

Z8470 Z80® DART

Dual Asynchronous Receiver/Transmitter

Product Specification

September 1983

Features

- Two independent full-duplex channels with separate modem controls. Modem status can be monitored.
- In x1 clock mode, data rates are 0 to 500K bits/second with a 2.5 MHz clock, or 0 to 800K bits/second with a 4.0 MHz clock.
- Receiver data registers are quadruply buffered; the transmitter is doubly buffered.
- Programmable options include 1, 1½ or 2 stop bits; even, odd or no parity; and x1, x16, x32 and x64 clock modes.
- Break generation and detection as well as parity-, overrun- and framing-error detection are available.
- Interrupt features include a programmable interrupt vector, a "status affects vector" mode for fast interrupt processing, and the standard Z-80 peripheral daisy-chain interrupt structure that provides automatic interrupt vectoring with no external logic.
- On-chip logic for ring indication and carrier-detect status.

Description

The Z-80 DART (Dual-Channel Asynchronous Receiver/Transmitter) is a dual-channel multi-function peripheral component that satisfies a wide variety of asynchronous serial data communications requirements in micro-computer systems. The Z-80 DART is used as a serial-to-parallel, parallel-to-serial converter/controller in asynchronous applications. In addition, the device also provides modem controls for both channels. In applications where

modem controls are not needed, these lines can be used for general-purpose I/O.

Zilog also offers the Z-80 SIO, a more versatile device that provides synchronous (Bisync, HDLC and SDLC) as well as asynchronous operation.

The Z-80 DART is fabricated with n-channel silicon-gate depletion-load technology, and is packaged in a 40-pin plastic or ceramic DIP.

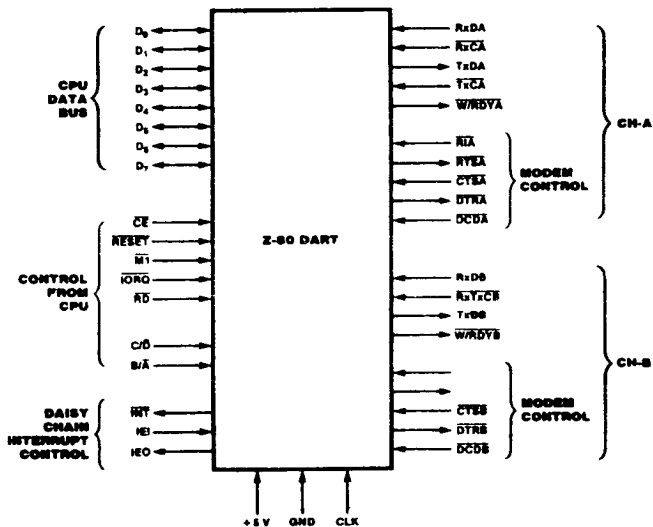


Figure 1. Z80 DART Pin Functions

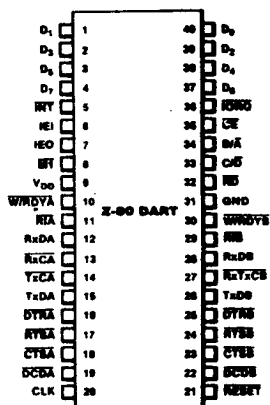


Figure 2. Pin Assignments

Pin	Description	
	B/\overline{A}. Channel A Or B Select (input, High selects Channel B). This input defines which channel is accessed during a data transfer between the CPU and the Z-80 DART.	as an interrupt acknowledge if the Z-80 DART is the highest priority device that has interrupted the Z-80 CPU.
	C/\overline{D}. Control Or Data Select (input, High selects Control). This input specifies the type of information (control or data) transferred on the data bus between the CPU and the Z-80 DART.	\overline{IORQ}. Input/Output Request (input from CPU, active Low). \overline{IORQ} is used in conjunction with B/ \overline{A} , C/ \overline{D} , \overline{CE} and \overline{RD} to transfer commands and data between the CPU and the Z-80 DART. When \overline{CE} , \overline{RD} and \overline{IORQ} are all active, the channel selected by B/ \overline{A} transfers data to the CPU (a read operation). When \overline{CE} and \overline{IORQ} are active, but \overline{RD} is inactive, the channel selected by B/ \overline{A} is written to by the CPU with either data or control information as specified by C/ \overline{D} .
	\overline{CE}. Chip Enable (input, active Low). A Low at this input enables the Z-80 DART to accept command or data input from the CPU during a write cycle, or to transmit data to the CPU during a read cycle.	RxC\overline{A}, RxC\overline{B}. Receiver Clocks (inputs). Receive data is sampled on the rising edge of RxC \overline{C} . The Receive Clocks may be 1, 16, 32 or 64 times the data rate.
	CLK. System Clock (input). The Z-80 DART uses the standard Z-80 single-phase system clock to synchronize internal signals.	\overline{RD}. Read Cycle Status. (input from CPU, active Low). If \overline{RD} is active, a memory or I/O read operation is in progress.
	CTSA, CTSB. Clear To Send (inputs, active Low). When programmed as Auto Enables, a Low on these inputs enables the respective transmitter. If not programmed as Auto Enables, these inputs may be programmed as general-purpose inputs. Both inputs are Schmitt-trigger buffered to accommodate slow-risetime signals.	RxDA, RxDB. Receive Data (inputs, active High).
	D$_0$-D$_7$. System Data Bus (bidirectional, 3-state) transfers data and commands between the CPU and the Z-80 DART.	RESET. Reset (input, active Low). Disables both receivers and transmitters, forces TxDA and TxDB marking, forces the modem controls High and disables all interrupts.
	DCDA, DCDB. Data Carrier Detect (inputs, active Low). These pins function as receiver enables if the Z-80 DART is programmed for Auto Enables; otherwise they may be used as general-purpose input pins. Both pins are Schmitt-trigger buffered.	R\overline{IA}, R\overline{IB}. Ring Indicator (inputs, Active Low). These inputs are similar to CTS and DCD. The Z-80 DART detects both logic level transitions and interrupts the CPU. When not used in switched-line applications, these inputs can be used as general-purpose inputs.
	DTRA, DTRB. Data Terminal Ready (outputs, active Low). These outputs follow the state programmed into the DTR bit. They can also be programmed as general-purpose outputs.	RTSA, RTSB. Request to Send (outputs, active Low). When the RTS bit is set, the RTS output goes Low. When the RTS bit is reset, the output goes High after the transmitter empties.
	IEI. Interrupt Enable In (input, active High) is used with IEO to form a priority daisy chain when there is more than one interrupt-driven device. A High on this line indicates that no other device of higher priority is being serviced by a CPU interrupt service routine.	TxCA, TxCB. Transmitter Clocks (inputs). Tx \overline{D} changes on the falling edge of Tx \overline{C} . The Transmitter Clocks may be 1, 16, 32 or 64 times the data rate; however, the clock multiplier for the transmitter and the receiver must be the same. The Transmit Clock inputs are Schmitt-trigger buffered. Both the Receiver and Transmitter Clocks may be driven by the Z-80 CTC Counter Time Circuit for programmable baud rate generation.
	IEO. Interrupt Enable Out (output, active High). IEO is High only if IEI is High and the CPU is not servicing an interrupt from this Z-80 DART. Thus, this signal blocks lower priority devices from interrupting while a higher priority device is being serviced by its CPU interrupt service routine.	TxDA, TxDB. Transmit Data (outputs, active High).
	INT. Interrupt Request (output, open drain, active Low). When the Z-80 DART is requesting an interrupt, it pulls INT Low.	W/RDYA, W/RDYB. Wait/Ready (outputs, open drain when programmed for Wait function, driven High and Low when programmed for Ready function). These dual-purpose outputs may be programmed as Ready lines for a DMA controller or as Wait lines that synchronize the CPU to the Z-80 DART data rate. The reset state is open drain.
	M\overline{I}. Machine Cycle One (input from Z-80 CPU, active Low). When M \overline{I} and \overline{RD} are both active, the Z-80 CPU is fetching an instruction from memory; when M \overline{I} is active while \overline{IORQ} is active, the Z-80 DART accepts M \overline{I} and \overline{IORQ}	

**Functional
Description**
(Continued)

POLLING. There are no interrupts in the Polled mode. Status registers RR0 and RR1 are updated at appropriate times for each function being performed. All the interrupt modes of the Z-80 DART must be disabled to operate the device in a polled environment.

While in its Polling sequence, the CPU examines the status contained in RR0 for each channel; the RR0 status bits serve as an acknowledge to the Poll inquiry. The two RR0

status bits D₀ and D₂ indicate that a data transfer is needed. The status also indicates Error or other special status conditions (see "Z-80 DART Programming"). The Special Receive Condition status contained in RR1 does not have to be read in a Polling sequence because the status bits in RR1 are accompanied by a Receive Character Available status in RR0.

INTERRUPTS. The Z-80 DART offers an elaborate interrupt scheme that provides fast interrupt response in real-time applications. As a member of the Z-80 family, the Z-80 DART can be daisy-chained along with other Z-80 peripherals for peripheral interrupt-priority resolution. In addition, the internal interrupts of the Z-80 DART are nested to prioritize the various interrupts generated by Channels A and B. Channel B registers WR2 and RR2 contain the interrupt vector that points to an interrupt service routine in the memory. To eliminate the necessity of writing a status analysis routine, the Z-80 DART can modify the interrupt vector in RR2 so it points directly to one of eight interrupt service routines. This is done under program control by setting a program bit (WR1, D₂) in Channel B called "Status Affects Vector." When this bit is set, the interrupt vector in RR2 is modified according to the assigned priority of the various interrupting conditions.

Transmit interrupts, Receive interrupts and External/Status interrupts are the main sources of interrupts. Each interrupt source is enabled under program control with Channel A having a higher priority than Channel B, and with Receiver, Transmit and External/Status interrupts prioritized in that order within each channel. When the Transmit interrupt is enabled, the CPU is interrupted by the transmit buffer becoming empty. (This implies that the transmitter must have had a data character written into it so it can become

empty.) When enabled, the receiver can interrupt the CPU in one of three ways:

- Interrupt on the first received character
- Interrupt on all received characters
- Interrupt on a Special Receive condition

Interrupt On First Character is typically used with the Block Transfer mode. Interrupt On All Receive Characters can optionally modify the interrupt vector in the event of a parity error. The Special Receive Condition interrupt can occur on a character basis. The Special Receive condition can cause an interrupt only if the Interrupt On First Receive Character or Interrupt On All Receive Characters mode is selected. In Interrupt On First Receive Character, an interrupt can occur from Special Receive conditions (except Parity Error) after the first receive character interrupt (example: Receive Overrun interrupt).

The main function of the External/Status interrupt is to monitor the signal transitions of the CTS, DCD and RI pins; however, an External/Status interrupt is also caused by the detection of a Break sequence in the data stream. The interrupt caused by the Break sequence has a special feature that allows the Z-80 DART to interrupt when the Break sequence is detected or terminated. This feature facilitates the proper termination of the current message, correct initialization of the next message, and the accurate timing of the Break condition.

CPU/DMA BLOCK TRANSFER. The Z-80 DART provides a Block Transfer mode to accommodate CPU block transfer functions and DMA block transfers (Z-80 DMA or other designs). The Block Transfer mode uses the W/RDY output in conjunction with the Wait/Ready bits of Write Register 1. The W/RDY output can be defined under software control as a Wait line in the CPU Block

Transfer mode or as a Ready line in the DMA Block Transfer mode.

To a DMA controller, the Z-80 DART Ready output indicates that the Z-80 DART is ready to transfer data to or from memory. To the CPU, the Wait output indicates that the Z-80 DART is not ready to transfer data, thereby requesting the CPU to extend the I/O cycle.

**Internal
Architecture**

The device internal structure includes a Z-80 CPU interface, internal control and interrupt logic, and two full-duplex channels. Each channel contains read and write registers, and discrete control and status logic that provides the interface to modems or other external devices.

The read and write register group includes five 8-bit control registers and two status registers. The interrupt vector is written into an additional 8-bit register (Write Register 2) in Channel B that may be read through Read Register 2 in Channel B. The registers for both channels are designated as follows:

- WR0-WR5 — Write Registers 0 through 5
- RR0-RR2 — Read Registers 0 through 2

The bit assignment and functional grouping of each register is configured to simplify and

organize the programming process.

The logic for both channels provides formats, bit synchronization and validation for data transferred to and from the channel interface. The modem control inputs Clear to Send (CTS), Data Carrier Detect (DCD) and Ring Indicator (RI) are monitored by the control logic under program control. All the modem control signals are general purpose in nature and can be used for functions other than modem control.

For automatic interrupt vectoring, the interrupt control logic determines which channel and which device within the channel has the highest priority. Priority is fixed with Channel A assigned a higher priority than Channel B; Receive, Transmit and External/Status interrupts are prioritized in that order within each channel.

Data Path. The transmit and receive data path illustrated for Channel A in Figure 4 is identical for both channels. The receiver has three 8-bit buffer registers in a FIFO arrangement in addition to the 8-bit receive shift register. This scheme creates additional time for the CPU to

service a Receive Character Available interrupt in a high-speed data transfer.

The transmitter has an 8-bit transmit data register that is loaded from the internal data bus, and a 9-bit transmit shift register that is loaded from the transmit data register.

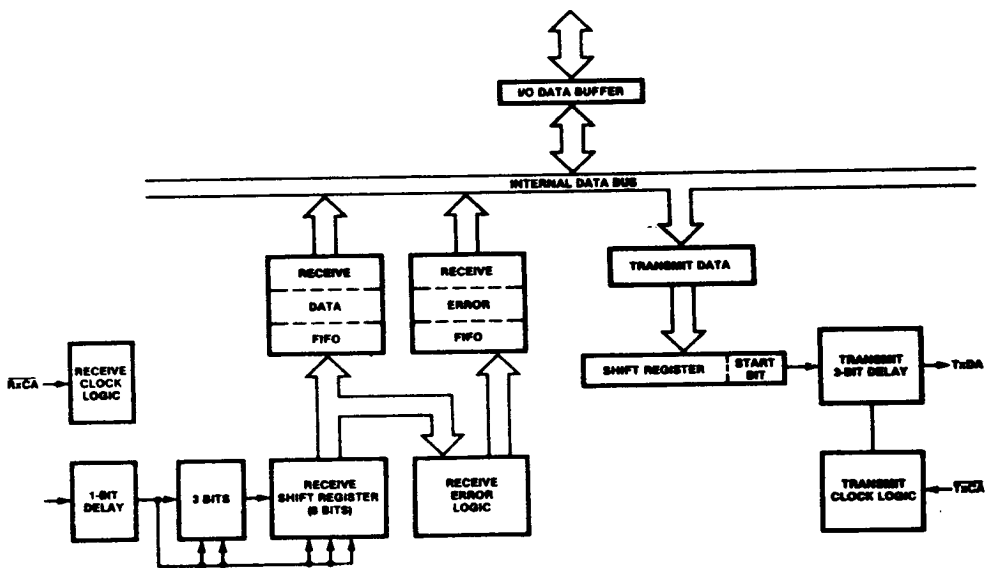


Figure 4. Data Path

200 DATA

Read, Write and Interrupt Timing

Read Cycle. The timing signals generated by a Z-80 CPU input instruction to read a Data or

Status byte from the Z-80 DART are illustrated in Figure 5a.

Write Cycle. Figure 5b illustrates the timing and data signals generated by a Z-80 CPU out-

put instruction to write a Data or Control byte into the Z-80 DART.

Interrupt Acknowledge Cycle. After receiving an Interrupt Request signal (INT pulled Low), the Z-80 CPU sends an Interrupt Acknowledge signal (\overline{MI} and \overline{IORQ} both Low). The daisy-chained interrupt circuits determine the highest priority interrupt requestor. The IEI of the highest priority peripheral is terminated High. For any peripheral that has no interrupt pending or under service, $IEO = IEI$. Any peripheral that does have an interrupt pending or under service forces its IEO Low.

To insure stable conditions in the daisy chain, all interrupt status signals are prevented from changing while \overline{MI} is Low. When \overline{IORQ} is Low, the highest priority interrupt requestor (the one with IEI High) places its interrupt vector on the data bus and sets its internal interrupt-under-service latch.

Refer to the *Z-80 SIO Technical Manual* for additional details on the interrupt daisy chain and interrupt nesting.

Return From Interrupt Cycle. Normally, the Z-80 CPU issues an RETI (Return From Interrupt) instruction at the end of an interrupt service routine. RETI is a 2-byte opcode (ED-4D) that resets the interrupt-under-service latch to terminate the interrupt that has just been processed.

When used with other CPUs, the Z-80 DART allows the user to return from the interrupt cycle with a special command called "Return From Interrupt" in Write Register 0 of Channel A. This command is interpreted by the Z-80 DART in exactly the same way it would interpret an RETI command on the data bus.

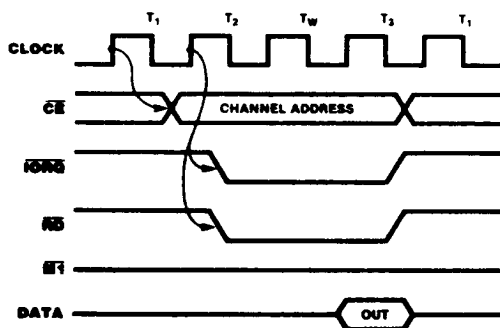


Figure 5a. Read Cycle

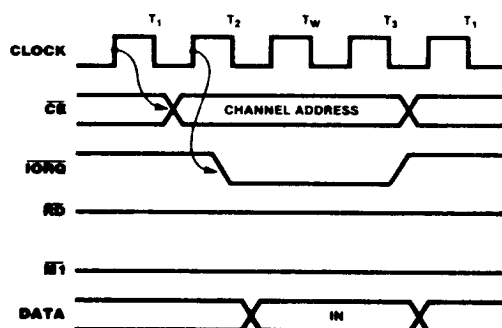


Figure 5b. Write Cycle

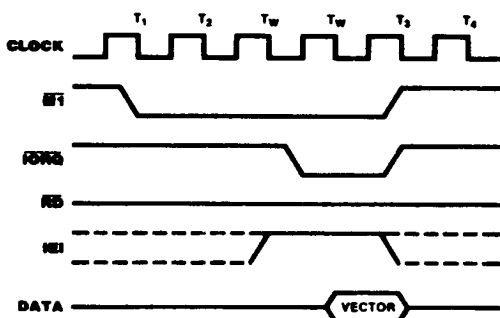


Figure 5c. Interrupt Acknowledge Cycle

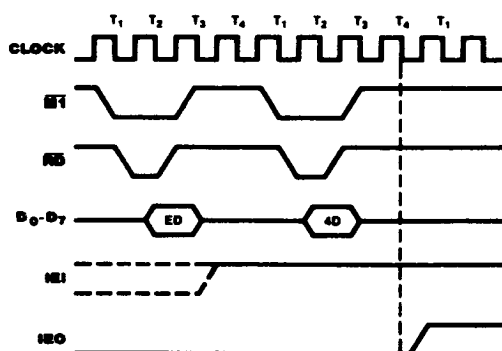


Figure 5d. Return from Interrupt Cycle

Z-80 DART Programming

To program the Z-80 DART, the system program first issues a series of commands that initialize the basic mode and then other commands that qualify conditions within the selected mode. For example, the character length, clock rate, number of stop bits, even or odd parity are first set, then the Interrupt mode and, finally, receiver or transmitter enable.

Both channels contain command registers that must be programmed via the system program prior to operation. The Channel Select input (B/\bar{A}) and the Control/Data input (C/\bar{D}) are the command structure addressing controls, and are normally controlled by the CPU address bus.

Write Registers. The Z-80 DART contains six registers (WR0-WR5) in each channel that are programmed separately by the system program to configure the functional personality of the channels (Figure 4). With the exception of WR0, programming the write registers requires two bytes. The first byte contains three bits (D_0 - D_2) that point to the selected register; the second byte is the actual control word that is written into the register to configure the Z-80 DART.

WR0 is a special case in that all the basic commands (CMD_0 - CMD_2) can be accessed with a single byte. Reset (internal or external) initializes the pointer bits D_0 - D_2 to point to WR0. This means that a register cannot be

pointed to in the same operation as a channel reset.

Write Register Functions

WR0	Register pointers, initialization commands for the various modes, etc.
WR1	Transmit/Receive interrupt and data transfer mode definition.
WR2	Interrupt vector (Channel B only)
WR3	Receive parameters and control
WR4	Transmit/Receive miscellaneous parameters and modes
WR5	Transmit parameters and controls

Read Registers. The Z-80 DART contains three registers (RR0-RR2) that can be read to obtain the status information for each channel (except for RR2, which applies to Channel B only). The status information includes error conditions, interrupt vector and standard communications-interface signals.

To read the contents of a selected read register other than RR0, the system program must first write the pointer byte to WR0 in exactly the same way as a write register operation. Then, by executing an input instruction, the contents of the addressed read register can be read by the CPU.

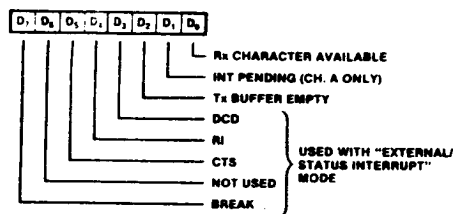
The status bits of RR0 and RR1 are carefully grouped to simplify status monitoring. For example, when the interrupt vector indicates that a Special Receive Condition interrupt has occurred, all the appropriate error bits can be read from a single register (RR1).

Read Register Functions

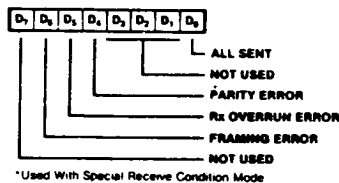
RR0	Transmit/Receive buffer status, interrupt status and external status
RR1	Special Receive Condition status
RR2	Modified interrupt vector (Channel B only)

Z-80 DART Read and Write Registers

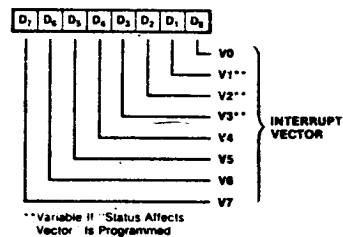
READ REGISTER 0



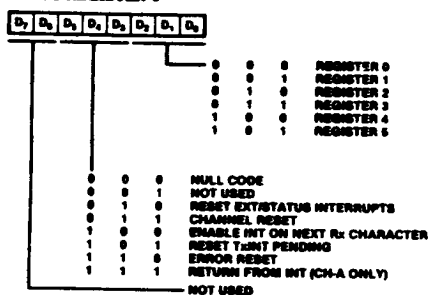
READ REGISTER 1*



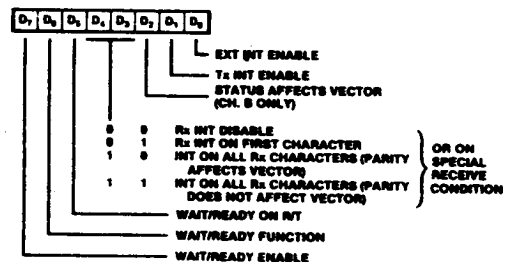
READ REGISTER 2



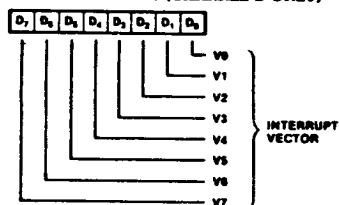
WRITE REGISTER 0



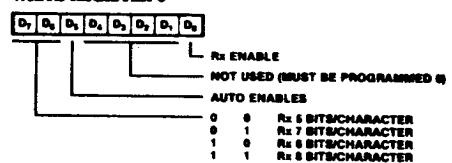
WRITE REGISTER 1



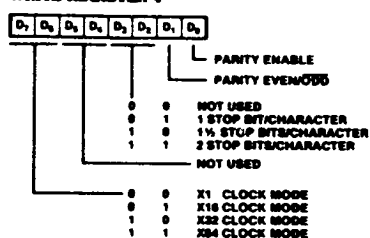
WRITE REGISTER 2 (CHANNEL B ONLY)



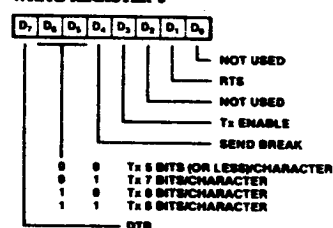
WRITE REGISTER 3



WRITE REGISTER 4



WRITE REGISTER 5



Absolute
Maximum
Ratings

Voltages on all inputs and outputs
with respect to GND -0.3 V to +7.0 V
Operating Ambient As Specified in
Temperature Ordering Information
Storage Temperature -65°C to +150°C

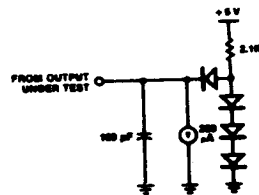
Stresses greater than those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; operation of the device at any condition above those indicated in the operational sections of these specifications is not implied. Exposure to absolute maximum rating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

Test
Conditions

The characteristics below apply for the following test conditions, unless otherwise noted. All voltages are referenced to GND (0 V). Positive current flows into the referenced pin. Available operating temperature ranges are:

- S* = 0°C to +70°C,
+4.75 V ≤ V_{CC} ≤ +5.25 V
- E* = -40°C to +85°C,
+4.75 V ≤ V_{CC} ≤ +5.25 V
- M* = -55°C to +125°C,
+4.5 V ≤ V_{CC} ≤ +5.5 V

*See Ordering Information section for package temperature range and product number.



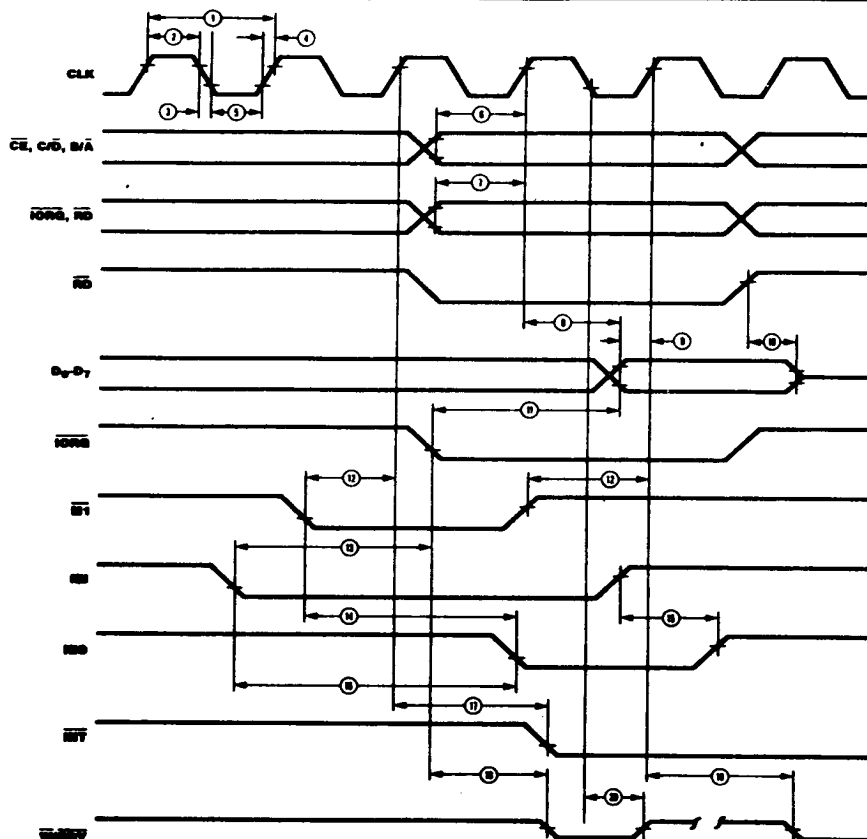
DC
Charac-
teristics

Symbol	Parameter	Min	Max	Unit	Test Condition
V _{ILC}	Clock Input Low Voltage	-0.3	+0.45	V	
V _{IHC}	Clock Input High Voltage	V _{CC} -0.6	+5.5	V	
V _{IL}	Input Low Voltage	-0.3	+0.8	V	
V _{IH}	Input High Voltage	+2.0	+5.5	V	
V _{OL}	Output Low Voltage		+0.4	V	I _{OL} = 2.0 mA
V _{OH}	Output High Voltage	+2.4		V	I _{OH} = -200 μA
I _L	Input/3-State Output Leakage Current	-10	+10	μA	0.4 < V < 2.4V
I _{L(RI)}	RI Pin Leakage Current	-40	+10	μA	0.4 < V < 2.4V
I _{CC}	Power Supply Current		100	mA	

T_A = 0°C to 70°C, V_{CC} = +5V, ±5%

DO NOT

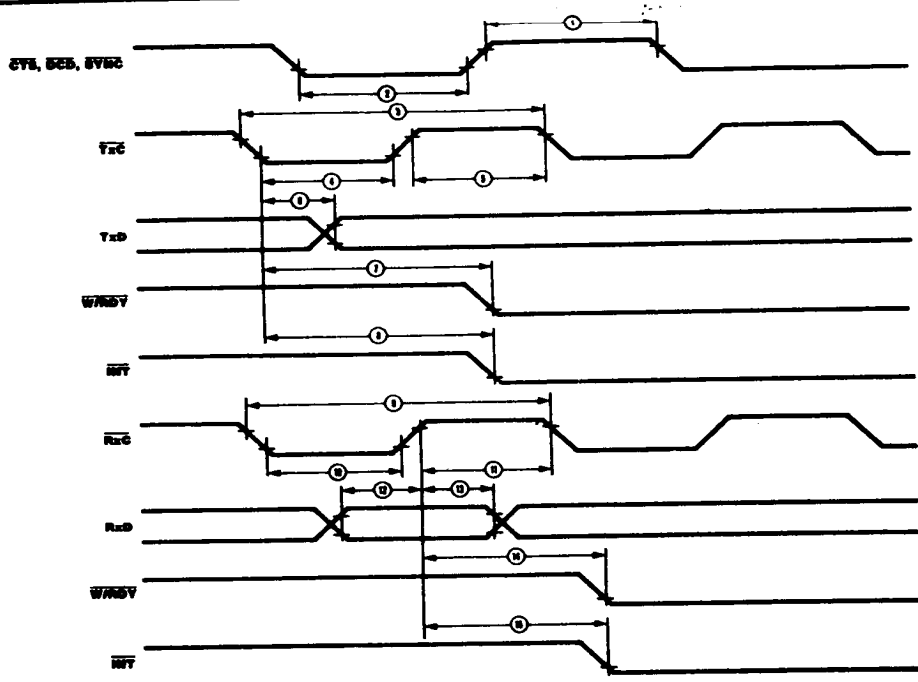
AC Electrical Characteristics



Number	Symbol	Parameter	Z-80 DART		Z-80A DART		Z-80B DART*†	
			Min	Max	Min	Max	Min	Max
1	T _c	Clock Cycle Time	400	4000	250	4000	165	4000
2	T _{wCh}	Clock Width (High)	170	2000	105	2000	70	2000
3	T _{fC}	Clock Fall Time		30		30		15
4	T _{rC}	Clock Rise Time		30		30		15
5	T _{wCl}	Clock Width (Low)	170	2000	105	2000	70	2000
6	T _{sAD(C)}	CE, C/D, B/A to Clock ↑ Setup Time	160		145		60	
7	T _{sCS(C)}	IORQ, RD to Clock ↑ Setup Time	240		115		60	
8	T _{dC(DO)}	Clock ↑ to Data Out Delay		240		220		150
9	T _{sDI(C)}	Data In to Clock ↑ Setup Time (Write or M1 Cycle)	50		50		30	
10	T _{dRD(DOz)}	RD ↑ to Data Out Float Delay		230		110		90
11	T _{dIO(DOI)}	IORQ ↑ to Data Out Delay (INTACK Cycle)		340		160		100
12	T _{sM1(C)}	M1 to Clock ↑ Setup Time	210		90		75	
13	T _{sIEI(IO)}	IEI to IORQ ↑ Setup Time (INTACK Cycle)	200		140		120	
14	T _{dM1(IEO)}	M1 ↑ to IEO ↑ Delay (interrupt before M1)		300		190		160
15	T _{dIEI(IEOr)}	IEI ↑ to IEO ↑ Delay (after ED decode)		150		100		70
16	T _{dIEI(IEOI)}	IEI ↑ to IEO ↑ Delay		150		100		70
17	T _{dC(INT)}	Clock ↑ to INT ↑ Delay		200		200		150
18	T _{dIO(W/RWf)}	IORQ ↑ or CE ↑ to W/RDY ↑ Delay (Wait Mode)		300		210		175
19	T _{dC(W/RR)}	Clock ↑ to W/RDY ↑ Delay (Ready Mode)		120		120		100
20	T _{dC(W/RWz)}	Clock ↑ to W/RDY Float Delay (Wait Mode)		150		130		110

*All timings are preliminary and subject to change.
†Units in ns.

AC
Electrical
Characteristics
(Continued)



200 DART

Number	Symbol	Parameter	Z-90 DART		Z-90A DART		Z-90B DART ¹		Notes [†]
			Min	Max	Min	Max	Min	Max	
1	TwPh	Pulse Width (High)	200		200		200		2
2	TwPl	Pulse Width (Low)	200		200		200		2
3	TcTxC	$\overline{\text{TxC}}$ Cycle Time	400	∞	400	∞	330	∞	2
4	TwTxCl	$\overline{\text{TxC}}$ Width (Low)	180	∞	180	∞	100	∞	2
5	TwTxCh	$\overline{\text{TxC}}$ Width (High)	180	∞	180	∞	100	∞	2
6	TdTxC(TxD)	$\overline{\text{TxC}}$ \downarrow to TxD Delay		400		300		220	2
7	TdTxC(W/RR!) $\overline{\text{TxC}}$ \downarrow to W/RR! Delay (Ready Mode)		5	9	5	9	5	9	3
8	TdTxC(INT) $\overline{\text{TxC}}$ \downarrow to INT \downarrow Delay		5	9	5	9	5	9	3
9	TcRxC	$\overline{\text{RxC}}$ Cycle Time	400	∞	400	∞	330	∞	2
10	TwRxCl	$\overline{\text{RxC}}$ Width (Low)	180	∞	180	∞	100	∞	2
11	TwRxCh	$\overline{\text{RxC}}$ Width (High)	180	∞	180	∞	100	∞	2
12	TsRxD(RxC)	RxD to $\overline{\text{RxC}}$ \uparrow Setup Time (x1 Mode)	0		0		0		2
13	ThRxD(RxC)	RxD Hold Time (x1 Mode)	140		140		100		2
14	TdRxC(W/RR!) $\overline{\text{RxC}}$ \downarrow to W/RR! Delay (Ready Mode)		10	13	10	13	10	13	3
15	TdRxC(INT) $\overline{\text{RxC}}$ \downarrow to INT \downarrow Delay		10	13	10	13	10	13	3

NOTES:
† In all modes, the System Clock rate must be at least five times the maximum data rate. RESET must be active a minimum of one complete clock cycle.

1. Timings are preliminary and subject to change.
2. Units in nanoseconds (ns).
3. Units equal to System Clock Periods.

Product Number	Package/ Temp	Speed	Description	Product Number	Package/ Temp	Speed	Description
Z8470	CE	2.5 MHz	Z80 DART (40-pin)	Z8470A	CS	4.0 MHz	Z80A DART (40-pin)
Z8470	CM	2.5 MHz	Same as above				
Z8470	CMB	2.5 MHz	Same as above	Z8470A	DE	4.0 MHz	Same as above
Z8470	CS	2.5 MHz	Same as above	Z8470A	DS	4.0 MHz	Same as above
Z8470	DE	2.5 MHz	Same as above	Z8470A	PE	4.0 MHz	Same as above
Z8470	DS	2.5 MHz	Same as above	Z8470A	PS	4.0 MHz	Same as above
Z8470	PE	2.5 MHz	Same as above	Z8470B	CE	6.0 MHz	Z80B DART (40-pin)
Z8470	PS	2.5 MHz	Same as above				
Z8470A	CE	4.0 MHz	Z80A DART (40-pin)	Z8470B	CS	6.0 MHz	Same as above
				Z8470B	DS	6.0 MHz	Same as above
Z8470A	CM	4.0 MHz	Same as above	Z8470B	PS	6.0 MHz	Same as above
Z8470A	CMB	4.0 MHz	Same as above				

*NOTES: C = Ceramic, D = Cerdip, P = Plastic; E = -40°C to +85°C, M = -55°C to +125°C, MB = -55°C to +125°C with MIL-STD-883 Class B processing, S = 0°C to +70°C.