8041A/8641A/8741A
UNIVERSAL PERIPHERAL INTERFACE
8-BIT MICROCOMPUTER

- **8-Bit CPU plus ROM, RAM, I/O, Timer and Clock in a Single Package**
- **One 8-Bit Status and Two Data Registers for Asynchronous Slave-to-Master Interface**
- **DMA, Interrupt, or Polled Operation Supported**
- **1024 x 8 ROM/EPROM, 64 x 8 RAM, 8-Bit Timer/Counter, 18 Programmable I/O Pins**
- **Fully Compatible with MCS-48™, MCS-80™, MCS-85™, and MCS-86™ Microprocessor Families**
- **Interchangeable ROM and EPROM Versions**
- **3.6 MHz 8741A-8 Available**
- **Expandable I/O**
- **RAM Power-Down Capability**
- **Over 90 Instructions: 70% Single Byte**
- **Single 5V Supply**

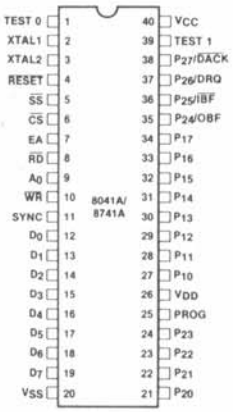
The Intel® 8041A/8741A is a general purpose, programmable interface device designed for use with a variety of 8-bit microprocessor systems. It contains a low cost microcomputer with program memory, data memory, 8-bit CPU, I/O ports, timer/counter, and clock in a single 40-pin package. Interface registers are included to enable the UPI device to function as a peripheral controller in MCS-48™, MCS-80™, MCS-85™, MCS-86™, and other 8-bit systems.

The UPI-41A™ has 1K words of program memory and 64 words of data memory on-chip. To allow full user flexibility the program memory is available as ROM in the 8041A version or as UV-erasable EPROM in the 8741A version. The 8741A and the 8041A are fully pin compatible for easy transition from prototype to production level designs. The 8641A is a one-time programmable (at the factory) 8741A which can be ordered as the first 25 pieces of a new 8041A order. The substitution of 8641A's for 8041A's allows for very fast turnaround for initial code verification and evaluation results.

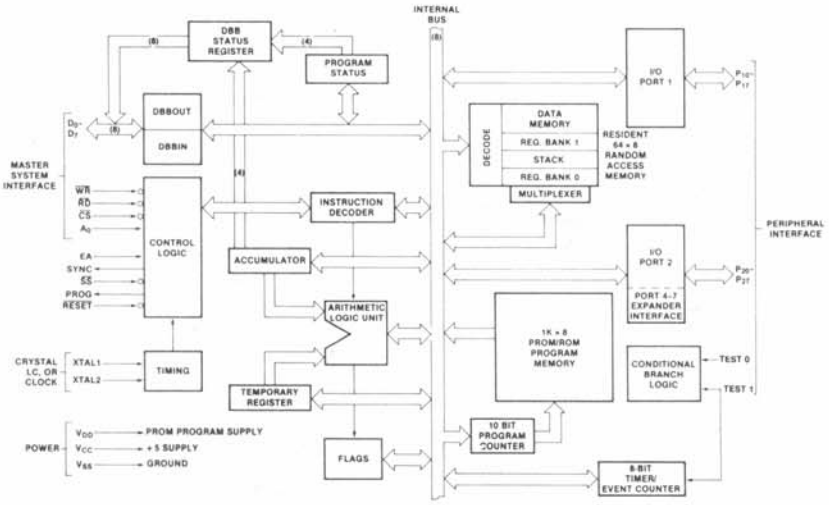
The device has two 8-bit, TTL compatible I/O ports and two test inputs. Individual port lines can function as either inputs or outputs under software control. I/O can be expanded with the 8243 device which is directly compatible and has 16 I/O lines. An 8-bit programmable timer/counter is included in the UPI device for generating timing sequences or counting external inputs. Additional UPI features include: single 5V supply, low power standby mode (in the 8041A), single-step mode for debug (in the 8741A), and dual working register banks.

Because it's a complete microcomputer, the UPI provides more flexibility for the designer than conventional LSI interface devices. It is designed to be an efficient controller as well as an arithmetic processor. Applications include keyboard scanning, printer control, display multiplexing and similar functions which involve interfacing peripheral devices to microprocessor systems.

PIN CONFIGURATION

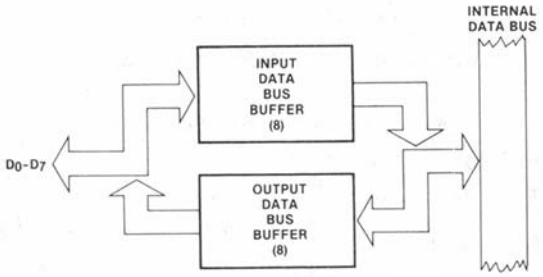


BLOCK DIAGRAM



UPI-41A™ FEATURES AND ENHANCEMENTS

1. Two Data Bus Buffers, one for input and one for output. This allows a much cleaner Master/Slave protocol.



2. 8 Bits of Status

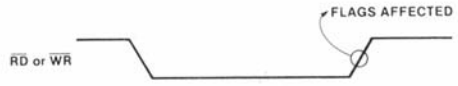
ST_7	ST_6	ST_5	ST_4	F_1	F_0	IBF	OBF
D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0

ST_4-ST_7 are user definable status bits. These bits are defined by the "MOV STS, A" single byte, single cycle instruction. Bits 4-7 of the accumulator are moved to bits 4-7 of the status register. Bits 0-3 of the status register are not affected.

MOV STS, A Op Code: 90H

1	0	0	1	0	0	0	0
D_7							D_0

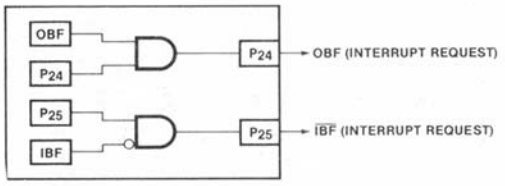
3. $\overline{RD}$ and $\overline{WR}$ are edge triggered. IBF, OBF, F_1 and INT change internally after the trailing edge of $\overline{RD}$ or $\overline{WR}$.



4. P_{24} and P_{25} are port pins or Buffer Flag pins which can be used to interrupt a master processor. These pins default to port pins on Reset.

   If the "EN FLAGS" instruction has been executed, P_{24} becomes the OBF (Output Buffer Full) pin. A "1" written to P_{24} enables the OBF pin (the pin outputs the OBF Status Bit). A "0" written to P_{24} disables the OBF pin (the pin remains low). This pin can be used to indicate that valid data is available from the UPI-41A (in Output Data Bus Buffer).

   If "EN FLAGS" has been executed, P_{25} becomes the $\overline{IBF}$ (Input Buffer Full) pin. A "1" written to P_{25} enables the $\overline{IBF}$ pin (the pin outputs the inverse of the IBF Status Bit). A "0" written to P_{25} disables the $\overline{IBF}$ pin (the pin remains low). This pin can be used to indicate that the UPI-41A is ready for data.



DATA BUS BUFFER INTERRUPT CAPABILITY

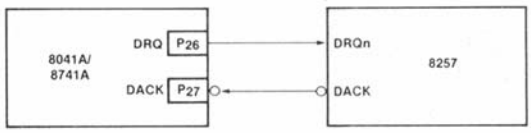
EN FLAGS Op Code: 0F5H

1	1	1	1	0	1	0	1
D_7							D_0

5. P_{26} and P_{27} are port pins or DMA handshake pins for use with a DMA controller. These pins default to port pins on Reset.

   If the "EN DMA" instruction has been executed, P_{26} becomes the DRQ (DMA ReQuest) pin. A "1" written to P_{26} causes a DMA request (DRQ is activated). DRQ is deactivated by DACK·RD, DACK·WR, or execution of the "EN DMA" instruction.

   If "EN DMA" has been executed, P_{27} becomes the $\overline{DACK}$ (DMA ACKnowledge) pin. This pin acts as a chip select input for the Data Bus Buffer registers during DMA transfers.



DMA HANDSHAKE CAPABILITY

EN DMA Op Code: 0E5H

1	1	1	0	0	1	0	1
D_1							D_0

Mnemonic	Description	Bytes	Cycles
CONTROL			
EN DMA	Enable DMA Handshake Lines	1	1
EN I	Enable IBF Interrupt	1	1
DIS I	Disable IBF Interrupt	1	1
EN FLAGS	Enable Master Interrupts	1	1
SEL RB0	Select register bank 0	1	1
SEL RB1	Select register bank 1	1	1
NOP	No Operation	1	1
REGISTERS			
INC Rr	Increment register	1	1
INC @Rr	Increment data memory	1	1
DEC Rr	Decrement register	1	1
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 F1 Flag	1	1
CPL F1	Complement F1 Flag	1	1
BRANCH			
JMP addr	Jump unconditional	2	2
JMPP @A	Jump indirect	1	2
DJNZ Rr, addr	Decrement register and jump	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 Flag = 1	2	2
JF1 addr	Jump on F1 Flag = 1	2	2
JTF addr	Jump on Timer Flag = 1, Clear Flag	2	2
JNIBF addr	Jump on IBF Flag = 0	2	2
JOBF addr	Jump on OBF Flag = 1	2	2
JBb addr	Jump on Accumulator Bit	2	2

APPLICATIONS

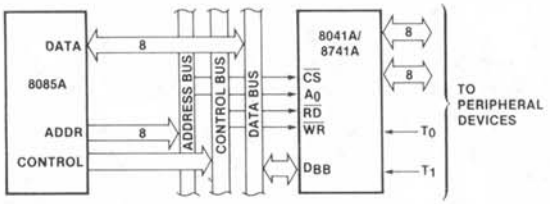


Figure 1. 8085A-8041A Interface

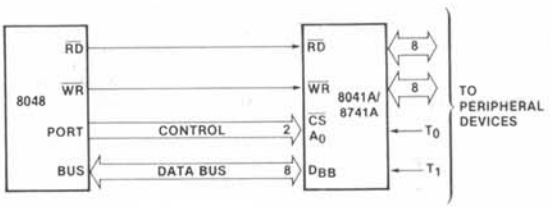


Figure 2. 8048-8041A Interface

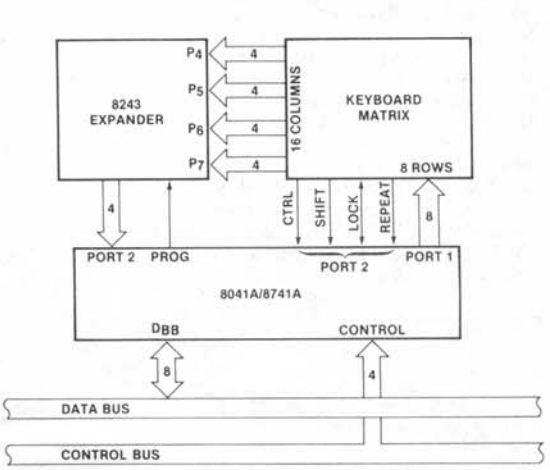


Figure 3. 8041A-8243 Keyboad Scanner

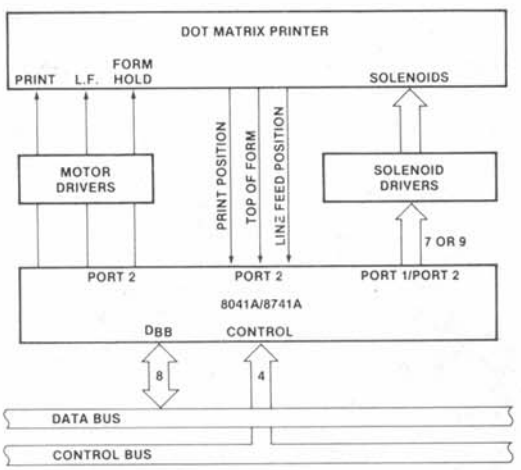


Figure 4. 8041A Matrix Printer Interface

D.C. AND OPERATING CHARACTERISTICS

$T_A = 0°C$ to $70°C$, $V_{SS} = 0V$, 8041A: $V_{CC} = V_{DD} = +5V \pm 10\%$, 8741A: $V_{CC} = V_{DD} = +5V \pm 5\%$

Symbol	Parameter	Min.	Max.	Unit	Test Cond
V_{IL}	Input Low Voltage (Except XTAL1, XTAL2, $\overline{RESET}$)	−0.5	0.8	V	
V_{IL1}	Input Low Voltage (XTAL1, XTAL2, $\overline{RESET}$)	−0.5	0.6	V	
V_{IH}	Input High Voltage (Except XTAL1, XTAL2, $\overline{RESET}$)	2.2	V_{CC}		
V_{IH1}	Input High Voltage (XTAL1, XTAL2, $\overline{RESET}$)	3.8	V_{CC}	V	
V_{OL}	Output Low Voltage (D_0-D_7)		0.45	V	$I_{OL} = 2.0$ mA
V_{OL1}	Output Low Voltage ($P_{10}P_{17}$, $P_{20}P_{27}$, Sync)		0.45	V	$I_{OL} = 1.6$ mA
V_{OL2}	Output Low Voltage (Prog)		0.45	V	$I_{OL} = 1.0$ mA
V_{OH}	Output High Voltage (D_0-D_7)	2.4		V	$I_{OH} = -400$ μ
V_{OH1}	Output High Voltage (All Other Outputs)	2.4		V	$I_{OH} = -50$ μA
I_{IL}	Input Leakage Current (T_0, T_1, $\overline{RD}$, $\overline{WR}$, $\overline{CS}$, A_0, EA)		±10	μA	$V_{SS} \le V_{IN} \le$
I_{OZ}	Output Leakage Current (D_0-D_7, High Z State)		±10	μA	$V_{SS} + 0.45 \le$
I_{LI}	Low Input Load Current ($P_{10}P_{17}$, $P_{20}P_{27}$)		0.5	mA	$V_{IL} = 0.8V$
I_{LI1}	Low Input Load Current ($\overline{RESET}$, $\overline{SS}$)		0.2	mA	$V_{IL} = 0.8V$
I_{DD}	V_{DD} Supply Current		15	mA	Typical = 5 m
$I_{CC} + I_{DD}$	Total Supply Current		125	mA	Typical = 60 m

A.C. CHARACTERISTICS

$T_A = 0°C$ to $70°C$, $V_{SS} = 0V$, 8041A: $V_{CC} = V_{DD} = +5V \pm 10\%$, 8741A: $V_{CC} = V_{DD} = +5V \pm 5\%$

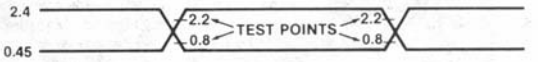
DBB READ

Symbol	Parameter	Min.	Max.	Unit	Test Co
t_{AR}	$\overline{CS}$, A_0 Setup to $\overline{RD}$↓	0		ns	
t_{RA}	$\overline{CS}$, A_0 Hold After $\overline{RD}$↓	0		ns	
t_{RR}	$\overline{RD}$ Pulse Width	250		ns	
t_{AD}	$\overline{CS}$, A_0 to Data Out Delay		225	ns	$C_L = 15$
t_{RD}	$\overline{RD}$↓ to Data Out Delay		225	ns	$C_L = 15$
t_{DF}	$\overline{RD}$↑ to Data Float Delay		100	ns	
t_{CY}	Cycle Time (Except 8741A-8)	2.5	15	μs	6.0 MH
t_{CY}	Cycle Time (8741A-8)	4.17	15	μs	3.6 MH

DBB WRITE

Symbol	Parameter	Min.	Max.	Unit	Test Co
t_{AW}	$\overline{CS}$, A_0 Setup to $\overline{WR}$↓	0		ns	
t_{WA}	$\overline{CS}$, A_0 Hold After $\overline{WR}$↑	0		ns	
t_{WW}	$\overline{WR}$ Pulse Width	250		ns	
t_{DW}	Data Setup to $\overline{WR}$↑	150		ns	
t_{WD}	Data Hold After $\overline{WR}$↑	0		ns	

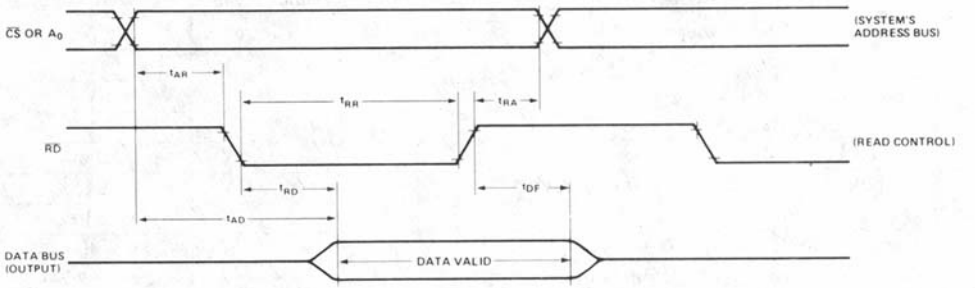
INPUT AND OUTPUT WAVEFORMS FOR A.C. TESTS



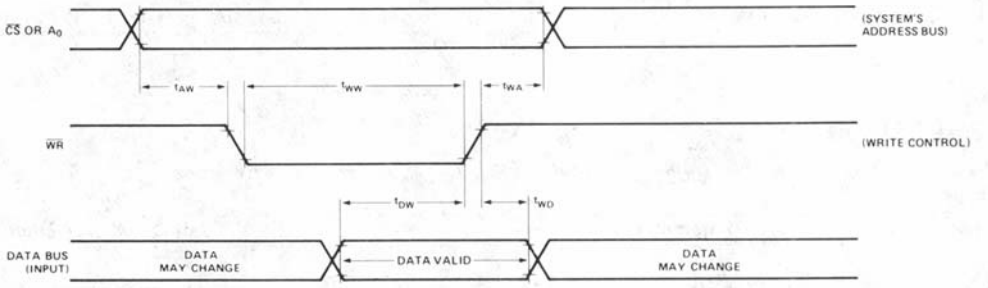
$C_L = 150$ pF

WAVEFORMS

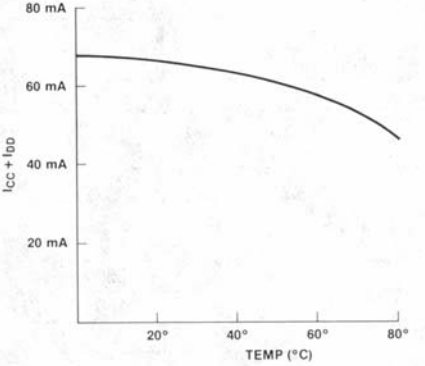
1. READ OPERATION—DATA BUS BUFFER REGISTER.



2. WRITE OPERATION—DATA BUS BUFFER REGISTER.



TYPICAL 8041/8741A CURRENT

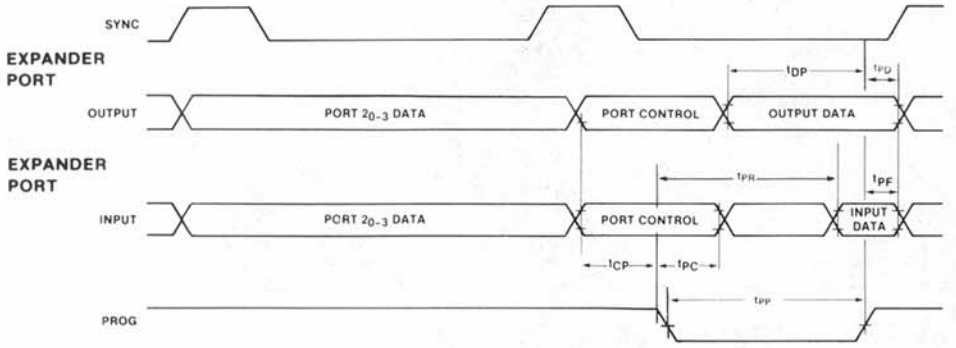


A.C. CHARACTERISTICS—PORT 2

$T_A = 0°C$ to $70°C$, 8041A: $V_{CC} = +5V \pm 10\%$, 8741A: $V_{CC} = +5V \pm 5\%$

Symbol	Parameter	Min.	Max.	Unit	Test Conditions
t_{CP}	Port Control Setup Before Falling Edge of PROG	110		ns	
t_{PC}	Port Control Hold After Falling Edge of PROG	100		ns	
t_{PR}	PROG to Time P2 Input Must Be Valid		810	ns	
t_{PF}	Input Data Hold Time	0	150	ns	
t_{DP}	Output Data Setup Time	250		ns	
t_{PD}	Output Data Hold Time	65		ns	
t_{PP}	PROG Pulse Width	1200		ns	

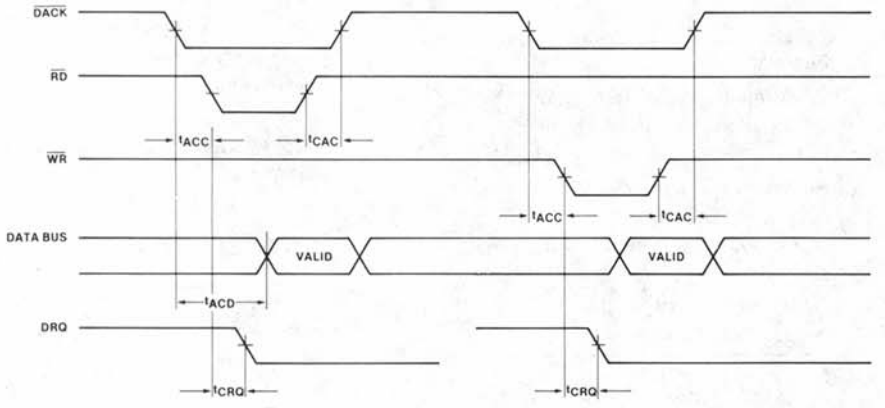
PORT 2 TIMING



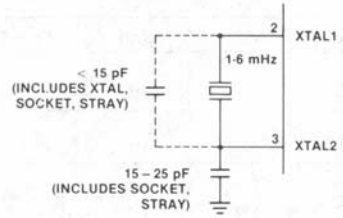
A.C. CHARACTERISTICS—DMA

Symbol	Parameter	Min.	Max.	Unit	Test Conditions
t_{ACC}	$\overline{DACK}$ to $\overline{WR}$ or $\overline{RD}$	0		ns	
t_{CAC}	$\overline{RD}$ or $\overline{WR}$ to $\overline{DACK}$	0		ns	
t_{ACD}	$\overline{DACK}$ to Data Valid		225	ns	$C_L = 150$ pF
t_{CRQ}	$\overline{RD}$ or $\overline{WR}$ to DRQ Cleared		200	ns	

WAVEFORMS—DMA

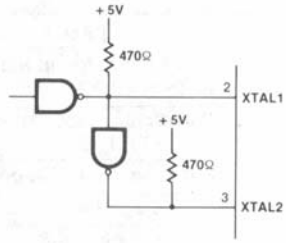


CRYSTAL OSCILLATOR MODE



CRYSTAL SERIES RESISTANCE SHOULD BE <75Ω AT 6 MHz; <180Ω AT 3.6 MHz.

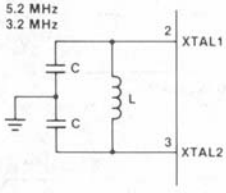
DRIVING FROM EXTERNAL SOURCE



BOTH XTAL1 AND XTAL2 SHOULD BE DRIVEN. RESISTORS TO V_{CC} ARE NEEDED TO ENSURE $V_{IH} = 3.8V$ IF TTL CIRCUITRY IS USED.

LC OSCILLATOR MODE

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



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

$$C' = \frac{C + 3C_{PP}}{2}$$

C_{PP} = 5 – 10 pF PIN-TO-PIN CAPACITANCE

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

PROGRAMMING, VERIFYING, AND ERASING THE 8741A 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 8741A will result in severe damage to the part. An indication of a properly socketed part is the appearance of the SYNC clock output. The lack of this clock may be used to disable the programmer.

The Program/Verify sequence is:

1. A_0 = 0V, $\overline{CS}$ = 5V, EA = 5V, $\overline{RESET}$ = 0V, TEST0 = 5V, V_{DD} = 5V, clock applied or internal oscillator operating, BUS and PROG floating.
2. Insert 8741A 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. $\overline{RESET}$ = 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. $\overline{RESET}$ = 0v and repeat from step 5
15. Programmer should be at conditions of step 1 when 8741A is removed from socket.

8741A Erasure Characteristics

The erasure characteristics of the 8741A are such that erasure begins to occur when exposed to light with wavelengths shorter than approximately 4000 Angstroms (Å). It should be noted that sunlight and certain types of fluorescent lamps have wavelengths in the 3000–4000Å range. Data show that constant exposure to room level fluorescent lighting could erase the typical 8741A in approximately 3 years while it would take approximately one week to cause erasure when exposed to direct sunlight. If the 8741A is to be exposed to these types of lighting conditions for extended periods of time, opaque labels are available from Intel which should be placed over the 8741A window to prevent unintentional erasure.

The recommended erasure procedure for the 8741A is exposure to shortwave ultraviolet light which has a wavelength of 2537Å. The integrated dose (i.e., UV intensity × exposure time) for erasure should be a minimum of 15 w-sec/cm^2. The erasure time with this dosage is approximately 15 to 20 minutes using an ultraviolet lamp with a 12,000 μW/cm^2 power rating. The 8741A should be placed within one inch of the lamp tubes during erasure. Some lamps have a filter on their tubes which should be removed before erasure.

A.C. TIMING SPECIFICATION FOR PROGRAMMING

T_A = 25°C ±5°C, V_{CC} = 5V ±5%, V_{DD} = 25V ±1V

Symbol	Parameter	Min.	Max.	Unit	Test Conditions
t_{AW}	Address Setup Time to $\overline{\text{RESET}}$ ↑	4t_{CY}			
t_{WA}	Address Hold Time After $\overline{\text{RESET}}$ ↑	4t_{CY}			
t_{DW}	Data in Setup Time to PROG ↑	4t_{CY}			
t_{WD}	Data in Hold Time After PROG ↓	4t_{CY}			
t_{PH}	$\overline{\text{RESET}}$ Hold Time to Verify	4t_{CY}			
t_{VDDW}	V_{DD} Setup Time to PROG ↑	4t_{CY}			
t_{VDDH}	V_{DD} Hold Time After PROG ↓	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}	$\overline{\text{RESET}}$ 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}	$\overline{\text{RESET}}$ Setup Time Before EA ↑.	4t_{CY}			

Note: If TEST 0 is high, t_{DO} can be triggered by $\overline{\text{RESET}}$ ↑.

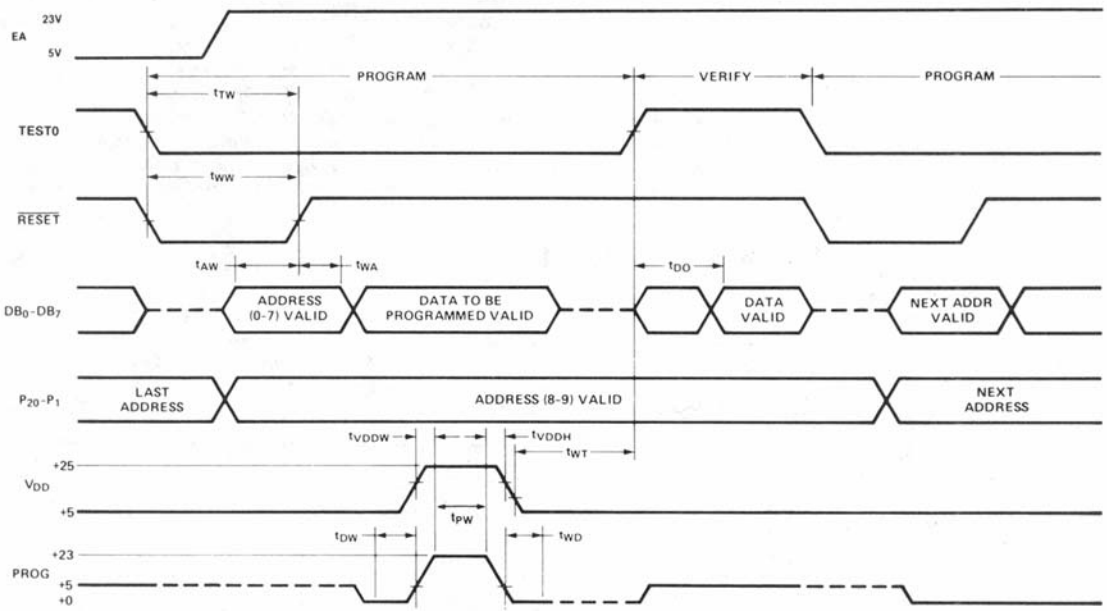
D.C. SPECIFICATION FOR PROGRAMMING

T_A = 25°C ±5°C, V_{CC} = 5V ±5%, V_{DD} = 25V ±1V

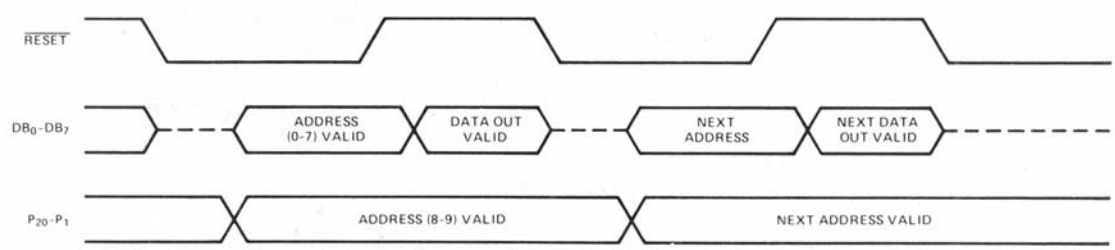
Symbol	Parameter	Min.	Max.	Unit	Test Conditions
V_{DOH}	V_{DD} Program Voltage High Level	24.0	26.0	V	
V_{DDL}	V_{DD} Voltage Low Level	4.75	5.25	V	
V_{PH}	PROG Program Voltage High Level	21.5	24.5	V	
V_{PL}	PROG Voltage Low Level		0.2	V	
V_{EAH}	EA Program or Verify Voltage High Level	21.5	24.5	V	
V_{EAL}	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 FOR PROGRAMMING

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 8741A. FOR THE 8041A PROG MUST ALWAYS FLOAT.**
2. **XTAL1 AND XTAL 2 DRIVEN BY 3.6 MHz CLOCK WILL GIVE 4.17 μsec t_{CY}. THIS IS ACCEPTABLE FOR 8741A-8 PARTS AS WELL AS STANDARD PARTS.**
3. **AO MUST BE HELD LOW (i.e., = 0V) DURING PROGRAM/VERIFY MODES.**