ZiLOG

PRELIMINARY PRODUCT SPECIFICATION

T-49-19-65

Z86C93

CMOS Z8 MULT/DIV MICROCONTROLLER

FEATURES

- Complete microcontroller, 24 I/O lines, and up to 64 Kbytes of addressable external space each for program and data memory.
- 16-bit x 16-bit hardwired multiplier with 32-bit product in 17 clock cycles.
- 32-bit by 16-bit hardwired divider with 16-bit quotient and 16-bit remainder in 20 clock cycles.
- 256-byte register file, including 236 general registers, four 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.
- Vectored, priority interrupts for I/O, counter/timers and UART.
- On-chip oscillator that accepts crystal or external clock drive.
- Full-duplex UART and two 16-bit counter timers with 6-bit prescalers.
- Third 16-bit counter/timer with 4-bit prescaler, one capture register and a fast decrement mode.
- Register Pointer so that short, fast instructions can access any one of the sixteen working register groups.
- Additional emulation signals SCLK, IACK, and /SYNC are made available.
- Single +5V power supply, all I/O pins TTL compatible
- 1.2 micron CMOS technology
- Clock speeds 16 and 20 MHz
- Two low power standby modes, STOP and HALT

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 fabricated using 1.2 micron CMOS technology. It is offered in 40-pin Plastic Dual-In-Line, 44-pin Leaded Chip Carrier and 44-pin Plastic Quad Flat Pack (Figures 2,3, 4, and 5). Besides the three additional emulation signals (SCLK, IACK, and /SYNC), the Z86C93 is fully pin compatible with Z86C91, yet it offers a much more powerful mathematical capability.

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

There are 256 registers located on-chip organized as 236 general purpose registers, 16 control and status registers, and four I/O port registers. The register file can be divided into sixteen 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.

Note: 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); /N//S (NORMAL and SYSTEM are both active Low).

GENERAL DESCRIPTION (Continued)

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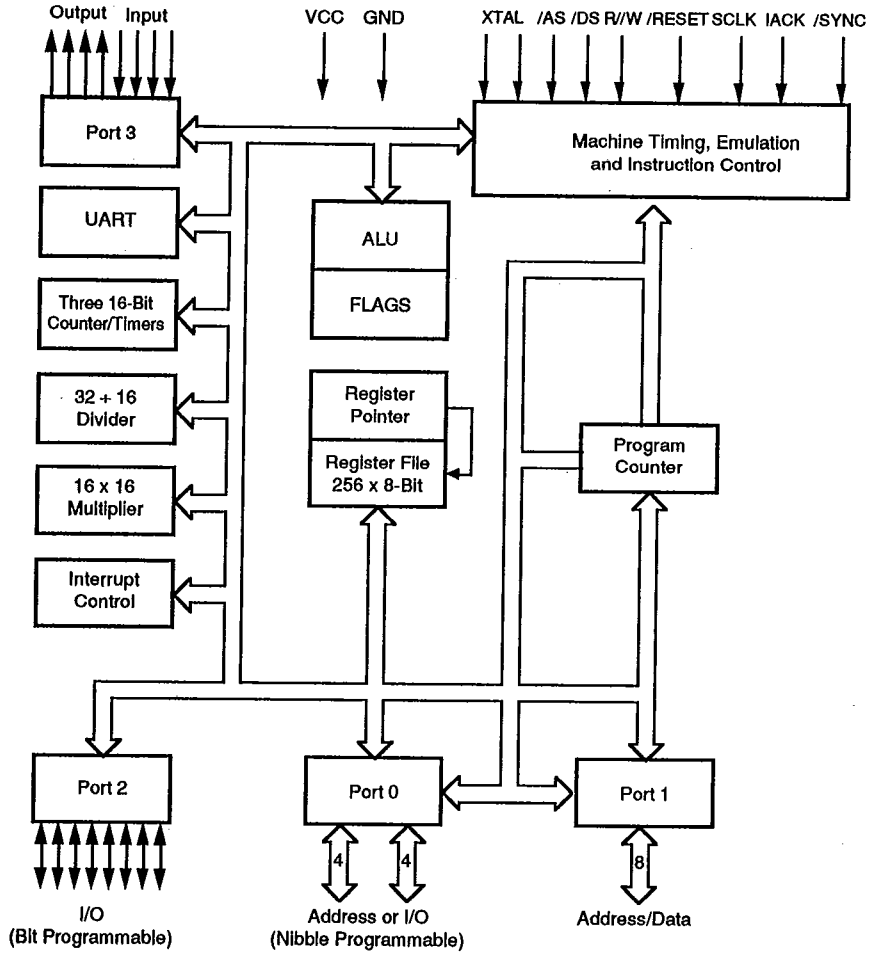

Figure 1. Functional Block Diagram

PIN DESCRIPTION

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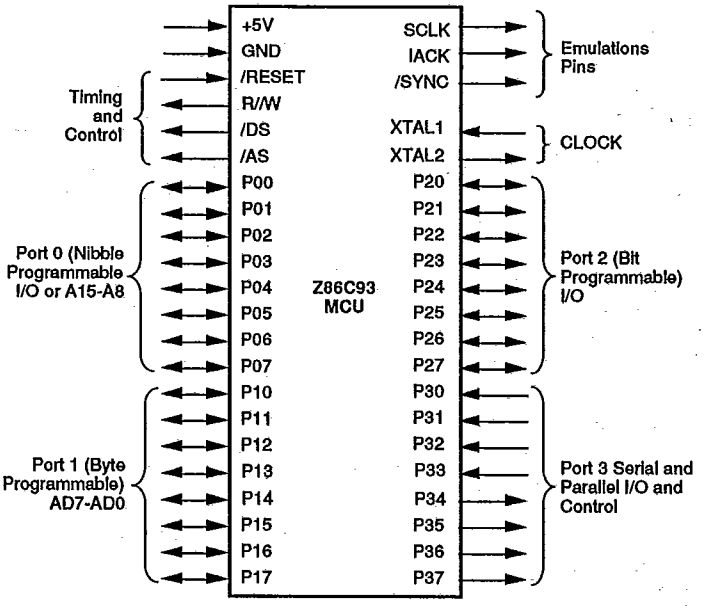

Figure 2. Pin Functions

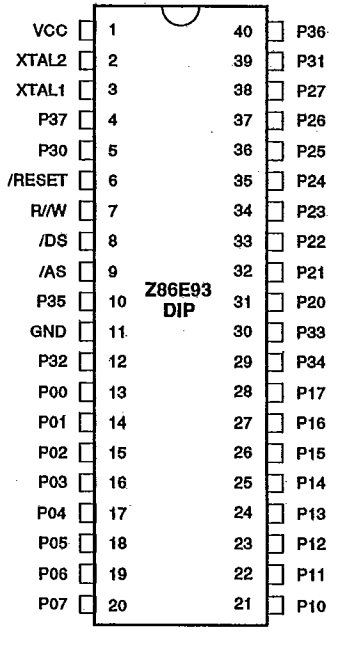

Figure 3. 40-Pin Dual-In-Line Package

Table 1. 40-Pin Dual-In-Line 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, GND	Input
12	P32	Port 3 pin 2	Input
13-20	P00-P07	Port 0 pin 0,1,2,3,4,5,6,7	In/Output
21-28	P10-P17	Port 1 pin 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 pin 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) T-49-19-65

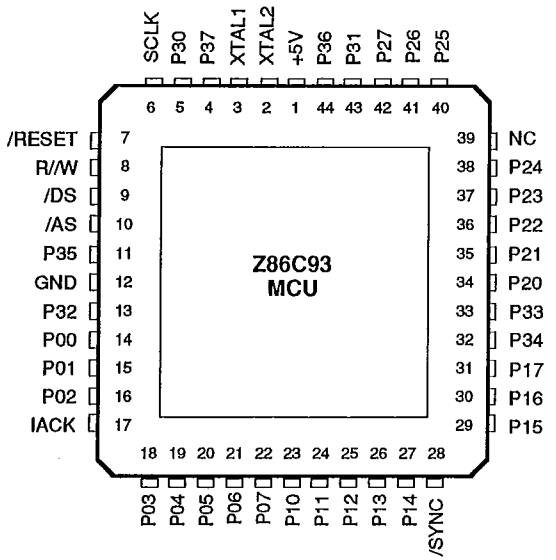

Figure 4. 44-Pin Leaded Chip Carrier

Table 2. 44-Pin Leaded Chip Carrier 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 GND	Input
13	P32	Port 3 pin 2	Input

No	Symbol	Function	Direction
14-16	P00-P02	Port 0 pin 0,1,2	In/Output
17	IACK	Int. Acknowledge	Output
18-22	P03-P07	Port 0 pin 3,4,5,6,7	In/Output
23-27	P10-P14	Port 1 pin 0,1,2,3,4	In/Output
28	/SYNC	Synchronize Pin	Output
29-31	P15-P17	Port 1 pin 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 pin 0,1,2,3,4	In/Output
39	N/C	Not Connected	Input
40-42	P25-P27	Port 2 pin 5,6,7	In/Output
43	P31	Port 3 pin 1	Input
44	P36	Port 3 pin 6	Output

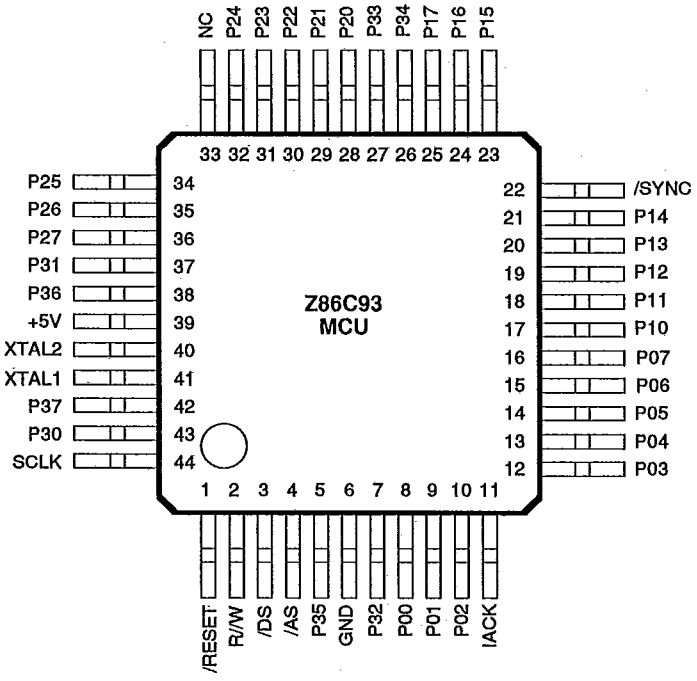

Figure 5. 44-Pin Quad Flat Pack

Table 3. 44-Pin Quad Flat Pack 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 GND	Input
7	P32	Port 3 pin 2	Input
8-10	P00-P02	Port 0 pin 0,1,2	In/Output
11	IACK	Int. Acknowledge	Output
12-16	P03-P07	Port 0 pin 3,4,5,6,7	In/Output
17-21	P10-P14	Port 1 pin 0,1,2,3,4	In/Output
22	/SYNC	Synchronize Pin	Output
23-25	P15-P17	Port 1 pin 5,6,7	In/Output

No	Symbol	Function	Direction
26	P34	Port 3 pin 4	Output
27	P33	Port 3 pin 3	Input
28-32	P20-P24	Port 2 pin 0,1,2,3,4	In/Output
33	N/C	Not Connected	Input
34-36	P25-P27	Port 2 pin 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 FUNCTIONS

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/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 via Port 1 for all external programs. When /RESET is asserted, /AS toggles. Memory address transfers are valid at the trailing edge of /AS. Under program control, /AS can be placed in the high-impedance state along with Ports 0 and 1, Data Strobe, and Read/Write.

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 5th 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 TpC/2. When /RESET is deactivated, program execution begins at location 000C (HEX). Reset time must be held low for 50 ms or until VCC is stable, whichever is longer.

SCLK. *System Clock* (output). The internal system clock is available at this pin.

IACK. *Interrupt Acknowledge* (output, active-High). This output, when high, indicates that the Z86C93 is in an interrupt cycle.

/SYNC. (output, active-Low). This signal indicates the last clock cycle of the currently executing instruction.

Port 0 P00-P07. 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 P04-P07. The lower nibble must have the same direction as the upper nibble to be under handshake control. Port 0 comes up as A15-A8 Address lines after /RESET.

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 6). The /OEN (Output Enable) signal in Figure 6 is an internal signal.

Port 1 P10-P17. Port 1 is an 8-bit, byte programmable, bidirectional, TTL compatible port. It has multiplexed Address (A7-A0) and Data (D7-D0) ports.

To interface external memory, Port 1 is programmed for the multiplexed Address/Data mode. If more than 256 external locations are required, Port 0 must output the additional lines (Figure 7).

Port 2 P20-P27. Port 2 is an 8-bit, bit programmable, bidirectional, CMOS compatible port. Each of these eight I/O lines are 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 controls 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 8).

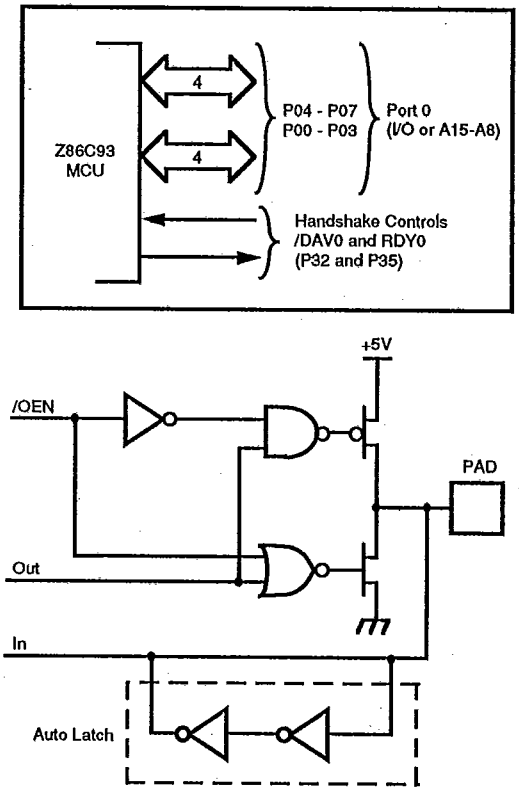

Figure 6. Port 0 Configuration

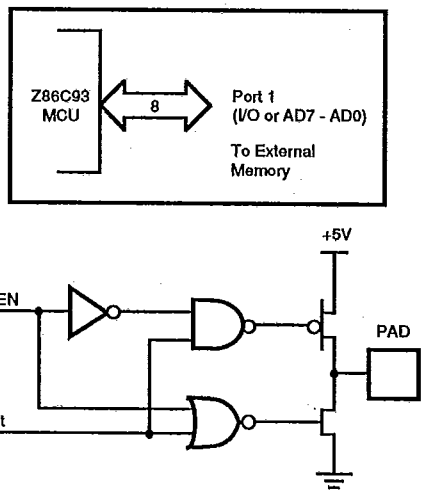

Figure 7. Port 1 Configuration

PIN FUNCTIONS (Continued) T-49-19-65

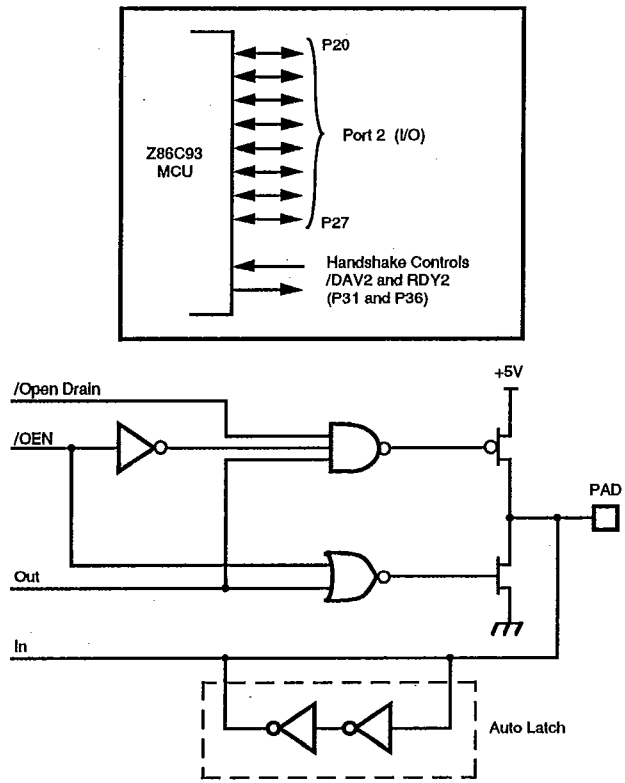

Figure 8. Port 2 Configuration

Port 3 P30-P37. Port 3 is an 8-bit, CMOS compatible four fixed input and four fixed output port. These 8 I/O lines have four-fixed (P30-P33) input and four fixed (P34-P37) output ports. Port 3 pins P30 and P37, when used as serial I/O, are programmed as serial in and serial out, respectively (Figure 9 and Table 4).

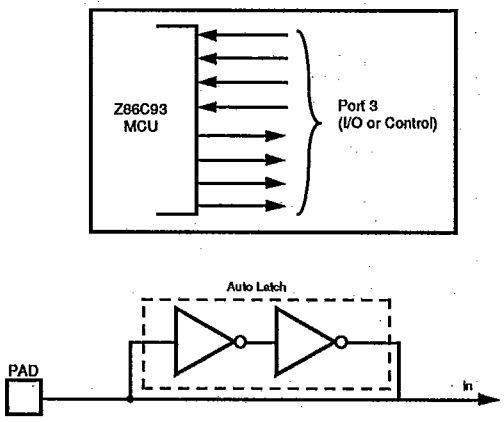

Figure 9. Port 3 Configuration

Table 4. Port 3 Pin Assignments

Pin #	I/O	CTC1	Int.	P0HS	P1HS	P2HS	UART	Ext.
P30	In		IRQ3				Serial In	
P31	In	Tin	IRQ2			D/R		
P32	In		IRQ0	D/R				
P33	In		IRQ1		D/R			
P34	Out				R/D			DM
P35	Out			R/D				
P36	Out	Tout				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 (Tin and Tout), 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/Timer 0.

The Z86C93 automatically adds a start bit and two stop bits to transmitted data (Figure 10). 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, 8 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.

Auto-Latch. The auto-latch 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.

PIN FUNCTIONS (Continued)

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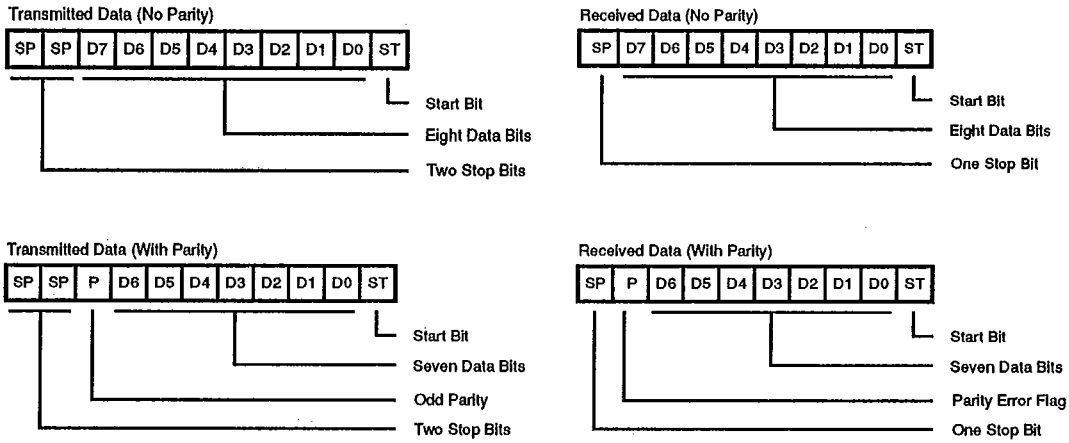

Figure 10. Serial Data Formats

ADDRESS SPACE

Program Memory. The Z86C93 can address up to 64 Kbytes of external program memory. Program execution begins at external location 000C (HEX) 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 pin P34, is used to distinguish between data and program memory space (Figure 11). 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.

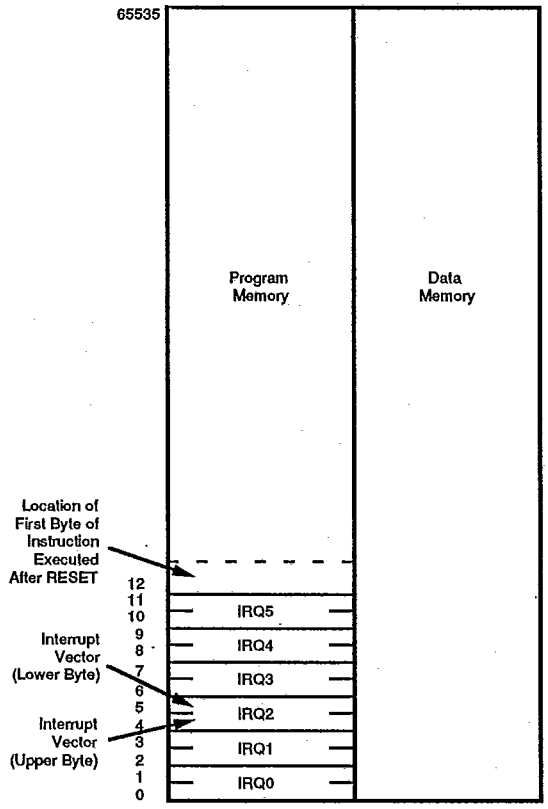

Figure 11. Program and Data Memory Configuration

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 12). 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 13). 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 via an 8-bit address field. The Z86C93 also allows short 4-bit register addressing using the Register Pointer (Figure 14). 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 Bank E0-EF can only be accessed through working register 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.

ADDRESS SPACE (Continued)

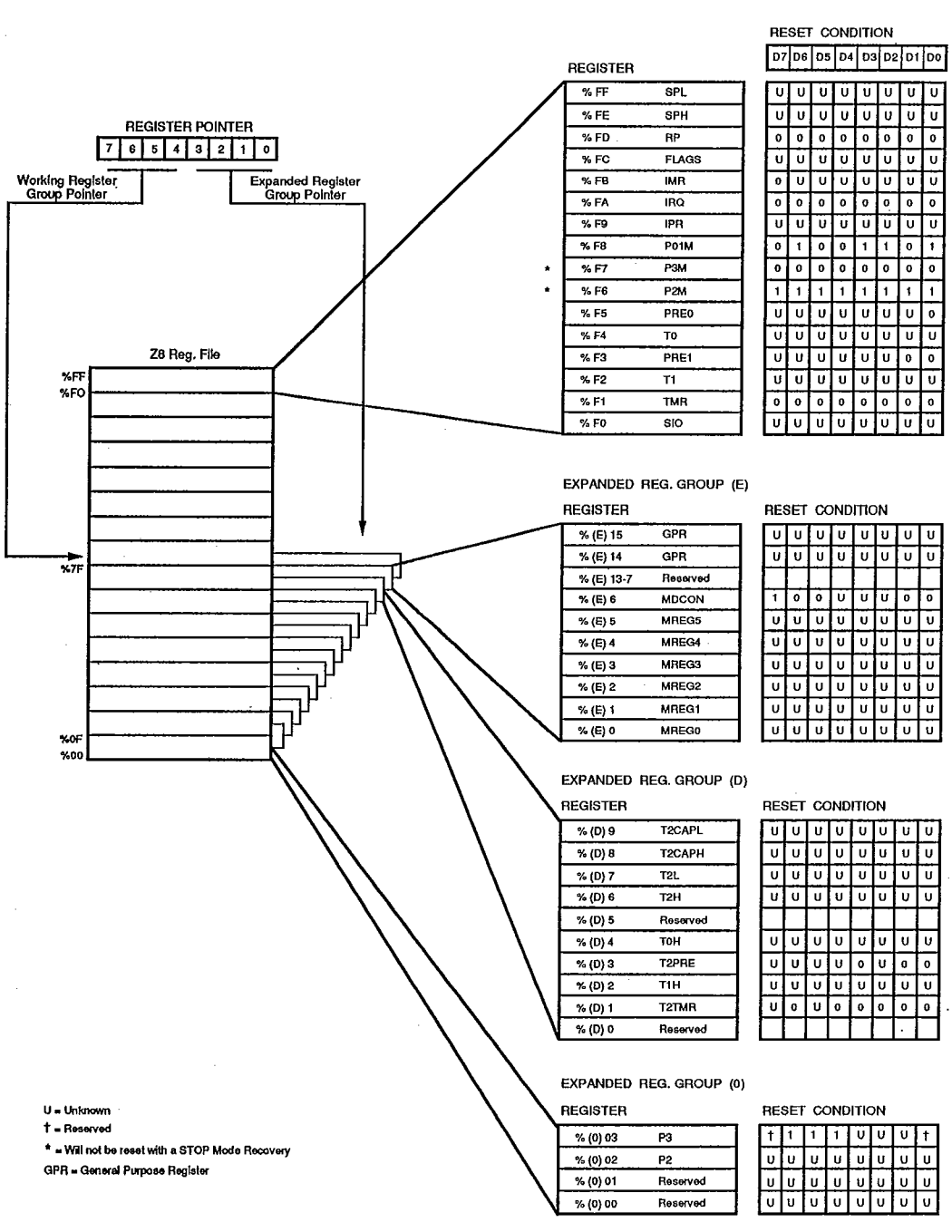

Figure 12. Register File

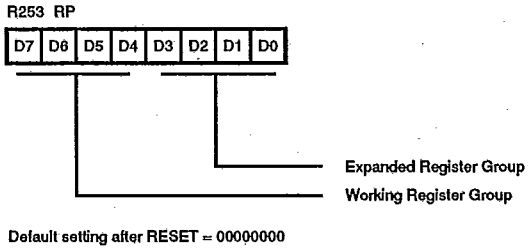

Figure 13. Register Pointer Register

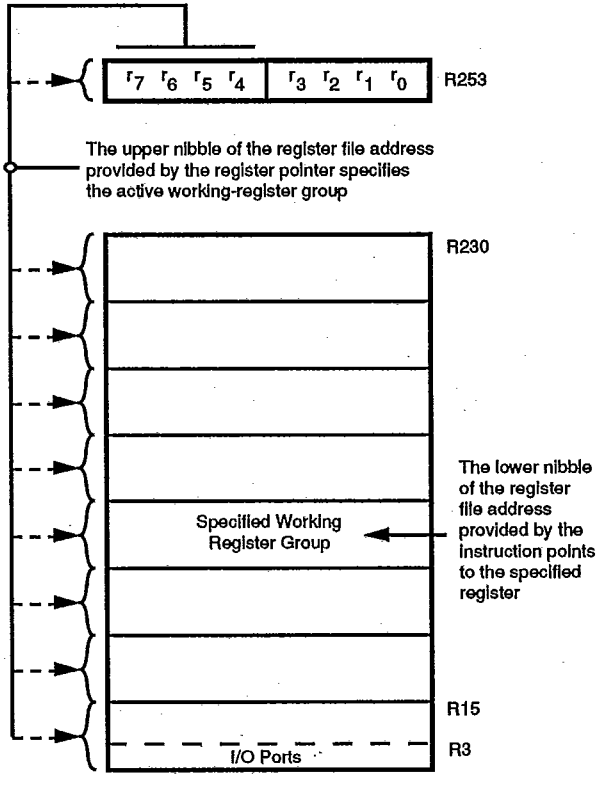

Figure 14. Register Pointer

FUNCTIONAL DESCRIPTION

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This section breaks down the Z86C93 into its main functional parts.

Multiply/Divide Unit

This section describes the basic features, implementation details of the interface between the Z8 and the multiply/divide unit.

Basic features:

- 16-bit by 16-bit multiply with 32-bit product
- 32-bit by 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 Z8 (Figure 15).

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

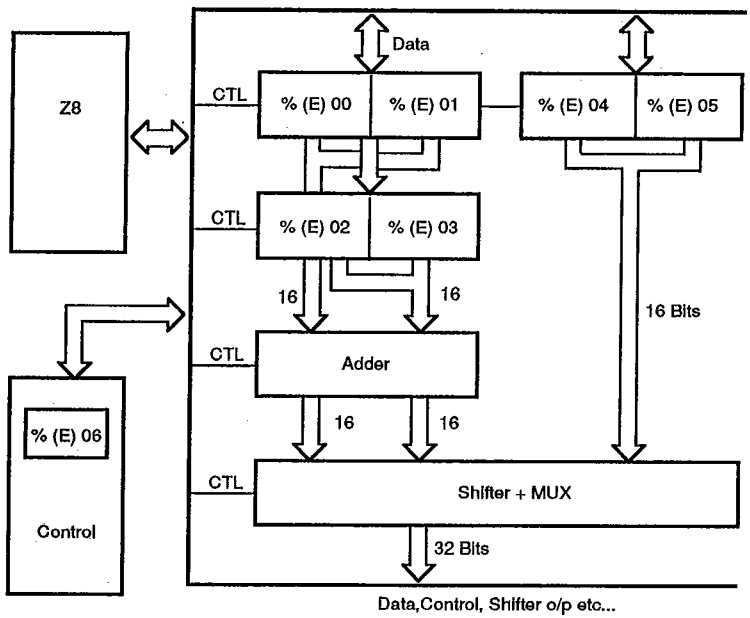

Figure 15. Multiply/Divide Unit Block Diagram

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

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.

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

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.

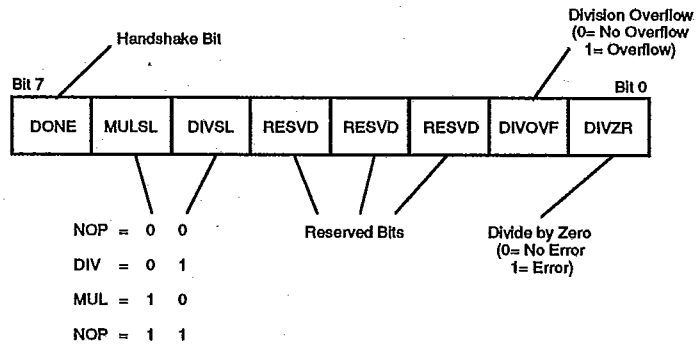

Figure 16. Multiply/Divide Control Register (MDCON)

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 one 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 zero 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 one, it indicates a multiply operation directive. Like the DONE bit, this bit is also write-protected during math unit operation and is reset to zero 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.

DIVOVF. *Division Overflow* (D1). This bit indicated 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 one, it indicates overflow error.

FUNCTIONAL DESCRIPTION (Continued)

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DIVZR. *Division by Zero* (D0). When set to one, this indicates an error of division by zero. 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.

On 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 thru 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 ONE 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 (GPR) can be used as scratch pad registers or as external data memory address pointers during an LDE instruction. MREG0 thru 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-bit x 16-bit) of 1.7 us. If the time to load operands and read results is included:

No. of internal clock cycles to load 5 registers: 30
No. 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 us. 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 us 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 us 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 via 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 via P36.

The following are the enhancements made to the counter/timer block on the Z86C93 (Figure 17):

- 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 5. 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 5. Counter Length Configurations

CAS 1	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.

T2 has a 16-bit capture register associated with T2 HIGH BYTE and T2 LOW BYTE registers. The negative going transition on pin 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 12). 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.

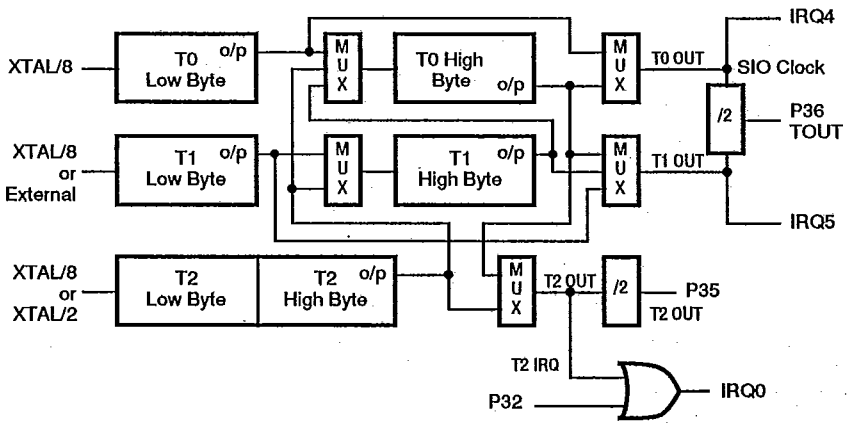


Figure 17. Counter/Timer Block Diagram

FUNCTIONAL DESCRIPTION (Continued)

T-49-19-65

Observations

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 pin (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 pin 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 18. 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.

The register map of the new CTC registers is shown in Figure 12. 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 19. Bits 1 and 0 of this register control the various cascade modes of the counters.

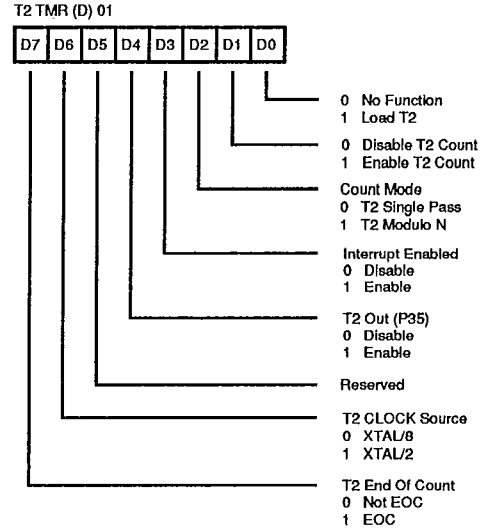


Figure 18. T2 Timer Mode Register (T2)

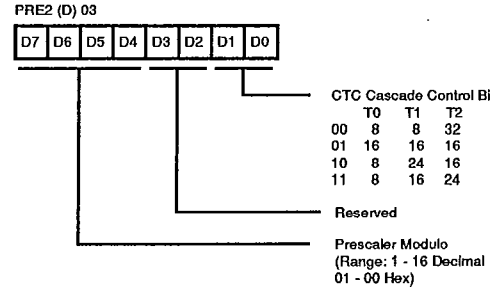


Figure 19. T2 Prescaler Register (PRE2)

Interrupts

The Z86C93 has six different interrupts from eight different sources. The interrupts are maskable and prioritized. The eight sources are divided as follow: four sources are claimed by Port 3 lines P30-P33, one in Serial Out, one in

Serial In, and two 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, and 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.

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 20 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 20).

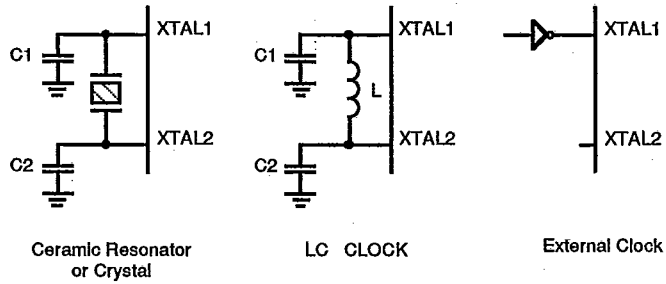


Figure 20. Oscillator Configuration

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.

STOP. This instruction turns off the internal clock and external crystal oscillation and reduces the standby current to 10 microamperes or less. The Stop mode is terminated by a /RESET, which causes the processor to restart the application program at address 000C (HEX).

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

T-49-19-65

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

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

Stress 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 (Figure 21).

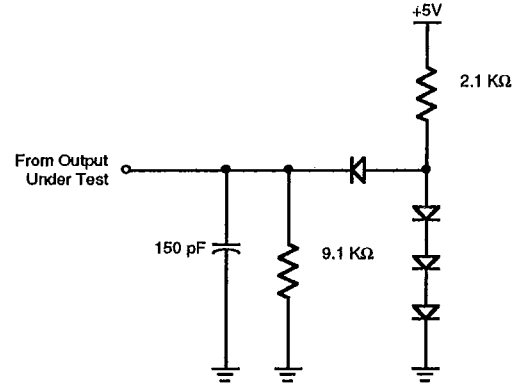


Figure 21. Test Load Diagram

DC ELECTRICAL CHARACTERISTICS

T-49-19-65

Sym	Parameter	T_A = 0°C to 70°C Min	Max	T_A = -40°C to 105°C Min	Max	Typical at 25°C	Units	Conditions
	Max Input Voltage		7		7		V	I_{IN} 250 µA
V_{CH}	Clock Input High Voltage	3.8	V_{CC}	3.8	V_{CC}		V	Driven by External Clock Generator
V_{CL}	Clock Input Low Voltage	-0.03	0.8	-0.03	0.8		V	Driven by External Clock Generator
V_{IH}	Input High Voltage	2.0	V_{CC}	2.0	V_{CC}		V	
V_{IL}	Input Low Voltage	-0.3	0.8	-0.3	0.8		V	
V_{OH}	Output High Voltge	2.4		2.4			V	I_{OH} = -2.0 mA
V_{OH}	Output High Voltge	V_{CC} - 100mV		V_{CC} - 100mV			V	I_{OH} = -100 µA
V_{OL}	Output Low Voltage		0.4		0.4		V	I_{OH} = +2.0 mA
V_{RH}	Reset Input High Voltage	3.8	V_{CC}	3.8	V_{CC}		V	
V_{RI}	Reset Input Low Voltage	-0.03	0.8	-0.03	0.8		V	
I_{IL}	Input Leakage	-2	2	-2	2		µA	Test at 0V, V_{CC}
I_{OL}	Output Leakage	-2	2	-2	2		µA	Test at 0V, V_{CC}
I_{IR}	Reset Input Current		-80		-80		µA	V_{RL} = 0V
I_{CC}	Supply Current		25		25	16	mA	@ 16 MHz [1]
			30		30	20	mA	@ 20 MHz [1]
I_{CC1}	Standby Current		10		10	8	mA	HALT Mode V_{IN} = 0V, V_{CC} @ 16 MHz [1]
			12		12	9	mA	HALT Mode V_{IN} = 0V, V_{CC} @ 20 MHz [1]
I_{CC2}	Standby Current		10		20	1	µA	STOP Mode V_{IN} = 0V, V_{CC} [1]
I_{ALL}	Auto Latch Low Current	-10	10	-14	14	5	µA	

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

AC CHARACTERISTICS

T-49-19-65

External I/O or Memory Read/Write Timing Diagram

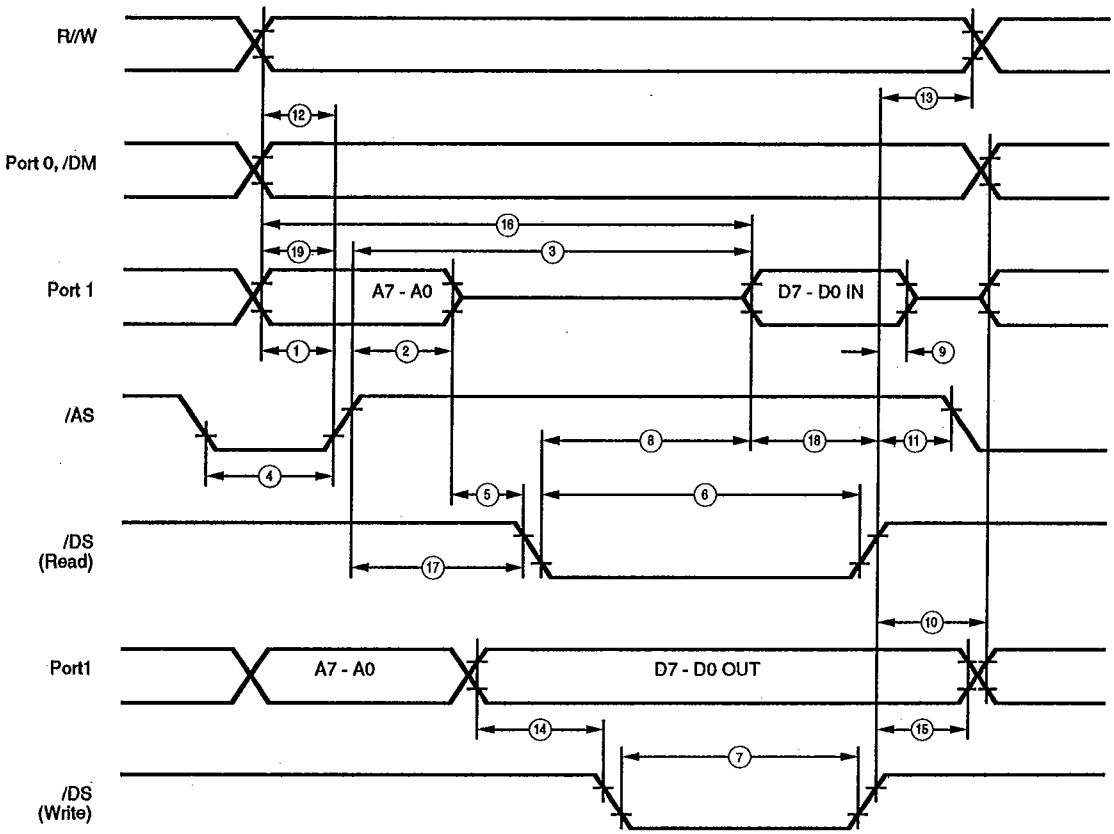


Figure 22. External I/O or Memory Read/Write Timing

AC CHARACTERISTICS

T-49-19-65

External I/O or Memory Read and Write Timing Table

No	Symbol	Parameter	T_A = 0°C to 70°C				T_A = -40°C to 105°C				Units	Notes
			16 MHz		20 MHz		16 MHz		20 MHz			
			Min	Max	Min	Max	Min	Max	Min	Max		
1	TdA(AS)	Address Valid to /AS Rise Delay	25		20		25		20		ns	[2,3]
2	TdAS(A)	/AS Rise to Address Float Delay	35		25		35		25		ns	[2,3]
3	TdAS(DR)	/AS Rise to Read Data Req'd Valid		180		150		180		150	ns	[1,2,3]
4	TwAS	/AS Low Width	40		30		40		30		ns	[2,3]
5	TdAZ(DS)	Address Float to /DS Fall	0		0		0		0		ns	
6	TwDSR	/DS (Read) Low Width	135		105		135		105		ns	[1,2,3]
7	TwDSW	/DS (Write) Low Width	80		65		80		65		ns	[1,2,3]
8	TdDSR(DR)	/DS Fall to Read Data Req'd Valid		75		55		75		55	ns	[1,2,3]
9	ThDR(DS)	Read Data to /DS Rise Hold Time	0		0		0		0		ns	[2,3]
10	TdDS(A)	/DS Rise to Address Active Delay	50		40		50		40		ns	[2,3]
11	TdDS(AS)	/DS Rise to /AS Fall Delay	35		25		35		25		ns	[2,3]
12	TdR/W(AS)	R//W Valid to /AS Rise Delay	25		20		25		20		ns	[2,3]
13	TdDS(R/W)	/DS Rise to R//W Not Valid	35		25		35		25		ns	[2,3]
14	TdDW(DSW)	Write Data Valid to /DS Fall (Write) Delay	25		20		25		20		ns	[2,3]
15	TdDS(DW)	/DS Rise to Write Data Not Valid Delay	35		25		35		25		ns	[2,3]
16	TdA(DR)	Address Valid to Read Data Req'd Valid		230		180		230		180	ns	[1,2,3]
17	TdAS(DS)	/AS Rise to /DS Fall Delay	45		35		45		35		ns	[2,3]
18	TdDI(DS)	Data Input Setup to /DS Rise	60		50		60		50		ns	[1,2,3]
19	TdDM(AS)	/DM Valid to /AS Rise Delay	30		20		30		20		ns	[2,3]

Notes:
[1] When using extended memory timing add 2 TpC.
[2] Timing numbers given are for minimum TpC.
[3] See clock cycle dependent characteristics table 5.

Standard Test Load
All timing references use 2.0V for a logic 1 and 0.8V for a logic 0.

Clock Dependent Equations

No	Symbol	Equation
1	TdA(AS)	0.40TpC + 0.32
2	TdAS(A)	0.59TpC - 3.25
3	TdAS(DR)	2.38TpC + 6.14
4	TwAS	0.66TpC - 1.65
6	TwDSR	2.33TpC - 10.56
7	TwDSW	1.27TpC + 1.67
8	TdDSR(DR)	1.97TpC - 42.5
10	TdDS(A)	0.8TpC
11	TdDS(AS)	0.59TpC - 3.14

No	Symbol	Equation
12	TdR/W(AS)	0.4TpC
13	TdDS(R/W)	0.8TpC - 15
14	TdDW(DSW)	0.4TpC
15	TdDS(DW)	0.88TpC - 19
16	TdA(DR)	4TpC - 20
17	TdAS(DS)	0.91TpC - 10.7
18	TsDI(DS)	0.8TpC - 10
19	TdDM(AS)	0.9TpC - 26.3

Note:
Equation units are in nanoseconds

AC CHARACTERISTICS
Additional Timing Diagram

T-49-19-65

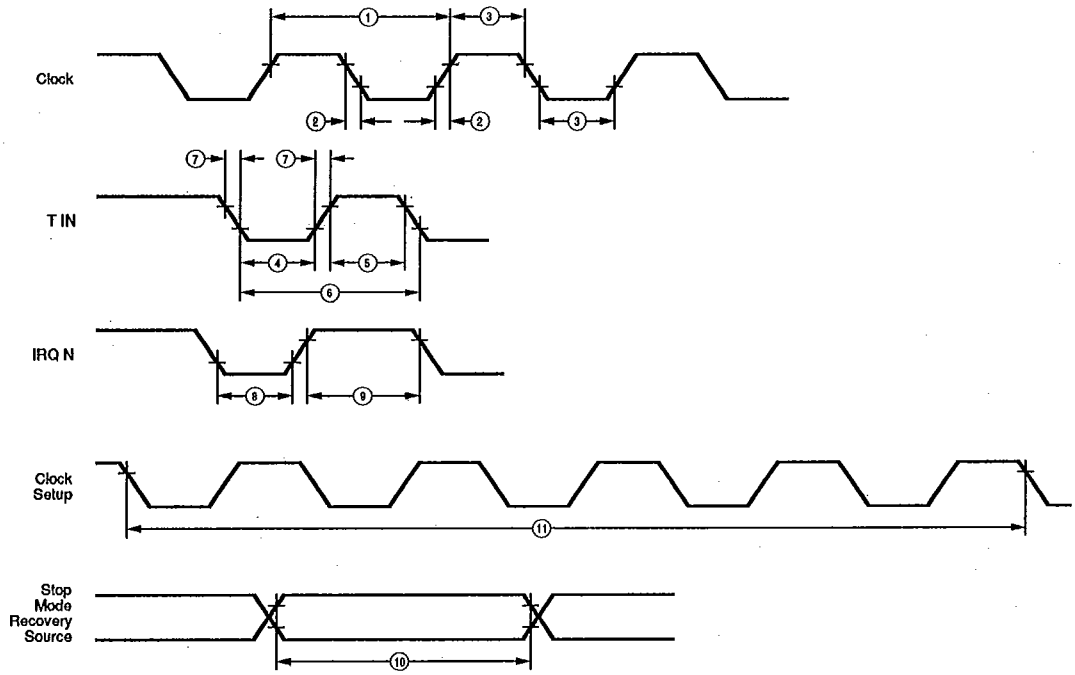


Figure 23. Additional Timing

AC CHARACTERISTICS
Additional Timing Table

T-49-19-65

No	Symbol	Parameter	T_A = 0°C to 70°C				T_A = -40°C to 105°C				Units	Notes
			16 MHz		20 MHz		16 MHz		20 MHz			
			Min	Max	Min	Max	Min	Max	Min	Max		
1	TpC	Input Clock Period	62.5	1000	50	1000	62.5	1000	50	1000	ns	[1]
2	TrC,TfC	Clock Imput Rise & Fall Times		10		10		10		10	ns	[1]
3	TwC	Input Clock Width	25		15		25		15		ns	[1]
4	TwTinL	Timer Input Low Width	75		75		75		75		ns	[2]
5	TwTinH	Timer Input High Width	3TpC		3TpC		3TpC		3TpC			[2]
6	TpTin	Timer Input Period	8TpC		8TpC		8TpC		8TpC			[2]
7	TrTin,TfTin	Timer Input Rise & Fall Times	100		100		100		100		ns	[2]
8A	TwIL	Interrupt Request Input Low Times	70		70		70		70		ns	[2,4]
8B	TwIL	Interrupt Request Input Low Times	5TpC		5TpC		5TpC		5TpC			[2,5]
9	TwIH	Interrupt Request Input High Times	3TpC		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 via Port 3.
[4] Interrupt request via Port 3 (P31-P33)`.
[5] Interrupt request via Port 30.

AC CHARACTERISTICS
Handshake Timing Diagrams

T-49-19-65

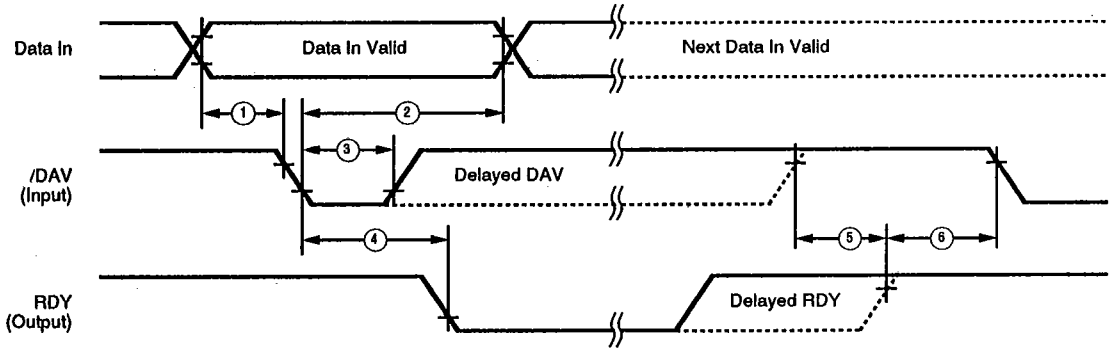


Figure 24. Input Handshake Timing

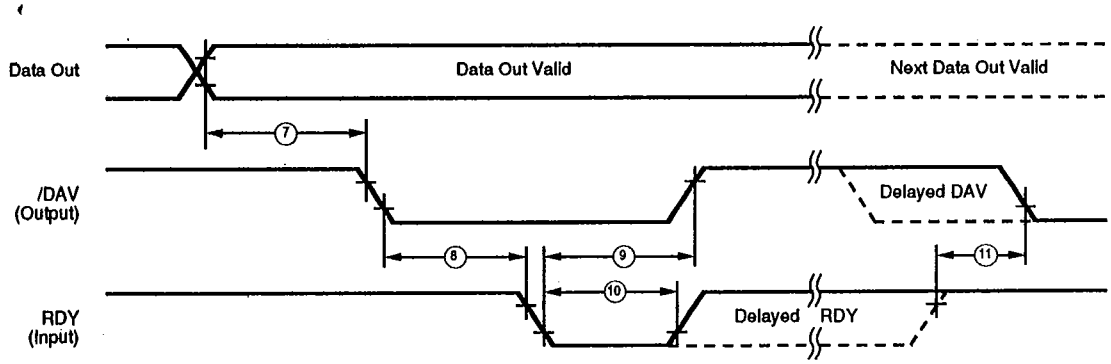


Figure 25. Output Handshake Timing

AC CHARACTERISTICS

T-49-19-65

Handshake Timing Table

No	Symbol	Parameter	T_A = 0°C to 70°C				T_A = -40°C to 105°C				Units	Notes
			16 MHz		20 MHz		16 MHz		20 MHz			
			Min	Max	Min	Max	Min	Max	Min	Max		
1	TsDI(DAV)	Data In Setup Time	0		0		0		0		ns	IN
2	ThDI(DAV)	Data In Hold Time	145		145		145		145		ns	IN
3	TwDAV	Data Available Width	110		110		110		110		ns	IN
4	TdDAVI(RDY)	DAV Fall to RDY Fall Delay		115		115		115		115	ns	IN
5	TdDAVId(RDY)	DAV Rise to RDY Rise Delay		115		115		115		115	ns	IN
6	TdDO(DAV)	RDY Rise to DAV Fall Delay	0		0		0		0		ns	IN
7	TcLDAV0(RDY)	Data Out to DAV Fall Delay		TpC		TpC		TpC		TpC		OUT
8	TcLDAV0(RDY)	DAV Fall to RDY Fall Delay	0		0		0		0		ns	OUT
9	TdRDY0(DAV)	RDY Fall to DAV Rise Delay		115		115		115		115	ns	OUT
10	TwRDY	RDY Width	110		110		110		110		ns	OUT
11	TdRDY0d(DAV)	RDY Rise to DAV Fall Delay		115		115		115		115	ns	OUT

EXPANDED REGISTER FILE CONTROL REGISTERS

T-49-19-65

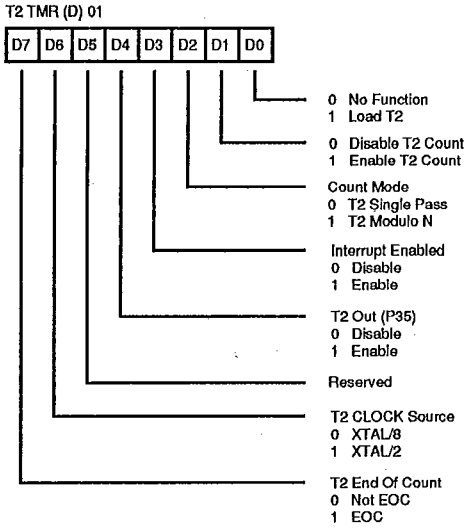


Figure 26. Timer 2 Mode Register [%(D) 01: Read/Write]

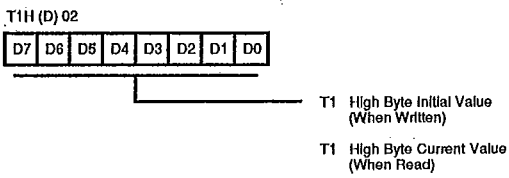


Figure 27. Counter Timer 1 Register High Byte [%(D) 02: Read/Write]

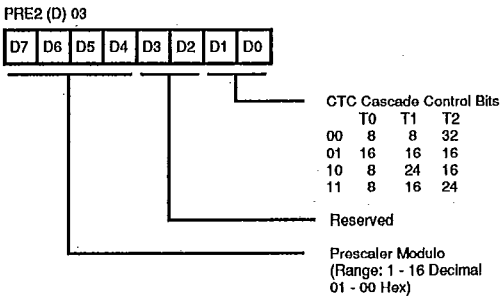


Figure 28. Prescaler 2 Register High Byte [%(D) 03: Write Only]

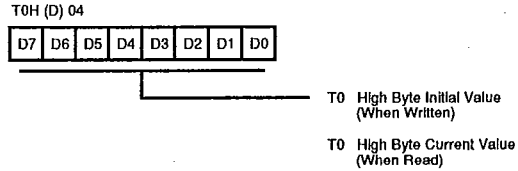


Figure 29. Counter Timer 0 Register High Byte [%(D) 04: Read/Write]

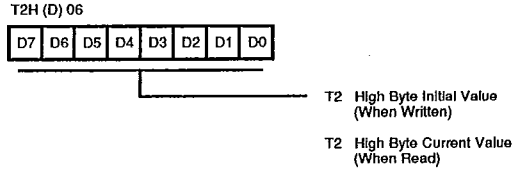


Figure 30. Counter Timer 2 Register High Byte [%(D) 06: Read/Write]

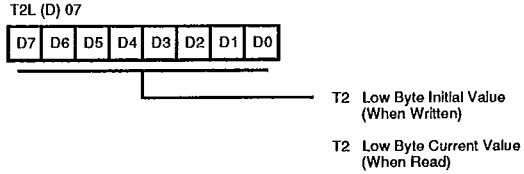


Figure 31. Counter Timer 2 Register Low Byte [%(D) 07: Read/Write]

Z8 CONTROL REGISTERS

T-49-19-65

R240 SIO

D7	D6	D5	D4	D3	D2	D1	D0

Serial Data (D0 = LSB)

Figure 32. Serial I/O Register (F0H: Read/Write)

R241 TMR

D7	D6	D5	D4	D3	D2	D1	D0

D0
0 No Function
1 Load T0

D1
0 Disable T0 Count
1 Enable T0 Count

D2
0 No Function
1 Load T1

D3
0 Disable T1 Count
1 Enable T1 Count

D4, D5
TIN Modes
00 External Clock Input
01 Gate Input
10 Trigger Input (Non-retriggerable)
11 Trigger Input (Retriggerable)

D6, D7
TOUT Modes
00 Not Used
01 T0 Out
10 T1 Out
11 Internal Clock Out

Figure 33. Timer Mode Register (F1H:Read/Write)

R242 T1

D7	D6	D5	D4	D3	D2	D1	D0

T1 Low Byte Initial Value (When Written)

T1 Low Byte Current Value (When Read)

Figure 34. Counter/Timer 1 Register (F2H:Read/Write)

R243 PRE1

D7	D6	D5	D4	D3	D2	D1	D0

D0
Count Mode
0 T1 Single Pass
1 T1 Modulo N

D1
Clock Source
1 T1 Internal
0 T1 External Timing Input (TIN) Mode

D2-D7
Prescaler Modulo
(Range: 1-64 Decimal
01-00 HEX)

Figure 35. Prescaler 1 Register (F3H:Write Only)

R244 T0

D7	D6	D5	D4	D3	D2	D1	D0

T0 Low Byte Initial Value (When Written)

T0 Low Byte Current Value (When Read)

Figure 36. Counter/Timer 0 Register (F4H:Read/Write)

R245 PRE0

D7	D6	D5	D4	D3	D2	D1	D0

D0
Count Mode
0 T0 Single Pass
1 T0 Modulo N

D1
Reserved

D2-D7
Prescaler Modulo
(Range: 1-64 Decimal
01-00 HEX)

Figure 37. Prescaler 0 Register (F5H:Write Only)

R246 P2M

D7	D6	D5	D4	D3	D2	D1	D0

P20 - P27 I/O Definition
0 Defines Bit as Output
1 Defines Bit as Input

Figure 38. Port 2 Mode Register (F6H: Write Only)

Z8 CONTROL REGISTERS (Continued)

T-49-19-65

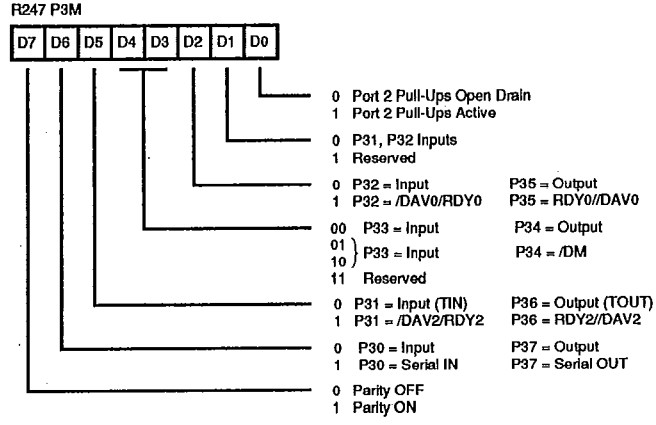


Figure 39. Port 3 Mode Register (F7H:Write Only)

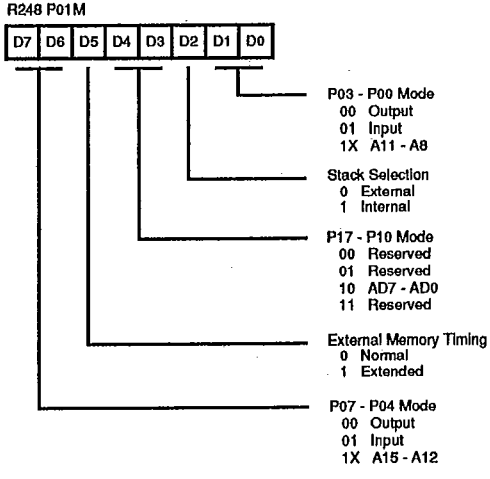


Figure 40. Ports 0 and 1 Mode Registers (F8H:Write Only)

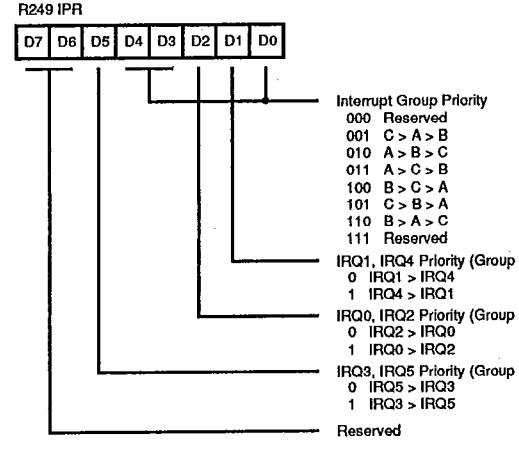


Figure 41. Interrupt Priority Register (F9H:Write Only)

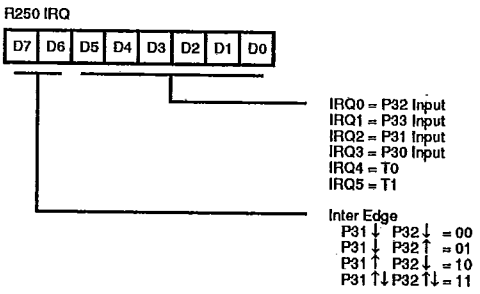


Figure 42. Interrupt Request Register (FAH:Read/Write)

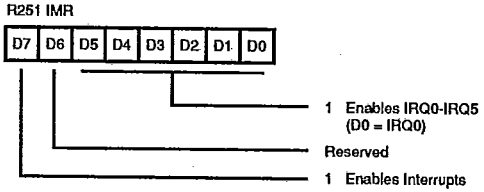


Figure 43. Interrupt Mask Register (FBH:Read/Write)

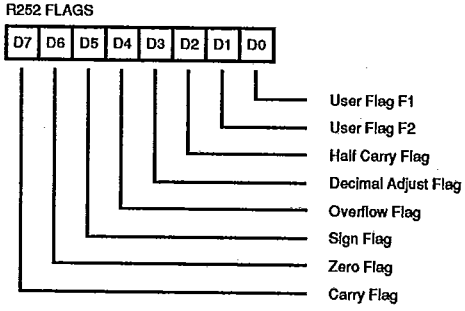


Figure 44. Flag Register (FCH:Read/Write)

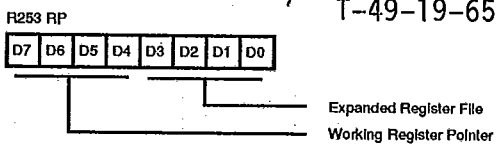


Figure 45. Register Pointer (FDH:Read/Write)

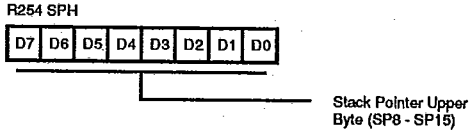


Figure 46. Stack Pointer High (FEH:Read/Write)

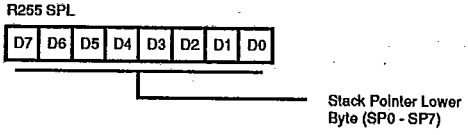


Figure 47. Stack Pointer Low (FFH:Read/Write)

INSTRUCTION SET NOTATION

T-49-19-65

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 flages are indicated by:

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

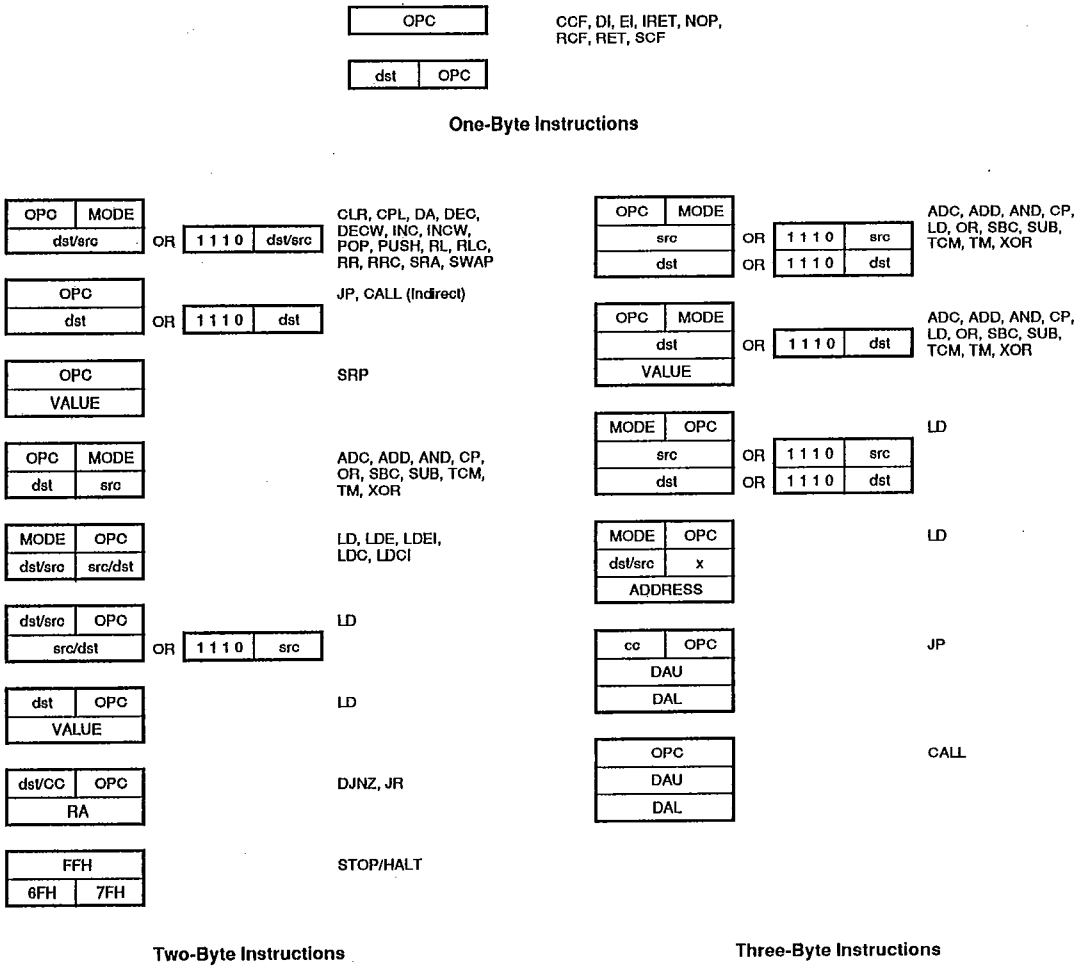
CONDITION CODES

T-49-19-65

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		Never True	

INSTRUCTION FORMATS

T-49-19-65



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 (Continued)

T-49-19-65

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 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	r	Irr	C2	-	-	-	-	-	-
LDCI dst, src dst←src r←r +1; rr←rr + 1	Ir	Irr	C3	-	-	-	-	-	-

INSTRUCTION SUMMARY (Continued)

T-49-19-65

Instruction and Operation	Address Mode dst	Address Mode 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 src RP←src		Im	31	-	-	-	-	-	-
STOP			6F	-	-	-	-	-	-
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.

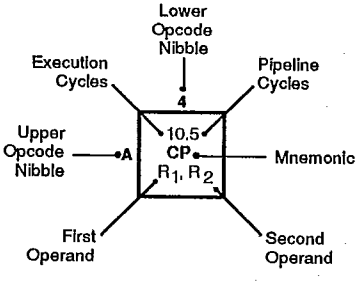
Address Mode dst	Address Mode src	Lower Opcode Nibble
r	r	[2]
r	Ir	[3]
R	R	[4]
R	IR	[5]
R	IM	[6]
IR	IM	[7]

OPCODE MAP

T-49-19-65

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** r2, Irr1	18.0 **LDCI** Ir2, Irr1	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
R_1 or r_2 = Dst address
R_1 or r_2 = Src address

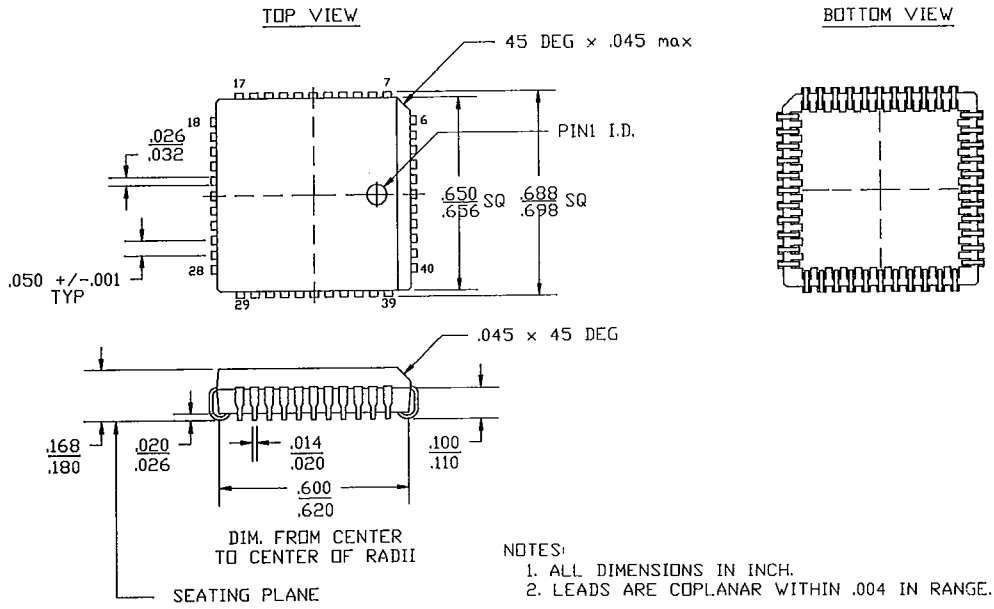
Sequence:
Opcode, First Operand, Second Operand

Note: The blank are not defined.

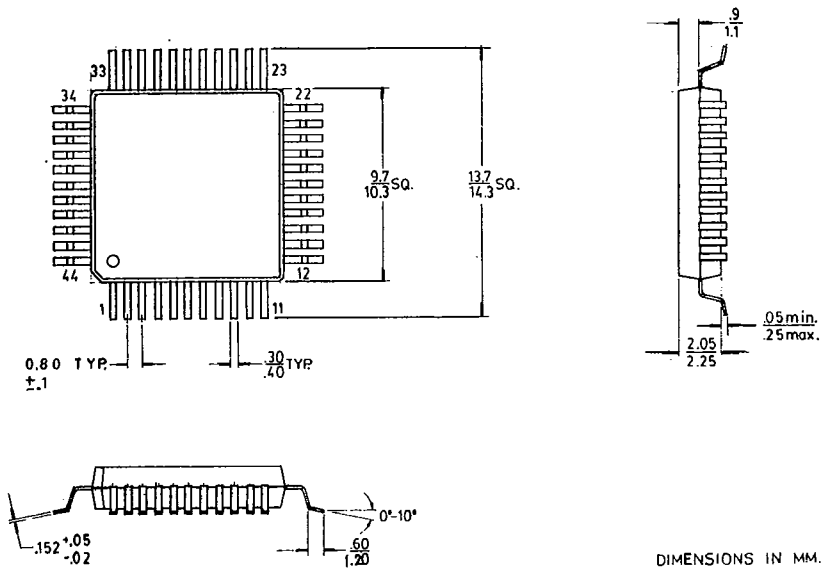
* 2-byte instruction appears as a 3-byte instruction

PACKAGE INFORMATION

T-49-19-65



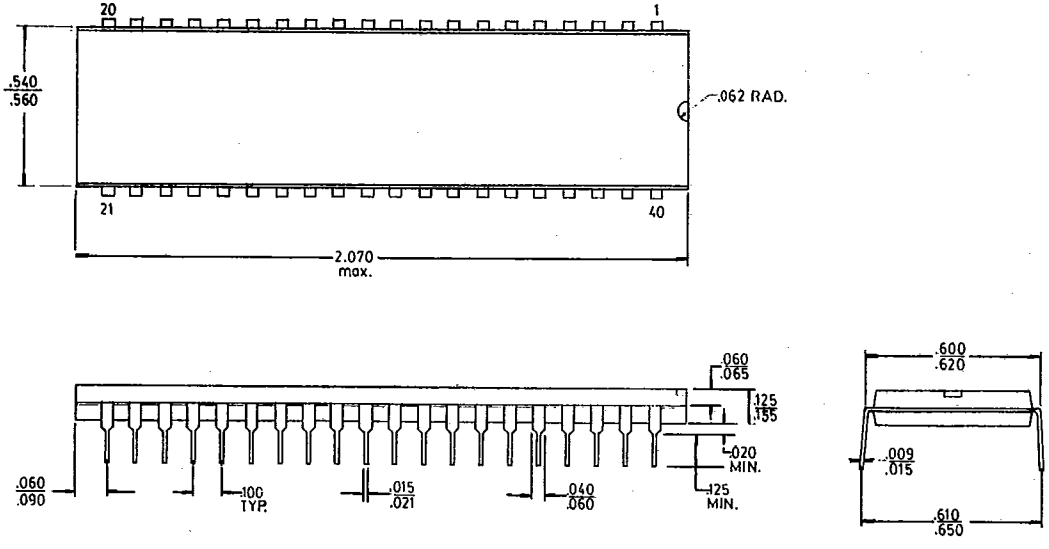
44-Pin PCC Plastic Chip Carrier



44-Pin Quad Flat Pack (QFP)

PACKAGE INFORMATION (Continued)

T-49-19-65



40-Pin Dual In-Line Package (DIP)

ORDERING INFORMATION

T-49-19-65

Z86C93

20 MHz

44-pin PLCC	44-pin QFP	40-pin DIP
Z86C9320VSC	Z86C9320FSC	Z86C9320PSC
Z86C9320VEC	Z86C9320FEC	Z86C9320PEC

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

CODES

Package
V = Plastic Chip Carrier
P - Plastic DIP

Longer Lead Time
F = Plastic Quad Flat Pack

Temperature
S = 0°C to + 70°C
E = -40°C to + 105°C

Speed
20 = 20 MHz

Environmental
C = Standard flow

Example:
Z 86C93 20 V S C is an 86C93 20 MHz, PLCC, 0°C to + 70°C, Plastic Standard Flow