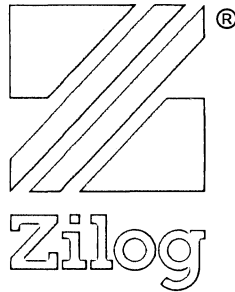


# Z80<sup>®</sup>-CPU Z80A-CPU



# Product Specification

MARCH 1978

The Zilog Z80 product line is a complete set of micro-computer components, development systems and support software. The Z80 microcomputer component set includes all of the circuits necessary to build high-performance microcomputer systems with virtually no other logic and a minimum number of low cost standard memory elements.

The Z80 and Z80A CPU's are third generation single chip microprocessors with unrivaled computational power. This increased computational power results in higher system through-put and more efficient memory utilization when compared to second generation microprocessors. In addition, the Z80 and Z80A CPU's are very easy to implement into a system because of their single voltage requirement plus all output signals are fully decoded and timed to control standard memory or peripheral circuits. The circuit is implemented using an N-channel, ion implanted, silicon gate MOS process.

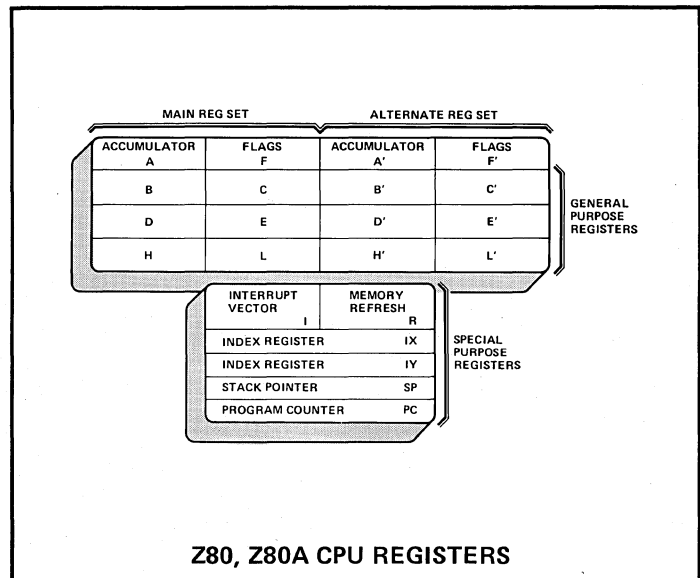
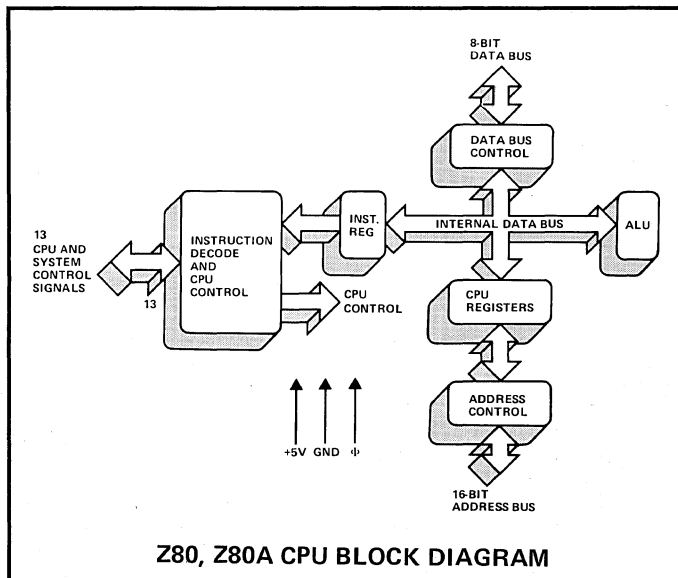
Figure 1 is a block diagram of the CPU, Figure 2 details the internal register configuration which contains 208 bits of Read/Write memory that are accessible to the programmer. The registers include two sets of six general purpose registers that may be used individually as 8-bit registers or as 16-bit register pairs. There are also two sets of accumulator and flag registers. The programmer has access to either set of main or alternate registers through a group of exchange instructions. This alternate set allows foreground/background mode of operation or may be reserved for very fast Interrupt response. Each CPU also contains a 16-bit stack pointer which permits simple implementation of

multiple level interrupts, unlimited subroutine nesting and simplification of many types of data handling.

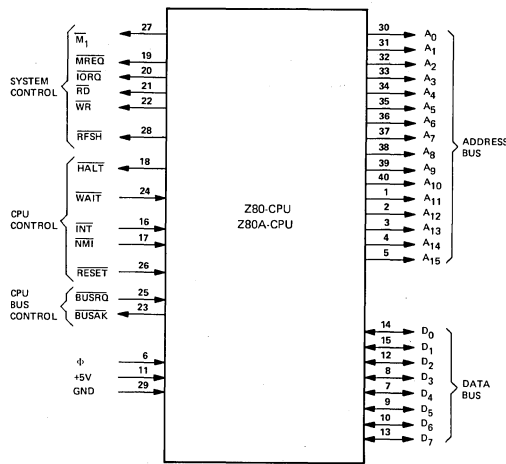
The two 16-bit index registers allow tabular data manipulation and easy implementation of relocatable code. The Refresh register provides for automatic, totally transparent refresh of external dynamic memories. The I register is used in a powerful interrupt response mode to form the upper 8 bits of a pointer to a interrupt service address table, while the interrupting device supplies the lower 8 bits of the pointer. An indirect call is then made to this service address.

## FEATURES

- Single chip, N-channel Silicon Gate CPU.
- 158 instructions—includes all 78 of the 8080A instructions with total software compatibility. New instructions include 4-, 8- and 16-bit operations with more useful addressing modes such as indexed, bit and relative.
- 17 internal registers.
- Three modes of fast interrupt response plus a non-maskable interrupt.
- Directly interfaces standard speed static or dynamic memories with virtually no external logic.
- 1.0  $\mu$ s instruction execution speed.
- Single 5 VDC supply and single-phase 5 volt Clock.
- Out-performs any other single chip microcomputer in 4-, 8-, or 16-bit applications.
- All pins TTL Compatible
- Built-in dynamic RAM refresh circuitry.



# Z80, Z80A-CPU Pin Description



## Z80, Z80A CPU PIN CONFIGURATION

**A<sub>0</sub>-A<sub>15</sub>**  
(Address Bus) Tri-state output, active high. A<sub>0</sub>-A<sub>15</sub> constitute a 16-bit address bus. The address bus provides the address for memory (up to 64K bytes) data exchanges and for I/O device data exchanges.

**D<sub>0</sub>-D<sub>7</sub>**  
(Data Bus) Tri-state input/output, active high. D<sub>0</sub>-D<sub>7</sub> constitute an 8-bit bidirectional data bus. The data bus is used for data exchanges with memory and I/O devices.

**M<sub>1</sub>**  
(Machine Cycle one) Output, active low.  $\overline{M_1}$  indicates that the current machine cycle is the OP code fetch cycle of an instruction execution.

**MREQ**  
(Memory Request) Tri-state output, active low. The memory request signal indicates that the address bus holds a valid address for a memory read or memory write operation.

**IORQ**  
(Input/Output Request) Tri-state output, active low. The IORQ signal indicates that the lower half of the address bus holds a valid I/O address for a I/O read or write operation. An IORQ signal is also generated when an interrupt is being acknowledged to indicate that an interrupt response vector can be placed on the data bus.

**RD**  
(Memory Read) Tri-state output, active low.  $\overline{RD}$  indicates that the CPU wants to read data from memory or an I/O device. The addressed I/O device or memory should use this signal to gate data onto the CPU data bus.

**WR**  
(Memory Write) Tri-state output, active low.  $\overline{WR}$  indicates that the CPU data bus holds valid data to be stored in the addressed memory or I/O device.

**RFSH**  
(Refresh) Output, active low.  $\overline{RFSH}$  indicates that the lower 7 bits of the address bus contain a refresh address for dynamic memories and the current MREQ signal should be used to do a refresh read to all dynamic memories.

**HALT**  
(Halt state) Output, active low.  $\overline{HALT}$  indicates that the CPU has executed a HALT software instruction and is awaiting either a non-maskable or a maskable interrupt (with the mask enabled) before operation can resume. While halted, the CPU executes NOP's to maintain memory refresh activity.

**WAIT**  
(Wait) Input, active low.  $\overline{WAIT}$  indicates to the Z-80 CPU that the addressed memory or I/O devices are not ready for a data transfer. The CPU continues to enter wait states for as long as this signal is active.

**INT**  
(Interrupt Request) Input, active low. The Interrupt Request signal is generated by I/O devices. A request will be honored at the end of the current instruction if the internal software controlled interrupt enable flip-flop (IFF) is enabled.

**NMI**  
(Non Maskable Interrupt) Input, active low. The non-maskable interrupt request line has a higher priority than INT and is always recognized at the end of the current instruction, independent of the status of the interrupt enable flip-flop.  $\overline{NMI}$  automatically forces the Z-80 CPU to restart to location 0066H.

**RESET** Input, active low.  $\overline{RESET}$  initializes the CPU as follows: reset interrupt enable flip-flop, clear PC and registers I and R and set interrupt to 8080A mode. During reset time, the address and data bus go to a high impedance state and all control output signals go to the inactive state.

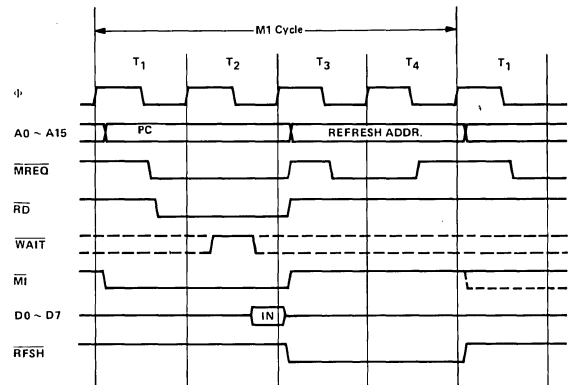
**BUSRQ**  
(Bus Request) Input, active low. The bus request signal has a higher priority than  $\overline{NMI}$  and is always recognized at the end of the current machine cycle and is used to request the CPU address bus, data bus and tri-state output control signals to go to a high impedance state so that other devices can control these busses.

**BUSAK**  
(Bus Acknowledge) Output, active low. Bus acknowledge is used to indicate to the requesting device that the CPU address bus, data bus and tri-state control bus signals have been set to their high impedance state and the external device can now control these signals.

# Timing Waveforms

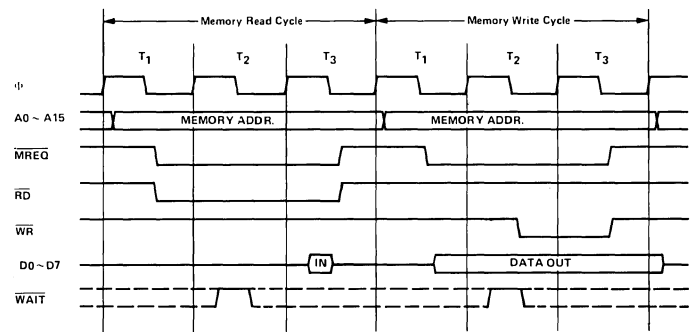
## INSTRUCTION OP CODE FETCH

The program counter content (PC) is placed on the address bus immediately at the start of the cycle. One half clock time later  $\overline{MREQ}$  goes active. The falling edge of  $\overline{MREQ}$  can be used directly as a chip enable to dynamic memories.  $\overline{RD}$  when active indicates that the memory data should be enabled onto the CPU data bus. The CPU samples data with the rising edge of the clock state  $T_3$ . Clock states  $T_3$  and  $T_4$  of a fetch cycle are used to refresh dynamic memories while the CPU is internally decoding and executing the instruction. The refresh control signal  $\overline{RFSH}$  indicates that a refresh read of all dynamic memories should be accomplished.



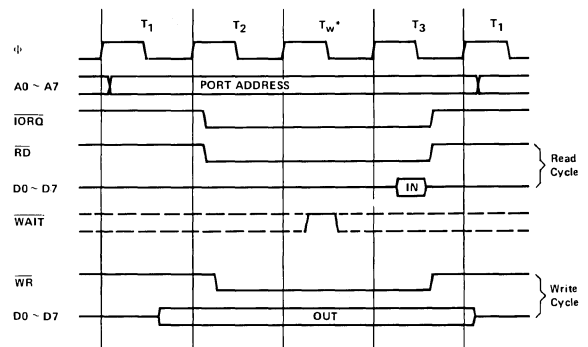
## MEMORY READ OR WRITE CYCLES

Illustrated here is the timing of memory read or write cycles other than an OP code fetch ( $M_1$  cycle). The  $\overline{MREQ}$  and  $\overline{RD}$  signals are used exactly as in the fetch cycle. In the case of a memory write cycle, the  $\overline{MREQ}$  also becomes active when the address bus is stable so that it can be used directly as a chip enable for dynamic memories. The  $\overline{WR}$  line is active when data on the data bus is stable so that it can be used directly as a R/W pulse to virtually any type of semiconductor memory.



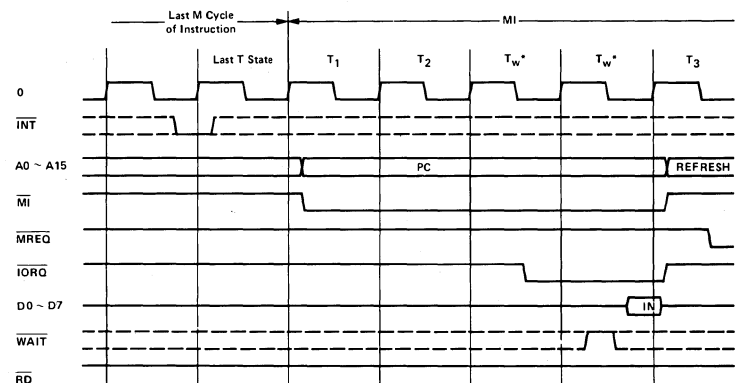
## INPUT OR OUTPUT CYCLES

Illustrated here is the timing for an I/O read or I/O write operation. Notice that during I/O operations a single wait state is automatically inserted ( $T_w^*$ ). The reason for this is that during I/O operations this extra state allows sufficient time for an I/O port to decode its address and activate the  $\overline{WAIT}$  line if a wait is required.



## INTERRUPT REQUEST/ACKNOWLEDGE CYCLE

The interrupt signal is sampled by the CPU with the rising edge of the last clock at the end of any instruction. When an interrupt is accepted, a special  $M_1$  cycle is generated. During this  $M_1$  cycle, the  $\overline{IORQ}$  signal becomes active (instead of  $\overline{MREQ}$ ) to indicate that the interrupting device can place an 8-bit vector on the data bus. Two wait states ( $T_w^*$ ) are automatically added to this cycle so that a ripple priority interrupt scheme, such as the one used in the Z80 peripheral controllers, can be easily implemented.



# Z80, Z80A Instruction Set

The following is a summary of the Z80, Z80A instruction set showing the assembly language mnemonic and the symbolic operation performed by the instruction. A more detailed listing appears in the Z80-CPU technical manual, and assembly language programming manual. The instructions are divided into the following categories:

8-bit loads	Miscellaneous Group
16-bit loads	Rotates and Shifts
Exchanges	Bit Set, Reset and Test
Memory Block Moves	Input and Output
Memory Block Searches	Jumps
8-bit arithmetic and logic	Calls
16-bit arithmetic	Restarts
General purpose Accumulator & Flag Operations	Returns

In the table the following terminology is used.

b	≡ a bit number in any 8-bit register or memory location
cc	≡ flag condition code
NZ	≡ non zero
Z	≡ zero
NC	≡ non carry
C	≡ carry
PO	≡ Parity odd or no over flow
PE	≡ Parity even or over flow
P	≡ Positive
M	≡ Negative (minus)

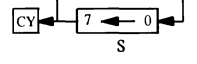
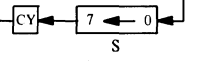
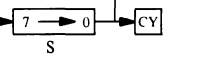
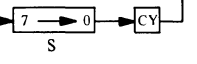
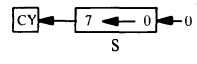
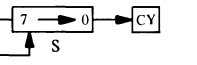
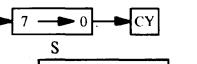
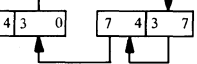
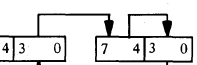
d	≡ any 8-bit destination register or memory location
dd	≡ any 16-bit destination register or memory location
e	≡ 8-bit signed 2's complement displacement used in relative jumps and indexed addressing
L	≡ 8 special call locations in page zero. In decimal notation these are 0, 8, 16, 24, 32, 40, 48 and 56
n	≡ any 8-bit binary number
nn	≡ any 16-bit binary number
r	≡ any 8-bit general purpose register (A, B, C, D, E, H, or L)
s	≡ any 8-bit source register or memory location
sb	≡ a bit in a specific 8-bit register or memory location
ss	≡ any 16-bit source register or memory location
subscript "L"	≡ the low order 8 bits of a 16-bit register
subscript "H"	≡ the high order 8 bits of a 16-bit register
( )	≡ the contents within the ( ) are to be used as a pointer to a memory location or I/O port number
	8-bit registers are A, B, C, D, E, H, L, I and R
	16-bit register pairs are AF, BC, DE and HL
	16-bit registers are SP, PC, IX and IY

Addressing Modes implemented include combinations of the following:

Immediate	Indexed
Immediate extended	Register
Modified Page Zero	Implied
Relative	Register Indirect
Extended	Bit

	Mnemonic	Symbolic Operation	Comments
8-BIT LOADS	LD r, s	$r \leftarrow s$	$s \equiv r, n, (HL), (IX+e), (IY+e)$
	LD d, r	$d \leftarrow r$	$d \equiv (HL), r, (IX+e), (IY+e)$
	LD d, n	$d \leftarrow n$	$d \equiv (HL), (IX+e), (IY+e)$
	LD A, s	$A \leftarrow s$	$s \equiv (BC), (DE), (nn), I, R$
	LD d, A	$d \leftarrow A$	$d \equiv (BC), (DE), (nn), I, R$
16-BIT LOADS	LD dd, nn	$dd \leftarrow nn$	$dd \equiv BC, DE, HL, SP, IX, IY$
	LD dd, (nn)	$dd \leftarrow (nn)$	$dd \equiv BC, DE, HL, SP, IX, IY$
	LD (nn), ss	$(nn) \leftarrow ss$	$ss \equiv BC, DE, HL, SP, IX, IY$
	LD SP, ss	$SP \leftarrow ss$	$ss = HL, IX, IY$
	PUSH ss	$(SP-1) \leftarrow ss_H; (SP-2) \leftarrow ss_L$	$ss = BC, DE, HL, AF, IX, IY$
POP dd	$dd_L \leftarrow (SP); dd_H \leftarrow (SP+1)$	$dd = BC, DE, HL, AF, IX, IY$	
EXCHANGES	EX DE, HL	$DE \leftrightarrow HL$	
	EX AF, AF'	$AF \leftrightarrow AF'$	
	EXX	$\begin{pmatrix} BC \\ DE \\ HL \end{pmatrix} \leftrightarrow \begin{pmatrix} BC' \\ DE' \\ HL' \end{pmatrix}$	
EX (SP), ss	$(SP) \leftrightarrow ss_L, (SP+1) \leftrightarrow ss_H$	$ss \equiv HL, IX, IY$	

	Mnemonic	Symbolic Operation	Comments
MEMORY BLOCK MOVES	LDI	$(DE) \leftarrow (HL), DE \leftarrow DE+1$ $HL \leftarrow HL+1, BC \leftarrow BC-1$	
	LDIR	$(DE) \leftarrow (HL), DE \leftarrow DE+1$ $HL \leftarrow HL+1, BC \leftarrow BC-1$ Repeat until $BC = 0$	
	LDD	$(DE) \leftarrow (HL), DE \leftarrow DE-1$ $HL \leftarrow HL-1, BC \leftarrow BC-1$	
	LDDR	$(DE) \leftarrow (HL), DE \leftarrow DE-1$ $HL \leftarrow HL-1, BC \leftarrow BC-1$ Repeat until $BC = 0$	
	MEMORY BLOCK SEARCHES	CPI	$A-(HL), HL \leftarrow HL+1$ $BC \leftarrow BC-1$
CPIR		$A-(HL), HL \leftarrow HL+1$ $BC \leftarrow BC-1$ , Repeat until $BC = 0$ or $A = (HL)$	$A-(HL)$ sets the flags only. $A$ is not affected
CPD		$A-(HL), HL \leftarrow HL-1$ $BC \leftarrow BC-1$	
CPDR		$A-(HL), HL \leftarrow HL-1$ $BC \leftarrow BC-1$ , Repeat until $BC = 0$ or $A = (HL)$	
8-BIT ALU		ADD s	$A \leftarrow A + s$
	ADC s	$A \leftarrow A + s + CY$	$CY$ is the carry flag
	SUB s	$A \leftarrow A - s$	
	SBC s	$A \leftarrow A - s - CY$	$s \equiv r, n, (HL), (IX+e), (IY+e)$
	AND s	$A \leftarrow A \wedge s$	
	OR s	$A \leftarrow A \vee s$	
	XOR s	$A \leftarrow A \oplus s$	

	Mnemonic	Symbolic Operation	Comments
8-BIT ALU	CP s	$A \leftarrow s$	$s = r, n$ (HL) (IX+e), (IY+e)
	INC d	$d \leftarrow d + 1$	$d = r, (HL)$ (IX+e), (IY+e)
	DEC d	$d \leftarrow d - 1$	
16-BIT ARITHMETIC	ADD HL, ss	$HL \leftarrow HL + ss$	} $ss \equiv BC, DE$ HL, SP
	ADC HL, ss	$HL \leftarrow HL + ss + CY$	
	SBC HL, ss	$HL \leftarrow HL - ss - CY$	
	ADD IX, ss	$IX \leftarrow IX + ss$	} $ss \equiv BC, DE,$ IX, SP
	ADD IY, ss	$IY \leftarrow IY + ss$	
	INC dd	$dd \leftarrow dd + 1$	} $dd \equiv BC, DE,$ HL, SP, IX, IY
	DEC dd	$dd \leftarrow dd - 1$	
GP ACC. & FLAG	DAA	Converts A contents into packed BCD following add or subtract.	Operands must be in packed BCD format
	CPL	$A \leftarrow \overline{A}$	
	NEG	$A \leftarrow 00 - A$	
	CCF	$CY \leftarrow \overline{CY}$	
	SCF	$CY \leftarrow 1$	
MISCELLANEOUS	NOP	No operation	8080A mode Call to 0038 <sub>H</sub> Indirect Call
	HALT	Halt CPU	
	DI	Disable Interrupts	
	EI	Enable Interrupts	
	IM 0	Set interrupt mode 0	
	IM 1	Set interrupt mode 1	
ROTATES AND SHIFTS	RLC s		$s \equiv r, (HL)$ (IX+e), (IY+e)
	RL s		
	RRC s		
	RR s		
	SLA s		
	SRA s		
	SRL s		
	RLD		
	RRD		

	Mnemonic	Symbolic Operation	Comments		
BIT S, R, & T	BIT b, s	$Z \leftarrow \overline{s_b}$	Z is zero flag		
	SET b, s	$s_b \leftarrow 1$	$s \equiv r, (HL)$		
	RES b, s	$s_b \leftarrow 0$	(IX+e), (IY+e)		
INPUT AND OUTPUT	IN A, (n)	$A \leftarrow (n)$	Set flags		
	IN r, (C)	$r \leftarrow (C)$			
	INI	$(HL) \leftarrow (C), HL \leftarrow HL + 1$ $B \leftarrow B - 1$			
	INIR	$(HL) \leftarrow (C), HL \leftarrow HL + 1$ $B \leftarrow B - 1$ Repeat until B = 0			
	IND	$(HL) \leftarrow (C), HL \leftarrow HL - 1$ $B \leftarrow B - 1$			
	INDR	$(HL) \leftarrow (C), HL \leftarrow HL - 1$ $B \leftarrow B - 1$ Repeat until B = 0			
	OUT(n), A	$(n) \leftarrow A$			
	OUT(C), r	$(C) \leftarrow r$			
	OUTI	$(C) \leftarrow (HL), HL \leftarrow HL + 1$ $B \leftarrow B - 1$			
	OTIR	$(C) \leftarrow (HL), HL \leftarrow HL + 1$ $B \leftarrow B - 1$ Repeat until B = 0			
	OUTD	$(C) \leftarrow (HL), HL \leftarrow HL - 1$ $B \leftarrow B - 1$			
	OTDR	$(C) \leftarrow (HL), HL \leftarrow HL - 1$ $B \leftarrow B - 1$ Repeat until B = 0			
	JUMPS	JP nn		$PC \leftarrow nn$	} $cc \left\{ \begin{array}{l} NZ \text{ PO} \\ Z \text{ PE} \\ NC \text{ P} \\ C \text{ M} \end{array} \right.$
		JP cc, nn		If condition cc is true $PC \leftarrow nn$ , else continue	
		JR e		$PC \leftarrow PC + e$	} $kk \left\{ \begin{array}{l} NZ \text{ NC} \\ Z \text{ C} \end{array} \right.$
		JR kk, e		If condition kk is true $PC \leftarrow PC + e$ , else continue	
		JP (ss)		$PC \leftarrow ss$	} $ss = HL, IX, IY$
DJNZ e		$B \leftarrow B - 1$ , if B = 0 continue, else $PC \leftarrow PC + e$			
CALLS	CALL nn	$(SP-1) \leftarrow PC_H$ $(SP-2) \leftarrow PC_L, PC \leftarrow nn$	} $cc \left\{ \begin{array}{l} NZ \text{ PO} \\ Z \text{ PE} \\ NC \text{ P} \\ C \text{ M} \end{array} \right.$		
	CALL cc, nn	If condition cc is false continue, else same as CALL nn			
RESTARTS	RST L	$(SP-1) \leftarrow PC_H$ $(SP-2) \leftarrow PC_L, PC_H \leftarrow 0$ $PC_L \leftarrow L$			
RETURNS	RET	$PC_L \leftarrow (SP),$ $PC_H \leftarrow (SP+1)$	} $cc \left\{ \begin{array}{l} NZ \text{ PO} \\ Z \text{ PE} \\ NC \text{ P} \\ C \text{ M} \end{array} \right.$		
	RET cc	If condition cc is false continue, else same as RET			
	RETI	Return from interrupt, same as RET			
	RETN	Return from non- maskable interrupt			

# A.C. Characteristics

# Z80-CPU

$T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$ ,  $V_{CC} = +5V \pm 5\%$ , Unless Otherwise Noted.

Signal	Symbol	Parameter	Min	Max	Unit	Test Condition
$\Phi$	$t_c$	Clock Period	.4	[12]	$\mu\text{sec}$	
	$t_w(\Phi H)$	Clock Pulse Width, Clock High	180	[E]	nsec	
	$t_w(\Phi L)$	Clock Pulse Width, Clock Low	180	2000	nsec	
	$t_r, t_f$	Clock Rise and Fall Time		30	nsec	
$A_{0-15}$	$t_D(AD)$	Address Output Delay		145	nsec	$C_L = 50\text{pF}$
	$t_F(AD)$	Delay to Float		110	nsec	
	$t_{acm}$	Address Stable Prior to $\overline{MREQ}$ (Memory Cycle)	[1]		nsec	
	$t_{aci}$	Address Stable Prior to $\overline{IORQ}$ , $\overline{RD}$ or $\overline{WR}$ (I/O Cycle)	[2]		nsec	
	$t_{ca}$	Address Stable From $\overline{RD}$ , $\overline{WR}$ , $\overline{IORQ}$ or $\overline{MREQ}$	[3]		nsec	
$D_{0-7}$	$t_D(D)$	Data Output Delay		230	nsec	$C_L = 50\text{pF}$
	$t_F(D)$	Delay to Float During Write Cycle		90	nsec	
	$t_S(\Phi D)$	Data Setup Time to Rising Edge of Clock During M1 Cycle	50		nsec	
	$t_S(\Phi D)$	Data Setup Time to Falling Edge of Clock During M2 to M5	60		nsec	
	$t_{dem}$	Data Stable Prior to $\overline{WR}$ (Memory Cycle)	[5]		nsec	
	$t_{dci}$	Data Stable Prior to $\overline{WR}$ (I/O Cycle)	[6]		nsec	
	$t_{cdf}$	Data Stable From $\overline{WR}$	[7]		nsec	
	$t_H$	Any Hold Time for Setup Time	0		nsec	
$\overline{MREQ}$	$t_{DL\Phi}(\overline{MR})$	$\overline{MREQ}$ Delay From Falling Edge of Clock, $\overline{MREQ}$ Low		100	nsec	$C_L = 50\text{pF}$
	$t_{DH\Phi}(\overline{MR})$	$\overline{MREQ}$ Delay From Rising Edge of Clock, $\overline{MREQ}$ High		100	nsec	
	$t_{DH\Phi}(\overline{MR})$	$\overline{MREQ}$ Delay From Falling Edge of Clock, $\overline{MREQ}$ High		100	nsec	
	$t_w(\overline{MRL})$	Pulse Width, $\overline{MREQ}$ Low	[8]		nsec	
	$t_w(\overline{MRH})$	Pulse Width, $\overline{MREQ}$ High	[9]		nsec	
$\overline{IORQ}$	$t_{DL\Phi}(\overline{IR})$	$\overline{IORQ}$ Delay From Rising Edge of Clock, $\overline{IORQ}$ Low		90	nsec	$C_L = 50\text{pF}$
	$t_{DL\Phi}(\overline{IR})$	$\overline{IORQ}$ Delay From Falling Edge of Clock, $\overline{IORQ}$ Low		110	nsec	
	$t_{DH\Phi}(\overline{IR})$	$\overline{IORQ}$ Delay From Rising Edge of Clock, $\overline{IORQ}$ High		100	nsec	
	$t_{DH\Phi}(\overline{IR})$	$\overline{IORQ}$ Delay From Falling Edge of Clock, $\overline{IORQ}$ High		110	nsec	
$\overline{RD}$	$t_{DL\Phi}(\overline{RD})$	$\overline{RD}$ Delay From Rising Edge of Clock, $\overline{RD}$ Low		100	nsec	$C_L = 50\text{pF}$
	$t_{DL\Phi}(\overline{RD})$	$\overline{RD}$ Delay From Falling Edge of Clock, $\overline{RD}$ Low		130	nsec	
	$t_{DH\Phi}(\overline{RD})$	$\overline{RD}$ Delay From Rising Edge of Clock, $\overline{RD}$ High		100	nsec	
	$t_{DH\Phi}(\overline{RD})$	$\overline{RD}$ Delay From Falling Edge of Clock, $\overline{RD}$ High		110	nsec	
$\overline{WR}$	$t_{DL\Phi}(\overline{WR})$	$\overline{WR}$ Delay From Rising Edge of Clock, $\overline{WR}$ Low		80	nsec	$C_L = 50\text{pF}$
	$t_{DL\Phi}(\overline{WR})$	$\overline{WR}$ Delay From Falling Edge of Clock, $\overline{WR}$ Low		90	nsec	
	$t_{DH\Phi}(\overline{WR})$	$\overline{WR}$ Delay From Rising Edge of Clock, $\overline{WR}$ High		100	nsec	
	$t_w(\overline{WRL})$	Pulse Width, $\overline{WR}$ Low	[10]		nsec	
$\overline{MI}$	$t_{DL}(\overline{MI})$	$\overline{MI}$ Delay From Rising Edge of Clock, $\overline{MI}$ Low		130	nsec	$C_L = 50\text{pF}$
	$t_{DH}(\overline{MI})$	$\overline{MI}$ Delay From Rising Edge of Clock, $\overline{MI}$ High		130	nsec	
$\overline{RFSH}$	$t_{DL}(\overline{RF})$	$\overline{RFSH}$ Delay From Rising Edge of Clock, $\overline{RFSH}$ Low		180	nsec	$C_L = 50\text{pF}$
	$t_{DH}(\overline{RF})$	$\overline{RFSH}$ Delay From Rising Edge of Clock, $\overline{RFSH}$ High		150	nsec	
$\overline{WAIT}$	$t_s(\overline{WT})$	$\overline{WAIT}$ Setup Time to Falling Edge of Clock	70		nsec	
$\overline{HALT}$	$t_D(\overline{HT})$	$\overline{HALT}$ Delay Time From Falling Edge of Clock		300	nsec	$C_L = 50\text{pF}$
$\overline{INT}$	$t_s(\overline{IT})$	$\overline{INT}$ Setup Time to Rising Edge of Clock	80		nsec	
$\overline{NMI}$	$t_w(\overline{NML})$	Pulse Width, $\overline{NMI}$ Low	80		nsec	
$\overline{BUSRQ}$	$t_s(\overline{BQ})$	$\overline{BUSRQ}$ Setup Time to Rising Edge of Clock	80		nsec	
$\overline{BUSAK}$	$t_{DL}(\overline{BA})$	$\overline{BUSAK}$ Delay From Rising Edge of Clock, $\overline{BUSAK}$ Low		120	nsec	$C_L = 50\text{pF}$
	$t_{DH}(\overline{BA})$	$\overline{BUSAK}$ Delay From Falling Edge of Clock, $\overline{BUSAK}$ High		110	nsec	
$\overline{RESET}$	$t_s(\overline{RS})$	$\overline{RESET}$ Setup Time to Rising Edge of Clock	90		nsec	
	$t_F(C)$	Delay to Float ( $\overline{MREQ}$ , $\overline{IORQ}$ , $\overline{RD}$ and $\overline{WR}$ )		100	nsec	
	$t_{mr}$	$\overline{MI}$ Stable Prior to $\overline{IORQ}$ (Interrupt Ack.)	[11]		nsec	

[12]  $t_c = t_w(\Phi H) + t_w(\Phi L) + t_r + t_f$

[1]  $t_{acm} = t_w(\Phi H) + t_r - 75$

[2]  $t_{aci} = t_c - 80$

[3]  $t_{ca} = t_w(\Phi L) + t_r - 40$

[4]  $t_{caf} = t_w(\Phi L) + t_r - 60$

[5]  $t_{dem} = t_c - 210$

[6]  $t_{dci} = t_w(\Phi L) + t_r - 210$

[7]  $t_{cdf} = t_w(\Phi L) + t_r - 80$

[8]  $t_w(\overline{MRL}) = t_c - 40$

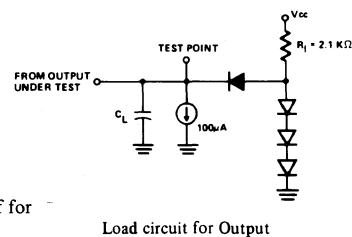
[9]  $t_w(\overline{MRH}) = t_w(\Phi H) + t_r - 30$

[10]  $t_w(\overline{WRL}) = t_c - 40$

[11]  $t_{mr} = 2t_c + t_w(\Phi H) + t_r - 80$

## NOTES:

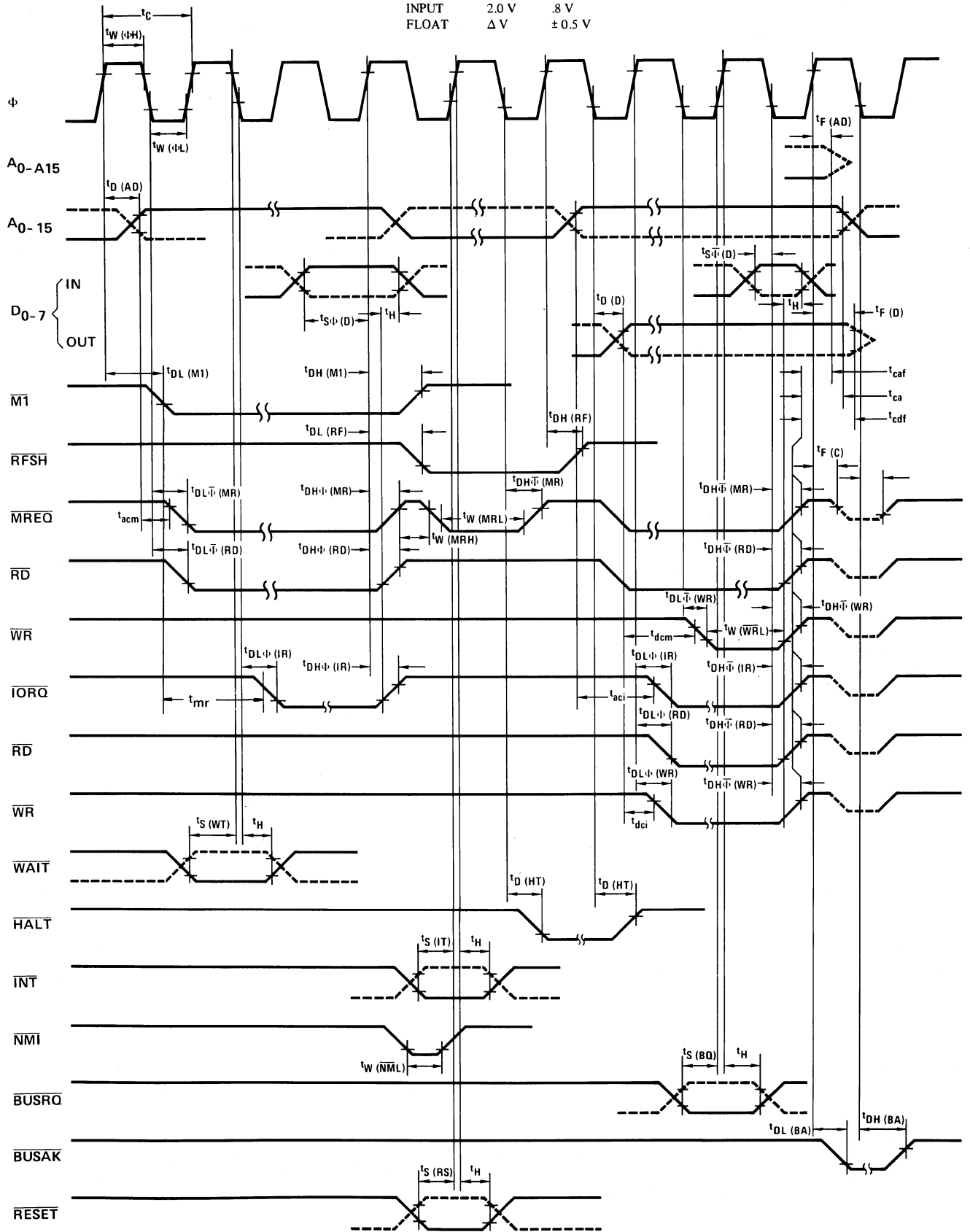
- Data should be enabled onto the CPU data bus when  $\overline{RD}$  is active. During interrupt acknowledge data should be enabled when  $\overline{MI}$  and  $\overline{IORQ}$  are both active.
- All control signals are internally synchronized, so they may be totally asynchronous with respect to the clock.
- The  $\overline{RESET}$  signal must be active for a minimum of 3 clock cycles.
- Output Delay vs. Loaded Capacitance  
 $T_A = 70^\circ\text{C}$      $V_{CC} = +5V \pm 5\%$   
 Add 10nsec delay for each 50pf increase in load up to a maximum of 200pf for the data bus & 100pf for address & control lines
- Although static by design, testing guarantees  $t_w(\Phi H)$  of 200  $\mu\text{sec}$  maximum



# A.C. Timing Diagram

Timing measurements are made at the following voltages, unless otherwise specified:

	"1"	"0"
CLOCK	$V_{cc} - .6V$	.45V
OUTPUT	2.0 V	.8 V
INPUT	2.0 V	.8 V
FLOAT	$\Delta V$	$\pm 0.5 V$



## Absolute Maximum Ratings

Temperature Under Bias	Specified operating range.
Storage Temperature	-65°C to +150°C
Voltage On Any Pin with Respect to Ground	-0.3V to +7V
Power Dissipation	1.5W

### \*Comment

Stresses above those listed under "Absolute Maximum Rating" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other condition above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Note: For Z80-CPU all AC and DC characteristics remain the same for the military grade parts except  $I_{CC}$ .

$$I_{CC} = 200 \text{ mA}$$

## Z80-CPU D.C. Characteristics

$T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$ .  $V_{CC} = 5\text{V} \pm 5\%$  unless otherwise specified

Symbol	Parameter	Min.	Typ.	Max.	Unit	Test Condition
$V_{ILC}$	Clock Input Low Voltage	-0.3		0.45	V	
$V_{IHC}$	Clock Input High Voltage	$V_{CC} - .6$		$V_{CC} + .3$	V	
$V_{IL}$	Input Low Voltage	-0.3		0.8	V	
$V_{IH}$	Input High Voltage	2.0		$V_{CC}$	V	
$V_{OL}$	Output Low Voltage			0.4	V	$I_{OL} = 1.8\text{mA}$
$V_{OH}$	Output High Voltage	2.4			V	$I_{OH} = -250\mu\text{A}$
$I_{CC}$	Power Supply Current			150	mA	
$I_{LI}$	Input Leakage Current			10	$\mu\text{A}$	$V_{IN} = 0$ to $V_{CC}$
$I_{LOH}$	Tri-State Output Leakage Current in Float			10	$\mu\text{A}$	$V_{OUT} = 2.4$ to $V_{CC}$
$I_{LOL}$	Tri-State Output Leakage Current in Float			-10	$\mu\text{A}$	$V_{OUT} = 0.4\text{V}$
$I_{LD}$	Data Bus Leakage Current in Input Mode			$\pm 10$	$\mu\text{A}$	$0 \leq V_{IN} \leq V_{CC}$

## Capacitance

$T_A = 25^\circ\text{C}$ ,  $f = 1 \text{ MHz}$ ,  
unmeasured pins returned to ground

Symbol	Parameter	Max.	Unit
$C_\phi$	Clock Capacitance	35	pF
$C_{IN}$	Input Capacitance	5	pF
$C_{OUT}$	Output Capacitance	10	pF

## Z80-CPU

### Ordering Information

C – Ceramic  
P – Plastic  
S – Standard  $5\text{V} \pm 5\%$   $0^\circ$  to  $70^\circ\text{C}$   
E – Extended  $5\text{V} \pm 5\%$   $-40^\circ$  to  $85^\circ\text{C}$   
M – Military  $5\text{V} \pm 10\%$   $-55^\circ$  to  $125^\circ\text{C}$

## Z80A-CPU D.C. Characteristics

$T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$ .  $V_{CC} = 5\text{V} \pm 5\%$  unless otherwise specified.

Symbol	Parameter	Min.	Typ.	Max.	Unit	Test Condition
$V_{ILC}$	Clock Input Low Voltage	-0.3		0.45	V	
$V_{IHC}$	Clock Input High Voltage	$V_{CC} - .6$		$V_{CC} + .3$	V	
$V_{IL}$	Input Low Voltage	-0.3		0.8	V	
$V_{IH}$	Input High Voltage	2.0		$V_{CC}$	V	
$V_{OL}$	Output Low Voltage			0.4	V	$I_{OL} = 1.8\text{mA}$
$V_{OH}$	Output High Voltage	2.4			V	$I_{OH} = -250\mu\text{A}$
$I_{CC}$	Power Supply Current		90	200	mA	
$I_{LI}$	Input Leakage Current			10	$\mu\text{A}$	$V_{IN} = 0$ to $V_{CC}$
$I_{LOH}$	Tri-State Output Leakage Current in Float			10	$\mu\text{A}$	$V_{OUT} = 2.4$ to $V_{CC}$
$I_{LOL}$	Tri-State Output Leakage Current in Float			-10	$\mu\text{A}$	$V_{OUT} = 0.4\text{V}$
$I_{LD}$	Data Bus Leakage Current in Input Mode			$\pm 10$	$\mu\text{A}$	$0 \leq V_{IN} \leq V_{CC}$

## Capacitance

$T_A = 25^\circ\text{C}$ ,  $f = 1 \text{ MHz}$ ,  
unmeasured pins returned to ground

Symbol	Parameter	Max.	Unit
$C_\phi$	Clock Capacitance	35	pF
$C_{IN}$	Input Capacitance	5	pF
$C_{OUT}$	Output Capacitance	10	pF

## Z80A-CPU

### Ordering Information

C – Ceramic  
P – Plastic  
S – Standard  $5\text{V} \pm 5\%$   $0^\circ$  to  $70^\circ\text{C}$



$T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$ ,  $V_{CC} = +5V \pm 5\%$ , Unless Otherwise Noted.

Signal	Symbol	Parameter	Min	Max	Unit	Test Condition
$\phi$	$t_c$	Clock Period	.25	112	$\mu\text{sec}$	
	$t_w(\Phi H)$	Clock Pulse Width, Clock High	110	[E]	nsec	
	$t_w(\Phi L)$	Clock Pulse Width, Clock Low	110	2000	nsec	
	$t_r, f$	Clock Rise and Fall Time		30	nsec	
$A_{0-15}$	$t_D(AD)$	Address Output Delay		110	nsec	$C_L = 50\text{pF}$
	$t_F(AD)$	Delay to Float		90	nsec	
	$t_{acm}$	Address Stable Prior to $\overline{MREQ}$ (Memory Cycle)	[1]		nsec	
	$t_{aci}$	Address Stable Prior to $\overline{IORQ}$ , $\overline{RD}$ or $\overline{WR}$ (I/O Cycle)	[2]		nsec	
	$t_{ca}$	Address Stable from $\overline{RD}$ , $\overline{WR}$ , $\overline{IORQ}$ or $\overline{MREQ}$	[3]		nsec	
$D_{0-7}$	$t_D(D)$	Data Output Delay		150	nsec	$C_L = 50\text{pF}$
	$t_F(D)$	Delay to Float During Write Cycle		90	nsec	
	$t_{SD}(D)$	Data Setup Time to Rising Edge of Clock During M1 Cycle	35		nsec	
	$t_{SF}(D)$	Data Setup Time to Falling Edge of Clock During M2 to M5	50		nsec	
	$t_{dcm}$	Data Stable Prior to $\overline{WR}$ (Memory Cycle)	[5]		nsec	
	$t_{dci}$	Data Stable Prior to $\overline{WR}$ (I/O Cycle)	[6]		nsec	
	$t_{cdf}$	Data Stable From $\overline{WR}$	[7]		nsec	
	$t_H$	Any Hold Time for Setup Time		0	nsec	
$\overline{MREQ}$	$t_{DL\Phi}(\overline{MR})$	$\overline{MREQ}$ Delay From Falling Edge of Clock, $\overline{MREQ}$ Low		85	nsec	$C_L = 50\text{pF}$
	$t_{DH\Phi}(\overline{MR})$	$\overline{MREQ}$ Delay From Rising Edge of Clock, $\overline{MREQ}$ High		85	nsec	
	$t_{DH\Phi}(\overline{MR})$	$\overline{MREQ}$ Delay From Falling Edge of Clock, $\overline{MREQ}$ High		85	nsec	
	$t_w(\overline{MRL})$	Pulse Width, $\overline{MREQ}$ Low	[8]		nsec	
	$t_w(\overline{MRH})$	Pulse Width, $\overline{MREQ}$ High	[9]		nsec	
$\overline{IORQ}$	$t_{DL\Phi}(\overline{IR})$	$\overline{IORQ}$ Delay From Rising Edge of Clock, $\overline{IORQ}$ Low		75	nsec	$C_L = 50\text{pF}$
	$t_{DL\Phi}(\overline{IR})$	$\overline{IORQ}$ Delay From Falling Edge of Clock, $\overline{IORQ}$ Low		85	nsec	
	$t_{DH\Phi}(\overline{IR})$	$\overline{IORQ}$ Delay From Rising Edge of Clock, $\overline{IORQ}$ High		85	nsec	
	$t_{DH\Phi}(\overline{IR})$	$\overline{IORQ}$ Delay From Falling Edge of Clock, $\overline{IORQ}$ High		85	nsec	
$\overline{RD}$	$t_{DL\Phi}(\overline{RD})$	$\overline{RD}$ Delay From Rising Edge of Clock, $\overline{RD}$ Low		85	nsec	$C_L = 50\text{pF}$
	$t_{DL\Phi}(\overline{RD})$	$\overline{RD}$ Delay From Falling Edge of Clock, $\overline{RD}$ Low		95	nsec	
	$t_{DH\Phi}(\overline{RD})$	$\overline{RD}$ Delay From Rising Edge of Clock, $\overline{RD}$ High		85	nsec	
	$t_{DH\Phi}(\overline{RD})$	$\overline{RD}$ Delay From Falling Edge of Clock, $\overline{RD}$ High		85	nsec	
$\overline{WR}$	$t_{DL\Phi}(\overline{WR})$	$\overline{WR}$ Delay From Rising Edge of Clock, $\overline{WR}$ Low		65	nsec	$C_L = 50\text{pF}$
	$t_{DL\Phi}(\overline{WR})$	$\overline{WR}$ Delay From Falling Edge of Clock, $\overline{WR}$ Low		80	nsec	
	$t_{DH\Phi}(\overline{WR})$	$\overline{WR}$ Delay From Falling Edge of Clock, $\overline{WR}$ High		80	nsec	
	$t_w(\overline{WRL})$	Pulse Width, $\overline{WR}$ Low	[10]		nsec	
$\overline{M1}$	$t_{DL}(\overline{M1})$	$\overline{M1}$ Delay From Rising Edge of Clock, $\overline{M1}$ Low		100	nsec	$C_L = 50\text{pF}$
	$t_{DH}(\overline{M1})$	$\overline{M1}$ Delay From Rising Edge of Clock, $\overline{M1}$ High		100	nsec	
$\overline{RFSH}$	$t_{DL}(\overline{RF})$	$\overline{RFSH}$ Delay From Rising Edge of Clock, $\overline{RFSH}$ Low		130	nsec	$C_L = 50\text{pF}$
	$t_{DH}(\overline{RF})$	$\overline{RFSH}$ Delay From Rising Edge of Clock, $\overline{RFSH}$ High		120	nsec	
$\overline{WAIT}$	$t_s(\overline{WT})$	$\overline{WAIT}$ Setup Time to Falling Edge of Clock	70		nsec	
$\overline{HALT}$	$t_D(\overline{HT})$	$\overline{HALT}$ Delay Time From Falling Edge of Clock		300	nsec	$C_L = 50\text{pF}$
$\overline{INT}$	$t_s(\overline{IT})$	$\overline{INT}$ Setup Time to Rising Edge of Clock	80		nsec	
$\overline{NMI}$	$t_w(\overline{NML})$	Pulse Width, $\overline{NMI}$ Low	80		nsec	
$\overline{BUSRQ}$	$t_s(\overline{BQ})$	$\overline{BUSRQ}$ Setup Time to Rising Edge of Clock	50		nsec	
$\overline{BUSAK}$	$t_{DL}(\overline{BA})$	$\overline{BUSAK}$ Delay From Rising Edge of Clock, $\overline{BUSAK}$ Low		100	nsec	$C_L = 50\text{pF}$
	$t_{DH}(\overline{BA})$	$\overline{BUSAK}$ Delay From Falling Edge of Clock, $\overline{BUSAK}$ High		100	nsec	
$\overline{RESET}$	$t_s(\overline{RS})$	$\overline{RESET}$ Setup Time to Rising Edge of Clock	60		nsec	
	$t_F(C)$	Delay to Float ( $\overline{MREQ}$ , $\overline{IORQ}$ , $\overline{RD}$ and $\overline{WR}$ )		80	nsec	
	$t_{mr}$	M1 Stable Prior to $\overline{IORQ}$ (Interrupt Ack.)	[11]		nsec	

$$[12] t_c = t_w(\Phi H) + t_w(\Phi L) + t_r + t_f$$

$$[1] t_{acm} = t_w(\Phi H) + t_f - 65$$

$$[2] t_{aci} = t_c - 70$$

$$[3] t_{ca} = t_w(\Phi L) + t_f - 50$$

$$[4] t_{caf} = t_w(\Phi L) + t_f - 45$$

$$[5] t_{dcm} = t_c - 170$$

$$[6] t_{dci} = t_w(\Phi L) + t_f - 170$$

$$[7] t_{cdf} = t_w(\Phi L) + t_f - 70$$

$$[8] t_w(\overline{MRL}) = t_c - 30$$

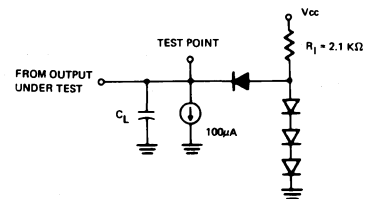
$$[9] t_w(\overline{MRH}) = t_w(\Phi H) + t_f - 20$$

$$[10] t_w(\overline{WRL}) = t_c - 30$$

$$[11] t_{mr} = 2t_c + t_w(\Phi H) + t_f - 65$$

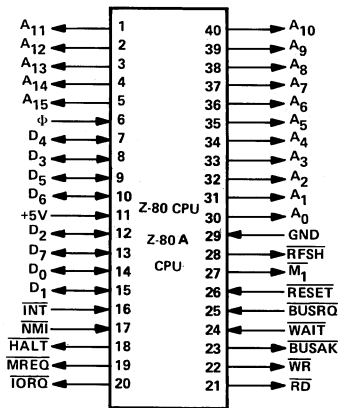
### NOTES:

- Data should be enabled onto the CPU data bus when  $\overline{RD}$  is active. During interrupt acknowledge data should be enabled when  $\overline{M1}$  and  $\overline{IORQ}$  are both active.
- All control signals are internally synchronized, so they may be totally asynchronous with respect to the clock.
- The  $\overline{RESET}$  signal must be active for a minimum of 3 clock cycles.
- Output Delay vs. Loaded Capacitance  
 $T_A = 70^\circ\text{C}$   $V_{CC} = +5V \pm 5\%$   
 Add 10nsec delay for each 50pf increase in load up to maximum of 200pf for data bus and 100pf for address & control lines.
- Although static by design, testing guarantees  $t_w(\Phi H)$  of 200  $\mu\text{sec}$  maximum

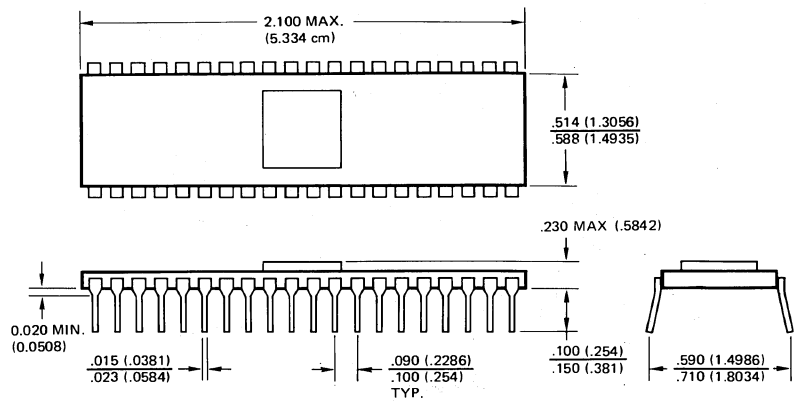


Load circuit for Output

## Package Configuration



## Package Outline



\*Dimensions for metric system are in parentheses

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