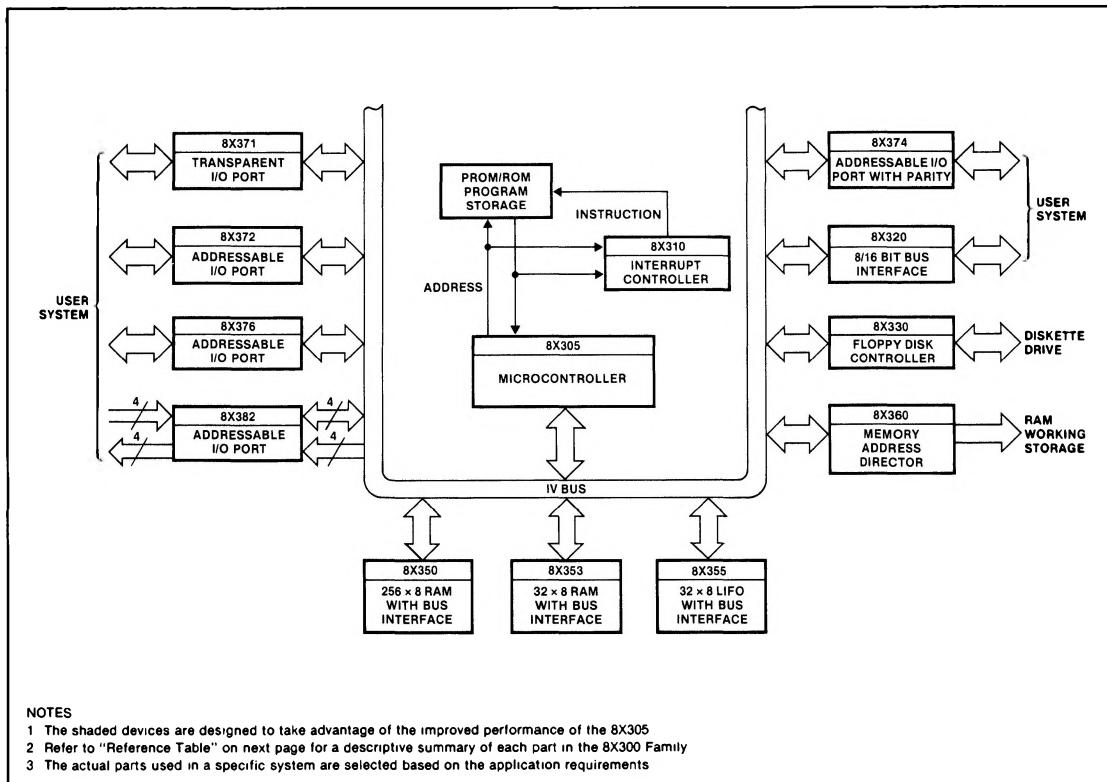


BIPOLAR MICROPROCESSORS**8X300 FAMILY****FEATURES**

- Minimum Parts Count
 - Bipolar Device Using Low Power Schottky Technology
 - High Performance
 - Source/Destination Architecture
 - Design Flexibility
 - After-Sales Support
- Reduced Cost
 - Extended Life of Product
 - Full System Drive Without Buffering
 - TTL Compatibility
 - Proven Reliability
 - Instruction Cycle Time of 200ns (8X305) or 250ns (8X300)
 - Bit Addressability — Instruction Data Formats of 1-to-8 Bits Without Added Delay
 - Efficient Use of Fixed Instruction Set
 - Easy to Program
 - Well-Suited for Control Applications
 - Single-Chip Processor
 - Full Complement of Support Devices
 - Development System
 - Training
 - Complete Documentation
 - Applications Support from Qualified Field Engineers

8X300 FAMILY

BIPOLE MICROPROCESSORS**8X300 FAMILY****PRODUCT LINE OVERVIEW**

The Bipolar LSI Microprocessor product line is centered around two high-speed, Schottky-fabricated, MicroControllers and a large family of I/O devices, support ICs, and development support tools to expedite and simplify system design. No other microprocessor product line offers the advantages of the 8X300 Family in systems requiring intelligent control of high-speed data streams.

The MicroControllers themselves are capable of fetching, decoding, and executing each instruction in one machine cycle (250ns for the 8X300 and 200ns for the 8X305). A single instruction can read data from the bus, mask it, shift it, perform an ALU operation on it, rotate it, merge it, and return it to the bus. The architecture and instruction set of each processor are designed to provide high data throughput with both bit and byte oriented operations. The 8X305 offers more on-chip registers

and significant data handling capability improvements over the original 8X300.

Because of its extremely high speed, the 8X300 family is able to perform through software many operations that would otherwise require additional hardware in the system. For example, using either MicroController, the 8X330 Floppy Disc Controller, and other support devices, a complete diskette drive controller can be built using only 10 Integrated Circuits. The resulting controller is programmable and capable of supporting multiple drive types and formats. Low parts counts typical of 8X300 Family designs result in reduced assembly and testing time, lower power consumption, and improved reliability.

The 8X300 Family is implemented using bipolar, Low-power Schottky technology to provide TTL speeds and drive capability without additional buffering. In addition, the family is compatible with most

special-purpose devices often required in control applications. The excellent environmental characteristics of the technology make the 8X300 family ideal for military applications as well.

A complete complement of development support tools are offered to simplify design using the 8X300. A self-contained universal development system is available that supports full speed In-circuit emulation. Software tools are provided to enable use of mainframe or minicomputers to generate 8X300 software. Complete documentation is in place, including both data sheets and comprehensive reference manuals. In addition, evaluation and demonstration systems are available. To supplement these tools, Signetics employs a large, professional staff of applications engineers both in the field and at the factory to support your 8X300 design efforts.

8X300 FAMILY REFERENCE TABLE

PART NO.	PRODUCT DESCRIPTION	FUNCTION
8X300	MicroController	250ns processor for I/O and data control
8X305	MicroController	200ns processor for I/O and data control
8X310	Interrupt Controller	3 prioritized Interrupts with 4-level stack
8X320	Bus Interface Array	2-port RAM for 8/16-bit mailbox interfacing
8X330	Floppy Disk Controller	1Mb/sec data rate, programmable, supports ECC
8X350	Bipolar RAM	256 x 8 high-speed memory with bus interface
8X360	Memory Address Director	16-bit address controller for working storage
8X337	Transparent I/O Port	High-speed, 8-bit bidirectional, 3-state
8X372	Addressable I/O Port	High-speed, 8-bit bidirectional, synchronous, 3-state
8X376	Addressable I/O Port	High-speed, 8-bit bidirectional, asynchronous, 3-state
8X382	Addressable I/O Port	High-speed, 4-in/4-out, 3-state
8T31	Transparent I/O Port	8-bit bidirectional, 3-state
8T32	Addressable I/O Port	8-bit bidirectional, synchronous, 3-state
8T36	Addressable I/O Port	8-bit bidirectional, asynchronous, 3-state

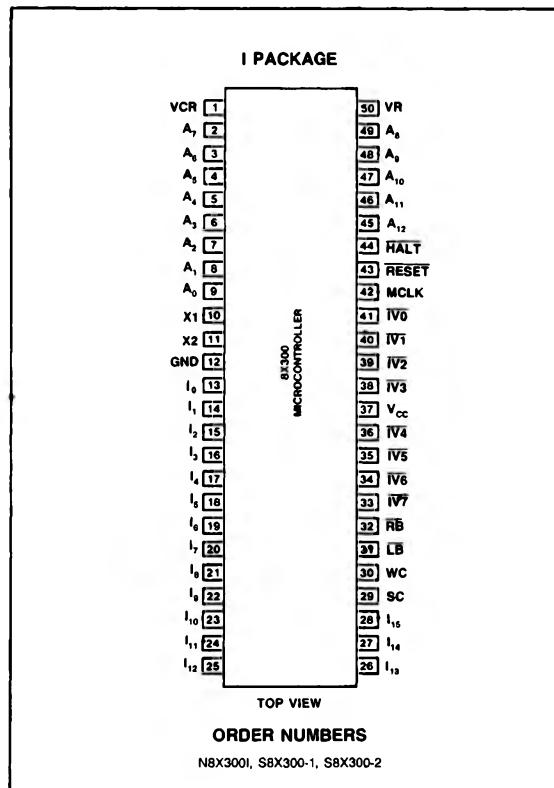
MICROCONTROLLER**8X300****FEATURES**

- Fetch, Decode, and Execute a 16-bit instruction in a minimum of 250-nanoseconds (one machine cycle)
- Bit-oriented instruction set (addressable single-or-multiple bit subfields)
- Separate address, instruction, and I/O buses
- Source/destination architecture
- On-Chip oscillator and timing generation
- Eight 8-bit working registers
- TTL inputs and outputs
- BiPolar Low-Power Schottky technology
- 3-State I/O bus
- Single +5V supply

ARCHITECTURAL OVERVIEW

The Signetics 8X300 Microcontroller (Figure 1) is a high-speed bipolar microprocessor implemented with low-power Schottky technology. The 8X300 brings together all the qualities needed—SPEED, FLEXIBILITY, and ECONOMY—for systems design in the many areas that require reliable bit stream management. Consider!—5V operation, TTL bus compatibility, and an on-chip clock—the result, a system with fewer parts. Consider!—the inherent power of LSI logic (programmable Rotate, Mask, Shift, and Merge functions in the data-processing path) and the ability to Fetch, Decode, and Execute a 16-bit instruction in a minimum of 250-nanoseconds—the result, a system with superior bit handling capabilities. Consider!—the 250ns cycle time in conjunction with extended microcode—the result, the flexibility of bit-slice devices with the programming ease of MOS microprocessors. Now, consider the results!—a device tailored to bit-stream management in the areas of Industrial Control, Input/Output Control, and Data Communications.

The 8X300 uses three separate buses—one for 13-bit instruction addresses, one for 16-bit instructions, and a bidirectional 8-bit input/output data bus; except for the I/O bus, there are no time multiplexing of functions.

PIN CONFIGURATION**ORDER NUMBERS**

N8X300I, S8X300-1, S8X300-2

MICROCONTROLLER

8X300

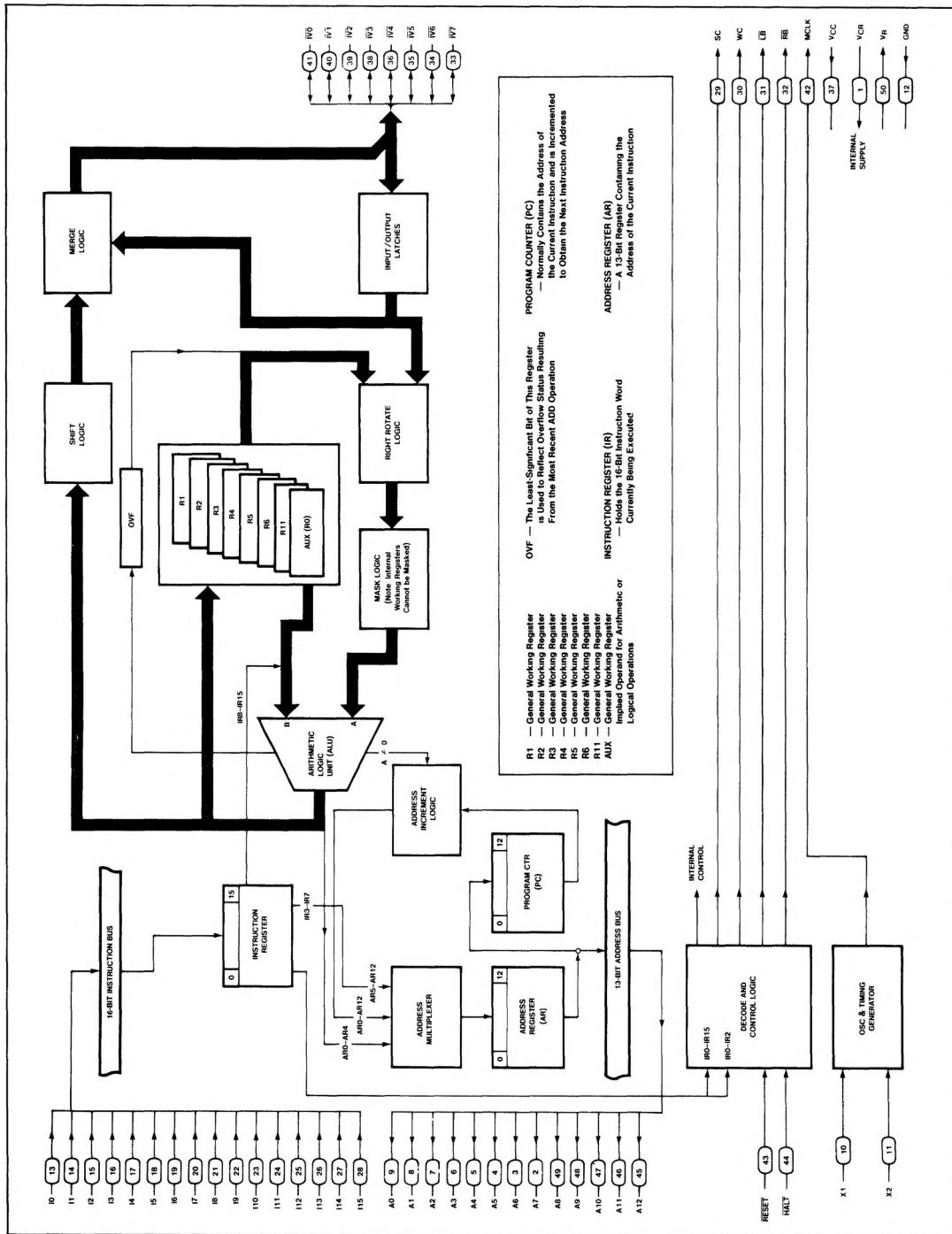
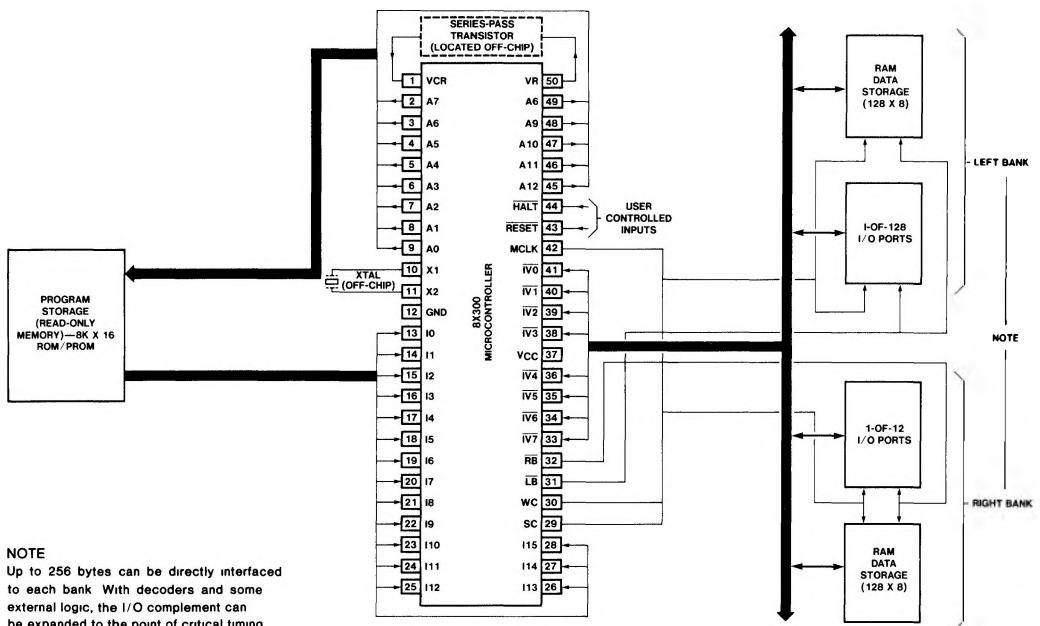


Figure 1. CPU Architecture and PIN Designations For 8X300 Microcontroller

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8X300



PIN NO.	IDENTIFIER	NAME AND FUNCTION	ACTIVE STATE
2-9/45-49	A0-A12	Program Address Lines: These outputs permit direct addressing of up to 8192 words of program storage. A high voltage level equals a binary "1"; A12 is Least Significant Bit	High
13-28	IO-I15	Instruction Lines: These input lines receive 16-bit instructions from program storage. A high voltage level equals a binary "1"; I15 is Least Significant Bit.	High
33-36 38-41	IV0-IV7	Input/Output Bus: These bidirectional three-state lines communicate with up to 512 I/O devices (256 per bank). A low voltage level equals a binary "1"; IV7 is Least Significant Bit.	Low
10 & 11	X1 & X2	Connections for a capacitor, a series-resonant crystal, or an external clock source with complementary outputs. For precise frequency control, a crystal or external source is required.	—
42	MCLK	Master Clock: This output is used for clocking I/O devices and/or synchronization of external logic.	High
30	WC	Write Command: When signal is high (binary 1), data is being output on pins IV0-IV7 of I/O bus.	High
29	SC	Select Command: When signal is high (binary 1), an address is being output on pins IV0-IV7 of I/O bus	High
31	LB	When the LB signal is low (binary 0), any one of up-to-256 I/O devices (or memory locations) in the left bank can be accessed. When the address of a particular device (or memory location) matches the address on the IV bus, that particular device (or memory location) is enabled and selected for input/output operations. All addresses on the left bank that do not match are deselected.	Low
32	RB	When the RB signal is low (binary 0), any one of up-to-256 I/O devices (or memory locations) in the right bank can be accessed. When the address of a particular device (or memory location) matches the address on the I/O bus, that particular device (or memory location) is enabled and selected for input/output operations. All addresses on the right bank that do not match are deselected.	Low
43	RESET	When reset input is low (binary 0), the microcontroller is initialized—sets Program Counter/Address to zero and inhibits MCLK output.	Low
44	HALT	When halt input is low (binary 0), internal operation of microcontroller stops at the start of next instruction. The stop function does not inhibit MCLK or affect any internal registers.	Low
50	VR	Internally-generated reference output voltage for external series-pass transistor.	—
1	VCR	Regulated voltage input from series-pass transistor (2N5320 or equivalent).	—
12	GND	Circuit ground.	—
37	V _{cc}	Input connection for +5V power.	—

Figure 2. Typical 8X300 System with Pin Definitions

MICROCONTROLLER**8X300****TYPICAL 8X300 SYSTEM HOOKUP**

Although the system hookup shown in Figure 2 is of the simplest form, it provides a fundamental look at the 8X300 microcontroller and peripheral relationships. As indicated, program storage can be either ROM or PROM and, by using various addressing-methods/decoding-schemes, memory paging techniques can be easily implemented. Also, by proper bit assignment, some external interface logic and, under software control, the program memory can be used as a storage device for interrupt-service subroutines. The user interface (IV0 through IV7) is capable of addressing 256 Input/Output ports and, with the additional bank-select bit (LB and RB), the number of addressable I/O ports is 512—the left bank and right bank each consisting of 256 ports. The I/O ports of each bank can be used in a variety of ways; one of these ways is shown in Figure 2. When LB is active low, the left bank can be enabled and, providing there is an address match, anyone of 128 I/O ports or anyone of 128 locations within the RAM memory can be accessed for input/output operations. When RB is active low, the same set of conditions are applicable to the right bank. With some sacrifice in speed, any given I/O port can be interfaced to a memory peripheral or other I/O device of the user.

PROGRAM STORAGE INTERFACE

As shown in Figure 2, program storage is connected to output address lines A0 through A12 (A12 = LSB) and input instruction lines I0 through I15. An address output on A0/A12 identifies one 16-bit instruction word in program storage. The instruction word is subsequently input on I0/I15 and defines the microcontroller operations which are to follow.

The Signetics 82S115 PROM or any TTL-compatible memory can be used for program storage. (Note. The worst-case access time depends upon the instruction cycle time, and also, the overall system configuration.)

I/O INTERFACE AND CONTROL

An 8-bit I/O data bus is used by the microcontroller to communicate with two fields of I/O devices. The complementary LB and RB signals identify which field of the I/O devices is enabled.

Both data and address information are output on the I/O bus. The SC (Select Command) and WC (Write Command) signals distinguish between data and address information as follows:

SC	WC	FUNCTION
High	Low	I/O address is being output on the I/O (IV) bus
Low	High	I/O data is being output on the I/O (IV) bus
Low	Low	Input data expected from selected I/O device
High	High	Invalid (not generated by 8X300)

DATA PROCESSING

From a data processing point of view, the 8X300 microcontroller chip (Figure 1) contains eight 8-bit working

registers (R1 through R6, R11, AUXiliary), an arithmetic logic unit (ALU), an overflow register (OVF), rotate/shift/mask/merge logic, and a bidirectional 8-bit I/O bus. Internal 8-bit data paths connect the registers and I/O bus to the ALU inputs, and the ALU output to the registers and I/O bus. Inputs to the ALU are preceded by the data-rotate and data-mask logic and the ALU output is followed by the shift and merge logic. Any one or all of the logic functions can operate on 8-bits of data in a single instruction cycle. Data from the source register can be right-rotated (end around) before processing by the ALU; external data (I/O bus) can also be masked to isolate a portion of the 8-bit field. Since the ALU always processes 8-bits of data, bit positions not specified by the mask operation are filled with zeroes.

When less than 8-bits of data are specified as output to the I/O bus from the ALU, the data field (shifted and masked, as required) is merged with prior contents of the I/O latches to form the output data. Bit positions of the I/O data not affected by the logic operations are not modified. Depending upon whether an I/O peripheral or an internal register is specified in the instruction as the source of data, the I/O latches contain, respectively, I/O-bus source data or destination data. For instance, when an internal register is specified as a source of data and an I/O peripheral as the destination, data from the peripheral is read into the I/O latches at the start of the instruction cycle; processed data is then merged with contents of the I/O latches to form the I/O output data at the end of the instruction cycle. When an I/O peripheral is specified as both data source and destination, data from the source is used both as the input to the I/O latches and as data to be processed; the processed data is then merged with data from the I/O latches to form the previously-described I/O bus output. If the data source and destination are on opposite banks of the 8X300 bus, the destination data is written with a full 8-bits, since the prior contents were not stored in the I/O latches.

INSTRUCTION CYCLE

Each microcontroller operation is executed in a single instruction cycle. The instruction cycle is divided into quarters with each quarter cycle being as short as 62.5-nanoseconds. Figure 3 shows the general functions that occur during each quarter cycle; specifics regarding minimum/maximum timing and other critical values are described under "Design Parameters" in this data sheet. During the first quarter cycle, a new instruction from program storage is input on signal lines I0 through I15; simultaneously, new data is fetched via the input/output bus (IV0 through IV7). At the end of the first quarter cycle, the new instruction is latched in the instruction register and the new I/O data is present at the input of the chip but is not, as yet, latched by the IV latches.

In the second quarter cycle, the I/O data stabilizes and preliminary processing is completed; at the end of this quarter, the IV latches are closed and final processing can be accomplished. During the third quarter cycle, the address for the next instruction is output to the I/O (IV) bus, control signals are generated, and I/O data is setup for the output

MICROCONTROLLER**8X300**

phase. During the fourth quarter cycle, a master clock signal (MCLK) generated by the 8X300 is used to latch valid address or data into peripheral devices connected to the I/O bus; MCLK is also used to synchronize any external logic with timing circuits of the 8X300. To summarize the action, the first half of the instruction cycle deals primarily with input functions and the second half is mostly concerned with output functions.

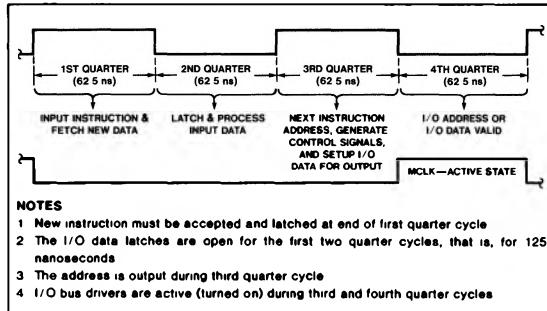
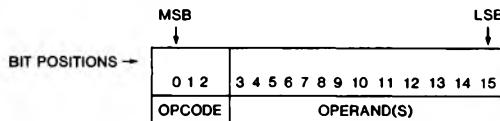


Figure 3. Instruction Cycle and MCLK with: Crystal = 8MHz and Cycle Time = 250 ns

INSTRUCTION SET**General Format and Basic Operations**

The 16-bit instruction word (IO through 15) from program storage is input to the instruction register (Figure 1) and is

subsequently decoded to implement the events to occur during the current instruction cycle. The instruction word is formatted as follows:



Rather than discrete instructions, the three operation code (OP CODE) bits specify eight instruction classes. Each instruction class is subject to a number of powerful variations; these variations are specified by the thirteen operand bits. General areas of control for the eight instruction classes are:

- Arithmetic and Logic Operations (ADD, AND, AND XOR)
- Movement of Data and Constants (MOVE and XMIT)
- Branch or Test (JMP, NZT, and XEC)

Basic operations for each of the eight instruction classes are as follows; a summary of the instruction set is provided in Table 1.

MOVE—data in source register or I/O-bus input is moved to destination register or I/O-bus output. Data can be shifted any number of places and/or masked to any length.

ADD—data in source register or I/O-bit input is added to content of AUX (R0) register and the result is placed in the destination register or I/O-bus output. Data can be shifted and/or masked, as required.

Table 1. SUMMARY OF 8X300 INSTRUCTION SET

INSTRUC CLASS	OPCODE	FORMATS													DESCRIPTION	I/O CONT SIG	STATE OF CONTROL SIGNAL DURING INSTRUCTION CYCLE						
		INPUT PHASE (INSTRUCTION INPUT & DATA PROCESSING)																OUTPUT PHASE (ADDRESS & I/O BUS)					
MOVE	0	F1: Register to Register													(S) → D Move content of internal register specified by S-field to internal register specified by D-field Prior to the "MOVE" operation, right-rotate contents of internal source register by octal value (0 through 7) defined by the R-field	SC = WC = LB = LB =	L L X X		H if "D" = 07 ₈ , 17 ₈ L H if "D" = 17 ₈ L if "D" = 07 ₈				
		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 OPCODE S R D																					
		Invalid values of "S" 07 ₈ , 17 ₈ , 20 ₈ -37 ₈ Invalid values of "D" 10 ₈ , 20 ₈ -37 ₈																					
		F2: I/O Bus to Register														SC = WC = LB = LB =	L L L if "S" = 20 ₈ -27 ₈ L if "S" = 30 ₈ -37 ₈		H if "D" = 07 ₈ , 17 ₈ L H if "D" = 17 ₈ L if "D" = 07 ₈				
		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 OPCODE S L D																					
		Valid values of "S" 20 ₈ -37 ₈ Invalid values of "D" 10 ₈ , 20 ₈ -37 ₈																					
		F2: Register to I/O Bus														SC = WC = LB = LB =	L L L if "D" = 20 ₈ -27 ₈ H if "D" = 30 ₈ -37 ₈		L H if "D" = 20 ₈ -27 ₈ H if "D" = 30 ₈ -37 ₈				
		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 OPCODE S L D																					
		Invalid values of "S" 07 ₈ , 17 ₈ , 20 ₈ -37 ₈ Valid values of "D" 20 ₈ -37 ₈																					
		F2: I/O Bus to I/O Bus														SC = WC = LB = LB =	L L L if "D" = 20 ₈ -27 ₈ H if "D" = 30 ₈ -37 ₈		L H if "D" = 20 ₈ -27 ₈ H if "D" = 30 ₈ -37 ₈				
		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 OPCODE S L D																					
		Valid values of "S" 20 ₈ -37 ₈ Valid values of "D" 20 ₈ -37 ₈																					

MICROCONTROLLER

8X300

Table 1. SUMMARY OF 8X300 INSTRUCTION SET (Continued)

INSTRUC CLASS	OPCODE	FORMATS	DESCRIPTION	I/O CONT SIG	STATE OF CONTROL SIGNAL DURING INSTRUCTION CYCLE	
					INPUT PHASE (INSTRUCTION INPUT & DATA PROCESSING)	OUTPUT PHASE (ADDRESS & I/O BUS)
ADD	1	Same as MOVE instruction class	(S) plus (AUX) → D Same as MOVE instruction class except that contents of AUX (R0) register are ADDED to the source data. If there is a "carry" from MSB, then OVF (overflow) = 1, otherwise OVF = 0		Same as MOVE instruction class	
AND	2	Same as MOVE instruction class	(S) ∧ (AUX) → D Same as MOVE instruction class except that contents of AUX (R0) register are ANDed with source data		Same as MOVE instruction class	
XOR	3	Same as MOVE instruction class	(S) ⊕ (AUX) → D Same as MOVE instruction class except that contents of AUX (R0) register are exclusively ORed with source data		Same as MOVE instruction class	
XEC	4	F3: Register Immediate	Execute instruction at current page address offset by J (literal) + (S). Return to normal instruction flow unless a branch is encountered.	SC = WC = LB =	L L X	L L X
		F4: I/O Bus Immediate	Execute instruction at an address determined by replacing the low-order 8-bits of the Program Counter with the following derived sum • Value of literal (J-field) plus • Contents of internal register specified by S-field The PC is not incremented and the overflow status (OVF) is not changed	SC = WC = LB = LB =	L L L if "S" = 20 ₈ -37 ₈ H if "S" = 30 ₈ -37 ₈	L L X X
		F3: Register Immediate	If data specified by the S-field is not equal to zero, jump to current page address offset by value of J-field; otherwise, increment the Program Counter. If contents of internal register specified by S-field is non-zero, transfer to address determined by replacing the low-order 8-bits of Program Counter with "J", otherwise, increment PC	SC = WC = LB =	L L X	L L X
		F4: I/O Bus Immediate	If right-rotated I/O bus data is non-zero, transfer to address determined by replacing low-order 8-bits of Program Counter with "J", otherwise, increment PC (The L-field specifies the length of source I/O data starting from the LSB-position and, if less than 8-bits, the remaining bits are filled with zeroes)	SC = WC = LB = LB =	L L L if "S" = 20 ₈ -27 ₈ H if "S" = 30 ₈ -37 ₈	L L X X
NZT	5	F3: Register Immediate		SC = WC = LB =		
		F4: I/O Bus Immediate		SC = WC = LB = LB =		
		F3: Register Immediate		SC = WC = LB =		
		F4: I/O Bus Immediate		SC = WC = LB = LB =		
XMIT	6	F3: Register Immediate	Transmit J → D Transmit and store 8-bit binary pattern in J-field to internal register specified by D-field	SC = WC = LB = LB =	L L X X	H if D = 07 ₈ or 17 ₈ L H if D = 17 ₈ L if D = 07 ₈
		F4: I/O Bus Immediate	Transmit binary pattern in J-field to I/O bus Before putting data on I/O bus, shift literal value "J" as specified by the D-field and merge bits specified by the L-field with existing I/O bus data. If the L-field specifies more than 5-bits starting from the LSB-position, all remaining bits are set to zero	SC = WC = LB = LB =	L L L if D = 20 ₈ -27 ₈ H if D = 30 ₈ -37 ₈	L H L if D = 20 ₈ -27 ₈ H if D = 30 ₈ -37 ₈
		F5: Address Immediate	Jump to address in program storage specified by A-field; this address is loaded into the Address Register and the Program Counter	SC = WC = LB =	L L X	L L X
		F6: Jump Immediate		SC = WC = LB =		
JMP	7	F5: Address Immediate		SC = WC = LB =		

NOTES • RB is complement of LB, X = Undefined

MICROCONTROLLER**8X300**

AND—data in source register or I/O-bus input is ANDed with content of AUX (R0) register and the result is placed in the destination register or I/O-bus output. Data can be shifted and/or masked, as required.

XOR—data in source register or I/O-bus input is exclusively ORed with contents of AUX (R0) register and the result is placed in the destination register or I/O-bus output. Data can be shifted and/or masked, as required.

XMIT—immediate data field of instruction word replaces data in destination register or I/O-bus output.

XEC—executes instruction at the program address which is formed by replacing the least significant bits of the last address with the sum of:

- Literal (J) field value of instruction plus,
- Value of data in source register or I/O-bus input.

NZT—least significant bits of program address are replaced by literal (J) field of instruction if the source register or I/O-bus is not equal to zero.

JMP—program address is replaced by address field of the instruction word.

Instruction Fields

As shown in Table 1, each instruction contains an operations

Table 2. OCTAL ADDRESSES OF 8X300 REGISTERS AND ADDRESS/BIT ASSIGNMENTS OF SOURCE/DESTINATION FIELDS

Octal Value	8X300 Register	Octal Value	8X300 Register
00	Auxiliary (R0)	10	OVF (Overflow Register)—used only as a source
01	R1	11	R11
02	R2	12	Unassigned
03	R3	13	Unassigned
04	R4	14	Unassigned
05	R5	15	Unassigned
06	R6	16	Unassigned
07	*IOL Register—Left Bank I/O Address Register; Used only as destination	17	*IOR Register—Right Bank I/O Address Register; Used only as destination

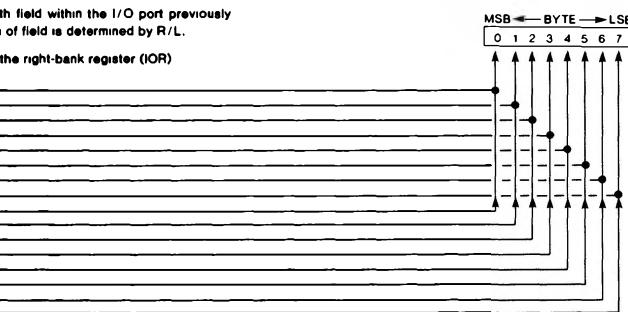
NOTE

*If IOL or IOR is specified as a source of data, the source data is all zeroes

NOTES:

- Octal Value NOTES:
 1. 20₈-27₈ specifies the LSB of a variable length field within the I/O port previously selected by the left-bank (IOL) register. Length of field is determined by R/L.
 2. 30₈-37₈ performs the counterpart function for the right-bank register (IOR).

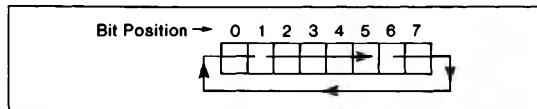
- Note 1 {
 20 — Field within previously selected port with LSB position = 0
 21 — Field within previously selected port with LSB position = 1
 22 — Field within previously selected port with LSB position = 2
 23 — Field within previously selected port with LSB position = 3
 24 — Field within previously selected port with LSB position = 4
 25 — Field within previously selected port with LSB position = 5
 26 — Field within previously selected port with LSB position = 6
 27 — Field within previously selected port with LSB position = 7
 30 — Field within previously selected port with LSB position = 0
 31 — Field within previously selected port with LSB position = 1
 32 — Field within previously selected port with LSB position = 2
 33 — Field within previously selected port with LSB position = 3
 34 — Field within previously selected port with LSB position = 4
 35 — Field within previously selected port with LSB position = 5
 36 — Field within previously selected port with LSB position = 6
 37 — Field within previously selected port with LSB position = 7
- Note 2 {



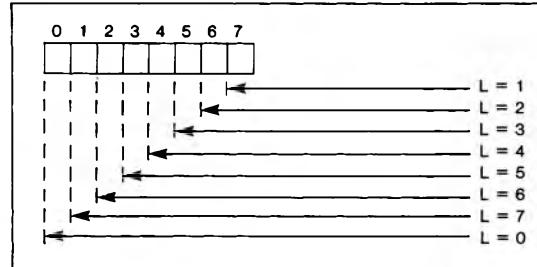
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Rotate (R) and Length (L) Field: The three-bit R/L field performs one of two functions, specifying either the field length (L) or a right-rotate (R). For a given instruction, the specified function depends upon the contents of the source (S) and destination (D) fields.

- When an internal register is specified by both the source and destination fields, the (R) field is invoked and it specifies a right-rotate of the data specified in the (S) field—see accompanying diagram. The source-register data (up to eight-bits) is right-rotated within one instruction cycle. (The right-rotate function is implemented on the bus and not in the source register.)

RIGHT-ROTATE FUNCTION

- When either or both of the source and destination fields specify a variable-length I/O data field, the (L) field specifies the length of the I/O data field—see accompanying diagram. If the source field specifies an I/O address (20g-37g) and the destination field specifies an internal register (00g-06g, 07g, 11g, or 17g), the L-field specifies the length of source data; the source data is formed by right-rotating the I/O bus data according to the source address (Table 2) and then masking result as specified by L-field. If length is less than eight-bits, all remaining bits are set to zero prior to processing data in the ALU. If the source field specifies an internal register (00g-06g, 10g, or 11g) and the destination field specifies I/O bus data (20g-37g), the L field specifies the length of the destination data. To form the destination data, the ALU output is left-shifted according to the destination address (Table 2) and then masked to the required length—see DATA LENGTH SPECIFICATION. The destination data is merged with data in the I/O latches to finalize the I/O bus data. Hence, a one-to-eight bit destination data field can be inserted into the existing eight-bit I/O port without modifying surrounding bits. If both the source and destination fields specify I/O bus data (20g-37g), the L-field specifies the length of both the source and destination data.

DATA LENGTH SPECIFICATION

To form the source data, the I/O bus data is right-rotated according to the source address (Table 2) and then masked to the required length—see preceding DATA LENGTH SPECIFICATION. If length is less than eight-bits, all remaining bits are set to zero before processing in the ALU. To form the destination data, the ALU output is left-shifted according to the destination address (Table 2) and masked to the required length specification. The destination data is then merged into the I/O bus data that was used to obtain the source; thus, if the source and destination addresses are on the same bank, the I/O bus data written to the destination register appears unmodified, except for bits changed during the shift-and-mask operations. If the source and destination addresses refer to different banks, the destination register is changed to contain the contents of the source register in those bit positions not affected by the destination data.

J-Field: The 5-bit or 8-bit (J) field is used to load a literal value (contained in the instruction) into a register, into a variable I/O data field, or to modify the low-order bits of the Program Counter. The bit-length of the (J) field is implied by the (S) field in the XEC, NZT, and XMIT instructions, based on the following considerations.

- When the source (S) field specifies an internal register, the literal value of the J-field is an 8-bit binary number.
- When the source (S) field specifies a variable I/O data field, the literal value of the J-field is a 5-bit binary number.

A-Field: The 13-bit (A) field is an address field which allows the 8X300 to directly address up 8192 locations in Program Storage memory.

INSTRUCTION SEQUENCE CONTROL**Formation of Instruction Address**

The Address Register and Program Counter are used to generate addresses for accessing an instruction from program storage. The instruction address is formed in any one of four ways:

- For all except the JMP, XEC, and a "satisfied" NZT instruction, the Program Counter is incremented by one and placed in the Address Register.
- For the JMP instruction, the 13-bit A-field contained in the JMP instruction word replaces the contents of both the Address Register and Program Counter.
- For the XEC instruction, the Address Register is loaded with the high-order bits of the Program Counter modified as follows:

XEC using I/O Bus Data: low order 5-bits of ALU output replaces counterpart bits in Address Register.

XEC using Data from Internal Register: low order 8-bits of ALU output replaces counterpart bits in Address Register.

The Program Counter is not modified for either of the above conditions.

- For a "satisfied" NZT instruction, the low order 5-bits (NZT source is I/O Bus Data) or low order 8/bits (NZT source is an Internal Register) of both the Address Register and Program Counter are loaded with the literal value specified by J-field of the instruction word.

MICROCONTROLLER**8X300****Data Addressing**

The source and/or destination addresses of the data to be operated upon are specified as part of the instruction word. As shown in Table 3, source/destination addresses are specified using a five-bit address (00_g through 37_g). When the most significant octal digit is a 0 or 1, the source and/or destination address is an internal register; if the most significant digit is a 2 or 3, an I/O bus address is indicated—2 specifying a left-bank (LB) address and 3 specifying a right-bank (RB) address. The least significant octal digit (0 through 7) indicates either a specific internal register address or positioning information for the least significant bit when specifying I/O bus data. Referring to Table 1, the AUXiliary register (00) is the implied source of the second argument for the ADD, AND, and XOR operations. IOL (destination address 07_g) and IVR (destination address 17_g) provide a means of routing address information to I/O registers. With IOL or IOR specified as the destination address, the data is placed on the I/O bus during the output phase of the instruction cycle. Simultaneously, a select command (SC) is generated to inform all I/O devices that information on the I/O bus is to be considered as an I/O address. Since IOL and IOR are not hardware registers, they should never be specified as a source address.

Control outputs LB and RB are used to partition I/O bus devices into two fields of 256 addresses. With LB in the active-low state and a source address of 20_g-27_g, the left bank of I/O devices are enabled during the input phase of the instruction cycle. With RB in the active-low state and a source address of 30_g-37_g, the right bank of devices are enabled. During the output phase, RB is low if the destination address is IOR (17_g) or 30_g-37_g; LB is low if the destination address is IOL (07_g) or 20_g-27_g. Each address field

(LB and RB) can have a different I/O device selected; thus, two devices can be directly accessed within one instruction cycle.

Table 3. SOURCE/DESTINATION ADDRESSES

SOURCE AND/OR DESTINATION FIELD (OCTAL)	SOURCE/DESTINATION
00	AUXiliary register (R0)
01-06	Working registers R1-R6, respectively
07	IOL Left-bank enable (Destination only)
10	Overflow status—OVF (Source only)
11	Working register R11
17	IOR Right-bank enable (Destination only)
2N (N = 0, 1, 2, 3, 4, 5, 6, or 7)	If a source, I/O data is right-rotated (7 - N) bits and then masked as specified by the L-field. LB = low and RB = high generated during input phase. If a destination, I/O data is left-shift (7 - N) bits and merged (specified by L-field) with data contained in the I/O latches. LB = low and RB = high generated during output phase.
3N (N = 0, 1, 2, 3, 4, 5, 6, or 7)	If a source, I/O data is right-rotated (7 - N) bits and then masked as specified by the L-field. LB = high and RB = low generated during input phase. If a destination, I/O data is left-shifted (7 - N) bits and merged (specified by L-field) with data contained in the I/O latches. LB = high and RB = low generated during output phase.

DESIGN PARAMETERS

Hardware design of an 8X300-based system largely consists of the following operations:

- Selecting and interfacing a Program Storage device—ROM, PROM, etc. (Pins 2 through 9 and 45 through 49 for 13-bit address interface; Pins 13 through 28 for 16-bit instruction interface.)
- Selecting and interfacing Input/Output devices—RAM, Multiplexers, I/O Ports, and other eight-bit addressable I/O devices. (Pins 33 through 36 and pins 38 through 41 for eight-bit I/O interface.)
- Choosing and implementing System Clock—Capacitor-Controlled, Crystal-Controlled, or Externally-Driven. (Pins 10 and 11 for System Clock interface.)

- Selection of 5-volt power supply and off-chip series-pass transistor.
- External logic, as required, to meet the control requirements of a particular application.

All information required for easy implementation of these design requirements is provided under the following captions.

- DC Characteristics
- AC Characteristics
- Timing Considerations
- Clock Considerations
- HALT/RESET Logic
- Voltage Regulator

MICROCONTROLLER**8X300****DC CHARACTERISTICS (Commercial Part)** $4.75V \leq V_{CC} \leq 5.25V$, $0^{\circ}C \leq T_A \leq 70^{\circ}C$

PARAMETER	TEST CONDITIONS	LIMITS			UNIT	COMMENTS
		Min	Typ	Max		
V_{CC}	Supply voltage	475	5.0	5.25	V	$5V \pm 5\%$; pin 37 only
V_{IH}	High level input voltage	0.6 2.0		2.0	V	X1 and X2 All other pins
V_{IL}	Low level input voltage			0.4 0.8	V	X1 and X2 All other pins
V_{OH}	High level output voltage	$V_{CC} = \text{min}; I_{OH} = -3mA$	2.4	3.0	V	
V_{OL}	Low level output voltage	$V_{CC} = \text{min}; I_{OL} = 8mA$ $V_{CC} = \text{min}; I_{OL} = 16mA$	0.39 0.39	0.55 0.55	V	A0 through A12 All other outputs
V_{CR}	Regulator voltage	$V_{CC} = 5V$		3.1	V	From series-pass transistor
V_{IC}	Input clamp voltage	$V_{CC} = \text{min}; I_{IN} = -10mA$		-1.5	V	Crystal inputs X1 and X2 do not have internal clamp diodes.
I_{IH}	High-level input current	$V_{CC} = \text{max}; V_{IH} = 0.6V$ $V_{IH} = 4.5V$		1	3.0 50 μA	X1 and X2 All other pins
I_{IL}	Low-level input current	$V_{CC} = \text{max}; V_{IL} = 0.4V$	-0.13 -0.67 -0.23	-3 -0.2 -1.6 -0.4	mA	X1 and X2 IV0-IV7 IO-115 HALT and RESET
I_{OS}	Short circuit output current	$V_{CC} = \text{max}; V_{CR} = V_{CRH}$ (Note: At any time, no more than one output should be connected to ground.)	-30		-140 mA	All output pins
I_{CC}	Supply current	$V_{CC} = \text{max}; V_{CR} = V_{CRH}$			160 mA	
I_{REG}	Regulator control	$V_{CC} = 5.0V$	-14		-21 mA	
I_{CR}	Regulator current	$V_{CC} = \text{max}$			230 mA 265 mA 290 mA	70°C 25°C 0°C

NOTES

1 Operating temperature ranges are guaranteed after thermal equilibrium has been reached

2 All voltages measured with respect to ground terminal

AC CHARACTERISTICS (Commercial Part) **CONDITIONS:** $V_{CC} = 5V (\pm 5\%)$, $V_{IN} = 0V$ or $3V$, $0^{\circ}C \leq T_A \leq 70^{\circ}C$
LOADING: (See test circuits)

PARAMETER (NOTE 1)	LIMITS (INSTRUCTION CYCLE TIME = 250 ns)			LIMITS (INSTRUCTION CYCLE TIME > 250 ns)			UNITS	COMMENTS
	Min	Typ	Max	Min	Typ	Max		
T_{PC}	Processor cycle time	250		250			ns	
T_{CP}	X1 clock period	125		125			ns	
T_{CH}	X1 clock high time	62		62			ns	
T_{CL}	X1 clock low time	62		62			ns	
T_{MCH}	MCLK high delay	31	42	52	31	42	52	ns
T_{MCL}	MCLK low delay	31	42	52	31	42	52	ns
T_W	MCLK pulse width	55	62	69	$T_{4Q}-7$	T_{4Q}		ns
T_{AS}	X1 falling edge to address stable	50	63	80	50	63	80	ns
								Note 2
								Note 7

MICROCONTROLLER

8X300

AC CHARACTERISTICS (Commercial Part) **CONDITIONS:** $V_{CC} = 5V (\pm 5\%)$, $V_{IN} = 0V$ or $3V$, $0^\circ C \leq T_A \leq 70^\circ C$
(Continued) **LOADING:** (See test circuits)

PARAMETER (NOTE 1)	LIMITS (INSTRUCTION CYCLE TIME = 250 ns)			LIMITS (INSTRUCTION CYCLE TIME > 250 ns)			UNITS	COMMENTS
	Min	Typ	Max	Min	Typ	Max		
T_{MAS} MCLK falling edge to address stable	130	143	160	$T_{1Q}+T_{2Q}+5$	$T_{1Q}+T_{2Q}+18$	$T_{1Q}+T_{2Q}+35$	ns	Notes 2, 3, & 7
T_{IA} Instruction to address			170			$T_{2Q}+108$	ns	Notes 2, 3, & 8
T_{IVA} Input data to address			105			105	ns	Notes 3 & 9
T_{IS} Instruction set-up time (X1 rising edge)	-7			-7			ns	Note 10
T_{MIS} MCLK falling edge to instruction stable			20			$T_{1Q}-42$	ns	Notes 2, 4, & 10
T_{IH} Instruction hold time (X1 rising edge)	45			45			ns	Note 11
T_{MIH} Instruction hold time (MCLK falling edge)	60			$T_{1Q}-2$			ns	Notes 2 & 11
T_{WH} X1 falling edge to SC/WC rising edge	40	49	58	40	49	58	ns	
T_{MWH} MCLK falling edge to SC/WC rising edge	125	130	135	$T_{1Q}+T_{2Q}$	$T_{1Q}+T_{2Q}+5$	$T_{1Q}+T_{2Q}+10$	ns ns	Note 2
T_{WL} X1 falling edge to SC/WC falling edge	40	49	58	40	49	58	ns	
T_{MWL} MCLK falling edge to SC/WC falling edge	5	7	15	5	7	15	ns	
T_{IBS} X1 falling edge to LB/RB (input phase)	48	60	70	48	60	70	ns	
T_{MIBS} MCLK falling edge to LB/RB (input phase)	7	17	25	7	17	25	ns	
T_{IIBS} Instruction to LB/RB (input phase)		27	35		27	35	ns	
T_{TOBS} X1 falling edge to LB/RB (Output phase)	48	60	70	48	60	70	ns	
T_{MOBS} MCLK falling edge to LB/RB (Output phase)	132	137	147	$T_{1Q}+T_{2Q}+7$	$T_{1Q}+T_{2Q}+12$	$T_{1Q}+T_{2Q}+22$	ns	Note 2
T_{IDS} Input data set-up time (X1 falling edge)	25	16		25	16		ns	
T_{MIDS} MCLK falling edge to input data stable		65	55		$T_{1Q}+T_{2Q}-60$	$T_{1Q}+T_{2Q}-70$	ns	Notes 2 & 5
T_{IDH} Input data hold time (X1 falling edge)	40	30		40	30		ns	
T_{MDIH} Input data hold time (MCLK falling edge)	125	112		$T_{1Q}+T_{2Q}$	$T_{1Q}+T_{2Q}-13$		ns	Note 2
T_{ODH} Output data hold time (X1 falling edge)	55	65	75	55	65	75	ns	
T_{MODH} Output data hold time (MCLK falling edge)	11	20	25	11	20	25	ns	
T_{ODS} Output data stable (X1 falling edge)	74	84	94	74	84	94	ns	Notes 12, 14, & 15
T_{MODS} Output data stable (MCLK falling edge)	150	160	170	$T_{1Q}+T_{2Q}+25$	$T_{1Q}+T_{2Q}+35$	$T_{1Q}+T_{2Q}+45$	ns	Notes 2, 12, 14, & 15

MICROCONTROLLER

8X300

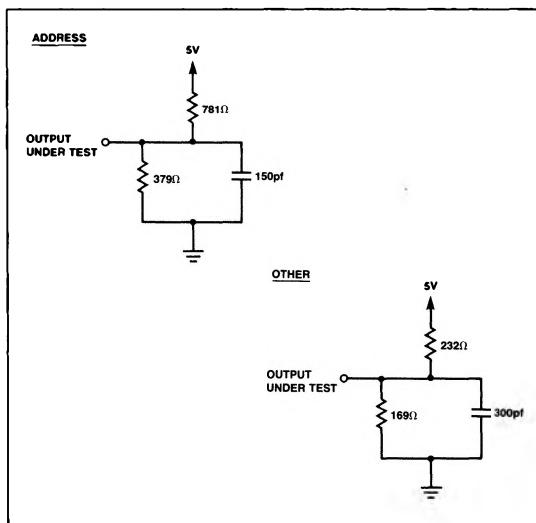
AC CHARACTERISTICS (Commercial Part)
(Continued)**CONDITIONS:** $V_{CC} = 5V (\pm 5\%)$, $V_{IN} = 0V$ or $3V$, $0^\circ C \leq T_A \leq 70^\circ C$
LOADING: (See test circuits)

PARAMETER (NOTE 1)	LIMITS (INSTRUCTION CYCLE TIME = 250 ns)			LIMITS (INSTRUCTION CYCLE TIME > 250 ns)			UNITS	COMMENTS
	Min	Typ	Max	Min	Typ	Max		
T_{DD} Input data to output data	104	120	136	104	120	136	ns	Notes 13 & 15
T_{HS} HALT set-up time (X1 rising edge)	0			0			ns	
T_{MHS} MCLK falling edge to HALT falling edge			18				$T_{1Q}-44$	Notes 2 & 6
T_{HH} HALT hold time (X1 rising edge)	32			32			ns	
T_{MHH} HALT hold time (MCLK falling edge)	50			$T_{1Q}-12$			ns	Note 2
T_{ACC} Program storage access time			80				ns	
T_{IO} I/O port output enable time (LB/RB to valid IV data input)			30				ns	

NOTES:

1. X1 and X2 inputs are driven by an external pulse generator with an amplitude of 1.5 volts; all timing parameters are measured at this voltage level.
2. Respectively, T_{1Q} , T_{2Q} , T_{3Q} , and T_{4Q} represent time intervals for the first, second, third, and fourth quarter cycles.
3. Capacitive loading for the address bus is 150 picofarads.
4. Same as TIS but referenced to falling edge of MCLK.
5. Same as TIDS but referenced to falling edge of MCLK.
6. Same as THS but referenced to falling edge of MCLK.
7. TAS is obtained by forcing a valid instruction and an I/O bus input to occur earlier than the specified minimum set-up time; the TAS parameter then represents the earliest time that the address bus is valid.
8. TIA is obtained by forcing a valid instruction input to occur earlier than the minimum set-up time.
9. TIVA is obtained by forcing a valid I/O bus input to just meet the minimum set-up time.
10. TMIS represents the set-up time required by internal latches of the 8X300. In system applications, the instruction input may have to be valid before the worst-case set-up time in order for the system to respond with a valid I/O bus input that meets the I/O bus input set-up time (TIDS and TMIDS).
11. TH represents the hold time required by internal latches of the 8X300. To generate proper LB/RB signals, the instruction must be held valid until the address bus changes.
12. TODS is obtained by forcing a valid I/O bus input to occur earlier than the I/O bus input set-up time (TIDS); this timing parameter represents the earliest time that the I/O output data can be valid.
13. TDD is obtained by forcing a valid I/O bus input to just meet the minimum I/O bus input set-up time; thus timing parameter represents the latest time that the I/O output data can be valid.
14. The minimum figure for these parameters represents the earliest time that I/O bus output drivers of the 8X300 will turn on.
15. For $TIDS \geq 35$ ns, TODS or TMODS should be used to determine when the output data is stable.

TEST CIRCUITS



MICROCONTROLLER

8X300

DC CHARACTERISTICS (Military Part) S8X300-1 $-40^{\circ}\text{C} \leq \text{TC} \leq 100^{\circ}\text{C}$ $\text{VCC} = 5\text{V} \pm 5\%$
 S8X300-2 $-20^{\circ}\text{C} \leq \text{TC} \leq 100^{\circ}\text{C}$ $\text{VCC} = 5\text{V} \pm 10\%$

PARAMETER	TEST CONDITIONS	LIMITS			UNIT
		Min	Typ	Max	
V_{IH} High level input voltage X1, X2 All others		0.6 2.0			V V
V_{IL} Low level input voltage X1, X2 All others				0.4 0.8	V V
V_{IC} Input clamp voltage (Notes 1 & 5)	$\text{VCC} = \text{min}$ $I_f = -10\text{mA}$			-1.5	V
I_{IH} High level input current X1, X2 All others	$\text{VCC} = \text{max}$ $V_{IH} = 0.6\text{V}$ $\text{VCC} = \text{max}$ $V_{IH} = 4.5\text{V}$			3.0 0.05	mA
I_{IL} Low level input current X1, X2	$\text{VCC} = \text{max}$ $V_{IL} = 0.4\text{V}$			-3.0	mA
$\overline{IV_0-IV_7}$	$\text{VCC} = \text{max}$ $V_{IL} = 0.4\text{V}$			-0.3	mA
	$\text{VCC} = \text{max}$ $V_{IL} = 0.4\text{V}$			-1.6	mA
	$\text{VCC} = \text{max}$ $V_{IL} = 0.4\text{V}$			-0.4	mA
V_{OL} Low level output voltage A0-A12 All others	$\text{VCC} = \text{min}$ $I_L = 4.25\text{mA}$ $\text{VCC} = \text{min}$ $I_{OL} = 16\text{mA}$			0.55 0.55	V V
V_{OH} High level output voltage	$\text{VCC} = \text{min}$ $I_{OH} = -3\text{mA}$	2.4			V
I_{OS} Short circuit output current (Note 2)	$\text{VCC} = \text{max}$	-30		-140	mA
I_{CC} Supply current (Note 4)	$\text{VCC} = \text{max}$			160	mA
I_{REG} Regulator control	$\text{VCC} = 5.0\text{V}$	-14		-21	mA
I_{CR} Regulator current	$\text{VCC} = \text{max}$			285	mA
I_{CR} Regulator current	$\text{TC} \geq 25^{\circ}\text{C}$ $\text{VCC} = \text{max}$			330	mA
V_{CR} Regulator voltage	$\text{TC} < 25^{\circ}\text{C}$ (Note 3)		3.1		V

NOTES

- 1 Crystal inputs X1 and X2 do not have clamp diodes
- 2 Only one output may be grounded at a time
- 3 From series-passed transistor under the following conditions
 $\text{VCC} = \text{Max}$, $\text{HALT} = \text{RESET} = \text{ADDRESS} = \text{IVX} = 0\text{V}$, all other pins open.
- 4 Pin 37 only

- 5 Test each input one at a time
- 6 All voltages are with respect to ground terminal
- 7 The operating temperature ranges are guaranteed after thermal equilibrium has been reached
- 8 Storage temperature -65°C to $+150^{\circ}\text{C}$

MICROCONTROLLER

8X300

AC CHARACTERISTICS (Military Part) CONDITIONS: S8X300-1— $V_{CC} = 5V (\pm 5\%)$ $-40^\circ C \leq T_C \leq 100^\circ C$
 S8X300-2— $V_{CC} = 5V (\pm 10\%)$ $-20^\circ C \leq T_C \leq 100^\circ C$

PARAMETER	TEST CONDITIONS (NOTES 1 & 2)	LIMITS			UNIT
		Min	Typ	Max	
Clock:					
T_{PC}	Processor cycle time		300		ns
T_{CP}	X1 clock period		150		ns
T_{CH}	X1 clock high time		62		ns
T_{CL}	X1 clock low time		62		ns
Controls:					
T_{HS}	HALT set-up time (X1 rising edge)		0		ns
T_{HH}	HALT hold time (X1 rising edge)		50		ns
Instructions:					
T_{AS}	X1 falling edge to address stable	CL = 100pF	35	92	ns
T_{IS}	Instruction set-up time (X1 rising edge)		0		ns
T_{IH}	Instruction hold time (X1 rising edge)		50		ns
T_{MCH}	MCLK high delay	X1 = 2.0V	20	55	ns
T_{MCL}	MCLK low delay	X1 = 2.0V	20	55	ns
T_{WH}	X1 falling edge to SC/WC rising edge			80	ns
T_{WL}	X1 falling edge to SC/WC falling edge			80	ns
T_{IIBS}	Instruction to LB/RB (input phase)			52	ns
T_{IBS}	X1 falling edge to LB/RB (input phase)		24		ns
T_{TOBS}	X1 falling edge to LB/RB (output phase)			90	ns
T_{IDS}	Input data set-up time (X1 falling edge)		36		ns
T_{IDH}	Input data hold time (X1 falling edge)		50		ns
T_{ODS}	Output data stable (X1 falling edge)			125	ns
T_{ODH}	Output data hold time (X1 falling edge)		35	85	ns
T_{ACC}	Instruction access time	Provided by worst case timing	80		ns
T_{IO}	Data I/O access time	Provided by worst case timing	40		ns

NOTES.

1 Operating temperature ranges are guaranteed after thermal equilibrium has been reached.

2 Unless otherwise noted CL = 300 pF, VIN = 3V

TIMING CONSIDERATIONS (Commercial Part)

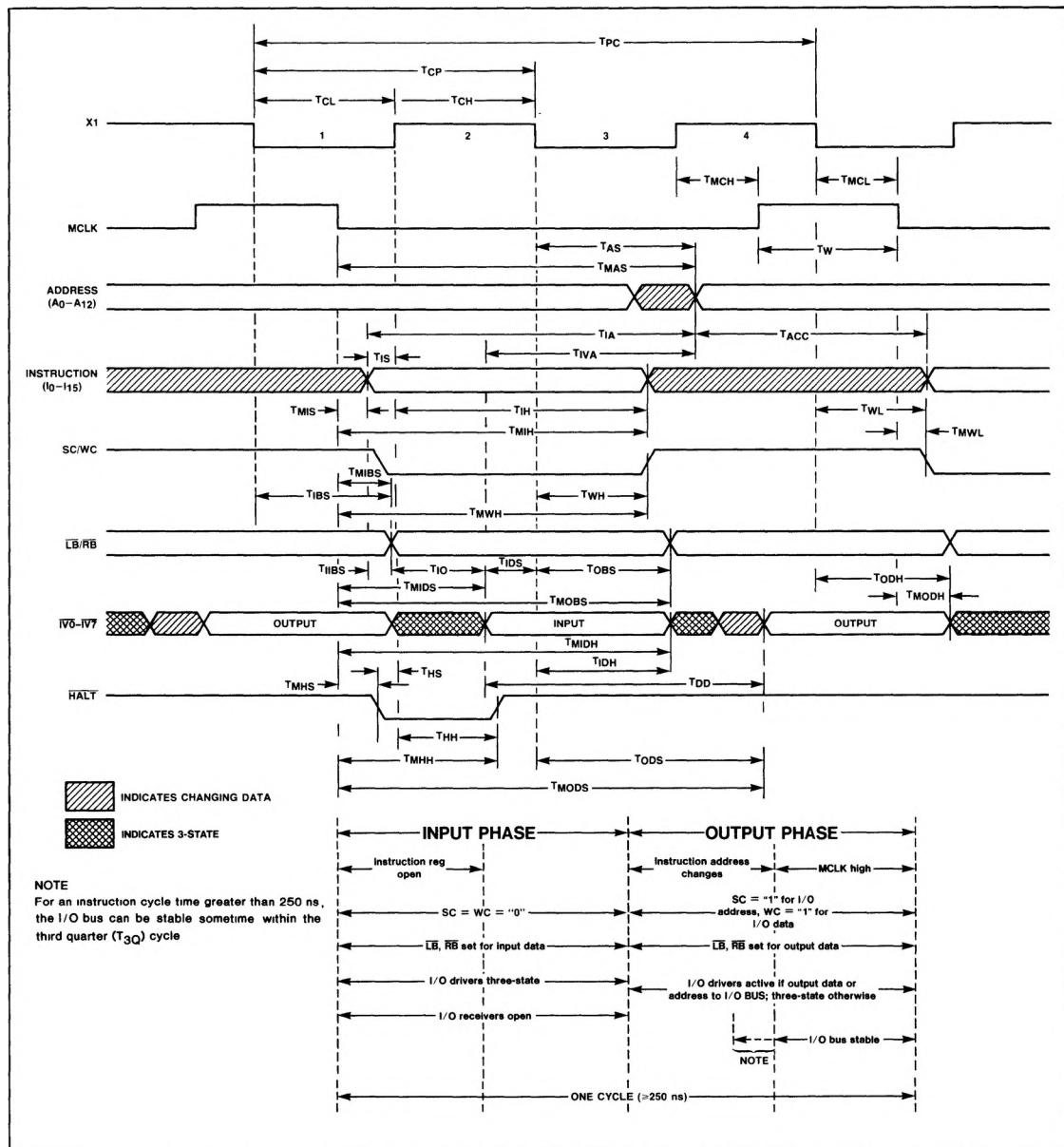
As shown in the "AC CHARACTERISTICS" table for this part, the minimum instruction cycle time is 25 ns, whereas, the maximum is determined by the on-chip oscillator frequency and can be any value the user chooses. With an instruction cycle time of 250 ns, the part can be characterized in terms of absolute values; these are shown in the first "LIMITS" column of the table. When the instruction cycle time is greater than 250 ns, certain parameters are cycle-time dependent; thus, these parameters are specified in terms of the

four quarter cycles (T_{1Q} , T_{2Q} , T_{3Q} , and T_{4Q}) that make up one instruction cycle—see 8X300 TIMING DIAGRAM. As the time interval for each instruction cycle increases (becomes greater than 250 ns), the delay for all parameters that are cycle-time dependent is likewise increased. In some cases, these delays have a significant impact on timing relationships and other areas of systems design; subsequent paragraphs describe these timing parameters and reliable methods of calculation.

MICROCONTROLLER

8X300

8X300 TIMING DIAGRAM



Timing parameters for the 8X300 are normally measured with reference to X1 or MCLK; those referenced to MCLK are prefaced with an "M" in the mnemonic—TMAS, TMH, and so on. To determine the timing relationship between a particular signal, say "A" and MCLK, the user should, at all times, use the value specified in the table—DO NOT

calculate the value by adding or subtracting two or more parameters that are referenced to X1. When deriving timing relationships between two signals (A to B, etc.) by adding or subtracting the parameter values, the user must consistently use the same parameter reference—MCLK or X1.

MICROCONTROLLER

8X300

System determinants for the instruction cycle time are:

- Propagation delays within the 8X300
- Access time of Program Storage
- Enable time of the I/O port

Normally, the instruction cycle time is constrained by one or more of the following conditions:

Condition 1—Instruction or MCLK to $\overline{LB}/\overline{RB}$ (input phase) plus I/O port access time (TIO) \leq IV data set-up time (Figure 4a).

Condition 2—Program storage access time (TACC) plus instruction to $\overline{LB}/\overline{RB}$ (input phase) plus I/O port access time (TIO) plus IV data (input phase) to address \leq instruction time (Figure 4b).

Condition 3—Program storage access time plus instruction to address \leq instruction cycle time (Figure 4c).

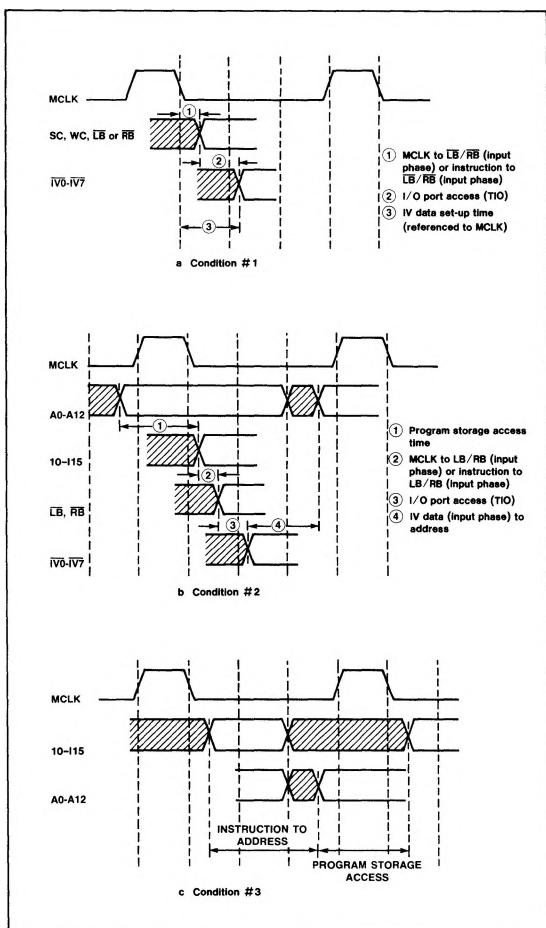


Figure 4. Constraints of 8X300 Instruction Cycle Time

From condition #1 and with an instruction cycle time of 250 ns, the I/O port access time (TIO) can be calculated as follows:

$$TMIBS + TIO \leq TMIDS$$

transposing, $TIO \leq TMIDS - TMIBS$

substituting, $TIO \leq 55ns - 25ns$

result, $TIO \leq 30 ns$

Using 30 ns for TIO, the constraint imposed by condition #1 can also be used to calculate the minimum cycle time:

$$TMIBS + TIO \leq TMIDS$$

thus, $25ns + 30ns \leq T1Q + T2Q - 70$

$$25ns + 30ns \leq \frac{1}{2} \text{ cycle} - 70 \text{ therefore, the}$$

worst-case instruction cycle time is 250 ns. With subject parameters referenced to X1, the same calculations are valid:

$$TIBS + TIO + TIDS \leq \frac{1}{2} \text{ cycle}$$

thus, $70ns + 30ns + 25ns \leq \frac{1}{2} \text{ cycle}$ therefore,

the worst-case instruction cycle time is again 250 ns. From condition #2 and with an instruction cycle time of 250 ns, the program storage access time can be calculated:

$$TACC + TIIBS + TIO + TIVA \leq 250ns$$

transposing, $TACC \leq 250ns - TIIBS - TIO - TIVA$

substituting, $TACC \leq 250ns - 35ns - 30ns - 105ns$

thus, $TACC \leq 80ns$ hence, for an instruction cycle time of 250 ns, a program storage access time of 80 ns is implied. The constraint imposed by condition #3 can be used to verify the maximum program storage access time:

$$TIA + TACC \leq \text{Instruction Cycle}$$

thus, $TACC \leq 250ns - 170ns$

and, $TACC \leq 80ns$, confirming that a program storage access time of 80 ns is satisfactory.

For an instruction cycle time of 250 ns and a program storage access time of 80 ns (Condition #2/Figure 4b), the instruction should be valid 10 ns before the falling edge of MCLK. This relationship can be derived by the following equation:

$$\begin{aligned} & 250ns - TMAS - TACC \\ & = 250ns - 160ns - 80ns \\ & = 10ns \end{aligned}$$

It is important to note that, during the input phase, the beginning of a valid $\overline{LB}/\overline{RB}$ signal is determined by either the instruction to $\overline{LB}/\overline{RB}$ delay (TIIBS) or the delay from the falling edge of MCLK to $\overline{LB}/\overline{RB}$ (TMIBS). Assuming the instruction is valid 10 ns before the falling edge of MCLK and adding the instruction-to-LB/RB delay (TIIBS) = 30ns, the $\overline{LB}/\overline{RB}$ signal will be valid 25 ns after the falling edge of MCLK. With a fast program storage memory and with a valid instruction more than 10 ns before the falling edge of MCLK—the $\overline{LB}/\overline{RB}$ signal will, due to the TMIBS delay, still be valid 25 ns after the falling edge of MCLK. Using a worst-case instruction cycle time of 250 ns, the user cannot gain a speed advantage by selecting a memory with faster access time. Under the same conditions, a speed advantage cannot be obtained by using an I/O port with fast access time (TIO) because the address bus will be stable 80 ns (TAS) after the beginning of the third quarter cycle—no matter how early the IV data input is valid.

MICROCONTROLLER**8X300****Internal Timing and Timing Relationships**

All timing and timing-control signals of the 8X300 are generated by the oscillator and sequencer shown in Figure 5. The sequencer outputs direct and control all of the timing parameters specified in the TIMING DIAGRAM. Observe that each input quarter cycle bears a fixed relationship to X1 via the propagation delay.

General and interactive timing relationships pertaining to I/O signals of the 8X300 are shown in Figure 6. Example—in the input phase, the switching point of the LB/RB signal is caused by the worst-case delay from the instruction to LB/RB or from the beginning of the first internal quarter cycle to LB/RB; the two arrows pointing to the LB/RB transition indicate this "either/or" dependency. This information coupled with tabular values and the TIMING DIAGRAM provides the user with the wherewithal to calculate any and all system timing parameters.

CLOCK CONSIDERATIONS

The on-chip oscillator and timing-generation circuits of the 8X300 can be controlled by any one of the following methods:

Capacitor: if timing is not critical

Crystal: if precise timing is required

External Drive: if application requires that the 8X300 be synchronized with system clock

Capacitor Timing: A non-polarized ceramic or mica capacitor with a working voltage equal to or greater than 25-volts is recommended. The lead lengths of capacitor should be approximately the same and as short as possible; also, the

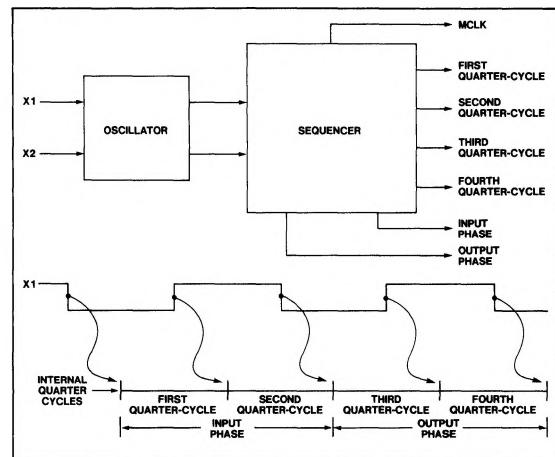


Figure 5. Timing and Timing Control Signals of the 8X300

timing circuits should not be in close proximity to external sources of noise. For various capacitor (C_x) values, the cycle time can be approximated as:

C_x (in pF)	APPROXIMATE CYCLE TIME
100	300 ns
200	500 ns
500	1.1 μ s
1000	2.0 μ s

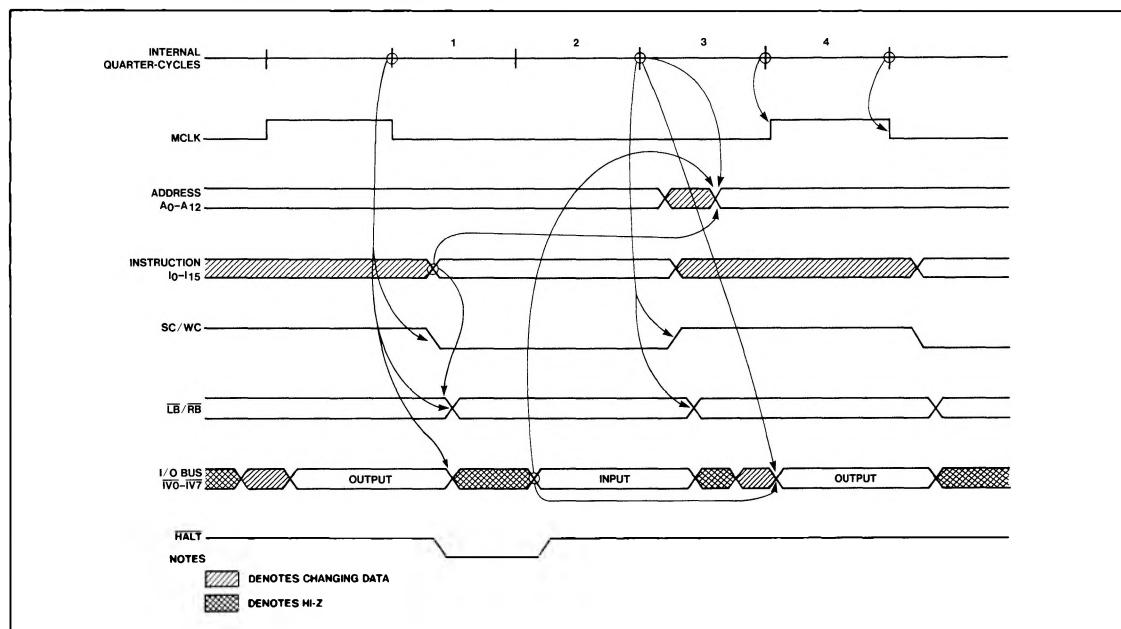


Figure 6. Timing Relationships of 8X300 I/O Signals

MICROCONTROLLER**8X300**

Crystal Timing: When a crystal is used, the on-chip oscillator operates at the resonant frequency (f_0) of the crystal; the series-resonant quartz crystal connects to the 8X300 via pins 10 (X1) and 11 (X2). The lead lengths of the crystal should be approximately equal and as short as possible; also, the timing circuits should not be in close proximity to external sources of noise. The crystal should be hermetically sealed (HC type can) and have the following electrical characteristics:

Type: Fundamental mode, series resonant

Impedance at Fundamental: 35-ohms maximum

Impedance at Harmonics and Spurs: 50-ohms minimum

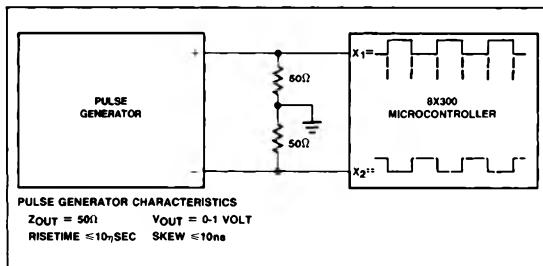


Figure 7. Clocking with a Pulse Generator

The resonant frequency (f_0) of the crystal is related to the desired cycle time (T) by the equation $f_0 = 2/T$; for a cycle time of 250 ns, $f_0 = 8\text{MHz}$.

Using an External Clock: The 8X300 can be synchronized with an external clock by simply connecting appropriate drive circuits to the X1/X2 inputs. Figure 7 shows how the on-chip oscillator can be driven from the complementary outputs of a pulse generator. In applications where the microcontroller must be driven from a master clock, the X1/X2 lines can be interfaced to TTL logic as shown in Figure 8.

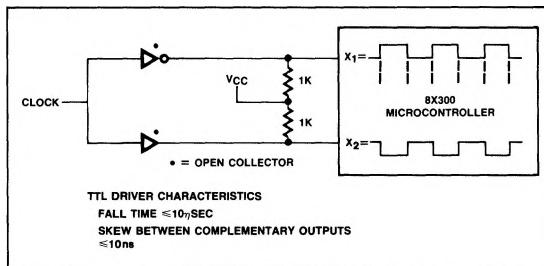


Figure 8. Clocking with TTL

RESET Logic

The RESET line (pin 43) can be driven from a high (inactive) state to a low (active) state at any time with respect to the system clock, that is, the reset function is asynchronous. To ensure proper operation, the RESET line should be held low (active) for one full instruction time. When the line is driven from a high state to an active-low state, several events occur—the precise instant of occurrence is basically a function of the propagation delay for that particular event. As shown in the accompanying RESET timing diagram, these events are:

- The Program Counter and Address Register are set to an all-zero configuration and remain in that state as long as the RESET line is low. Other than PC and AR, reset does not affect other internal registers.
- The input/output (IV) bus goes three-state and remains in that mode as long as the RESET line is low.
- The Select Command and Write Command signals are driven low and remain inactive as long as the RESET line is low.
- The Left Bank/Right Bank signals are undefined for the period in which the RESET line is low.

During the time RESET is active-low, MCLK is inhibited; moreover, if the RESET line is driven low during the last two

quarter cycles, MCLK can be shortened for that particular machine cycle. When RESET line is driven high (inactive)—one-quarter to one full instruction cycle later—MCLK appears just before normal operation is resumed. The RESET/MCLK relationship is clearly shown by "B" in the timing diagram. As long as the RESET line is active-low, the HALT signal (described next) is not sampled by internal logic of the 8X300.

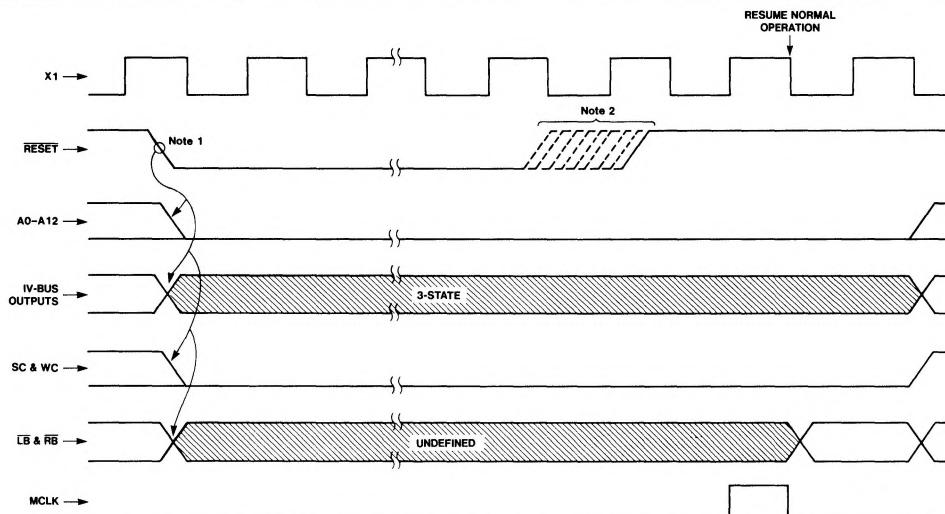
HALT Logic

The HALT signal is sampled via internal chip logic at the end of the first internal quarter of each instruction cycle. If, when sampled, the HALT signal is active-low, a halt is immediately executed and the current instruction cycle is terminated; however, the halt cycle does not inhibit MCLK nor does it affect any internal registers of the 8X300. As long as the HALT line is active-low, the SC and WC lines are low (inactive) and the input/output (IV) bus remains in the three-state mode of operation. The halt cycle continues until, when again sampled, the HALT line is found to be high; at this time, normal operation is resumed. Timing for the halt signal is shown in the accompanying diagram.

MICROCONTROLLER

8X300

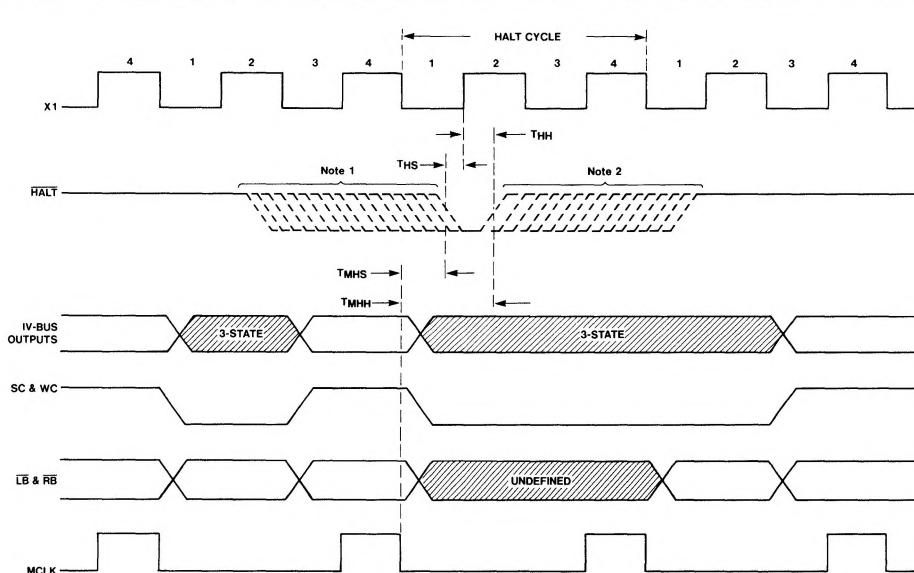
RESET TIMING DIAGRAM



NOTES

1. A High to Low transition of the **RESET** signal will force the Address Bus to an all-zero configuration.
2. The **RESET** signal can switch from Low to High at any point within this time interval and, in all cases, MCLK will occur at least one-quarter cycle time later as shown.

HALT TIMING DIAGRAM



NOTES

1. The **HALT** signal can switch from High to Low at any time during this interval.
2. The **HALT** signal can switch from Low to High at any time during this interval.

Timing Descriptions:

T_{HS}—set-up time from **HALT** to **X1** (independent of instruction cycle time)

T_{HH}—hold time from **X1** to **HALT** (independent of instruction cycle time)

T_{MHS}—set-up time from **MCLK** to **HALT** (dependent upon instruction cycle time)

T_{MHH}—hold time from **MCLK** to **HALT** (dependent upon instruction cycle time)

MICROCONTROLLER**8X300****VOLTAGE REGULATOR**

All internal logic of the 8X300 is powered by an on-chip voltage regulator that requires an external series-pass transistor. Electrical specifications for the off-chip power transistor and a typical hook-up are shown in the accompanying diagram. To minimize lead inductance, the transistor should be as close as possible to the 8X300 package and the emitter should be ac-grounded via a 0.1-microfarad ceramic capacitor.

PARAMETER	CONDITIONS	LIMITS
h_{FE}	$V_{CE} = 2V$, $100mA < I_C < 500mA$	> 50
BEON	$V_{CE} = 5V$, $I_C = 500mA$	$< 1V$
V_{CESAT}	$I_C = 500mA$, $I_B = 50mA$	$< 0.5V$
BV_{CEO}		$> 15V$
f_t		$> 30MHz$

NOTE
Typical approved parts—2N5320, 2N5337