M8048/M8748/M8035L
SINGLE COMPONENT 8-BIT MICROCOMPUTER

MILITARY

- **8048 Mask Programmable ROM**
- **8748 User Programmable/Erasable EPROM**
- **8035L Requires External ROM or EPROM**

- **-55°C to +125°C 6 MHz Operation (M8048/M8035L)**
- **-55°C to +125°C 3.6 MHz Operation (M8748)**
- **8-Bit CPU, ROM, RAM, I/O in Single Package**
- **Interchangeable ROM and EPROM Versions**
- **Single 5V Supply**
- **2.5 μsec and 5.0 μsec Cycle Versions All Instructions 1 or 2 Cycles.**
- **Over 90 Instructions: 70% Single Byte**
- **1K x 8 ROM/EPROM 64 x 8 RAM 27 I/O Lines**
- **Interval Timer/Event Counter**
- **Easily Expandable Memory and I/O**
- **Compatible with 8080/8085 Series Peripherals**
- **Single Level Interrupt**
- **Screened to MIL-STD-883B**

The Intel M8048/M8748/M8035L are totally self-sufficient 8-bit parallel computers fabricated on single silicon chips using Intel's N-Channel silicon gate MOS process.

The M8048 contains an 8-bit CPU, a 1K × 8 program memory, a 64 × 8 RAM data memory, 27 I/O lines, and an 8-bit timer/counter in addition to on-board oscillator and clock circuits. For systems that require extra capability, the M8048 can be expanded using standard memories and MCS-80®/MCS-85® peripherals. The M8035L is the equivalent of an M8048 without program memory, and has the RAM power down mode of the M8048. To reduce development problems to a minimum and provide maximum flexibility, three interchangeable pin-compatible* versions of this single component micro-computer exist: the M8748 with user-programmable and erasable EPROM program memory for prototype and preproduction systems, the M8048 with factory-programmed mask ROM program memory for low cost, high volume production, and the M8035L without program memory for use with external program memories.

This microprocessor is designed to be an efficient controller as well as an arithmetic processor. The M8048 has extensive bit handling capability as well as facilities for both binary and BCD arithmetic. Efficient use of program memory results from an instruction set consisting mostly of single byte instructions and no instructions over 2 bytes in length.

*V_{DD} is used to program the M8748 and used for low power standby on the M8048/8035L.

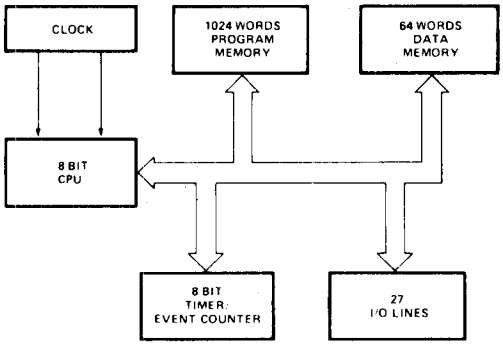


Figure 1. Block Diagram

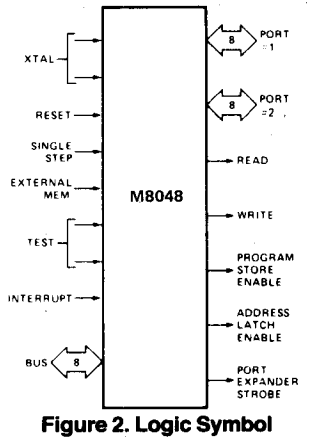


Figure 2. Logic Symbol

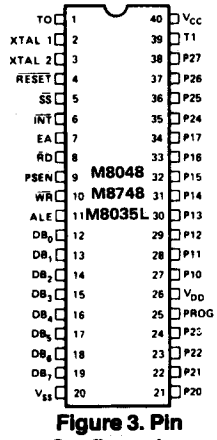


Figure 3. Pin Configuration

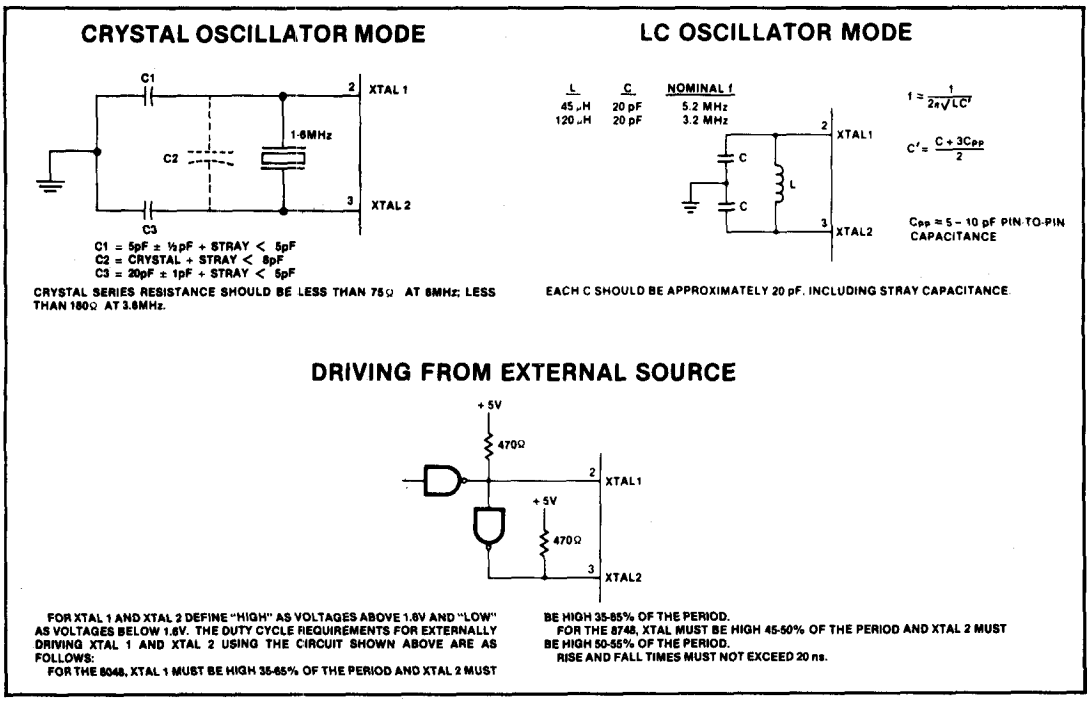


Figure 4

PROGRAMMING, VERIFYING, AND ERASING THE 8748 EPROM

Programming Verification

In brief, the programming process consists of: activating the program mode, applying an address, latching the address, applying data, and applying a programming pulse. Each word is programmed completely before moving on to the next and is followed by a verification step. The following is a list of the pins used for programming and a description of their functions:

Pin	Function
XTAL 1	Clock Input (1 to 6MHz)
$\overline{\text{Reset}}$	Initialization and Address Latching
Test 0	Selection of Program or Verify Mode
EA	Activation of Program/Verify Modes
BUS	Address and Data Input Data Output During Verify
P20-1	Address Input
V_{DD}	Programming Power Supply
PROG	Program Pulse Input

WARNING:

An attempt to program a missocketed 8748 will result in severe damage to the part. An indication of a properly socketed part is the appearance of the ALE clock output. The lack of this clock may be used to disable the programmer.

The Program/Verify sequence is:

1. V_{DD} = 5v, Clock applied or internal oscillator operating, $\overline{\text{RESET}}$ = 0v, TEST 0 = 5v, EA = 5v, BUS and PROG floating.
2. Insert 8748 in programming socket
3. TEST 0 = 0v (select program mode)
4. EA = 23v (activate program mode)
5. Address applied to BUS and P20-1
6. $\overline{\text{RESET}}$ = 5v (latch address)
7. Data applied to BUS
8. V_{DD} = 25v (programming power)
9. PROG = 0v followed by one 50ms pulse to 23v
10. V_{DD} = 5v
11. TEST 0 = 5v (verify mode)
12. Read and verify data on BUS
13. TEST 0 = 0v
14. $\overline{\text{RESET}}$ = 0v and repeat from step 5
15. Programmer should be at condition of step 1 when 8748 is removed from socket.

A.C. TIMING SPECIFICATION FOR PROGRAMMING $T_A = 25°C \pm 5°C$, $V_{CC} = 5V \pm 5\%$, $V_{DD} = 25V \pm 1V$

Symbol	Parameter	Min.	Max.	Unit	Test Conditions
t_{AW}	Address Setup Time to $\overline{RESET}\uparrow$	$4t_{CY}$			
t_{WA}	Address Hold Time After $\overline{RESET}\uparrow$	$4t_{CY}$			
t_{DW}	Data in Setup Time to PROG $\uparrow$	$4t_{CY}$			
t_{WD}	Data in Hold Time After PROG $\downarrow$	$4t_{CY}$			
t_{PH}	$\overline{RESET}$ Hold Time to Verify	$4t_{CY}$			
t_{VDDW}	V_{DD}	$4t_{CY}$			
t_{VDDH}	V_{DD} Hold Time After PROG $\downarrow$	0			
t_{PW}	Program Pulse Width	50	60	mS	
t_{TW}	Test 0 Setup Time for Program Mode	$4t_{CY}$			
t_{WT}	Test 0 Hold Time After Program Mode	$4t_{CY}$			
t_{DO}	Test 0 to Data Out Delay		$4t_{CY}$		
t_{WW}	$\overline{RESET}$ Pulse Width to Latch Address	$4t_{CY}$			
t_r, t_f	V_{DD} and PROG Rise and Fall Times	0.5	2.0	μs	
t_{CY}	CPU Operation Cycle Time	5.0		μs	
t_{RE}	$\overline{RESET}$ Setup Time Before EA $\uparrow$.	$4t_{CY}$			

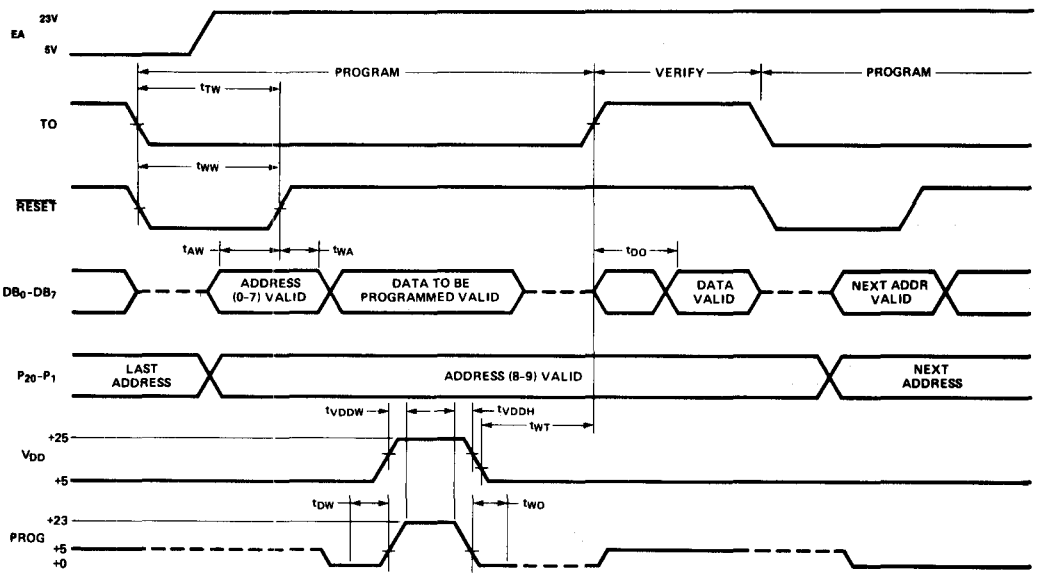
Note: If Test 0 is high t_{DO} can be triggered by $\overline{RESET}\uparrow$.

D.C. SPECIFICATION FOR PROGRAMMING $T_A = 25°C \pm 5°C$, $V_{CC} = 5V \pm 5\%$, $V_{DD} = 25V \pm 1V$

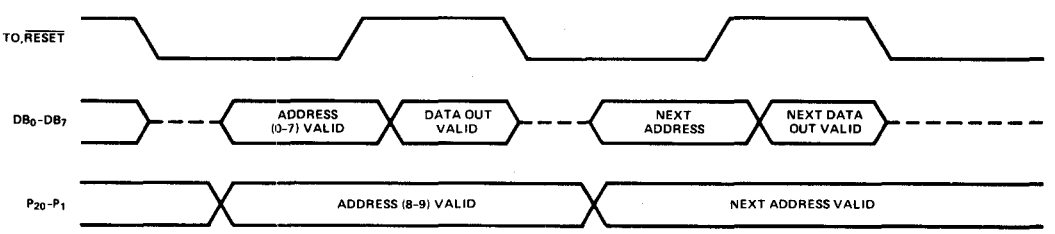
Symbol	Parameter	Min.	Max.	Unit	Test Conditions
V_{DDH}	V_{DD} Program Voltage High Level	24.0	26.0	V	
V_{DDL}	V_{DD} Voltage Low Level	4.75	5.25	V	
V_{PH}	PROG Program Voltage High Level	21.5	24.5	V	
V_{PL}	PROG Voltage Low Level		0.2	V	
V_{EAH}	EA Program or Verify Voltage High Level	21.5	24.5	V	8748
V_{EAH1}	EA1 Verify Voltage High Level	11.4	12.6	V	8048
V_{EAL}	EA Voltage Low Level		5.25	V	
I_{DD}	V_{DD} High Voltage Supply Current		30.0	mA	
I_{PROG}	PROG High Voltage Supply Current		16.0	mA	
I_{EA}	EA High Voltage Supply Current		1.0	mA	

WAVEFORMS

COMBINATION PROGRAM/VERIFY MODE (EPROM'S ONLY)



VERIFY MODE (ROM/EPROM)



NOTES:
1. **PROG MUST FLOAT IF EA IS LOW (i.e., ≠23V), OR IF T0 = 5V FOR THE 8748. FOR THE 8048 PROG MUST ALWAYS FLOAT.**
2. **X_1 AND X_2 DRIVEN BY 3 MHz CLOCK WILL GIVE 5μsec t_{CY}. THIS IS ACCEPTABLE FOR ALL PARTS.**

The 8748 EPROM can be programmed by either of two Intel products:

1. PROMPT-48 Microcomputer Design Aid, or
2. Universal PROM Programmer (UPP Series) peripheral of the Intellec® Development System with a UPP-848 Personality Card.

Table 1. Instruction Set Summary

	Mnemonic	Description	Bytes	Cycle
Accumulator	ADD A, R	Add register to A	1	1
	ADD A, @R	Add data memory to A	1	1
	ADD A, #data	Add immediate to A	2	2
	ADDC A, R	Add register with carry	1	1
	ADDC A, @R	Add data memory with carry	1	1
	ADDC A, #data	Add immediate with carry	2	2
	ANL A, R	And register to A	1	1
	ANL A, @R	And data memory to A	1	1
	ANL A, #data	And immediate to A	2	2
	ORL A, R	Or register to A	1	1
	ORL A, @R	Or data memory to A	1	1
	ORL A, #data	Or immediate to A	2	2
	XRL A, R	Exclusive or register to A	1	1
	XRL A, @R	Exclusive or data memory to A	1	1
	XRL A, #data	Exclusive or immediate to A	2	2
	INC A	Increment A	1	1
	DEC A	Decrement A	1	1
	CLR A	Clear A	1	1
	CPL A	Complement A	1	1
	DA A	Decimal adjust A	1	1
	SWAP A	Swap nibbles of A	1	1
	RL A	Rotate A left	1	1
	RLC A	Rotate A left through carry	1	1
	RR A	Rotate A right	1	1
	RRC A	Rotate A right through carry	1	1
Input/Output	IN A, P	Input port to A	1	2
	OUTL P, A	Output A to port	1	2
	ANL P, #data	And immediate to port	2	2
	ORL P, #data	Or immediate to port	2	2
	INS A, BUS	Input BUS to A	1	2
	OUTL BUS, A	Output A to BUS	1	2
	ANL BUS, #data	And immediate to BUS	2	2
	ORL BUS, #data	Or immediate to BUS	2	2
	MOVD A, P	Input expander port to A	1	2
	MOVD P, A	Output A to expander port	1	2
	ANLD P, A	And A to expander port	1	2
	ORLD P, A	Or A to expander port	1	2
Registers	INC R	Increment register	1	1
	INC @R	Increment data memory	1	1
	DEC R	Decrement register	1	1
Branch	JMP addr	Jump unconditional	2	2
	JMPP @A	Jump indirect	1	2
	DJNZ R, addr	Decrement register and skip	2	2
	JC addr	Jump on carry = 1	2	2
	JNC addr	Jump on carry = 0	2	2
	JZ addr	Jump on A zero	2	2
	JNZ addr	Jump on A not zero	2	2
	JT0 addr	Jump on T0 = 1	2	2
	JNT0 addr	Jump on T0 = 0	2	2
	JT1 addr	Jump on T1 = 1	2	2
	JNT1 addr	Jump on T1 = 0	2	2
	JF0 addr	Jump on F0 = 1	2	2
	JF1 addr	Jump on F1 = 1	2	2
	JTF addr	Jump on timer flag	2	2
	JNI addr	Jump on $\overline{INT}$ = 0	2	2
	JBb addr	Jump on accumulator bit	2	2

	Mnemonic	Description	Bytes	Cycles
Subroutine	CALL addr	Jump to subroutine	2	2
	RET	Return	1	2
	RETR	Return and restore status	1	2
Flags	CLR C	Clear carry	1	1
	CPL C	Complement carry	1	1
	CLR F0	Clear flag 0	1	1
	CPL F0	Complement flag 0	1	1
	CLR F1	Clear flag 1	1	1
	CPL F1	Complement flag 1	1	1
Data Moves	MOV A, R	Move register to A	1	1
	MOV A, @R	Move data memory to a	1	1
	MOV A, #data	Move immediate to A	2	2
	MOV R, A	Move A to register	1	1
	MOV @R, A	Move A to data memory	1	1
	MOV R, #data	Move immediate to register	2	2
	MOV @R, #data	Move immediate to data memory	2	2
	MOV A, PSW	Move PSW to A	1	1
	MOV PSW, A	Move A to PSW	1	1
	XCH A, R	Exchange A and register	1	1
	XCHA, @R	Exchange A and data memory	1	1
	XCHD A, @R	Exchange nibble of A and register	1	1
	MOVX A, @R	Move external data memory to A	1	2
	MOVX @R, A	Move A to external data memory	1	2
	MOVP A, @A	Move to A from current page	1	2
	MOVP3 A, @A	Move to A from page 3	1	2
Timer/Counter	MOV A, T	Read timer/counter	1	1
	MOV T, A	Load timer/counter	1	1
	STRT T	Start timer	1	1
	STRT CNT	Start counter	1	1
	STOP TCNT	Stop timer/counter	1	1
	EN TCNTI	Enable timer/counter interrupt	1	1
	DIS TCNTI	Disable timer/counter interrupt	1	1
Control	EN I	Enable external interrupt	1	1
	DIS I	Disable external interrupt	1	1
	SEL RB0	Select register bank 0	1	1
	SEL RB1	Select register bank 1	1	1
	SEL MB0	Select memory bank 0	1	1
	SEL MB1	Select memory bank 1	1	1
	ENT0 CLK	Enable clock output on T0	1	1
	NOP	No operation	1	1

Table 2. Pin Description

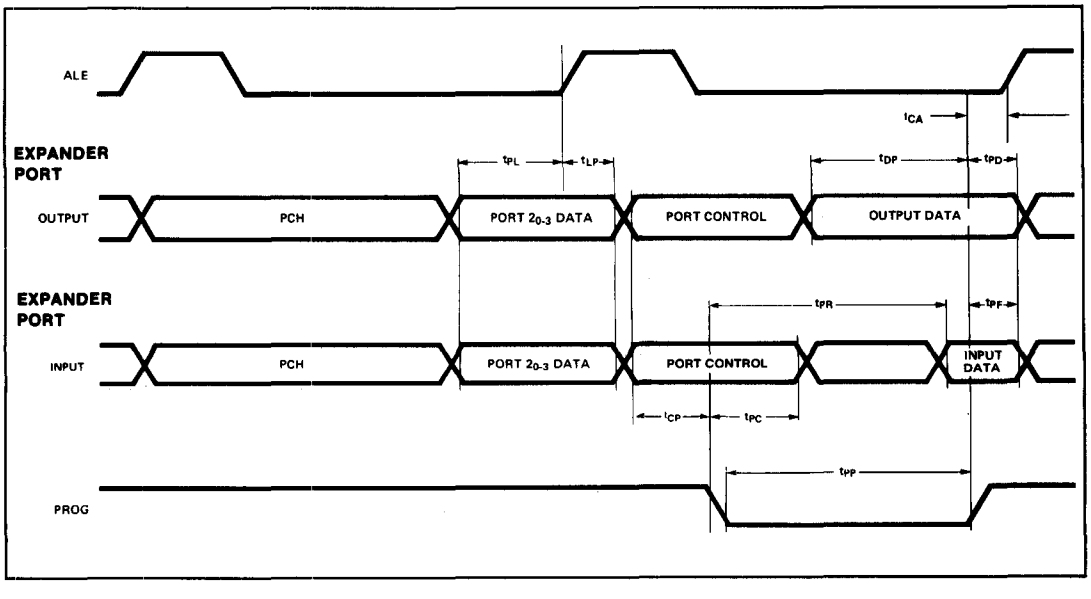
Symbol	Pin No.	Function
V_{SS}	20	Circuit GND potential
V_{DD}	26	Programming power supply; +25V during program, +5V during operation for both ROM and PROM. Low power standby pin in 8048 and 8035L.
V_{CC}	40	Main power supply; +5V during operation and programming.
PROG	25	Program pulse (+23V) input pin during 8748 programming.
		Output strobe for 8243 I/O expander.
P10-P17 Port 1	27-34	8-bit quasi-bidirectional port.
P20-P27 Port 2	21-24 35-38	8-bit quasi-bidirectional port. P20-P23 contain the four high order program counter bits during an external program memory fetch and serve as a 4-bit I/O expander bus for 8243.
DB_0-DB_7 BUS	12-19	True bidirectional port which can be written or read synchronously using the RD, WR strobes. The port can also be statically latched.
		Contains the 8 low order program counter bits during an external program memory fetch, and receives the addressed instruction under the control of PSEN. Also contains the address and data during an external RAM data store instruction, under control of ALE, RD, and WR.
T0	1	Input pin testable using the conditional transfer instructions JT0 and JNT0. T0 can be designated as a clock output using ENT0 CLK instruction. T0 is also used during programming.
T1	39	Input pin testable using the JT1, and JNT1 instructions. Can be designated the timer/counter input using the STRT CNT instruction.

Symbol	Pin No.	Function
$\overline{INT}$	6	Interrupt input. Initiates an interrupt if interrupt is enabled. Interrupt is disabled after a reset. Also testable with conditional jump instruction. (Active low)
$\overline{RD}$	8	Output strobe activated during a BUS read. Can be used to enable data onto the bus from an external device.
		Used as a read strobe to external data memory. (Active low)
$\overline{RESET}$	4	Input which is used to initialize the processor. Also used during PROM programming verification, and power down. (Active low) (Non TTL V_{IH})
$\overline{WR}$	10	Output strobe during a bus write. (Active low)
		Used as write strobe to external data memory.
ALE	11	Address latch enable. This signal occurs once during each cycle and is useful as a clock output.
		The negative edge of ALE strobes address into external data and program memory.
$\overline{PSEN}$	9	Program store enable. This output occurs only during a fetch to external program memory. (Active low)
$\overline{SS}$	5	Single step input can be used in junction with ALE to "single step" the processor through each instruction. (Active low)
EA	7	External access input which forces all program memory fetches to reference external memory. Useful for emulation and debug, and essential for testing and program verification. (Active high)
XTAL1	2	One side of crystal input for internal oscillator. Also input for external source. (Non TTL V_{IH})
XTAL2	3	Other side of crystal input.

A.C. CHARACTERISTICS (PORT 2 TIMING) T_A = 55°C to 125°C, V_{CC} = +5V ± 10%, V_{SS} = 0V

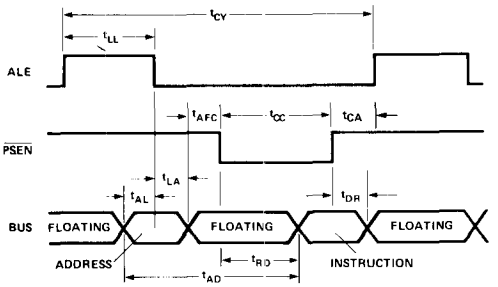
Symbol	Parameter	Min.	Max.	Unit	Test Conditions
t_{CP}	Port Control Setup Before Falling Edge of $\overline{PROG}$	115		ns	
t_{PC}	Port Control Hold After Falling Edge of $\overline{PROG}$	65		ns	
t_{PR}	PROG to Time P2 Input Must Be Valid		860	ns	
t_{PF}	Input Data Hold Time	0	160	ns	
t_{DP}	Output Data Setup Time	230		ns	
t_{PD}	Output Data Hold Time	25		ns	
t_{PP}	$\overline{PROG}$ Pulse Width	920		ns	
t_{PL}	Port 2 I/O Data Setup	300		ns	
t_{LP}	Port 2 I/O Data Hold	120		ns	

PORT 2 TIMING

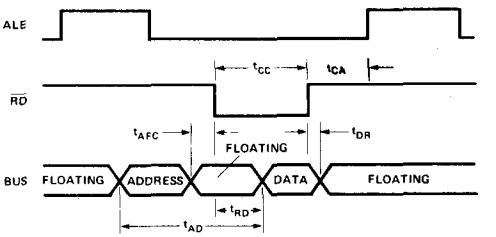


WAVEFORMS

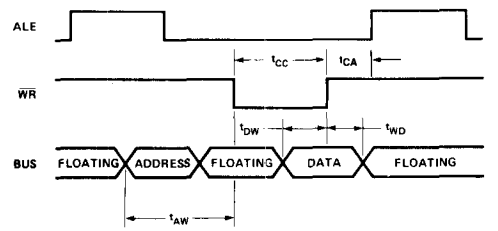
Instruction Fetch From External Program Memory



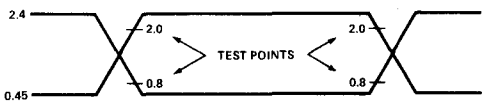
Read From External Data Memory



Write to External Data Memory



Input and Output Waveforms for A.C. Tests



A.C. CHARACTERISTICS T_A = -55°C to 125°C, $V_{CC} = V_{DD}$ = +5V ± 10%, V_{SS} = 0V

Symbol	Parameter	M8048 M8035L		M8748		Unit	Conditions (Note 1)
		Min.	Max.	Min.	Max.		
t_{LL}	ALE Pulse Width	200		300		ns	
t_{AL}	Address Setup to ALE	120		120		ns	
t_{LA}	Address Hold from ALE	80		80		ns	
t_{CC}	Control Pulse Width ($\overline{PSEN}$, $\overline{RD}$, $\overline{WR}$)	400		600		ns	
t_{DW}	Data Setup before $\overline{WR}$	420		600		ns	
t_{WD}	Data Hold After $\overline{WR}$	80		120		ns	C_L = 20pF
t_{CY}	Cycle Time	2.5	15.0	4.17	15.0	μs	(3.6 MHz XTAL 8748)
t_{DR}	Data Hold	0	200	0	200	ns	
t_{RD}	$\overline{PSEN}$, $\overline{RD}$ to Data In		400		600	ns	
t_{AW}	Address Setup to $\overline{WR}$	230		260		ns	
t_{AD}	Address Setup to Data In		600		900	ns	
t_{AFC}	Address Float to $\overline{RD}$, $\overline{PSEN}$	-40		-60		ns	
t_{CA}	Control Pulse to ALE	10		10		ns	

Note 1: Control outputs: C_L = 80 pF t_{CY} = 2.5 μs for 8048/8035L
BUS Outputs: C_L = 150 pF 4.17 μs for 8748

ABSOLUTE MAXIMUM RATINGS*

Ambient Temperature Under Bias
- 8748 ..... −55°C to +125°C
- 8048/8035L ..... −55°C to +125°C

Storage Temperature ..... −65°C to +125°C
Voltage On Any Pin With Respect to Ground ..... −0.5 to +7V
Power Dissipation ..... 1.5 Watt

NOTICE: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

D.C. CHARACTERISTICS $T_A = -55°C$ to 125°C, $V_{CC} = V_{DD} = +5V \pm 10\%$, $V_{SS} = 0V$

Symbol	Parameter	Limits			Unit	Test Conditions
		Min.	Typ.	Max.		
V_{IL}	Input Low Voltage (All Except $\overline{RESET}$, X1, X2)	−.5		.7	V	
V_{IL1}	Input Low Voltage ($\overline{RESET}$, X1, X2)	−.5		.5	V	
V_{IH}	Input High Voltage (All Except XTAL1, XTAL2, $\overline{RESET}$)	2.3		V_{CC}	V	
V_{IH1}	Input High Voltage ($\overline{RESET}$, X1, X2)	3.8		V_{CC}	V	
V_{OL}	Output Low Voltage (BUS, $\overline{RD}$, $\overline{WR}$, $\overline{PSEN}$, ALE)			.45	V	$I_{OL} = 1.2mA$
V_{OL1}	Output Low Voltage (All Other Outputs)			.45	V	$I_{OL} = 0.8mA$
V_{OH}	Output High Voltage (BUS)	2.4			V	$I_{OH} = -240\mu A$
V_{OH1}	Output High Voltage ($\overline{RD}$, $\overline{WR}$, $\overline{PSEN}$, ALE)	2.4			V	$I_{OH} = -50\mu A$
V_{OH2}	Output High Voltage (All Other Outputs)	2.4			V	$I_{OH} = -30\mu A$
I_{LI}	Input Leakage Current (T1, $\overline{INT}$)			±10	μA	$V_{SS} \le V_{IN} \le V_{CC}$
I_{LI1}	Input Leakage Current (P10-P17, P20-P27, EA, $\overline{SS}$)			−700	μA	$V_{SS} + .45 \le V_{IN} \le V_{CC}$
I_{LO}	Output Leakage Current (BUS, TO) (High Impedance State)			±10	μA	$V_{SS} + .45 \le V_{IN} \le V_{CC}$
I_{DD}	V_{DD} Supply Current		10	25	mA	
$I_{DD} + I_{CC}$	Total Supply Current		80	155	mA