OKI semiconductor

MSM80C85A-2RS/GS/JS

8-BIT CMOS MICROPROCESSOR

GENERAL DESCRIPTION

The MSM80C85A-2 is a complete 8-bit parallel central processor implemented in silicon gate C-MOS technology and compatible with MSM80C85A.

It is designed with higher processing speed (max. 5 MHz) and lower power consumption compared with MSM80C85A and power down mode is provided, thereby offering a high level of system integration.

The MSM80C85A-2 uses a multiplexed address/data bus.The address is split between the 8-bit address bus and the 8-bit data bus. The on-chip address latche of a MSM81C55-5 memory product allows a direct interface with the MSM80C85A-2.

FEATURES

- Power down mode (HALT·HOLD)
- Low Power Dissipation: 50mW Typ
- Single +3 to +6 V Power Supply
- −40 to +85°C, Operating Temperature
- Compatible with MSM80C85A
- 0.8μ Instruction Cycle (V_{CC} = 5V)
- On-Chip Clock Generator (with External Crystal)
- On-Chip System Controller; Advanced Cycle Status Information Available for Large System Control
- Four Vectored Interrupt Inputs (One is non-maskable) Plus the 8080A-compatible interrupt.
- Serial In/Serial Out Port
- Decimal, Binary and Double Precision Arithmetic
- Addressing Capability to 64K Bytes of Memory
- TTL Compatible
- 40 pin Plastic DIP (DIP40-P-600)
- 44 pin PLCC (QFJ44-P-S650)
- 44 pin-V Plastic QFP(QFP44-P-910-VK)

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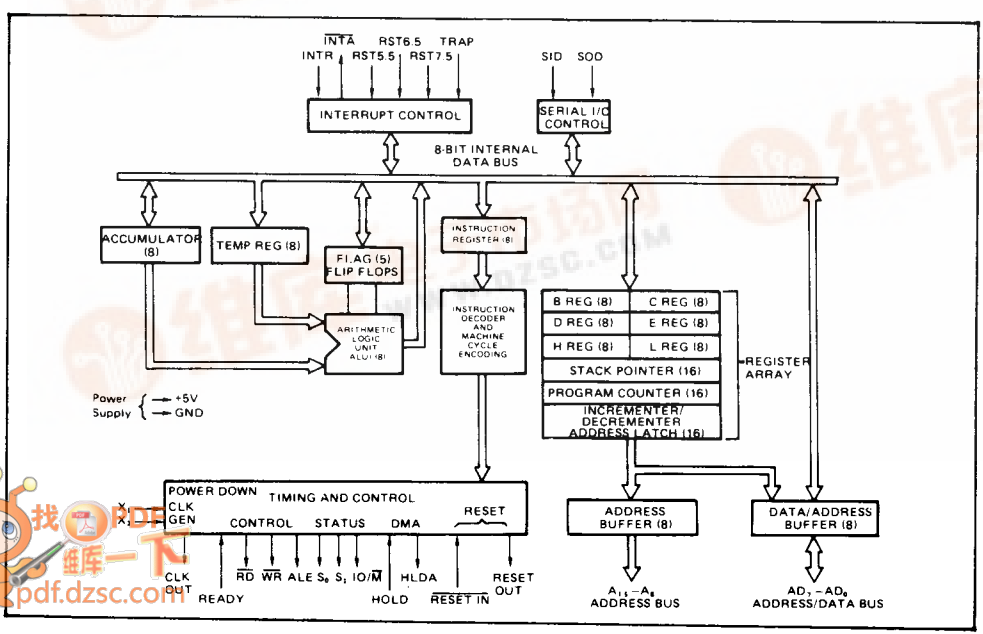
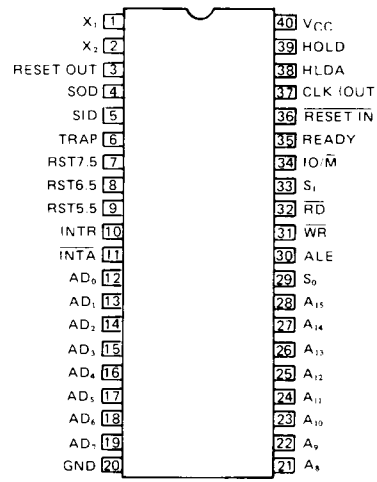
FUNCTIONAL BLOCK DIAGRAM

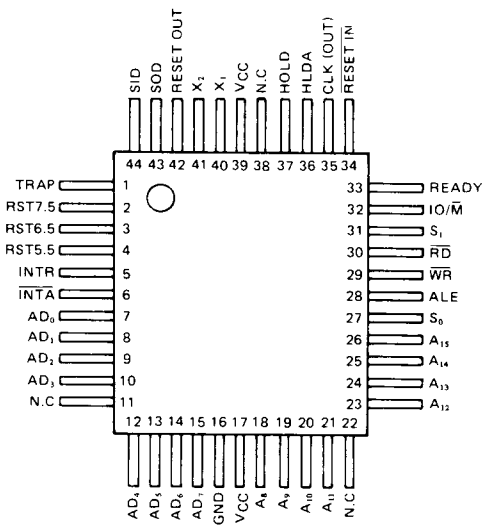


PIN CONFIGURATION

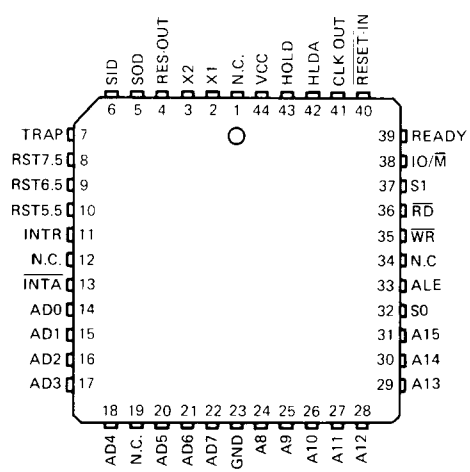
MSM80C85A-2RS (Top View)
40 Lead Plastic DIP



MSM80C85A-2GS (Top View)
44 Lead Plastic Flat Package



MSM80C85A-2JS (Top View)
44 Plastic Leaded Chip Carrier



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MSM80C85A-2 FUNCTIONAL PIN DEFINITION

The following describes the function of each pin:

Symbol	Function
A_8–A_{15} (Output, 3-state)	Address Bus: The most significant 8-bits of the memory address or the 8-bits of the I/O address, 3-stated during Hold and Halt modes and during RESET.
AD_0–AD_7 (Input/Output) 3-state	Multiplexed Address/Data Bus: Lower 8-bits of the memory address (or I/O address) appear on the bus during the first clock cycle (T state) of a machine cycle. It then becomes the data bus during the second and third clock cycles.
ALE (Output)	Address Latch Enable: It occurs during the first clock state of a machine cycle and enables the address to get latched into the on-chip latch of peripherals. The falling edge of ALE is set to guarantee setup and hold times for the address information. The falling edge of ALE can also be used to strobe the status information ALE is never 3-stated.
S_0, S_1, IO/$\overline{M}$ (Output)	Machine cycle status: IO/$\overline{M}$ S_1 S_0 States 0 0 1 Memory write 0 1 0 Memory read 1 0 1 I/O write 1 1 0 I/O read 0 1 1 Opcode fetch IO/$\overline{M}$ S_1 S_0 States 1 1 1 Interrupt Acknowledge . 0 0 Halt = 3-state . x x Hold (high impedance) . x x Reset x = unspecified S_1 can be used as an advanced R/W status. IO/$\overline{M}$, S_0 and S_1 become valid at the beginning of a machine cycle and remain stable throughout the cycle. The falling edge of ALE may be used to latch the state of these lines.
$\overline{RD}$ (Output, 3-state)	READ control: A low level on $\overline{RD}$ indicates the selected memory or I/O device is to be read and that the Data Bus is available for the data transfer, 3-stated during Hold and Halt modes and during RESET.
$\overline{WR}$ (Output, 3-state)	WRITE control: A low level on $\overline{WR}$ indicates the data on the Data Bus is to be written into the selected memory or I/O location. Data is set up at the trailing edge of $\overline{WR}$, 3-stated during Hold and Halt modes and during RESET.
READY (Input)	If READY is high during a read or write cycle, it indicates that the memory or peripheral is ready to send or receive data. If READY is low, the cpu will wait an integral number of clock cycles for READY to go high before completing the read or write cycle READY must conform to specified setup and hold times.
HOLD (Input)	HOLD indicates that another master is requesting the use of the address and data buses. The cpu, upon receiving the hold request, will relinquish the use of the bus as soon as the completion of the current bus transfer. Internal processing can continue. The processor can regain the bus only after the HOLD is removed. When the HOLD is acknowledged, the Address, Data, $\overline{RD}$, $\overline{WR}$, and IO/$\overline{M}$ lines are 3-stated. And status of power down is controlled by HOLD.
HLDA (Output)	HOLD ACKNOWLEDGE: Indicates that the cpu has received the HOLD request and that it will relinquish the bus in the next clock cycle. HLDA goes low after the Hold request is removed. The cpu takes the bus one half clock cycle after HLDA goes low.
INTR (Input)	INTERRUPT REQUEST: Is used as a general purpose interrupt. It is sampled on during the next to the last clock cycle of an instruction and during Hold and Halt states. If it is active, the Program Counter (PC) will be inhibited from incrementing and an $\overline{INTA}$ will be issued. During this cycle a RESTART or CALL instruction can be inserted to jump to the interrupt service routine. The INTR is enabled and disabled by software. It is disabled by Reset and immediately after an interrupt is accepted. Power down mode is reset by INTR.
$\overline{INTA}$ (Output)	INTERRUPT ACKNOWLEDGE: Is used instead of (and has the same timing as) $\overline{RD}$ during the instruction cycle after an INTR is accepted.
RST 5.5 RST 6.5 RST 7.5 (Input)	RESTART INTERRUPTS: These three inputs have the same timing as INTR except they cause an internal RESTART to be automatically inserted. The priority of these interrupts is ordered as shown in Table 1. These interrupts have a higher priority than INTR. In addition, they may be individually masked out using the SIM instruction. Power down mode is reset by these interrupts.
TRAP (Input)	Trap interrupt is a nonmaskable RESTART interrupt. It is recognized at the same timing as INTR or RST 5.5–7.5. It is unaffected by any mask or Interrupt Disable. It has the highest priority of any interrupt. (See Table 1.) Power down mode is reset by input of TRAP.

Symbol	Function
$\overline{\text{RESET IN}}$ (Input)	Sets the Program Counter to zero and resets the Interrupt Enable and HLDA flip-flops and release power down mode. The data and address buses and the control lines are 3-stated during RESET and because of the asynchronous nature of $\overline{\text{RESET}}$, the processor's internal registers and flags may be altered by RESET with unpredictable results. $\overline{\text{RESET IN}}$ is a Schmitt-triggered input, allowing connection to an R-C network for power-on RESET delay. The cpu is held in the reset condition as long as $\overline{\text{RESET IN}}$ is applied.
RESET OUT (Output)	Indicated cpu is being reset. Can be used as a system reset. The signal is synchronized to the processor clock and lasts an integral number of clock periods.
X_1, X_2 (Input)	X_1 and X_2 are connected to a crystal to drive the internal clock generator. X_1 can also be an external clock input from a logic gate. The input frequency is divided by 2 to give the processor's internal operating frequency.
CLK (Output)	Clock Output for use as a system clock. The period of CLK is twice the X_1, X_2 input period.
SID (Input)	Serial input data line. The data on this line is loaded into accumulator bit 7 whenever a RIM instruction is executed.
SOD (Output)	Serial output data line. The output SOD is set or reset as specified by the SIM instruction.
V_{CC}	+5 volt supply.
GND	Ground Reference.

Table 1 Interrupt Priority, Restart Address, and Sensitivity

Name	Priority	Address Branched To (1) When Interrupt Occurs	Type Trigger
TRAP	1	24H	Rising edge and high level until sampled.
RST 7.5	2	3CH	Rising edge (latched).
RST 6.5	3	34H	High level until sampled.
RST 5.5	4	2CH	High level until sampled.
INTR	5	(2)	High level until sampled.

Notes: (1) The processor pushes the PC on the stack before branching to the indicated address.
(2) The address branched to depends on the instruction provided to the cpu when the interrupt is acknowledged.

FUNCTIONAL DESCRIPTION

The MSM80C85A-2 is a complete 8-bit parallel central processor. It is designed with silicon gate C-MOS technology and requires a single +5 volt supply. Its basic clock speed is 5MHz, thus improving on the present MSM80C85A's performance with higher system speed and power down mode. Also it is designed to fit into a minimum system of three IC's: The cpu (MSM80C85A-2), and a RAM/IO (MSM81C55-5)

The MSM80C85A-2 has twelve addressable 8-bit register pairs. Six others can be used interchangeably as 8-bit registers or a 16-bit register pairs. The MSM-80C85A-2 register set is as follows:

Mnemonic	Register	Contents
ACC or A	Accumulator	8-bits
PC	Program Counter	16-bit address
BC, DE, HL	General-Purpose Registers; data pointer (HL)	8-bit x 6 or 16-bits x 3
SP	Stack Pointer	16-bit address
Flags or F	Flag Register	5 flags (8-bit space)

The MSM80C85A-2 uses a multiplexed Data Bus. The address is split between the higher 8-bit Address Bus and the lower 8-bit Address/Data Bus. During the first T state (clock cycle) of a machine cycle the low order address is sent out on the Address/Data Bus. These lower 8-bits may be latched externally by the Address Latch Enable signal (ALE). During the rest of the machine cycle the data bus is used for memory or I/O data.

The MSM80C85A-2 provides $\overline{RD}$, $\overline{WR}$, S_0, S_1 and IO/$\overline{M}$ signals for bus control. An Interrupt Acknowledge signal ($\overline{INTA}$) is also provided. Hold and all Interrupts are synchronized with the processor's internal clock. The MSM80C85A-2 also provides Serial Input Data (SID) and Serial Output Data (SOD) lines for a simple serial interface.

In addition to these features, the MSM80C85A-2 has three maskable, vector interrupt pins, one nonmaskable TRAP interrupt and power down mode with HALT and HOLD.

INTERRUPT AND SERIAL I/O

The MSM80C85A-2 has 5 interrupt inputs: INTR, RST 5.5, RST 6.5, RST 7.5, and TRAP. INTR is identical in function to the 8080A INT. Each of the three RESTART inputs, 5.5, 6.5, and 7.5, has a programmable mask. TRAP is also a RESTART interrupt but it is nonmaskable.

The three maskable interrupts cause the internal execution of RESTART (saving the program counter in the stack and branching to the RESTART address) if the interrupts are enabled and if the interrupt mask is not set. The nonmaskable TRAP causes the internal execution of a RESTART vector independent of the state of the interrupt enable or masks. (See Table 1.)

There are two different types of inputs in the restart interrupts. RST 5.5 and RST 6.5 are high level-sensitive like INTR (and INT on the 8080A) and are recognized with the same timing as INTR. RST 7.5 is rising edge-sensitive.

For RST 7.5, only a pulse is required to set an internal flip-flop which generates the internal interrupt request. The RST 7.5 request flip-flop remains set until the request is serviced. Then it is reset automatically. This flip-flop may also be reset by using the SIM instruction or by issuing a $\overline{RESET\ IN}$ to the MSM80C85A. The RST 7.5 internal flip-flop will be set by a pulse on the RST 7.5 pin even when the RST 7.5 interrupt is masked out.

The interrupts are arranged in a flixed priority that determines which interrupt is to be recognized if more than one is pending, as follows: TRAP—highest priority, RST 7.5, RST 6.5, RST 5.5, INTR—lowest priority. This priority scheme does not take into account the priority of a routine that was started by a higher priority interrupt. RST 5.5 can interrupt an RST 7.5 routine if the interrupts are re-enabled before the end of the RST 7.5 routine.

The TRAP interrupt is useful for catastrophic events such as power failure or bus error. The TRAP input is recognized just as any other interrupt but has the highest priority. It is not affected by any flag or mask. The TRAP input is both edge and level sensitive. The TRAP input must go high and remain high until it is acknowledged. It will not be recognized again until it goes low, then high again. This avoids any false triggering due to noise or logic glitches. Figure 3 illustrates the TRAP interrupt request circuitry within the MSM80C85A-2. Note that the servicing of any interrupt (TRAP, RST 7.5, RST 6.5, RST 5.5, INTR) disables all future interrupts (except TRAPs) until an EI instruction is executed.

The TRAP interrupt is special in that it disables interrupts, but preserves the previous interrupt enable status. Performing the first RIM instruction following a TRAP interrupt allows you to determine whether interrupts were enabled or disabled prior to the TRAP. All subsequent RIM instructions provide current interrupt enable status. Performing a RIM instruction following INTR or RST 5.5–7.5 will provide current Interrupt Enable status, revealing that Interrupts are disabled.

The serial I/O system is also controlled by the RIM and SIM instructions. SID is read by RIM, and SIM sets the SOD data.

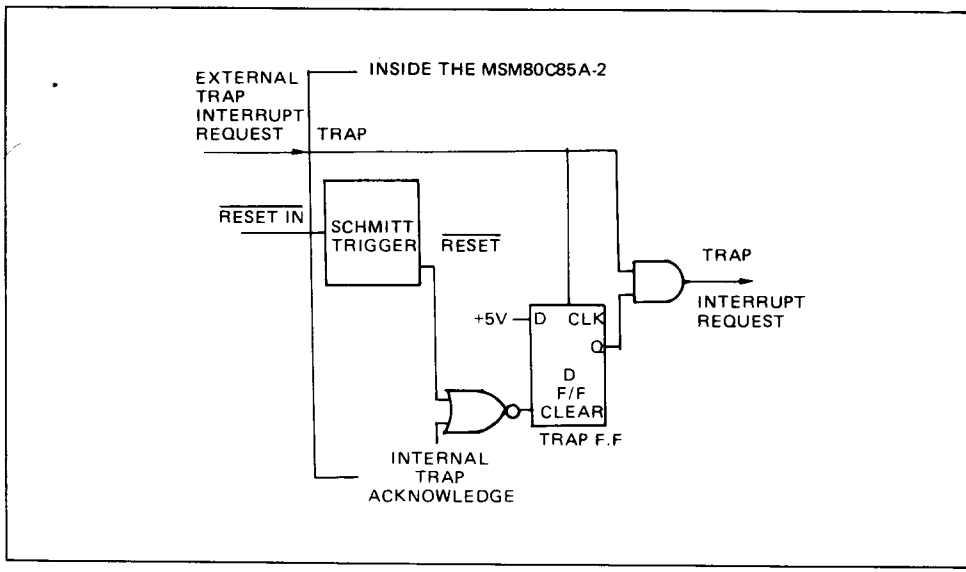


Figure 3 Trap and $\overline{\text{RESET IN}}$ Circuit

DRIVING THE X_1 and X_2 INPUTS

You may drive the clock inputs of the MSM80C-85A-2 with a crystal, or an external clock source. The driving frequency must be at least 1 MHz, and must be twice the desired internal clock frequency; hence, the MSM80C85A-2 is operated with a 6 MHz crystal (for 3 MHz clock). If a crystal is used, it must have the following characteristics:

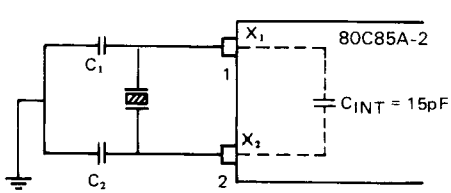
Parallel resonance at twice the clock frequency desired
C_L (load capacitance) $\leq$ 30 pF
C_S (shunt capacitance) $\leq$ 7 pF
R_S (equivalent shunt resistance) $\leq$ 75 ohms
Drive level: 10 mW
Frequency tolerance: ±.005% (suggested)

Note the use of the capacitors between X_1, X_2 and ground. These capacitors are required to assure oscillator startup at the correct frequency.

Figure 4 shows the recommended clock driver circuits. Note in B that a pullup resistor is required to assure that the high level voltage of the input is at least 4V.

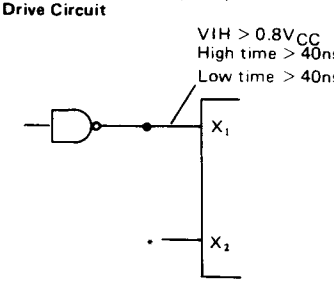
For driving frequencies up to and including 6 MHz you may supply the driving signal to X_1 and leave X_2 open-circuited (Figure 4B). To prevent self-oscillation of the MSM80C85A-2, be sure that X_2 is not coupled back to X_1 through the driving circuit.

A. Quartz Crystal Clock Driver



33pF Capacitor required for crystal frequency 10 to 6.25 MHz.
50pF Capacitor required for crystal frequency 6.25 to 4 MHz.
100pF Capacitor required for crystal frequency <4 MHz.

B. 1–10 MHz Input Frequency External Clock Drive Circuit



* X_2 Left floating

Figure 4 Clock Driver Circuits

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BASIC SYSTEM TIMING

The MSM80C85A-2 has a multiplexed Data Bus. ALE is used as a strobe to sample the lower 8-bits of address on the Data Bus. Figure 5 shows an instruction fetch, memory read and I/O write cycle (as would occur during processing of the OUT instruction). Note that during the I/O write and read cycle that the I/O port address is copied on both the upper and lower half of the address.

There are seven possible types of machine cycles. Which of these seven takes place is defined by the status of the three status lines ($IO/\overline{M}$, S_1, S_0) and the three control signals ($\overline{RD}$, $\overline{WR}$, and $\overline{INTA}$). (See Table 2.) The status line can be used as advanced controls (for device selection, for example), since they become active at the T_1 state, at the outset of each machine cycle. Control lines $\overline{RD}$ and $\overline{WR}$ become active later, at the time when the transfer of data is to take place, so are used as command lines.

A machine cycle normally consists of three T states, with the exception of OPCODE FETCH, which normally has either four or six T states (unless WAIT or HOLD states are forced by the receipt of READY or HOLD inputs). Any T state must be one of ten possible states, shown in Table 3.

Table 2 MSM80C85A-2 Machine Cycle Chart

Machine Cycle		Status			Control		
		$IO/\overline{M}$	S_1	S_0	$\overline{RD}$	$\overline{WR}$	$\overline{INTA}$
Opcode Fetch	(OF)	0	1	1	0	1	1
Memory Read	(MR)	0	1	0	0	1	1
Memory Write	(MW)	0	0	1	1	0	1
I/O Read	(IOR)	1	1	0	0	1	1
I/O Write	(IOW)	1	0	1	1	0	1
Acknowledge of INTR	(INA)	1	1	1	1	1	0
Bus Idle	(BI): DAD	0	1	0	1	1	1
	ACK. OF RST, TRAP	1	1	1	1	1	1
	HALT	TS	0	0	TS	TS	1

Table 3 MSM80C85A-2 Machine State Chart

Machine State	Status & Buses				Control		
	S_1, S_0	$IO/\overline{M}$	A_8-A_{15}	AD_0-AD_7	$\overline{RD}, \overline{WR}$	$\overline{INTA}$	ALE
T_1	X	X	X	X	1	1	1(1)
T_2	X	X	X	X	X	X	0
T_{WAIT}	X	X	X	X	X	X	0
T_3	X	X	X	X	X	X	0
T_4	1	0 (2)	X	TS	1	1	0
T_5	1	0 (2)	X	TS	1	1	0
T_6	1	0 (2)	X	TS	1	1	0
T_{RESET}	X	TS	TS	TS	TS	1	0
T_{HALT}	0	TS	TS	TS	TS	1	0
T_{HOLD}	X	TS	TS	TS	TS	1	0

0 = Logic "0"
1 = Logic "1"
TS = High Impedance
X = Unspecified

Notes: (1) ALE not generated during 2nd and 3rd machine cycles of DAD instruction.
(2) $IO/\overline{M}$ = 1 during $T_4 \sim T_6$ of INA machine cycle.

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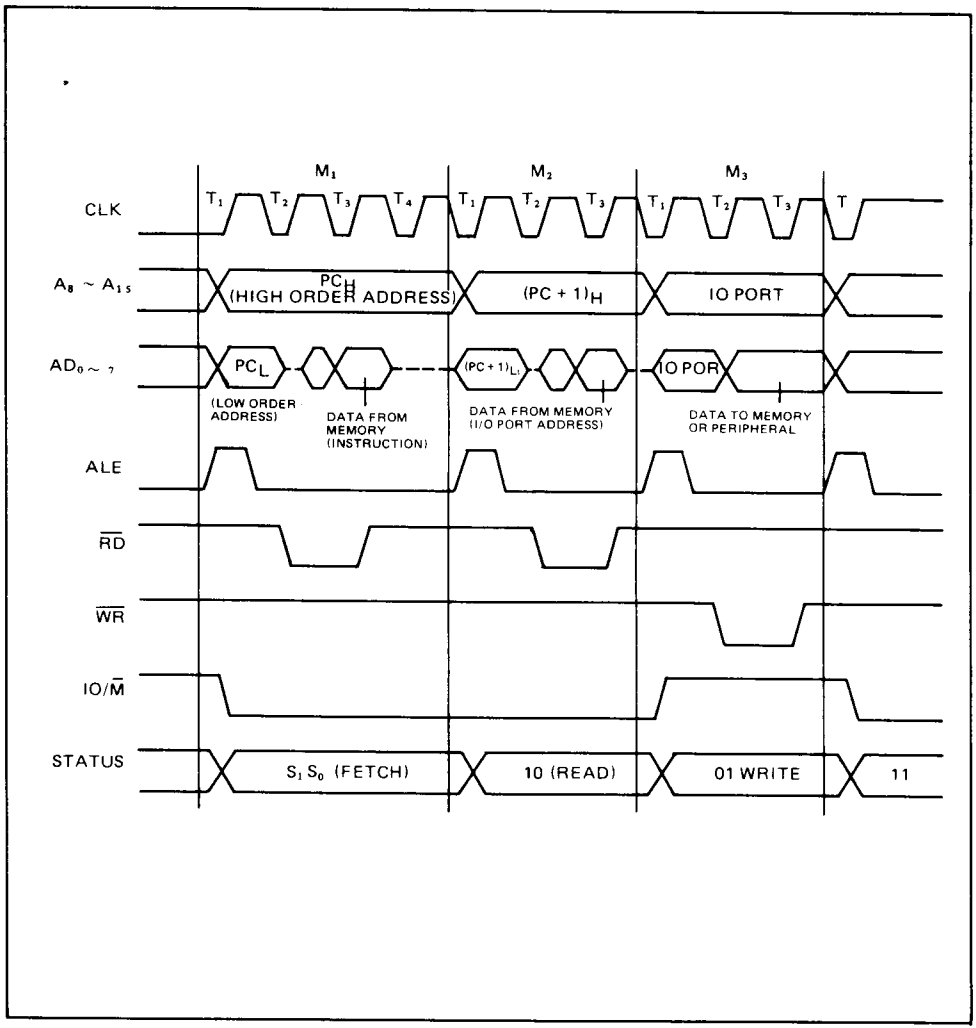

Figure 5. MSM80C85A-2 Basic System Timing

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POWER DOWN Mode (a newly added function)

The MSM80C85A-2 is compatible with the MSM80C85A in function and POWER DOWN mode. This reduces power consumption further.

There are two methods available for starting this POWER DOWN mode. One is through software control by using the HALT command and the other is under hardware control by using the pin HOLD. This mode is released by the HOLD, RESET, and interrupt pins (TRAP, RST7.5, RST6.5, RST5.5, or INTR). (See Table 4.)

Since the sequence of HALT, HOLD, RESET, and INTERRUPT is compatible with MSM80C85A, every the POWER DOWN mode can be used with no special attention.

Table 4 POWER DOWN Mode Releasing Method

Start by means of HALT command	Released by using pins RESET and INTERRUPT (not by pin HOLD)
Start by means of HOLD pin	Released by using RESET and HOLD pins (not by interrupt pins)

(1) Start by means of HALT command

(See Figures 6 and 7.)

The POWER DOWN mode can be started by executing the HALT command.

At this time, the system is put into the HOLD status and therefore the POWER DOWN mode cannot be released even when the HOLD is released later.

In this case, the POWER DOWN mode can be released by means of the RESET or interrupt.

(2) Start by means of HOLD pin (See Figure 8.)

During the execution of commands other than the HALT, the POWER DOWN mode is started when the system is put into HOLD status by means of the HOLD pin.

Since no interrupt works during the execution of the HOLD, the POWER DOWN mode cannot be released by means of interrupt pins.

In this case, the POWER DOWN mode can be released either by means of the RESET pin or by releasing the HOLD status by means of HOLD pin.

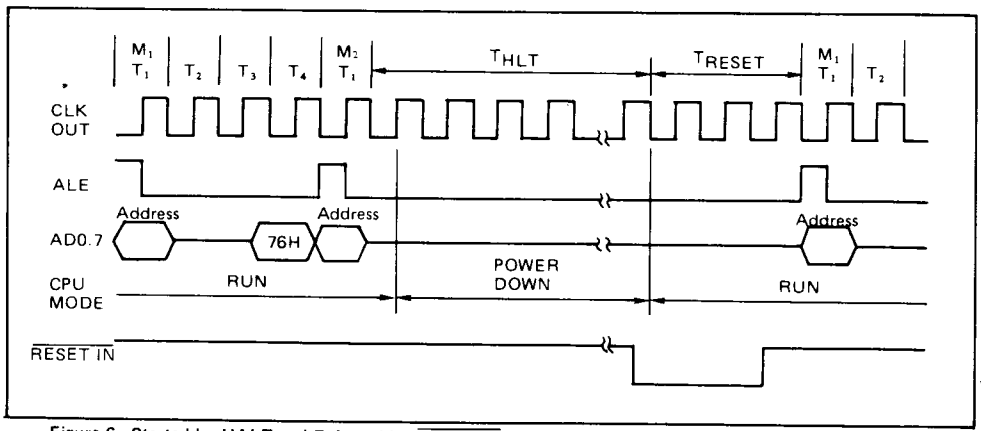


Figure 6. Started by HALT and Released by $\overline{\text{RESET IN}}$

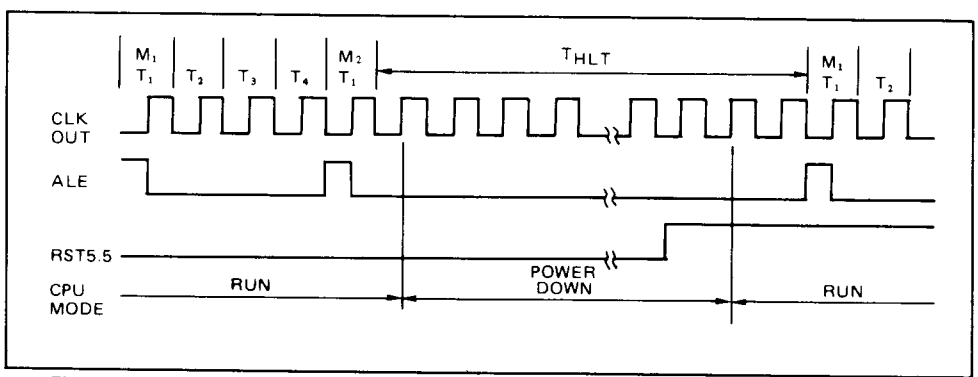


Figure 7. Started by HALT and Released by RST5.5

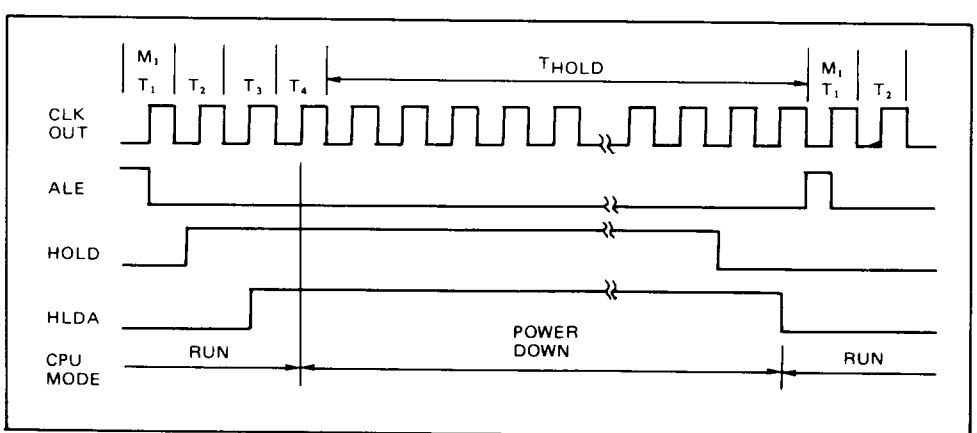


Figure 8. Started and Released by HOLD

ABSOLUTE MAXIMUM RATINGS

• Parameter	Symbol	Condition	Limits			Unit
			MSM80C85A-2RS	MSM80C85A-2GS	MSM80C85A-2JS	
Power Supply Voltage	V_{CC}	With respect to GND	−0.5 ~ +7			V
Input Voltage	V_{IN}		−0.5 ~ V_{CC} +0.5			V
Output Voltage	V_{OUT}		−0.5 ~ V_{CC} +0.5			V
Storage Temperature	Tstg		−55 ~ +150			°C
Power Dissipation	P_D	Ta = 25°C	1.0	0.7	1.0	W

OPERATING RANGE

Parameter	Symbol	Limits	Unit
Power Supply Voltage	V_{CC}	3 ~ 6	V
Operating Temperature	Top	−40 ~ +85	°C

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Min.	Typ.	Max.	Unit
Power Supply Voltage	V_{CC}	4.5	5	5.5	V
Operating Temperature	T_{OP}	−40	+25	+85	°C
"L" Input Voltage	V_{IL}	−0.3		+0.8	V
"H" Output Voltage	V_{IH}	2.2		V_{CC} + 0.3	V
"L" RESET IN Input Voltage	V_{ILR}	−0.3		+0.8	V
"H" RESET IN Input Voltage	V_{IHR}	3.0		V_{CC} + 0.3	V

D.C. CHARACTERISTICS

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit
"L" Output Voltage	V_{OL}	I_{OL} = 2mA				0.45	V
"H" Output Voltage	V_{OH}	I_{OH} = −400μA	V_{CC} = 4.5V ~ 5.5V Ta = −40°C ~ +85°C	2.4			V
		I_{OH} = −40μA		4.2			V
Input Leak Current	I_{LI}	0 ≤ V_{IN} ≤ V_{CC}		−10		10	μA
Output Leak Current	I_{LO}	0 ≤ V_{OUT} ≤ V_{CC}		−10		10	μA
Operating Supply Current	I_{CC}	Tcyc = 200ns C_L = 0pF at reset			10	20	mA
		Tcyc = 200ns C_L = 0pF at power down mode			3	7	mA

A.C. CHARACTERISTICS

($T_a = -40°C \sim 85°C$, $V_{CC} = 4.5V \sim 5.5V$)

Parameter	Symbol	Condition	Min.	Max.	Unit
CLK Cycle Period	t_{CYC}		200	2000	ns
CLK Low Time	t_1		40		ns
CLK High Time	t_2		70		ns
CLK Rise and Fall Time	t_r, t_f			30	ns
X_1 Rising to CLK Rising	t_{XKR}		25	120	ns
X_1 Rising to CKK Failing	t_{XKF}		30	150	ns
$A_8 \sim A_{15}$ Valid to Leading Edge of Control (1)	t_{AC}		115		ns
$A_0 \sim A_7$ Valid to Leading Edge of Control	t_{ACL}		115		ns
$A_0 \sim A_{15}$ Valid Data In	t_{AD}			330	ns
Address Float After Leading Edge of RD INTA	t_{AFR}			0	ns
$A_8 \sim A_{15}$ Valid Before Trailing Edge of ALE (1)	t_{AL}		50		ns
$A_0 \sim A_7$ Valid Before Trailing Edge of ALE	t_{ALL}		50		ns
READY Valid from Address Valid	t_{ARY}			100	ns
Address ($A_8 \sim A_{15}$) Valid After Control	t_{CA}		60		ns
Width of Control Law (RD, WR, INTA)	t_{CC}		230		ns
Trailing Edge of Control to Leading Edge of ALE	t_{CL}		25		ns
Data Valid to Trailing Edge of WR	t_{DW}		230		ns
HLDA to Bus Enable	t_{HABE}			150	ns
Bus Float After HLDA	t_{HABF}	$t_{CYC} = 200ns$		150	ns
HLDA Valid to Trailing Edge of CLK	t_{HACK}	$C_L = 150pF$	40		ns
HOLD Hold Time	t_{HDH}		0		ns
HOLD Step Up Time to Trailing Edge of CLK	t_{HDS}		120		ns
INTR Hold Time	t_{INH}		0		ns
INTR, RST and TRAP Setup Time to Falling Edge of CLK	t_{INS}		150		ns
Address Hold Time After ALE	t_{LA}		50		ns
Trailing Edge of ALE to Leading Edge of Control	t_{LC}		60		ns
ALE Low During CLK High	t_{LCK}		50		ns
ALE to Valid Data During Read	t_{LDR}			250	ns
ALE to Valid Data During Write	t_{LDW}			140	ns
ALE Width	t_{LL}		80		ns
ALE to READY Stable	t_{LRY}			30	ns
Trailing Edge of RD to Re-enabling of Address	t_{RAE}		90		ns
RD (or INTA) to Valid Data	t_{RD}			150	ns
Control Trailing Edge to Leading Edge of Next Control	t_{RV}		220		ns
Data Hold Time After RD INTA (7)	t_{RDH}		0		ns
READY Hold Time	t_{RYH}		0		ns
READY Setup Time to Leading Edge of CLK	t_{RYS}		100		ns
Data Valid After Trailing Edge of WR	t_{WD}		60		ns
LEADING Edge of WR to Data Valid	t_{WDL}			20	ns

Notes: (1) $A_8 \sim A_{15}$ address Specs apply to IO/M, S_0, and S_1 except $A_8 \sim A_{15}$ are undefined during $T_4 \sim T_8$ of OF cycle whereas IO/M, S_0, and S_1 are stable.

(2) Test conditions: $t_{CYC} = 200ns$ $C_L = 150pF$

(3) For all output timing where $C_L = 150pF$ use the following correction factors:
$25pF \leq C_L < 150pF$: −0.10ns/pF
$150pF < C_L \leq 300pF$: +0.30ns/pF

(4) Output timings are measured with purely capacitive load.

(5) All timings are measured at output voltage $V_L = 0.8V$, $V_H = 2.2V$, and 1.5V with 10ns rise and fall time on inputs.

(6) To calculate timing specifications at other values of t_{CYC} use Table 7.

(7) Data hold time is guaranteed under all loading conditions.

Input Waveform for A.C. Tests:

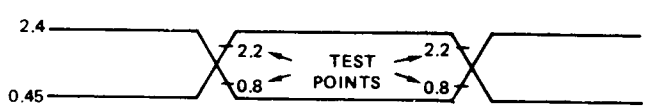


Table 7 Bus Timing Specification as a T_{CYC} Dependent

($Ta = -40°C \sim +85°C$, $V_{CC} = 4.5V \sim 5.5V$, $C_L = 150pF$)

	MSM80C85A-2		
t_{AL}	–	(1/2)T – 50	MIN
t_{LA}	–	(1/2)T – 50	MIN
t_{LL}	–	(1/2)T – 20	MIN
t_{LCK}	–	(1/2)T – 50	MIN
t_{LC}	–	(1/2)T – 40	MIN
t_{AD}	–	(5/2 + N)T – 170	MAX
t_{RD}	–	(3/2 + N)T – 150	MAX
t_{RAE}	–	(1/2)T – 10	MIN
t_{CA}	–	(1/2)T – 40	MIN
t_{DW}	–	(3/2 + N)T – 70	MIN
t_{WD}	–	(1/2)T – 40	MIN
t_{CC}	–	(3/2 + N)T – 70	MIN
t_{CL}	–	(1/2)T – 75	MIN
t_{ARY}	–	(3/2)T – 200	MAX
t_{HACK}	–	(1/2)T – 60	MIN
t_{HABF}	–	(1/2)T + 50	MAX
t_{HABE}	–	(1/2)T + 50	MAX
t_{AC}	–	(2/2)T – 85	MIN
t_1	–	(1/2)T – 60	MIN
t_2	–	(1/2)T – 30	MIN
t_{RV}	–	(3/2)T – 80	MIN
t_{LDR}	–	(2+N)T – 150	MAX

Note: N is equal to the total WAIT states.
$T = t_{CYC}$

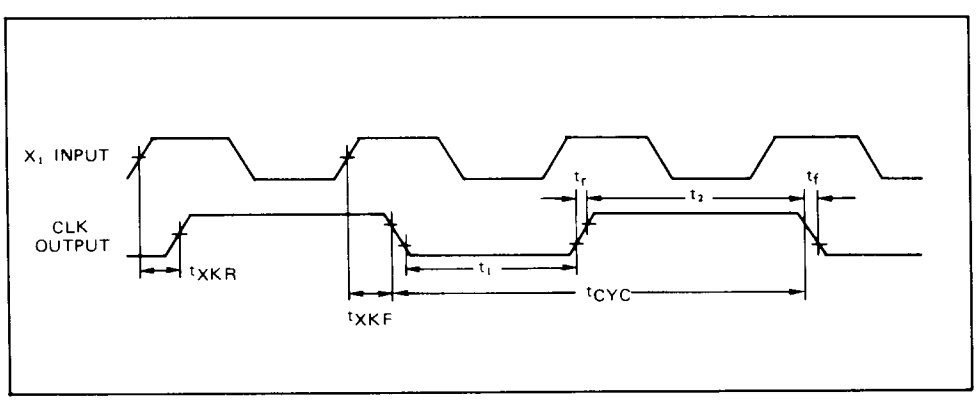
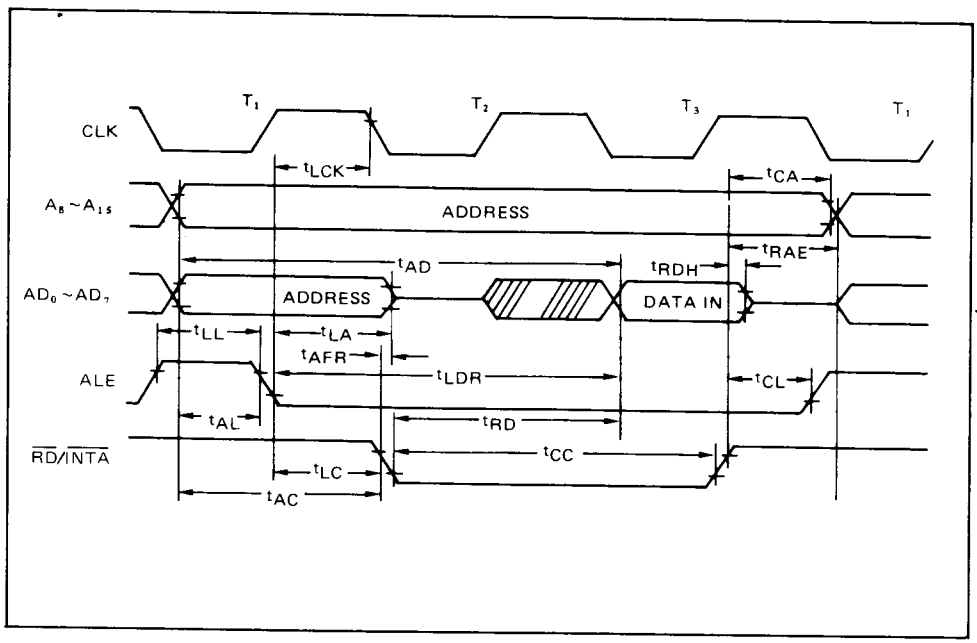
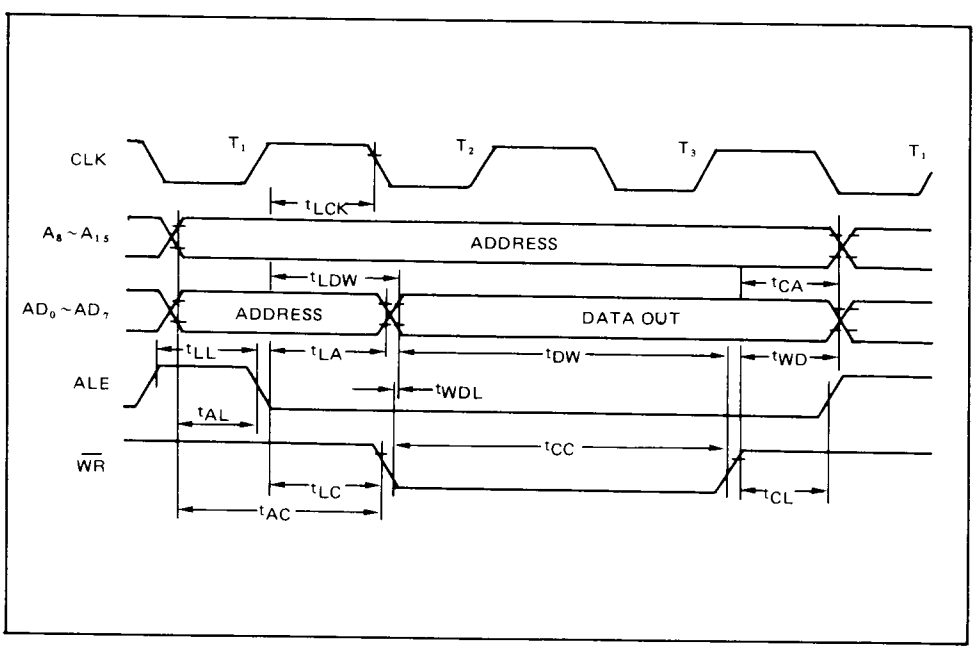


Figure 6 Clock Timing Waveform

READ OPERATION



WRITE OPERATION



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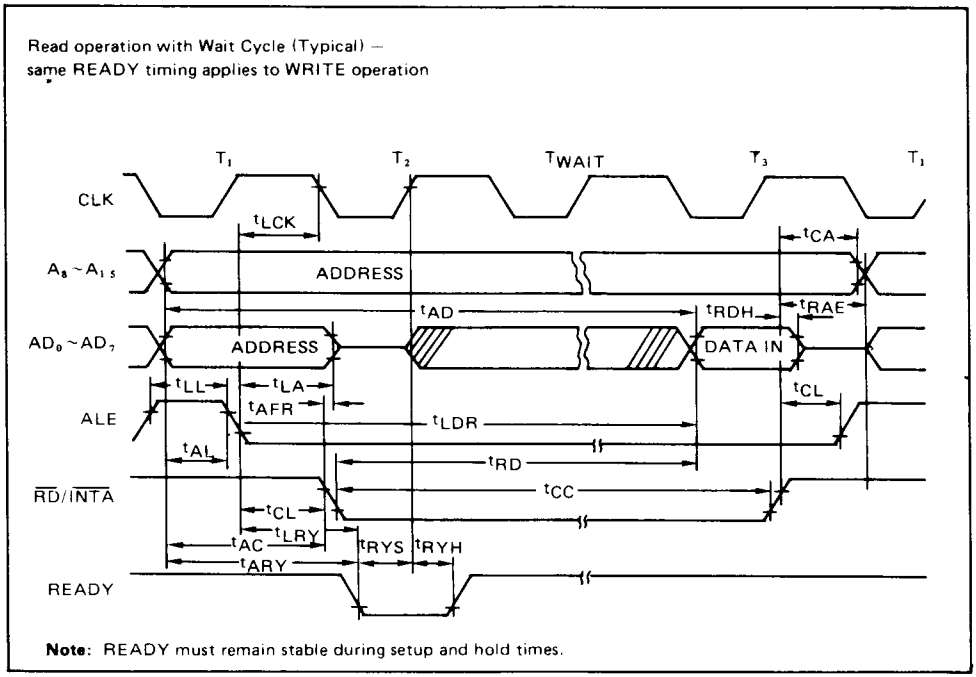


Figure 7 MSM80C85A-2 Bus Timing, With and Without Wait

HOLD OPERATION

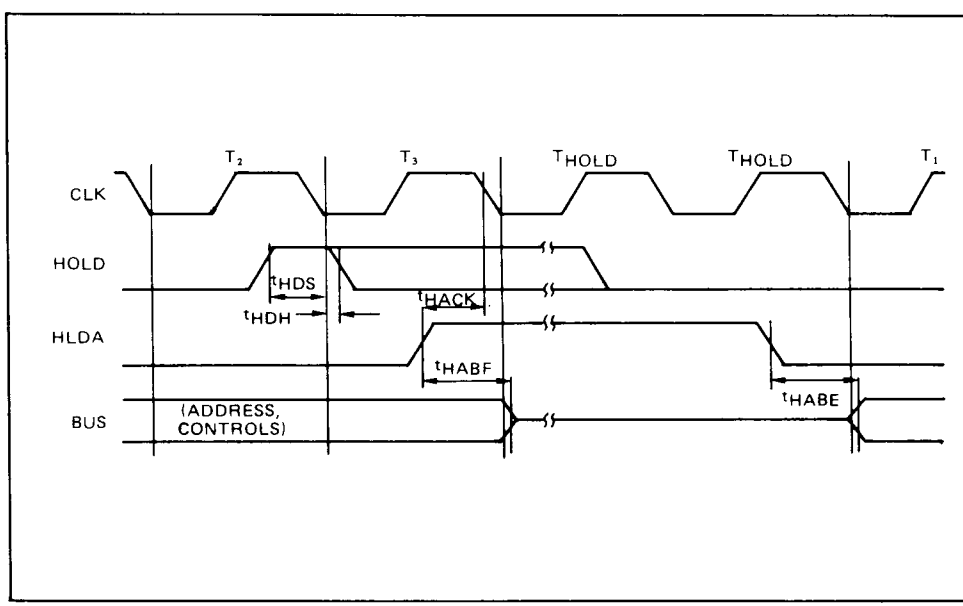
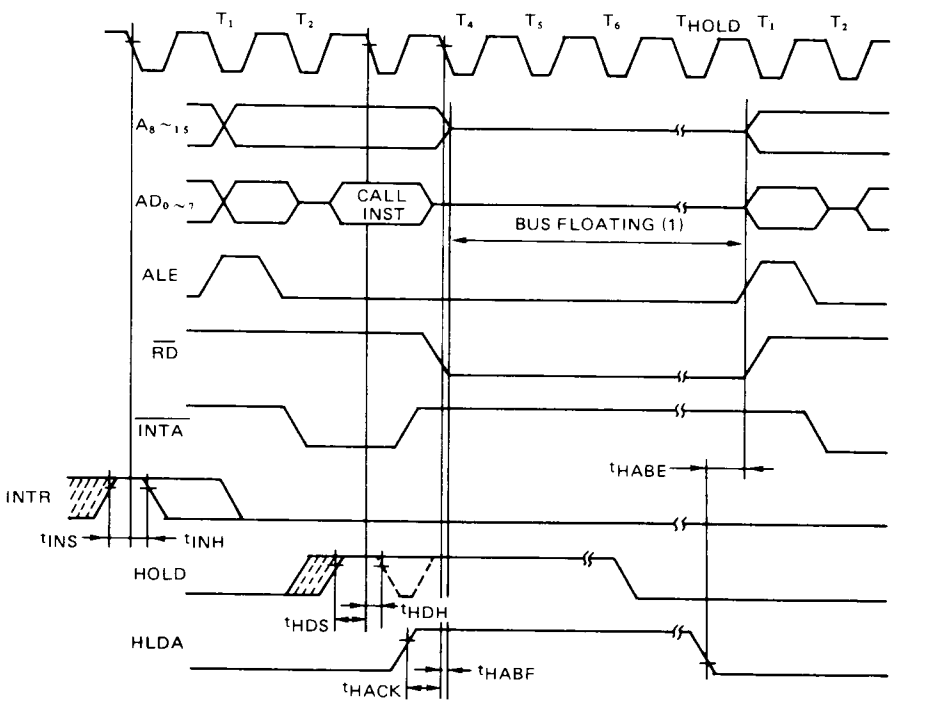


Figure 8 MSM80C85A-2 Hold Timing



Note: (1) IO/$\overline{M}$ is also floating during this time.

Figure 9 MSM80C85A-2 Interrupt and Hold Timing

Table 8 Instruction Set Summary

Mnemonic	Description	Instruction Code (1) D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	Clock (2) Cycles
MOVE, LOAD, AND STORE										
MOVr1 r2	Move register to register	0	1	D	D	D	S	S	S	4
MOV M r	Move register to memory	0	1	1	1	0	S	S	S	7
MOV r M	Move memory to register	0	1	D	D	D	1	1	0	7
MVI r	Move immediate register	0	0	D	D	D	1	1	0	7
MVI M	Move immediate memory	0	0	1	1	0	1	1	0	10
LXI B	Load immediate register Pair B & C	0	0	0	0	0	0	0	1	10
LXI D	Load immediate register Pair D & E	0	0	0	1	0	0	0	1	10
LXI H	Load immediate register Pair H & L	0	0	1	0	0	0	0	1	10
LXI SP	Load immediate stack pointer	0	0	1	1	0	0	0	1	10
STAX B	Store A indirect	0	0	0	0	0	0	1	0	7
STAX D	Store A indirect	0	0	0	1	0	0	1	0	7
LDAX B	Load A indirect	0	0	0	0	1	0	1	0	7
LDAX D	Load A indirect	0	0	0	1	1	0	1	0	7
STA	Store A direct	0	0	1	1	0	0	1	0	13
LDA	Load A direct	0	0	1	1	1	0	1	0	13
SHLD	Store H & L direct	0	0	1	0	0	0	1	0	16
LHLD	Load H & L direct	0	0	1	0	1	0	1	0	16
XCHG	Exchange D & E H & L registers	1	1	1	0	1	0	1	1	4
STACK OPS										
PUSH B	Push register Pair B & C on stack	1	1	0	0	0	1	0	1	12
PUSH D	Push register Pair D & E on stack	1	1	0	1	0	1	0	1	12
PUSH H	Push register Pair H & L on stack	1	1	1	0	0	1	0	1	12
PUSH PSW	Push A and Flags on stack	1	1	1	1	0	1	0	1	12
POP B	Pop register Pair B & C off stack	1	1	0	0	0	0	0	1	10
POP D	Pop register Pair D & E off stack	1	1	0	1	0	0	0	1	10
POP H	Pop register Pair H & L off stack	1	1	1	0	0	0	0	1	10
POP PSW	Pop A and Flags off stack	1	1	1	1	0	0	0	1	10
XTHL	Exchange top of stack H & L	1	1	1	0	0	0	1	1	16
SPHL	H & L to stack pointer	1	1	1	1	1	0	0	1	6
JUMP										
JMP	Jump unconditional	1	1	0	0	0	0	1	1	10
JC	Jump on carry	1	1	0	1	1	0	1	0	7/10
JNC	Jump on no carry	1	1	0	1	0	0	1	0	7/10
JZ	Jump on zero	1	1	0	0	1	0	1	0	7/10
JNZ	Jump on no zero	1	1	0	0	0	0	1	0	7/10
JP	Jump on positive	1	1	1	1	0	0	1	0	7/10
JM	Jump on minus	1	1	1	1	1	0	1	0	7/10
JPE	Jump on parity even	1	1	1	0	1	0	1	0	7/10
JPO	Jump on parity odd	1	1	1	0	0	0	1	0	7/10
PCHL	H & L to program counter	1	1	1	0	1	0	0	1	6
CALL										
CALL	Call unconditional	1	1	0	0	1	1	0	1	18
CC	Call on carry	1	1	0	1	1	1	0	0	9/18
CNC	Call on no carry	1	1	0	1	0	1	0	0	9/18
CZ	Call on zero	1	1	0	0	1	1	0	0	9/18
CNZ	Call on no zero	1	1	0	0	0	1	0	0	9/18
CP	Call on positive	1	1	1	1	0	1	0	0	9/18
CM	Call on minus	1	1	1	1	1	1	0	0	9/18
CPE	Call on parity even	1	1	1	0	1	1	0	0	9/18
CPO	Call on parity odd	1	1	1	0	0	1	0	0	9/18

Table 8 Instruction Set Summary cont'd

Mnemonic	Description	Instruction Code(1) D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	Clock(2) Cycles
RETURN										
RET	Return	1	1	0	0	1	0	0	1	10
RC	Return on carry	1	1	0	1	1	0	0	0	6/12
RNC	Return on no carry	1	1	0	1	0	0	0	0	6/12
RZ	Return on zero	1	1	0	0	1	0	0	0	6/12
RNZ	Return on no zero	1	1	0	0	0	0	0	0	6/12
RP	Return on positive	1	1	1	1	0	0	0	0	6/12
RM	Return on minus	1	1	1	1	1	0	0	0	6/12
RPE	Return on parity even	1	1	1	0	1	0	0	0	6/12
RPO	Return on parity odd	1	1	1	0	0	0	0	0	6/12
RESTART										
RST	Restart	1	1	A	A	A	1	1	1	12
INPUT/OUTPUT										
IN	Input	1	1	0	1	1	0	1	1	10
OUT	Output	1	1	0	1	0	0	1	1	10
INCREMENT AND DECREMENT										
INR r	Increment register	0	0	D	D	D	1	0	0	4
DCR r	Decrement register	0	0	D	D	D	1	0	1	4
INR M	Increment memory	0	0	1	1	0	1	0	0	10
DCR M	Decrement memory	0	0	1	1	0	1	0	1	10
INX B	Increment B & C registers	0	0	0	0	0	0	1	1	6
INX D	Increment D & E registers	0	0	0	1	0	0	1	1	6
INX H	Increment H & L registers	0	0	1	0	0	0	1	1	6
INX SP	Increment stack pointer	0	0	1	1	0	0	1	1	6
DCX B	Decrement B & C	0	0	0	0	1	0	1	1	6
DCX D	Decrement D & E	0	0	0	1	1	0	1	1	6
DCX H	Decrement H & L	0	0	1	0	1	0	1	1	6
DCX SP	Decrement stack pointer	0	0	1	1	1	0	1	1	6
ADD										
ADD r	Add register to A	1	0	0	0	0	S	S	S	4
ADC r	Add register to A with carry	1	0	0	0	1	S	S	S	4
ADD M	Add memory to A	1	0	0	0	0	1	1	0	7
ADC M	Add memory to A with carry	1	0	0	0	1	1	1	0	7
ADI	Add immediate to A	1	1	0	0	0	1	1	0	7
ACI	Add immediate to A with carry	1	1	0	0	1	1	1	0	7
DAD B	Add B & C to H & L	0	0	0	0	1	0	0	1	10
DAD D	Add D & E to H & L	0	0	0	1	1	0	0	1	10
DAD H	Add H & L to H & L	0	0	1	0	1	0	0	1	10
DAD SP	Add stack pointer to H & L	0	0	1	1	1	0	0	1	10
SUBTRACT										
SUB r	Subtract register from A	1	0	0	1	0	S	S	S	4
SBB r	Subtract register from A with borrow	1	0	0	1	1	S	S	S	4
SUB M	Subtract memory from A	1	0	0	1	0	1	1	0	7
SBB M	Subtract memory from A with borrow	1	0	0	1	1	1	1	0	7
SUI	Subtract immediate from A	1	1	0	1	0	1	1	0	7
SBI	Subtract immediate from A with borrow	1	1	0	1	1	1	1	0	7

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Table 8 Instruction Set Summary cont'd

Mnemonic	Description	Instruction Code(1) D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	Clock(2) Cycles
LOGICAL										
ANA r	And register with A	1	0	1	0	0	S	S	S	4
XRA r	Exclusive Or register with A	1	0	1	0	1	S	S	S	4
ORA r	Or register with A	1	0	1	1	0	S	S	S	4
CMP r	Compare register with A	1	0	1	1	1	S	S	S	4
ANA M	And memory with A	1	0	1	0	0	1	1	0	7
XRA M	Exclusive Or Memory with A	1	0	1	0	1	1	1	0	7
ORA M	Or memory with A	1	0	1	1	0	1	1	0	7
CMP M	Compare memory with A	1	0	1	1	1	1	1	0	7
ANI	And immediate with A	1	1	1	0	0	1	1	0	7
XRI	Exclusive Or immediate with A	1	1	1	0	1	1	1	0	7
ORI	Or immediate with A	1	1	1	1	0	1	1	0	7
CPI	Compare immediate with A	1	1	1	1	1	1	1	0	7
ROTATE										
RLC	Rotate A left	0	0	0	0	0	1	1	1	4
RRC	Rotate A right	0	0	0	0	1	1	1	1	4
RAL	Rotate A left through carry	0	0	0	1	0	1	1	1	4
RAR	Rotate A right through carry	0	0	0	1	1	1	1	1	4
SPECIALS										
CMA	Complement A	0	0	1	0	1	1	1	1	4
STC	Set carry	0	0	1	1	0	1	1	1	4
CMC	Complement carry	0	0	1	1	1	1	1	1	4
DAA	Decimal adjust A	0	0	1	0	0	1	1	1	4
CONTROL										
EI	Enable Interrupts	1	1	1	1	1	0	1	1	4
DI	Disable Interrupts	1	1	1	1	0	0	1	1	4
NOP	No-operation	0	0	0	0	0	0	0	0	4
HLT	Halt (Power down)	0	1	1	1	0	1	1	0	5
RIM	Read Interrupt Mask	0	0	1	0	0	0	0	0	4
SIM	Set Interrupt Mask	0	0	1	1	0	0	0	0	4

Notes: (1) DDD or SSS. B 000. C 001. D 010. E 011. H 100. L 101. Memory 110. A 111.
(2) Two possible cycle times, (6/12) indicate instruction cycles dependent on condition flags.

Precautions for operation

(1) When the oscillation circuit is to be used, keep the RES input low until the oscillation is sufficiently stabilized after power is turned on.

(2) When power is turned on, the SOD output level is irregular before the equipment is reset.

■ NOTE

Item: Precautions for operation of MSM80C85A-2

1. **Error phenomenon**

When the power down mode of the OKI 8-bit microprocessor MSM80C85A-2, which is activated under the conditions indicated below, is released, a malfunction occurs. Although the operation cycle is increased, the operation cycle is increased, the operation sequence is normal. If the HOLD function is not used, no problems are caused.

Condition 1: During the HALT instruction fetch, the HOLD function is activated and an interruption is simultaneously requested. (See Fig.1.)

Conditions 2: During the HALT instruction fetch, the HOLD function is activated and no intterruption is requested. (See Fig.2.) (When the HALT cycle starts after the HOLD function is released)

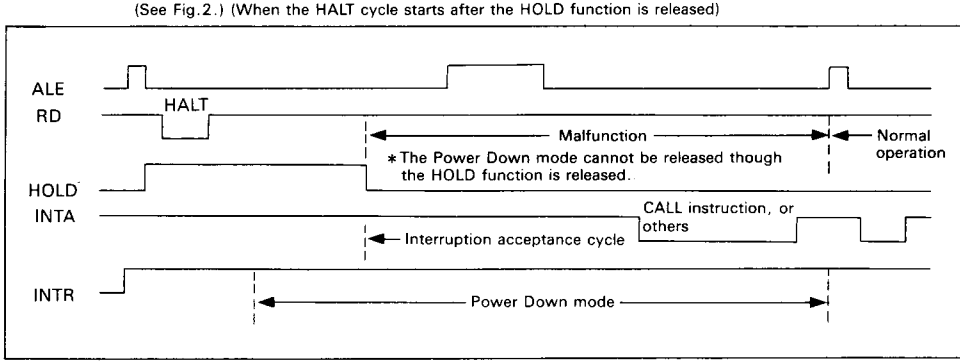


Fig.1 Malfunction timing chart 1

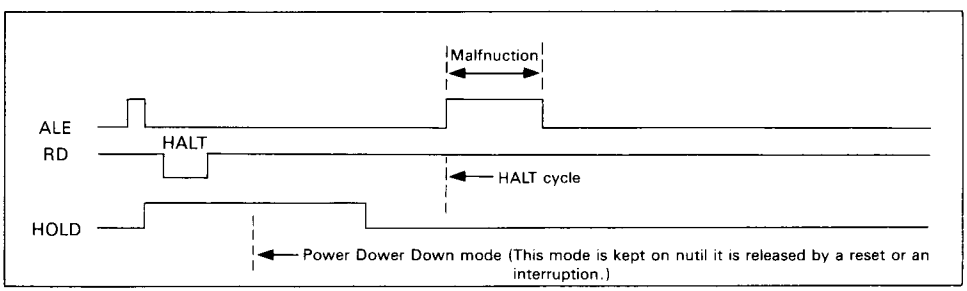


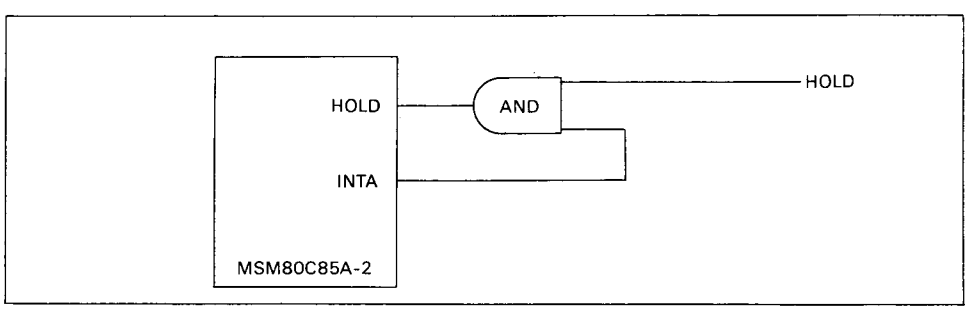
Fig.2 Malfunction timing chart 2

2. **Error cause**

An error occurs in the Power Down mode release circuit under the above conditions.

3. **Precautions for operation**

A problem caused by the above malfunction is that the bus conflict with each other because the HOLD function is accepted during the interruption (INTR) acceptance cycle. To prevent the bus from confliction, it is necessary to design so that the HOLD function is not accepted during the interruption (INTR) acceptance cycle. (See Fig.3.)



4. **Others**

A revised edition of MSM80C85AH which is free of the above error is under development.