

May. 2001

ver1.1

8-BIT SINGLE-CHIP MONITOR MICROCONTROLLERS

# HMS9xC7132 HMS9xC7134

## User's Manual

**hyunix**  
Semiconductor

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Version 1.1

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# HMS9xC7132 / HMS9xC7134

## CMOS SINGLE-CHIP 8-BIT MICROCONTROLLER FOR MONITOR

### 1. OVERVIEW

#### 1.1 Description

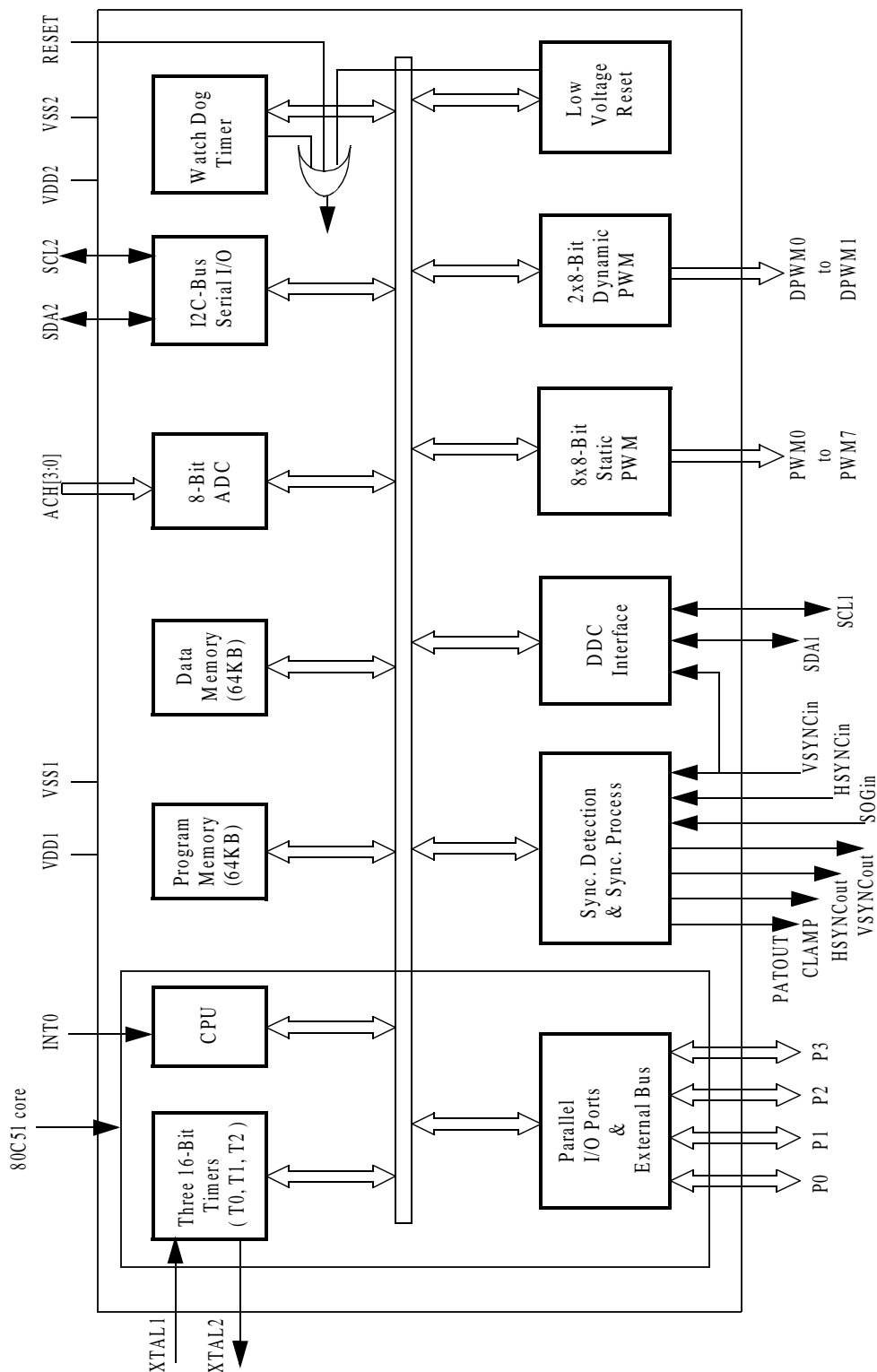
The HMS9xC7132/4 is a single-chip microcontroller of the 80C51 family, which is dedicated for monitor application. It is particularly suitable for multi-sync computer monitor controller. This contains DDC interfaces to the PC host, sync-detector and sync-processor for auto-sync application, ADC, static PWM, dynamic PWM and I<sup>2</sup>C bus interface for control of the video and deflection functions of the monitor.

Device name	ROM Size	RAM Size	I/O	OTP	Package
HMS91C7132/4	32K bytes Mask ROM	512 bytes	30(42DIP) 32(42SDIP)	HMS97C7132/4	40DIP(HMS91C7132/4), 42SDIP(HMS91C7132/4K)

#### 1.2 Features

- **80C51 core**
- **32K bytes of ROM for HMS91C7132/4**  
(32K bytes of OTP ROM for HMS97C7132/4)
- **256 bytes of RAM and 256 bytes of XRAM for DDC operation**
- **Uses an external crystal of 12 MHz**
- **One DDC compliant interface :**
  - Fully supports DDC1 with dedicated hardware
  - DDC2B, DDC2AB and DDC2B+ compliant dedicated hardware based on an I<sup>2</sup>C bus interface
  - RAM buffer with programmable size, 128 bytes or 256 bytes, which can be used for DDC operation or shared as system RAM
- **On-chip sync processor**
  - HSYNC frequency with 12-bit resolution
  - VSYNC frequency with 12-bit resolution
  - HSYNC and VSYNC polarity
  - HSYNC and VSYNC presence detection
  - Composite sync separation
  - Free running sync. generation
  - Clamping pulse output
  - Pattern generation
- Separate input for a SOG signal
- Missing pulse insertion option
- HSYNC/ VSYNC change interrupt
- **One multi-master/slave I2C interface (up to 400K bit/s) for control of other system IC's**
- **Eight 8-bit Static PWM outputs for digital control applications**
- **Two 8-bit Dynamic PWM outputs for various waveform generation**
- **One 8-bit ADC with 4 input channels**
- **LED driver port ; two port lines with 15 mA drive capability**
- **One 8-bit port only for I/O function**
- **24 derivative I/O ports configurable for alternative functions**
- **Watchdog timer (524ms max.)**
- **On-chip low VDD voltage detect and reset (reset period: 524ms)**
- **Operating temperature : 0°C to 70°C**
- **Special idle and power-down modes with low power consumption**
- **Single power supply : 4.5V to 5.5V**

## 2. BLOCK DIAGRAM

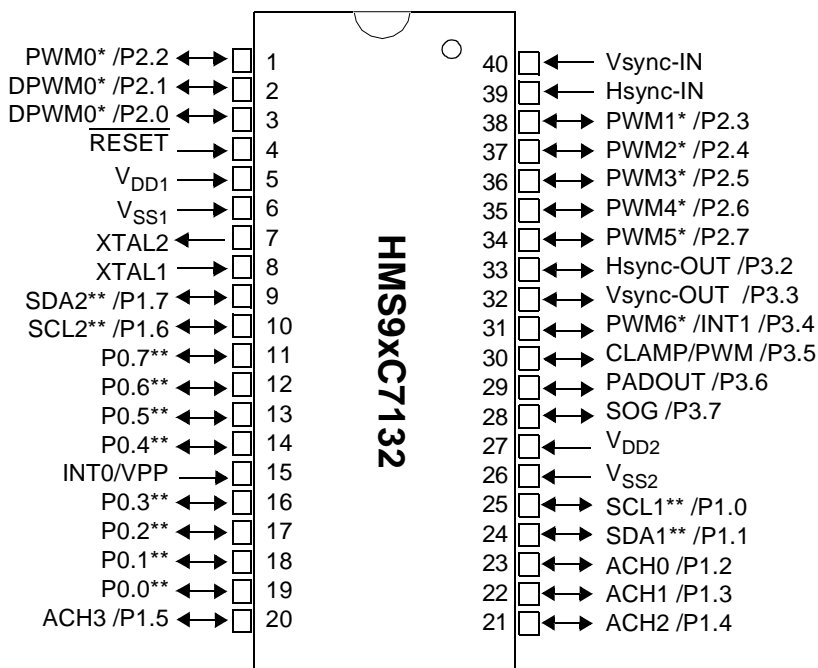


### 3. PIN ASSIGNMENT

#### 3.1 40PDIP pinning

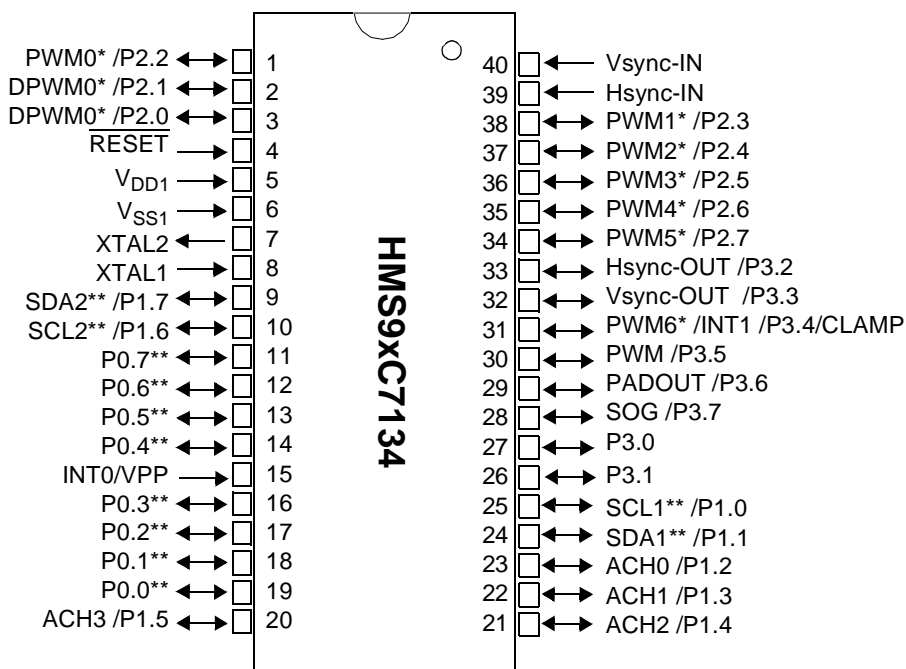
**40DIP  
(Top View)**

\* : Open-drain option  
\*\* : Open-drain type pin



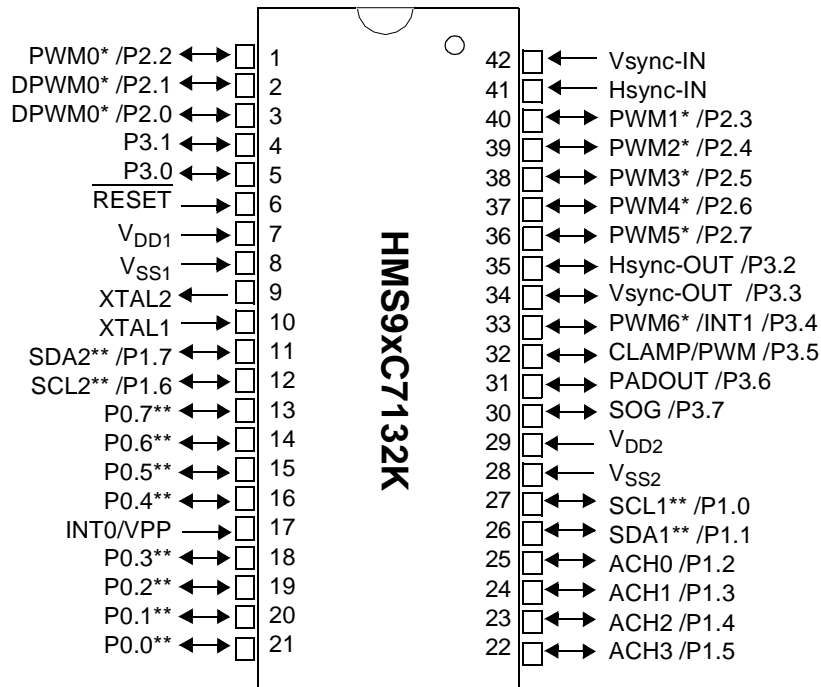
**40DIP  
(Top View)**

\* : Open-drain option  
\*\* : Open-drain type pin



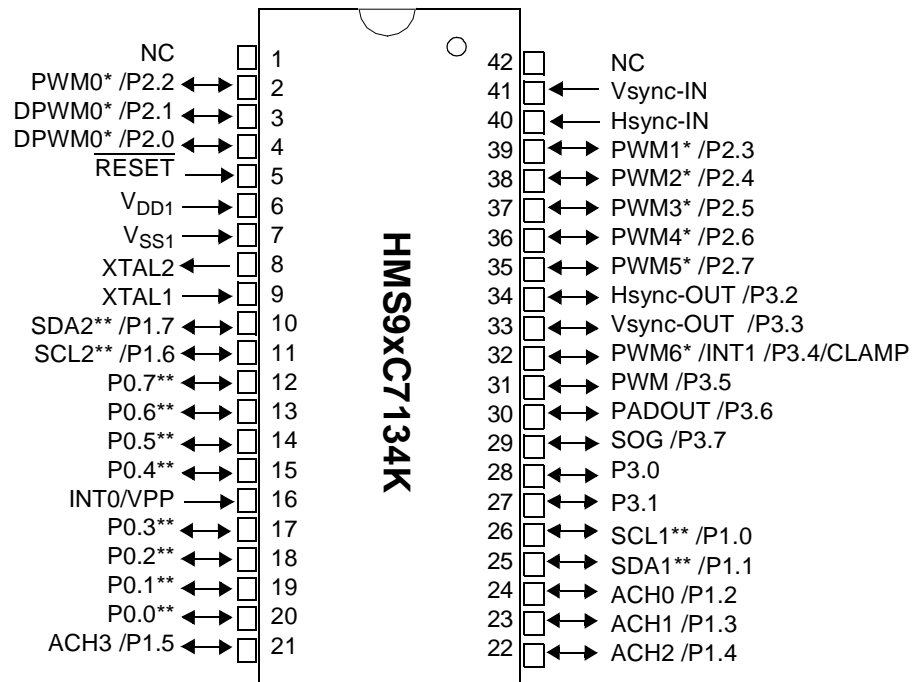
### 3.2 42SDIP pinning

**42SDIP  
(Top View)**



\* : Open-drain option  
 \*\* : Open-drain type pin

**42SDIP  
(Top View)**

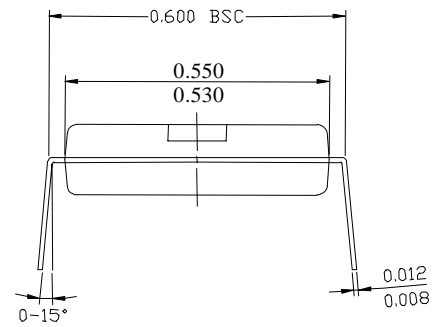
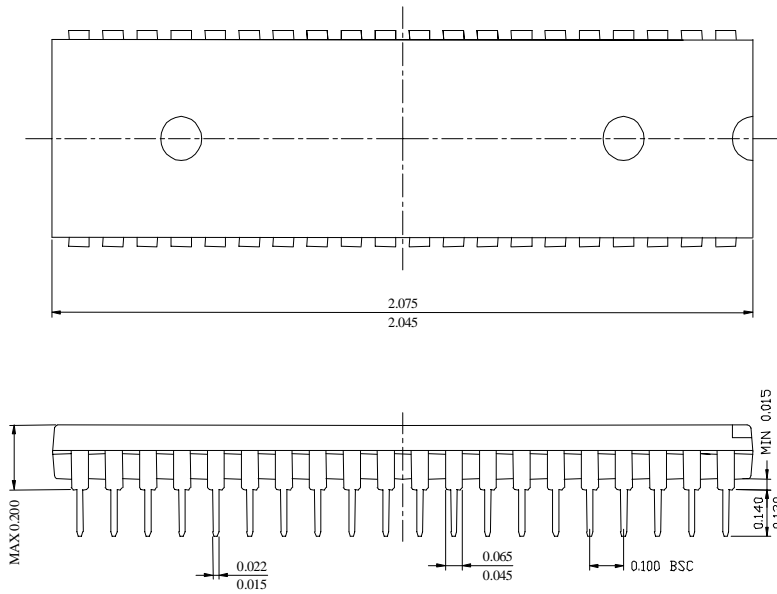


\* : Open-drain option  
 \*\* : Open-drain type pin



## 4. PACKAGE DIMENSIONS

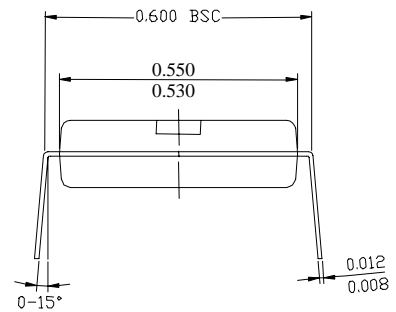
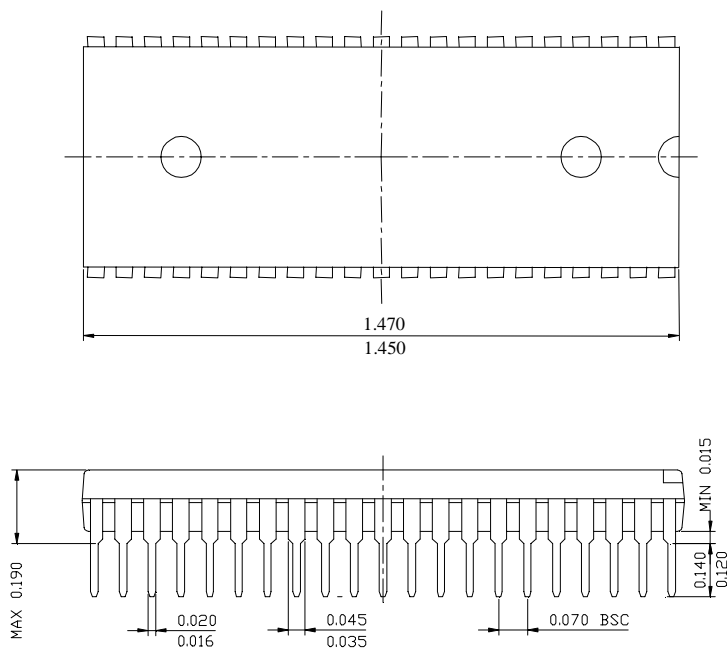
### 4.1 40 PDIP



#### NOTE

1. DIMENSIONS DO NOT INCLUDE MOLD FLASH AND DAMBAR PROTRUSION. ALLOWABLE MOLD FLASH IS 0.010 INCH.
2. CONTROLLING DIMENSION : INCH.

### 4.2 42 SDIP



#### NOTE

1. DIMENSIONS DO NOT INCLUDE MOLD FLASH AND DAMBAR PROTRUSION. ALLOWABLE MOLD FLASH IS 0.010 INCH.
2. CONTROLLING DIMENSION : INCH.

## 5. PIN FUNCTION

**V<sub>DD1</sub>**: Supply voltage (Digital).

**V<sub>SS1</sub>**: Circuit ground (Digital).

**V<sub>DD2</sub>**: Supply voltage (Analog).

**V<sub>SS2</sub>**: Circuit ground (Analog).

**RESET**: Reset the MCU.

**XTAL1**: Input to the inverting oscillator amplifier and input to the internal main clock operating circuit.

**XTAL2**: Output from the inverting oscillator amplifier.

**HSYNC<sub>IN</sub>**: Horizontal sync input

**VSYNC<sub>IN</sub>**: Vertical sync input

**INT0/V<sub>PP</sub>**: External Interrupt input. Programming supply voltage(during OTP programming)

### PORT:

The HMS9xC7132 has four 8-bit ports (Port0, Port1, Port2, and Port3). Port0 - Port3 are the same as in the 80C51, with the exception of the additional functions of Port1, Port2 and Port3. Each has latch, SFR P0~P3' output driver and input buffer.

**P0.0~P0.7**: P0 is an 8-bit CMOS bidirectional I/O port. P0 pins have not pull-up resistor and open-drain port. It has the capability of drive LED. However, while the alternative function is performed, the port type will remain the same. In case of application to extension of external memory, P0 outputted Write/Read byte and lower byte of external memory address. Therefore when it is used as normal I/O port, P0 is open-drain driver and when it used as bus port, P0 is 3-state driver.

Port pin	Alternate function
P0.0	No (Only for I/O function)
P0.1	No (Only for I/O function)
P0.2	No (Only for I/O function)
P0.3	No (Only for I/O function)
P0.4	No (Only for I/O function)
P0.5	No (Only for I/O function)
P0.6	No (Only for I/O function)
P0.7	No (Only for I/O function)

**P1.0~P1.7**: P1 is an 8-bit CMOS bidirectional I/O port. Because P1 pins have pull-up resistor, it is called as Quasi-Bidirectional port.

Port pin	Alternate function
P1.0	SCL1 (DDC-SCL)
P1.1	SDA1 (DDC-SDA)
P1.2	ACH0
P1.3	ACH1
P1.4	ACH2
P1.5	ACH3
P1.6	SCL2 (I <sup>2</sup> C-SCL)
P1.7	SDA2 (I <sup>2</sup> C-SDA)

**P2.0~P2.7**: P2 is an 8-bit CMOS bidirectional I/O port. Because P2 pins have pull-up resistor, it is called as Quasi-Bidirectional port. .

Port pin	Alternate function
P2.0	DPWM0*
P2.1	DPWM1*
P2.2	PWM0*
P2.3	PWM1*
P2.4	PWM2*
P2.5	PWM3*
P2.6	PWM4*
P2.7	PWM5*

**P3.0~P3.7**: P3 is an 8-bit CMOS bidirectional I/O port. Because P3 pins have pull-up resistor, it is called as Quasi-Bidirectional port.

Port pin	Alternate function
P3.0	Reserved
P3.1	Reserved
P3.2	HSYNC <sub>OUT</sub>
P3.3	VSYNC <sub>OUT</sub>
P3.4	PWM6*
P3.5	CLAMP/PWM7
P3.6	PATOUT
P3.7	SOG

## 5.1 40DIP Pin Description

PIN NAME (Alternate)	Pin No.	In/Out (Alternate)	Function	
			Basic	Alternate
PWM0 /P2.2	1	I/O	General I/O port P2.2	8-bit Pulse Width Modulation output0
DPWM0 /P2.1	2	I/O	General I/O port P2.1	8-bit Dynamic Pulse Width Modulation output0
DPWM0 /P2.0	3	I/O	General I/O port P2.0	8-bit Dynamic Pulse Width Modulation output1
RESET	4	I	Reset input	
V <sub>DD1</sub>	5	-	Power supply1(+5V)	
V <sub>SS1</sub>	6	-	Ground1	
XTAL2	7	O	Oscillator output pin for system clock	
XTAL1	8	I	Oscillator input pin for system clock	
SDA2 /P1.7	9	I/O	General I/O port P1.7	I <sup>2</sup> C serial data I/O port
SCL2 /P1.6	10	I/O	General I/O port P1.6	I <sup>2</sup> C serial clock I/O port
P0.7	11	I/O	General I/O port P0.7; adapted for LED driver	
P0.6	12	I/O	General I/O port P1.6; adapted for LED driver	
P0.5	13	I/O	General I/O port P0.5	
P0.4	14	I/O	General I/O port P0.4	
INT0 /V <sub>PP</sub>	15	I	External interrupt input0; Programming supply voltage (during OTP programming)	
P0.3	16	I/O	General I/O port P0.3	
P0.2	17	I/O	General I/O port P0.2	
P0.1	18	I/O	General I/O port P0.1	
P0.0	19	I/O	General I/O port P0.0	
ACH3 /P1.5	20	I/O	General I/O port P1.5	ADC channel3 input
ACH2 /P1.4	21	I/O	General I/O port P1.4	ADC channel2 input
ACH0 /P1.3	22	I/O	General I/O port P1.3	ADC channel1 input
ACH0 /P1.2	23	I/O	General I/O port P1.2	ADC channel0 input
SDA1 /P1.1	24	I/O	General I/O port P1.1	I <sup>2</sup> C serial data I/O port for DDC interface
SCL1 /P1.0	25	I/O	General I/O port P1.0	I <sup>2</sup> C serial clock I/O port for DDC interface
V <sub>SS2</sub>	26	-	Ground2	
V <sub>DD2</sub>	27	-	Power supply2(+5V)	
SOGin /P3.7	28	I/O	General I/O port P3.7	Sync on Green input
PATOUT /P3.7	29	I/O	General I/O port P3.6	Pattern out
CLAMP /PWM7 / P3.5 /PROG	30	I/O	General output only port P3.5 Program pulse input(during OTP programming)	Clamp out ; 8-bit Pulse Width Modulation output7
PWM6 /P3.4 / INT1	31	I/O	General I/O port P3.4	8-bit Pulse Width Modulation output6; External interrupt input1
VSYNCout /P3.3	32	I/O	General I/O port P3.3	Vertical sync output
HSYNCout /P3.2	33	I/O	General I/O port P3.2	Horizontal sync output
PWM5 /P2.7	34	I/O	General I/O port P2.7	8-bit Pulse Width Modulation output5
PWM4 /P2.6	35	I/O	General I/O port P2.6	8-bit Pulse Width Modulation output4
PWM3 /P2.5	36	I/O	General I/O port P2.5	8-bit Pulse Width Modulation output3
PWM2 /P2.4	37	I/O	General I/O port P2.4	8-bit Pulse Width Modulation output2

**Table 5-1 Port Function Description(40DIP)**

PIN NAME (Alternate)	Pin No.	In/Out (Alter- nate)	Function	
			Basic	Alternate
PWM1 /P2.3	38	I/O	General I/O port P2.3	8-bit Pulse Width Modulation output1
HSYNCin	39	I	Horizontal sync input	
VSYNcIn	40	I	Vertical sync input	

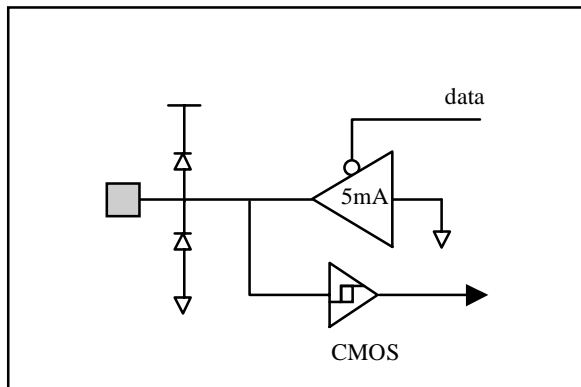
**Table 5-1 Port Function Description(40DIP)**

## 5.2 42SDIP Pin Description

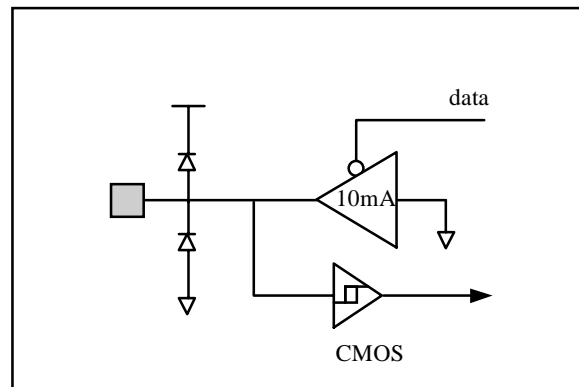
The 42SDIP type pin description is the same as The 40DIP type pin description except for adding two pins(P3.1, P3.0) to it between pin no.4 and 5.

## 6. PORT STRUCTURES

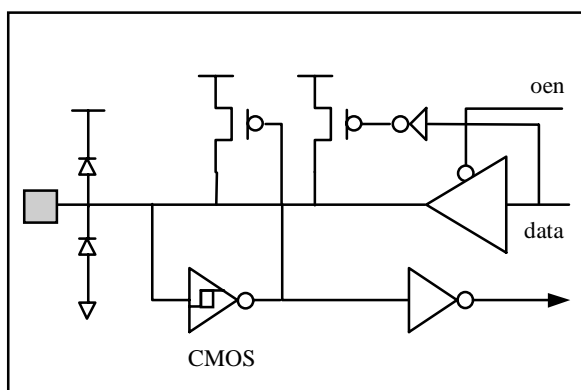
P0.0 - P0.5



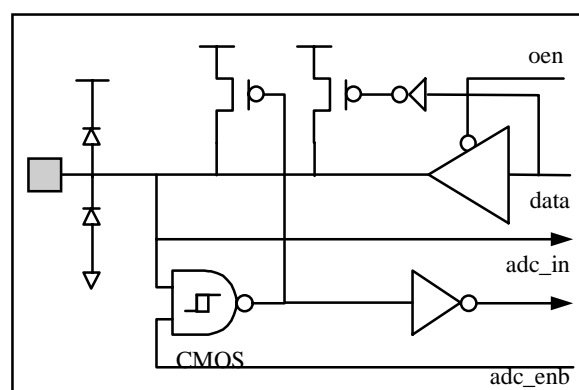
P0.6 - P0.7



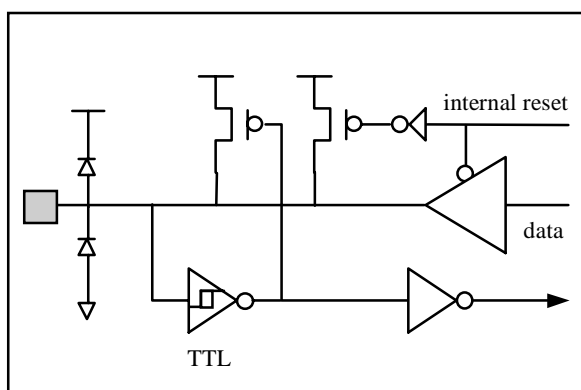
P1.0, P1.1, P1.6, P1.7, P2.0~7, P3.0, P3.1, P3.4, P3.6



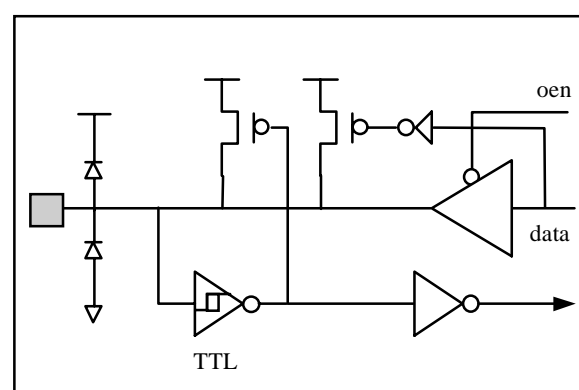
P1.2 - P1.5



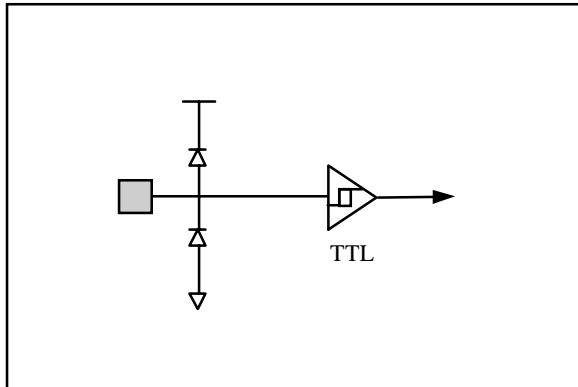
P3.2, P3.3, P3.5



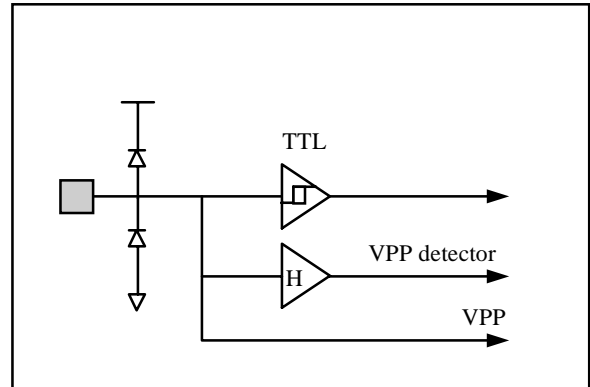
P3.7



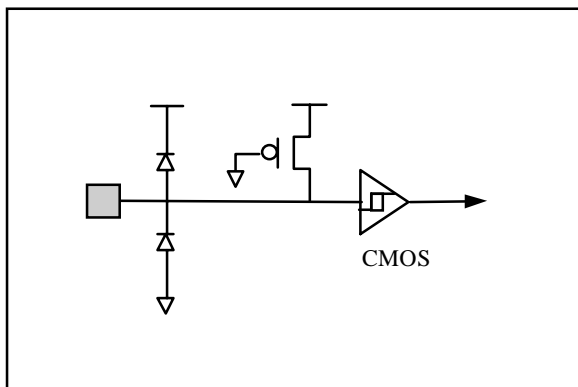
HSYNCIN, VSYNCIN



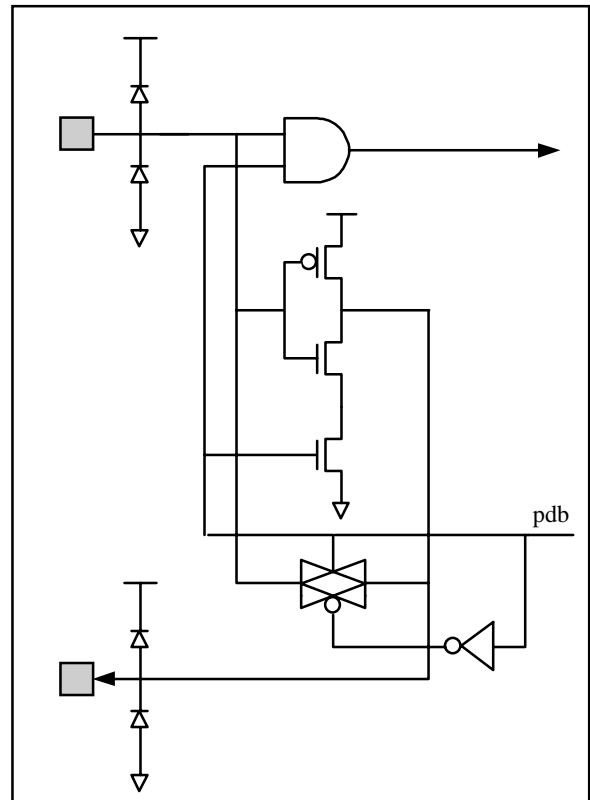
INT0/VPP



RESET



XTAL1, XTAL2



## 7. ELECTRICAL CHARACTERISTICS

### 7.1 Absolute Maximum Ratings

Supply voltage.....-0.5 to +6.5 V

Storage Temperature ..... -65 to +150 °C

Voltage on any pin with respect to Ground ( $V_{SS}$ )

.....-0.5 to  $V_{DD}+0.5$

*um Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.*

**Note:** Stresses above those listed under "Absolute Maxi-

### 7.2 Recommended Operating Conditions

Parameter	Symbol	Condition	Specifications		Unit
			Min.	Max.	
Supply Voltage	$V_{DD}$	$f_{XIN}=12\text{MHz}$	4.5	5.5	V
Operating Frequency	$f_{XIN}$	$V_{DD}=4.5\sim 5.5\text{V}$	10	16	MHz
Operating Temperature	$T_{OPR}$	-	0	70	°C

### 7.3 DC Electrical Characteristics

( $T_A = 0\sim 70^\circ\text{C}$ ,  $V_{DD}=4.5\sim 5.5\text{V}$ ,  $V_{SS}=0\text{V}$  ),

Symbol	Parameter	Condition	Specifications			Unit
			Min.	Typ.	Max.	
SUPPLY						
VDD	power supply voltage	-	4.5	5.0	5.5	V
IDD	power supply current	Fosc - 12MHz	-	TBD	-	mA
VLVR	low voltage reset	-	3.3	3.7	4.1	V
OTP SUPPLY						
VDD	power supply voltage	-	4.5	5.0	5.5	V
VPP	programming voltage	-	-	12.75	-	V
IDDP	power supply current	Fosc - 4MHz	-	TBD	-	mA
IPP	programming current	Fosc - 4MHz	-	TBD	-	mA
RESET						
IRST	RESET input pull-up resistance	VIN - 0V	-	33	-	μA
IIH	input leakage current	VIN - VDD	-	0	1	μA
VIL1	LOW-level input voltage	-	VSS-0.5	-	0.3VDD	V
VIH1	HIGH-level input voltage	-	0.7VDD	-	VDD+0.5	V
XTAL						
VOP	open bias voltage	-	-	2.5	-	V
IFR	feedback resistor current	VIN - 5V	-	10	-	μA
VIL1	LOW-level input voltage	-	VSS-0.5	-	0.3VDD	V
VIH1	HIGH-level input voltage	-	0.7VDD	-	VDD+0.5	V
INT0, HSYNCIN, VSYNCIN						
IIL	input leakage current	VIN - VSS	-1	0	-	μA
IIH	input leakage current	VIN - VDD	-	0	1	μA
VIL	LOW-level input voltage	-	VSS-0.5	-	0.3VDD	V

Symbol	Parameter	Condition	Specifications			Unit
			Min.	Typ.	Max.	
VIH	HIGH-level input voltage	-	2.0	-	VDD+0.5	V
SOG/P3.7						
IIL1	input leakage current	VIN - 0.45V	-55	-	-10	μA
ITL	input transition current	VIN - 2.0V	-650	-	-65	μA
IIH	input leakage current	VIN - VDD	-	0	1	μA
VIL	LOW-level input voltage	-	VSS-0.5	-	0.8	V
VIH	HIGH-level input voltage	-	2.0	-	VDD+0.5	V
VOL	LOW-level output voltage	IOL - 5mA	0	-	0.4	V
VOH	HIGH-level input voltage	IOH - 5mA	3.5	-	VDD	V
P0.0 to P0.5						
IIL	input leakage current	VIN - VSS	-1	0	-	μA
IIH	input leakage current	VIN - VDD	-	0	1	μA
VIL1	LOW-level input voltage	-	VSS-0.5	-	0.3VDD	V
VIH1	HIGH-level input voltage	-	0.7VDD	-	VDD+0.5	V
VOL	LOW-level output voltage	IOL - 5mA	0	-	0.4	V
P0.6 to P0.7						
IIL	input leakage current	VIN - VSS	-1	0	-	μA
IIH	input leakage current	VIN - VDD	-	0	1	μA
VIL1	LOW-level input voltage	-	VSS-0.5	-	0.3VDD	V
VIH1	HIGH-level input voltage	-	0.7VDD	-	VDD+0.5	V
VOL1	LOW-level output voltage	IOL - 10mA	0	-	0.4	V
P2.0 to P2.7(BP2.0 to BP2.7)						
IIL1	input leakage current	VIN - 0.45V	-55	-	-10	μA
ITL1	input transition current	VIN - 3.5V	-650	-	-65	μA
IIH	input leakage current	VIN - VDD	-	0	1	μA
VIL1	LOW-level input voltage	-	VSS-0.5	-	0.3VDD	V
VIH1	HIGH-level input voltage	-	0.7VDD	-	VDD+0.5	V
VOL	LOW-level output voltage	IOL - 5mA	0	-	0.4	V
VOH	HIGH-level input voltage	IOH - 5mA	3.5	-	VDD	V
P1.0 to P1.7,P3.0,P3.1,P3.4,P3.6,P3.7						
IIL1	input leakage current	VIN - 0.45V	-55	-	-10	μA
ITL1	input transition current	VIN - 3.5V	-650	-	-65	μA
IIH	input leakage current	VIN - VDD	-	0	1	μA
VIL1	LOW-level input voltage	-	VSS-0.5	-	0.3VDD	V
VIH1	HIGH-level input voltage	-	0.7VDD	-	VDD+0.5	V
VOL	LOW-level output voltage	IOL - 5mA	0	-	0.4	V
VOH	HIGH-level input voltage	IOH - 5mA	3.5	-	VDD	V
P3.2 to P3.3,P3.5						
IIL2	input leakage current	VIN - 0.45V	-960		-320	μA
ITL2	input transition current	VIN - 2.0V	-1240		-350	μA
IIH	input leakage current	VIN - VDD		0	1	μA
VIL	LOW-level input voltage	-	VSS-0.5		0.8	V
VIH	HIGH-level input voltage	-	2.0		VDD+0.5	V



Symbol	Parameter	Condition	Specifications			Unit
			Min.	Typ.	Max.	
VOL	LOW-level output voltage	IOL - 5mA	0		0.4	V
VOH	HIGH-level input voltage	IOH - 5mA	3.5		VDD	V

## 7.4 AC Characteristics

(T<sub>A</sub>=-0~70°C, V<sub>DD</sub>=5.0V, V<sub>SS</sub>=0V)

Symbol	Parameter	Condition	Specifications			Unit
			Min.	Typ.	Max.	
XTAL						
fosc	oscillator frequency	VDD - 5V	10	12	16	MHz
C1	xtal1 external Cap.	-	-	20	-	pF
C2	xtal2 external Cap.	-	-	20	-	pF
A/D Converter						
V <sub>AIN</sub>	analog input voltage	-	VSS	-	VDD	V
η <sub>AOFF</sub>	zero offset error	-	-	-	TBD	LSB
η <sub>FS</sub>	full scale error	-	-	20	TBD	LSB
η <sub>ACC</sub>	overall accuracy	-	-	-	TBD	LSB
t <sub>CONV</sub>	conversion time	fosc - 12MHz	-	13	-	μs
DDC1 Mode						
t <sub>H(VCLK)</sub>	VCLK high time	-	20	-	-	μsV
t <sub>L(VCLK)</sub>	VCLK low time	-	20	-	-	μs
t <sub>DOV</sub>	VCLK to output valid	fosc - 12MHz	-	-	680	μs
t <sub>SU(DDC1)</sub>	DDC1 mode setup time	-	-	TBD	-	μs
t <sub>NC(IN)</sub>	cancelled noise input	fosc - 12MHz	-	-	300	μs
DDC2 Mode						
f <sub>SCL</sub>	SCL clock frequency	-	0	-	100	kHz
t <sub>HD(SDA)</sub>	Start condition hold time	-	4.0	-	-	μs
t <sub>SU(STO)</sub>	Stop condition setup time	-	4.0	-	-	μs
t <sub>HD(DAT)</sub>	Data hold time	-	300	-	-	μs
t <sub>SU(STA)</sub>	Rstart(1) condition setup time	-	4.7	-	-	μs
t <sub>H(SCL)</sub>	SCL high period	-	4.0	-	-	μs
t <sub>L(SCL)</sub>	SCL low period	-	4.7	-	-	μs
HSYNCin						
f <sub>(HSYNC)</sub>	HSYNC input frequency	-	12	-	120	kHz
t <sub>W(HSYNC)</sub>	HSYNC input pulse width	-	0.25	-	8	μs
d <sub>(HSYNC)</sub>	HSYNC duty cycle	-	-	-	25	%
VSYNCin						
f <sub>(VSYNC)</sub>	VSYNC input frequency	-	32	-	200	Hz
t <sub>W(VSYNC)</sub>	VSYNC input pulse width	-	1	-	24	t <sub>P(H)</sub>
d <sub>(VSYNC)</sub>	VSYNC duty cycle	-	-	-	25	%
SOGin						

Symbol	Parameter	Condition	Specifications			Unit
			Min.	Typ.	Max.	
$t_{P(EQ)}$	equalizing pulse period	-	-	0.5	-	$t_{P(H)}$
$t_{W(EQ)}$	equalizing pulse width	-	-	0.5	-	$t_{W(H)}$
$n_{(EQ)}$	equalizing pulse interval	-	-	-	30	$t_{P(H)}$
HSYNCout, VSYNCout						
$t_{D(HSYNC)}$	HSYNC input to output	-	-	-	100	ns
$t_{D,MAX(HSYNC)}$	HSYNC input to output after missing HSYNCin	-	-	-	250	ns
$t_{D(VSYNC)}$	VSYNC input to output	-	-	-	180	ns
$t_{D,MAX(VSYNC)}$	VSYNC input to output after missing VSYNCin	-	-	-	1	$t_{P(H)}$
$t_{D(CLAMP)}$	HSYNCin to CLAMP	-	-	-	100	ns

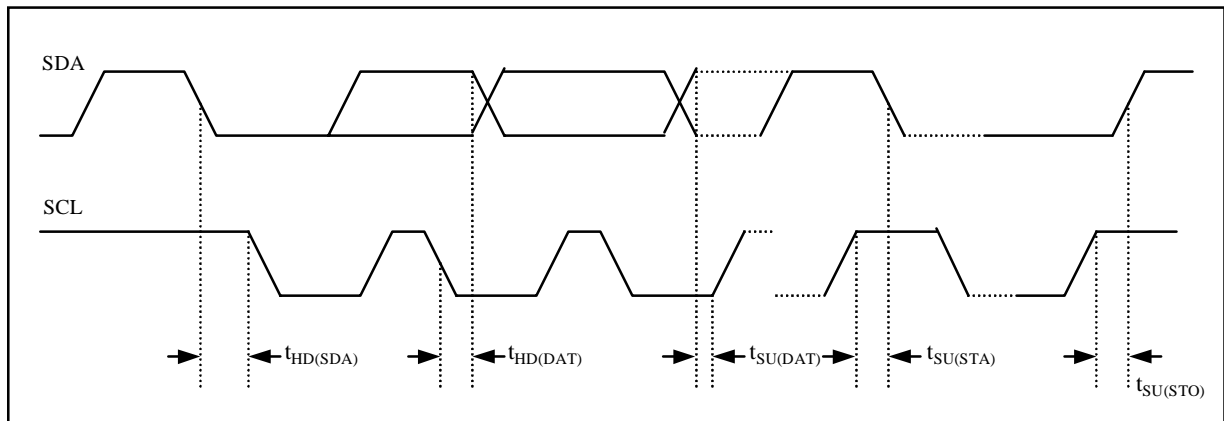


Figure 7-1 timing on the I2C-bus

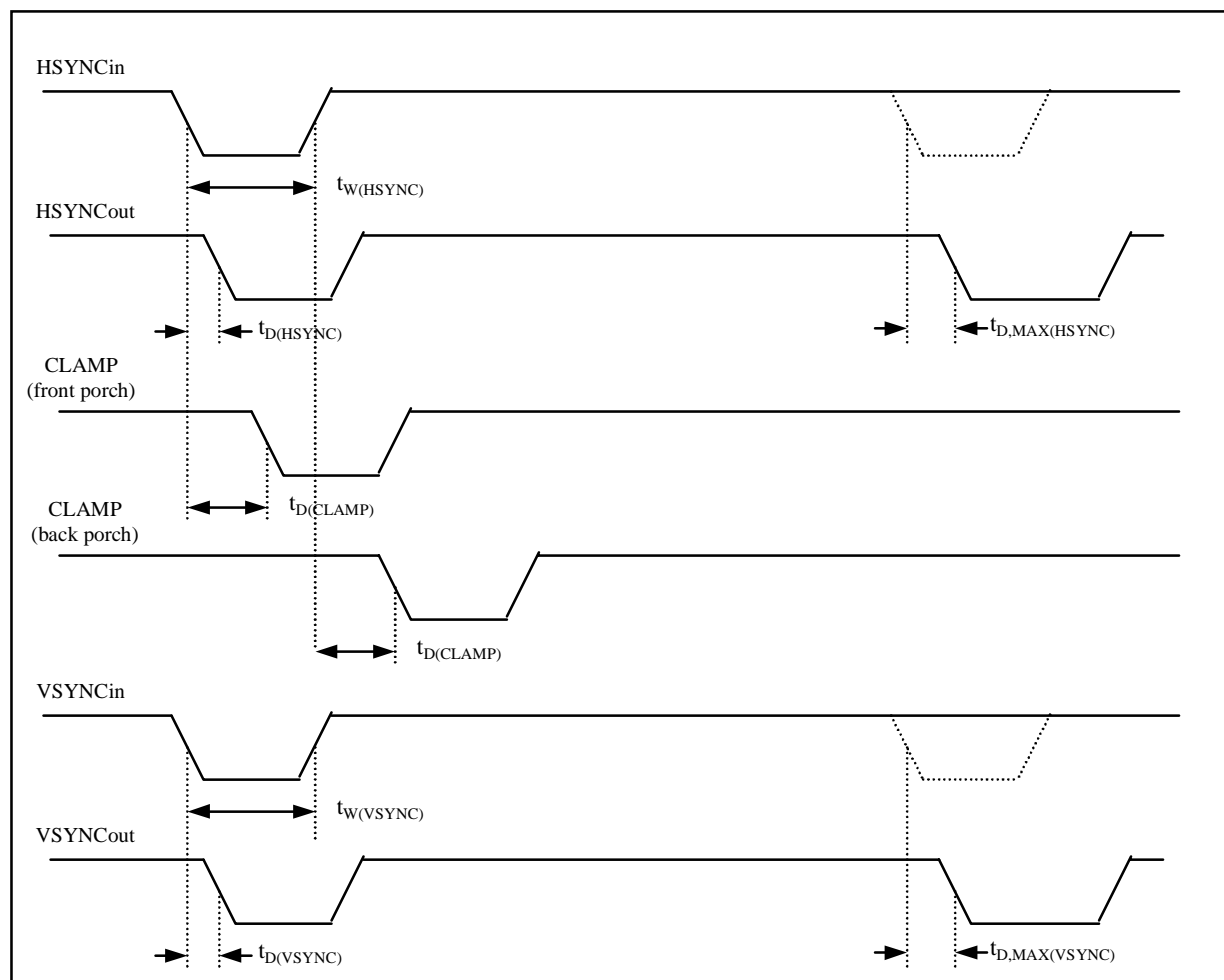


Figure 7-2 SYNC timing

## 8. MEMORY ORGANIZATION

The HMS91C7132 has separate address spaces for Program memory, Data Memory. Program memory can only be read, not written to. It can be up to 32K bytes of Program memory.(OPT type: HMS97C7132 32K bytes)

Data memory can be read and written to up to 256 bytes including the stack area.(Internal RAM) and 256bytes (External RAM: 256bytes of XRAM0).

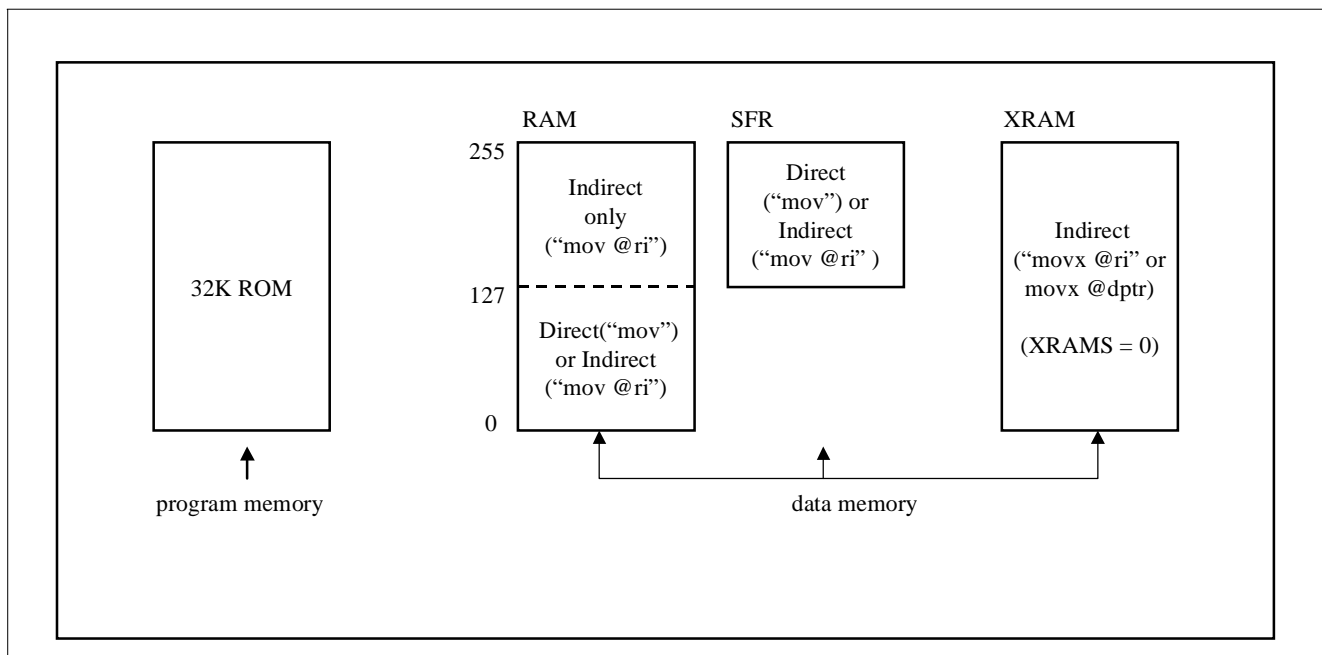


Figure 8-1 Memory map and address spaces

### 8.1 Registers

This device has several registers that are the Program Counter (PC), Accumulator (A), B register(B), the Stack Pointer (SP), the Program Status Word(PSW), General purpose register(R0~R7)and DPTR(Data pointer register).

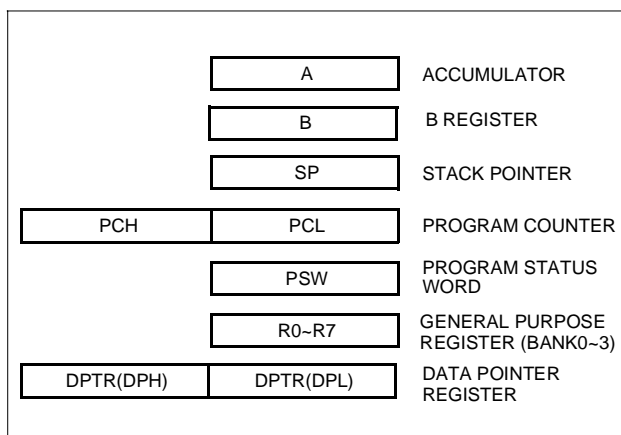


Figure 8-2 Configuration of Registers

**Accumulator:** The Accumulator is the 8-bit general purpose register, used for data operation such as transfer, temporary saving,

and conditional judgement, etc. The Accumulator can be used as a 16-bit register with B Register as shown below.

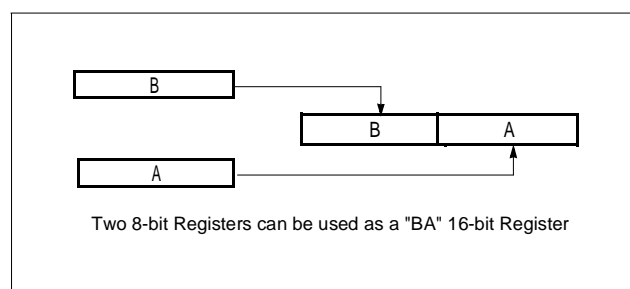
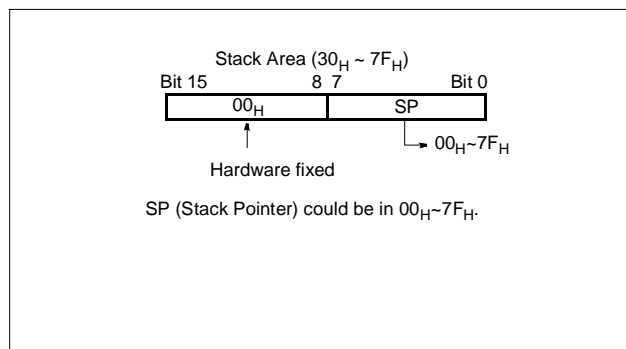


Figure 8-3 Configuration of BA 16-bit Registers

**B Register:** The B Register is the 8-bit purpose register, used for an arithmetic operation such as multiply, division with Accumulator

**Stack Pointer:** The Stack Pointer is an 8-bit register used for occurrence interrupts and calling out subroutines. Stack Pointer identifies the location in the stack to be access (save or restore).The stack can be located at any position within 0000<sub>H</sub> to 007F<sub>H</sub> of the internal data memory. The SP is not initialized by hardware, requiring to write the initial value (the location with

which the use of the stack starts) by using the initialization routine. Normally, the initial value of "07<sub>H</sub>" is used and the stack area is 00<sub>H</sub> to 7F<sub>H</sub>.



**Program Counter:** The Program Counter is a 16-bit wide which consists of two 8-bit registers, PCH and PCL. This counter indicates the address of the next instruction to be executed. In reset state, the program counter has reset routine address (PC<sub>H</sub>:0FF<sub>H</sub>, PC<sub>L</sub>:0FE<sub>H</sub>).

**Program Status Word:** The Program Status Word (PSW) contains several bits that reflect the current state of the CPU and select Internal RAM(00H~1FH:Bank0~Bank3). The PSW is described in Figure 8-4. It contains the Carry flag, the Auxiliary carry flag, the Half Carry (for BCD operation), the General purpose flag, the Register bank select flags, the Overflow flag, the undefined flag and Parity flag.

[Carry flag CY]

This flag stores any carry or not borrow from the ALU of CPU after an arithmetic operation and is also changed by the Shift Instruction or Rotate Instruction.

[Auxiliary carry flag AC]

After operation, this is set when there is a carry from bit 3 of ALU or there is no borrow from bit 4 of ALU.

[Register bank select flags RS0, RS1]

This flags select one of four bank(00~07H:bank0, 08~0FH:bank1, 10~17H:bank2, 17~1FH:bank3)in Internal RAM.

[Overflow flag OV]

This flag is set to "1" when an overflow occurs as the result of an arithmetic operation involving signs. An overflow occurs when the result of an addition or subtraction exceeds +127(7F<sub>H</sub>) or -128(80<sub>H</sub>). The CLR V instruction clears the overflow flag. There is no set instruction. When the BIT instruction is executed, bit 6 of memory is copied to this flag.

[Parity flag P]

This flag reflect on number of Accumulator's 1. If number of Accumulator's 1 is odd, P=0. otherwise P=1. Sum of adding Accumulator's 1 to P is always even.

**R0~R7:** General purpose register.

**Data Pointer Register:**Data Pointer Register is 16-bit wide which consists of two-8bit registers, DPH and DPL. This register is used as a data pointer for the data transmission with external data memory.

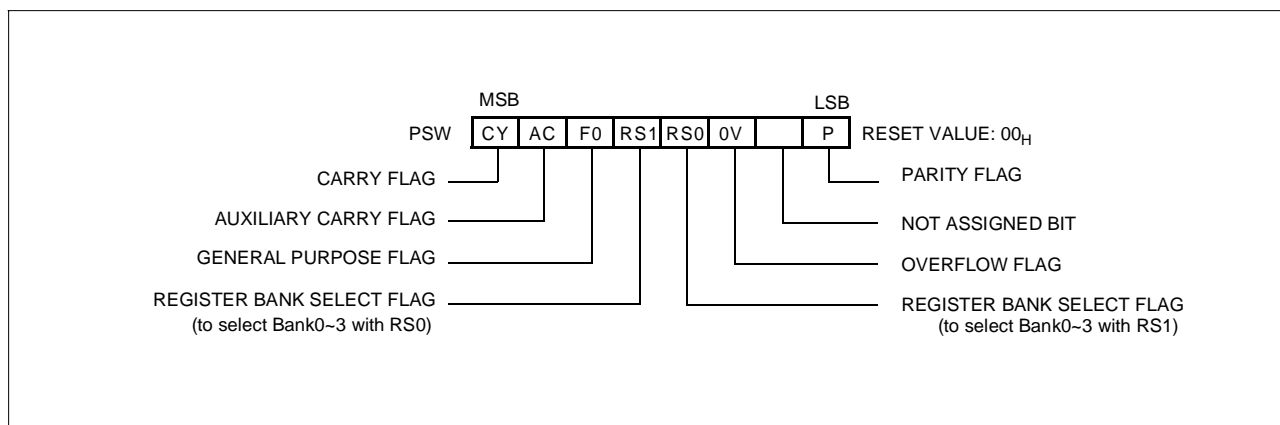


Figure 8-4 PSW(Program Status Word)Register

## 8.2 Program Memory

The program memory consists of ROM : 32K bytes (HMS91C7132) and 32K bytes (HMS97C7132)

## 8.3 Data memory

The internal data memory is divided into four physically separated part : 256 bytes of RAM, 256 bytes of XRAM0, and 128 bytes of Special Function Registers (SFRs) areas.

**RAM**

Four register banks, each 8 registers wide, occupy locations 0 through 31 in the lower RAM area. Only one of these banks may be enabled at a time. The next 16 bytes, locations 32 through 47,

contain 128 directly addressable bit locations. The stack depth is only limited by the available internal RAM space of 256 bytes.

XRAM0

The 256 bytes of XRAM0 used to support DDC interface is also available for system usage by indirect addressing through the address pointer DDCADR and data I/O buffer RAMBUF. The address pointer (DDCADR) is equipped with the postincrement capability to facilitate the transfer of data in bulk (for details refer to DDC Interface part). However, it is also possible to address the DRAM through MOVX command as usually used in the internal

RAM extension of 80C51 derivatives. XRAM0 0 to 255 is directly addressable as external data memory locations 0 to 255 via MOVX-DPTR instruction or via MOVX-Ri instruction when the EXCON's LSB is zero. Since external access function is not available, any access to XRAM0 0 to 255 will not affect the ports.

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

Table 8-1 Extended control Register(EXCON)

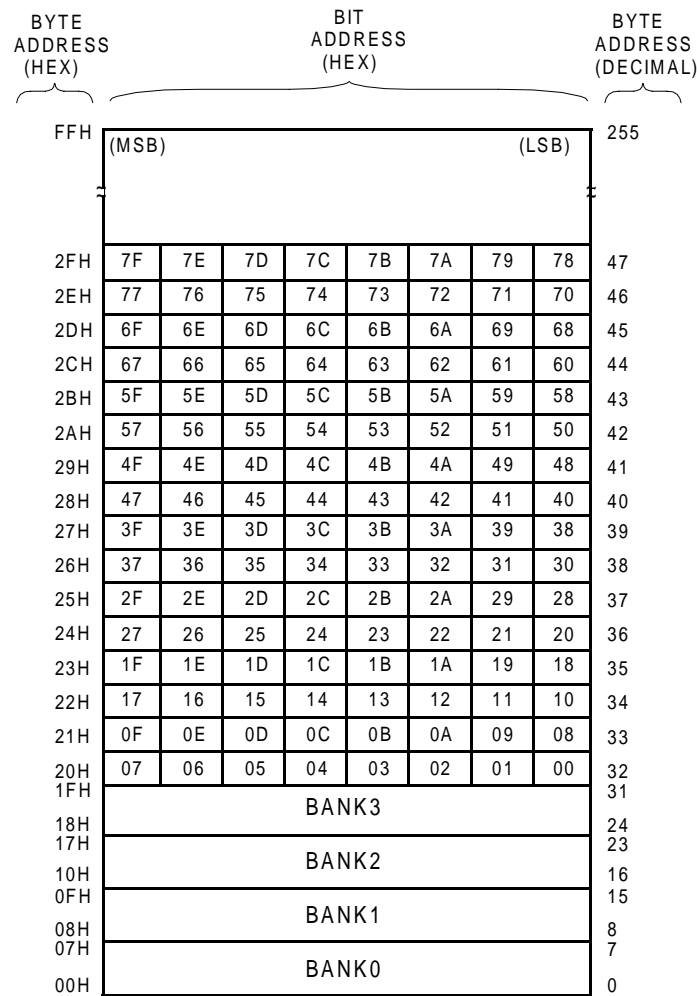


Figure 8-5 RAM ADDRESS

## SFR

The SFRs can only be addressed directly in the address range from 128 to 255. Table 8.2 gives an overview of the Special Function Registers space. Sixteen address in the SFRs space are both-

byte and bit-addressable. The bit-addressable SFRs are those whose address ends in 0H and 8H. The bit addresses in this area are 80H to FFH.

F8	-	HVGEN	CPGEN	VFH	VFL	HFH	HFL		FF
F0	*B	MDCON	MDST	VPH	HPH	VHPL			F7
E8	*EXCON					-	-	-	EF
E0	*ACC	-	-		-	-	-	-	E7
D8	*S1CON	S1STA	S1DAT	S1ADR0	S2CON	S2STA	S2DAT	S2ADR	DF
D0	*PSW			S1SDR1	RAMBUF	DDCDAT	DDCADR	DDCCON	D7
C8	*T2CON	-	RC2L	RC2H	-	-			CF
C0	-						-		C7
B8	*IP	-							BF
B0	*P3	DPWMCON	DPWM0	DPWM1		-	IPA	-	B7
A8	*IE	-	PWM4	PWM5	PWM6	PWM7	WDTKEY		AF
A0	*P2	PWMCON	PWM0	PWM1	PWM2	PWM3	WDTRST	IEA	A7
98	-	-							9F
90	*P1	P1SFS	P2SFS	P3SFS			ADAT	ACON	97
88	*TCON	TMOD	TL0	TL1	TH0	TH1			8F
80	*P0	SP	DPL	DPH				PCON	87

**Table 8-2 SFR Memory Map**

Note: \* The register that can be bit-addressing.

## 8.4 List of SFRS

Register	Description	Address	R/W	Initial Value							
				7	6	5	4	3	2	1	0
P0	Port0 Register	80H	R/W	1	1	1	1	1	1	1	1
SP	Stack Point register	81H	R/W	0	0	0	0	0	1	1	1
DPL	Data Pointer(Low byte) Register	82H	R/W	0	0	0	0	0	0	0	0
DPH	Data Pointer(High byte) Register	83H	R/W	0	0	0	0	0	0	0	0
PCON	Power Control Register	87H	R/W	x	x	0	0	0	0	0	0
TCON	Timer/Counter Control Register	88H	R/W	0	0	0	0	0	0	0	0
TMOD	Timer/Counter Mode Control Register	89H	R/W	0	0	0	0	0	0	0	0
TL0	Timer/Counter0 Low byte Register	8AH	R/W	0	0	0	0	0	0	0	0
TL1	Timer/Counter1 Low byte Register	8BH	R/W	0	0	0	0	0	0	0	0
TH0	Timer/Counter0 High byte Register	8CH	R/W	0	0	0	0	0	0	0	0
TH1	Timer/Counter1 High byte Register	8DH	R/W	0	0	0	0	0	0	0	0
P1	Port1 Register	90H	R/W	1	1	1	1	1	1	1	1
P1SFS	Port1 Special Function Selection Register	91H	R/W	0	0	0	0	0	0	0	0
P2SFS	Port2 Special Function Selection Register	92H	R/W	0	0	0	0	0	0	0	0
P3SFS	Port3 Special Function Selection Register	93H	R/W	0	0	0	0	0	0	0	0
ADAT	ADC Data Register	96H	R/W	0	0	0	0	0	0	0	0
ACON	ADC Control Register	97H	R/W	x	x	0	x	0	0	0	1
P2	Port2 Register	0A0H	R/W	1	1	1	1	1	1	1	1
PWMCON	PWM Control Register	0A1H	R/W	0	0	0	0	0	0	0	0
PWM0	PWM0 Output Register	0A2H	R/W	1	1	1	1	1	1	1	1
PWM1	PWM1 Output Register	0A3H	R/W	1	1	1	1	1	1	1	1
PWM2	PWM2 Output Register	0A4H	R/W	1	1	1	1	1	1	1	1
PWM3	PWM3 Output Register	0A5H	R/W	1	1	1	1	1	1	1	1
PWM4	PWM4 Output Register	0AAH	R/W	1	1	1	1	1	1	1	1
PWM5	PWM5 Output Register	0ABH	R/W	1	1	1	1	1	1	1	1
PWM6	PWM6 Output Register	0ACH	R/W	1	1	1	1	1	1	1	1
PWM7	PWM7 Output Register	0ADH	R/W	1	1	1	1	1	1	1	1
WDTKEY	Watchdog Key Register	0AEH	R/W	0	0	0	0	0	0	0	0
WDRST	Watchdog Timer Reset Register	0A6H	R/W	0	0	0	0	0	0	0	0
IEA	Interrupt Enable Register	0A7H	R/W	0	x	x	x	x	x	0	0
IE	Interrupt Enable Register	0A8H	R/W	0	0	0	0	0	0	0	0
P3	Port3 Register	0B0H	R/W	1	1	1	1	1	1	1	1
DPWMCON	Dynamic PWM Control Register	0B1H	R/W	0	x	x	x	x	x	0	0
DPWM0	Dynamic PWM0 Output Register	0B2H	R/W	1	1	1	1	1	1	1	1
DPWM1	Dynamic PWM1 Output Register	0B3H	R/W	1	1	1	1	1	1	1	1
IPA	Interrupt Priority Register	0B6H	R/W	0	x	x	x	x	x	0	0
IP	Interrupt Priority Register	0B8H	R/W	x	0	0	0	0	0	0	0
T2CON	Timer2 Control Register	0C8H	R/W	0	x	x	x	x	0	x	x
RC2L	Reload Low Register	0CAH	R/W	0	0	0	0	0	0	0	0
RC2H	Reload High Register	0CBH	R/W	0	0	0	0	0	0	0	0
PSW	Program Status Word Register	0D0H	R/W	0	0	0	0	0	0	0	0
RAMBUF	RAM Buffer I/O Interface Register	0D4H	R/W	x	x	x	x	x	x	x	x



Register	Description	Address	R/W	Initial Value							
				7	6	5	4	3	2	1	0
DDCDAT	Data Shift Register for DDC1	0D5H	R/W	0	0	0	0	0	0	0	0
DDCADR	DDC Address Pointer Register	0D6H	R/W	0	0	0	0	0	0	0	0
DDCCON	DDC Mode Status and DDC1 Control Register	0D7H	R/W	x	0	0	x	0	0	0	0
S1CON	Serial Control Register for DDC2	0D8H	R/W	0	0	0	0	0	0	0	0
S1STA	Serial Status Register for DDC2	0D9H	R	0	x	0	0	x	x	x	x
S1DAT	Data Shift Register for DDC2	0DAH	R/W	0	0	0	0	0	0	0	0
S1ADR0	Serial Address0 Register for DDC2	0DBH	R/W	0	0	0	0	0	0	0	x
S1ADR1	Serial Address1 Register for DDC2	0D3H	R/W	0	0	0	0	0	0	0	x
S2CON	Serial Control Register	0DCH	R/W	0	0	0	0	0	0	0	0
S2STA	Serial Status Register	0DDH	R	0	x	0	0	x	x	x	x
S2ADR	Serial Address Register for I2C	0DFH	R/W	0	0	0	0	0	0	0	x
S2DAT	Data Shift Register for I2C	0DEH	R/W	0	0	0	0	0	0	0	0
ACC	Accumulator	0E0H	R/W	0	0	0	0	0	0	0	0
EXCON	Extended Control Register	0E8H	R/W	x	x	x	x	x	x	x	0
B	B Register	0F0H	R/W	0	0	0	0	0	0	0	0
MDCON	Mode Indication Register	0F1H	R/W	0	0	0	x	x	0	0	0
MDST	Mode Status Register	0F2H	R	x	0	0	0	0	0	0	0
VPH	Vertical scan period High byte Register	0F3H	R/W	0	0	0	0	0	0	0	0
HPH	Horizontal scan period High byte Register	0F4H	R/W	0	0	0	0	0	0	0	0
VHPL	V/H scan period High byte Register	0F5H	R/W	0	0	0	0	0	0	0	0
HVGEN	H/V pulse Control Register	0F9H	R/W	x	0	0	0	x	0	0	0
CPGEN	Clamping pulse and Pattern Control register	0FAH	R/W	0	0	0	0	0	x	0	0
VFH	Vertical free-running output pulse period High byte register	0FBH	R/W	0	0	1	0	0	0	0	0
VFL	Vertical free-running output pulse period Low byte register	0FCH	R/W	0	0	0	0	1	0	1	0
HFH	Horizontal free-running output pulse period High byte register	0FDH	R/W	0	1	1	0	0	0	0	0
HFL	Horizontal free-running output pulse period Low byte register	0FEH	R/W	0	0	x	1	1	1	1	1

## 8.5 Addressing Mode

The addressing modes in HMS9xC7132 instruction set are as follows

- Direct addressing
- Indirect addressing
- Register addressing
- Register-specific addressing
- Immediate constants addressing
- Indexed addressing

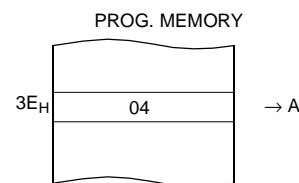
Note that refer to “Chapter 22. Instruction Set” those addressing modes and related instructions.

### (1) Direct addressing

In a direct addressing the operand is specified by an 8-bit address field in the instruction. Only internal Data RAM and SFRs(80~FFH RAM) can be directly addressed.

Example:

```
mov A, 3EH ; A ← RAM[3E]
```

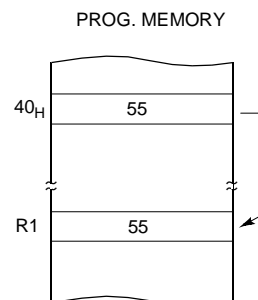


### (2) Indirect addressing

In indirect addressing the instruction specifies a register which contains the address of the operand. Both internal and external RAM can be indirectly addressed. The address register for 8-bit addresses can be R0 or R1 of the selected register bank, or the Stack Pointer. The address register for 16-bit addresses can only be the 16-bit “data pointer” register, DPTR.

Example:

```
mov @R1, 40H ; [R1] ← [40H]
```



### (3) Register addressing

The register banks, containing registers R0 through R7, can be accessed by certain instructions which carry a 3-bit register specification within the opcode of the instruction. Instructions that access the registers this way are code efficient, since this mode eliminates an address byte. When the instruction is executed, one of four banks is selected at execution time by the two bank select bits in the PSW.

Example;

```
mov PSW, #0001000B ; select Bank0
mov A, #30H
mov R1, A
```

### (4) Register-specific addressing

Some instructions are specific to a certain register. For example, some instructions always operate on the Accumulator, or Data

Pointer, etc., so no address byte is needed to point it. The opcode itself does that.

## (5) Immediate constants addressing

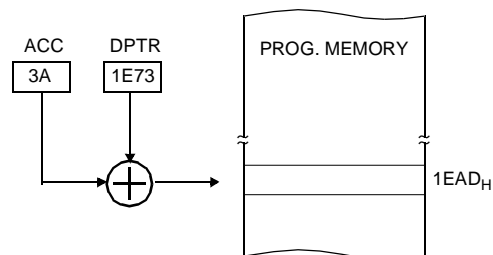
The value of a constant can follow the opcode in Program memory.

Example; `mov A, #100H.`

## (6) Indexed addressing

Only Program memory can be accessed with indexed addressing, and it can only be read. This addressing mode is intended for reading look-up tables in Program memory. A 16-bit base register (either DPTR or PC) points to the base of the table, and the Accumulator is set up with the table entry number. The address of the table entry in Program memory is formed by adding the Accumulator data to the base pointer.

Example; `movc A, @A+DPTR`



## 9. INTERRUPTS

There are interrupt requests from 9 sources as follows.

- INT0 external interrupt
- INT1 external interrupt
- Timer0 interrupt
- Timer1 interrupt
- Timer2 interrupt
- DDC interrupt
- MD interrupt
- VSYNC interrupt
- I2C interrupt

### 9.1 Interrupt sources

#### INT0 external interrupt:

- The INT0 can be either level-active or transition-active depending on bit IT0 in register TCON. The flag that actually generates this interrupt is bit IE0 in TCON.
- When an external interrupt is generated, the corresponding request flag is cleared by the hardware when the service routine is

vectored to only if the interrupt was transition-activated.

- If the interrupt was level-activated then the interrupt request flag remains set until the requested interrupt is actually generated. Then it has to deactivate the request before the interrupt service routine is completed, or else another interrupt will be generated.

#### INT1 external interrupt:

- The INT1 can be either level-active or transition-active depending on bit IT1 in register TCON. The flag that actually generates this interrupt is bit IE1 in TCON.
- When an external interrupt is generated, the corresponding request flag is cleared by the hardware when the service routine is

vectored to only if the interrupt was transition-activated.

- If the interrupt was level-activated then the interrupt request flag remains set until the requested interrupt is actually generated. Then it has to deactivate the request before the interrupt service routine is completed, or else another interrupt will be generated.

#### MD interrupt:

- A MD interrupt is generated by the hardware mode detector in case of mode change, horizontal or vertical.

- This flag has to be cleared by the software.

#### VSYNC interrupt:

- The changing of the VSYNC level can generate an interrupt. This depends on the setting that is programmed in the MDCON-SFR. Via this register it is possible to enable the edge of the VSYNC-signal that should generate the interrupt. Both edges can

be controlled separately.

- The interrupt flag has to be cleared by the software.

#### DDC interrupt:

- The DDC interrupt is generated either by bit INTR in the S1STA register for DDC2B/DDC2AB/DDC2B+ protocol or by bit DDC\_int in the DDCCON register for DDC1 protocol or by bit SWHINT bit in the DDCCON register when DDC protocol is

changed from DDC1 to DDC2.

- Flags except the INTR have to be cleared by the software. INTR flag is cleared by hardware.

#### I2C interrupt:

- The interrupt of the second I2C is generated by bit INTR in the register S2STA.

- This flag is cleared by hardware.

### Timer0 and Timer1 interrupt:

- Timer0 and Timer1 interrupts are generated by TF0 and TF1 which are set by an overflow of their respective Timer/Counter registers(except for Timer0 in mode3).

- These flags are cleared by the internal hardware.

### Timer2 interrupt:

- Timer2 interrupt is generated by TF2 which is set by an overflow of Timer2.

- This flag has to be cleared by the software.

All of the bits that generate interrupts can be set or cleared by software, with the same result as though it had been set or cleared by hardware. That is, interrupts can be generated or pending interrupts can be cancelled in software.

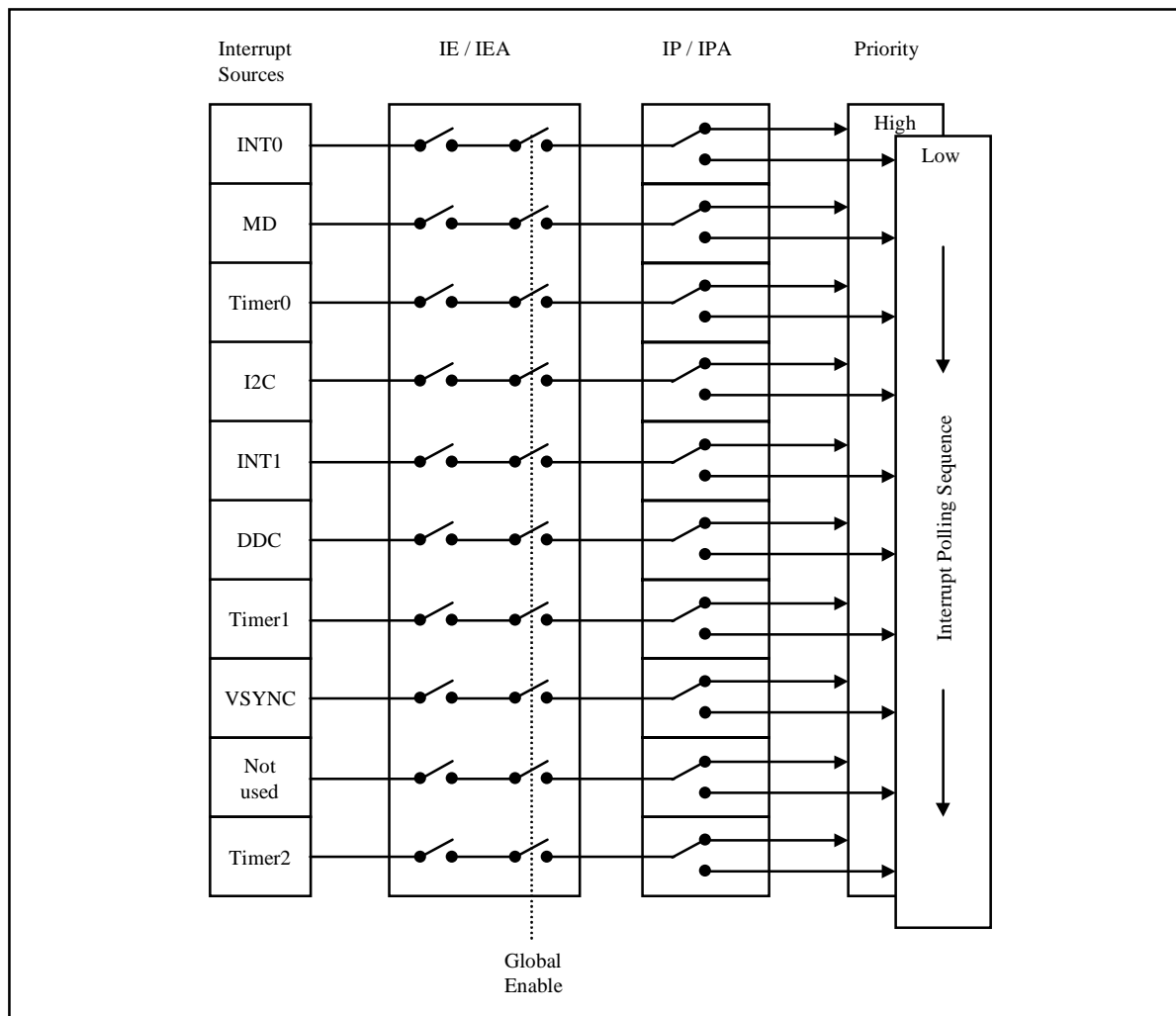


Figure 9-1 Interrupt system

## 9.2 Interrupt Enable structure

Each interrupt source can be individually enabled or disabled by setting or clearing a bit in the interrupt enable special function

register IE and IEA. All interrupt source can also be globally disabled by clearing bit EA in IE.

7	6	5	4	3	2	2	0
EA	EVSYNC	ET2	ES	ET1	EX1	ET0	EX0

**Table 9-1 Interrupt Enable Register(IE: 0A8H) RESET VALUE:0000000B**

BIT	SYMBOL	FUNCTION
7	EA	Disable all interrupts. 0 : no interrupt will be acknowledged 1 : each interrupt source is individually enabled or disabled by setting or clearing its enable bit
6	EVSYNC	Enable Vsync interrupt
5	ET2	Enable timer2 interrupt
4	ES	Not used
3	ET1	Enable timer1 interrupt
2	EX1	Enable external interrupt (INT1)
1	ET0	Enable timer0 interrupt
0	EX0	Enable external interrupt (INT0)

**Table 9-2 Description of the IE bits**

7	6	5	4	3	2	2	0
EDDC	-	-	-	-	-	EI2C	EMD

**Table 9-3 Interrupt Enable Register(IEA: 0A7H) RESET VALUE:0xxxxx00B**

BIT	SYMBOL	FUNCTION
7	EDDC	Enable DDC interrupt
6	EX6	Not used
5	EX5	Not used
4	EX4	Not used
3	EX3	Not used
2	EX2	Not used
1	EI2C	Enable I2C interrupt
0	EMD	Enable MD interrupt

**Table 9-4 Description of Enable Register(IEA: 0A7H)**

### 9.3 Interrupt Priority structure

Each interrupt source can be assigned one of two priority levels.

Interrupt priority levels are defined by the interrupt priority special function register IP and IPA.

“0” - low priority

“1” - high priority

A low priority interrupt may be interrupted by a high priority in-

terrupt level interrupt. A high priority interrupt routine cannot be interrupted by any other interrupt source. If two interrupts of different priority occur simultaneously, the high priority level request is serviced. If requests of the same priority are received simultaneously, an internal polling sequence determines which request is serviced. Thus, within each priority level, there is a second priority structure determined by the polling sequence. This second priority structure is shown in Table 9.5.

SOURCE	PRIORITY WITHIN LEVEL
INT0	<div style="text-align: center;"> 1(highest)  ⋮  ↓  9(lowest) </div>
MD	
Timer0	
I2C	
INT1	
DDC	
Timer1	
VSYN	
Timer2	

Table 9-5 Priority levels

Note

- The “Priority within level” structure is only used to resolve simultaneous requests of the same priority level.
- The MD interrupt needs a higher priority than ALL the other interrupts. This is to avoid that a mode change will not be

served in time and that the setting of the S-curve is not updated in time. When the S-curve settings are not updated in time (after a mode change) the monitor may be damaged.

7	6	5	4	3	2	2	0
-	PVSYNC	PT2	PS	PT1	PX1	PT0	PX0

Table 9-6 Interrupt Priority Register(IP: 0B8H)

RESET VALUE: x0000000B

BIT	SYMBOL	FUNCTION
7	-	Reserved
6	PVSYNC	Vsync interrupt priority level
5	PT2	Timer2 interrupt priority level
4	PS	Not used
3	PT1	Timer1 interrupt priority level
2	PX1	External interrupt (INT1) priority level
1	PT0	Timer0 interrupt priority level
0	PX0	External interrupt (INT0) priority level

Table 9-7 Description of the IP bits

7	6	5	4	3	2	2	0
PDDC	-	-	-	-	-	PI2C	PMD

**Table 9-8 Interrupt Priority Register(IPA: 0B6H)**
**RESET VALUE: 0xxxxx00B**

BIT	SYMBOL	FUNCTION
7	PDDC	DDC interrupt priority level
6	PX6	Not used
5	PX5	Not used
4	PX4	Not used
3	PX3	Not used
2	PX2	Not used
1	PI2C	I2C interrupt priority level
0	PMD	MD interrupt priority level

**Table 9-9 Description of the IPA bits**



## 9.4 How Interrupt are handled

The interrupt flags are sampled at S5P2 of every machine cycle. The samples are polled during following machine cycle. If one of the flags was in a set condition at S5P2 of the preceding cycle, the polling cycle will find it and the interrupt system will generate an LCALL to the appropriate service routine, provided this H/W generated LCALL is not blocked by any of the following conditions :

- An interrupt of equal priority or higher priority level is already in progress.
- The current machine cycle is not the final cycle in the execution of the instruction in progress.
- The instruction in progress is RETI or any access to the interrupt priority or interrupt enable registers.

The polling cycle is repeated with each machine cycle, and the values polled are the values that were present at S5P2 of the previous machine cycle. Note that if an interrupt flag is active but being responded to for one of the above mentioned conditions, if the flag is still inactive when the blocking condition is removed, the

denied interrupt will not be serviced. In other words, the fact that the interrupt flag was once active but not serviced is not remembered. Every polling cycle is new.

The processor acknowledges an interrupt request by executing a hardware generated LCALL to the appropriate service routine. The hardware generated LCALL pushes the contents of the Program Counter on to the stack (but it does not save the PSW) and reloads the PC with an address that depends on the source of the interrupt being vectored to as shown in Table 9-10.

Execution proceeds from that location until the RETI instruction is encountered. The RETI instruction informs the processor that the interrupt routine is no longer in progress, then pops the top two bytes from the stack and reloads the Program Counter. Execution of the interrupted program continues from where it left off.

Note that a simple RET instruction would also return execution to the interrupted program, but it would have left the interrupt control system thinking an interrupt was still in progress, making future interrupts impossible.

SOURCE	VECTOR ADDRESS
INT0	0003H
MD	004BH
Timer0	000BH
I2C	0043H
INT1	0013H
DDC	003BH
Timer1	001BH
VSYNC	0033H
Timer2	002BH

Table 9-10 Vector addresses

## 10. POWER-SAVING MODE

Two software selectable modes of reduced power consumption are implemented.

- Idle mode
- Power-down mode

The following functions are switched off when the microcontroller enters the Idle mode.

- CPU (halted)
- I2C interface (halted)
- PWM0 to PWM7 and DPWM0 to DPWM2 (reset, output = High)
- 8-bit ADC (aborted if conversion in progress)

The following functions remain active during Idle mode.

These functions may generate an interrupt or reset and thus terminate the Idle mode.

- Timer0, Timer1 and Timer2
- Watchdog timer
- DDC interface
- External interrupt
- Mode detection

In Power-down mode, the system clock is halted. Both the oscillator will be stopped after setting the bit PD in PCON.

### 10.1 Power control register

The modes Idle and Power-down are activated by software via the PCON register.

7	6	5	4	3	2	2	0
-	-	LVREN	LVRLS	GF1	GF0	PD	IDL

**Table 10-1 Power control Register(PCON:87H) RESET VALUE:xx000000B**

BIT	SYMBOL	FUNCTION
7 to 6	-	Not used
5	LVREN	Enable low voltage reset
4	LVRLS	Select low VDD level ; 3.7V or 3.5V
3	GF1	General purpose flag bit
2	GF0	General purpose flag bit
1	PD	Activate Power-down mode
0	IDL	Activate Idle mode

**Table 10-2 Description of the PCON bits**

MODE	MEMORY	PORT0-3	SYNC	PWM	I2C	DDC	-	-
Idle	Intenal	Data	on	High	High-Z	on	-	-
Power-down	Intenal	Data	High	High	High-Z	High-Z	-	-

**Table 10-3 External Pin Status During Idle and Power-down modes**

## 10.2 Idle mode

The instruction that sets PCON.0 is the last instruction executed in the normal operating mode before idle mode is activated. Once in the idle mode, the CPU status is preserved in its entirety : Stack pointer, Program counter, Program status word, Accumulator, RAM and All other registers maintain their data during idle mode.

There are three ways to terminate the idle mode.

- Activation of any enabled interrupt X0, T0, X1, T1 etc. will cause PCON.0 to be cleared by hardware terminating Idle

## 10.3 Power-down mode

The instruction that sets PCON.1 is the last executed prior to going into the Power-down mode. Once in Power-down mode, the oscillator is stopped. The contents of the on-chip RAM and the Special Function Register are preserved.

mode. The interrupt is serviced, and following return from interrupt instruction RETI, the next instruction to be executed will be the one which follows the instruction that wrote a logic 1 to PCON.0.

- External hardware reset : the hardware reset is required to be active for two machine cycle to complete the reset operation.
- Internal watchdog reset : the microcontroller restarts after 3 machine cycles in all cases.

The power-down mode can be terminated by an external RESET in the same way as in the 80C51 (but SFRs are cleared due to RESET).

## 11. I/O PORTS

The HMS9xC7132 has four 8-bit ports (Port0, Port1, Port2 and Port3). Port0 - Port3 are the same as in the 80C51, with the exception of the additional functions of Port1, Port2 and Port3. All ports are bidirectional and Pins of which the alternative function is not used may be used as normal bidirectional I/Os except Port3.2, Port3.3 and Port3.5 (These Pins can be only used as the output).

The use of Port1- Port3 pins as alternative functions are carried out automatically by the HMS9xC7132 provided the associated SFR bit is set HIGH. Port0 is the type of open-drain I/O. Port0.6 and Port0.7 have the capability to drive LED.

Fig. 11.1 shows the port structure.

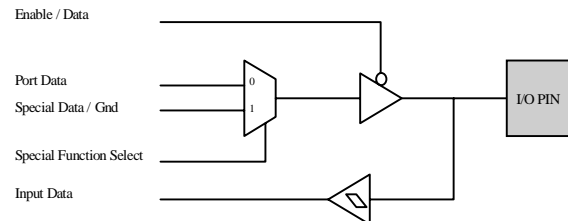


Figure 11-1 Standard output with the open-drain port

The alternative function for Port1, Port2 and Port3 can be described as follows.

- Port 0 : No alternative function.
- Port 1 : P1.0 is combined with the SCL1 interface line(open-drain)
  - P1.1 is combined with the SDA1 interface line (open-drain)
  - P1.2 is combined with the ACH0 interface line (high-z)
  - P1.3 is combined with the ACH1 interface line (high-z)
  - P1.4 is combined with the ACH2 interface line (high-z)
  - P1.5 is combined with the ACH3 interface line (high-z)
  - P1.6 is combined with the SCL2 interface line (open-drain)
  - P1.7 is combined with the SDA2 interface line (open-drain)
- Port 2 : P2.0 is combined with the dynamic PWM0 interface line(open-drain or push-pull)
  - P2.1 is combined with the dynamic PWM1 interface line (open-drain or push-pull)
  - P2.2 is combined with the static PWM0 interface line (open-drain or push-pull)
  - P2.3 is combined with the static PWM1 interface line (open-drain or push-pull)
  - P2.4 is combined with the static PWM2 interface line (open-drain or push-pull)
  - P2.5 is combined with the static PWM3 interface line (open-drain or push-pull)
  - P2.6 is combined with the static PWM4 interface line (open-drain or push-pull)
  - P2.7 is combined with the static PWM5 interface line (open-drain or push-pull)
- Port 3 : P3.0 has not alternative function.
  - P3.1 has not alternative function.
  - P3.2 is combined with the HSYNCout interface line (push-pull)
  - P3.3 is combined with the VSYNCout interface line (push-pull)
  - P3.4 is combined with the PWM6 interface line (open-drain or push-pull)
  - P3.5 is combined with the CLAMP or PWM7 interface line (push-pull)
  - P3.6 is combined with the PATOUT interface line (push-pull)
  - P3.7 is combined with the SOG interface line (pull-up)

## 11.1 Pin function selection

### Special function selection Registers(PxSFS)

Several SFR(P1SFS/P2SFS/P3SFS)s are used to select the port-function or the alternative function of the external pin.

- P1SFS(Port1 special function selection register)

7	6	5	4	3	2	2	0
P1SFS7	P1SFS6	P1SFS5	P1SFS4	P1SFS3	P1SFS2	P1SFS1	P1SFS0

**Table 11-1 P1SFS bits(91H)**

BIT	SYMBOL	FUNCTION	RESET
7	P1SFS7	The selection of the pin function. 0 : pin 9 has P1.7 function. 1 : pin 9 has SDA2 function.	0
6	P1SFS6	The selection of the pin function. 0 : pin 10 has P1.6 function. 1 : pin 10 has SCL2 out function.	0
5	P1SFS5	The selection of the pin function. 0 : pin 20 has P1.5 function. 1 : pin 20 has ACH3 out function.	0
4	P1SFS4	The selection of the pin function. 0 : pin 21 has P1.4 function. 1 : pin 21 has ACH2 out function.	0
3	P1SFS3	The selection of the pin function. 0 : pin 22 has P1.3 function. 1 : pin 22 has ACH1 out function.	0
2	P1SFS2	The selection of the pin function. 0 : pin 23 has P1.2 function. 1 : pin 23 has ACH0 out function.	0
1	P1SFS1	The selection of the pin function. 0 : pin 24 has P1.1 function. 1 : pin 24 has SDA1 out function.	0
0	P1SFS0	The selection of the pin function. 0 : pin 25 has P1.0 function. 1 : pin 25 has SCL1 out function.	0

**Table 11-2 Description of the P1SFS bits**

- P2SFS(Port2 special function selection register)

7	6	5	4	3	2	2	0
P2SFS7	P2SFS6	P2SFS5	P2SFS4	P2SFS3	P2SFS2	P2SFS1	P2SFS0

Table 11-3 P2SFS bits(92H)

BIT	SYMBOL	FUNCTION	RESET
7	P2SFS7	The selection of the pin function. 0 : pin 34 has P2.7 function. 1 : pin 34 has PWM5 function.	0
6	P2SFS6	The selection of the pin function. 0 : pin 35 has P2.6 function. 1 : pin 35 has PWM4 out function.	0
5	P2SFS5	The selection of the pin function. 0 : pin 36 has P2.5 function. 1 : pin 36 has PWM3 out function.	0
4	P2SFS4	The selection of the pin function. 0 : pin 37 has P2.4 function. 1 : pin 37 has PWM2 out function.	0
3	P2SFS3	The selection of the pin function. 0 : pin 38 has P2.3 function. 1 : pin 38 has PWM1 out function.	0
2	P2SFS2	The selection of the pin function. 0 : pin 1 has P2.2 function. 1 : pin 1 has PWM0 out function.	0
1	P2SFS1	The selection of the pin function. 0 : pin 2 has P2.1 function. 1 : pin 2 has DPWM1 out function.	0
0	P2SFS0	The selection of the pin function. 0 : pin 3 has P2.0 function. 1 : pin 3 has DPWM0 out function.	0

Table 11-4 Description of the P2SFS bits

- P3SFS(Port3 special function selection register)

7	6	5	4	3	2	2	0
P3SFS7	P3SFS6	P3SFS5	P3SFS4	P3SFS3	P3SFS2	P3SFS1	P3SFS0

**Table 11-5 P3SFS bits(93H)**

BIT	SYMBOL	FUNCTION	RESET
7	P3SFS7	The selection of the pin function. 0 : pin 28 has P3.7 function. 1 : pin 28 has SOG input function.	0
6	P3SFS6	The selection of the pin function. 0 : pin 29 has P3.6 function. 1 : pin 29 has PATOUT out function.	0
5	P3SFS5	The selection of the pin function. 0 : pin 30 has P3.5 function. 1 : pin 30 has CLAMP or PWM7 out function.	0
4	P3SFS4	The selection of the pin function. 0 : pin 31 has P3.4 function. 1 : pin 31 has PWM6 out function.	0
3	P3SFS3	The selection of the pin function. 0 : pin 32 has P3.3 function. 1 : pin 32 has VSYNCout function.	0
2	P3SFS2	The selection of the pin function. 0 : pin 33 has P3.2 function. 1 : pin 33 has VSYNCout function.	0
1	P3SFS1	The selection of the pin function. reserved	0
0	P3SFS0	The selection of the pin function. reserved	0

**Table 11-6 Description of the P3SFS bits**

12. OSCIALLTOR

The oscillator circuit of the HMS9xC7132 is a single stage invert- ing amplifier in a Pierce oscillator configuration. The circuitry between XTAL1 and XTAL2 is basically an inverter biased to the transfer point. Either a crystal or ceramic resonator can be used as the feedback element to complete the oscillator circuit. Both are operated in parallel resonance.

XTAL1 is the high gain amplifier input, and XTAL2 is the out- put. To drive the HMS9xC7132 externally, XTAL1 is driven

from an external source and XTAL2 left open-circuit.

Main clock	Minimum instruction cycle time (ex:NOP ; f <sub>ex</sub> 12clock is needed)
12MHz	1uS

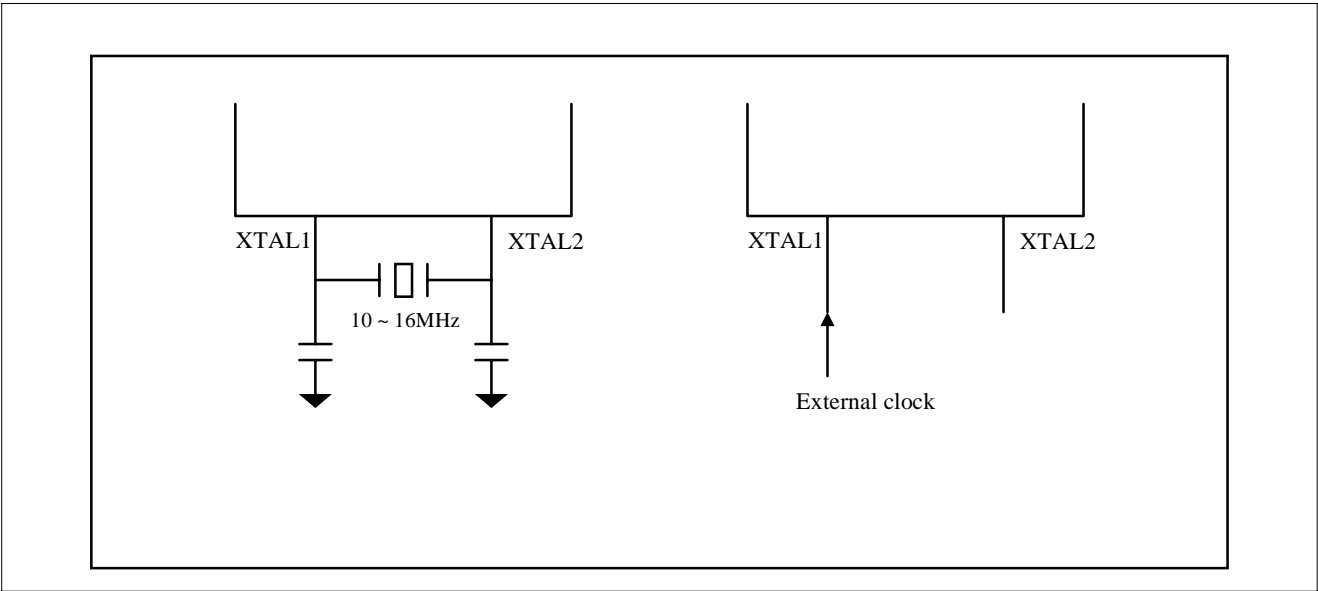
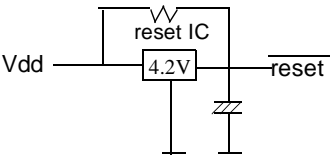
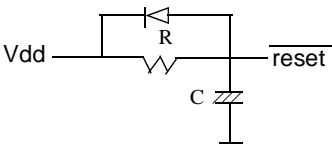


Figure 12-1 Oscillator configuration

ideal



standard; R=10KΩ C=10uF (Recommanded)





## 13. RESET

There are three ways to invoke a reset and initialize the HMS9xC7132.

Via the external RESET pin

Via the Watchdog Timer overflow

Via low VDD voltage reset

Each reset source will cause an internal reset signal active. The CPU responds by executing an internal reset and puts the internal registers in a defined state.

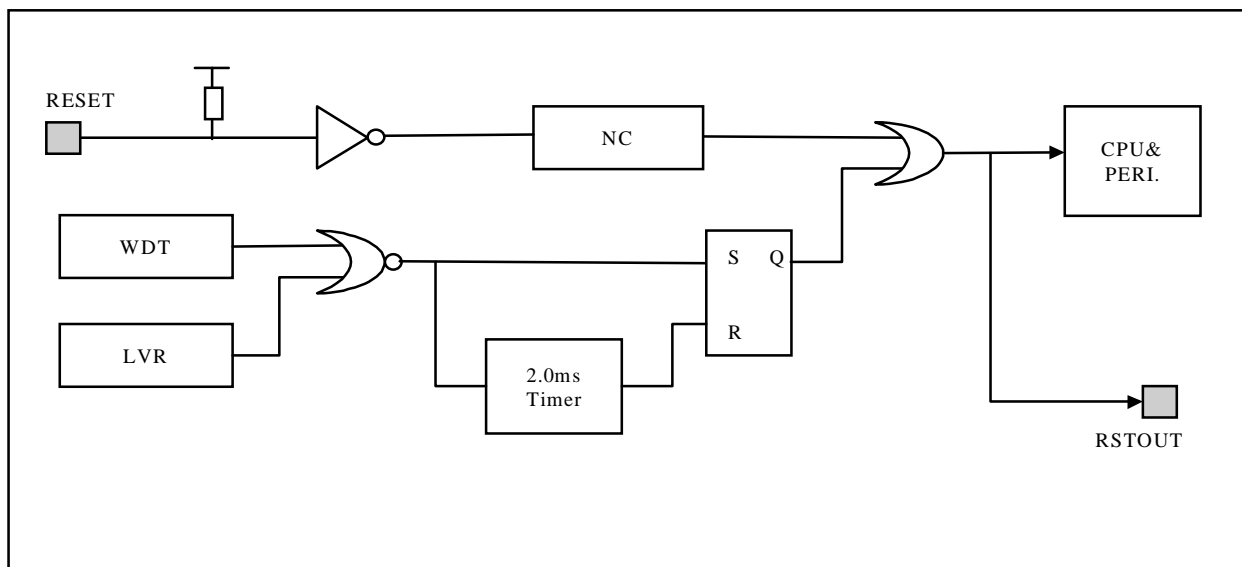


Figure 13-1 The reset mechanism

### 13.1 External reset

The reset pin RESET is connected to a Schmitt trigger for noise reduction. A reset is accomplished by holding the RESET pin LOW for at least 2 machine cycles (24 system clock), while the oscillator is running.

An automatic reset can be obtained by switching on VDD, if the

RESET pin is connected to GND via a capacitor and to the VDD via resistor. The capacitor should be at least 10uF.

The increase of the RESET pin voltage depends on the capacitor. The voltage must remain below the higher threshold for at minimum the oscillator start-up time plus 2 machine cycles.

### 13.2 Watchdog timer overflow

The length of the output pulse from the WDT is over 2048 machine cycles. In chapter 14, the watchdog timer is described in more detail.

### 13.3 Low VDD voltage reset

When VDD is below 3.7V, the built-in low voltage detector generates an internal reset signals. The reset signal will be LOW during 2ms @ 12MHz after the voltage is higher than 3.7V.

## 14. WATCHDOG TIMER

The hardware watchdog timer (WDT) resets the HMS9xC7132 when it overflows. The WDT is intended as a recovery method in situations where the CPU may be subjected to a software upset. To prevent a system reset the timer must be reloaded in time by the application software. If the processor suffers a hardware/software malfunction, the software will fail to reload the timer. This failure will result in a reset upon overflow thus preventing the processor running out of control.

In the idle mode the watchdog timer and reset circuitry remain active. The WDT consists of a 19-bit counter, the watchdog timer reset(WDTRST) SFR and watchdog key register(WDTKEY). Since the WDT is automatically enabled while the processor is running, the user only needs to be concerned with servicing it. The 19-bit counter overflows when it reaches 524288(3FFFH). The WDT increments once every machine cycle.

This means the user must reset the WDT at least every 524288 machine cycles (524ms @12MHz). To reset the WDT the user must write 01EH and then 0E1H to WDTRST. WDTRST is a write only register. The WDT count cannot be read or written.

The watchdog timer is controlled by the watchdog key register, WDTKEY. Only pattern 01010101(=55H), disables the watchdog timer. The rest of pattern combinations will keep the watchdog timer enabled. This security key will prevent the watchdog timer from being terminated abnormally when the function of the watchdog timer is needed.

In Idle mode, the oscillator continues to run. To prevent the WDT from resetting the processor while in Idle, the user should always set up a timer that will periodically exit Idle, service the WDT, and re-enter Idle mode.

7	6	5	4	3	2	2	0
WDTKEY7	WDTKEY6	WDTKEY5	WDTKEY4	WDTKEY3	WDTKEY2	WDTKEY1	WDTKEY0

**Table 14-1 Watchdog timer key register (WDTKEY : 0AEH)      RESET VALUE:00000000B**

BIT	SYMBOL	FUNCTION
7 to 0	WDTKEY7 to WDTKEY0	Enable or disable watchdog timer. 01010101(=55H) : disable watchdog timer. others : enable watchdog timer.

**Table 14-2 Description of the WDTKEY bits**

7	6	5	4	3	2	2	0
WDTRST7	WDTRST6	WDTRST5	WDTRST4	WDTRST3	WDTRST2	WDTRST1	WDTRST0

**Table 14-3 Watchdog timer clear register (WDTRST : 0A6H)      RESET VALUE:00000000B**

BIT	SYMBOL	FUNCTION
7 to 0	WDTKEY7 to WDTKEY0	Enable or disable watchdog timer. 01010101(=55H) : disable watchdog timer. others : enable watchdog timer.

**Table 14-4 Description of the WDTRST bits**

Example Program; Watch Dog Timer

Reset & WDT\_refresh Part

Reset:

```
clr    EA
mov    PSW, #00
mov    SP, #STACK_DATA;
mov    WDTKEY, #55h ; Watchdog stop
```

WDT\_refresh:

```
mov    WDTRST, #1Eh ; Watchdog timer reset
mov    WDTRST, #0E1h ; Watchdog timer reset
mov    WDTKEY, #0F0h ; Watchdog start
ret
```

### 15. TIMER

HMS9xC7132 has two 16-bit timers/counters (Timer0, Timer1) to be placed in 80C51 core and one 16-bit auto-reload timer(Timer2) for dynamic PWM.

#### 15.1 Timer0 and Timer1

The external input pin that the Timer/Counter0 and Timer/Counter1 in 80C51 core have is eliminated. In the timer function, timer register is incremented every machine cycle. Thus, you can think of it as counting machinecycles. Since a machine cycle consists of 12 oscillator periods, the count rate is 1/12 of the oscilla-

tor frequency.

Timer 0, Timer 1 have four operating modes. These modes is selected by bit-pairs(M1, M0) in TMOD.

7	6	5	4	3	2	2	0
GATE	C/T	M1	M0	GATE	C/T	M1	M0

**Table 15-1 Timer Mode Control register(TMOD)**

**RESET VALUE:0000000B**

BIT	SYMBOL	FUNCTION
7,3	GATE	Gating control when set. Timer "x" is enabled only while "INTx" pin is high and "TRx" control bit is set. When cleared Timer"x" is enabled whenever "TRx"control bit is set.
6,2	C/T	Timer or Counter selector 0 : Timer 1 : Counter, not supported.
7 to 0	M1, M0  0, 0 0, 1 1, 0 1, 1	Operating modes  8-bit Timer "THx" with "TLx" as 5-bit prescaler 16-bit Timer "THx" and "TLx" are cascaded : there is no prescaler 8-bit auto-reload Timer "THx" holds a value which is to be reloaded into "TLx" each time it overflows. Timer0 : TL0 is an 8-bit Timer controlled by the standard Timer 0 control bit. : TH0 is an 8-bit timer only controlled by Timer 1 control bit. Timer1 : Timer 1 stopped.

**Table 15-2 Description of the TMOD bits**

7	6	5	4	3	2	2	0
TF1	TR1	TF0	TR0	IE1	IT1	IE0	IT0

Table 15-3 Timer Control register(TCON)

RESET VALUE:0000000B

BIT	SYMBOL	FUNCTION
7	TF1	Timer1 overflow flag. Set by hardware on Timer overflow. Cleared by hardware when processor vectors to interrupt routine.
6	TR1	Timer1 run control bit. Set/cleared by software to turn Timer on/off .
5	TF0	Timer0 overflow flag. Set by hardware on Timer overflow. Cleared by hardware when processor vectors to interrupt routine.
4	TR0	Timer0 run control bit. Set/cleared by software to turn Timer on/off .
3	IE1	Interrupt1 edge flag. Set by hardware when external interrupt edge detected. Cleared when interrupt processed.
2	IT1	Interrupt1 type control bit. Set/cleared by software to specified falling edge/low level triggered external interrupts.
1	IE0	Interrupt0 edge flag. Set by hardware when external interrupt edge detected. Cleared when interrupt processed.
0	IT0	Interrupt0 type control bit. Set/cleared by software to specified falling edge/low level triggered external interrupts.

Table 15-4 Description of the TCON bits

## 15.2 TIMER2

Timer2 is a 16-bit auto-reload timer. The 16-bit capture mode, baud rate generation mode and an event counter function that the Timer/Counter2 in 80C52 core has are eliminated. Since the clock of this timer comes from the system oscillator, Timer2 can be used to count a time period more accurately comparing with Timer0 and Timer1, but the longest period is limited as  $65536 \times (tOSC/2)$ .

The interval between interrupt =

$$65536 \times (2 \times tOSC) - (RC2H \times 256 + RC2L) \times (2 \times tOSC)$$

The maximum interrupt period =

$$65536 \times (2 \times tOSC)$$

7	6	5	4	3	2	2	0
TF2	-	-	-	-	TR2	-	-

Table 15-5 Timer2 control register (T2CON : 0C8H)

RESET VALUE:0xxxx0xxB

BIT	SYMBOL	FUNCTION
7	TF2	Timer2 overflow flag. Set by hardware on Timer overflow. Must be cleared by software.
6 to 3	-	Reserved
2	TR2	Timer2 run control bit. set/cleared by software to turn Timer on/off.
1 to 0	TR0	Reserved

Table 15-6 Description of the TCON bits

7	6	5	4	3	2	2	0
RC2H7	RC2H6	RC2H5	RC2H4	RC2H3	RC2H2	RC2H1	RC2H0

**Table 15-7 Reload/Capture high register (RC2H : 0CBH)**

**RESET VALUE:00000000B**

BIT	SYMBOL	FUNCTION
7 to 0	RC2H7 to RC2H0	Reload low register bit7 to bit0

7	6	5	4	3	2	2	0
RC2L7	RC2L6	RC2L5	RC2L4	RC2L3	RC2L2	RC2L1	RC2L0

**Table 15-8 Reload/Capture low register (RC2L : 0CAH)**

**RESET VALUE:00000000B**

BIT	SYMBOL	FUNCTION
7 to 0	RC2L7 to RC2L0	Reload low register bit7 to bit0

### Example Program; Timer

#### Initial & Timer1 Interrupt part

initial:

```
; mov IP, #00h; Interrupt Priority
mov PCON, #00;
mov TCON, #01010000B; T1, T0 enable
mov TMOD, #00010001B; 16 bit timer set
mov IE, #11001000B; Global En(7), Vsync(6), Timer1(3)
```

T1\_Isr:

```
push PSW; PSW
push DPH; DPTR
push DPL;
push ACC; A
push 00h; R0
push 01h; R1
push 02h; R2
mov TH1, #0F0h; F060h to Generate 4mSec
mov TL1, #60h;
```

## 16. DDC INTERFACE

The monitor typically includes a number of user controls to set picture size, position, color balance, brightness and contrast. Furthermore, to optimize some internal setting for different display modes, the timing characteristics should be acquired by the control side. In these days, it is getting popular for these controls to go to PC host. Therefore the communication between monitor and host becomes issue. DDC1, DDC2B, DDC2B+, and DDC2AB (ACCESS.bus) emerge as a standard for monitor inter-

face. A transmitter clocked by incoming VSYNC is dedicated for DDC1 operation. An I2C interface hardware logic forms the kernel of DDC2B, DDC2B+, and DDC2AB. An address pointer, with post increment capability is employed to serve DDC1, DDC2B, DDC2B+ and DDC2AB modes.

The conceptual block diagram is illustrated in Fig. 16.1

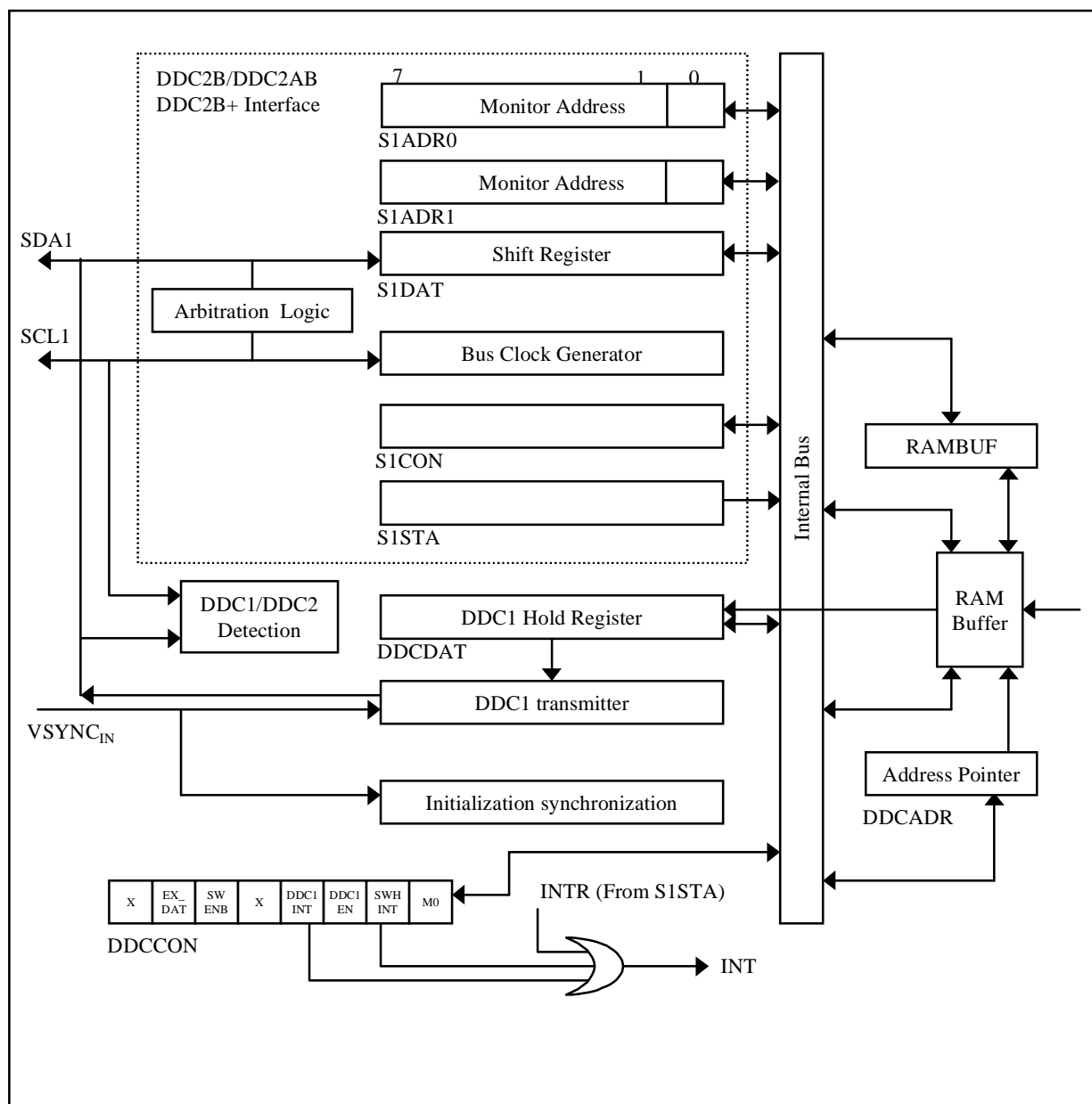


Figure 16-1 DDC Interface block diagram

## 16.1 The Special Function register for DDC Interface.

Eight SFR : S1CON, S1STA, S1DAT, S1ADR, RAMBUF, DDCCON, DDCADR, DDCDAT.

S1CON, S1STA, S1DAT, S1ADR are just the copies of the corresponding registers in general I2C-bus interface.

7	6	5	4	3	2	2	0
-	EX_DAT	SWENB	-	DDCINT	DDC1EN	SWHINT	M0

**Table 16-1 DDC mode status and DDC1 control register (DDCCON : 0D7H)**

**RESET VALUE:x00x0000B**

BIT	SYMBOL	FUNCTION
7	-	Reserved
6	EX_DAT (R/W)	This bit defines the size of the EDID data. It is related to the function of the post increment of the address pointer, DDCADR. When the upper limit is reached, the DDCADR will wrap around to 00H. If EX_DAT is 1: The data size is 256 byte. 0: The data size is 128 byte(The addressing range for the EDID data buffer is mapped from 0 to 127 ; the rest, 128 to 255 , can still be used by the system).
5	SWENB (R/W)	This bit indicates if the software/CPU is needed to take care of the operation of DDC1 protocol. If SWENB is 1 : In DDC1 protocol, CPU is interrupted during the period of the 9th transmitting bit so that the S/W service routine can update the hold register of transmitter by moving new data from appropriate area(it is not necessary to be the RAM buffer which is pointed by DDCADR) to the register DDCDAT. This transmitting must be done within 40us. 0 : The hold register of the transmitter will be automatically updated from the RAM buffer without the intervention of CPU.
4	-	Reserved
3	DDC1INT (R/W)	Interrupt Request Bit. This bit is only valid in DDC1 protocol while S/W handling is enabled. This bit is set by H/W and should be cleared by S/W in interrupt service routine. 1 : Interrupt request is pending. 0 : No interrupt request
2	DDC1EN (R/W)	DDC1 enable control bit. If DDC1EN is 1 : DDC1 is enabled. 0 : DDC1 is disabled ; The activity on VSYNC is ignored.
1	SWHINT (R/W)	Interrupt Request Bit. This bit is set by H/W when DDC interface switches from DDC1 to DDC2 (i.e. The voltage transient from high to low is observed on SCL1 pin). This bit should be cleared by S/W in interrupt service routine. 1 : Interrupt request is pending. 0 : No interrupt request
0	M0 (R/W)	DDC mode indication bit. This bit will be set by H/W when the voltage transient from high to low is observed on SCL1 pin. Once mode changes into DDC2 mode, the mode is reserved until power is off. 0: DDC1 is set. 1: DDC2 is set.

**Table 16-2 Description of the DDCCON bits**

DDC1 DATA register for transmission (**DDCDAT** : 0D5H)

- 8bit read and write register.
- Indicates DATA BYTE to be transmitted in DDC1 protocol.

Address pointer for DDC interface (**DDCADR** : 0D6H)

- 8bit read and write register.
- Address pointer with the capability of the post increment. After each access to RAMBUF register(either by software or by hardware DDC1 interface), the content of this register will be increased by one. It's available-

both in DDC1, DDC2 (DDC2B, DDC2B+, and DDC2AB) and system operation.

Host type detection

The detection procedure conforms to the sequences proposed by VESA Monitor Display Data Channel(DDC) specification. The monitor needs to determine the type of host system:

- DDC1 or OLD type host.
- DDC2B host (Host is master, monitor is always slave)
- DDC2B+/DDC2AB(ACCESS.bus) host.



The monitor where HMS9xC7132 resides is always both DDC1 and DDC2 capable with DDC2 having the higher priority. The display shall start transmitting DDC1 signals whenever it is powered on and the vertical sync signal is applied to it from the host for the first time. The display shall switch to DDC2 within 3 system clocks as soon as it sees a high to low transition on the clockline(SCL), indicating that there are DDC2 devices connected to the bus. Under that condition, the mode flag, M0 will be changed from the default setting 0, to 1. Accordingly, the interrupt will be invoked by setting flag, SWHINT as high.

Fig. 16.2 illustrates the concept and interaction between the monitor and the host. After power on, the DDC1EN bit is set by S/W to act as a DDC1 device. Therefore, the mode flag, M0, is set as 0. Following VSYNC as clock, the monitor will transmit EDID data stream to the host. However, if DDC2 clock, SCL clock, is present, the monitor will be switched to DDC2B device with the mode flag setting as 1. Software will judge it is a DDC2B, DDC2B+, or DDC2AB protocol.

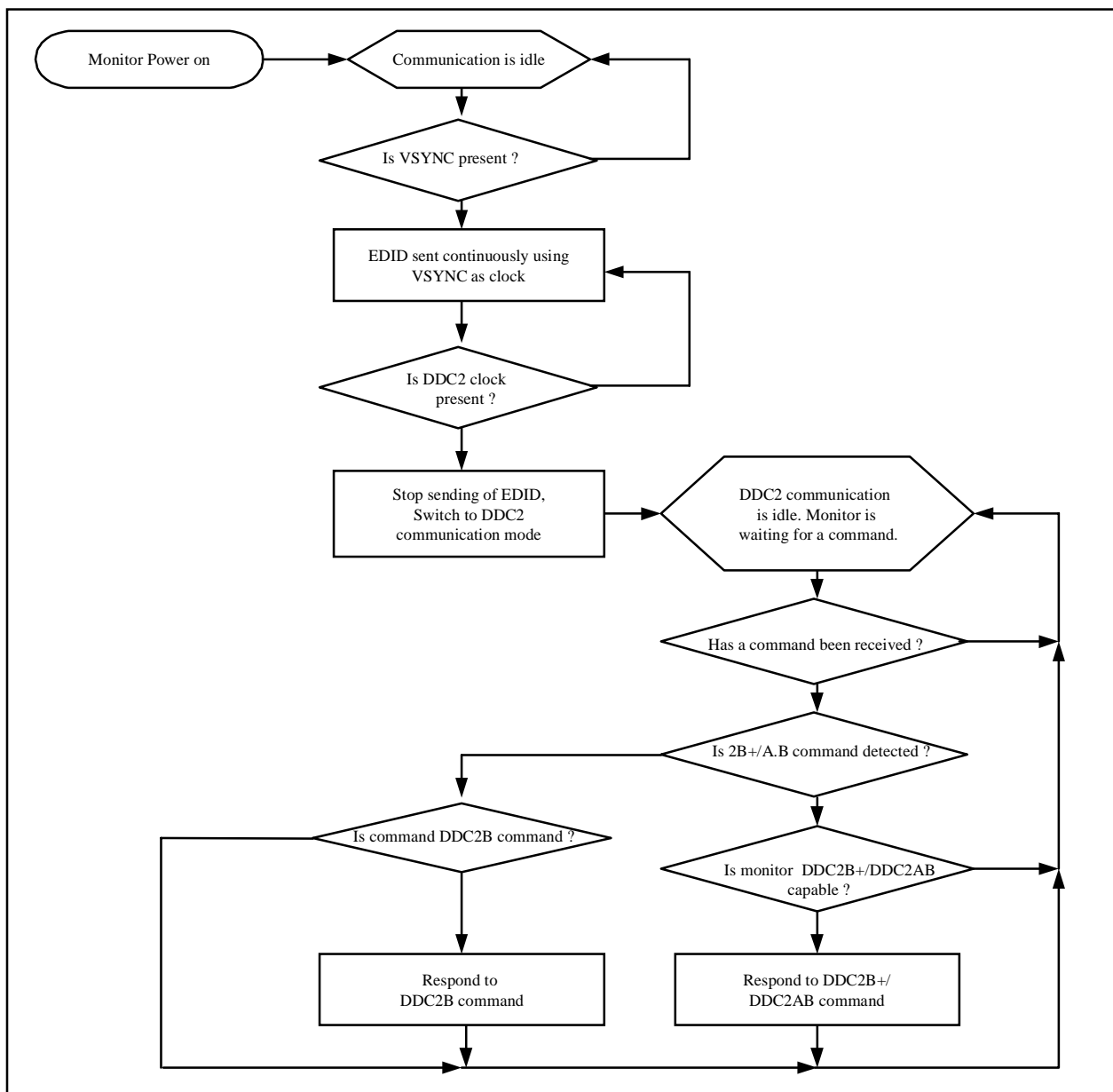


Figure 16-2 Host type detection

## 16.2 DDC1 protocol

DDC1 is primitive and a point to point interface. The monitor is always put at "Transmit only" mode. In the initialization phase, 9 clock cycles on VSYNC pin will be given for the internal synchronization. During this period, the SDA pin will be kept at high impedance state.

If DDC1 hardware mode is used, the following procedure is recommended to proceed DDC1 operation.

Step1 : Reset DDC1EN (by default, DDC1EN is cleared as low after power on reset).

Step2 : Set SWENB as high (the default value is zero.)

Step3 : Depending on the data size of EDID data, set EX\_DAT as low (128 bytes) or high (256 bytes).

Step4 : By using bulky moving commands (DDCADR, RAMBUF involved) to move the entire EDID data to RAM buffer.

Step5 : Reset SWENB to low.

Step6 : Reset DDCADR to 00H.

Step7 : Set DDC1EN as high.

In case SWENB is set as high, interrupt service routine must be finished within 40 machine cycles in 12 MHz system clock.

Note : If EX\_DAT equals to low, it is meant the lower part is occupied by DDC1 operation and the upper part is still free to the system. Nevertheless, the effect of the post increment just applies to the part related to DDC1 operation.

In other words, the system program is still able to address the locations from 128 to 255 in the RAM buffer through MOVX command but without the facility of the post increment.

ex) In case of accessing 200 of the RAM Buffer.

```
MOV R0, #200
MOVX A, @R0
```

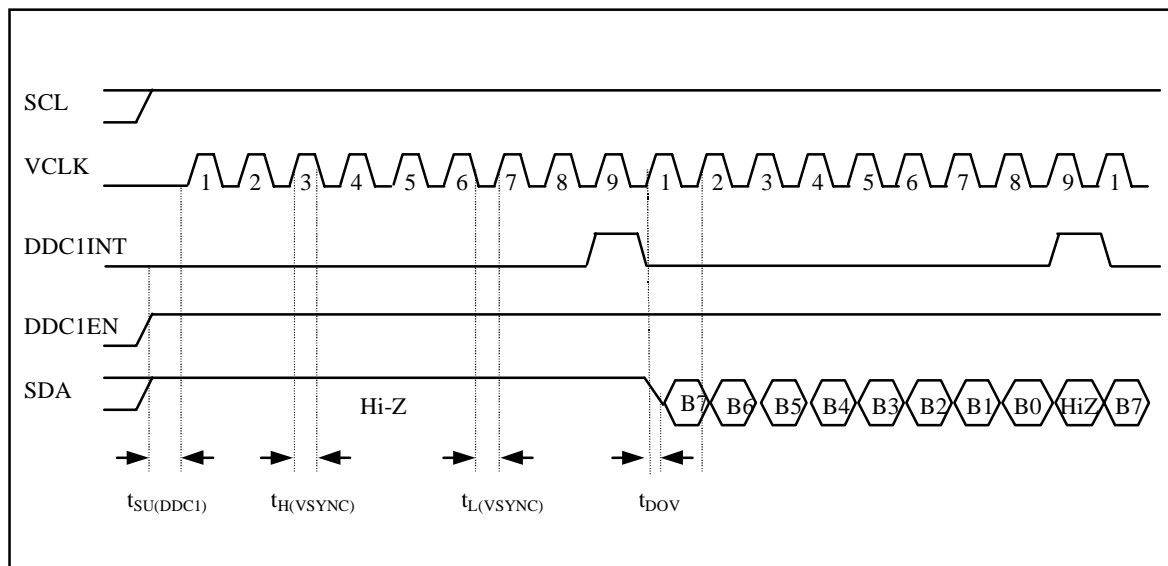


Figure 16-3 Transmission protocol in DDC1 interface.

## 16.3 DDC2B protocol

DDC2B is constructed base on Philips I2C interface. However, in the level of DDC2B, PC host is fixed as the master and the monitor is always regarded as the slave. Both master and slave can be operated as a transmitter or receiver, but the master device determines which mode is activated. In this protocol, address pointer is also used.

According to DDC2B specification, A0 (for write mode) and A1 (for read mode) are assigned as the default address of moni-

tors.

The reception of the incoming data in write mode or the updating of the outgoing data in read mode should be finished within the specified time limit. If software in the slave's side cannot react to the master in time, based on I2C protocol, SCL pin can be stretched low to inhibit the further action from the master. The transaction can be proceeded in either byte or burst format.

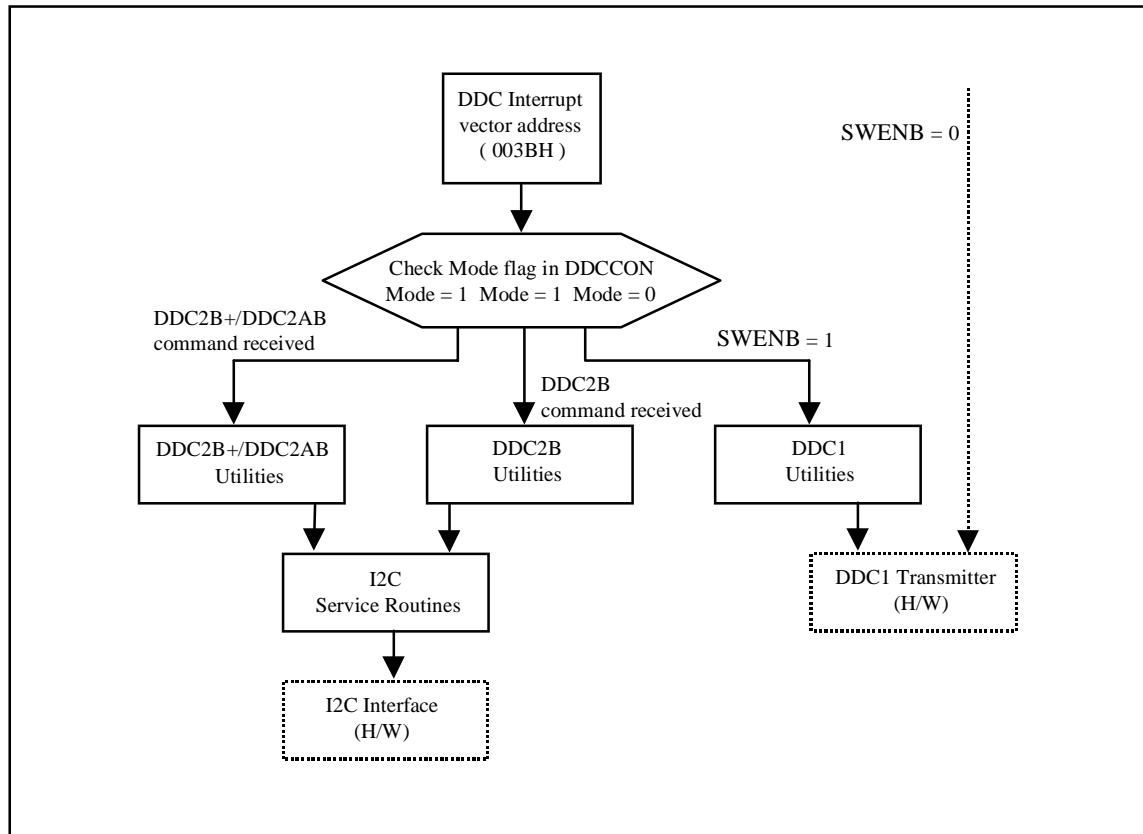


Figure 16-4 The conceptual structure of DDC Interface

## 16.4 DDC2AB/DDC2B+ protocol

DDC2AB/DDC2B+ is a superset of DDC2B. Monitors that implement DDC2AB/DDC2B+ are full featured ACCESS.bus devices. Monitor that implement DDC2B+ uses the same command set as DDC2AB but cannot use Access.bus device.

Essentially, they are similar to DDC2B. I2C interface forms the fundamental layer for both protocols. The default address for monitors is assigned as 6EH other than A0/A1H in DDC2B. Monitors and hosts can play both the roles of master and slave. Under this kind of protocol, it is easy to extend the support for hosts to read VDI(VESA Video Display Information Format) and remotely control monitor functions.

Command / Information sequence between host and monitor must conform to the specification of ACCESS.bus. Timing rules specified in ACCESS.bus such as maximum response time to RESET message(< 250 ms) from host, maximum time to hold SCL low(< 2ms) etc. can be satisfied through software check and built-in timers such as Timer0, Timer1.

In DDC2AB/DDC2B+, monitor itself can act as a monitor to activate the transaction. The default address assigned for host is 50H.

## 16.5 The RAM Buffer and DDC application

RAM Buffer (RAMBUF) : the RAM buffer can be shared as the system RAM or DDC RAM buffer.

MODE	EX_DAT	SWENB	XRAM : 0 to 127	XRAM : 128 to 255
DDC1	0	0	Normally reserved for DDC1 EDID data (Note 1, Note 2, Note 3)	Available for the system access. (Note 2)
	1	0	Normally reserved for DDC1 EDID data (Note 1, Note 2)	Normally reserved for DDC1 EDID data. (Note 1, Note 2, Note 4)
	0	1	Normally reserved for DDC1 EDID data (Note 3, Note 5)	Available for the system access.
	1	1	Normally reserved for DDC1 EDID data (Note 5)	Normally reserved for DDC1 EDID data. (Note 4, Note 5)
DDC2	0	1	Normally reserved for DDC2 EDID data (Note 3)	Available for the system access.
	1	1	Normally reserved for DDC2 EDID data	Normally reserved for DDC2 EDID data. (Note 4)

**Table 16-3 Description of the EX\_DAT and SWENB**

Note

1. READ/WRITE through MOVX instruction might conflict with the access from DDC1 hardware. So, the access from CPU by using MOVX instruction is forbidden.
2. READ/WRITE through DDCADR and RAMBUF registers has the conflicting problem also. Even the content of DDCADR, which should be employed by DDC1 hardware, will be damaged. So, it is inhibited to use this type of access.
3. If DDCADR reaches 127, it will automatically wrap around to 0 after the access is done.
4. If DDCADR reaches 255, it will automatically wrap around to 0 after the access is done.
5. The access conflicting can be avoided because DDC1 access is done by the interrupt service routine. However, the EDID transferring from the RAM buffer should be finished within 40 us.

### Example Program; DDC Interface

#### Initial & Interrupt part

```

Initial:
mov     DDCCON,#01h           ; SWENB(0)
mov     DDCADR,#0             ;
mov     DDCCON,#00100100b     ; 128(6),DDC1_Int(5),DDC1_enable(1)
mov     S1CON,#47h            ; 100kHz(011),ENI1(1),ACK_enable(1)
mov     S1ADR0,#0A1h          ; DDC2B Slave address
mov     S1ADR1,#41h           ; Factory Alignment Host

=====
: DDC Interface 관련 주의사항
: 1. ISR 내에서 S1STA를 자주 읽으면 S1DAT가 깨진다.
: 2. ISR 수행 후 최종 S1CON을 반드시 Refresh할 필요는 없다.
: 3. Slaver Receive Address match될 때 S1DAT를 읽고 S1STA에
:    Dummy Data를 Writing한다. 이 후 Slave Receive에서는 무관하다.
=====
: task          : DDC interrupt Service
: input         : Control & Status Peripheral register
=====

DDC_Header:
db      00,0FFh,0FFh,0FFh,0FFh,0FFh,00

DDC_Isr:
push    PSW                  ;
push    DPH                  ;
push    DPL                  ;
push    ACC                  ;
push    00                   ;
push    01                   ;
mov     A, DDCCON             ;
anl     A, #00001000b         ; (1) DDC1INT request(bit3=1)?
jz      DDC2_svc              ;

=====
DDC1_mode:
mov     A, mIICFlag           ;
anl     A, #00000011b         ; bUserSoftDDC(1), bDDC1Enable(0)
cjne    A, #03h, DDC1Enable   ;
mov     A, #0FFh              ;
mov     DDCCDAT, A            ;
mov     DDC_Int_end           ;
ljmp

DDC1Enable:
mov     A, mDDCData           ;
mov     DDCCDAT, A            ;
mov     A, mDDCAddress         ;
cjne    A, #80h, DDC1_Svc     ;
mov     DDCCON, #01h          ; DDC1 Disable, DDC2 Mode

DDC1_Svc:
clr     C                     ;
subb    A, #8                  ;
jnc     NormalDDC1            ;
mov     DPTR, #DDC_Header     ;
mov     A, R0                  ;
movc    A, @A+DPTR             ;
sjmp    DDC1_Save             ;

NormalDDC1:
mov     A, #EDID_DATA         ;
add     A, R0                  ; data post
mov     R0, A                  ;
movx    A, @R0                 ;

DDC1_Save:
mov     DDCCDAT, A            ;
inc     mDDCAddress            ;
ljmp    DDC_Int_end           ;

=====
DDC2_svc:
mov     A, DDCCON             ;
anl     A, #00000010b         ; (2) SWHINT (SCLLow bit1=1) SCL activity ?
jz      DDC_I2C_svc           ;
mov     mDDCAddress, #00h     ; DDC1 Disable, DDC2 Mode
mov     DDCCON, #00000001b    ;

DDC_I2C_svc:
mov     A, S1STA               ; (3) i2C abnormal by G-call, Stop, Arbitration and no Acknowledge
mov     mI2C_status, A        ;
anl     A, #11000110b         ; 1 1 0 0 0 1 1 0
jnz     DDC_Abnormal           ; GC, STOP, INTR, TX_MODE, BUSY, BLOST, /ACK_REP, SLV
mov     A, S1CON               ;
anl     A, #00001000b         ; (4) Host address matched ?
jnz     ADDR_Match            ;
ljmp    DDC2B_svc             ; (5) 1 byte data access by DDC2B format

Addr_Match:
mov     DDCCON, #01h          ; DDC1 Disable, DDC2 Mode
setb    bI2C_Dir              ; TX
mov     A, S1DAT               ;
anl     A, #0FEh              ; LSB BIT MASKING
cjne    A, #60h, DDC2B_mode    ; 60h = Factory Host ?

```

```

Factory_mode:
    setb      bFactoryMode      ; Factory Alignment Host matched 40h
    setb      bService          ;
    mov       A, mI2C_status    ;
    anl       A, #10h           ;
    jz        Align_Add_Rx      ; Slave Receive command
    jmp       Align_I2C_Tx      ; Slave Transmit command

Align_Add_Rx:
    clr       bI2C_Dir          ; RX MCU <== Host
    mov       A, #0             ;
    mov       mIICBuffer+pSave, A ;
    mov       mIICBuffer+pRead, A ;
    mov       S1DAT, #0FFh      ; Dummy write
    mov       S1CON, #01000111b ; i2C enable, Ack out when own slave address in
    jmp       DDC_Int_end       ; Factory Slave Receive start

DDC2B_mode:
    clr       bFactoryMode      ; Factory Alignment Host matched
    cjne      A, #0A0h, DDC_Abnormal; A0h = DDC2B Host ?
    mov       A, mI2C_status    ;
    anl       A, #10h           ;
    jnz       DDC_I2C_Tx        ; Slave Transmit
    clr       bI2C_Dir          ;
    mov       S1DAT, #0FFh      ; Dummy write
    mov       S1CON, #01000111b ; i2C enable, Ack out when own slave address in
    jmp       DDC_Int_end       ; DDC Slave Receive start

;=====
DDC2B_svc:
    jb        bFactoryMode, Line_svc ; 1 byte data handling
    mov       A, mI2C_status    ;
    anl       A, #10h           ;
    jnz       DDC_I2C_Tx        ; Slave Transmit
    ;

DDC_I2C_Rx:
    mov       A, S1DAT          ; Slave-Receive
    mov       mDDCAddress, A    ; subaddress catch
    sjmp      DDC_I2C_ref       ;

DDC_I2C_Tx:
    mov       A, mDDCAddress    ; Slave Transmit
    anl       A, #7Fh           ;
    mov       R0, A             ;
    clr       C                 ;
    subb      A, #8             ;
    mov       A, R0             ;
    jnc       Tx_mode_svc       ;
    mov       DPTR, #DDC_Header ; Header load
    movc      A, @A+DPTR        ;
    sjmp      Tx_Mode_out       ;

Tx_mode_svc:
    add       A, #EDID_DATA     ; 0x80~0xFF
    mov       R0, A             ;
    movx      A, @R0            ;

Tx_Mode_out:
    mov       S1DAT, A          ; EDID data store at S1DAT
    inc       mDDCAddress       ;
    mov       S1CON, #47h       ; clear ADDR(bit3)11-15 edit
    mov       nI2C_Abn_Cnt, #80h ; no Ack within 128 mSec, P1SFS.1=port
    sjmp      DDC_Int_end       ;

;=====
DDC_Abnormal:
    mov       S1CON, #00000111b ; i2C enable, stop out, Ack out
    mov       nI2C_Abn_Cnt, #0   ; Initial hangup check counter
    mov       P1SFS, #00001111b ; normal I2C hardware interface
    ;
    clr       bFactoryMode      ;
    mov       DDCCON, #01h      ; SWENB(0)
    mov       DDCADR, #0        ;
    mov       DDCCON, #00100100b ; 128(6), DDC1_Int(5), DDC1_enable(1)
    mov       S1CON, #47h       ; 100kHz(011), EN1(1), ACK_enable(1)
    mov       S1ADR0, #0A1h     ; DDC2B Slave address
    mov       S1ADR1, #41h      ; Factory Alignment Host
    jnz       DDC_I2C_sTx       ;

DDC_I2C_sRx:
    mov       A, S1DAT          ; Receive
    sjmp      DDC_I2C_ref       ;

DDC_I2C_sTx:
    mov       S1DAT, #0FFh      ; Transmit
    sjmp      DDC_I2C_ref       ;

DDC_I2C_ref:
    mov       S1CON, #01000111b ; i2C enable, Ack out when own slave address in
    ;
;-----
DDC_Int_end:
    pop       01                ;
    pop       00                ;
    pop       ACC               ;
    pop       DPL               ;
    pop       DPH               ;
    pop       PSW               ;
    reti                          ;
;-----

```

## 17. I2C INTERFACE

In the Monitor MCU are two I2C interfaces implemented.

- The first one is used by the DDC protocols.
- The second one is dedicated for internal connection. With this one it's possible to control the video, deflection, convergence and some other functions of the monitor.

The serial port supports the twin line I2C-bus, consists of a data line(SDAx) and a clock line(SCLx).

- SDA1, SCL1 : the serial port line for DDC Protocol
- SDA2, SCL2 : the serial port line for Internal Connection

In both I2C interfaces, these lines also function as I/O port lines as follows.

- SDA1 / P1.1, SCL1 / P1.0, SDA2 / P1.7, SCL2 / P1.6

The system is unique because data transport, clock generation, address recognition and bus control arbitration are all controlled by hardware.

The I2C serial I/O has complete autonomy in byte handling and operates in 4 modes.

- Master transmitter
- Master receiver
- Slave transmitter
- Slave receiver

These functions are controlled by the SFRs.

- SxCON : the control of byte handling and the operation of 4 mode.
- SxSTA : the contents of its register may also be used as a vector to various service routines.
- SxDAT : data shift register.
- SxADR : slave address register. Slave address recognition is performed by On-Chip H/W.

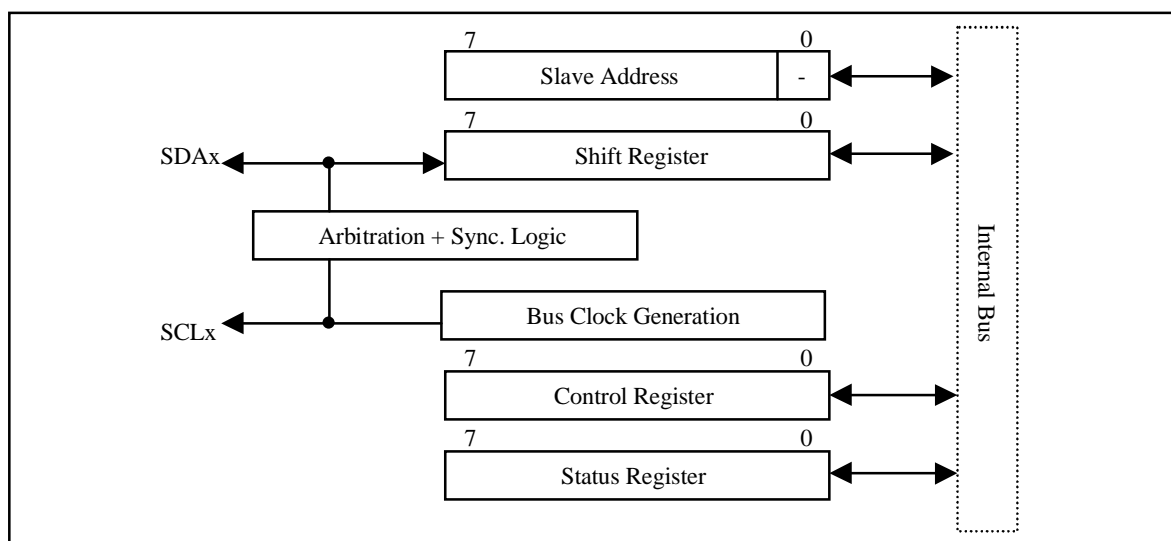


Figure 17-1 The block diagram of the I2C-bus serial I/O.

## 17.1 The Special Function register for I<sup>2</sup>C Interface.

### Serial Control Register(SXCON; S1CON, S2CON)

7	6	5	4	3	2	1	0
CR2	ENI1	STA	STO	ADDR	AA	CR1	CR0

**Table 17-1 Serial control register(SxCON; S1CON : 0D8H , S2CON : 0DCH)**

BIT	SYMBOL	FUNCTION
7	CR2	This bit along with bits CR1 and CR0 determines the serial clock frequency when SIO is in the Master mode.
6	ENI1	Enable IIC. When ENI1 = 0, the IIC is disabled. SDA and SCL outputs are in the high impedance state.
5	STA	START flag. When this bit is set, the SIO H/W checks the status of the I2C-bus and generates a START condition if the bus free. If the bus is busy, the SIO will generate a repeated START condition when this bit is set.
4	STO	STOP flag. With this bit set while in Master mode a STOP condition is generated. When a STOP condition is detected on the I2C-bus, the SIO hardware clears the STO flag.
3	ADDR	This bit is set when address byte was received. Must be cleared by software.
2	AA	Acknowledge enable signal. If this bit is set, an acknowledge(low level to SDA) is returned during the acknowledge clock pulse on the SCL line when : •Own slave address is received •A data byte is received while the device is programmed to be a Master Receiver •A data byte is received while the device is a selected Slave Receiver. When this bit is reset, no acknowledge is returned. SIO release SDA line as high during the acknowledge clock pulse.
1	CR1	These two bits along with the CR2 bit determine the serial clock frequency when SIO is in the Master mode.
0	CR0	

**Table 17-2 Description of the SxCON bits**

CR2	CR1	CR0	f <sub>osc</sub> DIVISOR	BIT RATE (kHz) at f <sub>osc</sub>		
				8MHz	12MHz	16MHz
0	0	0	16	250	375	-
0	0	1	14	285.71	428.57	-
0	1	0	40	100	150	-
0	1	1	60	66.67	100	-
1	0	0	120	33.33	50	-

**Table 17-3 Selection of the serial clock frequency SCL in Master mode of operation.**



### Serial Status Register(SXSTA)

SxSTA is a read-only register. The contents of this register may be used as a vector to a service routine. This optimized the response time of the software and consequently that of the I2C-bus. The status codes for all possible modes of the I2C-bus interface are given Table

7	6	5	4	3	2	1	0
GC	STOP	INTR	TX_MODE	BBUSY	BLOST	/ACK_REP	SLV

**Table 17-4 Serial status register(SXSTA; S1STA:0D9H, S2STA:0DDH)**

BIT	SYMBOL	FUNCTION
7	GC	General Call flag. This bit is set when a STOP condition was received.
6	STOP	STOP flag. This bit is set when a STOP condition was received.
5	INTR	Interrupt flag. This bit is set when a SIO interrupt is requested.
4	TX_MODE	Transmission mode flag. This bit is set when the SIO is a transmitter. Otherwise, this bit is reset.
3	BBUSY	Bus busy state flag. This bit is set when the bus is being used by another master. Otherwise, this bit is reset.
2	BLOST	Bus lost flag. This bit is set when the master loses the bus contention. Otherwise, this bit is reset.
1	/ACK_REP	Acknowledge response flag. This bit is set when the receiver transmits the not acknowledge signal. This bit is reset when the receiver transmits the acknowledge signal.
0	SLV	Slave mode flag. This bit is set when the SIO plays role in the slave mode. Otherwise, this bit is reset.

**Table 17-5 Description of SxSTA**

### Data Shift Register(SXDAT; S1DAT, S2DAT)

SxDAT contains the serial data to be transmitted or data which has just been received. The MSB (bit7) is transmitted or received first; I.e. data shifted from right to left.

7	6	5	4	3	2	1	0
SxDAT7	SxDAT6	SxDAT5	SxDAT4	SxDAT3	SxDAT2	SxDAT1	SxDAT0

**Table 17-6 Serial data shift register**

### Addressing Register(SXADR)

This 8-bit register may be loaded with the 7-bit slave address to which the controller will respond when programmed as a slave receive/transmitter.

7	6	5	4	3	2	1	0
SLA6	SLA5	SLA4	SLA3	SLA2	SLA1	SLA0	-

**Table 17-7 Address register(SLA6 to SLA0 : Own slave address.)**

## 17.2 Programmer's Guide for I2C and DDC2

The I2C serial I/O and DDC Interface has operates in 4 modes.

- Master transmitter
- Master receiver
- Slave transmitter
- Slave receiver

### 17.2.1 Master transmitter mode

```

1. Read SxSTA.
2. If BBUSY == 1 then
    go to step1.
    Else then
        write slave address to SxDAT and set both ENI and STA, reset AA in SxCON.
3. Wait for interrupt.
4. Read SxSTA.
    If BLOST == 1 or /ACK_REP == 1* then
        write dummy data to SxDAT.
        Go to step1.
    Else then
        clear STA.
5. Perform required service routines.
    If this datum == LAST then
        set STO in SxCON and write last data to SxDAT**.
        Go to step 6.
    Else then
        write next data to SxDAT**.
        Go to step3.
6. Wait for interrupt.
    Write dummy data to SxDAT**.

* : 1. If the master don't receive the acknowledge from the slave, it generates the STOP condition and returns to the IDLE state.
**: 1. This action should be the last in service routine.

```

### Slave transmitter mode

```

1. Write slave address to SxADR, set AA and ENI in SxCON.
2. Wait for interrupt.
3. Read SxSTA and write the first data to SxDAT*. Reset AA in SxCON.
5. Wait for interrupt.
6. Read SxSTA.
    If /ACK_REP == 1** then
        Go to step7.
    Else then
        write the next SxDAT*.
        Go to step5.
7. Write dummy data to SxDAT*.

* : 1. These actions should be the last.
**: 1. If the master want to stop the current data requests, it don't have to acknowledge to the slave transmitter.
    2. If the slave don't receive the acknowledge from the master, it releases the SDA and enters the IDLE state,
        so if the master is to resume the data requests, it must regenerate the START condition.

```

## Master receiver mode

```

1. Read SxSTA.
2. If BBUSY == 1 then
    go to step1.
    Else then
        write slave address to SxDAT and set both ENI1 and STA, reset AA in SxCON.
3. Wait for interrupt.
4. Read SxSTA.
    If BLOST == 1 or /ACK_REP == 1 then
        write dummy data to SxDAT
        Go to step1.
    Else then
        clear STA and write FFH to SxDAT.
        Set AA in SxCON.
5. Wait for interrupt.
6. Read SxSTA.
    If this datum == LAST then
        reset AA* and read SxDAT**.
        Go to step7.
    Else then
        read SxDAT**.
        Go to step5.
7. Wait for interrupt.
    Read SxSTA.
    Read SxDAT**.

```

\* : 1. If the master want to terminate the current data requests, it don't have to acknowledge to the slave.

\*\* : 1. This action should be the last.

## Slave transmitter mode

```

1. Write slave address to SxADR, set AA and ENI in SxCON.
2. Wait for interrupt.
3. Read SxSTA and write FFH to SxDAT*.
5. Wait for interrupt.
6. Read SxSTA.
    If STOP == 1 then
        Go to step7.
    Else then
        read data from SxDAT*.
        Go to step5.
7. Read dummy data from SxDAT*.

```

\* : 1. This action should be the last.

**Master : restart (transmitter)**

```
1. Read SxSTA.
2. If BBUSY == 1 then
    go to step1.
    Else then
        write slave address to SxDAT and set both ENI1 and STA in SxCON.
        Reset AA in SxCON.
3. Wait for interrupt.
4. Read SxSTA.
    If BLOST == 1 or /ACK_REP == 1 then
        write dummy data to SxDAT.
        Go to step1.
    Else then
        clear STA.
5. Perform required service routines.
    If this datum == LAST then
        if RESTART is required then
            set STA in SxCON and write last data to SxDAT*.
            Go to step6.
        Else then
            set STO in SxCON and write last data to SxDAT*.
            Go to step7.
    Else then
        write next data to SxDAT*.
        Go to step3.
6. Wait for interrupt.
    Write slave address to SxDAT*.
    Go to step3.
7. Wait for interrupt.
    Write dummy data to SxDAT*.
```

\* : 1. This action should be the last in service routine.

## 18. PULSE WIDTH MODULATION

### 18.1 Static PWM

There are eight static PWM in the HMS9xC7132.

These channels provide output pulses of programmable duty cycle and polarity. The duty cycle is defined by a counter.

The 8-bit counter of a PWM counts modulo 256, i.e. from 0 to 255 inclusive. The value held in the 8-bit counter is compared to the contents of the Special Function Register(PWMn) of the corresponding PWM. The polarity of the PWM outputs is programmable and selected by the PWMLVL bit in PWMCON register.

Provided the contents of a PWMn register is equal to or greater than the counter value, the corresponding PWM output is set HIGH (with PWMLVL = "0"). If the contents of this register is less than the counter value, the corresponding PWM output is set LOW(with PWMLVL = "0"). The pulse-width-ratio is therefore

defined by the contents of the corresponding Special Function Register(PWMn) of a PWM. By loading the corresponding Special Function Register(PWMn) with either 00H or FFH, the PWM output can be retained at a constant HIGH or LOW level respectively(with PWMLVL = "0").

The PWM outputs PWM0 to PWM7 register share the same pins as Port2.2~Port2.7, Port3.4 and Port3.5 respectively.

Selection of the pin function as either a PWM output, a Port line or the other function is achieved by using the appropriate value of P2SF register.

The repetition frequency (fPWM) at a PWM output is given by:

$$f_{PWM} = f_{OSC} / (2 \times 256)$$

7	6	5	4	3	2	1	0
PWMLVL	PWM6CFG	PWM5CFG	PWM4CFG	PWM3CFG	PWM2CFG	PWM1CFG	PWM0CFG

**Table 18-1 PWM control register (PWMCON : 0A1H)**

BIT	SYMBOL	FUNCTION
7	PWMLVL	Polarity selection of the PWMs. 0 : PWM outputs are not inverted. 1 : PWM outputs are inverted.
6 to 0	PWM6CFG to PWM0CFG	Output type selection of the PWMs. 0 : open-drain type. 1 : push-pull type

**Table 18-2 Description of the PWMCON bits**

## 18.2 Dynamic PWM

There are two dynamic PWMs in the HMS9xC7132. The DPWMs can be used to generate various waveform by software programming, and are used to achieve geometric compensation by generating a parabola output waveform which is synchronized with VSYNCin signal for pin/trap, bow/tilt, vertical linearity or focus compensation in monitor system.

This is achieved by utilizing timer2. The low 8-bit in timer2 is used as 8-bit counter for PWM signal and the high 8-bit in timer2 is used to decide the number of PWMs in one video frame. One

video frame can be divided to any number of blocks according to the register RC2H value within 256 blocks, and here the RC2L will be 00H for 8-bit PWM resolution.

The dynamic PWM outputs DPWM0 to DPWM1 register share the same pins as Port2.0~Port2.1 respectively.

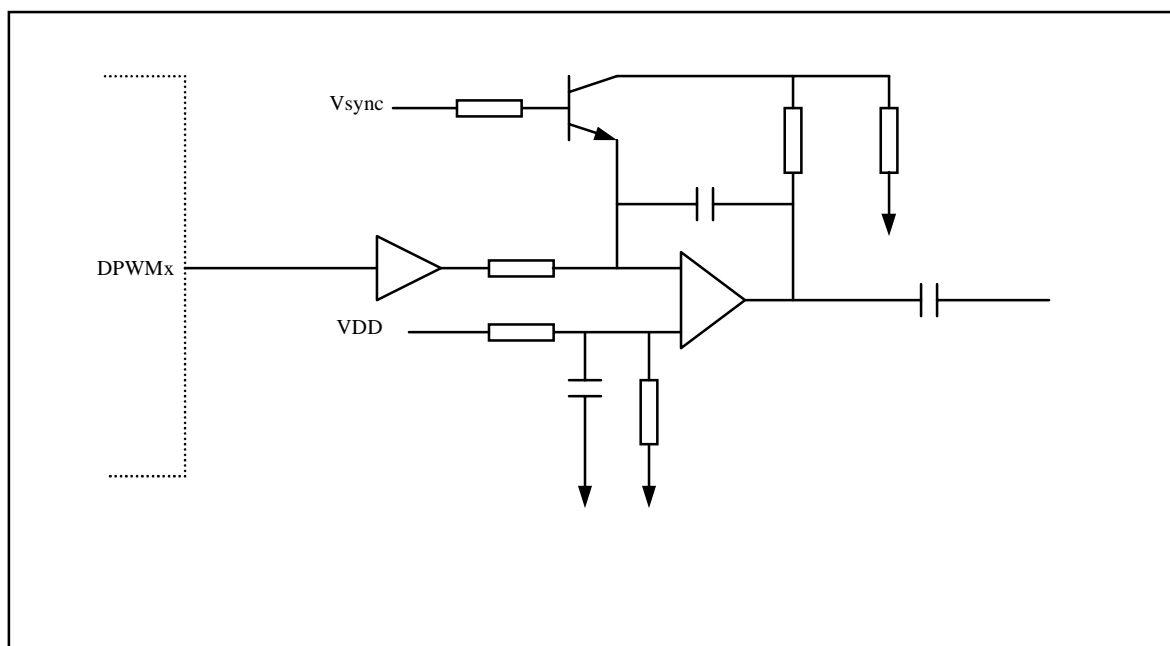
The repetition frequency (fDPWM) at a DPWM output is given by (in case of RC2L=00H):  $f_{DPWM} = f_{OSC} / (2 \times 256)$

7	6	5	4	3	2	1	0
DPWMLVL	-	-	-	-	-	DPWM1CFG	DPWM0CFG

**Table 18-3 Dynamic PWM control register (DPWMCON : 0B1H)**

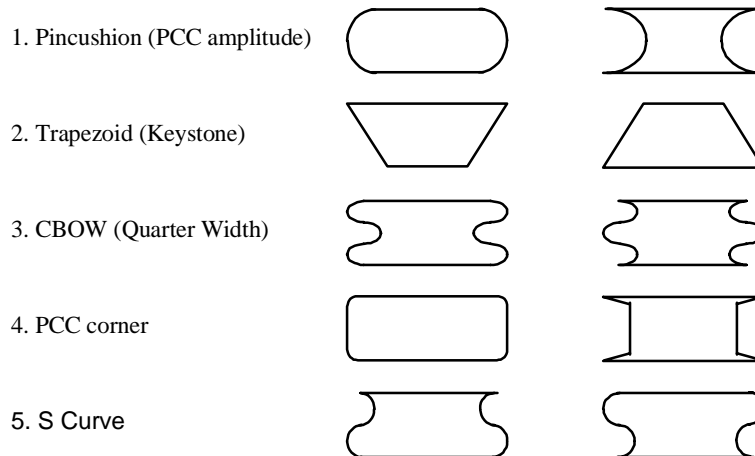
BIT	SYMBOL	FUNCTION
7	DPWMLVL	Polarity selection of the DPWMs. 0 : DPWM outputs are not inverted. 1 : DPWM outputs are inverted.
1 to 0	DPWM1CFG to DPWM0CFG	Output type selection of the DPWMs. 0 : open-drain type. 1 : push-pull type

### Table 18-4 Description of the DPWMCON bits

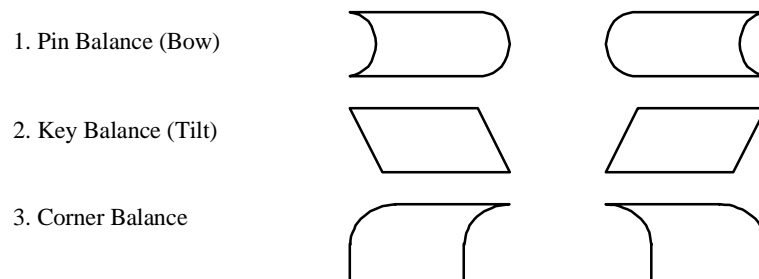


### Table 18-5 DPWM application circuit

**Using one Dynamic PWM to compensate the following H size distortion :**



**Using one Dynamic PWM to compensate the following H center distortion :**



## 19. SYNC PROCESSOR

The characteristics of Sync processor are as follows.

Automatic mode detection by hardware to capture the following signal characteristics :

- Hsync and Vsync frequency measured with 12-bit accuracy (fSH= 12MHz, fSV= 125KHz)
- Hsync and Vsync polarity
- Hsync and Vsync presence needed for implementing the VESA DPMS standard

Integrated composite sync separation

Integrated signal generators for generating :

- Free running horizontal and vertical sync pulses
- Clamping pulse(Back porch, Front porch)
- Pattern signal (white picture, black picture, cross hatch and inverse cross hatch)

Special option :

- Missing sync pulse insertion

All measured parameters are stored in Special Function Register such that the data is available at any time.

The block diagram of the complete sync processor is given in Figure 19-1

### 19.1 Sync input signals

The sync inputs are able to handle standard TTL level sync signals. From Figure 19-1 it can be seen that both the HSYNCin and SOGin inputs accept composite sync signals. The HSYNCin and VSYNCin input is meant to be connected to the Hsync and Vsync of the VGA cable while SOGin input is meant to be connected to

a sync slicer in order to handle Sync-On-Green at the video input. This last signal should have a TTL level also. The selection between the HSYNCin and the SOGin inputs, as well as the selection between the VSYNCin and separated Vsync, can be done via software.

Select Flag	Signal to detector
HSEL	0 : HSYNCin 1 : SOGin
VSEL	0 : VSYNCin 1 : Separated VSYNC

**Table 19-1 Sync Input selection**

### 19.2 Horizontal polarity correction

In order to simplify the processing in the following stages, the HSYNC polarity correction circuit is able to convert the input sync signals to positive polarity signals in all situations. This correction is achieved by the aid of HPOL and HP.

HPOL and HP are only settled down in several horizontal scanning lines or a few milliseconds after power-on or timing mode change.

### 19.3 Vertical polarity correction

The purpose of the vertical polarity correction is similar to the horizontal polarity correction. To get the correct result after power-on or a timing mode change, at least 5 frames is needed.

er-on or a timing mode change, at least 5 frames is needed.

### 19.4 Vertical sync separation

This block separates the vertical sync from a composite sync signal. At approximately 1/4 of each HSYNC line the logical level is latched. This yields a slightly delayed vertical sync signal. Special precautions have been taken to suppress equalizing pulses

when present and to allow both polarities of the composite signal. The format of the composite sync signal can be standard, as given in Figure 19-2, or can be one of the non standard format as given in Figure 19-3



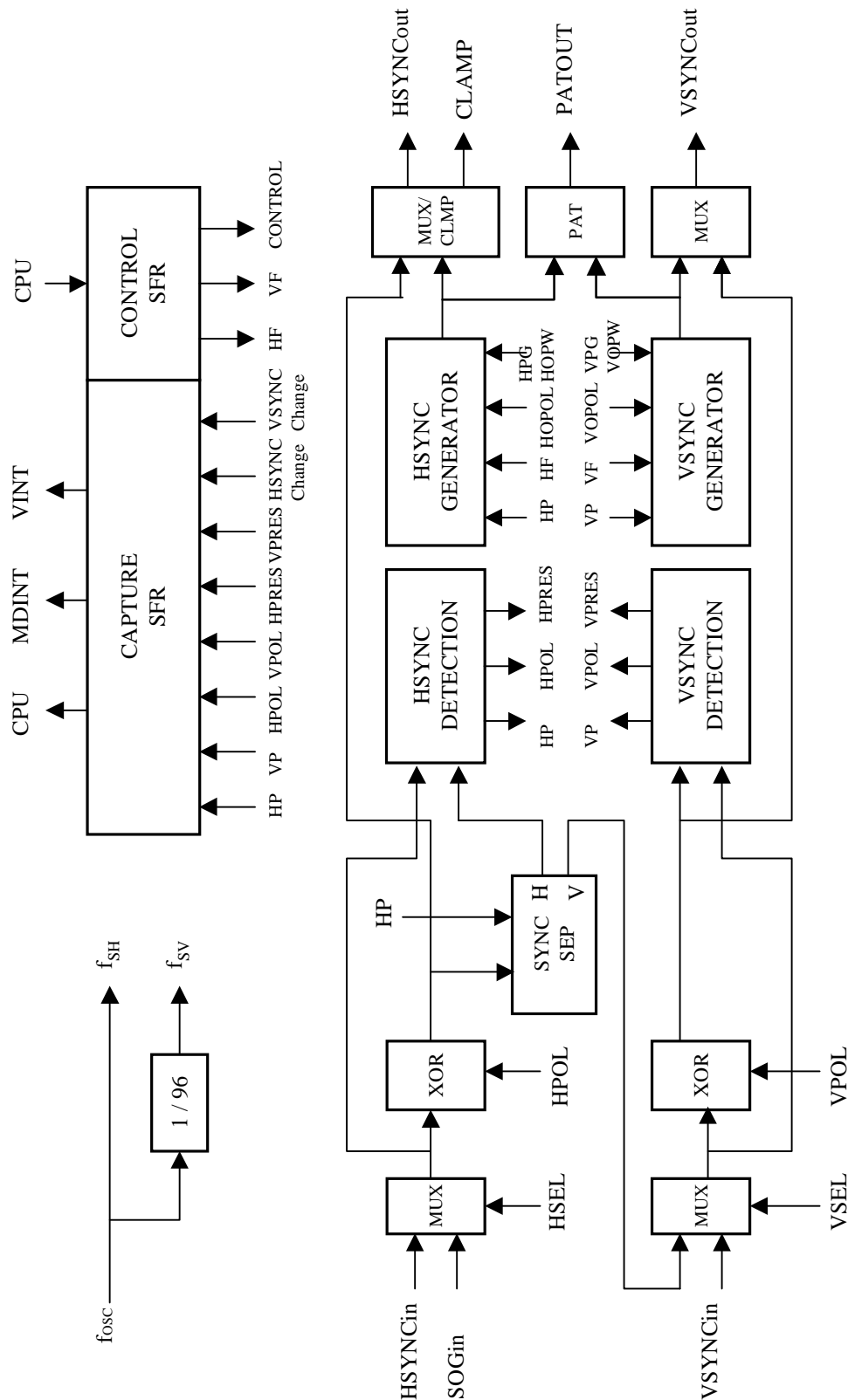


Figure 19-1 Block diagram of sync processor

## 19.5 Horizontal sync. detection

This block extracts the following parameters from the incoming horizontal or composite sync :

- HPER : The number of clock cycles ( $f_{SH} = 12\text{MHz}$ ) between five sync pulses (4 period time), thus the 12 bits value HPER will be equal to  $((4 \times 12 \times 106 / f_H) - 1)$  where  $f_H$  is the horizontal sync frequency in Hz.
- HPOL : The polarity of the sync signal, HPOL will be reset in case of a positive polarity and set in case of a negative polarity. The 1/4 point value of HSYNC period time will be latched for HPOL.

## 19.6 Vertical sync. detection

This block extracts the following parameters from the incoming vertical sync:

- VPER : Either the number of clock cycles ( $f_{SV}=125\text{kHz}$  sampling) between two sync pulses(period time). In case the period time is measured this 12 bits VPER will be equal to  $125 \times 103 / f_V$  where  $f_V$  is the vertical sync frequency in Hz.
- VPOL : The polarity of the sync signal, VPOL will be reset in case of a positive polarity and reset in case of a negative polarity. It should be noted here that in case of a composite sync signal at the input the parameter VPOL will be set always, disregarding the polarity of the incoming composite

• HPRES :To detect the presence of the valid HSYNC signal, Detector measures the time interval between five sync pulses (4 period time). No active sync is coming in if the counter reaches a value of FF0H(4080).

• HCHG : The HCHG flag will be set if a change is detected in either the polarity or the period time. To avoid unintended setting of the HCHG flag a small deviation in the period time is allowed.The allowed deviation is approximately 167ns per line.

sync. The 1/4 value of incoming VSYNC value will be latched for VPOL.

• VPRES : To detect the presence of the valid VSYNC signal, Detector measures the time interval between two consecutive rising edges of the input signal. No active sync is coming in if the counter reaches a value of FF0H(4080).

• VCHG : The VCHG flag will be set if a change is detected in either the polarity or the period time. To avoid unintended setting of the VCHG flag a small deviation in the period time is allowed.The allowed deviation is approximately 32us per line.

Detection input	Threshold frequency
HSYNC input	12 KHz
VSYNC input	30 Hz

**Table 19-2 Threshold frequencies of the presence detector**

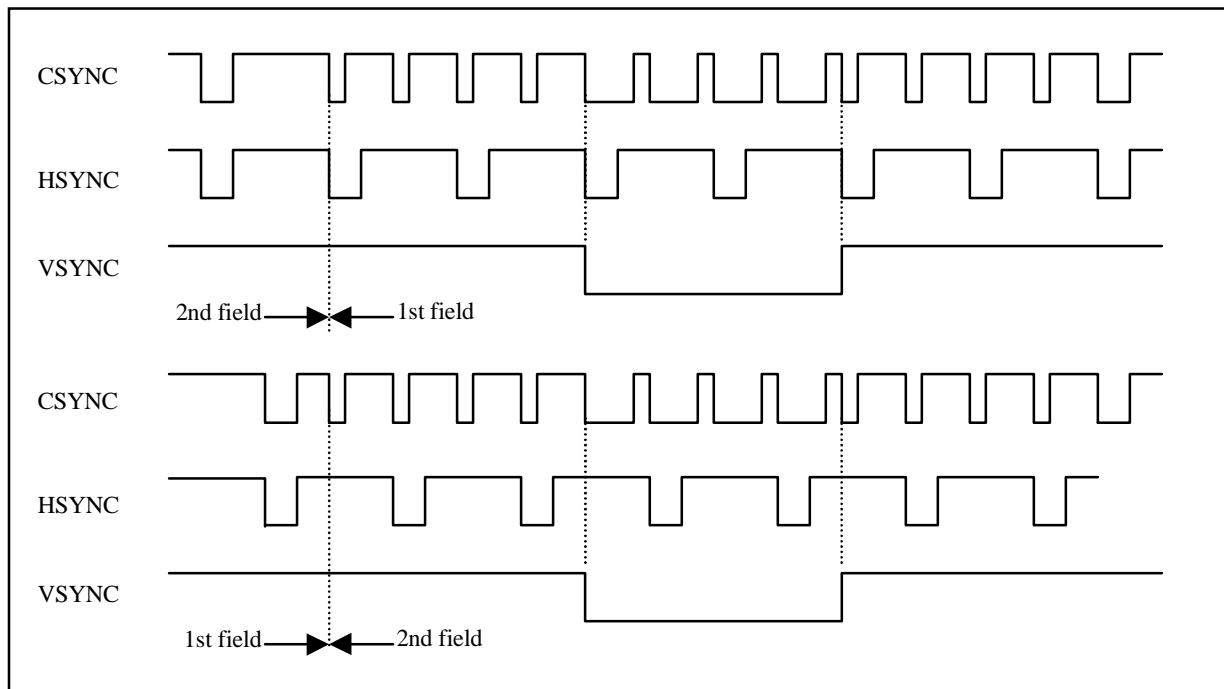


Figure 19-2 Standard composite sync signals

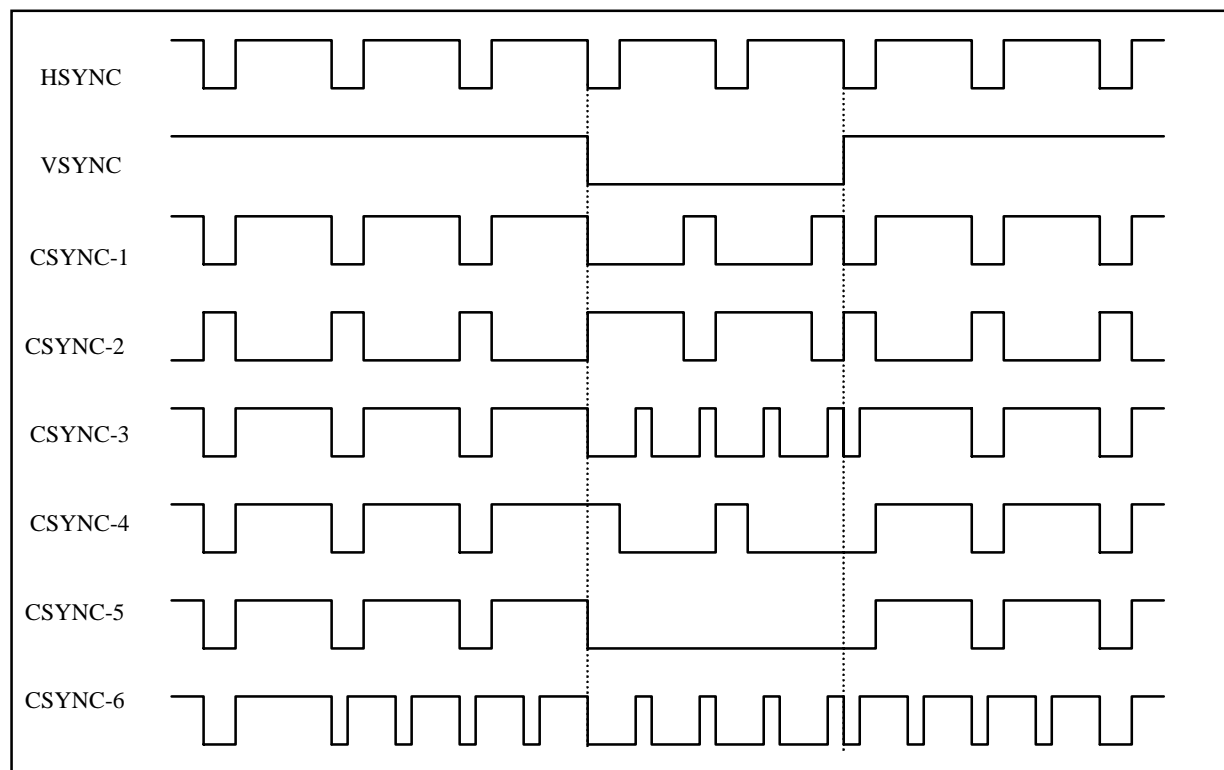


Figure 19-3 Non-standard composite sync signals

Both the HCHG and the VCHG signals are combined and connected to the internal interrupt. Interrupt will be issued when change is continuously detected like following table.

Due to this fast interrupt the S-correction can be set to a safe level before any damage to the deflection circuitry will occur.

Mode change			Interval between mode change and interrupt
HSYNC	Period	HPnew < HPpre	HPnew x 61 to (4 x HPnew x 15) - (n x HPpre)
		HPnew > HPpre	(4 x HPnew) x 3 - (n x HPpre)
		To Static State	(4 x HPnew) x 3 - (n x HPpre)
	Polarity	POS => NEG	60 HSYNC lines
		NEG => POS	60 HSYNC lines
VSYNC	Period	VPnew < VPpre	(VPnew x 2 + VPprev) to (Vnew x 3)
		VPnew > VPpre	(VPnew) to (VPnew x 2)
		To Static State	(VPnew) to (VPnew x 2)
	Polarity	POS => NEG	3 VSYNC lines
		NEG => POS	2 VSYNC lines

**Table 19-3 Time interval between mode change and interrupt**

Internally there are two 12-bit counter for HSYNC and VSYNC period check, HSYNC counter count up from 0 to 4096 for 4 HSYNC lines according to 12MHz clock, and VSYNC counter count up from 0 to 4096 for one VSYNC line according to

125KHz clock. For HSYNC static state that HSYNC frequency is under 12KHz, counter value is more than 4080 value, and for VSYNC static state that VSYNC frequency is under 32Hz, counter value is more than 4080 value.

## 19.7 Horizontal sync. generator

This block generates horizontal sync pulses with positive polarity. This can be done in 3 modes, selectable with HPG. When HPG is 00, the generator operates in the free running mode and the generated pulse repetition period equals  $HF \times 1/12$  MHz clock period, where HF is a 10 bit value. As a result the frequency of the

free running output sync pulse equals  $12 \times 10^6 / HF$ , with about 12 kHz as lower boundary. When HPG is 01, the input sync pulse is followed and a substitution pulse is inserted. In case HPG equals 11, the inputsync pulse is followed but a substitution pulse is disabled, while the incoming sync is missing.

HPG[1:0]	Selected mode
0 0	Free running mode Period time of horizontal pulse generator (= HF)
0 1	The same pulse as the input horizontal sync Substitution pulse insertion in case of a missing sync pulse
1 0	Reserved
1 1	The same pulse as the input horizontal sync No substitution pulse insertion in case of a missing sync pulse

**Table 19-4 Modes of the horizontal pulse generator**

HOPW[4:0]	Selected mode
00000	2 x 83 ns
00001	3 x 83 ns
00010	4 x 83 ns
-----	Incremented by 83ns ( $1/12 \times 10^{-6}$ )
11101	31 x 83 ns
11110	32 x 83 ns
11111	33 x 83 ns

**Table 19-5 Free running horizontal sync pulse width**

Example Program; Freerun mode

```

=====
;
;                               Free running
;
=====
SetFreeRunning:
    lcall    SetVcp
SetFreeRunning1:
    mov     A, #01000100b        ; rising Edge Interrupt
    mov     MDCON, A             ;
    mov     HFH, #00101110b      ; Hf = 64.6 kHz
    mov     HFL, #01010000b      ; HOPW[10000]
    mov     VFH, #01000010b      ; Vf = 60 Hz
    mov     VFL, #11001000b      ; VOPW[1000]
    mov     CPGEN, #11100000b    ; White Picture Clamping and Pattern
    mov     A, #01000000b        ; Negative Hsync, Positive Vsync free-run
    mov     HVGEN, A             ;
    lcall    DpmsHLinearity      ;
    ret

```

## 19.8 Vertical sync. generator

This block generates vertical sync pulses with positive polarity. This can be done in 3 modes, selectable with VPG. When VPG is 00, the generator operates in the free running mode and the generated pulse repetition period equals  $VF \times HF \times 1/12$  MHz clock period, where VF is a 12 bit value. As a result the frequency of

the free running output sync pulse equals  $12 \times 106 / HF / VF$ . When VPG is 01, the input sync pulse is followed and a substitution pulse is inserted. In case VPG equals 11, the input sync pulse is followed but a substitution pulse is disabled, while the incoming sync is missing.

VPG[1:0]	Selected mode
0 0	Free running mode Period time of vertical pulse generator (= VF)
0 1	The same pulse as the input horizontal sync Substitution pulse insertion in case of a missing sync pulse
1 0	Reserved
1 1	The same pulse as the input vertical sync No substitution pulse insertion in case of a missing sync pulse

**Table 19-6 Modes of the vertical pulse generator**

VOPW[3:0]	Selected mode
0000	$2 \times t_{H(\text{free})}$
0001	$3 \times t_{H(\text{free})}$
0010	$4 \times t_{H(\text{free})}$
-----	Incremented by $t_{H(\text{free})}$
1101	$15 \times t_{H(\text{free})}$
1110	$16 \times t_{H(\text{free})}$
1111	$17 \times t_{H(\text{free})}$

**Table 19-7 Free running vertical sync pulse width**

## 19.9 HSYNC / VSYNC output driver

This is output stage for HSYNCout and VSYNCout. It offers output selection, output enabling/disabling and output polarity selection.

With HOPOL and VOPOL the output is selected.

### 19.10 Clamp pulse generator

The clamp pulse is generated by setting CLMPEN and always accompanies the HSYNCout pulse, even in the free running mode. This block generates a clamping pulse with programmable pulse

width, determined by CPW. It can be started at the front porch (CFB reset) or at the back porch (CFB set), and the polarity can be set with COPOL.

CPW[2:0]	Clamping pulse width
000(11)	5 x 83ns
001(11)	9 x 83ns
010(11)	13 x 83ns
011(11)	17 x 83ns
100(11)	21 x 83ns
101(11)	25 x 83ns
110(11)	29 x 83ns
111(11)	33 x 83ns

**Table 19-8 Clamping pulse width**

### 19.11 Pattern generator

This generator is used for test pattern generation when in free running mode. Four picture can be selected : a white, a cross hatch, a black and inverted cross hatch pictures. When not in free running mode , the output is disabled. The pattern output can be used for

burn-in test or e.g. for quick servicing without the need of a video source. The displayed pattern might look different in the different timing modes, symmetric display is not guaranteed.

### 19.12 Suspend mode

The complete Sync processor can be set into a suspend mode for lowering the power consumption by means of signal MDDN.

MDDN	Mode
0	Sync. processor is running.(default)
1	Sync. processor is disabled.

**Table 19-9 Suspend mode**

7	6	5	4	3	2	1	0
MDDN	CLMPEN	PATEN	-	-	VINTE	HSEL	VSEL

**Table 19-10 Mode detection control register.(MDCON : 0F1H)**

BIT	SYMBOL	FUNCTION
7	MDDN	0 : hardware mode detection operating normally(default) 1 : hardware mode detection disabled (low power consumption)
6	CLMPEN	0 : clamp pulse out disabled(default) 1 : clamp pulse out enabled
5	PATEN	0 : pattern out disabled(default) 1 : pattern out enabled
4 to 3	-	Not used
2	VINTE	Vsync rising or falling edge interrupt select 0: Vsync rising edge interrupt 1: Vsync falling edge interrupt
1	HSEL	0 : HSYNCin 1 : SOGIN
0	VSEL	0 : VSYNCin 1 : separated VSYNC

Table 19-11 Description of the MDCON bits

7	6	5	4	3	2	1	0
-	VINT	HPRES	VPRES	HPOL	VPOL	HCHG	VCHG

Table 19-12 Mode detection status register(MDST : 0F2H)

BIT	SYMBOL	FUNCTION
7	-	Not used
6	VINT	Vsync interrupt flag
5	HPRES	Indicate the presence of Hsync 0 : not present (Hfreq < 12 kHz) 1 : present ( Hfreq ≥ 12 kHz)
4	VPRES	Indicate the presence of Vsync 0 : not present (Vfreq < 30 Hz) 1 : present ( Vfreq ≥ 30 Hz)
3	HPOL	Indicate the polarity of Hsync/Csync : 0 : positive polarity 1 : negative polarity
2	VPOL	Indicate the polarity of Vsync : 0 : positive polarity 1 : negative polarity
1	HCHG	Indicate a change in horizontal period and/or polarity: 0 : no change 1 : change detected
0	VCHG	Indicate a change in vertical period and/or polarity: 0 : no change 1 : change detected

Table 19-13 Description of the MDST bits



7	6	5	4	3	2	1	0
VP11	VP10	VP9	VP8	VP7	VP6	VP5	VP4

**Table 19-14 Vsync period low byte register (VPH : 0F3H)**

7	6	5	4	3	2	1	0
HP11	HP10	HP9	HP8	HP7	HP6	HP5	HP4

**Table 19-15 Hsync period low byte register (HPH : 0F4H)**

7	6	5	4	3	2	1	0
VP3	VP2	VP1	VP0	HP3	HP2	HP1	HP0

**Table 19-16 Vsync and Hsync period low high register (VHPL : 0F5H)**

7	6	5	4	3	2	1	0
-	HOPOL	HPG1	HPG0	-	VOPOL	VPG1	VPG0

**Table 19-17 Hsync and Vsync generation control register.(HVGEN : 0F9H)**

BIT	SYMBOL	FUNCTION
7	-	Not used
6	HOPOL	Select polarity of the horizontal output pulse 0 : positive polarity 1 : negative polarity
5 to 4	HPG1 to HPG0	Horizontal pulse output modes 00 : free running 01 : missing insertion 10 : reserved 11 : the same pulse as the incoming horizontal sync.
3	-	Not used
2	VOPOL	Select polarity of the vertical output pulse 0 : positive polarity 1 : negative polarity
1 to 0	VPG1 to VPG0	Vertical pulse output modes 00 : free running 01 : missing insertion 10 : reserved 11 : the same pulse as the incoming vertical sync.

**Table 19-18 Description of the HVGEN bits**

7	6	5	4	3	2	1	0
VF11	VF10	VF9	VF8	VF7	VF6	VF5	VF4

**Table 19-19 Vsync free running output high byte register (VFH : 0FBH)**

7	6	5	4	3	2	1	0
VF3	VF2	VF1	VF0	VOPW3	VOPW2	VOPW1	VOPW0

**Table 19-20 Vsync free running output low byte register (VFL : 0FCH)**

7	6	5	4	3	2	1	0
HF9	HF8	HF7	HF6	HF5	HF4	HF3	HF2

**Table 19-21 Hsync free running output high byte register (HFH : 0FDH)**

7	6	5	4	3	2	1	0
HF1	HF0	-	HOPW4	HOPW3	HOPW2	HOPW1	HOPW0

**Table 19-22 Hsync free running output low byte register (HFL : 0FEH)**

7	6	5	4	3	2	1	0
COPOL	CFB	CPW2	CPW1	CPW0	-	PATS1	PATS0

**Table 19-23 Clamping and Pattern control register(CPGEN : 0FAH)**

BIT	SYMBOL	FUNCTION
7	COPOL	Select the polarity or level of the clamping pulse: 0 : positive polarity when enabled, static low level when disabled 1 : negative polarity when enabled, static high level when disabled
6	CFB	Select the trigger moment of the clamping output pulse : 0 : clamp pulse after FRONT porch of horizontal sync 1 : clamp pulse after BACK porch of horizontal sync
5 to 3	CPW2 to CPW0	Clamp pulse width
2	-	Not used
1 to 0	PATS1 to PATS0	Select one of the following patterns : 00 : white picture 01 : cross hatch picture 10 : black picture 11 : inverse cross hatch picture

**Table 19-24 Description of the CPGEN bits**

## 20. ANALOG-TO-DIGITAL CONVERTOR (ADC)

The analog to digital converter (A/D) allows conversion of an analog input to a corresponding 8-bit digital value. The A/D module has four analog inputs, which are multiplexed into one sample and hold. The output of the sample and hold is the input into the converter, which generates the result via successive approximation. The analog supply voltage is connected to VDD2 of ladder resistance of A/D module.

The A/D module has two registers which are the control register ACON and A/D result register ADAT. The register ACON, shown in Table 17.1, controls the operation of the A/D converter module. To use analog inputs, I/O is selected by P1SFS register.

The processing of conversion starts when the start bit ADST is set to "1". After one cycle, it is cleared by hardware. The register ADAT contains the results of the A/D conversion. When conversion is completed, the result is loaded into the ADAT the A/D conversion status bit ADSF is set to "1".

The block diagram of the A/D module is shown in Fig. 17.1. The A/D status bit ADSF is set automatically when A/D conversion is completed, cleared when A/D conversion is in process. The conversion time takes maximum 13us (@12MHz)

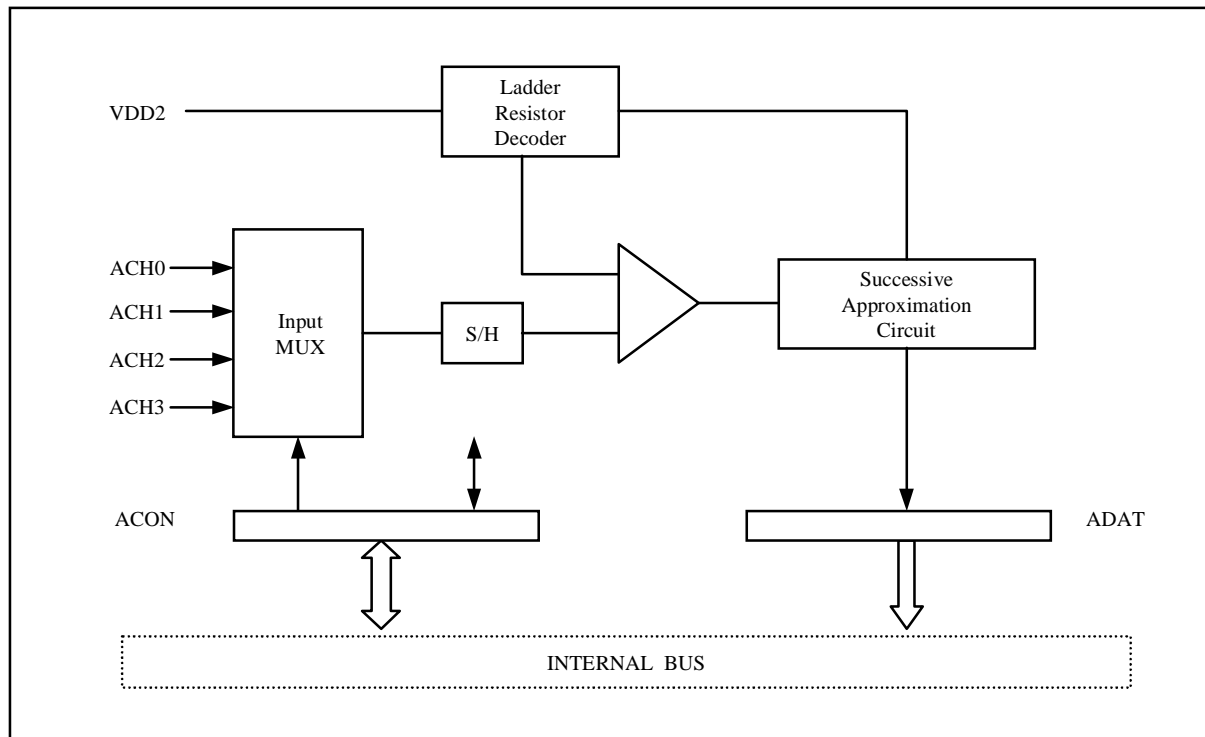


Figure 20-1 A/D block diagram

7	6	5	4	3	2	1	0
-	-	ADEN	-	ADS1	ADS0	ADST	ADSF

**Table 20-1 ADC control register (ACON : 97H)**

BIT	SYMBOL	FUNCTION
7 to 6	-	Reserved
5	ADEN	ADC enable bit 0 : ADC shut off and consumes no operating current 1 : enable ADC
4	-	Reserved
3 to 2	ADS1, ADS0 0, 0 0, 1 1, 0 1, 1	Analog channel select Channel0 (ACH0) Channel1 (ACH1) Channel2 (ACH2) Channel3 (ACH3)
1	ADST	ADC start bit 0 : force to zero 1 : start an ADC; after one cycle, bit is cleared to "0"
0	ADSF	ADC status bit 0 : A/D conversion is in process 1 : A/D conversion is completed, not in process

**Table 20-2 Description of the ACON bits**

7	6	5	4	3	2	1	0
ADAT7	ADAT6	ADAT5	ADAT4	ADAT3	ADAT2	ADAT1	ADAT0

**Table 20-3 ADC data register (ADAT : 96H)**

BIT	SYMBOL	FUNCTION
7 to 6	ADAT7 to ADAT0	A/D conversion result bit7 to bit0

**Table 20-4 Description of the ADAT bits**

## 21. OPERATION MODE





### 21.1 OTP MODE

The HMS97C7132 is programmed by using a modified Quick-Pulse Programming algorithm. The HMS97C7132 contains two signature bytes that can be read and used by an EPROM programming system to identify the device. The signature bytes identify the device as an manufactured by HME. Table 21-1 shows the logic levels for reading the signature byte, and for programming

the program memory, the encryption table, and the security bits. The circuit configuration and waveforms for quick pulse programming are shown in Figure 21-1 and Figure 21-2. Figure 21-3 shows the circuit configuration for normal program memory verification.

#### •Program / Verify algorithms

Any algorithm in agreement with the conditions listed in Table 21-1, and which satisfies the timing specifications is suitable.

MODE	RESET	P3.3	P3.5/ PROG	P3.2	INT0/ VPP	P2.7	P2.6	P3.7	P3.6
Read Signature	0	0	1	1	1	0	0	0	0
Program Code Data	0	0		1	VPP	1	0	1	1
Verify Code Data	0	0	1	1	1	0	0	1	1
Program Encryption Table	0	0		1	VPP	1	0	1	0
Program Lock Bit 1	0	0		1	VPP	1	1	1	1
Program Lock Bit 2	0	0		1	VPP	1	1	0	0

**Table 21-1 EPROM programming modes**

Note :

1. "0" = Valid low for that pin, "1" = Valid high for that pin.
2. VPP = 12.75V  $\pm$  0.25V
3. VDD = 5V  $\pm$  10% during programming and verification.
4. P3.5/PROG receives 10 programming pulses while VPP is held at 12.75V.

Each programming pulse is low for 100  $\mu$ s (  $\pm$  10 $\mu$ s ) and high for a minimum of 10 $\mu$ s

#### •Program Memory Lock Bits

The two-level Program Lock system consists of 2 Lock Bits and a 64-bytes Encryption Array which are used to protect the program memory against software piracy.

MODE	LB1	LB2	Protection Type
1	U	U	No program lock features
2	P	U	Further programming of the EPROM is disabled
3	P	P	Same as mode 2, also verify is disabled

U : unprogrammed, P : programmed

**Table 21-2Lock Bit Protection Modes**

### •Encryption Array

Within the EPROM array are 64bytes of Encryption Array that are initially unprogrammed (all 1s). Every time that a byte addressed during a verify, address line are used to select a byte of the Encryption array. This byte is then exclusive NOR-ed (XNOR) with the code byte, creating an Encrypted Verify byte.

The algorithm, with the array in the unprogrammed state (all 1s), will return the code in its original, unmodified form. It is recommended that whenever the Encryption Array is used, at least one of the Lock Bits be programmed as well.

### •Reading the Signature Bytes

The HMS97C7132 signature bytes in location 30H and 20H. To read these bytes follow the procedure for EPROM verify, except that P3.6 and P3.7 need to be pulled to a logic low.

Device	Location	Contents	Remarks
HMS97C7132	30H	ADH	Manufacturer ID
	20H	68H	Device ID

**Table 21-3 The Value**

### •Quick-pulse programming

The setup for micro-controller quick-pulse programming is shown in Figure 21-2. Note that the HMS97C7132 is running with a 4 to 6MHz oscillator. The reason the oscillator needs to be running is that the device is executing internal address and program data transfers.

The address of the EPROM location to be programmed is applied to port 1, 2 and VSYNCIN, as shown in Figure 21-1. The code byte to be programmed into that location is applied to port 0. RESET, PSEN and pins of port2 and 3 in Table 21.1 are held at the "Program Code Data" levels indicated in Table 21.1. The P3.5/PROG is pulsed low 10 times as shown Figure 21-2.

To program the encryption table, repeat the 10 pulses programming sequence for address 0 through 3F H, using the "Program

Encryption Table" levels. Do not forget that after the encryption table is programmed, verification cycle will produce only encrypted data.

To program the security bits, repeat the 10 pulses programming sequence using the "Program Security Bit" levels. After one security bit is programmed, further programming of the code memory and encryption table is disabled. However, the other security bit can still be programmed. Note that INT0/VPP pin must not be allowed to go above the maximum specified VPP level for any amount of time. Even a narrow glitch above that voltage can cause permanent damage to the device.

The VPP source should be well regulated and free glitches and overshoot.

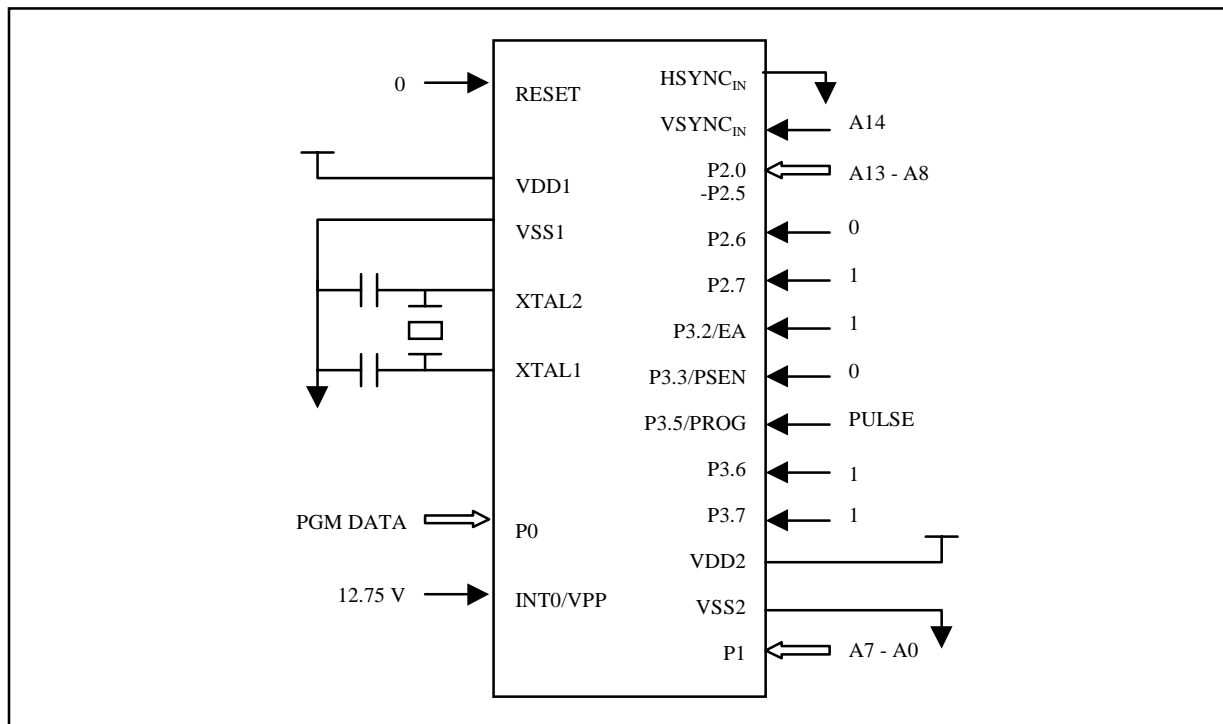


Figure 21-1 Programming Configuration

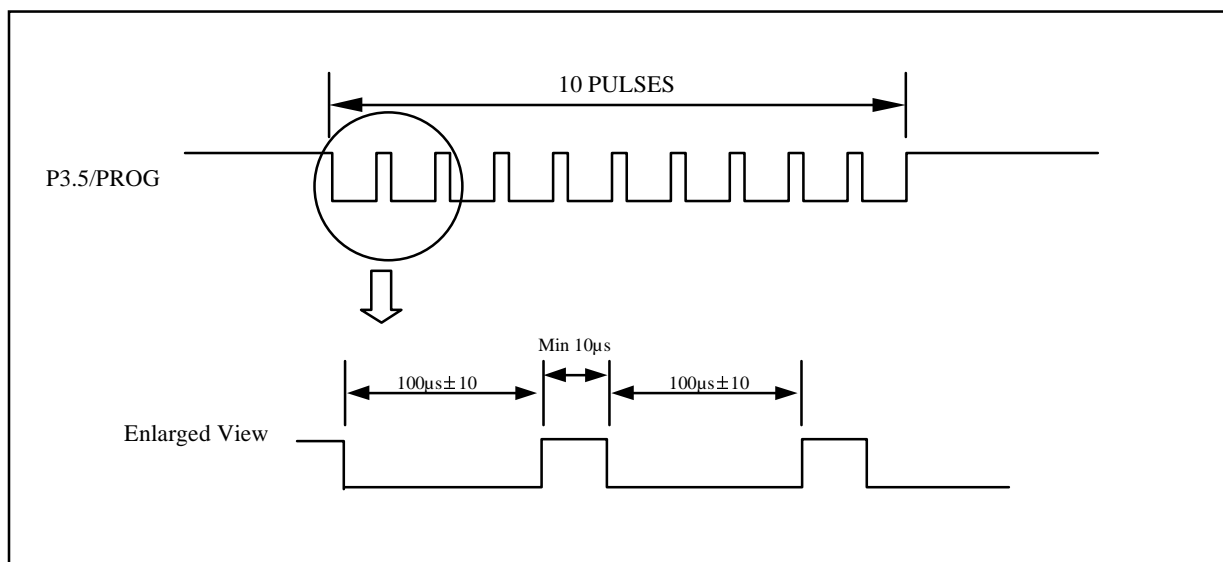


Figure 21-2 PROG Waveform

### •Program Verification

If Lock Bit 2 has not been programmed, the on-chip program memory can be read out for program verification. The address of the program memory location to be read is applied to port 1, 2 and VSYNCIN as shown in Figure 21-4. The other pins are held at the "Verify Code Data" levels indicated in Table 21.1. The contents of the address location will be emitted on port 0 for this op-

eration. If the encryption table has been programmed, the data presented at port 0 will be the exclusive NOR of the program byte with one of the encryption bytes. The user will have to know the encryption table contents in order to correctly decode the verification data. The encryption table itself cannot be read out.

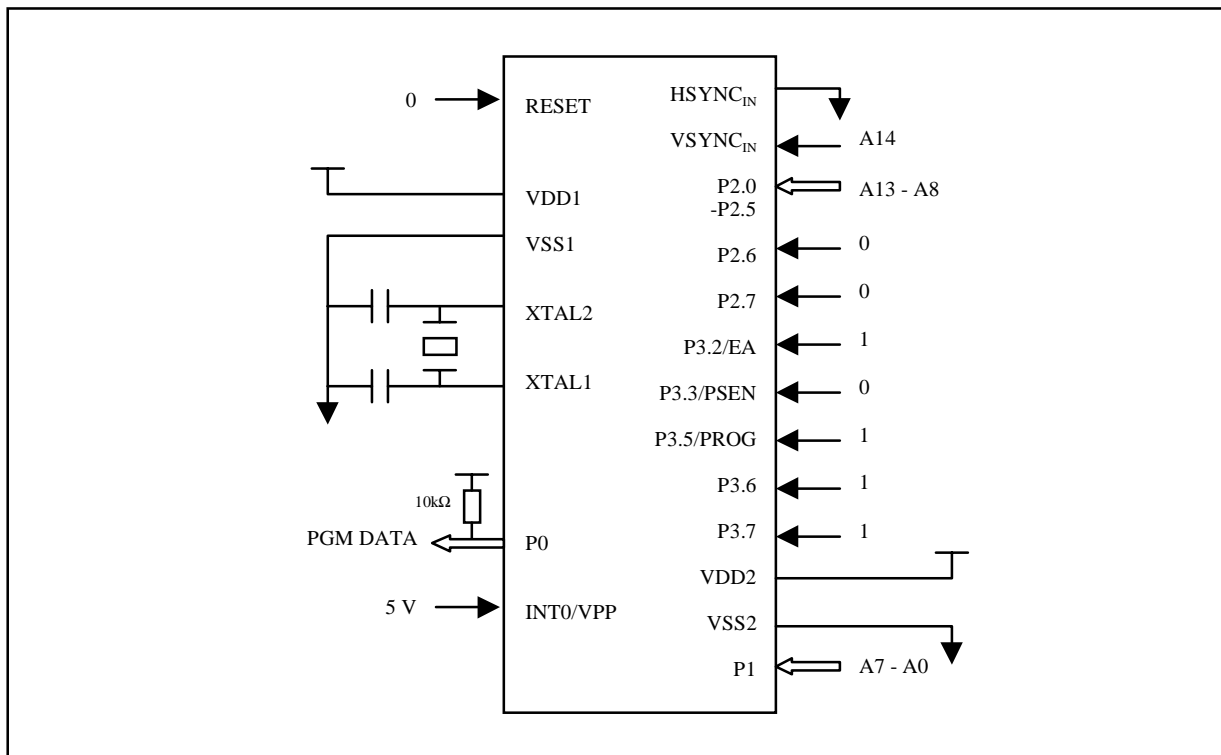


Figure 21-3 Verification Configuration



### EPROM Programming and Verification Characteristics

TA = 21 °C to 27 °C, Vcc = 5V + 10%, Vss = 0V

Parameter	Symbol	Limit Values		Unit
		Min	Max	
Programming supply voltage	VPP	12.5	13.0	V
Programming supply current	IPP	-	50	mA
Oscillator frequency	1/tCLCL	4	6	MHz
Address setup to PROG low	tAVGL	48 tCLCL	-	-
Address hold after PROG	tGHAX	48 tCLCL	-	-
Data setup to PROG	tDVGL	48 tCLCL	-	-
Data hold after PROG	tGHDX	48 tCLCL	-	-
P2.7 (ENABLE) high to VPP	tEHS	48 tCLCL	-	-
VPP setup to PROG	tSHGL	10	-	μs
VPP hold after PROG	tGHSL	10	-	μs
PROG width	tGLGL	90	110	μs
Address to data valid	tAVQV	-	48 tCLCL	-
ENABLE low to data valid	tELQV	-	48 tCLCL	-
Data float after ENABLE	tEHQZ	0	48 tCLCL	-
PROG high to PROG low	tGHGL	10	-	μs

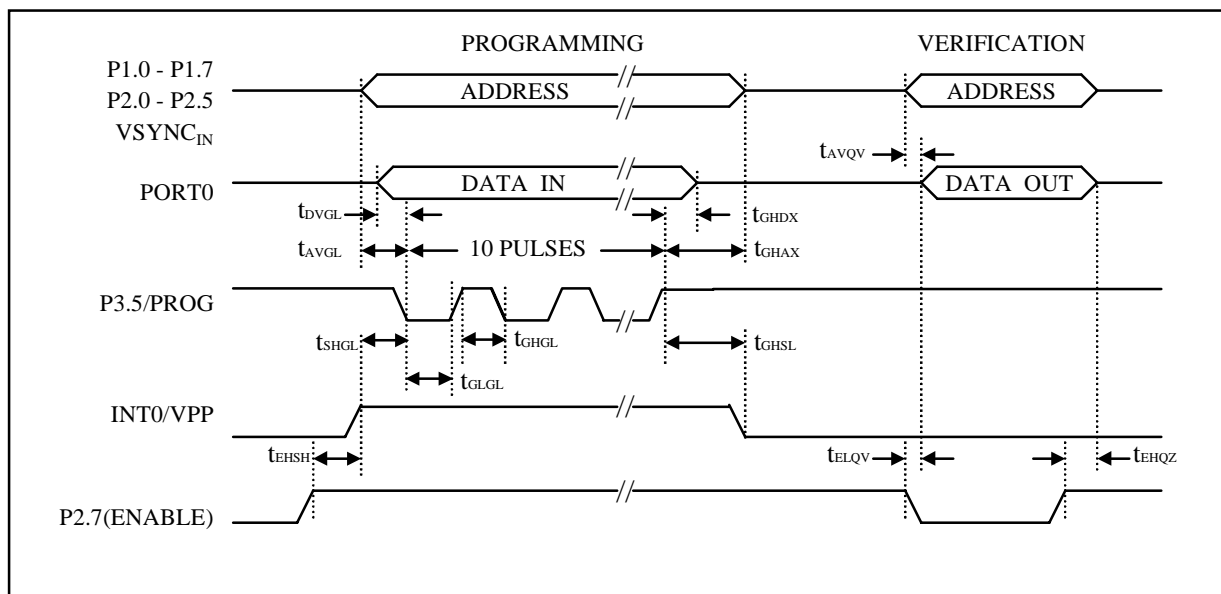
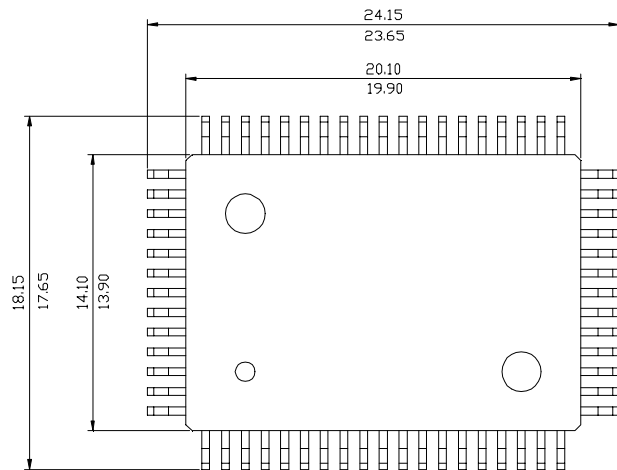
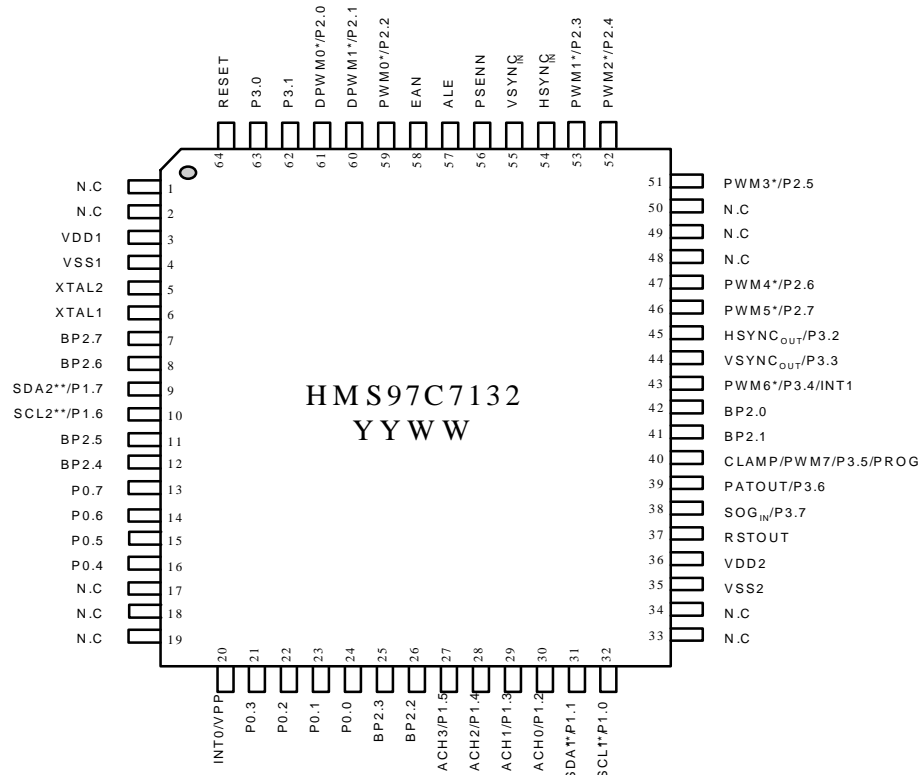
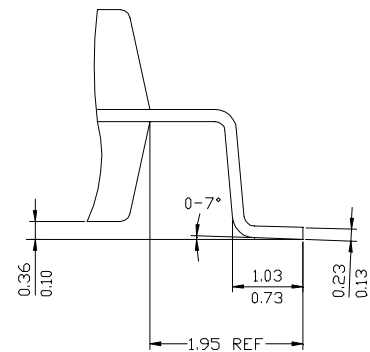
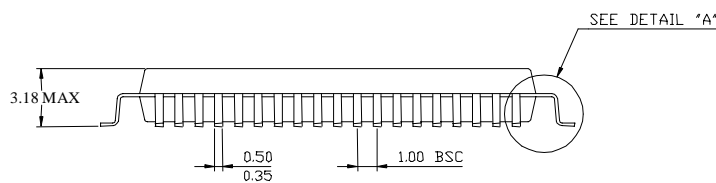


Figure 21-4 EPROM Programming and Verification

## 21.2 64MQFP pinning and Package Dimensions



- NOTE**
1. DIMENSIONS DO NOT INCLUDE MOLD PROTRUSION AND DAMBAR PROTRUSION.  
ALLOWABLE MOLD PROTRUSION IS 0.254mm.  
ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08mm  
TOTAL AT MAXIMUM MATERIAL CONDITION.
  2. FORMED LEAD SHALL BE PLANAR WITH RESPECT ANOTHER  
WITHIN 0.10mm
  3. CONTROLLING DIMENSION : MILLIMETER.  
THIS OUTLINE CONFIRMS TO JEDEC PUBLICATION 95  
RESISTRATION MO-112.



DETAIL "A"

## 21.3 64MQFP Pin Description

PIN NAME (Alternate)	Pin No.	In/Out (Alter- nate)	Function	
			Basic	Alternate
N.C	1	-	No connection	
N.C	2	-	No connection	
V <sub>DD1</sub>	3	-	Power supply1(+5V)	
V <sub>SS1</sub>	4	-	Ground1	
XTAL2	5	O	Oscillator output pin for system clock	
XTAL1	6	I	Oscillator input pin for system clock	
BP2.7	7	I/O	External Access / Emulation port2.7	
BP2.6	8	I/O	External Access / Emulation port2.6	
SDA2 / P1.7	9	I/O	General I/O port P1.7	I <sup>2</sup> C serial data I/O port
SCL2 / P1.6	10	I/O	General I/O port P1.6	I <sup>2</sup> C serial clock I/O port
BP2.5	11	I/O	External Access / Emulation port2.5	
BP2.4	12	I/O	External Access / Emulation port2.4	
P0.7	13	I/O	General I/O port P0.7; adapted for LED driver	
P0.6	14	I/O	General I/O port P0.6; adapted for LED driver	
P0.5	15	I/O	General I/O port P0.5	
P0.4	16	I/O	General I/O port P0.4	
N.C	17	-	No connection	
N.C	18	-	No connection	
N.C	19	-	No connection	
INT0 / V <sub>PP</sub>	20	I	External interrupt input0; Programming supply voltage (during OTP programming)	
P0.3	21	I/O	General I/O port P0.3	
P0.2	22	I/O	General I/O port P0.2	
P0.1	23	I/O	General I/O port P0.1	
P0.0	24	I/O	General I/O port P0.0	
BP2.3	25	I/O	External Access / Emulation port2.3	
BP2.2	26	I/O	External Access / Emulation port2.2	
ACH3 / P1.5	27	I/O	General I/O port P1.5	ADC channel3 input
ACH2 / P1.4	28	I/O	General I/O port P1.4	ADC channel2 input
ACH0 / P1.3	29	I/O	General I/O port P1.3	ADC channel1 input
ACH0 / P1.2	30	I/O	General I/O port P1.2	ADC channel0 input
SDA1 / P1.1	31	I/O	General I/O port P1.1	I <sup>2</sup> C serial data I/O port for DDC interface
SCL1 / P1.0	32	I/O	General I/O port P1.0	I <sup>2</sup> C serial clock I/O port for DDC interface
N.C	33	-	No connection	
N.C	34	-	No connection	
V <sub>SS2</sub>	35	-	Ground2	
V <sub>DD2</sub>	36	-	Power supply2(+5V)	
RSTOUT	37	O	RESET or Internal reset out / EH-IC reset signal; active High	
SOGin / P3.7	38	I/O	General I/O port P3.7	Sync on Green input

**Table 21-4 Port Function Description(64MQFP)**

PIN NAME (Alternate)	Pin No.	In/Out (Alternate)	Function	
			Basic	Alternate
PATOUT /P3.6	39	I/O	General I/O port P3.6	Pattern out
CLAMP /PWM7 / P3.5 /PROG	40	I/O	General output only port P3.5 Program pulse input(during OTP programming)	Clamp out ; 8-bit Pulse Width Modulation output7
BP2.1	41	I/O	External Access / Emulation port2.1	
BP2.0	42	I/O	External Access / Emulation port2.0	
PWM6 /P3.4 INT1	43	I/O	General I/O port P3.4	8-bit Pulse Width Modulation output6; External interrupt input1
VSYNCOut /P3.3	44	I/O	General I/O port P3.3	Vertical sync output
HSYNCOut /P3.2	45	I/O	General I/O port P3.2	Horizontal sync output
PWM5 /P2.7	46	I/O	General I/O port P2.7	8-bit Pulse Width Modulation output5
PWM4 /P2.6	47	I/O	General I/O port P2.6	8-bit Pulse Width Modulation output4
N.C	48	-	No connection	
N.C	49	-	No connection	
N.C	50	-	No connection	
PWM3 /P2.5	51	I/O	General I/O port P2.5	8-bit Pulse Width Modulation output3
PWM2 /P2.4	52	I/O	General I/O port P2.4	8-bit Pulse Width Modulation output2
PWM1 /P2.3	53	I/O	General I/O port P2.3	8-bit Pulse Width Modulation output1
HSYNCCin	54	I	Horizontal sync input	
VSYNCCin	55	I	Vertical sync input	
PSENN	56	I/O	Program Store Enable Not / Emulation PSEN	
ALE	57	I/O	Address Latch Enable / Emulation ALE	
EAN	58	I/O	External Access Not / Emulation EA	
PWM0 /P2.2	59	I/O	General I/O port P2.2	8-bit Pulse Width Modulation output0
DPWM0 /P2.1	60	I/O	General I/O port P2.1	8-bit Dynamic Pulse Width Modulation output0
DPWM0 /P2.0	61	I/O	General I/O port P2.0	8-bit Dynamic Pulse Width Modulation output1
P3.1	62	I/O	General I/O port P3.1	
P3.0	63	I/O	General I/O port P3.0	
<u>RESET</u>	64	I	Reset input	

**Table 21-4 Port Function Description(64MQFP)**

### 21.4 Development Tools

The HMS9xC7132 is supported by a full-featured macro assembler / linker , an in-circuit emulator MetaICE™.

Product	Developer	An agency in Korea
In Circuit Emulators	MetaICE	zeusemtek( <a href="http://www.emtek.co.kr">www.emtek.co.kr</a> )
Compiler	KEIL C51 Compiler, A51/A251 Assembler/Linker	Hankook MDS( <a href="http://www.hkmds.com">www.hkmds.com</a> )
Debugger	XHP3051.exe (Source-level Debugging)	

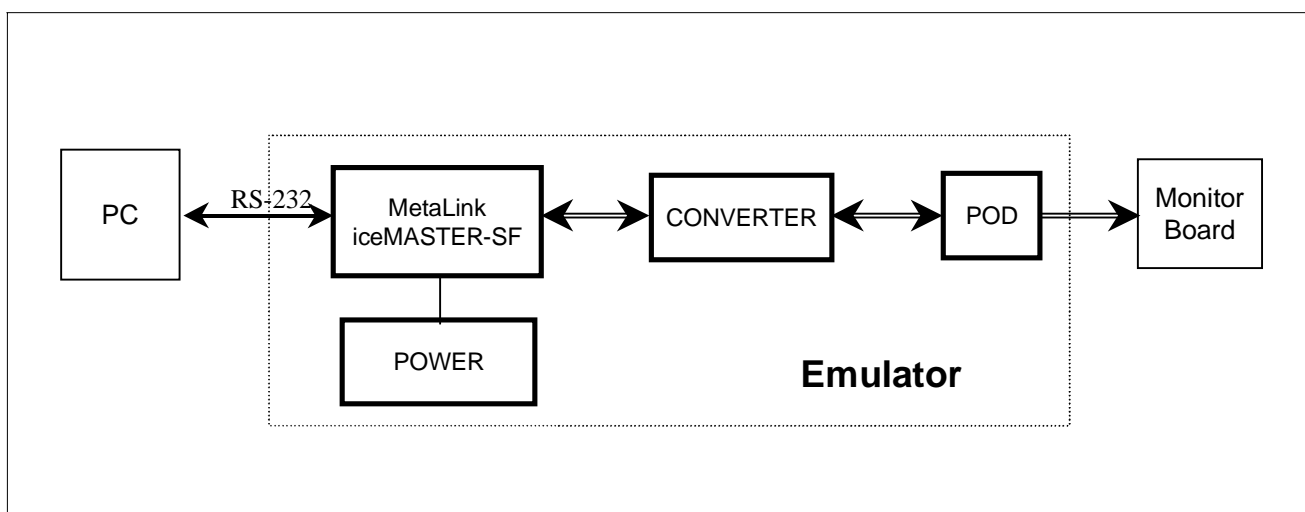


Figure 21-5 Development system Hardware Blockdiagram

## 22. INSTRUCTION SET

The HMS9xC7132 uses a powerful instruction set which permits the expansion of on-chip CPU peripherals and optimizes byte efficiency and execution speed. Assigned opcodes add new high-power operation and permit new addressing modes.

The instruction set consists of 49 single-byte, 46 two-byte and 16 three-byte instructions. When using a 12MHz oscillator, 64 in-

structions execute in 1us and 45 instructions execute in 2us. Multiply and divide instructions execute in 4 us.

For the description of the Date Addressing modes and Hexadecimal opcode cross-reference see Boolean variable manipulation, Program branching.

### •Arithmetic operations

Mnemonic	Description	Bytes	Cycles	Hex Code
ADD A, Rn	add register to A	1	1	2x
ADD A, direct	add direct byte to A	2	1	25
ADD A, @Ri	add indirect RAM to A	1	1	26,27
ADD A, #data	add immediate data to A	2	1	24
ADDC A, Rn	add register to A with carry flag	1	1	3x
ADDC A, direct	add direct byte to A with carry flag	2	1	35
ADDC A, @Ri	add indirect RAM to A with carry flag	1	1	36,37
ADDC A, #data	add immediate data to A with carry flag	2	1	34
SUBB A, Rn	subtract register from A with borrow	1	1	9x
SUBB A, direct	subtract direct byte from A with borrow	2	1	95
SUBB A, @Ri	subtract indirect RAM from A with borrow	1	1	96,97
SUBB A, #data	subtract immediate data from A with borrow	1	1	94
INC A	increment A	1	1	04
INC Rn	increment register	1	1	0x
INC direct	increment direct byte			
INC @Ri	increment indirect RAM	1	1	06,07
DEC A	decrement A	1	1	14
DEC Rn	decrement Rn	1	1	1x
DEC direct	decrement direct byte	2	1	15
DEC @Ri	decrement indirect RAM	1	1	16,17
INC DTPR	increment data pointer	1	2	A3
MUL AB	multiply A and B	1	4	A4
DIV AB	divide A by B	1	4	84
DA A	decimal adjust A	1	1	D4

# •Logical operations

Mnemonic	Description	Bytes	Cycles	Hex Code
ANL A, Rn	AND register to A	1	1	5x
ANL A, direct	AND direct byte to A	2	1	55
ANL A, @Ri	AND indirect RAM to A	1	1	56,57
ANL A, #data	AND immediate data to A	2	1	54
ANL direct, A	AND A to direct byte	2	1	52
ANL direct, #data	AND immediate data to direct byte	3	2	53
ORL A, Rn	OR register to A	1	1	4x
ORL A, direct	OR direct byte to A	2	1	45
ORL A, @Ri	OR indirect RAM to A	1	1	46,47
ORL A, #data	OR immediate data to A	2	1	44
ORL direct, A	OR A to direct byte	2	1	42
ORL direct, #data	OR immediate data to direct byte	3	2	43
XRL A, Rn	exclusive-OR register to A	1	1	6x
XRL A, direct	exclusive-OR direct byte to A	2	1	65
XRL A, @Ri	exclusive-OR indirect RAM to A	2	1	66,67
XRL A, #data	exclusive-OR immediate data to A	2	1	64
XRL direct, A	exclusive-OR A to direct byte	2	1	62
XRL direct, #data	exclusive-OR immediate data to direct byte	3	2	63
CLR A	clear A	1	1	E4
CPL A	complement A	1	1	F4
RL A	rotate A left	1	1	23
RLC A	rotate A left through the carry flag	1	1	33
RR A	rotate A right	1	1	03
RRC A	rotate A right through the carry flag	1	1	13
SWAP A	swap nibbles within A	1	1	C4

# •Data transfer

Mnemonic	Description	Bytes	Cycles	Hex Code
MOV A, Rn	move register to A	1	1	Ex
MOV A, direct	move direct byte to A	2	1	E5
MOV A, @Ri	move indirect RAM to A	1	1	E6,E7
MOV A, #data	move immediate data to A	2	1	74
MOV Rn, A	move A to register	1	1	Fx
MOV Rn, direct	move direct byte to register	2	2	Ax
MOV Rn, #data	move immediate data to register	2	1	7x
MOV direct, A	move A to direct byte	2	1	F5
MOV direct, Rn	move register to direct byte	2	2	8x
MOV direct, direct	move direct byte to direct byte	3	2	85

Mnemonic	Description	Bytes	Cycles	Hex Code
MOV direct, @Ri	move indirect RAM to direct byte	2	2	86,87
MOV direct, #data	move immediate data to direct byte	3	2	75
MOV @Ri, A	move A to indirect RAM	1	1	F6,F7
MOV @Ri, direct	move direct byte to indirect RAM	2	2	A6,A7
MOV @Ri, #data	move immediate data to indirect RAM	2	1	76,77
MOV DPTR, #data16	load data pointer with a 16-bit constant	3	2	90
MOVC A, @A+DPTR	move code byte relative to DPTR to A	1	2	93
MOVC A, @A+C	move code byte relative to PC to A	1	2	83
MOVX A, @Ri	move external RAM (8-bit address) to A	1	2	E2,E3
MOVX A, @DPTR	move external RAM (16-bit address) to A	1	2	E0
MOVX @Ri, A	move A to external RAM (8-bit address)	1	2	F2,F3
MOVX @DPTR, A	move A to external RAM (16-bit address)	1	2	F0
PUSH direct	push direct byte onto stack	2	2	C0
POP direct	pop direct byte from stack	2	2	D0
XCH A, Rn	exchange register with A	1	1	Cx
XCH A, direct	exchange direct byte with A	2	4	C5
XCH A, @Ri	exchange indirect RAM with A	1	1	C6,C7
XCHD A, @Ri	exchange LOW-order digit indirect RAM with A	1	1	D6,D7

#### •Boolean variable manipulation

Mnemonic	Description	Bytes	Cycles	Hex Code
CLR C	clear carry flag	1	1	C3
CLR bit	clear direct bit	2	1	C2
SETB C	set carry flag	1	1	D3
SETB bit	set direct bit	2	1	D2
CPL C	complement carry flag	1	1	B3
CPL bit	complement direct bit	2	1	B2
ANL C, bit	AND direct bit to carry flag	2	1	82
ANL C, /bit	AND complement of direct bit to carry flag	2	2	B0
OR C, bit	OR direct bit to carry flag	2	2	72
OR C, /bit	OR complement of direct bit to carry flag	2	2	A0
MOV C, bit	move direct bit to carry flag	2	1	A2
*MOV bit, C	move carry flag to direct bit	2	2	92
JC rel	jump if carry flag is set	2	2	40
JNC rel	jump if carry flag is not set	2	2	50
JB bit, rel	jump if direct bit is set	3	2	20
JNB bit, rel	jump if direct bit is not set	3	2	30
JBC bit, rel	jump if direct bit is set and clear bit	3	2	10

Note: \* This command is not available under OTP Emulation Mode



# •Program branching

Mnemonic	Description	Bytes	Cycles	Hex Code
ACALL addr11	absolute subroutine call	2	2	y1
LCALL addr16	long subroutine call	3	1	12
RET	return from subroutine	1	2	22
RETI	return from interrupt	2	2	32
AJMP addr16	absolute jump	2	2	z1
LJMP addr16	long jump	3	2	02
SJMP addr16	short jump(relative address)	2	2	80
JMP @A+DPTR	jump indirect relative to the DPTR	1	2	73
JZ rel	jump if A is zero	2	2	60
JNZ rel	jump if A is not zero	2	2	70
CJNE A, direct, rel	compare direct byte to A and jump if not equal	3	2	B5
CJNE A, #data, rel	compare immediate data to A and jump if not equal	3	2	B4
CJNE Rn, #data, rel	compare immediate data to register and jump if not equal	3	2	Bx
CJNE A, @Ri, rel	compare immediate data to indirect RAM and jump if not equal	3	2	B6,B7
DJNZ Rn, rel	decrement register and jump if not zero	2	2	Dx
DJNZ direct, rel	decrement direct byte and jump if not zero	3	2	D5
NOP	no operation	1	1	00

# •Data addressing modes

Mnemonic	Description
Rn	working register R0-R7
direct	128 internal RAM locations and any special function register (SFR)
@Ri	indirect internal RAM location addressed by register by register R0 or R1 of the actual register bank
#data	8-bit constant included in instruction
#data16	16-bit constant included as bytes 2 and 3 of instruction
bit	direct addressed bit in internal RAM or SFR
addr16	16-bit destination address. Used by LCALL and LJMP; the branch will be anywhere within the 64 kbytes Program Memory address space
addr11	11-bit destination address. Used by ACALL and AJMP;the branch will be within the same 2 kbytes page of Program Memory as the first byte of the following instruction
rel	signed(two's complement) 8-bit offset byte. Used by SJMP and all conditional jumps; range is - 128 to + 127 bytes relative to first byte of the following instruction

## •Hexadecimal opcode cross-reference

Mnemonic	Description
x	8, 9, A, B, C, D, E, F
y	1, 3, 5, 7, 9, B, D, F
z	0, 2, 4, 6, 8, A, C, E