

Description

The μPD78213, μPD78214, and μPD78P214 are high-performance, 8-bit, single-chip microcomputers. They contain extended addressing capabilities for up to 1M byte of external memory. The devices also integrate sophisticated analog and digital peripherals as well as two low-power standby modes that make them ideal for low-power/battery backup applications.

The μPD7821x family focuses on embedded control with features like hardware multiply and divide, two levels of interrupt response, four banks of main registers for multi-tasking, and macroservice for processor-independent peripheral and memory DMA. Augmenting this high-performance core are advanced components like a high-precision A/D converter, two independent serial interfaces, several counter/timers for PWM outputs as well as a real-time output port. On board memory includes 512 bytes of RAM and 16K bytes of mask ROM, EPROM, or OTP ROM.

The macroservice routine allows data to be transferred between any combination of memory and peripherals independent of the current program execution. The four banks of processor registers allow simplified context switching to be performed. Both features combined with powerful on-chip peripherals make this part ideal for a wide variety of embedded control applications.

Features

- Complete single-chip microcomputer
 - 8-bit ALU
 - 16K ROM
 - 512 bytes RAM
 - Both 1-bit and 8-bit logic
- Instruction prefetch queue
- Hardware multiply and divide
- Memory expansion
 - 8085 bus-compatible
 - 64K program address space
 - 1M data address space
- Large I/O capacity: up to 54 I/O port lines
- Software pullup options
- Extensive timer/counter functions
 - One 16-bit timer/counter/event counter
 - Three 8-bit timer/counter/event counter

- Four timer-controlled PWM channels
- Two 4-bit real-time output ports
- Extensive interrupt handler
 - Vectored interrupt handling
 - Programmable priority
 - Macroservice mode
- Two independent serial ports
- Refresh output for pseudostatic RAM
- On-chip clock generator
 - 12-MHz maximum CPU clock frequency
 - 0.33-μs instruction cycle
- CMOS silicon gate technology
- 5-volt power supply

Ordering Information

Part Number	ROM	Package
μPD78213CW ✓	ROMless	64-pin plastic shrink DIP
μPD78213GQ-36 ✓		64-pin plastic QUIP
μPD78213GJ ✓		74-pin plastic QFP
μPD78213L ✓		68-pin PLCC
μPD78214CW ✓	16K Mask ROM	64-pin plastic shrink DIP
μPD78214GQ-36 ✓		64-pin plastic QUIP
μPD78214GJ ✓		74-pin plastic QFP
μPD78214L ✓		68-pin PLCC
μPD78P214CW ✓	16K OTP ROM	64-pin plastic shrink DIP
μPD78P214GQ-36 ✓		64-pin plastic QUIP
μPD78P214GJ ✓		74-pin plastic QFP
μPD78P214L ✓		68-pin PLCC
μPD78P214DW ✓	16K UV EPROM	64-pin shrink cerdip
μPD78P214R ✓		64-pin ceramic QUIP

Note:

A 74-pin plastic QFP that can be reflow soldered will be available.

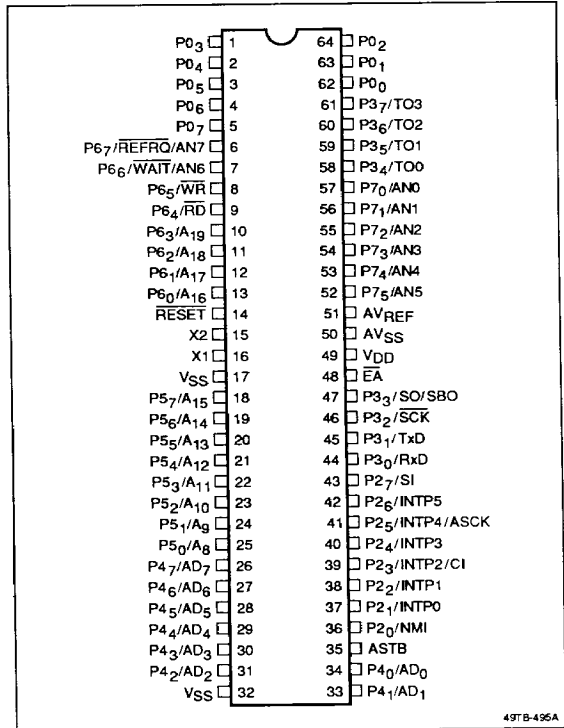
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Pin Identification

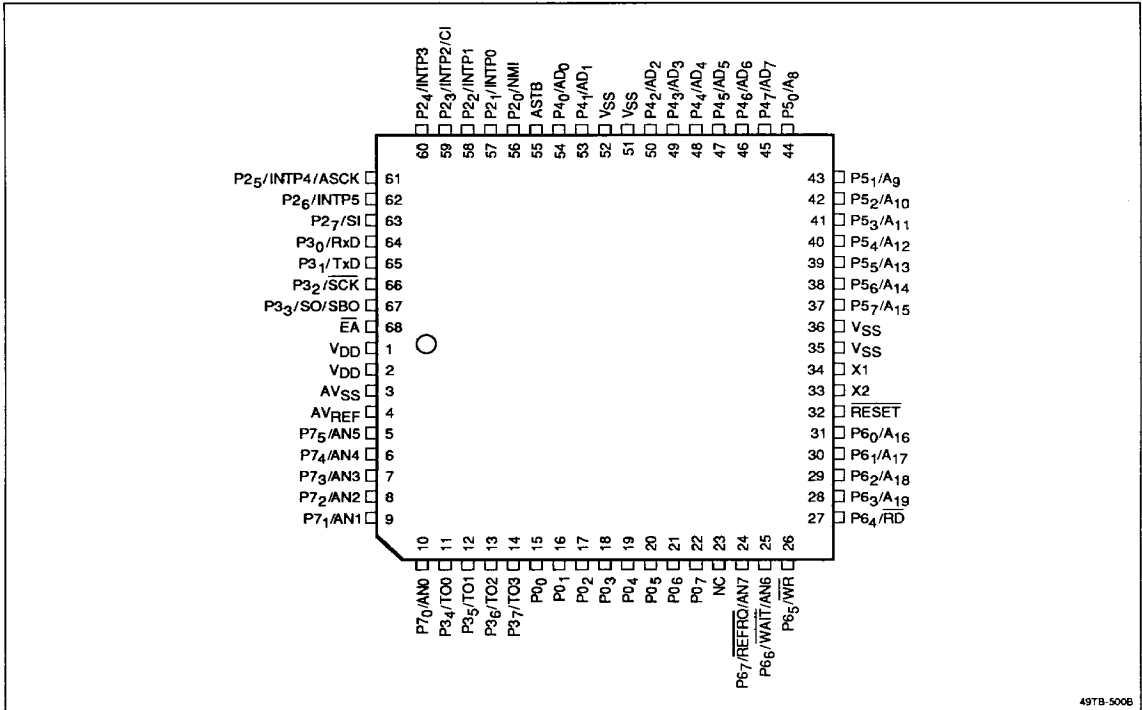
Symbol	Function
P0 ₀ -P0 ₇	Output port 0
P2 ₀ /NMI	Input port 2/Non-maskable interrupt input
P2 ₁ -P2 ₂ /INTP0-INTP1	Input port 2/External interrupt input/timer trigger
P2 ₃ /INTP2/CI	Input port 2/External interrupt input/Clock input
P2 ₄ /INTP3	Input port 2/External interrupt input/timer trigger
P2 ₅ /INTP4/ASCK	Input port 2/External interrupt input/Asynchronous serial clock
P2 ₆ /INTP5	Input port 2/External interrupt input
P2 ₇ /SI	Input port 2/Serial input
P3 ₀ /RxD	I/O port 3/Serial receive input
P3 ₁ /TxD	I/O port 3/Serial transmit output
P3 ₂ /SCK	I/O port 3/Serial clock input/output
P3 ₃ /SO/SBO	I/O port 3/Serial output/Serial bus I/O
P3 ₄ -P3 ₇ /TO0-TO3	I/O port 3/Timer output
P4 ₀ -P4 ₇ /AD ₀ -AD ₇	I/O port 4/Lower address byte/data bus
P5 ₀ -P5 ₇ /A ₈ -A ₁₅	I/O port 5/Upper address byte
P6 ₀ -P6 ₃ /A ₁₆ -A ₁₉	Output port 6/Extended address nibble
P6 ₄ /RD	I/O port 6/Read strobe output
P6 ₅ /WR	I/O port 6/Write strobe output
P6 ₆ /WAIT/AN6	I/O port 6/Wait input/A/D converter input
P6 ₇ /REFRQ/AN7	I/O port 6/Refresh output/A/D converter input
P7 ₀ -P7 ₅ /AN0-AN5	Input port 7/A/D converter input
ASTB	Address strobe output
RESET	External reset input
EA	External memory access control input
X1, X2	External crystal or external clock input
AVREF	A/D converter reference voltage
AV _{SS}	Analog ground
VDD	Positive power supply input
VSS	Power return; normally ground
NC	No connection

Pin Configurations

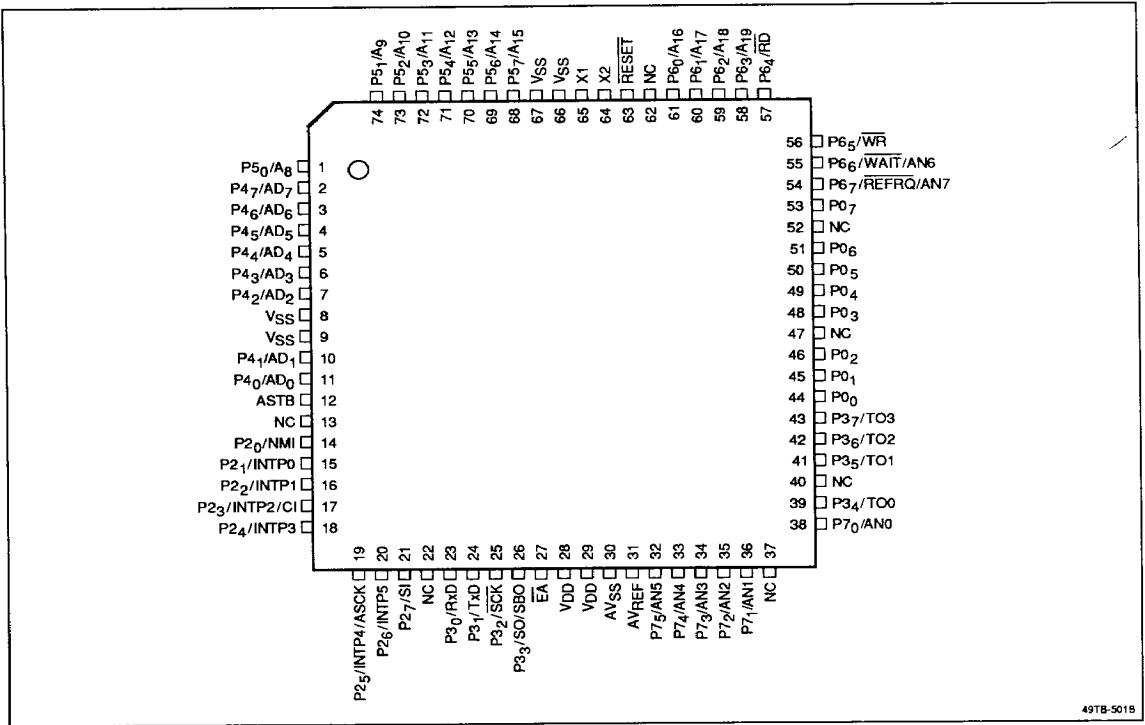
64-Pin Shrink DIP and QUIP (Plastic or Ceramic)



68-Pin PLCC



74-Pin Plastic QFP



49TB-501B

Pin Functions

P0₀-P0₇. Port 0 is an 8-bit, tristate output port with direct transistor drive capability. Port 0 can also be configured as two 4-bit, real-time (timer-controlled) output ports.

P2₀-P2₇. Port 2 is an 8-bit input port with the programmable pullup option except for P2₀ and P2₁.

NMI. Non-maskable interrupt input.

INTP0-INTP5. External interrupt inputs. INTP0, INTP1, and INTP3 are timer capture trigger inputs.

Cl. External clock input to the timer.

ASCK. Asynchronous serial clock input.

SI. Serial data input for three-wire serial I/O mode.

P3₀-P3₇. Port 3 is an 8-bit tristate I/O port with the programmable pullup option.

RxD. Receive serial data input.

TxD. Transmit serial data output.

SCK. Serial shift clock output.

SO. Serial data output for three-wire serial I/O mode.

SBO. I/O bus for the clocked serial interface.

TO0-TO3. Timer flip-flop outputs.

P4₀-P4₇. Port 4 is an 8-bit, bidirectional tristate port with the programmable pullup option. Port 4 has direct LED drive capability.

AD₀-AD₇. Multiplexed address/data bus used with external memory or expanded I/O.

P5₀-P5₇. Port 5 is an 8-bit, bidirectional tristate port with the programmable pullup option. Port 5 has direct LED drive capability.

A₈-A₁₅. Upper-order address bus used with external memory or expanded I/O.

P6₀-P6₃. Pins P6₀-P6₃ of port 6 are outputs.

A₁₆-A₁₉. Extended-order address bus used with external memory.

P6₄-P6₇. Pins P6₄-P6₇ of port 6 are tristate I/Os with the programmable pullup option.

RD. Read strobe output used by external memory (or data registers) to place data on the I/O bus during a read operation.

WR. Write strobe output used by external memory (or data registers) to latch data from the I/O bus during a write operation.

WAIT. Wait signal input.

REFRQ. Refresh pulse output used by external pseudo-static memory.

AN6, AN7. Analog voltage inputs to A/D converter.

P7₀-P7₅. Port 7 is a 6-bit input port.

AN0-AN5. Analog voltage inputs to A/D converter.

ASTB. Address strobe output used by external circuitry to latch the low-order 8 address bits during the first part of a read or write cycle.

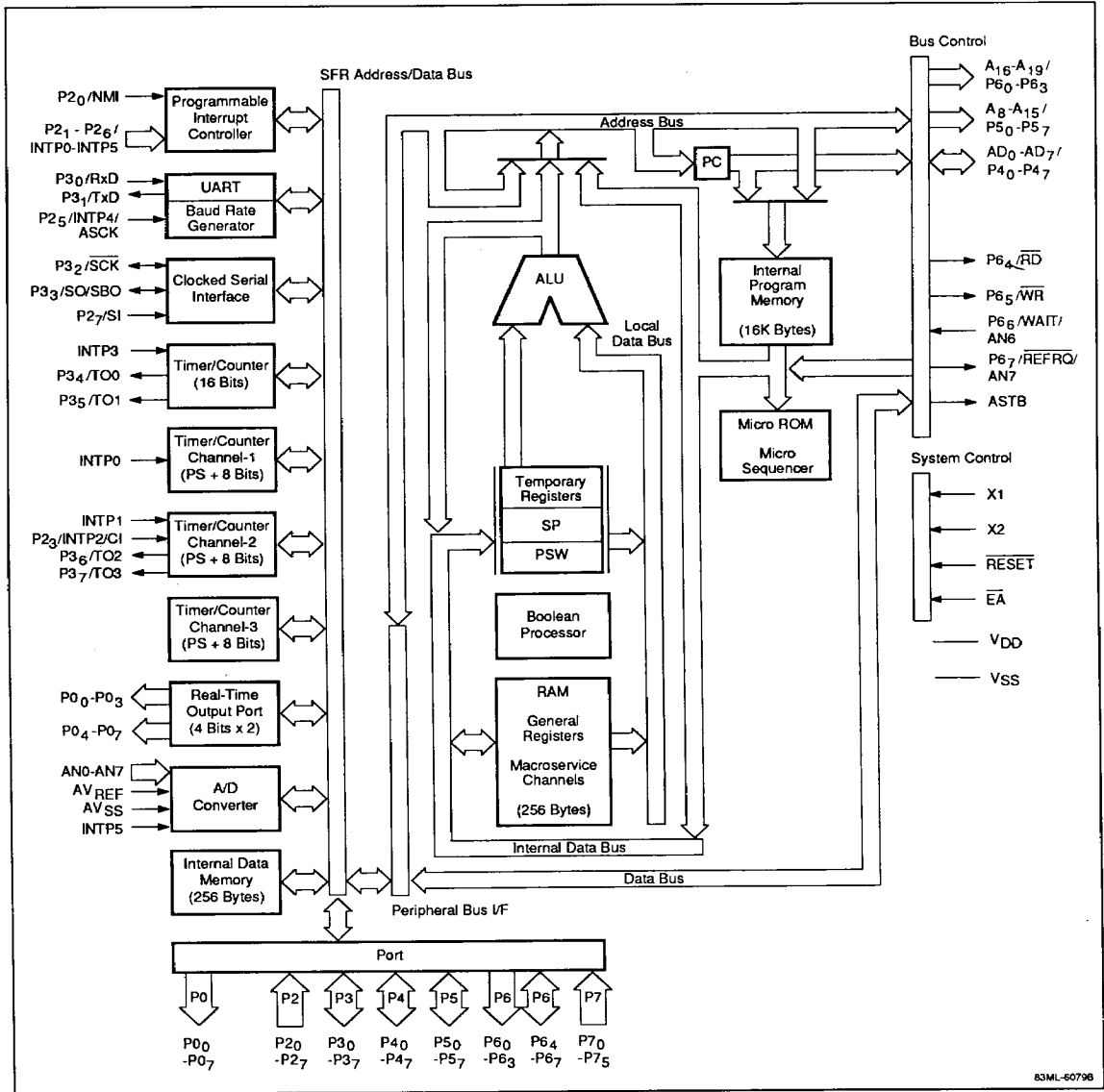
RESET. A low level on this external reset input sets all registers to their specified reset values. This pin, together with P2₀/NMI, sets the μPD78P214 in the PROM programming mode.

EA. Control signal input that selects external memory (\overline{EA} low) or internal ROM (\overline{EA} high) as the program memory. When EA is low, μPD78214 is set in ROMless mode and external memory is accessed.

X1, X2. For frequency control of the internal clock oscillator, a crystal is connected to X1 and X2. If the clock is supplied by an external source, the clock signal is connected to X1 and the inverted clock signal is connected to X2.

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μPD7821x Block Diagram



83ML-60796

FUNCTIONAL DESCRIPTION

Timing

The maximum clock frequency is 12 MHz. The clock is derived from an external crystal or an external oscillator. The internal processor clock is two-phase and the machine states are executed at a rate of 6 MHz. The shortest instructions require two states (333 ns). The CPU contains a one-byte instruction prefetch. This allows a subsequent instruction to be fetched during the execution of an instruction that does not reference memory.

Memory Map

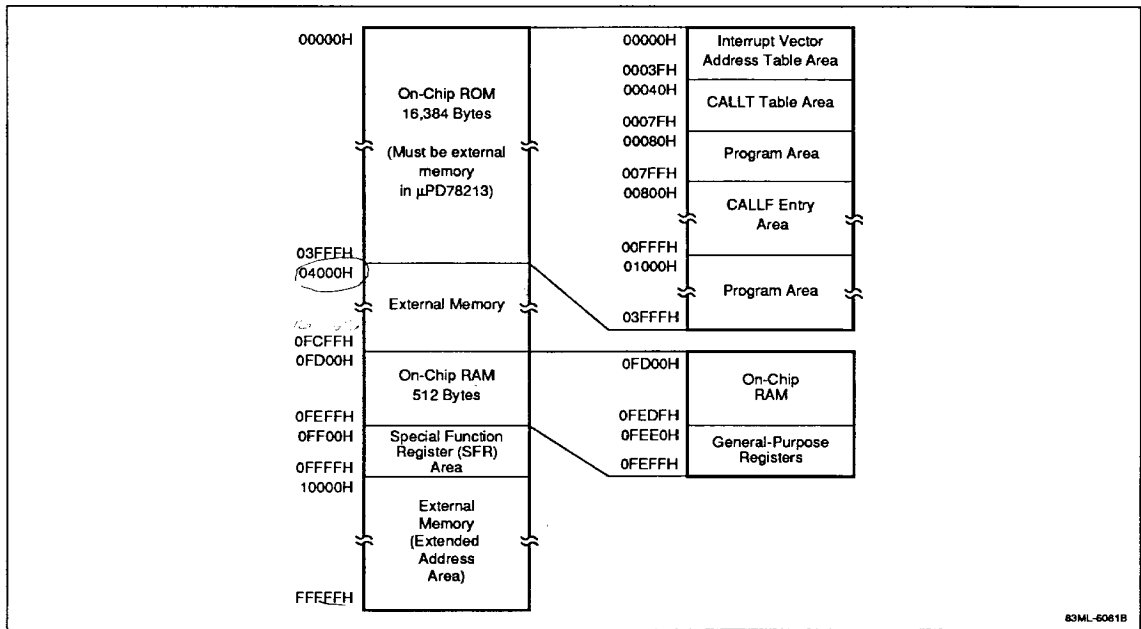
The μPD7821x has 1M byte of address space. This address space is partitioned into 64K bytes of program

memory starting at address 00000H. (See figure 1.) The remainder of the 1M bytes can be accessed as data memory space.

External memory is supported by I/O port 4, an 8-bit multiplexed address/data bus. The memory mapping register controls the size of external memory as well as the number of added wait states. The upper address byte is derived from port 5, and the extended address nibble is derived from port 6.

The μPD78214 has on-chip mask ROM occupying the space from 00000H to 03FFFH. When the ROM is used and no other program or data space is required, ports 4, 5, and 6 are available as additional I/O ports.

Figure 1. Memory Map

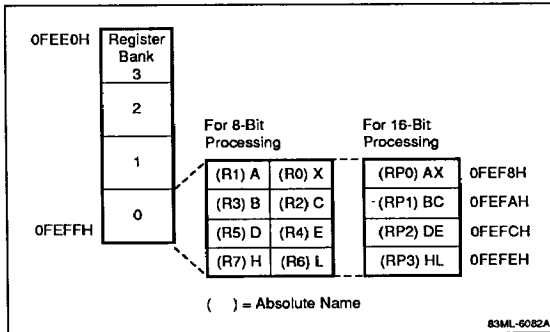


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General-Purpose Registers

The general-purpose registers are mapped into specific addresses in data memory. They are made up of four banks, each bank consisting of eight 8-bit or four 16-bit registers. The register bank used is specified by a CPU instruction. This can be checked by reading RBS0 and RBS1 in the program status word (PSW). The general-purpose register configuration is shown in figure 2.

Figure 2. Register Mapping



Special Registers

There are three different special registers. The first is a 16-bit binary counter that holds the next program address to be executed and is named the program counter. The stack pointer is the second special 16-bit register. The stack pointer holds the address of the stack area (a last in, first out system). The third special register is an 8-bit program status word. This register contains various flags that are set or reset depending on the results of instruction execution. The program status word format is as follows:

7	0						
IE	Z	RBS1	AC	RBS0	0	ISP	CY

- CY Carry flag
- ISP Interrupt priority status flag
- RBS0, RBS1 Register bank selection flags
- AC Auxiliary carry flag
- Z Zero flag
- IE Interrupt request enable flag

Special Function Registers

These registers are assigned to special functions such as the mode and control registers for on-chip peripheral hardware. They are mapped into the 256-byte memory space from 0FF00H to 0FFFFH. Table 1 is a list of special function registers.

Table 1. Special Function Registers

Address	Special Function Register (SFR) Name	Symbol	R/W	Handleable Bit Unit			On Reset
				1 Bit	8 Bit	16 Bit	
0FF00H	Port 0	P0	R/W	o	o	–	Indeterminate
0FF02H	Port 2	P2	R	o	o	–	Indeterminate
0FF03H	Port 3	P3	R/W	o	o	–	Indeterminate
0FF04H	Port 4	P4	R/W	o	o	–	Indeterminate
0FF05H	Port 5	P5	R/W	o	o	–	Indeterminate
0FF06H	Port 6	P6	R/W	o	o	–	x0H
0FF07H	Port 7	P7	R/W	o	o	–	Indeterminate
0FF0AH	Port 0 buffer register (low)	P0L	R/W	o	o	–	Indeterminate
0FF0BH	Port 0 buffer register (high)	P0H	R/W	o	o	–	Indeterminate
0FF0CH	Real-time output port control register	RTPC	R/W	o	o	–	00H
0FF10H, 0FF11H	16-bit compare register 0 (16-bit timer/counter)	CR00	R/W	–	–	o	Indeterminate
0FF12H, 0FF13H	16-bit compare register 1 (16-bit timer/counter)	CR01	R/W	–	–	o	Indeterminate
0FF14H	8-bit compare register (8-bit timer/counter 1)	CR10	R/W	–	o	–	Indeterminate
0FF15H	8-bit compare register (8-bit timer/counter 2)	CR20	R/W	–	o	–	Indeterminate
0FF16H	8-bit compare register (8-bit timer/counter 2)	CR21	R/W	–	o	–	Indeterminate
0FF17H	8-bit compare register (8-bit timer/counter 3)	CR30	R/W	–	o	–	Indeterminate
0FF18H, 0FF19H	16-bit capture register (16-bit timer/counter)	CR02	R	–	–	o	Indeterminate
0FF1AH	8-bit capture register (8-bit timer/counter 2)	CR22	R	–	o	–	Indeterminate
0FF1CH	8-bit capture/compare register (8-bit timer/counter 1)	CR11	R/W	–	o	–	Indeterminate
0FF20H	Port 0 mode register	PM0	W	–	o	–	FFH
0FF23H	Port 3 mode register	PM3	W	–	o	–	FFH
0FF25H	Port 5 mode register	PM5	W	–	o	–	FFH
0FF26H	Port 6 mode register	PM6	R/W	–	o	–	FxH
0FF30H	Capture/compare control register 0	CRC0	W	–	o	–	10H
0FF31H	Timer output control register	TOC	W	–	o	–	00H
0FF32H	Capture/compare control register 1	CRC1	W	–	o	–	00H
0FF34H	Capture/compare control register 2	CRC2	W	–	o	–	00H
0FF40H	Pull-up option register	PUO	R/W	o	o	–	00H
0FF43H	Port 3 mode control register	PMC3	R/W	o	o	–	00H
0FF50H, 0FF51H	16-bit timer register 0	TM0	R	–	–	o	0000H
0FF52H	8-bit timer register 1	TM1	R	–	o	–	00H

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Table 1. Special Function Registers (cont)

Address	Special Function Register (SFR) Name	Symbol	R/W	Handleable Bit Unit			On Reset
				1 Bit	8 Bit	16 Bit	
0FF54H	8-bit timer register 2	TM2	R	-	o	-	00H
0FF56H	8-bit timer register 3	TM3	R	-	o	-	00H
0FF5CH	Prescaler mode register 0	PRM0	W	-	o	-	00H
0FF5DH	Timer control register 0	TMC0	R/W	-	o	-	00H
0FF5EH	Prescaler mode register 1	PRM1	W	-	o	-	00H
0FF5FH	Timer control register 1	TMC1	R/W	-	o	-	00H
0FF68H	A/D converter mode register	ADM	R/W	o	o	-	00H
0FF6AH	A/D conversion result register	ADCR	R	o	o	-	Indeterminate
0FF80H	Clocked serial interface mode register	CSIM	R/W	o	o	-	00H
0FF82H	Serial bus interface control register	SBIC	R/W	o	o	-	00H
0FF86H	Serial shift register	SIO	R/W	-	o	-	Indeterminate
0FF88H	Asynchronous serial interface mode register	ASIM	R/W	o	o	-	80H
0FF8AH	Asynchronous serial interface status register	ASIS	R	o	o	-	00H
0FF8CH	Serial receive buffer: UART	RxB	R	-	o	-	Indeterminate
0FF8EH	Serial send shift register: UART	TxS	W	-	o	-	Indeterminate
0FF90H	Baud rate generator control register	BRGC	W	-	o	-	00H
0FFC0H	Standby control register	STBC	R/W	-	o	-	0000 x 000B
0FFC4H	Memory expansion mode register	MM	R/W	o	o	-	20H
0FFC5H	Programmable wait control register	PW	R/W	o	o	-	80H
0FFC6H	Refresh mode register	RFM	R/W	o	o	-	00H
0FFE0H	Interrupt request flag register L	IF0L IF0	R/W	o	o	o	0000H
0FFE1H	Interrupt request flag register H	IF0H	R/W	o	o		0000H
0FFE4H	Interrupt mask flag register L	MK0L MK0	R/W	o	o	o	FFFFH
0FFE5H	Interrupt mask flag register H	MK0H	R/W	o	o		FFFFH
0FFE8H	Priority specification flag register L	PR0L PR0	R/W	o	o	o	FFFFH
0FFE9H	Priority specification flag register H	PR0H	R/W	o	o		FFFFH
0FFECH	Interrupt service mode specification flag register L	ISM0L ISM0	R/W	o	o	o	0000H
0FFEDH	Interrupt service mode specification flag register H	ISM0H	R/W	o	o		0000H
0FFF4H	External interrupt mode register 0	INTM0	R/W	o	o	-	00H
0FFF5H	External interrupt mode register 1	INTM1	R/W	o	o	-	00H
0FFF8H	Interrupt status register	IST	R/W	o	o	-	00H

Input/Output Ports

Port 0 is a byte programmable tristate output port. Port 2 is bit selectable as input or control pins. Port 3 is bit programmable as input, output, or control pins. Port 4 is byte programmable as an I/O port or as the external address/data bus. Port 5 is bit programmable as I/O or the upper address byte. Port 6 is bit programmable as I/O, control pins, or the extended address nibble. Port 7 is an input only port.

Real-Time Output Port

The real-time output port (figure 3) shares pins with port 0. The high and low nibbles may be treated separately or together. In the real-time output function, data stored beforehand in the buffer register is transferred to the output latch simultaneously with the generation of either a timer interrupt or external interrupt. Using the real-time output function in conjunction with the macroservice function enables port 0 to output preprogrammed patterns at pre-programmed variable time intervals.

A/D Converter

The μPD7821x A/D converter (figure 4) uses the successive-approximation method of converting any or all of the eight multiplexed analog inputs into 8-bit digital data. This data is stored in a result register that can be accessed at any time. The conversion time is 30 μs at 12-MHz operation. Quantization error is ±1/2 LSB; maximum full-scale error is 0.4%.

There are two methods for starting the A/D conversion operation. Conversion may be started by hardware by using an external interrupt as a trigger. The second method of starting conversion is with a software command.

There are also two methods by which the μPD7821x will operate after conversion has begun. The first, the scan method, selects several analog input signals sequentially and obtains data from each pin producing an interrupt with each conversion. The converted data can be successively transferred to memory by using the macroservice function. The second, the select mode, chooses any one input and the result is updated continuously, with or without interrupt generation depending on the chosen start method.

Figure 3. Real-Time Output Port

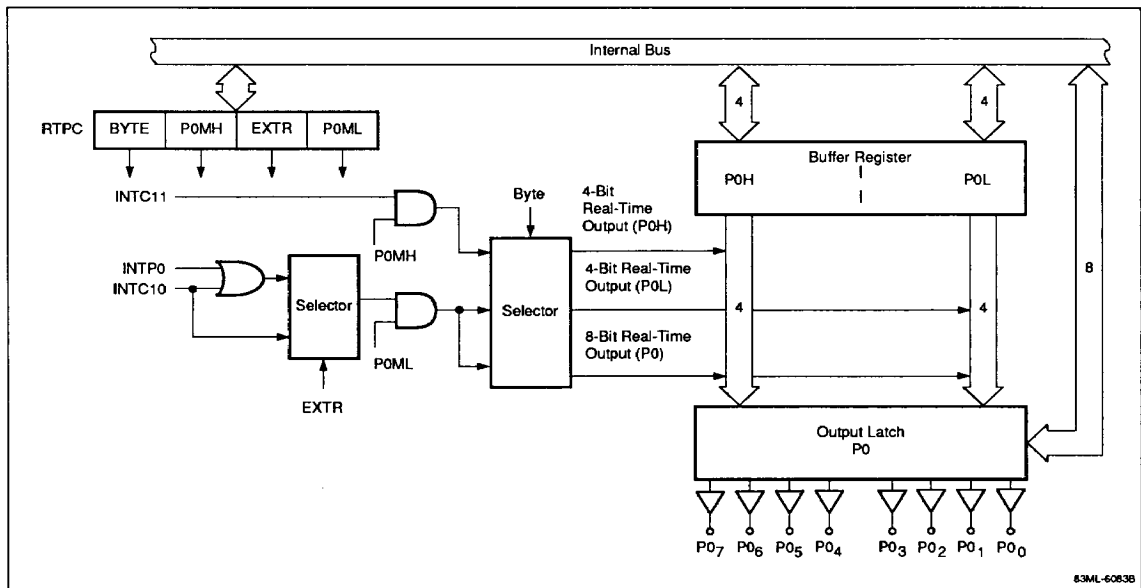
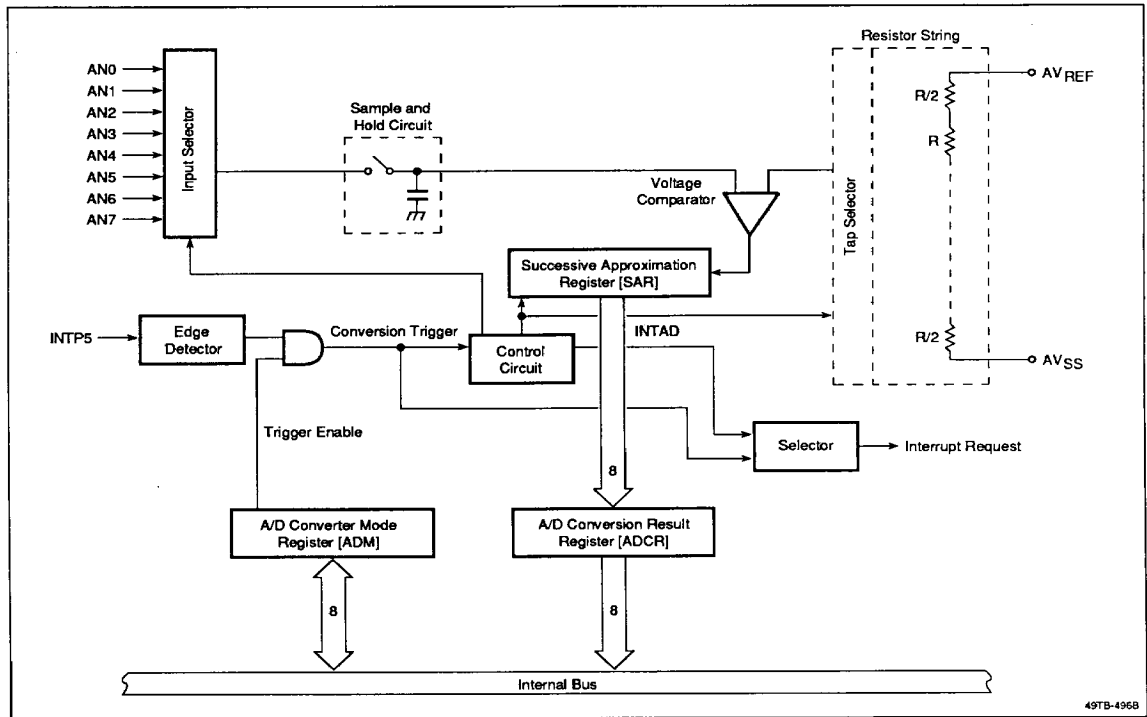


Figure 4. Analog-to-Digital Converter



Serial Interface

The μPD7821x has two independent serial interfaces.

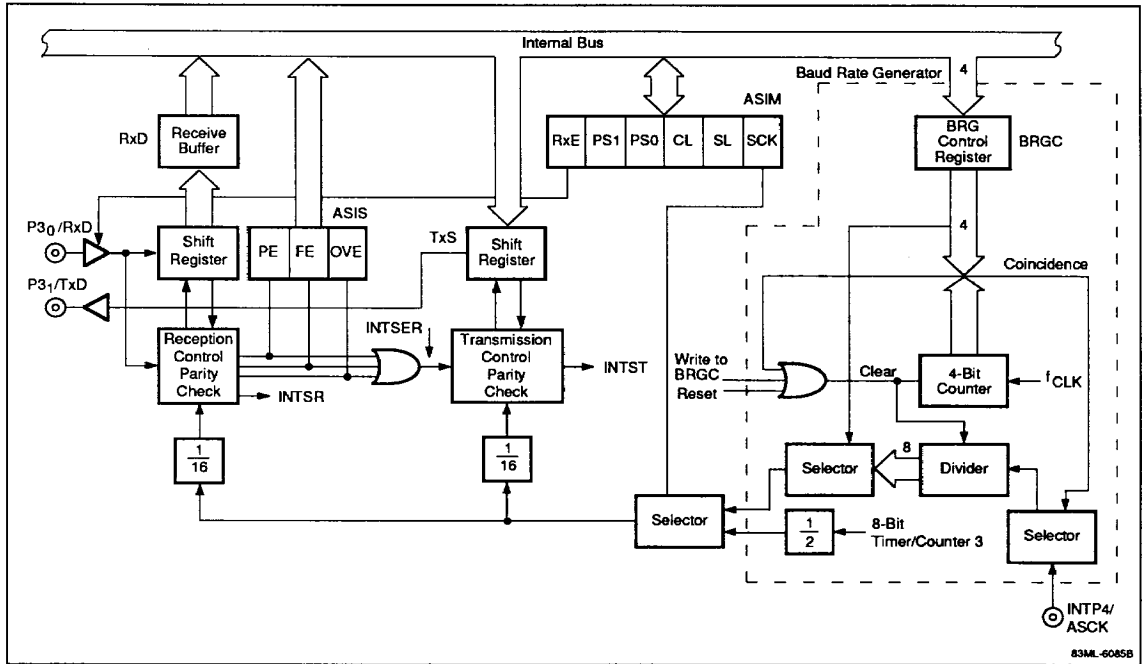
- Asynchronous serial interface (UART) (figure 5)
- Clock-synchronized serial interface (figure 6)

A universal asynchronous receiver transmitter (UART) is used as an asynchronous serial interface. This interface transfers one byte of data following a start bit. The μPD7821x contains a baud rate generator. This allows data to be transferred over a wide range of transfer rates. Transfer rates may also be defined by dividing the clock input to the ASCK pin. Transfer rates may also be generated by 8-bit timer counter 3.

The clock-synchronized serial interface has two different modes of operation:

- Three-line serial I/O mode.
In this mode, data 8 bits long is transferred along three lines: a serial clock (SCK) line and two serial bus lines (SO and SI). This mode is convenient when the μPD7821x is connected to peripheral I/Os and display controllers that have the conventional clock-synchronized serial interface.
- Serial bus interface mode (SBI).
In this mode the μPD7821x can communicate data with several devices using the serial clock (SCK) and the serial data bus (SBO) lines. This mode conforms to NEC's serial bus format. In SBI mode, addresses that select a device to communicate with, commands that direct the device, and actual data are output to the serial data bus. A handshake line, which was required for connecting several devices in the conventional clock-synchronized serial interface, is not needed.

Figure 5. Asynchronous Serial Interface



Timer/Counters

The μPD7821X has four timer/counters: one 16-bit and three 8-bit. The 16-bit timer/counter (figure 7) has the basic functionality of an interval timer, a programmable square-wave output, and a pulse width measurer. These functions can provide a digital delayed one-shot output, a pulse width modulated output, and a cycle measurer.

The first two 8-bit timer/counters can provide the basic functions of an interval timer and a pulse width measurer. Timer/counter 1 can also be used as a timer for output trigger generation for the real-time output port. Timer/counter 2 can also provide an external event counter, a one-shot timer, a programmable square-wave output, a pulse-width modulated output, and a cycle measurer. Timer/counter 3 can operate as an internal timer or as a counter to generate clocks for a baud rate generator. See figures 8, 9, and 10.

Figure 7. 16-Bit Timer/Counter

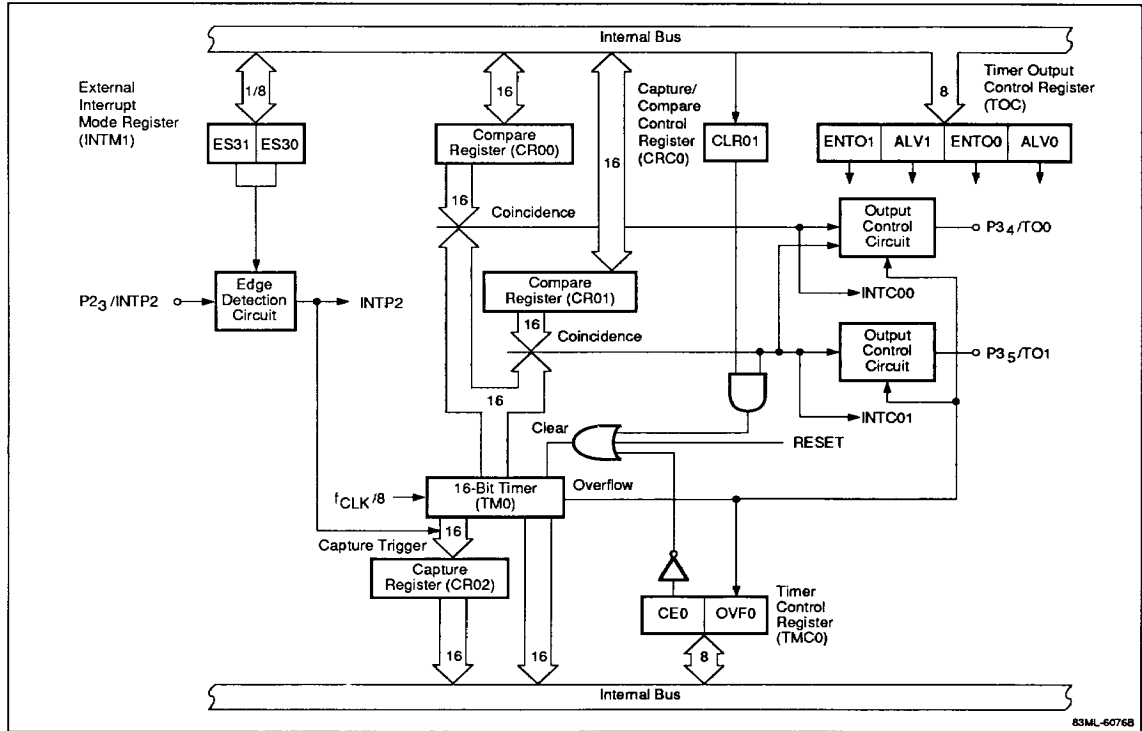


Figure 8. 8-Bit Timer/Counter 1

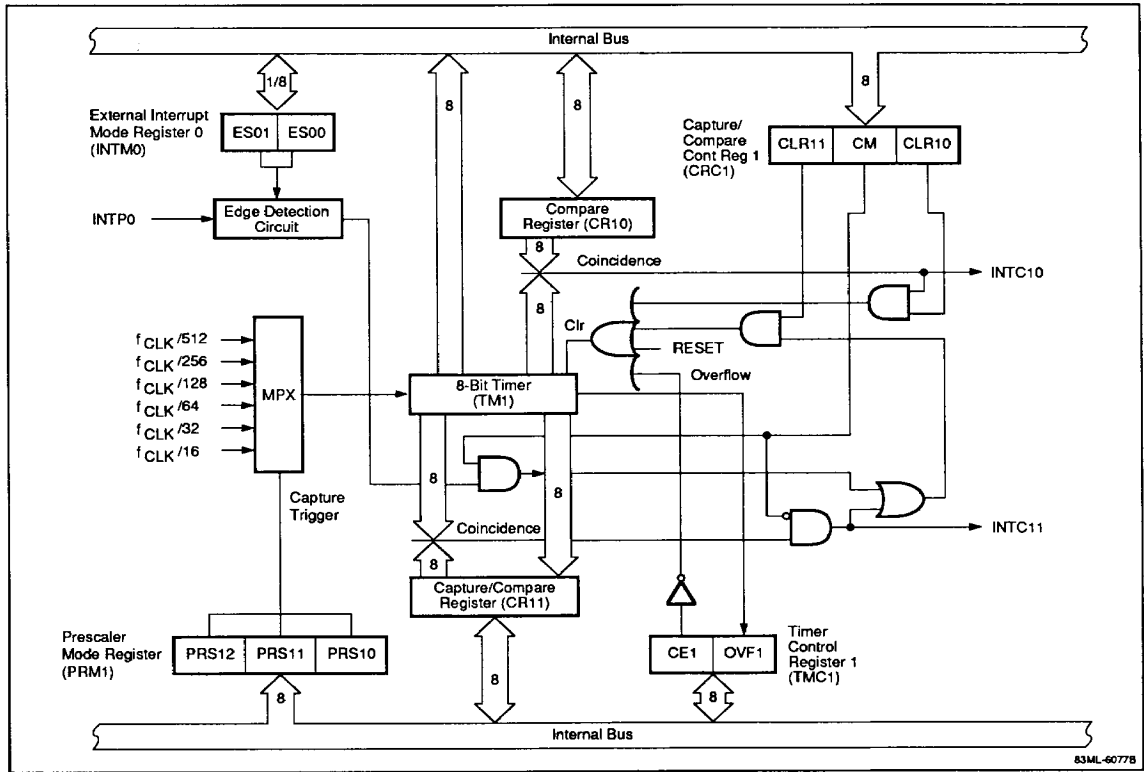
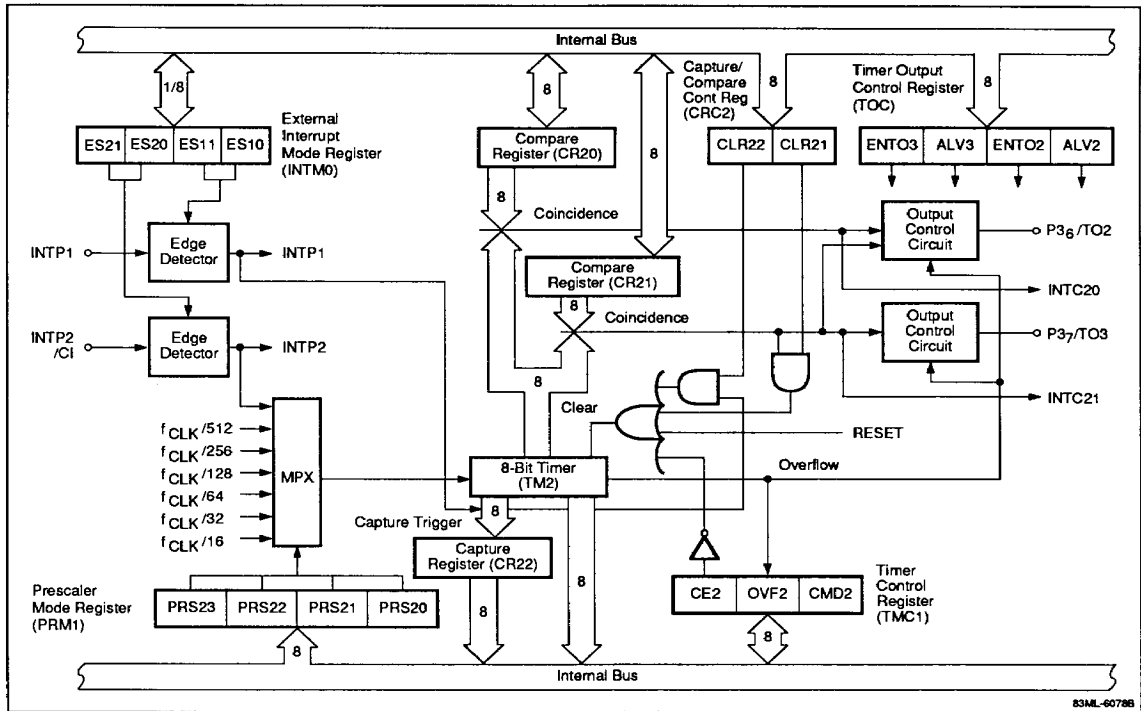


Figure 9. 8-Bit Timer/Counter 2

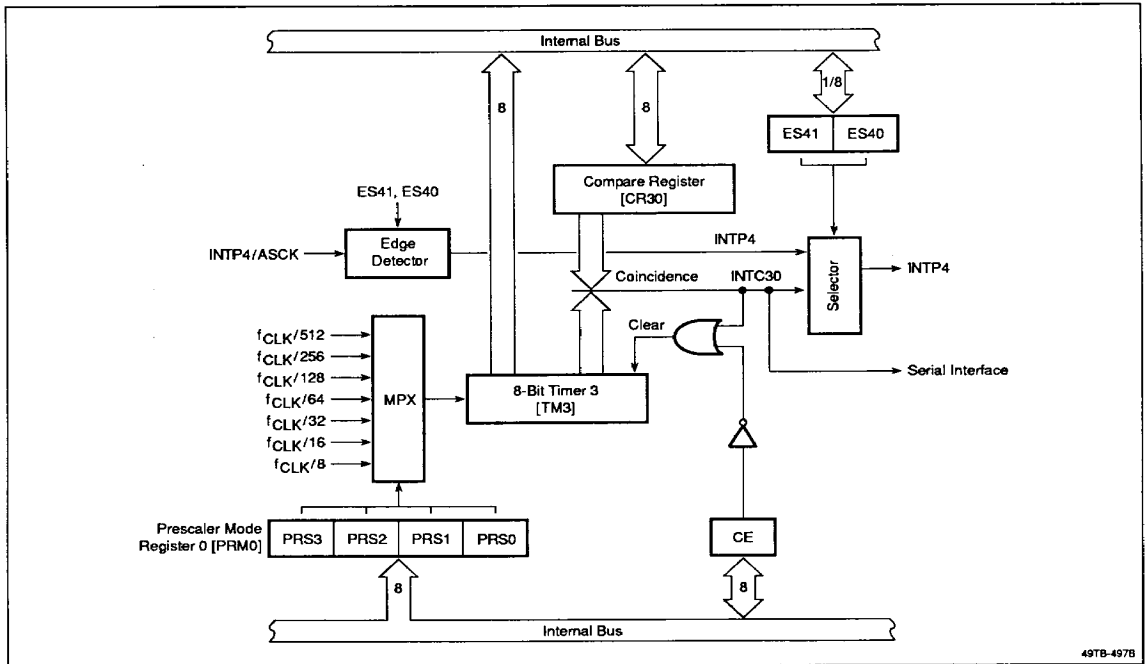


Interrupts

There are 20 interrupt request sources; each source is allocated a location in the vector table. (See table 2.) There is one software interrupt request and one of the remaining 19 interrupts is non-maskable. The software interrupt and the non-maskable interrupt are unconditionally received even in the DI state. These two interrupts possess the maximum priority. The maskable interrupt requests are subject to mask control by the setting of the interrupt mask flag.

There are default priorities associated with each maskable interrupt and these can be assigned to either of two programmable priority levels. Interrupts may be serviced by the vectored interrupt method where a branch to a desired service program is executed. Interrupts may also be handled by the macroservice function where a preassigned process is performed without program intervention.

Figure 10. 8-Bit Timer/Counter 3



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Table 2. Interrupt Sources and Vector Addresses

Interrupt Request Type	Default Priority	Interrupt Request Generation Source	Macroservice Mode	Vector Table Address
Software	None	BRK instruction execution	—	003EH
Non-maskable	None	NMI (pin input edge detection)	—	0002H
Maskable	0	INTP0 (pin input edge detection)	Yes	0006H
	1	INTP1 (pin input edge detection)	Yes	0008H
	2	INTP2 (pin input edge detection)	Yes	000AH
	3	INTP3 (pin input edge detection)	Yes	000CH
	4	INTC00 (TM0-CR00 coincidence signal generation)	Yes	0014H
	5	INTC01 (TM0-CR01 coincidence signal generation)	Yes	0016H
	6	INTC10 (TM1-CR10 coincidence signal generation)	Yes	0018H
	7	INTC11 (TM1-CR11 coincidence signal generation)	Yes	001AH
	8	INTC21 (TM2-CR21 coincidence signal generation)	Yes	001CH
	9	INTP4 (pin input edge detection)/INTC30 (TM3-CR30 coincidence signal generation)	Yes	000EH
	10	INTP5 (pin input edge detection)/INTAD (end of A/D conversion)	Yes	0010H
	11	INTC20 (TM2-CR20 coincidence signal generation)	Yes	0012H
	12	INTSER (generation of asynchronous serial interface receive error)	—	0020H
	13	INTSR (end of asynchronous serial interface reception)	Yes	0022H
	14	INTST (end of asynchronous serial interface transmission)	Yes	0024H
15	INTCSI (end of clocked serial interface transmission)	Yes	0026H	

Macroservice

The macroservice function can be programmed to transfer data from a special function register to memory or from memory to a special function register. Transfer events are triggered by interrupt requests and take place without software intervention. There are 17 interrupt requests where macroservicing can be executed. The macroservice function is controlled by the macroservice mode register and the macroservice channel pointer. The macroservice mode register assigns the macroservicing mode and the macroservice channel pointer indicates the address of the memory location pointers. The location of each register and its corresponding interrupt is shown in figure 11.

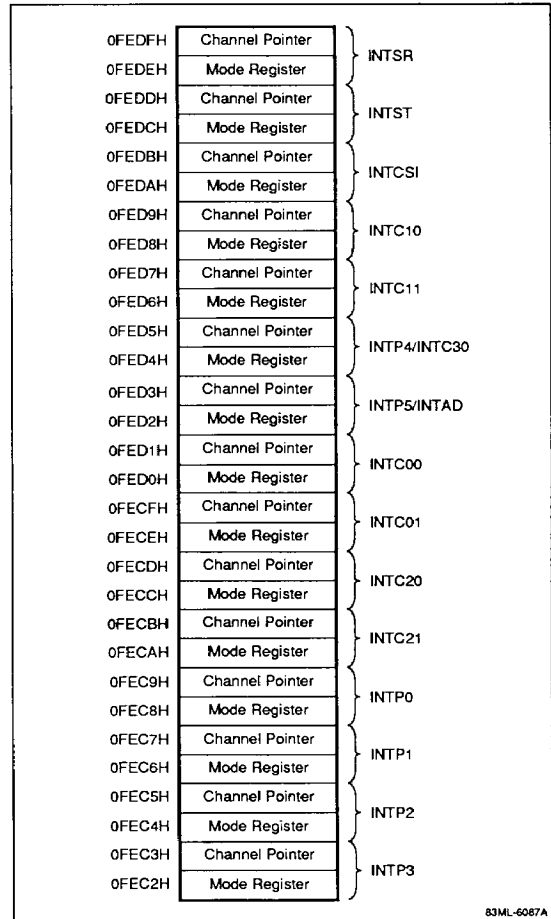
Refresh

The refresh signal is used with a pseudostatic RAM. The refresh cycle can be set to one of four intervals ranging from 2.6 to 21.3 μs. The refresh is timed to follow a read or write operation so there is no interference.

Standby Modes

Halt and stop functions reduce system power consumption. In the halt mode, the CPU stops and the system clock continues to run. A release of the halt mode is initiated by an unmasked interrupt request, an NMI, or a RESET input. In the stop mode, the CPU and system clock are both stopped, reducing the power consumption even further. The stop mode is released by an NMI input or a RESET input.

Figure 11. Macroservice Control Word Map



83ML-6087A

ELECTRICAL SPECIFICATIONS

Absolute Maximum Ratings

T_A = +25°C.

Item	Symbol	Conditions	Rating	Unit
Operating voltage	V _{DD}		-0.5 to +7.0	V
	AV _{REF}		-0.5 to V _{DD}	V
	AV _{SS}		-0.5 to +0.5	V
Input voltage	V _{I1}	Note 1	-0.5 to V _{DD} + 0.5	V
	V _{I2}	Note 2	-0.5 to AV _{REF} + 0.5	V
	V _{I3}	Note 3; for μPD78P214	-0.5 to +13.5	V
Output voltage	V _O		-0.5 to V _{DD} + 0.5	V
Low-level output current	I _{OL}	One output pin	30 (peak)	mA
			15 (mean value)	mA
	All output pins total		150 (peak)	mA
			100 (mean value)	mA
High-level output current	I _{OH}	One output pin	-2	mA
		All output pins total	-50	mA
Operating temperature	T _{OPT}		-40 to +85	°C
Storage temperature	T _{STG}		-65 to +150	°C

Notes:

- (1) Pins P7₀-P7₅/AN0-AN5, P6₆/WAIT/AN6, and P6₇/REFRQ/AN7 except when Note 2 is applicable.
- (2) Pin used as the A/D converter input or pin selected by bits ANI0-ANI2 of the ADM register when the A/D converter is not in operation.
- (3) P2₀/NMI, EA/V_{PP}, and P2₁/INTP0/A₉ pins in the PROM programming mode.

Operating Frequency

Oscillation Frequency	T _A	V _{DD}
f _{XX} = 4 to 12 MHz	-40 to +85°C	+5V ± 10%

Capacitance

T_A = +25°C; V_{DD} = V_{SS} = 0 V.

Item	Symbol	Typ	Max	Unit	Conditions
Input capacitance	C _I	20		pF	f = 1 MHz; pins not used for measurement are at 0 V
Output capacitance	C _O	20		pF	
Input/output capacitance	C _{IO}	20		pF	

DC Characteristics

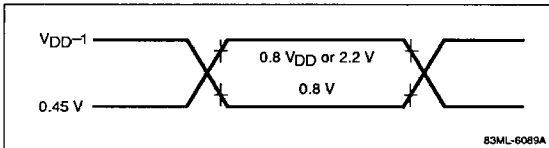
$T_A = -40$ to $+85^\circ\text{C}$; $V_{DD} = +5\text{ V} \pm 10\%$; $V_{SS} = 0\text{ V}$.

Item	Symbol	Conditions	Min	Typ	Max	Unit
Low-level input voltage	V_{IL}		0		0.8	V
High-level input voltage	V_{IH1}	Except the specified pins (Notes 1, 2)	2.2		V_{DD}	V
	V_{IH2}	Specified pins (Note 1)	2.2		AV_{REF}	V
	V_{IH3}	Specified pins (Note 2)	$0.8V_{DD}$		V_{DD}	V
Low-level output voltage	V_{OL1}	$I_{OL} = 2.0\text{ mA}$			0.45	V
	V_{OL2}	$I_{OL} = 8.0\text{ mA}$ (Note 3)			1.0	V
High-level output voltage	V_{OH1}	$I_{OH} = -1.0\text{ mA}$	$V_{DD} - 1.0$			V
	V_{OH2}	$I_{OH} = -100\text{ }\mu\text{A}$	$V_{DD} - 0.5$			V
	V_{OH3}	$I_{OH} = -5.0\text{ mA}$ (Note 4)	2.0			V
Input leakage current	I_{LI}	$0\text{ V} \leq V_I \leq V_{DD}$			± 10	μA
Output leakage current	I_{LO}	$0\text{ V} \leq V_O \leq V_{DD}$			± 10	μA
AV_{REF} current	AI_{REF}	Operating mode, $f_{XX} = 12\text{ MHz}$		1.5	5.0	mA
V_{DD} power supply current	$IDD1$	Operating mode, $f_{XX} = 12\text{ MHz}$		20	40	mA
	$IDD2$	HALT mode, $f_{XX} = 12\text{ MHz}$		7	20	mA
Data retention voltage	V_{DDDR}	STOP mode	2.5		5.5	V
Data retention current	$IDDDR$	STOP mode $V_{DDDR} = 2.5\text{ V}$		2	20	μA
		$V_{DDDR} = 5\text{ V} \pm 10\%$		5	50	μA
Pullup resistor	R_L	$V_I = 0\text{ V}$	15	40	80	$\text{k}\Omega$

Notes:

- (1) Pins $P7_0$ - $P7_5$ / $AN0$ - $AN5$, $P6_6$ / $WAIT$ / $AN6$, and $P6_7$ / $REFRQ$ / $AN7$ when the pin is used as the A/D converter input or is selected by bits $AN10$ - $AN12$ of the ADM register when the A/D converter is not in operation.
- (2) $X1$, $X2$, $RESET$, $P2_0$ / NMI , $P2_1$ / $INTP0$, $P2_2$ / $INTP1$, $P2_3$ / $INTP2$ / CI , $P2_4$ / $INTP3$, $P2_5$ / $INTP4$ / $ASCK$, $P2_6$ / $INTP5$, $P2_7$ / SI , $P3_2$ / SCK , $P3_3$ / SO / SBO , and EA pins.
- (3) Pins $P4_0$ - $P4_7$ / AD_0 - AD_7 and $P5_0$ - $P5_7$ / A_8 - A_{15} .
- (4) Pins $P0_0$ - $P0_7$.

Figure 12. Voltage Thresholds for Timing Measurements



Read/Write Operation

$T_A = -40$ to $+85^\circ\text{C}$; $V_{DD} = +5\text{ V} \pm 10\%$; $V_{SS} = 0\text{ V}$; $f_{XX} = 12\text{ MHz}$; $C_L = 100\text{ pF}$.

Item	Symbol	Conditions	Min	Max	Unit
X1 input clock cycle time	t_{CYX}		82	250	ns
Address setup time to $\overline{\text{ASTB}} \downarrow$	t_{SAST}		52		ns
Address hold time from $\overline{\text{ASTB}} \downarrow$ (Note 1)	t_{HSTA}	$R_L = 5\text{ k}\Omega$, $C_L = 50\text{ pF}$	25		ns
Address to $\overline{\text{RD}} \downarrow$ delay time	t_{DAR}		129		ns
Address float time from $\overline{\text{RD}} \downarrow$	t_{FAR}		11		ns
Address to data input time	t_{DAID}			228	ns
$\overline{\text{ASTB}} \downarrow$ to data input time	t_{DSTID}			181	ns
$\overline{\text{RD}} \downarrow$ to data input time	t_{DRID}			99	ns
$\overline{\text{ASTB}} \downarrow$ to $\overline{\text{RD}} \downarrow$ delay time	t_{DSTR}		52		ns
Data hold time from $\overline{\text{RD}} \uparrow$	t_{HRID}		0		ns
$\overline{\text{RD}} \uparrow$ to address active time	t_{DRA}		124		ns
$\overline{\text{RD}} \uparrow$ to $\overline{\text{ASTB}} \uparrow$ delay time	t_{DRST}		124		ns
$\overline{\text{RD}}$ low-level width	t_{WRL}		124		ns
$\overline{\text{ASTB}}$ high-level width	t_{WSTH}		52		ns
Address to $\overline{\text{WR}} \downarrow$ delay time	t_{DAW}		129		ns
$\overline{\text{ASTB}} \downarrow$ to data output time	t_{DSTOD}			142	ns
$\overline{\text{WR}} \downarrow$ to data output time	t_{DWOD}			60	ns
$\overline{\text{ASTB}} \downarrow$ to $\overline{\text{WR}} \downarrow$ delay time	t_{DSTW1}		52		ns
	t_{DSTW2}	Refresh mode	129		ns
Data setup time to $\overline{\text{WR}} \uparrow$	t_{SODWR}		146		ns
Data setup time to $\overline{\text{WR}} \downarrow$ (Note 1)	t_{SODWF}	Refresh mode	22		ns
Data hold time from $\overline{\text{WR}} \uparrow$	t_{HWOD}		20		ns
$\overline{\text{WR}} \uparrow$ to $\overline{\text{ASTB}} \uparrow$ delay time	t_{DWST}		42		ns
$\overline{\text{WR}}$ low-level width	t_{WWL1}		196		ns
	t_{WWL2}	Refresh mode	114		ns
Address to $\overline{\text{WAIT}} \downarrow$ input time	t_{DAWT}			146	ns
$\overline{\text{ASTB}} \downarrow$ to $\overline{\text{WAIT}} \downarrow$ input time	t_{DSTWT}			84	ns
$\overline{\text{WAIT}}$ hold time from $\text{X1} \downarrow$	t_{HWTX}		0		ns
$\overline{\text{WAIT}}$ setup time to $\text{X1} \uparrow$	t_{SWTX}		0		ns

Notes:

- (1) The hold time includes the time during which V_{OH} and V_{OL} are retained under the following load conditions: $C_L = 100\text{ pF}$ and $R_L = 2\text{ k}\Omega$.

Figure 13. Read Operation Timing

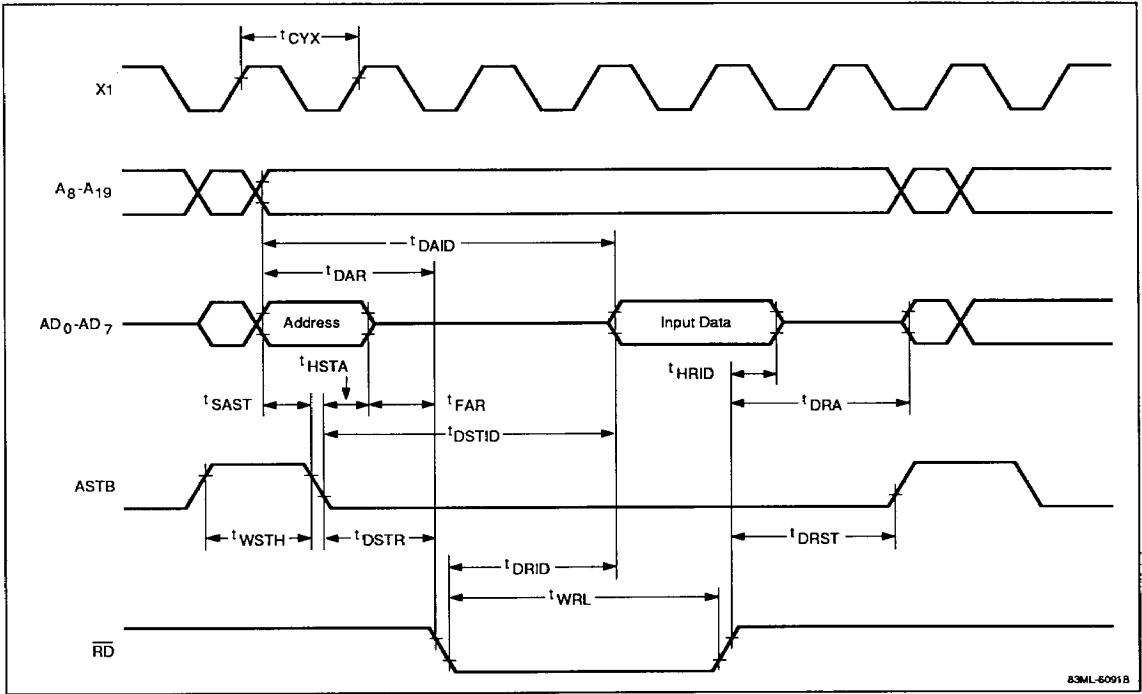


Figure 14. Write Operation Timing

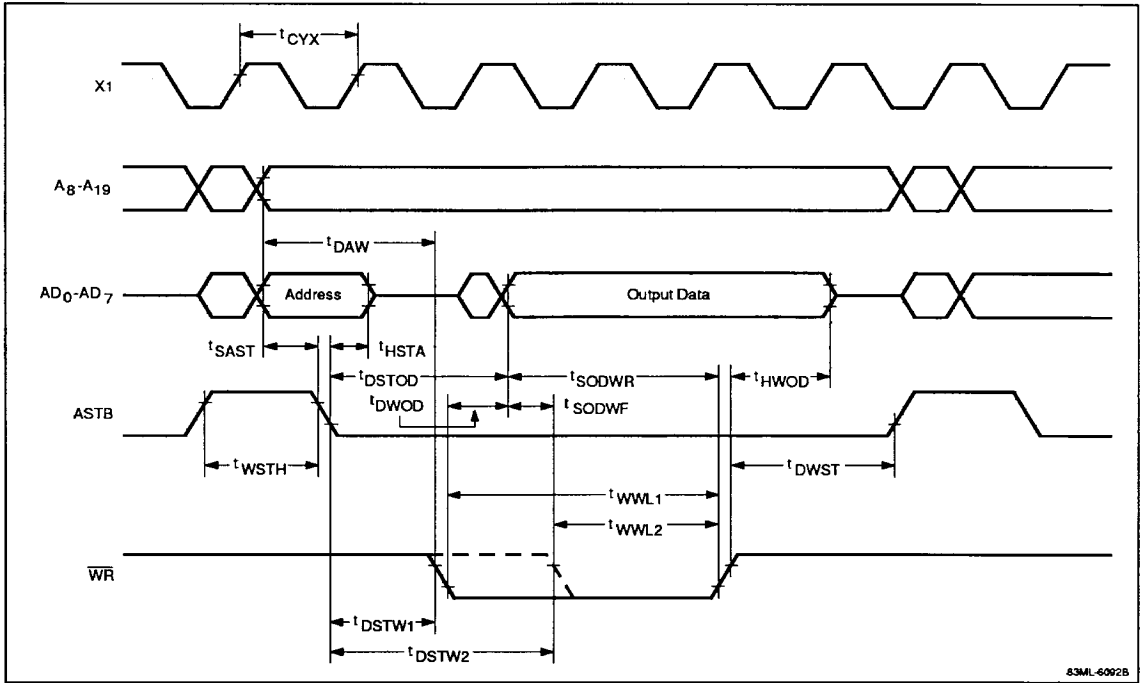
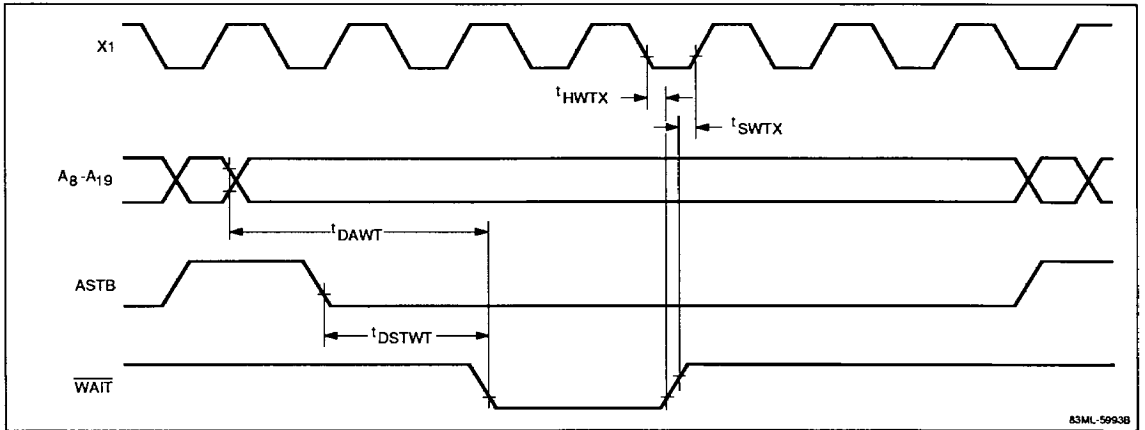


Figure 15. External \overline{WAIT} Input Timing



Serial Port Operation

$T_A = -40$ to $+85^\circ\text{C}$; $V_{DD} = +5\text{ V} \pm 10\%$; $V_{SS} = 0\text{ V}$; $f_{XX} = 12\text{ MHz}$; $C_L = 100\text{ pF}$.

Item	Symbol	Conditions	Min	Max	Unit
Serial clock cycle time	t_{CYSK}	Input External clock	1.0		μs
		Output Internal clock/16	1.3		μs
			Internal clock/64	5.3	
Serial clock low-level width	t_{WSKL}	Input External clock	420		ns
		Output Internal clock/16	556		ns
			Internal clock/64	2.5	
Serial clock high-level width	t_{WSKH}	Input External clock	420		ns
		Output Internal clock/16	556		ns
			Internal clock/64	2.5	
SI, SBO setup time to $\overline{\text{SCK}} \uparrow$	t_{SSSK}		150		ns
SI, SBO hold time from $\overline{\text{SCK}} \downarrow$	t_{HSSK}		400		ns
SO/SBO output delay time from $\overline{\text{SCK}} \uparrow$	t_{DSBSK1}	CMOS push-pull output (3-line serial I/O mode)	0	300	ns
	t_{DSBSK2}	Open-drain output (SBI mode), $R_L = 1\text{ k}\Omega$	0	800	ns
SBO high, hold time from $\overline{\text{SCK}} \uparrow$	t_{HSBSK}	SBI mode	4		t_{CYX}
SBO low, setup time to $\overline{\text{SCK}} \downarrow$	t_{SSBSK}	SBI mode	4		t_{CYX}
SBO low-level width	t_{WSBL}		4		t_{CYX}
SBO high-level width	t_{WSBH}		4		t_{CYX}
RxD setup time to $\overline{\text{SCK}} \uparrow$	t_{SRXSK}		80		ns
RxD hold time after $\overline{\text{SCK}} \uparrow$	t_{HSKRX}		80		ns
$\overline{\text{SCK}} \downarrow$ to TxD delay time	t_{DSKTX}			210	ns

Figure 16. Three-Line Serial I/O Timing

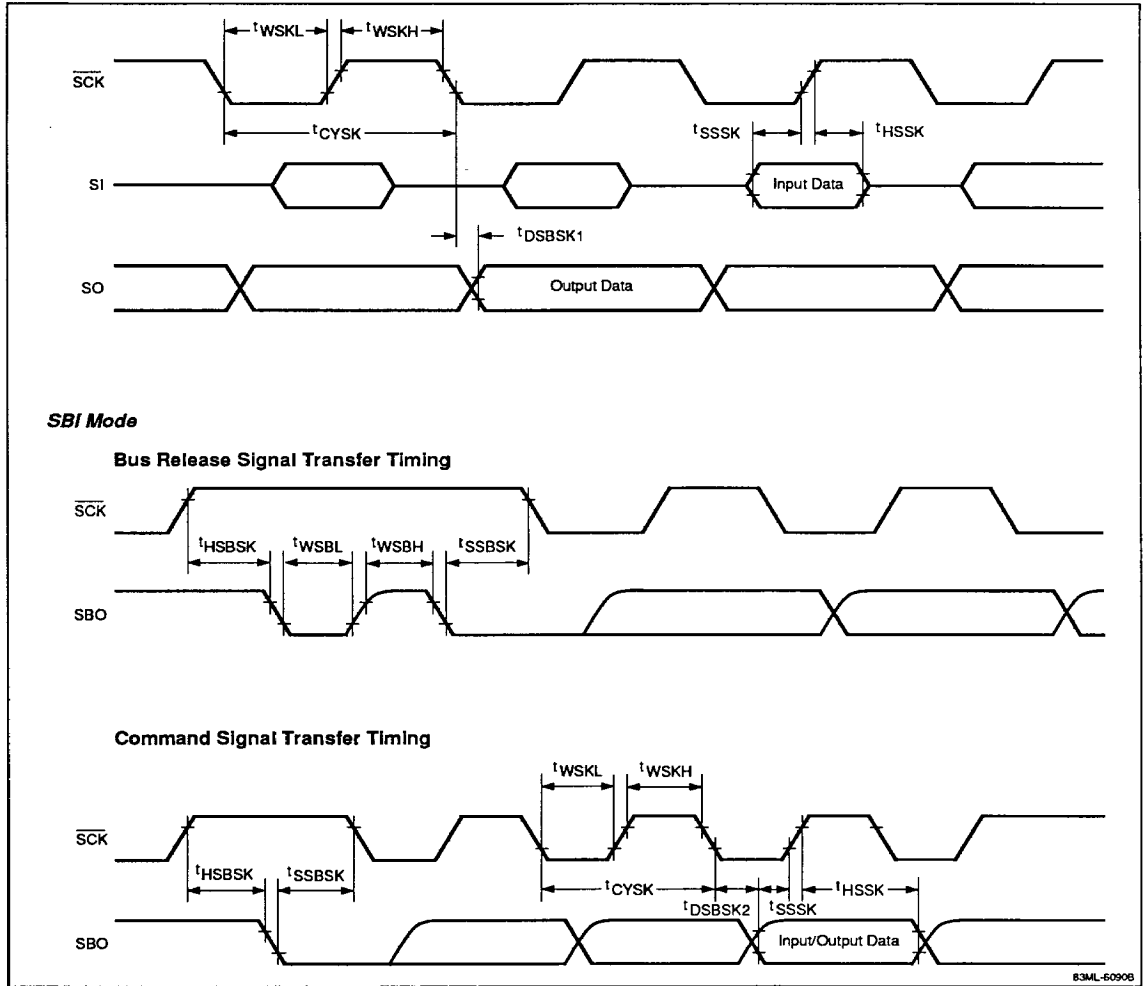
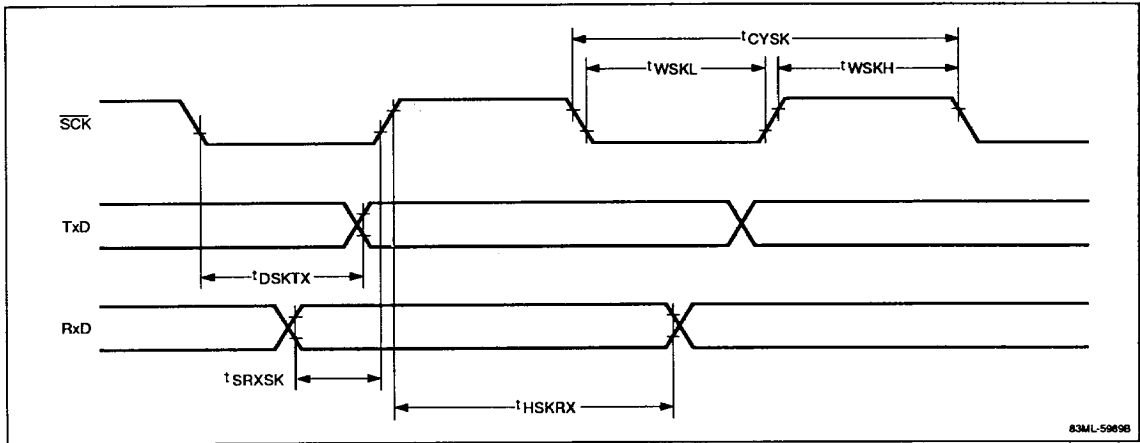


Figure 17. Asynchronous Mode Timing



A/D Converter Operation

$T_A = -40$ to $+85^\circ\text{C}$; $V_{DD} = +5\text{ V} \pm 10\%$; $V_{SS} = AV_{SS} = 0\text{ V}$.

Item	Symbol	Conditions	Min	Typ	Max	Unit
Resolution			8			Bit
Full-scale error		$AV_{REF} = 4.0\text{ V to }V_{DD}; T_A = -10\text{ to }+70^\circ\text{C}$			0.4	%
		$AV_{REF} = 3.4\text{ V to }V_{DD}; T_A = -10\text{ to }+70^\circ\text{C}$			0.8	%
		$AV_{REF} = 4.0\text{ V to }V_{DD}$			0.8	%
Quantization error					$\pm 1/2$	LSB
Conversion time	t_{CONV}	$82\text{ ns} \leq t_{CYX} \leq 125\text{ ns}$	360			t_{CYX}
		$125\text{ ns} \leq t_{CYX} \leq 250\text{ ns}$	240			t_{CYX}
Sampling time	t_{SAMP}	$82\text{ ns} \leq t_{CYX} \leq 125\text{ ns}$	72			t_{CYX}
		$125\text{ ns} \leq t_{CYX} \leq 250\text{ ns}$	48			t_{CYX}
Analog input voltage	V_{IAN}		0		AV_{REF}	V
Input impedance	R_{AN}			1000		M Ω
Analog reference voltage	AV_{REF}		3.4		V_{DD}	V
AV_{REF} current	AI_{REF}	Operating mode, $f_{CX} = 12\text{ MHz}$		1.5	5.0	mA
		STOP mode		0.2	1.5	mA

6

Interrupt Timing Operation

Item	Symbol	Conditions	Min	Max	Unit
NMI low-level width	t_{WNIL}		10		μs
NMI high-level width	t_{WNIH}		10		μs
INTP0-INTP5 low-level width	t_{WITL}		24	t_{CYX}	
INTP0-INTP5 high-level width	t_{WITH}		24	t_{CYX}	
RESET low-level width	t_{WRSL}		10		μs
RESET high-level width	t_{WRSH}		10		μs

Figure 18. Interrupt Input Timing

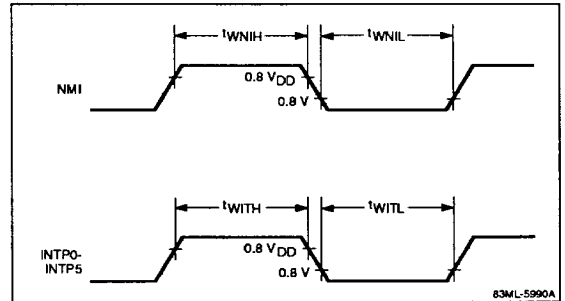
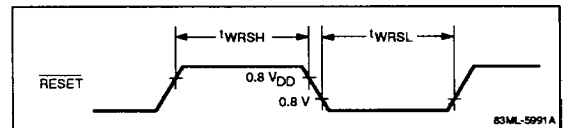


Figure 19. Reset Input Timing



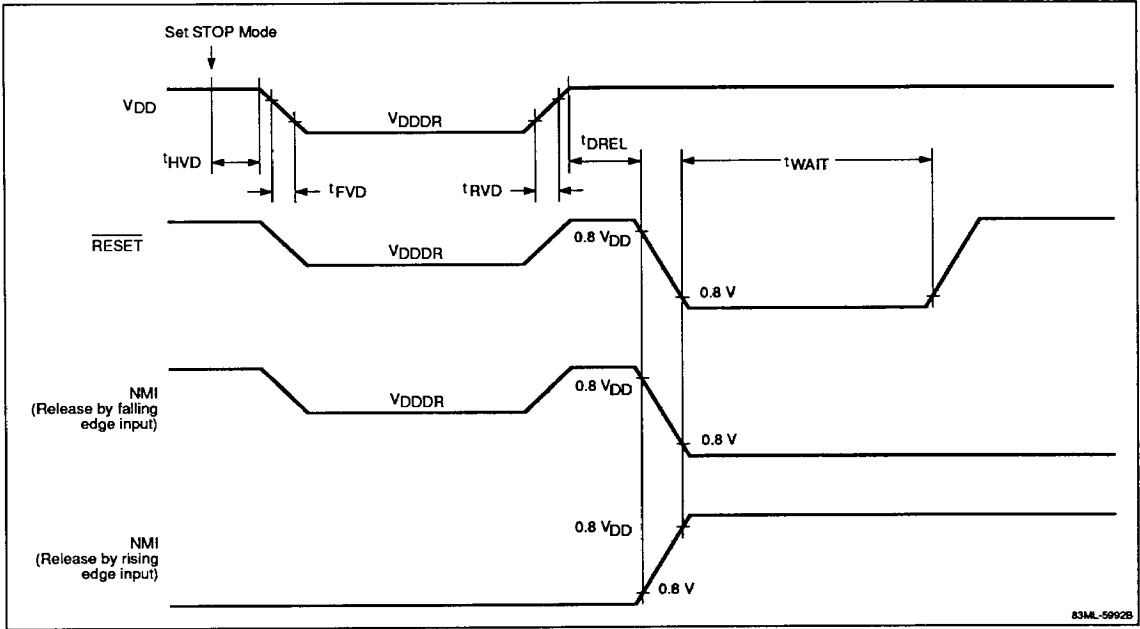
Data Retention Characteristics

Item	Symbol	Conditions	Min	Typ	Max	Unit
Data retention voltage	V_{DDDR}	STOP mode	2.5		5.5	V
Data retention current	I_{DDDR}	$V_{DDDR} = 2.5 V$		2	15	μA
		$V_{DDDR} = 5 V \pm 10\%$		5	20	μA
V_{DD} rise time	t_{RVD}		200			μs
V_{DD} fall time	t_{FVD}		200			μs
V_{DD} retention time (for STOP mode setting)	t_{HVD}		0			ms
STOP release signal input time	t_{DREL}		0			ms
Oscillation stabilization wait time	t_{WAIT}	Crystal oscillator	30			ms
		Ceramic resonator	5			ms
Low-level input voltage	V_{IL}	Specified pins (Note 1)	0		$0.1 V_{DDDR}$	V
High-level input voltage	V_{IH}		$0.9 V_{DDDR}$		V_{DDDR}	V

Notes:

- (1) RESET, P₂₀/NMI, P₂₁/INTP0, P₂₂/INTP1, P₂₃/INTP2/CI, P₂₄/INTP3, P₂₅/INTP4/ASCK, P₂₆/INTP5, P₂₇/SI, P₃₂/SCK, P₃₃/SO/SB0, and EA pins.

Figure 20. Data Retention Characteristics



Timing Dependent on t_{CYX}

Item	Symbol	Calculation Formula	Min/Max	12 MHz	Unit
X1 input clock cycle time	t _{CYX}		Min	82	ns
Address setup time to ASTB ↓	t _{SAST}	t _{CYX} - 30	Min	52	ns
Address to RD ↓ delay time	t _{DAR}	2t _{CYX} - 35	Min	129	ns
Address float time from RD ↓	t _{FAR}	t _{CYX} /2 - 30	Min	11	ns
Address to data input time	t _{DAID}	(4 + 2n) t _{CYX} - 100	Max	228	ns
ASTB ↓ to data input time	t _{DSTID}	(3 + 2n) t _{CYX} - 65	Max	181	ns
RD ↓ to data input time	t _{DRID}	(2 + 2n) t _{CYX} - 65	Max	99	ns
ASTB ↓ to RD ↓ delay time	t _{DSTR}	t _{CYX} - 30	Min	52	ns
RD ↑ to address active time	t _{DRA}	2t _{CYX} - 40	Min	124	ns
RD ↑ to ASTB ↑ delay time	t _{DRST}	2t _{CYX} - 40	Min	124	ns
RD low-level width	t _{WRL}	(2 + 2n) t _{CYX} - 40	Min	124	ns
ASTB high-level width	t _{WSTH}	t _{CYX} - 30	Min	52	ns
Address to WR ↓ delay time	t _{DAW}	2t _{CYX} - 35	Min	129	ns
ASTB ↓ to data output time	t _{DSTOD}	t _{CYX} + 60	Max	142	ns
ASTB ↓ to WR ↓ delay time	t _{DSTW1}	t _{CYX} - 30	Min	52	ns
	t _{DSTW2}	2t _{CYX} - 35 (refresh mode)	Min	129	ns
Data setup time to WR ↑	t _{SODWR}	(3 + 2n) t _{CYX} - 100	Min	146	ns
Data setup time to WR ↓	t _{SODWF}	t _{CYX} - 60 (refresh mode)	Min	22	ns
WR ↑ to ASTB ↑ delay time	t _{DWST}	t _{CYX} - 40	Min	42	ns
WR low-level width	t _{WWL1}	(3 + 2n) t _{CYX} - 50	Min	196	ns
	t _{WWL2}	(2 + 2n) t _{CYX} - 50 (refresh mode)	Min	114	ns
Address to WAIT ↓ input time	t _{DAWT}	3t _{CYX} - 100	Max	146	ns
ASTB ↓ to WAIT ↓ input time	t _{DSTWT}	2t _{CYX} - 80	Max	84	ns

Notes:

(1) n indicates the number of wait states.

Figure 21. Recommended Oscillator Circuit

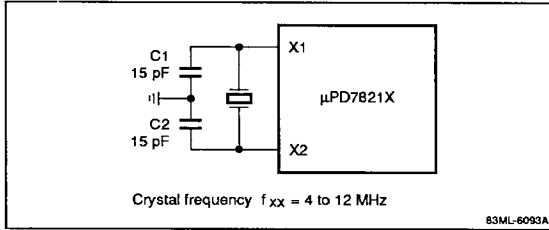
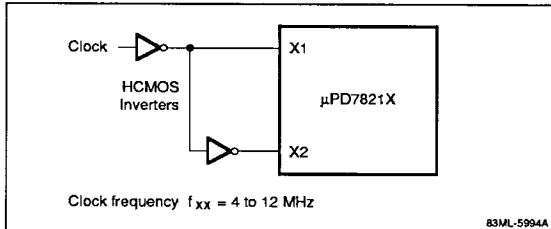


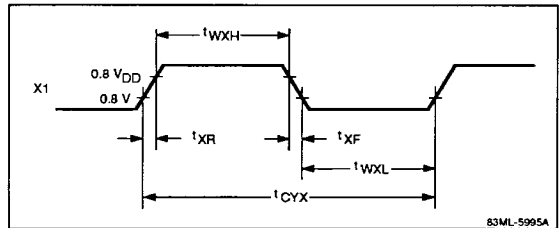
Figure 22. Recommended External Clock Circuit



External Clock Operation

Item	Symbol	Conditions	Min	Max	Unit
X1 input low-level width	t_{WXL}		30	130	ns
X1 input high-level width	t_{WXH}		30	130	ns
X1 input rise time	t_{XR}		0	30	ns
X1 input fall time	t_{XF}		0	30	ns
X1 input clock cycle time	t_{CYX}		82	250	ns

Figure 23. External Clock Timing



μPD78P214 PROGRAMMING

In the 78P214, the mask ROM of 78214 is replaced by a one-time programmable ROM (OTP ROM) or a reprogrammable, ultraviolet erasable ROM (UV EPROM). The ROM is 16,384 × 8 bits and can be programmed using a general-purpose PROM writer with a μPD27C256A programming mode.

The PA-78P214CW/GJ/GQ/L are the socket adaptors used for configuring the μPD78P214 to fit a standard PROM socket.

Refer to tables 3 through 6 and figures 24 and 25 for special information applicable to PROM programming.

Table 3. Pin Functions During EPROM Programming

Pin		Function
P0 ₀ -P0 ₇	A ₀ -A ₇	Input pins for PROM write/verify operations
P5 ₀ /A ₈	A ₈	Input pin for PROM write/verify operation
P2 ₁ /INTP ₀	A ₉	Input pin for PROM write/verify operation
P5 ₂ -P5 ₆ /A ₁₀ -A ₁₄	A ₁₀ -A ₁₄	Input pins for PROM write/verify operations
P4 ₀ -P4 ₇ /AD ₀ -AD ₇	D ₀ -D ₇	Data pins for PROM write/verify operations
P6 ₅ /WR	CE	Strobe data into the PROM
P6 ₄ /RD	OE	Enable a data read from the PROM
P2 ₀ /NMI	NMI	PROM programming mode is entered by applying a high voltage to this pin
RESET	RESET	PROM programming mode requires applying a low voltage to this pin
EA	V _{pp}	High voltage applied to this pin for program write/verify
V _{DD}	V _{DD}	Positive power supply pin
V _{SS}	V _{SS}	Ground

Table 4. Summary of Operation Modes for PROM Programming

Mode	NMI	RESET	CE	OE	V _{pp}	V _{DD}	D ₀ -D ₇
Program write	+12.5 V	L	L	H	+12.5 V	+6 V	Data input
Program verify	+12.5 V	L	H	L	+12.5 V	+6 V	Data output
Program inhibit	+12.5 V	L	H	H	+12.5 V	+6 V	High Z
Read out	+12.5 V	L	L	L	+5 V	+5 V	Data output
Output disable	+12.5 V	L	L	H	+5 V	+5 V	High Z
Standby	+12.5 V	L	H	L/H	+5 V	+5 V	High Z

Notes:

When +12.5 V is applied to V_{pp} and +6 V to V_{DD}, both CE and OE cannot be set to low level (L) simultaneously.

Table 5. DC Programming Characteristics

$T_A = 25 \pm 5^\circ\text{C}$, $V_{IP} = 12.5 \pm 0.5\text{ V}$ applied to NMI pin, $V_{SS} = 0\text{ V}$.

Parameter	Symbol	Symbol*	Condition	Min	Typ	Max	Unit
High-level input voltage	V_{IH}	V_{IH}		2.4		$V_{DDP} + 0.3$	V
Low-level input voltage	V_{IL}	V_{IL}		-0.3		0.8	V
Input leakage current	I_{LIP}	I_{LI}	$0 \leq V_I \leq V_{DDP}$			10	μA
High-level output voltage	V_{OH1}	V_{OH}	$I_{OH} = -400\ \mu\text{A}$	2.4			V
	V_{OH2}	V_{OH2}	$I_{OH} = -100\ \mu\text{A}$	$V_{DD} - 0.7$			V
Low-level output voltage	V_{OL}	V_{OL}	$I_{OH} = 2.1\ \text{mA}$			0.45	V
Output leakage current	I_{LO}		$0 \leq V_D \leq V_{DDP}$, $\overline{OE} = V_{IH}$			10	μA
NMI pin high-voltage input current	I_{IP}					±10	μA
V_{DDP} power voltage	V_{DDP}	V_{CC}	Program memory write mode	5.75	6.0	6.25	V
			Program memory read mode	4.5	5.0	5.5	V
V_{PP} power voltage	V_{PP}	V_{PP}	Program memory write mode	12.2	12.5	12.8	V
			Program memory read mode		$V_{PP} = V_{DDP}$		V
V_{DDP} power current	I_{DD}	I_{CC}	Program memory write mode		5	30	mA
			Program memory read mode $CE = V_{IL}$, $V_I = V_{IH}$		5	30	mA
V_{PP} power current	I_{PP}	I_{PP}	Program memory write mode $CE = V_{IL}$, $\overline{OE} = V_{IH}$		5	30	mA
			Program memory read mode		1	100	μA

* Corresponding symbols of the μPD27C256A.

Table 6. AC Programming Characteristics

$T_A = 25 \pm 5^\circ\text{C}$, $V_{IP} = 12.5 \pm 0.5\text{ V}$ applied to NMI pin, $V_{SS} = 0\text{ V}$, $V_{DD} = 6 \pm 0.25\text{ V}$, $V_{PP} = 12.5 \pm 0.3\text{ V}$.

Parameter	Symbol	Symbol*	Condition	Min	Typ	Max	Unit
Address setup time to $\overline{CE} \downarrow$	t_{SAC}	t_{AS}		2			μs
Data to $\overline{OE} \downarrow$ delay time	t_{DDO0}	t_{OES}		2			μs
Input data setup time to $\overline{CE} \downarrow$	t_{SIDC}	t_{DS}		2			μs
Address hold time from $\overline{CE} \uparrow$	t_{HCA}	t_{AH}		2			μs
Input data hold time from $\overline{CE} \uparrow$	t_{HCID}	t_{DH}		2			μs
Output data hold time to $\overline{OE} \uparrow$	t_{HOOD}	t_{DF}		0		130	ns
V_{PP} setup time to $\overline{CE} \downarrow$	t_{SVPC}	t_{VPS}		1			ms
V_{DDP} setup time to $\overline{CE} \downarrow$	t_{SVDC}	t_{VDS}		1			ms
Initial program pulse width	t_{WL1}	t_{PW}		0.95	1.0	1.05	ms
Additional program pulse width	t_{WL2}	t_{OPW}		2.85		78.75	ms
NMI high-voltage input setup time (vs. $\overline{CE} \downarrow$)	t_{SPC}			2			μs
Address to data output time	t_{DAOD}	t_{ACC}	$\overline{CE} = \overline{OE} = V_{IL}$			200	ns
$\overline{CE} \downarrow$ to data output time	t_{DCOD}	t_{CE}	$\overline{OE} = V_{IL}$			200	ns
$\overline{OE} \downarrow$ to data output time	t_{DOOD}	t_{OE}	$\overline{CE} = V_{IL}$			75	ns
Data hold time from $\overline{OE} \uparrow$	t_{HCOD}	t_{DF}	$\overline{CE} = V_{IL}$	0		60	ns
Data hold time from address	t_{HAOD}	t_{OH}	$\overline{CE} = \overline{OE} = V_{IL}$	0			ns

* Corresponding symbols of the μPD27C256A.

Figure 24. PROM Write Mode Timing

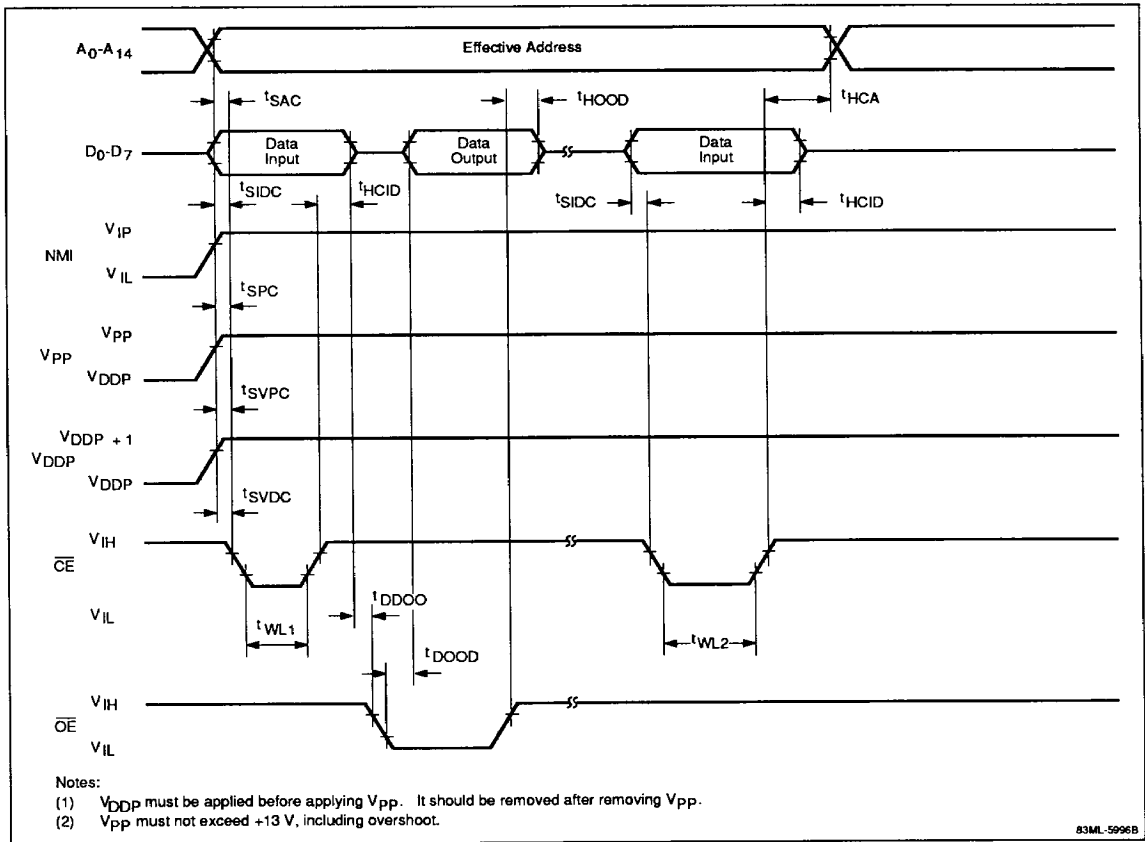
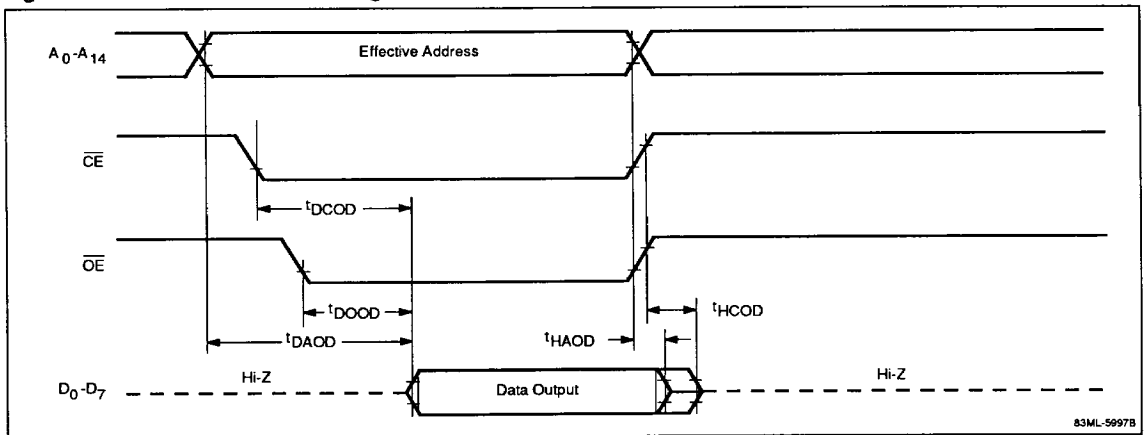


Figure 25. PROM Read Mode Timing



PROM Write Procedure

- (1) Connect the $\overline{\text{RESET}}$ pin to a low level and apply +12.5 V to the NMI pin.
- (2) Apply +6 V to the V_{DD} pin and +12.5 V to the V_{pp} pin.
- (3) Provide the initial address.
- (4) Provide write data.
- (5) Provide 1- μs program pulse (active low) to the $\overline{\text{CE}}$ pin.
- (6) This bit is now verified with a pulse (active low) to the $\overline{\text{OE}}$ pin. If the data has been written, proceed to step 8; if not, repeat steps 4 to 6. If the data cannot be correctly written after 25 attempts, go to step 7.
- (7) Classify as defective and stop write operation.
- (8) Provide write data and supply program pulse (for additional writing) for 3 ms times the number of repeats performed between steps 4 to 6.
- (9) Increment the address.
- (10) Repeat steps 4 to 9 until the end address.

PROM Read Procedure

- (1) Fix the $\overline{\text{RESET}}$ pin to a low level and apply +12.5 V to the NMI pin.
- (2) Apply +5 V to the V_{DD} and V_{pp} pins.
- (3) Input the address of the data to be read to pins A_0 - A_{14} .
- (4) Read mode is entered with a pulse (active low) on both the $\overline{\text{CE}}$ and $\overline{\text{OE}}$ pins.
- (5) Data is output to the D_0 to D_7 pins.

EPROM Erasure

Data in an EPROM is erased by exposing the quartz window in the ceramic package to light having a wavelength shorter than 400 nm, including ultraviolet rays, direct sunlight, and fluorescent light. To prevent unintentional erasure, mask the window.

Typically, data is erased by 254-nm ultraviolet rays. A minimum lighting level of $15 \text{ W} \cdot \text{s}/\text{cm}^2$ (ultraviolet ray intensity \times exposure time) is required to completely erase written data. Erasure by an ultraviolet lamp rated at $12 \text{ mW}/\text{cm}^2$ takes approximately 15 to 20 minutes. Remove any filter on the lamp and place the device within 2.5 cm of the lamp tubes.

INSTRUCTION SET

All microcomputers in the μPD7821x family have a 1-byte instruction lookahead buffer. This allows the first byte of the next opcode in program memory to be fetched while the current opcode is being executed. This pipeline architecture allows instruction fetch and execute cycles to overlap. An instruction can be fetched from program memory while data is being read from or written to RAM or an I/O port.

The advantage of the pipeline is that one instruction can be executed while another is being fetched, virtually halving the time required for these two operations and thereby reducing overall program execution time.

Operands and Operations

Refer to tables 7 and 8 for the meanings of symbols in the operand and operations columns of the Instruction Set table.

Specify operands in accordance with the rules of operand representation; for details, refer to the assembler specifications. If two or more description methods are available, select one. The symbols +, -, #, !, \$, /, [], and & are keywords and must be used in conjunction with each instruction.

When describing immediate data as a label, use one of the following modifiers: +, -, #, !, \$, /, [], and &. Symbols r and rp can be described in both the function name and absolute name.

Table 7. Operands

Symbol	Meaning
+	Autoincrement
-	Autodecrement
#	Immediate data
!	Absolute address
\$	Relative address
/	Bit inversion
[]	Indirect addressing
&	Subbank
r	Register Function name: X, A, C, B, E, D, L, H Absolute name: R0 to R7
r1	Register group 1: C, B
rp	Register pair Function name: AX, BC, DE, HL Absolute name: RP0 to RP3
sfr	Special function register: P0, P2-P7, P0H, P0L, RTPC, CR10, CR11, CR20, CR21, CR22, CR30, PM0, PM3, PM5, PM6, PMC3, PU0, CRC0-CRC2, TOC, TM1-TM3, TMC0, TMC1, PRM0, PRM1, ADM, ADCR, CSIM, SBIC, SIO, ASIM, ASIS, RxB, TxS, BRGC, STBC (dedicated instruction only), MM, PW, RFM, IF0L, IF0H, MK0L, MK0H, PR0L, PR0H, ISM0L, ISM0H, INTM0, INTM1, IST

Table 7. Operands (cont)

Symbol	Meaning
sfrp	Special function register pair: CR00-CR02, TM0, IF0, MK0, PR0, ISM0
mem	Memory address indirectly addressed Register indirect mode: [DE], [HL], [DE+], [HL+], [DE-], [HL-] Base mode: [DE+byte], [HL+byte], [SP+byte] Indexed mode: word[A], word[B], word[DE], word[HL]
mem1	Memory address addressed by means of indirect addressing group 1: [DE], [HL]
saddr	Memory address indirectly addressed: FE20H-FF1FH immediate data or label
saddrp	Memory address addressed by means of direct addressing pair: FE20H-FF1EH immediate data (LSB=0; odd address) or label
addr16	16-bit address: 0000H-FFFFH immediate data or label
addr11	11-bit address: 800H-FFFFH immediate data or label
addr5	5-bit address: 40H-7EH immediate data or label
word	16-bit data: 16-bit immediate data or label
byte	8-bit data: 8-bit immediate data or label
bit	3-bit data: 3-bit immediate data or label
n	Number of shift bits: 3-bit immediate data (0-7)
RBn	Register bank: RB0-RB3

Table 8. Registers and Flags

Symbol	Meaning
A	A register; 8-bit accumulator
X	X register
B	B register
C	C register
D	D register
E	E register
H	H register
L	L register
R0-R7	Registers 0 to 7 (absolute names)
AX	Register pair (AX); 16-bit accumulator
BC	Register pair (BC)
DE	Register pair (DE)
HL	Register pair (HL)
RP0-RP3	Register pairs 0 to 3 (absolute names)
PC	Program counter
SP	Stack pointer
PSW	Program status word
CY	Carry flag
AC	Auxiliary flag
Z	Zero flag
RBS1-RBS0	Register bank select flags
IE	Interrupt enable flag
STBC	Standby control register

Table 8. Registers and Flags (cont)

Symbol	Meaning
()	Memory contents indicated by address or register contents in ()
xxH	Hexadecimal number
x _H , x _L	Higher 8 bits and lower 8 bits of 16-bit register pair

Clocks

The clock field specifies the number of clocks required under the conditions defined by the four column headings as follows:

- IROM** Program in internal ROM is executed.
- IRAM** Program in external ROM is executed and internal RAM is accessed.
- SFR** Program in external ROM is executed and special function register is accessed.
- EMEM** Program in external ROM is executed and external memory is accessed.

In a shift/rotate instruction, n in the clock field indicates the number of bits by which data is shifted.

The hyphen (-) indicates a range of values; for example 10-13 means 10, 11, 12, or 13.

The virgule symbol (/) means either/or; for example, a/b means either a or b.

The number of clocks when execution is branched by a conditional branch instruction is shown after the symbol (/).

The number of clocks for instruction having the saddr or saddrp operand and when an SFR is accessed with FF00H to FFFFH described as saddr or saddrp is shown after the symbol (/).

Bytes and Clocks

The number of bytes and clocks for instructions with a mem or &mem operand depends on the particular instruction and the memory addressing mode (register indirect, base, or indexed). Table 9 is applicable when the program in internal ROM is executed (ROM clock column of the instruction Set table). Table 10 is applicable when the program in external ROM is executed (IRAM, SFR, and EMEM clock columns).

Flags

The symbols in the flag field have the following meanings.

- Blank No change
- 0 Cleared to 0
- 1 Set to 1
- x Set or cleared depending on the result
- R Value previously saved is restored

Operation Codes

Table 11 defines the symbols used in the operation code field.

Registers and Register Pairs. The r, r1, and rp operands are specified in the opcode by one or more bits as shown in figure 26. For example, 001 as bits R₂R₁R₀ (or R₆R₅R₄) specifies register A.

In the first and second operands are registers or register pairs, the higher 4 bits of the register specification byte define the first operand and the lower 4 bits define the second operand. For example, in the MOV A,L instruction (transfer L register contents to register A), the second byte of the opcode is obtained from figure 26 as shown below.

Instruction	Opcode, Bytes 1 and 2
MOV r,r	0 0 1 0 0 1 0 0 0 R ₆ R ₅ R ₄ 0 R ₂ R ₁ R ₀
MOV A,L	0 0 1 0 0 1 0 0 0 0 0 1 0 1 1 0

Memory Addressing Modes. The 3-bit mem code and the 5-bit mod code are selected from figure 27 according to the description of mem in the operand field (table 7).

A MOV instruction with register indirect mode specified for mem is a special 1-byte instruction. When base mode or indexed mode is specified for mem, the 8-bit or 16-bit offset data corresponding to byte and word, respectively, is added from the third byte onward.

The opcode for an &mem or &mem1 operand is modified by inserting a 01H code as the first byte preceding the first-byte code listed in the Instruction Set table. Subsequent bytes are as shown in the table.

Figure 26. Opcodes for Registers (r, r1, rp)

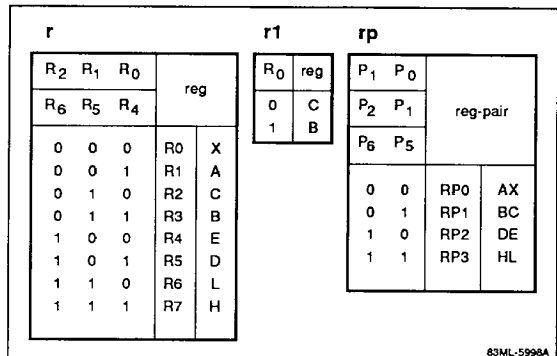


Figure 27. Opcodes for Memory Addressing Modes (mem, mod)

Mod Mem		1 0 1 1 0	0 0 1 1 0	0 1 0 1 0
		Register Indirect Mode	Base Mode	Index Mode
0 0 0	[DE+]	[DE+byte]	word [DE]	
0 0 1	[HL+]	[SP+byte]	word [A]	
0 1 0	[DE-]	[HL+byte]	word [HL]	
0 1 1	[HL-]	-	word [B]	
1 0 0	[DE]	-	-	
1 0 1	[HL]	-	-	

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Table 9. Bytes and Cycles for Instructions With "mem" and "&mem" Operands; Internal ROM (IROM)

Instruction	mem	Register Indirect Mode		Base Mode		Indexed Mode	
		[DE+] [HL+] [DE-] [HL-]	[DE] [HL]	[DE+byte] [HL+byte]	[SP+byte]	word[A] word[B] word[DE] word[HL]	
Bytes	mem	1/2*	1/2*	3	3	4	
	&mem	2/3*	2/3*	4	4	5	
Clock Cycles	MOV	A, mem	6/8	6/8	8-11	9-12	8-11
		mem, A					
		A, &mem	8/10	8/10	10-13	11-14	10-13
		&mem, A					
	XCH	A, mem	11-15	9-13	10-15	11-16	10-15
		A, &mem	13-17	11-15	12-17	13-18	12-17
ADD, ADDC, SUB, SUBC, AND, OR, XOR, CMP	A, mem	10/12	8/12	9/12	10-13	9-12	
	A, &mem	12/14	10/14	11/14	12-15	11-14	

* When internal RAM is accessed with an instruction having a mem operand, the number of bytes is the number before the symbol (/).

When the external memory (including the SFR area) is accessed, the number of bytes is the number after the symbol (/).

Table 10. Bytes and Clocks for Instructions With “mem” and “&mem” Operands; External ROM (IRAM, SFR, EMEM)

Instruction		Register Indirect Mode		Base Mode		Indexed Mode	
		[DE+] [HL+] [DE-] [HL-]	[DE] [HL]	[DE + byte] [HL + byte]	[SP + byte]	word[A] word[B] word[DE] word[HL]	
Bytes	mem	2*	2*	3	3	4	
	&mem	3*	3*	4	4	5	
Clock Cycles	MOV	A, mem	9/11	6/8	11/13	12/14	14/16
		mem, A					
		A, &mem	12/14	9/11	14/16	15/17	17/19
		&mem, A					
	XCH	A, mem	14/18	12/16	13/17	14/18	16/20
		A, &mem	17/21	15/19	16/20	17/21	19/23
	ADD, ADDC, SUB, SUBC, AND, OR, XOR, CMP	A, mem	13/15	11/13	12/14	13/15	15/17
		A, &mem	16/18	14/16	15/17	16/18	18/20

* When [DE], [HL], [DE+], [HL+], [DE-], or [HL-] is specified as the mem operand of a MOV instruction, the instruction is used as a dedicated 1-byte type. When the operand is &mem, the instruction is 2-byte.

Table 11. Opcode Symbols

Symbol	Meaning
Bn	Immediate data corresponding to bit
Nn	Immediate data corresponding to n
Data	8-bit immediate data corresponding to byte
Low/High Byte	16-bit immediate data corresponding to word
Saddr-offset	Lower 8-bit offset data of 16-bit address corresponding to saddr
Sfr-offset	Lower 8-bit offset data of 16-bit address of special function register (sfr)
Low/High Offset	16-bit offset data corresponding to word in indexed addressing
Low/High Addr	16-bit immediate data corresponding to addr16
jdisp	Signed 2's complement data (8 bits) indicating relative address distance between first address of next instruction and branch destination address
fa	Lower 11 bits of immediate data corresponding to addr11
ta	Lower 5 bits of immediate data corresponding to (addr5xdis)

Instruction Set

Mnemonic	Operand	Operation	Bytes	Clocks				Flags			Operation Code (Bits 7-0) Bytes B1 thru B5
				IROM	IRAM	SFR	EMEM	Z	AC	CY	
8-Bit Data Transfer											
MOV	r,#byte	r ← byte	2	2	6						1 0 1 1 1 R ₂ R ₁ R ₀ Data
	saddr,#byte	(saddr) ← byte	3	3/5	9	9	12				0 0 1 1 1 0 1 0 Saddr-offset Data
	sfr,#byte	sfr ← byte	3	5		9	12				0 0 1 0 1 0 1 1 Sfr-offset Data
	r,r	r ← r	2	2	6						0 0 1 0 0 1 0 0 0 R ₆ R ₅ R ₄ 0 R ₂ R ₁ R ₀
	A,r	A ← r	1	2	3						1 1 0 1 0 R ₂ R ₁ R ₀
	A,saddr	A ← (saddr)	2	2/4	6	6	9				0 0 1 0 0 0 0 0 Saddr-offset
	saddr,A	(saddr) ← A	2	3/5	6	8					0 0 1 0 0 0 1 0 Saddr-offset
	saddr, saddr	(saddr) ← (saddr)	3	3-7	9						0 0 1 1 1 0 0 0 Saddr-offset Saddr-offset
	A,sfr	A ← sfr	2	4		6					0 0 0 1 0 0 0 0 Sfr-offset
	sfr,A	sfr ← A	2	5		6					0 0 0 1 0 0 1 0 Sfr-offset
	A,mem	A ← (mem)	1-4	6-12	6-14	8-16	8-16				* 0 1 0 1 1 mem 0 0 0 mod 0 mem 0 0 0 0 Low Offset High Offset
	A,&mem	A ← (&mem)	2-5	8-14	9-17	11-19	11-19				* 0 0 0 0 0 0 0 1 0 1 0 1 1 mem 0 0 0 0 0 0 0 1 0 0 0 mod 0 mem 0 0 0 0 Low Offset High Offset

Note:

* If [DE], [HL], [DE+], [DE-], [HL+] or [HL-] is described as mem, these instructions are used as dedicated 1-byte codes. If the register name is described as &mem, the instructions are used as dedicated 2-byte codes.

Instruction Set (cont)

Mnemonic	Operand	Operation	Bytes	Clocks				Flags			Operation Code (Bits 7-0) Bytes B1 thru B5						
				IROM	IRAM	SFR	EMEM	Z	AC	CY							
8-Bit Data Transfer (cont)																	
MOV	mem,A	(mem) ← A	1-4	6-12	6-14	8-16	8-16	*	0	1	0	1	0	mem			
									0	0	0		mod				
									1	mem	0	0	0	0			
									Low Offset								
High Offset																	
&mem,A	(&mem) ← A	2-5	8-14	9-17	11-19	11-19	*	0	0	0	0	0	0	1			
								0	1	0	1	0	mem				
								0	0	0	0	0	0	0	1		
								0	0	0		mod					
Low Offset																	
High Offset																	
A,laddr16	A ← (laddr16)	4	6/8	14		16		0	0	0	0	1	0	0	1		
								1	1	1	1	0	0	0	0		
								Low Addr									
								High Addr									
A,&laddr16	A ← (&laddr16)	5	8/10			19		0	0	0	0	0	0	0	1		
								0	0	0	0	1	0	0	1		
								1	1	1	1	0	0	0	0		
								Low Addr									
High Addr																	
laddr16,A	(laddr16) ← A	4	6/8	14		17		0	0	0	0	1	0	0	1		
								1	1	1	1	0	0	0	1		
								Low Addr									
								High Addr									
&laddr16,A	(&laddr16) ← A	5	8/10			20		0	0	0	0	0	0	0	1		
								0	0	0	0	1	0	0	1		
								1	1	1	1	0	0	0	1		
								Low Addr									
High Addr																	
PSW,#byte	PSW ← byte	3	3	9	9	9	x	x	x	0	0	1	0	1	0	1	1
										1	1	1	1	1	1	1	0
										Data							
										0	0	0	1	0	0	1	0
PSW,A	PSW ← A	2	2	6	6	6	x	x	x	0	0	0	1	0	0	1	0
										1	1	1	1	1	1	1	0
A,PSW	A ← PSW	2	2	6	6	6				0	0	0	1	0	0	0	0
										1	1	1	1	1	1	1	0

Instruction Set (cont)

Mnemonic	Operand	Operation	Bytes	Clocks				Flags			Operation Code (Bits 7-0) Bytes B1 thru B5
				IROM	IRAM	SFR	EMEM	Z	AC	CY	
8-Bit Data Transfer (cont)											
XCH	A,r	A ↔ r	1	4	4					1 1 0 1 1 R ₂ R ₁ R ₀	
	r,r	r ↔ r	2	3	6					0 0 1 0 0 1 0 1 0 R ₆ R ₅ R ₄ 0 R ₂ R ₁ R ₀	
A,mem	A ↔ (mem)	A ↔ (mem)	2-4	9-16	12-16					0 0 0 mod	
										0 mem 0 1 0 0	
										Low Offset High Offset	
A,&mem	A ↔ (&mem)	A ↔ (&mem)	3-5	11-18	15-19					0 0 0 0 0 0 0 1	
										0 0 0 mod	
										0 mem 0 1 0 0	
A,saddr	A ↔ (saddr)	A ↔ (saddr)	2	4/8	6					0 0 1 0 0 0 0 1	
										Saddr-offset	
A,sfr	A ↔ sfr	A ↔ sfr	3	6/10		13				0 0 0 0 0 0 0 1	
										0 0 1 0 0 0 0 1	
										Sfr-offset	
saddr,saddr	(saddr) ↔ (saddr)	(saddr) ↔ (saddr)	3	6-14		10				0 0 1 1 1 0 0 1	
										Saddr-offset	
										Saddr-offset	
16-Bit Data Transfer											
MOVW	rp,#word	rp ← word	3	3	9					0 1 1 0 0 P ₂ P ₁ 0	
										Low Byte High Byte	
saddrp,#word	(saddrp) ← word	(saddrp) ← word	4	4/8	12	12	18			0 0 0 0 1 1 0 0	
										Saddrp-offset	
										Low Byte High Byte	
sfrp,#word	sfrp ← word	sfrp ← word	4	8		12				0 0 0 0 1 0 1 1	
										Saddrp-offset	
										Low Byte High Byte	
rp,rp	rp ← rp	rp ← rp	2	4	6					0 0 1 0 0 1 0 0	
										0 P ₆ P ₅ 0 1 P ₂ P ₁ 0	
AX,saddrp	AX ← (saddrp)	AX ← (saddrp)	2	6/10	8	12				0 0 0 1 1 1 0 0	
										Saddrp-offset	
saddrp,AX	(saddrp) ← AX	(saddrp) ← AX	2	5/9	8	12				0 0 0 1 1 0 1 0	
										Saddrp-offset	

Instruction Set (cont)

Mnemonic	Operand	Operation	Bytes	Clocks				Flags			Operation Code (Bits 7-0) Bytes B1 thru B5
				IROM	IRAM	SFR	EMEM	Z	AC	CY	
16-Bit Data Transfer (cont)											
MOVW	AX,sfr	AX ← sfr	2	10		12					0 0 0 1 0 0 0 1
											Sfr-offset
	sfr,AX	sfr ← AX	2	9		12					0 0 0 1 0 0 1 1
											Sfr-offset
	AX,mem1	AX ← (mem1)	2	9-15	12	16	16				0 0 0 0 0 1 0 1
											1 1 1 0 0 0 1 R ₀
	AX,&mem1	AX ← (&mem1)	3	11-17	15	19	19				0 0 0 0 0 0 0 1
											0 0 0 0 0 1 0 1
											1 1 1 0 0 0 1 R ₀
	mem1,AX	(mem1) ← AX	2	8-14	11	15	15				0 0 0 0 0 1 0 1
											1 1 1 0 0 1 1 R ₀
	&mem1,AX	(&mem1) ← AX	3	10-16	14	18	18				0 0 0 0 0 0 0 1
											0 0 0 0 0 1 0 1
											1 1 1 0 0 1 1 R ₀
8-Bit Operation											
ADD	A,#byte	A,CY ← A + byte	2	2	6			x	x	x	1 0 1 0 1 0 0 0
											Data
	saddr,#byte	(saddr),CY ← (saddr) + byte	3	3/7	9	11		x	x	x	0 1 1 0 1 0 0 0
											Saddr-offset
											Data
	sfr,#byte	sfr,CY ← sfr + byte	4	9		14		x	x	x	0 0 0 0 0 0 0 1
											0 1 1 0 1 0 0 0
											Sfr-offset
											Data
	r,r	r,CY ← r + r	2	3	7			x	x	x	1 0 0 0 1 0 0 0
											0 R ₆ R ₅ R ₄ 0 R ₂ R ₁ R ₀
	A,saddr	A,CY ← A + (saddr)	2	3/5	6	7	8	x	x	x	1 0 0 1 1 0 0 0
											Saddr-offset
	A,sfr	A,CY ← A + sfr	3	7		10		x	x	x	0 0 0 0 0 0 0 1
											1 0 0 1 1 0 0 0
											Sfr-offset
	saddr,saddr	(saddr),CY ← (saddr) + (saddr)	3	3-9	9	11		x	x	x	0 1 1 1 1 0 0 0
											Saddr-offset
											Saddr-offset

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Instruction Set (cont)

Mnemonic	Operand	Operation	Bytes	Clocks				Flags			Operation Code (Bits 7-0) Bytes B1 thru B5										
				IROM	IRAM	SFR	EMEM	Z	AC	CY											
8-Bit Operation (cont)																					
ADD	A,mem	A,CY ← A + (mem)	2-4	8-13	11-15	13-17	13-17	x	x	x	0	0	0	mod							
											0	mem	1	0	0	0					
														Low Offset							
														High Offset							
	A,&mem	A,CY ← A + (&mem)	3-5	10-15	14-18	16-20	16-20	x	x	x	0	0	0	0	0	0	1				
											0	0	0	mod							
														Low Offset							
														High Offset							
ADDC	A,#byte	A,CY ← A + byte + CY	2	2	6					x	x	x	1	0	1	0	1	0	0	1	
														Data							
	saddr,#byte	(saddr),CY ← (saddr) + byte + CY	3	3/7	9	11					x	x	x	0	1	1	0	1	0	0	1
														Saddr-offset							
														Data							
	sfr,#byte	sfr,CY ← sfr + byte + CY	4	9		14					x	x	x	0	0	0	0	0	0	0	1
														Sfr-offset							
														Data							
	r,r	r,CY ← r + r + CY	2	3	7						x	x	x	1	0	0	1	1	0	0	1
														0 R ₆ R ₅ R ₄ 0 R ₂ R ₁ R ₀							
	A,saddr	A,CY ← A + (saddr) + CY	2	2/5	6	7	8				x	x	x	1	0	0	1	1	0	0	1
														Saddr-offset							
	A,sfr	A,CY ← A + sfr + CY	3	7		10					x	x	x	0	0	0	0	0	0	0	1
														1 0 0 1 1 0 0 1							
														Sfr-offset							
	saddr,saddr	(saddr),CY ← (saddr) + (saddr) + CY	3	3-9	9	11					x	x	x	0	1	1	1	1	0	0	1
													Saddr-offset								
													Saddr-offset								
A,mem	A,CY ← A + (mem) + CY	2-4	8-13	11-15	13-17	13-17	x	x	x	0	0	0	mod								
										0	mem	1	0	0	1						
														Low Offset							
														High Offset							
A,&mem	A,CY ← A + (&mem) + CY	3-5	10-15	14-18	16-20	16-20	x	x	x	0	0	0	0	0	0	0	0	1			
										0	0	0	mod								
														Low Offset							
														High Offset							

Instruction Set (cont)

Mnemonic	Operand	Operation	Bytes	Clocks				Flags			Operation Code (Bits 7-0) Bytes B1 thru B5
				IROM	IRAM	SFR	EMEM	Z	AC	CY	
8-Bit Operation (cont)											
SUB	A,#byte	A,CY ← A-byte	2	2	6			x	x	x	1 0 1 0 1 0 1 0
											Data
	saddr,#byte	(saddr),CY ← (saddr)-(byte)	3	3/7	9	11		x	x	x	0 1 1 0 1 0 1 0
											Saddr-offset
											Data
	sfr,#byte	sfr,CY ← sfr-byte	4	9		14		x	x	x	0 0 0 0 0 0 0 1
											0 1 1 0 1 0 1 0
											Sfr-offset
											Data
	r,r	r,CY ← r-r	2	3	7			x	x	x	1 0 0 0 1 0 1 0
											0 R ₆ R ₅ R ₄ 0 R ₂ R ₁ R ₀
	A,saddr	A,CY ← A-(saddr)	2	3/5	6	7	8	x	x	x	1 0 0 1 1 0 1 0
											Saddr-offset
	A,sfr	A,CY ← A-sfr	3	7		10		x	x	x	0 0 0 0 0 0 0 1
											1 0 0 1 1 0 1 0
											Sfr-offset
	saddr,saddr	(saddr),CY ← (saddr)-(saddr)	3	3-9	9	11		x	x	x	0 1 1 1 1 0 1 0
											Saddr-offset
											Saddr-offset
	A,mem	A,CY ← A-(&mem)	2-4	8-13	11-15	13-17	13-17	x	x	x	0 0 0 mod
											0 mem 1 0 1 0
											Low Offset
											High Offset
	A,&mem	A,CY ← A-(&mem)	3-5	10-15	14-18	16-20	16-20	x	x	x	0 0 0 0 0 0 0 1
											0 0 0 mod
											0 mem 1 0 1 0
											Low Offset
											High Offset
SUBC	A,#byte	A,CY ← A-byte-CY	2	2	6			x	x	x	1 0 1 0 1 0 1 1
											Data
	saddr,#byte	(saddr),CY ← (saddr)-byte-CY	3	3/7	9	11		x	x	x	0 1 1 0 1 0 1 1
											Saddr-offset
											Data
	sfr,#byte	sfr,CY ← sfr-byte-CY	4	9		14		x	x	x	0 0 0 0 0 0 0 1
											0 1 1 0 1 0 1 1
											Sfr-offset
											Data

Instruction Set (cont)

Mnemonic	Operand	Operation	Bytes	Clocks				Flags			Operation Code (Bits 7-0) Bytes B1 thru B5
				IROM	IRAM	SFR	EMEM	Z	AC	CY	
8-Bit Operation (cont)											
SUBC	r,r	$r, CY \leftarrow r - r - CY$	2	3	7			x	x	x	1 0 0 0 1 0 1 1 0 R ₆ R ₅ R ₄ 0 R ₂ R ₁ R ₀
	A,saddr	$A, CY \leftarrow A - (saddr) - CY$	2	3/5	6	7	8	x	x	x	1 0 0 1 1 0 1 1 Saddr-offset
	A,sfr	$A, CY \leftarrow A - sfr - CY$	3	7		10		x	x	x	0 0 0 0 0 0 0 1 1 0 0 1 1 0 1 1 Sfr-offset
	saddr,saddr	$(saddr), CY \leftarrow (saddr) - (saddr) - CY$	3	3-9	9	11		x	x	x	0 1 1 1 1 0 1 1 Saddr-offset Saddr-offset
	A,mem	$A, CY \leftarrow A - (mem) - CY$	2-4	8-13	11-15	13-17	13-17	x	x	x	0 0 0 mod 0 mem 1 0 1 1 Low Offset High Offset
	A,&mem	$A, CY \leftarrow A - (&mem) - CY$	3-5	10-15	14-18	16-20	16-20	x	x	x	0 0 0 0 0 0 0 1 0 0 0 mod 0 mem 1 0 1 1 Low Offset High Offset
AND	A,#byte	$A \leftarrow A \wedge \text{byte}$	2	2	6					x	1 0 1 0 1 1 1 0 0 Data
	saddr,#byte	$(saddr) \leftarrow (saddr) \wedge \text{byte}$	3	3/7	9	11				x	0 1 1 0 1 1 0 0 Saddr-offset Data
	sfr,#byte	$sfr \leftarrow sfr \wedge \text{byte}$	4	9		14				x	0 0 0 0 0 0 0 1 0 1 1 0 1 1 0 0 Sfr-offset Data
	r,r	$r \leftarrow r \wedge r$	2	3	7					x	1 0 0 0 1 1 0 0 0 R ₆ R ₅ R ₄ 0 R ₂ R ₁ R ₀
	A,saddr	$A \leftarrow A \wedge (saddr)$	2	3/5	6	7	8			x	1 0 0 1 1 1 0 0 Saddr-offset
	A,sfr	$A \leftarrow A \wedge (sfr)$	3	7		10				x	0 0 0 0 0 0 0 1 1 0 0 1 1 1 0 0 Sfr-offset
	saddr,saddr	$(saddr) \leftarrow (saddr) \wedge (saddr)$	3	3-9	9	11				x	0 1 1 1 1 1 0 0 Saddr-offset Saddr-offset

Instruction Set (cont)

Mnemonic	Operand	Operation	Bytes	Clocks				Flags		Operation Code (Bits 7-0)					
				IROM	IRAM	SFR	EMEM	Z	AC CY	Bytes B1 thru B5					
8-Bit Operation (cont)															
AND	A,mem	A ← A ∧ (mem)	2-4	8-13	11-15	13-17	13-17	x	0 0 0	mod					
									0 mem	1 1 0 0	Low Offset				
									High Offset						
	A,&mem	A ← A ∧ (&mem)	3-5	10-15	14-18	16-20	16-20	x	0 0 0 0	0 0 0 1					
0 0 0									mod						
								Low Offset							
								High Offset							
OR	A,#byte	A ← A V byte	2	2	6			x	1 0 1 0	1 1 1 0					
									Data						
	saddr,#byte	(saddr) ← (saddr) V byte	3	3/7	9	11			x	0 1 1 0	1 1 1 0				
										Saddr-offset					
									Data						
	sfr,#byte	sfr ← sfr V byte	4	9			14			x	0 0 0 0	0 0 0 1			
								0 1 1 0 1 1 1 0							
											Sfr-offset				
											Data				
	r,r	r ← r V r	2	3	7					x	1 0 0 0	1 1 1 0			
											0 R ₆ R ₅ R ₄ 0 R ₂ R ₁ R ₀				
	A,saddr	A ← A V (saddr)	2	3/5	6	7	8			x	1 0 0 1	1 1 1 0			
											Saddr-offset				
	A,sfr	A ← A V sfr	3	7			10			x	0 0 0 0	0 0 0 1			
										1 0 0 1 1 1 1 0					
										Sfr-offset					
saddr,saddr	(saddr) ← (saddr) V (saddr)	3	3-9	9	11					x	0 1 1 1	1 1 1 0			
												Saddr-offset			
												Saddr-offset			
A,mem	A ← A V (mem)	2-4	8-13	11-15	13-17	13-17			x	0 0 0	mod				
										0 mem	1 1 1 0				
										Low Offset					
										High Offset					
A,&mem	A ← A V (&mem)	3-5	10-15	14-18	16-20	16-20	x	0 0 0 0	0 0 0 1						
								0 0 0	mod						
									0 mem 1 1 1 0						
											Low Offset				
										High Offset					

Instruction Set (cont)

Mnemonic	Operand	Operation	Bytes	Clocks				Flags			Operation Code (Bits 7-0) Bytes B1 thru B5
				IROM	IRAM	SFR	EMEM	Z	AC	CY	
8-Bit Operation (cont)											
XOR	A,#byte	$A \leftarrow A \nabla \text{byte}$	2	2	6				x		1 0 1 0 1 1 0 1
											Data
	saddr,#byte	$(\text{saddr}) \leftarrow (\text{saddr}) \nabla \text{byte}$	3	3/5	9	11			x		0 1 1 0 1 1 0 1
											Saddr-offset
											Data
	sfr,#byte	$\text{sfr} \leftarrow \text{sfr} \nabla \text{byte}$	4	7		14			x		0 0 0 0 0 0 0 1
											0 1 1 0 1 1 0 1
											Sfr-offset
											Data
	r,r	$r \leftarrow r \nabla r$	2	3	7				x		1 0 0 0 1 1 0 1
											0 R ₆ R ₅ R ₄ 0 R ₂ R ₁ R ₀
	A,saddr	$A \leftarrow A \nabla (\text{saddr})$	2	3/5	6	7	8	x			1 0 0 1 1 1 0 1
											Saddr-offset
	A,sfr	$A \leftarrow A \nabla (\text{sfr})$	3	7		10		x			0 0 0 0 0 0 0 1
											1 0 0 1 1 1 0 1
											Sfr-offset
	saddr,saddr	$(\text{saddr}) \leftarrow (\text{saddr}) \nabla (\text{saddr})$	3	3-9	9	11		x			0 1 1 1 1 1 0 1
											Saddr-offset
											Saddr-offset
	A,mem	$A \leftarrow A \nabla (\text{mem})$	2-4	8-13	11-15	13-17	13-17	x			0 0 0 mod
											0 mem 1 1 0 1
											Low Offset
											High Offset
	A,&mem	$A \leftarrow A \nabla (\&\text{mem})$	3-5	10-15	14-18	16-20	16-20	x			0 0 0 0 0 0 0 1
											0 0 0 mod
											0 mem 1 1 0 1
											Low Offset
											High Offset
CMP	A,#byte	$A - \text{byte}$	2	2	6				x x x		1 0 1 0 1 1 1 1
											Data
	saddr,#byte	$(\text{saddr}) - \text{byte}$	3	3/5	9	11			x x x		0 1 1 0 1 1 1 1
											Saddr-offset
											Data
	sfr,#byte	$\text{sfr} - \text{byte}$	4	7		14			x x x		0 0 0 0 0 0 0 1
											0 1 1 0 1 1 1 1
											Sfr-offset
											Data

Instruction Set (cont)

Mnemonic	Operand	Operation	Bytes	Clocks				Flags			Operation Code (Bits 7-0) Bytes B1 thru B5
				IROM	IRAM	SFR	EMEM	Z	AC	CY	
8-Bit Operation (cont)											
CMP	r,r	r-r	2	3	7			x	x	x	1 0 0 0 1 1 1 1
	A,saddr	A-(saddr)	2	3/5	6	7	8	x	x	x	0 R ₆ R ₅ R ₄ 0 R ₂ R ₁ R ₀
											Saddr-offset
A,sfr	A-sfr	A-sfr	3	7		10		x	x	x	0 0 0 0 0 0 0 1
											1 0 0 1 1 1 1 1
											Sfr-offset
saddr,saddr	(saddr)-(saddr)	(saddr)-(saddr)	3	3-7	9	11		x	x	x	0 1 1 1 1 1 1 1
											Saddr-offset
											Saddr-offset
A,mem	A-(mem)	A-(mem)	2-4	8-13	11-15	13-17	13-17	x	x	x	0 0 0 mod
											0 mem 1 1 1 1
											Low Offset
											High Offset
A,&mem	A-(&mem)	A-(&mem)	3-5	10-15	14-18	16-20	16-20	x	x	x	0 0 0 0 0 0 0 1
											0 0 0 mod
											0 mem 1 1 1 1
											Low Offset
											High Offset
16-Bit Operation											
ADDW	AX,#word	AX,CY ← AX + word	3	4	9			x	x	x	0 0 1 0 1 1 0 1
											Low Byte
											High Byte
AX,rp	AX,CY ← AX + rp	AX,CY ← AX + rp	2	6	8			x	x	x	1 0 0 0 1 0 0 0
											0 0 0 0 1 P ₂ P ₁ 0
AX,saddrp	AX,CY ← AX + (saddrp)	AX,CY ← AX + (saddrp)	2	7/11	9	13		x	x	x	0 0 0 1 1 1 0 1
											Saddr-offset
AX,sfrp	AX,CY ← AX + sfrp	AX,CY ← AX + sfrp	3	13		16		x	x	x	0 0 0 0 0 0 0 1
											0 0 0 1 1 1 0 1
											Sfr-offset
SUBW	AX,#word	AX,CY ← AX - word	3	4	9			x	x	x	0 0 1 0 1 1 1 0
											Low Byte
											High Byte
AX,rp	AX,CY ← AX - rp	AX,CY ← AX - rp	2	6	8			x	x	x	1 0 0 0 1 0 1 0
											0 0 0 0 1 P ₂ P ₁ P ₀
AX,saddrp	AX,CY ← AX - (saddrp)	AX,CY ← AX - (saddrp)	2	7/11	9	13		x	x	x	0 0 0 1 1 1 1 0
											Saddr-offset

Instruction Set (cont)

Mnemonic	Operand	Operation	Bytes	Clocks				Flags			Operation Code (Bits 7-0)	
				IROM	IRAM	SFR	EMEM	Z	AC	CY	Bytes B1 thru B5	
16-Bit Operation (cont)												
SUBW	AX,sfrp	AX,CY ← AX - sfrp	3	13		16		x	x	x	0 0 0 0 0 0 0 1 0 0 0 1 1 1 1 0	
											Sfr-offset	
CMPW	AX,#word	AX - word	3	3	9			x	x	x	0 0 1 0 1 1 1 1	
											Low Byte	
	AX,rp	AX - rp	2	5	7			x	x	x	1 0 0 0 1 1 1 1 0 0 0 0 1 P ₂ P ₁ 0	
											High Byte	
	AX,saddrp	AX - (saddrp)	2	6/10	8	12		x	x	x	0 0 0 1 1 1 1 1	
											Saddr-offset	
	AX,sfrp	AX - sfrp	3	12		15		x	x	x	0 0 0 0 0 0 0 1 0 0 0 1 1 1 1 1	
											Sfr-offset	
Multiplication/Division												
MULU	r	AX ← Axr	2	22	24						0 0 0 0 0 1 0 1 0 0 0 0 1 R ₂ R ₁ R ₀	
DIVUW	r	AX(quotient), r(remainder) ← AX ÷ r	2	71	76						0 0 0 0 0 1 0 1 0 0 0 1 1 R ₂ R ₁ R ₀	
Increment/Decrement												
INC	r	r ← r + 1	1	2	3			x	x		1 1 0 0 0 R ₂ R ₁ R ₀	
	saddr	(saddr) ← (saddr) + 1	2	2/6	6	7		x	x		0 0 1 0 0 1 1 0	
											Saddr-offset	
DEC	r	r ← r - 1	1	2	3			x	x		1 1 0 0 1 R ₂ R ₁ R ₀	
	saddr	(saddr) ← (saddr) - 1	2	2/6	6	7		x	x		0 0 1 0 0 1 1 1	
											Saddr-offset	
INCW	rp	rp ← rp + 1	1	3	3						0 1 0 0 0 1 P ₁ P ₀	
DECW	rp	rp ← rp - 1	1	3	3						0 1 0 0 1 1 P ₁ P ₀	
Shift/Rotate												
ROR	r,n	(CY,r ₇ ← r ₀ , r _{m-1} ← r _m) xn times, n=0-7	2	3+2n	5+2n			x			0 0 1 1 0 0 0 0 0 1 N ₂ N ₁ N ₀ R ₂ R ₁ R ₀	
ROL	r,n	(CY,r ₀ ← r ₇ , r _{m+1} ← r _m) xn times, n=0-7	2	3+2n	5+2n			x			0 0 1 1 0 0 0 1 0 1 N ₂ N ₁ N ₀ R ₂ R ₁ R ₀	

Instruction Set (cont)

Mnemonic	Operand	Operation	Bytes	Clocks				Flags			Operation Code (Bits 7-0) Bytes B1 thru B5
				IROM	IRAM	SFR	EMEM	Z	AC	CY	
Shift/Rotate (cont)											
RORC	r,n	(CY ← r ₀ , r ₇ ← CY, r _{m-1} ← r _m) xn times, n=0-7	2	3+2n	5+2n				x	0 0 1 1 0 0 0 0	
										0 0 N ₂ N ₁ N ₀ R ₂ R ₁ R ₀	
ROLC	r,n	(CY ← r ₇ , r ₀ ← CY, r _{m+1} ← r _m) xn times, n=0-7	2	3+2n	5+2n				x	0 0 1 1 0 0 0 1	
										0 0 N ₂ N ₁ N ₀ R ₂ R ₁ R ₀	
SHR	r,n	(CY ← r ₀ , r ₇ ← 0, r _{m-1} ← r _m) xn times, n=0-7	2	3+2n	5+2n				x 0 x	0 0 1 1 0 0 0 0	
										1 0 N ₂ N ₁ N ₀ R ₂ R ₁ R ₀	
SHL	r,n	(CY ← r ₇ , r ₀ ← 0, r _{m+1} ← r _m) xn times, n=0-7	2	3+2n	5+2n				x 0 x	0 0 1 1 0 0 0 1	
										1 0 N ₂ N ₁ N ₀ R ₂ R ₁ R ₀	
SHRW	rp,n	(CY ← rp ₀ , rp ₁₅ ← 0, rp _{m-1} ← rp _m) xn times, n=0-7	2	3+3n	5+3n				x 0 x	0 0 1 1 0 0 0 0	
										1 1 N ₂ N ₁ N ₀ R ₂ R ₁ R ₀	
SHLW	rp,n	(CY ← rp ₁₅ , rp ₀ ← 0, rp _{m+1} ← rp _m) xn times, n=0-7	2	3+3n	5+3n				x 0 x	0 0 1 1 0 0 0 1	
										1 1 N ₂ N ₁ N ₀ R ₂ R ₁ R ₀	
ROR4	mem1	A ₃₋₀ ← (mem1) ₃₋₀ , (mem1) ₇₋₄ ← A ₃₋₀ , (mem1) ₃₋₀ ← (mem1) ₇₋₄	2	24	26	34	34			0 0 0 0 0 1 0 1	
										1 0 0 0 1 1 R ₁ 0	
	&mem1	A ₃₋₀ ← (&mem1) ₃₋₀ , (&mem1) ₇₋₄ ← A ₃₋₀ , (&mem1) ₃₋₀ ← (&mem1) ₇₋₄	3	26	29	37	37			0 0 0 0 0 0 0 1	
										0 0 0 0 0 1 0 1	
										1 0 0 0 1 1 R ₁ 0	
ROL4	mem1	A ₃₋₀ ← (mem1) ₇₋₄ , (mem1) ₃₋₀ ← A ₃₋₀ , (mem1) ₇₋₄ ← (mem1) ₃₋₀	2	25	27	35	35			0 0 0 0 0 1 0 1	
										1 0 0 1 1 1 R ₁ 0	
	&mem1	A ₃₋₀ ← (&mem1) ₇₋₄ , (&mem1) ₃₋₀ ← A ₃₋₀ , (&mem1) ₇₋₄ ← (&mem1) ₃₋₀	3	27	30	38	38			0 0 0 0 0 0 0 1	
										0 0 0 0 0 1 0 1	
										1 0 0 1 1 1 R ₁ 0	

Instruction Set (cont)

Mnemonic	Operand	Operation	Bytes	Clocks				Flags			Operation Code (Bits 7-0)									
				IROM	IRAM	SFR	EMEM	Z	AC	CY	Bytes B1 thru B5									
BCD Adjustment																				
ADJBA		Decimal adjust accumulator after addition	1	3		3		x	x	x	0	0	0	0	1	1	1	0		
ADJBS		Decimal adjust accumulator after addition	-1	3		3		x	x	x	0	0	0	0	1	1	1	1		
Bit Manipulation																				
MOV1	CY,saddr.bit	CY ← (saddr bit)	3	5/7	9	9	11				x	0	0	0	0	1	0	0	0	
												0	0	0	0	0	B ₂	B ₁	B ₀	
												Saddr-offset								
	CY,sfr.bit	CY ← sfr.bit	3	7		9					x	0	0	0	0	1	0	0	0	
												0	0	0	0	1	B ₂	B ₁	B ₀	
												Sfr-offset								
	CY,A.bit	CY ← A.bit	2	5	7						x	0	0	0	0	0	0	1	1	
												0	0	0	0	1	B ₂	B ₁	B ₀	
	CY,X.bit	CY ← X.bit	2	5	7						x	0	0	0	0	0	0	1	1	
												0	0	0	0	0	B ₂	B ₁	B ₀	
												Sfr-offset								
	CY,PSW.bit	CY ← PSW.bit	2	5		7					x	0	0	0	0	0	0	0	1	0
												0	0	0	0	0	B ₂	B ₁	B ₀	
	saddr.bit,CY	(saddr bit) ← CY	3	8/12	12	14	14					0	0	0	0	1	0	0	0	
												0	0	0	1	0	B ₂	B ₁	B ₀	
												Saddr-offset								
	sfr.bit,CY	sfr.bit ← CY	3	12		14						0	0	0	0	1	0	0	0	
												0	0	0	1	1	B ₂	B ₁	B ₀	
												Sfr-offset								
	A.bit,CY	A.bit ← CY	2	8	10							0	0	0	0	0	0	1	1	
												0	0	0	1	1	B ₂	B ₁	B ₀	
	X.bit,CY	X.bit ← CY	2	8	10							0	0	0	0	0	0	1	1	
												0	0	0	1	0	B ₂	B ₁	B ₀	
												Sfr-offset								
	PSW.bit,CY	PSW.bit ← CY	2	7		9		x	x			0	0	0	0	0	0	1	0	
												0	0	0	1	0	B ₂	B ₁	B ₀	
AND1	CY,saddr.bit	CY ← CY ∧ (saddr bit)	3	5/7	9	11					x	0	0	0	0	1	0	0	0	
												0	0	1	0	0	B ₂	B ₁	B ₀	
												0	0	1	0	0	B ₂	B ₁	B ₀	
												Saddr-offset								

Instruction Set (cont)

Mnemonic	Operand	Operation	Bytes	Clocks				Flags			Operation Code (Bits 7-0) Bytes B1 thru B5
				IROM	IRAM	SFR	EMEM	Z	AC	CY	
Bit Manipulation (cont)											
AND1	CY,/saddr.bit	$CY \leftarrow CY \wedge (\text{saddr.bit})$	3	5/7	9	11				x	0 0 0 0 1 0 0 0 0 0 1 1 0 B ₂ B ₁ B ₀ Sfr-offset
	CY,/sfr.bit	$CY \leftarrow CY \wedge \text{sfr.bit}$	3	7		11				x	0 0 0 0 1 0 0 0 0 0 1 0 1 B ₂ B ₁ B ₀ Sfr-offset
	CY,/sfr.bit	$CY \leftarrow CY \wedge \text{sfr.bit}$	3	7		11				x	0 0 0 0 1 0 0 0 0 0 1 1 1 B ₂ B ₁ B ₀
	CY,/A.bit	$CY \leftarrow CY \wedge A.bit$	2	5	7					x	0 0 0 0 0 0 0 1 1 0 0 1 0 1 B ₂ B ₁ B ₀
	CY,/A.bit	$CY \leftarrow CY \wedge \bar{A}.bit$	2	5	7					x	0 0 0 0 0 0 0 1 1 0 0 1 1 1 B ₂ B ₁ B ₀
	CY,/X.bit	$CY \leftarrow CY \wedge X.bit$	2	5	7					x	0 0 0 0 0 0 0 1 1 0 0 1 0 0 B ₂ B ₁ B ₀
	CY,/X.bit	$CY \leftarrow CY \wedge \bar{X}.bit$	2	5	7					x	0 0 0 0 0 0 0 1 1 0 0 1 1 0 B ₂ B ₁ B ₀
	CY,/PSW.bit	$CY \leftarrow CY \wedge \text{PSW.bit}$	2	5		7				x	0 0 0 0 0 0 0 1 0 0 0 1 0 0 B ₂ B ₁ B ₀
	CY,/PSW.bit	$CY \leftarrow CY \wedge \bar{\text{PSW.bit}}$	2	5		7				x	0 0 0 0 0 0 0 1 0 0 0 1 1 0 B ₂ B ₁ B ₀
OR1	CY,/saddr.bit	$CY \leftarrow CY \vee (\text{saddr.bit})$	3	5/7	9	11				x	0 0 0 0 1 0 0 0 0 1 0 0 0 B ₂ B ₁ B ₀ Saddr-offset
	CY,/saddr.bit	$CY \leftarrow CY \vee (\text{saddr.bit})$	3	5/7	9	11				x	0 0 0 0 1 0 0 0 0 1 0 1 0 B ₂ B ₁ B ₀ Sfr-offset
	CY,/sfr.bit	$CY \leftarrow CY \vee \text{sfr.bit}$	3	7		11				x	0 0 0 0 1 0 0 0 0 1 0 1 1 B ₂ B ₁ B ₀ Sfr-offset

Instruction Set (cont)

Mnemonic	Operand	Operation	Bytes	Clocks				Flags			Operation Code (Bits 7-0) Bytes B1 thru B5
				IROM	IRAM	SFR	EMEM	Z	AC	CY	
Bit Manipulation (cont)											
OR1	CY,sfr.bit	CY ← CY V sfr.bit	3	7		11			x	0 0 0 0 1 0 0 0 0 0 1 0 1 1 B ₂ B ₁ B ₀	
	CY,A.bit	CY ← CY V A.bit	2	5	7				x	0 0 0 0 0 0 0 1 1 0 1 0 0 1 B ₂ B ₁ B ₀	
	CY,/A.bit	CY ← CY V A̅.bit	2	5	7				x	0 0 0 0 0 0 0 1 1 0 1 0 1 1 B ₂ B ₁ B ₀	
	CY,X.bit	CY ← CY V X.bit	2	5	7				x	0 0 0 0 0 0 0 1 1 0 1 0 0 0 B ₂ B ₁ B ₀	
	CY,/X.bit	CY ← CY V X̅.bit	2	5	7				x	0 0 0 0 0 0 0 1 1 0 1 0 1 0 B ₂ B ₁ B ₀	
	CY,PSW.bit	CY ← CY V PSW.bit	2	5		7			x	0 0 0 0 0 0 0 1 0 0 1 0 0 0 B ₂ B ₁ B ₀	
	CY,/PSW.bit	CY ← CY V PSW̅.bit	2	5		7			x	0 0 0 0 0 0 0 1 0 0 1 0 1 0 B ₂ B ₁ B ₀	
	XOR1	CY,saddr.bit	CY ← CY ⊕ (saddr.bit)	3	5/7	9	11			x	0 0 0 0 1 0 0 0 0 0 1 1 0 0 B ₂ B ₁ B ₀ Saddr-offset
CY,sfr.bit		CY ← CY ⊕ sfr.bit	3	7		11			x	0 0 0 0 1 0 0 0 0 0 1 1 0 1 B ₂ B ₁ B ₀ Sfr-offset	
CY,A.bit		CY ← CY ⊕ A.bit	2	5	7				x	0 0 0 0 0 0 0 1 1 0 1 1 0 1 B ₂ B ₁ B ₀	
CY,X.bit		CY ← CY ⊕ X.bit	2	5	7				x	0 0 0 0 0 0 0 1 1 0 1 1 0 0 B ₂ B ₁ B ₀	
CY,PSW.bit		CY ← CY ⊕ PSW.bit	2	5		7			x	0 0 0 0 0 0 0 1 0 0 1 1 0 0 B ₂ B ₁ B ₀	
SET1		saddr.bit	(saddr.bit) ← 1	2	3/7	6					1 0 1 1 0 B ₂ B ₁ B ₀ Saddr-offset
		sfr.bit	sfr.bit ← 1	3	10		14				0 0 0 0 1 0 0 0 0 1 0 0 0 1 B ₂ B ₁ B ₀ Sfr-offset

Instruction Set (cont)

Mnemonic	Operand	Operation	Bytes	Clocks			Flags			Operation Code (Bits 7-0) Bytes B1 thru B5	
				IROM	IRAM	SFR	EMEM	Z	AC		CY
Bit Manipulation (cont)											
SET1	A.bit	A.bit ← 1	2	6	8					0 0 0 0 0 0 1 1 1 0 0 0 1 B ₂ B ₁ B ₀	
	X.bit	X.bit ← 1	2	6	8					0 0 0 0 0 0 1 1 1 0 0 0 0 B ₂ B ₁ B ₀	
	PSW.bit	PSW.bit ← 1	2	5	7		x	x	x	0 0 0 0 0 0 1 0 1 0 0 0 0 B ₂ B ₁ B ₀	
											1 0 0 0 0 B ₂ B ₁ B ₀
CLR1	saddr.bit	(saddr.bit) ← 0	2	6/10	6					1 0 1 0 0 B ₂ B ₁ B ₀ Saddr-offset	
	sfr.bit	sfr.bit ← 0	3	10	14					0 0 0 0 1 0 0 0 1 0 0 1 1 B ₂ B ₁ B ₀	
										Sfr-offset	
	A.bit	A.bit ← 0	2	6	8					0 0 0 0 0 0 1 1 1 0 0 1 1 B ₂ B ₁ B ₀	
	X.bit	X.bit ← 0	2	6	8					0 0 0 0 0 0 1 1 1 0 0 1 0 B ₂ B ₁ B ₀	
	PSW.bit	PSW.bit ← 0	2	5	7		x	x	x	0 0 0 0 0 0 1 0 1 0 0 1 0 B ₂ B ₁ B ₀	
											1 0 0 1 0 B ₂ B ₁ B ₀
											Saddr-offset
											0 0 0 0 1 0 0 0 0 1 1 1 1 B ₂ B ₁ B ₀
											Sfr-offset
NOT1	saddr.bit	(saddr.bit) ← 0 (saddr.bit)	3	6/10	10	14				0 0 0 0 1 0 0 0 0 1 1 1 0 B ₂ B ₁ B ₀ Saddr-offset	
	sfr.bit	sfr.bit ← sfr.bit	3	10	14					0 0 0 0 1 0 0 0 0 1 1 1 1 B ₂ B ₁ B ₀	
										Sfr-offset	
	A.bit	A.bit ← A.bit	2	6	8					0 0 0 0 0 0 1 1 0 1 1 1 1 B ₂ B ₁ B ₀	
	X.bit	X.bit ← X.bit	2	6	8					0 0 0 0 0 0 1 1 0 1 1 1 0 B ₂ B ₁ B ₀	
	PSW.bit	PSW.bit ← PSW.bit	2	5	7		x	x	x	0 0 0 0 0 0 1 0 0 1 1 1 0 B ₂ B ₁ B ₀	
SET1	CY	CY ← 1	1	2	3					1 0 1 0 0 0 0 0 1	
CLR1	CY	CY ← 0	1	2	3					0 0 1 0 0 0 0 0 0	
NOT1	CY	CY ← CY	1	2	3					x 0 1 0 0 0 0 1 0	

Instruction Set (cont)

Mnemonic	Operand	Operation	Bytes	Clocks				Flags		Operation Code (Bits 7-0) Bytes B1 thru B5
				IROM	IRAM	SFR	EMEM	Z	AC CY	
Call/Return										
CALL	laddr16	(SP-1) ← (PC+3) _H , (SP-2) ← (PC+3) _L , PC ← laddr16, SP ← SP-2	3	10-15	17		21			0 0 1 0 1 0 0 0
										Low Addr
										High Addr
	rp	(SP-1) ← (PC+2) _H , (SP-2) ← (PC+2) _L , PC _H ← r _{PH} , PC _L ← r _{PL} , SP ← SP-2	2	12-17	15		19			0 0 0 0 0 1 0 1 0 1 0 1 1 P ₂ P ₁ 0
CALLF	laddr11	(SP-1) ← (PC+2) _H , (SP-2) ← (PC+2) _L , PC ₁₅₊₁₁ ← 00001, PC ₁₀₋₀ ← laddr11, SP ← SP-2	2	10-15	14		18			1 0 0 1 0 ← fa →
CALLT	[addr5]	(SP-1) ← (PC+1) _H , (SP-2) ← (PC+1) _L , PC _H ← (00000000, addr5+1), PC _L ← (00000000, addr5), SP ← SP-2	1	14-20	20		24			1 1 1 ← ta →
BRK		(SP-1) ← PSW, (SP-2) ← (PC+1) _H , (SP-3) ← (PC+1) _L , PC _H ← (003FH), PC _L ← (003FH), SP ← SP-3, IE ← 0	1	16-26	22		28			0 1 0 1 1 1 1 0
RET		PC _L ← (SP), PC _H ← (SP+1), SP ← SP+2	1	10-15	11		15			0 1 0 1 0 1 1 0
RETI		PC _L ← (SP), PC _H ← (SP+1), PSW ← (SP+2), SP ← SP+3, NMIS ← 0	1	12-20	15		21	R R R		0 1 0 1 0 1 1 1
RETB		PC _L ← (SP), PC _H ← (SP+1), PSW ← (SP+2), SP ← SP+3	1	12-20	13		19	R R R		0 1 0 1 1 1 1 1
Stack Manipulation										
PUSH	PSW	(SP-1) ← PSW, SP ← SP-1	1	4-8	5		7			0 1 0 0 1 0 0 1
	sfr	(SP-1) ← sfr, SP ← SP-1	2	7-9	9		12			0 0 1 0 1 0 0 1
										Sfr-offset
	rp	(SP-1) ← r _{PH} (SP-2) ← r _{PL} , SP ← SP-2	1	8-13	8		12			0 0 1 1 1 1 P ₁ P ₀

Instruction Set (cont)

Mnemonic	Operand	Operation	Bytes	Clocks			Flags			Operation Code (Bits 7-0) Bytes B1 thru B5													
				IROM	IRAM	SFR	EMEM	Z	AC	CY													
Stack Manipulation (cont)																							
POP	PSW	PSW ← (SP), SP ← SP + 1	1	4-8	6	8	R	R	R	0	1	0	0	1	0	0	0	0					
	sfr	sfr ← (SP), SP ← SP + 1	2	9-11	9	12									0	1	0	0	0	0	1	1	
														Sfr-offset									
	rp	rp _L ← (SP), rp _H ← (SP + 1), SP ← SP + 2	1	10-15	11	15									0	0	1	1	0	1	P ₁	P ₀	
MOVW	SP,#word	SP ← word	4	8	12									0	0	0	0	1	0	1	1		
														1	1	1	1	1	1	0	0		
														Low Byte									
														High Byte									
		SP,AX	SP ← AX	2	9	11									0	0	0	1	0	0	1	1	
	AX,SP	AX ← SP	2	10	12									1	1	1	1	1	1	0	0		
														0	0	0	1	0	0	0	1		
														1	1	1	1	1	1	0	0		
INCW	SP	SP ← SP + 1	2	5	7									0	0	0	0	0	1	0	1		
														1	1	0	0	1	0	0	0		
DECW	SP	SP ← SP - 1	2	5	7									0	0	0	0	0	1	0	1		
														1	1	0	0	1	0	0	1		

Instruction Set (cont)

Mnemonic	Operand	Operation	Bytes	Clocks			Flags		Operation Code (Bits 7-0)	
				IntROM	Branch	No Branch	Z	AC CY	Bytes B1 thru B5	
Unconditional Branch										
BR	laddr16	PC ← laddr16	3	5	11			0 0 1 0	1 1 0 0	
								Low Addr		
	rp	PC _H ← rP _H , PC _L ← rP _L	2	6	10			0 0 0 0	0 1 0 1	
	\$addr16	PC ← \$addr16	2	4	9			0 1 0 0	1 P ₂ P ₁ 0	
								0 0 0 1	0 1 0 0	
								jdisp		
Conditional Branch										
BC	\$addr16	PC ← \$addr16 if CY = 1	2	2/4	9	6		1 0 0 0	0 0 1 1	
BL								jdisp		
BNC	\$addr16	PC ← \$addr16 if CY = 0	2	2/4	9	6		1 0 0 0	0 0 1 0	
BNL								jdisp		
BZ	\$addr16	PC ← \$addr16 if Z = 1	2	2/4	9	6		1 0 0 0	0 0 0 1	
BE								jdisp		
BNZ	\$addr16	PC ← \$addr16 if Z = 0	2	2/4	9	6		1 0 0 0	0 0 0 0	
BNE								jdisp		
BT	saddr.bit, \$addr16	PC ← \$addr16 if (saddr.bit) = 1	3	5-9	12	9		0 1 1 1	0 B ₂ B ₁ B ₀	
								Saddr-offset		
								jdisp		
	sfr.bit, \$addr16	PC ← \$addr16 if sfr.bit = 1	4	7/9	16	13		0 0 0 0	1 0 0 0	
								1 0 1 1	1 B ₂ B ₁ B ₀	
								Sfr-offset		
								jdisp		
	A.bit, \$addr16	PC ← \$addr16 if A.bit = 1	3	5/7	12	9		0 0 0 0	0 0 1 1	
								1 0 1 1	1 B ₂ B ₁ B ₀	
								jdisp		
	X.bit, \$addr16	PC ← \$addr16 if X.bit = 1	3	5/7	12	9		0 0 0 0	0 0 1 1	
								1 0 1 1	0 B ₂ B ₁ B ₀	
								jdisp		
	PSW.bit, \$addr16	PC ← \$addr16 if PSW.bit = 1	3	5/7	12	9		0 0 0 0	0 0 1 0	
								1 0 1 1	0 B ₂ B ₁ B ₀	
								jdisp		

Instruction Set (cont)

Mnemonic	Operand	Operation	Bytes	Clocks			Flags			Operation Code (Bits 7-0) Bytes B1 thru B5
				Int	ROM	Branch	No Branch	Z	AC	
Conditional Branch (cont)										
BF	saddr.bit,\$addr16	PC ← \$addr16 if (saddr.bit) = 0	4	5-9	15	12				0 0 0 0 1 0 0 0 1 0 1 0 1 B ₂ B ₁ B ₀ Saddr-offset jdisp
	sfr.bit,\$addr16	PC ← \$addr16 if sfr.bit = 0	4	7/9	16	13				0 0 0 0 1 0 0 0 1 0 1 0 1 B ₂ B ₁ B ₀ Sfr-offset jdisp
	A.bit,\$addr16	PC ← \$addr16 if A.bit = 0	3	5/7	12	9				0 0 0 0 0 0 1 1 1 0 1 0 1 B ₂ B ₁ B ₀ jdisp
	X.bit,\$addr16	PC ← \$addr16 if X.bit = 0	3	5/7	12	9				0 0 0 0 0 0 1 1 1 0 1 0 0 B ₂ B ₁ B ₀ jdisp
	PSW.bit,\$addr16	PC ← \$addr16 if PSW.bit = 0	3	5/7	12	9				0 0 0 0 0 0 1 0 1 0 1 0 0 B ₂ B ₁ B ₀ jdisp
BTCLR	saddr.bit,\$addr16	PC ← \$addr16 if (saddr.bit) = 1 then reset (saddr.bit)	4	5-13	15	12				0 0 0 0 1 0 0 0 1 1 0 1 1 B ₂ B ₁ B ₀ Saddr-offset jdisp
	sfr.bit,\$addr16	PC ← \$addr16 if sfr.bit = 1 then reset sfr.bit	4	7/13	18	13				0 0 0 0 1 0 0 0 1 1 0 1 1 B ₂ B ₁ B ₀ Sfr-offset jdisp
	A.bit,\$addr16	PC ← \$addr16 if A.bit = 1 then reset A.bit	3	5/9	12	9				0 0 0 0 0 0 1 1 1 1 0 1 1 B ₂ B ₁ B ₀ jdisp
	X.bit,\$addr16	PC ← \$addr16 if X.bit = 1 then reset X.bit	3	5/9	12	9				0 0 0 0 0 0 1 1 1 1 0 1 0 B ₂ B ₁ B ₀ jdisp
	PSW.bit,\$addr16	PC ← \$addr16 if PSW.bit = 1 then reset PSW.bit	3	5/8	12	9	x	x	x	0 0 0 0 0 0 1 0 1 1 0 1 0 B ₂ B ₁ B ₀ jdisp

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Instruction Set (cont)

Mnemonic	Operand	Operation	Bytes	Clocks			Flags		Operation Code (Bits 7-0) Bytes B1 thru B5
				Int ROM	Branch	No Branch	Z	AC CY	
Conditional Branch (cont)									
DBNZ	ri,\$addr16	ri ← ri - 1, then PC ← \$addr16 if ri ≠ 0	2	3/5	9	6			0 0 1 1 0 0 1 R ₀ jdisp
	saddr,\$addr16	(saddr) ← (saddr) - 1, then PC ← \$addr16 if (saddr) ≠ 0	3	4-10	12	9			0 0 1 1 1 0 1 1 Saddr-offset jdisp
CPU Control									
MOV	STBC,#byte	STBC ← byte	4	10		15			0 0 0 0 1 0 0 1 1 1 0 0 0 0 0 0 Data Data
SEL	Rbn	RBS1-0 ← n, n = 0-3	2	2		6			0 0 0 0 0 1 0 1 1 0 1 0 1 0 N ₁ N ₀
NOP		No Operation	1	2		3			0 0 0 0 0 0 0 0
EI		IE ← 1 (Enable Interrupt)	1	2		3			0 1 0 0 1 0 1 1
DI		IE ← 0 (Disable Interrupt)	1	2		3			0 1 0 0 1 0 1 0