Z86C93

CMOS Z8® MULTIPLY/DIVIDE MICROCONTROLLER

FEATURES

- Complete Microcontroller, up to 24 I/O lines, and up to 64 Kbytes of Addressable External Space each for Program and Data Memory.
- 16 x 16-Bit Hardwired Multiplier with 32-Bit Product in 17 Clock Cycles.
- 32 x 16-Bit Hardwired Divider with 16-Bit Quotient and 16-Bit Remainder in 20 Clock Cycles.
- 256-Byte Register File, Including 236 General-Purpose Registers, up to Three I/O Port Registers, and 16 Status and Control Registers.
- 17-Byte Expanded Register File, Including Two General-Purpose Registers and 15 Status and Control Registers.
- Two 16-Bit Counter Timers with 6-Bit Prescalers.
- Two Low Power Standby Modes, STOP and HALT
- On-Chip Oscillator that Accepts Crystal or External Clock Drive.
- Vectored, Priority Interrupts for I/O, Counter/Timers and UART.
- Three 16-Bit Counter/Timers with 4-Bit Prescaler, One Capture Register and a Fast Decrement Mode.
- Register Pointer for Short, Fast Instructions that can Access Any One of the 16 Working Register Groups.
- Additional Emulation Signals SCLK, IACK, and /SYNC are Made Available.
- Full-Duplex UART
- 3.3V ±10% Operation at 25 MHz
- 5.0V ±10% Operation at 20, 25, and 33 MHz

GENERAL DESCRIPTION

The Z86C93 is a CMOS ROMless Z8® microcontroller enhanced with a hardwired 16-bit x 16-bit multiplier and 32-bit/16-bit divider and three 16-bit counter timers (Figure 1). A capture register and a fast decrement mode is also provided. It is offered in 40-pin DIP, 44-pin PLCC, 44-pin QFP, and 48-pin VQFP (Figures 2, 3, 4, 5, and 6). Besides the four additional signals (SCLK, IACK, /SYNC, and /WAIT), the Z86C93 is compatible with the Z86C91, yet it offers a much more powerful mathematical capability.

The Z86C93 provides up to 16 output address lines permitting an address space of up to 64 Kbytes of data and program memory each. Eight address outputs (AD7-AD0) are provided by a multiplexed, 8-bit, Address/Data bus. The remaining eight bits can be provided by the software configuration of Port 0 to output address bits A15-A8.

Notes:
All Signals with a preceding front slash, "/", are active Low, e.g., B/W (WORD is active Low); /B/W (BYTE is active Low, only).

Power connections follow conventional descriptions below:

Connection	Circuit	Device
Power	V_{CC}	V_{DD}
Ground	GND	V_{SS}

GENERAL DESCRIPTION (Continued)

There are 256 registers located on-chip and organized as 236 general-purpose registers, 16 control and status registers, and four I/O port registers. The register file can be divided into 16 groups of 16 working registers each. Configuration of the registers in this manner allows the use of short format instructions; in addition, any of the individual registers can be accessed directly. There are an additional 17 registers implemented in the Expanded Register File in Banks D and E. Two of the registers may be used as general-purpose registers, while 15 registers supply the data and control functions for the Multiply/Divide Unit and Counter/Timer blocks.

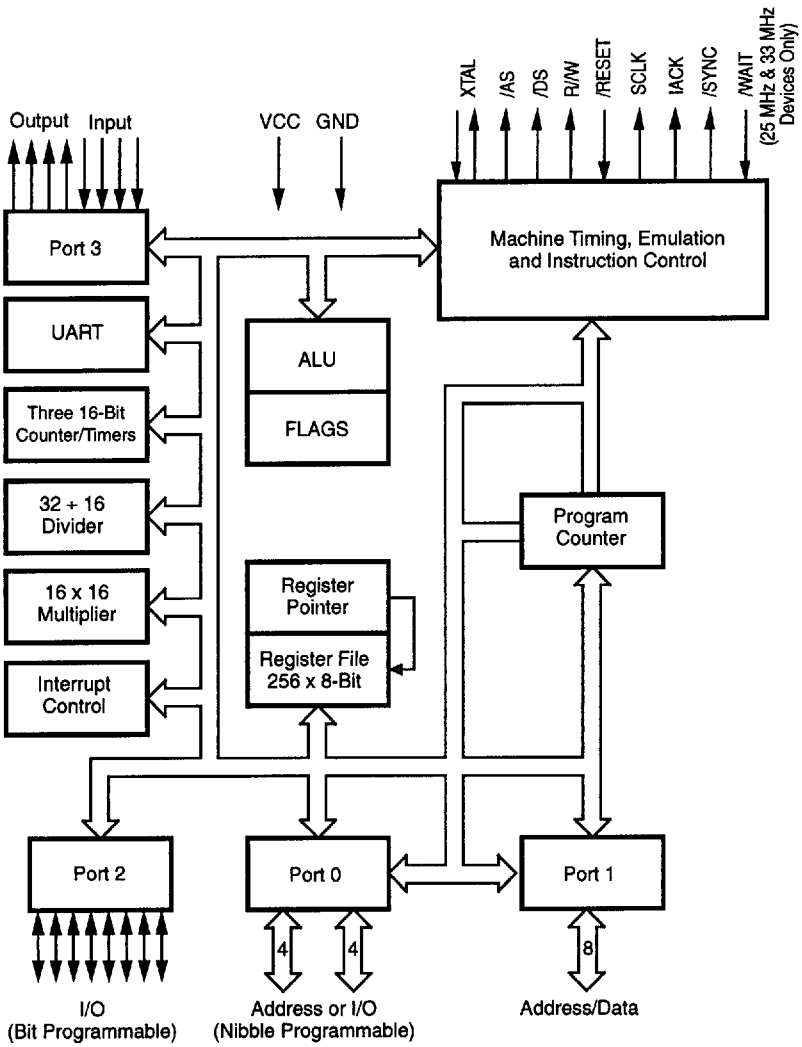

Figure 1. Functional Block Diagram

PIN DESCRIPTION

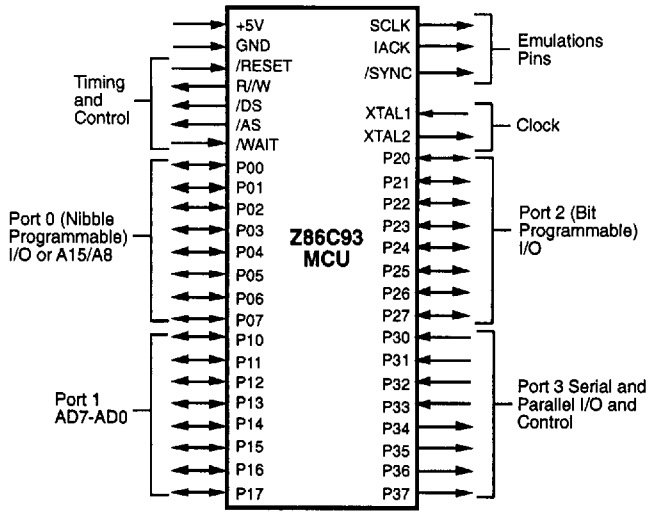

Figure 2. Z86C93 Pin Functions

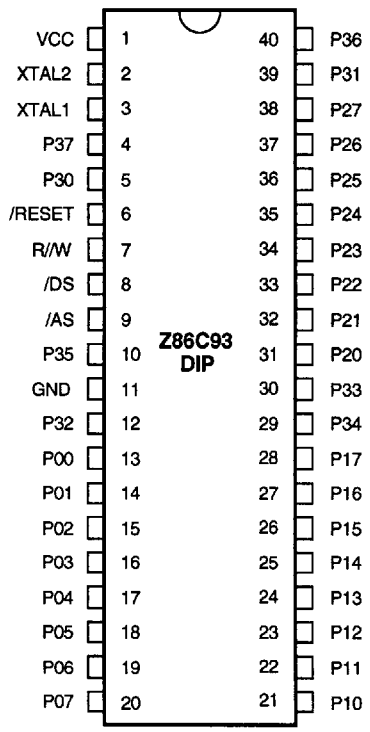

Figure 3. 40-Pin DIP Assignments

Table 1. 40-Pin DIP Pin Identification

Pin #	Symbol	Function	Direction
1	V_{CC}	Power Supply	Input
2	XTAL1	Crystal, Oscillator Clock	Input
3	XTAL2	Crystal, Oscillator Clock	Output
4	P37	Port 3, Pin 7	Output
5	P30	Port 3, Pin 0	Input
6	/RESET	Reset	Input
7	R/W	Read/Write	Output
8	/DS	Data Strobe	Output
9	/AS	Address Strobe	Output
10	P35	Port 3, Pin 5	Output
11	GND	Ground	Input
12	P32	Port 3, Pin 2	Input
13-20	P00-P07	Port 0, Pins 0,1,2,3,4,5,6,7	In/Output
21-28	P10-P17	Port 1, Pins 0,1,2,3,4,5,6,7	In/Output
29	P34	Port 3, Pin 4	Output
30	P33	Port 3, Pin 3	Input
31-38	P20-P27	Port 2, Pins 0,1,2,3,4,5,6,7	In/Output
39	P31	Port 3, Pin 1	Input
40	P36	Port 3, Pin 6	Output

PIN DESCRIPTION (Continued)

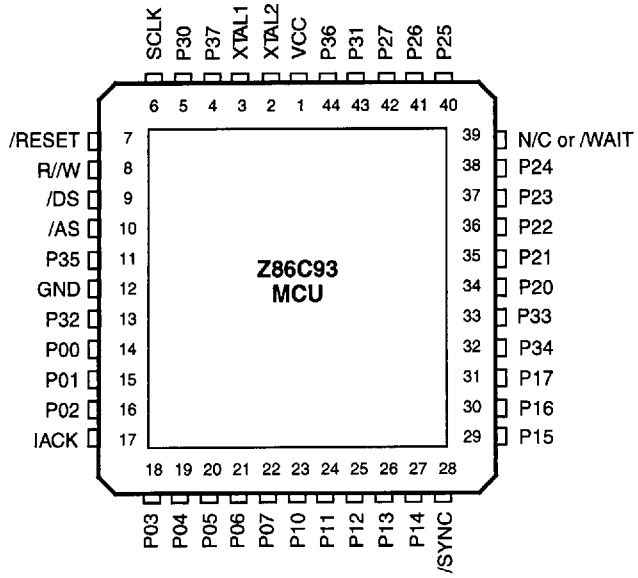

Figure 4. 44-Pin PLCC Pin Assignments

Table 2. 44-Pin PLCC Pin Identification

No	Symbol	Function	Direction
1	V_{CC}	Power Supply	Input
2	XTAL2	Crystal, Osc. Clock	Output
3	XTAL1	Crystal, Osc. Clock	Input
4	P37	Port 3, Pin 7	Output
5	P30	Port 3, Pin 0	Input
6	SCLK	System Clock	Output
7	/RESET	Reset	Input
8	R/W	Read/Write	Output
9	/DS	Data Strobe	Output
10	/AS	Address Strobe	Output
11	P35	Port 3, Pin 5	Output
12	GND	Ground	Input
13	P32	Port 3, Pin 2	Input

No	Symbol	Function	Direction
14-16	P00-P02	Port 0, Pins 0,1,2	In/Output
17	IACK	Int. Acknowledge	Output
18-22	P03-P07	Port 0, Pins 3,4,5,6,7	In/Output
23-27	P10-P14	Port 1, Pins 0,1,2,3,4	In/Output
28	/SYNC	Synchronize Pin	Output
29-31	P15-P17	Port 1 Pins 5,6,7	In/Output
32	P34	Port 3, Pin 4	Output
33	P33	Port 3, Pin 3	Input
34-38	P20-P24	Port 2 Pins 0,1,2,3,4	In/Output
39	N/C	Not Connected (20 MHz)	Input
	/WAIT	WAIT (25 or 33 MHz)	Input
40-42	P25-P27	Port 2, Pins 5,6,7	In/Output
43	P31	Port 3, Pin 1	Input
44	P36	Port 3, Pin 6	Output

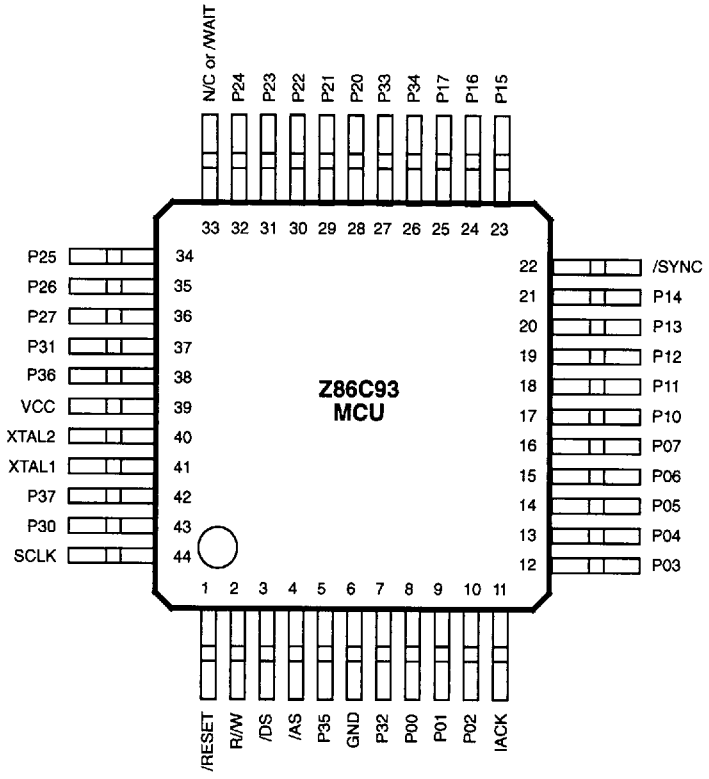

Figure 5. 44-Pin QFP Pin Assignments

Table 3. 44-Pin QFP Pin Identification

No	Symbol	Function	Direction
1	/RESET	Reset	Input
2	R//W	Read/Write	Output
3	/DS	Data Strobe	Output
4	/AS	Address Strobe	Output
5	P35	Port 3, Pin 5	Input
6	GND	Ground	Input
7	P32	Port 3, Pin 2	Input
8-10	P00-P02	Port 0, Pins 0,1,2	In/Output
11	IACK	Int. Acknowledge	Output
12-16	P03-P07	Port 0, Pins 3,4,5,6,7	In/Output
17-21	P10-P14	Port 1, Pins 0,1,2,3,4	In/Output
22	/SYNC	Synchronize Pin	Output
23-25	P15-P17	Port 1, Pins 5,6,7	In/Output
26	P34	Port 3, Pin 4	Output
27	P33	Port 3, Pin 3	Input
28-32	P20-P24	Port 2, Pins 0,1,2,3,4	In/Output
33	N/C	Not Connected (20 MHz)	Input
	/WAIT	WAIT (25 or 33 MHz)	Input
34-36	P25-P27	Port 2, Pins 5,6,7	In/Output
37	P31	Port 3, Pin 1	Input
38	P36	Port 3, Pin 6	Output
39	V_{CC}	Power Supply	Input
40	XTAL2	Crystal, Osc. Clock	Output
41	XTAL1	Crystal, Osc. Clock	Input
42	P37	Port 3, Pin 7	Output
43	P30	Port 3, Pin 0	Input
44	SCLK	System Clock	Output

PIN DESCRIPTION (Continued)

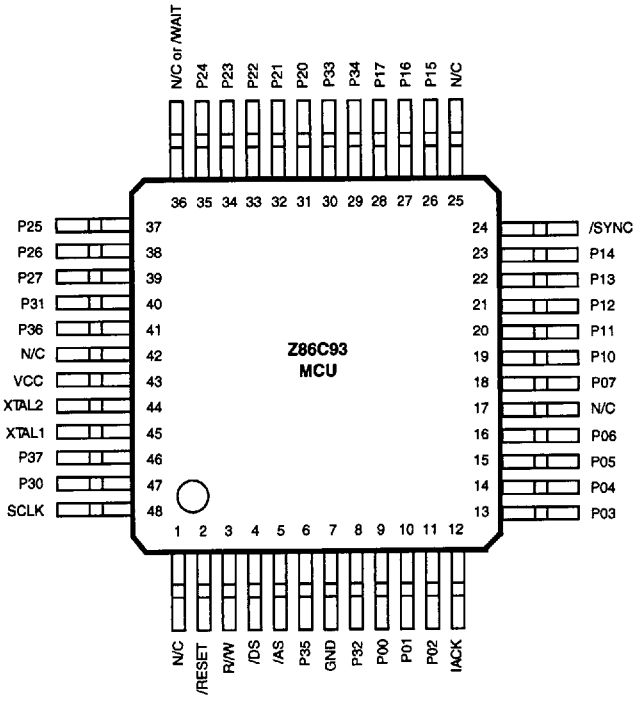

Figure 6. 48-Pin VQFP Pin Assignments

Table 4. 48-Pin VQFP Pin Identification

No	Symbol	Function	Direction
1	N/C	Not Connected	Input
2	/RESET	Reset	Input
3	R/W	Read/Write	Output
4	/DS	Data Strobe	Output
5	/AS	Address Strobe	Output
6	P35	Port 3, Pin 5	Input
7	GND	Ground	Input
8	P32	Port 3, Pin 2	Input
9-11	P00-P02	Port 0, Pins 3,4,5,6	In/Output
12	IACK	Int. Acknowledge	Output
13-16	P03-P06	Port 0, Pins 3,4,5,6	In/Output
17	N/C	Not Connected	Input
18	P07	Port 0, Pin 7	In/Output
19-23	P10-P14	Port 1, Pins 0,1,2,3,4	In/Output
24	/SYNC	Synchronize Pin	Output

No	Symbol	Function	Direction
25	N/C	Not Connected	Input
26-28	P15-P17	Port 1, Pins 5,6,7	In/Output
29	P34	Port 3, Pin 4	Output
30	P33	Port 3, Pin 33	Input
31-35	P20-P24	Port 2, Pins 0,1,2,3,4	In/Output
36	N/C	Not Connected (20 MHz)	Input
	/WAIT	WAIT (25 or 33 MHz)	Input
37-39	P25-P27	Port 2, Pins 5,6,7	In/Output
40	P31	Port 3, Pin 1	Input
41	P36	Port 3, Pin 6	Output
42	N/C	Not Connected	Input
43	V_{CC}	Power Supply	Input
44	XTAL2	Crystal, Osc. Clock	Output
45	XTAL1	Crystal, Osc. Clock	Input
46	P37	Port 3, Pin 7	Output
47	P30	Port 3, Pin 0	Input
48	SCLK	System Clock	Output

PIN FUNCTIONS

/DS (output, active Low). Data Strobe is activated once for each external memory transfer. For a READ operation, data must be available prior to the trailing edge of /DS. For WRITE operations, the falling edge of /DS indicates that output data is valid.

/AS (output, active Low). Address Strobe is pulsed once at the beginning of each machine cycle. Address output is through Port 1 for all external programs. When /RESET is asserted, /AS toggles. Memory address transfers are valid at the trailing edge of /AS.

XTAL1, XTAL2 *Crystal 1, Crystal 2* (time-based input and output, respectively). These pins connect a parallel-resonant crystal, ceramic resonator, LC, or any external single-phase clock to the on-chip oscillator and buffer.

R/W (output, read High/write Low). The Read/Write signal is Low when the MCU is writing to the external program or data memory. It is High when the MCU is reading from the external program or data memory.

/RESET (input, active Low). To avoid asynchronous and noisy reset problems, the Z86C93 is equipped with a reset filter of four external clocks (4TpC). If the external /RESET signal is less than 4TpC in duration, no reset occurs.

On the fifth clock after the /RESET is detected, an internal RST signal is latched and held for an internal register count of 18 external clocks, or for the duration of the external /RESET, whichever is longer. During the reset cycle, /DS is held active Low while /AS cycles at a rate of 2TpC. When /RESET is deactivated, program execution begins at location 000CH. Reset time must be held Low for 50 ms or until V_{CC} is stable, whichever is longer.

SCLK *System Clock* (output). The internal system clock is available at this pin. Available in the PLCC, QFP, and VQFP packages only.

IACK *Interrupt Acknowledge* (output, active High). This output, when High, indicates that the Z86C93 is in an interrupt cycle. Available in the PLCC, QFP, and VQFP packages only.

/SYNC (output, active Low). This signal indicates the last clock cycle of the currently executing instruction. Available in the PLCC, QFP, and VQFP packages only.

/WAIT (input, active Low). Introduces asynchronous wait states into the external memory fetch cycle. When this input goes Low during an external memory access, the Z86C93 freezes the fetch cycle until this pin goes High. This pin is sampled after /DS goes Low; should be pulled up if not used. Available in the 25 MHz and 33 MHz devices only.

Port 0 (P07-P00). Port 0 is an 8-bit, nibble programmable, bidirectional, TTL compatible port. These eight I/O lines can be configured under software control as a nibble I/O port, or as an address port for interfacing external memory. When used as an I/O port, Port 0 may be placed under handshake control. In this configuration, Port 3, lines P32 and P35 are used as the handshake control /DAV0 and RDY0 (Data Available and Ready). Handshake signal assignment is dictated by the I/O direction of the upper nibble P07-P04. The lower nibble must have the same direction as the upper nibble to be under handshake control.

For external memory references, Port 0 can provide address bits A11-A8 (lower nibble) or A15-A8 (lower and upper nibble) depending on the required address space. If the address range requires 12 bits or less, the upper nibble of Port 0 can be programmed independently as I/O while the lower nibble is used for addressing. If one or both nibbles are needed for I/O operation, they must be configured by writing to the Port 0 Mode register.

After a hardware reset, Port 0 lines are defined as address lines A15-A8, and extended timing is set to accommodate slow memory access. The initialization routine can include reconfiguration to eliminate this extended timing mode (Figure 7). The /OEN (Output Enable) signal in Figure 7 is an internal signal.

The Auto Latch on Port 0 puts valid CMOS levels on all CMOS inputs which are not externally driven. Whether this level is 0 or 1, cannot be determined. A valid CMOS level, rather than a floating node, reduces excessive supply current flow in the input buffer.

PIN FUNCTIONS (Continued)

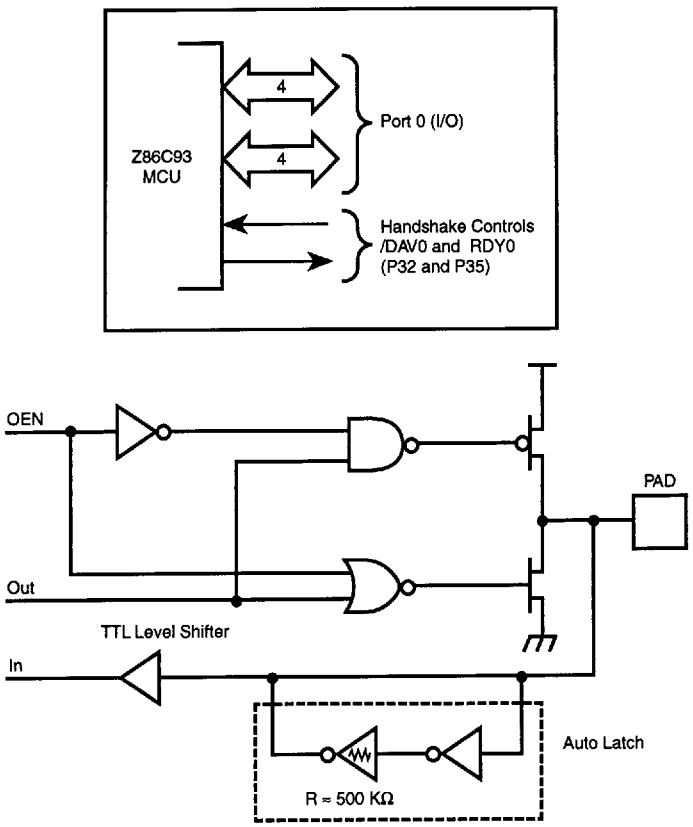

Figure 7. Port 0 Configuration

Port 1 (P17-P10). Port 1 is an 8-bit, TTL compatible port. It has multiplexed Address (A7-A0) and Data (D7-D0) ports for interfacing external memory (Figure 8).

If more than 256 external locations are required, Port 0 must output the additional lines.

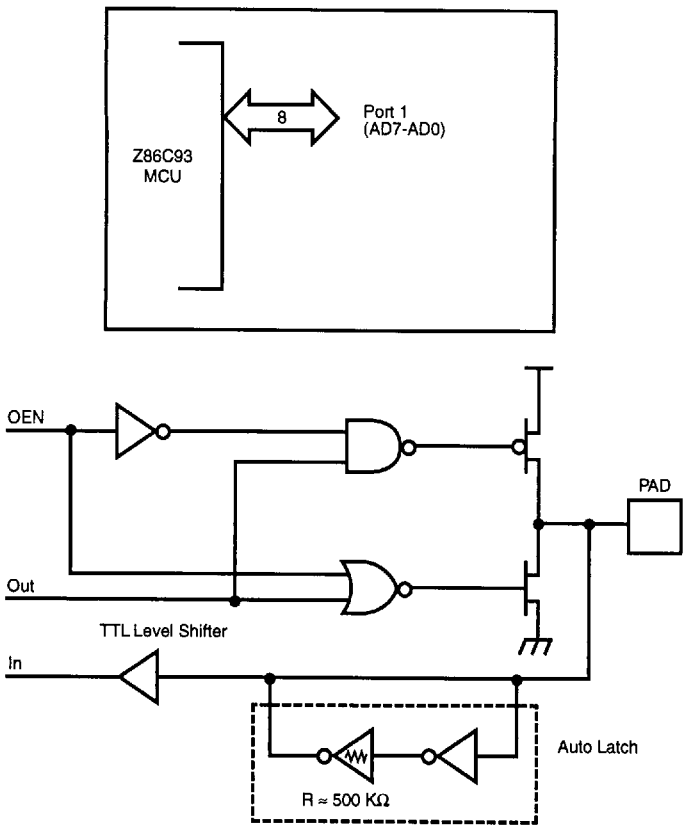

Figure 8. Port 1 Configuration

PIN FUNCTIONS (Continued)

Port 2 (P27-P20). Port 2 is an 8-bit, bit programmable, bidirectional, TTL compatible port. Each of these eight I/O lines can be independently programmed as an input or output or globally as an open-drain output. Port 2 is always available for I/O operation. When used as an I/O port, Port 2 is placed under handshake control. In this configuration, Port 3 lines P31 and P36 are used as the handshake control lines /DAV2 and RDY2. The handshake signal assignment for Port 3 lines P31 and P36 is dictated by the direction (input or output) assigned to P27 (Figure 9).

The Auto Latch on Port 2 puts valid CMOS levels on all CMOS inputs which are not externally driven. Whether this level is 0 or 1, cannot be determined. A valid CMOS level, rather than a floating node, reduces excessive supply current flow in the input buffer.

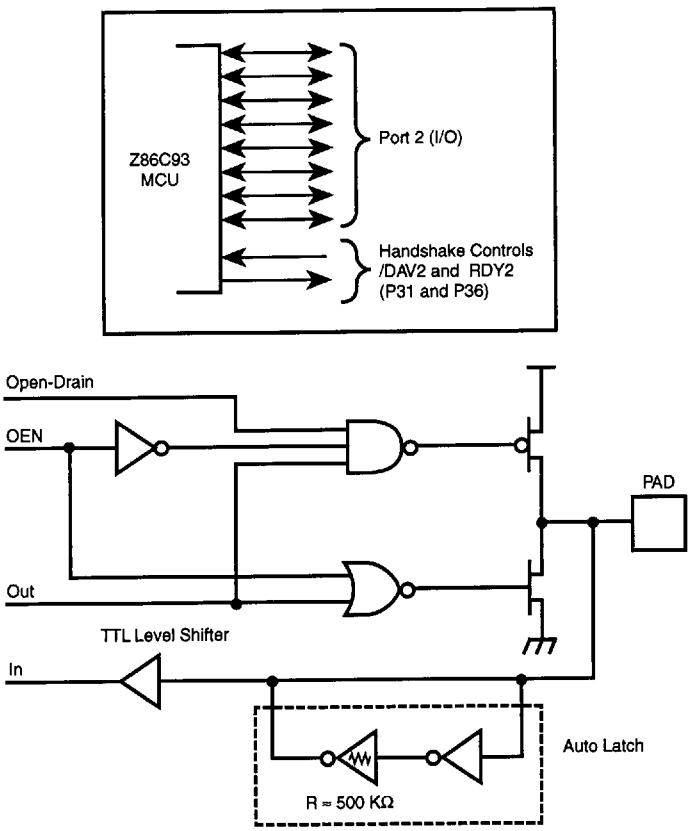

Figure 9. Port 2 Configuration

Port 3 (P37-P30). Port 3 is an 8-bit, TTL compatible four fixed input and four fixed output ports. These eight I/O lines have four fixed (P33-P30) input and four fixed (P37-P34) output ports. Port 3 pins P30 and P37 when used as serial I/O, are programmed as serial in and serial out, respectively (Figure 10 and Table 5).

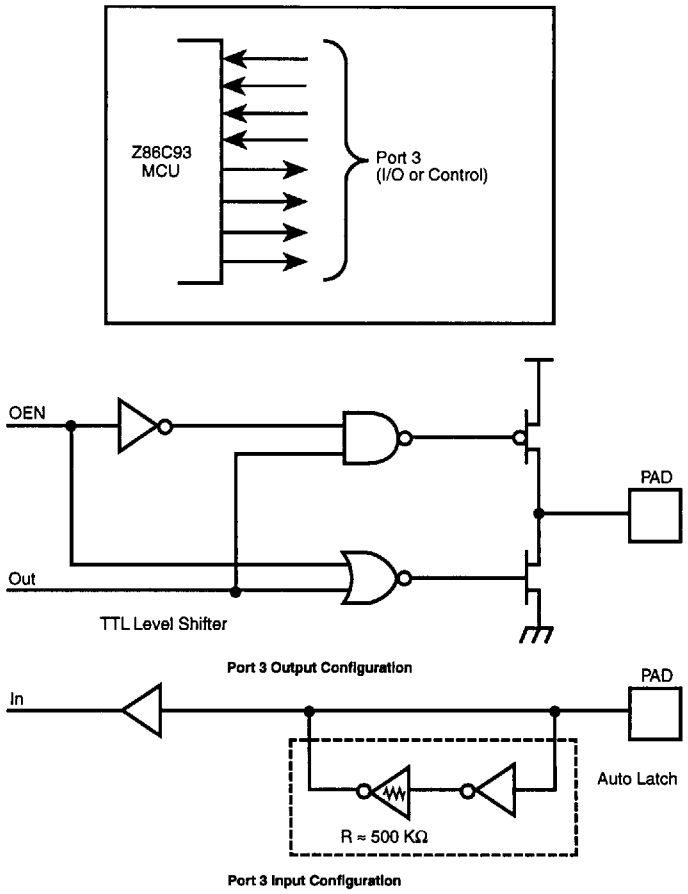

Figure 10. Port 3 Configuration

PIN FUNCTIONS (Continued)

Table 5. Port 3 Pin Assignments

Pin #	I/O	CTC1	Int.	P0HS	P2HS	UART	Ext.
P30	In		IRQ3			Serial In	
P31	In	T_{IN}	IRQ2		D/R		
P32	In		IRQ0	D/R			
P33	In		IRQ1				
P34	Out						DM
P35	Out			R/D			
P36	Out	T_{OUT}			R/D		
P37	Out					Serial Out	

Port 3 is configured under software control to provide the following control functions: handshake for Ports 0 and 2 (/DAV and RDY); four external interrupt request signals (IRQ0-IRQ3); timer input and output signals (T_{IN} and T_{OUT}), and Data Memory Select (/DM).

Port 3 lines P30 and P37 can be programmed as serial I/O lines for full-duplex serial asynchronous receiver/transmitter operation. The bit rate is controlled by the Counter/Timer0.

The Z86C93 automatically adds a start bit and two stop bits to transmitted data (Figure 11). Odd parity is also available as an option. Eight data bits are always transmitted, regardless of parity selection. If parity is enabled, the eighth bit is the odd parity bit. An interrupt request (IRQ4) is generated on all transmitted characters.

Received data must have a start bit, eight data bits and at least one stop bit. If parity is on, bit 7 of the received data is replaced by a parity error flag. Received characters generate the IRQ3 interrupt request.

The Auto Latch on Port 3 puts a valid CMOS level on all CMOS inputs that are not externally driven. Whether this level is zero or one, cannot be determined. A valid CMOS level rather than a floating node reduces excessive supply current flow in the input buffer.

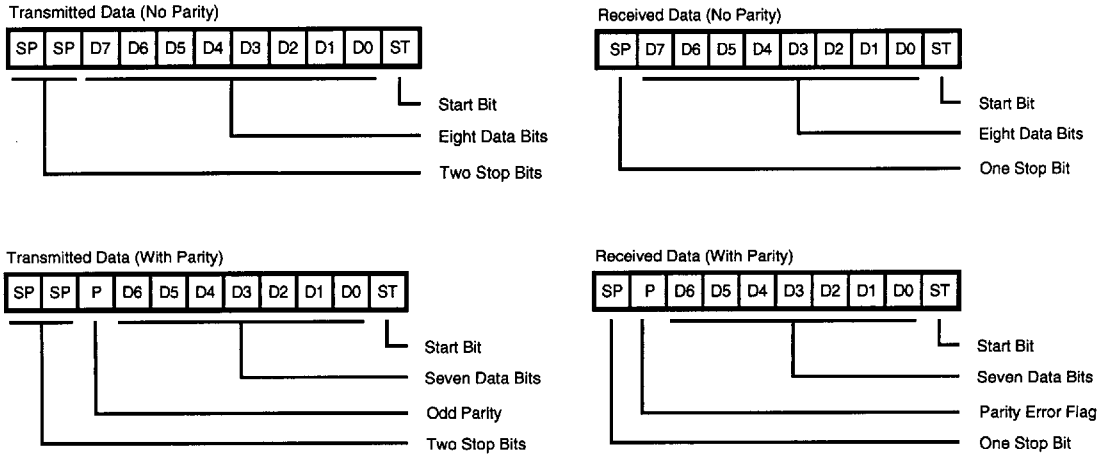

Figure 11. Serial Data Formats

ADDRESS SPACE

Program Memory. The Z86C93 can address up to 64 Kbytes of external program memory. Program execution begins at external location 000CH after a reset.

Data Memory. The Z96C93 can address up to 64 Kbytes of external data memory. External data memory is included with, or separated from, the external program memory space. /DM, an optional I/O function that can be programmed to appear on P34 is used to distinguish between data and program memory space (Figure 12). The state of the /DM signal is controlled by the type instruction being executed. An LDC opcode references PROGRAM (/DM inactive) memory, and an LDE instruction references DATA (/DM active Low) memory.

Expanded Register File. The register file has been expanded to allow for additional system control registers, and for mapping of additional peripheral devices along with I/O ports into the register address area (Figure 13). The Z8 register address space R0 through R15 has now been implemented as 16 groups of 16 registers per group. These register groups are known as the ERF (Expanded Register File). Bits 7-4 of register RP select the working register group. Bits 3-0 of register RP select the expanded register group (Figure 14). The registers that are used in the multiply/divide unit reside in the Expanded Register File at Bank E and those for the additional timer control words reside in Bank D. The rest of the Expanded Register is not physically implemented and is open for future expansion.

Register File. The Register File consists of four I/O port registers, 236 general-purpose registers and 16 control and status registers. The instructions can access registers directly or indirectly through an 8-bit address field. The Z86C93 also allows short 4-bit register addressing using the Register Pointer (Figure 15). In the 4-bit mode, the Register File is divided into 16 working register groups, each occupying 16 continuous locations. The Register Pointer addresses the starting location of the active working-register group.

Note: Register Group E0-EF can only be accessed through working registers and indirect addressing modes.

Stack. The Z86C93 has a 16-bit Stack Pointer (R254-R255), used for external stack, that resides anywhere in the data memory. An 8-bit Stack Pointer (R255) is used for the internal stack that resides within the 236 general-purpose registers (R4-R239). The high byte of the Stack Pointer (SPH, Bits 8-15) can be used as a general-purpose register when using internal stack only.

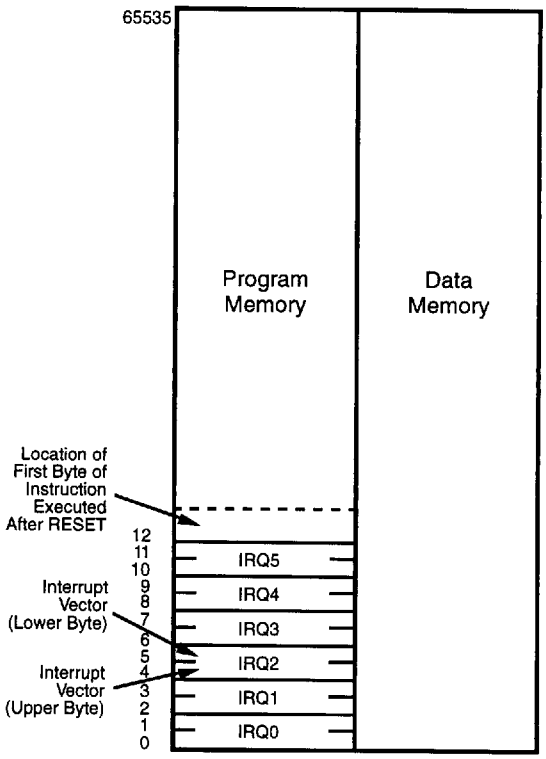

Figure 12. Program and Data Memory Configuration

ADDRESS SPACE (Continued)

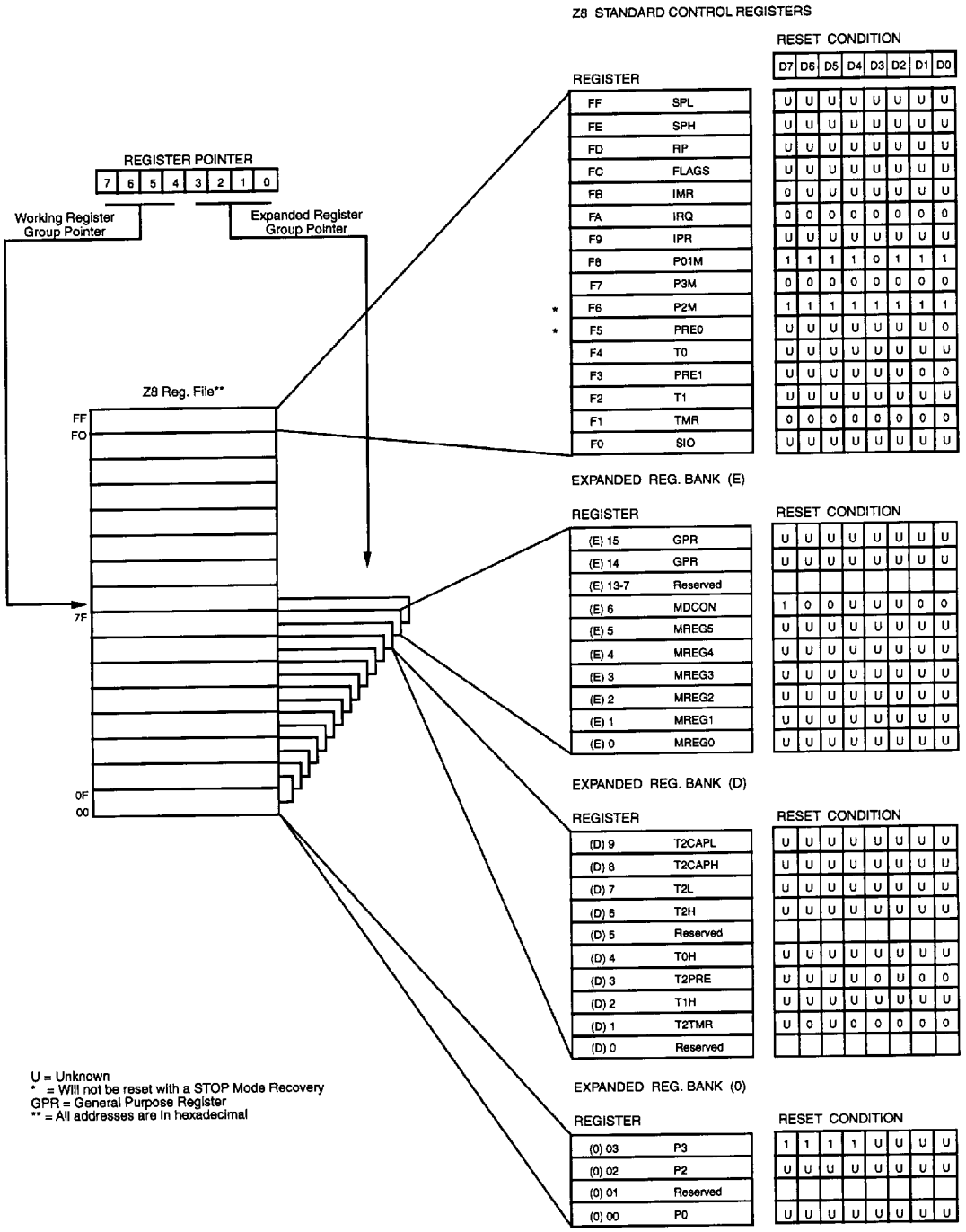

Figure 13. Register File

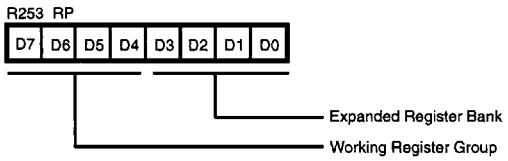

Figure 14. Register Pointer Register

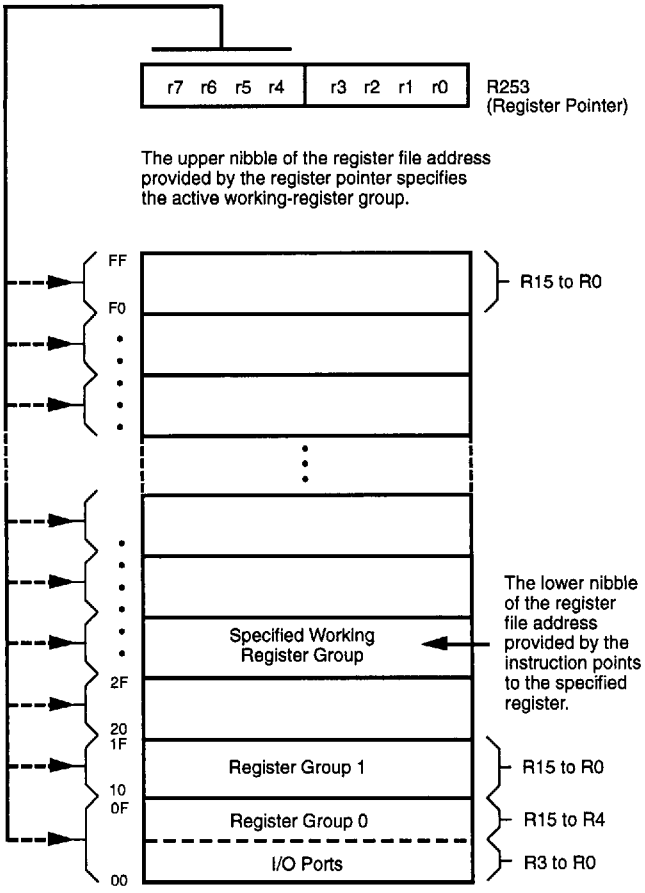

Figure 15. Register Pointer

FUNCTIONAL DESCRIPTION

Multiply/Divide Unit

The Multiply/Divide unit describes the basic features, implementation details of the interface between the Z8 and the multiply/divide unit.

Basic features:

- 16 x 16-bit multiply with 32-bit product
- 32 x 16-bit divide with 16-bit quotient and 16-bit remainder
- Unsigned integer data format
- Simple interface to Z8®

Interface to Z8. The following is a brief description of the register mapping in the multiply/divide unit and its interface to the Z8 (Figure 16).

The multiply/divide unit is interfaced like a peripheral. The only addressing mode available with the peripheral interface is register addressing. In other words, all of the operands are in the respective registers before a multiplication/division can start.

Register Mapping. The registers used in the multiply/divide unit are mapped onto the expanded register file in Bank E. The exact register locations used are shown below.

Register	Address
MREG0	(E) 00
MREG1	(E) 01
MREG2	(E) 02
MREG3	(E) 03
MREG4	(E) 04
MREG5	(E) 05
MDCON	(E) 06
GPR	(E) 14
GPR	(E) 15

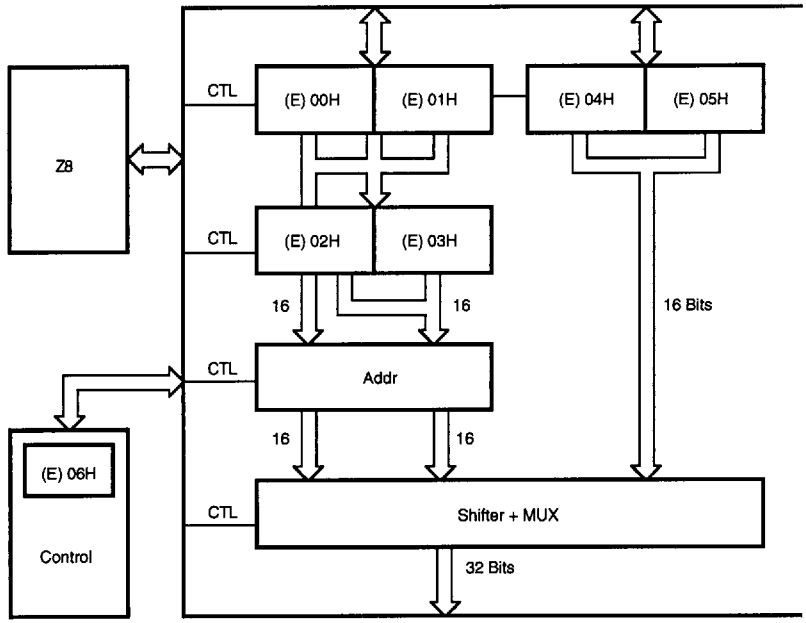

Figure 16. Multiply/Divide Unit Block Diagram

Register Allocation. The following is the register allocation during multiplication.

Register	Allocation
Multiplier high byte	MREG2
Multiplier low byte	MREG3
Multiplicand high byte	MREG4
Multiplicand low byte	MREG5
Result high byte of high word	MREG0
Result low byte of high word	MREG1
Result high byte of low word	MREG2
Result low byte of low word	MREG3
Multiply/Divide Control register	MDCON

The following is the register allocation during division.

Register	Allocation
High byte of high word of dividend	MREG0
Low byte of high word of dividend	MREG1
High byte of low word of dividend	MREG2
Low byte of low word of dividend	MREG3
High byte of divisor	MREG4
Low byte of divisor	MREG5
High byte of remainder	MREG0
Low byte of remainder	MREG1
High byte of quotient	MREG2
Low byte of quotient	MREG3
Multiply/Divide Control register	MDCON

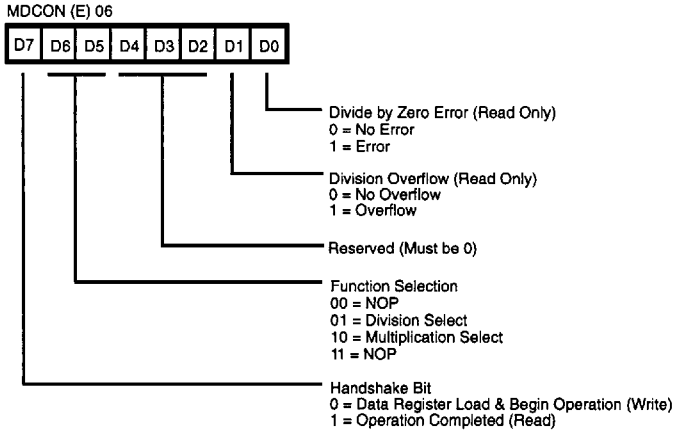

Figure 17. Multiply/Divide Control Register (MDCON)

Control Register. The MDCON (Multiply/Divide Control Register) is used to interface with the multiply/divide unit (Figure 16). Specific functions of various bits in the control register are given below.

DONE Bit (D7). This bit is a handshake bit between the math unit and the external world. On power-up, this bit is set to 1 to indicate that the math unit has completed the previous operation and is ready to perform the next operation.

Before starting a new multiply/divide operation, this bit should be reset to 0 by the processor/programmer. This indicates that all the data registers have been loaded and the math unit can now begin a multiply/divide operation. During the process of multiplication or division, this bit is write-protected. Once the math unit completes its operation it sets this bit to indicate the completion of operation. The processor/programmer can then read the result.

MULSL *Multiply Select* (D6). If this bit is set to 1, it indicates a multiply operation directive. Like the DONE bit, this bit is also write-protected during math unit operation and is reset to 0 by the math unit upon starting of the multiply/divide operation.

DIVSL *Division Select* (D5). Similar to D6, D5 starts a division operation.

D4-D2. Reserved.

FUNCTIONAL DESCRIPTION (Continued)

DIVOVF *Division Overflow* (D1). This bit indicates an overflow during the division process. Division overflow occurs when the high word of the dividend is greater than or equal to the divisor. This bit is read only. When set to 1, it indicates overflow error.

DIVZR *Division by Zero* (D0). When set to 1, this indicates an error of division by 0. This bit is read only.

Example: Upon reset, the status of the MDCON register is 100uuu00b (D7 to D0).

u = Undefined
x = Irrelevant
b = Binary

If multiplication operation is desired, the MDCON register is set to 010xxxxxb.

If the MDCON register is READ during multiplication, it would have a value of 000uuu00b.

Upon completion of multiplication, the result of the MDCON register is 100uuu00b.

If division operation is desired, the MDCON register is set to 001xxxxxb.

During division operation, the register would contain 000uu??b (?- value depends on the DIVIDEND, DIVISOR).

Upon completion of division operation, the MDCON register contains 100uuu??b.

Note that once the multiplication/division operation starts, all data registers (MREG5 through MREG0) are write-protected and so are the writable bits of the MDCON register. The write protection is released once the math unit operation is complete. However, the registers may be read at any time.

A multiplication sequence would look like:

1. Load multiplier and multiplicand.
2. Load MDCON register to start multiply operation.
3. Wait for the DONE bit of the MDCON register to be set to 1 and then read results.

Note that while the multiply/divide operation is in progress, the programmer can use the Z8 to do other things. Also, since the multiplication/division takes a fixed number of cycles, he can start reading the results before the DONE bit is set.

During a division operation, the error flag bits are set at the beginning of the division operation which means the flag bits can be checked by the Z8 while the division operation is being done.

The two general purpose registers can be used as scratch pad registers or as external data memory address pointers during an LDE instruction. MREG0 through MREG5, if not used for multiplication or division, can be used as general purpose registers.

Performance of Multiplication. The actual multiplication takes 17 internal clock cycles. It is expected that the chip would run at a 10 MHz internal clock frequency (external clock divided-by-two). This results in an actual multiplication time (16 x 16-bit) of 1.7 µs. If the time to load operands and read results is included:

Number of internal clock cycles to load 5 registers: 30
Number of internal clock cycles to read 4 registers: 24

The total internal clock cycles to perform a multiplication is 71. This results in a net multiplication time of 7.1 µs. Note that this would be the worst case. This assumes that all of the operands are loaded from the external world as opposed to some of the operands being already in place as a result of a previous operation whose destination register is one of the math unit registers.

Performance of Division. The actual division needs 20 internal clock cycles. This translates to 2.0 µs for the actual division at 10 MHz (internal clock speed). If the time to load operands and read results is included:

Number of internal clock cycles to load operands: 42
Number of internal clock cycles to read results: 24

The total internal clock cycles to perform a division is 86. This translates to 8.6 µs at 10 MHz.

Counter/Timers

This section describes the enhanced features of the counter/timers (CTC) on the Z86C93. It contains the register mapping of CTC registers and the bit functions of the newly added Timer2 control register.

In a standard Z8, there are two 8-bit programmable counter/timers (T0 and T1), each driven by its own 6-bit programmable prescaler. The T1 prescaler is driven by internal or external clock sources; however, the T0 prescaler is driven by the internal clock only.

The 6-bit prescalers divide the input frequency of the clock source by any integer number from 1 to 64. Each prescaler drives its counter, which decrements the value (1 to 256) that has been loaded into the counter. When the counter reaches the end of the count, a timer interrupt request IRQ4 (T0) or IRQ5 (T1), is generated.

The counters are programmed to start, stop, restart to continue, or restart from the initial value. The counters can also be programmed to stop upon reaching zero (single pass mode) or to automatically reload the initial value and continue counting (modulo-n continuous mode).

The counters, but not the prescalers, are read at any time without disturbing their value or count mode. The clock source for T1 is user-definable and is either the internal microprocessor clock divided by four, or an external signal input through Port 3. The Timer Mode register configures the external timer input (P31) as an external clock, a trigger input that is retriggerable or non-retriggerable, or as a gate input for the internal clock. The counter/timers are cascaded by connecting the T0 output to the input of T1. Either T0 or T1 can be outputted through P36.

The following are the enhancements made to the counter/timer block on the Z86C93 (Figure 18):

- T0 counter length is extended to 16 bits. For example, T0 now has a 6-bit prescaler and 16-bit down counter.
- T1 counter length is extended to 16 bits. For example, T1 now has a 6-bit prescaler and 16-bit down counter.
- A new counter/timer T2 is added. T2 has a 4-bit prescaler and a 16-bit down counter with capture register.

These three counters are cascadable as shown in Table 6. The result is that T2 may be extendable to 32 bits and T1 extendable to 24 bits. Bits 1 and 0 (CAS1 AND CAS0) of the T2 Prescaler Register (PRE2) determine the counter length.

Table 6. Counter Length Configurations

CAS1	CAS0	T0	T1	T2
0	0	8	8	32
0	1	16	16	16
1	0	8	24	16
1	1	8	16	24

The controlling clock input to T2 is programmed to XTAL/2 or XTAL/8 (only when T2 counter length is 16 bits), which results in a resolution of 100 ns at an external XTAL clock speed of 20 MHz.

FUNCTIONAL DESCRIPTION (Continued)

Capture Register. T2 has a 16-bit capture register associated with T2 HIGH BYTE and T2 LOW BYTE registers. The negative going transition on P33 enables the latching of the current T2 value (16 bits) into the capture register. The register mapping of the capture register is in Bank D (Figure 13). Note that the negative transition on P33 is capable of generating an interrupt. Also, the negative transition on P33 always latches the current T2 value into the capture register. There is no need for a control bit to enable/disable the latching; the capture register is read only.

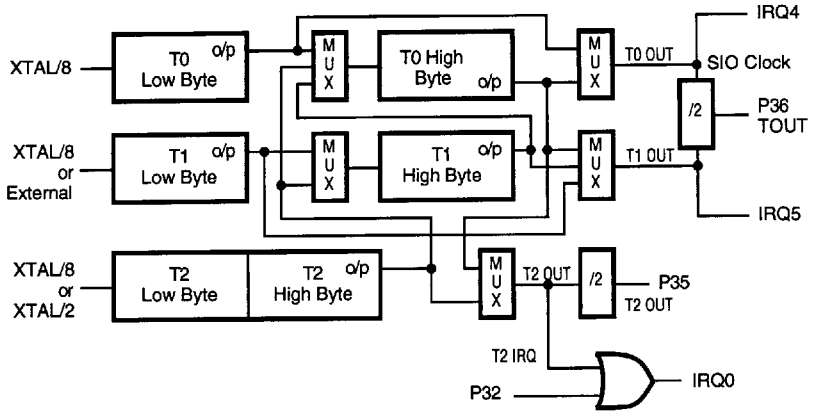

Figure 18. Counter/Timer Block Diagram

Operation

Except for the programmable down counter length and clock input, T2 is identical to T0.

T0 and T1 retain all their features except that now they are extendable interims of the down-counter length.

The output of T2, under program control, goes to an output (P35). Also, the interrupt generated by T2 is ORed with the interrupt request generated by P32. Note that the service routine then has to poll the T2 flag bit and also clear it (bit 7 of T2 Timer Mode Register).

On power-up, T0 and T1 are configured in the 8-bit down counter length mode (to be compatible with Z86C91) and T2 is in the 32-bit mode with its output disabled (no interrupt is generated and T2 output ***does not*** go to port P35).

The UART uses T0 for generating the bit clock. This means, while using UART, T0 should be in 8-bit mode. So, while using the UART there are only two independent timer/counters.

The counters are configured in the following manner:

Timer	Mode	Byte
T0	8-bit	Low Byte (T0)
T0	16-bit	High Byte (T0) + Low Byte (T0)
T1	8-bit	Low Byte (T1)
T1	16-bit	High Byte (T1)+ Low Byte (T1)
T1	24-bit	High Byte (T0) + High Byte (T1) + Low Byte (T1)
T2	16-bit	High Byte (T2) + Low Byte (T2)
T2	24-bit	High Byte (T0) + High Byte (T2) + Low Byte (T2)
T2	32-bit	High Byte (T0) + High Byte (T1) + High Byte (T2) + Low Byte (T2)

Note that the T2 interrupt is logically ORed with P32 to generate IRQ0.

The T2 Timer Mode register is shown in Figure 19. Upon reaching end of count, bit 7 of this register is set to one. This bit ***is not*** reset in hardware and it has to be cleared by the interrupt service routine.

T2 interrogates the state of the Count Mode Bit (D2) once it has counted down to its zero value. T2 then makes the decision to continue counting (Modulo-n Mode) or stop (Single Pass Mode). Monitor this function if attempting to modify the count mode prior to the end of count bit (D7) being set.

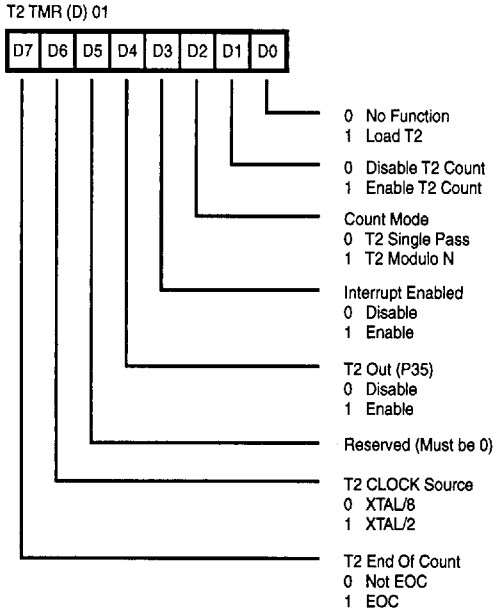

Figure 19. T2 Timer Mode Register (T2)

The register map of the new CTC registers is shown in Figure 13. T0 high byte and T1 high byte are at the same relative locations as their respective low bytes, but in a different register bank.

The T2 Prescaler Register is shown in Figure 20. Bits 1 and 0 of this register control the various cascade modes of the counters.

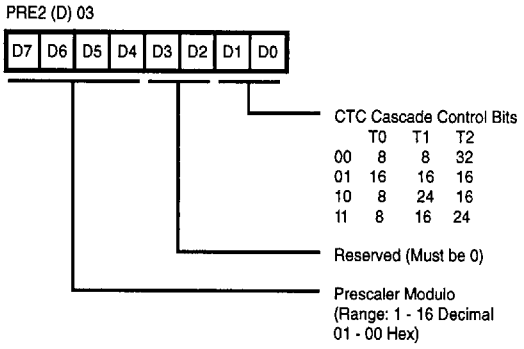

Figure 20. T2 Prescaler Register (PRE2)

2

FUNCTIONAL DESCRIPTION (Continued)

Interrupts

The Z86C93 has six different interrupts from nine different sources (Figure 21). The interrupts are maskable and prioritized. The nine sources are divided as follows: four sources are claimed by Port 3 lines P33-P30, one in Serial Out, one in Serial In, and three in the counter/timers. The Interrupt Mask Register globally or individually enables or disables the six interrupt requests. When more than one interrupt is pending, priorities are resolved by a programmable priority encoder that is controlled by the Interrupt Priority register. All Z86C93 interrupts are vectored through locations in the program memory. When an interrupt machine cycle is activated an interrupt request is granted. Thus, this disables all of the subsequent interrupts, save the Program Counter and Status Flags, and then branches to the program memory vector location reserved for that interrupt. This memory location and the next byte contain the 16-bit address of the interrupt service routine for that particular interrupt request.

To accommodate polled interrupt systems, interrupt inputs are masked and the Interrupt Request register is polled to determine which of the interrupt requests need service. Software initiated interrupts are supported by setting the appropriate bit in the Interrupt Request Register (IRQ).

Internal interrupt requests are sampled on the falling edge of the last cycle of every instruction. The interrupt request must be valid 5TpC before the falling edge of the last clock cycle of the currently executing instruction.

When the device samples a valid interrupt request, the next 48 (external) clock cycles are used to prioritize the interrupt, and push the two PC bytes and the FLAG register on the stack. The following nine cycles are used to fetch the interrupt vector from external memory. The first byte of the interrupt service routine is fetched beginning on the 58th TpC cycle following the internal sample point, which corresponds to the 63rd TpC cycle following the external interrupt sample point.

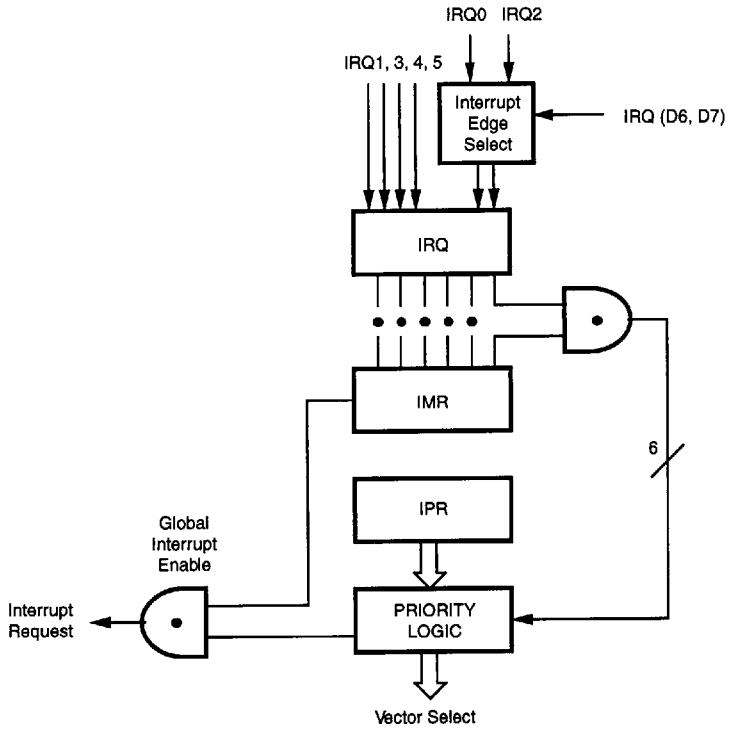

Figure 21. Interrupt Block Diagram

Table 7. Interrupt Types, Sources, and Vectors

Name	Source	Vector Location	Comments
IRQ0	/DAV0, P32, T2	0, 1	External (P32), Programmable Rise or Fall Edge Triggered
IRQ1	P33	2, 3	External (P33), Fall Edge Triggered
IRQ2	/DAV2, P31, T_{IN}	4, 5	External (P31), Programmable Rise or Fall Edge Triggered
IRQ3	P30, Serial In	6, 7	External (P30), Fall Edge Triggered
IRQ4	T0, Serial Out	8, 9	Internal
IRQ5	T1	10, 11	Internal

Clock

The Z86C93 on-chip oscillator has a high-gain, parallel-resonant amplifier for connection to a crystal, LC, ceramic resonator, or any suitable external clock source (XTAL1 = Input, XTAL2 = Output). The external clock levels are not TTL. The crystal should be AT cut, 1 MHz to 25 MHz max, and series resistance (RS) is less than or equal to 100 Ohms. The crystal should be connected across XTAL1 and XTAL2 using the recommended capacitors (10 pF<CL<100 pF) from each pin to ground (Figure 22).

Note: Actual capacitor values specified by the crystal manufacturer.

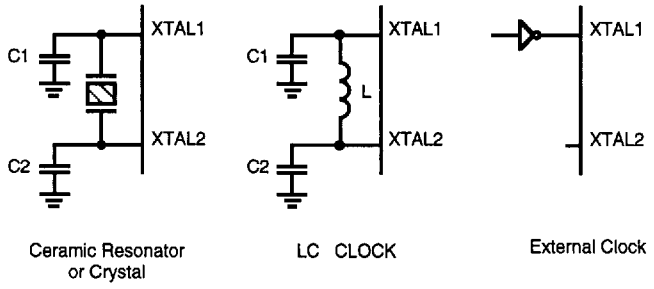

Figure 22. Oscillator Configuration

Power Down Modes

HALT. Turns off the internal CPU clock but not the XTAL oscillation. The counter/timers and the external interrupts IRQ0, IRQ1, IRQ2, and IRQ3 remain active. The devices are recovered by interrupts, either externally or internally generated. An interrupt request must be executed (enabled) to exit HALT mode, After the interrupt service routine, the program continues from the instruction after the HALT.

STOP. This instruction turns off the internal clock and external crystal oscillation and reduces the standby current to 5 µA (typical) or less. The STOP mode is terminated by a /RESET, which causes the processor to restart the application program at address 000CH.

In order to enter STOP (or HALT) mode, it is necessary to first flush the instruction pipeline to avoid suspending execution in mid-instruction. To do this, the user executes a NOP (opcode = OFFH) immediately before the appropriate sleep instruction, i.e.:

```
FF  NOP   ; clear the pipeline
6F  STOP  ; enter STOP mode
          or
FF  NOP   ; clear the pipeline
7F  HALT  ; enter HALT mode
```

ABSOLUTE MAXIMUM RATINGS

Symbol	Description	Min	Max	Units
V_{CC}	Supply Voltage*	–0.3	+7.0	V
T_{STG}	Storage Temp	–65°	+150°	C
T_A	Oper Ambient Temp	†	†	C

Notes:
* Voltages on all pins with respect to GND.
† See Ordering Information

Stresses greater than those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; operation of the device at any condition above those indicated in the operational sections of these specifications is not implied. Exposure to absolute maximum rating conditions for an extended period may affect device reliability.

STANDARD TEST CONDITIONS

The characteristics listed below apply for standard test conditions as noted. All voltages are referenced to GND. Positive current flows into the referenced pin Test Load Diagram (Figure 23).

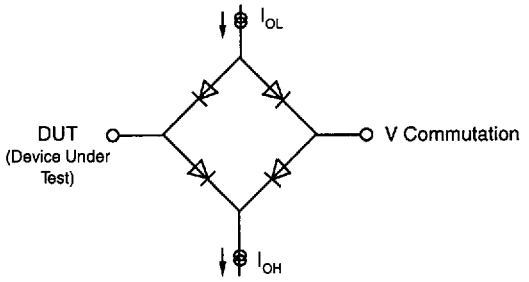

Figure 23. Test Load Diagram

DC ELECTRICAL CHARACTERISTICS

V_{CC} = 3.3V ±10%

Sym	Parameter	T_A = 0°C to +70°C Min	Max	Typical at 25°C	Units	Conditions	Notes
	Max Input Voltage	7			V	I_{IN} < 250 µA	
V_{CH}	Clock Input High Voltage	0.8 V_{CC}	V_{CC}		V	Driven by External Clock Generator	
V_{CL}	Clock Input Low Voltage	–0.3	0.1 V_{CC}		V	Driven by External Clock Generator	
V_{IH}	Input High Voltage	0.7 V_{CC}	V_{CC}		V		
V_{IL}	Input Low Voltage	–0.3	0.1 V_{CC}		V		
V_{OH}	Output High Voltage	1.8			V	I_{OH} = –1.0 mA	
V_{OH}	Output High Voltage	V_{CC} – 100 mV			V	I_{OH} = –100 µA	
V_{OL}	Output Low Voltage	0.4			V	I_{OL} = +1.0 mA	
V_{RH}	Reset Input High Voltage	0.8 V_{CC}	V_{CC}		V		
V_{RI}	Reset Input Low Voltage	–0.3	0.1 V_{CC}		V		
I_{IL}	Input Leakage	–2	2		µA	Test at 0V, V_{CC}	
I_{OL}	Output Leakage	–2	2		µA	Test at 0V, V_{CC}	
I_{IR}	Reset Input Current	–120			µA	V_{RL} = 0V	
I_{CC}	Supply Current		30	20	mA	@ 25 MHz	[1]
I_{CC1}	Stand By Current (HALT mode)		12	8	mA	HALT mode V_{IN} = 0V, V_{CC} @ 25 MHz	[1]
I_{CC2}	Stand By Current (HALT mode)		8	1	µA	STOP mode V_{IN} = 0V, V_{CC}	[1]
I_{ALL}	Auto Latch Low Current	–10	10	5	µA		

Note:
[1] All inputs driven to 0V, V_{CC} and outputs floating.

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DC ELECTRICAL CHARACTERISTICS

V_{CC} = 5.0V ±10%

Sym	Parameter	T_A = 0°C to +70°C Min	Max	Typical at 25°C	Units	Conditions	Notes
	Max Input Voltage	7			V	I_{IN} < 250 µA	
V_{CH}	Clock Input High Voltage	3.8	V_{CC}		V	Driven by External Clock Generator	
V_{CL}	Clock Input Low Voltage	–0.3	0.8		V	Driven by External Clock Generator	
V_{IH}	Input High Voltage	2.0	V_{CC}		V		
V_{IL}	Input Low Voltage	–0.3	0.8		V		
V_{OH}	Output High Voltage	2.4			V	I_{OH} = –2.0 mA	
V_{OH}	Output High Voltage	V_{CC} –100 mV			V	I_{OH} = –100 µA	
V_{OL}	Output Low Voltage	0.4			V	I_{OL} = +5 mA	
V_{RH}	Reset Input High Voltage	3.8	V_{CC}		V		
V_{RI}	Reset Input Low Voltage	–0.3	0.8		V		
I_{IL}	Input Leakage	–2	2		µA	Test at 0V, V_{CC}	
I_{OL}	Output Leakage	–2	2		µA	Test at 0V, V_{CC}	
I_{IR}	Reset Input Current	–120			µA	V_{RL} = 0V	
I_{CC}	Supply Current	55		35	mA	@ 33 MHz	[1]
		40		25	mA	@ 25 MHz	[1]
		30		20	mA	@ 20 MHz	[1]
I_{CC1}	Standby Current (HALT mode)	15		9	mA	HALT mode V_{IN} = 0V, V_{CC} @ 25 MHz	[1]
		20		15	mA	HALT mode V_{IN} = 0V, V_{CC} @ 33 MHz	[1]
		12		7	mA	HALT mode V_{IN} = 0V, V_{CC} @ 20 MHz	[1]
I_{CC2}	Standby Current (STOP mode)	10		1	µA	STOP mode V_{IN} = 0V, V_{CC}	[1]
I_{ALL}	Auto Latch Current	–16	16	5	µA		

Note:
[1] All inputs driven to 0V, or V_{CC} and outputs floating.

AC CHARACTERISTICS

External I/O or Memory Read/Write Timing Diagram

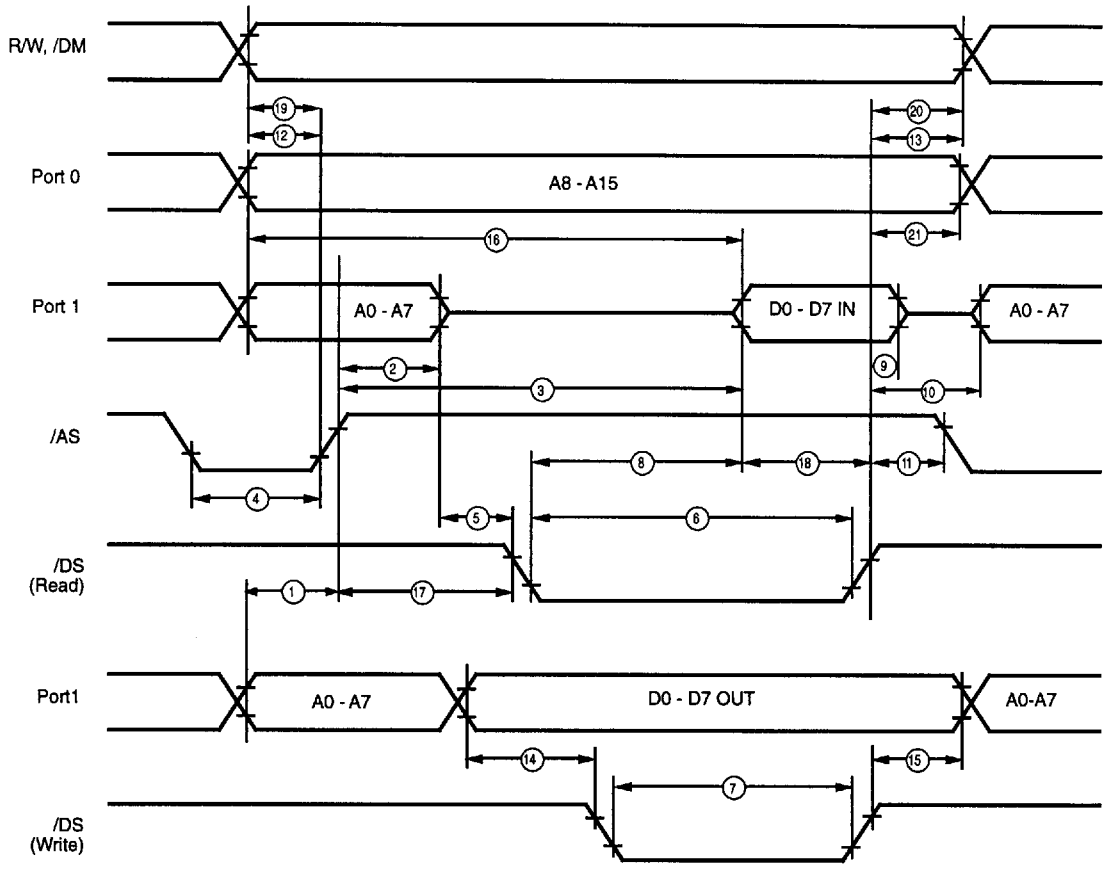

Figure 24. External I/O or Memory Read/Write Timing

AC CHARACTERISTICS

External I/O or Memory Read and Write; DSR/DSW; WAIT Timing Table

No	Symbol	Parameter	T_A = 0°C to +70°C 33 MHz Min	33 MHz Max	25 MHz Min	25 MHz Max	20 MHz Min	20 MHz Max	Typical V_{CC} = 5.0V @ 25°C	Units
1	TdA(AS)	Address Valid To /AS Rise Delay	13		22		26			ns
2	TdAS(A)	/AS Rise To Address Hold Time	20		25		28			ns
3	TdAS(DI)	/AS Rise Data In Req'd Valid Delay		90		130		160		ns
4	TwAS	/AS Low Width	20		28		36			ns
5	TdAZ(DSR)	Address Float To /DS Fall (Read)	0		0		0			ns
6	TwDSR	/DS (Read) Low Width	65		100		130			ns
7	TwDSW	/DS (Write) Low Width	40		65		75			ns
8	TdDSR(DI)	/DS Fall (Read) To Data in Req'd Valid Delay		30		85		100		ns
9	ThDSR(DI)	/DS Rise (Read) to Data In Hold Time	0		0		0			ns
10	TdDS(A)	/DS Rise To Address Active Delay	25		40		48			ns
11	TdDS(AS)	/DS Rise To /AS Delay	16		30		36			ns
12	TdR/W(AS)	R/W Valid To /AS Rise Delay	12		26		32			ns
13	TdDS(R/W)	/DS Rise To R/W Not Valid Delay	12		30		36			ns
14	TdDO(DSW)	Data Out To /DS Fall (Write) Delay	12		34		40			ns
15	ThDSW(DO)	/DS Rise (Write) To Data Out Hold Time	12		34		40			ns
16	TdA(DI)	Address Valid To Data In Req'd Valid Delay		110		160		200		ns
17	TdAS(DSR)	/AS Rise To /DS Fall (Read) Delay	20		40		48			ns
18	TaDI(DSR)	Data In Set-up Time To /DS Rise Read	16		28		36			ns
19	TdDM(AS)	/DM Valid To /AS Rise Delay	10		22		26			ns
20	TdDS(DM)	/DS Rise To /DM Valid Delay							34*	ns
21	ThDS(A)	/DS Rise To Address Valid Hold Time							34*	ns
22	TdXT(SCR)	XTAL Falling to SCLK Rising							20*	ns
23	TdXT(SCF)	XTAL Falling to SCLK Falling							23*	ns
24	TdXT(DSRF)	XTAL Falling to/DS Read Falling							29*	ns
25	TdXT(DSRR)	XTAL Falling to /DS Read Rising							29*	ns
26	TdXT(DSWF)	XTAL Falling to /DS Write Falling							29*	ns
27	TdXT(DSWF)	XTAL Falling to /DS Write Rising							29*	ns
28	TsW(XT)	Wait Set-up Time							10*	ns
29	ThW(XT)	Wait Hold Time							15*	ns
30	TwW	Wait Width (One Wait Time)							25*	ns

Notes:
When using extended memory timing add 2 TpC.
Timing numbers given are for minimum TpC.
* Preliminary value to be characterized.

AC CHARACTERISTICS (Continued)

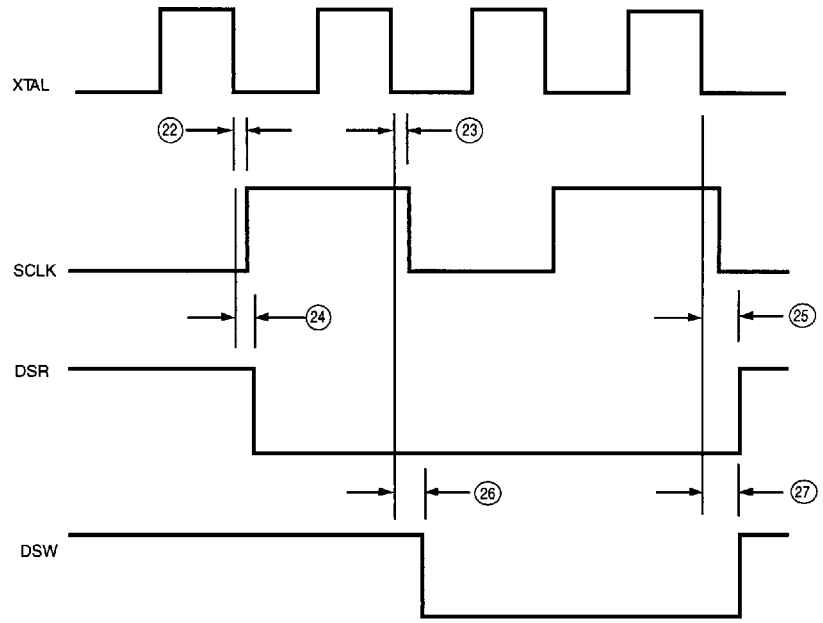

Figure 25. XTAL/SCLK to DSR and DSW Timing

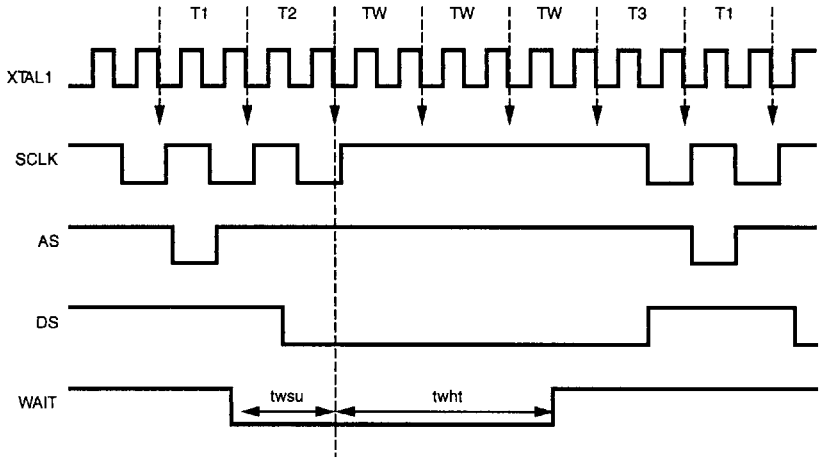

**Figure 26. XTAL/SCLK to WAIT Timing
(25 MHz & 33 MHz Device only)**

AC CHARACTERISTICS
Additional Timing Diagram

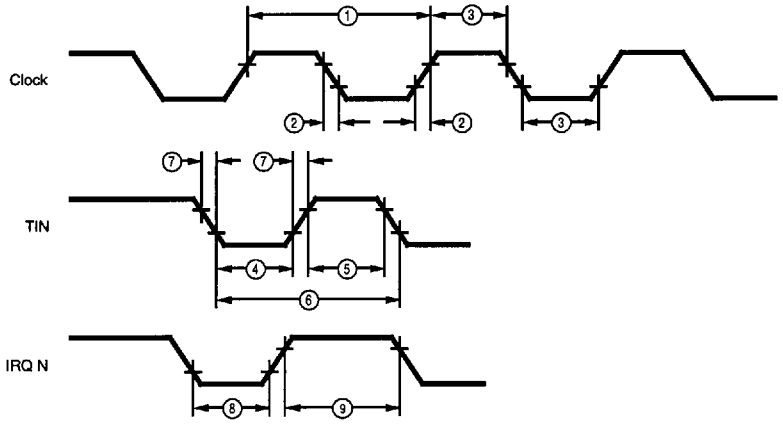

Figure 27. Additional Timing

AC CHARACTERISTICS
Additional Timing Table

			T_A = 0°C to +70° C							
			33 MHz		25 MHz		20 MHz			
No	Symbol	Parameter	Min	Max	Min	Max	Min	Max	Units	Notes
1	TpC	Input Clock Period	30	1000	42	1000	50	1000	ns	[1]
2	TrC,TfC	Clock Input Rise & Fall Times		5		10		10	ns	[1]
3	TwC	Input Clock Width	10	11		15			ns	[1]
4	TwTinL	Timer Input Low Width	75	75		75			ns	[2]
5	TwTinH	Timer Input High Width	3TpC	3TpC		3TpC				[2]
6	TpTin	Timer Input Period	8TpC	8TpC		8TpC				[2]
7	TrTin,TfTin	Timer Input Rise & Fall Times	100	100		100			ns	[2]
8A	TwIL	Interrupt Request Input Low Times	70	70		70			ns	[2,4]
8B	TwIL	Interrupt Request Input Low Times	5TpC	5TpC		5TpC				[2,5]
9	TwIH	Interrupt Request Input High Times	3TpC	3TpC		3TpC				[2,3]

Notes:
[1] Clock timing references use 3.8V for a logic 1 and 0.8V for a logic 0.
[2] Timing references use 2.0V for a logic 1 and 0.8V for a logic 0.
[3] Interrupt references request through Port 3.
[4] Interrupt request through Port 3 (P33-P31).
[5] Interrupt request through Port 30.

AC CHARACTERISTICS
Handshake Timing Diagrams

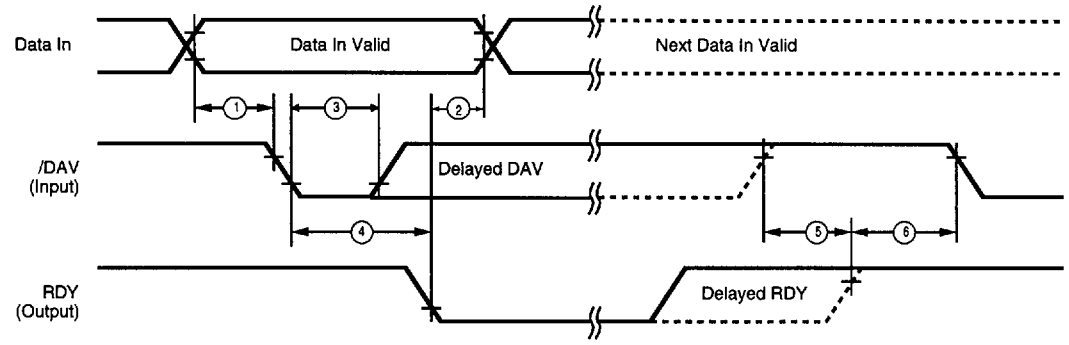

Figure 28. Input Handshake Timing

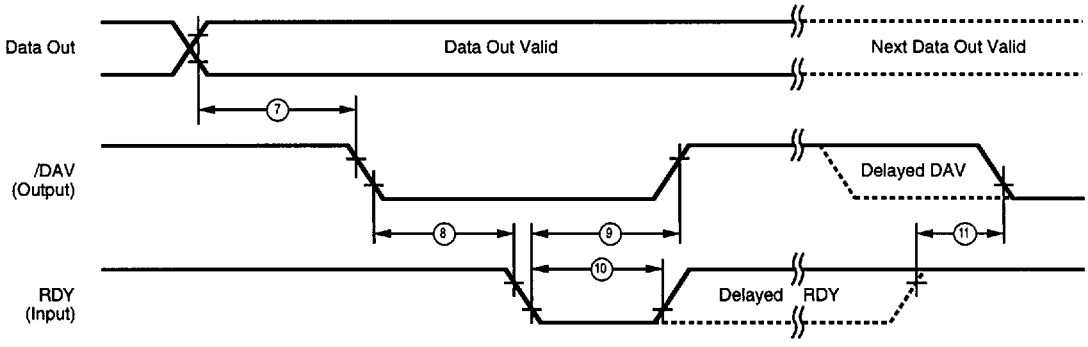

Figure 29. Output Handshake Timing

AC CHARACTERISTICS
Handshake Timing Table

No	Symbol	Parameter	T_A = 0°C to +70°C Min	Max	Units	Data Direction
1	TsDI(DAV)	Data In Setup Time to /DAV	0		ns	In
2	ThDI(DAV)	RDY to Data In Hold Time	0		ns	In
3	TwDAV	/DAV Width	40		ns	In
4	TdDAVIf(RDYf)	/DAV to RDY Delay		70	ns	In
5	TdDAVIr(RDYr)	DAV Rise to RDY Wait Time		40	ns	In
6	TdRDYOr(DAVIf)	RDY Rise to DAV Delay	0		ns	In
7	TdDO(DAV)	Data Out to DAV Delay		TpC	ns	Out
8	TdDAVOf(RDYIf)	/DAV to RDY Delay	0		ns	Out
9	TdRDYIf(DAVOr)	RDY to /DAV Rise Delay		70	ns	Out
10	TwRDY	RDY Width	40		ns	Out
11	TdRDYIr(DAVOf)	RDY Rise to DAV Wait Time		40	ns	Out

EXPANDED REGISTER FILE CONTROL REGISTERS

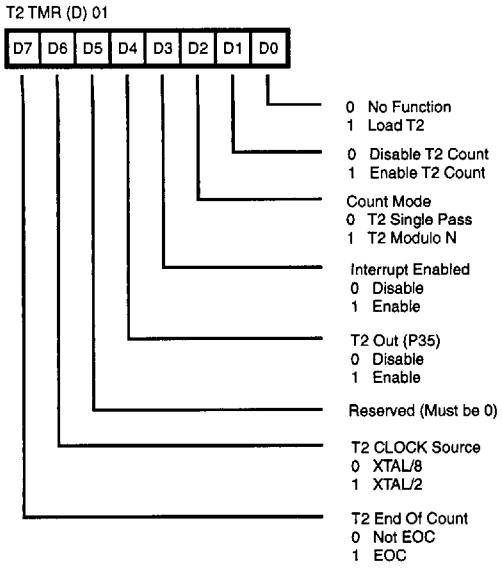

Figure 30. Timer 2 Mode Register (01H: Read/Write)

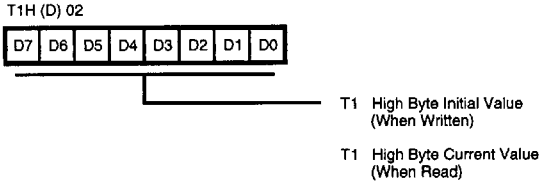

Figure 31. Counter Timer 1 Register High Byte (02H: Read/Write)

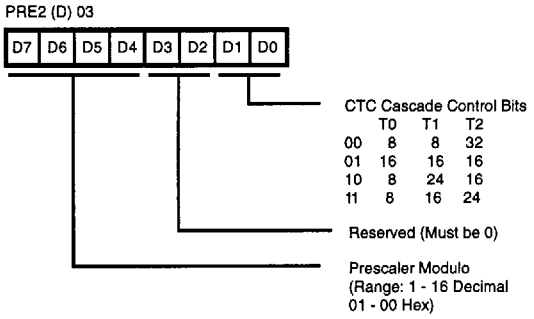

Figure 32. Prescaler 2 Register High Byte (03H: Write Only)

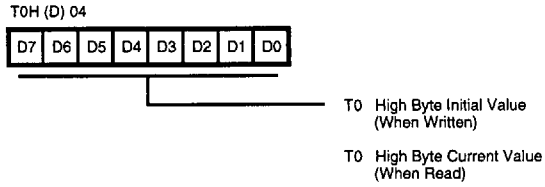

Figure 33. Counter Timer 0 Register High Byte (04H: Read/Write)

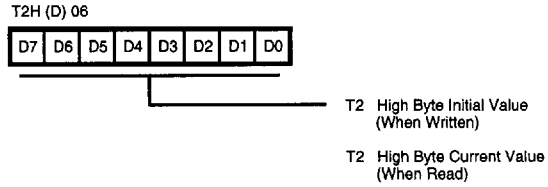

Figure 34. Counter Timer 2 Register High Byte (06H: Read/Write)

Z8 CONTROL REGISTERS

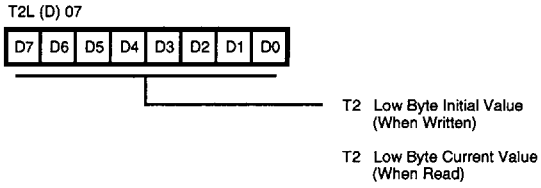

Figure 35. Counter Timer 2 Register Low Byte (07H: Read/Write)

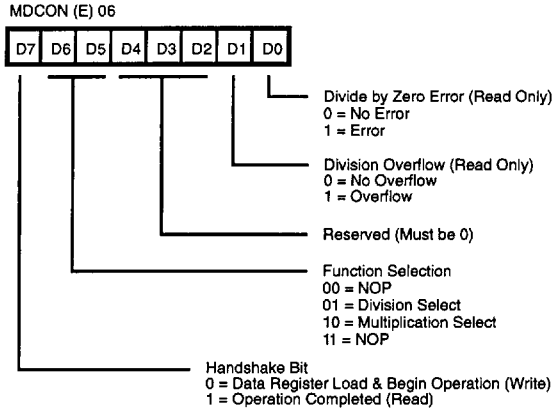

Figure 36. Multiply/Divide Control Register (MDCON)

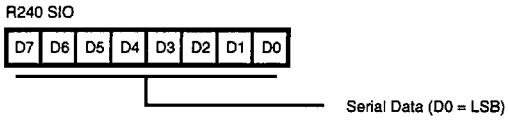

Figure 37. Serial I/O Register (F0H: Read/Write)

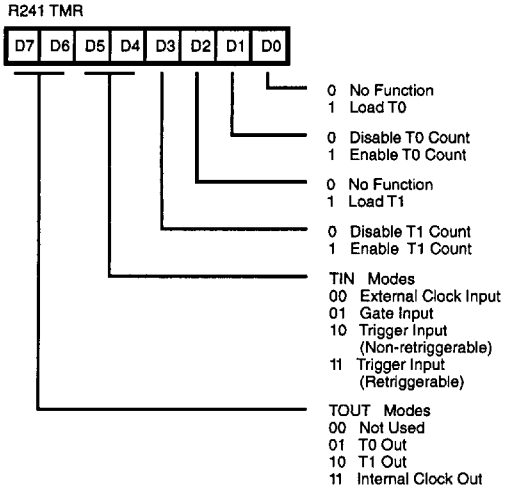

Figure 38. Timer Mode Register (F1H: Read/Write)

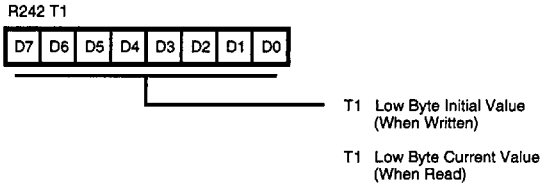

Figure 39. Counter/Timer 1 Register (F2H: Read/Write)

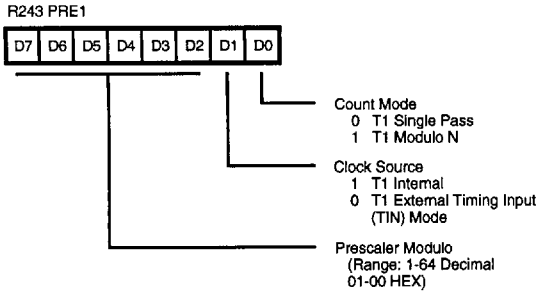

Figure 40. Prescaler 1 Register (F3H: Write Only)

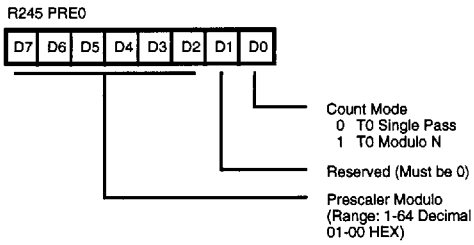

Figure 42. Prescaler 0 Register (F5H: Write Only)

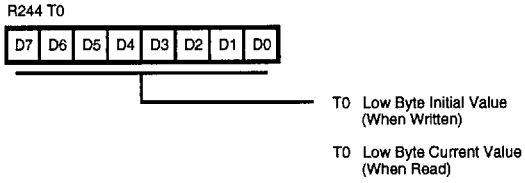

Figure 41. Counter/Timer 0 Register (F4H: Read/Write)

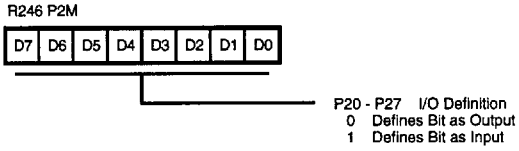

Figure 43. Port 2 Mode Register (F6H: Write Only)

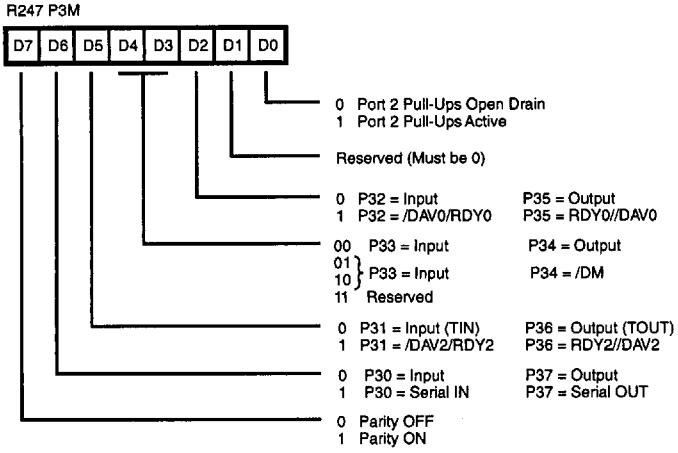

Figure 44. Port 3 Mode Register (F7H: Write Only)

Z8 CONTROL REGISTERS (Continued)

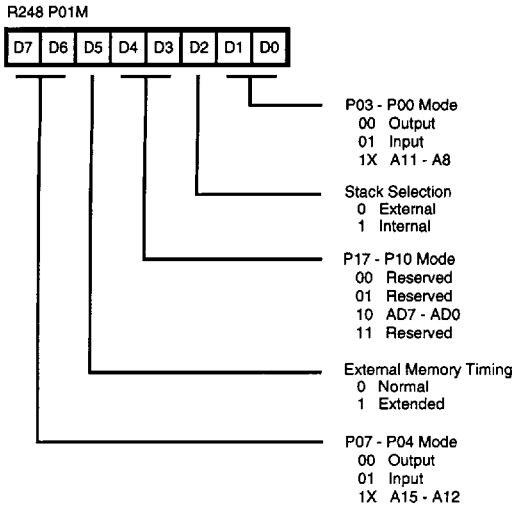

Figure 45. Ports 0 and 1 Mode Registers (F8H: Write Only)

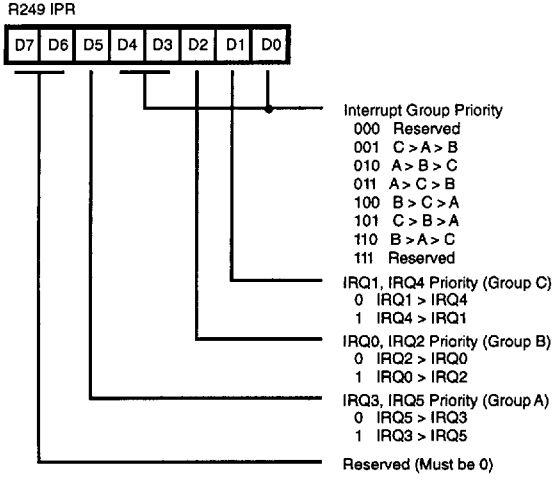

Figure 46. Interrupt Priority Register (F9H: Write Only)

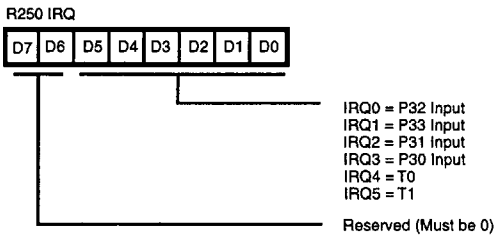

Figure 47. Interrupt Request Register (FAH: Read/Write)

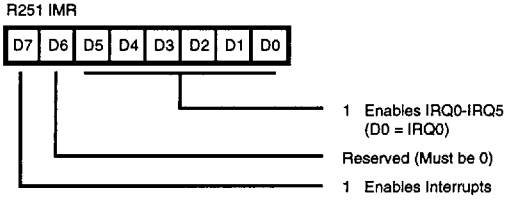

Figure 48. Interrupt Mask Register (FBH: Read/Write)

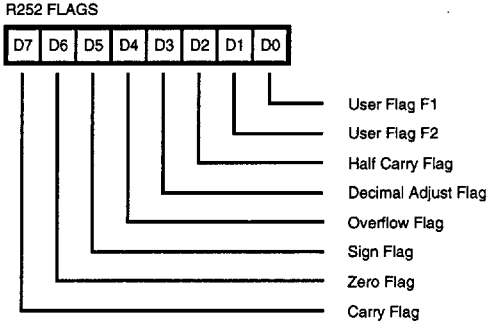

Figure 49. Flag Register (FCH: Read/Write)

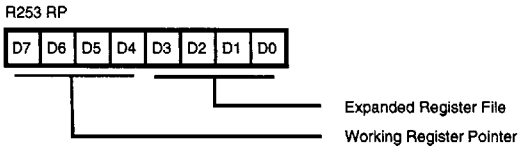

Figure 50. Register Pointer (FDH: Read/Write)

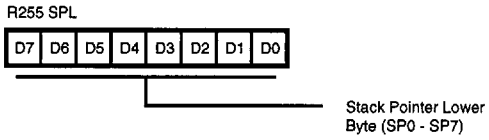

Figure 52. Stack Pointer Low (FFH: Read/Write)

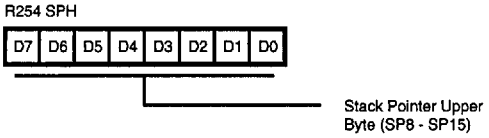

Figure 51. Stack Pointer High (FEH: Read/Write)

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INSTRUCTION SET NOTATION

Addressing Modes. The following notation is used to describe the addressing modes and instruction operations as shown in the instruction summary.

Symbol	Meaning
IRR	Indirect register pair or indirect working-register pair address
Irr	Indirect working-register pair only
X	Indexed address
DA	Direct address
RA	Relative address
IM	Immediate
R	Register or working-register address
r	Working-register address only
IR	Indirect-register or indirect working-register address
Ir	Indirect working-register address only
RR	Register pair or working register pair address

Symbols. The following symbols are used in describing the instruction set.

Symbol	Meaning
dst	Destination location or contents
src	Source location or contents
cc	Condition code
@	Indirect address prefix
SP	Stack Pointer
PC	Program Counter
FLAGS	Flag register (Control Register 252)
RP	Register Pointer (R253)
IMR	Interrupt mask register (R251)

Flags. Control register (R252) contains the following six flags:

Symbol	Meaning
C	Carry flag
Z	Zero flag
S	Sign flag
V	Overflow flag
D	Decimal-adjust flag
H	Half-carry flag

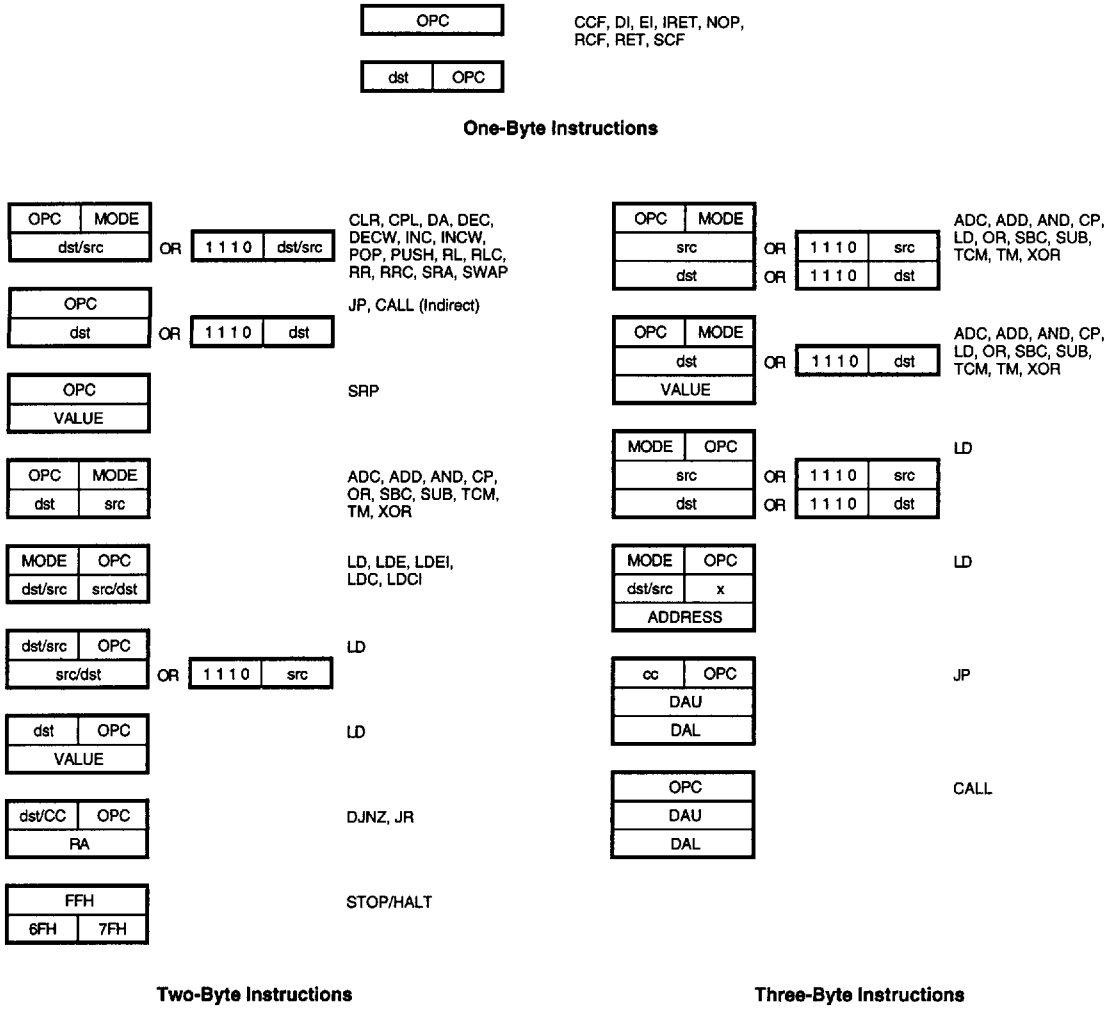
Affected flags are indicated by:

0	Clear to zero
1	Set to one
*	Set to clear according to operation
-	Unaffected
x	Undefined

CONDITION CODES

Value	Mnemonic	Meaning	Flags Set
1000		Always True	
0111	C	Carry	C = 1
1111	NC	No Carry	C = 0
0110	Z	Zero	Z = 1
1110	NZ	Not Zero	Z = 0
1101	PL	Plus	S = 0
0101	MI	Minus	S = 1
0100	OV	Overflow	V = 1
1100	NOV	No Overflow	V = 0
0110	EQ	Equal	Z = 1
1110	NE	Not Equal	Z = 0
1001	GE	Greater Than or Equal	(S XOR V) = 0
0001	LT	Less than	(S XOR V) = 1
1010	GT	Greater Than	[Z OR (S XOR V)] = 0
0010	LE	Less Than or Equal	[Z OR (S XOR V)] = 1
1111	UGE	Unsigned Greater Than or Equal	C = 0
0111	ULT	Unsigned Less Than	C = 1
1011	UGT	Unsigned Greater Than	(C = 0 AND Z = 0) = 1
0011	ULE	Unsigned Less Than or Equal	(C OR Z) = 1
0000	F	Never True (Always False)	—

INSTRUCTION FORMATS



INSTRUCTION SUMMARY

Note: Assignment of a value is indicated by the symbol " ← ". For example:

dst ← dst + src

indicates that the source data is added to the destination data and the result is stored in the destination location. The notation "addr (n)" is used to refer to bit (n) of a given operand location. For example:

dst (7)

refers to bit 7 of the destination operand.

INSTRUCTION SUMMARY

Instruction and Operation	Address Mode dst	Address Mode src	Opcode Byte (Hex)	Flags Affected C	Z	S	V	D	H
ADC dst, src dst←dst + src +C	†		1[ ]	*	*	*	*	0	*
ADD dst, src dst←dst + src	†		0[ ]	*	*	*	*	0	*
AND dst, src dst←dst AND src	†		5[ ]	-	*	*	0	-	-
CALL dst SP←SP – 2 @SP←PC, PC←dst	DA IRR		D6 D4	-	-	-	-	-	-
CCF C←NOT C			EF	*	-	-	-	-	-
CLR dst dst←0	R IR		B0 B1	-	-	-	-	-	-
COM dst dst←NOT dst	R IR		60 61	-	*	*	0	-	-
CP dst, src dst – src	†		A[ ]	*	*	*	*	-	-
DA dst dst←DA dst	R IR		40 41	*	*	*	X	-	-
DEC dst dst←dst – 1	R IR		00 01	-	*	*	*	-	-
DECW dst dst←dst – 1	RR IR		80 81	-	*	*	*	-	-
DI IMR(7)←0			8F	-	-	-	-	-	-
DJNZr, dst r←r – 1 if r ≠ 0 PC←PC + dst Range: +127, –128	RA		rA r = 0 - F	-	-	-	-	-	-
EI IMR(7)←1			9F	-	-	-	-	-	-
HALT			7F	-	-	-	-	-	-

Instruction and Operation	Address Mode dst	Address Mode src	Opcode Byte (Hex)	Flags Affected C	Z	S	V	D	H
INC dst dst←dst + 1	r R IR		rE r = 0 – F 20 21	-	*	*	*	-	-
INCW dst dst←dst + 1	RR IR		A0 A1	-	*	*	*	-	-
IRET FLAGS←@SP; SP←SP + 1 PC←@SP; SP←SP + 2; IMR(7)←1			BF	*	*	*	*	*	*
JP cc, dst if cc is true, PC←dst	DA IRR		cD c = 0 – F 30	-	-	-	-	-	-
JR cc, dst if cc is true, PC←PC + dst Range: +127, –128	RA		cB c = 0 – F	-	-	-	-	-	-
LD dst, src dst←src	r r R r X r r Ir R R R IR IR	Im R r X r Ir r R IR IM IM R	rC r8 r9 r = 0 – F C7 D7 E3 F3 E4 E5 E6 E7 F5	-	-	-	-	-	-
LDC dst, src dst←src	r	Irr	C2	-	-	-	-	-	-
LDCI dst, src dst←src r←r + 1;rr←rr + 1	Ir	Irr	C3	-	-	-	-	-	-

2

INSTRUCTION SUMMARY (Continued)

Instruction and Operation	Address Mode dst	src	Opcode Byte (Hex)	Flags Affected C	Z	S	V	D	H
NOP			FF	-	-	-	-	-	-
OR dst, src dst←dst OR src	†		4[ ]	-	*	*	0	-	-
POP dst dst←@SP; SP←SP + 1	R IR		50 51	-	-	-	-	-	-
PUSH src SP←SP – 1; @SP←src	R IR		70 71	-	-	-	-	-	-
RCF C←0			CF	0	-	-	-	-	-
RET PC←@SP; SP←SP + 2			AF	-	-	-	-	-	-
RL dst	R IR		90 91	*	*	*	*	-	-
RLC dst	R IR		10 11	*	*	*	*	-	-
RR dst	R IR		E0 E1	*	*	*	*	-	-
RRC dst	R IR		C0 C1	*	*	*	*	-	-
SBC dst, src dst←dst←src←C	†		3[ ]	*	*	*	*	1	*
SCF C←1			DF	1	-	-	-	-	-
SRA dst	R IR		D0 D1	*	*	*	0	-	-
SRP dst RP←src	Im		31	-	-	-	-	-	-

Instruction and Operation	Address Mode dst	src	Opcode Byte (Hex)	Flags Affected C	Z	S	V	D	H
STOP			6F	1	-	-	-	-	-
SUB dst, src dst←dst←src	†		2[ ]	*	*	*	*	1	*
SWAP dst	R IR		F0 F1	X	*	*	X	-	-
TCM dst, src (NOT dst) AND src	†		6[ ]	-	*	*	0	-	-
TM dst, src dst AND src	†		7[ ]	-	*	*	0	-	-
XOR dst, src dst←dst XOR src	†		B[ ]	-	*	*	0	-	-

† These instructions have an identical set of addressing modes, which are encoded for brevity. The first opcode nibble is found in the instruction set table above. The second nibble is expressed symbolically by a '[ ]' in this table, and its value is found in the following table to the left of the applicable addressing mode pair.

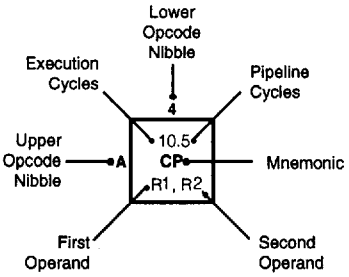
For example, the opcode of an ADC instruction using the addressing modes r (destination) and Ir (source) is 13.

Address Mode dst	src	Lower Opcode Nibble
r	r	[2]
r	Ir	[3]
R	R	[4]
R	IR	[5]
R	IM	[6]
IR	IM	[7]

OPCODE MAP

Lower Nibble (Hex)

Upper Nibble (Hex)	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	6.5 **DEC** R1	6.5 **DEC** IR1	6.5 **ADD** r1, r2	6.5 **ADD** r1, Ir2	10.5 **ADD** R2, R1	10.5 **ADD** IR2, R1	10.5 **ADD** R1, IM	10.5 **ADD** IR1, IM	6.5 **LD** r1, R2	6.5 **LD** r2, R1	12/10.5 **DJNZ** r1, RA	12/10.0 **JR** cc, RA	6.5 **LD** r1, IM	12.10.0 **JP** cc, DA	6.5 **INC** r1	
1	6.5 **RLC** R1	6.5 **RLC** IR1	6.5 **ADC** r1, r2	6.5 **ADC** r1, Ir2	10.5 **ADC** R2, R1	10.5 **ADC** IR2, R1	10.5 **ADC** R1, IM	10.5 **ADC** IR1, IM								
2	6.5 **INC** R1	6.5 **INC** IR1	6.5 **SUB** r1, r2	6.5 **SUB** r1, Ir2	10.5 **SUB** R2, R1	10.5 **SUB** IR2, R1	10.5 **SUB** R1, IM	10.5 **SUB** IR1, IM								
3	8.0 **JP** IRR1	6.1 **SRP** IM	6.5 **SBC** r1, r2	6.5 **SBC** r1, Ir2	10.5 **SBC** R2, R1	10.5 **SBC** IR2, R1	10.5 **SBC** R1, IM	10.5 **SBC** IR1, IM								
4	8.5 **DA** R1	8.5 **DA** IR1	6.5 **OR** r1, r2	6.5 **OR** r1, Ir2	10.5 **OR** R2, R1	10.5 **OR** IR2, R1	10.5 **OR** R1, IM	10.5 **OR** IR1, IM								
5	10.5 **POP** R1	10.5 **POP** IR1	6.5 **AND** r1, r2	6.5 **AND** r1, Ir2	10.5 **AND** R2, R1	10.5 **AND** IR2, R1	10.5 **AND** R1, IM	10.5 **AND** IR1, IM								
6	6.5 **COM** R1	6.5 **COM** IR1	6.5 **TCM** r1, r2	6.5 **TCM** r1, Ir2	10.5 **TCM** R2, R1	10.5 **TCM** IR2, R1	10.5 **TCM** R1, IM	10.5 **TCM** IR1, IM								6.0 **STOP**
7	10/12.1 **PUSH** R2	12/14.1 **PUSH** IR2	6.5 **TM** r1, r2	6.5 **TM** r1, Ir2	10.5 **TM** R2, R1	10.5 **TM** IR2, R1	10.5 **TM** R1, IM	10.5 **TM** IR1, IM								7.0 **HALT**
8	10.5 **DECW** RR1	10.5 **DECW** IR1	12.0 **LDE** r1, Irr2	18.0 **LDEI** Ir1, Irr2												6.1 **DI**
9	6.5 **RL** R1	6.5 **RL** IR1	12.0 **LDE** r2, Irr1	18.0 **LDEI** Ir2, Irr1												6.1 **EI**
A	10.5 **INCW** RR1	10.5 **INCW** IR1	6.5 **CP** r1, r2	6.5 **CP** r1, Ir2	10.5 **CP** R2, R1	10.5 **CP** IR2, R1	10.5 **CP** R1, IM	10.5 **CP** IR1, IM								14.0 **RET**
B	6.5 **CLR** R1	6.5 **CLR** IR1	6.5 **XOR** r1, r2	6.5 **XOR** r1, Ir2	10.5 **XOR** R2, R1	10.5 **XOR** IR2, R1	10.5 **XOR** R1, IM	10.5 **XOR** IR1, IM								16.0 **IRET**
C	6.5 **RRC** R1	6.5 **RRC** IR1	12.0 **LDC** r1, Irr2	18.0 **LDCI** Ir1, Irr2				10.5 **LD** r1,x,R2								6.5 **RCF**
D	6.5 **SRA** R1	6.5 **SRA** IR1	12.0 **LDC** r1, Irr2	18.0 **LDCI** Ir1, Irr2	20.0 **CALL*** IRR1		20.0 **CALL** DA	10.5 **LD** r2,x,R1								6.5 **SCF**
E	6.5 **RR** R1	6.5 **RR** IR1		6.5 **LD** r1, IR2	10.5 **LD** R2, R1	10.5 **LD** IR2, R1	10.5 **LD** R1, IM	10.5 **LD** IR1, IM								6.5 **CCF**
F	8.5 **SWAP** R1	8.5 **SWAP** IR1		6.5 **LD** Ir1, r2		10.5 **LD** R2, IR1										6.0 **NOP**
Bytes per Instruction	2			3					2					3	1	



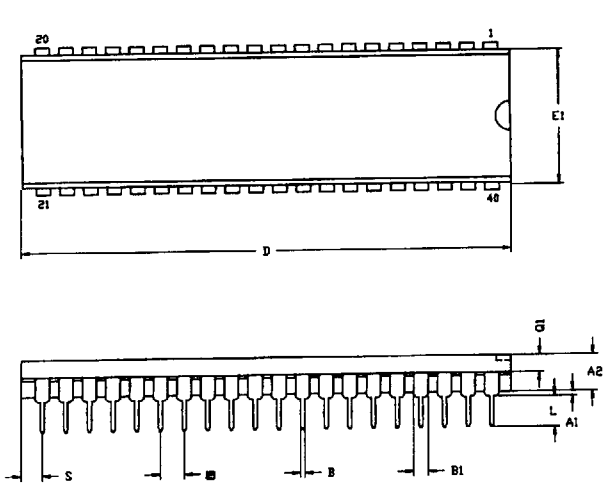
Legend:
R = 8-bit Address
r = 4-bit Address
R1 or r1 = Dst Address
R2 or r2 = Src Address

Sequence:
Opcode, First Operand,
Second Operand

Note: Blank areas not defined.

*2-byte instruction appears as a 3-byte instruction

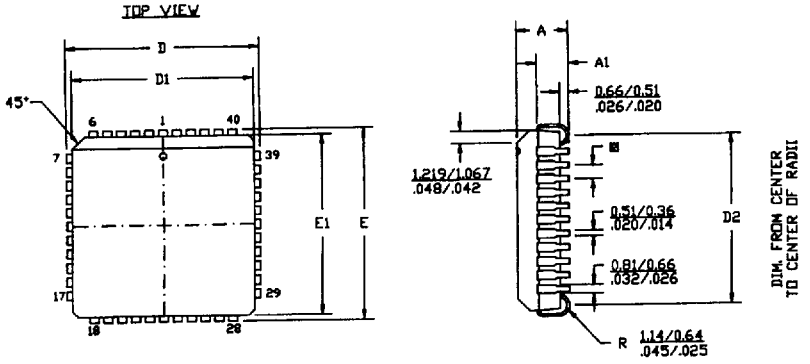
PACKAGE INFORMATION



SYMBOL	MILLIMETER		INCH	
	MIN	MAX	MIN	MAX
A1	0.51	0.81	.020	.032
A2	3.25	3.43	.128	.135
B	0.38	0.53	.015	.021
B1	1.02	1.52	.040	.060
C	0.23	0.38	.009	.015
D	52.07	52.58	2.050	2.070
E	15.24	15.75	.600	.620
E1	13.59	14.22	.535	.560
e	2.54 TYP		.100 TYP	
eA	15.49	16.51	.610	.650
L	3.18	3.81	.125	.150
Q1	1.52	1.91	.060	.075
S	1.52	2.29	.060	.090

CONTROLLING DIMENSIONS : INCH

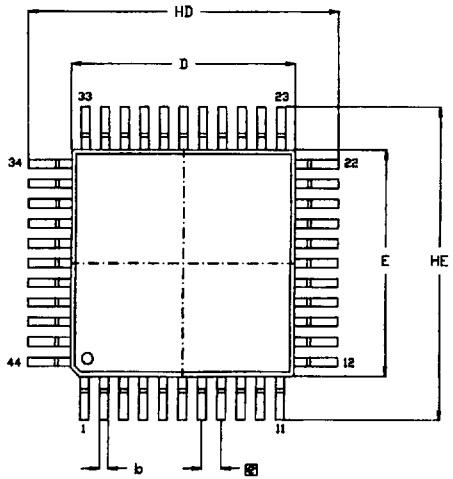
40-Pin DIP Package Diagram



NOTES:
1. CONTROLLING DIMENSIONS : INCH
2. LEADS ARE COPLANAR WITHIN .004 IN.
3. DIMENSION : MM / INCH

SYMBOL	MILLIMETER		INCH	
	MIN	MAX	MIN	MAX
A	4.27	4.57	.168	.180
A1	2.67	2.92	.105	.115
D/E	17.40	17.65	.685	.695
D1/E1	16.51	16.66	.650	.656
D2	15.24	16.00	.600	.630
e	1.27 TYP		.050 TYP	

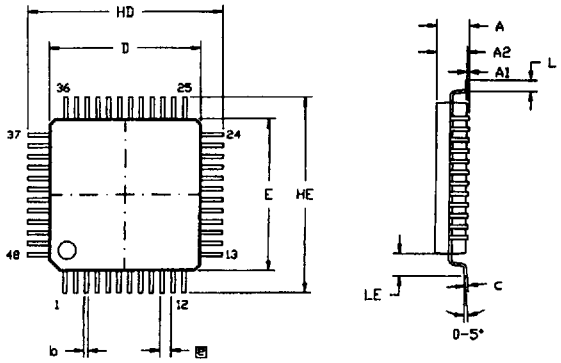
44-Pin PLCC Package Diagram



NOTES:
1. CONTROLLING DIMENSIONS : MILLIMETER
2. LEAD COPLANARITY : MAX .10 mm / .004"

SYMBOL	MILLIMETER		INCH	
	MIN	MAX	MIN	MAX
A1	0.05	0.25	.002	.010
A2	2.00	2.25	.078	.089
b	0.25	0.45	.010	.018
c	0.13	0.20	.005	.008
HD	13.70	14.30	.539	.563
D	9.90	10.10	.390	.398
HE	13.70	14.30	.539	.563
E	9.90	10.10	.390	.398
e	0.80 TYP		.031 TYP	
L	0.60	1.20	.024	.047

44-Pin QFP Package Diagram



SYMBOL	MILLIMETER		INCH	
	MIN	MAX	MIN	MAX
A	1.35	1.60	.053	.063
A1	0.05	0.20	.002	.008
A2	1.30	1.50	.051	.059
b	0.15	0.26	.006	.010
c	0.10	0.18	.004	.007
HD	8.60	9.40	.339	.370
D	6.90	7.10	.272	.280
HE	8.60	9.40	.339	.370
E	6.90	7.10	.272	.280
e	0.50 TYP		.020 TYP	
L	0.30	0.70	.012	.028
LE	0.90	1.10	.035	.043

1. CONTROLLING DIMENSIONS : MM
2. MAX COPLANARITY : .10mm / .004"

48-Pin VQFP Package Diagram

ORDERING INFORMATION

Z86C93

20 MHz			
44-pin PLCC	**44-pin QFP**	**40-pin DIP**	**48-pin VQFP**
Z86C9320VSC	Z86C9320FSC	Z86C9320PSC	Z86C9320ASC
25 MHz			
44-pin PLCC	**44-pin QFP**	**40-pin DIP**	**48-pin VQFP**
Z86C9325VSC	Z86C9325FSC	Z86C9325PSC	Z86C9325ASC
33 MHz			
44-pin PLCC	**44-pin QFP**	**40-pin DIP**	**48-pin VQFP**
Z86C9333VSC	Z86C9333FSC	Z86C9333PSC	Z86C9333ASC

For fast results, contact your local Zilog sales office for assistance in ordering the part desired.

Package
V = Plastic Leaded Chip Carrier
P = Plastic Dual In Line Package

Longer Lead Time
F = Plastic Quad Flat Pack
A = Very Small Quad Flat Pack

Temperature
S= 0°C to +70°C

Speed
20 = 20 MHz
25 = 25 MHz
33 = 33 MHz

Environmental
C = Standard Flow

Example:

Z 86C93 33 V S C is a Z86C93, 33 MHz, PLCC, 0°C to +70°C, Plastic Standard Flow