(MARCOM) DC2572 DOCUMENT CONTROL MASTER

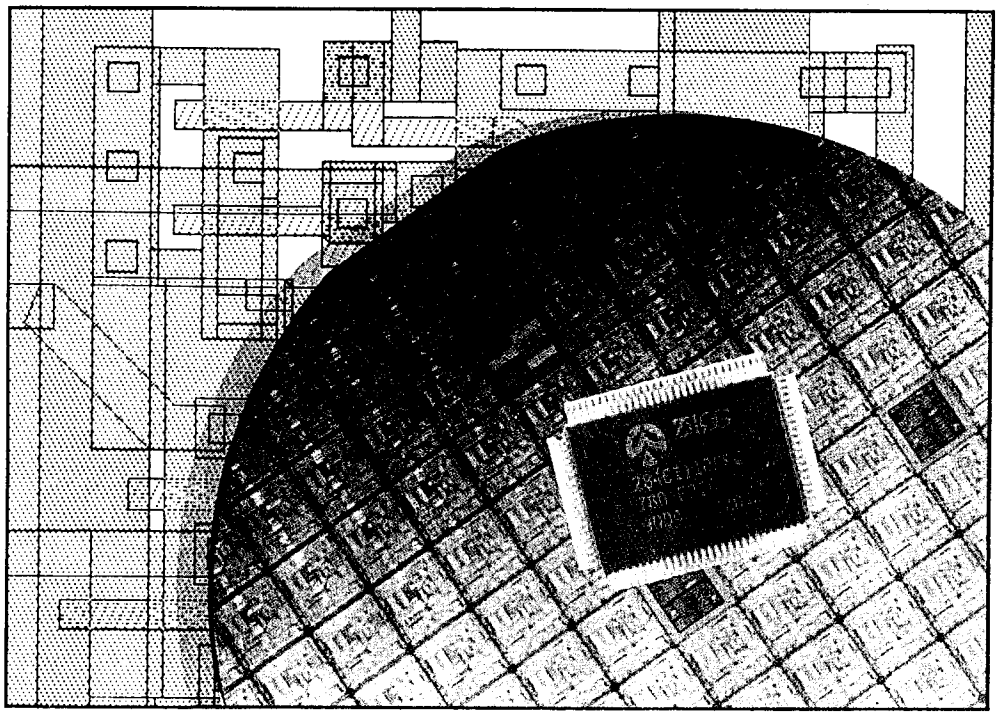
ZiLOG

PRODUCT SPECIFICATION

Z86C11

CMOS Z8®

MICROCONTROLLER



Q2/91

PRODUCT SPECIFICATION

Z86C11

CMOS Z8®
MICROCONTROLLER

FEATURES

- 8-bit CMOS microcontroller, 40- or 44-pin package
- 4.5 to 5.5 Voltage operating range
- Low power Consumption - 220 mW (max) @ 16 MHz
- Fast instruction pointer - 1.0 microseconds @ 12 MHz
- Two standby modes - STOP and HALT
- 32 input/output lines
- Full-Duplex UART
- All digital inputs are TTL levels
- Auto Latches
- RAM and ROM protect
- Low EMI option
- 4 Kbytes of ROM
- 236 bytes of RAM
- Two programmable 8-bit Counter/Timers each with 6-bit programmable prescaler.
- Six vectored, priority interrupts from eight different sources
- Clock speeds 12 and 16 MHz
- On-Chip oscillator that accepts a crystal, ceramic resonator, LC or external clock drive.

GENERAL DESCRIPTION

The Z86C11 microcontroller (MCU) introduces a new level of sophistication to single-chip architecture. The Z86C11 is a member of the Z8 single-chip microcontroller family with 4 Kbytes of ROM and 236 bytes of RAM.

The MCU is housed in a 40-pin DIP, 44-pin Leaded Chip-Carrier, or a 44-pin Quad Flat Pack, and is manufactured in CMOS technology. The ROMless pin option is available on the 44-pin versions only. Having the ROM/ROMless selectivity, the MCU offers both external memory and preprogrammed ROM. This enables the Z8 microcontroller to be used in high volume applications or where code flexibility is required.

Zilog's CMOS microcontroller offers fast execution, efficient use of memory, sophisticated interrupts, input/output bit manipulation capabilities, and easy hardware/software system expansion along with low cost and low power consumption.

The Z86C11 architecture is characterized by Zilog's 8-bit microcontroller core. The device offers a flexible I/O scheme, an efficient register and address space structure, multiplexed capabilities between address/data, I/O, and a number of ancillary features that are useful in many industrial and advanced scientific applications.

The device applications demand powerful I/O capabilities. The Z86C11 fulfills this with 32 pins dedicated to input and output. These lines are grouped into four ports. Each port consists of eight-lines, and is configurable under software control to provide timing, status signals, serial or parallel I/O with or without handshake, and an address/data bus for interfacing external memory.

There are three basic address spaces available to support this wide range of configuration: Program Memory, Data Memory and 236 General-Purpose Registers.

GENERAL DESCRIPTION (Continued)

To unburden the program from coping with the real-time problems such as counting/timing and serial data communication, the Z86C11 offers two on-chip counter/timers with a large number of user selectable modes, and an asynchronous receiver/transmitter (UART - Figure 1).

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).

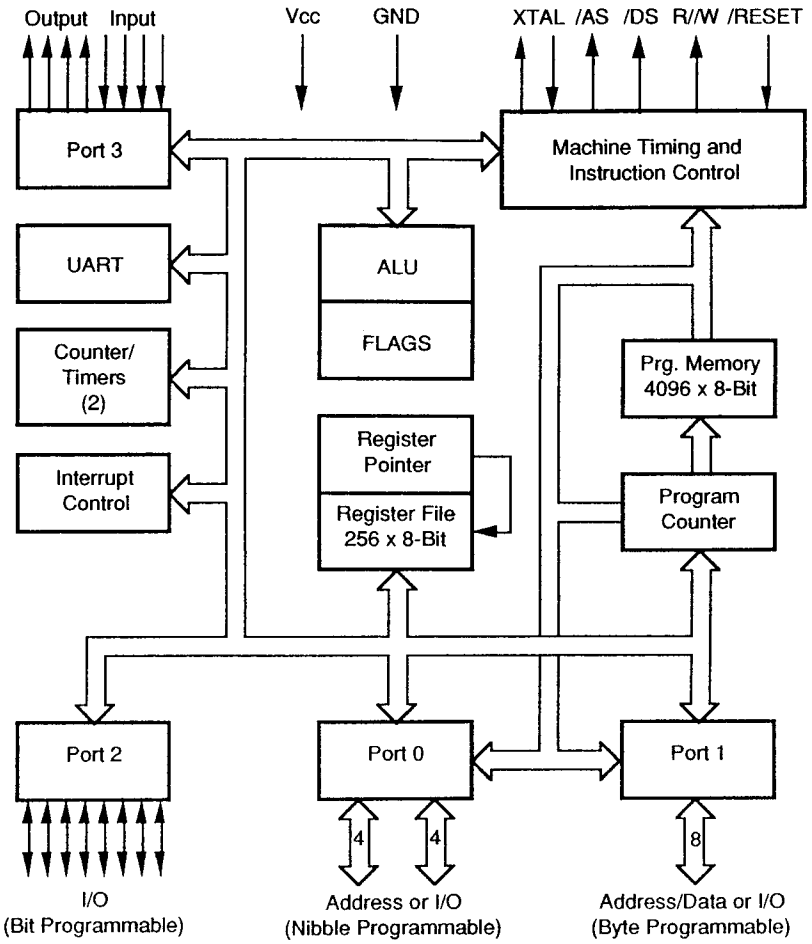


Figure 1. Functional Block Diagram

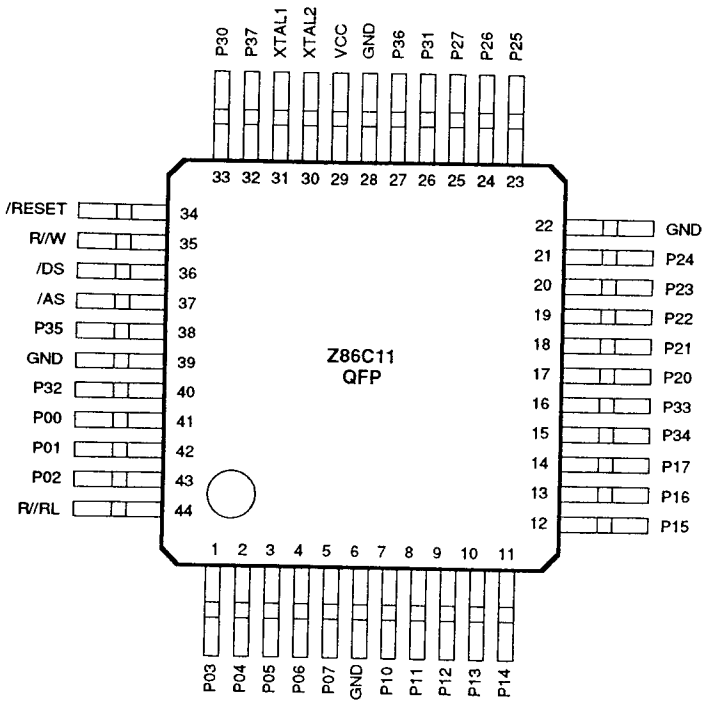


Figure 4. 44-Pin Quad Flat Pack Pin Assignments

Table 3. 44-Pin Quad Flat Pack Pin Identification

Pin #	Symbol	Function	Direction
1-5	P03-P07	Port 0 pin 3,4,5,6,7	In/Output
6	GND	Ground	Input
7-14	P10-P17	Port 1 pin 0,1,2,3,4,5,6,7	In/Output
15	P34	Port 3 pin 4	Output
16	P33	Port 3 pin 3	Input
17-21	P20-P24	Port 2 pin 0,1,2,3,4	In/Output
22	GND	Ground	Input
23-25	P25-P27	Port 2 pin 5,6,7	In/Output
26	P31	Port 3 pin 1	Input
27	P36	Port 3 pin 6	Output
28	GND	Ground	Input
29	V_{cc}	Power Supply	Input
30	XTAL2	Crystal, Oscillator Clock	Output
31	XTAL1	Crystal, Oscillator Clock	Input
32	P37	Port 3 pin 7	Output
33	P30	Port 3 pin 0	Input
34	/RESET	Reset	Input
35	R//W	Read/Write	Output
36	/DS	Data Strobe	Output
37	/AS	Address Strobe	Output
38	P35	Port 3 pin 5	Output
39	GND	Ground	Input
40	P32	Port 3 pin 2	Input
41-43	P00-P02	Port 0 pin 0,1,2	In/Output
44	R//RL	ROM/ROMless control	Input

PIN DESCRIPTION (Continued)

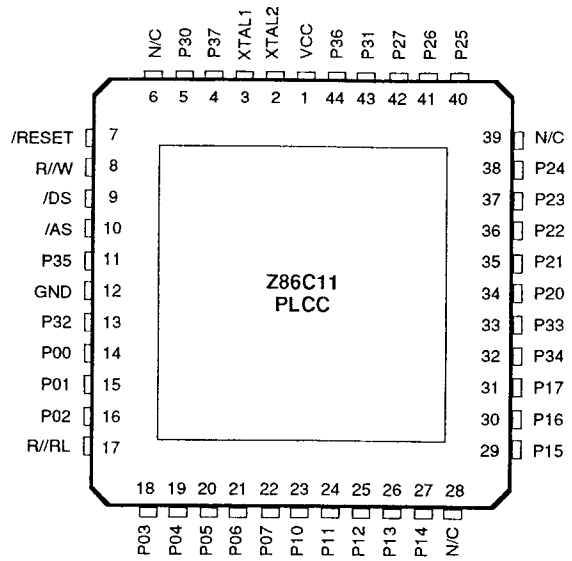


Figure 3. 44-Pin Plastic Leaded Chip Carrier Pin Assignments

Table 2. 44-Pin Plastic Leaded Chip Carrier Pin Identification

Pin #	Symbol	Function	Direction
1	V_{cc}	Power Supply	Input
2	XTAL2	Crystal, Oscillator Clock	Output
3	XTAL1	Crystal, Oscillator Clock	Input
4	P37	Port 3 pin 7	Output
5	P30	Port 3 pin 0	Input
6	N/C	Not Connected	Input
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

Pin #	Symbol	Function	Direction
14-16	P00-P02	Port 0 pin 0,1,2	In/Output
17	R//RL	ROM/ROMless control	Input
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	N/C	Not Connected	Input
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

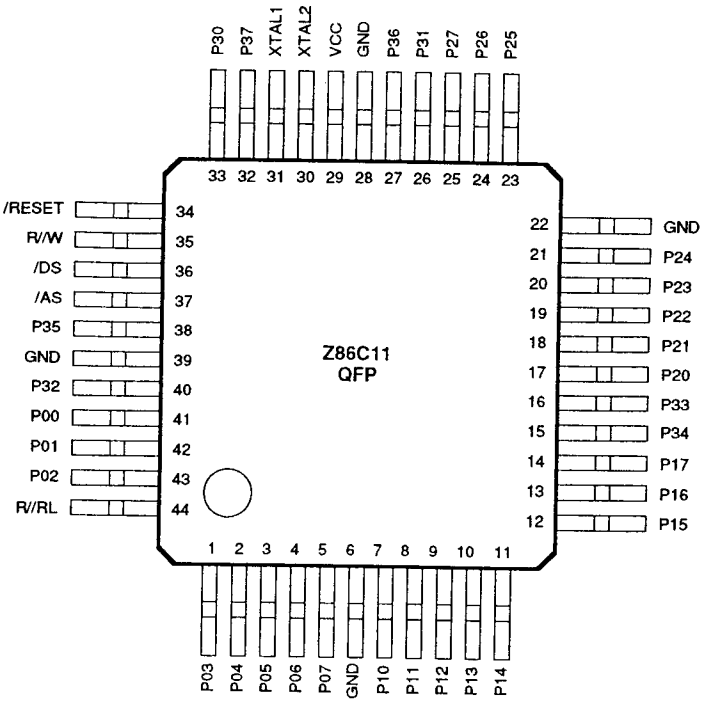


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15	P34	Port 3 pin 4	Output
16	P33	Port 3 pin 3	Input
17-21	P20-P24	Port 2 pin 0,1,2,3,4	In/Output
22	GND	Ground	Input
23-25	P25-P27	Port 2 pin 5,6,7	In/Output
26	P31	Port 3 pin 1	Input
27	P36	Port 3 pin 6	Output
28	GND	Ground	Input
29	V_{cc}	Power Supply	Input
30	XTAL2	Crystal, Oscillator Clock	Output
31	XTAL1	Crystal, Oscillator Clock	Input
32	P37	Port 3 pin 7	Output
33	P30	Port 3 pin 0	Input
34	/RESET	Reset	Input
35	R//W	Read/Write	Output
36	/DS	Data Strobe	Output
37	/AS	Address Strobe	Output
38	P35	Port 3 pin 5	Output
39	GND	Ground	Input
40	P32	Port 3 pin 2	Input
41-43	P00-P02	Port 0 pin 0,1,2	In/Output
44	R//RL	ROM/ROMless control	Input

PIN FUNCTIONS

/ROMless. (input, active Low). This pin when connected to GND disables the internal ROM and forces the device to function as a Z86C91 ROMless Z8. (Note that, when left unconnected or pulled high to V_{CC}, the part functions as a normal Z86C11 ROM version). This pin is only available on the 44-pin versions of the Z86C11.

/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. 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, write Low). The Read/Write signal is low when the MCU is writing to the external program or data memory.

/RESET. (input, active-Low). To avoid asynchronous and noisy reset problems, the Z86C11 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). Power-up reset time must be held low for 50 mS, or until VCC is stable, whichever is longer.

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 is 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. For the ROMless option, Port 0 comes up as A15-A8 Address lines after /RESET.

For external memory references, Port 0 can provide address bit 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. In ROMless mode, 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 includes reconfiguration to eliminate this extended timing mode (Figure 5).

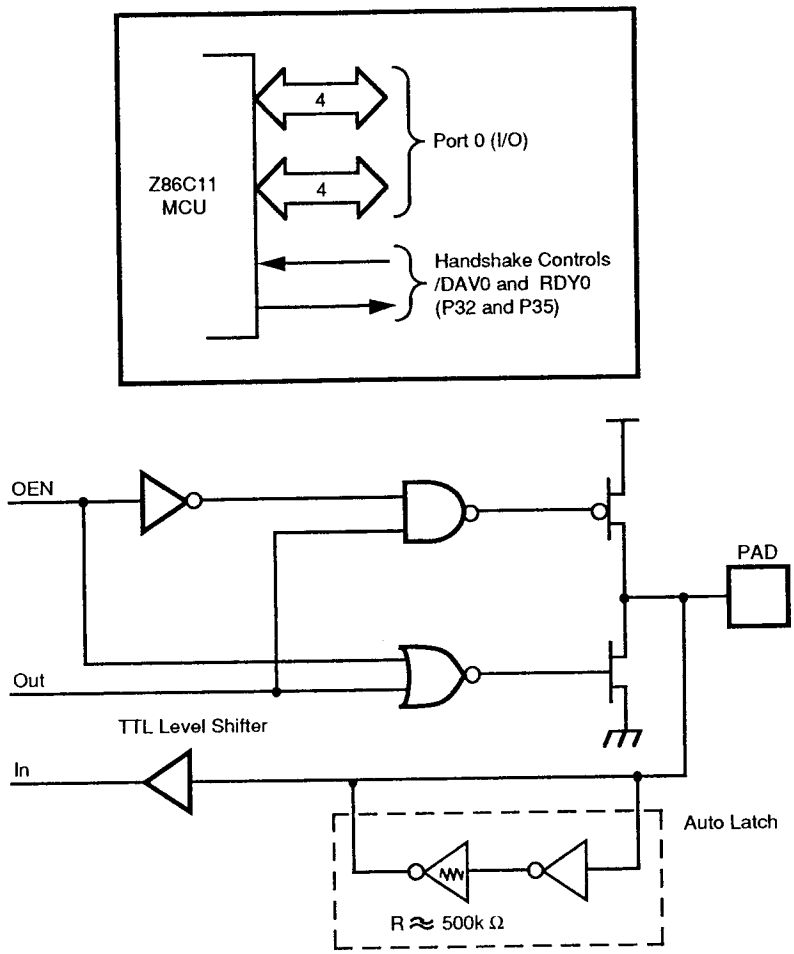


Figure 5. Port 0 Configuration

PIN FUNCTION (Continued)

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. For Z86C11, these eight I/O lines can be programmed as Input or Output lines or can be configured under software control as an address/data port for interfacing external memory. When used as an I/O port, Port 1 is placed under handshake control. In this configuration, Port 3 lines P33 and P34 are used as the handshake controls RDY1 and /DAV1.

Memory locations greater than 4096 are referenced through Port 1. 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.

Port 1 can be placed in high-impedance state along with Port 0, /AS, /DS and R//W, allowing the MCU to share common resource in multiprocessor and DMA applications. Data transfers can be controlled by assigning P33 as a Bus Acknowledge input, and P34 as a Bus request output (Figure 6).

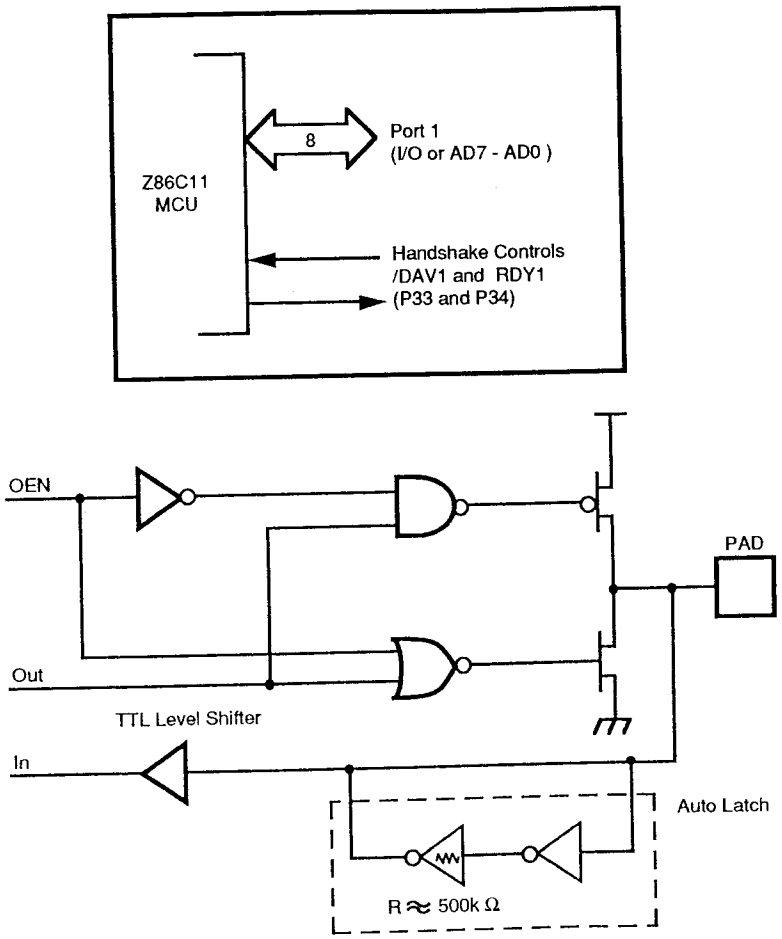


Figure 6. Port 1 Configuration

Port 2. (P20-P27). 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 may be 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 7).

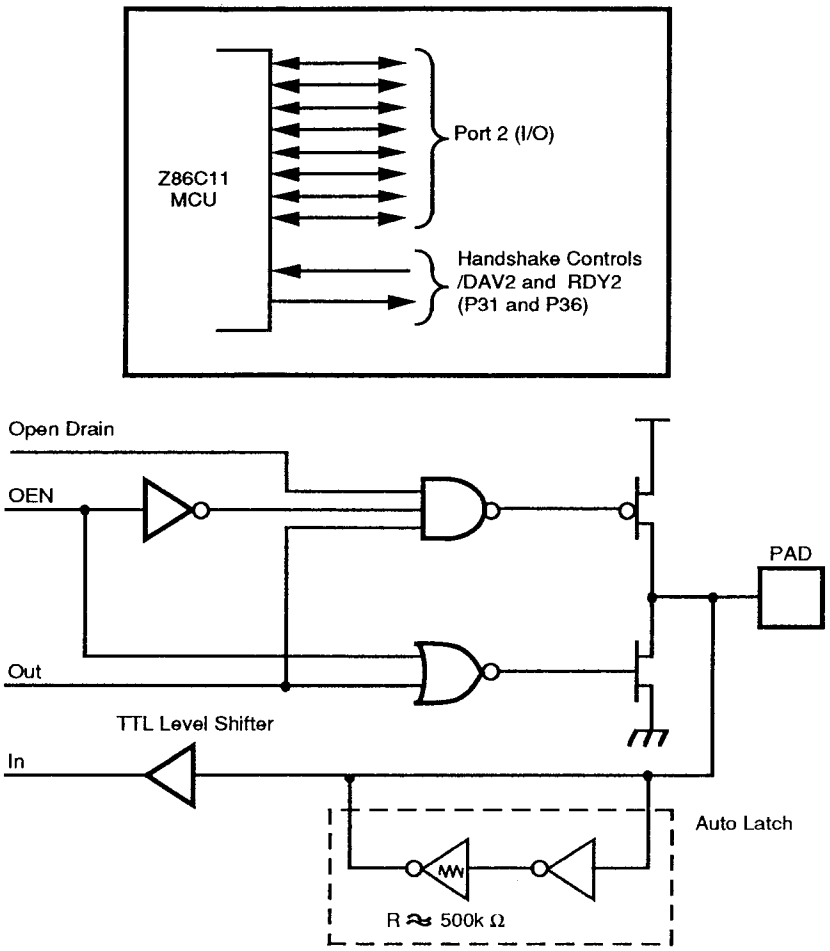


Figure 7. Port 2 Configuration

PIN FUNCTION (Continued)

Port 3. (P30-P37). Port 3 is an 8-bit, TTL compatible four-fixed input and four-fixed output port. These eight 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 8).

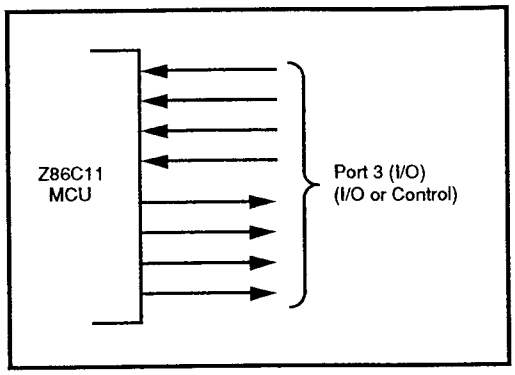


Figure 8. Port 3 Configuration

Port 3 is configured under software control to provide the following control functions: handshake for Ports 0, 1 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).

Table 4. Port 3 Pin Assignments

Pin	I/O	CTC1	Int.	P0 HS	P1 HS	P2 HS	UART	Ext
P30	IN		IRQ3				Serial In	
P31	IN	T_{IN}	IRQ2			D/R		
P32	IN		IRQ0	D/R				
P33	IN		IRQ1		D/R			
P34	OUT				R/D			DM
P35	OUT			R/D				
P36	OUT	T_{OUT}				R/D		
P37	OUT						Serial Out	

Notes:
HS = HANDSHAKE SIGNALS
D = Data Available
R = Ready

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 Z86C11 automatically adds a start bit and two stop bits to transmitted data (Figure 9). 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.

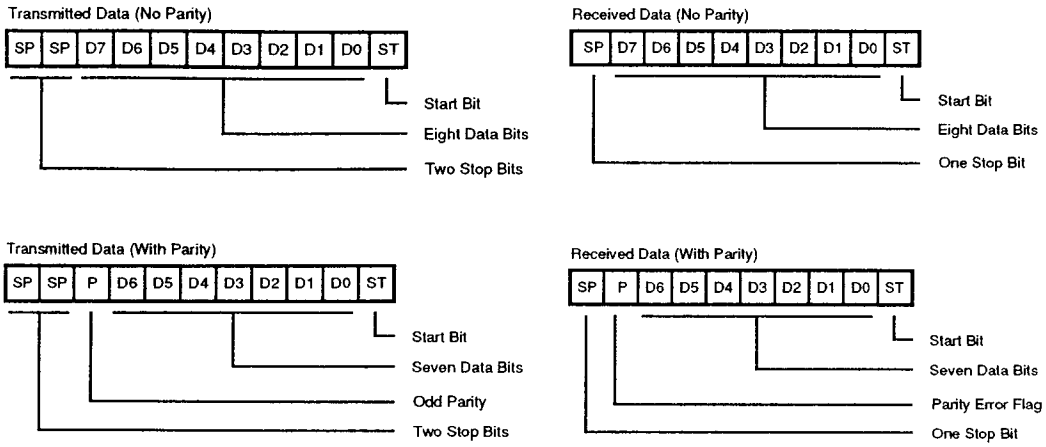


Figure 9. Serial Data Formats

Auto-Latch. The Auto-Latch puts valid CMOS levels on all CMOS inputs that are not externally driven. This will reduce excessive supply current flow in the input buffer when it is not been driven by any source.

Low EMI Option. The Z86C11 is available in a low EMI option. This option is mask-programmable, to be selected by the customer at the time when the ROM code is submitted. Use of this feature results in:

- Less than 1 mA current consumptions during HALT mode.
- The pre-drivers slew rate reduced to 10 ns typical.
- Low EMI output drivers have resistance of 200 ohms typical.
- Oscillator divide-by-two circuitry is eliminated.
- Internal SCLK/TCLK operation is limited to a maximum of 4 MHz (250 ns cycle time)

FUNCTIONAL DESCRIPTION

Address Space

Program Memory. The Z86C11 can address up to 60 K bytes of external program memory (Figure 10). The first 12 bytes of program memory are reserved for the interrupt vectors. These locations contain six 16-bit vectors that correspond to the six available interrupts. For ROM mode, byte 13 to byte 4095 consists of on-chip ROM. At address 4096 and greater, the Z86C11 executes external program memory fetches. In the ROMless mode, the Z86C11 can address up to 64 Kbytes of external program memory. Program execution begins at external location 000C (HEX) after a reset.

Data Memory (/DM). The ROM version can address up to 60 Kbytes of external data memory space beginning at location 4096. The ROMless version can address up to 64 Kbytes of external data memory. External data memory may be 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.

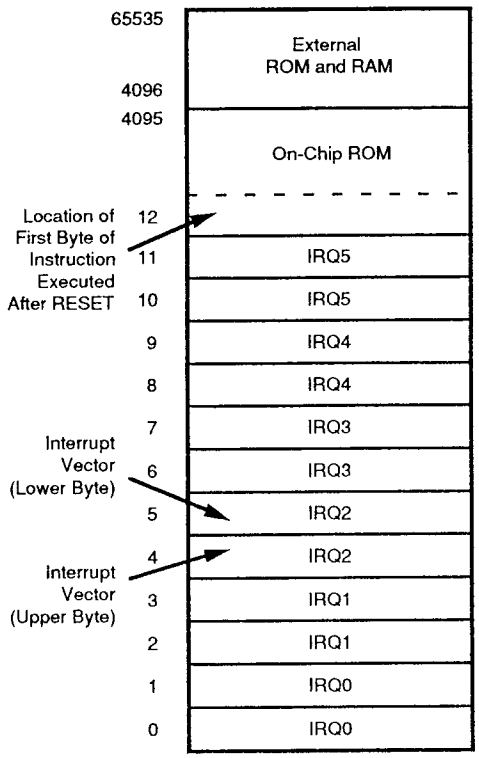


Figure 10. Program Memory Configuration

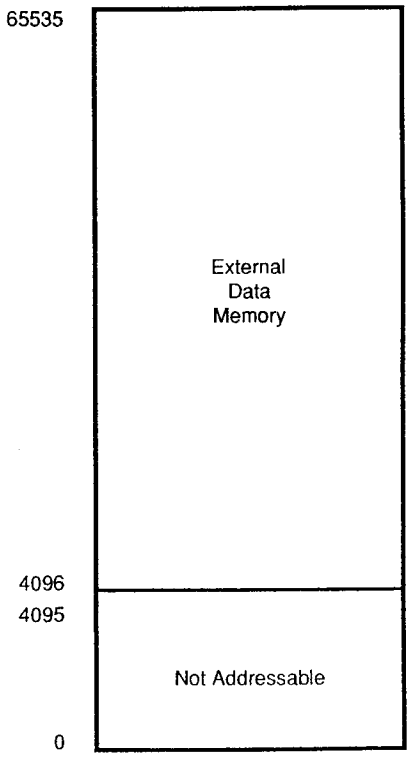


Figure 11. Data Memory Configuration

Register File. The Register File consists of four I/O port registers, 236 general-purpose registers and 16 control and status registers (Figure 12). The instructions can access registers directly or indirectly via an 8-bit address field. The Z86C11 also allows short 4-bit register addressing using the Register Pointer (Figure 13). 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 registers and indirect addressing modes.

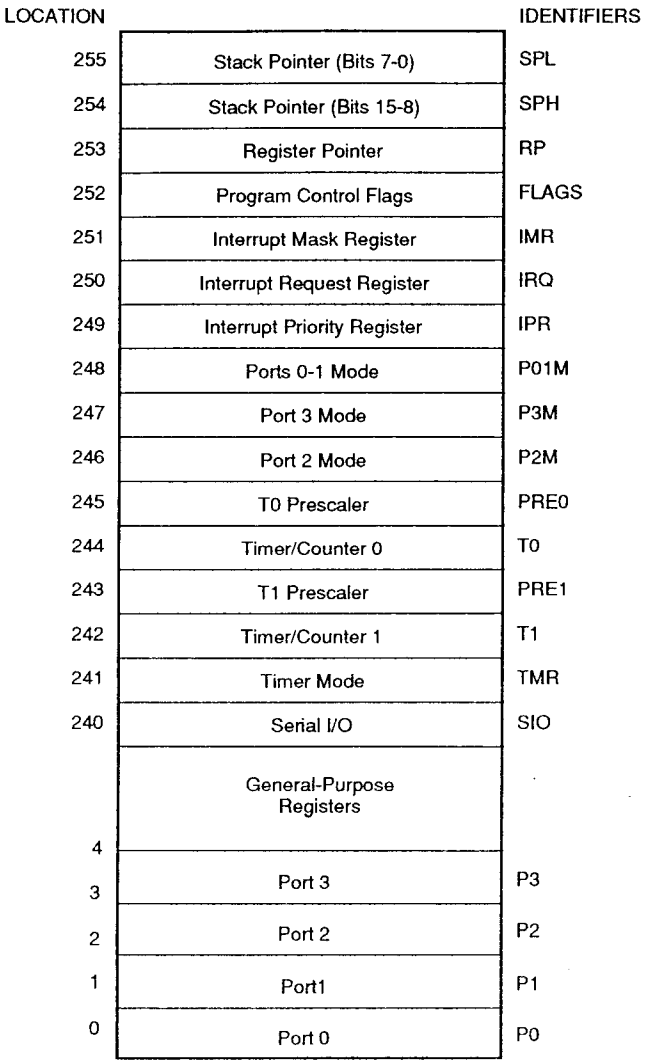


Figure 12. Register File

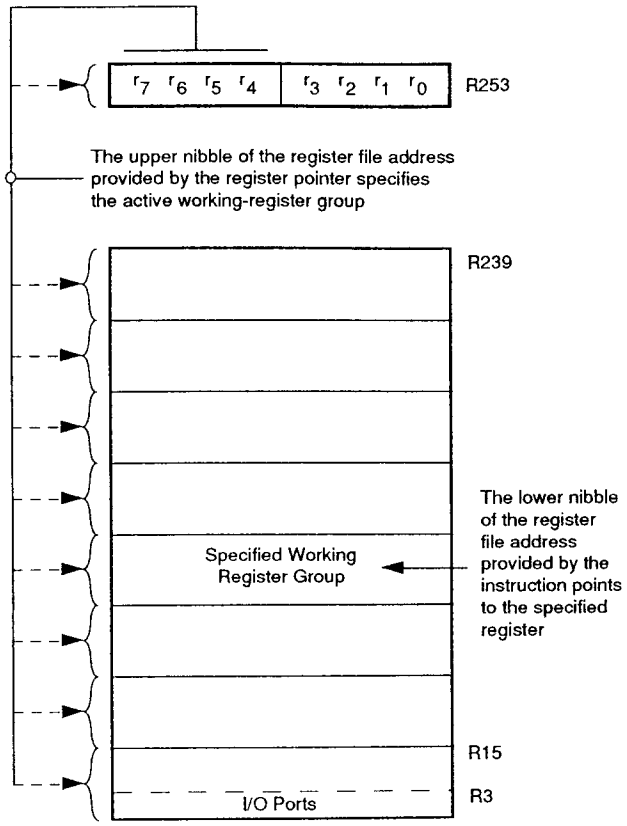


Figure 13. Register Pointer

RAM Protect. The upper portion of the RAM's address spaces 80H to EFH (excluding the control registers) can be protected from reading and writing. The RAM Protect bit option is mask-programmable and is selected by the customer when the ROM code is submitted. After the mask option is selected, the user can activate from the internal ROM code to turn off/on the RAM Protect by loading a bit D6 in the IMR register to either a 0 or a 1, respectively. A 1 in D6 indicates RAM Protect enabled.

ROM Protect. The first 4 Kbytes of program memory is mask programmable. A ROM protect feature prevents dumping of the ROM contents by inhibiting execution of LDC, LDCI, LDE, and LDEI instructions to Program Memory in all modes.

The ROM Protect option is mask-programmable, to be selected by the customer at the time when the ROM code is submitted.

Stack. The Z86C11 has a 16-bit Stack Pointer (R254-R255) used for external stack that resides anywhere in the data memory for the ROMless mode, but only from 4096 to 65535 in the ROM mode. 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-Bit 8-15) is used as a general purpose register when using internal stack only.

Counter/Timers. There are two 8-bit programmable counter/timers (T0-T1), each driven by its own 6-bit programmable prescaler. The T1 prescaler can be driven by internal or external clock sources; however, the T0 prescaler is driven by the internal clock only (Figure 14).

The 6-bit prescalers can 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 both the counters and prescaler reach the end of the count, a timer interrupt request, IRQ4 (T0) or IRQ5 (T1), is generated.

The counter can be 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 counter, but not the prescalers, can be read at any time without disturbing their value or count mode. The clock source for T1 is user-definable and can be 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 can be retriggerable or non-retriggerable, or as a gate input for the internal clock. Port 3 line P36 also serves as a timer output (TOUT) through which T0, T1 or the internal clock can be output. The counter/timers are cascaded by connecting the T0 output to the input of T1.

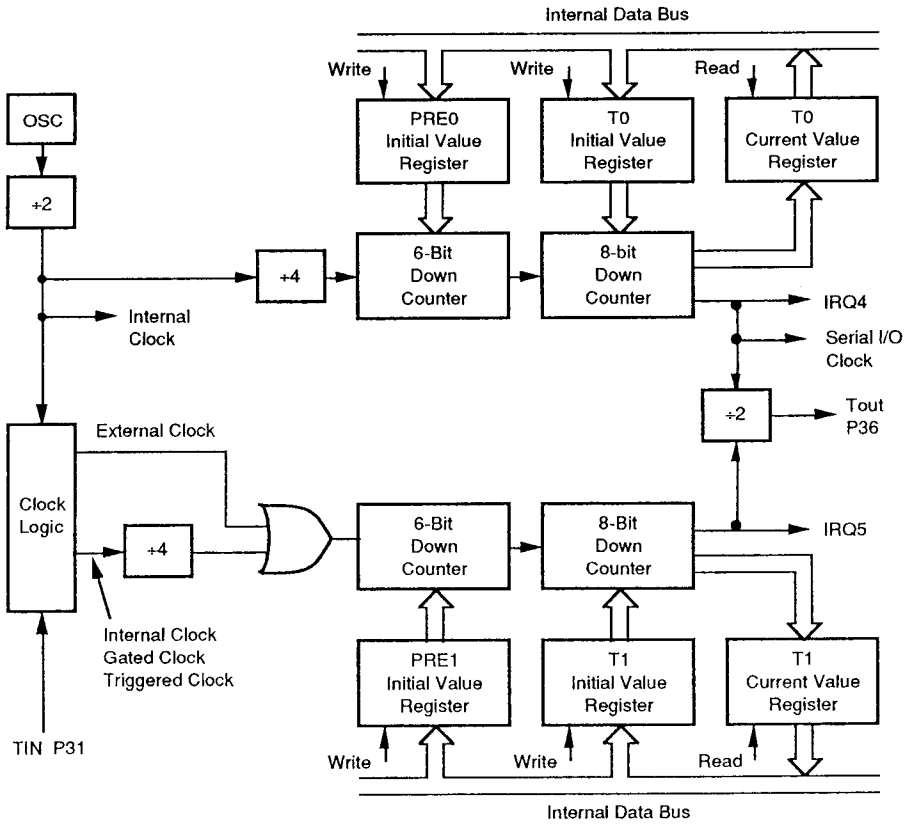


Figure 14. Counter/Timers Block Diagram

FUNCTIONAL DESCRIPTION (Continued)

Interrupts. The Z86C11 has six different interrupts from eight different sources. The interrupts are maskable and prioritized. The eight sources are divided as follows: four sources are claimed by Port 3 lines P30-P33, one in Serial Out, one in Serial In, and two in the counter/timers (Figure 15). 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 Z86C11 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, saves 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 initialed interrupts are supported by setting the appropriate bit in the Interrupt Request (IRQ) register.

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.

For the ROMless mode, 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.

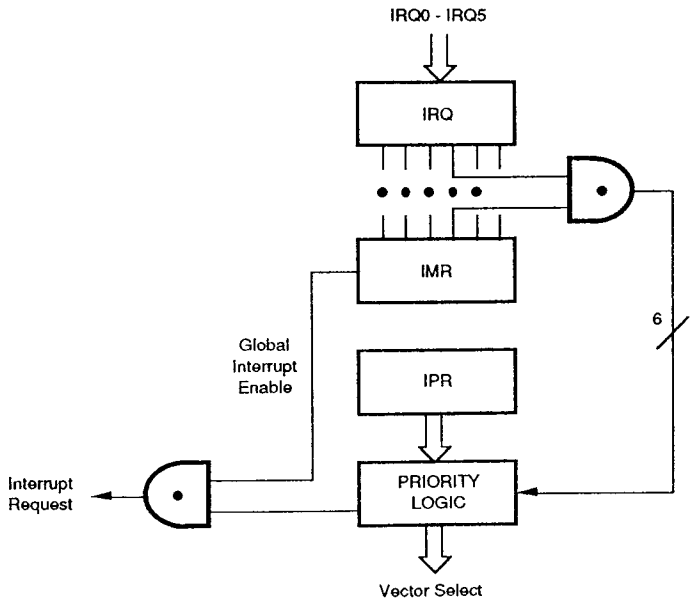
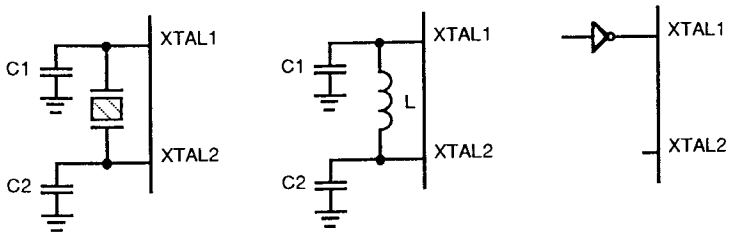


Figure 15. Interrupt Block Diagram

Clock. The Z86C11 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 crystal should be AT cut, 1 MHz to 16 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 < 300 pF) from each pin to ground (Figure 16).



Ceramic Resonator or Crystal | LC Clock | External Clock

Figure 16. Oscillator Configuration

HALT. Will turn off the internal CPU clock but not the XTAL oscillation. The counter/timers and the external interrupts IRQ0, IRQ1, IRQ2 and IRQ3 remains 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

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

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 17).

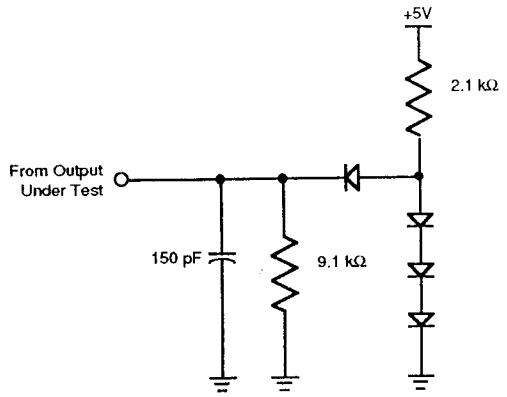


Figure 17. Test Load Diagram

DC CHARACTERISTICS

Sym	Parameter	T_A = 0°C to 70°C		T_A = -40°C to105°C		Typical at 25°C	Units	Conditions
		Min	Max	Min	Max			
	Max Input Voltage		7		7		V	I_{IN} 250µA
V_{CH}	Clock Input High Voltage	3.8	V_{CC}+0.3	3.8	V_{CC}+0.3		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}+0.3	2.0	V_{CC}+0.3		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_{OL} = +5.0 mA
V_{RH}	Reset Input High Voltage	3.8	V_{CC}+0.3	3.8	V_{CC}+0.3		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	V_{IN} = 0V, V_{CC}
I_{OL}	Output Leakage	-2	2	-2	2		µA	V_{IN} = 0V, V_{CC}
I_{IR}	Reset Input Current		-80		-80		µA	V_{RL} = 0V
I_{CC}	Supply Current		30		30	20	mA	[1] @ 12 MHz
			35		35	24	mA	[1] @ 16 MHz
I_{CC1}	Standby Current		6.5		6.5	4	mA	[1] HALT Mode V_{IN} = 0V, V_{CC}@ 12 MHz
			7.0		7.0	4.5	mA	[1] HALT Mode V_{IN} = 0V,V_{CC}@ 16 MHz
I_{CC2}	Standby Current		10		20	5	µA	[1,2] STOP Mode V_{IN} = 0V,V_{CC}

Notes:

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

[2] I_{CC2} requires loading TMR (F1H) with any value prior to STOP execution.

Use this sequence:

```
LD TMR,#00
NOP
STOP
```

AC CHARACTERISTICS

External I/O or Memory Read or Write Timing Diagram

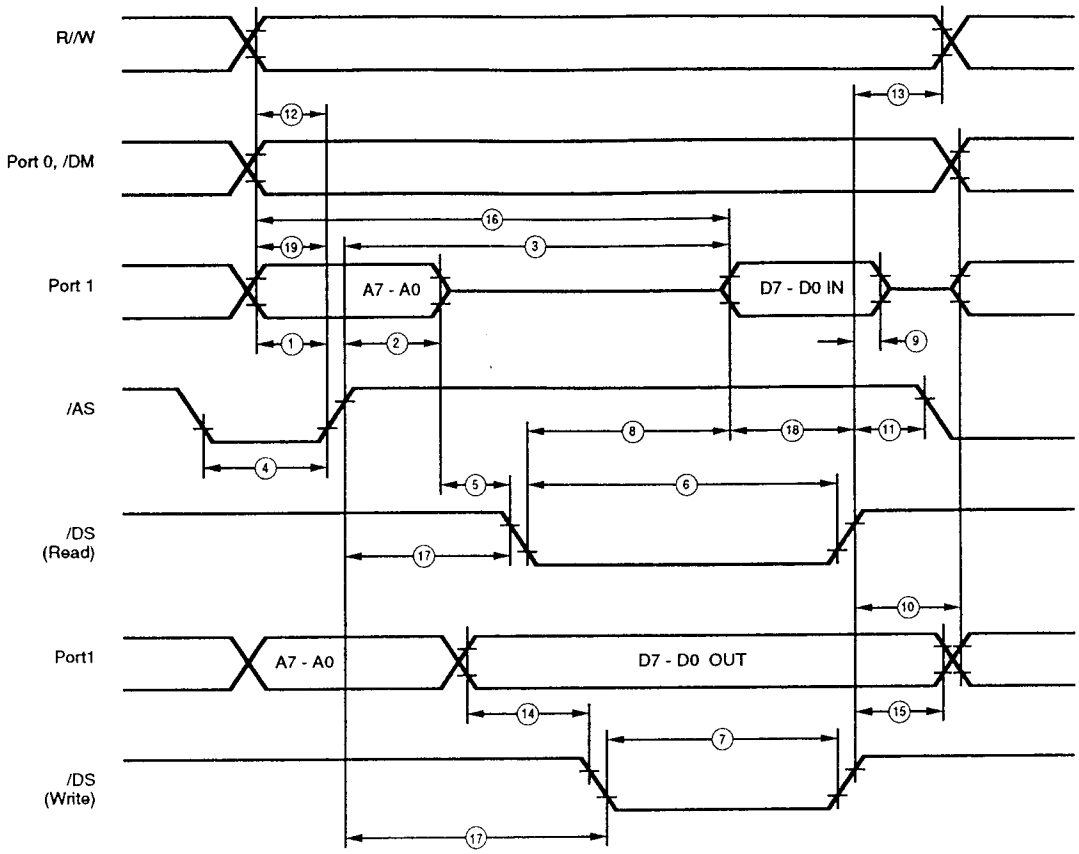


Figure 18. External I/O or Memory Read/Write Timing