is reset by hardware to 00h. These bits control bits 5 and 4 of the enhanced TDR register.

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

Drive ID Register, Index F1h

- Drive 0 ID
- Drive 1 ID
- Reserved
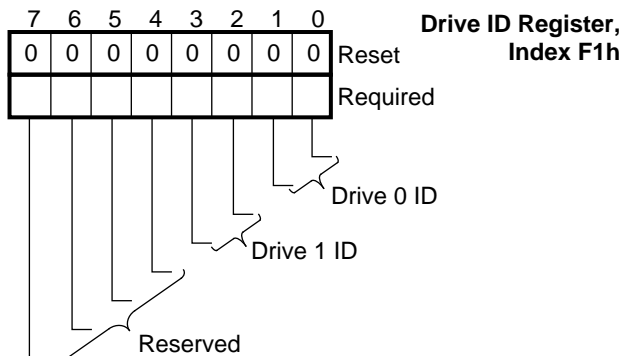
Bits 1,0 - Drive 0 ID

These bits are reflected on bits 5 and 4, respectively, of the Tape Drive Register (TDR) of the FDC when drive 0 is accessed. See Section 3.3.4 "Tape Drive Register (TDR)" on page 41.

Bits 3,2 - Drive 1 ID

These bits are reflected on bits 5 and 4, respectively, of the TDR register of the FDC when drive 1 is accessed. See Section 3.3.4 "Tape Drive Register (TDR)" on page 41.

Bits 7-4 - Reserved

2.6 SUPERI/O PARALLEL PORT CONFIGURATION REGISTER (LOGICAL DEVICE 1)

This read/write register is reset by hardware to F2h. To maintain compatibility with future chips, it is recommended not to change bits 7-4 during normal operation. Before changing from any EPP mode to another mode, initialize bits 3-0 of CTR to 0100b. (See 4.2.4 on page 81.)

7	6	5	4	3	2	1	0	
1	1	1	1	0	0	1	0	Reset
								Required

SuperI/O Parallel Port Configuration Register, Index F0h

- TRI-STATE Control
- Clock Enable
- Reserved
- Reserved
- Configuration Bits within the Parallel Port
- Parallel Port Mode Select
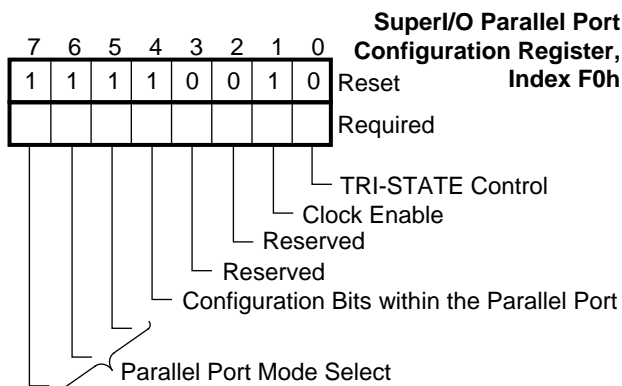
Bit 0 - TRI-STATE Control

When set, this bit causes the parallel port pins to be in TRI-STATE (except IRQ and DMA pins) when the parallel port is inactive (disabled). This bit is ORed with a bit of the PMC1 register of Logical Device4.

Bit 1 - Clock Enable

0: Parallel port clock disabled.

ECP modes and EPP timeout are not functional when the logical device is active. Registers are maintained.

1: Parallel port clock enabled.

All operation modes are functional when the logical device is active. This bit is ANDed with a bit of the PMC3 register of the Power Management device (Logical Device4).

Bit 2,3 - Reserved

Bit 4 - Configuration Bits within the Parallel Port

0: The registers at base (address) + 403h, base + 404h and base + 405h are not accessible (reads and writes are ignored).

1: When IEEE1284 mode is selected by bits 7 through 5, the registers at base (address) + 403h, base + 404h and base + 405h are accessible.

This option supports run-time configuration within the Parallel Port address space. An 8-byte (and 1024-byte) aligned base address is required to access these registers. See Chapter 4 "Parallel Port (Logical Device 1)" on page 79 for details.

Bit 7-5 - Parallel Port Mode Select

Bit 5 is the LSB.

Selection of EPP 1.7 or 1.9 in ECP mode 4 is controlled by bit 4 of the Control2 configuration register of the parallel port at offset 02h. See Section 4.5.17 "Control2 Register" on page 93.

000: SPP Compatible mode. PD7-0 are always output signals.

001: SPP Extended mode. PD7-0 direction controlled by software.

010:EPP 1.7 mode.

011:EPP 1.9 mode.

100:IEEE1284 mode (selects IEEE1284 register set), with no support for EPP mode.

101:Reserved.

110:Reserved.

111:IEEE1284 mode (selects IEEE1284 register set), with EPP mode selectable as mode 4.

2.7 SUPERI/O UART2 AND INFRARED CONFIGURATION REGISTER (LOGICAL DEVICE 2)

This read/write register is reset by hardware to 02h.

SuperI/O UART2 Configuration Register, Index F0h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	1	0	Reset
								Required

TRI-STATE Control for UART2 Pins
Power Mode Control
Busy Indicator
Reserved
Bank Select Enable
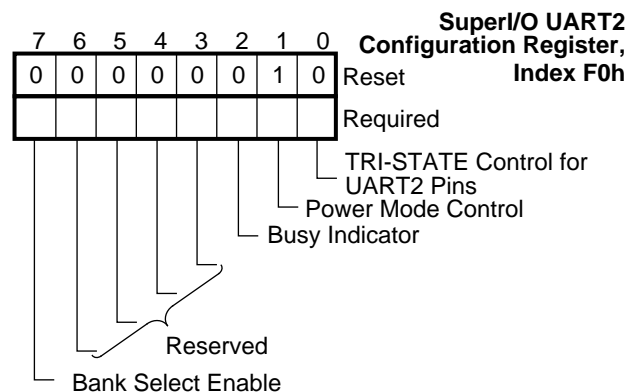
Bit 0 - TRI-STATE Control for UART2 signals

This bit controls the TRI-STATE status of UART signals (except IRQ and DMA signals) when UART2 is inactive (disabled). This bit is ORed with a bit of the PMC1 register of the Power Management device (Logical Device4).

0: Signals not in TRI-STATE.

1: Signals in TRI-STATE.

Bit 1 - Power Mode Control

0: Low power mode.

UART2 Clock disabled. UART2 output signals are set to their default state. The $\overline{RI}$ input signal can be programmed to generate an interrupt. Registers are maintained.

1: Normal power mode.

UART2 clock enabled. The UART2 is functional when the logical device is active. This bit is ANDed with a bit of the PMC3 register of the Power Management device (Logical Device 4).

Bit 2 - Busy Indicator

This read-only bit can be used by power management software to decide when to power down UART2 logical device. This bit is also accessed via the PMC3 register of the Power Management device (Logical Device 4).

0: No transfer in progress.

1: Transfer in progress.

Bits 6-3 - Reserved

Bit 7 - Bank Select Enable

Enables bank switching for UART2. If this bit is cleared, all attempts to access the extended registers are ignored.

2.8 SUPERI/O UART1 CONFIGURATION REGISTER (LOGICAL DEVICE 3)

This read/write register is reset by hardware to 02h. Its bits function like the bits in the SuperI/O UART2 Configuration register

SuperI/O UART1 Configuration Register, Index F0h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	1	0	Reset
								Required

- TRI-STATE Control for UART1 Pins
- Power Mode Control
- Busy Indicator
- Reserved
- Bank Select Enable
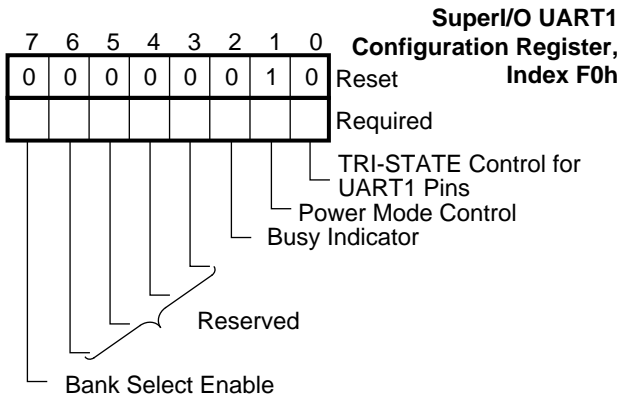
2.9 SUPERI/O KBC CONFIGURATION REGISTER (LOGICAL DEVICE 6)

This read/write register is reset by hardware to 40h.

SuperI/O KBC Configuration Register, Index F0h

7	6	5	4	3	2	1	0	
0	1	0	0	0	0	0	0	Reset
								Required

- TRI-STATE Control
- Reserved
- KBC Clock Source
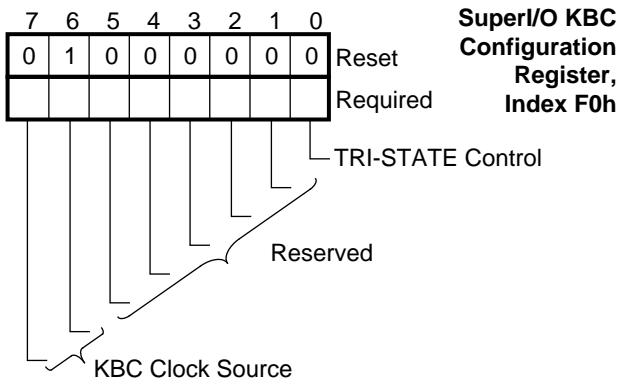
Bit 0 - TRI-STATE Control

When set, it causes the KBC pins (including the mouse clock and mouse data, but excluding DMA and IRQ), to be in TRI-STATE when the KBC is inactive (disabled).

Bits 5-1 - Reserved

Bits 7,6 - KBC Clock Source

Bit 6 is the LSB. The clock source can be changed only when the KBC is inactive (disabled).

00: 8 MHz
01: 12 MHz
10: 16 MHz.
11: Reserved.

2.10 CONFIGURATION REGISTER BITMAPS

SID Register, Index 20h

7	6	5	4	3	2	1	0	
1	1	1	0	0	0	0	0	Reset
1	1	1	0	0	0	0	0	Required

- Chip ID

SuperI/O Configuration 1 Register (SIOCF1), Index 21h

7	6	5	4	3	2	1	0	
0	0	0	x	0	1	x	0	Reset
								Required

- BADDR0
- BADDR1
- PC-AT or PS/2 Drive Mode Select
- CFG0
- KBC-Lock
- Lock Scratch Bit
- General Purpose Scratch Bits

SuperI/O Configuration 2 Register (SIOCF2), Index 22h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

- $\overline{\text{MTR0}}$/DRATE0 Select
- $\overline{\text{MTR1}}$/P12 Select
- $\overline{\text{DR0,1}}$ Function
- $\overline{\text{DR1}}$/DENSEL Select
- IRRX1/P12/DRATE0 Select
- IRTX/DENSEL Select
- Reserved

SRID Register, Index 27h

7	6	5	4	3	2	1	0	
x	x	x	x	x	x	x	x	Reset
								Required

- Chip Revision ID

7	6	5	4	3	2	1	0	
0	1	0	0	0	0	0	0	Reset
								Required

SuperI/O KBC Configuration Register, Index F0h

TRI-STATE Control

Reserved

KBC Clock Source

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

SuperI/O UART1,2 Configuration Register, Index F0h

TRI-STATE Control for UART Pins

Power Mode Control

Busy Indicator

Reserved

Bank Select Enable

7	6	5	4	3	2	1	0	
0	0	1	0	0	0	0	0	Reset
								Required

Super I/O FDC Configuration Register, Index F0h

TRI-STATE Control

Reserved

DENSEL Polarity Control

TDR Register Mode

Four Drive Control

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

Drive ID Register, Index F1h

Drive 0 ID

Drive 1 ID

Reserved

7	6	5	4	3	2	1	0	
1	1	1	1	0	0	1	0	Reset
								Required

SuperI/O Parallel Port Configuration Register, Index F0h

TRI-STATE Control

Clock Enable

Reserved

Reserved

Configuration Bits within the Parallel Port

Parallel Port Mode Select

3.0 The Floppy Disk Controller (FDC) (Logical Device 0)

The Floppy Disk Controller (FDC) is suitable for all PC-AT, EISA, PS/2, and general purpose applications. DP8473 and N82077 software compatibility is provided. Key features include a 16-byte FIFO, PS/2 diagnostic register support, perpendicular recording mode, CMOS disk input and output logic, and a high performance Digital Data Separator (DDS).

Figure 3-1 shows a functional block diagram of the FDC. The rest of this chapter describes the FDC functions, data transfer, the FDC registers, the phases of FDC commands, the result phase status registers and the FDC commands, in that order.

3.1 FDC FUNCTIONS

FDC functions are enabled when the FDC Function Enable bit (bit 3) of the Function Enable Register 1 (FER1) at offset 00h in logical device 8 is set to 1. See Section 7.2.3 on page 155.

The PC87309 is software compatible with the DP8473 and 82077 Floppy Disk Controllers. Upon a power-on reset, the 16-byte FIFO is disabled. Also, the disk interface output signals are configured as active push-pull output signals, which are compatible with both CMOS input signals and open-collector resistor terminated disk drive input signals.

The FIFO can be enabled with the CONFIGURE command. The FIFO can be very useful at high data rates, with systems that have a long DMA bus latency, or with multi-tasking systems such as the EISA or MCA bus structures.

The FDC supports all the DP8473 MODE command features as well as some additional features. These include control over the enabling of the FIFO for read and write operations, disabling burst mode for the FIFO, a bit that will configure the disk interface outputs as open-drain output signals, and programmability of the DENSEL output signal.

DRATE0 and DENSEL pins are not available in the default configuration of Two-UART mode. You may optionally select them on other FDC pins or on IR pins. When working with no DRATE0 or DENSEL, you must set the BIOS and the floppy drive to support this operation.

3.1.1 Microprocessor Interface

The Floppy Disk Controller (FDC) receives commands, transfers data, and returns status information via an FDC microprocessor interface. This interface consists of the A9-3, AEN, $\overline{RD}$, and $\overline{WR}$ signals, which access the chip for read and write operations; the data signals D7-0; the address lines A2-0, which select the appropriate register (see TABLE 3-1 on page 38) an IRQ signal, and the DMA interface signals DRQ, $\overline{DACK}$, and TC.

3.1.2 System Operation Modes

The FDC operates in PC-AT or PS/2 drive mode, depending on the value of bit 2 of the SuperI/O Configuration 1 register at index 21h. See Section 2.4.2 on page 28.

Internal Control and Data Bus
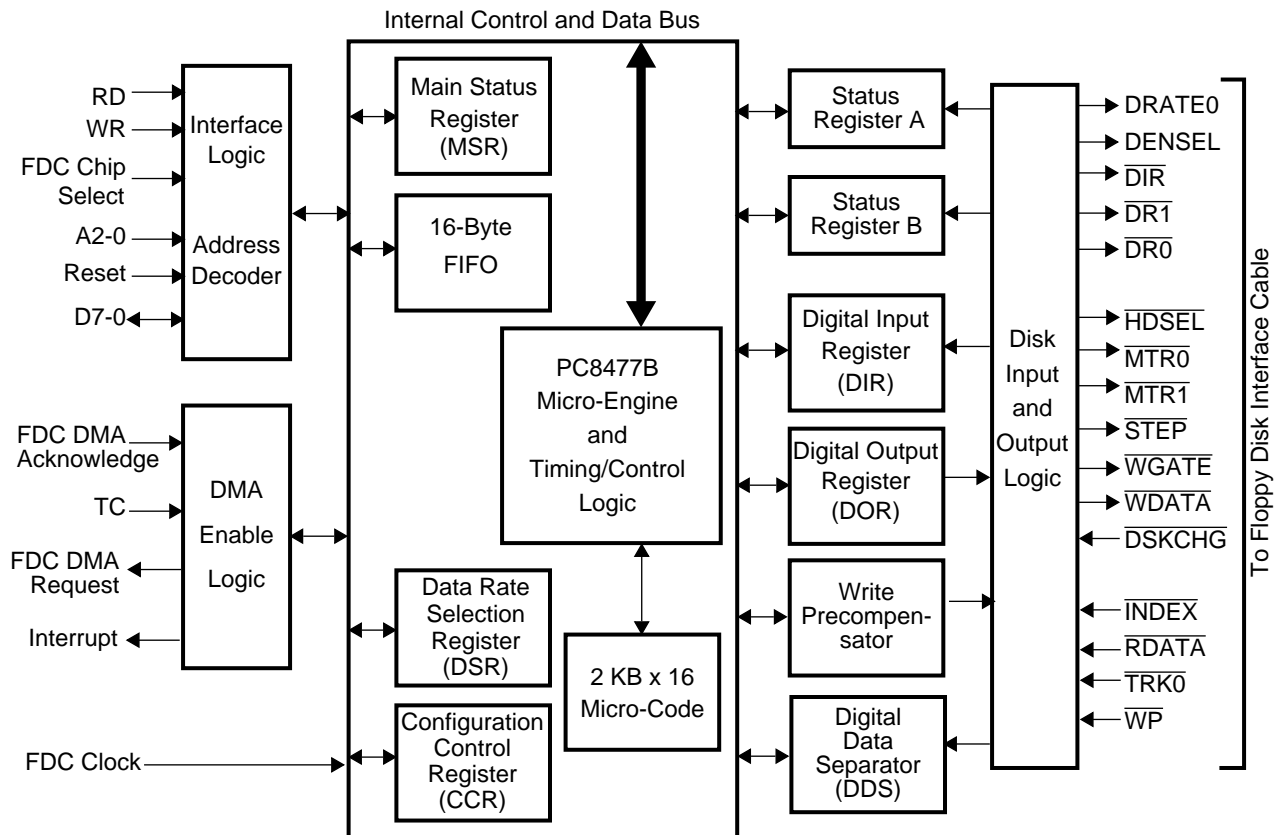
FIGURE 3-1. FDC Functional Block Diagram

PC-AT Drive Mode

The PC-AT register set is enabled. The DMA enable bit in the Digital Output Register (DOR) becomes valid (the appropriate IRQ and DRQ signals can be put in TRI-STATE). TC and DENSEL become active high signals (default to a 5.25" floppy disk drive).

PS/2 Drive Mode

This drive mode supports the PS/2 models 50/60/80 configuration and register set. The value of the DMA enable bit in the Digital Output Register (DOR) becomes unimportant (the IRQ and DRQ signals assigned to the FDC are always valid). TC and DENSEL become active low signals (default to 3.5" floppy drive).

3.2 DATA TRANSFER

3.2.1 Data Rates

The FDC supports the standard PC data rates of 250, 300 and 500 Kbps, as well as 1 Mbps. High performance tape and floppy disk drives that are currently emerging in the PC world, transfer data at 1 Mbps. The FDC also supports the perpendicular recording mode, a new format used for some high capacity disk drives at 1 Mbps.

The internal digital data separator needs no external components. It improves the window margin performance standards of the DP8473, and is compatible with the strict data separator requirements of floppy disk drives and tape drives.

The FDC contains write precompensation circuitry that defaults to 125 nsec for 250, 300, and 500 Kbps (41.67 nsec at 1 Mbps). These values can be overridden in software to disable write precompensation or to provide levels of precompensation up to 250 nsec.

The FDC has internal 24 mA data bus buffers which allow direct connection to the system bus. The internal 40 mA totem-pole disk interface buffers are compatible with both CMOS drive input signals and 150 resistor terminated disk drive input signals.

3.2.2 The Data Separator

The internal data separator is a fully digital PLL. The fully digital PLL synchronizes the raw data signal read from the disk drive. The synchronized signal is used to separate the encoded clock and data pulses. The data pulses are broken down into bytes, and then sent to the microprocessor by the controller.

The FDC supports data transfer rates of 250, 300, 500 Kbps and 1 Mbps in Modified Frequency Modulation (MFM) format.

The FDC has a dynamic window margin and lock range performance capable of handling a wide range of floppy disk drives. In addition, the data separator operates under a variety of conditions, including high fluctuations in the motor speed of tape drives that are compatible with floppy disk drives.

The dynamic window margin is the primary indicator of the quality and performance level of the data separator. It indicates the toleration of the data separator for Motor Speed Variation (MSV) of the drive spindle motor and bit jitter (or window margin).

FIGURE 3-2 shows the dynamic window margin in the performance of the FDC at different data rates, generated using a FlexStar FS-540 floppy disk simulator and a proprietary dynamic window margin test program written by National Semiconductor.

250,300, 500 Kbps and 1 Mbps

Motor Speed Variation (% of Nominal)

Typical Performance at 500 Kbps,
V_{DD} = 5.0 V, 25° C
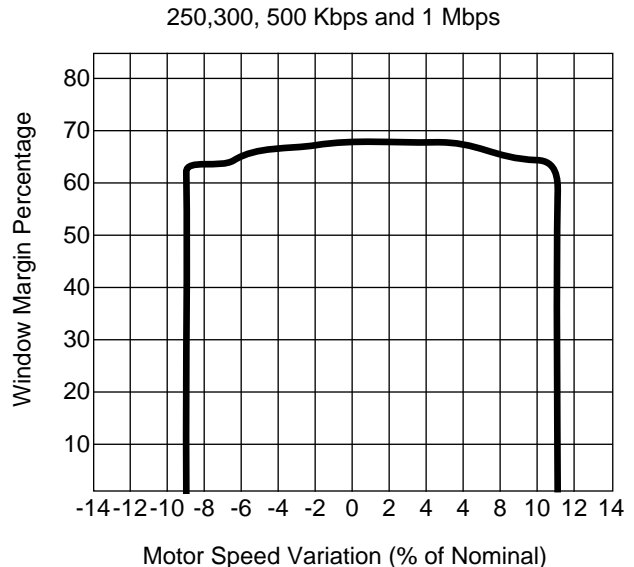
FIGURE 3-2. PC87309 Dynamic Window Margin Performance

The x axis measures MSV. MSV is translated directly to the actual rate at which the data separator reads data from the disk. In other words, a faster than nominal motor results in a higher data rate.

The dynamic window margin performance curve also indicates how much bit jitter (or window margin) can be tolerated by the data separator. This parameter is shown on the y-axis of the graph. Bit jitter is caused by the magnetic interaction of adjacent data pulses on the disk, which effectively shifts the bits away from their nominal positions in the middle of the bit window. Window margin is commonly measured as a percentage. This percentage indicates how far a data bit can be shifted early or late with respect to its nominal bit position, and still be read correctly by the data separator. If the data separator cannot correctly decode a shifted bit, then the data is misread and a CRC error results.

The dynamic window margin performance curve supplies two pieces of information:

- The maximum range of MSV (also called "lock range") that the data separator can handle with no read errors.

- The maximum percentage of window margin (or bit jitter) that the data separator can handle with no read errors.

Thus, the area under the dynamic window margin curves in FIGURE 3-2 is the range of MSV and bit jitter that the FDC can handle with no read errors. The internal digital data separator of the FDC performs much better than comparable digital data separator designs, and does not require any external components.

The controller maximizes the internal digital data separator by implementing a read algorithm that enhances the lock characteristics of the fully digital Phase-Locked Loop (PLL). The algorithm minimizes the effect of bad data on the synchronization between the PLL and the data.

It does this by forcing the fully digital PLL to re-lock to the clock reference frequency any time the data separator attempts to lock to a non-preamble pattern. See the state diagram of this read algorithm in FIGURE 3-3.
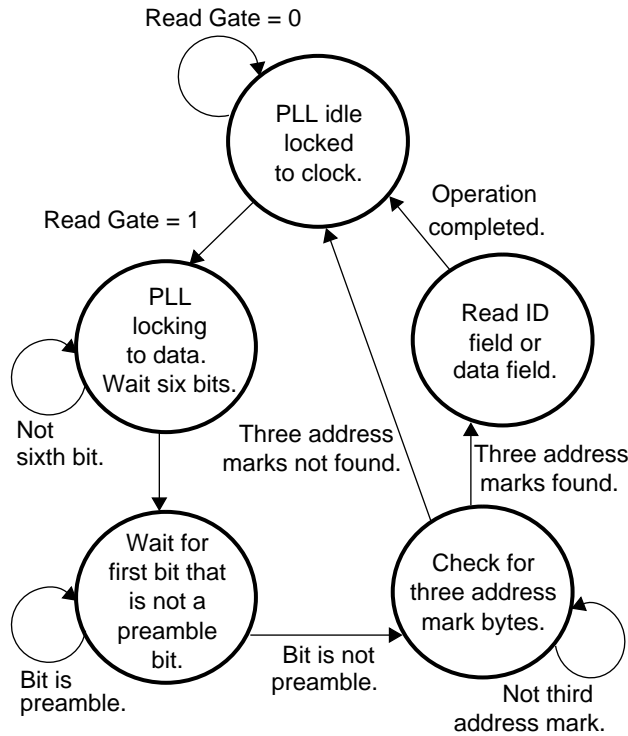
FIGURE 3-3. Read Algorithm State Diagram

3.2.3 Perpendicular Recording Mode Support

The FDC is fully compatible with perpendicular recording mode disk drives at all data transfer rates. These perpendicular drives are also called 4 Mbyte (unformatted) or 2.88 Mbyte (formatted) drives. This refers to their maximum storage capacity.

Perpendicular recording orients the magnetic flux changes (which represent bits) vertically on the disk surface, allowing for a higher recording density than conventional longitudinal recording methods. This increased recording density increases data rate by up to 1 Mbps, thereby doubling the storage capacity. In addition, the perpendicular 2.88 MB drive is read/write compatible with 1.44 MB and 720 KB diskettes (500 Kbps and 250 Kbps respectively).

The 2.88 MB drive has unique format and write data timing requirements due to its read/write head and pre-erase head design. This is illustrated in FIGURE 3-4.

Unlike conventional disk drives which have only a read/write head, the 2.88 MB drive has both a pre-erase head and read/write head. With conventional disk drives, the read/write head, itself, can rewrite the disk without problems. 2.88 MB drives need a pre-erase head to erase the magnetic flux on the disk surface before the read/write head can write to the disk surface. The pre-erase head is activated during disk write operations only, i.e. FORMAT and WRITE DATA commands.

In 2.88 MB drives, the pre-erase head leads the read/write head by 200 μm, which translates to 38 bytes at 1 Mbps (19 bytes at 500 Kbps).
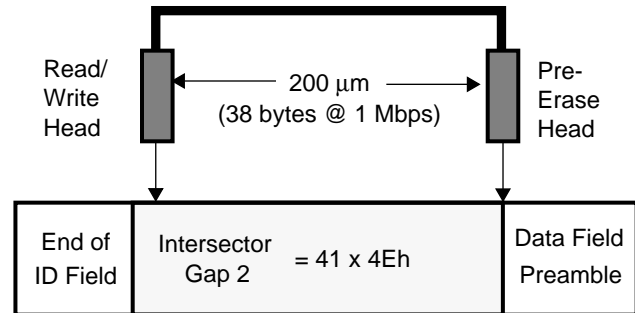
FIGURE 3-4. Perpendicular Recording Drive Read/Write Head and Pre-Erase Head

For both conventional and perpendicular drives, $\overline{\text{WGATE}}$ is asserted with respect to the position of the read/write head. With conventional drives, this means that $\overline{\text{WGATE}}$ is asserted when the read/write head is located at the beginning of the preamble to the data field.

With 2.88 MB drives, since the preamble must be erased before it is rewritten, $\overline{\text{WGATE}}$ should be asserted when the pre-erase head is located at the beginning of the preamble to the data field. This means that $\overline{\text{WGATE}}$ should be asserted when the read/write head is at least 38 bytes (at 1 Mbps) before the preamble. TABLES 3-14 on page 63 and 3-15 on page 63 show how the perpendicular format affects gap 2 and, consequently, $\overline{\text{WGATE}}$ timing, for different data rates.

Because of the 38-byte spacing between the read/write head and the pre-erase head at 1 Mbps, the gap 2 length of 22 bytes used in the standard IBM disk format is not long enough. The format standard for 2.88 MB drives at 1 Mbps called the Perpendicular Format, increases the length of gap 2 to 41 bytes. See FIGURE 3-5 on page 59.

The PERPENDICULAR MODE command puts the Floppy Disk Controller (FDC) into perpendicular recording mode, which allows it to read and write perpendicular media. Once this command is invoked, the read, write and format commands can be executed in the normal manner. The perpendicular mode of the FDC functions at all data rates, adjusting format and write data parameters accordingly. See Section 3.7.9 on page 62 for more details.

3.2.4 Data Rate Selection

The FDC sets the data rate in two ways. For PC compatible software, the Configuration Control Register (CCR) at offset 07h programs the data rate for the FDC. The lower bits D1 and D0 in the CCR set the data rate. The other bits should be set to zero. TABLE 3-5 on page 43 shows how to encode the desired data rate.

The lower two bits of the Data rate Select Register (DSR) at offset 04h can also set the data rate. These bits are encoded like the corresponding bits in the CCR. The remainder of the bits in the DSR have other functions. See the description of the DSR in Section 3.3.6 on page 43 for more details.

The data rate is determined by the last value written to either the CCR or the DSR. Either the CCR or the DSR can override the data rate selection of the other register. When the data rate is selected, the micro-engine and data separator clocks are scaled appropriately.

3.2.5 Write Precompensation

Write precompensation enables the $\overline{WDATA}$ output signal to adjust for the effects of bit shift on the data as it is written to the disk surface.

Bit shift is caused by the magnetic interaction of data bits as they are written to the disk surface. It shifts these data bits away from their nominal position in the serial MFM data pattern. Bit shift makes it much harder for a data separator to read data and can cause soft read errors.

Write precompensation predicts where bit shift could occur within a data pattern. It then shifts the individual data bits early, late, or not at all so that when they are written to the disk, the shifted data bits are back in their nominal position.

The FDC supports software programmable write precompensation. Upon power up, the default write precompensation values shown in TABLE 3-7 on page 43, are used. In addition, the default starting track number for write precompensation is track zero

You can use the DSR to change the write precompensation using any of the values in TABLE 3-6 on page 43. Also, the CONFIGURE command can change the starting track number for write precompensation.

3.2.6 FDC Low-Power Mode Logic

The FDC of the PC87309 supports two low-power modes, manual and automatic.

In low-power mode, the micro-code is driven from the clock. Therefore, it is disabled while the clock is off. Upon entering the power-down state, bit 7, the RQM (Request For Master) bit, in the Main Status Register (MSR) of the FDC is cleared to 0.

For details about entering and exiting low-power mode by setting bit 6 of the Data rate Select Register (DSR) or by executing the LOW PWR option of the FDC MODE command, see Recovery from Low-Power Mode later in this section, Section 3.3.6 on page 43 and Section 3.7.7 on page 60.

The DSR, Digital Output Register (DOR), and the Configuration Control Register (CCR) are unaffected and remain active in power-down mode. Therefore, you should make sure that the motor and drive select signals are turned off.

If the power to an external clock driving the PC87309 will be independently removed while the FDC is in power-down mode, it must not be done until 2 msec after the LOW PWR option of the FDC MODE command is issued.

Manual Low-Power Mode

Manual low power is enabled by writing a 1 to bit 6 of the DSR. The chip will power down immediately. This bit will be cleared to 0 after power up.

Manual low power can also be triggered by the MODE command. Manual low power mode functions as a logical OR function between the DSR low power bit and the LOW PWR option of the MODE command.

Automatic Low-Power Mode

Automatic low-power mode switches the controller to low power 500 msec (at the 500 Kbps MFM data rate) after it has entered the Idle state. Once automatic low-power mode is set, it does not have to be set again, and the controller automatically goes into low-power mode after entering the Idle state.

Automatic low-power mode can only be set with the LOW PWR option of the MODE command.

Recovery from Low-Power Mode

There are two ways the FDC section can recover from the power-down state.

Power up is triggered by a software reset via the DOR or DSR. Since a software reset requires initialization of the controller, this method might be undesirable.

Power up is also triggered by a read or write to either the Data Register (FIFO) or Main Status Register (MSR). This is the preferred way to power up since all internal register values are retained. It may take a few milliseconds for the clock to stabilize, and the microprocessor will be prevented from issuing commands during this time through the normal MSR protocol. That means that bit 7, the Request for Master (RQM) bit, in the MSR will be a 0 until the clock has stabilized. When the controller has completely stabilized after power up, the RQM bit in the MSR is set to 1 and the controller can continue where it left off.

3.2.7 Reset

The FDC can be reset by hardware or software.

A hardware reset consists of pulsing the Master Reset (MR) input signal. A hardware reset sets all of the user addressable registers and internal registers to their default values. The SPECIFY command values are unaffected by reset, so they must be initialized again.

The major default conditions affected by reset are:

- FIFO disabled
- DMA disabled
- Implied seeks disabled
- Drive polling enabled

A software reset can be triggered by bit 2 of the Digital Output Register (DOR) or bit 7 of the Data rate Select Register (DSR). Bit 7 of DSR clears itself, while bit 2 of DOR does not clear itself.

If the LOCK bit in the LOCK command was set to 1 before the software reset, the FIFO, THRESH, and PRETRK parameters in the CONFIGURE command will be retained. In addition, the FWR, FRD, and BST parameters in the MODE command will be retained if LOCK is set to 1. This function eliminates the need for total initialization of the controller after a software reset.

After a hardware (assuming the FDC is enabled in the FER) or software reset, the Main Status Register (MSR) is immediately available for read access by the microprocessor. It will return a 00h value until all the internal registers have been updated and the data separator is stabilized.

When the controller is ready to receive a command byte, the MSR returns a value of 80h (Request for Master (RQM, bit 7) bit is set). The MSR is guaranteed to return the 80h value within 250 μsec after a hardware or software reset.

All other user addressable registers other than the Main Status Register (MSR) and Data Register (FIFO) can be accessed at any time, even during software reset.

3.3 THE REGISTERS OF THE FDC

The FDC registers are mapped to the offset address shown in TABLE 3-1 on page 38, with the base address range provided by the on-chip address decoder. For PC-AT or PS/2 applications, the offset address range of the diskette controller is 00h through 07h from the index of logical device 0.

THE REGISTERS OF THE FDC

TABLE 3-1. The FDC Registers and Addresses

Symbol	Description	Offset			R/W
		A2	A1	A0	
SRA	Status Register A	0	0	0	R
SRB	Status Register B	0	0	1	R
DOR	Digital Output Register	0	1	0	R/W
TDR	Tape Drive Register	0	1	1	R/W
MSR	Main Status Register	1	0	0	R
DSR	Data Rate Select Register	1	0	0	W
FIFO	Data Register (FIFO)	1	0	1	R/W
-	(Bus in TRI-STATE)	1	1	0	X
DIR	Digital Input Register	1	1	1	R
CCR	CCR Configuration Control Register	1	1	1	W

The FDC supports two system operation modes: PC-AT drive mode and PS/2 drive mode (MicroChannel systems). Section 3.1.2 on page 34 describes each mode and "Bit 2 - PC-AT or PS/2 Drive Mode Select" on page 28 describes how each is enabled.

Unless specifically indicated otherwise, all fields in all registers are valid in both drive modes.

The FDC supports plug and play, as follows:

- The FDC interrupt can be routed on one of the following ISA interrupts: IRQ3-IRQ7, IRQ9-IRQ12 and IRQ15 (see PNP2 register).

- The FDC DMA signals can be routed to one of three 8-bit ISA DMA channels (see PNP2 register); and its base address is software configurable (see FBAL and FBAH registers).

- Upon reset, the DMA of the FDC is routed to the DRQ2 and $\overline{DACK2}$ pins.

3.3.1   Status Register A (SRA)

Status Register A (SRA) monitors the state of assigned IRQ signal and some of the disk interface signals. SRA is a read-only register that is valid only in PS/2 drive mode.

SRA can be read at any time while PS/2 drive mode is active. In PC-AT drive mode, all bits are in TRI-STATE during a microprocessor read.

PS/2 Drive Mode

Status Register A (SRA) Offset 00h
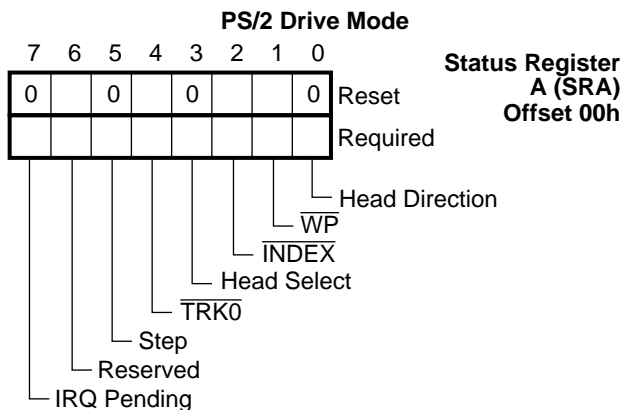
Bit 0 - Head Direction

This bit indicates the direction of the head of the Floppy Disk Drive (FDD). Its value is the inverse of the value of the $\overline{DIR}$ interface output signal.

0: $\overline{DIR}$ is not active, i.e., the head of the FDD steps outward. (Default)

1: $\overline{DIR}$ is active, i.e., the head of the FDD steps inward.

Bit 1 - Write Protect ($\overline{WP}$)

This bit indicates whether or not the selected Floppy Disk Drive (FDD) is write protected. Its value reflects the status of the $\overline{WP}$ disk interface input signal.

0: $\overline{WP}$ is active, i.e., the FDD in the selected drive is write protected.

1: $\overline{WP}$ is not active, i.e., the FDD in the selected drive is not write protected.

Bit 2 - Beginning of Track ($\overline{INDEX}$)

This bit indicates the beginning of a track. Its value reflects the status of the $\overline{INDEX}$ disk interface input signal.

0: $\overline{INDEX}$ is active, i.e., it is the beginning of a track.

1: $\overline{INDEX}$ is not active, i.e., it is not the beginning of a track.

Bit 3 - Head Select

This bit indicates which side of the Floppy Disk Drive (FDD) is selected by the head. Its value is the inverse of the $\overline{HDSEL}$ disk interface output signal.

0: $\overline{HDSEL}$ is not active, i.e., the head of the FDD selects side 0. (Default)

1: $\overline{HDSEL}$ is active, i.e., the head of the FDD selects side 1.

Bit 4 - At Track 0 ($\overline{TRK0}$)

This bit indicates whether or not the head of the Floppy Disk Drive (FDD) is at track 0. Its value reflects the status of the $\overline{TRK0}$ disk interface input signal.

0: $\overline{TRK0}$ is active, i.e., the head of the FDD is at track 0.

1: $\overline{TRK0}$ is not active, i.e., the head of the FDD is not at track 0.

Bit 5 - Step

This bit indicates whether or not the head of the Floppy Disk Drive (FDD) should move during a seek operation. Its value is the inverse of the $\overline{STEP}$ disk interface output signal.

0: $\overline{STEP}$ is not active, i.e., the head of the FDD moves. (Default)

1: $\overline{STEP}$ is active (low), i.e., the head of the FDD does not move.

Bit 6 - Reserved

Bit 7 - IRQ Pending

This bit signals the completion of the execution phase of certain FDC commands. Its value reflects the status of the IRQ signal assigned to the FDC.

0: The IRQ signal assigned to the FDC is not active.

1: The IRQ signal assigned to the FDC is active, i.e., the FDD has completed execution of certain FDC commands.

3.3.2 Status Register B (SRB)

Status Register B (SRB) is a read-only diagnostic register that is valid only in PS/2 drive mode.

SRB can be read at any time while PS/2 drive mode is active. In PC-AT drive mode, all bits are in TRI-STATE during a microprocessor read.

PS/2 Drive Mode

7	6	5	4	3	2	1	0	
1	1	0	0	0	0	0	0	Reset
1	1							Required

SRB Register Offset 01h

- MTR0
- MTR1
- WGATE
- RDATA
- WDATA
- Drive Select Status
- Reserved
- Reserved
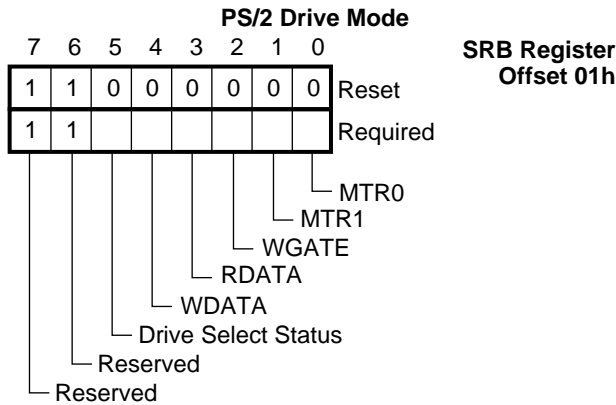
Bit 0 - Motor 0 Status (MTR0)

This bit indicates the complement of the $\overline{\text{MTR0}}$ output pin.

This bit is cleared to 0 by a hardware reset and unaffected by a software reset.

0: $\overline{\text{MTR0}}$ not active; motor 0 off (default).

1: $\overline{\text{MTR0}}$ active; motor 0 on.

Bit 1 - Motor 1 Status (MTR1)

This bit indicates the complement of the $\overline{\text{MTR1}}$ output pin.

This bit is cleared to 0 by a hardware reset and unaffected by a software reset.

0: $\overline{\text{MTR1}}$ not active; motor 1 off (default).

1: $\overline{\text{MTR1}}$ active.; motor 1 on.

Bit 2 - Write Circuitry Status (WGATE)

This bit indicates the complement of the $\overline{\text{WGATE}}$ output pin.

0: $\overline{\text{WGATE}}$ not active. The write circuitry of the selected FDD is enabled (default).

1: $\overline{\text{WGATE}}$ active. The write circuitry of the selected FDD is disabled.

Bit 3 - Read Data Status (RDATA)

If read data was sent, this bit indicates whether an odd or even number of bits was sent.

Every inactive edge transition of the $\overline{\text{RDATA}}$ disk interface output signal causes this bit to change state.

0: Either no read data was sent or an even number of bits of read data was sent. (Default)

1: An odd number of bits of read data was sent.

Bit 4 - Write Data Status (WDATA)

If write data was sent, this bit indicates whether an odd or even number of bits was sent.

Every inactive edge transition of the $\overline{\text{WDATA}}$ disk interface output signal causes this bit to change state.

0: Either no write data was sent or an even number of bits of write data was sent. (Default)

1: An odd number of bits of write data was sent.

Bit 5 - Drive Select Status

This bit reflects the status of drive select bit 0 in the Digital Output Register (DOR). See Section 3.3.3.

It is cleared after a hardware reset and unaffected by a software reset.

0: Either drive 0 or 2 is selected. (Default)

1: Either drive 1 or 3 is selected.

Bits 7,6 - Reserved

These bits are reserved and are always 1.

3.3.3 Digital Output Register (DOR)

DOR is a read/write register that can be written at any time. It controls the drive select and motor enable disk interface output signals, enables the DMA logic and contains a software reset bit.

The contents of the DOR is set to 00h after a hardware reset, and is unaffected by a software reset.

TABLE 3-2 shows how the bits of DOR select a drive and enable a motor when the FDC is enabled (bit 3 of the Function Enable Register 1 (FER1) at offset 00h of logical device 8 is 1) and bit 7 of the SuperI/O FDC Configuration register at index F0h is 1. Bit patterns not shown produce states that should not be decoded to enable any drive or motor.

When the FDC is enabled and bit 7 of the of the SuperI/O FDC Configuration register at index F0h is 1, $\overline{\text{MTR1}}$ presents a pulse that is the inverse of $\overline{\text{WR}}$. This pulse is active whenever an I/O write to address 02h occurs. This pulse is delayed for between 25 and 80 nsec after the leading edge of $\overline{\text{WR}}$. The leading edge of this pulse can be used to clock data into an external latch (e.g., 74LS175).

TABLE 3-2. Drive and Motor Pin Encoding for Four Drive Configurations and Drive Exchange Support

Digital Output Register Bits								Control Signals				Decoded Functions
								$\overline{\text{MTR}}$		DR		
7	6	5	4	3	2	1	0	1	0	1	0	
x	x	x	1	x	x	0	0	-	0	0	0	Activate Drive 0 and Motor 0
x	x	1	x	x	x	0	1	-	0	0	1	Activate Drive 1 and Motor 1
x	1	x	x	x	x	1	0	-	0	1	0	Activate Drive 2 and Motor 2
1	x	x	x	x	x	1	1	-	0	1	1	Activate Drive 3 and Motor 3
x	x	x	0	x	x	0	0	-	1	0	0	Activate Drive 0 and Deactivate Motor 0
x	x	0	x	x	x	0	1	-	1	0	1	Activate Drive 1 and deactivate Motor 1
x	0	x	x	x	x	1	0	-	1	1	0	Activate Drive 2 and Deactivate Motor 2
0	x	x	x	x	x	1	1	-	1	1	1	Activate Drive 3 and Deactivate Motor 3

Usually, the motor enable and drive select output signals for a particular drive are enabled together. TABLE 3-3 shows the DOR hexadecimal values that enable each of the four drives.

TABLE 3-3. Drive Enable Hexadecimal Values

Drive	DOR Value (Hex)
0	1C
1	2D
2	4E
3	8F

The motor enable and drive select signals for drives 2 and 3 are only available when four drives are supported, i.e., bit 7 of the SuperI/O FDC Configuration register at index F0h is 1, or when drives 2 and 0 are exchanged. These signals require external logic.

```
 7   6   5   4   3   2   1   0
┌───┬───┬───┬───┬───┬───┬───┬───┐
│ 0 │ 0 │ 0 │ 0 │ 0 │ 0 │ 0 │ 0 │  Reset
├───┼───┼───┼───┼───┼───┼───┼───┤
│   │   │   │   │   │   │   │   │  Required
└───┴───┴───┴───┴───┴───┴───┴───┘
```

Digital Output Register (DOR) Offset 02h

- Drive Select
- Reset Controller
- DMAEN
- Motor Enable 0
- Motor Enable 1
- Motor Enable 2
- Motor Enable 3
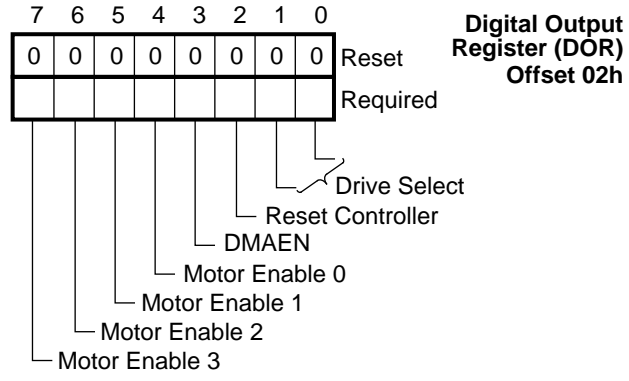
Bits 1,0 - Drive Select

These bits select a drive, so that only one drive select output signal is active at a time.

See "Bit 7 - Four Drive Control" on page 30 and "Bits 3,2 - Logical Drive Control (Enhanced TDR Mode Only)" on page 41 for more information.

00: Drive 0 is selected. (Default)

01: Drive 1 is selected.

10: If four drives are supported, or drives 2 and 0 are exchanged, drive 2 is selected.

11: If four drives are supported, drive 3 is selected.

Bit 2 - Reset Controller

This bit can cause a software reset. The controller remains in a reset state until this bit is set to 1.

A software reset affects the CONFIGURE and MODE commands. See Sections 3.7.2 on page 55 and 3.7.7 on page 60, respectively. A software reset does not affect the Data rate Select Register (DSR), Configuration Control Register (CCR) and other bits of this register (DOR).

This bit must be low for at least 100 nsec. There is enough time during consecutive writes to the DOR to reset software by toggling this bit.

0: Reset controller. (Default)

1: No reset.

Bit 3 - DMA Enable (DMAEN)

In PC-AT drive mode, this bit enables DMA operations by controlling $\overline{DACK}$, TC and the appropriate DRQ and IRQ DMA signals. In PC-AT mode, this bit is set to 0 after reset.

In PS/2 drive mode, this bit is reserved, and $\overline{DACK}$, TC and the appropriate DRQ and IRQ signals are enabled. During reset, these signals remain enabled.

0: In PC-AT drive mode, DMA operations are disabled. $\overline{DACK}$ and TC are disabled, and the appropriate DRQ and IRQ signals are put in TRI-STATE. (Default)

1: In PC-AT drive mode, DMA operations are enabled, i.e., $\overline{DACK}$, TC and the appropriate DRQ and IRQ signals are all enabled.

Bit 4- Motor Enable 0

If four drives are supported (bit 7 of the SuperI/O FDC Configuration register at index F0h is 1), this bit may control the motor output signal for drive 0, depending on the remaining bits of this register. See TABLE 3-2 on page 39.

If two drives are supported (bit 7 of the SuperI/O FDC Configuration register at index F0h is 0), this bit controls the motor output signal for drive 0.

0: The motor signal for drive 0 is not active.

1: The motor signal for drive 0 is active.

Bit 5 - Motor Enable 1

If four drives are supported (bit 7 of the SuperI/O FDC Configuration register at index F0h is 1), this bit may control the motor output signal for drive 0, depending on the remaining bits of this register. See TABLE 3-2.

If two drives are supported (bit 7 of the SuperI/O FDC Configuration register at index F0h is 0), this bit controls the motor output signal for drive 1.

0: The motor signal for drive 1 is not active.

1: The motor signal for drive 1 is active.

Bit 6 - Motor Enable 2

If drives 2 and 0 are exchanged (see "Bits 3,2 - Logical Drive Control (Enhanced TDR Mode Only)" on page 41), or if four drives are supported (bit 7 of the SuperI/O FDC Configuration register at index F0h is 1), this bit controls the motor output signal for drive 2. See TABLE 3-2.

0: The motor signal for drive 2 is not active.

1: The motor signal for drive 2 is active.

Bit 7 - Motor Enable 3

If four drives are supported (bit 7 of the SuperI/O FDC Configuration register at index F0h is 1), this bit may control the motor output signal for drive 3, depending on the remaining bits of this register. See TABLE 3-2.

0: The motor signal for drive 3 is not active.

1: The motor signal for drive 3 is active.

3.3.4 Tape Drive Register (TDR)

The TDR register is a read/write register that acts as the Floppy Disk Controller's (FDC) drive type register.

AT Compatible TDR Mode

In this mode, the TDR assigns a drive number to the tape drive support mode of the data separator. All other logical drives can be assigned as floppy drive support. Bits 7-2 are in TRI-STATE during read operations.

Enhanced TDR Mode

In this mode, all the bits of the TDR define operations with Enhanced floppy disk drives.

Enhanced TDR Mode

Tape Drive Register (TDR) Offset 03h

AT Compatible TDR Mode

Tape Drive Register (TDR) Offset 03h
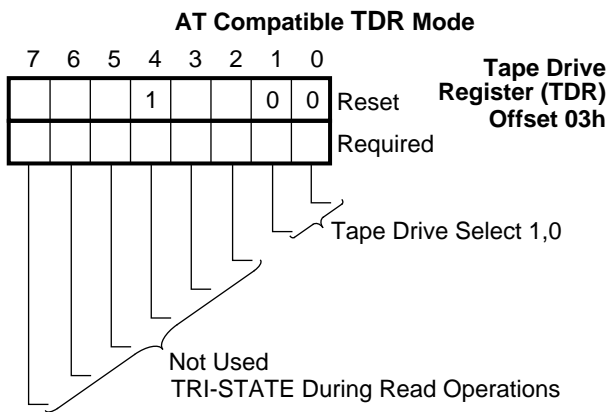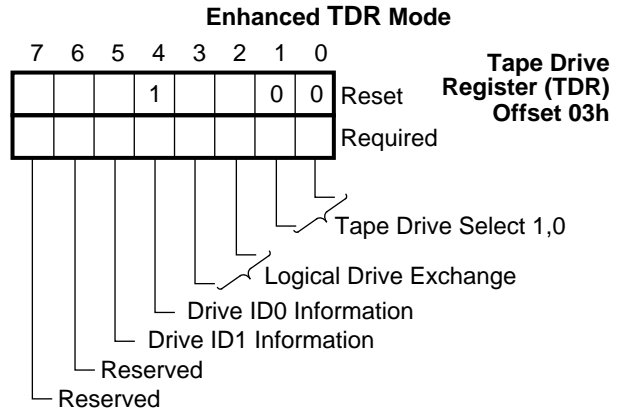
TABLE 3-4. TDR Bit Utilization and Reset Values in Different Drive Modes

TDR Mode	Bit 6 of SuperI/O FDC Configuration Register	Bits of TDR					
		Drive ID1	Drive ID0	Logical Drive Exchange		Drive Select	
		5	**4**	**3**	**2**	**1**	**0**
PC-AT Compatible	0	Not used. Floated in TRI-STATE during read operations.				0	0
Enhanced	1	1	1	0	0	0	0

Bits 1,0 - Tape Drive Select 1,0

These bits assign a logical drive number to a tape drive. Drive 0 is not available as a tape drive and is reserved as the floppy disk boot drive.

00: No drive selected.

01: Drive 1 selected.

10: Drive 2 selected.

11: Drive 3 selected.

Bits 3,2 - Logical Drive Control (Enhanced TDR Mode Only)

These read/write bits control logical drive exchange between drives 0 and 2, only.

They enable software to exchange the physical floppy disk drive and motor control signals assigned to pins.

Drive 3 is never exchanged for drive 2.

When four drives are configured, i.e., bit 7 of SuperI/O FDC Configuration register at index F0h is 1, logical drives are not exchanged.

00: No logical drive exchange.

01: Disk drive and motor control signal assignment to pins exchanged between logical drives 0 and 1.

10: Disk drive and motor control signal assignment to pins exchanged between logical drives 0 and 2.

11: Reserved. Unpredictable results when configured.

Bits 5,4 - Drive ID1,0 Information

If the value of bits 1,0 of the Digital Output Register (DOR) are 00, these bits reflect the ID of drive 0, i.e., the value of bits 1,0, respectively, of the Drive ID register at index F1h. See "Bits 1,0 - Drive 0 ID" on page 30.

If the value of bits 1,0 of the Digital Output Register (DOR) are 01, these bits reflect the ID of drive 1, i.e., the value of bits 3,2, respectively, of the Drive ID register at index F1h. See "Bits 3,2 - Drive 1 ID" on page 30.

Bits 7,6 - Reserved.

These bits are reserved and are read as 11b.

3.3.5   Main Status Register (MSR)

This read-only register indicates the current status of the Floppy Disk Controller (FDC), indicates when the disk controller is ready to send or receive data through the Data Register (FIFO) and controls the flow of data to and from the Data Register (FIFO).

The MSR can be read at any time. It should be read before each byte is transferred to or from the Data Register (FIFO) except during a DMA transfer. No delay is required when reading this register after a data transfer.

The microprocessor can read the MSR immediately after a hardware or software reset, or recovery from a power down. The MSR contains a value of 00h, until the FDC clock has stabilized and the internal registers have been initialized.

When the FDC is ready to receive a new command, it reports a value of 80h for the MSR to the microprocessor. System software can poll the MSR until the MSR is ready. The MSR must report an 80h value (RQM set to 1) within 2.5 msec after reset or power up.

Read Operations

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

Main Status Register (MSR) Offset 04h

- Drive 0 Busy
- Drive 1 Busy
- Drive 2 Busy
- Drive 3 Busy
- Command in Progress
- Non-DMA Execution
- Data I/O Direction
- RQM
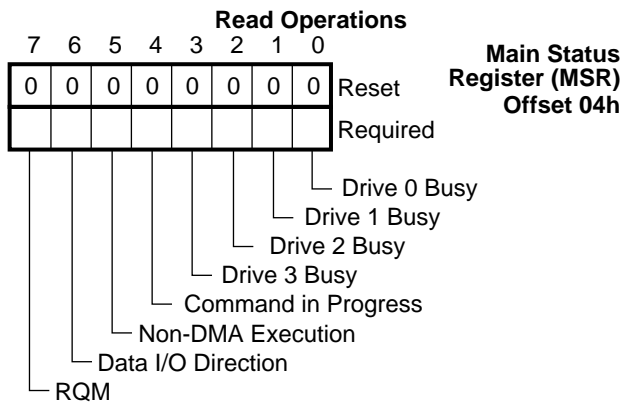
Bit 0 - Drive 0 Busy

This bit indicates whether or not drive 0 is busy.

It is set to 1 after the last byte of the command phase of a SEEK or RECALIBRATE command is issued for drive 0.

This bit is cleared to 0 after the first byte in the result phase of the SENSE INTERRUPT command is read for drive 0.

0: Not busy.

1: Busy.

Bit 1 - Drive 1 Busy

This bit indicates whether or not drive 1 is busy.

It is set to 1 after the last byte of the command phase of a SEEK or RECALIBRATE command is issued for drive 1.

This bit is cleared to 0 after the first byte in the result phase of the SENSE INTERRUPT command is read for drive 1.

0: Not busy.

1: Busy.

Bit 2 - Drive 2 Busy

This bit indicates whether or not drive 2 is busy.

It is set to 1 after the last byte of the command phase of a SEEK or RECALIBRATE command is issued for drive 2.

This bit is cleared to 0 after the first byte in the result phase of the SENSE INTERRUPT command is read for drive 2.

0: Not busy.

1: Busy.

Bit 3 - Drive 3 Busy

This bit indicates whether or not drive 3 is busy.

It is set to 1 after the last byte of the command phase of a SEEK or RECALIBRATE command is issued for drive 3.

This bit is cleared to 0 after the first byte in the result phase of the SENSE INTERRUPT command is read for drive 3.

0: Not busy.

1: Busy.

Bit 4 - Command in Progress

This bit indicates whether or not a command is in progress. It is set after the first byte of the command phase is written. This bit is cleared after the last byte of the result phase is read.

If there is no result phase in a command, the bit is cleared after the last byte of the command phase is written.

0: No command is in progress.

1: A command is in progress.

Bit 5 - Non-DMA Execution

This bit indicates whether or not the controller is in the execution phase of a byte transfer operation in non-DMA mode.

This bit is used for multiple byte transfers by the microprocessor in the execution phase through interrupts or software polling.

0: The FDC is not in the execution phase.

1: The FDC is in the execution phase.

Bit 6 - Data I/O (Direction)

Indicates whether the controller is expecting a byte to be written or read, to or from the Data Register (FIFO).

0: Data will be written to the FIFO.

1: Data will be read from the FIFO.

Bit 7 - Request for Master (RQM)

This bit indicates whether or not the controller is ready to send or receive data from the microprocessor through the Data Register (FIFO). It is cleared to 0 immediately after a byte transfer and is set to 1 again as soon as the disk controller is ready for the next byte.

During a Non-DMA execution phase, this bit indicates the status of the interrupt.

0: Not ready. (Default)

1: Ready to transfer data.

3.3.6   Data Rate Select Register (DSR)

This write-only register is used to program the data transfer rate, amount of write precompensation, power down mode, and software reset.

The data transfer rate is programmed via the CCR, not the DSR, for PC-AT, PS/2 and MicroChannel applications. Other applications can set the data transfer rate in the DSR.

The data rate of the floppy controller is determined by the most recent write to either the DSR or CCR.

The DSR is unaffected by a software reset. A hardware reset sets the DSR to 02h, which corresponds to the default precompensation setting and a data transfer rate of 250 Kbps.

Write Operations

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	1	0	Reset
								Required

Data Rate Select Register (DSR) Offset 04h

- Data Transfer Rate Select
- Precompensation Delay Select
- Undefined
- Low Power
- Software Reset
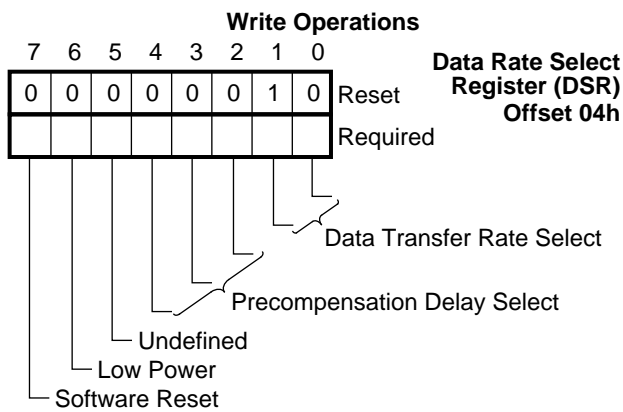
Bits 1,0 - Data Transfer Rate Select

These bits determine the data transfer rate for the Floppy Disk Controller (FDC), depending on the supported speeds. TABLE 3-5 shows the data transfer rate selected by each value of this field.

These bits are unaffected by a software reset, and are set to 10 (250 Kbps) after a hardware reset.

TABLE 3-5. Data Transfer Rate Encoding

DSR Bits		Data Transfer Rate
1	**0**	
0	0	500 Kbps
0	1	300 Kbps
1	0	250 Kbps
1	1	1 Mbps

Bits 4-2 - Precompensation Delay Select

This field sets the write precompensation delay that the Floppy Disk Controller (FDC) imposes on the $\overline{\text{WDATA}}$ disk interface output signal, depending on the supported speeds. TABLE   shows the delay for each value of this field.

In most cases, the default delays shown in TABLE 3-7 are adequate. However, alternate values may be used for specific drive and media types.

Track 0 is the default starting track number for precompensation. The starting track number can be changed using the CONFIGURE command.

TABLE 3-6. Write Precompensation Delays

DSR Bits			Duration of Delay
4	**3**	**2**	
0	0	0	Default (TABLE 3-7)
0	0	1	41.7 nsec
0	1	0	83.3 nsec
0	1	1	125.0 nsec
1	0	0	166.7 nsec
1	0	1	208.3 nsec
1	1	0	250.0 nsec
1	1	1	0.0 nsec

TABLE 3-7. Default Precompensation Delays

Data Rate	Precompensation Delay
1 Mbps	41.7 nsec
500 Kbps	125.0 nsec
300 Kbps	125.0 nsec
250 Kbps	125.0 nsec

Bit 5 - Undefined

Should be set to 0.

Bit 6 - Low Power

This bit triggers a manual power down of the FDC in which the clock and data separator circuits are turned off. A manual power down can also be triggered by the MODE command.

After a manual power down, the FDC returns to normal power after a software reset, or an access to the Data Register (FIFO) or the Main Status Register (MSR).

0: Normal power.

1: Trigger power down.

Bit 7 - Software Reset

This bit controls the same kind of software reset of the FDC as bit 2 of the Digital Output Register (DOR). The difference is that this bit is automatically cleared to 0 (no reset) 100 nsec after it was set to 1.

See also "Bit 2 - Reset Controller" on page 40.

0: No reset. (Default)

1: Reset.

3.3.7   Data Register (FIFO)

The Data Register of the FDC is a read/write register that is used to transfer all commands, data and status information between the microprocessor and the FDC.

During the command phase, the microprocessor writes command bytes into the Data Register after polling the RQM (bit 7) and DIO (bit 6) bits in the MSR. During the result phase, the microprocessor reads result bytes from the Data Register after polling the RQM and DIO bits in the MSR.

Use of the FIFO buffer lengthens the interrupt latency period and, thereby, reduces the chance of a disk overrun or underrun error occurring. Typically, the FIFO buffer is used at a 1 Mbps data transfer rate or with multi-tasking operating systems.

Enabling and Disabling the FIFO Buffer

The 16-byte FIFO buffer can be used for DMA, interrupt, or software polling type transfers during the execution of a read, write, format or scan command.

The FIFO buffer is enabled and its threshold is set by the CONFIGURE command.

When the FIFO buffer is enabled, only execution phase byte transfers use it. If the FIFO buffer is enabled, it is not disabled after a software reset if the LOCK bit is set in the LOCK command.

The FIFO buffer is always disabled during the command and result phases of a controller operation. A hardware reset disables the FIFO buffer and sets its threshold to zero. The MODE command can also disable the FIFO for read or write operations separately.

After a hardware reset, the FIFO buffer is disabled to maintain compatibility with PC-AT systems.

Burst Mode Enabled and Disabled

The FIFO buffer can be used with burst mode enabled or disabled by the MODE command.

In burst mode, the DRQ or IRQ signal assigned to the FDC remains active until all of the bytes have been transferred to or from the FIFO buffer.

When burst mode is disabled, the appropriate DRQ or IRQ signal is deactivated for 350 nsec to allow higher priority transfer requests to be processed.

FIFO Buffer Response Time

During the execution phase of a command involving data transfer to or from the FIFO buffer, the maximum time the system has to respond to a data transfer service request is calculated by the following formula:

$$\text{Max\_Time} = (\text{THRESH} + 1) \times 8 \times t_{DRP} - (16 \times t_{ICP})$$

This formula applies for all data transfer rates, whether the FIFO buffer is enabled or disabled. THRESH is a 4-bit value programmed by the CONFIGURE command, which sets the threshold of the FIFO buffer. If the FIFO buffer is disabled, THRESH is zero in the above formula. The last term in the formula, $(16 \times t_{ICP})$ is an inherent delay due to the microcode overhead required by the FDC. This delay is also data rate dependent. Section 10.3.14 on page 183 specifies minimum and maximum values for t_{DRP} and t_{ICP}.

The programmable FIFO threshold (THRESH) is useful in adjusting the FDC to the speed of the system. A slow system with a sluggish DMA transfer capability requires a high value for THRESH. this gives the system more time to respond to a data transfer service request (DRQ for DMA mode or IRQ for interrupt mode). Conversely, a fast system with quick response to a data transfer service request can use a low value for THRESH.

Data Register (FIFO) Offset 05h
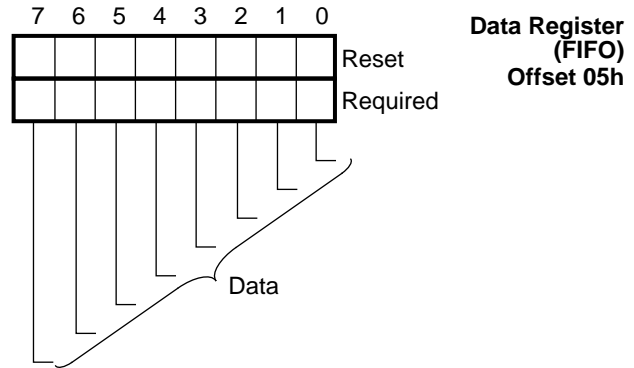
3.3.8 Digital Input Register (DIR)

This read-only diagnostic register is used to detect the state of the $\overline{\text{DSKCHG}}$ disk interface input signal and some diagnostic signals. DIR is unaffected by a software reset.

The bits of the DIR register function differently depending on whether the FDC is operating in PC-AT drive mode or in PS/2 drive mode. See Section 3.1.2 on page 34.

In PC-AT drive mode, bits 6 through 0 are in TRI-STATE to prevent conflict with the status register of the hard disk at the same address as the DIR.

Read Operations, PC-AT Drive Mode

Digital Input Register (DIR) Offset 07h

Read Operations, PS/2 Drive Mode

Digital Input Register (DIR) Offset 07h
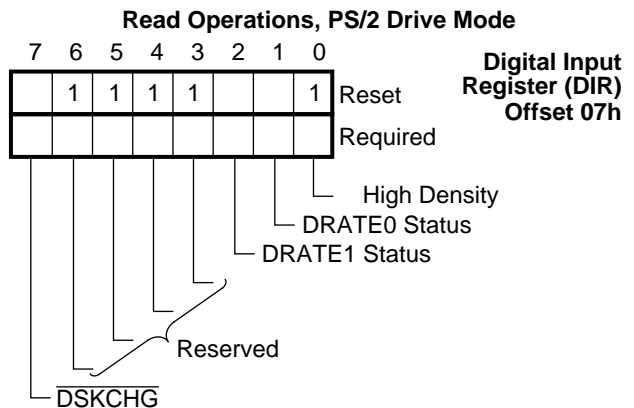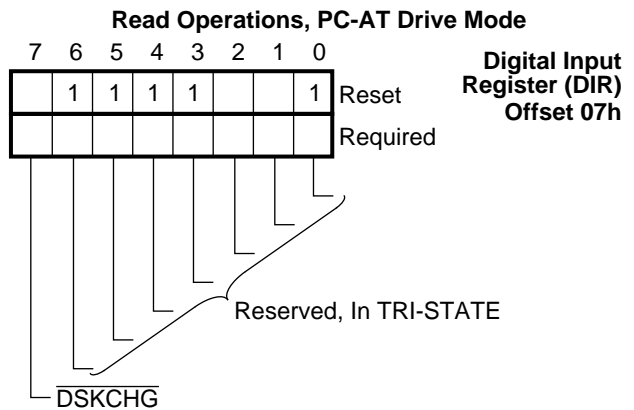
Bit 0 - High Density (PS/2 Drive Mode Only)

In PC-AT drive mode, this bit is reserved, in TRI-STATE and used by the status register of the hard disk.

In PS/2 drive mode, this bit indicates whether the data transfer rate is high or low.

0: The data transfer rate is high, i.e., 1 Mbps or 500 Kbps.

1: The data transfer rate is low, i.e., 300 Kbps or 250 Kbps.

Bits 2,1 - Data Rate Select 1,0 (DRATE1,0)
(PS/2 Drive Mode Only)

In PC-AT drive mode, these bits are reserved, in TRI-STATE and used by the status register of the hard disk.

In PS/2 drive mode, these bits indicate the status of the DRATE1,0 bits programmed in DSR or CCR, whichever is written last.

The significance of each value for these bits depends on the supported speeds. See TABLE 3-5 on page 43.

00: Data transfer rate is 500 Kbps.

01: Data transfer rate is 300 Kbps.

10: Data transfer rate is 250 Kbps.

11: Data transfer rate is 1 Mbps.

Bits 6-3 - Reserved

These bits are reserved and are always 1. In PC-AT mode these bits are also in TRI-STATE. They are used by the status register of the fixed hard disk.

Bit 7 - Disk Changed ($\overline{\text{DSKCHG}}$)

This bit reflects the status of the $\overline{\text{DSKCHG}}$ disk interface input signal.

During power down this bit is invalid, if it is read by the software.

0: $\overline{\text{DSKCHG}}$ is not active.

1: $\overline{\text{DSKCHG}}$ is active.

3.3.9 Configuration Control Register (CCR)

This write-only register can be used to set the data transfer rate (in place of the DSR) for PC-AT, PS/2 and MicroChannel applications. Other applications can set the data transfer rate in the DSR. See Section 3.3.6 on page 43.

This register is not affected by a software reset.

The data rate of the floppy controller is determined by the last write to either the CCR register or to the DSR register.

Write Operations

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	1	0	Reset
								Required

Configuration Control Register (CCR) Offset 07h

— DRATE0
— DRATE1

Reserved
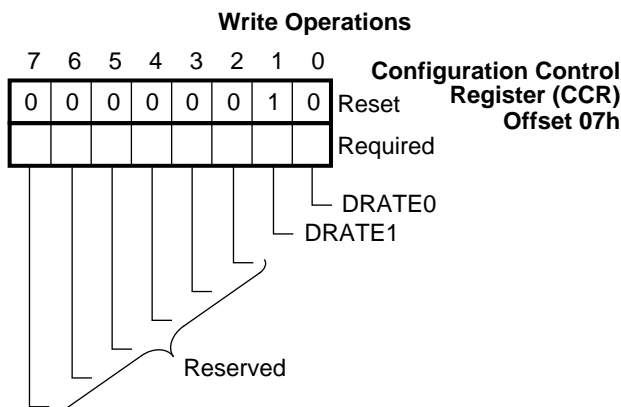
Bits 1,0 - Data Transfer Rate Select 1,0 (DRATE 1,0)

These bits determine the data transfer rate for the Floppy Disk Controller (FDC), depending on the supported speeds.

TABLE 3-5 on page 43 shows the data transfer rate selected by each value of this field.

These bits are unaffected by a software reset, and are set to 10 (250 Kbps) after a hardware reset.

Bits 7-2 - Reserved

These bits should be set to 0.

3.4 THE PHASES OF FDC COMMANDS

FDC commands may be in the command phase, the execution phase or the result phase. The active phase determines how data is transferred between the Floppy Disk Controller (FDC) and the host microprocessor. When no command is in progress, the FDC may be either idle or polling a drive.

3.4.1 Command Phase

During the command phase, the microprocessor writes a series of bytes to the Data Register (FIFO). The first command byte contains the opcode for the command, which the controller can interpret to determine how many more command bytes to expect. The remaining command bytes contain the parameters required for the command.

The number of command bytes varies for each command. All command bytes must be written in the order specified in the Command Description Table in Section 3.7 on page 53. The execution phase starts immediately after the last byte in the command phase is written.

Prior to performing the command phase, the Digital Output Register (DOR) should be set and the data rate should be set with the Data rate Select Register (DSR) or the Configuration Control Register (CCR).

The Main Status Register (MSR) controls the flow of command bytes, and must be polled by the software before writing each command phase byte to the Data Register (FIFO). Prior to writing a command byte, bit 7 of MSR (RQM, Request for Master) must be set and bit 6 of MSR (DIO, Data I/O direction) must be cleared.

After the first command byte is written to the Data Register (FIFO), bit 4 of MSR (CMD PROG, Command in Progress) is also set and remains set until the last result phase byte is read. If there is no result phase, the CMD PROG bit is cleared after the last command byte is written.

A new command may be initiated after reading all the result bytes from the previous command. If the next command requires selection of a different drive or a change in the data rate, the DOR and DSR or CCR should be updated, accordingly. If the command is the last command, the software should deselect the drive.

Normally, command processing by the controller core and updating of the DOR, DSR, and CCR registers by the microprocessor are operations that can occur independently of one another. Software must ensure that the these registers are not updated while the controller is processing a command.

3.4.2 Execution Phase

During the execution phase, the Floppy Disk Controller (FDC) performs the desired command.

Commands that involve data transfers (e.g., read, write and format operations) require the microprocessor to write or read data to or from the Data Register (FIFO) at this time. Some commands, such as SEEK or RECALIBRATE, control the read/write head movement on the disk drive during the execution phase via the disk interface signals. Execution of other commands does not involve any action by the microprocessor or disk drive, and consists of an internal operation by the controller.

Data can be transferred between the microprocessor and the controller during execution in DMA mode, interrupt transfer mode or software polling mode. The last two modes are non-DMA modes. All data transfer modes work with the FIFO enabled or disabled.

DMA mode is used if the system has a DMA controller. This allows the microprocessor to do other tasks while data transfer takes place during the execution phase.

If a non-DMA mode is used, an interrupt is issued for each byte transferred during the execution phase. Also, instead of using the interrupt during a non-DMA mode transfer, the Main Status Register (MSR) can be polled by software to indicate when a byte transfer is required.

DMA Mode - FIFO Disabled

DMA mode is selected by writing a 0 to the DMA bit in the SPECIFY command and by setting bit 3 of the DOR (DMA enabled) to 1.

In the execution phase when the FIFO is disabled, each time a byte is ready to be transferred, a DMA request (DRQ) is generated in the execution phase. The DMA controller should respond to the DRQ with a DMA acknowledge (DACK) and a read or write pulse. The DRQ is cleared by the leading edge of the active low DACK input signal. After the last byte is transferred, an interrupt is generated, indicating the beginning of the result phase.

During DMA operations, FDC address signals are ignored since AEN input signal is 1. The DACK signal acts as the chip select signal for the FIFO, in this case, and the state of the address lines A2-0 is ignored. The Terminal Count (TC) signal can be asserted by the DMA controller to terminate the data transfer at any time. Due to internal gating, TC is only recognized when DACK is low.

PC-AT Drive Mode

In PC-AT drive mode when the FIFO is disabled, the controller is in single byte transfer mode. That is, the system has the time it takes to transfer one byte, to service a DMA request (DRQ) from the controller. DRQ is deactivated between bytes.

PS/2 Drive Mode

In PS/2 drive mode, for DMA transfers with the FIFO disabled, instead of single byte transfer mode, the FIFO is enabled with THRESH = 0Fh. Thus, DRQ is asserted when one byte enters the FIFO during a read, and when one byte can be written to the FIFO during a write. DRQ is deactivated by the leading edge of the DACK input signal, and is asserted again when DACK becomes inactive high. This operation is very similar to burst mode transfer with the FIFO enabled except that DRQ is deactivated between bytes.

DMA Mode - FIFO Enabled

Read Data Transfers

Whenever the number of bytes in the FIFO is greater than or equal to (16 – THRESH), a DRQ is generated. This is the trigger condition for the FIFO read data transfers from the floppy controller to the microprocessor.

When the last byte in the FIFO has been read, DRQ becomes inactive. DRQ is asserted again when the FIFO trigger condition is satisfied. After the last byte of a sector is read from the disk, DRQ is again generated even if the FIFO has not yet reached its threshold trigger condition. This guarantees that all current sector bytes are read from the FIFO before the next sector byte transfer begins.

Burst Mode Enabled - DRQ remains active until enough bytes have been read from the controller to empty the FIFO.

Burst Mode Disabled - DRQ is deactivated after each read transfer. If the FIFO is not completely empty, DRQ is asserted again after a 350 nsec delay. This allows other higher priority DMA transfers to take place between floppy disk transfers.

In addition, this mode allows the controller to work correctly in systems where the DMA controller is put into a read verify mode, where only DACK signals are sent to the FDC, with no RD pulses. This read verify mode of the DMA controller is used in some PC software. When burst mode is disabled, a pulse from the DACK input signal may be issued by the DMA controller, to correctly clocks data from the FIFO.

Write Data Transfers

Whenever the number of bytes in the FIFO is less than or equal to THRESH, a DRQ is generated. This is the trigger condition for the FIFO write data transfers from the microprocessor to the FDC.

Burst Mode Enabled - DRQ remains active until enough bytes have been written to the controller to completely fill the FIFO.

Burst Mode Disabled - DRQ is deactivated after each write transfer. If the FIFO is not full, DRQ is asserted again after a 350 nsec delay. Deactivation of DRQ allows other higher priority DMA transfers to take place between floppy disk transfers.

The FIFO has a byte counter which monitors the number of bytes being transferred to the FIFO during write operations whether burst mode is enabled or disabled. When the last byte of a sector is transferred to the FIFO, DRQ is deactivated even if the FIFO has not been completely filled. Thus, the FIFO is cleared after each sector is written. Only after the FDC has determined that another sector is to be written, is DRQ asserted again. Also, since DRQ is deactivated immediately after the last byte of a sector is written to the FIFO, the system will not be delayed by deactivation of DRQ and is free to do other operations.

Read and Write Data Transfers

The DACK input signal from the DMA controller may be held active during an entire burst, or a pulse may be issued for each byte transferred during a read or write operation. In burst mode, the FDC deactivates DRQ as soon as it recognizes that the last byte of a burst was transferred.

If a DACK pulse is issued for each byte, the leading edge of this pulse is used to deactivate DRQ. If a DACK pulse is issued, RD or WR is not required. This is the case during the read-verify mode of the DMA controller.

If DACK is held active during the entire burst, the trailing edge of the RD or WR pulse is used to deactivate DRQ. DRQ is deactivated within 50 nsec of the leading edge of DACK, RD, or WR. This quick response should prevent the DMA controller from transferring extra bytes in most of the applications.

Overrun Errors

An overrun or underrun error terminates the execution of a command, if the system does not transfer data within the allotted data transfer time. (See Section 3.3.7 on page 43.) This puts the controller in the result phase.

During a read overrun, the microprocessor is required to read the remaining bytes of the sector before the controller asserts the appropriate IRQ signifying the end of execution.

During a write operation, an underrun error terminates the execution phase after the controller has written the remaining bytes of the sector with the last correctly written byte to the FIFO. Whether there is an error or not, an interrupt is generated at the end of the execution phase, and is cleared by reading the first result phase byte.

$\overline{DACK}$ asserted alone, without a $\overline{RD}$ or $\overline{WR}$ pulse, is also counted as a transfer. If pulses of $\overline{RD}$ or $\overline{WR}$ are not being issued for each byte, a $\overline{DACK}$ pulse must be issued for each byte so that the Floppy Disk Controller(FDC) can count the number of bytes correctly.

The VERIFY command, allows easy verification of data written to the disk without actually transferring the data on the data bus.

Interrupt Transfer Mode - FIFO Disabled

If interrupt transfer (non-DMA) mode is selected, the appropriate IRQ signal is asserted instead of DRQ, when each byte is ready to be transferred.

The Main Status Register (MSR) should be read to verify that the interrupt is for a data transfer. The RQM and NON DMA bits (bits 7 and 5, respectively) in the MSR are set to 1. The interrupt is cleared when the byte is transferred to or from the Data Register (FIFO). To transfer the data in or out of the Data register, you must use the address bits of the FDC together and $\overline{RD}$ or $\overline{WR}$ must be active, i.e., A2-0 must be valid. It is not enough to just assert the address bits of the FDC. $\overline{RD}$ or $\overline{WR}$ must also be active for a read or write transfer to be recognized.

The microprocessor should transfer the byte within the data transfer service time (see Section 3.3.7 on page 43). If the byte is not transferred within the time allotted, an overrun error is indicated in the result phase when the command terminates at the end of the current sector.

An interrupt is also generated after the last byte is transferred. This indicates the beginning of the result phase. The RQM and DIO bits (bits 7 and 6, respectively) in the MSR are set to 1, and the NON DMA bit (bit 5) is cleared to 0. This interrupt is cleared by reading the first result byte.

Interrupt Transfer Mode - FIFO Enabled

Interrupt transfer (non-DMA) mode with the FIFO enabled is very similar to interrupt transfer mode with the FIFO disabled. In this case, the appropriate IRQ signal is asserted instead of DRQ, under the same FIFO threshold trigger conditions.

The MSR should be read to verify that the interrupt is for a data transfer. The RQM and non-DMA bits (bits 7 and 5, respectively) in the MSR are set. To transfer the data in or out of the Data register, you must use the address bits of the FDC together and $\overline{RD}$ or $\overline{WR}$ must be active, i.e., A2-0 must be valid. It is not enough to just assert the address bits of the FDC. $\overline{RD}$ or $\overline{WR}$ must also be active for a read or write transfer to be recognized.

Burst mode may be used to hold the IRQ signal active during a burst, or burst mode may be disabled to toggle the IRQ signal for each byte of a burst. The Main Status Register (MSR) is always valid to the microprocessor. For example, during a read command, after the last byte of data has been read from the disk and placed in the FIFO, the MSR still indicates that the execution phase is active, and that data needs to be read from the Data Register (FIFO). Only after the last byte of data has been read by the microprocessor from the FIFO does the result phase begin.

The overrun and underrun error procedures for non-DMA mode are the same as for DMA mode. Also, whether there is an error or not, an interrupt is generated at the end of the execution phase, and is cleared by reading the first result phase byte.

Software Polling

If non-DMA mode is selected and interrupts are not suitable, the microprocessor can poll the MSR during the execution phase to determine when a byte is ready to be transferred. The RQM bit (bit 7) in the MSR reflects the state of the IRQ signal. Otherwise, the data transfer is similar to the interrupt mode described above, whether the FIFO is enabled or disabled.

3.4.3   Result Phase

During the result phase, the microprocessor reads a series of result bytes from the Data Register (FIFO). These bytes indicate the status of the command. They may indicate whether the command executed properly, or may contain some control information.

See the specific commands in Section 3.7 on page 53 or Section 3.3.7 on page 43 for details.

These result bytes are read in the order specified for that particular command. Some commands do not have a result phase. Also, the number of result bytes varies with each command. All result bytes must be read from the Data Register (FIFO) before the next command can be issued.

As it does for command bytes, the Main Status Register (MSR) controls the flow of result bytes, and must be polled by the software before reading each result byte from the Data Register (FIFO). The RQM bit (bit 7) and DIO bit (bit 6) of the MSR must both be set before each result byte can be read.

After the last result byte is read, the Command in Progress bit (bit 4) of the MSR is cleared, and the controller is ready for the next command.

For more information, see Section 3.5 on page 48.

3.4.4   Idle Phase

After a hardware or software reset, after the chip has recovered from power-down mode or when there are no commands in progress the controller is in the idle phase. The controller waits for a command byte to be written to the Data Register (FIFO). The RQM bit is set, and the DIO bit is cleared in the MSR.

After receiving the first command (opcode) byte, the controller enters the command phase. When the command is completed the controller again enters the idle phase. The Digital Data Separator (DDS) remains synchronized to the reference frequency while the controller is idle. While in the idle phase, the controller periodically enters the drive polling phase.

3.4.5 Drive Polling Phase

National Semiconductor's FDC supports the polling mode of old 8-inch drives, as a means of monitoring any change in status for each disk drive present in the system. This support provides backward compatibility with software that expects it.

In the idle phase, the controller enters a drive polling phase every 1 msec, based on a 500 Kbps data transfer rate. In the drive polling phase, the controller checks the status of each of the logical drives (bits 0 through 3 of the MSR). The internal ready line for each drive is toggled only after a hardware or software reset, and an interrupt is generated for drive 0.

At this point, the software must issue four SENSE INTERRUPT commands to clear the status bit for each drive, unless drive polling is disabled via the POLL bit in the CONFIGURE command. See "Bit 4 - Disable Drive Polling (POLL)" on page 55. The CONFIGURE command must be issued within 500 μsec (worst case) of the hardware or software reset to disable drive polling.

Even if drive polling is disabled, drive stepping and delayed power-down occur in the drive polling phase. The controller checks the status of each drive and, if necessary, it issues a pulse on the $\overline{\text{STEP}}$ output signal with the $\overline{\text{DIR}}$ signal at the appropriate logic level.

The controller also uses the drive polling phase to automatically trigger power down. When the specified time that the motor may be off expires, the controller waits 512 msec, based on data transfer rates of 500 Kbps and 1 Mbps, before powering down, if this function is enabled via the MODE command.

If a new command is issued while the FDC is in the drive polling phase, the MSR does not indicate a ready status for the next parameter byte until the polling sequence completes the loop. This can cause a delay between the first and second bytes of up to 500 μsec at 250 Kbps.

3.5 THE RESULT PHASE STATUS REGISTERS

In the result phase of a command, result bytes that hold status information are read from the Data Register (FIFO) at offset 05h. These bytes are the result phase status registers.

The result phase status registers may only be read from the Data Register (FIFO) during the result phase of certain commands, unlike the Main Status Register (MSR), which is a read only register that is always valid.

3.5.1 Result Phase Status Register 0 (ST0)
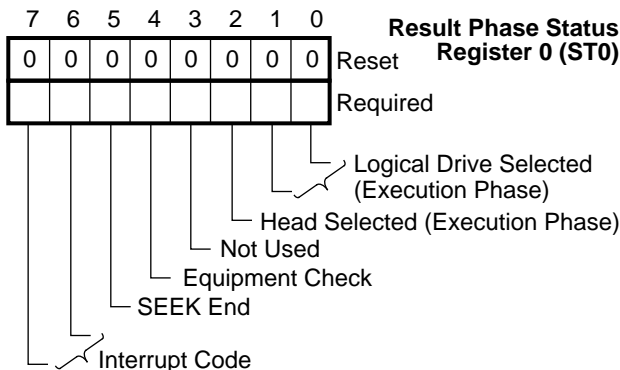
Bits 1,0 - Logical Drive Selected

These two binary encoded bits indicate the logical drive selected at the end of the execution phase.

The value of these bits is reflected in bits 1,0 of the SR3 register, described in Section 3.5.4 on page 50.

00: Drive 0 selected.

01: Drive 1 selected.

10: If four drives are supported, or drives 2 and 0 are exchanged, drive 2 is selected.

11: If four drives are supported, drive 3 is selected.

Bit 2 - Head Selected

This bit indicates which side of the Floppy Disk Drive (FDD) is selected. It reflects the status of the $\overline{\text{HDSEL}}$ signal at the end of the execution phase.

The value of this bit is reflected in bit 2 of the ST3 register, described in Section 3.5.4 on page 50.

0: Side 0 is selected.

1: Side 1 is selected.

Bit 3 - Not used.

This bit is not used and is always 0.

Bit 4 - Equipment Check

After a RECALIBRATE command, this bit indicates whether the head of the selected drive was at track 0, i.e., whether or not $\overline{\text{TRK0}}$ was active. This information is used during the SENSE INTERRUPT command.

0: Head was at track 0, i.e., a $\overline{\text{TRK0}}$ pulse occurred after a RECALIBRATE command.

1: Head was not at track 0, i.e., no $\overline{\text{TRK0}}$ pulse occurred after a RECALIBRATE command.

Bit 5 - SEEK End

This bit indicates whether or not a SEEK, RELATIVE SEEK, or RECALIBRATE command was completed by the controller. Used during a SENSE INTERRUPT command.

0: SEEK, RELATIVE SEEK, or RECALIBRATE command not completed by the controller.

1: SEEK, RELATIVE SEEK, or RECALIBRATE command was completed by the controller.

Bits 7,6 - Interrupt Code (IC)

These bits indicate the reason for an interrupt.

00: Normal termination of command.

01: Abnormal termination of command. Execution of command was started, but was not successfully completed.

10: Invalid command issued. Command issued was not recognized as a valid command.

11: Internal drive ready status changed state during the drive polling mode. This only occurs after a hardware or software reset.

3.5.2   Result Phase Status Register 1 (ST1)

```
 7   6   5   4   3   2   1   0
┌───┬───┬───┬───┬───┬───┬───┬───┐
│ 0 │ 0 │ 0 │ 0 │ 0 │ 0 │ 0 │ 0 │ Reset
├───┼───┼───┼───┼───┼───┼───┼───┤
│   │   │   │   │   │   │   │   │ Required
└───┴───┴───┴───┴───┴───┴───┴───┘
```
Result Phase Status Register 1 (ST1)

- Missing Address Mark
- Drive Write Protected
- Missing Data
- Not Used
- Overrun or Underrun
- CRC Error
- Not Used
- End of Track
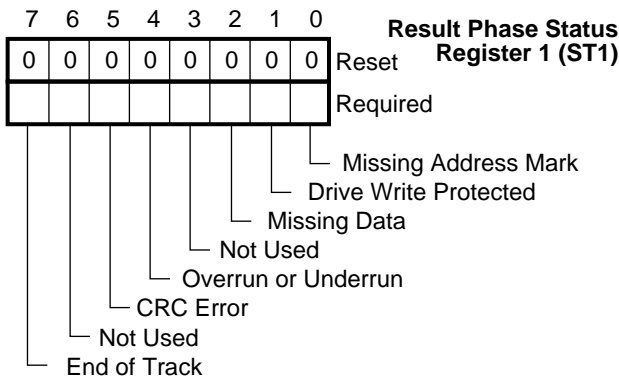
Bit 0 - Missing Address Mark

This bit indicates whether or not the Floppy Disk Controller (FDC) failed to find an address mark in a data field during a read, scan, or verify command.

0: No missing address mark.

1: Address mark missing.

Bit 0 of the result phase Status register 2 (ST2) indicates the when and where the failure occurred. See Section 3.5.3 on page 49.

Bit 1 - Drive Write Protected

When a write or format command is issued, this bit indicates whether or not the selected drive is write protected, i.e., the $\overline{WP}$ signal is active.

0: Selected drive is not write protected, i.e., $\overline{WP}$ is not active.

1: Selected drive is write protected, i.e., $\overline{WP}$ is active.

Bit 2 - Missing Data

This bit indicates whether or not data is missing for one of the following reasons:

— Controller cannot find the sector specified in the command phase during the execution of a read, write, scan, or VERIFY command. An Address Mark (AM) was found however, so it is not a blank disk.

— Controller cannot read any address fields without a CRC error during a READ ID command.

— Controller cannot find starting sector during execution of READ A TRACK command.

0: Data is not missing for one of these reasons.

1: Data is missing for one of these reasons.

Bit 3 - Not Used

This bit is not used and is always 0.

Bit 4 - Overrun or Underrun

This bit indicates whether or not the FDC was serviced by the microprocessor soon enough during a data transfer in the execution phase. For read operations, this bit indicates a data overrun. For write operations, it indicates a data underrun.

0: FDC was serviced in time.

1: FDC was not serviced fast enough. Overrun or underrun occurred.

Bit 5 - CRC Error

This bit indicates whether or not the FDC detected a Cyclic Redundancy Check (CRC) error.

0: No CRC error detected.

1: CRC error detected.

Bit 5 of the result phase Status register 2 (ST2) indicates when and where the error occurred. See Section 3.5.3.

Bit 6 - Not Used

This bit is not used and is always 0.

Bit 7 - End of Track

This bit is set to 1 when the FDC transfers the last byte of the last sector without the TC signal becoming active. The last sector is the End of Track sector number programmed in the command phase.

0: The FDC did not transfer the last byte of the last sector without the TC signal becoming active.

1: The FDC transferred the last byte of the last sector without the TC signal becoming active.

3.5.3   Result Phase Status Register 2 (ST2)

```
 7   6   5   4   3   2   1   0
┌───┬───┬───┬───┬───┬───┬───┬───┐
│ 0 │ 0 │ 0 │ 0 │ 0 │ 0 │ 0 │ 0 │ Reset
├───┼───┼───┼───┼───┼───┼───┼───┤
│   │   │   │   │   │   │   │   │ Required
└───┴───┴───┴───┴───┴───┴───┴───┘
```
Result Phase Status Register 2 (ST2)

- Missing Address Mark Location
- Bad Track
- Scan Not Satisfied
- Scan Equal Hit
- Wrong Track
- CRC Error in Data Field
- Control Mark
- Not Used
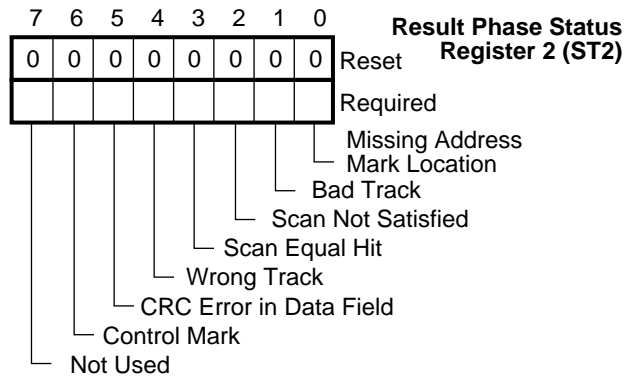
Bit 0 - Missing Address Mark Location

If the FDC cannot find the address mark of a data field or of an address field during a read, scan, or verify command, i.e., bit 0 of ST1 is 1, this bit indicates when and where the failure occurred.

0: The FDC failed to detect an address mark for the address field after two disk revolutions.

1: The FDC failed to detect an address mark for the data field after it found the correct address field.

Bit 1 - Bad Track

This bit indicates whether or not the FDC detected a bad track

0: No bad track detected.

1: Bad track detected.

The desired sector is not found. If the track number recorded on any sector on the track is FFh and this number is different from the track address specified in the command phase, then there is a hard error in IBM format.

Bit 2 - Scan Not Satisfied

This bit indicates whether or not the value of the data byte from the microprocessor meets any of the conditions specified by the scan command used.

Section 3.7.16 on page 69 and Table 3-20 on page 70 describe the conditions.

0: The data byte from the microprocessor meets at least one of the conditions specified.

1: The data byte from the microprocessor does not meet any of the conditions specified.

Bit 3 - Scan Satisfied

This bit indicates whether or not the value of the data byte from the microprocessor was equal to a byte on the floppy disk during any scan command.

0: No equal byte was found.

1: A byte whose value is equal to the byte from the microprocessor was found on the floppy disk.

Bit 4 - Wrong Track

This bit indicates whether or not there was a problem finding the sector because of the track number.

0: Sector found.

1: Desired sector not found.

The desired sector is not found. The track number recorded on any sector on the track is different from the track address specified in the command phase.

Bit 5 - CRC Error in Data Field

When the FDC detected a CRC error in the correct sector (bit 5 of the result phase Status register 1 (ST1) is 1), this bit indicates whether it occurred in the address field or in the data field.

0: The CRC error occurred in the address field.

1: The CRC error occurred in the data field.

Bit 6 - Control Mark

When the controller tried to read a sector, this bit indicates whether or not it detected a deleted data address mark during execution of a READ DATA or scan commands, or a regular address mark during execution of a READ DELETED DATA command.

0: No control mark detected.

1: Control mark detected.

Bit 7 - Not Used

This bit is not used and is always 0.

3.5.4   Result Phase Status Register 3 (ST3)
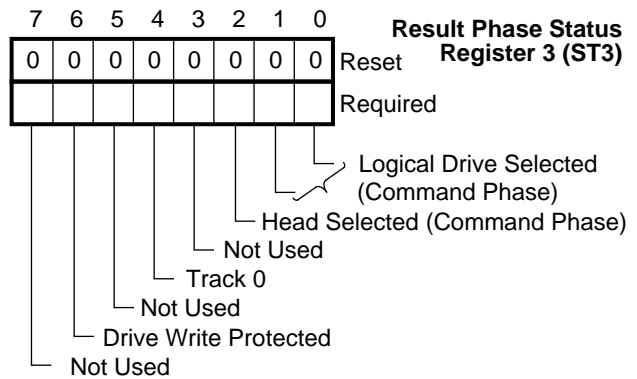
Result Phase Status Register 3 (ST3)

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

- Logical Drive Selected (Command Phase)
- Head Selected (Command Phase)
- Not Used
- Track 0
- Not Used
- Drive Write Protected
- Not Used

Bits 1,0 - Logical Drive Selected

These two binary encoded bits indicate the logical drive selected at the end of the command phase.

The value of these bits is the same as bits 1,0 of the SR0 register, described in Section 3.5.1 on page 48.

00: Drive 0 selected.

01: Drive 1 selected.

10: If four drives are supported, or drives 2 and 0 are exchanged, drive 2 is selected.

11: If four drives are supported, drive 3 is selected.

Bit 2 - Head Selected

This bit indicates which side of the Floppy Disk Drive (FDD) is selected. It reflects the status of the $\overline{\text{HDSEL}}$ signal at the end of the command phase.

The value of this bit is the same as bit 2 of the SR0 register, described in Section 3.5.1 on page 48.

0: Side 0 is selected.

1: Side 1 is selected.

Bit 3 - Not Used

This bit is not used and is always 1.

Bit 4 - Track 0

This bit Indicates whether or not the head of the selected drive is at track 0.

0: The head of the selected drive is not at track 0, i.e., $\overline{\text{TRK0}}$ is not active.

1: The head of the selected drive is at track 0, i.e., $\overline{\text{TRK0}}$ is active.

Bit 5 - Not Used

This bit is not used and is always 1.

Bit 6 - Drive Write Protected

This bit indicates whether or not the selected drive is write protected, i.e., the $\overline{\text{WP}}$ signal is active (low).

0: Selected drive is not write protected, i.e., $\overline{\text{WP}}$ is not active.

1: Selected drive is write protected, i.e., $\overline{\text{WP}}$ is active.

Bit 7 - Not Used

This bit is not used and is always 0.

3.6 FDC REGISTER BITMAPS
3.6.1 Standard

PS/2 Drive Mode

7	6	5	4	3	2	1	0	
0		0		0			0	Reset
								Required

Status Register A (SRA) Offset 00h

- Head Direction
- $\overline{WP}$
- $\overline{INDEX}$
- Head Select
- $\overline{TRK0}$
- Step
- Reserved
- IRQ Pending

Enhanced Drive Mode

7	6	5	4	3	2	1	0	
			1			0	0	Reset
								Required

Tape Drive Register (TDR) Offset 03h

- Tape Drive Select 1,0
- Logical Drive Exchange
- Drive ID0 Information
- Drive ID1 Information
- Reserved
- Reserved

PS/2 Drive Mode

7	6	5	4	3	2	1	0	
1	1	0	0	0	0	0	0	Reset
1	1							Required

Status Register B (SRB) Offset 01h

- MTR0
- MTR1
- WGATE
- RDATA
- WDATA
- Drive Select Status
- Reserved
- Reserved

Read Operations

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

Main Status Register (MSR) Offset 04h

- Drive 0 Busy
- Drive 1 Busy
- Drive 2 Busy
- Drive 3 Busy
- Command in Progress
- Non-DMA Execution
- Data I/O Direction
- RQM

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

Digital Output Register (DOR) Offset 02h

- Drive Select
- Reset Controller
- DMAEN
- Motor Enable 0
- Motor Enable 1
- Motor Enable 2
- Motor Enable 3

Write Operations

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	1	0	Reset
								Required

Data Rate Select Register (DSR) Offset 04h

- DRATE0
- DRATE1
- Precompensation Delay Select
- Undefined
- Low Power
- Software Reset

PC-AT Compatible Drive Mode

7	6	5	4	3	2	1	0	
			1			0	0	Reset
								Required

Tape Drive Register (TDR) Offset 03h

- Tape Drive Select 1,0
- Not Used
- TRI-STATE During Read Operations

7	6	5	4	3	2	1	0	
								Reset
								Required

Data Register (FIFO) Offset 05h

- Data

FDC REGISTER BITMAPS

Read Operations, PC-AT Drive Mode

7	6	5	4	3	2	1	0	
	1	1	1	1			1	Reset
								Required

Digital Input Register (DIR) Offset 07h

- DSKCHG
- Reserved, In TRI-STATE

Read Operations, PS/2 Drive Mode

7	6	5	4	3	2	1	0	
	1	1	1	1			1	Reset
								Required

Digital Input Register (DIR) Offset 07h

- High Density
- DRATE0 Status
- DRATE1 Status
- Reserved
- DSKCHG

Write Operations

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	1	0	Reset
								Required

Configuration Control Register (CCR) Offset 07h

- DRATE0
- DRATE1
- Reserved

3.6.2 Result Phase Status

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

Result Phase Status Register 0 (ST0)

- Logical Drive Selected (Execution Phase)
- Head Selected (Execution Phase)
- Not Used
- Equipment Check
- SEEK End
- Interrupt Code

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

Result Phase Status Register 1 (ST1)

- Missing Address Mark
- Drive Write Protected
- Missing Data
- Not Used
- Overrun or Underrun
- CRC Error
- Not Used
- End of Track

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

Result Phase Status Register 2 (ST2)

- Missing Address Mark Location
- Bad Track
- Scan Not Satisfied
- Scan Equal Hit
- Wrong Track
- CRC Error in Data Field
- Control Mark
- Not Used

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

Result Phase Status Register 3 (ST3)

- Logical Drive Selected (Command Phase)
- Head Selected (Command Phase)
- Not Used
- Track 0
- Not Used
- Drive Write Protected
- Not Used

3.7 COMMAND SET

The first command byte for each command in the FDC command set is the opcode byte. The FDC uses this byte to determine how many command bytes to expect.

If an invalid command byte is issued to the controller, it immediately enters the result phase and the status is 80h, signifying an invalid command.

TABLE 3-8 shows the FDC commands in alphabetical order with the opcode, i.e., the first command byte, for each.

In this table:

- MT is a multi-track enable bit (See "Bit 7 - Multi-Track (MT)" on page 64.)

- MFM is a modified frequency modulation parameter (See "Bit 6 - Modified Frequency Modulation (MFM)" on page 57.)

- SK is a skip control bit. (See "Bit 5 - Skip Control (SK)" on page 64.)

Section 3.7.1 explains some symbols and abbreviations you will encounter in the descriptions of the commands.

All phases of each command are described in detail, starting with Section 3.7.2 on page 55, with bitmaps of each byte in each phase.

Only named bits and fields are described in detail. When a bitmap shows a value (0 or 1) for a bit, that bit must have that value and is not described.

TABLE 3-8. FDC Command Set Summary

Command	Opcode							
	7	6	5	4	3	2	1	0
CONFIGURE	0	0	0	1	0	0	1	1
DUMPREG	0	0	0	0	1	1	1	0
FORMAT TRACK	0	MFM	0	0	1	1	0	1
INVALID	Invalid Opcode							
LOCK		0	0	1	0	1	0	0
MODE	0	0	0	0	0	0	0	1
NSC	0	0	0	1	1	0	0	0
PERPENDICULAR MODE	0	0	0	1	0	0	1	0
READ DATA	MT	MFM	SK	0	0	1	1	0
READ DELETED DATA	MT	MFM	SK	0	1	1	0	0
READ ID	0	MFM	0	0	1	0	1	0
READ TRACK	0	MFM	0	0	0	0	1	0
RECALIBRATE	0	0	0	0	0	1	1	1
RELATIVE SEEK	1	DIR	0	0	1	1	1	1
SCAN EQUAL	MT	MFM	SK	1	0	0	0	1
SCAN HIGH OR EQUAL	MT	MFM	SK	1	1	1	0	1
SCAN LOW OR EQUAL	MT	MFM	SK	1	1	0	0	1
SEEK	0	0	0	0	1	1	1	1
SENSE DRIVE STATUS	0	0	0	0	0	1	0	0
SENSE INTERRUPT	0	0	0	0	1	0	0	0
SET TRACK	0		1	0	0	0	0	1
SPECIFY	0	0	0	0	0	0	1	1
VERIFY	MT	MFM	SK	1	0	1	1	0
VERSION	0	0	0	1	0	0	0	0
WRITE DATA	MT	MFM	0	0	0	1	0	1
WRITE DELETED DATA	MT	MFM	0	0	1	0	0	1

3.7.1 Abbreviations Used in FDC Commands

BFR Buffer enable bit set in the MODE command. Enables open-collector output buffers.

BST Burst mode disable control bit set in MODE command. Disables burst mode for the FIFO, if the FIFO is enabled.

DC3-0 Drive Configuration for drives 3-0. Used to configure a logical drive to conventional or perpendicular mode in the PERPENDICULAR MODE command.

DENSEL
Density Select control bits set in the MODE command.

DIR Direction control bit used in RELATIVE SEEK command to indicate step in or out.

DMA DMA mode enable bit set in the SPECIFY command.

DS1-0 Drive Select for bits 1,0 used in most commands. Selects the logical drive.

EC Enable Count control bit set in the VERIFY command. When this bit is 1, SC (Sectors to read Count) command byte is required.

EIS Enable Implied Seeks. Set in the CONFIGURE command.

EOT End of Track parameter set in read, write, scan, and VERIFY commands.

ETR Extended Track Range set in the MODE command.

FIFO First-In First-Out buffer. Also a control bit set in the CONFIGURE command to enable or disable the FIFO.

FRD FIFO Read Disable control bit set in the MODE command

FWR FIFO Write disable control bit set in the MODE command.

Gap 2 The length of gap 2 in the FORMAT TRACK command and the portion of it that is rewritten in the WRITE DATA command depend on the drive mode, i.e., perpendicular or conventional. FIGURE 3-5 on page 59 illustrates gap 2 graphically. For more details, see "Bits 1,0 - Group Drive Mode Configuration (GDC)" on page 62.

Gap 3 Gap 3 is the space between sectors, excluding the synchronization field. It is defined in the FORMAT TRACK command. See FIGURE 3-5 on page 59.

GDC Group Drive Configuration for all drives. Configures all logical drives as conventional or perpendicular. Used in the PERPENDICULAR MODE command. Formerly, GAP2 and WG.

HD Head Select control bit used in most commands. Selects Head 0 or 1 of the disk.

IAF Index Address Field control bit set in the MODE command. Enables the ISO Format during the FORMAT command.

IPS Implied Seek enable bit set in the MODE, read, write, and scan commands.

LOCK Lock enable bit in the LOCK command. Used to prevent certain parameters from being affected by a software reset.

LOW PWR
Low Power control bits set in the MODE command.

MFM Modified Frequency Modulation parameter used in FORMAT TRACK, read, VERIFY and write commands.

MFT Motor Off Time. Now called Delay After Processing time. This delay is set by the SPECIFY command.

MNT Motor On Time. Now called Delay Before Processing time. This delay is set by the SPECIFY command.

MSB Most Significant Byte controls which whether the most or least significant byte is read or written in the SET TRACK command.

MT Multi-Track enable bit used in read, write, scan and VERIFY commands.

OW Overwrite control bit set in the PERPENDICULAR MODE command.

POLL Enable Drive Polling bit set in the CONFIGURE command.

PRETRK
Precompensation Track Number set in the CONFIGURE command

PTR Present Track number. Contains the internal 8-bit track number or the least significant byte of the 12-bit track number of one of the four logical disk drives. PTR is set in the SET TRACK command.

R255 Recalibration control bit set in MODE command. Sets maximum number of $\overline{STEP}$ pulses during RECALIBRATE command to 255.

RTN Relative Track Number used in the RELATIVE SEEK command.

SC Sector Count control bit used in the VERIFY command.

SK Skip control bit set in read and scan and VERIFY operations.

SRT Step Rate Time set in the SPECIFY command. Determines the time between $\overline{STEP}$ pulses for SEEK and RECALIBRATE operations.

ST0-3
Result phase Status registers 3-0 that contain status information about the execution of a command. See Sections 3.5.1 on page 48 through 3.5.4 on page 50.

THRESH
FIFO threshold parameter set in the CONFIGURE command

TMR Timer control bit set in the MODE command. Affects the timers set in the SPECIFY command.

WG Formerly, the Write Gate control bit. Now included in the Group Drive mode Configuration (GDC) bits in the PERPENDICULAR MODE command.

WLD Wildcard bit in the MODE command used to enable or disable the wildcard byte (FFh) during scan commands.

WNR Write Number controls whether to read an existing track number or to write a new one in the SET TRACK command.

3.7.2 The CONFIGURE Command

The CONFIGURE command controls some operation modes of the controller. It should be issued during the initialization of the FDC after power up.

The bits in the CONFIGURE registers are set to their default values after a hardware reset.

Command Phase

7	6	5	4	3	2	1	0
0	0	0	1	0	0	1	1
0	0	0	0	0	0	0	0
0	EIS	FIFO	POLL	Threshold (THRESH)			
Precompensation Track Number (PRETRK)							

Third Command Phase Byte

Bits 3-0 - The FIFO Threshold (THRESH)

These bits specify the threshold of the FIFO during the execution phase of read and write data transfers.

This value is programmable from 00h to 0Fh. A software reset sets this value to 00 if the LOCK bit (bit 7 of the opcode of the LOCK command) is 0. If the LOCK bit is 1, THRESH retains its value.

Use a high value of THRESH for systems that respond slowly and a low value for fast systems.

Bit 4 - Disable Drive Polling (POLL)

This bit enables and disabled drive polling. A software reset clears this bit to 0.

When drive polling is enabled, an interrupt is generated after a reset.

When drive polling is disabled, if the CONFIGURE command is issued within 500 msec of a hardware or software reset, then an interrupt is not generated. In addition, the four SENSE INTERRUPT commands to clear the Ready Changed State of the four logical drives is not required.

0: Enable drive polling. (Default)

1: Disable drive polling.

Bit 5 - Enable FIFO (FIFO)

This bit enables and disables the FIFO for execution phase data transfers.

If the LOCK bit (bit 7 of the opcode of the LOCK command) is 0, a software reset disables the FIFO, i.e., sets this bit to 1.

If the LOCK bit is 1, this bit retains its previous value after a software reset.

0: FIFO enabled for read and write operations.

1: FIFO disabled. (Default)

Bit 6 - Enable Implied Seeks (EIS)

This bit enables or disables implied seek operations. A software reset disables implied seeks, i.e., clears this bit to 0.

Bit 5 of the MODE command (Implied Seek (IPS) can override the setting of this bit and enable implied seeks even if they are disabled by this bit.

When implied seeks are enabled, a seek or sense interrupt operation is performed before execution of the read, write, scan, or verify operation.

0: Implied seeks disabled. The MODE command can still enable implied seek operations. (Default)

1: Implied seeks enabled for read, write, scan and VERIFY operations, regardless of the value of the IPS bit in the MODE command.

Fourth Command Phase Byte, Bits 7-0, Precompensation Track Number (PRETRK)

This byte identifies the starting track number for write precompensation. The value of this byte is programmable from track 0 (00h) to track 255 (FFh).

If the LOCK bit (bit 7 of the opcode of the LOCK command) is 0, after a software reset this byte indicates track 0 (00h).

If the LOCK bit is 1, PRETRK retains its previous value after a software reset.

Execution Phase

Internal registers are written.

Result Phase

None.

3.7.3 The DUMPREG Command

The DUMPREG command supports system run-time diagnostics, and application software development and debugging.

DUMPREG has a one-byte command phase (the opcode) and a 10-byte result phase, which returns the values of parameters set in other commands. See the commands that set each parameter for a detailed description of the parameter.

Command Phase

7	6	5	4	3	2	1	0
0	0	0	0	1	1	1	0

Execution Phase

Internal registers read.

Result Phase

7	6	5	4	3	2	1	0
Byte of Present Track Number (PTR) Drive 0							
Byte of Present Track Number (PTR) Drive 1							
Byte of Present Track Number (PTR) Drive 2							
Byte of Present Track Number (PTR) Drive 3							
Step Rate Time (SRT)				Delay After Processing			
Delay Before Processing							DMA
Sectors per Track or End of Track (EOT) Sector #							
LOCK	0	DC3	DC2	DC1	DC0	GDC	
0	EIS	FIFO	POLL	THRESH			
Precompensation Track Number (PRETRK)							

After a hardware or software reset, parameters in this phase are reset to their default values. Some of these parameters are unaffected by a software reset, depending on the state of the LOCK bit.

See the command that determines the setting for the bit or field for details.

First through Fourth Result Phase Bytes, Bits 7-0, Present Track Number (PTR) Drives 3-0

Each of these bytes contains either the internal 8-bit track number or the least significant byte of the 12-bit track number of the corresponding logical disk drive.

Fifth and Sixth Result Phase Bytes, Bits 7-0,
Step Rate Time, Motor Off Time, Motor On Time and DMA

These fields are all set by the SPECIFY command. See Section 3.7.21 on page 73.

Seventh Result Phase Byte -
Sectors Per Track or End of Track (EOT)

This byte varies depending on what commands have been previously executed.

If the last command issued was a FORMAT TRACK command, and no read or write commands have been issued since then, this byte contains the sectors per track value.

If a read or a write command was executed more recently than a FORMAT TRACK command, this byte specifies the number of the sector at the End of the Track (EOT).

Eighth Result Phase Byte

Bits 5-0 - DC3-0, GDC

Bits 5-0 of the second command phase byte of the PERPENDICULAR MODE command set bits 5-0 of this byte. See "Bits 5-2 -Drive 3-0 Mode Configuration (DC3-0)" on page 63.

Bit 7 - LOCK

This bit controls how the other bits in this command respond to a software reset. See Section 3.7.6 on page 60.

The value of this is determined by bit 7 of the opcode of the LOCK command.

0: Bits in this command are set to their default values after a software reset. (Default)

1: Bits in this command are unaffected by a software reset.

Ninth and Tenth Result Phase Bytes

These bytes reflect the values in the third and fourth command phase bytes of the CONFIGURE command. See Section 3.7.2 on page 55.

3.7.4 The FORMAT TRACK Command

This command formats one track on the disk in IBM, ISO, or Toshiba perpendicular format.

After a pulse from the $\overline{\text{INDEX}}$ signal is detected, data patterns are written on the disk including all gaps, Address Marks (AMs), address fields and data fields. See FIGURE 3-5 on page 59.

The format of the track is determined by the following parameters:

- The MFM bit in the opcode (first command) byte, which indicates the type of the disk drive and the data transfer rate and determines the format of the address marks and the encoding scheme.

- The Index Address Format (IAF) bit (bit 6 in the second command phase byte) in the MODE command, which selects IBM or ISO format.

- The Group Drive Configuration (GDC) bits in the PERPENDICULAR MODE command, which select either conventional or Toshiba perpendicular format.

- A bytes-per-sector code, which determines the sector size. See TABLE 3-10 on page 57.

- A sectors per track parameter, which specifies how many sectors are formatted on the track.

- The data pattern byte, which is used to fill the data field of each sector.

TABLE 3-9 on page 57 shows typical values for these parameters for specific PC compatible diskettes.

To allow flexible formatting, the microprocessor must supply the four address field bytes (track number, head number, sector number, bytes-per-sector code) for each sector formatted during the execution phase. This allows non-sequential sector interleaving.

This transfer of bytes from the microprocessor to the controller can be done in DMA or non-DMA mode (See Section 3.4.2 on page 45), with the FIFO enabled or disabled.

The FORMAT TRACK command terminates when a pulse from the $\overline{\text{INDEX}}$ signal is detected a second time, at which point an interrupt is generated.

Command Phase

7	6	5	4	3	2	1	0
0	MFM	0	0	1	1	0	1
X	X	X	X	X	HD	DS1	DS0
Bytes-Per-Sector Code							
Sectors per Track							
Bytes in Gap 3							
Data Pattern							

First Command Phase Byte, Opcode

Bit 6 - Modified Frequency Modulation (MFM)

This bit indicates the type of the disk drive and the data transfer rate, and determines the format of the address marks and the encoding scheme.

0: FM mode, i.e., single density.

1: MFM mode, i.e., double density.

TABLE 3-9. Typical Values for PC Compatible Diskette Media

Media Type	Bytes in Data Field (decimal)	Bytes-Per-Sector Code (hex)	End of Track (EOT) Sector # (hex)	Bytes in Gap 2 [1] (hex)	Bytes in Gap 3 [2] (hex)
360 KB	512	02	09	2A	50
1.2 MB	512	02	0F	1B	54
720 KB	512	02	09	1B	50
1.44 MB	512	02	12	1B	6C
2.88 MB[3]	512	02	24	1B	53

1. Gap 2 is specified in the command phase of read, write, scan, and verify commands. Although this is the recommended value, the FDC ignores this byte in read, write, scan and verify commands.
2. Gap 3 is the suggested value for the programmable GAP3 that is used in the FORMAT TRACK command and is illustrated in FIGURE 3-5 on page 59.
3. The 2.88 MB diskette media is a barium ferrite media intended for use in perpendicular recording drives at the data rate of up to 1 Mbps.

Second Command Phase Byte

Bits 1,0 - Logical Drive Select (DS1,0)

These bits indicate which logical drive is active. They reflect the values of bits 1,0 of the Digital Output Register (DOR) described in "Bits 1,0 - Drive Select" on page 40 and of result phase status registers 0 and 3 (ST0 and ST3) described in Sections 3.5.1 on page 48 and 3.5.4 on page 50.

00: Drive 0 is selected. (Default)

01: Drive 1 is selected.

10: If four drives are supported, or drives 2 and 0 are exchanged, drive 2 is selected.

11: If four drives are supported, drive 3 is selected.

Bit 2 - Head Select (HD)

This bit indicates which side of the Floppy Disk Drive (FDD) is selected by the head. Its value is the inverse of the $\overline{\text{HDSEL}}$ disk interface output signal.

This bit reflects the value of bit 3 of Status Register A (SRA) described in Section 3.3.1 on page 38 and bit 2 of result phase status registers 0 and 3 (ST0 and ST3) described in Sections 3.5.1 on page 48 and 3.5.4 on page 50, respectively.

0: $\overline{\text{HDSEL}}$ is not active, i.e., the head of the FDD selects side 0. (Default)

1: $\overline{\text{HDSEL}}$ is active, i.e., the head of the FDD selects side 1.

Third Command Phase Byte -Bytes-Per-Sector Code

This byte contains a code in hexadecimal format that indicates the number of bytes in a data field.

TABLE 3-10 on page 57 shows the number of bytes in a data field for each code.

TABLE 3-10. Bytes per Sector Codes

Bytes-Per-Sector Code (hex)	Bytes in Data Field
00	128
01	256
02	512
03	1024
04	2048
05	4096
06	8192
07	16384

Fourth Command Phase Byte - Sectors Per Track

The value in this byte specifies how many sectors there are in the track.

Fifth Command Phase Byte - Bytes in Gap 3

The number of bytes in gap 3 is programmable. The number to program for Gap 3 depends on the data transfer rate and the type of the disk drive. TABLE 3-11 on page 58 shows some typical values to use for Gap 3.

FIGURE 3-5 on page 59 illustrates the track format for each of the formats recognized by the FORMAT TRACK command.

Sixth Command Phase Byte - Data Pattern

This byte contains the contents of the data field.

Execution Phase

The system transfers four ID bytes (track number, head number, sector number and bytes-per-sector code) per sector to the Floppy Disk Controller (FDC) in either DMA or non-DMA mode. Section 3.4.2 on page 45 describes these modes.

The entire track is formatted. The data block in the data field of each sector is filled with the data pattern byte.

Only the first three status bytes in this phase are significant.

TABLE 3-11. Typical Gap 3 Values

Drive Type and Data Transfer Rate	Bytes in Data Field (decimal)	Bytes-Per-Sector Code (hex)	End of Track (EOT) Sector # (hex)	Bytes in Gap 2 [1] (hex)	Bytes in Gap 3 [2] (hex)
	256	01	12	0A	0C
	256	01	10	20	32
250 Kbps	512	02	08	2A	50
MFM	512	02	09	2A	50
	1024	03	04	80	F0
	2048	04	02	C8	FF
	4096	05	01	C8	FF
500 Kbps	256	010	1A	0E	36
MFM	512	02	0F	1B	54
	512	02	12	1B	6C
	1024	03	08	35	74
	2048	04	04	99	FF
	4096	05	02	C8	FF
	8192	06	01	C8	FF

1. Gap 2 is specified in the command phase of read, write, scan, and verify commands. Although this is the recommended value, the FDC ignores this byte in read, write, scan and verify commands.

2. Gap 3 is the suggested value for use in the FORMAT TRACK command. This is the programmable Gap 3 illustrated in FIGURE 3-5 on page 59.

Result Phase

7	6	5	4	3	2	1	0

Result Phase Status Register 0 (ST0)
Result Phase Status Register 1 (ST1)
Result Phase Status Register 2 (ST2)
Undefined
Undefined
Undefined
Undefined

3.7.5   The INVALID Command

If an INVALID command (illegal opcode byte in the command phase) is received by the Floppy Disk Controller (FDC), the controller responds with the result phase Status Register 0 (ST0) in the result phase. See Section 3.5.1 on page 48.

The controller does not generate an interrupt during this condition. Bits 7 and 6 in the MSR (see Section 3.3.6 on page 43) are both set to 1, indicating to the microprocessor that the controller is in the result phase and the contents of ST0 must be read.

Command Phase

7	6	5	4	3	2	1	0

Invalid Opcodes

Execution Phase

None.

Result Phase

The system reads the value 80h from ST0 indicating that an invalid command was received.

7	6	5	4	3	2	1	0

Result Phase Status Register 0 (STO) (80h)
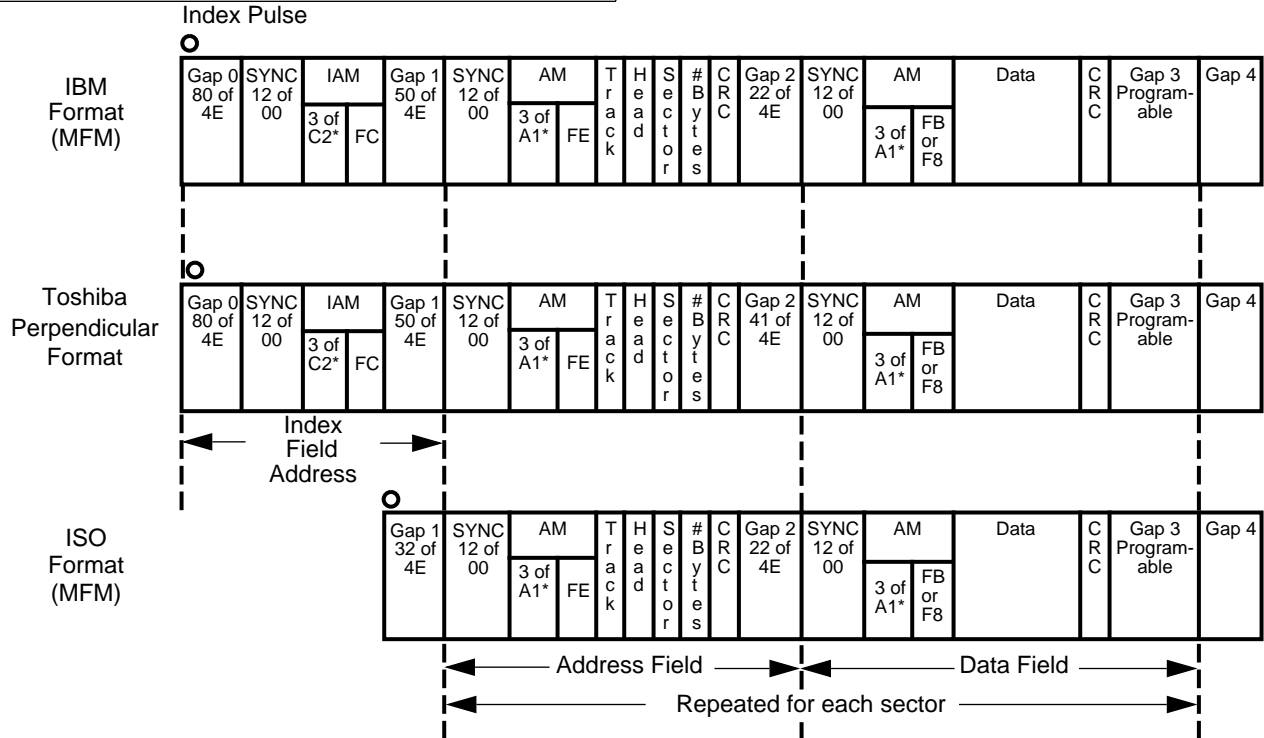
A1* = Data Pattern of A1, Clock Pattern of 0A. All other data rates use gap 2 = 22 bytes.
C2* = Data Pattern of C2, Clock Pattern of 14

FIGURE 3-5. IBM, Perpendicular, and ISO Formats Supported by the FORMAT TRACK Command

COMMAND SET

3.7.6 The LOCK Command

The LOCK command can be used to keep the FIFO enabled and to retain the values of some parameters after a software reset.

After the command byte of the LOCK command is written, its result byte must be read before the opcode of the next command can be read. The LOCK command is not executed until its result byte is read by the microprocessor.

If the part is reset after the command byte of the LOCK command is written but before its result byte is read, then the LOCK command is not executed. This prevents accidental execution of the LOCK command.

Command Phase

7	6	5	4	3	2	1	0
LOCK	0	0	1	0	1	0	0

Bit 7 - Control Reset Effect (LOCK)

This bit determines how the FIFO, THRESH, and PRETRK bits in the CONFIGURE command and, the FWR, FRD, and BST bits in the MODE command are affected by a software reset.

0: Set default values after a software reset. (Default)

1: Values are unaffected by a software reset.

Execution Phase

Internal register is written.

Result Phase

7	6	5	4	3	2	1	0
0	0	0	LOCK	0	0	0	0

Bit 4 - Control Reset Effect (LOCK)

Same as bit 7 of opcode in command phase.

3.7.7 The MODE Command

This command selects the special features of the controller. The bits in the command bytes of the MODE command are set to their default values after a hardware reset.

Command Phase

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	1
TMR	IAF	IPS	0	LOW PWR		0	ETR
FWR	FRD	BST	R255	0	0	0	0
DENSEL		BFR	WLD	Head Settle Factor			
0	0	0	0	0	0	0	0

Second Command Phase Byte

Bit 0 - Extended Track Range (ETR)

This bit determines how the track number is stored. It is cleared to 0 after a software reset.

0: Track number is stored as a standard 8-bit value compatible with the IBM, ISO, and Toshiba Perpendicular formats.

This allows access of up to 256 tracks during a seek operation. (Default)

1: Track number is stored as a 12-bit value.

The upper four bits of the track value are stored in the upper four bits of the head number in the sector address field.

This allows access of up to 4096 tracks during a seek operation. With this bit set, an extra byte is required in the SEEK command phase and SENSE INTERRUPT result phase.

Bits 3,2 - Low-Power Mode (LOW PWR)

These bits determine whether or not the FDC powers down and, if it does, they specific how long it will take.

These bits disable power down, i.e., are cleared to 0, after a software reset.

00: Disables power down. (Default)

01: Automatic power down.

At a 500 Kbps data transfer rate, the FDC goes into low-power mode 512 msec after it becomes idle.

At a 250 Kbps data transfer rate, the FDC goes into low-power mode 1 second after it becomes idle.

10: Manual power down.

The FDC powers down mode immediately.

11: Not used.

Bit 5 - Implied Seek (IPS)

This bit determines whether the Implied Seek (IPS) bit in a command phase byte of a read, write, scan, or verify command is ignored or READ.

A software reset clears this bit to its default value of 0.

0: The IPS bit in the command byte of a read, write, scan, or verify is ignored. (Default)

Implied seeks can still be enabled by the Enable Implied Seeks (EIS) bit (bit 6 of the third command phase byte) in the CONFIGURE command.

1: The IPS bit in the command byte of a read, write, scan, or verify is read.

If it is set to 1, the controller performs seek and sense interrupt operations before executing the command.

Bit 6 - Index Address Format (IAF)

This bit determines whether the controller formats tracks with or without an index address field.

A software reset clears this bit to its default value of 0.

0: The controller formats tracks with an index address field. (IBM and Toshiba Perpendicular format).

1: The controller formats tracks without an index address field. (ISO format).

Bit 7 - Motor Timer Values (TMR)

This bit determines which group of values to use to calculate the Delay Before Processing and Delay After Processing times. The value of each is programmed using the SPECIFY command, which is described in TABLES 3-23 on page 74 and 3-24 on page 74.

A software reset clears this bit to its default value of 0.

0: Use the TMR = 0 group of values. (Default)

1: Use the TMR = 1 group of values.

Third Command Phase Byte

Bit 4 - RECALIBRATE Step Pulses (R255)

This bit determines the maximum number of RECALIBRATE step pulses the controller issues before terminating with an error, depending on the value of the Extended Track Range (ETR) bit, i.e., bit 0 of the second command phase byte in the MODE command.

A software reset clears this bit to its default value of 0.

0: If ETR (bit 0) = 0, the controller issues a maximum of 85 recalibration step pulses.

If ETR (bit 0) = 1, the controller issues a maximum of 3925 recalibration step pulses. (Default)

1: If ETR (bit 0) = 0, the controller issues a maximum of 255 recalibration step pulses.

If ETR (bit 0) = 1, the controller issues a maximum of 4095 recalibration step pulses.

Bit 5 - Burst Mode Disable (BST)

This bit enables or disables burst mode, if the FIFO is enabled (bit 5 in the CONFIGURE command is 0). If the FIFO is not enabled in the CONFIGURE command, then the value of this bit is ignored.

A software reset enables burst mode, i.e., clears this bit to its default value of 0, if the LOCK bit (bit 7 of the opcode of the LOCK command) is 0. If it is 1, BST retains its value after a software reset.

0: Burst mode enabled for FIFO execution phase data transfers. (Default)

1: Burst mode disabled.

The FDC issues one DRQ or IRQ6 pulse for each byte to be transferred while the FIFO is enabled.

Bit 6 - FIFO Read Disable (FRD)

This bit enables or disables the FIFO for microprocessor read transfers from the controller, if the FIFO is enabled (bit 5 in the CONFIGURE command is 0). If the FIFO is not enabled in the CONFIGURE command, then the value of this bit is ignored.

A software reset enables the FIFO for reads, i.e., clears this bit to its default value of 0, if the LOCK bit (bit 7 of the opcode of the LOCK command) is 0. If it is 1, FRD retains its value after a software reset.

0: Enable FIFO. Execution phase of microprocessor read transfers use the internal FIFO. (Default)

1: Disable FIFO. All read data transfers take place without the FIFO.

Bit 7 - FIFO Write Enable or Disable (FWR)

This bit enables or disables write transfers to the controller, if the FIFO is enabled (bit 5 in the CONFIGURE command is 0). If the FIFO is not enabled in the CONFIGURE command, then the value of this bit is ignored.

A software reset enables the FIFO for writes, i.e., clears this bit to its default value of 0, if the LOCK bit (bit 7 of the opcode of the LOCK command) is 0. If it is 1, FWR retains its value after a software reset.

0: Enable FIFO. Execution phase microprocessor write transfers use the internal FIFO. (Default)

1: Disable FIFO. All write data transfers take place without the FIFO.

Fourth Command Phase Byte

Bits 3-0 - Head Settle Factor

This field is used to specify the maximum time allowed for the read/write head to settle after a seek during an implied seek operation.

The value specified by these bits (the head settle factor) is multiplied by the multiplier for selected data rate to specify a head settle time that is within the range for that data rate.

Use the following formula to determine the head settle factor that these bits should specify:

Head Settle Factor x Multiplier = Head Settle Time

TABLE 3-12 on page 61 shows the multipliers and head settle time ranges for each data transfer rate. The default head settle factor, i.e., value for these bits, is 8.

TABLE 3-12. Multipliers and Head Settle Time Ranges for Different Data Transfer Rates

Data Transfer Rate (Kbps)	Multiplier	Head Settle Time Range (msec)
250	8	0 - 120
300	6.666	0 - 100
500	4	0 - 60
1000	2	0 - 30

Bit 4 - Scan Wild Card (WLD)

This bit determines whether or not a value of FFh from either the microprocessor or the disk is recognized during a scan command as a wildcard character.

0: A value of FFh from either the microprocessor or the disk during a scan command is interpreted as a wildcard character that always matches. (Default)

1: The scan commands do not recognize a value of FFh as a wildcard character.

Bit 5 - CMOS Disk Interface Buffer Enable (BFR)

This bit configures drive output signals.

0: Drive output signals are configured as standard 4 mA push-pull output signals (40 mA sink, 4 mA source). (Default)

1: Drive output signals are configured as 40 mA open-drain output signals.

Bits 7,6 - Density Select Pin Configuration (DENSEL)

This field can configure the polarity of the Density Select output signal (DENSEL) as always low or always high, as shown in Table 4-3. This allows the user more flexibility with new drive types.

This field overrides the DENSEL polarity defined by the DENSEL polarity bit of the SuperI/O FDC configuration register at index F0h and described in Section 2.5.1 on page 30.

00: The DENSEL signal is always low.

01: The DENSEL signal is always high.

10: The DENSEL signal is undefined.

11: The polarity of the DENSEL signal is defined by the DENSEL Polarity bit (bit 5) of the SuperI/O FDC configuration register. See page "Bit 5 - DENSEL Polarity Control" on page 30. (Default)

TABLE 3-13. DENSEL Encoding

Bit 7	Bit 6	DENSEL Pin Definition
0	0	DENSEL low
0	1	DENSEL high
1	0	undefined
1	1	Set by bit 5 of the SuperI/O FDC configuration register at offset F0h.

Execution Phase

Internal registers are written.

Result Phase

None.

3.7.8   The NSC Command

The NSC command can be used to distinguish between the FDC versions and the 82077.

Command Phase

7	6	5	4	3	2	1	0
0	0	0	1	1	0	0	0

Execution Phase

Result Phase.

7	6	5	4	3	2	1	0
0	1	1	1	0	0	1	1

The result phase byte of the NSC command identifies the floppy disk controller (FDC) as a PC87309 by returning a value of 73h.

The 82077 and DP8473 return the value 80h, signifying an invalid command.

Bits 3-0 of this result byte are subject to change by NSC, and specify the version of the Floppy Disk Controller (FDC)

3.7.9   The PERPENDICULAR MODE Command

The PERPENDICULAR MODE command configures each of the four logical disk drives for perpendicular or conventional mode via the logical drive configuration bits 1,0 or 5-2, depending on the value of bit 7. The default mode is conventional. Therefore, if the drives in the system are conventional, it is not necessary to issue a PERPENDICULAR MODE command.

This command supports the unique FORMAT TRACK and WRITE DATA requirements of perpendicular (vertical) recording disk drives with a 4 MB unformatted capacity.

Perpendicular recording drives operate in extra high density mode at 1 or 2 Mbps, and are downward compatible with 1.44 MB and 720 KB drives at 500 kbps (high density) and 250 kbps (double density), respectively.

If the system includes perpendicular drives, this command should be issued during initialization of the FDC. Then, when a drive is accessed for a FORMAT TRACK or WRITE DATA command, the FDC adjusts the command parameters based on the data rate. See TABLE 3-14 on page 63.

Precompensation is set to zero for perpendicular drives at any data rate.

Perpendicular recording type disk drives have a pre-erase head that leads the read or write head by 200 μm, which translates to 38 bytes at a 1 Mbps data transfer rate (19 bytes at 500 Kbps).

The increased space between the two heads requires a larger gap 2 between the address field and data field of a sector at 1 or 2 Mbps. See Perpendicular Format in FIGURE 3-5 on page 59. A gap 2 length of 41 bytes (at 1 or 2 Mbps) ensures that the preamble in the data field is completely pre-erased by the pre-erase head.

Also, during WRITE DATA operations to a perpendicular drive, a portion of gap 2 must be rewritten by the controller to guarantee that the data field preamble has been pre-erased. See TABLE 3-14 on page 63.

Command Phase

7	6	5	4	3	2	1	0
0	0	0	1	0	0	1	0
OW	0	DC3	DC2	DC1	DC0	GDC	

Second Command Phase Byte

A hardware reset clears all the bits to zero (conventional mode for all drives). PERPENDICULAR MODE command bits may be written at any time.

The settings of bits 1 and 0 in this byte override the logical drive configuration set by bits 5 through 2. If bits 1 and 0 are both 0, bits 5 through 2 configure the logical disk drives as conventional or perpendicular. Otherwise, bits 2 and 0 configure them. See TABLE 3-21 on page 72.

Bits 1,0 - Group Drive Mode Configuration (GDC)

These bits configure all the logical disk drives as conventional or perpendicular. If the Overwrite bit (OW, bit 7) is 0, this setting may be overridden by bits 5-2.

It is not necessary to issue the FORMAT TRACK command if all drives are conventional.

These bits are cleared to 0 by a software reset.

00: Conventional. (Default)

01: Perpendicular. (500 Kbps)

10: Conventional.

11: Perpendicular. (1 or 2 Mbps)

Bits 5-2 -Drive 3-0 Mode Configuration (DC3-0)

If bits 1,0 are both 0, and bit 7 is 1, these bits configure logical drives 3-0 as conventional or perpendicular. Bits 5-2 (DC3–0) correspond to logical drives 3-0, respectively.

These bits are not affected by a software reset.

0: Conventional drive. (Default)

It is not necessary to issue the FORMAT TRACK command for conventional drives.

1: Perpendicular drive.

Bit 7 - Overwrite (OW)

This bit enables or disables changes in the mode of the logical drives by bits 5-2.

0: Changes in mode of logical drives via bits 5-2 are ignored. (Default)

1: Changes enabled.

Execution Phase

Internal registers are written.

Result Phase

None.

TABLE 3-14. Effect of Drive Mode and Data Rate on FORMAT TRACK and WRITE DATA Commands

Data Rates	Drive Mode	Length of Gap 2 in FORMAT TRACK Command	Portion of Gap 2 Rewritten in WRITE DATA Command
250, 300 or 500 Kbps	Conventional	22 bytes	0 bytes
	Perpendicular	22 bytes	19 bytes
1 or 2 Mbps	Conventional	22 bytes	0 bytes
	Perpendicular	41 bytes	38 bytes

TABLE 3-15. Effect of GDC Bits on FORMAT TRACK and WRITE DATA Commands

GDC Bits 1	0	Drive Mode	Length of Gap 2 in FORMAT TRACK Command	Portion of Gap 2 Rewritten in WRITE DATA Command
0	0	Conventional	22 bytes	0 bytes
0	1	Perpendicular (≤500 Kbps)	22 bytes	19 bytes
1	0	Conventional	22 bytes	0 bytes
1	1	Perpendicular (1 or 2 Mbps)	41 bytes	38 bytes

3.7.10 The READ DATA Command

The READ DATA command reads logical sectors that contain a normal data address mark from the selected drive and makes the data available to the host microprocessor.

Command Phase

7	6	5	4	3	2	1	0
MT	MFM	SK	0	0	1	1	0
IPS	X	X	X	X	HD	DS1	DS0
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							
End of Track (EOT) Sector Number							
Bytes Between Sectors - Gap 3							
Data Length (Obsolete)							

The READ DATA command phase bytes must specify the following ID information for the desired sector:

- Track number

- Head number

- Sector number

- Bytes-per-sector code (See TABLE 3-10 on page 57.)

- End of Track (EOT) sector number. This allows the controller to read multiple sectors.

- The value of the data length byte is ignored and must be set to FFh.

After the last command phase byte is written, the controller waits the Delay Before Processing time (see TABLE 3-24 on page 74) for the selected drive. During this time, the drive motor must be turned on by enabling the appropriate drive and motor select disk interface output signals via the bits of the Digital Output Register (DOR). See Section 3.3.3 on page 39.

First Command Phase Byte

Bit 5 - Skip Control (SK)

This controls whether or not sectors containing a deleted address mark will be skipped during execution of the READ DATA command. See TABLE 3-16 on page 65.

0: Do not skip sector with deleted address mark.

1: Skip sector with deleted address mark.

Bit 6 - Modified Frequency Modulation (MFM)

This bit indicates the type of the disk drive and the data transfer rate, and determines the format of the address marks and the encoding scheme.

0: FM mode, i.e., single density.

1: MFM mode, i.e., double density.

Bit 7 - Multi-Track (MT)

This bit controls whether or not the controller continues to side 1 of the disk after reaching the last sector of side 0.

0: Single track. The controller stops at the last sector of side 0.

1: Multiple tracks. the controller continues to side 1 after reaching the last sector of side 0.

Second Command Phase Byte

Bits 1,0 - Logical Drive Select (DS1,0)

These bits indicate which logical drive is active. See "Bits 1,0 - Logical Drive Select (DS1,0)" on page 57.

00: Drive 0 is selected. (Default)

01: Drive 1 is selected.

10: If four drives are supported, or drives 2 and 0 are exchanged, drive 2 is selected.

11: If four drives are supported, drive 3 is selected.

Bit 2 - Head (HD)

This bit indicates which side of the Floppy Disk Drive (FDD) is selected by the head. Its value is the inverse of the $\overline{HDSEL}$ disk interface output signal. See "Bit 2 - Head Select (HD)" on page 57.

0: $\overline{HDSEL}$ is not active, i.e., the head of the FDD selects side 0. (Default)

1: $\overline{HDSEL}$ is active, i.e., the FDD head selects side 1.

Bit 7 - Implied Seek (IPS)

This bit indicates whether or not an implied seek should be performed. See also, "Bit 5 - Implied Seek (IPS)" on page 60.

A software reset clears this bit to its default value of 0.

0: No implied seek operations. (Default)

1: The controller performs seek and sense interrupt operations before executing the command.

Third Command Phase Byte - Track Number

The value in this byte specifies the number of the track to read.

Fourth Command Phase Byte - Head Number

The value in this byte specifies head to use.

Fifth Command Phase Byte - Sector Number

The value in this byte specifies the sector to read.

Sixth Command Phase Byte - Bytes-Per-Sector Code

This byte contains a code in hexadecimal format that indicates the number of bytes in a data field. TABLE 3-10 on page 57 indicates the number of bytes that corresponds to each code.

Seventh Command Phase Byte - End of Track (EOT) Sector Number

This byte specifies the number of the sector at the End Of the Track (EOT).

Eighth Command Phase Byte - Bytes Between Sectors - Gap 3

   The value in this byte specifies how many bytes there are between sectors. See "Fifth Command Phase Byte - Bytes in Gap 3" on page 57.

Ninth Command Phase Byte - Data Length (Obsolete)

   The value in this byte is ignored and must be set to FFh.

Execution Phase

In this phase, data read from the disk drive is transferred to the system via DMA or non-DMA modes. See Section 3.4.2 on page 45.

The controller looks for the track number specified in the third command phase byte. If implied seeks are enabled, the controller also performs all operations of a SENSE INTERRUPT command and of a SEEK command (without issuing these commands). Then, the controller waits the head settle time. See bits 3-0 of the fourth command phase byte of the MODE command in "Bits 3-0 - Head Settle Factor" on page 61.

The controller then starts the data separator and waits for the data separator to find the address field of the next sector. The controller compares the ID information (track number, head number, sector number, bytes-per-sector code) in that address field with the corresponding information in the command phase bytes of the READ DATA command.

If the contents of the bytes do not match, then the controller waits for the data separator to find the address field of the next sector. The process is repeated   until a match or an error occurs.

Possible errors, the conditions that may have caused them and the actions that result are:

- The microprocessor aborted the command by writing to the FIFO.

   If there is no disk in the drive, the controller gets stuck. The microprocessor must then write a byte to the FIFO to advance the controller to the result phase.

- Two pulses of the INDEX signal were detected since the search began, and no valid ID was found.

   If the track address differs, either the Wrong Track bit (bit 4) or the Bad Track bit (bit 1) (if the track address is FFh) is set in result phase Status register 2 (ST2). See Section 3.5.3 on page 49.

   If the head number, sector number or bytes-per-sector code did not match, the Missing Data bit (bit 2) is set in result phase Status register 1 (ST1).

   If the Address Mark (AM) was not found, the Missing Address Mark bit (bit 0) is set in ST1.

   Section 3.5.2 on page 49 describes the bits of ST1.

- A CRC error was detected in the address field. In this case the CRC Error bit (bit 5) is set in ST1.

Once the address field of the desired sector is found, the controller waits for the data separator to find the data field for that sector.

If the data field (normal or deleted) is not found within the expected time, the controller terminates the operation, enters the result phase and sets bit 0 (Missing Address Mark) in ST1.

If a deleted data mark is found, and Skip (SK) control is set to 1 in the opcode command phase byte, the controller skips this sector and searches for the next sector address field as described above. The effect of Skip Control (SK) on the READ DATA command is summarized in TABLE 3-16 on page 65.

TABLE 3-16. Skip Control Effect on READ DATA Command

Skip Control (SK)	Data Type	Sector Read?	Control Mark Bit 6 of ST2	Result
0	Normal	Y	0	Normal Termination
0	Deleted	Y	1	No More Sectors Read
1	Normal	Y	0	Normal Termination
1	Deleted	N	1	Sector Skipped

After finding the data field, the controller transfers data bytes from the disk drive to the host until the bytes-per-sector count has been reached, or until the host terminates the operation by issuing the Terminal Count (TC) signal, reaching the end of the track or reporting an overrun.

See also Section 3.4 on page 45.

The controller then generates a Cyclic Redundancy Check (CRC) value for the sector and compares the result with the CRC value at the end of the data field.

After reading the sector, the controller reads the next logical sector unless one or more of the following termination conditions occurs:

- The DMA controller asserted the Terminal Count (TC) signal to indicate that the operation terminated. The Interrupt Code (IC) bits (bits 7,6) in ST0 are set to normal termination (00). See "Bits 7,6 - Interrupt Code (IC)" on page 48.

- The last sector address (of side 1, if the Multi-Track enable bit (MT) was set to 1) was equal to the End of Track sector number. The End of Track bit (bit 7) in ST1 is set. The IC bits in ST0 are set to abnormal termination (01). This is the expected condition during non-DMA transfers.

- Overrun error. The Overrun bit (bit 4) in ST1 is set. The Interrupt Code (IC) bits (bits 7,6) in ST0 are set to abnormal termination (01). If the microprocessor cannot service a transfer request in time, the last correctly read byte is transferred.

- CRC error. CRC Error bit (bit 5) in ST1 and CRC Error in Data Field bit (bit 5) in ST2, are set. The Interrupt Code (IC) bits (bits 7,6) in ST0 are set to abnormal termination (01).

If the Multi-Track (MT) bit was set in the opcode command byte, and the last sector of side 0 has been transferred, the controller continues with side 1.

Result Phase

7	6	5	4	3	2	1	0
Result Phase Status Register 0 (ST0)							
Result Phase Status Register 1 (ST1)							
Result Phase Status Register 2 (ST2)							
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							

Upon terminating the execution phase of the READ DATA command, the controller asserts IRQ6, indicating the beginning of the result phase. The microprocessor must then read the result bytes from the FIFO.

The values that are read back in the result bytes are shown in TABLE 3-17 on page 66. If an error occurs, the result bytes indicate the sector read when the error occurred.

3.7.11 The READ DELETED DATA Command

The READ DELETED DATA command reads logical sectors containing a Address Mark (AM) for deleted data from the selected drive and makes the data available to the host microprocessor.

This command is like the READ DATA command, except for the setting of the Control Mark bit (bit 6) in ST2 and the skipping of sectors. See description of execution phase. See READ DATA command for a description of the command bytes.

Command Phase

7	6	5	4	3	2	1	0
MT	MFM	SK	0	1	1	0	0
IPS	X	X	X	X	HD	DS1	DS0
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							
End of Track (EOT) Sector Number							
Bytes Between Sectors - Gap 3							
Data Length (Obsolete)							

Execution Phase

Data read from disk drive is transferred to the system in DMA or non-DMA modes. See Section 3.4.2 on page 45.

See TABLE 3-17 on page 66 for the state of the result bytes when the command terminates normally. The effect of Skip Control (SK) on the READ DELETED DATA command is summarized in TABLE 3-18 on page 67.

TABLE 3-17. Result Phase Termination Values with No Error

Multi-Track (MT)	Head # (HD)	End of Track (EOT) Sector Number	ID Information in Result Phase			
			Track Number	Head Number	Sector Number	Bytes-per-Sector Code
0	0	< EOT[1] Sector #	No Change	No Change	Sector[2] # + 1	No Change
0	0	= EOT[1] Sector #	Track[3] # + 1	No Change	1	No Change
0	1	< EOT[1] Sector #	No Change	No Change	Sector[2] # + 1	No Change
0	1	= EOT[1] Sector #	Track[3] # + 1	No Change	1	No Change
1	0	< EOT[1] Sector #	No Change	No Change	Sector[2] # + 1	No Change
1	0	= EOT[1] Sector #	No Change	1	1	No Change
1	1	< EOT[1] Sector #	No Change	No Change	Sector[2] # + 1	No Change
1	1	= EOT[1] Sector #	Track[3] # + 1	0	1	No Change

1. End of Track sector number from the command phase.
2. The number of the sector last operated on by controller.
3. Track number programmed in the command phase

TABLE 3-18. SK Effect on READ DELETED DATA Command

Skip Control (SK)	Data Type	Sector Read?	Control Mark Bit 6 of ST2	Result
0	Normal	Y	1	No More Sectors Read
0	Deleted	Y	0	Normal Termination
1	Normal	N	1	Sector Skipped
1	Deleted	Y	0	Normal Termination

Result Phase

7	6	5	4	3	2	1	0
Result Phase Status Register 0 (ST0)							
Result Phase Status Register 1 (ST1)							
Result Phase Status Register 2 (ST2)							
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							

3.7.12   The READ ID Command

The READ ID command finds the next available address field and returns the ID bytes (track number, head number, sector number, bytes-per-sector code) to the microprocessor in the result phase.

The controller reads the first ID Field header bytes it can find and reports these bytes to the system in the result bytes.

Command Phase

7	6	5	4	3	2	1	0
0	MFM	0	0	1	0	1	0
X	X	X	X	X	HD	DS1	DS0

After the last command phase byte is written, the controller waits the Delay Before Processing time (see TABLE 3-24 on page 74) for the selected drive. During this time, the drive motor must be turned on by enabling the appropriate drive and motor select disk interface output signals via the bits of the Digital Output Register (DOR). See Section 3.3.3 on page 39.

First Command Phase Byte, Opcode
   See "Bit 6 - Modified Frequency Modulation (MFM)" on page 57.

Second Command Phase Byte
   See "Second Command Phase Byte" on page 57 for a description of the Drive Select (DS1,0) and Head Select (HD) bits.

Execution Phase

There is no data transfer during the execution phase of this command. An interrupt is generated when the execution phase is completed.

The READ ID command does not perform an implied seek.

After waiting the Delay Before Processing time, the controller starts the data separator and waits for the data separator to find the address field of the next sector. If an error condition occurs, the Interrupt Code (IC) bits in ST0 are set to abnormal termination (01), and the controller enters the result phase.

Possible errors are:

- The microprocessor aborted the command by writing to the FIFO.

   If there is no disk in the drive, the controller gets stuck. The microprocessor must then write a byte to the FIFO to advance the controller to the result phase.

- Two pulses of the $\overline{\text{INDEX}}$ signal were detected since the search began, and no Address Mark (AM) was found.

   When the Address Mark (AM) is not found, the Missing Address Mark bit (bit 0) is set in ST1. Section 3.5.2 on page 49 describes the bits of ST1.

Result Phase

7	6	5	4	3	2	1	0
Result Phase Status Register 0 (ST0)							
Result Phase Status Register 1 (ST1)							
Result Phase Status Register 2 (ST2)							
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							

3.7.13 The READ A TRACK Command

The READ A TRACK command reads sectors from the selected drive, in physical order, and makes the data available to the host.

Command Phase

7	6	5	4	3	2	1	0
0	MFM	0	0	0	0	1	0
IPS	X	X	X	X	HD	DS1	DS0
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							
End of Track (EOT) Sector Number							
Bytes Between Sectors - Gap 3							
Data Length (Obsolete)							

The command phase bytes of the READ A TRACK command are like those of the READ DATA command, except for the MT and SK bits. Multi-track and skip operations are not allowed in the READ A TRACK command. Therefore, bits 7 and 5 of the opcode command phase byte (MT and SK, respectively) must be 0.

First Command Phase Byte, Opcode

  See "Bit 6 - Modified Frequency Modulation (MFM)" on page 57.

Second Command Phase Byte

  See "Second Command Phase Byte" on page 57 for a description of the Drive Select (DS1,0) and Head Select (HD) bits.
  See "Bit 5 - Implied Seek (IPS)" on page 60 for a description of the Implied Seek (IPS) bit.

Third through Ninth Command Phase Bytes

  See Section 3.7.10 on page 64.

Execution Phase

Data read from the disk drive is transferred to the system in DMA or non-DMA modes. See Section 3.4.2 on page 45.

Execution of this command is like execution of the READ DATA command except for the following differences:

- The controller waits for a pulse from the INDEX signal before it searches for the address field of a sector.
  If the microprocessor writes to the FIFO before the INDEX pulse is detected, the command enters the result phase with the Interrupt Code (IC) bits (bits 7,6) in ST0 set to abnormal termination (01).

- All the ID bytes of the sector address are compared, except the sector number. Instead, the sector number is set to 1, and then incremented for each successive sector read.

- If no match occurs when the ID bytes of the sector address are compared, the controller sets the Missing Data bit (bit 2) in ST1, but continues to read the sector. If there is a CRC error in the address field being read,

the controller sets CRC Error (bit 5) in ST1, but continues to read the sector.

- If there is a CRC error in the data field, the controller sets the CRC Error bit (bit 5) in ST1 and CRC Error in Data Field bit (bit 5) in ST2, but continues reading sectors.

- The controller reads a maximum of End of Track (EOT) physical sectors. There is no support for multi-track reads.

Result Phase

7	6	5	4	3	2	1	0
Result Phase Status Register 0 (ST0)							
Result Phase Status Register 1 (ST1)							
Result Phase Status Register 2 (ST2)							
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							

3.7.14 The RECALIBRATE Command

The RECALIBRATE command issues pulses that make the head of the selected drive step out until it reaches track 0.

Command Phase

7	6	5	4	3	2	1	0
0	0	0	0	0	1	1	1
X	X	X	X	X	HD	DS1	DS0

Second Command Phase Byte

  See "Second Command Phase Byte" on page 57 for a description of the Drive Select (DS1,0) and Head Select (HD) bits.

Execution Phase

After the last command byte is issued, the Drive Busy bit for the selected drive is set in the Main Status Register (MSR). See bits 3-0 in Section 3.3.5 on page 42.

The controller waits the Delay Before Processing time (see TABLE 3-24 on page 74) for the selected drive., and then becomes idle. See Section 3.4.4 on page 47.

Then, the controller issues pulses until the TRK0 disk interface input signal becomes active or until the maximum number of RECALIBRATE step pulses have been issued.

TABLE 3-19 on page 69 shows the maximum number of RECALIBRATE step pulses that may be issued, depending on the RECALIBRATE Step Pulses (R255) bit, bit 0 in the second command phase byte of the MODE command (page 60), and the Extended Track Range (ETR) bit, bit 4 of the third command byte of the MODE command (see Section 3.7.7 on page 60).

If the number of tracks on the disk drive exceeds the maximum number of RECALIBRATE step pulses, it may be necessary to issue another RECALIBRATE command.

TABLE 3-19. Maximum RECALIBRATE Step Pulses for Values of R255 and ETR

R255	ETR	Maximum Number of RECALIBRATE Step Pulses
0	0	85 (default)
1	0	255
0	1	3925
1	1	4095

The pulses actually occur while the controller is in the drive polling phase. See Section 3.4.5 on page 48.

An interrupt is generated after the $\overline{\text{TRK0}}$ signal is asserted, or after the maximum number of RECALIBRATE step pulses is issued.

Software should ensure that the RECALIBRATE command is issued for only one drive at a time. This is because the drives are actually selected via the Digital Output Register (DOR), which can only select one drive at a time.

No command, except a SENSE INTERRUPT command, should be issued while a RECALIBRATE command is in progress.

Result Phase

None.

3.7.15   The RELATIVE SEEK Command

The RELATIVE SEEK command issues $\overline{\text{STEP}}$ pulses that make the head of the selected drive step in or out a programmable number of tracks.

Command Phase

7	6	5	4	3	2	1	0
1	DIR	0	0	1	1	1	1
X	X	X	X	X	HD	DS1	DS0
Relative Track Number (RTN)							

First Command Phase Byte, Opcode, Bit - 6 Step Direction DIR

This bit defines the step direction.

0: Step head out.

1: Step head in.

Second Command Phase Byte

See "Second Command Phase Byte" on page 57 for a description of the Drive Select (DS1,0) and Head Select (HD) bits.

Third Command Phase Byte - Relative Track Number (RTN)

This value specifies how many tracks the head should step in or out from the current track.

Execution Phase

After the last command byte is issued, the Drive Busy bit for the selected drive is set in the Main Status Register (MSR). See bits 3-0 in Section 3.3.5 on page 42.

The controller waits the Delay Before Processing time (see TABLE 3-24 on page 74) for the selected drive., and then becomes idle. See Section 3.4.4 on page 47.

Then, the controller enters the idle phase and issues RTN $\overline{\text{STEP}}$ pulses until the $\overline{\text{TRK0}}$ disk interface input signal becomes active or until the specified number (RTN) of $\overline{\text{STEP}}$ pulses have been issued. After the RELATIVE SEEK operation is complete, the controller generates an interrupt.

Software should ensure that the RELATIVE SEEK command is issued for only one drive at a time. This is because the drives are actually selected via the Digital Output Register (DOR), which can only select one drive at a time.

No command, except the SENSE INTERRUPT command, should be issued while a RELATIVE SEEK command is in progress.

Result Phase

None.

3.7.16   The SCAN EQUAL, the SCAN LOW OR EQUAL and the SCAN HIGH OR EQUAL Commands

The scan commands compare data read from the disk with data sent from the microprocessor. This comparison produces a match for each scan command, as follows, and as shown in TABLE 3-20 on page 70:

- SCAN EQUAL - Disk data equals microprocessor data.

- SCAN LOW OR EQUAL - Disk data is less than or equal to microprocessor data.

- SCAN HIGH OR EQUAL - Disk data is greater than or equal to microprocessor data.

Command Phase

SCAN EQUAL

7	6	5	4	3	2	1	0
MT	MFM	SK	1	0	0	0	1
IPS	X	X	X	X	HD	DS1	DS0
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							
End of Track (EOT) Sector Number							
Bytes Between Sectors - Gap 3							
Sector Step Size							

SCAN LOW OR EQUAL

7	6	5	4	3	2	1	0
MT	MFM	SK	1	1	0	0	1
IPS	X	X	X	X	HD	DS1	DS0
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							
End of Track (EOT) Sector Number							
Bytes Between Sectors - Gap 3							
Sector Step Size							

SCAN HIGH OR EQUAL

7	6	5	4	3	2	1	0
MT	MFM	SK	1	1	1	0	1
IPS	X	X	X	X	HD	DS1	DS0
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							
End of Track (EOT) Sector Number							
Bytes Between Sectors - Gap 3							
Sector Step Size							

First through Eighth Command Phase Bytes -
All Scan Commands

See READ DATA command for a description of the first eight command phase bytes.

Ninth Command Phase Byte, Sector Step Size

During execution, the value of this byte is added to the current sector number to determine the next sector to read.

Execution Phase

The most significant bytes of each sector are compared first. If wildcard mode is enabled in bit 4 of the fourth command phase byte in the MODE command ("Bit 4 - Scan Wild Card (WLD)" on page 61), a value of FFh from either the disk or the microprocessor always causes a match.

After each sector is read, if there is no match, the next sector is read. The next sector is the current sector number plus the Sector Step Size specified in the ninth command phase byte.

The scan operation continues until the condition is met, the End of Track (EOT) is reached or the Terminal Count (TC) signal becomes active.

Read error conditions during scan commands are the same as read error conditions during the execution phase of the READ DATA command. See Section 3.7.10 on page 64.

If the Skip Control (SK) bit is set to 1, sectors with deleted data marks are ignored.

If all sectors read are skipped, the command terminates with bit 3 of ST2 set to 1, i.e., disk data equals microprocessor data.

Result Phase

7	6	5	4	3	2	1	0
Result Phase Status Register 0 (ST0)							
Result Phase Status Register 1 (ST1)							
Result Phase Status Register 2 (ST2)							
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							

TABLE 3-20 shows how all the scan commands affect bits 3,2 of the Status 2 (ST2) result phase register. See Section 3.5.3 on page 49.

TABLE 3-20. The Effect of Scan Commands on the ST2 Register

Command	Result Phase Status Register 2 (ST2)		Condition
	Bit 3 - Scan Satisfied	Bit 2 - Scan Not Satisfied	
SCAN EQUAL	1 0	0 1	Disk = μP Disk $\neq$ μP
SCAN LOW OR EQUAL	1 0 0	0 0 1	Disk = μP Disk < μP Disk > μP
SCAN HIGH OR EQUAL	1 0 0	0 0 1	Disk = μP Disk > μP Disk < μP

3.7.17   The SEEK Command

The SEEK command issues pulses of the $\overline{\text{STEP}}$ signal to the selected drive, to move it in or out until the desired track number is reached.

Software should ensure that the SEEK command is issued for only one drive at a time. This is because the drives are actually selected via the Digital Output Register (DOR), which can only select one drive at a time. See Section 3.3.3 on page 39.

No command, except a SENSE INTERRUPT command, should be issued while a SEEK command is in progress.

Command Phase

7	6	5	4	3	2	1	0
0	0	0	0	1	1	1	1
X	X	X	X	X	HD	DS1	DS0

| Number of Track to Seek | | | | | | | |

| MSN of Track # to Seek | | | | | | | |

When bit 2 of the second command phase byte (ETR) in the MODE command is set to 1, the track number is stored as a 12-bit value. See "Bit 0 - Extended Track Range (ETR)" on page 60.

In this case, a fourth command byte should be written in the command phase to hold the Most Significant Nibble (MSN), i.e., the four most significant bits, of the number of the track to seek. Otherwise (ETR bit in MODE is 0), this command phase byte is not required. and, only three command bytes should be written.

After the last command byte is issued, the Drive Busy bit for the selected drive is set in the Main Status Register (MSR). See bits 3-0 in Section 3.3.5 on page 42.

The controller waits the Delay Before Processing time (see TABLE 3-24 on page 74) for the selected drive, before issuing the first $\overline{\text{STEP}}$ pulse. After waiting the Delay Before Processing time, the controller becomes idle. See Section 3.4.4 on page 47.

Second Command Phase Byte

    See READ DATA command for a description of these bits.

Third Command Phase Byte, Number of Track to Seek

    The value in this byte is the number of the track to seek.

Fourth Command Phase Byte,
Bits 7-4 - MSN of Track Number

    If the track number is stored as a 12-bit value, these bits contain the Most Significant Nibble (MSN), i.e., the four most significant bits, of the number of the track to seek.

    Otherwise (the ETR bit in the MODE command is 0), this command phase byte is not required.

Execution Phase

During the execution phase of the SEEK command, the track number to seek to is compared with the present track number. The controller determines how many $\overline{\text{STEP}}$ pulses to issue and the $\overline{\text{DIR}}$ disk interface output signal indicates which direction the head should move.

The SEEK command issues step pulses while the controller is in the drive polling phase. The step pulse rate is determined by the value programmed in the second command phase byte of the SPECIFY command.

An interrupt is generated one step pulse period after the last step pulse is issued. A SENSE INTERRUPT command should be issued to determine the cause of the interrupt.

Result Phase

    None.

3.7.18 The SENSE DRIVE STATUS Command

The SENSE DRIVE STATUS command indicates which drive and which head are selected, whether or not the head is at track 0 and whether or not the track is write protected in result phase Status register 3 (ST3). See Section 3.5.4 on page 50.

This command does not generate an interrupt.

Command Phase

7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0
X	X	X	X	X	HD	DS1	DS0

See READ DATA command for a description of these bits.

Execution Phase

Disk drive status information is detected and reported.

Result Phase

7	6	5	4	3	2	1	0
Result Phase Status Register 3 (ST3)							

See Section 3.5.4 on page 50.

3.7.19 The SENSE INTERRUPT Command

The SENSE INTERRUPT command returns the cause of an interrupt that is caused by the change in status of any disk drive.

If a SENSE INTERRUPT command is issued when no interrupt is pending it is treated as an invalid command.

When to Issue SENSE INTERRUPT

The SENSE INTERRUPT command is issued to detect either of the following causes of an interrupt:

- The FDC became ready during the drive polling phase for an internally selected drive. See Section 3.4.5 on page 48. This can occur only after a hardware or software reset.

- A SEEK, RELATIVE SEEK or RECALIBRATE command terminated.

Interrupts caused by these conditions are cleared after the first result byte has been read. Use the Interrupt Code (IC) (bits 7,6) and SEEK End bits (bit 5) of result phase Status register 0 (ST0) to identify the cause of these interrupts. See "Bit 5 - SEEK End" on page 48 and TABLE 3-21 on page 72.

TABLE 3-21. Interrupt Causes Reported by SENSE INTERRUPT

Bits of ST0			Interrupt Cause
7	6	5	
1	1	0	FDC became ready during drive polling mode. SEEK, RELATIVE SEEK or RECALIBRATE not completed.
0	0	1	SEEK, RELATIVE SEEK or RECALIBRATE terminated normally.
0	1	1	SEEK, RELATIVE SEEK or RELCALIBRATE terminated abnormally.

When SENSE INTERRUPT is not Necessary

Interrupts that occur during most command operations do not need to be identified by the SENSE INTERRUPT. The microprocessor can identify them by checking the Request for Master (RQM) bit (bit 7) of the Main Status Register (MSR). See "Bit 7 - Request for Master (RQM)" on page 42.

It is not necessary to issue a SENSE INTERRUPT command to detect the following causes of Interrupts:

- The result phase of any of the following commands started:
  — READ DATA, READ DELETED DATA, READ A TRACK, READ ID
  — WRITE DATA, WRITE DELETED
  — FORMAT TRACK
  — SCAN EQUAL, SCAN EQUAL OR LOW, SCAN EQUAL OR HIGH
  — VERIFY

- Data is being transferred in non-DMA mode, during the execution phase of some command.

Interrupts caused by these conditions are cleared automatically, or by reading or writing information from or to the Data Register (FIFO).

Command Phase

7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	0

Execution Phase

Status of interrupt is reported.

Result Phase.

7	6	5	4	3	2	1	0
Result Phase Status Register 0 (ST0)							
Byte of Present Track Number (PTR)							
MSN of PTR							

When bit 2 of the second command phase byte (ETR) in the MODE command is set to 1, the track number is stored as a 12-bit value. See "Bit 0 - Extended Track Range (ETR)" on page 60.

In this case, a third result byte should be read to hold the Most Significant Nibble (MSN), i.e., the four most significant bits, of the number of the current track.

Otherwise (ETR bit in MODE is 0), this command phase byte is not required. and, only two result phase bytes should be read First Command Phase Byte, Result Phase Status Register 0

See Section 3.5.1 on page 48.

Second Command Phase Byte,
Present Track Number (PTR)

The value in this byte is the number of the current track.

Fourth Command Phase Byte,
Bits 7-4 - MSN of Track Number

If the track number is stored as a 12-bit value, these bits contain the Most Significant Nibble (MSN), i.e., the four most significant bits, of the number of the track to seek.

Otherwise (the ETR bit in the MODE command is 0), this result phase byte is not required.

3.7.20 The SET TRACK Command

This command is used to verify (read) or change (write) the number of the present track.

This command could be useful for recovery from disk tracking errors, where the true track number could be read from the disk using the READ ID command, and used as input to the SET TRACK command to correct the Present Track number (PTR) stored internally.

Terminating this command does not generate an interrupt

Command Phase

7	6	5	4	3	2	1	0
0	WNR	1	0	0	0	0	1
0	0	1	1	0	MSB	DS1	DS0
Byte of Present Track Number (PTR)							

When bit 2 of the second command phase byte (ETR) in the MODE command is set to 1, the track number is stored as a 12-bit value. See "Bit 0 - Extended Track Range (ETR)" on page 60.

In this case, issue SET TRACK twice - once for the Most Significant Byte (MSB) of the number of the current track and once for the Least Significant Byte (LSB).

Otherwise (ETR bit in MODE is 0), issue SET TRACK only once, with bit 2 (MSB) of the second command phase byte set to 0.

First Command Phase Byte, Bit 6 - Write Track Number (WNR)

0: Read the existing track number.

The result phase byte already contains the track number, and the third byte in the command phase is a dummy byte.

1: Change the track number by writing a new value to the result phase byte.

Second Command Phase Byte

Bits 1,0 - Logical Drive Select (DS1,0)

These bits indicate which logical drive is active. See "Bits 1,0 - Logical Drive Select (DS1,0)" on page 57.

00: Drive 0 is selected.

01: Drive 1 is selected.

10: If four drives are supported, or drives 2 and 0 are exchanged, drive 2 is selected.

11: If four drives are supported, drive 3 is selected.

Bit 2 - Most Significant Byte (MSB)

This bit, together with bits 1,0, determines the byte to read or write. See TABLE 3-22 on page 73.

0: Least significant byte of the track number.

1: Most significant byte of the track number.

TABLE 3-22. Defining Bytes to Read or Write Using SET TRACK

MSB	DS1	DS0	Byte to Read or Write
2	1	0	
0	0	0	Drive 0 (LSB)
1	0	0	Drive 0 (MSB)
0	0	1	Drive 1 (LSB)
1	0	1	Drive 1 (MSB)
0	1	0	Drive 2 (LSB)
1	1	0	Drive 2 (MSB)
0	1	1	Drive 3 (LSB)
1	1	1	Drive 3 (MSB)

Execution Phase

Internal register is read or written.

Result Phase

7	6	5	4	3	2	1	0
Byte of Present Track Number(PTR)							

This byte is one byte of the track number that was read or written, depending on the value of WNR in the first command byte.

3.7.21 The SPECIFY Command

The SPECIFY command sets initial values for the following time periods:

- The delay before command processing starts, formerly called Motor On Time (MNT)

- The delay after command processing terminates, formerly called Motor Off Time (MFT)

- The interval step rate time.

The FDC uses the Digital Output Register (DOR) to enable the drive and motor select signals. See Section 3.3.3 on page 39.

The delays may be used to support the μPD765, i.e., to insert delays from selection of a drive motor until a read or write operation starts, and from termination of a command until the drive motor is no longer selected, respectively.

The parameters used by this command are undefined after power up, and are unaffected by any reset. Therefore, software should always issue a SPECIFY command as part of an initialization routine to initialize these parameters.

Terminating this command does not generate an interrupt.

Command Phase.

7	6	5	4	3	2	1	0
0	0	0	0	0	0	1	1
Step Rate Time (SRT)				Delay After Processing			
Delay Before Processing							DMA

Second Command Phase Byte

Bits 3-0 - Delay After Processing Factor

These bits specify a factor that is multiplied by a constant to determine the delay after command processing ends, i.e., from termination of a command until the drive motor is no longer selected.

The value of the Motor Timer Values (TMR) bit (bit 7) of the second command phase byte in the MODE command determines which group of constants and delay ranges to use. See "Bit 7 - Motor Timer Values (TMR)" on page 60.

The specific constant that will be multiplied by this factor to determine the actual delay after processing for each data transfer rate is shown in TABLE 3-23 on page 74.

Use the smallest possible value for this factor, except 0, i.e., 1. If this factor is 0, the value 16 is used.

Bits 7-4 - $\overline{\text{STEP}}$ Time Interval Value (SRT)

These bits specify a value that is used to calculate the time interval between successive $\overline{\text{STEP}}$ signal pulses during a SEEK, IMPLIED SEEK, RECALIBRATE, or RELATIVE SEEK command.

TABLE 3-25 on page 74 shows how this value is used to calculate the actual time interval.

TABLE 3-23. Constant Multipliers for Delay After Processing Factor and Delay Ranges

Data Transfer Rate (bps)	Bit 7 of MODE (TMR) = 0		Bit 7 of MODE (TMR) = 1	
	Constant Multiplier	Permitted Range (msec)	Constant Multiplier	Permitted Range (msec)
1 M	8	8 -128	512	512 - 8192
500 K	16	16 - 256	512	512 - 8192
300 K	80 / 3	26.7 - 427	2560 / 3	853 - 13653
250 K	32	32 - 512	1024	1024 -16384

TABLE 3-24. Constant Multipliers for Delay Before Processing Factor and Delay Ranges

Data Transfer Rate (bps)	Bit 7 of MODE (TMR) = 0		Bit 7 of MODE (TMR) = 1	
	Constant Multiplier	Permitted Range (msec)	Constant Multiplier	Permitted Range (msec)
1 M	1	1 -128	32	32 - 4096
500 K	1	1 -128	32	32 - 4096
300 K	10 / 3	3.3 - 427	160 / 3	53 - 6827
250 K	4	4 - 512	64	64 - 8192

TABLE 3-25. $\overline{\text{STEP}}$ Time Interval Calculation

Data Transfer Rate (bps)	Calculation of Time Interval	Permitted Range (msec)
1 M	(16 − SRT) / 2	0.5 - 8
500 K	(16 − SRT)	1 - 16
300 K	(16 − SRT) x 1.67	1.67 - 26.7
250 K	(16 − SRT) x 2	2 - 32

Third Command Phase Byte

Bit 0 - DMA

This bit selects the data transfer mode in the execution phase of a read, write, or scan operation.

Data can be transferred between the microprocessor and the controller during execution in DMA mode or in non-DMA mode, i.e., interrupt transfer mode or software polling mode.

See Section 3.4.2 on page 45 for a description of these modes.

0: DMA mode is selected.

1: Non-DMA mode is selected.

Bits 3-0 - Delay Before Processing Factor

These bits specify a factor that is multiplied by a constant to determine the delay before command processing starts, i.e., from selection of a drive motor until a read or write operation starts.

The value of the Motor Timer Values (TMR) bit (bit 7) of the second command phase byte in the MODE command determines which group of constants and delay ranges to use. See "Bit 7 - Motor Timer Values (TMR)" on page 60.

The specific constant that will be multiplied by this factor to determine the actual delay before processing for each data transfer rate is shown in TABLE 3-24 on page 74.

Use the smallest possible value for this factor, except 0, i.e., 1. If this factor is 0, the value128 is used.

Execution Phase

Internal registers are written.

Result Phase

None.

3.7.22 The VERIFY Command

The VERIFY command verifies the contents of data and/or address fields after they have been formatted or written.

VERIFY reads logical sectors containing a normal data Address Mark (AM) from the selected drive, without transferring the data to the host.

The TC signal cannot terminate this command since no data is transferred. Instead, VERIFY simulates a TC signal by setting the Enable Count (EC) bit to1. In this case, VERIFY terminates when the number of sectors read equals the number of sectors to read, i.e., Sectors to read Count (SC). If SC = 0 then 256 sectors will be verified.

When EC is 0, VERIFY ends when the End of the Track (EOT) sector number equals the number of the sector checked. In this case, the ninth command phase byte is not needed and should be set to FFh.

TABLE 3-26 on page 75 shows how different values for the VERIFY parameters affect termination.

Command Phase

7	6	5	4	3	2	1	0
MT	MFM	SK	1	0	1	1	0
EC	X	X	X	X	HD	DS1	DS0
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							

7	6	5	4	3	2	1	0
End of Track (EOT) Sector Number							
Bytes Between Sectors - Gap 3							
Sectors to read Count (SC)							

First Command Phase Byte

See Section 3.7.10 on page 64 for a description of these bits.

Second Command Phase Byte

Bits 2-0 - Drive Select (DS1,0) and Head (HD) Select

See the description of the Drive Select bits (DS1,0) and the Head (HD) in Section 3.7.10 on page 64.

Bit 7 - Enable Count Control (EC)

This bit controls whether the End of Track sector number or the Sectors to read Count (SC) triggers termination of the VERIFY command.

See also TABLE 3-26 on page 75.

0: Terminate VERIFY when the number of last sector read equals the End of Track (EOT) sector number.

The ninth command phase byte (Sectors to read Count, SC), is not needed and should be set to FFh.

1: Terminate VERIFY when number of sectors read equals the number of sectors to read, i.e., Sectors to read Count (SC).

Third through Eighth Command Phase Bytes

See Section 3.7.10 on page 64.

Always set the End of Track (EOT) sector number to the number of the last sector to be checked on each side of the disk. If EOT is greater than the number of sectors per side, the command terminates with an error and no useful Address Mark (AM) or CRC data is returned.

Ninth Command Phase Byte, Sectors to Read Count (SC)

This byte specifies the number of sectors to read. If the Enable Count (EC) control bit (bit 7) of the second command byte is 0, this byte is not needed and should be set to the value FFh.

Execution Phase

Data is read from the disk, as the controller checks for valid address marks in the address and data fields.

This command is identical to the READ DATA command, except that it does not transfer data during the execution phase. See Section 3.7.10 on page 64.

If the Multi-Track (MT) parameter is 1 and SC is greater than the number of remaining formatted sectors on side 0, verification continues on side 1 of the disk.

Result Phase

7	6	5	4	3	2	1	0
Result Phase Status Register 0 (ST0)							
Result Phase Status Register 1 (ST1)							
Result Phase Status Register 2 (ST2)							
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							

TABLE 3-26 on page 75 shows how different conditions affect the termination status.

TABLE 3-26. VERIFY Command Termination Conditions

MT	EC	Sector Count (SC) or End of Track (EOT) Value	Termination Status
0	0	SC should be FFh EOT ≤ Sectors per Side[1]	No Errors
		SC should be FFh EOT > Sectors per Side	Abnormal Termination
0	1	SC ≤ Sectors per Side and SC ≤ EOT	No Errors
		SC > Sectors Remaining[2] or SC > EOT	Abnormal Termination
1	0	SC should be FFh EOT ≤ Sectors per Side	No Errors
		SC should be FFh EOT > Sectors per Side	Abnormal Termination
1	1	SC ≤ Sectors per Side and SC ≤ EOT	No Errors
		SC ≤ (EOT x 2) and EOT ≤ Sectors per Side	No Errors
		SC > (EOT x 2)	Abnormal Termination

1. Number of formatted sectors per side of the disk.
2. Number of formatted sectors left which can be read, including side 1 of the disk, if MT is 1.

3.7.23   The VERSION Command

The VERSION command returns the version number of the current Floppy Disk Controller (FDC).

Command Phase

Execution Phase

None.

Result Phase

The result phase byte returns a value of 90h for an FDC that is compatible with the 82077.

Other controllers, i.e., the DP8473 and other NEC765 compatible controllers, return a value of 80h (invalid command).

3.7.24   The WRITE DATA Command

The WRITE DATA command receives data from the host and writes logical sectors containing a normal data Address Mark (AM) to the selected drive.

This command is like the READ DATA command, except that the data is transferred from the microprocessor to the controller instead of the other way around.

Command Phase

7	6	5	4	3	2	1	0
MT	MFM	0	0	0	1	0	1
IPS	X	X	X	X	HD	DS1	DS0
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							
End of Track (EOT) Sector Number							
Bytes Between Sectors - Gap 3							
Data Length (Obsolete)							

See Section 3.7.10 on page 64 for a description of these bytes.

The controller waits the Delay Before Processing time before starting execution.

If implied seeks are enabled, i.e., IPS in the second command phase byte is 1, the operations performed by SEEK and SENSE INTERRUPT commands are performed (without these commands being issued).

Execution Phase

Data is transferred from the system to the controller via DMA or non-DMA modes and written to the disk.See Section 3.4.2 on page 45 for a description of these data transfer modes.

The controller starts the data separator and waits for it to find the address field of the next sector. The controller compares the address ID (track number, head number, sector number, bytes-per-sector code) with the ID specified in the command phase.

If there is no match, the controller waits to find the next sector address field. This process continues until the desired sector is found. If an error condition occurs, the Interrupt Control (IC) bits (bits 7,6) in ST0 are set to abnormal termination, and the controller enters the result phase. See "Bits 7,6 - Interrupt Code (IC)" on page 48.

Possible errors are:

- The microprocessor aborted the command by writing to the FIFO.

  If there is no disk in the drive, the controller gets stuck. The microprocessor must then write a byte to the FIFO to advance the controller to the result phase.

- Two pulses of the INDEX signal were detected since the search began, and no valid ID was found.

  If the track address differs, either the Wrong Track bit (bit 4) or the Bad Track bit (bit 1) (if the track address is FFh is set in result phase Status register 2 (ST2). See Section 3.5.3 on page 49.

  If the head number, sector number or bytes-per-sector code did not match, the Missing Data bit (bit 2) is set in result phase Status register 1 (ST1).

  If the Address Mark (AM) is not found, the Missing Address Mark bit (bit 0) is set in ST1.

  Section 3.5.2 on page 49 describes the bits of ST1.

- A CRC error was detected in the address field. In this case the CRC Error bit (bit 5) is set in ST1.

- The controller detected an active the Write Protect (WP) disk interface input signal, and set bit 1 of ST1 to 1.

If the correct address field is found, the controller waits for all (conventional drive mode) or part (perpendicular drive mode) of gap 2 to pass. See FIGURE 3-5 on page 59. The controller then writes the preamble field, Address Marks (AM) and data bytes to the data field. The microprocessor transfers the data bytes to the controller.

After writing the sector, the controller reads the next logical sector, unless one or more of the following termination conditions occurs:

- The DMA controller asserted the Terminal Count (TC) signal to indicate that the operation terminated. The Interrupt Code (IC) bits (bits 7,6) in ST0 are set to normal termination (00). See "Bits 7,6 - Interrupt Code (IC)" on page 48.

- The last sector address (of side 1, if the Multi-Track enable bit (MT) was set to 1) was equal to the End of Track sector number. The End of Track bit (bit 7) in ST1 is set. The IC bits in ST0 are set to abnormal termination (01). This is the expected condition during non-DMA transfers.

- Overrun error. The Overrun bit (bit 4) in ST1 is set. The Interrupt Code (IC) bits (bits 7,6) in ST0 are set to abnormal termination (01). If the microprocessor cannot service a transfer request in time, the last correctly written byte is written to the disk.

If the Multi-Track (MT) bit was set in the opcode command byte, and the last sector of side 0 has been transferred, the controller continues with side 1.

Result Phase

7	6	5	4	3	2	1	0
Result Phase Status Register 0 (ST0)							
Result Phase Status Register 1 (ST1)							
Result Phase Status Register 2 (ST2)							
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							

Upon terminating the execution phase of the WRITE DATA command, the controller asserts IRQ6, indicating the beginning of the result phase. The microprocessor must then read the result bytes from the FIFO.

The values that are read back in the result bytes are shown in TABLE 3-17 on page 66. If an error occurs, the result bytes indicate the sector read when the error occurred.

3.7.25 The WRITE DELETED DATA Command

The WRITE DELETED DATA command receives data from the host and writes logical sectors containing a deleted data Address Mark (AM) to the selected drive.

This command is identical to the WRITE DATA command, except that a deleted data AM, instead of a normal data AM, is written to the data field.

Command Phase

7	6	5	4	3	2	1	0
MT	MFM	0	0	1	0	0	1
IPS	X	X	X	X	HD	DS1	DS0
Track Number							
Head Number							
Sector Number							
Bytes-Per-Sector Code							
End of Track (EOT) Sector Number							
Bytes Between Sectors - Gap 3							
Data Length (Obsolete)							

See Section 3.7.10 on page 64 and Section 3.7.24 on page 76 for a description of these bytes.

Execution Phase

Data is transferred from the system to the controller in DMA or non-DMA modes, and written to the disk. See Section 3.4.2 on page 45 for a description of these data transfer modes.

3.8   EXAMPLE OF A FOUR-DRIVE CIRCUIT USING THE PC87309

Figure 3-6 shows one implementation of a four-drive circuit. Refer to TABLE 3-2 on page 39 to see how to encode the drive and motor bits for this configuration.

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G1	1Y0 — ▷ — Decoded Signal for Drive 0
A1	1Y1 — ▷ — Decoded Signal for Drive 1
B1	1Y2 — ▷ — Decoded Signal for Drive 2
	1Y3 — ▷ — Decoded Signal for Drive 3
	2Y0 — ▷ — Decoded Signal for Motor 0
G2	2Y1 — ▷ — Decoded Signal for Motor 1
A2	2Y2 — ▷ — Decoded Signal for Motor 2
B2	2Y3 — ▷ — Decoded Signal for Motor 3

PC87309

DR0

DR1

MTR0

Hex Buffers
ICC = 40 mA
Open Collector
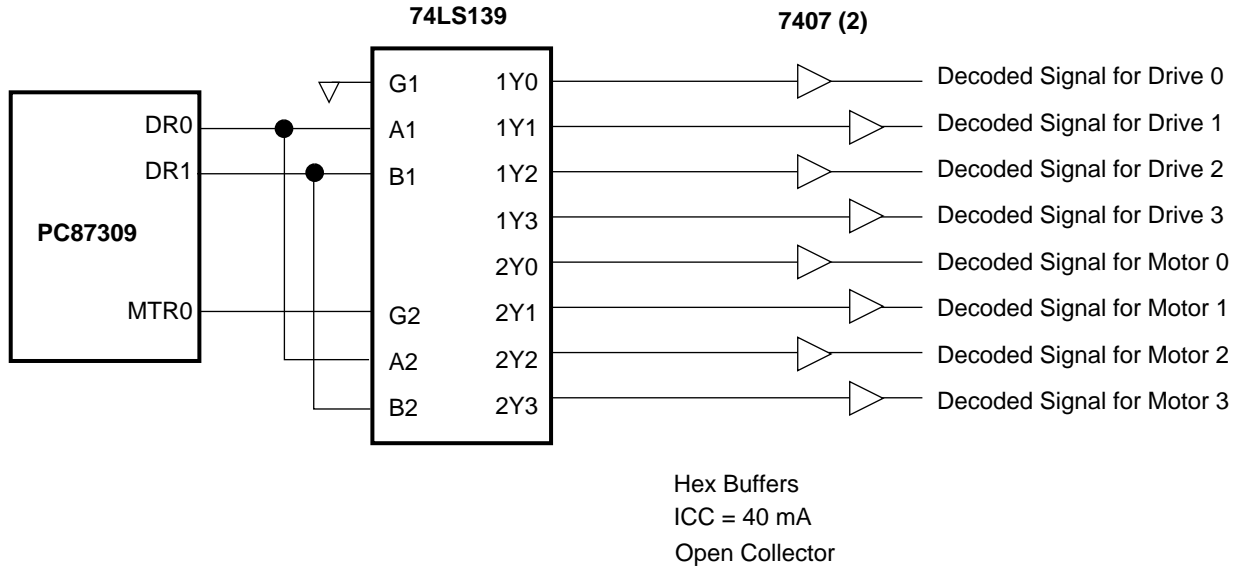
FIGURE 3-6. PC87309 Four Floppy Disk Drive Circuit

4.0   Parallel Port (Logical Device 1)

The Parallel Port is a communications device that transfers parallel data between the system and an external device. Originally designed to output data to an external printer, the use of this port has grown to include bidirectional communications, increased data rates and additional applications (such as network adaptors).

4.1   PARALLEL PORT CONFIGURATION

The PC87309 Parallel Port device offers a wide range of operational configurations. It utilizes the most advanced protocols in current use, while maintaining full backward compatability to support existing hardware and software. It supports two Standard Parallel Port (SPP) modes of operation for parallel printer ports (as found in the IBM PC-AT, PS/2 and Centronics systems), two Enhanced Parallel Port (EPP) modes of operation, and one Extended Capabilities Port (ECP) mode. This versatility is achieved by user software control of the mode in which the device functions.

The IEEE 1284 standard establishes a widely accepted handshake and transfer protocol that ensures transfer data integrity. This parallel interface fully supports the IEEE 1284 standard of parallel communications, in both Legacy and Plug and Play configurations, in all modes except the EPP revision 1.7 mode described in the next section.

4.1.1   Parallel Port Operation Modes

The PC87309 parallel port supports Standard Parallel Port (SPP), Enhanced Parallel Port (EPP) and Extended Capabilities Port (ECP) configurations.

- In the Standard Parallel Port (SPP) configuration, data rates of several hundred bytes per second are achieved. This configuration supports the following operation modes:
  — In SPP Compatible mode the port is write-only (for data). Data transfers are software-controlled and are accompanied by status and control handshake signals.
  — PP FIFO mode enhances SPP Compatible mode by the addition of an output data FIFO, and operation as a state-machine operation instead of software-controlled operation.
  — In SPP Extended mode, the parallel port becomes a read/write port, that can transfer a full data byte in either direction.

- The Enhanced Parallel Port (EPP) configuration supports two modes that offer higher bi-directional throughput and more efficient hardware-based handling.
  — The EPP revision 1.7 mode lacks a comprehensive handshaking scheme to ensure data transfer integrity between communicating devices with dissimilar data rates. This is the only mode that does not meet the requirements of the IEEE 1284 standard handshake and transfer protocol.
  — EPP revision 1.9 mode offers data transfer enhancement, while meeting the IEEE 1284 standard.

- The Extended Capabilities Port (ECP) configuration extends the port capabilities beyond EPP modes by adding a bi-directional 16-level FIFO with threshold interrupts, for PIO and DMA data transfer, including demand DMA operation. In this mode, the device becomes a hardware state-machine with highly efficient data transfer control by hardware in real-time.

The PC87309 enters ECP mode by default after reset.

The ECP configuration supports several modes that are determined by bits 7-5 of the ECP Extended Control Register (ECR) at offset 402h. Section 4.6 "DETAILED ECP MODE DESCRIPTIONS" on page 95 describes these modes in detail. The ECR register is described in Section 4.5.12 "Extended Control Register (ECR)" on page 91.

4.1.2   Configuring Operation Modes

The operation mode of the parallel port is determined by configuration bits that are controlled by software. If ECP mode is set upon initial system configuration, the operation mode may also be changed during run-time.

- **Configuration at System Initialization (Static)** - The parallel port operation mode is determined at initial system configuration by bits 7-5 of the SuperI/O Parallel Port Configuration register at index F0h

- **Configuration at System Initialization with Run-Time Reconfiguration (Dynamic)** - When ECP mode is selected as the static all other operational modes may be run from this state. In this case the operation mode is determined by bits 7-5 of the parallel port Extended Control register (ECR) at parallel port base address + 402h and by bits 7 and 4 of the Control2 register at second level offset 2. These registers are accessed via the internal ECP Mode Index and Data registers at parallel port base address + 403 and parallel port base address + 404h, respectively.

TABLE 4-1 "Parallel Port Mode Selection" on page 80 shows how to configure the parallel port for the different operation modes.

TABLE 2-3 "Parallel Port Address Range Allocation" on page 21 shows how to allocate a range for the base address of the parallel port for each mode. Parallel port address decoding is described in Section 2.2.2 "Address Decoding" on page 20.

The parallel port supports Plug and Play operation. Its interrupt can be routed on one of the following ISA interrupts: IRQ1 to IRQ15 except for IRQ 2 and 13. Its DMA signals can be routed to one of three 8-bit ISA DMA channels. See Section 4.5.19 "PP Confg0 Register" on page 94.

The parallel port device is activated by setting bit 4 of the system Function Enable Register 1 (FER1) to 1. See Section 7.2.3 "Function Enable Register 1 (FER1)" on page 155.

4.1.3   Output Pin Protection

The parallel port output pins are protected against potential damage from connecting an unpowered port to a powered-up printer.

4.2   STANDARD PARALLEL PORT (SPP) MODES

Compatible SPP mode is a data write-only mode that outputs data to a parallel printer, using handshake bits, under software control.

In SPP Extended mode, parallel data transfer is bi-directional. TABLE 4-12 "Parallel Port Pin Out" on page 101 lists the output signals for the standard 25-pin, D-type connector. TABLE 4-2 "Parallel Port Reset States" on page 80 lists the reset states for handshake output pins in this mode.

STANDARD PARALLEL PORT (SPP) MODES

TABLE 4-1. Parallel Port Mode Selection

Configuration Time	Operation Mode	SuperI/O Parallel Port Configuration Register (Index F0h)[1]			Extended Control Register (ECR) of the Parallel Port (Offset 402h) [2]			Control2 Register of the Parallel Port (Offset 02h) [3]	Notes
		7	6	5	7	6	5	4	
Configuration at System Initialization (Static)	SPP Compatible	0	0	0	-			-	-
	SPP Extended	0	0	1	-			-	-
	EPP Revision 1.7	0	1	0	-			-	-
	EPP Revision 1.9	0	1	1	-			-	-
Configuration at System Initialization with Run-Time Reconfiguration (Dynamic)	SPP Compatible	1 0 0 or 1 1 1			0	0	0	-	4
	PP FIFO				0	1	0	-	4
	SPP Extended				0	0	1	-	4
	EPP Revision 1.7	1 1 1			1 0 0			0	4
	EPP Revision 1.9							1	4
	ECP(Default)	1 0 0 or 1 1 1			0	1	1	-	-

1. Section 2.6 "SUPERI/O PARALLEL PORT CONFIGURATION REGISTER (LOGICAL DEVICE 1)" on page 30 describes the bits of the SuperI/O Parallel Port configuration register.
2. See Section 4.5.12 "Extended Control Register (ECR)" on page 91
3. Before modifying this bit, set bit 4 of the SuperI/O Parallel Port configuration register at index F0h to 1.
4. Use bit 7 of the Control2 register at second level offset 2 of the parallel port to further specify compatibility. See Section 4.5.17 "Control2 Register" on page 93.

TABLE 4-2. Parallel Port Reset States

Signal	Reset Control	State After Reset
SLIN	MR	TRI-STATE
INIT	MR	Zero
$\overline{AFD}$	MR	TRI-STATE
STB	MR	TRI-STATE
IRQ5,7	MR	TRI-STATE

4.2.1 SPP Modes Register Set

In all Standard Parallel Port (SPP) modes, port operation is controlled by the registers listed in TABLE 4-3 "Standard Parallel Port (SPP) Registers".

All register bit assignments are compatible with the assignments in existing SPP devices.

A single Data Register DTR is used for data input and output (see Section 4.2.2 "SPP Data Register (DTR)"). The direction of data flow is determined by the system setting in bit 5 of the Control Register CTR.

TABLE 4-3. Standard Parallel Port (SPP) Registers

Offset	Name	Description	R/W
00h	DTR	Data	R/W
01h	STR	Status	R
02h	CTR	Control	R/W
03h		-	TRI-STATE

4.2.2 SPP Data Register (DTR)

This bidirectional data port transfers 8-bit data in the direction determined by bit 5 of SPP register CTR at offset 02h and mode.

The read or write operation is activated by the system $\overline{RD}$ and $\overline{WR}$ strobes.

TABLE 4-4 "SPP DTR Register Read and Write Modes" tabulates DTR register operation.

TABLE 4-4. SPP DTR Register Read and Write Modes

Mode	Bit 5 of CTR	$\overline{RD}$	$\overline{WR}$	Result
SPP Compatible	x	1	0	Data written to PD7-0.
	x	0	1	Data read from the output latch
SPP Extended	0	1	0	Data written to PD7-0.
	1	1	0	Data written is latched
	0	0	1	Data read from output latch.
	1	0	1	Data read from PD7-0.

In SPP Compatible mode, the parallel port does not write data to the output signals. Bit 5 of the CTR register has no effect in this state. If data is written ($\overline{WR}$ goes low), the data is sent to the output signals PD7-0. If a read cycle is initiated ($\overline{RD}$ goes low), the system reads the contents of the output latch, and not data from the PD7-0 output signals.
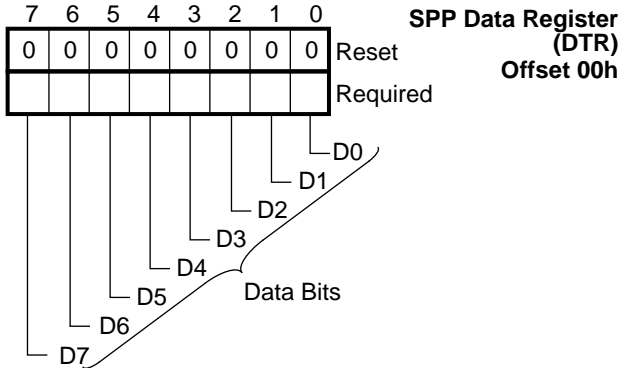
In SPP Extended mode, the parallel port can read and write external data via PD7-0. In this mode, bit 5 sets the direction for data in or data out, while read or write cycles are possible in both settings of bit 5.

If bit 5 of CTR is cleared to 0, data is written to the output signals PD7-0 when a write cycle occurs. (if a read cycle occurs in this setting, the system reads the output latch, not data from PD7-0).

If bit 5 of CTR is set to 1, data is read from the output signals PD7-0 when a read cycle occurs. A write cycle in this setting only writes to the output latch, not to the output signals PD7-0.

The reset value of this register is 0.

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

SPP Data Register (DTR)
Offset 00h

- D0
- D1
- D2
- D3
- D4
- D5
- D6
- D7

Data Bits

4.2.3   Status Register (STR)

This read-only register holds status information. A system write operation to STR is an invalid operation that has no effect on the parallel port.

7	6	5	4	3	2	1	0	
1	1	1	1	1	1	1	1	Reset
								Required

SPP Status Register (STR)
Offset 01h

- Time-Out Status
- Reserved
- IRQ Status
- $\overline{ERR}$ Status
- SLCT Status
- PE Status
- $\overline{ACK}$ Status
- Printer Status
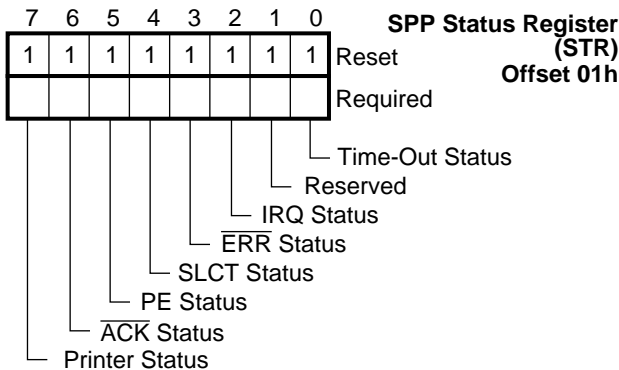
Bit 0 - Time-Out Status

In EPP modes only, this is the time-out status bit. In all other modes this bit has no function and has the constant value 1.

This bit is cleared when an EPP mode is enabled. Thereafter, this bit is set to 1 when a time-out occurs in an EPP cycle and is cleared when STR is read.

In EPP modes:

0: An EPP mode is set. No time-out occurred since STR was last read.

1: Time-out occurred on EPP cycle (minimum of 10 μsec). (Default)

Bit 1 - Reserved

This bit is reserved and is always 1.

Bit 2 - IRQ Status

In all modes except SPP Extended, this bit is always 1.

In SPP Extended mode this bit is the IRQ status bit. It remains high unless the interrupt request is enabled (bit 4 of CTR set high). This bit is high except when latched low when the $\overline{ACK}$ signal makes a low to high transition, indicating a character is now being transferred to the printer.

Reading this bit resets it to 1.

0: Interrupt requested in SPP Extended mode.

1: No interrupt requested. (Default)

Bit 3 - $\overline{ERR}$ Status

This bit reflects the current state of the printer error signal, $\overline{ERR}$. The printer sets this bit low when there is a printer error.

0: Printer error.

1: No printer error.

Bit 4 - SLCT Status

This bit reflects the current state of the printer select signal, SLCT. The printer sets this bit high when it is on-line and selected.

0: No printer selected.

1: Printer selected and online.

Bit 5 - PE Status

This bit reflects the current state of the printer paper end signal (PE). The printer sets this bit high when it detects the end of the paper.

0: Printer has paper.

1: End of paper in printer.

Bit 6 - $\overline{ACK}$ Status

This bit reflects the current state of the printer acknowledge signal, $\overline{ACK}$. The printer pulses this signal low after it has received a character and is ready to receive another one. This bit follows the state of the $\overline{ACK}$ pin.

0: Character reception complete.

1: No character received.

Bit 7 - Printer Status

This bit reflects the current state of the printer BUSY signal. The printer sets this bit low when it is busy and cannot accept another character.

This bit is the inverse of the (BUSY/$\overline{WAIT}$) pin.

0: Printer busy.

1: Printer not busy.

4.2.4   SPP Control Register (CTR)

The control register provides all the output signals that control the printer. Except for bit 5, it is a read and write register.

Normally when the Control Register (CTR) is read, the bit values are provided by the internal output data latch. These bit values can be superseded by the logic level of the $\overline{STB}$, $\overline{AFD}$, $\overline{INIT}$, and $\overline{SLIN}$ signals, if these signals are forced high or low by external voltage. To force these signals high or low the corresponding bits should be set to their inactive states (e.g., $\overline{AFD}$, $\overline{STB}$ and $\overline{SLIN}$ should all be 0; $\overline{INIT}$ should be 1).

Section 4.3.10 "EPP Mode Transfer Operations" on page 85 describes the transfer operations that are possible in EPP modes.
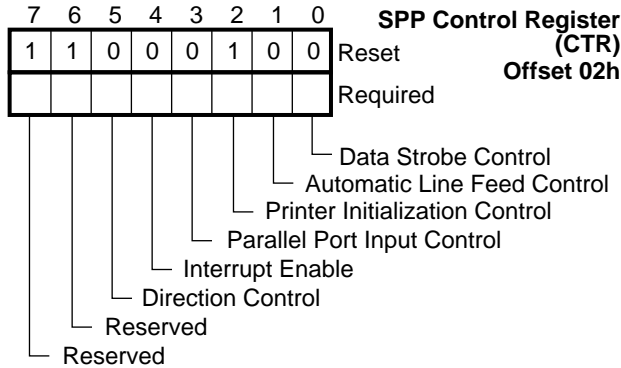
7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0

SPP Control Register (CTR)
Offset 02h

Reset
Required

— Data Strobe Control
— Automatic Line Feed Control
— Printer Initialization Control
— Parallel Port Input Control
— Interrupt Enable
— Direction Control
— Reserved
— Reserved

Bit 0 - Data Strobe Control

Bit 0 directly controls the data strobe signal to the printer via the $\overline{STB}$ signal.

This bit is the inverse of the $\overline{STB}$ signal.

Bit 1 - Automatic Line Feed Control

This bit directly controls the automatic line feed signal to the printer via the $\overline{AFD}$ pin. Setting this bit high causes the printer to automatically feed after each line is printed.

This bit is the inverse of the $\overline{AFD}$ signal.

0: No automatic line feed (Default)

1: Automatic line feed

Bit 2 - Printer Initialization Control

Bit 2 directly controls the signal to initialize the printer via the $\overline{INIT}$ pin. Setting this bit to low initializes the printer.

The value of the $\overline{INIT}$ signal reflects the value of this bit.

The default setting of 1 on this bit prevents printer initialization in SPP mode, and enables ECP mode after reset.

0: Initialize Printer

1: No action (Default)

Bit 3 - Select Input Signal Control

This bit directly controls the select in signal to the printer via the $\overline{SLIN}$ signal. Setting this bit high selects the printer.

It is the inverse of the $\overline{SLIN}$ signal.

This bit must be cleared to 0 before enabling the EPP or ECP mode.

0: Printer not selected. (Default)

1: Printer selected and online.

Bit 4 - Interrupt Enable

Bit 4 controls the interrupt generated by the $\overline{ACK}$ signal. Its function changes slightly depending on the parallel port mode selected.

In ECP mode, this bit should be set to 0.

In the following description, IRQx indicates an interrupt allocated for the parallel port.

0: In SPP Compatible, SPP Extended and EPP modes, IRQx is floated. (Default)

1: In SPP Compatible mode, IRQx follows $\overline{ACK}$ transitions.

In SPP Extended mode, IRQx is set active on the trailing edge of $\overline{ACK}$.

In EPP modes, IRQx follows $\overline{ACK}$ transitions, or is set when an EPP time-out occurs.

Bit 5 - Direction Control

This bit determines the direction of the parallel port in SPP Extended mode only. In the (default) SPP Compatible mode, this bit has no effect, since the port functions for output only.

This is a read/write bit in EPP modes. In SPP modes it is a write only bit. A read from it returns 1.

In SPP Compatible mode and in EPP modes it does not control the direction. See TABLE 4-4 "SPP DTR Register Read and Write Modes" on page 80.

0: Data output to PD7-0 in SPP Extended mode during write cycles. (Default)

1: Data input from PD7-0 in SPP Extended mode during read cycles.

Bits 7,6 - Reserved

These bits are reserved and are always 1.

4.3 ENHANCED PARALLEL PORT (EPP) MODES

EPP modes allow greater throughput than SPP modes by supporting faster transfer times (8, 16 or 32-bit data transfers in a single read or write operation) and a mechanism that allows the system to address peripheral device registers directly. Faster transfers are achieved by automatically generating the address and data strobes.

The connector pin assignments for these modes are listed in TABLE 4-12 "Parallel Port Pin Out" on page 101.

EPP modes support revision 1.7 and revision 1.9 of the IEEE 1284 standard, as shown in TABLE 4-1 "Parallel Port Mode Selection" on page 80.

In Legacy mode, EPP modes are supported for a parallel port whose base address is 278h or 378h, but not for a parallel port whose base address is 3BCh. (There are no EPP registers at 3BFh.) In both Legacy and Plug and Play modes, bits 2, 1 and 0 of the parallel port base address must be 000 in EPP modes.

SPP-type data transactions may be conducted in EPP modes. The appropriate registers are available for this type of transaction. (See TABLE 4-5 "Enhanced Parallel Port (EPP) Registers".) As in the SPP modes, software must generate the control signals required to send or receive data.

4.3.1 EPP Register Set

TABLE 4-5 lists the EPP registers. All are single-byte registers.

Bits 0, 1 and 3 of the CTR register must be 0 before the EPP registers can be accessed, since the signals controlled by these bits are controlled by hardware during EPP accesses. Once these bits are set to 0 by the software driver, multiple EPP access cycles may be invoked.

When EPP modes are enabled, the software can perform SPP Extended mode cycles. In other words, if there is no access to one of the EPP registers, EPP Address (ADDR)

or EPP Data Registers 0-3 (DATA0-3), EPP modes behave like SPP Extended mode, except for the interrupt, which is pulse triggered instead of level triggered.

Bit 7 of STR ($\overline{BUSY}$ status) must be set to 1 before writing to DTR in EPP modes to ensure data output to PD7-0.

The enhanced parallel port monitors the IOCHRDY signal during EPP cycles. If IOCHRDY is driven low for more then 10 μsec, an EPP time-out event occurs, which aborts the cycle by asserting IOCHRDY, thus releasing the system from a stuck EPP peripheral device. (This time-out event is only functional when the clock is applied to this logical device).

When the cycle is aborted, $\overline{ASTRB}$ or $\overline{DSTRB}$ becomes inactive, and the time-out event is signaled by asserting bit 0 of STR. If bit 4 of CTR is 1, the time-out event also pulses the IRQ5 or IRQ7 signals when enabled. (IRQ5 and IRQ7 can be routed to any other IRQ lines via the Plug and Play block).

EPP cycles to the external device are activated by invoking read or write cycles to the EPP.

TABLE 4-5. Enhanced Parallel Port (EPP) Registers

Offset	Name	Description	Mode	R/W
00h	DTR	SPP Data	SPP or EPP	R/W
01h	STR	SPP Status	SPP or EPP	R
02h	CTR	SPP Control	SPP or EPP	R/W
03h	ADDR	EPP Address	EPP	R/W
04h	DATA0	EPP Data Port 0	EPP	R/W
05h	DATA1	EPP Data Port 1	EPP	R/W
06h	DATA2	EPP Data Port 2	EPP	R/W
07h	DATA3	EPP Data Port 3	EPP	R/W

4.3.2 SPP or EPP Data Register (DTR)

The DTR register is the SPP Compatible or SPP Extended data register. A write to DTR sets the state of the eight data pins on the 25-pin D-shell connector.
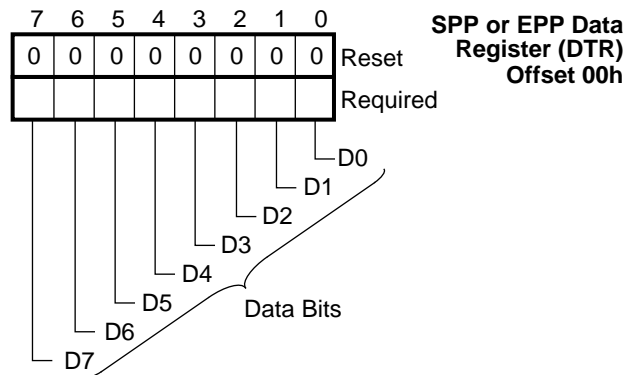
4.3.3 SPP or EPP Status Register (STR)

This status port is read only. A read presents the current status of the five pins on the 25-pin D-shell connector, and the IRQ.
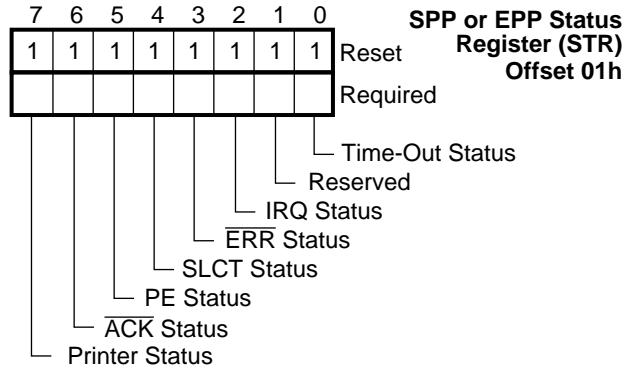
The bits of this register have the identical function in EPP mode as in SPP mode. See Section 4.2.3 "Status Register (STR)" on page 81 for a detailed description of each bit.

4.3.4 SPP or EPP Control Register (CTR)

This control port is read or write. A write operation to it sets the state of four pins on the 25-pin D-shell connector, and controls both the parallel port interrupt enable and direction.
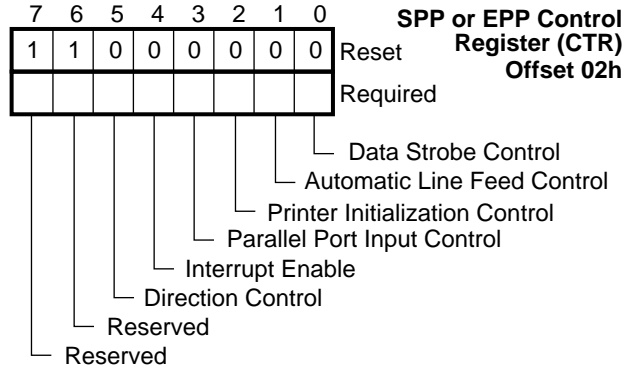
The bits of this register have the identical function in EPP modes as in SPP modes. See Section 4.2.4 "SPP Control Register (CTR)" on page 81 for a description of each bit.

4.3.5 EPP Address Register (ADDR)

This port is added in EPP modes to enhance system throughput by enabling registers in the remote device to be directly addressed by hardware.

This port can be read or written. Writing to it initiates an EPP device or register selection operation.

ENHANCED PARALLEL PORT (EPP) MODES

```
  7   6   5   4   3   2   1   0
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Reset
|   |   |   |   |   |   |   |   | Required
```

EPP Address Register (ADDR) Offset 03h

```
A0
A1
A2
A3
A4
A5
A6
A7
```

EPP Device or Register Selection Address Bits
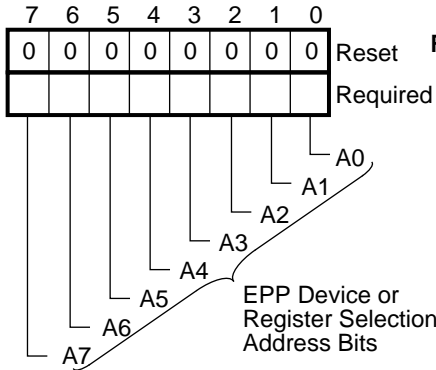
4.3.6   EPP Data Register 0 (DATA0)

DATA0 is a read/write register. Accessing it initiates device read or write operations of bits 7 through 0.

```
  7   6   5   4   3   2   1   0
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Reset
|   |   |   |   |   |   |   |   | Required
```

EPP Data Register 0 (DATA0) Offset 04h

```
D0
D1
D2
D3
D4
D5
D6
D7
```

EPP Device Read or Write Data
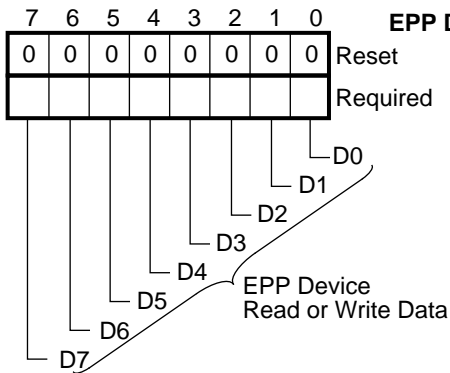
4.3.7   EPP Data Register 1 (DATA1)

DATA1 is only accessed to transfer bits 15 through 8 of a 16-bit read or write to EPP Data Register 0 (DATA0).

```
  7   6   5   4   3   2   1   0
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Reset
|   |   |   |   |   |   |   |   | Required
```

EPP Data Register 1 (DATA1) Offset 05h

```
D8
D9
D10
D11
D12
D13
D14
D15
```

EPP Device Read or Write Data
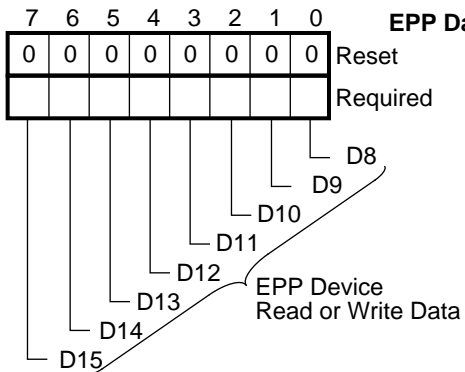
4.3.8   EPP Data Register 2 (DATA2)

This is the third EPP data register. It is only accessed to transfer bits 16 through 23 of a 32-bit read or write to EPP Data Register 0 (DATA0).

```
  7   6   5   4   3   2   1   0
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Reset
|   |   |   |   |   |   |   |   | Required
```

EPP Data Register 2 (DATA2) Offset 06h

```
D16
D17
D18
D19
D20
D21
D22
D23
```

EPP Device Read or Write Data

4.3.9   EPP Data Register 3 (DATA3)

This is the fourth EPP data register. It is only accessed to transfer bits 24 through 31 of a 32-bit read or write to EPP Data Register 0 (DATA0).

```
  7   6   5   4   3   2   1   0
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Reset
|   |   |   |   |   |   |   |   | Required
```

EPP Data Register 3 (DATA3) Offset 07h

```
D24
D25
D26
D27
D28
D29
D30
D31
```

EPP Device Read or Write Data

4.3.10 EPP Mode Transfer Operations

The EPP transfer operations are address read or write, and data read or write. An EPP transfer is composed of a system read or write cycle from or to an EPP register, and an EPP read or write cycle from a peripheral device to an EPP register or from an EPP register to a peripheral device.

EPP 1.7 Address Write

The following procedure selects a peripheral device or register as illustrated in FIGURE FIGURE 4-1 "EPP 1.7 Address Write".

1. The system writes a byte to the EPP Address register. $\overline{WR}$ becomes low to latch D7-0 into the EPP Address register. The latch drives the EPP Address register onto PD7-0 and the EPP pulls $\overline{WRITE}$ low.

2. The EPP pulls $\overline{ASTRB}$ low to indicate that data was sent.

3. If $\overline{WAIT}$ was low during the system write cycle, IOCHRDY becomes low. When $\overline{WAIT}$ becomes high, the EPP pulls IOCHRDY high.

4. When IOCHRDY becomes high, it causes $\overline{WR}$ to become high. If $\overline{WAIT}$ is high during the system write cycle, then the EPP does not pull IOCHRDY to low.

5. When $\overline{WR}$ becomes high, it causes the EPP to pull first $\overline{ASTRB}$ and then $\overline{WRITE}$ to high. The EPP can change PD7-0 only when $\overline{WRITE}$ and $\overline{ASTRB}$ are both high.
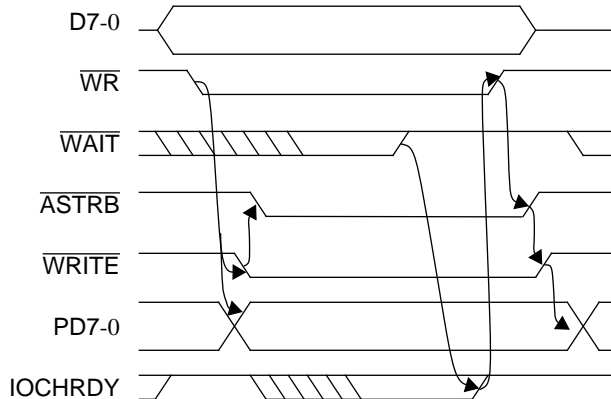
FIGURE 4-1. EPP 1.7 Address Write

EPP 1.7 Address Read

The following procedure reads from the EPP Address register as shown in FIGURE FIGURE 4-2 "EPP 1.7 Address Read".

1. The system reads a byte from the EPP Address register. $\overline{RD}$ goes low to gate PD7-0 into D7-0.

2. The EPP pulls $\overline{ASTRB}$ low to signal the peripheral to start sending data.

3. If $\overline{WAIT}$ is low during the system read cycle. Then the EPP pulls IOCHRDY low. When $\overline{WAIT}$ becomes high, the EPP stops pulling IOCHRDY to low.

4. When IOCHRDY becomes high, it causes $\overline{RD}$ to become high. If $\overline{WAIT}$ is high during the system read cycle then the EPP does not pull IOCHRDY to low.

5. When $\overline{RD}$ becomes high, it causes the EPP to pull $\overline{ASTRB}$ high. The EPP can change PD7-0 only when $\overline{ASTRB}$ is high. After $\overline{ASTRB}$ becomes high, the EPP

puts D7-0 in TRI-STATE.
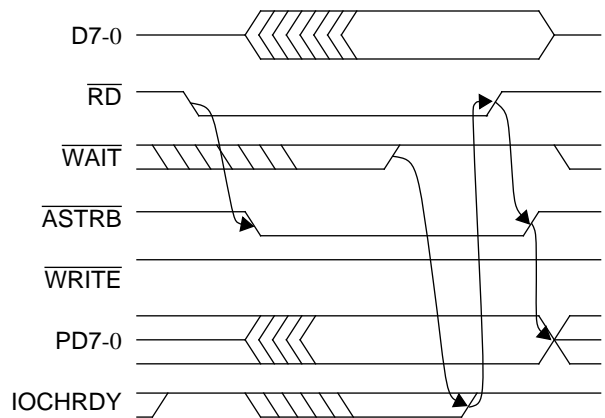
FIGURE 4-2. EPP 1.7 Address Read

EPP 1.7 Data Write and Read

This procedure writes to the selected peripheral device or register.

EPP 1.7 data read or write operations are similar to EPP 1.7 Address register read or write operations, except that the data strobe ($\overline{DSTRB}$ signal), and the EPP Data register, replace the address strobe ($\overline{ASTRB}$ signal) and the EPP Address register, respectively.

4.3.11 EPP 1.7 and 1.9 Data Write and Read Operations

EPP 1.9 Address Write

The following procedure selects a peripheral or register as shown in FIGURE FIGURE 4-3 "EPP 1.9 Address Write".

1. The system writes a byte to the EPP Address register.

2. The EPP pulls IOCHRDY low, and waits for $\overline{WAIT}$ to become low.

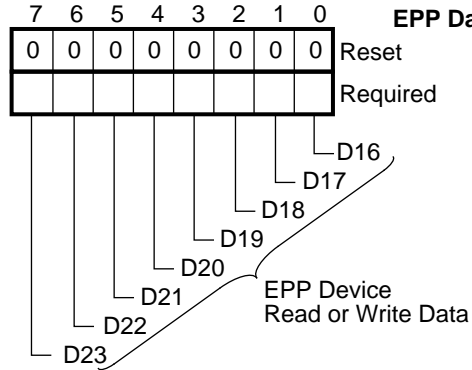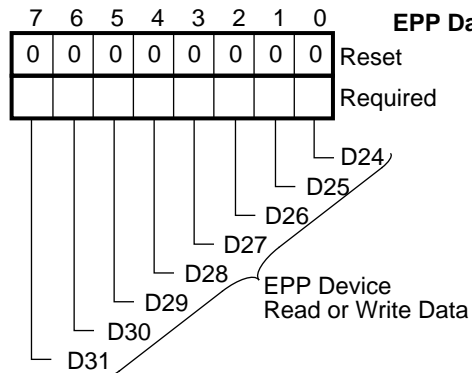3. When $\overline{WAIT}$ becomes low, the EPP pulls $\overline{WRITE}$ to low and drives the latched byte onto PD7-0. If $\overline{WAIT}$ was already low, steps 2 and 3 occur concurrently.

4. The EPP pulls $\overline{ASTRB}$ low and waits for $\overline{WAIT}$ to become high.

5. When $\overline{WAIT}$ becomes high, the EPP stops pulling IOCHRDY low, and waits for $\overline{WR}$ to become high.

6. When $\overline{WR}$ becomes high, the EPP pulls $\overline{ASTRB}$ high, and waits for $\overline{WAIT}$ to become low.

7. If no EPP write is pending when $\overline{WAIT}$ becomes low, the EPP pulls $\overline{WRITE}$ to high. Otherwise, $\overline{WRITE}$ remains low, and the EPP may change PD7-0.
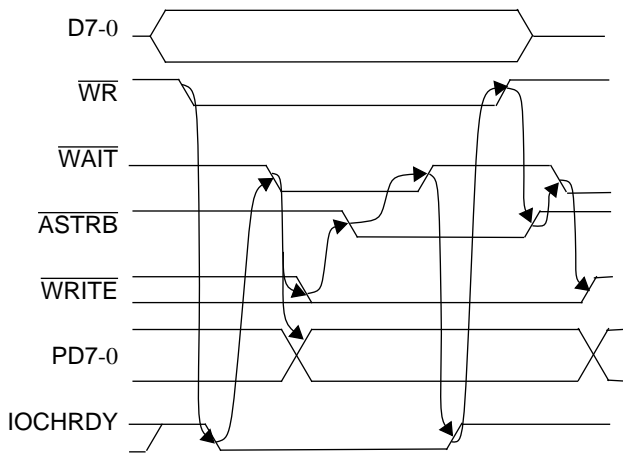
FIGURE 4-3. EPP 1.9 Address Write

EPP 1.9 Address Read

The following procedure reads from the address register.

1. The system reads a byte from the EPP address register. When $\overline{RD}$ becomes low, the EPP pulls IOCHRDY low, and waits for $\overline{WAIT}$ to become low.

2. When $\overline{WAIT}$ becomes low, the EPP pulls $\overline{ASTRB}$ low and waits for $\overline{WAIT}$ to become high. If $\overline{WAIT}$ was already low, steps 2 and 3 occur concurrently.

3. When $\overline{WAIT}$ becomes high, the EPP stops pulling IO-CHRDY low, and waits for $\overline{RD}$ to become high.

4. When $\overline{RD}$ becomes high, the EPP latches PD7-0 (to provide sufficient hold time), pulls $\overline{ASTRB}$ high, and puts D7-0 in TRI-STATE.
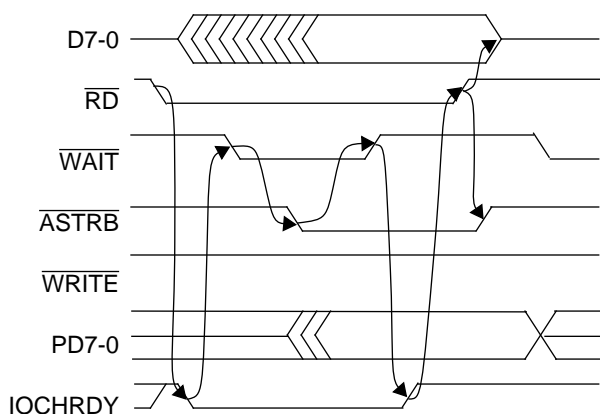
FIGURE 4-4. EPP 1.9 Address Read

EPP 1.9 Data Write and (Backward) Data Read

This procedure writes to the selected peripheral drive or register.

EPP 1.9 data read and write operations are similar to EPP 1.9 address read and write operations, except that the data strobe ($\overline{DSTRB}$ signal) and EPP Data register replace the address strobe ($\overline{ASTRB}$ signal) and the EPP Address register, respectively.

4.4 EXTENDED CAPABILITIES PARALLEL PORT (ECP)

In the Extended Capabilities Parallel Port (ECP) modes, the device is a state machine that supports a 16-byte FIFO that can be configured for either direction, command and data FIFO tags (one per byte), a FIFO threshold interrupt for both directions, FIFO empty and full status bits, automatic generation of strobes (by hardware) to fill or empty the FIFO, transfer of commands and data, and Run Length Encoding (RLE) expanding (decompression) as explained below. The FIFO can be accessed by PIO or system DMA cycles.

4.4.1 ECP Modes

ECP modes are enabled as described in TABLE 4-1 "Parallel Port Mode Selection" on page 80. The ECP mode is selected at reset by setting bits 7-5 of the SuperI/O Parallel Port Configuration register at index F0h (see Section 2.6 "SUPERI/O PARALLEL PORT CONFIGURATION REGISTER (LOGICAL DEVICE 1)" on page 30) to 100 or 111. Thereafter, the mode is controlled via the bits 7-5 of the ECP Extended Control Register (ECR) at offset 402h of the parallel port. See Section 4.5.12 "Extended Control Register (ECR)" on page 91.

TABLE 4-9 "ECP Modes Encoding" on page 92 lists the ECP modes. See TABLE 4-11 "ECP Modes" on page 96 and Section 4.6 "DETAILED ECP MODE DESCRIPTIONS" on page 95 for more detailed descriptions of these modes.

4.4.2 Software Operation

Software should operate as described in "*Extended Capabilities Port Protocol and ISA Interface Standard*".

Some of these operations are:

- Software should enable ECP after bits 3-0 of the parallel port Control Register (CTR) are set to 0100.

- When ECP is enabled, software should switch modes only through modes 000 or 001.

- When ECP is enabled, the software should change direction only in mode 001.

- Software should not switch from mode 010 or 011, to mode 000 or 001, unless the FIFO is empty.

- Software should switch to mode 011 when bits 0 and 1 of DCR are 0.

- Software should switch to mode 010 when bit 0 of DCR is 0.

- Software should disable ECP only in mode 000 or 001.

- Software should switch to mode 100 when bits 0, 1 and 3 of the DCR are 0.

- Software should switch from mode 100 to mode 000 or 001 only when bit 7 of the DSR ($\overline{BUSY}$) is 1. Otherwise, an on-going EPP cycle can be aborted.

- When the ECP is in mode 100, software should write 0 to bit 5 of the DCR before performing EPP cycles.

Software may switch from mode 011 backward to modes 000 or 001, when there is an on-going ECP read cycle. In this case, the read cycle is aborted by deasserting $\overline{AFD}$. The FIFO is reset (empty) and a potential byte expansion (RLE) is automatically terminated since the new mode is 000 or 001.

4.4.3 Hardware Operation

The ECP uses an internal clock, which can be frozen to reduce power consumption during power down. In this power-down state the DMA is disabled, all interrupts (except $\overline{ACK}$) are masked, and the FIFO registers are not accessible (access is ignored). The other ECP registers are unaffected by power-down and are always accessible when the ECP is enabled. During power-down the FIFO status and contents become inaccessible, and the system reads bit 2 of ECR as 0, bit 1 of ECR as 1 and bit 0 of ECR as 1, regardless of the actual values of these bits. The FIFO status and contents are not lost, however, and when the clock activity resumes, the values of these bits resume their designated functions.

When the clock is frozen, an on-going ECP cycle may be corrupted, but the next ECP cycle will not start even if the FIFO is not empty in the forward direction, or not full in the backward direction. If the ECP clock starts or stops toggling during a system cycle that accesses the FIFO, the cycle may yield wrong data.

ECP output signals are inactive when the ECP is disabled.

Only the FIFO, DMA and RLE do not function when the clock is frozen. All other registers are accessible and functional. The FIFO, DMA and RLE are affected by ECR modifications, i.e., they are reset when exits from modes 010 or 011 are carried out even while the clock is frozen.

4.5 ECP MODE REGISTERS

The ECP registers are each a byte wide, and are listed in TABLE Table 4-6 in order of their offsets from the base address of the parallel port. In addition, the ECP has control registers at second level offsets, that are accessed via the EIR and EDR registers. See 4.5.2 "Second Level Offsets" on page 88.

TABLE 4-6. Extended Capabilities Parallel Port (ECP) Registers

Offset	Symbol	Description	Modes (ECR Bits) 7 6 5	R/W
000h	DATAR	Parallel Port Data Register	0 0 0 0 0 1	R/W
000h	AFIFO	ECP Address FIFO	0 1 1	W
001h	DSR	Status Register	All Modes	R
002h	DCR	Control Register	All Modes	R/W
400h	CFIFO	Parallel Port Data FIFO	0 1 0	W
400h	DFIFO	ECP Data FIFO	0 1 1	R/W
400h	TFIFO	Test FIFO	1 1 0	R/W
400h	CNFGA	Configuration Register A	1 1 1	R
401h	CNFGB	Configuration Register B	1 1 1	R
402h	ECR	Extended Control Register	All Modes	R/W
403h	EIR	Extended Index Register	All Modes	R/W
404h	EDR	Extended Data Register	All Modes	R/W
405h	EAR	Extended Auxiliary Status Register	All Modes	R/W
Control Registers at Second Level Offsets				
00h		Control0	All Modes	R/W
02h		Control2	All Modes	R/W
04h		Control4	All Modes	R/W
05h		PP Confg0	All Modes	R/W

4.5.1 Accessing the ECP Registers

The AFIFO, CFIFO, DFIFO and TFIFO registers access the same ECP FIFO. The FIFO is accessed at Base + 000h, or Base + 400h, depending on the mode field of ECR and the register.

The FIFO can be accessed by system DMA cycles, as well as system PIO cycles.

When the DMA is configured and enabled (bit 3 of ECR is 1 and bit 2 of ECR is 0) the ECP automatically (by hardware) issues DMA requests to fill the FIFO (in the forward direction when bit 5 of DCR is 0) or to empty the FIFO (in the backward direction when bit 5 of DCR is 1). All DMA transfers are to or from these registers. The ECP does not assert DMA requests for more than 32 consecutive DMA cycles. The ECP stops requesting the DMA when TC is detected during an ECP DMA cycle.

A "Demand DMA" feature reduces system overhead caused by DMA data transfers. When this feature is enabled by bit 6 of the PP Config0 register at second level offset 05h, it prevents servicing of DMA requests until after four have accumulated and are held pending. See "Bit 6 - Demand DMA Enable" on page 94.

Writing into a full FIFO, and reading from an empty FIFO, are ignored. The written data is lost, and the read data is undefined. The FIFO empty and full status bits are not affected by such accesses.

Some registers are not accessible in all modes of operation, or may be accessed in one direction only. Accessing a non accessible register has no effect. Data read is undefined; data written is ignored; and the FIFO does not update. The SPP registers (DTR, STR and CTR) are not accessible when the ECP is enabled.

To improve noise immunity in ECP cycles, the state machine does not examine the control handshake response lines until the data has had time to switch.

In ECP modes:

- DATAR replaces DTR of SPP/EPP

- DSR replaces STR of SPP/EPP

- DCR replaces CTR of SPP/EPP

4.5.2   Second Level Offsets

The EIR, EDR, and EAR registers support enhanced control and status features. When bit 4 of the Parallel Port Configuration register is 1 (as described in Section 2.6 "SUPERI/O PARALLEL PORT CONFIGURATION REGISTER (LOGICAL DEVICE 1)" on page 30), EIR and EDR serve as index and data registers, respectively.

EIR and EDR at offsets 403 and 404, respectively, access the control registers (Control0, Control2, Control4 and PP Config0) at second level offsets 00h, 02h, 04h and 05h, respectively. These control registers are functional only. Accessing these registers is possible when bit 4 of the SuperI/O Parallel Port Configuration register at index F0h of Logical Device 1 is 1 and when bit 2 or 10 of the base address is 1.

4.5.3   ECP Data Register (DATAR)

The ECP Data Register (DATAR) register is the same as the DTR register (see Section 4.2.2 "SPP Data Register (DTR)" on page 80), except that a read always returns the values of the PD7-0 signals instead of the register latched data.

Bits 7-5 of ECR = 000 or 001
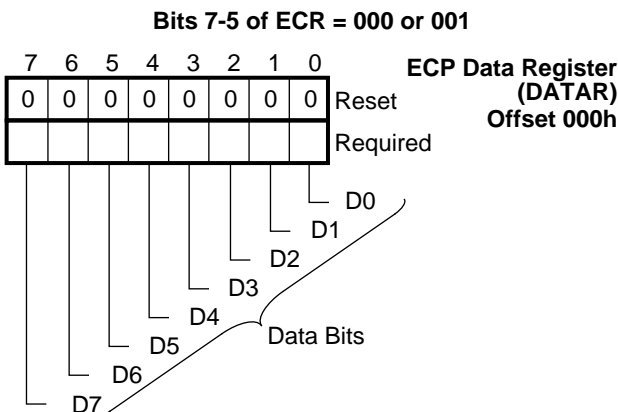
4.5.4   ECP Address FIFO (AFIFO) Register

The ECP Address FIFO Register (AFIFO) is write only. In the forward direction (when bit 5 of DCR is 0) a byte written into this register is pushed into the FIFO and tagged as a command.

Reading this register returns undefined contents. Writing to this register in a backward direction (when bit 5 of DCR is 1) has no effect and the data is ignored.

Bits 7-5 of ECR = 011
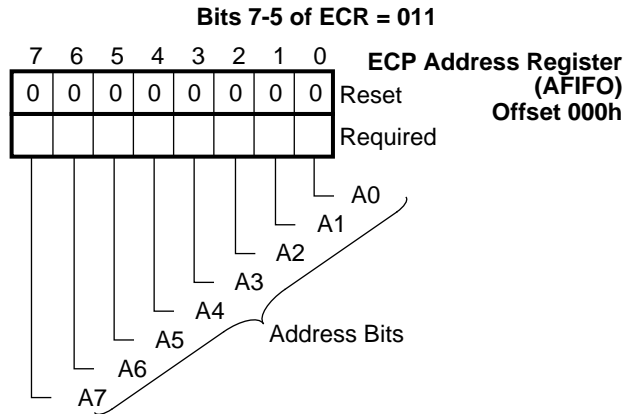
4.5.5   ECP Status Register (DSR)

This read-only register displays device status. Writes to this DSR have no effect and the data is ignored.

This register should not be confused with the DSR register of the Floppy Disk Controller (FDC).
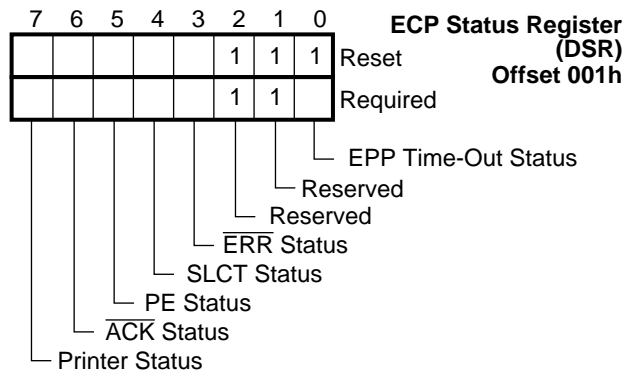
Bits 0 - EPP Time-Out Status

In EPP modes only, this is the time-out status bit. In all other modes this bit has no function and has the constant value 1.

This bit is cleared when an EPP mode is enabled. Thereafter, this bit is set to 1 when a time-out occurs in an EPP cycle and is cleared when STR is read.

In EPP modes:

0 - An EPP mode is set. No time-out occurred since STR was last read.

1: Time-out occurred on EPP cycle (minimum of 10 μsec). (Default)

Bits 2,1:   Reserved

These bits are reserved and are always 1.

Bit 3 - $\overline{ERR}$ Status

This bit reflects the status of the $\overline{ERR}$ signal.

0: Printer error.

1: No printer error.

Bit 4 - SLCT Status

This bit reflects the status of the Select signal. The printer sets this signal high when it is online and selected

0: Printer not selected. (Default)

1: Printer selected and on-line.

Bit 5 - PE Status

This bit reflects the status of the Paper End (PE) signal.

0: Paper not ended.

1: No paper in printer.

Bit 6 - $\overline{ACK}$ Status

This bit reflects the status of the $\overline{ACK}$ signal. This signal is pulsed low after a character is received.

0: Character received.

1: No character received. (Default)

Bit 7 - Printer Status

This bit reflects the inverse of the state of the BUSY signal.

0: Printer is busy (cannot accept another character now).

1: Printer not busy (ready for another character).

4.5.6 ECP Control Register (DCR)

Reading this register returns the register content (not the signal values, as in SPP mode).

7	6	5	4	3	2	1	0	
1	1	0	0	0	0	0	0	Reset
								Required

ECP Control Register (DCR) Offset 002h

- Data Strobe Control
- Automatic Line Feed Control
- Printer Initialization Control
- Parallel Port Input Control
- Interrupt Enable
- Direction Control
- Reserved
- Reserved

Bit 0 - Data Strobe Control

Bit 0 directly controls the data strobe signal to the printer via the $\overline{STB}$ signal. It is the inverse of the $\overline{STB}$ signal.

0: The $\overline{STB}$ signal is inactive in all modes except 010 and 011. In these modes, it may be active or inactive as set by the software.

1: In all modes, $\overline{STB}$ is active.

Bit 1 - Automatic Line Feed Control

This bit directly controls the automatic feed XT signal to the printer via the $\overline{AFD}$ signal. Setting this bit high causes the printer to automatically feed after each line is printed. This bit is the inverse of the $\overline{AFD}$ signal.

In mode 011, $\overline{AFD}$ is activated by both ECP hardware and by software using this bit.

0: No automatic line feed. (Default)

1: Automatic line feed.

Bit 2 - Printer Initialization Control

Bit 2 directly controls the signal to initialize the printer via the $\overline{INIT}$ signal. Setting this bit to low initializes the printer. The $\overline{INIT}$ signal follows this bit.

0: Initialize printer. (Default)

1: No action

Bit 3 - Parallel Port Input Control

This bit directly controls the select input device signal to the printer via the $\overline{SLIN}$ signal. It is the inverse of the $\overline{SLIN}$ signal.

This bit must be set to 1 before enabling the EPP or ECP modes.

0: The printer is not selected.

1: The printer is selected.

Bit 4 - Interrupt Enable

Bit 4 enables the interrupt generated by the $\overline{ACK}$ signal. In ECP mode, this bit should be set to 0. This bit does not float the IRQ pin.

0: Masked. (Default)

1: Enabled.

Bit 5 - Direction Control

This bit determines the direction of the parallel port.

This is a read/write bit in EPP mode. In SPP mode it is a write only bit. A read from it returns 1. In SPP Compatible mode and in EPP mode it does not control the direction. See TABLE 4-4 "SPP DTR Register Read and Write Modes" on page 80.

The ECP drives the PD7-0 pins in the forward direction, but does not drive them in the backward direction.

This bit is readable and writable. In modes 000 and 010 the direction bit is forced to 0, internally, regardless of the data written into this bit.

0: ECP drives forward in output mode. (Default)

1: ECP direction is backward.

Bits 7,6 - Reserved

These bits are reserved and are always 1.

4.5.7　Parallel Port Data FIFO (CFIFO) Register

The Parallel Port FIFO (CFIFO) register is write only. A byte written to this register by PIO or DMA is pushed into the FIFO and tagged as data.

Reading this register has no effect and the data read is undefined.

Bits 7-5 of ECR = 010

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

Parallel Port FIFO Register (CFIFO) Offset 400h

- D0
- D1
- D2
- D3
- D4
- D5
- D6
- D7

Data Bits

4.5.8　ECP Data FIFO (DFIFO) Register

This bi-directional FIFO functions as either a write-only device when bit 5 of DCR is 0, or a read-only device when it is 1.

In the forward direction (bit 5 of DCR is 0), a byte written to the ECP Data FIFO (DFIFO) register by PIO or DMA is pushed into the FIFO and tagged as data. Reading this register when set for write-only has no effect and the data read is undefined.

In the backward direction (bit 5 of DCR is 1), the ECP automatically issues ECP read cycles to fill the FIFO.

Reading from this register pops a byte from the FIFO. Writing to this register when it is set for read-only has no effect, and the data written is ignored.

Bits 7-5 of ECR = 011

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

ECP Data FIFO Register (DFIFO) Offset 400h

- D0
- D1
- D2
- D3
- D4
- D5
- D6
- D7

Data Bits

4.5.9　Test FIFO (TFIFO) Register

A byte written into the Test FIFO (TFIFO) register is pushed into the FIFO. A byte read from this register is popped from the FIFO. The ECP does not issue an ECP cycle to transfer the data to or from the peripheral device.

The TFIFO is readable and writable in both directions. In the forward direction (bit 5 of DCR is 0) PD7-0 are driven, but the data is undefined.

The FIFO does not stall when overwritten or underrun (access is ignored). Bytes are always read from the top of the FIFO, regardless of the direction bit setting (bit 5 of DCR). For example if 44h, 33h, 22h, 11h is written into the FIFO, reading the FIFO returns 44h, 33h, 22h, 11h (in the same order it was written).

Bits 7-5 of ECR = 110

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

Test FIFO Register (TFIFO) Offset 400h

- D0
- D1
- D2
- D3
- D4
- D5
- D6
- D7

Data Bits

4.5.10　Configuration Register A (CNFGA)

This register is read only. Reading CNFGA always returns 100 on bits 2 through 0 and 0001 on bits 7 through 4.

Writing this register has no effect and the data is ignored.

Bits 7-5 of ECR = 111

7	6	5	4	3	2	1	0	
0	0	0	1	0	1	0	0	Reset
0	0	0	1		1	0	0	Required

Configuration Register A (CNFGA) Offset 400h

- Always 0
- Always 0
- Always 1
- Bit 7 of PP Confg0
- Always 1
- Always 0
- Always 0
- Always 0
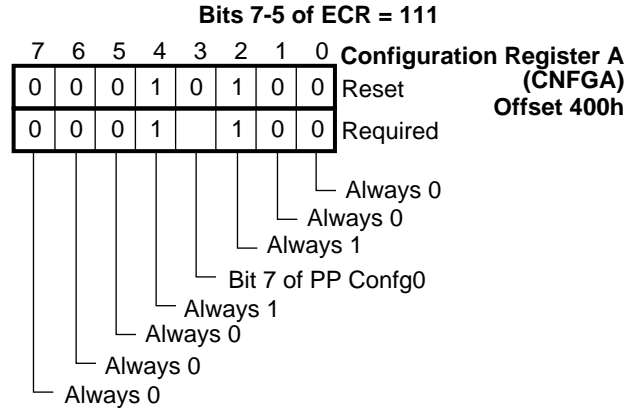
Bits 2-0 - Reserved

　These bits are reserved and are always 100.

Bit 3 - Bit 7 of PP Confg0

　This bit reflects the value of bit 7 of the ECP PP Confg0 register (second level offset 05h), which has no specific function. Whatever value is put in bit 7 of PP Confg0 will appear in this bit.

　This bit reflects a specific system configuration parameter, as opposed to other devices, e.g., 8-bit data word length.

Bit 7-4 - Reserved

　These bits are reserved and are always 0001.

4.5.11   Configuration Register B (CNFGB)

Configuration register B (CNFGB) is read only. Reading this register returns the configured parallel port interrupt line and DMA channel, and the state of the interrupt line.

Writing to this register has no effect and the data is ignored.

Bits 7-5 of ECR = 111

7	6	5	4	3	2	1	0	
0	0	x	x	x	0	0	0	Reset
								Required

Configuration Register B (CNFGB) Offset 401h

- DMA Channel Select
- Reserved
- Interrupt Select
- IRQ Signal Value
- Reserved
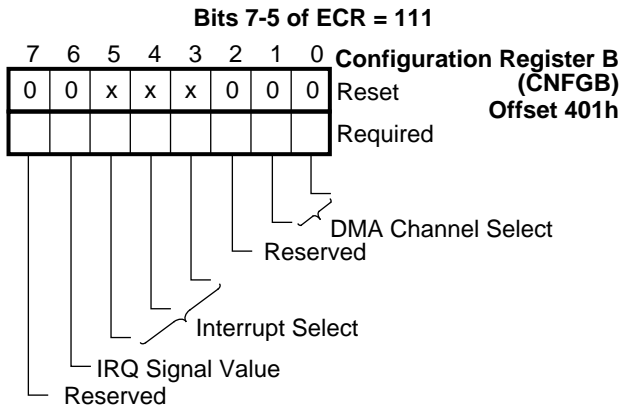
Bits 1,0 - DMA Channel Select

These bits reflect the value of bits 1,0 of the PP Config0 register (second level offset 05h). Microsoft's ECP Protocol and ISA Interface Standard defines these bits as shown in TABLE 4-7 "ECP Mode DMA Selection".

Bits 1,0 of PP Config0 are read/write bits, but CNFGB bits are read only.

Upon reset, these bits are initialized to 00.

TABLE 4-7. ECP Mode DMA Selection

Bit 1	Bit 0	DMA Configuration
0	0	8-bit DMA selected by jumpers. (Default)
0	1	DMA channel 1 selected.
1	0	DMA channel 2 selected.
1	1	DMA channel 3 selected.

Bit 2 - Reserved

This bit is reserved and is always 0.

Bits 5-3 - Interrupt Select Bits

These bits reflect the value of bits 5-3 of the PP Config0 register at second level index 05h. Microsoft's ECP Protocol and ISA Interface Standard defines these bits as shown in TABLE 4-8 "ECP Mode Interrupt Selection".

Bits 5-3 of PP Config0 are read/write bits, but CNFGB bits are read only.

Upon reset, these bits have undefined values.

TABLE 4-8. ECP Mode Interrupt Selection

Bit 5	Bit 4	Bit 3	Interrupt Selection
0	0	0	Selected by jumpers.
0	0	1	IRQ7 selected.
0	1	0	IRQ9 selected.
0	1	1	IRQ10 selected.
1	0	0	IRQ11 selected.
1	0	1	IRQ14 selected.
1	1	0	IRQ15 selected.
1	1	1	IRQ5 selected.

Bit 6 - IRQ Signal Value

This bit holds the value of the IRQ signal configured by the Interrupt Select register (index 70h of this logical device).

Bit 7 - Reserved

This bit is reserved and is always 0.

4.5.12   Extended Control Register (ECR)

This register controls the ECP and parallel port functions. On reset this register is initialized to 00010xx1 (bits 1 and 2 depend on the clock status). IOCHRDY is driven low on an ECR read when the ECR status bits do not hold updated data.

7	6	5	4	3	2	1	0	
0	0	0	1	0			1	Reset
								Required

Extended Control Register (ECR) Offset 402h

- FIFO Empty
- FIFO Full
- ECP Interrupt Service
- ECP DMA Enable
- ECP Interrupt Mask
- ECP Mode Control
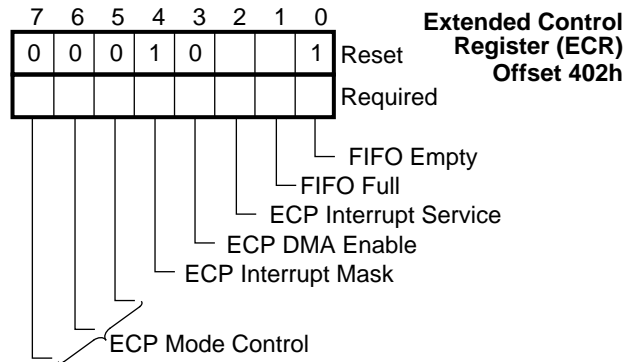
Bit 0 - FIFO Empty

This bit continuously reflects the FIFO state, and therefore can only be read. Data written to this bit is ignored.

When the ECP clock is frozen this bit is read as 1, regardless of the actual FIFO state.

0: The FIFO has at least one byte of data.

1: The FIFO is empty or ECP clock is frozen.

Bit 1 - FIFO Full

This bit continuously reflects the FIFO state, and therefore can only be read. Data written to this bit is ignored.

When the ECP clock is frozen this bit is read as 1, regardless of the actual FIFO state.

0: The FIFO has at least one free byte.

1: The FIFO is full or ECP clock frozen.

Bit 2 - ECP Interrupt Service

This bit enables servicing of interrupt requests. It is set to 1 upon reset, and by the occurrence of interrupt events. It is set to 0 by software.

While this bit is 1, neither the DMA nor the interrupt events listed below will generate an interrupt.

While this bit is 0, the interrupt setup is "armed" and an interrupt is generated on occurrence of an interrupt event.

While the ECP clock is frozen, this bit always returns a 0 value, although it retains its proper value and may be modified.

When one of the following interrupt events occurs while this bit is 0, an interrupt is generated and this bit is set to 1 by hardware.

— DMA is enabled (bit 3 of ECR is 1) and terminal count is reached.

— FIFO write threshold reached (no DMA - bit 3 of ECR is 0; forward direction (bit 5 of DCR is 0), and there are eight or more bytes free in the FIFO).

— FIFO read threshold reached (no DMA - bit 3 of ECR is 0; read direction set - bit 5 of DCR is 1, and there are eight or more bytes to read from the FIFO).

0: The DMA and the above interrupts are not disabled.

1: The DMA and the above three interrupts are disabled.

Bit 3 - ECP DMA Enable

0: The DMA request signal (DRQ3-0) is set to TRI-STATE and the appropriate acknowledge signal (DACK3-0) is assumed inactive.

1: The DMA is enabled and the DMA starts when bit 2 of ECR is 0.

Bit 4 - ECP Interrupt Mask

0: An interrupt is generated on $\overline{ERR}$ assertion (the high-to-low edge of $\overline{ERR}$). An interrupt is also generated while $\overline{ERR}$ is asserted when this bit is changed from 1 to 0; this prevents the loss of an interrupt between ECR read and ECR write.

1: No interrupt is generated.

Bits 7-5 - ECP Mode Control

These bits set the mode for the ECP device. See Section 4.6 "DETAILED ECP MODE DESCRIPTIONS" on page 95 for a more detailed description of operation in each of these ECP modes. The ECP modes are listed in TABLE 4-9 "ECP Modes Encoding" and described in detail in TABLE 4-11 "ECP Modes" on page 96.

TABLE 4-9. ECP Modes Encoding

ECR Bit Encoding			Mode Name
Bit 7	Bit 6	Bit 5	
0	0	0	Standard
0	0	1	PS/2
0	1	0	Parallel Port FIFO
0	1	1	ECP FIFO
1	0	0	EPP Mode
1	1	0	FIFO Test
1	1	1	Configuration

4.5.13 ECP Extended Index Register (EIR)

The parallel port is partially configured by bits within the logical device address space. These configuration bits are accessed via this read/write register and the Extended Data Register (EDR) (see Section 4.5.14 "ECP Extended Data Register (EDR)" on page 93), when bit 4 of the SuperI/O Parallel Port Configuration register at index F0h of Logical Device 1 is set to 1. See Section 2.6 on page 30.

The configuration bits within the parallel port address space are initialized to their default values on reset, and not when the parallel port is activated.

ECP Extended Index Register (EIR) Offset 403h
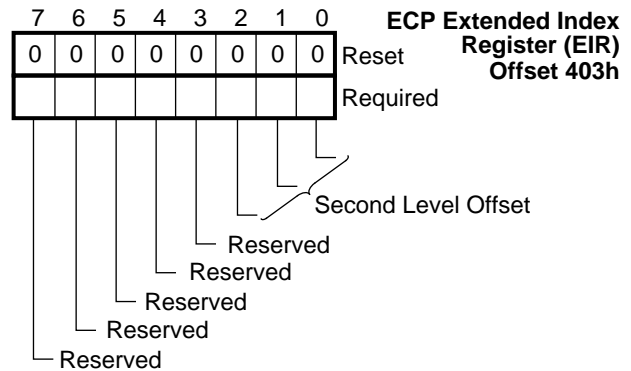
Bits 2-0 - Second Level Offset

Data written to these bits is used as a second level offset for accesses to a specific control register. Second level offsets of 00h, 02h, 04h and 05h are supported. Attempts to access registers at any other offset have no effect.

TABLE 4-10. Second Level Offsets

Second Level Offset	Control Register Name	Described in Section
00h	Control0	4.5.16
02h	Control2	4.5.17
04h	Control4	4.5.18
05h	PP Confg0	4.5.19

000:Access the Control0 register.

010:Access the Control2 register.

100:Access the Control4 register.

101:Access the PP Confg0 register.

Bits 7-3 - Reserved

These bits are treated as 0 for offset calculations. Writing any other value to them has no effect.

These bits are read only. They return 00000 on reads and must be written as 00000.

4.5.14 ECP Extended Data Register (EDR)

This read/write register is the data port of the control register indicated by the index stored in the EIR. Reading or writing this register reads or writes the data in the control register whose second level offset is specified by the EIR.

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

ECP Extended Data Register (EDR) Offset 404h

- D0
- D1
- D2
- D3
- D4 — Data Bits
- D5
- D6
- D7
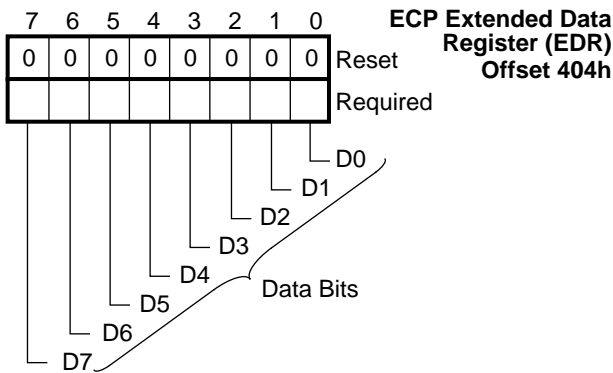
Bits 7-0 - Data Bits

These read/write data bits transfer data to and from the Control Register pointed at by the EIR register.

4.5.15 ECP Extended Auxiliary Status Register (EAR)

Upon reset, this register is initialized to 00h.

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

ECP Extended Auxiliary Status Register (EAR) Offset 405h
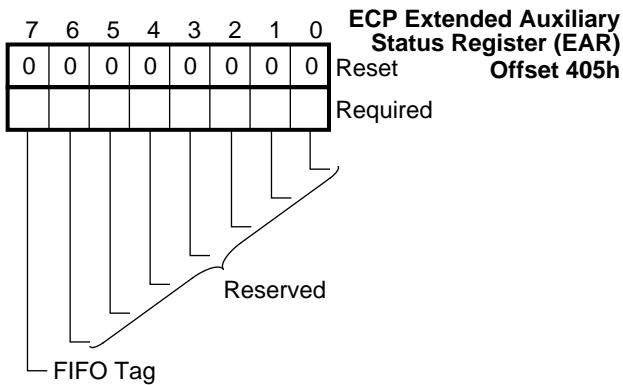
- Reserved
- FIFO Tag

Bits 6-0 - Reserved

Bit 7 - FIFO Tag

Read only. In mode 011, when bit 5 of the DCR is 1 (backward direction), this bit reflects the value of the tag bit (BUSY status) of the word currently in the bottom of the FIFO.

In other modes this bit is indeterminate.

4.5.16 Control0 Register

Upon reset, this register is initialized to 00h.

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

Control0 Register Second Level Offset 00h

- EPP Time-Out Interrupt Mask
- Reserved
- Reserved
- Reserved
- Freeze Bit
- DCR Register Live
- Reserved
- Reserved
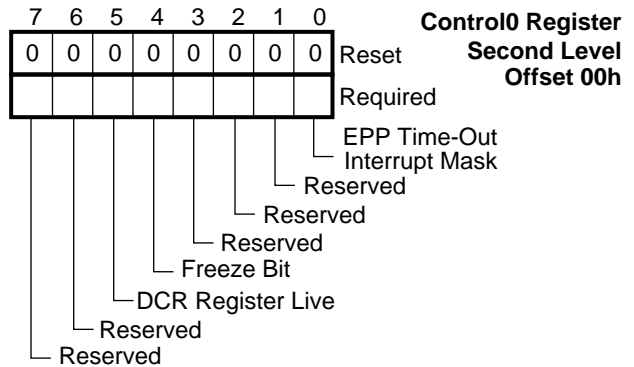
Bit 0 - EPP Time-Out Interrupt Mask

0: The EPP time-out is masked.

1: The EPP time-out is generated.

Bit 3-1 - Reserved

Bit 4 - Freeze Bit

In mode 011, setting this bit to 1 freezes part of the interface with the peripheral device, and clearing this bit to 0 releases and initializes it.

In all other modes the value of this bit is ignored.

Bit 5 - DCR Register Live

When this bit is 1, reading DCR (see Section 4.5.6 "ECP Control Register (DCR)" on page 89) reads the interface control lines pin values regardless of the mode selected.

Otherwise, reading the DCR reads the content of the register.

Bits 7, 6 - Reserved

4.5.17 Control2 Register

Upon reset, this register is initialized to 00h.

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

Control2 Register Second Level Offset 02h

- Reserved
- Revision 1.7 or 1.9 Select
- Reserved
- Channel Address Enable
- SPP Compatability
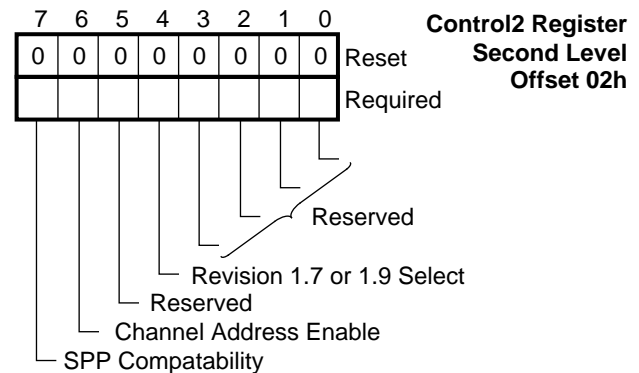
Bits 3-0 - Reserved

Bit 4 - EPP 1.7/1.9 Select

Selects EPP version 1.7 or 1.9.

0: EPP version 1.7.

1: EPP version 1.9.

Bit 5 - Reserved

Bit 6 - Channel Address Enable

When this bit is 1, mode is 011, direction is backward, there is an input command (BUSY is 0), and bit 7 of the data is 1, the command is written into the FIFO.

Bit 7 - SPP Compatibility

See "Bits 7-5 - ECP Mode Control" on page 92 for a description of each mode.

0: Modes 000, 001 and 100 are identical to ECP.

1: Modes 000 and 001 of the ECP are identical with Compatible and Extended modes of the SPP (see Section 4.1 "PARALLEL PORT CONFIGURATION" on page 79), and mode 100 of the ECP is compatible with EPP mode.

Modes 000, 001 and 100 differ as follows:

000, 001 and 100 – Reading DCR returns pin values of bits 3-0.

000 and 001 – Reading DCR returns 1 for bit 5.

000, or 001 or 100 when bit 5 of DCR is 0 (forward direction) – Reading DATAR returns register latched value instead of pin values.

000, 001, and 100, when bit 4 of DCR is 0 – IRQx is floated.

001 – $\overline{\text{IRQx}}$ is a level interrupt generated on the trailing edge of $\overline{\text{ACK}}$. Bit 2 of the DSR is the IRQ status bit (same behavior as bit 2 of the STR).

4.5.18 Control4 Register

Upon reset this register is initialized to 00000111.

This register enables control of the fairness mechanism of the DMA by programming the maximum number of bus cycles that the parallel port DMA request signals can remain active, and the minimum number of clock cycles that they will remain inactive after they were deactivated.

Control4 Register
Second Level
Offset 04h
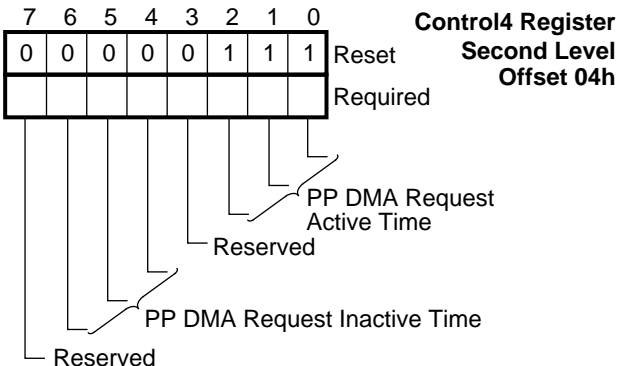
Bits 2- 0 - Parallel Port DMA Request Active Time

This field specifies the maximum number of consecutive bus cycles that the parallel port DMA signals can remain active.

The default value is 111, which specifies 32 cycles.

When these bits are 0, the number is 1 cycle.

Otherwise, the number is 4(n+1) where n is the value of these bits.

Bit 3 - Reserved

Bits 6-4 - Parallel Port DMA Request Inactive Time

This field specifies the minimum number of clock cycles that the parallel port DMA signals remain inactive after being deactivated by the fairness mechanism.

The default value is 000, which specifies 8 clock cycles.

Otherwise, the number of clock cycles is 8 + 32n, where n is the value of these bits.

Bit 7 - Reserved

4.5.19 PP Confg0 Register

Upon reset this register is initialized to 00h.

PP Confg0 Register
Second Level
Offset 05h
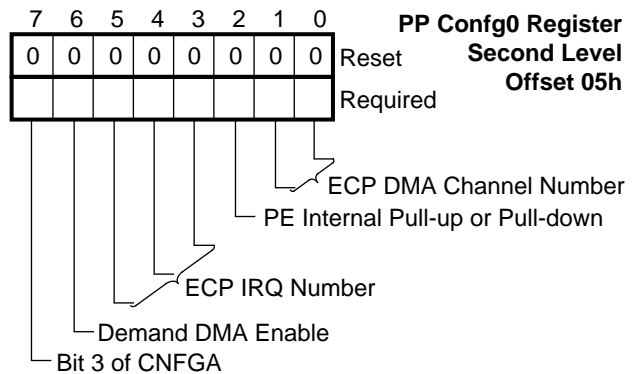
Bits 1, 0 - ECP DMA Channel Number

These bits identify the ECP DMA channel number, as reflected on bits 1 and 0 of the ECP CNFGB register. See Section 4.5.11 "Configuration Register B (CNFGB)" on page 91. Actual ECP DMA routing is controlled by the DMA channel select register (index 74h) of this logical device.

Microsoft's ECP protocol and ISA interface standard define bits 1 and 0 of CNFGB as shown in TABLE 4-7 "ECP Mode DMA Selection" on page 91.

Bit 2 - Paper End (PE) Internal Pull-up or Pull-down Resistor Select

0: PE has a nominal 25 KΩ internal pull-down resistor.

1: PE has a nominal 25 KΩ internal pull-up resistor.

Bits 5- 3 - ECP IRQ Number

These bits identify the ECP IRQ number, as reflected on bits 5 through 3 of the ECP CNFGB register. See Section 4.5.11 "Configuration Register B (CNFGB)" on page 91. Actual ECP IRQ routing is controlled by interrupt select register (index 70h) of this logical device.

Microsoft's ECP protocol and ISA interface standard defines bits 5 through 3 of CNFGB, as shown in TABLE 4-8 "ECP Mode Interrupt Selection" on page 91.

Bit 6 - Demand DMA Enable

If enabled, DRQ is asserted when a FIFO threshold of 4 is reached or when flush-time-out expires, except when DMA fairness prevents DRQ assertion. The threshold of 4 is for four empty entries forward and for four valid entries backward.

Once DRQ is asserted, it is held asserted for four DMA transfers, as long as the FIFO is able to process these four transfers, i.e., FIFO not empty backward.

When these four transfers are done, the DRQ behaves as follows:

— If DMA fairness prevents DRQ assertion (as in the case of 32 consecutive DMA transfers) then DRQ becomes low.

— If the FIFO is not able to process another four transfers (below threshold), then DRQ is becomes low.

— If the FIFO is able to process another four transfers (still above the threshold and no fairness to prevent DRQ assertion), then DRQ is held asserted as detailed above.

The flush time-out is an 8-bit counter that counts 256 clocks of 24 MHz and triggers DRQ assertion when the terminal-count is reached, i.e., when flush time-out expires). The counter is enabled for counting backward when the peripheral state machine writes a byte and DRQ is not asserted. Once enabled, it counts the 24 MHz clocks. The counter is reset and disabled when DRQ is asserted. The counter is also reset and disabled for counting forward and when demand the DMA is disabled.

This mechanism is reset whenever ECP mode is changed, the same way the FIFO is flushed in this case.

0: Disabled.

1: Enabled.

Bit 7 - Bit 3 of CNFGA

This bit may be utilized by the user. The value of this bit is reflected on bit 3 of the ECP CNFGA register.

4.6   DETAILED ECP MODE DESCRIPTIONS

TABLE 4-11 "ECP Modes" on page 96 summarizes the functionality of the ECP in each mode. The following Sections describe how the ECP functions in each mode, in detail.

4.6.1   Software Controlled Data Transfer (Modes 000 and 001)

Software controlled data transfer is supported in modes 000 and 001. The software generates peripheral-device cycles by modifying the DATAR and DCR registers and reading the DSR, DCR and DATAR registers. The negotiation phase and nibble mode transfer, as defined in the IEEE 1284 standard, are performed in these modes.

In these modes the FIFO is reset (empty) and is not functional, the DMA and RLE are idle.

Mode 000 is for the forward direction only; the direction bit (bit 5 of DCR) is forced to 0 and PD7-0 are driven. Mode 001 is for both the forward and backward directions. The direction bit controls whether or not pins PD7-0 are driven.

4.6.2   Automatic Data Transfer (Modes 010 and 011)

Automatic data transfer (ECP cycles generated by hardware) is supported only in modes 010 and 011 (Parallel Port and ECP FIFO modes). Automatic DMA access to fill or empty the FIFO is supported in modes 010, 011 and 110. Mode 010 is for the forward direction only; the direction bit is forced to 0 and PD7-0 are driven. Mode 011 is for both the forward and backward directions. The direction bit controls whether PD7-0 are driven.

Automatic Run Length Expanding (RLE) is supported in the backward direction.

Forward Direction (Bit 5 of DCR = 0)

When the ECP is in forward direction and the FIFO is not full (bit 1 of ECR is 0) the FIFO can be filled by software writes to the FIFO registers (AFIFO and DFIFO in mode 011, and CFIFO in mode 010).

When DMA is enabled (bit 3 of ECR is 1 and bit 2 of ECR is 0) the ECP automatically issues DMA requests to fill the FIFO with data bytes (not including command bytes).

When the ECP is in forward direction and the FIFO is not empty (bit 0 of ECR is 0) the ECP pops a byte from the FIFO and issues a write signal to the peripheral device. The ECP drives $\overline{AFD}$ according to the operation mode (bits 7-5 of ECR) and according to the tag of the popped byte as follows:

• In Parallel Port FIFO mode (mode 010) $\overline{AFD}$ is controlled by bit 1 of DCR.

• In ECP mode (mode 011) $\overline{AFD}$ is controlled by the popped tag. $\overline{AFD}$ is driven high for normal data bytes and driven low for command bytes.

ECP (Forward) Write Cycle

An ECP write cycle starts when the ECP drives the popped tag onto $\overline{AFD}$ and the popped byte onto PD7-0. When BUSY is low the ECP asserts $\overline{STB}$. In 010 mode the ECP deactivates $\overline{STB}$ to terminate the write cycle. In 011 mode the ECP waits for BUSY to be high.

When BUSY is high, the ECP deactivates $\overline{STB}$, and changes $\overline{AFD}$ and PD7-0 only after BUSY is low.

TABLE 4-11. ECP Modes

ECP Mode (ECR Bits)			ECP Mode Name	Operation Description
7	6	5		
0	0	0	Standard	Write cycles are under software control. $\overline{STB}$, $\overline{AFD}$, $\overline{INIT}$ and $\overline{SLIN}$ are open-drain output signals. Bit 5 of DCR is forced to 0 (forward direction) and PD7-0 are driven. The FIFO is reset (empty). Reading DATAR returns the last value written to DATAR.
0	0	1	PS/2	Read and write cycles are under software control. The FIFO is reset (empty). $\overline{STB}$, $\overline{AFD}$, $\overline{INIT}$ and $\overline{SLIN}$ are push-pull output signals.
0	1	0	Parallel Port FIFO	Write cycles are automatic, i.e., under hardware control ($\overline{STB}$ is controlled by hardware). Bit 5 of DCR is forced to 0 internally (forward direction) and PD7-0 are driven. $\overline{STB}$, $\overline{AFD}$, $\overline{INIT}$ and $\overline{SLIN}$ are push-pull output signals.
0	1	1	ECP FIFO	The FIFO direction is automatic, i.e., controlled by bit 5 of DCR. Read and write cycles to the device are controlled by hardware ($\overline{STB}$ and $\overline{AFD}$ are controlled by hardware). $\overline{STB}$, $\overline{AFD}$, $\overline{INIT}$ and $\overline{SLIN}$ are push-pull output signals.
1	0	0	EPP	EPP mode is enabled by bits 7 through 5 of the SuperI/O Parallel Port Configuration register, as described in Section 2.6. In this mode, registers DATAR, DSR, and DCR are used as registers at offsets 00h, 01h and 02h of the EPP instead of registers DTR, STR, and CTR. $\overline{STB}$, $\overline{AFD}$, $\overline{INIT}$, and $\overline{SLIN}$ are push-pull output buffers. When there is no access to one of the EPP registers (ADDR, DATA0, DATA1, DATA2 or DATA3), mode 100 behaves like mode 001, i.e., software can perform read and write cycles. The software should check that bit 7 of the DSR is 1 before reading or writing the DATAR register, to avoid corrupting an ongoing EPP cycle.
1	0	1	Reserved	
1	1	0	FIFO Test	The FIFO is accessible via the TFIFO register. The ECP does not issue ECP cycles to fill or empty the FIFO.
1	1	1	Configuration	CNFGA and CNFGB registers are accessible.
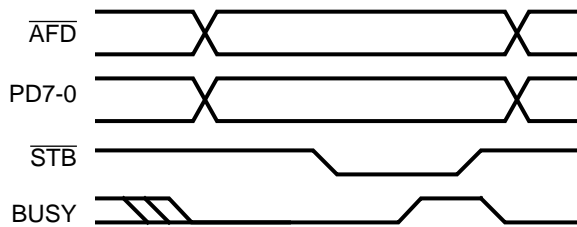
FIGURE 4-5. ECP Forward Write Cycle

Backward Direction (Bit 5 of DCR is 1)

When the ECP is in the backward direction, and the FIFO is not full (bit 1 of ECR is 0), the ECP issues a read cycle to the peripheral device and monitors the BUSY signal. If BUSY is high the byte is a data byte and it is pushed into the FIFO. If BUSY is low the byte is a command byte.

The ECP checks bit 7 of the command byte. If it is high the byte is ignored, if it is low the byte is tagged as an RLC byte (not pushed into the FIFO but used as a Run Length Count to expand the next byte read). Following an RLC read the ECP issues a read cycle from the peripheral device to read the data byte to be expanded. This byte is considered a

data byte, regardless of its BUSY state (even if it is low). This byte is pushed into the FIFO (RLC+1) times (e.g. for RLC=0, push the byte once. For RLC=127 push the byte 128 times).

When the ECP is in the backward direction, and the FIFO is not empty (bit 0 of ECR is 0), the FIFO can be emptied by software reads from the FIFO register (true only for the TFIFO in mode 011, not for AFIFO or CFIFO reads).

When DMA is enabled (bit 3 of ECR is 1 and bit 2 of ECR is 0) the ECP automatically issues DMA requests to empty the FIFO (only in mode 011).

ECP (Backward) Read Cycle

An ECP read cycle starts when the ECP drives $\overline{AFD}$ low.

The peripheral device drives BUSY high for a normal data read cycle, or drives BUSY low for a command read cycle, and drives the byte to be read onto PD7-0.

When $\overline{ACK}$ is asserted the ECP drives $\overline{AFD}$ high. When $\overline{AFD}$ is high the peripheral device deasserts $\overline{ACK}$. The ECP reads the PD7-0 byte, then drives $\overline{AFD}$ low. When $\overline{AFD}$ is low the peripheral device may change BUSY and PD7-0 states in preparation for the next cycle
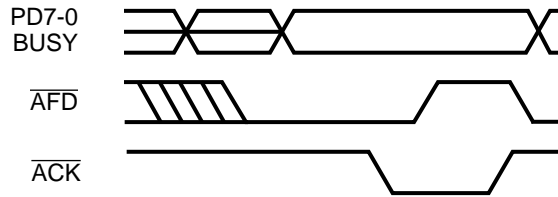
FIGURE 4-6. ECP (Backward) Read Cycle

Notes:

1. FIFO-full condition is checked before every expanded byte push.

2. Switching from modes 010 or 011 to other modes removes pending DMA requests and aborts pending RLE expansion.

3. FIFO pushes and pops are neither synchronized nor linked at the hardware level. The FIFO will not delay these operations, even if performed concurrently. Care must be taken by the programmer to utilize the empty and full FIFO status bits to avoid corrupting PD7-0 or D7-0 while a previous FIFO port access not complete.

4. In the forward direction, the empty bit is updated when the ECP cycle is completed, not when the last byte is popped from the FIFO (valid cleared on cycle end).

5. The one-bit command/data tag is used only in the forward direction.

4.6.3 Automatic Address and Data Transfers (Mode 100)

Automatic address and data transfer (EPP cycles generated by hardware) is supported in mode 100. Fast transfers are achieved by automatically generating the address and data strobes.

In this mode, the FIFO is reset (empty) and is not functional, the DMA and RLE are idle.

The direction of the automatic data transfers is determined by the $\overline{RD}$ and $\overline{WR}$ signals. The direction of software data transfer can be forward or backward, depending on bit 5 of the DCR. Bit 5 of the DCR determines the default direction of the data transfers only when there is no on-going EPP cycles.

In EPP mode 100, registers DATAR, DSR and DCR are used instead of DTR, STR and CTR respectively.

Some differences are caused by the registers. Reading DATAR returns pins values instead of register value returned when reading DTR. Reading DSR returns register value instead of pins values returned when reading STR. Writing to the DATAR during an on-going EPP 1.9 forward cycle (i.e. - when bit 7 of DSR is 1) causes the new data to appear immediately on PD7-0, instead of waiting for BUSY to become low to switch PD7-0 to the new data when writing to the DTR.

In addition, the bit 4 of the DCR functions differently relative to bit 4 of the CTR (IRQ float).

4.6.4 FIFO Test Access (Mode 110)

Mode 110 is for testing the FIFO in PIO and DMA cycles. Both read and write operations (pop and push) are supported, regardless of the direction bit.

In the forward direction PD7-0 are driven, but the data is undefined. This mode can be used to measure the system-ECP cycle throughput, usually with DMA cycles. This mode can also be used to check the FIFO depth and its interrupt threshold, usually with PIO cycles.

4.6.5 Configuration Registers Access (Mode 111)

The two configuration registers, CNFGA and CNFGB, are accessible only in this mode.

4.6.6 Interrupt Generation

An interrupt is generated when any of the events described in this section occurs. Interrupt events 2, 3 and 4 are level events. They are shaped as interrupt pulses, and are masked (inactive) when the ECP clock is frozen.

Event 1

Bit 2 of ECR is 0, bit 3 of ECR is 1 and TC is asserted during ECP DMA cycle. Interrupt event 1 is a pulse event.

Event 2

Bit 2 of ECR is 0, bit 3 of ECR is 0, bit 5 of DCR is 0 and there are eight or more bytes free in the FIFO.

This event includes the case when bit 2 of ECR is cleared to 0 and there are already eight or more bytes free in the FIFO (modes 010, 011 and 110 only).

Event 3

Bit 2 of ECR is 0, bit 3 of ECR is 0, bit 5 of DCR is 1 and there are eight or more bytes to be read from the FIFO.

This event includes the case when bit 2 of ECR is cleared to 0 and there are already eight or more bytes to be read from the FIFO (modes 011 and 110 only).

Event 4

Bit 4 of ECR is 0 and $\overline{ERR}$ is asserted (high to low edge) or $\overline{ERR}$ is asserted when bit 4 of ECR is modified from 1 to 0.

This event may be lost when the ECP clock is frozen.

Event 5

When bit 4 of DCR is 1 and $\overline{ACK}$ is deasserted (low-to-high edge).

This event behaves as in the normal SPP mode, i.e., the IRQ signal follows the $\overline{ACK}$ signal transition.

4.7   PARALLEL PORT REGISTER BITMAPS

4.7.1   EPP Modes

4.7.2   ECP Modes

Bits 7-5 of ECR = 000 or 001

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

**ECP Data Register
(DATAR)
Offset 000h**

- D0
- D1
- D2
- D3
- D4 — Data Bits
- D5
- D6
- D7

Bits 7-5 of ECR = 010

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

**Parallel Port FIFO
Register (CFIFO)
Offset 400h**

- D0
- D1
- D2
- D3
- D4 — Data Bits
- D5
- D6
- D7

Bits 7-5 of ECR = 011

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

**ECP Address Register
(AFIFO)
Offset 000h**

- A0
- A1
- A2
- A3
- A4 — Address Bits
- A5
- A6
- A7

Bits 7-5 of ECR = 011

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

**ECP Data FIFO
Register (DFIFO)
Offset 400h**

- D0
- D1
- D2
- D3
- D4 — Data Bits
- D5
- D6
- D7

7	6	5	4	3	2	1	0	
					1	1	1	Reset
								Required

**ECP Status Register
(DSR)
Offset 001h**

- EPP Time-Out Status
- Reserved
- Reserved
- ERR Status
- SLCT Status
- PE Status
- ACK Status
- Printer Status

Bits 7-5 of ECR = 110

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

**Test FIFO
Register (TFIFO)
Offset 400h**

- D0
- D1
- D2
- D3
- D4
- D5 — Data Bits
- D6
- D7

7	6	5	4	3	2	1	0	
1	1	0	0	0	0	0	0	Reset
								Required

**ECP Control
Register (DCR)
Offset 002h**

- Data Strobe Control
- Automatic Line Feed Control
- Printer Initialization Control
- Parallel Port Input Control
- Interrupt Enable
- Direction Control
- Reserved
- Reserved

Bits 7-5 of ECR = 111

7	6	5	4	3	2	1	0	
0	0	0	1	0	1	0	0	Reset
0	0	0	1		1	0	0	Required

**Configuration Register A
(CNFGA)
Offset 400h**

- Always 0
- Always 0
- Always 1
- Bit 7 of PP Confg0
- Always 1
- Always 0
- Always 0
- Always 0

PARALLEL PORT REGISTER BITMAPS

Bits 7-5 of ECR = 111

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0

Configuration Register B (CNFGB) Offset 401h
Reset
Required

— DMA Channel Select
— Reserved
— Interrupt Select
— IRQ Signal Value
— Reserved

ECP Extended Auxiliary Status Register (EAR) Offset 405h

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0

Reset
Required

— Reserved
— FIFO Tag

Extended Control Register(ECR) Offset 402h

7	6	5	4	3	2	1	0
0	0	0	1	0			1

Reset
Required

— FIFO Empty
— FIFO Full
— ECP Interrupt Service
— ECP DMA Enable
— ECP Interrupt Mask
— ECP Mode Control

Control0 Register Second Level Offset 00h

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0

Reset
Required

— EPP Time-Out Interrupt Mask
— Reserved
— Reserved
— Reserved
— Freeze Bit
— DCR Register Live
— Reserved

ECP Extended Index Register (EIR) Offset 403h

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0

Reset
Required

— Second Level Offset
— Reserved
— Reserved
— Reserved
— Reserved
— Reserved

Control2 Register Second Level Offset 02h

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0

Reset
Required

— Reserved
— Reserved
— Reserved
— Reserved
— Revision 1.7 or 1.9 Select
— Reserved
— Channel Address Enable
— SPP Compatability

ECP Extended Data Register (EDR) Offset 404h

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0

Reset
Required

— D0
— D1
— D2
— D3
— D4
— D5
— D6
— D7
Data Bits

4.8 PARALLEL PORT PIN/SIGNAL LIST

TABLE 4-12 shows the standard 25-pin, D-type connector definition for parallel port operations.

TABLE 4-12. Parallel Port Pin Out

Connector Pin	Pin No.	SPP, ECP Mode	I/O	EPP Mode	I/O
1	67	$\overline{\text{STB}}$	I/O	$\overline{\text{WRITE}}$	I/O
2	75	PD0	I/O	PD0	I/O
3	76	PD1	I/O	PD1	I/O
4	77	PD2	I/O	PD2	I/O
5	78	PD3	I/O	PD3	I/O
6	79	PD4	I/O	PD4	I/O
7	80	PD5	I/O	PD5	I/O
8	81	PD6	I/O	PD6	I/O
9	82	PD7	I/O	PD7	I/O
10	68	$\overline{\text{ACK}}$	I	$\overline{\text{ACK}}$	I
11	66	BUSY	I	$\overline{\text{WAIT}}$	I
12	70	PE	I	PE	I
13	69	SLCT	I	SLCT	I
14	74	$\overline{\text{AFD}}$	I/O	$\overline{\text{DSTRB}}$	I/O
15	71	$\overline{\text{ERR}}$	I	$\overline{\text{ERR}}$	I
16	72	$\overline{\text{INIT}}$	I/O	$\overline{\text{INIT}}$	I/O
17	73	$\overline{\text{SLIN}}$	I/O	$\overline{\text{ASTRB}}$	I/O
18 - 23		GND		GND	
25		GND		GND	

5.0 Enhanced Serial Port with IR - UART2 (Logical Device 2)

This module provides advanced, versatile serial communications features with infrared capabilities. It supports four modes of operation: UART, Sharp-IR, IrDA 1.0 SIR (hereafter called SIR) and Consumer-IR (also called TV-Remote or Consumer remote-control). In UART mode, the module can function as a standard 16450 or 16550, or as an Extended UART.

Existing 16550-based legacy software is completely and transparently supported. Module organization and specific fallback mechanisms switch the module to 16550 compatibility mode upon reset or when initialized by 16550 software.

You can configure this module for either partial or full infrared communication support, as follows:

I Mode 1: Full-IR Mode (CFG0 = 0)
Fully IR-compliant device only. All the UART compliance pins of UART2 are not available (i.e. the outputs are not routed and the inputs are assumed inactive). Any attempt to work with the port as a UART in this mode has no effect.

I Mode 2: Two-UART Mode (CFG0 = 1)
Works as UART or as partially IR-compliant device. The IR interface includes only two signals, IRTX and IRRX1. The IRSL2-0 pins and ID3-0 inputs are not available in this mode. Any attempt to work with IRRX2 and/or to manipulate IRSL2-0 in this mode has no effect.

This module does not recognize the operation mode, and there is no hardware protection against invalid usage or configuration. The software must therefore avoid any invalid operation of the UART2 in either one of these two modes.

This module includes two DMA channels; the device can use either 1 or 2 of these channels. One channel is required for infrared-based applications, since infrared communication works in half duplex fashion. Two channels would normally be needed to handle high-speed full duplex UART based applications.

5.1 FEATURES

- Fully compatible with 16550 and 16450 devices
- Automatic fallback to 16550 compatibility mode
- Extended UART mode
- UART baud rates up to 1.5 Mbps
- Sharp-IR with selectable internal or external modulation/demodulation
- IrDA 1.0 SIR with data rates up to 115.2 Kbps
- Consumer-IR (TV-Remote) mode
- Full duplex infrared capability for diagnostics
- Transmission deferral (in Consumer-IR mode)
- Selectable 16-level transmission and reception FIFOs (RX_FIFO & TX_FIFO respectively)
- Multiple optical transceiver support
- Automatic or manual transceiver configuration
- Support for Plug-n-Play infrared adapters

5.2 FUNCTIONAL MODES OVERVIEW

This multi-mode module can be configured to act as any one of several different functions. Although each mode is unique, certain system resources and features are common to some or to all modes.

5.2.1 UART Modes: 16450 or 16550, and Extended

UART modes support serial data communications with a remote peripheral device or modem using a wired interface. The device transmits and receives data concurrently in full-duplex operation, performing parallel-to-serial and serial-to-parallel conversion and other functions required to exchange parallel data with the system. It also interfaces with external devices using a programmable serial communications format.

The following UART modes are supported:

- 16450 or 16550 mode (Non-Extended modes)
- Extended mode

The 16450 or 16550 mode is functionally and software-compatible with the standard 16450 or 16550 UARTs. This is the default mode of operation after power up, after reset or when initialized by software written for the 16450 or 16550 UART (Special mechanisms switch the module automatically to 16550 UART mode when standard 16550 software is run).

The 16550 UART mode has all the features of the 16450 mode, with the addition of 16-byte data FIFOs for more efficient data I/O.

In Extended mode, additional features become available that enhance the UART performance, such as additional interrupts and DMA ability (see "Extended UART Mode" on page 104).

The UART supports baud rates of up to 115.2 Kbps in 16450 or 16550 mode, and up to 1.5 Mbps in Extended mode.

5.2.2 Sharp-IR, IrDA SIR Infrared Modes

The Sharp-IR mode provides bidirectional communication by transmitting and receiving infrared radiation. In this mode, infrared I/O circuits was added to the UART, which operates at 38.4 Kbps in half-duplex, using normal UART serial data formats with Digital Amplitude Shift Keying (DASK) modulation. The modulation/demodulation can be operated internally or externally.

In SIR mode, the system functions similarly to the Sharp-IR mode, but at 115.2 Kbps.

5.2.3 Consumer IR Mode

Consumer-IR mode supports all the protocols presently used in remote-controlled home entertainment equipment: RC-5, RC-6, RECS 80, NEC and RCA. The serial format is not compatible with UART operation, and specific circuitry performs all the hardware tasks required for signal conditioning and formatting. The software is responsible for the generation of the infrared code to be transmitted, and for the interpretation of the received code.

5.3 REGISTER BANK OVERVIEW

Eight register banks, each containing eight registers, control UART operation. All registers use the same 8-byte address space to indicate offsets 00h through 07h, and the active bank must be selected by the software.

The register bank organization enables access to the banks as required for activation of all module modes, while maintaining transparent compatibility with 16450 or 16550 software, which activates only the registers and specific bits used in those devices. For details, See Section 5.4.

The Bank Selection Register (BSR) selects the active bank and is common to all banks. See Figure 5-1. Therefore, each bank defines seven new registers.
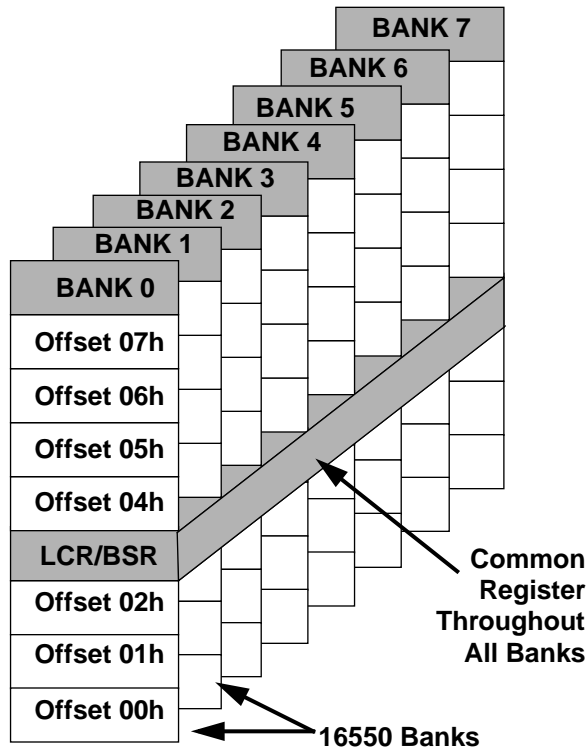
FIGURE 5-1. Register Bank Architecture

The default bank selection after system reset is 0, which places the module in the UART 16550 mode. Additionally, setting the baud in bank 1 (as required to initialize the 16550 UART) switches the module to a Non-Extended UART mode. This ensures that running existing 16550 software will switch the system to the 16550 configuration without software modification.

Table 5-1 shows the main functions of the registers in each bank. Banks 0-3 control both UART and infrared modes of operation; banks 4-7 control and configure the infrared modes only.

TABLE 5-1. Register Bank Summary

Bank	UART	IR Mode	Main Functions
0	✓	✓	Global Control and Status
1	✓	✓	Legacy Bank
2	✓	✓	Baud Generator Divisor, Extended Control and Status
3	✓	✓	Module Revision ID and Shadow Registers
4		✓	IR mode setup
5		✓	Infrared Control
6		✓	Infrared Physical Layer Configuration
7		✓	Consumer-IR and Optical Transceiver Configuration

Banks 0 and 1 are the 16550 register banks. The registers in these banks are equivalent to the registers contained in the 16550 UARTs and are accessed by 16550 software drivers as if the module was a 16550. Bank 1 contains the legacy Baud Generator Divisor Ports. Bank 0 registers control all other aspects of the UART function, including data transfers, format setup parameters, interrupt setup and status monitoring.

Bank 2 contains the non-legacy Baud Generator Divisor Ports, and controls the extended features special to this UART, that are not included in the 16550 repertoire. These include DMA usage. See "Extended UART Mode" on page 104.

Bank 3 contains the Module Revision ID and shadow registers. The Module Revision ID (MRID) register contains a code that identifies the revision of the module when read by software. The shadow registers contain the identical content as reset-when-read registers within bank 0. Reading their contents from the shadow registers lets the system read the register content without resetting them.

Bank 4 contains setup parameters for the Infra-red modes.

Bank 5 registers control infrared parameters related to the logical system I/O parameters.

Bank 6 registers control physical characteristics involved in infrared communications (e.g. pulse width selection).

Bank 7 registers are dedicated to Consumer-IR configuration and control.

5.4 UART MODES – DETAILED DESCRIPTION

The UART modes support serial data communications with a remote peripheral device or modem using a wired interface.

The module provides receive and transmit channels that can operate concurrently in full-duplex mode. This module performs all functions required to conduct parallel data interchange with the system and composite serial data exchange with the external data channel, including:

- Format conversion between the internal parallel data format and the external programmable composite serial format. See Figure 5-2.

- Serial data timing generation and recognition

- Parallel data interchange with the system using a choice of bi-directional data transfer mechanisms

- Status monitoring for all phases of the communications activity

The module supplies modem control registers, and a prioritized interrupt system for efficient interrupt handling.

5.4.1 16450 or 16550 UART Mode

The module defaults to 16450 mode after power up or reset. UART 16550 mode is equivalent to 16450 mode, with the addition of a 16-byte data FIFO for more efficient data I/O. Transparent compatibility is maintained with this UART mode in this module.

Despite the many additions to the basic UART hardware and organization, the UART responds correctly to existing software drivers with no software modification required. When 16450 software initializes and addresses this module, it will in always perform as a 16450 device.

Data transfer takes place by use of data buffers that interface internally in parallel and with the external data channel in a serial format. 16-byte data FIFOs may reduce host overhead by enabling multiple-byte data transfers within a single interrupt. With FIFOs disabled, this module is equivalent to the standard 16450 UART. With FIFOs enabled, the hardware functions as a standard 16550 UART.

The composite serial data stream interfaces with the data channel through signal conditioning circuitry such as TTL/RS232 converters, modem tone generators, etc.

Data transfer is accompanied by software-generated control signals, which may be utilized to activate the communications channel and "handshake" with the remote device. These may be supplied directly by the UART, or generated by control interface circuits such as telephone dialing and answering circuits, etc.

FIGURE 5-2. Composite Serial Data

The composite serial data stream produced by the UART is illustrated in Figure 5-2. A data word containing five to eight bits is preceded by start bits and followed by an optional parity bit and a stop bit. The data is clocked out, LSB first, at a predetermined rate (the baud).

The data word length, parity bit option, number of start bits and baud are programmable parameters.

The UART includes a programmable Baud Generator that produces the baud clocks and associated timing signals for serial communication.

The system can monitor this module status at any time. Status information includes the type and condition of the transfer operation in process, as well as any error conditions (e.g., parity, overrun, framing, or break interrupt).

The module resources include modem control capability and a prioritized interrupt system. Interrupts can be programmed to match system requirements, minimizing the CPU overhead required to handle the communications link.

Programmable Baud Generator

This module contains a programmable Baud Generator that generates the clock rates for serial data communication (both transmit and receive channels). It divides its input clock by any divisor value from 1 to 2^{16} - 1. The output clock frequency of the Baud Generator must be programmed to be sixteen times the baud value. A 24 MHz input frequency is divided by a prescale value (PRESL field of EXCR2 - see page 121. Its default value is 13) and by a 16-bit programmable divisor value contained in the Baud Generator Divisor High and Low registers (BGD(H) and BGD(L) - see page 119). Each divisor value yields a clock signal (BOUT) and a further division by 16 produces the baud clock for the serial data stream. It may also be output as a test signal when enabled (see bit 7 of EXCR1 on page 120.)

These user-selectable parameters enable the user to generate a large choice of serial data rates, including all standard baud rates. A list of baud rates and their settings appears in Table 5-14 on page 119.

Module Operation

Before module operation can begin, both the communications format and baud must be programmed by the software. The communications format is programmed by loading a control byte into the LCR register, while the baud is selected by loading an appropriate value into the Baud Generator Divisor Registers and the divisor preselect values (PRESL) into EXCR2 (see page 121).

The software can read the status of the module at any time during operation. The status information includes full or empty state for both transmission and reception channels, and any other condition detected on the received data stream, like parity error, framing error, data overrun, or break event.

5.4.2 Extended UART Mode

In Extended UART mode of operation, the module configuration changes and additional features become available which enhance UART capabilities.

- The interrupt sources are no longer prioritized; they are presented bit-by-bit in the EIR (see page 110).

- An auxiliary status and control register replaces the scratchpad register. It contains additional status and control flag bits ("Auxiliary Status and Control Register (ASCR)" on page 117).

- The TX_FIFO can generate interrupts when the number of outgoing bytes in the TX_FIFO drops below a programmable threshold. In the Non-Extended UART modes, only reception FIFOs have the thresholding feature.

- DMA capability is available.

- Interrupts occur when the transmitter becomes empty or a DMA event occurs.

5.5 SHARP-IR MODE – DETAILED DESCRIPTION

This mode supports bidirectional data communication with a remote device using infrared radiation as the transmission medium. Sharp-IR uses Digital Amplitude Shift Keying (DASK) and allows serial communication at baud rates up to 38.4 Kbaud. The format of the serial data is similar to the UART data format. Each data word is sent serially beginning with a zero value start bit, followed by up to eight data bits (LSB first), an optional parity bit, and ending with at least one stop bit with a binary value of one. A logical zero is signalled by sending a 500 KHz continuous pulse train of infrared radiation. A logical 1 is signalled by the absence of any infrared signal. This module can perform the modulation and demodulation operations internally, or can rely on the external optical module to perform them.

Sharp-IR device operation is similar to the operation in UART mode, the main difference being that data transfer operations are normally performed in half duplex fashion, and the modem control and status signals are not used. Selection of the Sharp-IR mode is controlled by the Mode Select (MDSL) bits in the MCR register when the module is in Extended mode, or by the IR_SL bits in the IRCR1 register when the module is not in extended mode. This prevents legacy software, running in non-extended mode, from spuriously switching the module to UART mode, when the software writes to the MCR register.

5.6 SIR MODE – DETAILED DESCRIPTION

This operational mode supports bidirectional data communication with a remote device using infrared radiation as the transmission medium.

SIR allows serial communication at baud rates up to 115.2 Kbuad. The serial data format is similar to the UART data format. Each data word is sent serially beginning with a 0 value start bit, followed by eight data bits (LSB first), an optional parity bit, and ending with at least one stop bit with a binary value of 1.

A zero value is signalled by sending a single infrared pulse. A one value is signalled by not sending any pulse. The width of each pulse can be either 1.6 μsec or 3/16 of the time required to transmit a single bit. (1.6 μsec equals 3/16 of the time required to transmit a single bit at 115.2 Kbps). This way, each word begins with a pulse for the start bit.

The module operation in SIR is similar to the operation in UART mode, the main difference being that data transfer operations are normally performed in half duplex fashion. Selection of the IrDA 1.0 SIR mode is controlled by the MDSL bits in the MCR register when the UART is in Extended mode, or by the IR_SL bits in the IRCR1 register when the UART is not in Extended mode. This prevents legacy software, running in Non-Extended mode, from spuriously switching the module to UART mode, when the software writes to the MCR register.

5.7 CONSUMER-IR MODE – DETAILED DESCRIPTION

The Consumer-IR circuitry in this module is designed to optimally support all the major protocols presently used in remote-controlled home entertainment equipment: RC-5, RC-6, RECS 80, NEC and RCA.

This module, in conjunction with an external optical device, provides the physical layer functions necessary to support these protocols. These functions include: modulation, demodulation, serialization, deserialization, data buffering, status reporting, interrupt generation, etc.

The software is responsible for the generation of the infrared code to be transmitted, and for the interpretation of the received code.

5.7.1 Consumer-IR Transmission

The code to be transmitted consists of a sequence of bytes that represent either a bit string or a set of run-length codes. The number of bits or run-length codes usually needed to represent each infrared code bit depends on the infrared protocol to be used. The RC-5 protocol, for example, needs two bits or between one and two run-length codes to represent each infrared code bit.

Transmission is initiated when the CPU or DMA module writes code bytes into the empty TX_FIFO. Transmission is normally completed when the CPU sets the S_EOT bit in the ASCR register (See Section 5.11.10 on page 117), before writing the last byte, or when the DMA controller activates the TC (terminal count) signal. Transmission will also terminate if the CPU simply stops transferring data and the transmitter becomes empty. In this case, however, a transmitter-underrun condition will be generated, which must be cleared in order to begin the next transmission.

The transmission bytes are either de-serialized or run-length encoded, and the resulting bit string modulates a carrier signal and is sent to the transmitter LED. The transfer rate of this bit string, like in the UART mode, is determined by the value programmed in the Baud Generator Divisor Registers. Unlike a UART transmission, start, stop and parity bits are not included in the transmitted data stream. A logic 1 in the bit string keeps the LED off, so no infrared signal is transmitted. A logic 0, generates a sequence of modulating pulses which will turn on the transmitter LED. Frequency and pulse width of the modulating pulses are programmed by the MCFR and MCPW fields in the IRTXMC register as well as the TXHSC bit in the RCCFG register. Sections 5.18.2 and 5.18.3 describe these registers in detail.

The RC_MMD field selects the transmitter modulation mode. If C_PLS mode is selected, modulating pulses are generated continuously for the entire logic 0 bit time. If 6_PLS or 8_PLS mode is selected, six or eight pulses are generated each time a logic 0 bit is transmitted following a logic 1 bit. The total transmission time for the logic 0 bits must be equal-to or greater-than 6 or 8 times the period of the modulation subcarrier, otherwise, fewer pulses will be transmitted.

C_PLS modulation mode is used for RC-5, RC-6, NEC and RCA protocols. 8_PLS or 6_PLS modulation mode is used for the RECS 80 protocol. The 8_PLS or 6_PLS mode allows minimization of the number of bits needed to represent the RECS 80 infrared code sequence. The current transmitter implementation supports only the modulated modes of the RECS 80 protocol. It does not support Flash mode.

5.7.2 Consumer-IR Reception

The Consumer-IR receiver is significantly different from a UART receiver in two ways. Firstly, the incoming infrared signals are DASK modulated. Therefore, demodulation may be necessary. Secondly, there are no start bits in the incoming data stream.

Whenever an infrared signal is detected, receiver operations depend on whether or not receiver demodulation is enabled. If demodulation is disabled, the receiver immediately becomes active. If demodulation is enabled, the receiver checks the carrier frequency of the incoming signal, and becomes active only if the frequency is within the programmed range. Otherwise, the signal is ignored and no other action is taken.

When the receiver enters the active state, the RXACT bit in the ASCR register is set to 1. Once in the active state, the receiver keeps sampling the infrared input signal and generates a bit string where a logic 1 indicates an idle condition and a logic 0 indicates the presence of infrared energy. The infrared input is sampled regardless of the presence of infrared pulses at a rate determined by the value loaded into the Baud Generator Divisor Registers. The received bit string is either de-serialized and assembled into 8-bit characters, or it is converted to run-length encoded values. The resulting data bytes are then transferred into the RX_FIFO.

The receiver also sets the RXWDG bit in the ASCR register each time an infrared pulse signal is detected. This bit is automatically cleared when the ASCR register is read, and it is intended to assist the software in determining when the infrared link has been idle for a certain time. The software can then stop the data reception by writing a 1 into the RXACT bit to clear it and return the receiver to the inactive state.

The frequency bandwidth for the incoming modulated infrared signal is selected by the DFR and DBW fields in the IRRXDC register.

There are two Consumer-IR reception data modes: "Over-sampled" and "Programmed T Period" mode. For either mode the sampling rate is determined by the setting of the Baud Generator Divisor Registers.

The "Over-sampled" mode can be used with the receiver demodulator either enabled or disabled. It should be used with the demodulator disabled when a detailed snapshot of the incoming signal is needed, for example to determine the period of the carrier signal. If the demodulator is enabled, the stream of samples can be used to reconstruct the incoming bit string. To obtain good resolution, a fairly high sampling rate should be selected.

The "Programmed-T-Period" mode should be used with the receiver demodulator enabled. The T Period represents one half bit time for protocols using biphase encoding, or the basic unit of pulse distance for protocols using pulse distance encoding. The baud is usually programmed to match the T Period. For long periods of logic low or high, the receiver samples the demodulated signal at the programmed sampling rate.

Whenever a new infrared energy pulse is detected, the receiver synchronizes the sampling process to the incoming signal timing. This reduces timing related errors and eliminates the possibility of missing short infrared pulse sequences, especially with the RECS 80 protocol.

In addition, the "Programmed-T-Period" sampling minimizes the amount of data used to represent the incoming infrared signal, therefore reducing the processing overhead in the host CPU.

5.8 FIFO TIME-OUTS

Time-out mechanisms prevent received data from remaining in the RX_FIFO indefinitely, if the programmed interrupt or DMA thresholds are not reached.

An RX_FIFO time-out generates a Receiver Data Ready interrupt and/or a receiver DMA request if bit 0 of IER and/or bit 2 of MCR (in Extended mode) are set to 1 respectively. An RX_FIFO time-out also sets bit 0 of ASCR to 1 if the RX_FIFO is below the threshold. When a Receiver Data Ready interrupt occurs, this bit is tested by the software to determine whether a number of bytes indicated by the RX_FIFO threshold can be read without checking bit 0 of the LSR register.

The conditions that must exist for a time-out to occur in the various modes of operation are described below.

When a time-out has occurred, it can only be reset when the FIFO is read by the CPU or DMA controller.

5.8.1 UART, SIR or Sharp-IR Mode Time-Out Conditions

Two timers (timer1 and timer 2) are used to generate two different time-out events (A and B, respectively). Timer 1 times out after 64 μsec. Timer 2 times out after four character times.

Time-out event A generates an interrupt and sets the RXF_TOUT bit (bit 0 of ASCR) when all of the following are true:

- At least one byte is in the RX_FIFO, and

- More than 64 μsec or four character times, whichever is greater, have elapsed since the last byte was loaded into the RX_FIFO from the receiver logic, and

- More than 64 μsec or four character times, whichever is greater, have elapsed since the last byte was read from the RX_FIFO by the CPU or DMA controller.

Time-out event B activates the receiver DMA request and is invisible to the software. It occurs when all of the following are true:

- At least one byte is in the RX_FIFO, and

- More than 64 μsec or four character times, whichever is smaller, have elapsed since the last byte was loaded into the RX_FIFO from the receiver logic, and

- More than 64 μsec or four character times, whichever is smaller, have elapsed since the last byte was read from the RX_FIFO by the CPU or DMA controller.

5.8.2 Consumer-IR Mode Time-Out Conditions

The RX_FIFO time-out, in Consumer-IR mode, is disabled while the receiver is active. It occurs when all of the following are true:

- At least one byte has been in the RX_FIFO for 64 μsec or more, and

- The receiver has been inactive (RXACT = 0) for 64 μsec or more, and

- More than 64 μsec have elapsed since the last byte was read from the RX_FIFO by the CPU or DMA controller.

5.8.3 Transmission Deferral

This feature allows software to send high-speed data in Programmed Input/Output (PIO) mode without the risk of generating a transmitter underrun.

Transmission deferral is available only in Extended mode and when the TX_FIFO is enabled. When transmission deferral is enabled (TX_DFR bit in the MCR register set to 1) and the transmitter becomes empty, an internal flag is set and locks the transmitter. If the CPU now writes data into the TX_FIFO, the transmitter does not start sending the data until the TX_FIFO level reaches 14 at which time the internal flag is cleared. The internal flag is also cleared and the transmitter starts transmitting when a time-out condition is reached. This prevents some bytes from being in the TX_FIFO indefinitely if the threshold is not reached.

The time-out mechanism is implemented by a timer that is enabled when the internal flag is set and there is at least one byte in the TX_FIFO. Whenever a byte is loaded into the TX_FIFO the timer gets reloaded with the initial value. If no bytes are loaded for a 64-µsec time, the timer times out and the internal flag is cleared, thus enabling the transmitter.

5.9 AUTOMATIC FALLBACK TO A NON-EXTENDED UART MODE

The automatic fallback feature supports existing legacy software packages that use the 16550 UART by automatically turning off any Extended mode features and switches the UART to Non-Extended mode when either of the LBGD(L) or LBGD(H) ports in bank 1 is read from or written to by the CPU.

This eliminates the need for user intervention prior to running a legacy program.

In order to avoid spurious fallbacks, alternate baud registers are provided in bank 2. Any program designed to take advantage of the UART's extended features, should not use LBGD(L) and LBGD(H) to change the baud. It should use the BGD(L) and BGD(H) registers instead. Access to these ports will not cause fallback.

Fallback can occur in any mode. In Extended UART mode, fallback is always enabled. In this case, when a fallback occurs, the following happens:

- Transmission and Reception FIFOs switch to 16 levels.

- A value of 13 is selected for the Baud Generator Prescaler

- The BTEST and ETDLBK bits in the EXCR1 register are cleared.

- UART mode is selected.

- A switch to a Non-Extended UART mode occurs.

When a fallback occurs in a Non-Extended UART mode, the last two of the above actions do not take place.

No switch to UART mode occurs if either SIR or Sharp-IR mode was selected. This prevents spurious switching to UART mode when a legacy program running in infrared mode accesses the Baud Generator Divisor Registers from bank 1.

Fallback from a Non-Extended mode can be disabled by setting the LOCK bit in register EXCR2. When LOCK is set to 1 and the UART is in a Non-Extended mode, two scratch registers overlaid with LBGD(L) and LBGD(H) are enabled. Any attempted CPU access of LBGD(L) and LBGD(H) accesses the scratch registers, and the baud setting is not affected. This feature allows existing legacy programs to run faster than 115.2 Kbps.

5.10 OPTICAL TRANSCEIVER INTERFACE

This module implements a flexible interface for the external infrared transceiver. Several signals are provided for this purpose. A transceiver module with one or two reception signals, or two transceiver modules can interface directly with this module without any additional logic.

Since various operational modes are supported by this module, the transmitter power as well as the receiver filter in the transceiver module must be configured according to the selected mode.

This module provides four interface pins to control the infrared transceiver. ID/IRSL(2-0) are three I/O pins and ID3 is an Input pin. All of these pins are powered up as inputs.

When in input mode, they can be used to read the identification data of Plug-n-Play infrared adapters.

When in output mode, the logic levels of IRSL(2-0) can be either controlled directly by the software by setting bits 2-0 of the IRCFG1 register, or they can be automatically selected by this module whenever the operation mode changes.

The automatic transceiver configuration is enabled by setting the AMCFG bit (bit 7) in the IRCFG4 register to 1. It allows the low-level functional details of the transceiver module being used to be hidden from the software drivers.

The operation mode settings for the automatic configuration are determined by various bit fields in the Infrared Interface Configuration registers (IRCFG[4-1]) that must be programmed when the UART is initialized.

The ID0/IRSL0/IRRX2 pin can also be used as an input to support an additional infrared reception signal. In this case, however, only two configuration pins are available.

The IRSL0_DS and IRSL21_DS bits in the IRCFG4 register determines the direction of IRSL(2-0).

5.11 BANK 0 – GLOBAL CONTROL AND STATUS REGISTERS

In the Non-Extended modes of operation, bank 0 is compatible with both the 16450 and the 16550. Upon reset, this module defaults to the 16450 mode. In the Extended mode, all the Registers (except RXD/ TXD) offer additional features.

TABLE 5-2. Bank 0 Serial Controller Base Registers

Offset	Register Name	Description
00h	RXD/ TXD	Receiver Data Port/ Transmitter Data Port
01h	IER	Interrupt Enable Register
02h	EIR/ FCR	Event Identification Register/ FIFO Control Register
03h	LCR/ BSR	Link Control Register/ Bank Select Register
04h	MCR	Modem Control Register
05h	LSR	Link Status Register
06h	MSR	Modem Status Register
07h	SCR/ ASCR	Scratch Register/ Auxiliary Status and Control Register

5.11.1 Receiver Data Port (RXD) or the Transmitter Data Port (TXD)

These ports share the same address.

RXD is accessed during CPU read cycles. It is used to read data from the Receiver Holding Register when the FIFOs are disabled, or from the bottom of the RX_FIFO when the FIFOs are enabled.
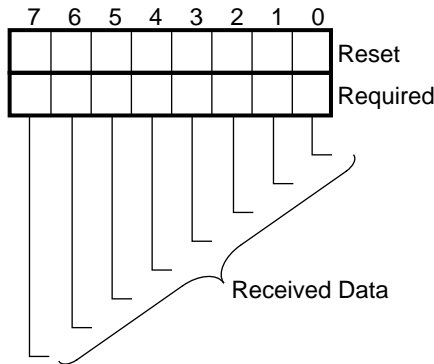
Receiver Data Port (RXD)

Bits 7-0 - Received Data

    Used to access the Receiver Holding Register when the FIFOs are disabled, or the bottom of the RX_FIFO when the FIFOs are enabled.

TXD is accessed during CPU write cycles. It is used to write data to the Transmitter Holding Register when the FIFOs are disabled, or to the TX_FIFO when the FIFOs are enabled.

DMA cycles always access the TXD and RXD ports, regardless of the selected bank.

Transmitter Data Port (TXD)
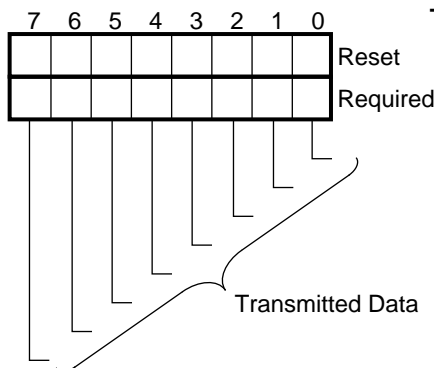
Bits 7-0 - Transmitted Data

    Used to access the Transmitter Holding Register when the FIFOs are disabled or the top of TX_FIFO when the FIFOs are enabled.

5.11.2 Interrupt Enable Register (IER)

This register controls the enabling of various interrupts. Some interrupts are common to all operating modes of the module, while others are mode specific. Bits 4 to 7 can be set in Extended mode only. They are cleared in Non-Ex-tended mode. The bits of the Interrupt Enable Register (IER) are defined differently, depending on the operating mode of the module.

The different modes can be divided into the following four groups:

- Non-Extended (which includes UART, Sharp-IR and SIR).
- UART and Sharp-IR in Extended mode.
- SIR in Extended mode.
- Consumer-IR.

The following sections describe the bits in this register for each of these modes.

The reset mode for the IER is the Non-Extended UART mode.

When edge-sensitive interrupt triggers are employed, user is advised to clear all IER bits immediately upon entering the interrupt service routine and to re-enable them prior to exiting (or alternatively, to disable CPU interrupts and re-enable prior to exiting). This will guarantee proper interrupt triggering in the interrupt controller in case one or more interrupt events occur during execution of the interrupt routine.

If the LSR, MSR or EIR registers are to be polled, interrupt sources which are identified by self-clearing bits should have their corresponding IER bits set to 0, to prevent spurious pulses on the interrupt output pin.

If an interrupt source must be disabled, the CPU can do so by clearing the corresponding bit in the IER register. However, if an interrupt event occurs just before the corresponding enable bit in the IER register is cleared, a spurious interrupt may be generated. To avoid this problem, the clearing of any IER bit should be done during execution of the interrupt service routine. If the interrupt controller is programmed for level-sensitive interrupts, the clearing of IER bits can also be performed outside the interrupt service routine, but with the CPU interrupt disabled.

Interrupt Enable Register (IER), in the Non-Extended Modes (UART, SIR and Sharp-IR)

Upon reset, the IER supports UART, SIR and Sharp-IR in the Non-Extended modes. See the bitmap of the Interrupt Enable Register in these modes.

IER in Non-Extended Modes
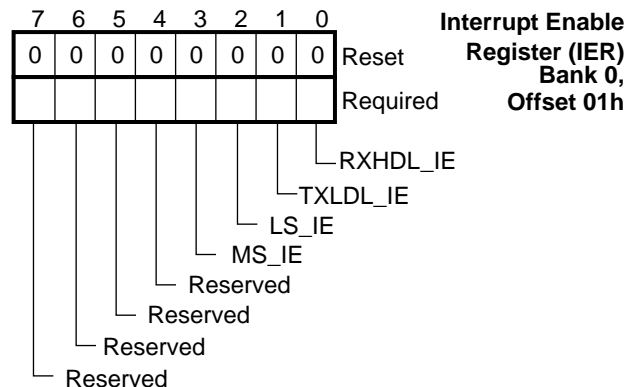
Bit 0 - Receiver High-Data-Level Interrupt Enable (RXHDL_IE)

    Setting this bit enables interrupts on Receiver High-Data-Level, or RX_FIFO Time-Out events (EIR Bits 3-0 are 0100 or 1100. See Table 5-3 on page 110).

0: Disable Receiver High-Data-Level and RX_FIFO Time-Out interrupts (Default).

1: Enable Receiver High-Data-Level and RX_FIFO Time-Out interrupts.

Bit 1 - Transmitter Low-Data-Level Interrupt Enable (TXLDL_IE)

Setting this bit enables interrupts on Transmitter Low Data-Level-events (EIR Bits 3-0 are 0010. See Table 5-3 on page 110).

0: Disable Transmitter Low-Data-Level Interrupts (Default).

1: Enable Transmitter Low-Data-Level Interrupts.

Bit 2 - Link Status Interrupt Enable (LS_IE)

Setting this bit enables interrupts on Link Status events. (EIR Bits 3-0 are 0110. See Table 5-3 on page 110).

0: Disable Link Status Interrupts (LS_EV) (Default).

1: Enable Link Status Interrupts (LS_EV).

Bit 3 - Modem Status Interrupt Enable (MS_IE)

Setting this bit enables the interrupts on Modem Status events. (EIR Bits 3-0 are 0000. See Table 5-3 on page 110).

0 - Disable Modem Status Interrupts (MS_EV) (Default).

1: Enable Modem Status Interrupts (MS_EV).

Bits 7-4- Reserved

These bits are reserved.

Interrupt Enable Register (IER), in the Extended Modes of UART, Sharp-IR and SIR

See the bitmap of the Interrupt Enable Register in these modes.

Extended Mode of UART, Sharp-IR and SIR

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

Interrupt Enable Register (IER) Bank 0, Offset 01h

- RXHDL_IE
- TXLDL_IE
- LS_IE
- MS_IE
- DMA_IE
- TXEMP_IE
- Reserved
- Reserved

Bit 0 - Receiver High-Data-Level Interrupt Enable (RXHDL_IE)

Setting this bit enables interrupts when the RX_FIFO is equal to or above the RX_FIFO threshold level, or an RX_FIFO time out occurs.

0: Disable Receiver Data Ready interrupt. (Default)

1: Enable Receiver Data Ready interrupt.

Bit 1 - Transmitter Low-Data-Level Interrupt Enable (TXLDL_IE)

Setting this bit enables interrupts when the TX_FIFO is below the threshold level or the Transmitter Holding Register is empty.

0: Disable Transmitter Low-Data-Level Interrupts (Default).

1: Enable Transmitter Low-Data-Level Interrupts.

Bit 2 - Link Status Interrupt Enable (LS_IE)

Setting this bit enables interrupts on Link Status events.

0: Disable Link Status Interrupts (LS_EV) (Default)

1: Enable Link Status Interrupts (LS_EV).

Bit 3 - Modem Status Interrupt Enable (MS_IE)

Setting this bit enables the interrupts on Modem Status events.

0: Disable Modem Status Interrupts (MS_EV) (Default)

1: Enable Modem Status Interrupts (MS_EV).

Bit 4 - DMA Interrupt Enable (DMA_IE)

Setting this bit enables the interrupt on terminal count when the DMA is enabled.

0: Disable DMA terminal count interrupt (Default)

1: Enable DMA terminal count interrupt.

Bit 5 - Transmitter Empty Interrupt Enable (TXEMP_IE)

Setting this bit enables interrupt generation if the transmitter and TX_FIFO become empty.

0: Disable Transmitter Empty interrupts (Default)

1: Enable Transmitter Empty interrupts.

Bits 7,6 - Reserved

Reserved.

Interrupt Enable Register (IER), Consumer-IR Mode

See the bitmap of the Interrupt Enable Register (IER) in this mode.

Consumer-IR Mode

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

Interrupt Enable Register (IER) Bank 0, Offset 01h

- RXHDL_IE
- TXLDL_IE
- LS_IE or TXUR_IE
- MS_IE
- DMA_IE
- TXEMP_IE
- Reserved
- Reserved
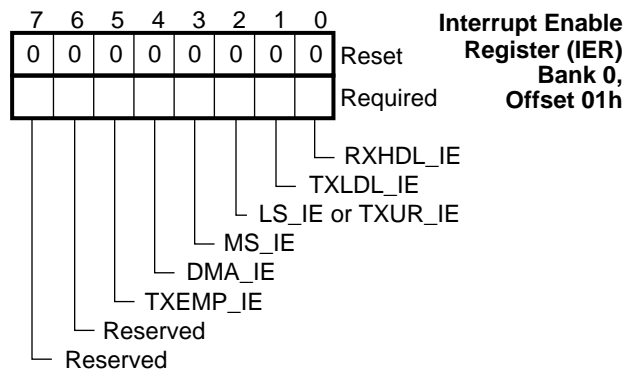
Bit 1-0 -

Same as in the Extended Modes of UART and Sharp-IR (See previous sections).

Bit 2 - Link Status Interrupt Enable (LS_IE) or TX_FIFO
Underrun Interrupt Enable (TXUR_IE)

> On reception, Setting this bit enables Link Status Interrupts.

> On transmission, Setting this bit enables TX_FIFO underrun interrupts.

> 0: Disable Link Status and TX_FIFO underrun interrupts (Default)

> 1: Enable Link Status and TX_FIFO underrun interrupts.

Bit 7-3 - Same as in the Extended Modes of UART and Sharp-IR (See the section "Interrupt Enable Register (IER), in the Extended Modes of UART, Sharp-IR and SIR" on page 109).

5.11.3 Event Identification Register (EIR)

The **Event Identification Register (EIR)** and the **FIFO Control Register (FCR) (**see next register description) share the same address. The **EIR** is accessed during CPU read cycles while the **FCR** is accessed during CPU write cycles.The Event Identification Register (EIR) indicates the interrupt source. The function of this register changes according to the selected mode of operation.

Event Identification Register (EIR), Non-Extended Mode

When Extended mode is not selected (EXT_SL bit in EXCR1 register is set to 0), this register is the same as in the 16550.

In a Non-Extended UART mode, this module prioritizes interrupts into four levels. The EIR indicates the highest level of interrupt that is pending. The encoding of these interrupts is shown in Table 5-3 on page 110.
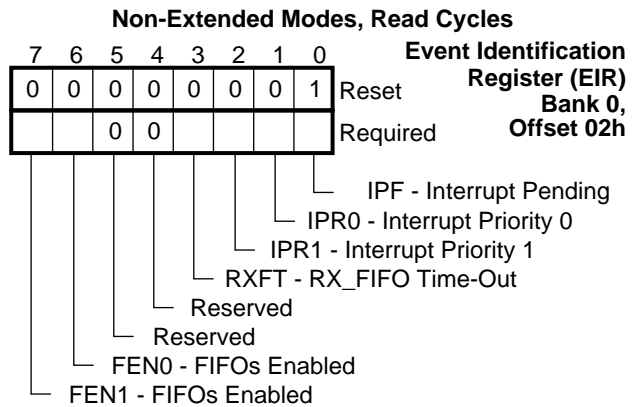
Non-Extended Modes, Read Cycles

**Event Identification
Register (EIR)
Bank 0,
Offset 02h**

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	1	Reset
		0	0					Required

- IPF - Interrupt Pending
- IPR0 - Interrupt Priority 0
- IPR1 - Interrupt Priority 1
- RXFT - RX_FIFO Time-Out
- Reserved
- Reserved
- FEN0 - FIFOs Enabled
- FEN1 - FIFOs Enabled

Bit 0 - Interrupt Pending Flag (IPF)

> 0: There is an interrupt pending.

> 1: No interrupt pending. (Default)

Bits 2,1 - Interrupt Priority 1,0 (IPR1,0)

> When bit 0 (IPF) is 0, these bits indicate the pending interrupt with the highest priority. See Table 5-3 on page 110.

> Default value is 00.

Bit 3 - RX_FIFO Time-Out (RXFT)

> In the 16450 mode, this bit is always 0. In the 16550 mode (FIFOs enabled), this bit is set to 1 when an RX_FIFO read time-out occurred and the associated interrupt is currently the highest priority pending interrupt.

Bits 5,4 - Reserved

> Read/Write 0.

Bit 7,6 - FIFOs Enabled (FEN1,0)

> 0: No FIFO enabled. (Default)

> 1: FIFOs are enabled (bit 0 of FCR is set to 1).

TABLE 5-3. Non-Extended Mode Interrupt Priorities

EIR Bits 3 2 1 0	Interrupt Set and Reset Functions			
	Priority Level	Interrupt Type	Interrupt Source	Interrupt Reset Control
0 0 0 1	—	None	None	—
0 1 1 0	Highest	Link Status	Parity error, framing error, data overrun or break event	Read Link Status Register (LSR).
0 1 0 0	Second	Receiver High Data Level Event	Receiver Holding Register (RXD) full, or RX_FIFO level equal to or above threshold.	Reading the RXD or, RX_FIFO level drops below threshold.

EIR Bits 3 2 1 0	Interrupt Set and Reset Functions			
	Priority Level	Interrupt Type	Interrupt Source	Interrupt Reset Control
1 1 0 0	Second	RX_FIFO Time-Out	At least one character is in the RX_FIFO, and no character has been input to or read from the RX_FIFO for 4 character times.	Reading the RXD port.
0 0 1 0	Third	Transmitter Low Data Level Event	Transmitter Holding Register or TX_FIFO empty.	Reading the EIR Register if this interrupt is currently the highest priority pending interrupt, or writing into the TXD port.
0 0 0 0	Fourth	Modem Status	Any transition on $\overline{CTS}$, $\overline{DSR}$ or $\overline{DCD}$ or a low to high transition on $\overline{RI}$.	Reading the Modem Status Register (MSR).

Event Identification Register (EIR), Extended Mode

In Extended mode, each of the previously prioritized and encoded interrupt sources is broken down into individual bits. Each bit in this register acts as an interrupt pending flag, and is set to 1 when the corresponding event occurred or is pending, regardless of the IER register bit setting.

When this register is read the DMA event bit (bit 4) is cleared if an 8237 type DMA is used. All other bits are cleared when the corresponding interrupts are acknowledged by reading the relevant register (e.g. reading MSR clears MS_EV bit).
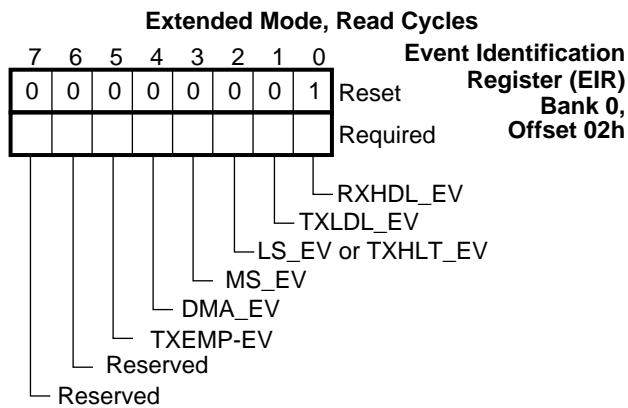
Extended Mode, Read Cycles

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	1	Reset
								Required

Event Identification Register (EIR) Bank 0, Offset 02h

- RXHDL_EV
- TXLDL_EV
- LS_EV or TXHLT_EV
- MS_EV
- DMA_EV
- TXEMP-EV
- Reserved
- Reserved

Bit 0 - Receiver High-Data-Level Event (RXHDL_EV)

When FIFOs are disabled, this bit is set to 1 when a character is in the Receiver Holding Register.

When FIFOs are enabled, this bit is set to 1 when the RX_FIFO is above threshold or an RX_FIFO time-out has occurred.

Bit 1 - Transmitter Low-Data-Level Event (TXLDL_EV)

When FIFOs are disabled, this bit is set to 1 when the Transmitter Holding Register is empty.

When FIFOs are enabled, this bit is set to 1 when the TX_FIFO is below the threshold level.

Bit 2 - Link Status Event (LS_EV) or Transmitter Halted Event (TXHLT_EV)

In the **UART, Sharp-IR** and **SIR** modes, this bit is set to 1 when a receiver error or break condition is reported.

When FIFOs are enabled, the Parity Error(PE), Frame Error(FE) and Break(BRK) conditions are only reported when the associated character reaches the bottom of the RX_FIFO. An Overrun Error (OE) is reported as soon as it occurs.

In the **Consumer-IR** mode, this bit indicates that a Link Status Event (LS_EV) or a Transmitter Halted Event (TXHLT_EV) occurred. It is set to 1 when any of the following conditions occurs:

— A receiver overrun.

— A transmitter underrun.

Bit 3 - Modem Status Event (MS_EV)

In UART mode this bit is set to 1 when any of the 0 to 3 bits in the MSR register is set to 1.

In any **IR** mode, the function of this bit depends on the setting of the IRMSSL bit in the IRCR2 register (see Table 5-4 and also "Bit 1 - MSR Register Function Select in Infrared Mode (IRMSSL)" on page 124).

TABLE 5-4. Modem Status Event Detection Enable

IRMSSL Value	Bit Function
0	Modem Status Event (MS_EV)
1	Forced to 0.

Bit 4 - DMA Event Occurred (DMA_EV)

When an 8237 type DMA controller is used, this bit is set to 1 when a DMA terminal count (TC) is signalled. It is cleared upon read.

Bit 5 - Transmitter Empty (TXEMP_EV)

In **UART, Sharp-IR** and **Consumer-IR** modes, this bit is the same as bit 6 of the LSR register. It is set to 1 when the transmitter is empty.

Bits 7,6 - Reserved

Read/Write 0.

5.11.4 FIFO Control Register (FCR)

The FIFO Control Register (FCR) is write only. It is used to enable the FIFOs, clear the FIFOs and set the interrupt thresholds levels for the reception and transmission FIFOs.

Write Cycles

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
				0				Required

**FIFO Control Register (FCR)
Bank 0,
Offset 02h**

- FIFO_EN
- RXSR
- TXSR
- Reserved
- TXFTH0
- TXFTH1
- RXFTH0
- RXFTH1
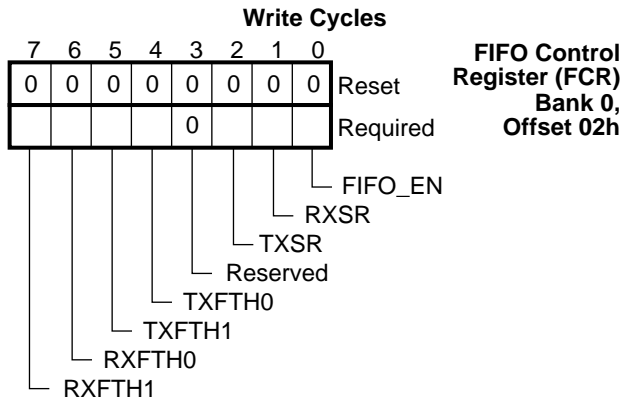
Bit 0 - FIFO Enable (FIFO_EN)

When set to 1 enables both the Transmision and Reception FIFOs. Resetting this bit clears both FIFOs.

In **Consumer-IR** modes the FIFOs are always enabled and the setting of this bit is ignored.

Bit 1 - Receiver Soft Reset (RXSR)

Writing a 1 to this bit generates a receiver soft reset, which clears the RX_FIFO and the receiver logic. This bit is automatically cleared by the hardware.

Bit 2 - Transmitter Soft Reset (TXSR)

Writing a 1 to this bit generates a transmitter soft reset, which clears the TX_FIFO and the transmitter logic. This bit is automatically cleared by the hardware.

Bit 3 - Reserved

Read/Write 0.

Writing to this bit has no effect on the UART operation.

Bits 5,4 - TX_FIFO Threshold Level (TXFTH1,0)

These bits select the TX_FIFO interrupt threshold level. An interrupt is generated when the level of the data in the TX_FIFO drops below the encoded threshold.

TABLE 5-5. TX_FIFO Level Selection

TXFTH (Bits 5,4)	TX_FIF0 Threshold
00(Default)	1
01	3
10	9
11	13

Bits 7,6 - RX_FIFO Threshold Level (RXFTH1,0)

These bits select the RX_FIFO interrupt threshold level. An interrupt is generated when the level of the data in the RX_FIFO is equal to or above the encoded threshold.

TABLE 5-6. RX_FIFO Level Selection

RXFTH (Bits 5,4)	RX_FIF0 Threshold
00(Default)	1
01	4
10	8
11	14

5.11.5 Link Control Register (LCR) and Bank Selection Register (BSR)

The **Link Control Register (LCR)** and the **Bank Select Register (BSR)** (see the next register) share the same address.

The **Link Control Register (LCR)** selects the communications format for data transfers in UART, SIR and Sharp-IR modes.

Upon reset, all bits are set to 0.

Reading the register at this address location returns the content of the BSR. The content of LCR may be read from the Shadow of Link Control Register (SH_LCR) register in bank 3 (See Section 5.14.2 on page 122). During a write operation to this register at this address location, the setting of bit 7 (Bank Select Enable, BKSE) determines whether LCR or BSR is to be accessed, as follows:

- If bit 7 is 0, the write affects both LCR and BSR.

- If bit 7 is 1, the write affects only BSR, and LCR remains unchanged. This prevents the communications format from being spuriously affected when a bank other than 0 or 1 is accessed.

Upon reset, all bits are set to 0.

Link Control Register (LCR)

Bits 6-0 are only effective in UART, Sharp-IR and SIR modes. They are ignored in Consumer-IR mode.
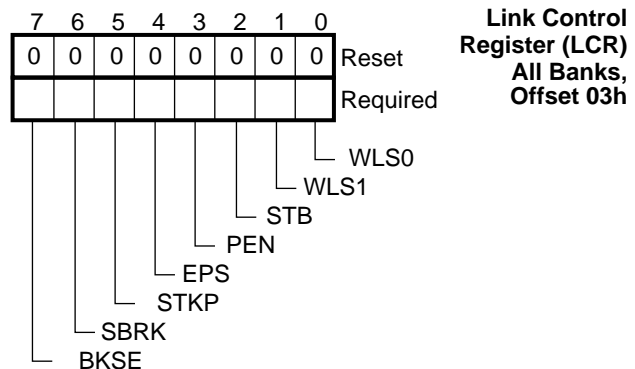
7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

**Link Control Register (LCR)
All Banks,
Offset 03h**

- WLS0
- WLS1
- STB
- PEN
- EPS
- STKP
- SBRK
- BKSE

Bits 1,0 - Character Length Select (WLS1,0)

These bits specify the number of data bits in each transmitted or received serial character. Table 5-7 shows how to encode these bits.

TABLE 5-7. Word Length Select Encoding

WLS1	WLS0	Character Length
0	0	5 (Default)
0	1	6
1	0	7
1	1	8

Bits 2 - Number of Stop Bits (STB)

This bit specifies the number of stop bits transmitted with each serial character.

0: One stop bit is generated. (Default)

1: If the data length is set to 5-bits via bits 1,0 (WLS1,0), 1.5 stop bits are generated. For 6, 7 or 8 bit word lengths, two stop bits are transmitted. The receiver checks for one stop bit only, regardless of the number of stop bits selected.

Bit 3 - Parity Enable (PEN)

This bit enable the parity bit See Table 5-8 on page 113.

The parity enable bit is used to produce an even or odd number of 1s when the data bits and parity bit are summed, as an error detection device.

0: No parity bit is used. (Default)

1: A parity bit is generated by the transmitter and checked by the receiver.

Bit 4 - Even Parity Select (EPS)

When Parity is enabled (PEN is 1), this bit, together with bit 5 (STKP), controls the parity bit as shown in Table 5-8.

0: If parity is enabled, an odd number of logic 1s are transmitted or checked in the data word bits and parity bit. (Default)

1: If parity is enabled, an even number of logic 1s are transmitted or checked.

Bit 5 - Stick Parity (STKP)

When Parity is enabled (PEN is 1), this bit, together with bit 4 (EPS), controls the parity bit as show in Table 5-8.

TABLE 5-8. Bit Settings for Parity Control

PEN	EPS	STKP	Selected Parity Bit
0	x	x	None
1	0	0	Odd
1	1	0	Even
1	0	1	Logic 1
1	1	1	Logic 0

Bit 6 - Set Break (SBRK)

This bit enables or disables a break. During the break, the transmitter can be used as a character timer to accurately establish the break duration.

This bit acts only on the transmitter front-end and has no effect on the rest of the transmitter logic.

When set to 1 the following occurs:

— If a **UART** mode is selected, the SOUT pin is forced to a logic 0 state.

— If **SIR** mode is selected, pulses are issued continuously on the IRTX pin.

— If **Sharp-IR** mode is selected and internal modulation is enabled, pulses are issued continuously on the IRTX pin.

— If **Sharp-IR** mode is selected and internal modulation is disabled, the IRTX pin is forced to a logic 1 state.

To avoid transmission of erroneous characters as a result of the break, use the following procedure to set SBRK:

1. Wait for the transmitter to be empty. (TXEMP = 1).

2. Set SBRK to 1.

3. Wait for the transmitter to be empty, and clear SBRK when normal transmission must be restored.

Bit 7 - Bank Select Enable (BKSE)

0: This register functions as the Link Control Register (LCR).

1: This register functions as the Bank Select Register (BSR).

5.11.6 Bank Selection Register (BSR)
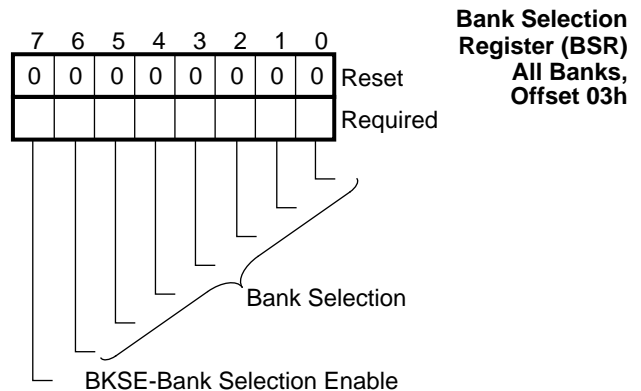
Bank Selection Register (BSR) All Banks, Offset 03h

The Bank Selection Register (BSR) selects which register bank is to be accessed next.

About accessing this register see the description of bit 7 of the LCR Register.

Bits 6-0 - Bank Selection

When bit 7 is set to 1, bits 6-0 of BSR select the bank, as shown in Table 5-9.

Bit 7 - Bank Selection Enable (BKSE)

0: Bank 0 is selected.

1: Bits 6-0 specify the selected bank.

TABLE 5-9. Bank Selection Encoding

BSR Bits								Bank Selected	LCR
7	6	5	4	3	2	1	0		
0	x	x	x	x	x	x	x	0	LCR is written
1	0	x	x	x	x	x	x	1	
1	1	x	x	x	x	1	x	1	
1	1	x	x	x	x	x	1	1	
1	1	1	0	0	0	0	0	2	LCR is not written
1	1	1	0	0	1	0	0	3	
1	1	1	0	1	0	0	0	4	
1	1	1	0	1	1	0	0	5	
1	1	1	1	0	0	0	0	6	
1	1	1	1	0	1	0	0	7	
1	1	1	1	1	x	0	0	Reserved	
1	1	0	x	x	x	0	0	Reserved	

5.11.7 Modem/Mode Control Register (MCR)

This register controls the interface with the modem or data communications set, and the device operational mode when the device is in the **Extended** mode. The register function differs for Extended and Non-Extended modes.

Modem/Mode Control Register (MCR), Non-Extended Mode

Non-Extended UART mode

```
       7   6   5   4   3   2   1   0
      | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Reset
      | 0 | 0 | 0 |   |   |   |   |   | Required
                              └── DTR
                          └── RTS
                      └── RILP
                  └── ISEN or DCDLP
              └── LOOP
          └── Reserved
      └── Reserved
  └── Reserved
```

Modem Control Register (MCR) Bank 0, Offset 04h

Bit 0 - Data Terminal Ready (DTR)

This bit controls the $\overline{DTR}$ signal output. When set to 1, $\overline{DTR}$ is driven low. When loopback is enabled (LOOP is set to 1), this bit internally drives $\overline{DSR}$.

Bit 1 - Request To Send (RTS)

This bit controls the $\overline{RTS}$ signal output. When set to 1, drives $\overline{RTS}$ low. When loopback is enabled (LOOP is set), this bit drives $\overline{CTS}$, internally.

Bit 2 - Loopback Interrupt Request (RILP)

When loopback is enabled, this bit internally drives $\overline{RI}$. Otherwise it is unused.

Bit 3 - Interrupt Signal Enable (ISEN) or Loopback DCD (DCDLP)

In normal operation (standard 16450 or 16550) mode, this bit controls the interrupt signal and must be set to 1 in order to enable the interrupt request signal.

When loopback is enabled, the interrupt output signal is always enabled, and this bit internally drives $\overline{DCD}$.

New programs should always keep this bit set to 1 during normal operation. The interrupt signal should be controlled through the Plug-n-Play logic.

Bit 4 - Loopback Enable (LOOP)

When this bit is set to 1, it enables loopback. This bit accesses the same internal register as bit 4 of the EXCR1 register. (see "Bit 4 - Loopback Enable (LOOP)" on page 120 for more information on the Loopback mode).

0: Loopback disabled. (Default)

1: Loopback enabled.

Bits 7-5 - Reserved

Read/Write 0.

Modem/Mode Control Register (MCR), Extended Mode

In Extended mode, this register is used to select the operation mode (IrDA, Sharp, etc.) of the device and to enable the DMA interface. In these modes, the interrupt output signal is always enabled, and loopback can be enabled by setting bit 4 of the EXCR1 register.

Extended Mode

```
       7   6   5   4   3   2   1   0
      | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Reset
      |   |   |   |   |   |   |   |   | Required
                              └── DTR
                          └── RTS
                      └── DMA_EN
                  └── TX_DFR
              └── Reserved
          └── MDSL0
      └── MDSL1
  └── MDSL2
```

Modem Control Register (MCR) Bank 0, Offset 04h
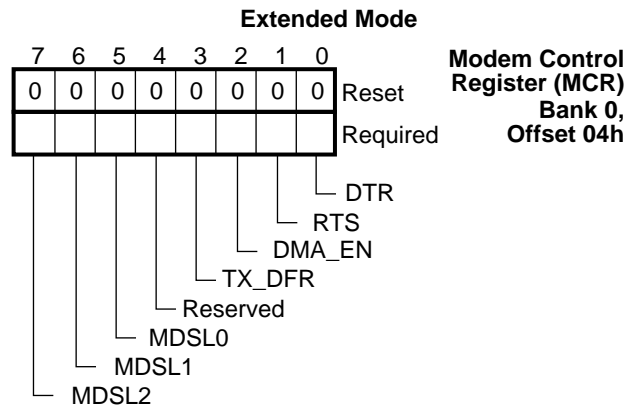
Bit 0 - Data Terminal Ready (DTR)

This bit controls the $\overline{DTR}$ signal output. When set to 1, $\overline{DTR}$ is driven low. When loopback is enabled (LOOP is set), this bit internally drives both $\overline{DSR}$ and $\overline{RI}$.

Bit 1 - Request To Send (RTS)

This bit controls the $\overline{RTS}$ signal output. When set to 1, $\overline{RTS}$ is driven low. When loopback is enabled (LOOP is set), this bit internally drives both $\overline{CTS}$ and $\overline{DCD}$.

Bit 2 - DMA Enable (DMA_EN)

When set to 1, DMA mode of operation is enabled. When DMA is selected, transmit and/or receive interrupts should be disabled to avoid spurious interrupts.

DMA cycles always address the Data Holding Registers or FIFOs, regardless of the selected bank.

Bit 3 - Transmission Deferral (TX_DFR)

> For a detailed description of the Transmission Deferral see "Transmission Deferral" on page 107.
>
> 0: No transmission deferral enabled. (Default)
>
> 1: Transmission deferral enabled.
>
> This bit is effective only if the Transmission FIFOs is enabled.

Bit 4 - Reserved

> Read/Write 0.

Bits 7-5 - Mode Select (MDSL2-0)

> These bits select the operational mode of the module when in **Extended** mode, as shown in Table 5-10.
>
> When the mode is changed, the transmission and reception FIFOs are flushed, Link Status and Modem Status Interrupts are cleared, and all of the bits in the auxiliary status and control register are cleared.

TABLE 5-10. The Module Operation Modes

MDSL2 (Bit 7)	MDSL1 (Bit 6)	MDSL0 (Bit 5)	Operational Mode
0	0	0	UART mode (Default)
0	0	1	Reserved
0	1	0	Sharp-IR
0	1	1	SIR
1	0	0	Reserved
1	0	1	Reserved
1	1	0	Consumer-IR
1	1	1	Reserved

5.11.8 Link Status Register (LSR)

This register provides status information concerning the data transfer. They are cleared when one of the following events occurs:

- .
- The receiver is soft-reset.
- The LSR register is read.

Upon reset this register assumes the value of 0x60h.

The bit definitions change depending upon the operation mode of the module.

Bits 4 through 1 of the LSR are the error conditions that generate a Receiver Link Status interrupt whenever any of the corresponding conditions are detected and that interrupt is enabled.

The LSR is intended for read operations only. Writing to the LSR is not permitted

Link Status Register (LSR) Bank 0, Offset 05h

Bit 0 - Receiver Data Available (RXDA)

> Set to 1 when the Receiver Holding Register is full.
>
> If the FIFOs are enabled, this bit is set when at least one character is in the RX_FIFO.
>
> Cleared when the CPU reads all the data in the Holding Register or in the RX_FIFO.

Bit 1 - Overrun Error (OE)

> This bit is set to 1 as soon as an overrun condition is detected by the receiver.
>
> Cleared upon read.
>
> With **FIFOs Disabled:**
>
> An overrun occurs when a new character is completely received into the receiver front-end section and the CPU has not yet read the previous character in the receiver holding register. The new character is discarded, and the receiver holding register is not affected.
>
> With **FIFOs Enabled:**
>
> An overrun occurs when a new character is completely received into the receiver front-end section and the RX_FIFO is full. The new character is discarded, and the RX_FIFO is not affected.

Bit 2 - Parity Error (PE)

> In **UART, Sharp-IR** and **SIR** modes, this bit is set to 1 if the received data character does not have the correct parity, even or odd as selected by the parity control bits of the LCR register.
>
> If the FIFOs are enabled, this error is associated with the particular character in the FIFO that it applies to. This error is revealed to the CPU when its associated character is at the bottom of the RX_FIFO.
>
> This bit is cleared upon read.

Bit 3 - Framing Error (FE)

> In **UART, Sharp-IR** and **SIR** modes, this bit is set to 1 when the received data character does not have a valid stop bit (i.e., the stop bit following the last data bit or parity bit is a 0).
>
> If the FIFOs are enabled, this Framing Error is associated with the particular character in the FIFO that it applies to. This error is revealed to the CPU when its associated character is at the bottom of the RX_FIFO.
>
> After a framing error is detected, the receiver will try to resynchronize.

If the bit following the erroneous stop bit is 0, the receiver assumes it to be a valid start bit and shifts in the new character. If that bit is a 1, the receiver enters the idle state and awaits the next start bit.

This bit is cleared upon read.

Bit 4 - Break Event Detected (BRK)

In **UART, Sharp-IR** and **SIR** modes this bit is set to 1 when a break event is detected (i.e. when a sequence of logic 0 bits, equal or longer than a full character transmission, is received). If the FIFOs are enabled, the break condition is associated with the particular character in the RX_FIFO to which it applies. In this case, the BRK bit is set when the character reaches the bottom of the RX_FIFO.

When a break event occurs, only one zero character is transferred to the Receiver Holding Register or to the RX_FIFO.

The next character transfer takes place after at least one logic 1 bit is received followed by a valid start bit.

This bit is cleared upon read.

Bit 5 - Transmitter Ready (TXRDY)

This bit is set to 1 when the Transmitter Holding Register or the TX_FIFO is empty.

It is cleared when a data character is written to the TXD register.

Bit 6 - Transmitter Empty (TXEMP)

This bit is set to 1 when the Transmitter Holding Register or the TX_FIFO is empty, and the transmitter front-end is idle.

Bit 7 - Error in RX_FIFO (ER_INF)

In **UART, Sharp-IR** and **SIR** modes, this bit is set to a 1 if there is at least 1 framing error, parity error or break indication in the RX_FIFO.

This bit is always 0 in the 16450 mode.

This bit is cleared upon read.

5.11.9   Modem Status Register (MSR)

The function of this register depends on the selected operational mode. When a **UART** mode is selected, this register provides the current-state as well as state-change information of the status lines from the modem or data transmission module.

When any of the infrared modes is selected, the register function is controlled by the setting of the IRMSSL bit in the IRCR2 (see page 124). If IRMSSL is 0, the MSR register works as in UART mode. If IRMSSL is 1, the MSR register returns the value 30 hex, regardless of the state of the modem input lines.

When loopback is enabled, the MSR register works similarly except that its status input signals are internally driven by appropriate bits in the MCR register since the modem input lines are internally disconnected. Refer to at the MCR (see page 114) and to the LOOP & ETDLBK bits at the EXCR1 (see page 120) for more information.

A description of the various bits of the MSR register, with Loopback disabled and UART Mode selected, is provided below.

When bits 0, 1, 2 or 3 is set to 1, a Modem Status Event (MS_EV) is generated if the MS_IE bit is enabled in the IER

Bits 0 to 3 are set to 0 as a result of any of the following events:

- A hardware reset occurs.

- The operational mode is changed and the IRMSSL bit is 0.

- The MSR register is read.

In the reset state, bits 4 through 7 are indeterminate as they reflect their corresponding input signals.

Note: The modem status lines can be used as general purpose inputs. They have no effect on the transmitter or receiver operation.

7	6	5	4	3	2	1	0	
X	X	X	X	0	0	0	0	Reset
								Required

Modem Status Register (MSR) Bank 0, Offset 06h

Bit 7 → DCD
Bit 6 → RI
Bit 5 → DSR
Bit 4 → CTS
Bit 3 → DDCD
Bit 2 → TERI
Bit 1 → DDSR
Bit 0 → DCTS

Bit 0 - Delta Clear to Send (DCTS)
Set to 1, when the $\overline{CTS}$ input signal changes state.
This bit is cleared upon read.

Bit 1 - Delta Data Set Ready (DDSR)
Set to 1, when the $\overline{DSR}$ input signal changes state.
This bit is cleared upon read

Bit 2 - Trailing Edge Ring Indicate (TERI)
Set to 1, when the $\overline{RI}$ input signal changes state from low to high.
This bit is cleared upon read

Bit 3 - Delta Data Carrier Detect (DDCD)
Set to 1, when the $\overline{DCD}$ input signal changes state.
1:   $\overline{DCD}$ signal state changed.

Bit 4 - Clear To Send (CTS)
This bit returns the inverse of the $\overline{CTS}$ input signal.

Bit 5 - Data Set Ready (DSR)
This bit returns the inverse of the $\overline{DSR}$ input signal.

Bit 6 - Ring Indicate (RI)
This bit returns the inverse of the $\overline{RI}$ input signal.

Bit 7 - Data Carrier Detect (DCD)
This bit returns the inverse of the $\overline{DCD}$ input signal.

5.11.10 Scratchpad Register (SPR)

This register shares a common address with the ASCR Register.

In **Non-Extended** mode, this is a scratch register (as in the 16550) for temporary data storage.

Non-Extended Modes

Scratchpad Register (SCR)
Bank 0, Offset 07h

Scratch Data

5.11.11 Auxiliary Status and Control Register (ASCR)

This register shares a common address with the previous one (SCR).

This register is accessed when the **Extended** mode of operation is selected. The definition of the bits in this case is dependent upon the mode selected in the MCR register, bits 7 through 5. This register is cleared upon hardware reset Bits 2 and 6 are cleared when the transmitter is "soft reset". Bits 0,1,4 and 5 are cleared when the receiver is "soft reset".

Extended Modes

Auxiliary Status Register (ASCR)
Bank 0, Offset 07h

RXF_TOUT
Reserved
S_EOT
Reserved
RXWDG
RXACT
TXUR
Reserved

Bit 0 - RX_FIFO Time-Out (RXF_TOUT)

This bit is read only and set to 1 when an RX_FIFO timeout occurs. It is cleared when a character is read from the RX_FIFO.

Bit 1 -Reserved

Read/Write 0.

Bit 2 - Set End of Transmission (S_EOT)

In **Consumer-IR** mode this is the Set End of Transmission bit. When a 1 is written into this bit position before writing the last character into the TX_FIFO, data transmission is gracefully completed.

In this mode, if the CPU simply stops writing data into the TX_FIFO at the end of the data stream, a transmitter underrun is generated and the transmitter stops. In this case this is not an error, but the software must clear the underrun before the next transmission can occur. This bit is automatically cleared by hardware when a character is written to the TX_FIFO.

Bit 3 - Reserved

Read/Write 0.

Bit 4 - Reception Watchdog (RXWDG)

In **Consumer-IR** mode, this is the Reception Watchdog (RXWDG) bit. It is set to 1 each time a pulse or pulse-train (modulated pulse) is detected by the receiver. It can be used by the software to detect a receiver idle condition. It is cleared upon read.

Bit 5 - Receiver Active (RXACT)

In **Consumer-IR** Mode this is the Receiver Active (RX-ACT) bit. It is set to 1 when an infrared pulse or pulse-train is received. If a 1 is written into this bit position, the bit is cleared and the receiver is deactivated. When this bit is set, the receiver samples the infrared input continuously at the programmed baud and transfers the data to the RX_FIFO. See "Consumer-IR Reception" on page 106.

Bit 6 - Infrared Transmitter Underrun (TXUR)

In the **Consumer-IR** mode, this is the Transmitter Underrun flag. This bit is set to 1 when a transmitter underrun occurs. It is always cleared when a mode other than Consumer-IR is selected. This bit must be cleared, by writing 1 into it, to re-enable transmission.

Bit 7 - Reserved

Read/Write 0.

5.12 BANK 1 – THE LEGACY BAUD GENERATOR DIVISOR PORTS

This register bank contains two Baud Generator Divisor Ports, and a bank select register.

The Legacy Baud Generator Divisor (LBGD) port provides an alternate path to the Baud Divisor Generator register. This bank is implemented to maintain compatibility with 16550 standard and to support existing legacy software packages. In case of using legacy software, the addresses 0 and 1 are shared with the data ports RXD/TXD (see page 108). The selection between them is controlled by the value of the BKSE bit (LCR bit 7 page 112).

TABLE 5-11. Bank 1 Register Set

Offset	Register Name	Description
00h	LBGD(L)	Legacy Baud Generator Divisor Port (Low Byte)
01h	LBGD(H)	Legacy Baud Generator Divisor Port (High Byte)
02h		Reserved
03h	LCR/ BSR	Link Control / Bank Select Register
04h - 07h		Reserved

In addition, a fallback mechanism maintains this compatibility by forcing the UART to revert to 16550 mode if 16550 software addresses the module after a different mode was set. Since setting the Baud Divisor values is a necessary initialization of the 16550, setting the divisor values in bank 1 forces the UART to enter 16550 mode. (This is called fallback.)

To enable other modes to program their desired baud rates without activating this fallback mechanism, the Baud Generator Divisor Port pair in bank 2 should be used.

5.12.1 Legacy Baud Generator Divisor Ports (LBGD(L) and LBGD(H)),

The programmable baud rates in the Non-Extended mode are achieved by dividing a 24 MHz clock by a prescale value of 13, 1.625 or 1. This prescale value is selected by the PRESL field of EXCR2 (see page 121). This clock is subdivided by the two Baud Generator Divisor buffers, which output a clock at 16 times the desired baud (this clock is the BOUT clock). This clock is used by I/O circuitry, and after a last division by 16 produces the output baud.

Divisor values between 1 and $2^{16}-1$ can be used. (Zero is forbidden). The Baud Generator Divisor must be loaded during initialization to ensure proper operation of the Baud Generator. Upon loading either part of it, the Baud Generator counter is immediately loaded. Table 5-15 on page 120 shows typical baud divisors. After reset the divisor register contents are indeterminate.

Any access to the **LBGD(L)** or **LBGD(H)** ports causes a reset to the default Non-Extended mode, i.e., 16550 mode (See "AUTOMATIC FALLBACK TO A NON-EXTENDED UART MODE" on page 107). To access a Baud Generator Divisor when in the **Extended** mode, use the port pair in bank 2 (BGD on page 119).

Table 5-12 shows the bits which are cleared when Fallback occurs during **Extended** or **Non-Extended** modes.

If the UART is in **Non-Extended** mode and the LOCK bit is 1, the content of the divisor (BGD) ports will not be affected and no other action is taken.

When programming the baud, the new divisor is loaded upon writing into LBGD(L) and LBGD(H). After reset, the contents of these registers are indeterminate.

Divisor values between 1 and $2^{16}-1$ can be used. (Zero is forbidden.) Table 5-14 shows typical baud divisors.

TABLE 5-12. Bits Cleared On Fallback

Register	UART Mode & LOCK bit before Fallback		
	Extended Mode LOCK = x	Non-Extended Mode LOCK = 0	Non-Extended Mode LOCK = 1
MCR	2 to 7	none	none
EXCR1	0, 5 and 7	5 and 7	none
EXCR2	0 to 5	0 to 5	none
IRCR1	2 and 3	none	none

Legacy Baud Generator Divisor Low Byte port (LBGD(L)) Bank 1, Offset 00h

Least Significant Byte of Baud Generator

Legacy Baud Generator Divisor High Byte port (LBGD(H)) Bank 1, Offset 01h

Most Significant Byte of Baud Generator
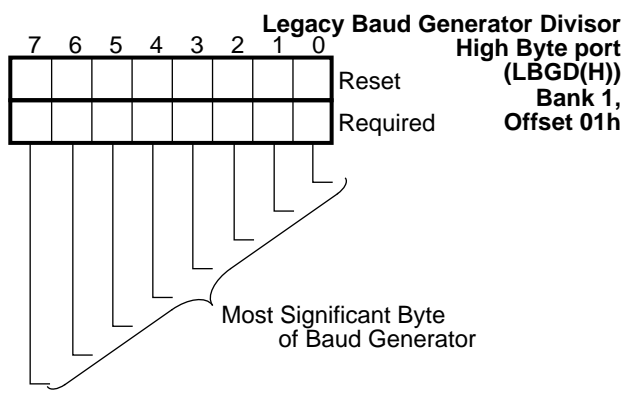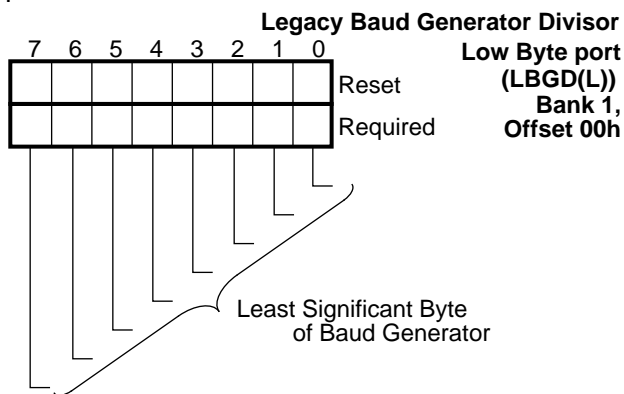
5.12.2 Link Control Register (LCR) and Bank Select Register (BSR)

These registers are the same as the registers at offset 03h in bank 0.

5.13 BANK 2 – EXTENDED CONTROL AND STATUS REGISTERS

Bank 2 contains two alternate Baud Generator Divisor ports and the Extended Control Registers (EXCR1 and EXCR2).

TABLE 5-13. Bank 2 Register Set

Offset	Register Name	Description
00h	BGD(L)	Baud Generator Divisor Port (Low byte)
01h	BGD(H)	Baud Generator Divisor Port (High byte)
02h	EXCR1	Extended Control Register 1
03h	LCR/BSR	Link Control/ Bank Select Register
04h	EXCR2	Extended Control Register 2
05h		Reserved
06h	TXFLV	TX_FIFO Level
07h	RXFLV	RX_FIFO Level

5.13.1 Baud Generator Divisor Ports, LSB (BGD(L)) and MSB (BGD(H))

These ports perform the same function as the Legacy Baud Divisor Ports in Bank 1 and are accessed identically, but do not change the operation mode of the module when accessed. Refer to Section 5.12.1 on page 118 for more details.

Use these ports to set the baud when operating in Extended mode to avoid fallback to a Non-Extended operation mode, i.e., 16550 compatible.When programming the baud, writing to BGDH causes the baud to change immediately.

Baud Generator Divisor High Byte Port (BGD(H)) Bank 2, Offset 01h

Most Significant Byte of Baud Generator

Baud Generator Divisor Low Byte Port (BGD(L)) Bank 2, Offset 00h

Least Significant Byte of Baud Generator
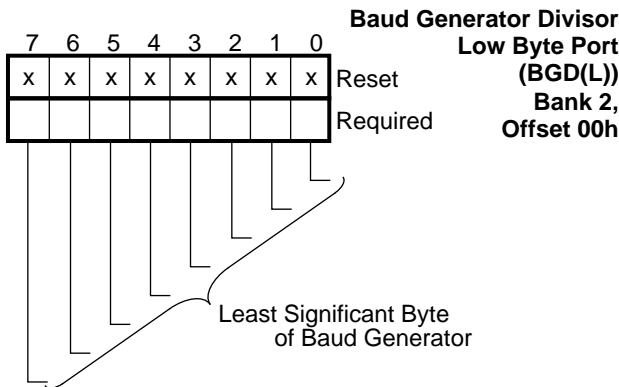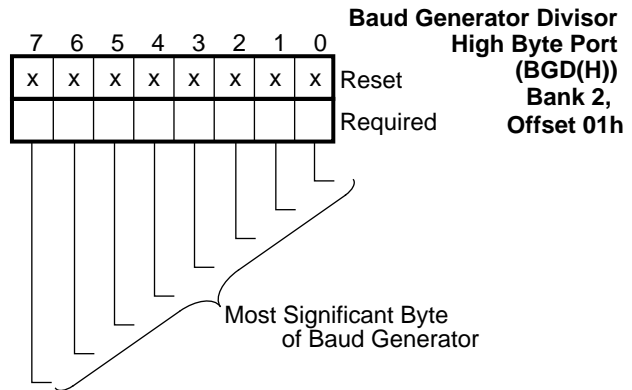
TABLE 5-14. Baud Generator Divisor Settings

Prescaler Value	13		1.625		1	
Baud	**Divisor**	**% Error**	**Divisor**	**% Error**	**Divisor**	**% Error**
50	2304	0.16%	18461	0.00%	30000	0.00%
75	1536	0.16%	12307	0.01%	20000	0.00%
110	1047	0.19%	8391	0.01%	13636	0.00%
134.5	857	0.10%	6863	0.00%	11150	0.02%
150	768	0.16%	6153	0.01%	10000	0.00%
300	384	0.16%	3076	0.03%	5000	0.00%
600	192	0.16%	1538	0.03%	2500	0.00%
1200	96	0.16%	769	0.03%	1250	0.00%
1800	64	0.16%	512	0.16%	833	0.04%
2000	58	0.53%	461	0.12%	750	0.00%
2400	48	0.16%	384	0.16%	625	0.00%
3600	32	0.16%	256	0.16%	416	0.16%
4800	24	0.16%	192	0.16%	312	0.16%
7200	16	0.16%	128	0.16%	208	0.16%
9600	12	0.16%	96	0.16%	156	0.16%
14400	8	0.16%	64	0.16%	104	0.16%
19200	6	0.16%	48	0.16%	78	0.16%
28800	4	0.16%	32	0.16%	52	0.16%
38400	3	0.16%	24	0.16%	39	0.16%
57600	2	0.16%	16	0.16%	26	0.16%
115200	1	0.16%	8	0.16%	13	0.16%
230400	---	---	4	0.16%	---	---
460800	---	---	2	0.16%	---	---
750000	---	---	---	---	2	0.00%
921600	---	---	1	0.16%	---	---
1500000	---	---	---	---	1	0.00%

5.13.2 Extended Control Register 1 (EXCR1)

Use this register to control module operation in the Extended mode. Upon reset all bits are set to 0.

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
	1							Required

Extended Control and Status Register 1 (EXCR1) Bank 2, Offset 02h

- EXT_SL
- DMANF
- DMATH
- DMASWP
- LOOP
- ETDLBK
- Reserved
- BTEST
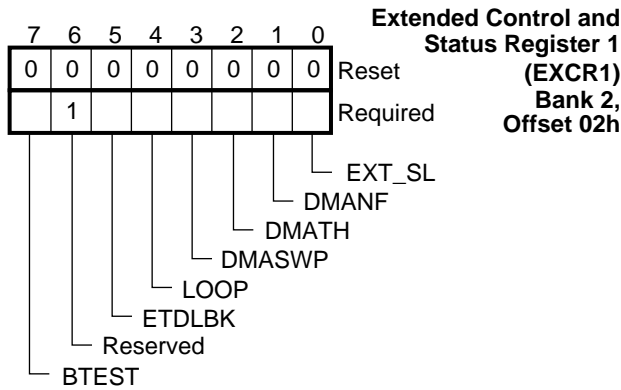
Bit 0 - Extended Mode Select (EXT_SL)

When set to 1, the Extended mode is selected.

Bit 1 - DMA Fairness Control (DMANF)

This bit controls the maximum duration of DMA burst transfers.

0: DMA requests are forced inactive after approximately 10.5 µsec of continuous transmitter and/or receiver DMA operation. (Default)

1: A transmission DMA request is deactivated when the TX_FIFO is full. A reception DMA request is deactivated when the RX_FIFO is empty.

Bit 2 - DMA FIFO Threshold (DMATH)

This bit selects the TX_FIFO and RX_FIFO threshold levels used by the DMA request logic to support demand transfer mode.

A transmission DMA request is generated when the TX_FIFO level is below the threshold.

A reception DMA request is generated when the RX_FIFO level reaches the threshold or when a DMA timeout occurs.

Table 5-15 lists the threshold levels for each FIFO.

TABLE 5-15. DMA Threshold Levels

Bit Value	DMA Threshold for FIFO Type	
	RX_FIFO	Tx_FIFO
0	4	13
1	10	7

Bit 3 - DMA Swap (DMASWP)

This bit selects the routing of the DMA control signals between the internal DMA logic and the configuration module of the chip. When this bit is 0, the transmitter and receiver DMA control signals are not swapped. When it is 1, they are swapped. A block diagram illustrating the control signals routing is given in Fig. 5-3.

The swap feature is particularly useful when only one 8237 DMA channel is used to serve both transmitter and receiver. In this case only one external DRQ/DACK signal pair will be interconnected to the swap logic by the configuration module. Routing the external DMA chan-

nel to either the transmitter or the receiver DMA logic is then simply controlled by the DMASWP bit. This way, the infrared device drivers do not need to know the details of the configuration module.
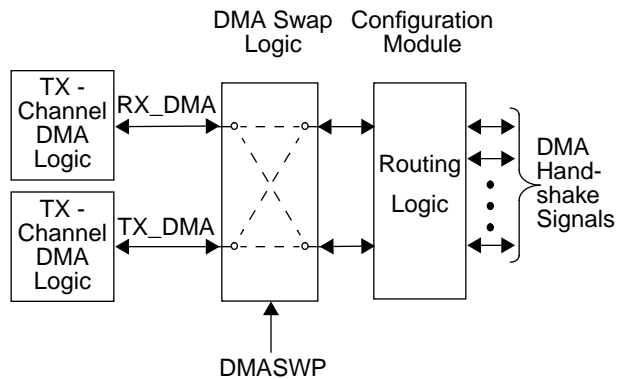
FIGURE 5-3. DMA Control Signals Routing

Bit 4 - Loopback Enable (LOOP)

During loopback, the transmitter output is connected internally to the receiver input, to enable system self-test of serial communications. In addition to the data signal, all additional signals within the UART are interconnected to enable real transmission and reception using the UART mechanisms.

When this bit is set to 1, loopback is selected. This bit accesses the same internal register as bit 4 in the MCR register, when the UART is in a Non-Extended mode.

Loopback behaves similarly in both Non-Extended and Extended modes.

When Extended mode is selected, the $\overline{\text{DTR}}$ bit in the MCR register internally drives both $\overline{\text{DSR}}$ and $\overline{\text{RI}}$, and the $\overline{\text{RTS}}$ bit drives $\overline{\text{CTS}}$ and $\overline{\text{DCD}}$.

During loopback, the following actions occur:

1. The transmitter and receiver interrupts are fully operational. The Modem Status Interrupts are also fully operational, but the interrupt sources are now the lower bits of the MCR register. Modem interrupts in infrared modes are disabled unless the IRMSSL bit in the IRCR2 register is 0. Individual interrupts are still controlled by the IER register bits.

2. The DMA control signals are fully operational.

3. UART and infrared receiver serial input signals are disconnected. The internal receiver input signals are connected to the corresponding internal transmitter output signals.

4. The UART transmitter serial output is forced high and the infrared transmitter serial output is forced low, unless the ETDLBK bit is set to 1. In which case they function normally.

5. The modem status input pins ($\overline{\text{DSR}}$, $\overline{\text{CTS}}$, $\overline{\text{RI}}$ and $\overline{\text{DCD}}$) are disconnected. The internal modem status signals, are driven by the lower bits of the MCR register.

Bit 5 - Enable Transmitter During Loopback (ETDLBK)

When this bit is set to 1, the transmitter serial output is enabled and functions normally when loopback is enabled.

Bit 6 - Reserved

Write 1.

Bit 7 - Baud Generator Test (BTEST)

When set to 1, this bit routes the Baud Generator output to the $\overline{DTR}$ pin for testing purposes.

5.13.3 Link Control Register (LCR) and Bank Select Register (BSR)

These registers are the same as the registers at offset 03h in bank 0.

5.13.4 Extended Control and Status Register 2 (EXCR2)

This register configures the Prescaler and controls the Baud Divisor Register Lock.

Upon reset all bits are set to 0.

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
	0			0	0	0	0	Required

Extended Control and and Status Register 2 (EXCR2) Bank 2, Offset 04h

- Reserved (bits 3-2-1-0)
- PRESL0
- PRESL1
- Reserved
- LOCK
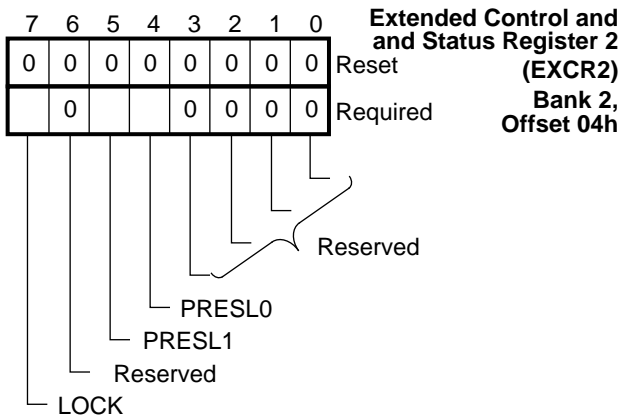
Bits 3 - 0 - Reserved

Read/Write 0.

Bits 5,4 - Prescaler Select

The prescaler divides the 24 MHz input clock frequency to provide the clock for the Baud Generator. (See Table 5-16).

TABLE 5-16. Prescaler Select

Bit 5	Bit 4	Prescaler Value
0	0	13
0	1	1.625
1	0	Reserved
1	1	1.0

Bit 6 - Reserved

Read/Write 0.

Bit 7 - Baud Divisor Register Lock (LOCK)

When set to 1, accesses to the Baud Generator Divisor Register through LBGD(L) and LBGD(H) as well as fall-back are disabled from non-extended mode.

In this case two scratchpad registers overlaid with LBGD(L) and LBGD(H) are enabled, and any attempted CPU access of the Baud Generator Divisor Register

through LBGD(L) and LBGD(H) will access the Scratch-Pad Registers instead. This bit must be set to 0 when extended mode is selected.

5.13.5 Reserved Register

Upon reset, all bits in Bank 2 register with offset 05h are set to 0.

Bits 7-0 - Reserved

Read/Write 0.

5.13.6 TX_FIFO Current Level Register (TXFLV)

This read-only register returns the number of bytes in the TX_FIFO. It can be used to facilitate programmed I/O modes during recovery from transmitter underrun in one of the fast infrared modes.

Extended Modes

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
0	0	0						Required

TX_FIFO Current Level Register (TXFLV) Bank 2, Offset 06h

- TFL0
- TFL1
- TFL2
- TFL3
- TFL4
- Reserved
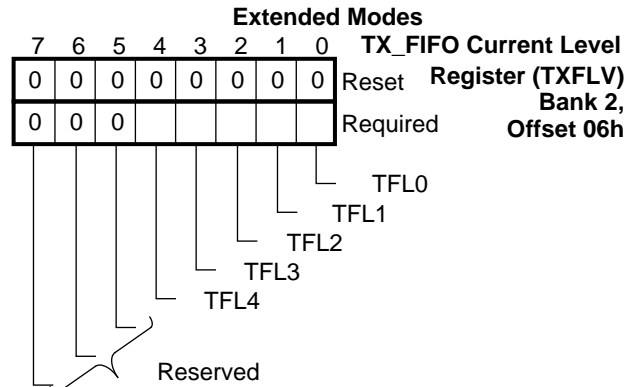
Bits 4-0 - Number of Bytes in TX_FIFO (TFL(4-0))

These bits specify the number of bytes in the TX_FIFO.

Bits 7,6 - Reserved

Read/Write 0.

5.13.7 RX_FIFO Current Level Register (RXFLV)

This read-only register returns the number of bytes in the RX_FIFO. It can be used for software debugging.

Extended Modes

RX_FIFO Current Level Register (RXFLV) Bank 2, Offset 07h
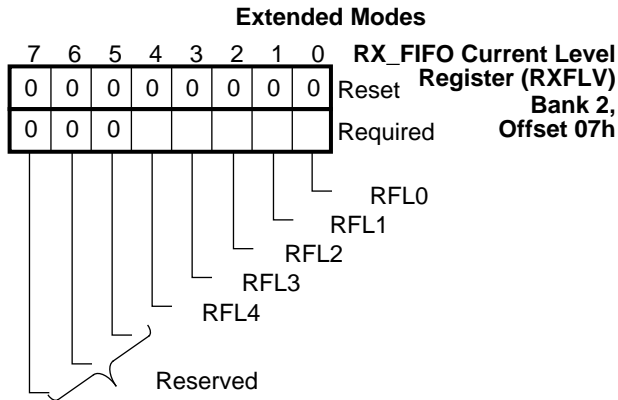
Bits 4-0 - Number of Bytes in RX_FIFO (RFL(4-0))

These bits specify the number of bytes in the RX_FIFO.

Bits 7-5 - Reserved

Read/Write 0.

Note: The contents of TXFLV and RXFLV are not frozen during CPU reads. Therefore, invalid data could be returned if the CPU reads these registers during normal transmitter and receiver operation. To obtain correct data, the software should perform three consecutive reads and then take the data from the second read, if first and second read yield the same result, or from the third read, if first and second read yield different results.

5.14 BANK 3 – MODULE REVISION ID AND SHADOW REGISTERS

Bank 3 contains the Module Revision ID register which identifies the revision of the module, shadow registers for monitoring various registers whose contents are modified by being read, and status and control registers for handling the flow control.

TABLE 5-17. Bank 3 Register Set

Offset	Register Name	Description
00h	MRID	Module Revision ID Register
01h	SH_LCR	Shadow of LCR Register (Read Only)
02h	SH_FCR	Shadow of FIFO Control Register (Read Only)
03h	LCR/ BSR	Link Control Register/ Bank Select Register
04h-07h		Reserved

5.14.1 Module Revision ID Register (MRID)

This read-only register identifies the revision of the module. When read, it returns the module ID and revision level. This module returns the code 2xh, where x indicates the revision number.

Module Revision ID Register (MRID) Bank 3, Offset 00h
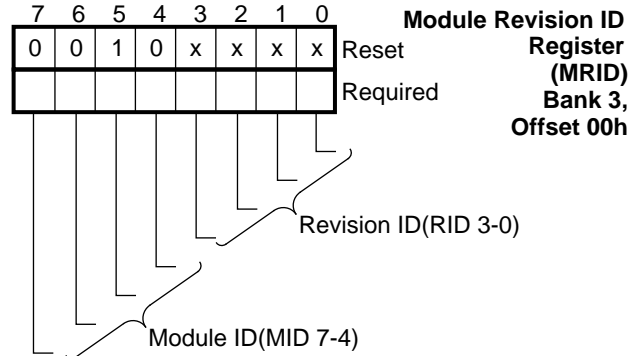
Bits 3-0 - Revision ID (MID3-0)

The value in these bits identifies the revision level.

Bits 7-4 - Module ID (MID7-4)

The value in these bits identifies the module type.

5.14.2 Shadow of Link Control Register (SH_LCR)

This register returns the value of the LCR register. The LCR register is written into when a byte value according to Table 5-9 on page 114, is written to the LCR/BSR registers location (at offset 03h) from any bank.

Shadow of Link Control Register (SH_LCR) Bank 3, Offset 01h
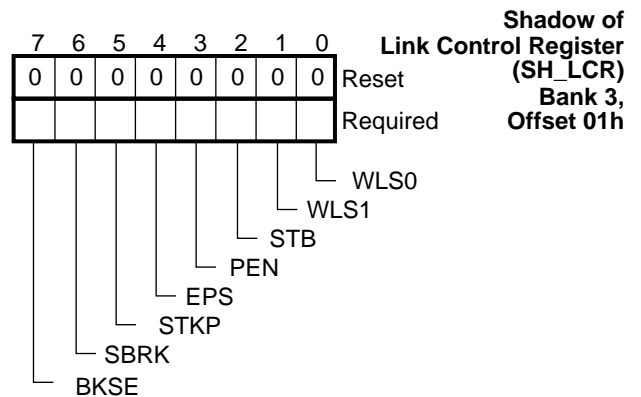
See "Link Control Register (LCR)" on page 112 for bit descriptions.

5.14.3 Shadow of FIFO Control Register (SH_FCR)

This read-only register returns the contents of the FCR register in bank 0.

Shadow of FIFO Control Register (SH_FCR) Bank 3, Offset 02h

```
  7   6   5   4   3   2   1   0
+---+---+---+---+---+---+---+---+
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  Reset
+---+---+---+---+---+---+---+---+
|   |   |   |   |   |   |   |   |  Required
+---+---+---+---+---+---+---+---+
```

- FIFO_EN
- RXSR
- TXSR
- Reserved
- TXFTH0
- TXFHT1
- RXFTH0
- RXFTH1
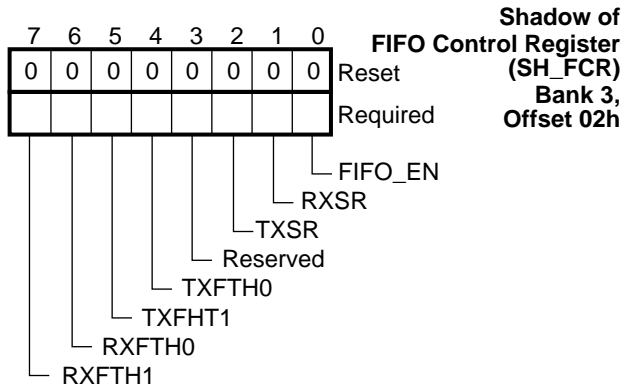
See "FIFO Control Register (FCR)" on page 112 for bit descriptions.

5.14.4 Link Control Register (LCR) and Bank Select Register (BSR)

These registers are the same as the registers at offset 03h in bank 0.

5.15 BANK 4 – IR MODE SETUP REGISTER

TABLE 5-18. Bank 4 Register Set

Offset	Register Name	Description
00-01h		Reserved
02h	IRCR1	Infrared Control Register 1
03h	LCR/ BSR	Link Control/ Bank Select Registers
04-07h		Reserved

5.15.1 Reserved Registers

Bank 4 registers with offsets 00h and 01h are reserved.

5.15.2 Infrared Control Register 1 (IRCR1)

This register enables the Sharp-IR or SIR infrared mode in the Non-Extended mode of operation.

Upon reset, all bits are set to 0.

Infrared Control Register1 (IRCR1) Bank 4, Offset 02h

```
  7   6   5   4   3   2   1   0
+---+---+---+---+---+---+---+---+
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  Reset
+---+---+---+---+---+---+---+---+
| 0 | 0 | 0 | 0 |   |   | 0 | 0 |  Required
+---+---+---+---+---+---+---+---+
```

- Reserved
- Reserved
- IR_SL0
- IR_SL1
- Reserved
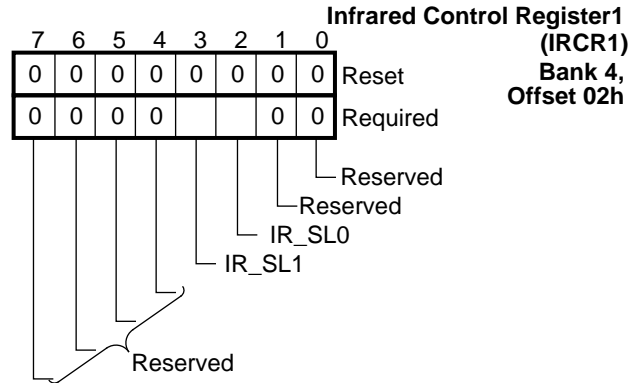
Bits 1,0 - Reserved

Read/Write 0.

Bits 3,2 - Sharp-IR or SIR Mode Select (IR_SL1,0), Non-Extended Mode Only

These bits enable Sharp-IR and SIR modes in Non-Extended mode. They allow selection of the appropriate infrared interface when Extended mode is not selected. These bits are ignored when Extended mode is selected.

TABLE 5-19. Sharp-IR or SIR Mode Selection

IR_SL1	IR_SL0	Selected Mode
0	0	UART (Default)
0	1	Reserved
1	0	Sharp-IR
1	1	SIR

Bits 7-4 - Reserved

Read/Write 0.

5.15.3 Link Control Register (LCR) and Bank Select Register (BSR)

These registers are the same as the registers at offset 03h in bank 0.

5.15.4 Reserved Registers

Bank 4 registers with offsets 04h-07h are reserved.

5.16 BANK 5 – INFRARED CONTROL REGISTERS

TABLE 5-20. Bank 5 Registers

Offset	Register Name	Description
00-02h		Reserved
03h	LCR/ BSR	Link Control Register/ Bank Select Register
04h	IRCR2	Infrared Control Register 2
05h - 07h		Reserved

5.16.1 Reserved Registers

Bank 5 registers with offsets 00h-02h are reserved.

5.16.2 (LCR/BSR) Register

These registers are the same as the registers at offset 03h in bank 0.

5.16.3 Infrared Control Register 2 (IRCR2)

This register controls the basic settings of the infrared modes.

Upon reset, the content of this register is 02h.
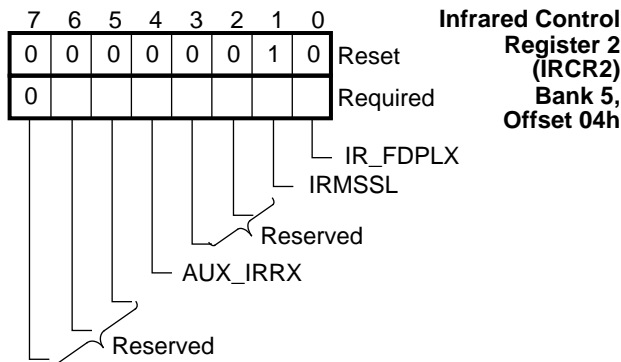
Bit 0 - Enable Infrared Full Duplex Mode (IR_FDPLX)

When set to 1, the infrared receiver is not masked during transmission.

Bit 1 - MSR Register Function Select in Infrared Mode (IRMSSL)

This bit selects the behavior of the Modem Status Register (MSR) and the Modem Status Interrupt (MS_EV) when any infrared mode is selected. When a UART mode is selected, the Modem Status Register and the Modem Status Interrupt function normally, and this bit is ignored.

0: MSR register and modem status interrupt work in the IR modes as in the UART mode (Enables external circuitry to perform carrier detection and provide wake-up events).

1: The MSR returns 30h, and the Modem Status Interrupt is disabled. (Default)

Bits 3,2 -Reserved

Read/Write 0.

Bit 4 - Auxiliary Infrared Input Select (AUX_IRRX)

When set to 1, the infrared signal is received from the auxiliary input. (Separate input signals may be desired for different front-end circuits). See Table 5-29 on page 130.

Bit 5-7 - Reserved

Read/Write 0.

5.16.4 Reserved Registers

Bank 5 registers with offsets 05h-07h are reserved.

5.17 BANK 6 – INFRARED PHYSICAL LAYER CONFIGURATION REGISTERS

This Bank of registers controls aspects of the framing and timing of the infrared modes.

TABLE 5-21. Bank 6 Register Set

Offset	Register Name	Description
00h	IRCR3	Infrared Control Register 3
01h		Reserved
02h	SIR_PW	SIR Pulse Width Control (≤ 115 Kbps)
03h	LCR/ BSR	Link Control Register/ Bank Select Register
04h - 07h		Reserved

5.17.1 Infrared Control Register 3 (IRCR3)

This register enables/disables modulation in Sharp-IR mode.

Upon reset, the content of this register is 20h.
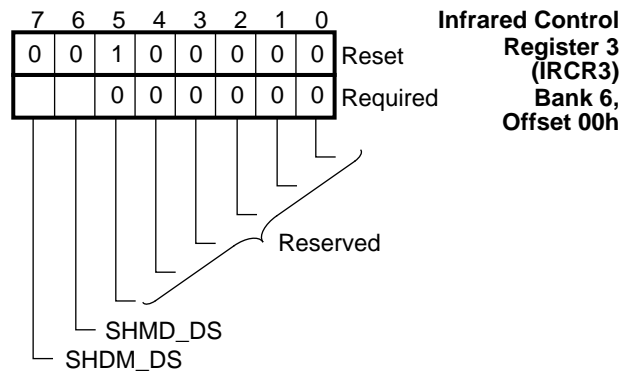
Bit 0-5 - Reserved

Read/Write 0.

Bit 6 - Sharp-IR Modulation Disable (SHMD_DS)

0: Enables internal 500 KHz transmitter modulation. (Default)

1: Disables internal modulation.

Bit 7 - Sharp-IR Demodulation Disable (SHDM_DS)

0: Enables internal 500 KHz receiver demodulation. (Default)

1: Disables internal demodulation.

5.17.2 Reserved Register

Bank 6 register with offset 01h is reserved.

5.17.3 SIR Pulse Width Register (SIR_PW)

This register sets the pulse width for transmitted pulses in SIR operation mode. These setting do not affect the receiver. Upon reset, the content of this register is 00h, which defaults to a pulse width of 3/16 of the baud.

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
0	0	0	0					Required

SIR Pulse Width Register (SIR_PW) Bank 6, Offset 02h

SPW(3-0)
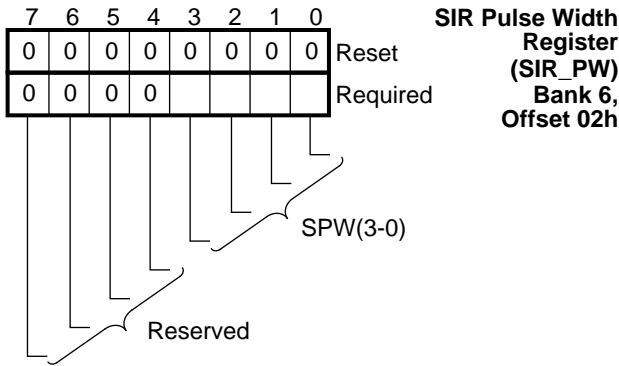
Reserved

Bits 3-0 - SIR Pulse Width Register (SPW)

Two codes for setting the pulse width are available. All other values for this field are reserved.

0000: Pulse width is 3/16 of the bit period. (Default)

1101: Pulse width is 1.6 µsec.

Bits 7-4 - Reserved

Read/Write 0.

5.17.4 Link Control Register (LCR) and Bank Select Register (BSR)

These registers are the same as the registers at offset 03h in Bank 0.

5.17.5 Reserved Registers

Bank 6 registers with offsets 04h-07h are reserved.

5.18 BANK 7 – CONSUMER-IR AND OPTICAL TRANSCEIVER CONFIGURATION REGISTERS

Bank 7 contains the registers that configure Consumer-IR functions and infrared transceiver controls. See Table 5-22.

TABLE 5-22. Bank 7 Register Set

Offset	Register Name	Description
00h	IRRXDC	Infrared Receiver Demodulator Control Register
01h	IRTXMC	Infrared Transmitter Modulator Control Register
02h	RCCFG	Consumer-IR Configuration Register
03h	LCR/BSR	Link Control Register/ Bank Select Register
04h	IRCFG1	Infrared Interface Configuration Register 1
05h		Reserved
06h	IRCFG3	Infrared Interface Configuration Register 3
07h	IRCFG4	Infrared Interface Configuration Register 4

The Consumer-IR utilizes two carrier frequency ranges (see also Table 5-26).

— Low range which spans from 30 KHz to 56 KHz, in 1 KHz increments, and

— High range which includes three frequencies: 400 KHz, 450 KHz or 480 KHz.

High and low frequencies are specified independently to allow separate transmission and reception modulation settings. The transmitter uses the carrier frequency settings in Table 5-26.

The four registers at offsets 04h through 07h (the infrared transceiver configuration registers) are provided to configure the Infrared Interface (the transceiver). The transceiver mode is selected by up to three special output signals (IRSL2-0). When programmed as outputs these signals are forced to low when automatic configuration is enabled (AMCFG bit set to 1) and a UART mode is selected.

5.18.1 Infrared Receiver Demodulator Control Register (IRRXDC)

This register controls settings for Sharp-IR and Consumer IR reception. After reset, the content of this register is 29h. This setting selects a subcarrier frequency in a range between 34.61 KHz and 38.26 KHz for the Consumer-IR mode, and from 480.0 to 533.3 KHz for the Sharp-IR mode. The value of this register is ignored in both modes if the receiver demodulator is disabled. The available frequency ranges for Consumer-IR and Sharp-IR modes are given in Tables 5-23 through 5-25.

7	6	5	4	3	2	1	0	
0	0	1	0	1	0	0	1	Reset
								Required

Infrared Receiver Demodulation Control Register (IRRXDC) Bank 7, Offset 00h

DFR0
DFR1
DFR2
DFR3
DFR4
DBW0
DBW1
DBW2
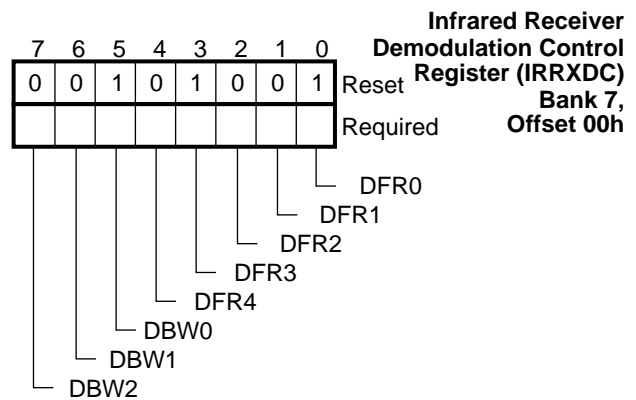
Bits 4-0 - Demodulator Frequency (DFR(4-0))

These bits select the subcarrier's center frequency for the Consumer-IR receiver demodulator. Table 5-25 shows the selection for low speed demodulation (bit 5 of RCCFG=0, see page 128), and Table 5-24 shows the selection for high speed demodulation (bit 5 of RCCFG=1).

Bits 7-5 - Demodulator Bandwidth (DBW(2-0))

These bits set the demodulator bandwidth for the selected frequency range. The subcarrier signal frequency must fall within the specified frequency range in order to be accepted. Used for both Sharp-IR and Consumer-IR modes.

See Tables 5-23, 5-25 and bit 5 (RXHSC) of the Consumer-IR Configuration (RCCFG) Register on page 128.

5.18.2 Infrared Transmitter Modulator Control Register (IRTXMC)

This register controls modulation subcarrier parameters for Consumer-IR and Sharp-IR mode transmission. For Sharp-IR, only the carrier pulse width is controlled by this register - the carrier frequency is fixed at 500 KHz.

After reset, the value of this register is 69h, selecting a carrier frequency of 36 KHz and an IR pulse width of 7 μsec for Consumer-IR, or a pulse width of 0.8 μsec for Sharp-IR.

Infrared Transmitter Modulation Control Register (IRTXMC) Bank 7, Offset 01h

7	6	5	4	3	2	1	0	
0	1	1	0	1	0	0	1	Reset
								Required

MCFR(4-0)

MCPW(2-0)
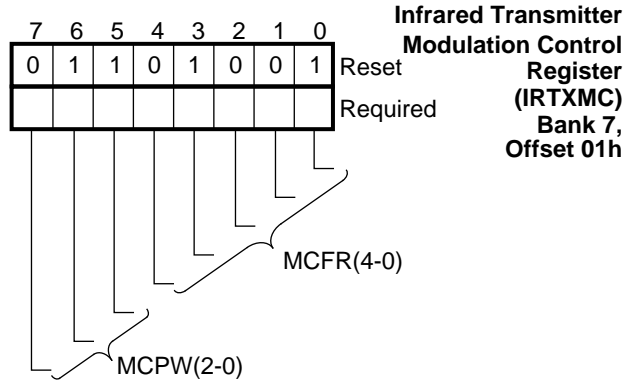
Bits 4-0 - Modulation Subcarrier Frequency (MCFR)
    These bits set the frequency for the Consumer-IR modulation subcarrier. The encoding are defined in Table 5-26.

Bits 7-5 - Modulation Subcarrier Pulse Width (MCPW)
    Specify the pulse width of the subcarrier clock as shown in Table 5-27.

TABLE 5-23. Consumer IR, High Speed Demodulator (RXHSC = 1) (Frequency Ranges in KHz)

DFR Bits 4 3 2 1 0	DBW2-0 (Bits 7, 6 and 5 of IRRXDC)						
	min/max	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0
0 0 0 1 1	min	380.95	363.63	347.82	333.33	320.00	307.69
	max	421.05	444.44	470.58	500.00	533.33	571.42
0 1 0 0 0	min	436.36	417.39	400.00	384.00	369.23	355.55
	max	480.00	505.26	533.33	564.70	600.00	640.00
0 1 0 1 1	min	457.71	436.36	417.39	400.00	384.00	369.92
	max	502.26	533.33	564.70	600.00	640.00	685.57

TABLE 5-24. Sharp-IR Demodulator (Frequency Ranges in KHz)

DFR Bits 4 3 2 1 0	DBW2-0 (Bits 7, 6 and 5 of IRRXDC)						
	min/max	001	010	011	100	101	110
x x x x x x	min	480.0	457.1	436.4	417.4	400.0	384.0
	max	533.3	564.7	600.0	640.0	685.6	738.5

TABLE 5-25. Consumer-IR, Low Speed Demodulator (RXHSC = 0) (Frequency Ranges in KHz)

DFR Bits 4 3 2 1 0	DBW2-0 (Bits 7, 6 and 5 of IRRXDC)						
	min/max	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0
0 0 0 1 0	min	26.66	25.45	24.34	23.33	22.40	21.53
	max	29.47	31.11	32.94	35.00	37.33	40.00
0 0 0 1 1	min	28.57	27.27	26.08	25.00	24.00	23.07
	max	31.57	33.33	35.29	37.50	40.00	42.85
0 0 1 0 0	min	29.28	27.95	26.73	25.62	24.60	23.65
	max	32.37	34.16	36.17	38.43	41.00	43.92
0 0 1 0 1	min	30.07	28.68	27.43	26.29	25.24	24.27
	max	33.24	35.05	37.11	39.43	42.06	45.07

DFR Bits 4 3 2 1 0	DBW2-0 (Bits 7, 6 and 5 of IRRXDC)						
	min/max	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0
0 0 1 1 0	min	31.74	30.30	28.98	27.77	26.66	25.63
	max	35.08	37.03	39.21	41.66	44.44	47.61
0 0 1 1 1	min	32.60	31.13	29.78	28.54	27.40	26.34
	max	36.00	38.05	40.29	42.81	45.66	48.92
0 1 0 0 0	min	33.57	32.04	30.65	29.37	28.20	27.11
	max	37.10	39.16	41.47	44.06	47.00	50.35
0 1 0 0 1	min	34.61	33.04	31.60	30.29	29.08	27.96
	max	38.26	40.38	42.76	45.43	48.46	51.92
0 1 0 1 0	min	35.71	34.09	32.60	31.25	30.00	28.84
	max	39.47	41.66	44.11	46.87	50.00	53.57
0 1 0 1 1	min	36.85	35.18	33.65	32.25	30.96	29.76
	max	40.73	43.00	45.52	48.37	51.60	55.28
0 1 1 0 0	min	38.10	36.36	34.78	33.33	32.00	30.77
	max	42.10	44.44	47.05	50.00	53.33	57.14
0 1 1 0 1	min	39.40	37.59	36.00	34.45	33.08	31.80
	max	43.55	45.94	48.64	51.68	55.13	59.07
0 1 1 1 0	min	40.81	38.95	37.26	35.70	34.28	32.96
	max	45.11	47.61	50.41	53.56	57.13	61.21
1 0 0 1 0	min	42.32	40.40	38.64	37.03	35.55	34.18
	max	46.78	49.37	52.28	55.55	59.25	63.48
1 0 0 1 1	min	43.95	41.95	40.13	38.45	36.92	35.50
	max	48.58	51.27	54.29	57.68	61.53	65.92
1 0 1 0 1	min	45.71	43.63	41.74	40.00	38.40	36.92
	max	50.52	53.33	56.47	60.00	64.00	68.57
1 0 1 1 1	min	47.62	45.45	43.47	41.66	40.00	38.46
	max	52.63	55.55	58.82	62.50	66.66	71.42
1 1 0 1 0	min	49.66	47.40	45.34	43.45	41.72	40.11
	max	54.90	57.94	61.35	65.18	69.53	74.50
1 1 0 1 1	min	51.90	49.54	47.39	45.41	43.60	41.92
	max	57.36	60.55	64.11	68.12	72.66	77.85
1 1 1 0 1	min	54.38	51.90	49.65	47.58	45.68	43.92
	max	60.10	63.44	67.17	71.37	76.13	81.57

TABLE 5-26. Consumer-IR Carrier Frequency Encoding

Encoding MCFR Bits 43210	Low Frequency (TXHSC = 0)	High Frequency (TXHSC = 1)
00000	reserved	reserved
00001	reserved	reserved
00010	reserved	reserved
00011	30 KHz	400 KHz
00100	31 KHz	reserved
00101	32 KHz	reserved
00110	33 KHz	reserved
00111	34 KHz	reserved
01000	35 KHz	450 KHz
01001	36 KHz	reserved
01010	37 KHz	reserved
01011	38 KHz	480 KHz
01100	39 KHz	reserved
01101	40 KHz	reserved
01110	41 KHz	reserved
. . .	. . .	. . .
11010	53 KHz	reserved
11011	54 KHz	reserved
11100	55 KHz	reserved
11101	56 KHz	reserved
11110	56.9 KHz	reserved
11111	reserved	reserved

TABLE 5-27. Carrier Clock Pulse Width Options

Encoding MCPW Bits 7 6 5	Low Frequency (TXHSC = 0)	High Frequency (TXHSC = 1)
0 0 0	Reserved	Reserved
0 0 1	Reserved	Reserved
0 1 0	6 µsec	0.7 µsec
0 1 1	7 µsec	0.8 µsec
1 0 0	9 µsec	0.9 µsec
1 0 1	10.6 µsec	Reserved
1 1 0	Reserved	Reserved
1 1 1	Reserved	Reserved

5.18.3 Consumer-IR Configuration Register (RCCFG)

This register control the basic operation of the Consumer-IR mode. After reset, the content of this register is 00h.

Consumer-IR Configuration Register (RCCFG) Bank 7, Offset 02h
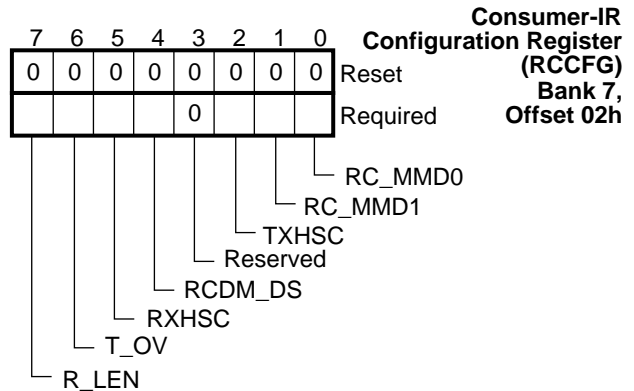
Bits 1,0 - Transmitter Modulator Mode (RC_MMD(1,0))

Determines how infrared pulses are generated from the transmitted bit string. (see Table 5-28).

TABLE 5-28. Transmitter Modulation Mode Selection

RCCFG Bits 1 0	Modulation Mode
0 0	**C_PLS Modulation mode.** Pulses are generated continuously for the entire logic 0 bit time.
0 1	**8_PLS Modulation Mode.** 8 pulses are generated each time one or more logic 0 bits are transmitted following a logic 1 bit.
1 0	**6_PLS Modulation Mode.** 6 pulses are generated each time one or more logic 0 bits are transmitted following a logic 1 bit.
1 1	**Reserved.** Result is indeterminate.

Bit 2 - Transmitter Subcarrier Frequency Select (TXHSC)

This bit selects the modulation carrier frequency range.

0: Low frequency: 30-56.9 KHz

1: High frequency: 400-480 KHz

Bit 3 - Reserved

Read/Write 0.

Bit 4 - Receiver Demodulation Disable (RCDM_DS)

When this bit is 1, the internal demodulator is disabled. The internal demodulator, when enabled, performs carrier frequency checking and envelope detection.

This bit must be set to 1 (disabled), when the demodulation is performed externally, or when oversampling mode is selected to determine the carrier frequency.

0: Internal demodulation enabled.

1: Internal demodulation disabled.

Bit 5 - Receiver Carrier Frequency Select (RXHSC)

This bit selects the receiver demodulator frequency range.

0: Low frequency: 30-56.9 KHz

1: High frequency: 400-480 KHz

Bit 6 - Receiver Sampling Mode Select(T_OV)

0: Programmed-T-period sampling.

1: Oversampling mode.

Bit 7 - Run Length Control (R_LEN)

Enables or disables run length encoding/decoding. The format of a run length code is:

YXXXXXXX

where, Y is the bit value and XXXXXXX is the number of bits minus 1 (Selects from 1 to 128 bits).

0: Run Length Encoding/decoding is disabled.

1: Run Length Encoding/decoding is enabled.

5.18.4 Link Control/Bank Select Registers (LCR/BSR)

These registers are the same as the registers at offset 03h in bank 0.

5.18.5 Infrared Interface Configuration Register 1 (IRCFG1)

This register holds the transceiver configuration data for Sharp-IR and SIR modes. It is also used to directly control the transceiver operation mode when automatic configuration is not enabled. The four least significant bits are also used to read the identification data of a Plug and Play infrared interface adaptor.

Infrared Configuration Register 1 (IRCFG1) Bank 7, Offset 04h
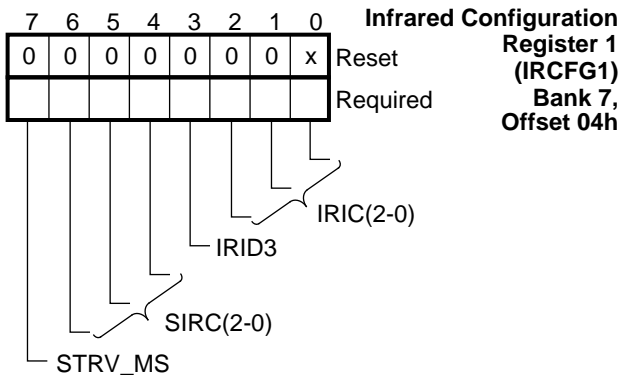
Bit 0 - Transceiver Identification/Control Bit 0 (IRIC0)

The function of this bit depends on whether the ID0/IRSL0/IRRX2 pin is programmed as an input or an output.

If ID0/IRSL0/IRRX2 is programmed as an input (IRSL0_DS = 0) then:

— Upon read, this bit returns the logic level of the pin (allowing external devices to identify themselves).

— Data written to this bit position is ignored.

If ID0/IRSL0/IRXX2 is programmed as an output (IRSL0_DS = 1), then:

— If AMCFG (bit 7 of IRCFG4) is set to 1, this bit drives the ID0/IRSL0/IRRX2 pin when Sharp-IR mode is selected.

— If AMCFG is 0, this bit will drive the ID0/IRSL0/IRRX2 pin, regardless of the selected mode.

Upon read, this bit returns the value previously written.

Bits 2-1 - Transceiver Identification/Control Bits 2-1 (IRIC2-1)

The function of these bits depends on whether the ID/IRSL(2-1) pins are programmed as inputs or outputs.

If ID/IRSL(2-1) are programmed as input (IRSL21_DS = 0) then:

— Upon read, these bits return the logic level of the pins (allowing external devices to identify themselves).

— Data written to these bit positions will be ignored.

If ID/IRSL(2-1) are programmed as output (IRSL21_DS = 1) then:

— If AMCFG (bit 7 of IRCFG4) is set to 1, these bits drive the ID/IRSL(2-1) pins when Sharp-IR mode is selected.

— If AMCFG is 0, these bits will drive the ID/IRSL(2-1)pins, regardless of the selected mode.

Upon read, these bits return the values previously written.

Bit 3 - Transceiver identification (IRID3)

Upon read, this bit returns the logic level of the ID3 pin.

Data written to this bit position is ignored.

Bits 6-4 - SIR Mode Transceiver Configuration (SIRC(2-0))

These bits will drive the ID/IRSL(2-0) pins when AMCFG (bit 7 of IRCFG4) is 1 and SIR mode is selected. They are unused when AMCFG is 0 or when the ID/IRSL (2-0) pins are programmed as inputs. SIRC0 is also unused when the IRSL0_DS bit in IRCFG4 is 0.

Upon read, these bits return the values previously written.

Bit 7 - Special Transceiver Mode Selection (STRV_MS)

When this bit is set to 1, the IRTX output signal is forced to active high and a timer is started.

The timer times out after 64 µsec, at which time the bit is reset and the IRTX output signal becomes low again. The timer is restarted every time a 1 is written to this bit.

Although it is possible to extend the period during which IRTX remains high beyond 64 µsec, this should be avoided to prevent damage to the transmitter LED.

Writing a zero to this bit has no effect.

5.18.6 Reserved Register

Bank 7 register with offset 05h is reserved.

5.18.7 Infrared Interface Configuration 3 Register (IRCFG3)

This register sets the external transceiver configuration for the low speed and high speed Consumer IR modes of operation. Upon reset, the content of this register is 00h.

Infrared Configuration Register 3 (IRCFG3) Bank 7, Offset 06h
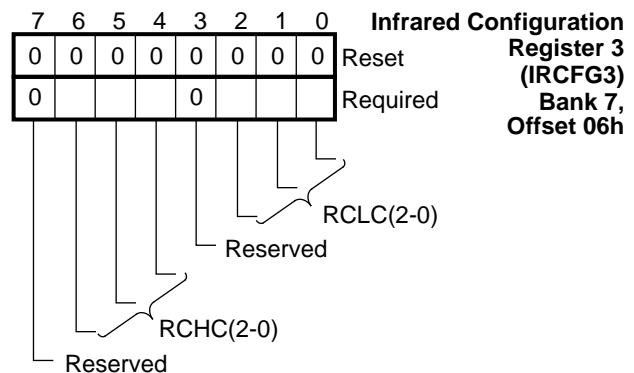
Bits 2-0 - Consumer-IR Mode Transceiver Configuration, Low-Speed (RCLC)

These bits drive the ID/IRSL(2-0) pins when AMCFG is 1 and Consumer-IR mode with 30-56 KHz receiver carrier frequency is selected. They are unused when AMCFG is 0 or when the ID/IRSL(2-0) pins are programmed as inputs. Upon read, these bits return the values previously written.

Bit 3 - Reserved

Read/Write 0.

Bits 6-4 - Consumer-IR Mode Transceiver Configuration, High-Speed (RCHC)

These bits drive the IRSL(2-0) pins when AMCFG (bit 7 of IRCFG4) is 1 and Consumer-IR mode with 400-480 KHz receiver carrier frequency is selected. They are unused when AMCFG is 0 or when the ID/IRSL(2-0) pins are programmed as inputs.

Upon read, these bits return the values previously written.

Bit 7 - Reserved

Read/Write 0.

5.18.8 Infrared Interface Configuration Register 4 (IRCFG4)

This register configures the receiver data path and enables the automatic selection of the configuration pins.

After reset, this register contains 00h.

Infrared Configuration Register 4 (IRCFG4) Bank 7, Offset 07h
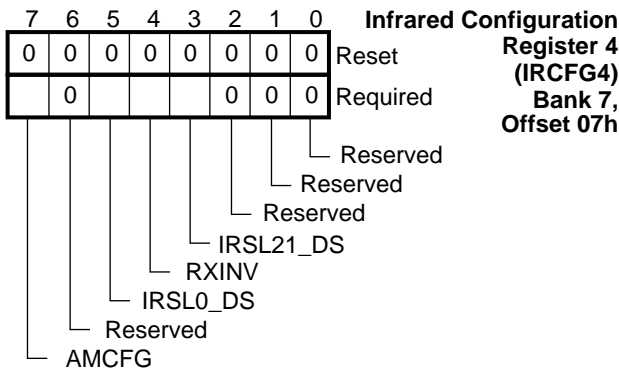
Bits 2-0 - Reserved

Read/write 0.

Bit 3- ID/IRSL(2-1) Pins' Direction Select (IRSL21_DS)

This bit determines the direction of the ID/IRSL2 and ID/IRSL1 pins.

0: Pins' direction is input.

1: Pins' direction is output.

Bit 4 - IRRX Signal Invert (RXINV)

This bit supports optical transceivers with receive signals of opposite polarity (active high instead of active low).

When set to 1 an inverter is put on the path of the input signal of the receiver.

Bit 5 - ID0/IRSL0/IRRX2 Pin Direction Select (IRSL0_DS)

This bit determines the direction of the ID0/IRSL0/IRRX2 pin. See Table 5-29 on page 130.

0: Pin's direction is input.

1: Pin's direction is output.

Bit 6 - Reserved

Read/Write 0.

Bit 7 - Automatic Module Configuration (AMCFG)

When set to 1, this bit enables automatic infrared configuration.

TABLE 5-29. Infrared Receiver Input Selection

Bit 5 of IRCFG4[1] (IRSL0_DS)	Bit 4 of IRCR2 (AUX_IRRX)[2]	Selected IRRX
0	0	IRRX1
0	1	IRRX2
1	0	IRRX1
1	1	1

1. IRCFG4 is in bank 7, offset 07h. It is described on page 130.
2. AUX_IRRX (bit 4 of IRCR2) is described on page 124.

5.19 UART2 WITH IR REGISTER BITMAPS

Read Cycles

7	6	5	4	3	2	1	0	
								Reset
								Required

Receiver Data Register (RXD) Bank 0, Offset 00h

Received Data

Extended Mode, Read Cycles

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	1	Reset
0	0							Required

Event Identification Register (EIR) Bank 0, Offset 02h

- RXHDL_EV
- TXLDL_EV
- LS_EV or TXHLT_EV
- MS_EV
- DMA_EV
- TXEMP-EV
- Reserved
- Reserved

Write Cycles

7	6	5	4	3	2	1	0	
								Reset
								Required

Transmitter Data Register (TXD) Bank 0, Offset 00h

Transmitted Data

Write Cycles

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
				0				Required

FIFO Control Register (FCR) Bank 0, Offset 02h

- FIFO_EN
- RXSR
- TXSR
- Reserved
- TXFTH0
- TXFTH1
- RXFTH0
- RXFTH1

Extended Mode

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
0	0							Required

Interrupt Enable Register (IER) Bank 0, Offset 01h

- RXHDL_IE
- TXLDL_IE
- LS_IE or TXUR_IE
- MS_IE
- DMA_IE
- TXEMP_IE
- Reserved
- Reserved

Link Control Register (LCR) All Banks, Offset 03h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

- WLS0
- WLS1
- STB
- PEN
- EPS
- STKP
- SBRK
- BKSE

Non-Extended Modes, Read Cycles

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	1	Reset
		0	0					Required

Event Identification Register (EIR) Bank 0, Offset 02h

- IPF - Interrupt Pending
- IPR0 - Interrupt Priority 0
- IPR1 - Interrupt Priority 1
- RXFT - RX_FIFO Time-Out
- Reserved
- Reserved
- FEN0 - FIFO Enabled
- FEN1 - FIFO Enabled

Bank Selection Register (BSR) All Banks, Offset 03h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

Bank Selected

- BKSE-Bank Selection Enable

Non-Extended Mode

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
0	0	0						Required

Modem Control Register (MCR) Bank 0, Offset 04h

- DTR
- RTS
- RILP
- ISEN or DCDLP
- LOOP
- Reserved
- Reserved
- Reserved

Non-Extended Mode

7	6	5	4	3	2	1	0	
								Reset
								Required

Scratch Register (SCR) Bank 0, Offset 07h

- Scratch Data

Extended Mode

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

Modem Control Register (MCR) Bank 0, Offset 04h

- DTR
- RTS
- DMA_EN
- TX_DFR
- IR_PLS
- MDSL0
- MDSL1
- MDSL2

Extended Mode

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
				0				Required

Auxiliary Status Register (ASCR) Bank 0, Offset 07h

- RXF_TOUT
- EOF_INF
- S_EOT
- Reserved
- RXWDG
- RXACT
- TXUR
- Reserved

Non-Extended Mode

7	6	5	4	3	2	1	0	
0	1	1	0	0	0	0	0	Reset
								Required

Link Status Register (LSR) Bank 0, Offset 05h

- RXDA
- OE
- PE
- FE
- BRK
- TXRDY
- TXEMP
- ER_INF

Legacy Baud Generator Divisor Low Byte Register (LBGD(L) Bank 1, Offset 00h

7	6	5	4	3	2	1	0	
								Reset
								Required

- Least Significant Byte of Baud Generator

Modem Status Register (MSR) Bank 0, Offset 06h

7	6	5	4	3	2	1	0	
X	X	X	X	0	0	0	0	Reset
								Required

- DCTS
- DDSR
- TERI
- DDCD
- CTS
- DSR
- RI
- DCD

Legacy Baud Generator Divisor High Byte Register (LBGD(H)) Bank 1, Offset 01h

7	6	5	4	3	2	1	0	
								Reset
								Required

- Most Significant Byte of Baud Generator

Baud Generator Divisor Low Byte Register (BGD(L)) Bank 2, Offset 00h

7	6	5	4	3	2	1	0	
x	x	x	x	x	x	x	x	Reset
								Required

Least Significant Byte of Baud Generator

TX_FIFO Current Level Register (TXFLV) Bank 2, Offset 06h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
0	0	0						Required

- TFL0
- TFL1
- TFL2
- TFL3
- TFL4

Reserved

Baud Generator Divisor High Byte Register (BGD(H)) Bank 2, Offset 01h

7	6	5	4	3	2	1	0	
x	x	x	x	x	x	x	x	Reset
								Required

Most Significant Byte of Baud Generator

RX_FIFO Current Level Register (RXFLV) Bank 2, Offset 07h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
0	0	0						Required

- RFL0
- RFL1
- RFL2
- RFL3
- RFL4

Reserved

Extended Control and Status Register 1 (EXCR1) Bank 2, Offset 02h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
	1							Required

- EXT_SL
- DMANF
- DMATH
- DMASWP
- LOOP
- ETDLBK
- Reserved
- BTEST

Module Revision ID Register (MRID) Bank 3 Offset 00h

7	6	5	4	3	2	1	0	
0	0	1	0	x	x	x	x	Reset
								Required

Revision ID(RID 3-0)

Module ID(MID 7-4)

Extended Control and Status Register 2 (EXCR2) Bank 2, Offset 04h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
	0			0	0	0	0	Required

Reserved

- PRESL0
- PRESL1
- Reserved
- LOCK

Shadow of Link Control Register (SH_LCR) Bank 3, Offset 01h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

- WLS0
- WLS1
- STB
- PEN
- EPS
- STKP
- SBRK
- BKSE

UART2 WITH IR REGISTER BITMAPS

Shadow of FIFO Control Register (SH_FCR) Bank 3, Offset 02h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
				0				Required

- FIFO_EN
- RXFR
- TXFR
- Reserved
- TXFTH0
- TXFHT1
- RXFTH0
- RXFTH1

SIR Pulse Width Register (SIR_PW) Bank 6, Offset 02h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
0	0	0	0					Required

- SPW(3-0)
- Reserved

Infrared Control Register1 (IRCR1) Bank 4, Offset 02h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
0	0	0	0					Required

- Reserved
- IR_SL0
- IR_SL1
- Reserved

Infrared Receiver Demodulation Control Register (IRRXDC) Bank 7, Offset 00h

7	6	5	4	3	2	1	0	
0	0	1	0	1	0	0	1	Reset
								Required

- DFR0
- DFR1
- DFR2
- DFR3
- DFR4
- DBW0
- DBW1
- DBW2

Infrared Control Register 2 (IRCR2) Bank 5, Offset 04h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	1	0	Reset
0	0	0						Required

- IR_FDPLX
- IRMSSL
- Reserved
- Reserved
- AUX_IRRX
- Reserved

Infrared Transmitter Modulation Control Register (IRTXMC) Bank 7, Offset 01h

7	6	5	4	3	2	1	0	
0	1	1	0	1	0	0	1	Reset
								Required

- MCFR(4-0)
- MCPW(2-0)

Infrared Control Register 3 (IRCR3) Bank 6, Offset 00h

7	6	5	4	3	2	1	0	
0	0	1	0	0	0	0	0	Reset
				0			0	Required

- Reserved
- SHMD_DS
- SHDM_DS

Consumer-IR Mode Configuration Register (RCCFG) Bank 7, Offset 02h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
				0				Required

- RC_MMD0
- RC_MMD1
- TXHSC
- Reserved
- RCDM_DS
- RXHSC
- T_OV
- R_LEN

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	x	Reset
								Required

Infrared Configuration Register 1 (IRCFG1) Bank 7, Offset 04h

IRIC(2-0)

IRID3

SIRC(2-0)

STRV_MS

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
0				0				Required

Infrared Configuration Register 3 (IRCFG3) Bank 7, Offset 06h

RCLC(2-0)

Reserved

RCHC(2-0)

Reserved

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
	0				0	0	0	Required

Infrared Configuration Register 4 (IRCFG4) Bank 7, Offset 07h

Reserved

IRSL21_DS

RXINV

IRSL0_DS

Reserved

AMCFG

6.0 Enhanced Serial Port - UART1 (Logical Device 3)

UART1 supports serial data communications with a remote peripheral device or modem using a wired interface. The module can function as a standard 16450 or 16550, or as an Extended UART.

This module provides receive and transmit channels that can operate concurrently in full-duplex mode. This module performs all functions required to conduct parallel data interchange with the system and composite serial data exchange with the external data channel, including:

- Format conversion between the internal parallel data format and the external programmable composite serial format. See Figure 6-2.

- Serial data timing generation and recognition.

- Parallel data interchange with the system using a choice of bi-directional data transfer mechanisms.

- Status monitoring for all phases of communications activity.

Existing 16550-based legacy software is completely and transparently supported. Module organization and specific fallback mechanisms switch the module to 16550 compatibility mode upon reset or when initialized by 16550 software.

6.1 REGISTER BANK OVERVIEW

Four register banks, each containing eight registers, control UART operation. All registers use the same 8-byte address space to indicate offsets 00h through 07h, and the active bank must be selected by the software.

The register bank organization enables access to the banks as required for activation of all module modes, while maintaining transparent compatibility with 16450 or 16550 software, which activates only the registers and specific bits used in those devices. For details, See Section 6.2.

The Bank Selection Register (BSR) selects the active bank and is common to all banks. See Figure 6-1. Therefore, each bank defines seven new registers.
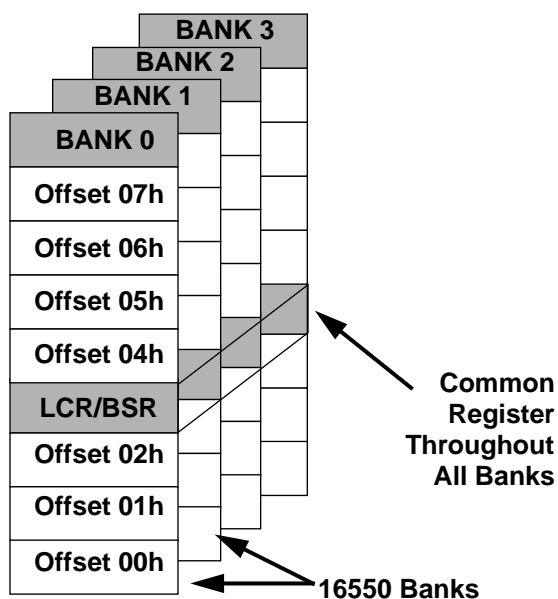

FIGURE 6-1. Register Bank Architecture

The default bank selection after system reset is 0, which places the module in the UART 16550 mode. Additionally, setting the baud in bank 1 (as required to initialize the 16550 UART) switches the module to a Non-Extended UART mode. This ensures that running existing 16550 software will switch the system to the 16550 configuration without software modification.

Table 6-1 shows the main functions of the registers in each bank.

TABLE 6-1. Register Bank Summary

Bank	Main Functions
0	Global Control and Status
1	Legacy Bank
2	Baud Generator Divisor, Extended Control and Status
3	Module Revision ID and Shadow Registers

Banks 0 and 1 are the 16550 register banks. The registers in these banks are equivalent to the registers contained in the 16550 UARTs and are accessed by 16550 software drivers as if the module was a 16550. Bank 1 contains the legacy Baud Generator Divisor Ports. Bank 0 registers control all other aspects of the UART function, including data transfers, format setup parameters, interrupt setup and status monitoring.

Bank 2 contains the non-legacy Baud Generator Divisor Ports, and controls the extended features special to this UART, that are not included in the 16550 repertoire. See "Extended UART Mode" on page 137.

Bank 3 contains the Module Revision ID and shadow registers. The Module Revision ID (MRID) register contains a code that identifies the revision of the module when read by software. The shadow registers contain the identical content as reset-when-read registers within bank 0. Reading their contents from the shadow registers lets the system read the register content without resetting them.

6.2 DETAILED DESCRIPTION

The module provides receive and transmit channels that can operate concurrently in full-duplex mode. This module performs all functions required to conduct parallel data interchange with the system and composite serial data exchange with the external data channel, including:

- Format conversion between the internal parallel data format and the external programmable composite serial format. See Figure 6-2.

- Serial data timing generation and recognition

- Parallel data interchange with the system using a choice of bi-directional data transfer mechanisms

- Status monitoring for all phases of the communications activity

The module supplies modem control registers, and a prioritized interrupt system for efficient interrupt handling.
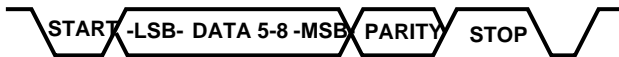
6.2.1   16450 or 16550 UART Mode

The module defaults to 16450 mode after power up or reset. UART 16550 mode is equivalent to 16450 mode, with the addition of a 16-byte data FIFO for more efficient data I/O. Transparent compatibility is maintained with this UART mode in this module.

Despite the many additions to the basic UART hardware and organization, the UART responds correctly to existing software drivers with no software modification required. When 16450 software initializes and addresses this module, it will in always perform as a 16450 device.

Data transfer takes place by use of data buffers that interface internally in parallel and with the external data channel in a serial format. 16-byte data FIFOs may reduce host overhead by enabling multiple-byte data transfers within a single interrupt. With FIFOs disabled, this module is equivalent to the standard 16450 UART. With FIFOs enabled, the hardware functions as a standard 16550 UART.

The composite serial data stream interfaces with the data channel through signal conditioning circuitry such as TTL/RS232 converters, modem tone generators, etc.

Data transfer is accompanied by software-generated control signals, which may be utilized to activate the communications channel and "handshake" with the remote device. These may be supplied directly by the UART, or generated by control interface circuits such as telephone dialing and answering circuits, etc.

FIGURE 6-2. Composite Serial Data

The composite serial data stream produced by the UART is illustrated in Figure 6-2. A data word containing five to eight bits is preceded by start bits and followed by an optional parity bit and a stop bit. The data is clocked out, LSB first, at a predetermined rate (the baud).

The data word length, parity bit option, number of start bits and baud rate are programmable parameters.

The UART includes a programmable baud rate generator that produces the baud rate clocks and associated timing signals for serial communication.

The system can monitor this module status at any time. Status information includes the type and condition of the transfer operation in process, as well as any error conditions (e.g., parity, overrun, framing, or break interrupt).

The module resources include modem control capability and a prioritized interrupt system. Interrupts can be programmed to match system requirements, minimizing the CPU overhead required to handle the communications Line.

Programmable Baud Generator

This module contains a programmable baud rate generator that generates the clock rates for serial data communication (both transmit and receive channels). It divides its input clock by any divisor value from 1 to 2^{16} - 1. The output clock frequency of the baud rate generator must be programmed to be sixteen times the baud rate value. A 24 MHz input frequency is divided by a prescale value (PRESL field of EXCR2 - see page 149. Its default value is 13) and by a 16-bit programmable divisor value contained in the Baud Generator Divisor High and Low registers (BGD(H) and BGD(L)

- see page 148). Each divisor value yields a clock signal (BOUT) and a further division by 16 produces the baud rate clock for the serial data stream. It may also be output as a test signal when enabled (see bit 7 of EXCR1 on page 149.)

These user-selectable parameters enable the user to generate a large choice of serial data rates, including all standard baud rates. A list of baud rates and their settings appears in Table 6-12 on page 148.

Module Operation

Before module operation can begin, both the communications format and baud rate must be programmed by the software. The communications format is programmed by loading a control byte into the LCR register, while the baud rate is selected by loading an appropriate value into the baud rate generator divisor registers and the divisor preselect values (PRESL) into EXCR2 (see page 149).

The software can read the status of the module at any time during operation. The status information includes full or empty state for both transmission and reception channels, and any other condition detected on the received data stream, like parity error, framing error, data overrun, or break event.

6.2.2   Extended UART Mode

In Extended UART mode of operation, the module configuration changes and additional features become available which enhance UART capabilities.

- The interrupt sources are no longer prioritized; they are presented bit-by-bit in the EIR (see page 140).

- An auxiliary status and control register replaces the scratchpad register. It contains additional status and control flag bits ("Auxiliary Status and Control Register (ASCR)" on page 146).

- The TX_FIFO can generate interrupts when the number of outgoing bytes in the TX_FIFO drops below a programmable threshold. In the Non-Extended UART modes, only reception FIFOs have the thresholding feature.

6.3   FIFO TIME-OUTS

Time-out mechanisms prevent received data from remaining in the RX_FIFO indefinitely, if the programmed interrupt threshold is not reached.

An RX_FIFO time-out generates a Receiver Data Ready interrupt if bit 0 of IER is set to 1. An RX_FIFO time-out also sets bit 0 of ASCR to 1 if the RX_FIFO is below the threshold. When a Receiver Data Ready interrupt occurs, this bit is tested by the software to determine whether a number of bytes indicated by the RX_FIFO threshold can be read without checking bit 0 of the LSR register.

The conditions that must exist for a time-out to occur in the various modes of operation are described below.

When a time-out has occurred, it can only be reset when the FIFO is read by the CPU.

Time-out event A generates an interrupt and sets the RXF_TOUT bit (bit 0 of ASCR) when all of the following are true:

- At least one byte is in the RX_FIFO, and

- More than 64 μsec or four character times, whichever is greater, have elapsed since the last byte was loaded into the RX_FIFO from the receiver logic, and

- More than 64 μsec or four character times, whichever is greater, have elapsed since the last byte was read from the RX_FIFO by the CPU.

6.4 AUTOMATIC FALLBACK TO A NON-EXTENDED UART MODE

The automatic fallback feature supports existing legacy software packages that use the 16550 UART by automatically turning off any Extended mode features and switches the UART to Non-Extended mode when either of the LBGD(L) or LBGD(H) ports in bank 1 is read from or written to by the CPU.

This eliminates the need for user intervention prior to running a legacy program.

In order to avoid spurious fallbacks, alternate baud rate registers are provided in bank 2. Any program designed to take advantage of the UART's extended features, should not use LBGD(L) and LBGD(H) to change the baud rate. It should use the BGD(L) and BGD(H) registers instead. Access to these ports will not cause fallback.

Fallback can occur in any mode. In Extended UART mode, fallback is always enabled. In this case, when a fallback occurs, the following happens:

- Transmission and Reception FIFOs switch to 16 levels.

- A value of 13 is selected for the baud rate generator prescaler

- The BTEST and ETDLBK bits in the EXCR1 register are cleared.

- UART mode is selected.

- A switch to a Non-Extended UART mode occurs.

When a fallback occurs in a Non-Extended UART mode, the last two of the above actions do not take place.

Fallback from a Non-Extended mode can be disabled by setting the LOCK bit in register EXCR2. When LOCK is set to 1 and the UART is in a Non-Extended mode, two scratch registers overlaid with LBGD(L) and LBGD(H) are enabled. Any attempted CPU access of LBGD(L) and LBGD(H) accesses the scratch registers, and the baud rate setting is not affected. This feature allows existing legacy programs to run faster than 115.2 Kbps.

6.4.1 Transmission Deferral

This feature allows software to send high-speed data in Programmed Input/Output (PIO) mode without the risk of generating a transmitter underrun.

Transmission deferral is available only in Extended mode and when the TX_FIFO is enabled. When transmission deferral is enabled (TX_DFR bit in the MCR register set to 1) and the transmitter becomes empty, an internal flag is set and locks the transmitter. If the CPU now writes data into the TX_FIFO, the transmitter does not start sending the data until the TX_FIFO level reaches 14 at which time the internal flag is cleared. The internal flag is also cleared and the transmitter starts transmitting when a time-out condition is reached. This prevents some bytes from being in the TX_FIFO indefinitely if the threshold is not reached.

The time-out mechanism is implemented by a timer that is enabled when the internal flag is set and there is at least one byte in the TX_FIFO. Whenever a byte is loaded into the TX_FIFO the timer gets reloaded with the initial value. If

no bytes are loaded for a 64-μsec time, the timer times out and the internal flag is cleared, thus enabling the transmitter.

6.5 BANK 0 – GLOBAL CONTROL AND STATUS REGISTERS

In the Non-Extended modes of operation, bank 0 is compatible with both the 16450 and the 16550. Upon reset, this module defaults to the 16450 mode. In the Extended mode, all the Registers (except RXD/ TXD) offer additional features.

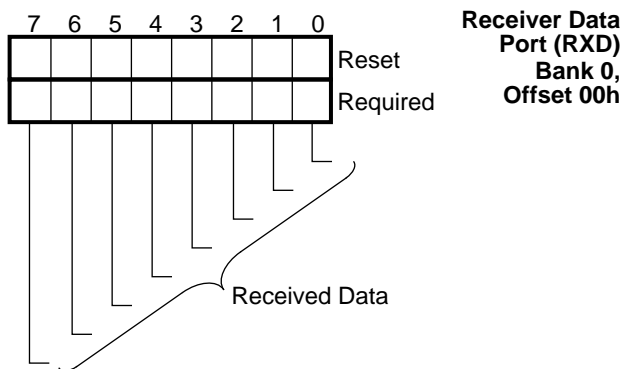**TABLE 6-2. Bank 0 Serial Controller Base Registers**

Offset	Register Name	Description
00h	RXD/ TXD	Receiver Data Port/ Transmitter Data Port
01h	IER	Interrupt Enable Register
02h	EIR/ FCR	Event Identification Register/ FIFO Control Register
03h	LCR/ BSR	Line Control Register/ Bank Select Register
04h	MCR	Modem Control Register
05h	LSR	Line Status Register
06h	MSR	Modem Status Register
07h	SCR/ ASCR	Scratch Register/ Auxiliary Status and Control Register

6.5.1 Receiver Data Port (RXD) or the Transmitter Data Port (TXD)

These ports share the same address.

RXD is accessed during CPU read cycles. It is used to read data from the Receiver Holding Register when the FIFOs are disabled, or from the bottom of the RX_FIFO when the FIFOs are enabled.

Receiver Data Port (RXD)

Receiver Data Port (RXD) Bank 0, Offset 00h

Bits 7-0 - Received Data

Used to access the Receiver Holding Register when the FIFOs are disabled, or the bottom of the RX_FIFO when the FIFOs are enabled.

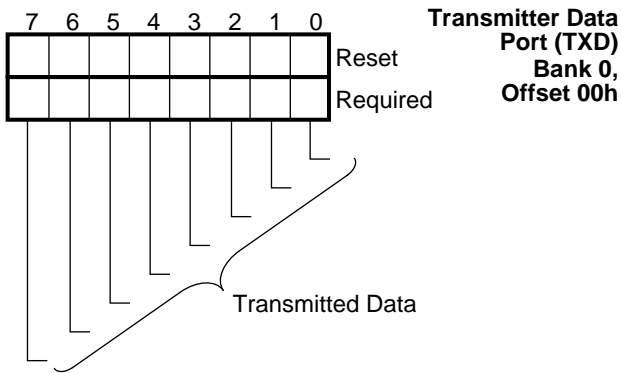TXD is accessed during CPU write cycles. It is used to write data to the Transmitter Holding Register when the FIFOs are disabled, or to the TX_FIFO when the FIFOs are enabled.

IER in Non-Extended Modes

```
  7   6   5   4   3   2   1   0
┌───┬───┬───┬───┬───┬───┬───┬───┐
│ 0 │ 0 │ 0 │ 0 │ 0 │ 0 │ 0 │ 0 │ Reset
├───┼───┼───┼───┼───┼───┼───┼───┤
│   │   │   │   │   │   │   │   │ Required
└───┴───┴───┴───┴───┴───┴───┴───┘
```

Interrupt Enable Register (IER) Bank 0, Offset 01h

RXHDL_IE
TXLDL_IE
LS_IE
MS_IE
Reserved
Reserved
Reserved
Reserved

```
  7   6   5   4   3   2   1   0
┌───┬───┬───┬───┬───┬───┬───┬───┐
│   │   │   │   │   │   │   │   │ Reset
├───┼───┼───┼───┼───┼───┼───┼───┤
│   │   │   │   │   │   │   │   │ Required
└───┴───┴───┴───┴───┴───┴───┴───┘
```

Transmitter Data Port (TXD) Bank 0, Offset 00h

Transmitted Data

Bits 7-0 - Transmitted Data

Used to access the Transmitter Holding Register when the FIFOs are disabled or the top of TX_FIFO when the FIFOs are enabled.

6.5.2   Interrupt Enable Register (IER)

This register controls the enabling of various interrupts. Some interrupts are common to all operating modes of the module, while others are mode specific. Bits 4 to 7 can be set in Extended mode only. They are cleared in Non-Extended mode. The bits of the Interrupt Enable Register (IER) are defined differently, depending on operating the module in Extended or Non-Extended mode.

The following sections describe the bits in this register for each of these modes.

The reset mode for the IER is the Non-Extended UART mode.

When edge-sensitive interrupt triggers are employed, user is advised to clear all IER bits immediately upon entering the interrupt service routine and to re-enable them prior to exiting (or alternatively, to disable CPU interrupts and re-enable prior to exiting). This will guarantee proper interrupt triggering in the interrupt controller in case one or more interrupt events occur during execution of the interrupt routine.

If the LSR, MSR or EIR registers are to be polled, interrupt sources which are identified by self-clearing bits should have their corresponding IER bits set to 0, to prevent spurious pulses on the interrupt output pin.

If an interrupt source must be disabled, the CPU can do so by clearing the corresponding bit in the IER register. However, if an interrupt event occurs just before the corresponding enable bit in the IER register is cleared, a spurious interrupt may be generated. To avoid this problem, the clearing of any IER bit should be done during execution of the interrupt service routine. If the interrupt controller is programmed for level-sensitive interrupts, the clearing of IER bits can also be performed outside the interrupt service routine, but with the CPU interrupt disabled.

Interrupt Enable Register (IER), in the Non-Extended Mode

Upon reset, the IER supports the Non-Extended mode. See the bitmap of the Interrupt Enable Register in these modes.
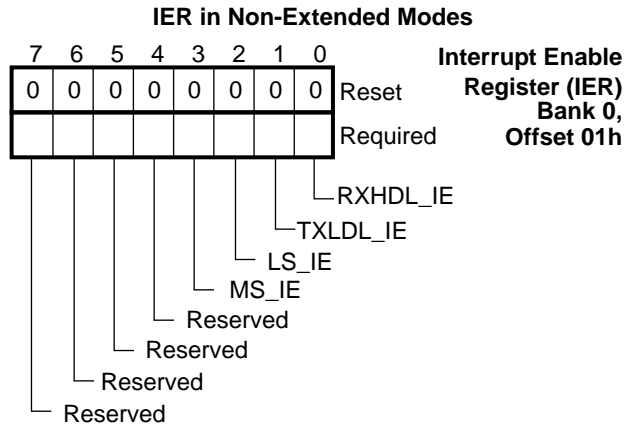
Bit 0 - Receiver High-Data-Level Interrupt Enable (RXHDL_IE)

Setting this bit enables interrupts on Receiver High-Data-Level, or RX_FIFO Time-Out events (EIR Bits 3-0 are 0100 or 1100. See Table 6-3 on page 141).

0: Disable Receiver High-Data-Level and RX_FIFO Time-Out interrupts (Default).

1: Enable Receiver High-Data-Level and RX_FIFO Time-Out interrupts.

Bit 1 - Transmitter Low-Data-Level Interrupt Enable (TXLDL_IE)

Setting this bit enables interrupts on Transmitter Low Data-Level-events (EIR Bits 3-0 are 0010. See Table 6-3 on page 141).

0: Disable Transmitter Low-Data-Level Interrupts (Default).

1: Enable Transmitter Low-Data-Level Interrupts.

Bit 2 - Line Status Interrupt Enable (LS_IE)

Setting this bit enables interrupts on Line Status events. (EIR Bits 3-0 are 0110. See Table 6-3 on page 141).

0: Disable Line Status Interrupts (LS_EV) (Default).

1: Enable Line Status Interrupts (LS_EV).

Bit 3 - Modem Status Interrupt Enable (MS_IE)

Setting this bit enables the interrupts on Modem Status events. (EIR Bits 3-0 are 0000. See Table 6-3 on page 141).
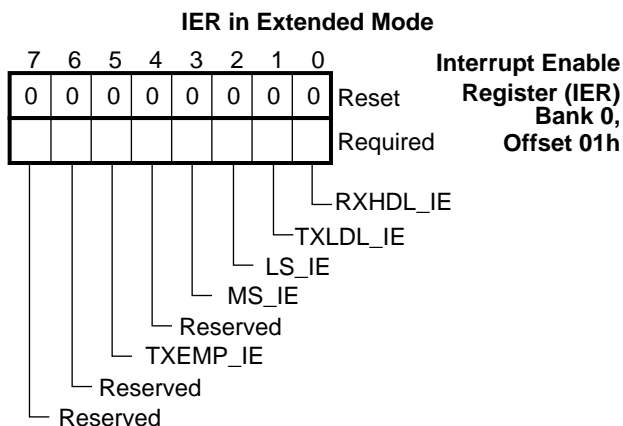
0 - Disable Modem Status Interrupts (MS_EV) (Default).

1: Enable Modem Status Interrupts (MS_EV).

Bits 7-4- Reserved

These bits are reserved.

Interrupt Enable Register (IER), in the Extended Mode

See the bitmap of the Interrupt Enable Register in these mode.

IER in Extended Mode

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

Interrupt Enable Register (IER) Bank 0, Offset 01h

RXHDL_IE
TXLDL_IE
LS_IE
MS_IE
Reserved
TXEMP_IE
Reserved
Reserved

Bit 0 - Receiver High-Data-Level Interrupt Enable (RXHDL_IE)

Setting this bit enables interrupts when the RX_FIFO is equal to or above the RX_FIFO threshold level, or an RX_FIFO time out occurs.

0: Disable Receiver Data Ready interrupt. (Default)

1: Enable Receiver Data Ready interrupt.

Bit 1 - Transmitter Low-Data-Level Interrupt Enable (TXLDL_IE)

Setting this bit enables interrupts when the TX_FIFO is below the threshold level or the Transmitter Holding Register is empty.

0: Disable Transmitter Low-Data-Level Interrupts (Default).

1: Enable Transmitter Low-Data-Level Interrupts.

Bit 2 - Line Status Interrupt Enable (LS_IE)

Setting this bit enables interrupts on Line Status events.

0: Disable Line Status Interrupts (LS_EV) (Default)

1: Enable Line Status Interrupts (LS_EV).

Bit 3 - Modem Status Interrupt Enable (MS_IE)

Setting this bit enables the interrupts on Modem Status events.

0: Disable Modem Status Interrupts (MS_EV) (Default)

1: Enable Modem Status Interrupts (MS_EV).

Bit 4 - Reserved

Reserved.

Bit 5 - Transmitter Empty Interrupt Enable (TXEMP_IE)

Setting this bit enables interrupt generation if the transmitter and TX_FIFO become empty.

0: Disable Transmitter Empty interrupts (Default)

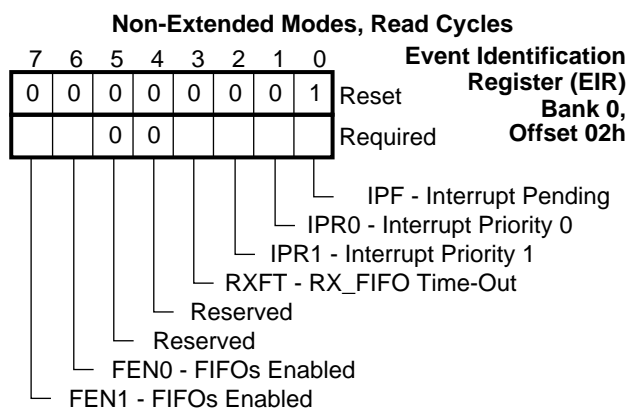1: Enable Transmitter Empty interrupts.

Bits 7,6 - Reserved

Reserved.

6.5.3 Event Identification Register (EIR)

The **Event Identification Register (EIR)** and the **FIFO Control Register (FCR) (**see next register description) share the same address. The **EIR** is accessed during CPU read cycles while the **FCR** is accessed during CPU write cycles.The Event Identification Register (EIR) indicates the interrupt source. The function of this register changes according to the selected mode of operation.

Event Identification Register (EIR), Non-Extended Mode

When Extended mode is not selected (EXT_SL bit in EXCR1 register is set to 0), this register is the same as in the 16550.

In a Non-Extended UART mode, this module prioritizes interrupts into four levels. The EIR indicates the highest level of interrupt that is pending. The encoding of these interrupts is shown in Table 6-3 on page 141.

Non-Extended Modes, Read Cycles

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	1	Reset
		0	0					Required

Event Identification Register (EIR) Bank 0, Offset 02h

IPF - Interrupt Pending
IPR0 - Interrupt Priority 0
IPR1 - Interrupt Priority 1
RXFT - RX_FIFO Time-Out
Reserved
Reserved
FEN0 - FIFOs Enabled
FEN1 - FIFOs Enabled

Bit 0 - Interrupt Pending Flag (IPF)

0: There is an interrupt pending.

1: No interrupt pending. (Default)

Bits 2,1 - Interrupt Priority 1,0 (IPR1,0)

When bit 0 (IPF) is 0, these bits indicate the pending interrupt with the highest priority. See Table 6-3 on page 141.

Default value is 00.

Bit 3 - RX_FIFO Time-Out (RXFT)

In the 16450 mode, this bit is always 0. In the 16550 mode (FIFOs enabled), this bit is set to 1 when an RX_FIFO read time-out occurred and the associated interrupt is currently the highest priority pending interrupt.

Bits 5,4 - Reserved

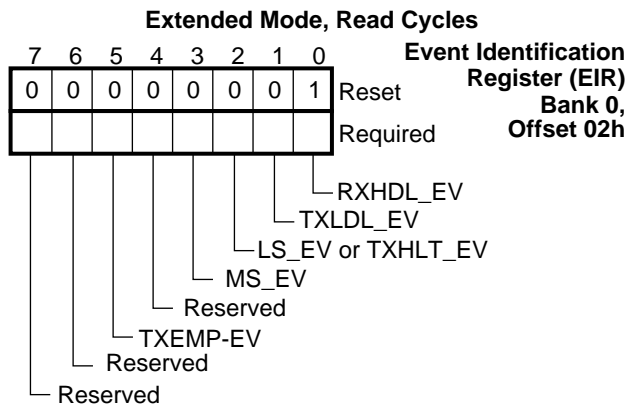Read/Write 0.

Bit 7,6 - FIFOs Enabled (FEN1,0)

0: No FIFO enabled. (Default)

1: FIFOs are enabled (bit 0 of FCR is set to 1).

TABLE 6-3. Non-Extended Mode Interrupt Priorities

EIR Bits 3 2 1 0	Interrupt Set and Reset Functions			
	Priority Level	Interrupt Type	Interrupt Source	Interrupt Reset Control
0 0 0 1	—	None	None	—
0 1 1 0	Highest	Line Status	Parity error, framing error, data overrun or break event	Read Line Status Register (LSR).
0 1 0 0	Second	Receiver High Data Level Event	Receiver Holding Register (RXD) full, or RX_FIFO level equal to or above threshold.	Reading the RXD or, RX_FIFO level drops below threshold.
1 1 0 0	Second	RX_FIFO Time-Out	At least one character is in the RX_FIFO, and no character has been input to or read from the RX_FIFO for 4 character times.	Reading the RXD port.
0 0 1 0	Third	Transmitter Low Data Level Event	Transmitter Holding Register or TX_FIFO empty.	Reading the EIR Register if this interrupt is currently the highest priority pending interrupt, or writing into the TXD port.
0 0 0 0	Fourth	Modem Status	Any transition on $\overline{CTS}$, $\overline{DSR}$ or $\overline{DCD}$ or a low to high transition on $\overline{RI}$.	Reading the Modem Status Register (MSR).

Event Identification Register (EIR), Extended Mode

In Extended mode, each of the previously prioritized and encoded interrupt sources is broken down into individual bits. Each bit in this register acts as an interrupt pending flag, and is set to 1 when the corresponding event occurred or is pending, regardless of the IER register bit setting.

Extended Mode, Read Cycles

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	1	Reset
								Required

Event Identification Register (EIR) Bank 0, Offset 02h

- RXHDL_EV
- TXLDL_EV
- LS_EV or TXHLT_EV
- MS_EV
- Reserved
- TXEMP-EV
- Reserved
- Reserved

Bit 0 - Receiver High-Data-Level Event (RXHDL_EV)

When FIFOs are disabled, this bit is set to 1 when a character is in the Receiver Holding Register.

When FIFOs are enabled, this bit is set to 1 when the RX_FIFO is above threshold or an RX_FIFO time-out has occurred.

Bit 1 - Transmitter Low-Data-Level Event (TXLDL_EV)

When FIFOs are disabled, this bit is set to 1 when the Transmitter Holding Register is empty.

When FIFOs are enabled, this bit is set to 1 when the TX_FIFO is below the threshold level.

Bit 2 - Line Status Event (LS_EV) or Transmitter Halted Event (TXHLT_EV)

This bit is set to 1 when a receiver error or break condition is reported.

When FIFOs are enabled, the Parity Error(PE), Frame Error(FE) and Break(BRK) conditions are only reported when the associated character reaches the bottom of the RX_FIFO. An Overrun Error (OE) is reported as soon as it occurs.

Bit 3 - Modem Status Event (MS_EV)

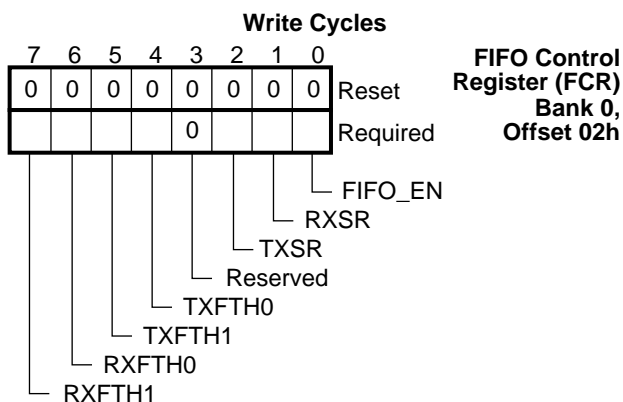In UART mode this bit is set to 1 when any of the 0 to 3 bits in the MSR register is set to 1.

Bit 4 - Reserved

Read/Write 0.

Bit 5 - Transmitter Empty (TXEMP_EV)

This bit is the same as bit 6 of the LSR register. It is set to 1 when the transmitter is empty.

Bits 7,6 - Reserved

Read/Write 0.

6.5.4 FIFO Control Register (FCR)

The FIFO Control Register (FCR) is write only. It is used to enable the FIFOs, clear the FIFOs and set the interrupt thresholds levels for the reception and transmission FIFOs.

Write Cycles

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
				0				Required

FIFO Control Register (FCR) Bank 0, Offset 02h

- FIFO_EN
- RXSR
- TXSR
- Reserved
- TXFTH0
- TXFTH1
- RXFTH0
- RXFTH1

Bit 0 - FIFO Enable (FIFO_EN)

When set to 1 enables both the Transmision and Reception FIFOs. Resetting this bit clears both FIFOs.

Bit 1 - Receiver Soft Reset (RXSR)

Writing a 1 to this bit generates a receiver soft reset, which clears the RX_FIFO and the receiver logic. This bit is automatically cleared by the hardware.

Bit 2 - Transmitter Soft Reset (TXSR)

Writing a 1 to this bit generates a transmitter soft reset, which clears the TX_FIFO and the transmitter logic. This bit is automatically cleared by the hardware.

Bit 3 - Reserved

Read/Write 0.

Bits 5,4 - TX_FIFO Threshold Level (TXFTH1,0)

In **Non-Extended** modes, these bits have no effect.

In **Extended** modes, these bits select the TX_FIFO interrupt threshold level. An interrupt is generated when the level of the data in the TX_FIFO drops below the encoded threshold.

TABLE 6-4. TX_FIFO Level Selection

TXFTH (Bits 5,4)	TX_FIF0 Threshold
00(Default)	1
01	3
10	9
11	13

Bits 7,6 - RX_FIFO Threshold Level (RXFTH1,0)

These bits select the RX_FIFO interrupt threshold level. An interrupt is generated when the level of the data in the RX_FIFO is equal to or above the encoded threshold.

TABLE 6-5. RX_FIFO Level Selection

RXFTH (Bits 5,4)	RX_FIF0 Threshold
00(Default)	1
01	4
10	8
11	14

6.5.5 Line Control Register (LCR) and Bank Selection Register (BSR)

The **Line Control Register (LCR)** and the **Bank Select Register (BSR)** (see the next register) share the same address.

The **Line Control Register (LCR)** selects the communications format for data transfers.
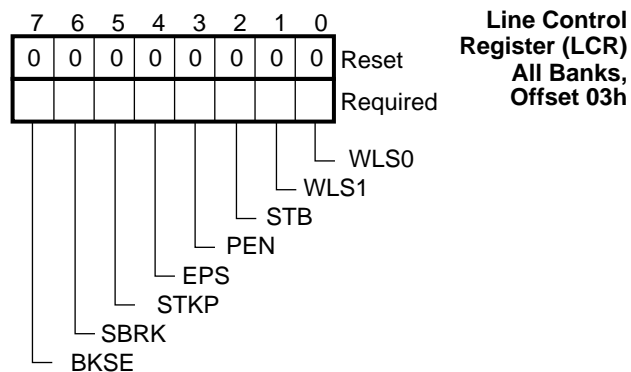
Upon reset, all bits are set to 0.

Reading the register at this address location returns the content of the BSR. The content of LCR may be read from the Shadow of Line Control Register (SH_LCR) register in bank 3 (See Section 6.8.2 on page 151). During a write operation to this register at this address location, the setting of bit 7 (Bank Select Enable, BKSE) determines whether LCR or BSR is to be accessed, as follows:

- If bit 7 is 0, the write affects both LCR and BSR.

- If bit 7 is 1, the write affects only BSR, and LCR remains unchanged. This prevents the communications format from being spuriously affected when a bank other than 0 or 1 is accessed.

Upon reset, all bits are set to 0.

Line Control Register (LCR)

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

Line Control Register (LCR) All Banks, Offset 03h

- WLS0
- WLS1
- STB
- PEN
- EPS
- STKP
- SBRK
- BKSE

Bits 1,0 - Character Length Select (WLS1,0)

These bits specify the number of data bits in each transmitted or received serial character. Table 6-6 shows how to encode these bits.

TABLE 6-6. Word Length Select Encoding

WLS1	WLS0	Character Length
0	0	5 (Default)
0	1	6
1	0	7
1	1	8

Bits 2 - Number of Stop Bits (STB)

This bit specifies the number of stop bits transmitted with each serial character.

0: One stop bit is generated. (Default)

1: If the data length is set to 5-bits via bits 1,0 (WLS1,0), 1.5 stop bits are generated. For 6, 7 or 8 bit word lengths, two stop bits are transmitted. The receiver checks for one stop bit only, regardless of the number of stop bits selected.

Bit 3 - Parity Enable (PEN)

This bit enable the parity bit See Table 6-7 on page 143.

The parity enable bit is used to produce an even or odd number of 1s when the data bits and parity bit are summed, as an error detection device.

0: No parity bit is used. (Default)

1: A parity bit is generated by the transmitter and checked by the receiver.

Bit 4 - Even Parity Select (EPS)

When Parity is enabled (PEN is 1), this bit, together with bit 5 (STKP), controls the parity bit as shown in Table 6-7.

0: If parity is enabled, an odd number of logic 1s are transmitted or checked in the data word bits and parity bit. (Default)

1: If parity is enabled, an even number of logic 1s are transmitted or checked.

Bit 5 - Stick Parity (STKP)

When Parity is enabled (PEN is 1), this bit, together with bit 4 (EPS), controls the parity bit as show in Table 6-7.

TABLE 6-7. Bit Settings for Parity Control

PEN	EPS	STKP	Selected Parity Bit
0	x	x	None
1	0	0	Odd
1	1	0	Even
1	0	1	Logic 1
1	1	1	Logic 0

Bit 6 - Set Break (SBRK)

This bit enables or disables a break. During the break, the transmitter can be used as a character timer to accurately establish the break duration.

This bit acts only on the transmitter front-end and has no effect on the rest of the transmitter logic.

When set to 1 the SOUT pin is forced to a logic 0 state.

To avoid transmission of erroneous characters as a result of the break, use the following procedure to set SBRK:
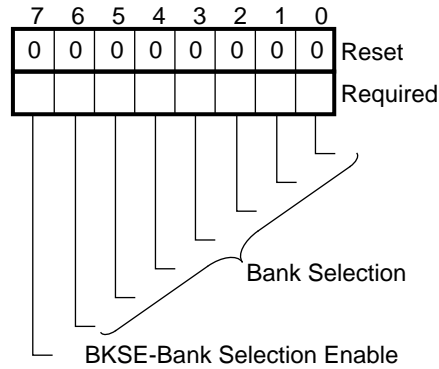
1. Wait for the transmitter to be empty. (TXEMP = 1).

2. Set SBRK to 1.

3. Wait for the transmitter to be empty, and clear SBRK when normal transmission must be restored.

Bit 7 - Bank Select Enable (BKSE)

0: This register functions as the Line Control Register (LCR).

1: This register functions as the Bank Select Register (BSR).

6.5.6   Bank Selection Register (BSR)

Bank Selection Register (BSR) All Banks, Offset 03h

The Bank Selection Register (BSR) selects which register bank is to be accessed next.

About accessing this register see the description of bit 7 of the LCR Register.

Bits 6-0 - Bank Selection

When bit 7 is set to 1, bits 6-0 of BSR select the bank, as shown in Table 6-8.

Bit 7 - Bank Selection Enable (BKSE)

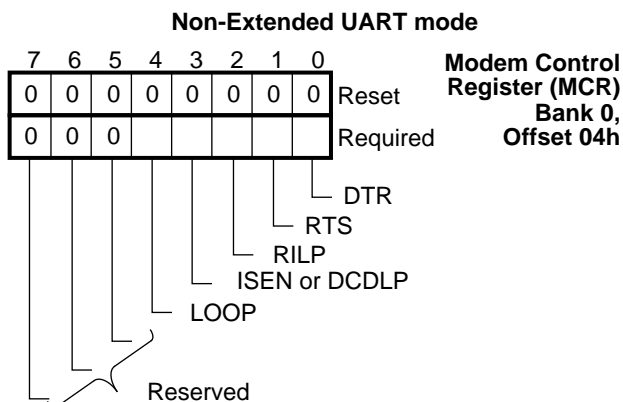0: Bank 0 is selected.

1: Bits 6-0 specify the selected bank.

TABLE 6-8. Bank Selection Encoding

BSR Bits								Bank Selected	LCR
7	6	5	4	3	2	1	0		
0	x	x	x	x	x	x	x	0	LCR is written
1	0	x	x	x	x	x	x	1	
1	1	x	x	x	x	1	x	1	
1	1	x	x	x	x	x	1	1	
1	1	1	0	0	0	0	0	2	LCR is not written
1	1	1	0	0	1	0	0	3	

6.5.7   Modem/Mode Control Register (MCR)

This register controls the interface with the modem or data communications set, and the device operational mode when the device is in the **Extended** mode. The register function differs for Extended and Non-Extended modes.

Modem/Mode Control Register (MCR), Non-Extended Mode

Non-Extended UART mode

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
0	0	0						Required

Modem Control Register (MCR) Bank 0, Offset 04h

- DTR
- RTS
- RILP
- ISEN or DCDLP
- LOOP
- Reserved

Extended Mode

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
0	0	0	0					Required

Modem Control Register (MCR) Bank 0, Offset 04h

- DTR
- RTS
- Reserved
- TX_DFR
- Reserved

Bit 0 - Data Terminal Ready (DTR)

This bit controls the $\overline{DTR}$ signal output. When set to 1, $\overline{DTR}$ is driven low. When loopback is enabled (LOOP is set to 1), this bit internally drives $\overline{DSR}$.

Bit 1 - Request To Send (RTS)

This bit controls the $\overline{RTS}$ signal output. When set to 1, drives $\overline{RTS}$ low. When loopback is enabled (LOOP is set), this bit drives $\overline{CTS}$, internally.

Bit 2 - Loopback Interrupt Request (RILP)

When loopback is enabled, this bit internally drives $\overline{RI}$. Otherwise it is unused.

Bit 3 - Interrupt Signal Enable (ISEN) or Loopback DCD (DCDLP)

In normal operation (standard 16450 or 16550) mode, this bit controls the interrupt signal and must be set to 1 in order to enable the interrupt request signal.

When loopback is enabled, the interrupt output signal is always enabled, and this bit internally drives $\overline{DCD}$.

New programs should always keep this bit set to 1 during normal operation. The interrupt signal should be controlled through the Plug-n-Play logic.

Bit 4 - Loopback Enable (LOOP)

When this bit is set to 1, it enables loopback. This bit accesses the same internal register as bit 4 of the EXCR1 register. (see "Bit 4 - Loopback Enable (LOOP)" on page 149 for more information on the Loopback mode).
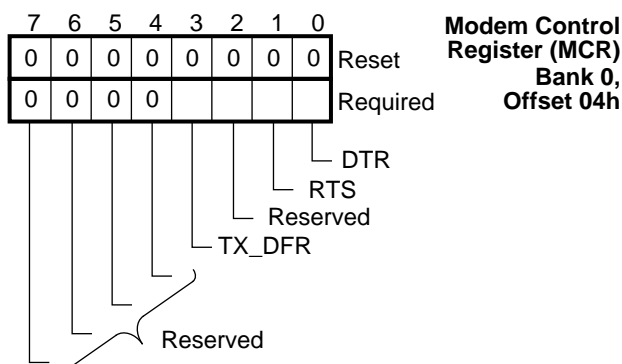
0: Loopback disabled. (Default)

1: Loopback enabled.

Bits 7-5 - Reserved

Read/Write 0.

Modem/Mode Control Register (MCR), Extended Mode

In Extended mode the interrupt output signal is always enabled, and loopback can be enabled by setting bit 4 of the EXCR1 register.

Bit 0 - Data Terminal Ready (DTR)

This bit controls the $\overline{DTR}$ signal output. When set to 1, $\overline{DTR}$ is driven low. When loopback is enabled (LOOP is set), this bit internally drives both $\overline{DSR}$ and $\overline{RI}$.

Bit 1 - Request To Send (RTS)

This bit controls the $\overline{RTS}$ signal output. When set to 1, $\overline{RTS}$ is driven low. When loopback is enabled (LOOP is set), this bit internally drives both $\overline{CTS}$ and $\overline{DCD}$.

Bit 2 - Reserved

Read/Write 0.

Bit 3 - Transmission Deferral (TX_DFR)

For a detailed description of the Transmission Deferral see "Fallback from a Non-Extended mode can be disabled by setting the LOCK bit in register EXCR2. When LOCK is set to 1 and the UART is in a Non-Extended mode, two scratch registers overlaid with LBGD(L) and LBGD(H) are enabled. Any attempted CPU access of LBGD(L) and LBGD(H) accesses the scratch registers, and the baud rate setting is not affected. This feature allows existing legacy programs to run faster than 115.2 Kbps." on page 138.

0: No transmission deferral enabled. (Default)

1: Transmission deferral enabled.

This bit is effective only if the Transmission FIFOs is enabled.

Bits 7- 4 - Reserved

Read/Write 0.

6.5.8 Line Status Register (LSR)

This register provides status information concerning the data transfer. They are cleared when one of the following events occurs:

- .

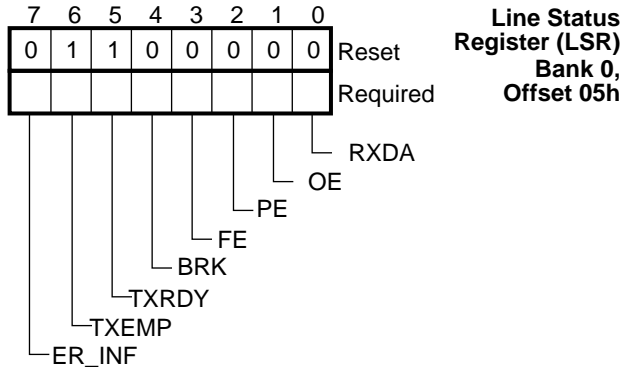- The receiver is soft-reset.

- The LSR register is read.

Upon reset this register assumes the value of 0x60h.

The bit definitions change depending upon the operation mode of the module.

Bits 4 through 1 of the LSR are the error conditions that generate a Receiver Line Status interrupt whenever any of the corresponding conditions are detected and that interrupt is enabled.

The LSR is intended for read operations only. Writing to the LSR is not permitted

7	6	5	4	3	2	1	0	
0	1	1	0	0	0	0	0	Reset
								Required

Line Status Register (LSR) Bank 0, Offset 05h

- RXDA
- OE
- PE
- FE
- BRK
- TXRDY
- TXEMP
- ER_INF

Bit 0 - Receiver Data Available (RXDA)

Set to 1 when the Receiver Holding Register is full.

If the FIFOs are enabled, this bit is set when at least one character is in the RX_FIFO.

Cleared when the CPU reads all the data in the Holding Register or in the RX_FIFO.

Bit 1 - Overrun Error (OE)

This bit is set to 1 as soon as an overrun condition is detected by the receiver.

Cleared upon read.

With **FIFOs Disabled:**

An overrun occurs when a new character is completely received into the receiver front-end section and the CPU has not yet read the previous character in the receiver holding register. The new character is discarded, and the receiver holding register is not affected.

With **FIFOs Enabled:**

An overrun occurs when a new character is completely received into the receiver front-end section and the RX_FIFO is full. The new character is discarded, and the RX_FIFO is not affected.

Bit 2 - Parity Error (PE)

This bit is set to 1 if the received data character does not have the correct parity, even or odd as selected by the parity control bits of the LCR register.

If the FIFOs are enabled, this error is associated with the particular character in the FIFO that it applies to. This error is revealed to the CPU when its associated character is at the bottom of the RX_FIFO.

This bit is cleared upon read.

Bit 3 - Framing Error (FE)

This bit is set to 1 when the received data character does not have a valid stop bit (i.e., the stop bit following the last data bit or parity bit is a 0).

If the FIFOs are enabled, this Framing Error is associated with the particular character in the FIFO that it applies to. This error is revealed to the CPU when its associated character is at the bottom of the RX_FIFO.

After a framing error is detected, the receiver will try to resynchronize.

If the bit following the erroneous stop bit is 0, the receiver assumes it to be a valid start bit and shifts in the new character. If that bit is a 1, the receiver enters the idle state and awaits the next start bit.

This bit is cleared upon read.

Bit 4 - Break Event Detected (BRK)

This bit is set to 1 when a break event is detected (i.e. when a sequence of logic 0 bits, equal or longer than a full character transmission, is received). If the FIFOs are enabled, the break condition is associated with the particular character in the RX_FIFO to which it applies. In this case, the BRK bit is set when the character reaches the bottom of the RX_FIFO.

When a break event occurs, only one zero character is transferred to the Receiver Holding Register or to the RX_FIFO.

The next character transfer takes place after at least one logic 1 bit is received followed by a valid start bit.

This bit is cleared upon read.

Bit 5 - Transmitter Ready (TXRDY)

This bit is set to 1 when the Transmitter Holding Register or the TX_FIFO is empty.

It is cleared when a data character is written to the TXD register.

Bit 6 - Transmitter Empty (TXEMP)

This bit is set to 1 when the Transmitter Holding Register or the TX_FIFO is empty, and the transmitter front-end is idle.

Bit 7 - Error in RX_FIFO (ER_INF)

This bit is set to a 1 if there is at least 1 framing error, parity error or break indication in the RX_FIFO.

This bit is always 0 in the 16450 mode.

This bit is cleared upon read.

6.5.9   Modem Status Register (MSR)

The function of this register depends on the selected operational mode. When a UART mode is selected, this register provides the current-state as well as state-change information of the status lines from the modem or data transmission module.

When loopback is enabled, the MSR register works similarly except that its status input signals are internally driven by appropriate bits in the MCR register since the modem input lines are internally disconnected. Refer to at the MCR (see page 143) and to the LOOP & ETDLBK bits at the EXCR1 (see page 149) for more information.

A description of the various bits of the MSR register, with Loopback disabled and UART Mode selected, is provided below.

When bits 0, 1, 2 or 3 is set to 1, a Modem Status Event (MS_EV) is generated if the MS_IE bit is enabled in the IER

Bits 0 to 3 are set to 0 as a result of any of the following events:

- Hardware reset occurs.

- The MSR register is read.

In the reset state, bits 4 through 7 are indeterminate as they reflect their corresponding input signals.

Note: The modem status lines can be used as general purpose inputs. They have no effect on the transmitter or receiver operation.
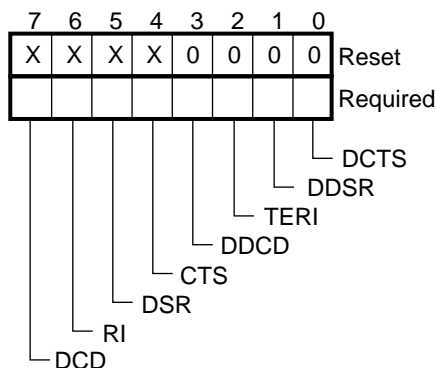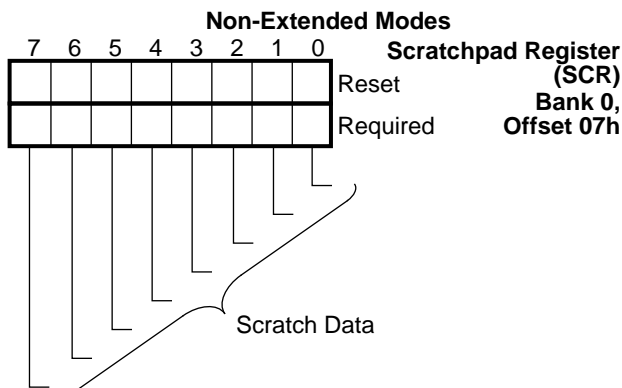

Modem Status Register (MSR)
Bank 0, Offset 06h

Bit 0 - Delta Clear to Send (DCTS)

Set to 1, when the $\overline{CTS}$ input signal changes state.
This bit is cleared upon read.

Bit 1 - Delta Data Set Ready (DDSR)

Set to 1, when the $\overline{DSR}$ input signal changes state.
This bit is cleared upon read

Bit 2 - Trailing Edge Ring Indicate (TERI)

Set to 1, when the $\overline{RI}$ input signal changes state from low to high.
This bit is cleared upon read

Bit 3 - Delta Data Carrier Detect (DDCD)

Set to 1, when the $\overline{DCD}$ input signal changes state.
1: $\overline{DCD}$ signal state changed.

Bit 4 - Clear To Send (CTS)

This bit returns the inverse of the $\overline{CTS}$ input signal.

Bit 5 - Data Set Ready (DSR)

This bit returns the inverse of the $\overline{DSR}$ input signal.

Bit 6 - Ring Indicate (RI)

This bit returns the inverse of the $\overline{RI}$ input signal.

Bit 7 - Data Carrier Detect (DCD)

This bit returns the inverse of the $\overline{DCD}$ input signal.

6.5.10 Scratchpad Register (SPR)

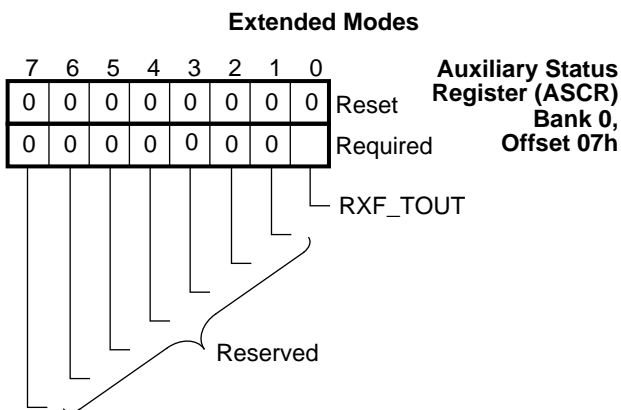This register shares a common address with the ASCR Register.

In **Non-Extended** mode, this is a scratch register (as in the 16550) for temporary data storage.

Non-Extended Modes

Scratchpad Register (SCR)
Bank 0, Offset 07h

6.5.11 Auxiliary Status and Control Register (ASCR)

This register shares a common address with the previous one (SCR).

This register is accessed when the **Extended** mode of operation is selected. The definition of the bits in this case is dependent upon the mode selected in the MCR register, bits 7 through 5. This register is cleared upon hardware reset Bits 2 and 6 are cleared when the transmitter is "soft reset". Bits 0,1,4 and 5 are cleared when the receiver is "soft reset".

Extended Modes

Auxiliary Status Register (ASCR)
Bank 0, Offset 07h

Bit 0 - RX_FIFO Time-Out (RXF_TOUT)

This bit is read only and set to 1 when an RX_FIFO timeout occurs. It is cleared when a character is read from the RX_FIFO.

Bits 7 - 1 -Reserved

Read/Write 0.

6.6 BANK 1 – THE LEGACY BAUD GENERATOR DIVISOR PORTS

This register bank contains two registers as the Baud Generator Divisor Port, and a bank select register.

The Legacy Baud Generator Divisor (LBGD) port provides an alternate path to the Baud Divisor Generator register. This bank is implemented to maintain compatibility with 16550 standard and to support existing legacy software packages. In case of using legacy software, the addresses 0 and 1 are shared with the data ports RXD/TXD (see page 138). The selection between them is controlled by the value of the BKSE bit (LCR bit 7 page 142).

TABLE 6-9. Bank 1 Register Set

Offset	Register Name	Description
00h	LBGD(L)	Legacy Baud Generator Divisor Port (Low Byte)
01h	LBGD(H)	Legacy Baud Generator Divisor Port (High Byte)
02h		Reserved
03h	LCR/ BSR	Line Control / Bank Select Register
04h - 07h		Reserved

In addition, a fallback mechanism maintains this compatibility by forcing the UART to revert to 16550 mode if 16550 software addresses the module after a different mode was set. Since setting the baud rate divisor values is a necessary initialization of the 16550, setting the divisor values in bank 1 forces the UART to enter 16550 mode. (This is called fallback.)

To enable other modes to program their desired baud rates without activating this fallback mechanism, the baud rate divisor register in bank 2 should be used.

6.6.1 Legacy Baud Generator Divisor Ports (LBGD(L) and LBGD(H)),

The programmable baud rates in the Non-Extended mode are achieved by dividing a 24 MHz clock by a prescale value of 13, 1.625 or 1. This prescale value is selected by the PRESL field of EXCR2 (see page 149). This clock is subdivided by the two baud rate generator divisor buffers, which output a clock at 16 times the desired baud rate (this clock is the BOUT clock). This clock is used by I/O circuitry, and after a last division by 16 produces the output baud rate.

Divisor values between 1 and $2^{16}-1$ can be used. (Zero is forbidden). The baud rate generator divisor must be loaded during initialization to ensure proper operation of the baud rate generator. Upon loading either part of it, the baud rate generator counter is immediately loaded. Table 6-12 on page 148 shows typical baud divisors. After reset the divisor register contents are indeterminate.

Any access to the **LBGD(L)** or **LBGD(H)** ports causes a reset to the default Non-Extended mode, i.e., 16550 mode (See "AUTOMATIC FALLBACK TO A NON-EXTENDED UART MODE" on page 138).To access a Baud Generator Divisor when in the **Extended** mode, use the port pair in bank 2 (BGD on page 148).

Table 6-10 shows the bits which are cleared when Fallback occurs during **Extended** or **Non-Extended** modes.
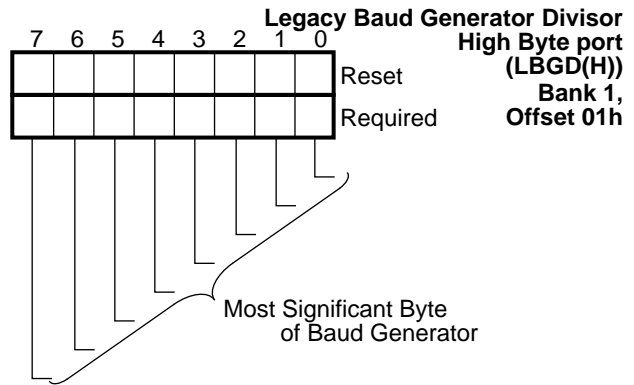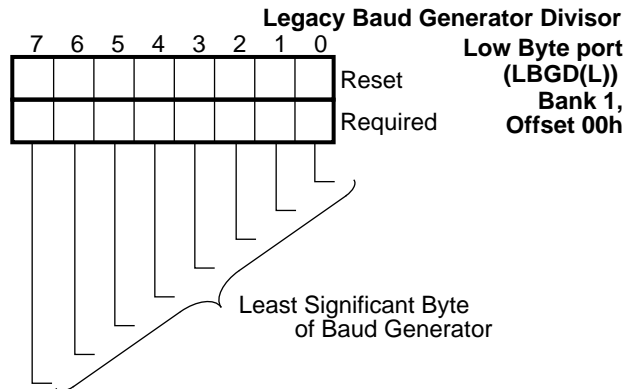
If the UART is in **Non-Extended** mode and the LOCK bit is 1, the content of the divisor (BGD) ports will not be affected and no other action is taken.

When programming the baud rate, the new divisor is loaded upon writing into LBGD(L) and LBGD(H). After reset, the contents of these registers are indeterminate.

Divisor values between 1 and $2^{16}-1$ can be used. (Zero is forbidden.) Table 6-12 shows typical baud rate divisors.

TABLE 6-10. Bits Cleared On Fallback

Register	UART Mode & LOCK bit before Fallback		
	Extended Mode LOCK = x	Non-Extended Mode LOCK = 0	Non-Extended Mode LOCK = 1
MCR	2 to 7	none	none
EXCR1	0, 5 and 7	5 and 7	none
EXCR2	0 to 5	0 to 5	none

.

Legacy Baud Generator Divisor Low Byte port (LBGD(L)) Bank 1, Offset 00h

Least Significant Byte of Baud Generator

.

Legacy Baud Generator Divisor High Byte port (LBGD(H)) Bank 1, Offset 01h

Most Significant Byte of Baud Generator

6.6.2 Line Control Register (LCR) and Bank Select Register (BSR)

These registers are the same as the registers at offset 03h in bank 0.

6.7 BANK 2 – EXTENDED CONTROL AND STATUS REGISTERS

Bank 2 contains two alternate Baud rate Generator Divisor ports and the Extended Control Registers (EXCR1 and EXCR2).

TABLE 6-11. Bank 2 Register Set

Offset	Register Name	Description
00h	BGD(L)	Baud Generator Divisor Port (Low byte)
01h	BGD(H)	Baud Generator Divisor Port (High byte)
02h	EXCR1	Extended Control Register 1
03h	LCR/BSR	Line Control/ Bank Select Register
04h	EXCR2	Extended Control Register 2
05h		Reserved
06h	TXFLV	TX_FIFO Level
07h	RXFLV	RX_FIFO Level

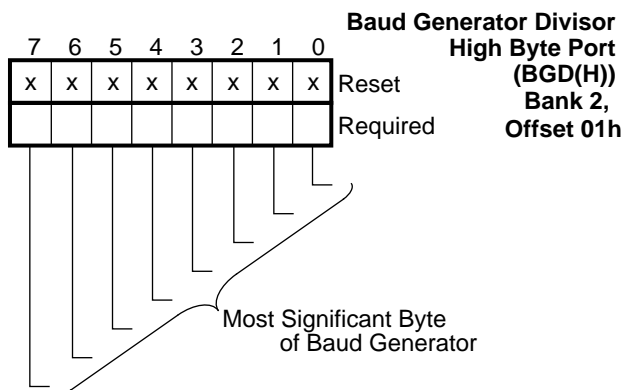#### 6.7.1 Baud Generator Divisor Ports, LSB (BGD(L)) and MSB (BGD(H))

These ports perform the same function as the Legacy Baud Divisor Ports in Bank 1 and are accessed identically to them, but do not change the operation mode of the module when accessed. Refer to Section 6.6.1 on page 147 for more detail.

Use these ports to set the baud rate when operating in Extended mode to avoid fallback to a Non-Extended operation mode, i.e., 16550 compatible.When programming the baud rate, writing to BGDH causes the baud rate to change immediately.
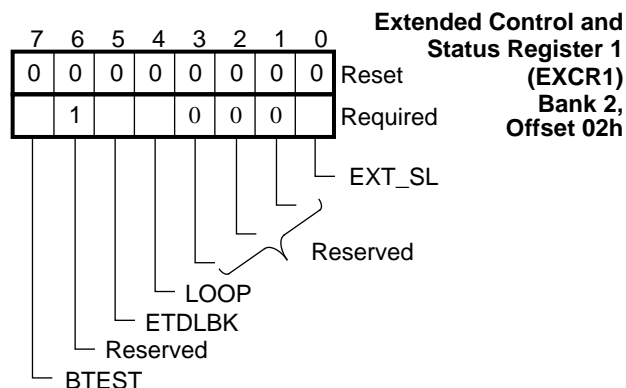

Baud Generator Divisor Low Byte Port (BGD(L)) Bank 2, Offset 00h

Least Significant Byte of Baud Generator
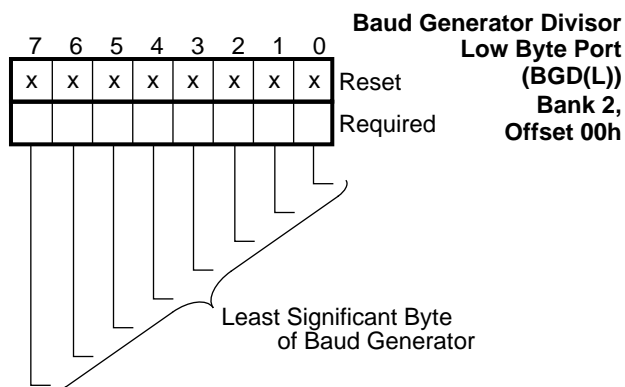
TABLE 6-12. Baud Generator Divisor settings

Prescaler Value	13		1.625		1	
Baud	**Divisor**	**% Error**	**Divisor**	**% Error**	**Divisor**	**% Error**
50	2304	0.16%	18461	0.00%	30000	0.00%
75	1536	0.16%	12307	0.01%	20000	0.00%
110	1047	0.19%	8391	0.01%	13636	0.00%
134.5	857	0.10%	6863	0.00%	11150	0.02%
150	768	0.16%	6153	0.01%	10000	0.00%
300	384	0.16%	3076	0.03%	5000	0.00%
600	192	0.16%	1538	0.03%	2500	0.00%
1200	96	0.16%	769	0.03%	1250	0.00%
1800	64	0.16%	512	0.16%	833	0.04%
2000	58	0.53%	461	0.12%	750	0.00%
2400	48	0.16%	384	0.16%	625	0.00%
3600	32	0.16%	256	0.16%	416	0.16%
4800	24	0.16%	192	0.16%	312	0.16%
7200	16	0.16%	128	0.16%	208	0.16%
9600	12	0.16%	96	0.16%	156	0.16%
14400	8	0.16%	64	0.16%	104	0.16%
19200	6	0.16%	48	0.16%	78	0.16%
28800	4	0.16%	32	0.16%	52	0.16%
38400	3	0.16%	24	0.16%	39	0.16%
57600	2	0.16%	16	0.16%	26	0.16%
115200	1	0.16%	8	0.16%	13	0.16%
230400	---	---	4	0.16%	---	---
460800	---	---	2	0.16%	---	---
750000	---	---	---	---	2	0.00%
921600	---	---	1	0.16%	---	---
1500000	---	---	---	---	1	0.00%

```
      7   6   5   4   3   2   1   0        Baud Generator Divisor
     ┌───┬───┬───┬───┬───┬───┬───┬───┐       High Byte Port
     │ x │ x │ x │ x │ x │ x │ x │ x │ Reset      (BGD(H))
     ├───┼───┼───┼───┼───┼───┼───┼───┤        Bank 2,
     │   │   │   │   │   │   │   │   │ Required   Offset 01h
     └───┴───┴───┴───┴───┴───┴───┴───┘
```

Most Significant Byte
of Baud Generator

6.7.2 Extended Control Register 1 (EXCR1)

Use this register to control module operation in the Extended mode. Upon reset all bits are set to 0.

```
      7   6   5   4   3   2   1   0        Extended Control and
     ┌───┬───┬───┬───┬───┬───┬───┬───┐     Status Register 1
     │ 0 │ 0 │ 0 │ 0 │ 0 │ 0 │ 0 │ 0 │ Reset      (EXCR1)
     ├───┼───┼───┼───┼───┼───┼───┼───┤        Bank 2,
     │   │ 1 │   │   │ 0 │ 0 │ 0 │   │ Required   Offset 02h
     └───┴───┴───┴───┴───┴───┴───┴───┘
```

EXT_SL

Reserved

LOOP

ETDLBK

Reserved

BTEST

Bit 0 - Extended Mode Select (EXT_SL)

When set to 1, the Extended mode is selected.

Bits 3 - 1 - Reserved

Read/Write 0.

Bit 4 - Loopback Enable (LOOP)

During loopback, the transmitter output is connected internally to the receiver input, to enable system self-test of serial communications. In addition to the data signal, all additional signals within the UART are interconnected to enable real transmission and reception using the UART mechanisms.

When this bit is set to 1, loopback is selected. This bit accesses the same internal register as bit 4 in the MCR register, when the UART is in a Non-Extended mode.

Loopback behaves similarly in both Non-Extended and Extended modes.

When Extended mode is selected, the $\overline{DTR}$ bit in the MCR register internally drives both $\overline{DSR}$ and $\overline{RI}$, and the $\overline{RTS}$ bit drives $\overline{CTS}$ and $\overline{DCD}$.

During loopback, the following actions occur:

1. The transmitter and receiver interrupts are fully operational. The Modem Status Interrupts are also fully operational, but the interrupt sources are now the lower bits of the MCR register.

2. UART and infrared receiver serial input signals are disconnected. The internal receiver input signals are connected to the corresponding internal transmitter output signals.

3. The UART transmitter serial output is forced high and the infrared transmitter serial output is forced low, unless the ETDLBK bit is set to 1. In which case they function normally.

4. The modem status input pins ($\overline{DSR}$, $\overline{CTS}$, $\overline{RI}$ and $\overline{DCD}$) are disconnected. The internal modem status signals, are driven by the lower bits of the MCR register.

Bit 5 - Enable Transmitter During Loopback (ETDLBK)

When this bit is set to 1, the transmitter serial output is enabled and functions normally when loopback is enabled.

Bit 6 - Reserved

Read/Write 0.

Bit 7 - Baud Generator Test (BTEST)

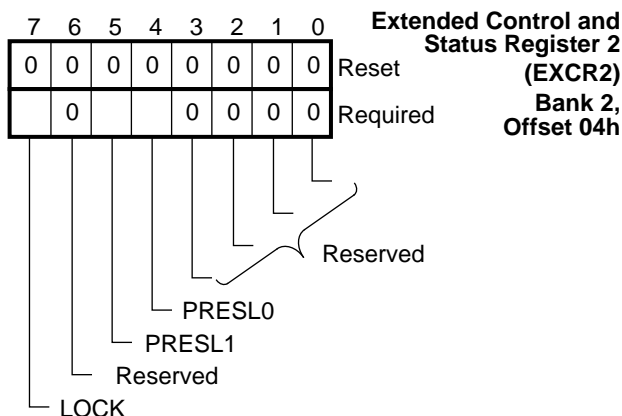When set to 1, this bit routes the Baud Generator to the $\overline{DTR}$ pin for testing purposes.

6.7.3 Line Control Register (LCR) and Bank Select Register (BSR)

These registers are the same as the registers at offset 03h in bank 0.

6.7.4 Extended Control and Status Register 2 (EXCR2)

This register configures the Prescaler and controls the Baud Divisor Register Lock.

Upon reset all bits are set to 0.

```
      7   6   5   4   3   2   1   0        Extended Control and
     ┌───┬───┬───┬───┬───┬───┬───┬───┐     Status Register 2
     │ 0 │ 0 │ 0 │ 0 │ 0 │ 0 │ 0 │ 0 │ Reset      (EXCR2)
     ├───┼───┼───┼───┼───┼───┼───┼───┤        Bank 2,
     │   │ 0 │   │   │ 0 │ 0 │ 0 │ 0 │ Required   Offset 04h
     └───┴───┴───┴───┴───┴───┴───┴───┘
```

Reserved

PRESL0

PRESL1

Reserved

LOCK

Bits 3 - 0 - Reserved

Read/Write 0.

Bits 5,4 - Prescaler Select

The prescaler divides the 24 MHz input clock frequency to provide the clock for the Baud Generator. (See Table 6-13).

TABLE 6-13. Prescaler Select

Bit 5	Bit 4	Prescaler Value
0	0	13
0	1	1.625
1	0	Reserved
1	1	1.0

Bit 6 - Reserved

Read/Write 0.

Bit 7 - Baud Divisor Register Lock (LOCK)

When set to 1, accesses to the Baud Generator Divisor Register through LBGD(L) and LBGD(H) as well as fall-back are disabled from non-extended mode.

In this case two scratchpad registers overlaid with LBGD(L) and LBGD(H) are enabled, and any attempted CPU access of the Baud Generator Divisor Register through LBGD(L) and LBGD(H) will access the scratchpad registers instead. This bit must be set to 0 when extended mode is selected.

6.7.5 Reserved Register

Upon reset, all bits in Bank 2 register with offset 05h are set to 0.

Bits 7-0 - Reserved

Read/write 0.

6.7.6 TX_FIFO Current Level Register (TXFLV)

This read-only register returns the number of bytes in the TX_FIFO. It can be used to facilitate programmed I/O modes during recovery from transmitter underrun in one of the fast infrared modes.

Extended Modes

TX_FIFO Current Level Register (TXFLV) Bank 2, Offset 06h
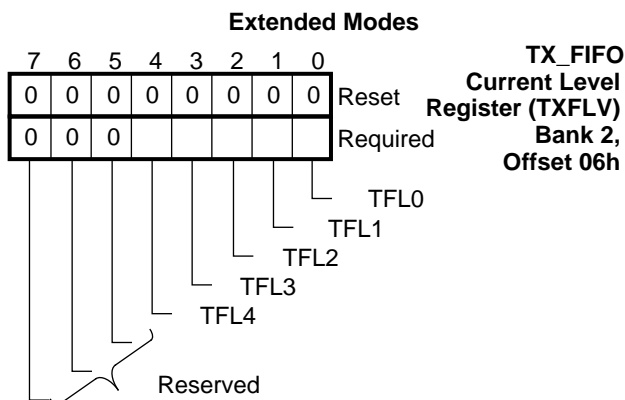
Bits 4-0 - Number of Bytes in TX_FIFO (TFL(4-0))

These bits specify the number of bytes in the TX_FIFO.

Bits 7,6 - Reserved

Read/Write 0.

6.7.7 RX_FIFO Current Level Register (RXFLV)

This read-only register returns the number of bytes in the RX_FIFO. It can be used for software debugging.

Extended Modes

Current Level Register (RXFLV) Bank 2, Offset 07h
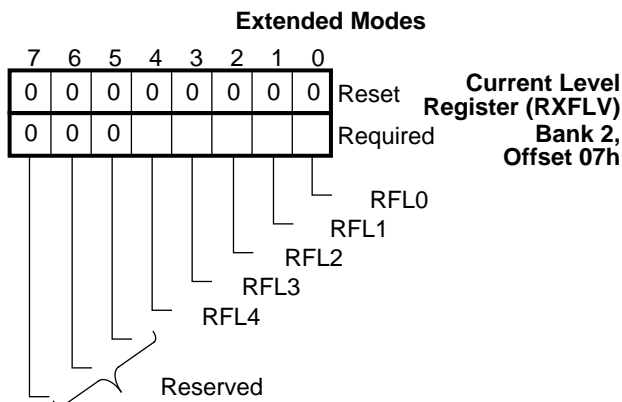
Bits 4-0 - Number of Bytes in RX_FIFO (RFL(4-0))

These bits specify the number of bytes in the RX_FIFO.

Bits 7,6 - Reserved

Read/Write 0.

Note: The contents of TXFLV and RXFLV are not frozen during CPU reads. Therefore, invalid data could be returned if the CPU reads these registers during normal transmitter and receiver operation. To obtain correct data, the software should perform three consecutive reads and then take the data from the second read, if first and second read yield the same result, or from the third read, if first and second read yield different results.

### 6.8 BANK 3 – MODULE REVISION ID AND SHADOW REGISTERS

Bank 3 contains the Module Revision ID register which identifies the revision of the module, shadow registers for monitoring various registers whose contents are modified by being read, and status and control registers for handling the flow control.

TABLE 6-14. Bank 3 Register Set

Offset	Register Name	Description
00h	MRID	Module Revision ID Register
01h	SH_LCR	Shadow of LCR Register (Read Only)
02h	SH_FCR	Shadow of FIFO Control Register (Read Only)
03h	LCR/ BSR	Line Control Register/ Bank Select Register
04h-07h		Reserved

6.8.1   Module Revision ID Register (MRID)

This read-only register identifies the revision of the module. When read, it returns the module ID and revision level. This module returns the code 2xh, where x indicates the revision number.
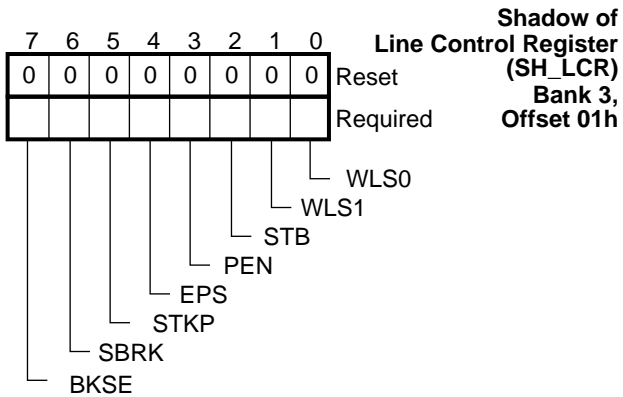
7	6	5	4	3	2	1	0	
0	0	1	0	x	x	x	x	Reset
								Required

Module Revision ID Register (MRID) Bank 3, Offset 00h

Revision ID(RID 3-0)
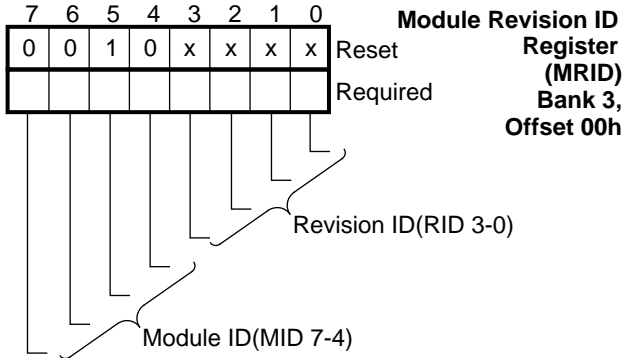
Module ID(MID 7-4)

Bits 3-0 - Revision ID (MID3-0)

The value in these bits identifies the revision level.

Bits 7-4 - Module ID (MID7-4)

The value in these bits identifies the module type.

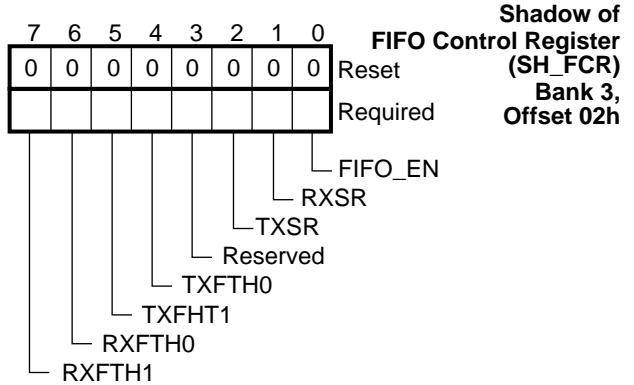### 6.8.2   Shadow of Line Control Register (SH_LCR)

This register returns the value of the LCR register. The LCR register is written into when a byte value according to Table 6-8 on page 143, is written to the LCR/BSR registers location (at offset 03h) from any bank.

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

Shadow of Line Control Register (SH_LCR) Bank 3, Offset 01h

WLS0
WLS1
STB
PEN
EPS
STKP
SBRK
BKSE

See "Line Control Register (LCR)" on page 142 for bit descriptions.

6.8.3   Shadow of FIFO Control Register (SH_FCR)

This read-only register returns the contents of the FCR register in bank 0.

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

Shadow of FIFO Control Register (SH_FCR) Bank 3, Offset 02h

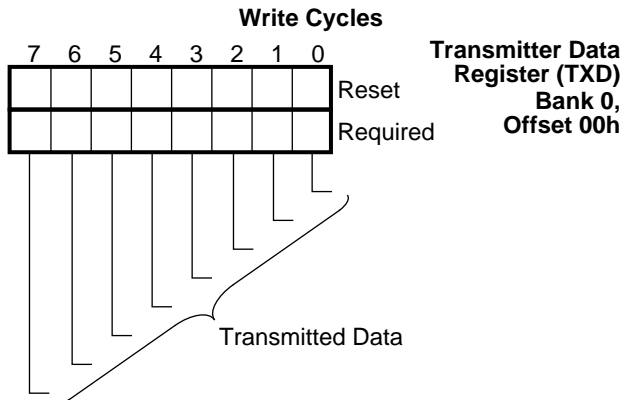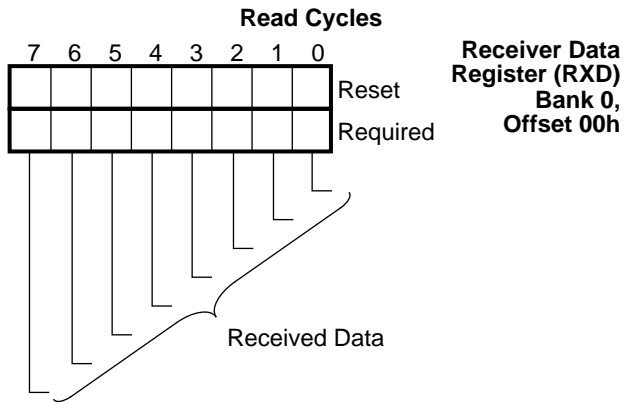FIFO_EN
RXSR
TXSR
Reserved
TXFTH0
TXFHT1
RXFTH0
RXFTH1

See "FIFO Control Register (FCR)" on page 142 for bit descriptions.

6.8.4   Line Control Register (LCR) and Bank Select Register (BSR)

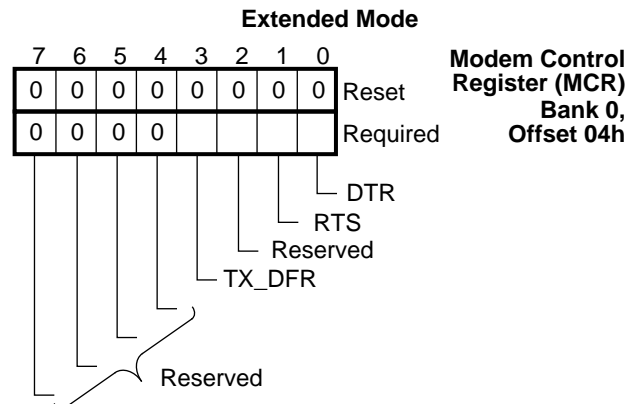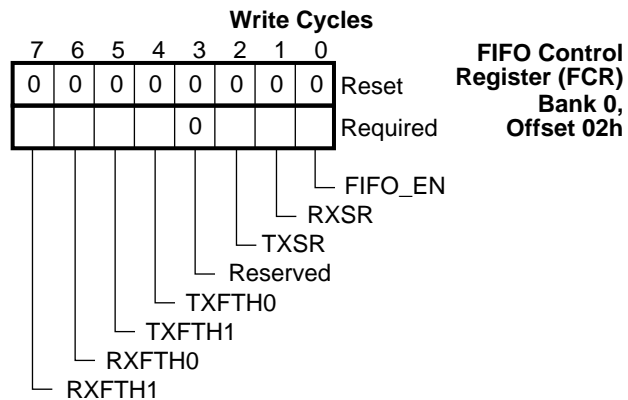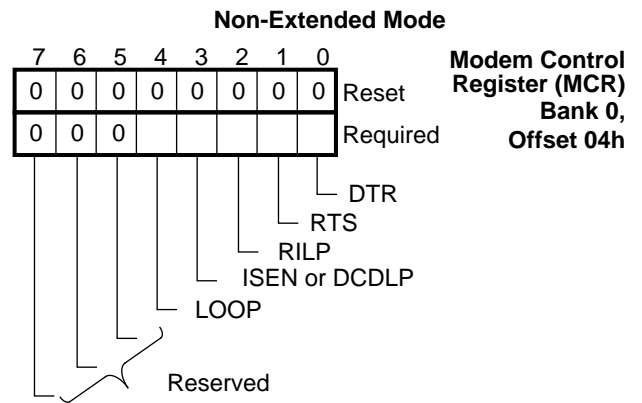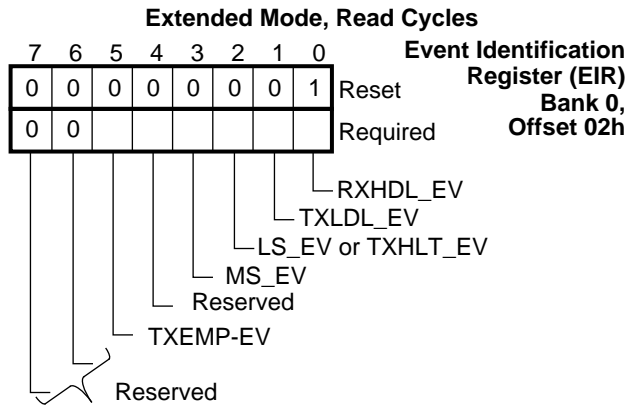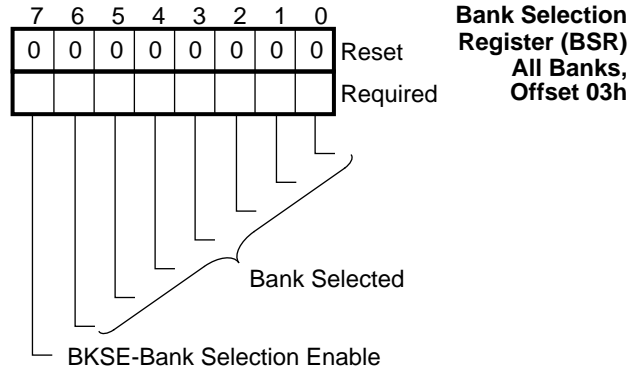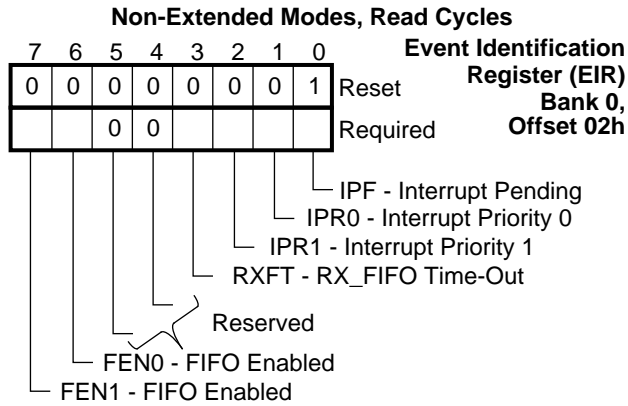These registers are the same as the registers at offset 03h in bank 0.

6.9   UART1 REGISTER BITMAPS

Read Cycles

7	6	5	4	3	2	1	0	
								Reset
								Required

Receiver Data Register (RXD) Bank 0, Offset 00h

Received Data

Write Cycles

7	6	5	4	3	2	1	0	
								Reset
								Required

Transmitter Data Register (TXD) Bank 0, Offset 00h

Transmitted Data

UART1 REGISTER BITMAPS

Extended Mode

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
0	0							Required

**Interrupt Enable Register (IER)
Bank 0,
Offset 01h**

- RXHDL_IE
- TXLDL_IE
- LS_IE or TXUR_IE
- MS_IE
- Reserved
- TXEMP_IE
- Reserved

**Line Control
Register (LCR)
All Banks,
Offset 03h**

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

- WLS0
- WLS1
- STB
- PEN
- EPS
- STKP
- SBRK
- BKSE

Non-Extended Modes, Read Cycles

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	1	Reset
		0	0					Required

**Event Identification
Register (EIR)
Bank 0,
Offset 02h**

- IPF - Interrupt Pending
- IPR0 - Interrupt Priority 0
- IPR1 - Interrupt Priority 1
- RXFT - RX_FIFO Time-Out
- Reserved
- FEN0 - FIFO Enabled
- FEN1 - FIFO Enabled

**Bank Selection
Register (BSR)
All Banks,
Offset 03h**

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

- Bank Selected
- BKSE-Bank Selection Enable

Extended Mode, Read Cycles

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	1	Reset
0	0							Required

**Event Identification
Register (EIR)
Bank 0,
Offset 02h**

- RXHDL_EV
- TXLDL_EV
- LS_EV or TXHLT_EV
- MS_EV
- Reserved
- TXEMP-EV
- Reserved

Non-Extended Mode

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
0	0	0						Required

**Modem Control
Register (MCR)
Bank 0,
Offset 04h**

- DTR
- RTS
- RILP
- ISEN or DCDLP
- LOOP
- Reserved

Write Cycles

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
				0				Required

**FIFO Control
Register (FCR)
Bank 0,
Offset 02h**

- FIFO_EN
- RXSR
- TXSR
- Reserved
- TXFTH0
- TXFTH1
- RXFTH0
- RXFTH1

Extended Mode

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
0	0	0	0					Required

**Modem Control
Register (MCR)
Bank 0,
Offset 04h**

- DTR
- RTS
- Reserved
- TX_DFR
- Reserved

Non-Extended Mode

7	6	5	4	3	2	1	0	
0	1	1	0	0	0	0	0	Reset
								Required

Line Status Register (LSR) Bank 0, Offset 05h

- RXDA
- OE
- PE
- FE
- BRK
- TXRDY
- TXEMP
- ER_INF

7	6	5	4	3	2	1	0	
X	X	X	X	0	0	0	0	Reset
								Required

Modem Status Register (MSR) Bank 0, Offset 06h

- DCTS
- DDSR
- TERI
- DDCD
- CTS
- DSR
- RI
- DCD

Non-Extended Mode

7	6	5	4	3	2	1	0	
								Reset
								Required

Scratch Register (SCR) Bank 0, Offset 07h

Scratch Data

Extended Mode

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
				0				Required

Auxiliary Status Register (ASCR) Bank 0, Offset 07h

- RXF_TOUT

Reserved

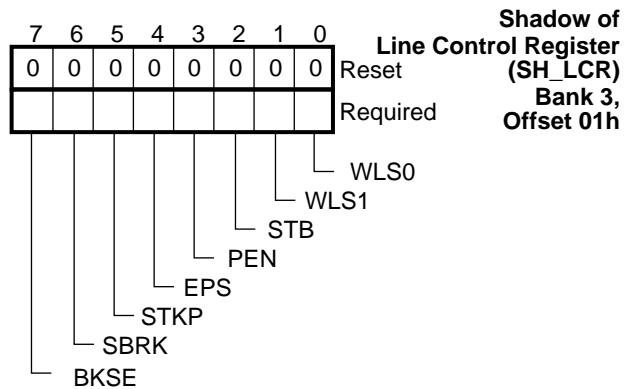**Legacy Baud Generator Divisor Low Byte Register (LBGD(L)) Bank 1, Offset 00h**

7	6	5	4	3	2	1	0	
								Reset
								Required

Least Significant Byte of Baud Generator

Legacy Baud Generator Divisor High Byte Register (LBGD(H)) Bank 1, Offset 01h

7	6	5	4	3	2	1	0	
								Reset
								Required

Most Significant Byte of Baud Generator

Baud Generator Divisor Low Byte Register (BGD(L)) Bank 2, Offset 00h

7	6	5	4	3	2	1	0	
x	x	x	x	x	x	x	x	Reset
								Required

Least Significant Byte of Baud Generator

Baud Generator Divisor High Byte Register (BGD(H)) Bank 2, Offset 01h

7	6	5	4	3	2	1	0	
x	x	x	x	x	x	x	x	Reset
								Required

Most Significant Byte of Baud Generator

UART1 REGISTER BITMAPS

Extended Control and Status Register 1 (EXCR1) Bank 2, Offset 02h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
	1			0	0	0		Required

- EXT_SL
- Reserved
- LOOP
- ETDLBK
- Reserved
- BTEST

Module Revision ID Register (MRID) Bank 3 Offset 00h

7	6	5	4	3	2	1	0	
0	0	1	0	x	x	x	x	Reset
								Required

- Revision ID(RID 3-0)
- Module ID(MID 7-4)

Extended Control and Status Register 2 (EXCR2) Bank 2, Offset 04h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
	0			0	0	0	0	Required

- Reserved
- PRESL0
- PRESL1
- Reserved
- LOCK

Shadow of Line Control Register (SH_LCR) Bank 3, Offset 01h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
								Required

- WLS0
- WLS1
- STB
- PEN
- EPS
- STKP
- SBRK
- BKSE

IrDA or Consumer-IR Modes — TX_FIFO Current Level Register (TXFLV) Bank 2, Offset 06h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
0	0	0						Required

- TFL0
- TFL1
- TFL2
- TFL3
- TFL4
- Reserved

Shadow of FIFO Control Register (SH_FCR) Bank 3, Offset 02h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
				0				Required

- FIFO_EN
- RXFR
- TXFR
- Reserved
- TXFTH0
- TXFHT1
- RXFTH0
- RXFTH1

IrDA or Consumer-IR Modes — RX_FIFO Current Level Register (RXFLV) Bank 2, Offset 07h

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Reset
0	0	0						Required

- RFL0
- RFL1
- RFL2
- RFL3
- RFL4
- Reserved

7.0 Power Management (Logical Device 4)

7.1 POWER MANAGEMENT OPTIONS

The Power Management logical device provides configuration options. Registers in this logical device enable activation of other logical devices, and set signal characteristics for certain I/O pins. (See Section 7.2 "THE POWER MANAGEMENT REGISTERS".)

7.2 THE POWER MANAGEMENT REGISTERS

Seventeen Power Management register control, activate and monitor all activity of the power Management Logical device.

Access to these registers is achieved by the use of two registers mapped in the PC87309 address space. The Power Management registers are accessed via the Power Management Index and Data registers, which are located at base address and base address + 01h, respectively. The base address is indicated by the Base Address registers at indexes 60h and 61h of Logical Device 4, respectively. See TABLE 2-15 "Power Management Configuration Registers - Logical Device 4" on page 27. TABLE 7-1 "The Power Management Registers" lists these registers.

TABLE 7-1. The Power Management Registers

Index	Symbol	Description	Type
Base+0		Power Management Index Register	R/W
Base+1		Power Management Data Register	R/W
00h	FER1	Function Enable Register 1	R/W
01h		Reserved	
02h	PMC1	Power Management Control 1	R/W
03h		Reserved	
04h	PMC3	Power Management Control 3	R/W
05h-07h		Reserved	

7.2.1 Power Management Index Register

This read/write register points to one of the Power Management registers. Bits 7 through 3 are read only and return 00000 when read.

It is reset by hardware to 00h. The data in the indicated register is accessed via the Power Management Data register at the base address + 01h.

Power Management Index Register, Base Address +00h
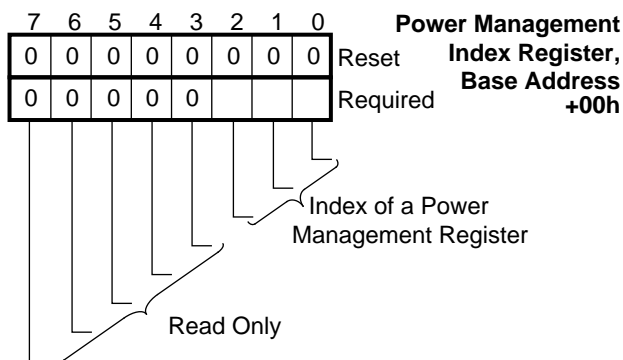
7.2.2 Power Management Data Register

This read/write register contains the data in the register pointed to by the Power Management Index register at the base address.

Power Management Data Register, Base Address + 01h
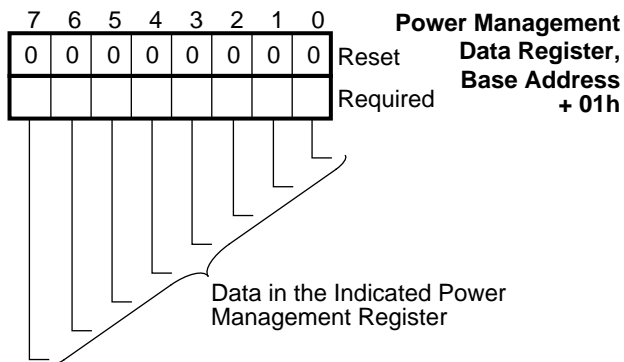
7.2.3 Function Enable Register 1 (FER1)

The bits of this register enable or disable activity of Logic devices within the PC87309.

A set bit enables activation of the corresponding logical device via its Active register at index 30h.

A cleared bit disables the corresponding logical device regardless of the value in its Active register. Bit 0 of the Active register of a logical device is ignored when the corresponding FER1 bit is cleared.

Hard reset sets this read/write register to FFh.

Function Enable Register 1 (FER1), Index 00h
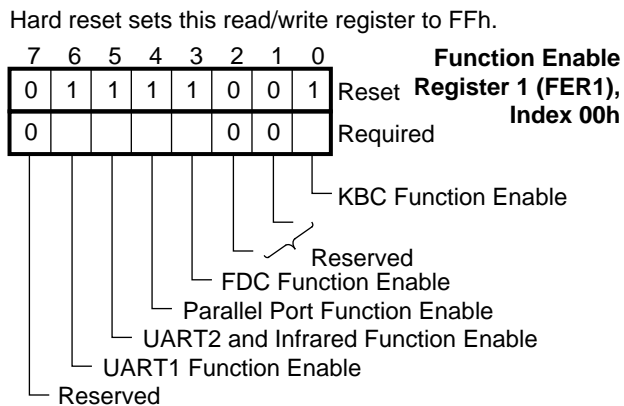
Bit 0 - KBC Function Enable
  0: Disabled.
  1: Enabled. (Default)

Bit 1 - Reserved

Bit 2 - Reserved

Bit 3 - FDC Function Enable
  0: Disabled.
  1: Enabled. (Default)

Bit 4 - Parallel Port Function Enable
  0: Disabled.
  1: Enabled. (Default).

Bit 5 - UART2 and Infrared Function Enable
  0: Disabled.

1: Enabled. (Default).

Bit 6 - UART1 Function Enable

   0: Disabled.

   1: Enabled. (Default).

Bit 7 - Reserved

7.2.4 Power Management Control Register (PMC1)

The bits of this register place the signals of the corresponding inactive logical device in TRI-STATE (except IRQ and DMA pins) when set to "1",regardless of the value of bit 0 of the corresponding logical device register at index F0h.

A cleared bit has no effect. In this case, the TRI-STATE status of signals is controlled by bit 0 of the corresponding logical device register at index F0h.

This is an OR function between PMC1 and the register at index F0h of the corresponding logical device.

Hard reset clears this read/write register to 00h.
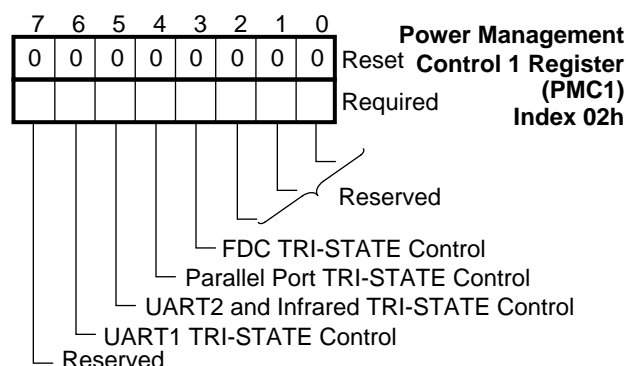
Bits 2-0 - Reserved

Bit 3 - FDC TRI-STATE Control

   0: No effect. TRI-STATE controlled by bit 0 of the SuperI/O FDC Configuration register. (Default)

     See Section 2.5.1 "SuperI/O FDC Configuration Register" on page 30.

   1: FDC signals are in TRI-STATE.

Bit 4 - Parallel Port TRI-STATE Control

   0: No effect. TRI-STATE controlled by bit 0 of the SuperI/O Parallel Port Configuration register. (Default)

     See Section 2.6 "SUPERI/O PARALLEL PORT CONFIGURATION REGISTER (LOGICAL DEVICE 1)" on page 30.

   1: Parallel Port signals are in TRI-STATE.

Bit 5 - UART2 and Infrared TRI-STATE Control

   0: No effect. TRI-STATE controlled by bit 0 of the SuperI/O UART2 Configuration register. (Default)

     See "Bit 0 - TRI-STATE Control for UART2 signals" on page 31.

   1: UART2 signals are in TRI-STATE.

Bit 6 - UART1 TRI-STATE Control

   0: No effect. TRI-STATE controlled by bit 0 of the SuperI/O UART1 Configuration register. (Default)

See Section 2.8 "SUPERI/O UART1 CONFIGURATION REGISTER (LOGICAL DEVICE 3)" on page 32.

   1: UART1 signals are in TRI-STATE.

Bit 7 - Reserved

   Reserved.

7.2.5 Power Management Control 3 Register (PMC3)

This register enables and monitors functions and devices.

Hard reset initializes this register to 0Eh.
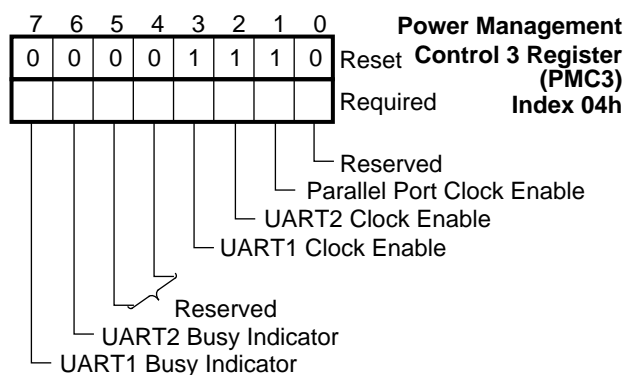
Bit 0 - Power Management Timer CLock Enable

   0: The clock is disabled.
The PM Timer registers (see Fixed ACPI registers) are not accessible. Reads are ignored.
The TMR_STS and the TMR_EN bits (in PM1 Event registers) are read-only bits. Read returns 0.

   1: The clock is enabled.
The PM Timer registers (see Fixed ACPI registers) are accessible.
The TMR_STS and the TMR_EN bits (in PM1 Event registers) are functional.

Bit 1 - Parallel Port Clock Enable

   This bit is ANDed with bit 1 of the SuperI/O Parallel Port Configuration register at index F0h of Logical Device 4. If either bit is cleared to 0, the clock is disabled. Both bits must be set to 1 to enable the clock.

   0: The clock is disabled.

   1: If bit 1 of the SuperI/O Parallel Port Configuration register is set to 1, the clock is enabled. (Default)

Bit 2 - UART2 Clock Enable

   This bit is ANDed with bit 1 of the SuperI/O UART2 Configuration register at index F0h of Logical Device 2. If either bit is cleared to 0, the clock is disabled. Both bits must be set to 1 to enable the clock.

   0: The clock is disabled.

   1: If bit 1 of the SuperI/O UART2 Configuration register is set to 1, the clock is enabled. (Default)

Bit 3 - UART1 Clock Enable

This bit is ANDed with bit 1 of the SuperI/O UART1 Configuration register at index F0h of Logical Device 3. If, either bit is cleared to 0, the clock is disabled. Both bits must be set to 1 to enable the clock.

0: The clock is disabled.

1: If bit 1 of the SuperI/O UART1 Configuration register is set to 1, the clock is enabled. (Default)
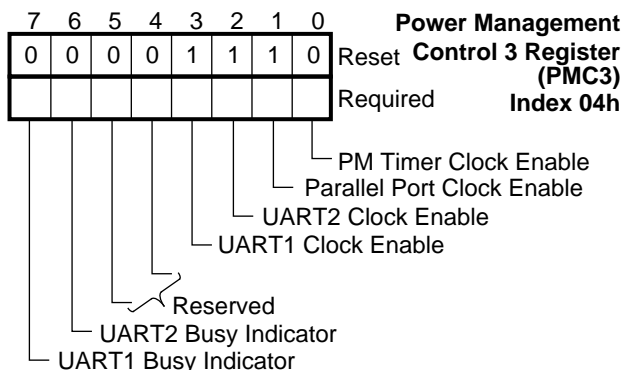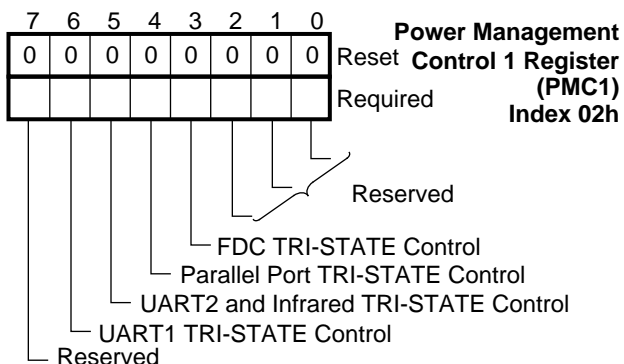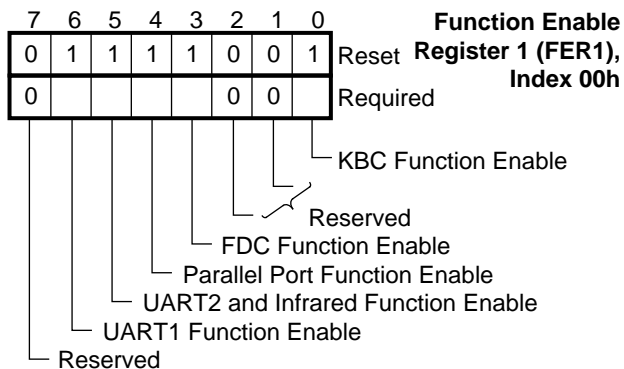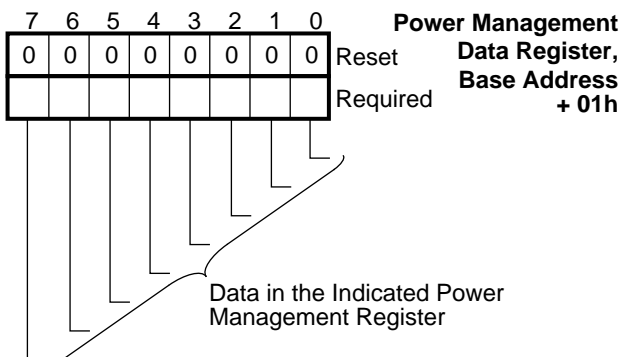
Bits 5,4 - Reserved

Bit 6 - UART2 Busy Indicator

When set to 1, this read-only bit indicates the UART2 is busy. It is also accessed via the SuperI/O UART2 Configuration register at index F0h of Logical Device 2. See Section 2.7 on page 31.

Bit 7 - UART1 Busy Indicator

When set to 1, this read-only bit indicates the UART1 is busy. It is also accessed via the SuperI/O UART1Configuration register at index F0h of Logical Device 3. See Section 2.8 on page 32.

7.3 POWER MANAGEMENT REGISTER BITMAPS

Power Management Index Register, Base Address +00h

Index of a Power Management Register

Read Only

Power Management Data Register, Base Address + 01h

Data in the Indicated Power Management Register

Function Enable Register 1 (FER1), Index 00h

KBC Function Enable
Reserved
FDC Function Enable
Parallel Port Function Enable
UART2 and Infrared Function Enable
UART1 Function Enable
Reserved

Power Management Control 1 Register (PMC1) Index 02h

Reserved
FDC TRI-STATE Control
Parallel Port TRI-STATE Control
UART2 and Infrared TRI-STATE Control
UART1 TRI-STATE Control
Reserved

Power Management Control 3 Register (PMC3) Index 04h

PM Timer Clock Enable
Parallel Port Clock Enable
UART2 Clock Enable
UART1 Clock Enable
Reserved
UART2 Busy Indicator
UART1 Busy Indicator

8.0 Mouse and Keyboard Controller (KBC) (Logical Devices 5 and 6)

The Keyboard Controller (KBC) is a functionally independent programmable device controller. It is implemented physically as a single hardware module on the PC87309 multi-I/O chip and houses two separate logical devices: a mouse controller (Logical Device 5) and a keyboard controller (Logical Device 6).

The KBC accepts user input from the keyboard or mouse, and transfers this input to the host PC via the common PC87309-PC interface.

The KBC is functionally equivalent to the industry standard 8042A keyboard controller, which may serve as a detailed technical reference for the KBC.

The KBC is delivered preprogrammed with customer-supplied code. KBC firmware code is identical to 8042 code, and to code of the keyboard controller of the PC87323VUL chip. The PC87323VUL is a recommended development platform for the KBC since it uses identical code and includes internal program RAM that enables software development.

8.1 SYSTEM ARCHITECTURE

The KBC is a general purpose microcontroller, with an 8-bit internal data bus. See FIGURE FIGURE 8-1 "KBC System Functional Block Diagram". It includes these functional blocks:

Serial Open-collector Drivers: Four open-collector bi-directional serial lines enable serial data exchange with the external devices (keyboard and mouse) using the PS/2 protocol.

Program ROM: 2 Kbytes of ROM store program machine code in non-erasable memory. The code is copied to this ROM during manufacture, from customer-supplied code.

Data RAM: A 256-byte data RAM enables run-time internal data storage, and includes an 8-level stack and 16 8-bit registers.

Timer/Counter: An internal 8-bit timer/counter can count external events or pre-divided system clock pulses. An internal time-out interrupt may be generated by this device.

I/O Ports: Two 8-bit ports (Port 1 and Port 2) serve various I/O functions. Some are for general purpose use, others are utilized by the KBC firmware.
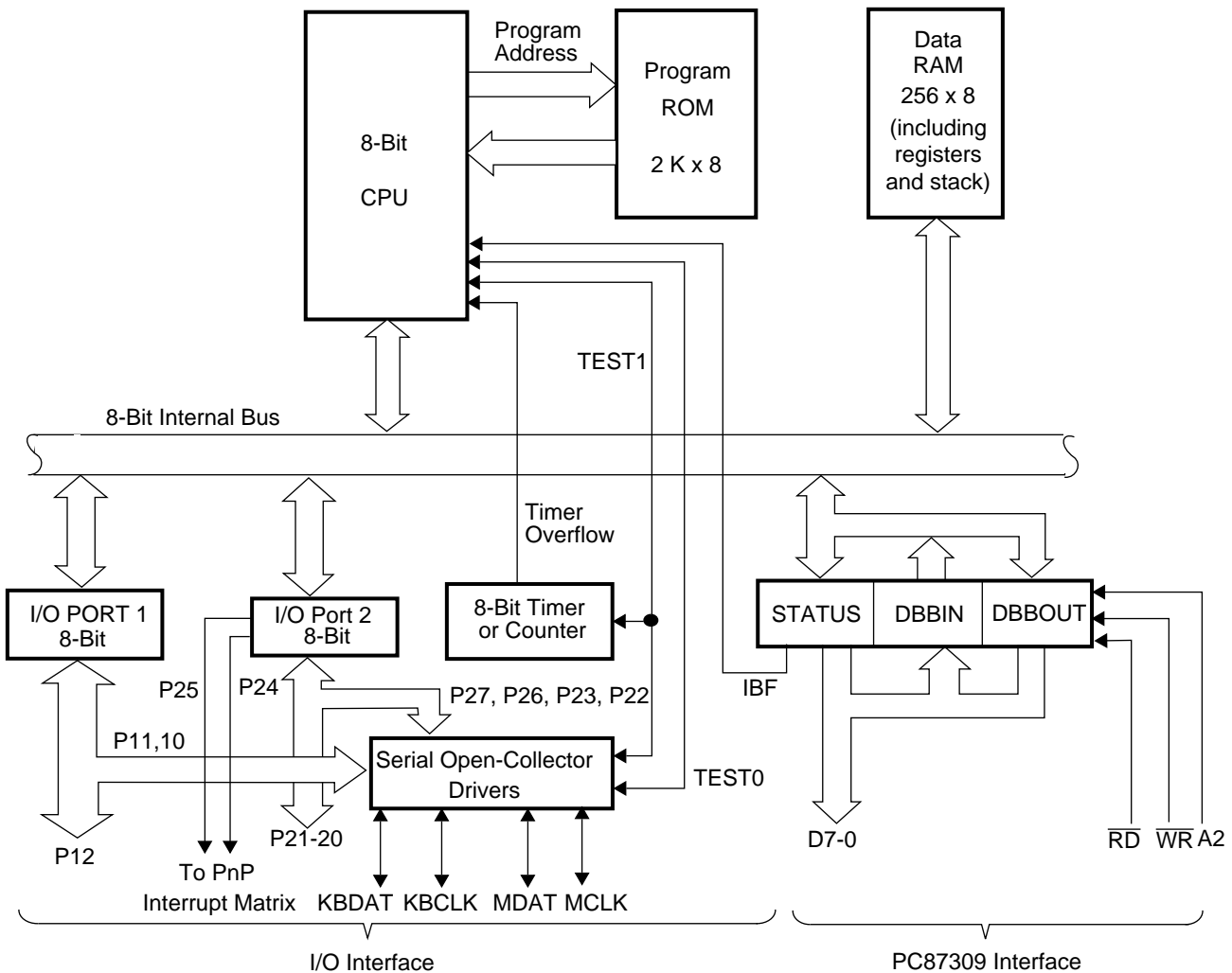

FIGURE 8-1. KBC System Functional Block Diagram

8.2 FUNCTIONAL OVERVIEW

The KBC supports two external devices — a keyboard and a mouse. Each device communicates with the KBC via two bidirectional serial signals. Five additional external general-purpose I/O signals are provided.

KBC operation involves three signal interfaces:

- External I/O interface
- Internal KBC - PC87309 interface
- PC87309 - PC chip set interface.

These system interfaces are shown in FIGURE FIGURE 8-2 "System Interfaces".

The KBC uses two data registers (for input and output) and a status register to communicate with the PC87309 central system. Data exchange between these units may be based on programmed I/O or interrupt-driven.

The KBC has two internal interrupts: the Input Buffer Full (IBF) interrupt and Timer Overflow interrupt (see FIGURE 8-1 "KBC System Functional Block Diagram" on page 158). These two interrupts can be independently enabled or dis-abled by KBC firmware. Both are disabled by a hard reset. These two interrupts only affect the execution flow of the KBC firmware, and have no connection with the external interrupts requested by this logical device.

The KBC can generate two external interrupt requests. These request signals are controlled by the KBC firmware which generates them by manipulating I/O port signals. See Section 8.3.2 "Interrupt Request Signals".

The PC87309 supports the KBC and handles interactions with the PC chip set. In addition to data transfer, these interactions include KBC configuration, activation and status monitoring. The PC87309 interconnects with the host via one interface that is shared by all chip devices

The KBC clock is generated from the main clock of the chip, which may come from an external clock source or from the internal frequency multiplier. (See Section 8.3 "DEVICE CONFIGURATION" and FIGURE 8-5 "Timing Generation and Timer Circuit" on page 161.) The KBC clock rate is configured by the SIO Configuration Registers.
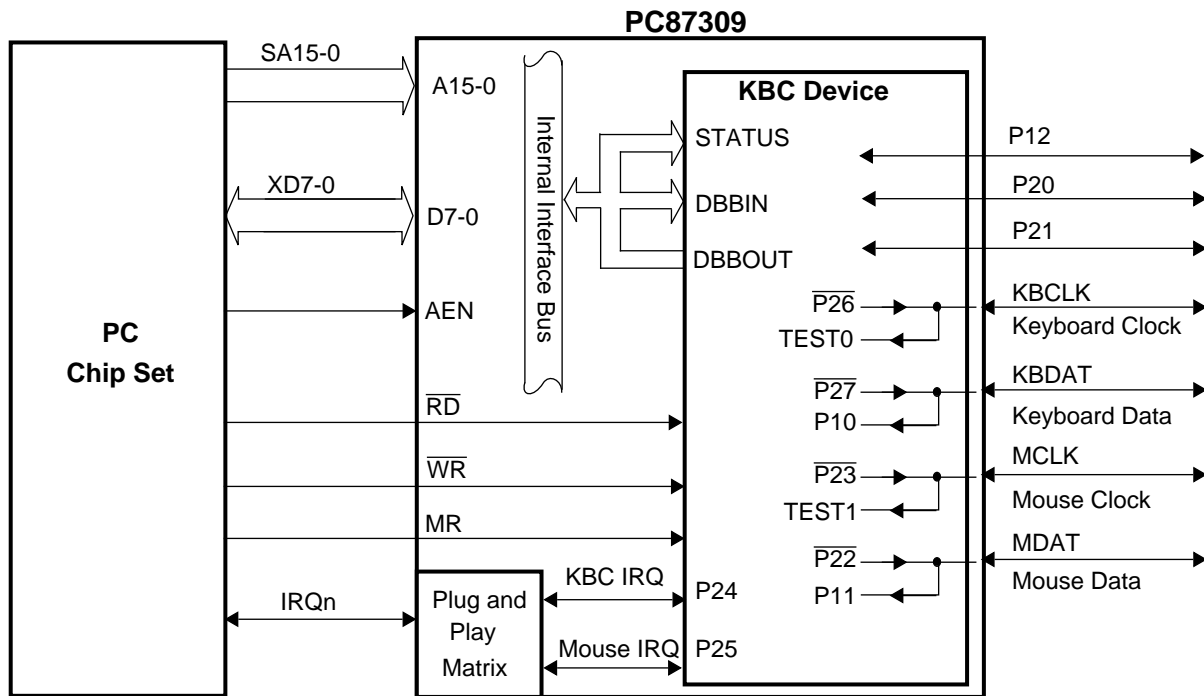
FIGURE 8-2. System Interfaces

8.3 DEVICE CONFIGURATION

The KBC hardware contains two logical devices—the mouse (Logical Device 5) and the keyboard (Logical Device 6).

8.3.1 I/O Address Space

The KBC has two I/O addresses and one IRQ line (KBC IRQ) and can operate without the companion mouse.

The mouse cannot operate without the KBC device. It has one IRQ line (mouse IRQ) but has no I/O address. It utilizes the KBC I/O addresses.

8.3.2 Interrupt Request Signals

The KBC IRQ and Mouse IRQ interrupt request signals are identical to (or functions of) the P24 and P25 signals of the 8042. These interrupt request signals are routed internally to the Plug and Play interrupt Matrix and may be routed to user-programmable IRQ pins. Each logical device is independently controlled.

The Interrupt Select registers (index 70h for each logical device) select the IRQ pin to which the corresponding interrupt request is routed. The interrupt may also be disabled by not routing its request signal to any IRQ pin.

Bit 0 of the Interrupt Type registers (index 71h for each logical device) determines whether the interrupts are passed (bit 0 = 0) or latched (bit 0 = 1). If bit 0 = 0, interrupt request signals (P24 and P25) are passed directly to the selected IRQ pin. If bit 0 = 1, interrupt request signals that become active are latched on their rising edge, and held until read from the KBC output buffer (port 60h).

FIGURE FIGURE 8-3 "Interrupt Request Logic" illustrates the internal interrupt request logic. Refer to FIGURE 8-4 "Instruction Timing" for a timing diagram.
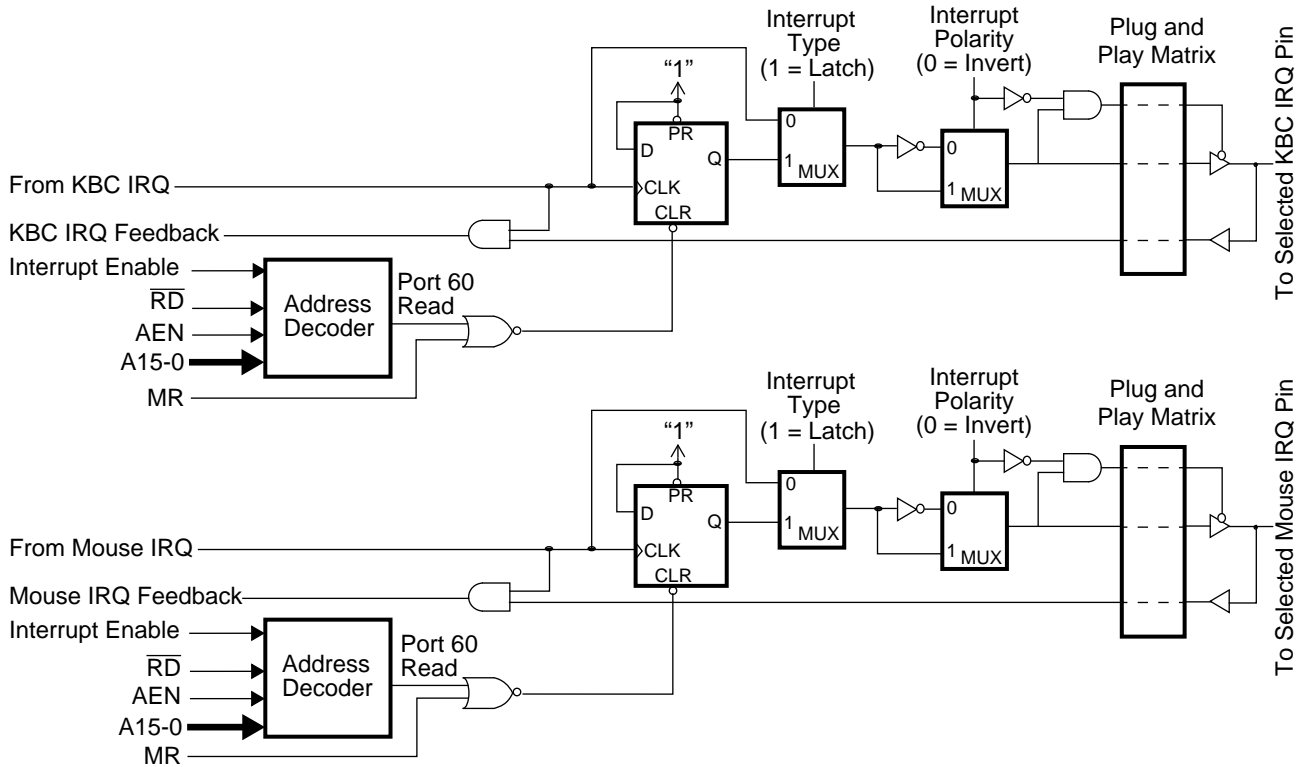
FIGURE 8-3. Interrupt Request Logic
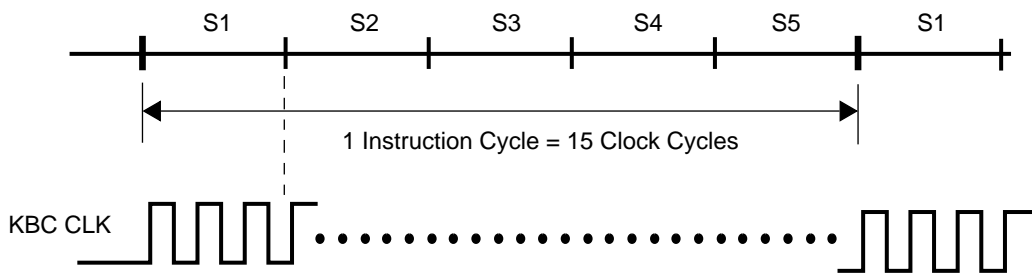
FIGURE 8-4. Instruction Timing

Note: The EN FLAGS command (for routing OBF and IBF onto P24 and P25 in the 8042) causes unpredictable results and should not be issued
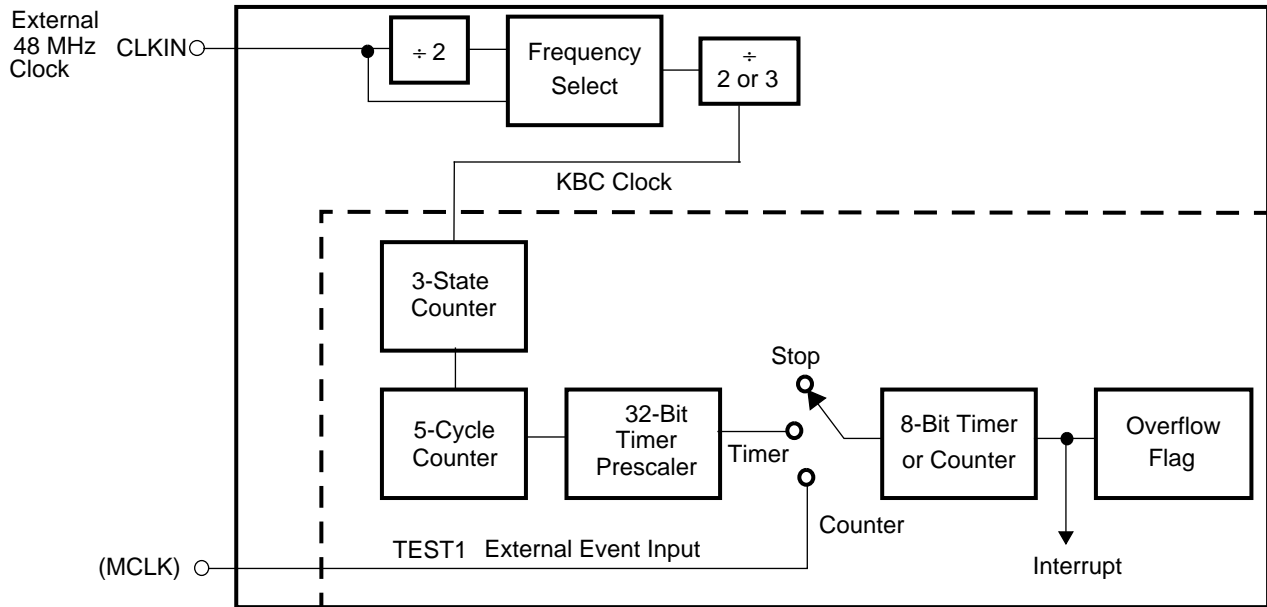
FIGURE 8-5. Timing Generation and Timer Circuit

8.3.3   KBC Clock

The KBC clock frequency is selected by the SuperI/O KBC Configuration Register at index F0h of Logical Device 6 to be either 8, 12 or 16 MHz.

For details regarding the configuration of each device, refer to TABLES 2-17 "KBC Configuration Registers for Keyboard - Logical Device 6" and 2-16 "KBC Configuration Registers for Mouse - Logical Device 5" on page 27.

8.3.4   Timer or Event Counter

The keyboard controller includes an 8-bit counter, which can be used as a timer or an event counter, as selected by the firmware.

Timer Operation

When the internal clock is chosen as the counter input, the counter functions as a timer. The clock fed to the timer consists of the KBC instruction cycle clock, divided by 32. (See FIGURES 8-4 "Instruction Timing" on page 160 and FIGURE 8-5 "Timing Generation and Timer Circuit".) The divisor is reset only by a hardware reset or when the timer is started by an STRT T instruction.

Event Counter Operation

When the clock input of the counter is switched to the external input (MCLK), it becomes an event counter. The falling edge of the signal on the MCLK pin causes the counter to increment. Timer Overflow Flag and Timer interrupt operate as in the timer mode.

8.4   EXTERNAL I/O INTERFACES

The PC chip set interfaces with the PC87309 as illustrated in FIGURE 8-2 "System Interfaces" on page 159.

All data transactions between the KBC and the PC chip set are handled by the PC87309.

The PC87309 decodes all I/O device chip-select functions from the address bus. The KBC chip-select codes are, traditionally, 60h or 64h, as described in TABLE 8-1 "System Interface Operations" on page 163. (These addresses are user-programmable.)

The external interface includes two sets of signals: the keyboard and mouse interface signals, and the general-purpose I/O signals.

8.4.1   Keyboard and Mouse Interface

Four serial I/O signals interface with the external keyboard and mouse. These signals are driven by open-collector drivers with signals derived from two I/O ports residing on the internal bus. Each output can drive 16 mA, making them suitable for driving the keyboard and mouse cables. The signals are named KBCLK, KBDAT, MCLK and MDAT, and they are the logical complements of P26, P27, P23 and P22, respectively.

TEST0 and TEST1 are dedicated test pins, internally connected to KBCLK and MCLK, respectively, as shown in FIGURES 8-1 "KBC System Functional Block Diagram" on page 158 and 8-2 "System Interfaces" on page 159. These pins may be used as logical conditions for conditional jump instructions, which directly check the logical levels at the pins.

KBDAT and MDAT are connected to pins P10 and P11, respectively.

MCLK also provides input to the event counter.

8.4.2 General Purpose I/O Signals

The P12, P20 and P21 general purpose I/O signals interface to two I/O ports (port1 and port2). P12 is mapped to port 1 and P20 and P21 are mapped to port 2.

P12 does not exist in the default configuration of Two-UART mode see "Wake Up Options" on page 19. In this mode, P12 input is connected implicitly to the port output. It may be optionally select on either IRRX or MTR1, in which case it is open drain and not quasi-bidirectional as described below.
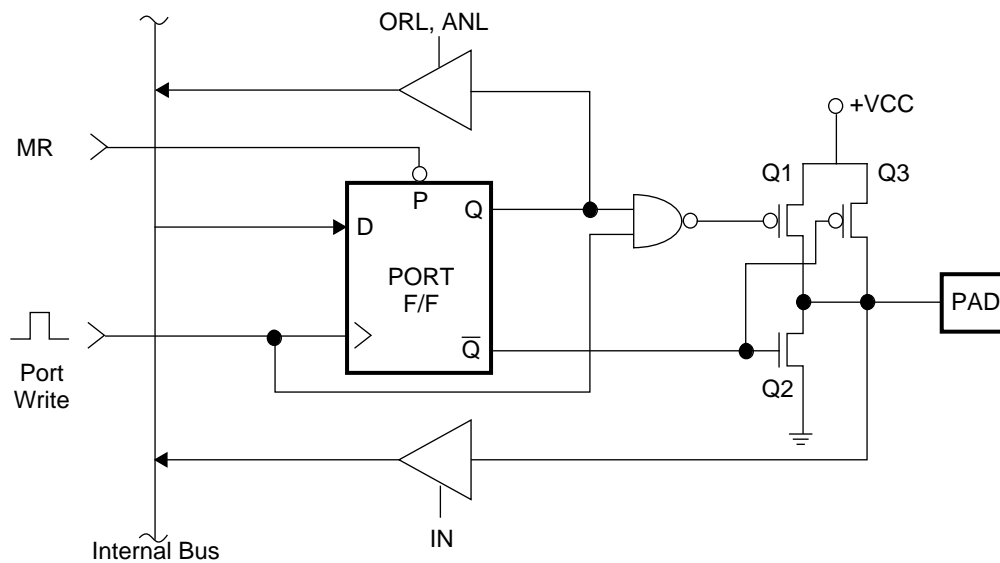
P12 is driven by quasi-bidirectional drivers. (See FIGURE FIGURE 8-6 "Quasi-Bidirectional Driver".) These signals are called quasi-bidirectional because the output buffer cannot be turned off (even when the I/O signal is used for input).

During output, a 1 written to output is strongly pulled up for the duration of a (short) write pulse, and thereafter maintained by a high impedance "weak" active pull-up (implemented by a degenerated transistor employed as a switchable pull-up resistor). A series resistor to those port lines used for input is recommended to limit the surge current during the strong pull-up. See FIGURE FIGURE 8-7 "Current Limiting Resistor".
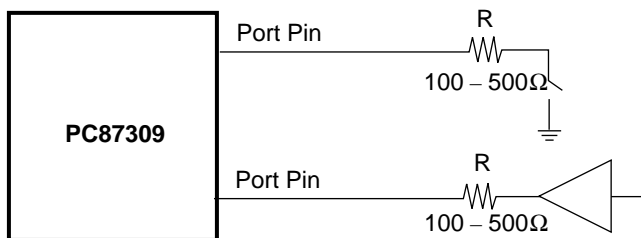
If a 1 is asserted, an externally applied signal may pull down the output. Therefore, input from this quasi-bidirectional circuit can be correctly read if preceded by a 1 written to output.

P20 and P21 are driven by open-drain drivers.

When the KBC is reset, all port data bits are initialized to 1.

FIGURE 8-6. Quasi-Bidirectional Driver

FIGURE 8-7. Current Limiting Resistor

8.5 INTERNAL KBC - PC87309 INTERFACE

The KBC interfaces internally with the PC87309 via three registers: an input (DBBIN), output (DBBOUT) and status (STATUS) register. See FIGURE 8-1 "KBC System Functional Block Diagram" on page 158 and TABLE 8-1 "System Interface Operations".

TABLE 8-1. System Interface Operations

RD	WR	Default Addresses	Operation
0	1	60h	Read DBBOUT
1	0	60h	Write DBBIN, F1 Clear (Data)
0	1	64h	Read STATUS
1	0	64h	Write DBBIN, F1 Set (Command)

TABLE 8-1 "System Interface Operations" illustrates the use of address line A2 to differentiate between data and commands. The device is selected by chip identification of default address 60h (when A2 is 0) or 64h (when A2 is 1). After reset, these addresses can be changed by software.

8.5.1 The KBC DBBOUT Register, Offset 60h, Read Only

The DBBOUT register transfers data from the keyboard controller to the PC87309. It is written to by the keyboard controller and read by the PC87309 for transfer to the PC. The PC may be notified of the need to read data from the KBC by an interrupt request or by polling the Output Buffer Full (OBF) bit (bit 0 of the KBC STATUS register described in Section 8.5.3 "The KBC STATUS Register").

8.5.2 The KBC DBBIN Register, Offset 60h (F1 Clear) or 64h (F1 Set), Write Only

The DBBIN register transfers data from the PC87309 system to the keyboard controller. (This transaction is transparent to the user, who should program the device as if direct access to the registers were in effect.)

When data is received in this manner, an Input Buffer Full (IBF) internal interrupt may be generated in the KBC, to deal with this data. Alternatively, reception of data in this manner can be detected by the KBC polling the Input Buffer Full bit (IBF, bit 1 of the KBC STATUS register).

8.5.3 The KBC STATUS Register

The STATUS register holds information regarding the system interface status.The bitmap below shows the bit definition of this register. This register is controlled by the KBC firmware and hardware, and is read-only for the system.
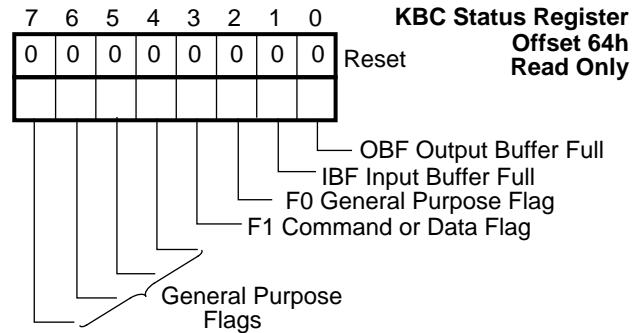
Bit 0 - OBF, Output Buffer Full

A 1 indicates that data has been written into the DBBOUT register by the KBC. It is cleared by a system read operation from DBBOUT.

Bit 1 - IBF, Input Buffer Full

When a write operation is performed by the host system, this bit is set to 1, which may be set up to trigger the IBF interrupt. Upon executing an IN A, DBB instruction, it is cleared.

Bit 2 - F0, General Purpose Flag

A general purpose flag that can be cleared or toggled by the keyboard controller firmware.

Bit 3 - F1, Command/Data Flag

This flag holds the state of address line A2 while a write operation is performed by the host system. It distinguishes between commands and data from the host system. In this device, a write with A2 = 1 (hence F1 = 1) is defined as a command, and A2 = 0 (hence F1 = 0) is data.

Bits 7-4, General Purpose Flags

These flags may be modified by KBC firmware.

8.6 INSTRUCTION TIMING

The KBC clock is first divided by 3 to generate the state timing, then by 5 to generate the instruction timing. Thus each instruction cycle consists of five states and 15 clock cycles.

Most keyboard controller instructions require only one instruction cycle, while some require two cycles. Refer to the 8042 or PC87323VUL instruction set for details.

9.0   Interrupt and DMA Mapping

The standard Plug and Play configuration registers map IRQs and DMA channels for the PC87309. See TABLES 2-7 "Plug and Play (PnP) Interrupt Configuration Registers" and 2-8 "Plug and Play (PnP) DMA Configuration Registers" on page 24.

9.1   IRQ MAPPING

The PC87309 allows connection of some logical devices to the seven IRQ signals.

The polarity of an IRQ signal is controlled by bit 1 of the Interrupt Type registers (index 71h) of each logical device. The same bit also controls selection of push-pull or open-drain IRQ output. High polarity implies push-pull output. Low polarity implies open-drain output with strong pull-up for a short time, followed by weak pull-up.

The IRQ input signals of the KBC or mouse, and of the parallel port are not affected by this bit, i.e., bit 1 at index 71h of each logical device. This bit affects only the output buffer, not the input buffer.

Only the UART1 and UART2 may map more than one logical device to any IRQ signal. Other devices may not do so.

An IRQ signal is in TRI-STATE when any of the following conditions is true:

- No logical device is mapped to the IRQ signal.

- The logical device mapped to the IRQ signal is inactive.

- The logical device mapped to the IRQ signal floats its IRQ signal.

9.2   DMA MAPPING

Although the PC87309 allows some logical devices to be connected to the three 8-bit DMA channels, it is illegal to map two logical devices to the same pair of DMA signals.

A DRQ signal is in TRI-STATE and the $\overline{DACK}$ input signal is blocked to 1 when any of the following conditions is true:

- No logical device is mapped to the DMA channel.

- The logical device mapped to the DMA channel is inactive.

- The logical device mapped to the DMA channel floats its DRQ signal.

10.0 Device Specifications

10.1 GENERAL DC ELECTRICAL CHARACTERISTICS

10.1.1 Recommended Operating Conditions

Symbol	Parameter	Min	Typ	Max	Unit
V_{DD}	Supply Voltage	4.5	5.0	5.5	V
T_A	Operating Temperature	0		+70	°C

10.1.2 Absolute Maximum Ratings

Absolute maximum ratings are values beyond which damage to the device may occur. Unless otherwise specified, all voltages are relative to ground.

Symbol	Parameter	Conditions	Min	Max	Unit
V_{DD}	Supply Voltage		−0.5	6.5	V
V_I	Input Voltage		−0.5	$V_{DD} + 0.5$	V
V_O	Output Voltage		−0.5	$V_{DD} + 0.5$	V
T_{STG}	Storage Temperature		−65	+165	°C
P_D	Power Dissipation			1	W
T_L	Lead Temperature Soldering (10 sec)			+260	°C
	ESD Tolerance	C_{ZAP} = 100 pF R_{ZAP} = 1.5 KΩ[1]	1500		V

1. Value based on test complying with RAI-5-048-RA human body model ESD testing.

10.1.3 Capacitance

Symbol	Parameter	Min	Typ	Max	Unit
C_{IN}	Input Pin Capacitance		5	7	pF
C_{IN1}	Clock Input Capacitance		8	10	pF
C_{IO}	I/O Pin Capacitance		10	12	pF
C_O	Output Pin Capacitance		6	8	pF

T_A = 25°C, f = 1 MHz

10.1.4 Power Consumption under Recommended Operating Conditions

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
I_{CC}	V_{DD} Average Main Supply Current	V_{IL} = 0.5 V V_{IH} = 2.4 V No Load		32	50	mA
I_{CCSB}	V_{DD} Quiescent Main Supply Current in Low Power Mode	$V_{IL} = V_{SS}$ $V_{IH} = V_{DD}$ No Load		1.3	1.7	mA

10.2 DC CHARACTERISTICS OF PINS, BY GROUP

The following tables list the DC characteristics of all device pins described in Section 1.2. The pin list preceeding each table lists the device pins to which the table applies.

10.2.1   Group 1

Pin List:

A11-0, AEN, CLKIN, $\overline{\text{CTS2,1}}$, $\overline{\text{DACK3-1}}$, $\overline{\text{DCD2,1}}$, $\overline{\text{DSKCHG}}$, $\overline{\text{DSR2,1}}$, ID3-0, $\overline{\text{INDEX}}$, $\overline{\text{IORD}}$, $\overline{\text{IOWR}}$, MR, $\overline{\text{RDATA}}$, $\overline{\text{RI2,1}}$, SIN2,1, TC, $\overline{\text{TRK0}}$, $\overline{\text{WP}}$

All Group 1 pins are back-drive protected.

Symbol	Parameter	Conditions	Min	Max	Unit
V_{IH}	Input High Voltage		2.0	V_{DD}[1]	V
V_{IL}	Input Low Voltage		−0.5[1]	0.8	V
I_{IL}	Input Leakage Current	$V_{IN} = V_{DD}$		10	μA
		$V_{IN} = V_{SS}$		−10	μA
V_H	Input Hysteresis		250		mV

1. Not tested. Guaranteed by design.

10.2.2   Group 2

Pin List:

BUSY, PE, SLCT, $\overline{\text{WAIT}}$

Output from SLCT, PE and BUSY is open-drain in all SPP modes, except in SPP Compatible mode when the setup mode is ECP-based FIFO and bit 4 of the Control2 parallel port register is 1. (See TABLE 4-1 "Parallel Port Mode Selection" on page 80.) Otherwise, output from these signals is level 2. External 4.7 KΩ pull-up resistors should be used.

PE is in Group 2 only if bit 2 of PP Confg0 Register is "0" (see Section 4.5.19 "PP Confg0 Register" on page 94).

All group 2 pins are back-drive protected.

Symbol	Parameter	Conditions	Min	Max	Unit
V_{IH}	Input High Voltage		2.0	V_{DD}[1]	V
V_{IL}	Input Low Voltage		−0.5[1]	0.8	V
I_{IL}	Input Leakage Current	$V_{IN} = V_{DD}$		120	μA
		$V_{IN} = V_{SS}$		−10	μA

1. Not tested. Guaranteed by design.

10.2.3   Group 3

Pin List:

$\overline{\text{ACK}}$, $\overline{\text{ERR}}$, PE

Output from $\overline{\text{ACK}}$ and $\overline{\text{ERR}}$ is open-drain in all SPP modes, except in SPP Compatible mode when the setup mode is ECP-based FIFO and bit 4 of the Control2 parallel port register is 1. (See TABLE 4-1 "Parallel Port Mode Selection" on page 80.) Otherwise, output from these signals is level 2.

External 4.7 KΩ pull-up resistors should be used.

PE is in Group 3 only if bit 2 of PP Confg0 Register is "1" (see Section 4.5.19 "PP Confg0 Register" on page 94).

All group 3 pins are back-drive protected.

Symbol	Parameter	Conditions	Min	Max	Unit
V_{IH}	Input High Voltage		2.0	V_{DD}[1]	V
V_{IL}	Input Low Voltage		−0.5[1]	0.8	V
I_{IL}	Input Leakage Current	$V_{IN} = V_{DD}$		10	μA
		$V_{IN} = V_{SS}$		−120	μA

1. Not tested. Guaranteed by design.

10.2.4   Group 4

Pin List:

BADDR1,0, CFG0

These are CMOS input pins.

Symbol	Parameter	Conditions	Min	Max	Unit
V_{IH}	Input High Voltage		2.5	V_{DD}[1]	V
I_{IL}	Input Leakage Current	During Reset: $V_{IN} = V_{DD}$		200	μA
		$V_{IN} = V_{SS}$		−10	μA

1. Not tested. Guaranteed by design.

10.2.5   Group 5

Pin List:

D7-0

Input

Symbol	Parameter	Conditions	Min	Max	Unit
V_{IH}	Input High Voltage		2.0	V_{DD}[1]	V
V_{IL}	Input Low Voltage		−0.5[1]	0.8	V
I_{IL}	Input Leakage Current	$V_{IN} = V_{DD}$		10	μA
		$V_{IN} = V_{SS}$		−10	μA
V_H	Hysteresis		250		mV

1. Not tested. Guaranteed by design.

Output

Symbol	Parameter	Conditions	Min	Max	Unit
V_{OH}	Output High Voltage	$I_{OH} = -15$ mA	2.4		V
V_{OL}	Output Low Voltage	$I_{OL} = 24$ mA		0.4	V

10.2.6   Group 6

Pin List:

KBCLK, KBDAT, MCLK, MDAT

Output from these signals is open-drain and cannot be forced high.

Input

Symbol	Parameter	Conditions	Min	Max	Unit
V_{IH}	Input High Voltage		2.0	V_{DD}[1]	V
V_{IL}	Input Low Voltage		−0.5[1]	0.8	V
I_{IL}	Input Leakage Current	$V_{IN} = V_{DD}$		10	μA
		$V_{IN} = V_{SS}$		−10	μA
V_H	Hysteresis		250		mV

1. Not tested. Guaranteed by design.

Output

Symbol	Parameter	Conditions	Min	Max	Unit
V_{OL}	Output Low Voltage	$I_{OL} = 16$ mA		0.4	V

10.2.7 Group 7

Pin List:

P12, P20, P21

Input

Symbol	Parameter	Conditions	Min	Max	Unit
V_{IH}	Input High Voltage		2.0	V_{DD}[1]	V
V_{IL}	Input Low Voltage		-0.5[1]	0.8	V
I_{IL}	Input Leakage Current	$V_{IN} = V_{DD}$		10	μA
		$V_{IN} = V_{SS}$		-10	μA
V_H	Hysteresis		250		mV

1. Not tested. Guaranteed by design.

Output

Symbol	Parameter	Conditions	Min	Max	Unit
V_{OH}	Output High Voltage	$I_{OH} = -14$ mA[1]	2.4		V
V_{OL}	Output Low Voltage	$I_{OL} = 14$ mA		0.4	V

1. I_{OH} is driven for 10 nsec after the low-to-high transition, on pins P12.

10.2.8 Group 8

Pin List:

$\overline{\text{AFD}}$, $\overline{\text{ASTRB}}$, $\overline{\text{DSTRB}}$, $\overline{\text{INIT}}$, $\overline{\text{SLIN}}$, $\overline{\text{STB}}$, $\overline{\text{WRITE}}$

These pins are back-drive protected.

Input

Symbol	Parameter	Conditions	Min	Max	Unit
V_{IH}	Input High Voltage		2.0	V_{DD}[1]	V
V_{IL}	Input Low Voltage		-0.5[1]	0.8	V
I_{IL}	Input Leakage Current	$V_{IN} = V_{DD}$		10	μA
		$V_{IN} = V_{SS}$		-10	μA
V_H	Hysteresis		250		mV

1. Not tested. Guaranteed by design.

Output

Symbol	Parameter	Conditions	Min	Max	Unit
V_{OH}	Output High Voltage[1]	$I_{OH} = -2$ mA	2.4		V
V_{OL}	Output Low Voltage	$I_{OL} = 2$ mA		0.4	V

1. Output from $\overline{\text{STB}}$, $\overline{\text{AFD}}$, $\overline{\text{INIT}}$, $\overline{\text{SLIN}}$ is open-drain in all SPP modes, except in SPP Compatible mode when the setup mode is ECP-based (FIFO). (See TABLE 4-1 "Parallel Port Mode Selection" on page 80.) Otherwise, output from these signals is Level 2. External 4.7 KΩ pull-up resistors should be used.

10.2.9   Group 9

Pin List:

PD7-0

These pins are back-drive protected.

Input

Symbol	Parameter	Conditions	Min	Max	Unit
V_{IH}	Input High Voltage		2.0	V_{DD}[1]	V
V_{IL}	Input Low Voltage		−0.5[1]	0.8	V
I_{IL}	Input Leakage Current	$V_{IN} = V_{DD}$		10	μA
		$V_{IN} = V_{SS}$		−10	μA
V_H	Hysteresis		250		mV

1. Not tested. Guaranteed by design.

Output

Symbol	Parameter	Conditions	Min	Max	Unit
V_{OH}	Output High Voltage[1]	I_{OH} = −14 mA	2.4		V
V_{OL}	Output Low Voltage	I_{OL} = 14mA		0.4	V

1. Output from PD7-0 is open-drain in all SPP modes, except in SPP Compatible mode
when the setup mode is ECP-based (FIFO) and bit 4 of the Control2 parallel port reg-
ister is 1. (See TABLE 4-1 "Parallel Port Mode Selection" on page 80.) Otherwise,
output from these signals is Level 2. External 4.7 KΩ pull-up resistors should be used.

10.2.10   Group 10

Pin List:

IRQ1,3,4,5,6,7,12.

Symbol	Parameter	Conditions	Min	Max	Unit
V_{OH}	Output High Voltage	I_{OH} = −15 mA	2.4		V
V_{OL}	Output Low Voltage	I_{OL} = 24 mA		0.4	V

10.2.11   Group 11

Pin List:

DENSEL, $\overline{DIR}$, $\overline{DR1,0}$, $\overline{HDSEL}$, $\overline{MTR1,0}$, $\overline{STEP}$, $\overline{WDATA}$, $\overline{WGATE}$

Symbol	Parameter	Conditions	Min	Max	Unit
V_{OH}	Output High Voltage	I_{OH} = −4 mA	2.4		V
V_{OL}	Output Low Voltage[1]	I_{OL} = 40 mA		0.4	V

1. Not 100% tested. Guaranteed by characterization.

10.2.12   Group 12

Pin List:

BOUT2,1, $\overline{DTR2,1}$, IRSL2-0, $\overline{RTS2,1}$, SOUT2,1, IRTX

Symbol	Parameter	Conditions	Min	Max	Unit
V_{OH}	Output High Voltage	I_{OH} = −6 mA	2.4		V
V_{OL}	Output Low Voltage	I_{OL} = 12 mA		0.4	V

10.2.13 Group 13

Pin List:

DRQ3-1

Symbol	Parameter	Conditions	Min	Max	Unit
V_{OH}	Output High Voltage	I_{OH} = −15 mA	2.4		V
V_{OL}	Output Low Voltage	I_{OL} = 24 mA		0.4	V

10.2.14 Group 14

Pin List:

DRATE0

Symbol	Parameter	Conditions	Min	Max	Unit
V_{OH}	Output High Voltage	I_{OH} = −6 mA	2.4		V
V_{OL}	Output Low Voltage	I_{OL} = 12 mA		0.4	V

10.2.15 Group 15

Pin List:

$\overline{\text{IOCHRDY}}$

Symbol	Parameter	Conditions	Min	Max	Unit
V_{OH}	Output High Voltage	I_{OH} = −15 mA	2.4		V
V_{OL}	Output Low Voltage	I_{OL} = 24 mA		0.4	V

10.2.16 Group 18

Pin List:

IRRX2,1

These pins are back-drive protected.

Symbol	Parameter	Conditions	Min	Max	Unit
V_{IH}	Input High Voltage		2.0	V_{DD}[1]	V
V_{IL}	Input Low Voltage		−0.5[1]	0.8	V
I_{IL}	Input Leakage Current	V_{IN} = V_{DD}		10	μA
		V_{IN} = V_{SS}		−10	μA
V_H	Input Hysteresis		250		mV

1. Not tested. Guaranteed by design.

10.3 AC ELECTRICAL CHARACTERISTICS

10.3.1 AC Test Conditions

Load Circuit (Notes 1, 2, 3)
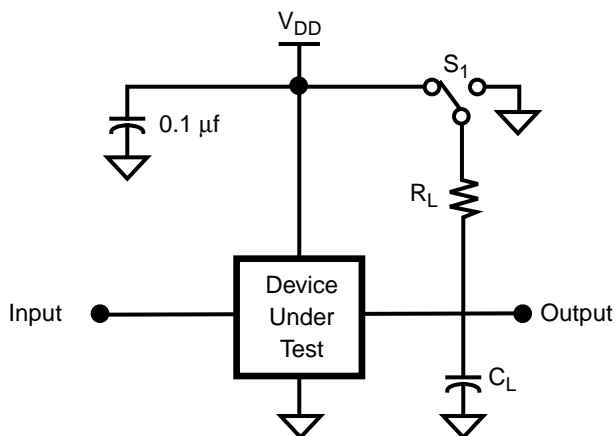
AC Testing Input, Output Waveform
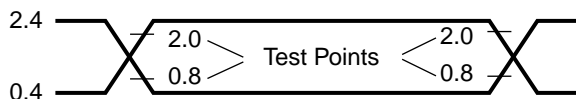
FIGURE 10-1. AC Test Conditions, T_A = 0 °C to 70 °C, V_{DD} = 5.0 V ±10%

Notes:

1. C_L = 100 pF, includes jig and scope capacitance.

2. S_1 = Open for push-pull output pins.
    S_1 = V_{DD} for high impedance to active low and active low to high impedance measurements.
    S_1 = GND for high impedance to active high and active high to high impedance measurements.
    R_L = 1.0KΩ for μP interface pins.

3. For the FDC open-drive interface pins, S_1 = V_{DD} and R_L = 150Ω.

10.3.2 Clock Timing

Symbol	Parameter	Min	Max	Unit
t_{CH}	Clock High Pulse Width[1]	8.4		nsec
t_{CL}	Clock Low Pulse Width[1]	8.4		nsec
t_{CP}	Clock Period[1]	20.6	21	nsec

1. Not tested. Guaranteed by design.
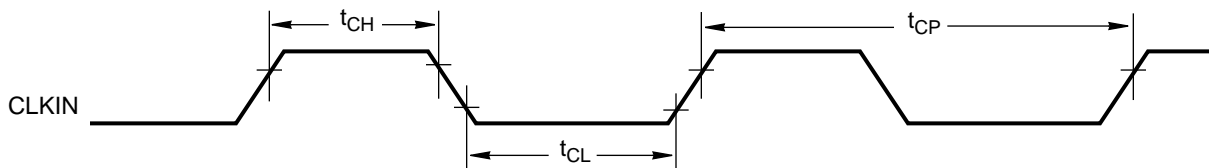
10.3.3   Microprocessor Interface Timing

Symbol	Parameter	Min	Max	Unit
t_{AR}	Valid Address to Read Active	18		nsec
t_{AW}	Valid Address to Write Active	18		nsec
t_{DH}	Data Hold	0		nsec
t_{DS}	Data Setup	18		nsec
t_{HZ}	Read to Floating Data Bus[1]	13	25	nsec
t_{PS}	Port Setup	10		nsec
t_{RA}	Address Hold from Inactive Read	0		nsec
t_{RCU}	Read Cycle Update[1]	45		nsec
t_{RD}	Read Strobe Width	60		nsec
t_{RDH}	Read Data Hold	10		nsec
t_{RI}	Read Strobe to Clear IRQ6		55	nsec
t_{RVD}	Active Read to Valid Data		55	nsec
t_{WA}	Address Hold from Inactive Write	0		nsec
t_{WCU}	Write Cycle Update[1]	45		nsec
t_{WI}	Write Strobe to Clear IRQ6		55	nsec
t_{WO}	Write Data to Port Update		60	nsec
t_{WR}	Write Strobe Width	60		nsec
t_{WRR}	$\overline{RD}$ low after $\overline{WR}$ high[1]	80		nsec
RC	Read Cycle = $t_{AR} + t_{RD} + t_{RCU}$[1]	123		nsec
WC	Write Cycle = $t_{AW} + t_{WR} + t_{WC}$[1]	123		nsec

1. Not tested. Guaranteed by design.
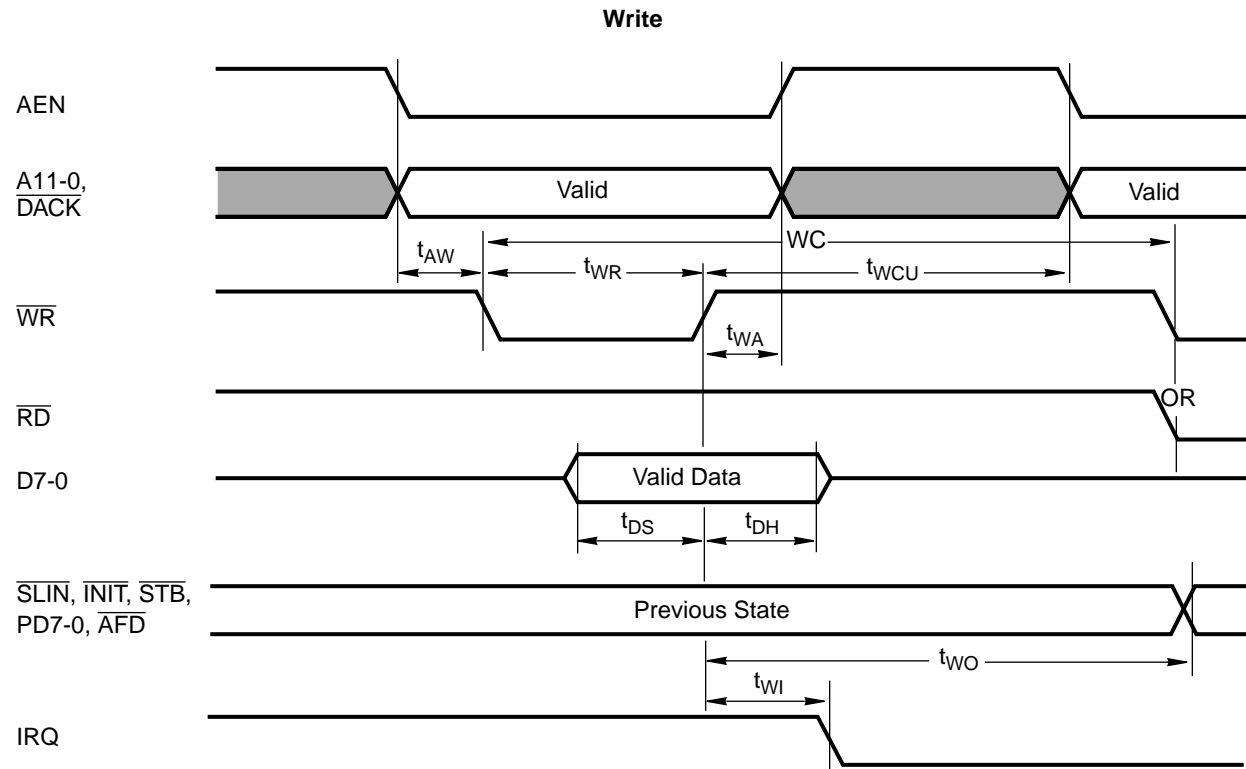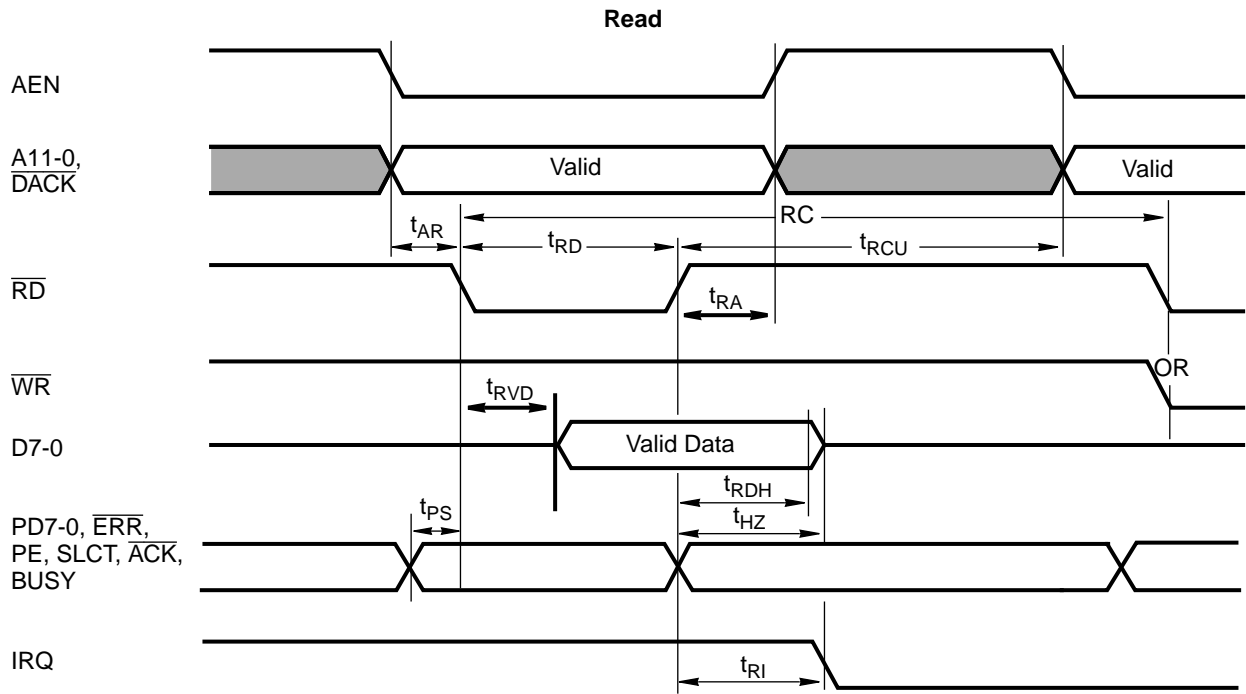
Read

Write

Read After Write Operation to All Registers and RAM
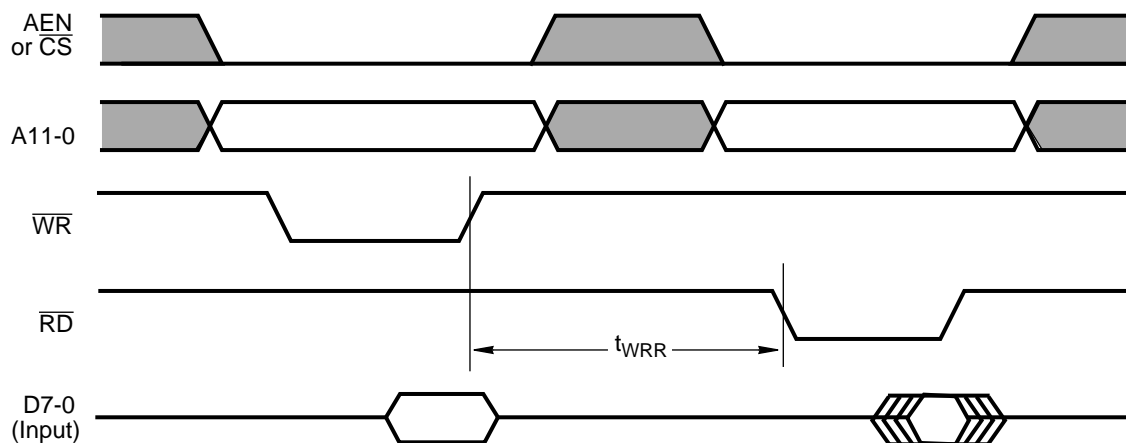
10.3.4 Baud Output Timing

Symbol	Parameter	Conditions	Min	Max	Unit
N	Baud Divisor		1	65535	nsec
t_{BHD}	Baud Output Positive Edge Delay[1]	CLK = 24 MHz/2, 100 pF load		56	nsec
t_{BLD}	Baud Output Negative Edge Delay[1]	CLK = 24 MHz/2, 100 pF load		56	nsec

1. Not tested. Guaranteed by design.
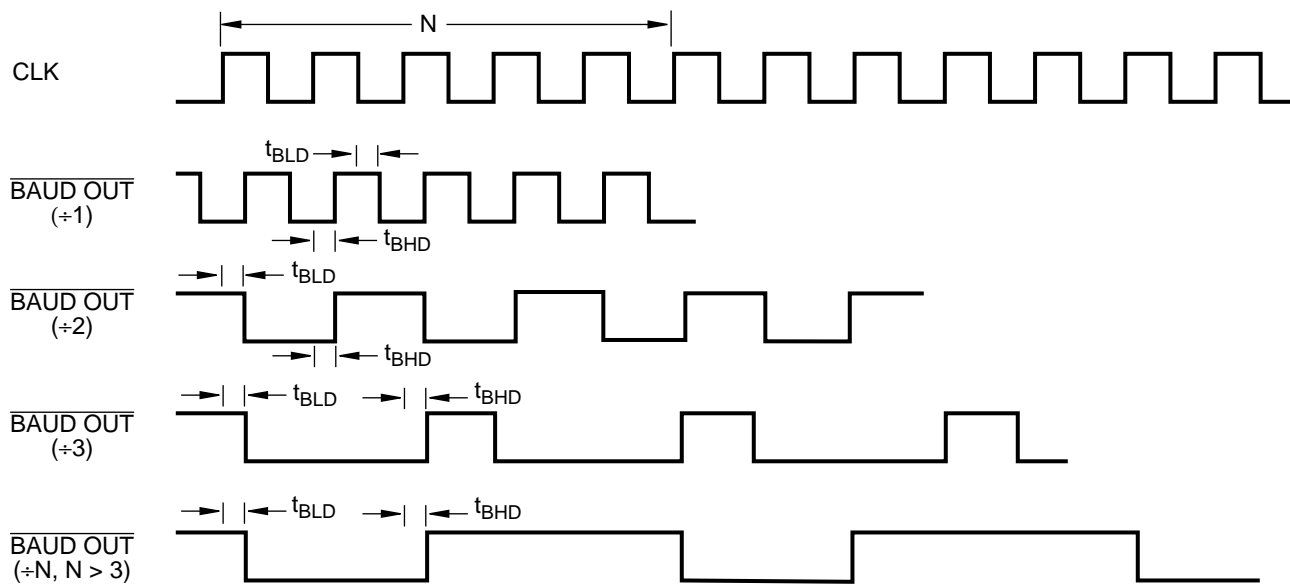
10.3.5 Transmitter Timing

Symbol	Parameter	Min	Max	Unit
t_{HR}	Delay from $\overline{WR}$ (WR THR) to Reset IRQ		40	nsec
t_{IR}	Delay from $\overline{RD}$ (RD IIR) to Reset IRQ (THRE)		55	nsec
t_{IRS}	Delay from Initial IRQ Reset to Transmit Start[1]	8	24	Baud Output Cycles
t_{SI}	Delay from Initial Write to IRQ[1]	16	24	Baud Output Cycles
t_{STI}	Delay from Start Bit to IRQ (THRE)[1]		8	Baud Output Cycles

    1. Not tested. Guaranteed by design.
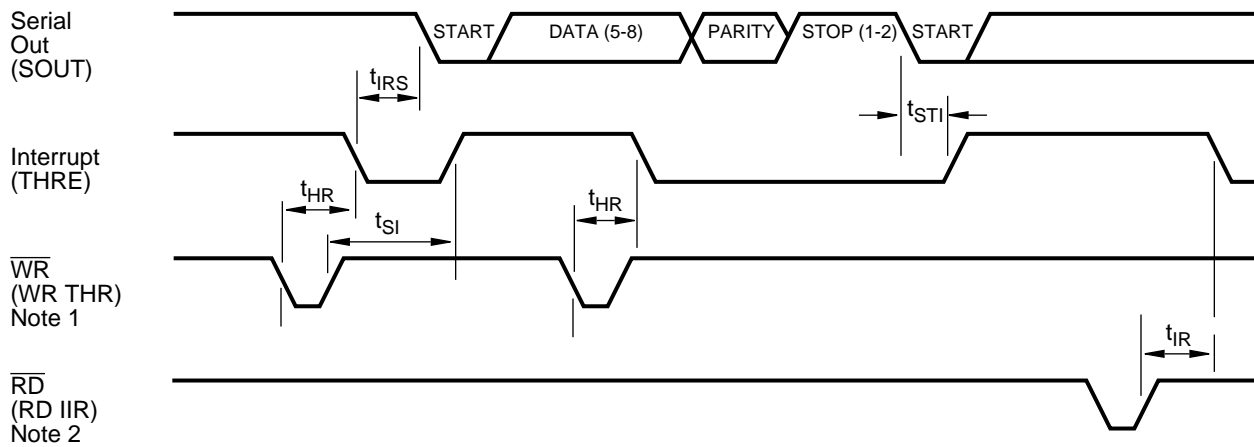
Notes:

1. See write cycle timing in Section 10.3.3 on page 172.
2. See read cycle timing in Section 10.3.3 on page 172.

10.3.6   Receiver Timing

Symbol	Parameter	Min	Max	Unit
t_{RAI1}	Delay from Active Edge of $\overline{RD}$ to Reset IRQ		78	nsec
t_{RAI2}	Delay from Active Edge of $\overline{RD}$ to Reset IRQ		78	nsec
t_{RAI3}	Delay from Active Edge of $\overline{RD}$ to Reset IRQ		78	nsec
t_{RINT}	Delay from Inactive Edge of $\overline{RD}$ (RD LSR) to Reset IRQ		55	nsec
t_{SCD}	Delay from RCLK to Sample Time[1]		41	nsec
t_{SINT}	Delay from Stop bit to Set Interrupt[2]		2	Baud Output Cycles

1. This is internal timing and is therefore not tested.
2. Not tested. Guaranteed by design.

Standard Mode

FIFO Mode

SIN

Sample Clock

Trigger Level Interrupt

LSI Interrupt

$\overline{RD}$ ($\overline{RD}$ LSR)

$\overline{RD}$ ($\overline{RD}$ RBR)

Data (5-8)   Stop

(FIFO at or above Trigger Level)

(FIFO Below Trigger Level)

Note

t_{SINT}

t_{RAI2}

t_{RINT}

Active
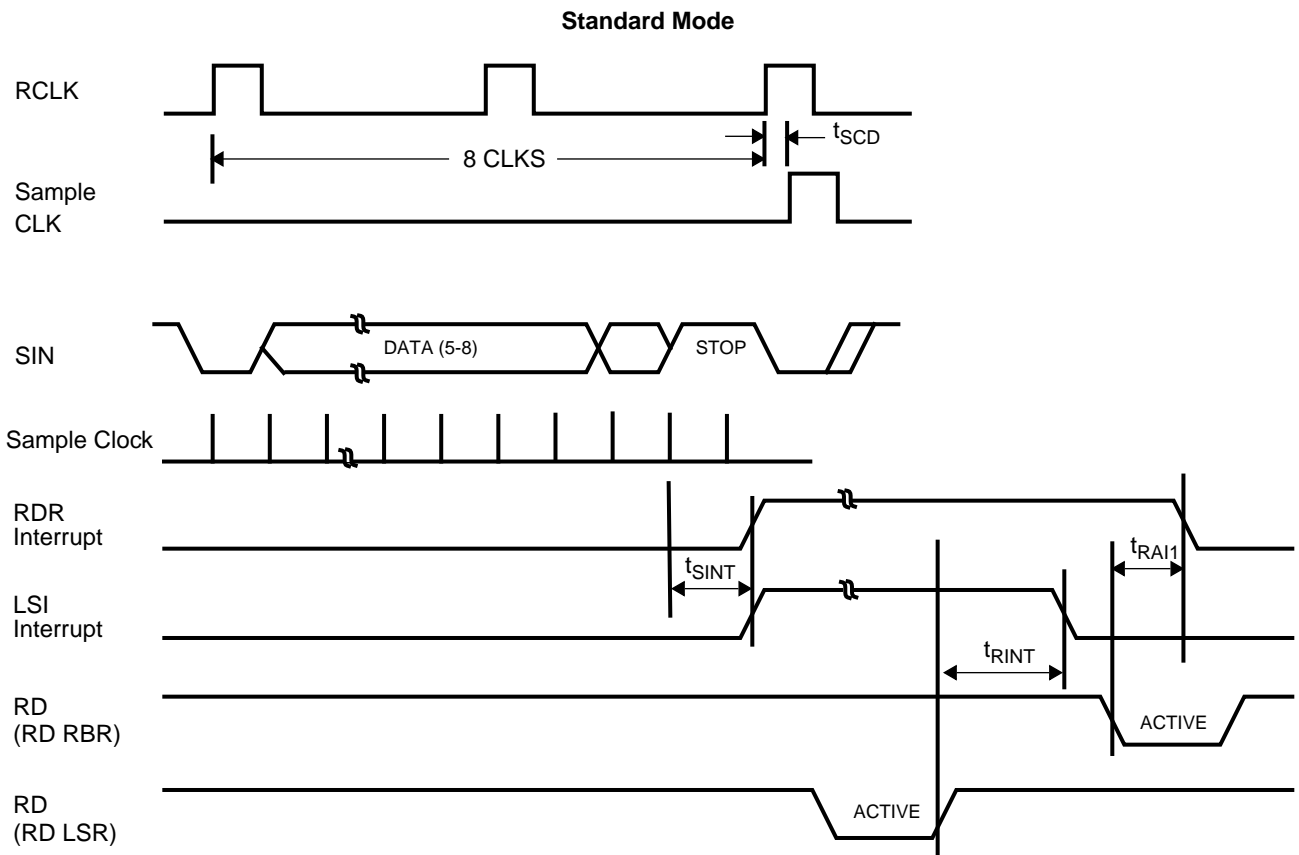
Active
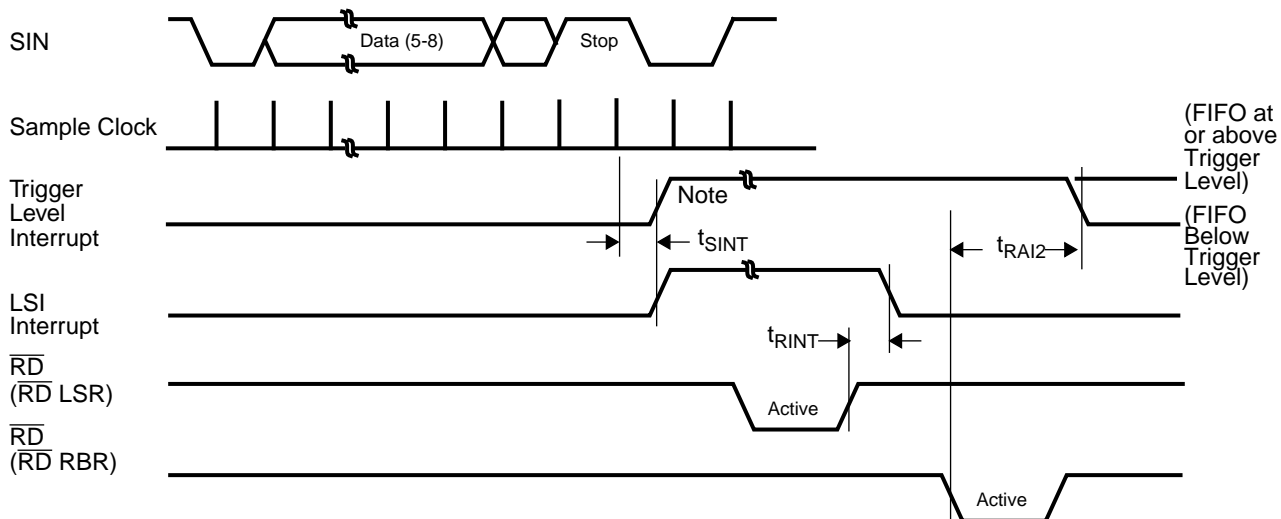
Note:

If SCR0 = 1, then t_{SINT} = 3 RCLKs. For a time-out interrupt, t_{SINT} = 8 RCLKs.

Time-Out Mode

SIN

Sample Clock

Time-Out or Trigger Level Interrupt

LSI Interrupt

$\overline{RD}$ ($\overline{RD}$ LSR)

$\overline{RD}$ ($\overline{RD}$ RBR)

Stop

(FIFO at or above Trigger Level)

(FIFO Below Trigger Level)

Note

t_{SINT}

t_{RAI3}

Top Byte of FIFO

t_{SINT} t_{RINT}

Active

Active

Active

Previous Byte Read From FIFO
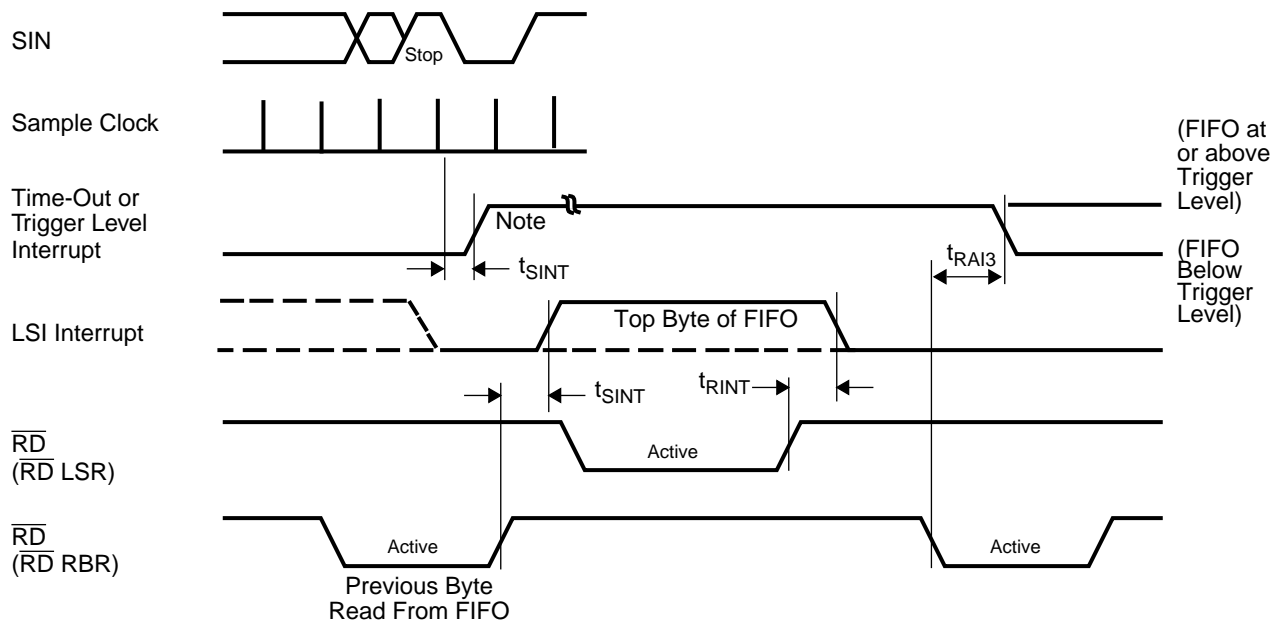
Note:

If SCR0 = 1, then t_{SINT} = 3 RCLKs. For a time-out interrupt, t_{SINT} = 8 RCLKs

10.3.7 UART, Sharp-IR, SIR and Consumer Remote Control Timing

Symbol	Parameter	Conditions	Min	Max	Unit
t_{BT}	Single Bit Time in UART and Sharp-IR	Transmitter	$t_{BTN} - 25$[1]	$t_{BTN} + 25$	nsec
		Receiver	$t_{BTN} - 2\%$	$t_{BTN} + 2\%$	nsec
t_{CMW}	Modulation Signal Pulse Width in Sharp-IR and Consumer Remote Control	Transmitter	$t_{CWN} - 25$[2]	$t_{CWN} + 25$	nsec
		Receiver	500		nsec
t_{CMP}	Modulation Signal Period in Sharp-IR and Consumer Remote Control	Transmitter	$t_{CPN} - 25$[3]	$t_{CPN} + 25$	nsec
		Receiver	t_{MMIN}[4]	t_{MMAX}[4]	nsec
t_{SPW}	SIR Signal Pulse Width	Transmitter, Variable	$(^3/_{16}) \times t_{BTN} - 15$[1]	$(^3/_{16}) \times t_{BTN} + 15$[1]	nsec
		Transmitter, Fixed	1.48	1.78	μsec
		Receiver	1		μsec
S_{DRT}	SIR Data Rate Tolerance. % of Nominal Data Rate.	Transmitter		± 0.87%	
		Receiver		± 2.0%	
t_{SJT}	SIR Leading Edge Jitter. % of Nominal Bit Duration.	Transmitter		± 2.5%	
		Receiver		± 6.5%	

1. t_{BTN} is the nominal bit time in UART, Sharp-IR, SIR and Consumer Remote Control modes. It is determined by the setting of the Baud Generator Divisor registers.
2. t_{CWN} is the nominal pulse width of the modulation signal for Sharp-IR and Consumer Remote Control modes. It is determined by the MCPW field (bits 7-5) of the IRTXMC register at bank 7, offset 01h, and the TXHSC bit (bit 2) of the RCCFG register at bank 7, offset 02h.
3. t_{CPN} is the nominal period of the modulation signal for Sharp-IR and Consumer Remote Control modes. It is determined by the MCFR field (bits 4-0) of the IRTXMC register at offset 01h and the TXHSC bit (bit 2) of the RCCFG register at offset 02h.
4. t_{MMIN} and t_{MMAX} define the time range within which the period of the incoming subcarrier signal has to fall in order for the signal to be accepted by the receiver. These time values are determined by the content of register IRRXDC at bank 7, offset 00h and the setting of the RXHSC bit (bit 5) of the RCCFG register at bank 7, offset 02h.
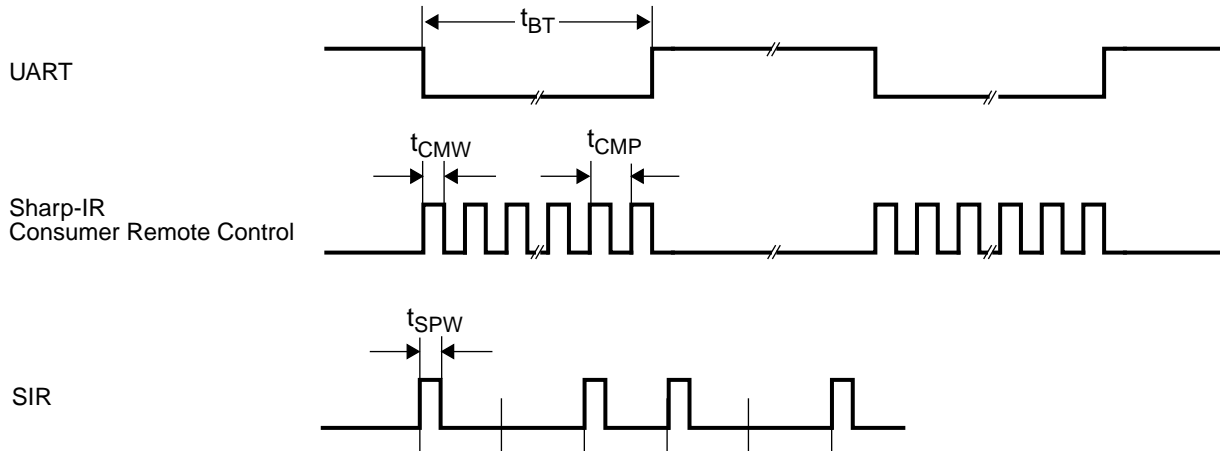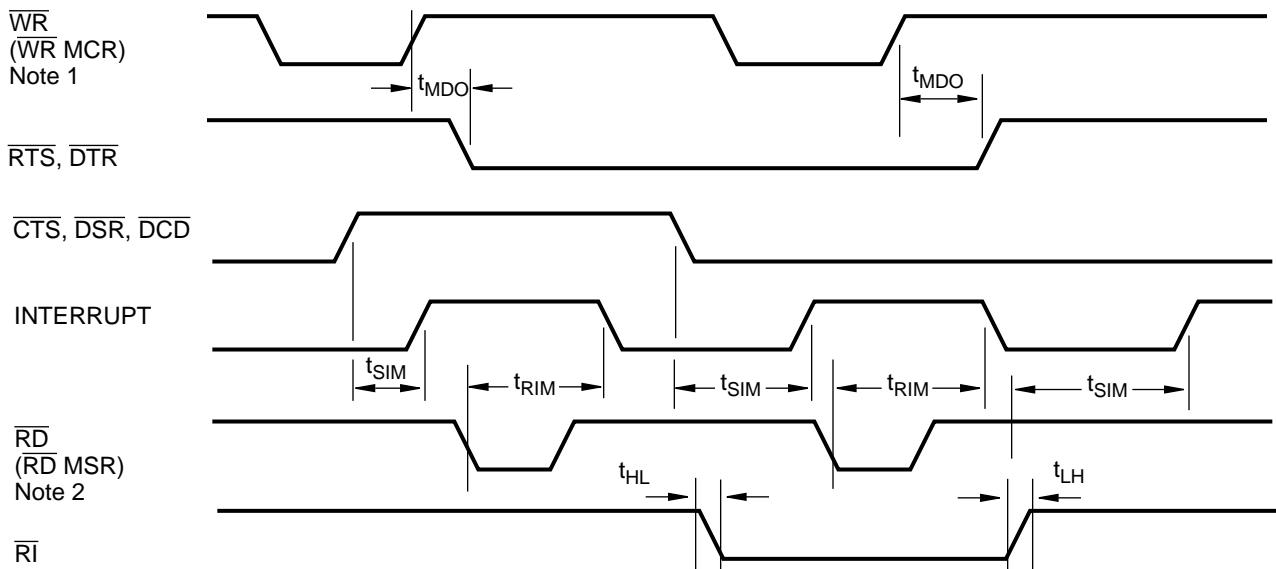
10.3.8 IRSLn Write Timing

Parameter	Symbol	Min	Max	Unit
IRSLn Output Delay from Write Inactive	t_{WOD}		60	nsec

WR

IRSLn

t_{WOD}
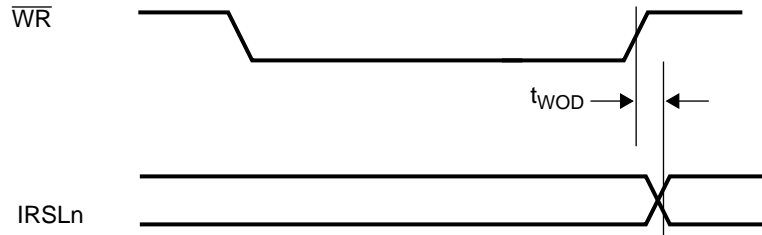
10.3.9 Modem Control Timing

Symbol	Parameter	Min	Max	Unit
t_{HL}	$\overline{RI2,1}$ High to Low Transition	10		nsec
t_{LH}	$\overline{RI2,1}$ Low to High Transition	10		nsec
t_{MDO}	Delay from $\overline{WR}$ ($\overline{WR}$ MCR) to Output		40	nsec
t_{RIM}	Delay to Reset IRQ from $\overline{RD}$ ($\overline{RD}$ MSR)		78	nsec
t_{SIM}	Delay to Set IRQ from Modem Input		40	nsec

$\overline{WR}$
($\overline{WR}$ MCR)
Note 1

t_{MDO} t_{MDO}

$\overline{RTS}, \overline{DTR}$

$\overline{CTS}, \overline{DSR}, \overline{DCD}$

INTERRUPT

t_{SIM} t_{RIM} t_{SIM} t_{RIM} t_{SIM}

$\overline{RD}$
($\overline{RD}$ MSR)
Note 2

t_{HL} t_{LH}

$\overline{RI}$

Notes:

1. See write cycle timing, Section 10.3.3 on page 172.

2. See read cycle timing, Section 10.3.3 on page 172.

10.3.10 FDC DMA Timing

Symbol	Parameter	Min	Max	Unit
t_{KI}	$\overline{DACK}$ Inactive Pulse Width	25		nsec
t_{KK}	$\overline{DACK}$ Active Pulse Width	65		nsec
t_{KQ}	$\overline{DACK}$ Active Edge to DRQ Inactive		65	nsec
t_{QK}	DRQ to $\overline{DACK}$ Active Edge	10		nsec
t_{QP}	DRQ Period (Except Non-Burst DMA)	$8 \times t_{DRP}$[1]		
t_{QQ}	DRQ Inactive Non-Burst Pulse Width	300	400[2]	nsec
t_{QR}	DRQ to $\overline{RD}$, $\overline{WR}$ Active	15		nsec
t_{QW}	DRQ to End of $\overline{RD}$, $\overline{WR}$ (DRQ Service Time)		$(8 \times t_{DRP}) - (16 \times t_{ICP})$[1][3]	
t_{QT}	DRQ to TC Active (DRQ Service Time)		$(8 \times t_{DRP}) - (16 \times t_{ICP})$[1][3]	
t_{RQ}	$\overline{RD}$, $\overline{WR}$ Active Edge to DRQ Inactive [4]		65	nsec
t_{TQ}	TC Active Edge to DRQ Inactive		75	nsec
t_{TT}	TC Active Pulse Width	50		nsec

1. t_{DRP} and t_{ICP} are defined in TABLE   "" on page 171.
2. Only in case of pending DRQ.
3. Values shown are with the FIFO disabled, or with FIFO enabled and THRESH = 0. For nonzero values of THRESH, add (THRESH x 8 x t_{DRP}) to the values shown.
4. The active edge of $\overline{RD}$ or $\overline{WR}$ and TC is recognized only when $\overline{DACK}$ is active.
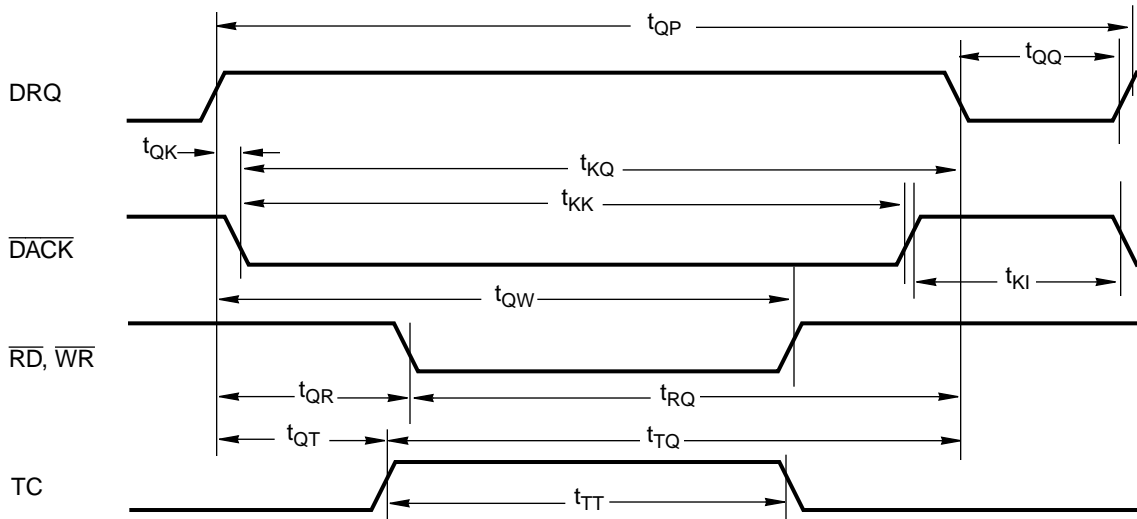
10.3.11 ECP DMA Timing

Symbol	Parameter	Min	Max	Unit
t_{KIP}	$\overline{DACK}$ Inactive Pulse Width	25		nsec
t_{KKP}	$\overline{DACK}$ Active Pulse Width	65		nsec
t_{KQP}	$\overline{DACK}$ Active Edge to DRQ Inactive[1] [2]		$65 + (6 \times 32 \times t_{CP})$	nsec
t_{QKP}	DRQ to $\overline{DACK}$ Active Edge	10		nsec
t_{QPP}	DRQ Period	330		nsec
t_{QQP}	DRQ Inactive Non-Burst Pulse Width	300	400[3]	nsec
t_{QRP}	DRQ to $\overline{RD}$, $\overline{WR}$ Active	15		nsec
t_{RQP}	$\overline{RD}$, $\overline{WR}$ Active Edge to DRQ Inactive[4]		65	nsec
t_{TQP}	TC Active Edge to DRQ Inactive		75	nsec
t_{TT}	TC Active Pulse Width	50		nsec

1. One DMA transaction takes six clock cycles.
2. t_{CP} is defined in Section 10.3.2 on page 171.
3. Only in case of pending DRQ.
4. The active edge of $\overline{RD}$ or $\overline{WR}$ and TC is recognized only when $\overline{DACK}$ is active.
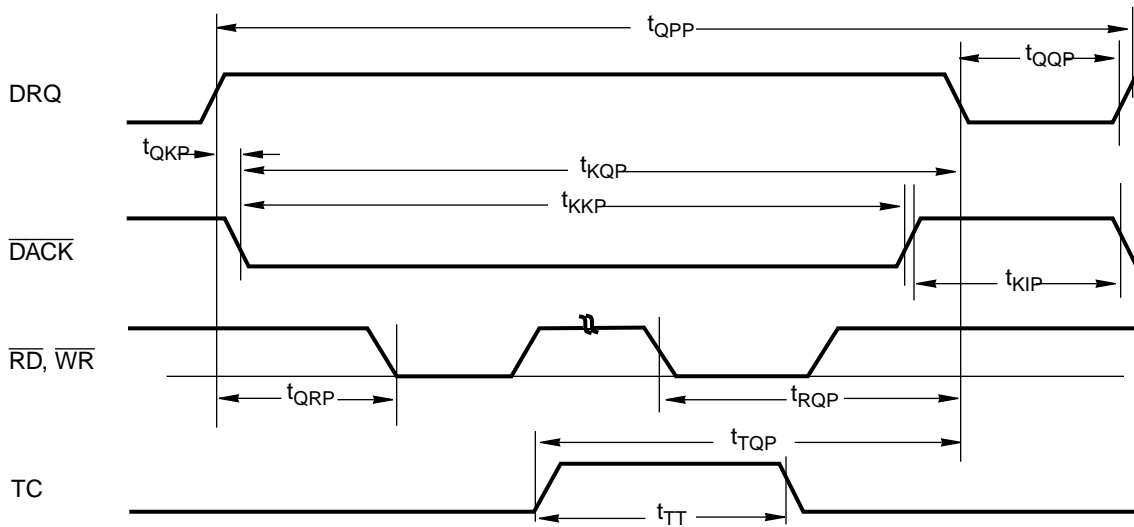
10.3.12 UART2 DMA Timing

Symbol	Parameter	Min	Max	Unit
t_{ACH}	AEN Hold from RD, WR Inactive	5		nsec
t_{ACS}	AEN Signal Setup	15		nsec
t_{DCH}	$\overline{DACK}$ Hold from RD, WR Inactive	0		nsec
t_{DCS}	$\overline{DACK}$ Signal Setup	15		nsec
tDSW	$\overline{RD}$, $\overline{WR}$ Pulse Width	60	1000	nsec
t_{RQS}	DRQ Inactive from $\overline{RD}$, $\overline{WR}$ Active		60	nsec
t_{TCH}	TC Hold from $\overline{RD}$, $\overline{WR}$ Inactive	2		nsec
t_{TCS}	TC Signal Setup	60		nsec
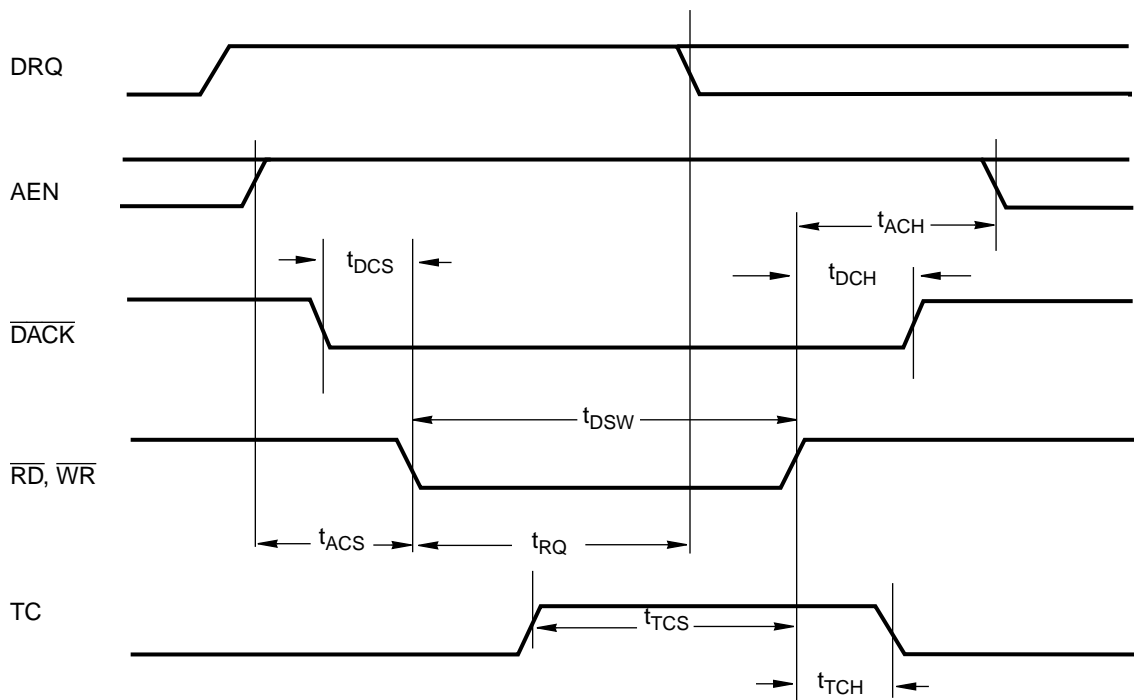
10.3.13 Reset Timing

Symbol	Parameter	Min	Max	Unit
t_{RW}	Reset Width[1]	100		μsec
t_{SRC}	Reset to Control Inactive[2]		300	nsec

1. The software reset pulse width is 100 nsec.
2. Not tested. Guaranteed by design.
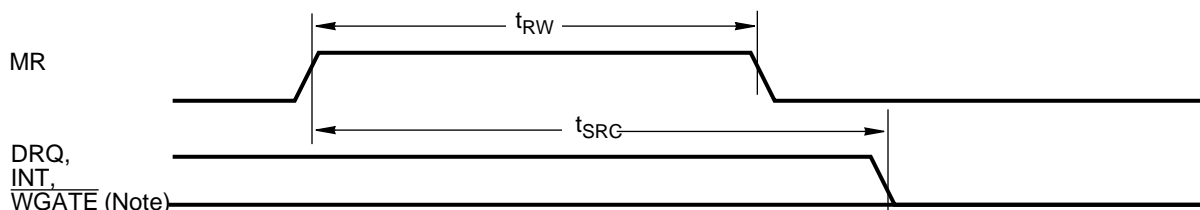
Note:

In PC-AT mode, the DRQ and IRQ signals of the FDC are in TRI-STATE after time t_{SRC}.

10.3.14 FDC - Write Data Timing

Symbol	Parameter	Min	Max	Unit
t_{HDH}	HDSEL Hold from WGATE Inactive[1]	750		μsec
t_{HDS}	HDSEL Setup to WGATE Active[1]	100		μsec
t_{WDW}	Write Data Pulse Width	See tDRP tICP tWDW Values below		

1. Not tested. Guaranteed by design.
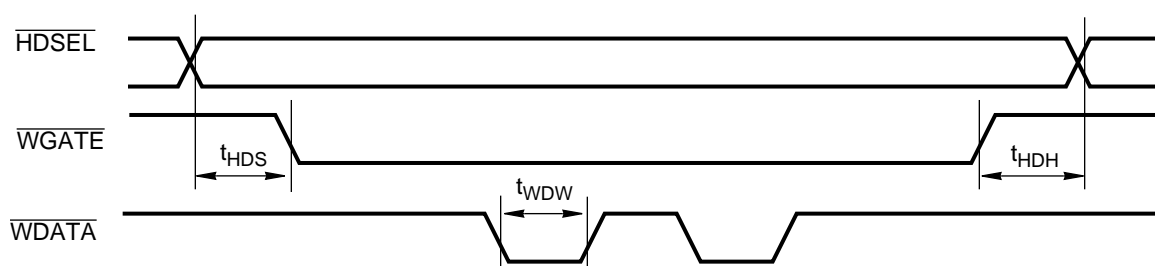
t_{DRP} t_{ICP} t_{WDW} Values

Data Rate	t_{DRP}	t_{ICP}	t_{ICP} Nominal	t_{WDW}	t_{WDW} Minimum	Unit
1 Mbps	1000	6 x t_{CP}[1]	125	2 x t_{ICP}	250	nsec
500 Kbps	2000	6 x t_{CP}[1]	125	2 x t_{ICP}	250	nsec
300 Kbps	3333	10 x t_{CP}[1]	208	2 x t_{ICP}	375	nsec
250 Kbps	4000	12 x t_{CP}[1]	250	2 x t_{ICP}	500	nsec

1. t_{CP} is the Clock Period defined in Section 10.3.2 "Clock Timing" on page 171.

10.3.15 FDC - Drive Control Timing

Symbol	Parameter	Min	Max	Unit
t_{DRV}	$\overline{DR1,0}$ and $\overline{MTR1,0}$ from End of $\overline{WR}$		110	nsec
t_{DST}	$\overline{DIR}$ Setup to $\overline{STEP}$ Active[1]	6		μsec
t_{IW}	Index Pulse Width	100		nsec
t_{STD}	$\overline{DIR}$ Hold from $\overline{STEP}$ Inactive	t_{STR}		msec
t_{STP}	$\overline{STEP}$ Active High Pulse Width	8		μsec
t_{STR}	$\overline{STEP}$ Rate Time (See TABLE 3-25.)	1		msec

1. Not tested. Guaranteed by design.
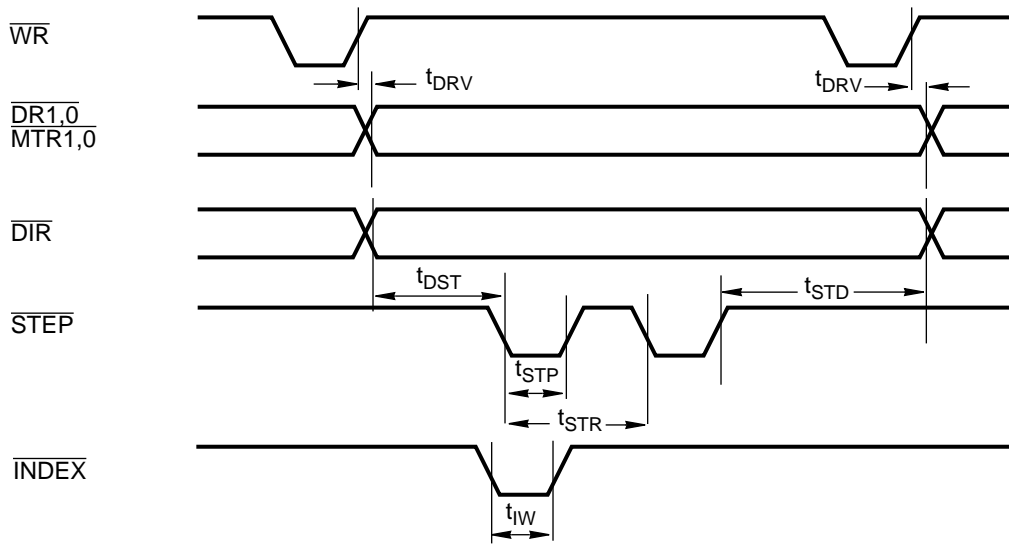
10.3.16 FDC - Read Data Timing

Symbol	Parameter	Min	Max	Unit
t_{RDW}	Read Data Pulse Width	50		nsec
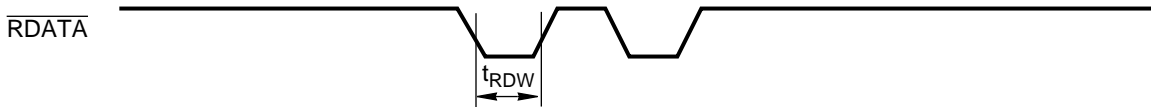
10.3.17 Standard Parallel Port Timing

Symbol	Parameter	Conditions	Typ	Max	Unit
t_{PDH}	Port Data Hold	These times are system dependent and are therefore not tested.	500		nsec
t_{PDS}	Port Data Setup	These times are system dependent and are therefore not tested.	500		nsec
t_{PILa}	Port Active Low Interrupt, Active			33	nsec
t_{PILia}	Port Active Low Interrupt, Inactive			33	nsec
t_{PIHa}	Port Active High Interrupt, Active			33	nsec
t_{PIHia}	Port Active High Interrupt, Inactive			33	nsec
t_{PIz}	Port Active High Interrupt, TRISTATE			33	nsec
t_{SW}	Strobe Width	These times are system dependent and are therefore not tested.	500		nsec

Compatible Mode
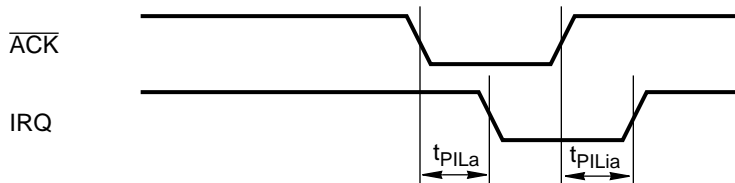
Extended Mode
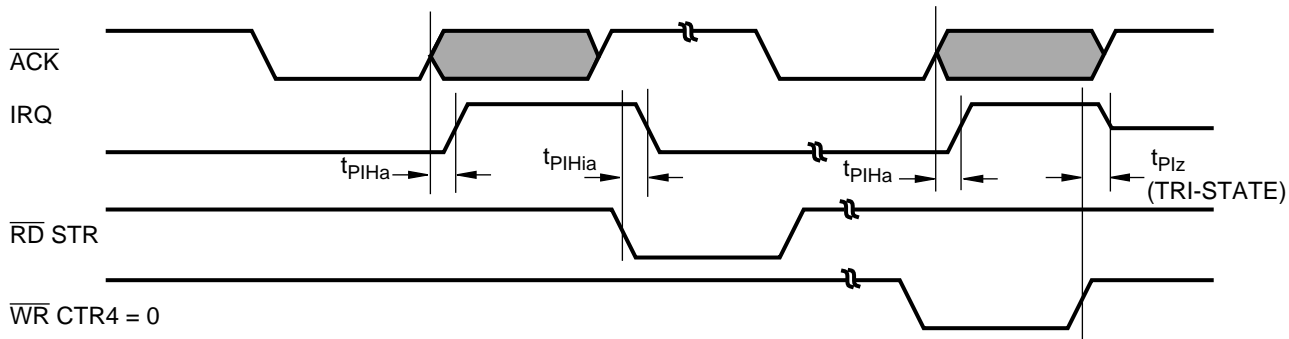
Typical Data Exchange
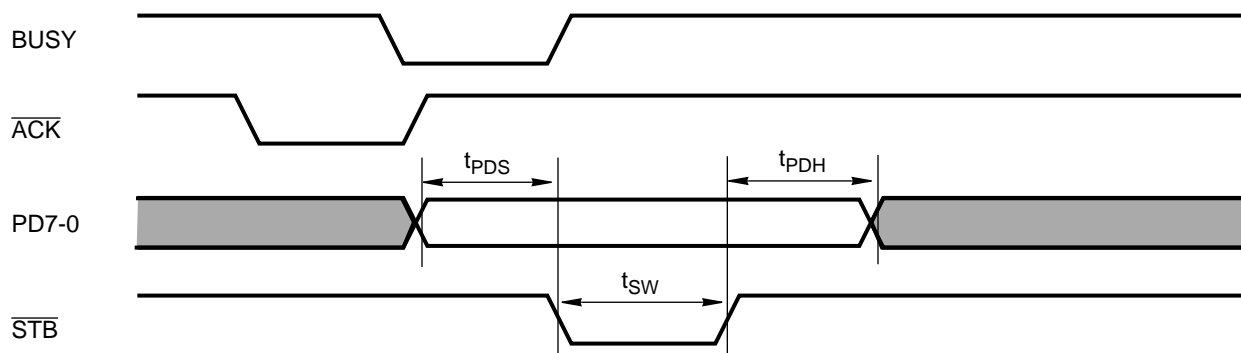
10.3.18 Enhanced Parallel Port 1.7 Timing

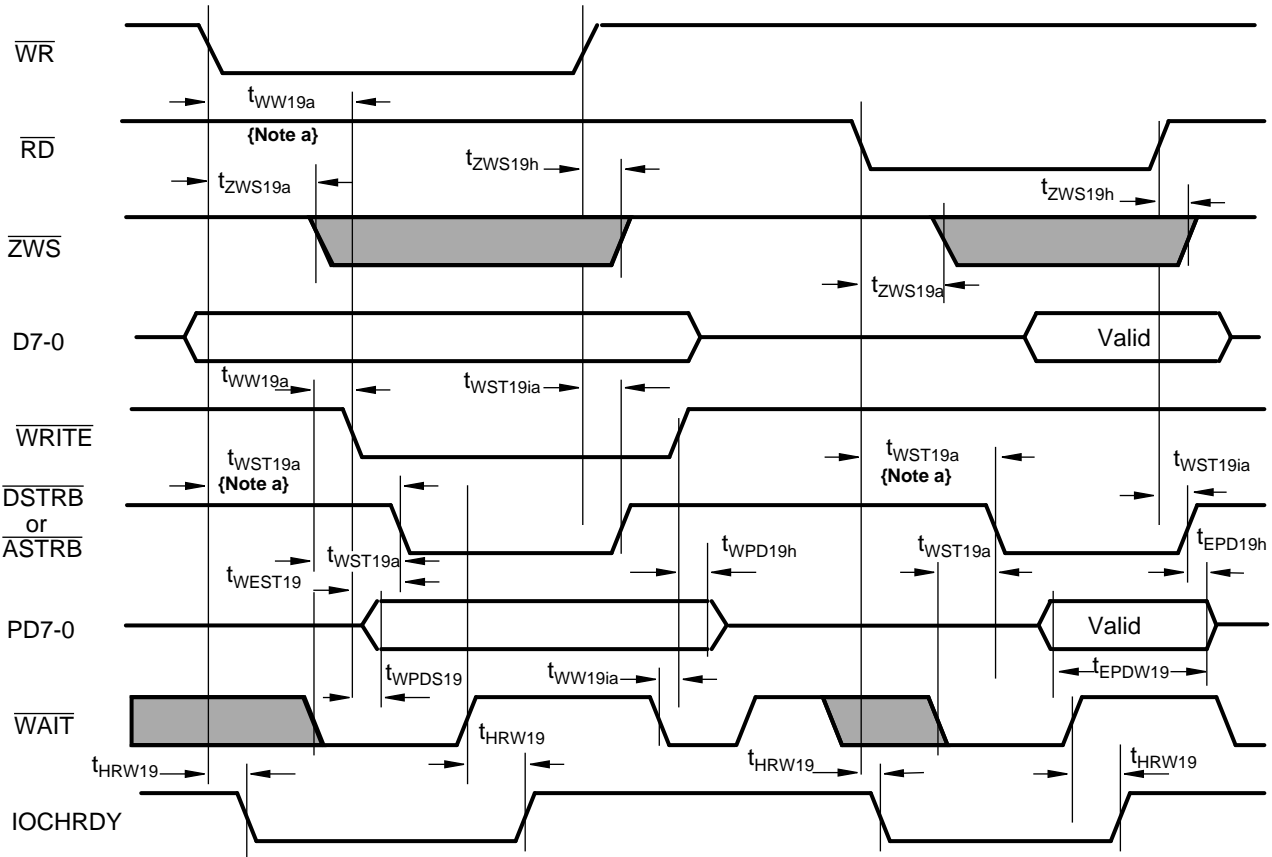| Symbol	Parameter	Min	Max	Unit
t_{WW17}	$\overline{WRITE}$ Active or Inactive from $\overline{WR}$ Active or Inactive		45	nsec
t_{WST17}	$\overline{DSTRB}$ or $\overline{ASTRB}$ Active or Inactive from $\overline{WR}$ or $\overline{RD}$ Active or Inactive[1]		45	nsec
t_{WEST17}	$\overline{DSTRB}$ or $\overline{ASTRB}$ Active after $\overline{WRITE}$ Becomes Active	0		nsec
t_{WPD17h}	PD7-0 Hold after $\overline{WRITE}$ Becomes Inactive	50		nsec
t_{HRW17}	IOCHRDY Active or Inactive after $\overline{WAIT}$ Becomes Active or Inactive		40	nsec
t_{WPDS17}	PD7-0 Valid after $\overline{WRITE}$ Becomes Active[2]		15	nsec
t_{EPDW17}	PD7-0 Valid Width	80		nsec
t_{EPD17h}	PD7-0 Hold after $\overline{DSTRB}$ or $\overline{ASTRB}$ Becomes Inactive	0		nsec
t_{ZWS17a}	$\overline{ZWS}$ Valid after $\overline{WR}$ or $\overline{RD}$ Active		45	nsec
t_{ZWS17h}	$\overline{ZWS}$ Hold after $\overline{WR}$ or $\overline{RD}$ Inactive	0		nsec

1. The PC87309 design guarantees that $\overline{WRITE}$ will not change from low to high before $\overline{DSTRB}$, or $\overline{ASTRB}$, goes from low to high.
2. D7-0 is stable 15 nsec before $\overline{WR}$ becomes active.
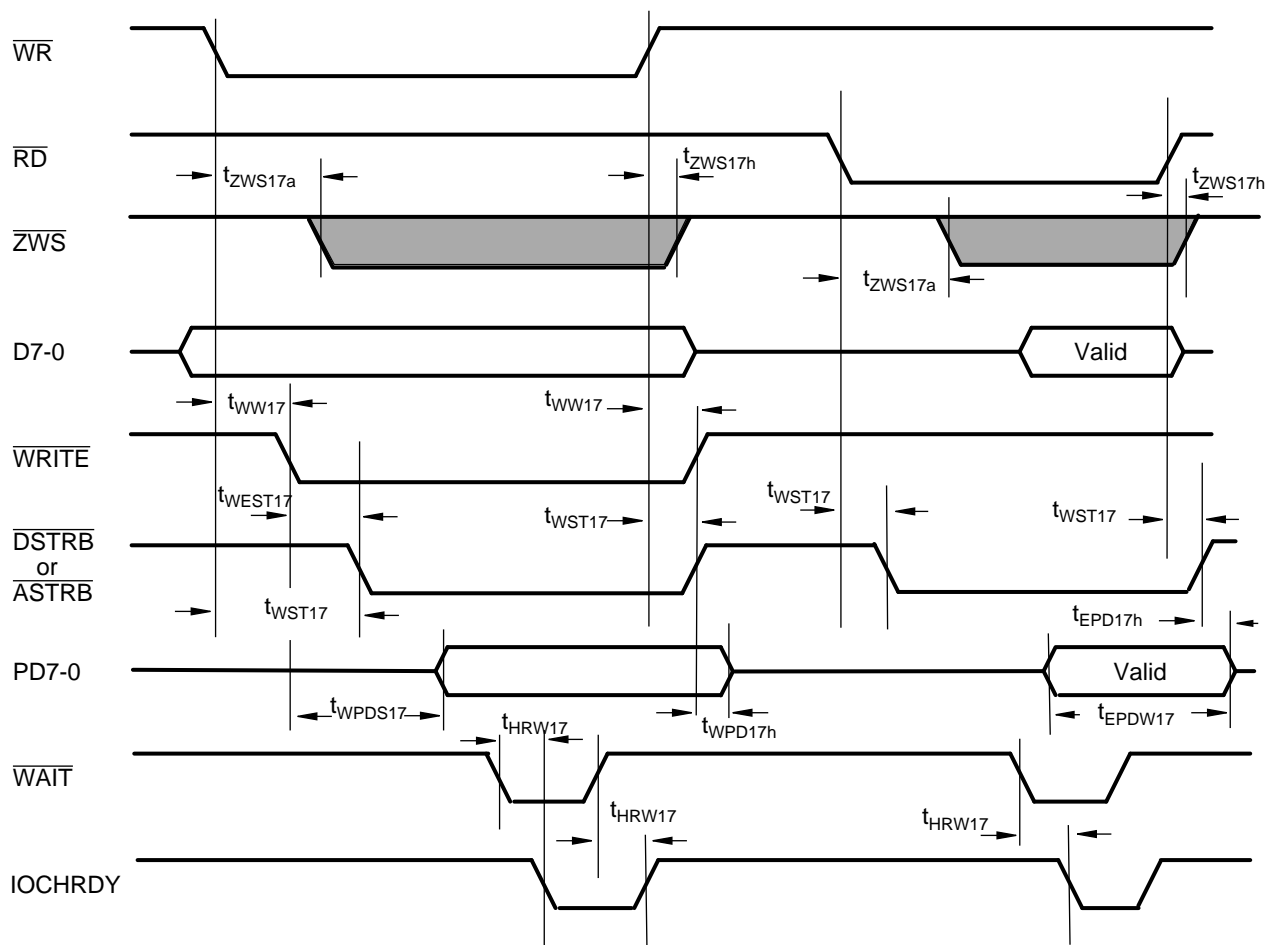
10.3.19 Enhanced Parallel Port 1.9 Timing

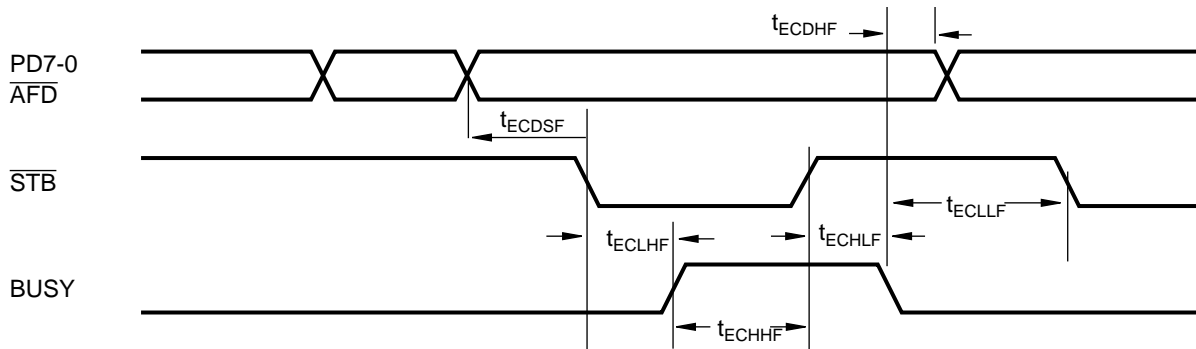| Symbol	Parameter	Min	Max	Unit
t_{WW119a}	$\overline{WRITE}$ Active from $\overline{WR}$ Active or $\overline{WAIT}$ Low[1]		45	nsec
t_{WW19ia}	$\overline{WRITE}$ Inactive from $\overline{WAIT}$ Low		45	nsec
t_{WST19a}	$\overline{DSTRB}$ or $\overline{ASTRB}$ Active from $\overline{WR}$ or $\overline{RD}$ Active or $\overline{WAIT}$ Low[1,2]		65	nsec
$t_{WST19ia}$	$\overline{DSTRB}$ or $\overline{ASTRB}$ Inactive from $\overline{WR}$ or $\overline{RD}$ High		45	nsec
t_{WEST19}	$\overline{DSTRB}$ or $\overline{ASTRB}$ Active after $\overline{WRITE}$ Active	10		nsec
t_{WPD19h}	PD7-0 Hold after $\overline{WRITE}$ Inactive	0		nsec
t_{HRW19}	IOCHRDY Active after $\overline{WR}$ or $\overline{RD}$ Active or Inactive after $\overline{WAIT}$ High		40	nsec
t_{WPDS19}	PD7-0 Valid after $\overline{WRITE}$ Active[3]		15	nsec
t_{EPDW19}	PD7-0 Valid Width	80		nsec
t_{EPD19h}	PD7-0 Hold after $\overline{DSTRB}$ or $\overline{ASTRB}$ Inactive	0		nsec
t_{ZWS19a}	$\overline{ZWS}$ Valid after $\overline{WR}$ or $\overline{RD}$ Active		45	nsec
t_{ZWS19h}	$\overline{ZWS}$ Hold after $\overline{WR}$ or $\overline{RD}$ Inactive	0		nsec

1. When $\overline{WAIT}$ is low, t_{WST19a} and t_{WW19a} are measured after $\overline{WR}$ or $\overline{RD}$ becomes active; else t_{WST19a} and t_{WW19a} are measured after $\overline{WAIT}$ becomes low.
2. The PC87307VUL design guarantees that $\overline{WRITE}$ will not change from low to high before $\overline{DSTRB}$, or $\overline{ASTRB}$, goes from low to high.
3. D7-0 is stable 15 nsec before $\overline{WR}$ becomes active.

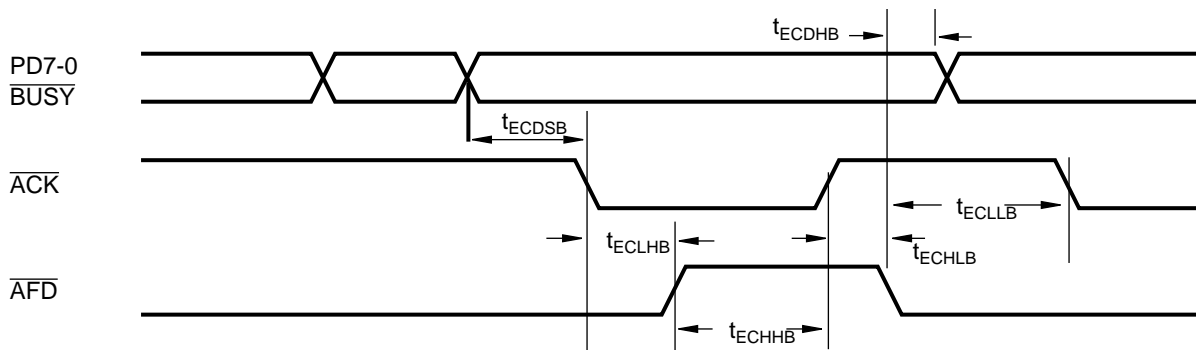**10.3.20 Extended Capabilities Port (ECP) Timing**

Forward

Symbol	Parameter	Min	Max	Unit
t_{ECDSF}	Data Setup before $\overline{STB}$ Active	0		nsec
t_{ECDHF}	Data Hold after BUSY Inactive	0		nsec
t_{ECLHF}	BUSY Active after $\overline{STB}$ Active	75		nsec
t_{ECHHF}	$\overline{STB}$ Inactive after BUSY Active	0	1	sec
t_{ECHLF}	BUSY Inactive after $\overline{STB}$ Active	0	35	msec
t_{ECLLF}	$\overline{STB}$ Active after BUSY Inactive	0		nsec

Backward

Symbol	Parameter	Min	Max	Unit
t_{ECDSB}	Data Setup before $\overline{ACK}$ Active	0		nsec
t_{ECDHB}	Data Hold after $\overline{AFD}$ Active	0		nsec
t_{ECLHB}	$\overline{AFD}$ Inactive after $\overline{ACK}$ Active	75		nsec
t_{ECHHB}	$\overline{ACK}$ Inactive after $\overline{AFD}$ Inactive	0	1	sec
t_{ECHLB}	$\overline{AFD}$ Active after $\overline{ACK}$ Inactive	0	35	msec
t_{ECLLB}	$\overline{ACK}$ Active after $\overline{AFD}$ Active	0		nsec

Glossary

ADDR

Address Register of the Parallel Port in EPP modes.

AFIFO

Address FIFO for the Parallel Port in Extended Capabilities Port (ECP) mode 011.

ASCR

Auxiliary Status and Control Register for the UART2 in Extended operation modes.

ASK-IR

Amplitude Shift Keying Infrared.

BGD(H) and BGD(L)

Baud rate Generator Divisor buffer (High and Low bytes) for the UARTs.

BSR

Bank Selection Register for the UARTs, when enabled, i.e., when bit 7 of this register is 1.

CCR

Configuration Control Register of the Floppy Disk Controller (FDC) for write operations.

CFIFO

Parallel port data FIFO in Extended Capabilities Port (ECP) mode 010.

CNFGA and CNFGB

Configuration registers A and B for the Parallel Port in Extended Capabilities Port (ECP) mode 111.

Confg0

See PP Confg0.

Consumer Remote Control Mode

This IR mode supports all four protocols currently used in remote-controlled home entertainment equipment. Also called TV-Remote mode.

Control0, Control2 and Control4

Internal configuration registers of the Parallel Port in Extended Capabilities Port (ECP) modes.

CSN

Card Select Number register - an 8-bit register with a unique value that identifies an ISA card when using PnP protocol.

CTR

Control Register of the Parallel Port in SPP modes.

DASK-IR

Digital Amplitude Shift Keying Infrared.

DATA0, DATA1, DATA2 and DATA3

Data Registers of the Parallel Port in EPP modes.

DATAR

Data Register for the Parallel Port in Extended Capability Port (ECP) modes 000 and 001.

DCR

Data Control Register for the Parallel Port in Extended Capabilities Port (ECP) modes.

Device

Any circuit that performs a specific function, such as a Parallel Port.

DFIFO

ECP Data FIFO in Extended Capabilities Port (ECP) mode 011.

DID

Device ID register for the UARTs.

DIR

Digital Input Register of the Floppy Disk Controller (FDC) for read operations.

DOR

Digital Output Register of the Floppy Disk Controller (FDC).

DSR

Two expressions:

1. Data rate Select Register of the Floppy Disk Controller (FDC) for write operations.
2. The Data Status Register of the Parallel Port in Extended Capabilities Port (ECP) modes.

DTR

Data Register of the Parallel Port in SPP or EPP modes.

EAR

Extended Auxiliary Register of the Parallel Port in Extended Capabilities Port (ECP) modes.

ECP

Extended Capabilities Port.

ECR

Extended Control Register for the Parallel Port in Extended Capabilities Port (ECP) modes.

EDR

Extended Data Register for the Parallel Port in extended Capabilities Port (ECP) modes.

EIR

Two expressions:

1. Extended Index Register of the Parallel Port Extended Capabilities Port (ECP) modes.
2. Event Identification Register for the UARTs for read cycles.

Extended UART Operation Mode

This UART operation mode supports standard 16450 and 16550A UART operations plus additional interrupts and DMA features.

EPP

Enhanced Parallel Port.

EXCR1 and EXCR2

Extended Control Registers 1 and 2 for the UARTs.

FCR

The FIFO Control Register for the UARTs.

FDC

Floppy Disk Controller.

FDD

Floppy Disk Drive.

FER1 and FER2

Function Enable Registers of the Power Management.

Full-IR mode

In this mode, the PC87309 decodes address lines A0-A10, and UART2 is a fully featured UART with IR. The mode is configured during reset, via CFG0 strap pin.

IER

The Interrupt Enable Register for the UARTs.

IR

Infrared.

IRCFG1, IRCFG3 and IRCFG4

Infrared module Configuration registers for UART2.

IRCR1, IRCR2 and IRCR3

Infrared Module Control Registers 1, 2 and 3 for UART2.

IrDA

Infrared Data Association.

IRRXDC

Infrared Receiver Demodulator Control register for the UART2. (Logical Device 2, bank 7, offset 00h.)

IRTXMC

Infrared Transmitter Modulator Control register for UART2.

LBGD(H) and LBGD(L)

Legacy Baud rate Generator Divisor port (High and Low bytes) for the UARTs.

LCR

Link Control Register for the UARTs.

Legacy

Usually refers to older devices or systems that are not Plug and Play compatible.

Legacy Mode

In this mode, the interrupts and the base addresses of the FDC, UARTs, KBC and the Parallel Port of the PC87309 are configured as in earlier SuperI/O chips.

LFSR

The Linear Feedback Shift Register. This register is used to prepare the chip for operation in Plug and Play (PnP) mode.

LSR

Link Status Register for the UARTs.

MCR

Modem Control Register for the UARTs.

MSR

Two expressions:

1. Main Status Register of the FDC.
2. Modem Status Register for the UARTs.

Non-Extended UART Operation Modes

These UART operation modes support only UART operations that are standard for 15450 or 16550A devices.

PIO

Programmable Input/Output.

P_MDR

Pipeline Mode Register for the UARTs.

Plug and Play

A design philosophy and a set of specifications that describe hardware and software changes to the PC and its peripherals that automatically identify and arbitrate resource requirements among all devices and buses on the system. Plug and Play is abbreviated as PnP.

PM

Power Management.

PME

Power Management Event.

PMC1, PMC2 and PMC3

Power Management Control registers.

PnP

Plug and Play.

PnP Mode

In this mode, the interrupts, the DMA channels and the base address of the FDC, UARTs, KBC, GPIO and the Parallel Port of the PC87309 are fully Plug and Play.

PP Confg0

Internal configuration register of the Parallel Port in Extended Capabilities Port (ECP) modes.

Precompensation

Also called write precompensation, is a way of pre-conditioning the $\overline{WDATA}$ output signal to adjust for the effects of bit shift on the data as it is written to the disk surface.

RBR

Receiver Buffer Register for the UARTs read operations.

RCCFG

Consumer Remote Control Configuration register for UART2.

RLC

Run Length Count byte for parallel ports.

RLE

Run Length Expander for parallel ports.

RXFLV

Reception FIFO Level for the UARTs.

SCI

System Control Interrupt.

SCR

Scratch Register for the UARTs.

SH_FCR

Shadow of the FIFO Control Register (FCR) for the UARTs.

SH_LCR

Shadow of the Line Control Register (LCR) for the UARTs for read operations.

Sharp IR Mode

In this mode, the PC87309 supports a Sharp Infrared interface.

SIR

    Serial Infrared mode.

SIR_PW

    SIR Pulse Width control for UART2.

SPP

    The Standard Parallel Port configuration of the Parallel Port device supports the Compatible SPP mode and the Extended PP mode.

SRA and SRB

    Status Registers A and B of the FDC.

ST0, ST1, ST2 and ST3

    Status registers 0, 1, 2 and 3 of the FDC.

STR

    Status Register of the Parallel Port in SPP modes.

TDR

    Tape Drive Register of the FDC.

TFIFO

    Test FIFO for the Parallel Port in Extended Capabilities Port (ECP) mode 110.

TV-Remote Mode

    See Consumer Remote Control mode.

Two-UART mode

    In this mode, the PC87309 decodes address lines A0-A11. UART2 provides a 16550 UART with SIN2/SOUT2 interface signals only or a partially IR support with IRRX and IRTX signals only. The mode is configured during reset, via CFG0 strap pin.

TXFLV

    Transmission FIFO Level for the UARTs.

Physical Dimensions
All dimensions are in millimeters
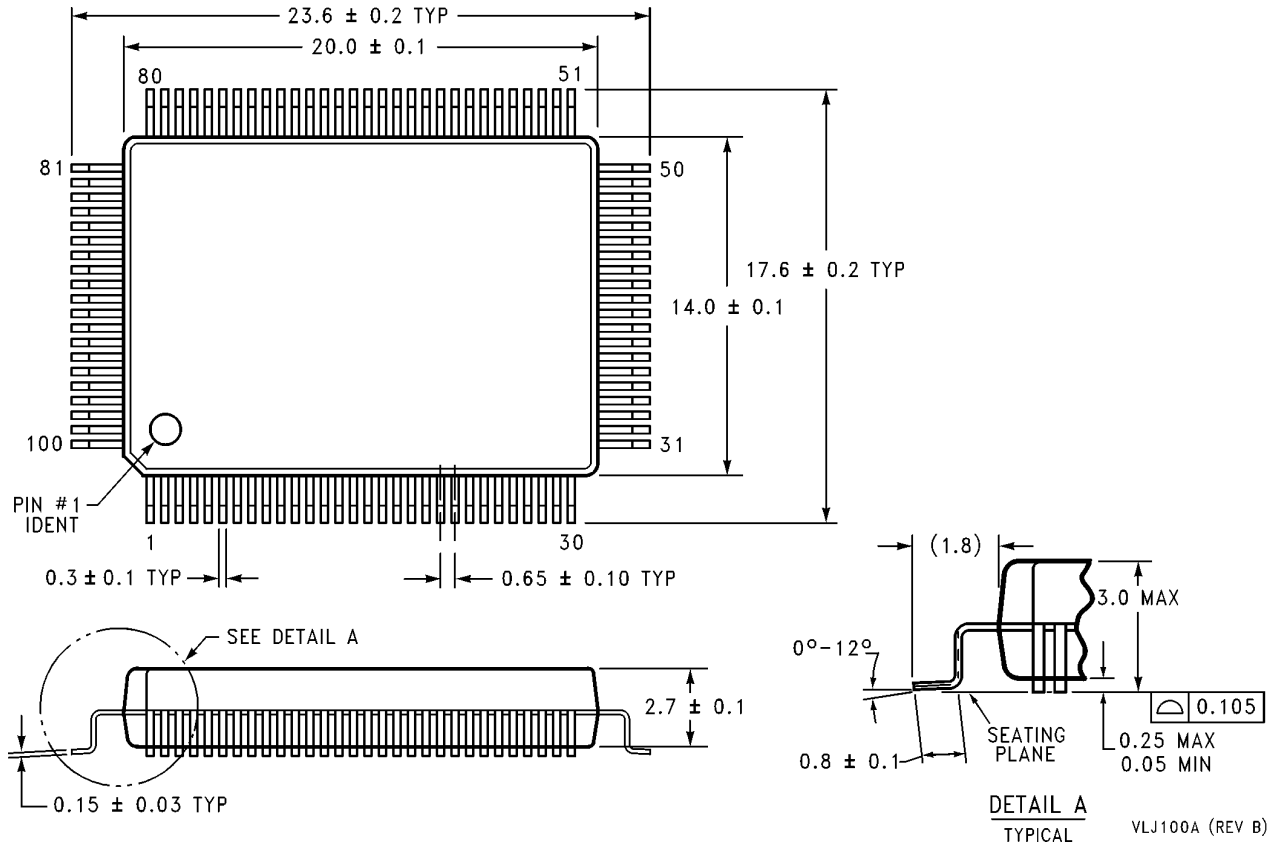
Plastic Quad Flatpack (PQFP), EIAJ
Order Number PC87309VLJ
NS Package Number VLJ100A

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