8048H/8048H-1/8035HL/8035HL-1
HMOS SINGLE COMPONENT 8-BIT MICROCOMPUTER

- 8048H/8048H-1 Mask Programmable ROM
- 8035HL/8035HL-1 CPU Only with Power Down Mode

- 8-BIT CPU, ROM, RAM, I/O in Single Package
- High Performance HMOS
- Reduced Power Consumption
- 1.4 µsec and 1.9 µsec Cycle Versions All Instructions 1 or 2 Cycles
- Over 90 Instructions: 70% Single Byte
- 1K x 8 ROM 64 x RAM 27 I/O Lines
- Interval Timer/Event Counter
- Easily Expandable Memory and I/O
- Compatible with 8080/8085 Series Peripherals
- Two Single Level Interrupts

The Intel® 8048H/8048H-1/8035HL/8035HL-1 are totally self-sufficient, 8-bit parallel computers fabricated on single silicon chips using Intel's advanced N-channel silicon gate HMOS process.

The 8048H contains a 1K X 8 program memory, a 64 X 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 8048H can be expanded using standard memories and MCS-80® /MCS-85® peripherals. The 8035HL is the equivalent of the 8048H without program memory and can be used with external ROM and RAM.

To reduce development problems to a minimum and provide maximum flexibility, a logically and functionally pin compatible version of the 8048H with UV-erasable user-programmable EPROM program memory is available. The 8748 will emulate the 8048H up to 6 MHz clock frequency with minor differences.

The 8048H is fully compatible with the 8048 when operated at 6MHz.

These microcomputers are designed to be efficient controllers as well as arithmetic processors. They have 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.

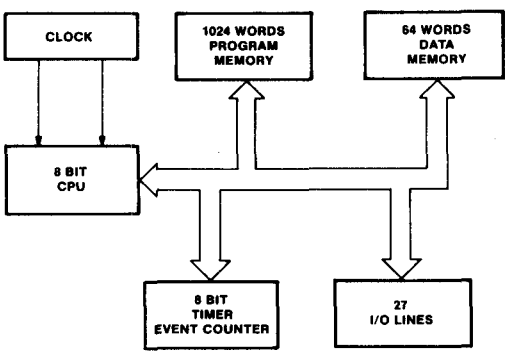


Figure 1. Block Diagram

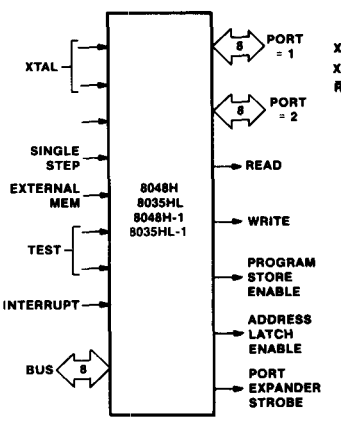


Figure 2. Logic Symbol

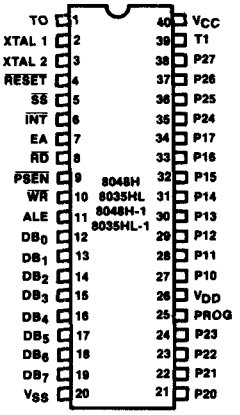


Figure 3. Pin Configuration (top view)

Table 1. Pin Description

Symbol	Pin No.	Function
V_{SS}	20	Circuit GND potential
V_{DD}	26	Low power standby pin
V_{CC}	40	Main power supply; +5V during operation.
PROG	25	Output strobe for 8243 I/O expander.
P10-P17 Port 1	27-34	8-bit quasi-bidirectional port.
P20-P27 Port 2	21-24	8-bit quasi-bidirectional port.
	35-38	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.
DB0-DB7 BUS	12-19	True bidirectional port which can be written or read synchronously using the $\overline{RD}$, $\overline{WR}$ 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 $\overline{PSEN}$. Also contains the address and data during an external RAM data store instruction, under control of ALE, $\overline{RD}$, and $\overline{WR}$.
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.
T1	39	Input pin testable using the JT1, and JNT1 instructions. Can be designated the timer/counter input using the STRT CNT instruction.
$\overline{INT}$	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. (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 conjunction 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.

Table 2. Instruction Set

Accumulator

Mnemonic	Description	Bytes	Cycles
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

Mnemonic	Description	Bytes	Cycles
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

Mnemonic	Description	Bytes	Cycles
INC R	Increment register	1	1
INC @R	Increment data memory	1	1
DEC R	Decrement register	1	1

Branch

Mnemonic	Description	Bytes	Cycles
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
JTO addr	Jump on TO = 1	2	2
JNTO addr	Jump on TO = 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
JN1 addr	Jump on INT = 0	2	2
JBb addr	Jump on accumulator bit	2	2

Subroutine

Mnemonic	Description	Bytes	Cycles
CALL addr	Jump to subroutine	2	2
RETR	Return	1	2
RETR	Return and restore status	1	2

Flags

Mnemonic	Description	Bytes	Cycles
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

Mnemonic	Description	Bytes	Cycles
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
XCH A, @R	Exchange A and data memory	1	1
XCHD A, @R	Exchange nibble of A and register	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, @	Move to A from page 3	1	2

Timer/Counter

Mnemonic	Description	Bytes	Cycles
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

Mnemonic	Description	Bytes	Cycles
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
ENT 0 CLK	Enable clock output on T0	1	1

Mnemonic	Description	Bytes	Cycles
NOP	No operation	1	1

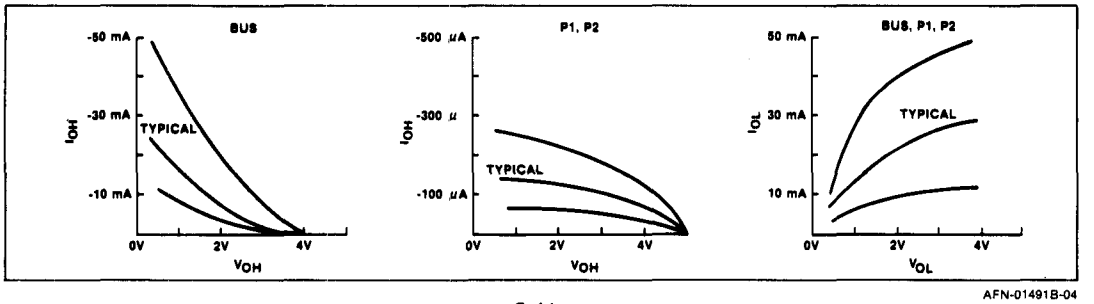
ABSOLUTE MAXIMUM RATINGS*

Ambient Temperature Under Bias ..... 0°C to 70°C
Storage Temperature .....-65°C to +150°C
Voltage On Any Pin With Respect to Ground ..... -0.5V 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 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 = 0°C to 70°C, $V_{CC} = V_{DD}$ = 5V + 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		.8	V	
V_{IL1}	Input Low Voltage ($\overline{RESET}$, X1, X2)	-.5		.6	V	
V_{IH}	Input High Voltage (All Except XTAL1, XTAL2, $\overline{RESET}$)	2.0		V_{CC}	V	
V_{IH1}	Input High Voltage (X1, X2, $\overline{RESET}$)	3.8		V_{CC}	V	
V_{OL}	Output Low Voltage (BUS)			.45	V	I_{OL} = 2.0 mA
V_{OL1}	Output Low Voltage ($\overline{RD}$, $\overline{WR}$, $\overline{PSEN}$, ALE)			.45	V	I_{OL} = 1.8 mA
V_{OL2}	Output Low Voltage (PROG)			.45	V	I_{OL} = 1.0 mA
V_{OL3}	Output Low Voltage (All Other Outputs)			.45	V	I_{OL} = 1.6 mA
VOH	Output High Voltage (BUS)	2.4			V	I_{OH} = -400μA
V_{OH1}	Output High Voltage ($\overline{RD}$, $\overline{WR}$, $\overline{PSEN}$, ALE)	2.4			V	I_{OH} = -100μA
V_{OH2}	Output High Voltage (All Other Outputs)	2.4			V	I_{OH} = -40μA
I_{L1}	Input Leakage Current (T1, $\overline{INT}$)			± 10	μA	$V_{SS} \leq V_{IN} \leq V_{CC}$
I_{LI1}	Input Leakage Current (P10-P17, P20-P27, EA, $\overline{SS}$)			-500	μA	V_{SS} + .45$\leq V_{IN} \leq V_{CC}$
I_{LO}	Output Leakage Current (BUS, TO) (High Impedance State)			± 10	μA	V_{SS} + .45$\leq V_{IN} \leq V_{CC}$
I_{DD}	V_{DD} Supply Current		4	8	mA	
I_{DD} + I_{CC}	Total Supply Current		40	80	mA	
V_{DD}	RAM Standby Pin Voltage	2.2		5.5	V	Standby Mode, Reset $\leq$0.6V



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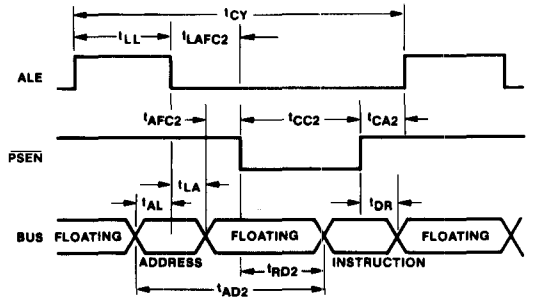
A.C. CHARACTERISTICS (T_A = 0°C to 70°C, V_{CC} = V_{DD} = 5V ± 10%, V_{SS} = 0V)

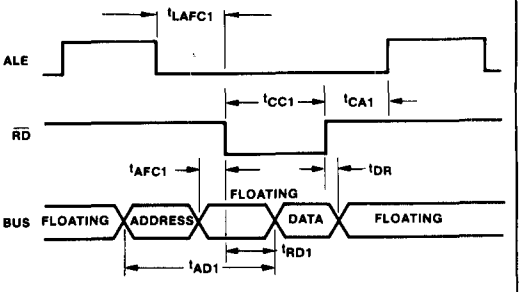
Symbol	Parameter	F (t_{CY})	8048H 8035HL 6 MHz Min.	8048H 8035HL 6 MHz Max.	8048H 8035HL 8 MHz Min.	8048H 8035HL 8 MHz Max.	8048H-1 8035HL-1 11 MHz Min.	8048H-1 8035HL-1 11 MHz Max.	Unit	Conditions (Note 1)
t_{LL}	ALE Pulse Width	7/30 t_{CY} -170	410		260		150			
t_{AL}	Addr Setup to ALE	1/5 t_{CY} -110	390		260		160			
t_{LA}	Addr Hold from ALE	1/15 t_{CY} -40	120		80		50			
t_{CC1}	Control Pulse Width ($\overline{RD}$, $\overline{WR}$)	1/2 t_{CY} -200	1050		730		480			
t_{CC2}	Control Pulse Width ($\overline{PSEN}$)	2/5 t_{CY} -200	800		550		350			
t_{DW}	Data Setup before $\overline{WR}$	13/30 t_{CY} -200	880		610		390			
t_{WD}	Data Hold after $\overline{WR}$	1/5 t_{CY} -150	350		220		120			(Note 2)
t_{DR}	Data Hold ($\overline{RD}$, $\overline{PSEN}$)	1/10 t_{CY} -30	0	220	0	160	0	110		
t_{RD1}	$\overline{RD}$ to Data in	2/5 t_{CY} -200		800		550		350		
t_{RD2}	$\overline{PSEN}$ to Data in	3/10 t_{CY} -200		550		360		210		
t_{AW}	Addr Setup to $\overline{WR}$	2/5 t_{CY} -150	850		600		300			
t_{AD1}	Addr Setup to Data ($\overline{RD}$)	23/30 t_{CY} -250		1670		1190		750		
t_{AD2}	Addr Setup to Data ($\overline{PSEN}$)	3/5 t_{CY} -250		1250		880		480		
t_{AFC1}	Addr Float to $\overline{RD}$, $\overline{WR}$	2/15 t_{CY} -40	290		210		140			
t_{AFC2}	Addr Float to $\overline{PSEN}$	1/30 t_{CY} -40	40		20		10			
t_{LAFC1}	ALE to Control ($\overline{RD}$, $\overline{WR}$)	1/5 t_{CY} -75	420		300		200			
t_{LAFC2}	ALE to Control ($\overline{PSEN}$)	1/10 t_{CY} -75	170		110		60			
t_{CA1}	Control to ALE ($\overline{RD}$, $\overline{WR}$, $\overline{PROG}$)	1/15 t_{CY} -40	120		80		50			
t_{CA2}	Control to ALE ($\overline{PSEN}$)	4/15 t_{CY} -40	620		460		320			
t_{CP}	Port Control Setup to $\overline{PROG}$	1/10 t_{CY} -40	210		140		100			
t_{PC}	Port Control Hold to $\overline{PROG}$	4/15 t_{CY} -200	460		300		160			
t_{PR}	$\overline{PROG}$ to P2 Input Valid	17/30 t_{CY} -120		1300		940		650		
t_{PF}	Input Data Hold from $\overline{PROG}$	1/10 t_{CY}		250	0	190	0	140		
t_{DP}	Output Data Setup	2/5 t_{CY} -150	850		600		400			
t_{PD}	Output Data Hold	1/10 t_{CY} -50	200		130		90			
t_{PP}	$\overline{PROG}$ Pulse Width	7/10 t_{CY} -250	1500		1060		700			
t_{PL}	Port 2 I/O Setup to ALE	4/15 t_{CY} -200	460		300		160			
t_{LP}	Port 2 I/O Hold to ALE	1/10 t_{CY} -100	150		80		40			
t_{PV}	Port Output from ALE	3/10 t_{CY} +100		850		660		510		
t_{CY}	Cycle Time		2.5		1.875		1.36			
t_{0PRR}	T0 Rep Rate	3/15 t_{CY}	500		370		270			

Notes:
1. Control Outputs CL = 80pF
   BUS Outputs CL = 150pF
2. BUS High Impedance Load 20pF

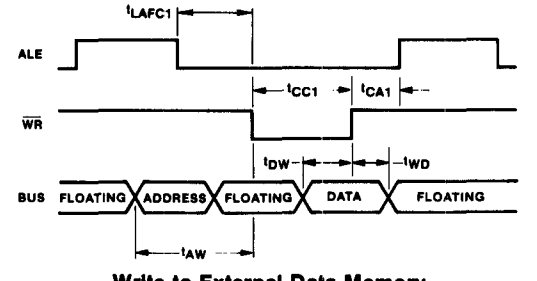
WAVEFORMS



Instruction Fetch From External Program Memory



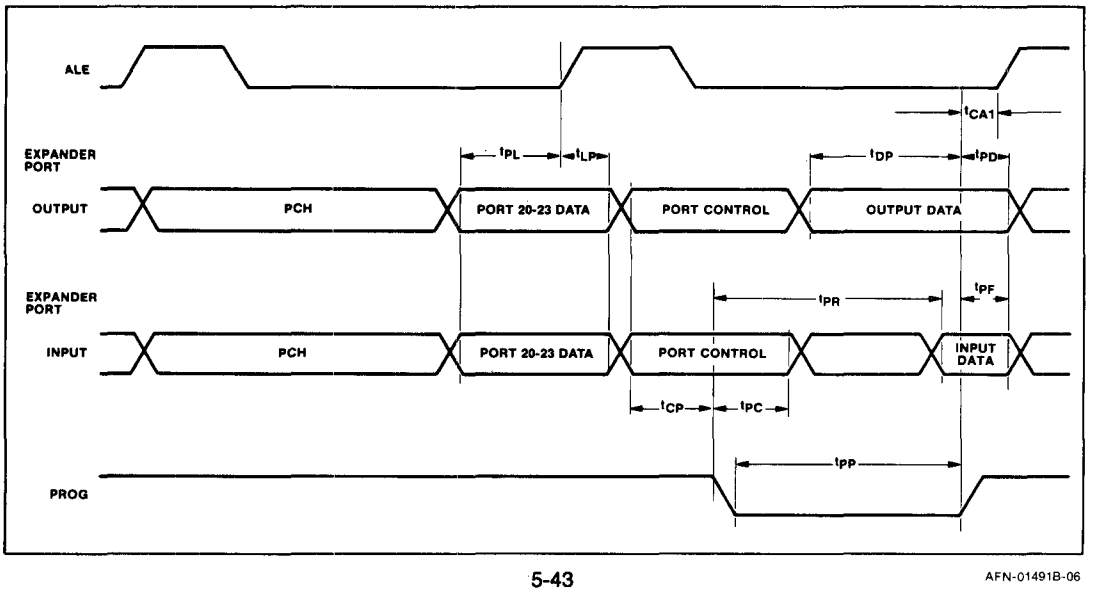
Read From External Data Memory



Write to External Data Memory

Input and Output for A.C.Tests

PORT 2 TIMING



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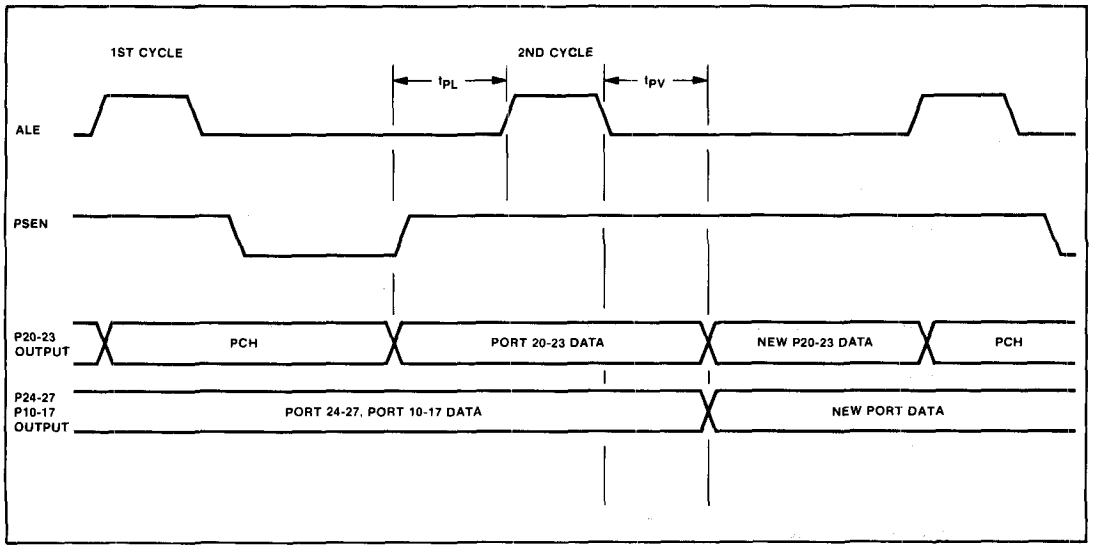
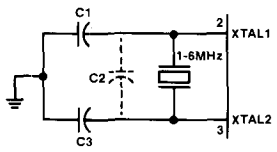
I/O PORT TIMING

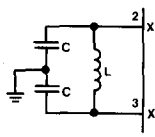


Crystal Oscillator Mode



C1 = 5pF + 1/2pF + STRAY 5pF
C2 = CRYSTAL + STRAY 8pF
C3 = 20pF + 1pF + STRAY 5pF

LC Oscillator Mode



$f \approx \frac{1}{2\pi\sqrt{LC'}}$

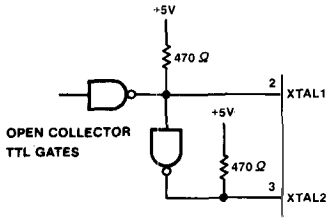
$C' = \frac{3C_{pp}}{2}$

$C_{pp} \approx$ 5-10 pF PIN-TO-PIN CAPACITANCE

L	C	NOMINAL f
45 μH	20pF	5.2 MHz
120 μH	20pF	3.2 MHz

EACH C SHOULD BE APPROXIMATELY 20pF, INCLUDING STRAY CAPACITANCE.

Driving From External Source



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