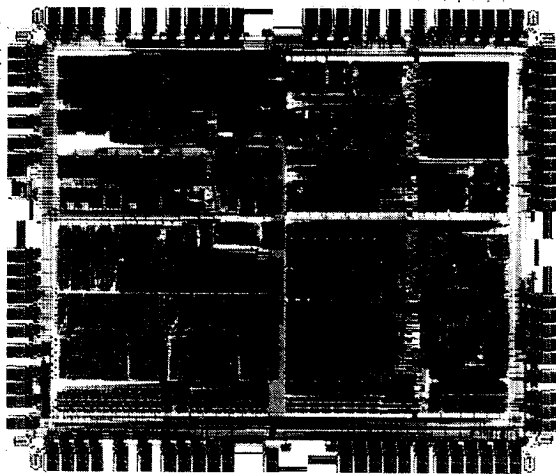


# 80C188EB-16, -13, -8 16-BIT HIGH-INTEGRATION EMBEDDED PROCESSOR

- Full Static Operation
- True CMOS Inputs and Outputs
- -40°C to +85°C Operating Temperature Range
- Low System Cost 8-Bit Interface

- **Integrated Feature Set**
  - Low-Power Static CPU Core
  - Two Independent UARTs each with an Integral Baud Rate Generator
  - Two 8-Bit Multiplexed I/O Ports
  - Programmable Interrupt Controller
  - Three Programmable 16-Bit Timer/Counters
  - Clock Generator
  - Ten Programmable Chip Selects with Integral Wait-State Generator
  - Memory Refresh Control Unit
  - System Level Testing Support (ONCE™ Mode)
- **Direct Addressing Capability to 1 Mbyte Memory and 64 Kbyte I/O**
- **Speed Versions Available:**
  - 16 MHz (80C188EB-16)
  - 13 MHz (80C188EB-13)
  - 8 MHz (80C188EB-8)
- **Low-Power Operating Modes:**
  - Idle Mode Freezes CPU Clocks but keeps Peripherals Active
  - Powerdown Mode Freezes All Internal Clocks
- **Complete System Development Support**
  - ASM86 Assembler, PL/M 86, Pascal 86, Fortran 86, C-86, and System Utilities
  - In-Circuit Emulator (ICE™-188EB)
- **Available In:**
  - 80-Pin Quad Flat Pack (TS80C188EB)
  - 84-Pin Plastic Leaded Chip Carrier (TN80C188EB)

The 80C188EB is a second generation CHMOS High-Integration microprocessor. It has features that are new to the 80C188 family and include a STATIC CPU core, an enhanced Chip Select decode unit, two independent Serial Channels, I/O ports, and the capability of Idle or Powerdown low power modes.



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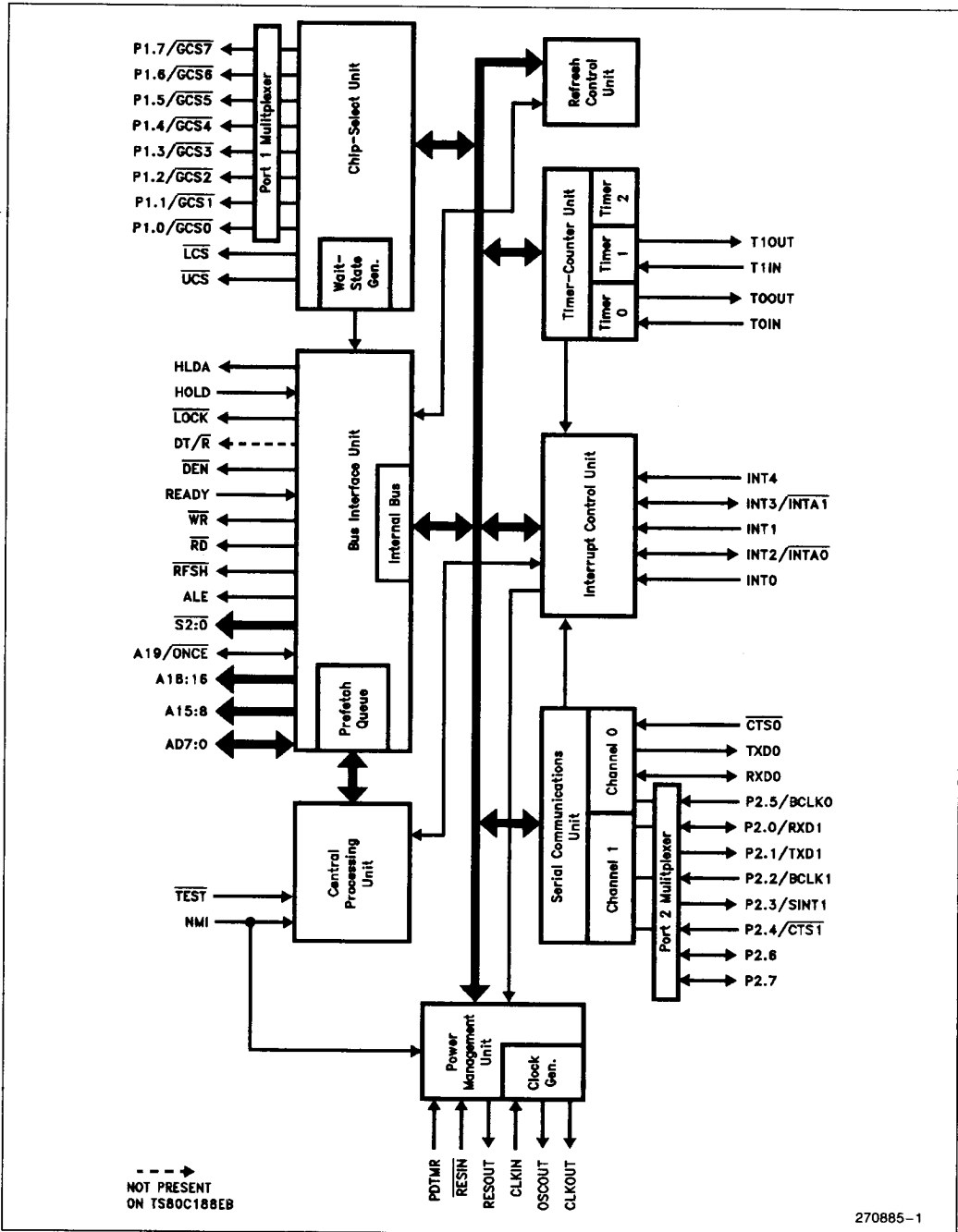


Figure 1. 80C188EB Block Diagram

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**INTRODUCTION**

The 80C188EB is the first product in a new generation of low-power, high-integration microprocessors. It enhances the existing 186 family by offering new features and new operating modes. The 80C188EB is object code compatible with the 80C186/80C188 microprocessors. The 80C188EB has an 8-bit external data bus but still retains a 16-bit internal bus. An 8-bit external bus reduces system cost by requiring that only single byte-wide memories be used.

The feature set of the 80C188EB meets the needs of low power, space critical applications. Low-Power applications benefit from the static design of the CPU core and the integrated peripherals. Minimum current consumption is achieved by providing a Power-down mode that halts operation of the device, and freezes the clock circuits. Peripheral design enhancements ensure that non-initialized peripherals consume little current.

Space critical applications benefit from the integration of commonly used system peripherals. Two serial channels are provided for services such as diagnostics, inter-processor communication, modem interface, terminal display interface, and many others. A flexible chip select unit simplifies memory and peripheral interfacing. The interrupt unit provides sources for up to 129 external interrupts and will prioritize these interrupts with those generated from the on-chip peripherals. Three general purpose timer/counters and sixteen multiplexed I/O port pins round out the feature set of the 80C188EB.

**OVERVIEW**

Figure 1 shows a block diagram of the 80C188EB. The Execution Unit (EU) is an enhanced 8088 CPU core that includes: dedicated hardware to speed up effective address calculations, enhance execution speed for multiple-bit shift and rotate instructions and for multiply and divide instructions, string move instructions that operate at full bus bandwidth, ten new instruction, and full static operation. The Bus Interface Unit (BIU) is the same as that found on the original 188 family products, except the queue-status mode has been deleted and buffer interface control has been changed to ease system design timings. An independent internal bus is used to allow communication between the BIU and internal peripherals.

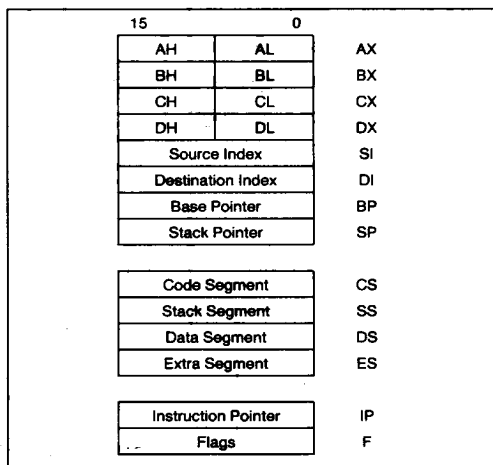
**80C188EB Core Architecture**

**REGISTER SET**

The 8086, 8088, 80186, 80188, 80C186, and 80C188 all contain the same basic set of registers, instructions, and addressing modes. The 80C188EB is upward compatible with all of these microprocessors.

The 80C188EB base architecture has fourteen 16-bit registers as shown in Figure 2. There are eight general purpose registers which may be used for arithmetic and logic operands. Four of these registers (AX, BX, CX, and DX) can be used as 16-bit registers or split into pairs of separate 8-bit registers. The other four registers (BP, SI, DI, and SP) may also be used to determine offset addresses of operands in memory. These registers may contain base addresses or indexes to particular locations within a segment. The addressing mode selects the specific registers for operand and address calculations.

Another four 16-bit registers (CS, DS, ES, SS) select the segments of memory that are immediately addressable for code, stack, and data. There are two remaining special purpose registers (IP and F) that record or alter certain aspects of the 80C188EB processor state.



**Figure 2. 80C188EB Register Set**

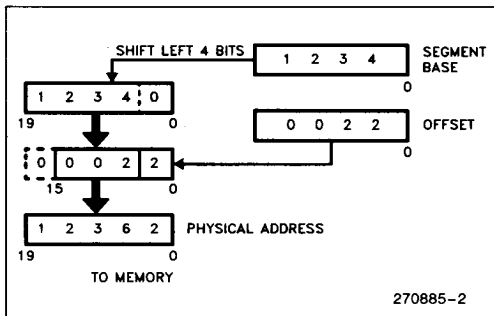
**INSTRUCTION SET**

The instruction set is divided into seven categories: data transfer, arithmetic, shift/rotate/logical, string manipulation, control transfer, high-level instructions, and processor control. These categories are summarized in Figure 4.

An 80C188EB instruction can reference anywhere from zero to several operands. An operand can reside in a register, in the instruction itself, or in memory.

**MEMORY ORGANIZATION**

Memory is organized in sets of segments. Each segment is a linear contiguous sequence of up to 64K (2<sup>16</sup>) 8-bit bytes. Memory is addressed using a two-component address (a pointer) that consists of a 16-bit base segment and a 16-bit offset. The 16-bit base segment values are contained in one of four internal segment registers (code, data stack, extra). The physical address is calculated by shifting the base value left by four bits and adding the 16-bit offset value to yield a 20-bit physical address (see Figure 3). The resulting 20-bit address allows for a 1 Mbyte address range.



**Figure 3. Two Component Address**

All instructions that address operands in memory must specify the base segment and the 16-bit offset value. For speed and compact instruction encoding, the segment register used for a physical address generation is implied by the addressing mode used (see Table 1). Special segment override instruction prefixes allow the implicit segment register selection rules to be overridden for special cases. The code, stack, data, and extra segments may coincide for simple programs.

**Table 1. Segment Register Selection Rules**

Memory Reference Needed	Segment Register Used	Implicit Segment Selection Rule
Instructions	Code (CS)	Instruction prefetch and immediate data
Stack	Stack (SS)	All stack pushes and pops; any memory references which use the BP register as a base
External	Extra (ES)	All String instruction references which use the DI register as an index
Local Data	Data (DS)	All other data references

**ADDRESSING MODES**

The 80C188EB provides eight categories of addressing modes to specify operands. Two addressing modes are provided for instructions that operate on register or immediate operands:

- *Register Operand Mode*: The operand is located in one of the 8- or 16-bit general registers.
- *Immediate Operand Mode*: The operand is included in the instruction.

Six modes are provided to specify the location of an operand in a memory segment. A memory operand address consists of two 16-bit components: a segment base and an offset. The segment base is supplied by a 16-bit segment register either implicitly chosen by the addressing mode or explicitly chosen by a segment override prefix. The offset, also called the effective address, is calculated by summing any combination of the following three address elements:

- the *displacement* (an 8- or 16-bit immediate value contained in the instruction);
- the *base* (contents of either the BX or BP base registers); and
- the *index* (contents of either the SI or DI index registers).

GENERAL PURPOSE	DIVISION	NO OPERATION
MOV	DIV	NOP
PUSH	IDIV	
POP	AAD	<b>HIGH LEVEL INSTRUCTIONS</b>
PUSHA	CBW	ENTER
POPA	CWD	LEAVE
XCHG		BOUND
XLAT	<b>STRING OPERATIONS</b>	
<b>INPUT/OUTPUT</b>	MOVS	<b>CONDITIONAL TRANSFERS</b>
IN	INS	JA/JNBE
OUT	OUTS	JAE/JNB
<b>ADDRESS OBJECT</b>	CMPS	JB/JNAE
LEA	SCAS	JBE/JNA
LDS	LODS	JC
LES	STOS	JE/JZ
<b>FLAG TRANSFER</b>	REP	JG/JNLE
LAHF	REPE/REPZ	JGE/JNL
SAHF	REPNE/REPZ	JL/JNGE
PUSHF		JLE/JNG
POPF	<b>LOGICALS</b>	JNC
<b>ADDITION</b>	NOT	JNE/JNZ
ADD	AND	JNO
INC	OR	JNP/JPO
AAA	XOR	JNS
DAA	TEST	JO
<b>SUBTRACTION</b>	<b>SHIFTS</b>	JP/JPE
SUB	SHL/SAL	JS
SBB	SHR	<b>UNCONDITIONAL TRANSFERS</b>
DEC	SAR	CALL
NEG	<b>ROTATES</b>	RET
CMP	ROL	JMP
AAS	ROR	<b>ITERATION CONTROLS</b>
DAS	RCL	LOOP
<b>MULTIPLICATION</b>	RCR	LOOPE/LOOPZ
MUL	<b>FLAG OPERATIONS</b>	LOOPNE/LOOPNZ
IMUL	STC	JCXZ
AAM	CLC	<b>INTERRUPTS</b>
	CMC	INT
	STD	INTO
	CLD	IRET
	STI	
	CLI	
	<b>EXTERNAL SYNCHRONIZATION</b>	
	HLT	
	WAIT	
	LOCK	

Figure 4. 80C188EB Instruction Set

Any carry out from the 16-bit addition is ignored. 8-bit displacements are sign extended to 16-bit values.

Combinations of these three address elements define the six memory addressing modes, described below.

- **Direct Mode:** The operand's offset is contained in the instruction as an 8- or 16-bit displacement element.
- **Register Indirect Mode:** The operand's offset is in one of the registers SI, DI, BX, or BP.
- **Based Mode:** The operand's offset is the sum of an 8- or 16-bit displacement and the contents of a base register (BX or BP).
- **Indexed Mode:** The operand's offset is the sum of an 8- or 16-bit displacement and the contents of an index register (SI or DI).
- **Based Indexed Mode:** The operand's offset is the sum of the contents of a base register and an index register.
- **Based Indexed Mode with Displacement:** The operand's offset is the sum of a base register's contents, an index register's contents, and an 8- or 16-bit displacement.

## DATA TYPES

The 80C188EB directly supports the following data types:

- **Integer:** A signed binary numeric value contained in an 8-bit byte or 16-bit word. All operations assume a 2's complement representation. Signed 32- and 64-bit integers are supported using the 80C187 Numerics Coprocessor.
- **Ordinal:** An unsigned binary numeric value contained in an 8-bit byte or 16-bit word.
- **Pointer:** A 16- or 32-bit quantity, composed of a 16-bit offset component, or a 16-bit segment base component and a 16-bit offset component.
- **String:** A contiguous sequence of bytes or words. A string may contain from 1 Kbyte to 64 Kbytes.
- **ASCII:** A byte representation of alphanumeric and control characters using the ASCII standard of character representation.

- **BCD:** A byte (unpacked) representation of the decimal digits 0–9.
- **Packed BCD:** A byte (packed) representation of two decimal digits (0–9). One digit is stored in each nibble (4 bits) of the byte.

In general, individual data elements must fit within defined segment limits.

## INTERRUPTS

An interrupt transfers execution to a new program location. The old program address (CS:IP) and machine state (F) are saved on the stack to allow resumption of the interrupted program. Interrupts fall into three classes: hardware initiated, software (program) initiated, and instruction exception initiated. Hardware initiated interrupts occur in response to an external or internal input and are classified as non-maskable or maskable.

Programs may cause an interrupt by executing the "INT" instruction. Instruction exceptions occur when an illegal opcode has been fetched into the queue and is read by the execution unit. Another type of exception can be generated when executing an "ESC" instruction.

For all cases except the "ESC" exception, the return address from an exception will point at the instruction immediately following the instruction causing the exception. The return address after an "ESC" exception will point back to the ESC instruction causing the exception, or to the segment override prefix immediately preceding the ESC instruction if the prefix was present.

A table containing up to 256 pointers defines the proper interrupt service routine for each interrupt. Interrupts 0–31 are reserved by Intel. Table 2 shows the 80C188EB predefined type and default priority levels. For each interrupt, an 8-bit vector (Vector Type) identifies the appropriate table entry. Multiplying the 8-bit vector by 4 defines the vector address. INT instructions contain or imply the vector type and allow access to all 256 interrupts.

Table 2. 80C188EB Interrupt Vectors

Interrupt Name	Vector Type	Vector Address	Default Priority	Related Instructions
Divide Error	0	00H	1	DIV, IDIV
Single Step Interrupt	1	04H	1A	All
Non-Maskable Interrupt	2	08H	1	INT 2 or NMI
One Byte Interrupt	3	0CH	1	INT
Interrupt on Overflow	4	10H	1	INTO
Array Bounds Check	5	14H	1	BOUND
Invalid OP-Code	6	18H	1	Illegal Inst
ESC OP-Code Interrupt	7	1CH	1	ESC OP-Codes
Timer 0 Interrupt	8	20H	2	
Reserved	9-11	24H-2CH		
INT0 Interrupt	12	30H	5	
INT1 Interrupt	13	34H	6	
INT2 Interrupt	14	38H	7	
INT3 Interrupt	15	3CH	8	
Reserved	16	40H		
INT4 Interrupt	17	44H	4	
Timer1 Interrupt	18	48H	2A	
Timer2 Interrupt	19	4CH	2B	
UART 0 Receive Interrupt	20	50H	3	
UART 0 Transmit Interrupt	21	54H	3A	
Reserved	22-31	58H-7CH		

**BUS INTERFACE UNIT**

The 80C188EB core incorporates a bus controller that generates local bus control signals. In addition, it employs a HOLD/HLDA protocol to share the local bus with other bus masters.

The bus controller is responsible for generating 20 bits of address, read and write strobes, bus cycle status information, and data (for write operations) information. It is also responsible for reading data off the local bus during a read operation. A READY input pin is provided to extend a bus cycle beyond the minimum four states (clocks).

A HOLD/HLDA protocol is provided by the local bus controller to allow multiple bus masters to share the same local bus. When the 80C188EB relinquishes control of the local bus, it floats certain bus control signals to allow another bus master to drive these pins directly. Refer to the Pin Description section to determine which pins the 80C188EB will float during a HOLD/HLDA bus exchange.

The 80C188EB local bus controller also generates two control signals ( $\overline{DEN}$  and DT/R) when interfacing to external transceiver chips. (Both  $\overline{DEN}$  and DT/R are available on the TN80C188EB device, only  $\overline{DEN}$  is available on the TS80C188EB device.) This capability allows the addition of transceivers for simple buffering of the multiplexed address/data bus.

**CLOCK GENERATOR**

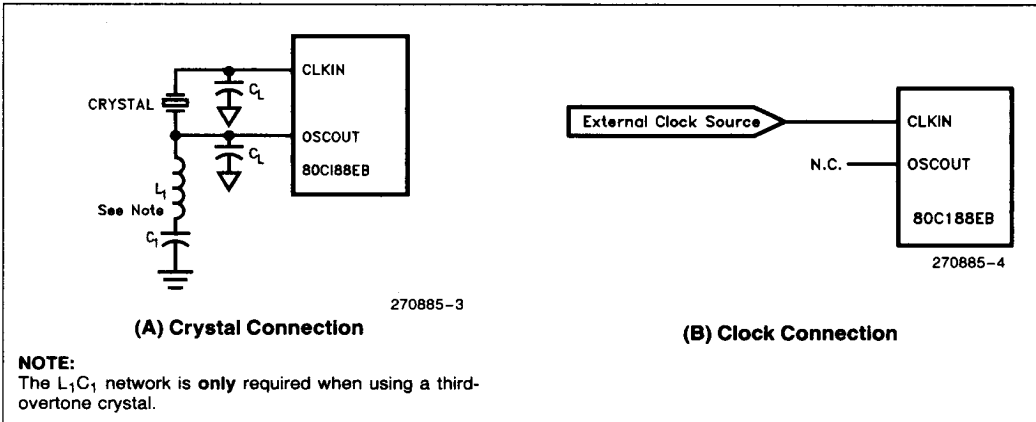
The 80C188EB provides an on-chip clock generator for both internal and external clock generation. The clock generator features a crystal oscillator, a divide-by-two counter, and two low-power operating modes.

The oscillator circuit is designed to be used with either a **parallel resonant** fundamental or third-overtone mode crystal network. Alternatively, the oscillator circuit may be driven from an external clock source. Figure 5 shows the various operating modes of the 80C188EB oscillator circuit.

The crystal or clock frequency chosen must be twice the required processor operating frequency due to the internal divide-by-two counter. This counter is used to drive all internal phase clocks and the external CLKOUT signal. CLKOUT is a 50% duty cycle processor clock and can be used to drive other system components. All A.C. timings are referenced to CLKOUT.

The following parameters are recommended when choosing a crystal:

Temperature Range:	Application Specific
ESR (Equivalent Series Resistance):	40Ω max
C0 (Shunt Capacitance of Crystal):	7.0 pF max
C <sub>L</sub> (Load Capacitance):	20 pF ± 2 pF
Drive Level:	1 mW max



**Figure 5. 80C188EB Clock Configurations**



## 80C188EB Peripheral Architecture

The 80C188EB has integrated several common system peripherals with a CPU core to create a compact, yet powerful system. The integrated peripherals are designed to be flexible and provide logical interconnections between supporting units (e.g., the interrupt control unit supports interrupt requests from the timer/counters or serial channels).

The list of integrated peripherals include:

- 7-Input Interrupt Control Unit
- 3-Channel Timer/Counter Unit
- 2-Channel Serial Communications Unit
- 10-Output Chip-Select Unit
- I/O Port Unit
- Refresh Control Unit
- Power Management Unit

The registers associated with each integrated peripheral are contained within a 128 x 16 register file called the Peripheral Control Block (PCB). The PCB can be located in either memory or I/O space on any 256 Byte address boundary. During bus cycles that access the PCB, the bus controller will signal the operation externally (i.e., the  $\overline{RD}$ ,  $\overline{WR}$ , status, address, data, etc., lines will be driven as in a normal bus cycle). However,  $\overline{READY}$  is ignored and the contents of the data bus during a read operation is ignored. When using any of the internal registers (AX, BX, etc.) as the source of data to be moved into a PCB register, it is recommended that a **byte** operation be specified. Since the 80C188EB retains a 16-bit internal bus architecture, all byte write operations to the PCB registers will result in word operation. If immediate data is used, then a word write must be specified.

The starting address of the PCB is controlled by a relocation register and can overlap any of the memory or I/O regions programmed into the Chip Select Unit. In this case, the overlapped chip select will not go active when the PCB is read or written.

Figure 6 provides a list of the registers associated with the PCB. The Register Bit Summary at the end of this specification individually lists all of the registers and identifies each of their programming attributes.

### INTERRUPT CONTROL UNIT

The 80C188EB can receive interrupts from a number of sources, both internal and external. The interrupt control unit serves to merge these requests, on a priority basis, for individual service by the CPU.

Each interrupt source can be independently masked by the Interrupt Control Unit (ICU) or all interrupts can be globally masked by the CPU.

Internal interrupt sources include the Timers and Serial channel 0. External interrupt sources come from the five input pins INT4:0. The NMI interrupt pin is not controlled by the ICU and is passed directly to the CPU. Although the Timer and Serial channel each have only one request input to the ICU, separate vector types are generated to service individual interrupts within the Timer and Serial channel units.

The 80C188EB ICU provides a mechanism for expanding the number of external interrupt sources. Two pairs of pins can be independently configured to support an external slave interrupt controller (82C59A). Each pair of external pins can be expanded to support 64 interrupts, making it possible for the 80C188EB to support a total of 129 external interrupts.

The ICU may be used in a polled mode if interrupts are undesirable. When polling, the processor disables interrupts and then polls the ICU whenever it is convenient.

### TIMER/COUNTER UNIT

The 80C188EB Timer/Counter Unit (TCU) provides three 16-bit programmable timers. Two of these are highly flexible and are connected to external pins for control or clocking. A third timer is not connected to any external pins and can only be clocked internally. However, it can be used to clock the other two timer channels. The TCU can be used to count external events, time external events, generate non-repetitive waveforms, generate timed interrupts, etc.

Each timer has at least one 16-bit compare register and one 16-bit count register. Timers 0 and 1 each have an additional 16-bit compare register. The count register is incremented every fourth CPU clock cycle (internal clocking), every time Timer2 expires (Timers 0 and 1 only), or every Low-to-High transition on the timer input pin (Timers 0 and 1 only). The input clock to Timers 0 and 1 must not exceed one fourth the operating frequency of the 80C188EB. When the count register matches the value programmed into the compare register, several operations may happen.

All three timers can generate an interrupt when the compare register matches the value in the count register. Additionally, Timers 0 and 1 have an output pin that can change state or pulse when the compare condition occurs.

PCB Offset	Function	PCB Offset	Function	PCB Offset	Function	PCB Offset	Function
00H	Reserved	40H	Timer2 Count	80H	GCS0 Start	C0H	Reserved
02H	End Of Interrupt	42H	Timer2 Compare	82H	GCS0 Stop	C2H	Reserved
04H	Poll	44H	Reserved	84H	GCS1 Start	C4H	Reserved
06H	Poll Status	46H	Timer2 Control	86H	GCS1 Stop	C6H	Reserved
08H	Interrupt Mask	48H	Reserved	88H	GCS2 Start	C8H	Reserved
0AH	Priority Mask	4AH	Reserved	8AH	GCS2 Stop	CAH	Reserved
0CH	In-Service	4CH	Reserved	8CH	GCS3 Start	CCH	Reserved
0EH	Interrupt Request	4EH	Reserved	8EH	GCS3 Stop	CEH	Reserved
10H	Interrupt Status	50H	Reserved	90H	GCS4 Start	D0H	Reserved
12H	Timer Control	52H	Port0 Pin	92H	GCS4 Stop	D2H	Reserved
14H	Serial Control	54H	Port0 Control	94H	GCS5 Start	D4H	Reserved
16H	INT4	56H	Port0 Latch	96H	GCS5 Stop	D6H	Reserved
18H	INT0 Control	58H	Port1 Direction	98H	GCS6 Start	D8H	Reserved
1AH	INT1 Control	5AH	Port1 Pin	9AH	GCS6 Stop	DAH	Reserved
1CH	INT2 Control	5CH	Port1 Control	9CH	GCS7 Start	DCH	Reserved
1EH	INT3 Control	5EH	Port1 Latch	9EH	GCS7 Stop	DEH	Reserved
20H	Reserved	60H	Serial0 Baud	A0H	LCS Start	E0H	Reserved
22H	Reserved	62H	Serial0 Count	A2H	LCS Stop	E2H	Reserved
24H	Reserved	64H	Serial0 Control	A4H	UCS Start	E4H	Reserved
26H	Reserved	66H	Serial0 Status	A6H	UCS Stop	E6H	Reserved
28H	Reserved	68H	Serial0 RBUF	A8H	Relocation	E8H	Reserved
2AH	Reserved	6AH	Serial0 TBUF	AAH	Reserved	EAH	Reserved
2CH	Reserved	6CH	Reserved	ACH	Reserved	ECH	Reserved
2EH	Reserved	6EH	Reserved	AEH	Reserved	EEH	Reserved
30H	Timer0 Count	70H	Serial1 Baud	B0H	Refresh Base	F0H	Reserved
32H	Timer0 Compare A	72H	Serial1 Count	B2H	Refresh Time	F2H	Reserved
34H	Timer0 Compare B	74H	Serial1 Control	B4H	Refresh Control	F4H	Reserved
36H	Timer0 Control	76H	Serial1 Status	B6H	Refresh Address	F6H	Reserved
38H	Timer1 Count	78H	Serial1 RBUF	B8H	Power Control	F8H	Reserved
3AH	Timer1 Compare A	7AH	Serial1 TBUF	BAH	Reserved	FAH	Reserved
3CH	Timer1 Compare B	7CH	Reserved	BCH	Step ID	FCH	Reserved
3EH	Timer1 Control	7EH	Reserved	BEH	Reserved	FEH	Reserved

Figure 6. 80C188EB Peripheral Control Block Registers

Other timer programming options include:

- All three timers can be set to halt or continue after a compare match.
- Timers 0 and 1 can be reset or retriggered using their respective input pins.
- TCU registers can be read or written at any time.

## SERIAL COMMUNICATIONS UNIT

The Serial Control Unit (SCU) of the 80C188EB contains two independent channels. Each channel is identical in operation except that only channel 0 is supported by the integrated interrupt controller (channel 1 has an external interrupt pin). Each channel has its own baud rate generator that is independent of the Timer/Counter Unit, and can be internally or externally clocked up at one half the 80C188EB operating frequency.

Each serial channel supports one synchronous and four asynchronous modes of operation and is compatible with the serial ports of the MCS<sup>®</sup>-51 and MCS<sup>®</sup>-96 family of products. Data field length can be 7-, 8-, or 9-bits with optional odd or even parity (generated and checked) and one stop bit (generated and checked). The 9-bit mode has an optional "addressing" feature to simplify interprocessor communication. Each serial port is doubled buffered in both transmit and receive operation (data can be read or written to a buffer register while data is shifted into or out of a shifting register, respectively).

A Clear-To-Send input pin can be programmed to prevent data transmission if the pin is sampled inactive. Serial channel 0 is supported by the integrated interrupt controller, providing separate receive and transmit vector types. Serial channel 1 has an external interrupt pin which OR's the receive and transmit interrupts. This external interrupt pin can be routed to either the external pins of the ICU, the NMI pin, or any other external system interrupt controller. Status bits are provided to allow polling of the serial channels if interrupts are not desired.

Independent baud rate generators are provided for each of the serial channels. For the asynchronous modes, the generator supplies an 8x baud clock to both the receive and transmit register logic. A 1x baud clock is provided in the synchronous mode.

Additional features of the SCU include:

- Framing error, receive buffer overrun error, and parity error detection.
- Break detect.
- Break send.

## CHIP-SELECT UNIT

The 80C188EB Chip-Select Unit (CSU) integrates logic which provides up to ten programmable chip-selects to access both memories and peripherals. In addition, each chip-select can be programmed to automatically insert additional clocks (wait-states) into the current bus cycle and automatically terminate a bus cycle independent of the condition of the READY input pin.

Each of the chip-selects can be programmed to go active for either memory or I/O accesses. UCS is the only chip-select that is active after a reset and is enabled for memory addresses in the range 0FFC00H to 0FFFFFFH (this allows a boot-ROM to be accessed using UCS). Every chip-select has a programmable start and stop register that defines the active region for the chip-select, and the ready characteristics for the region.

The start and stop address fields are 10 bits in length and are matched against the upper 10 bits of either the memory or I/O address. A 10-bit compare results in a granularity of 1 Kbytes for memory accesses and 64 bytes for I/O accesses. Each chip select can be disabled by programming its start address greater than its stop address or by clearing its enable bit.

Each chip-select can be programmed to automatically insert wait-states, and to control whether the external READY input is to be ignored or used. The 80C188EB bus controller will wait the programmed number of wait-states before the external READY pin can be used to extend or terminate the bus cycle.

Overlapping of chip-selects is allowed. However, each one that overlaps will go active. If any overlapping chip-select has been programmed to use external ready, the bus control unit will insert the least amount of programmed wait-states programmed before the external ready pin is used. If all overlapped chip-selects ignore external ready, the bus controller will insert the maximum number of programmed wait-states. Any chip-select that overlaps the Peripheral Control Block (PCB) will not go active for that portion of the address range allocated to the PCB.

The Generic Chip-Selects (GCS7:0) are multiplexed with an output only Port function. Any channel that is being used as a chip-select must be disabled as a port pin by correctly programming the port pin control registers (see the following section).

### I/O PORT UNIT

The I/O Port Unit (IPU) on the 80C188EB supports two 8-bit channels of input, output, or input/output operation. Port 1 is multiplexed with the chip select pins and is output only. Most of Port 2 is multiplexed with the serial channel pins. Port 2 pins are limited to either an output or input function depending on the operation of the serial pin it is multiplexed with.

Two bits of Port 2 are not multiplexed with any other peripheral functions and can be used as either an input or an output function. A port direction register is used to define the function of the port pin. The output for these two pins are open drain.

Besides a direction register, each port channel has a port latch register, port pin register, and a port multiplexer control register.

### REFRESH CONTROL UNIT

The Refresh Control Unit (RCU) automatically generates a periodic memory read bus cycle to keep dynamic or pseudo-static memory refreshed. A 9-bit counter controls the number of clocks between refresh requests.

A 12-bit address generator is maintained by the RCU and is presented on the A12:1 address lines during the refresh bus cycle. The address generator is incremented only after the refresh bus cycle is run. This ensures that all address combinations will be presented to the memory array even if the refresh bus cycle is not run before another request is generated. Address bits A19:13 are programmable to allow the refresh address block to be located on any 8 Kbyte boundary.

The chip-select unit is active during refresh bus cycles. This means that a chip-select will go active if the refresh address is within the limits specified for the channel. In addition,  $\overline{RFSH}$  is driven active to signal that a refresh bus cycle is in progress. Data on the AD7:0 bus is ignored.

A pending refresh request will attempt to abort a HOLD/HLDA bus exchange. HLDA is deasserted when a refresh request is pending and a bus HOLD is already in progress. HOLD must then be released in order for the 80C188EB to execute the refresh bus cycle.

### POWER MANAGEMENT UNIT

The 80C188EB Power Management Unit (PMU) is provided to control the power consumption of the device. The PMU provides three power modes: Active, Idle, and Powerdown.

Active Mode indicates that all units on the 80C188EB are functional and the device consumes maximum power (depending on the level of peripheral operation). Idle Mode freezes the clocks of the Execution and Bus units at a logic zero state (all peripherals continue to operate normally). An unmasked interrupt, NMI, or reset will cause the 80C188EB to exit the Idle mode.

The Powerdown mode freezes all internal clocks at a logic zero level and disables the crystal oscillator. All internal registers hold their values provided  $V_{CC}$  is maintained. Current consumption is reduced to just transistor junction leakage. An NMI or processor reset will cause the 80C188EB to exit the Powerdown Mode. A timing pin is provided to establish the length of time between exiting Powerdown and resuming device operation. (Length of time depends on startup time of crystal oscillator and is application dependent.)

### ONCE™ Test Mode

To facilitate testing and inspection of devices when fixed into a target system, the 80C188EB has a test mode available which forces all output and input/output pins to be placed in the high-impedance state. ONCE stands for "ON Circuit Emulation". The ONCE mode is selected by forcing the A19/ONCE pin LOW (0) during a processor reset (this pin is weakly held to a HIGH (1) level while  $\overline{RESIN}$  is active).

**PACKAGE INFORMATION**

This section describes the pins, pinouts, and thermal characteristics for the 80C188EB in the Plastic Leaded Chip Carrier (PLCC) package and Quad Flat Pack (QFP) package. For complete package specifications and information, see the Intel Packaging Outlines and Dimensions Guide (Order Number: 231369).

**Pin Descriptions**

The 80C188EB pins are described in this section. Table 3 presents the legend for interpreting the pin descriptions in Table 4. Figure 7 provides an example pin description entry. The "I/O" signifies that the pins are bidirectional (i.e., have both an input and output function). The "S" indicates that, as an input, the signal is synchronized to CLKOUT for proper operation. The "H(Z)" indicates that these pins will float while the processor is in the Hold Acknowledge state. R(Z) indicates that these pins will float while  $\overline{RESIN}$  is low. P(X) Indicates that these pins will retain their current value when Idle or Powerdown Modes are entered.

All pins float while the processor is in the ONCETM Mode, except OSCOUT (OSCOU is required for crystal operation).

Name	Type	Description
AD7:0	I/O S(L) H(Z) R(Z) P(X)	These pins provide a multiplexed ADDRESS and DATA bus. During the address phase of the bus cycle, address bits 0 through 15 are presented on the bus and can be latched using ALE. 8-bit data information are transferred during the data phase of the bus cycle.

**Figure 7. Example Pin Description Entry**

**Table 4. Pin Description Nomenclature**

Symbol	Description
I	Input Only Pin
O	Output Only Pin
I/O	Pin can be either input or output
—	Pin "must be" connected as described
S(..)	Synchronous. Input must meet setup and hold times for proper operation of the processor. The pin is: S(E) edge sensitive S(L) level sensitive
A(..)	Asynchronous. Input must meet setup and hold only to guarantee recognition. The pin is: A(E) edge sensitive A(L) level sensitive
H(..)	While the processor's bus is in the Hold Acknowledge state, the pin: H(1) is driven to $V_{CC}$ H(0) is driven to $V_{SS}$ H(Z) floats H(Q) remains active H(X) retains current state
R(..)	While the processor's $\overline{RES}$ line is low, the pin: R(1) is driven to $V_{CC}$ R(0) is driven to $V_{SS}$ R(Z) floats R(WH) weak pullup R(WL) weak pulldown
P(..)	While Idle or Powerdown modes are active, the pin: P(1) is driven to $V_{CC}$ P(0) is driven to $V_{SS}$ P(Z) floats P(Q) remains active(1) P(X) retains current state

**NOTE:**

- Any pin that specifies P(Q) are valid for Idle Mode. All pins are P(X) for Powerdown Mode.

Table 4. 80C188EB Pin Descriptions

Name	Type	Description
V <sub>CC</sub>		<b>POWER</b> connections consist of four pins which must be shorted externally to a V <sub>CC</sub> board plane.
V <sub>SS</sub>		<b>GROUND</b> connections consist of six pins which must be shorted externally to a V <sub>SS</sub> board plane.
CLKIN	I A(E)	<b>CLock Input</b> is an input for an external clock. An external oscillator operating at two times the required 80C188EB operating frequency can be connected to CLKIN. For crystal operation, CLKIN (along with OSCOUT) are the crystal connections to an internal Pierce oscillator.
OSCOUT	O H(Q) R(Q) P(Q)	<b>OSCillator OUTput</b> is only used when using a crystal to generate the external clock. OSCOUT (along with CLKIN) are the crystal connections to an internal Pierce oscillator. This pin is not to be used as 2X clock output for non-crystal applications (i.e., this pin is N.C. for non-crystal applications). OSCOUT does not float in ONCE mode.
CLKOUT	O H(Q) R(Q) P(Q)	<b>CLock OUTput</b> provides a timing reference for inputs and outputs of the processor, and is one-half the input clock (CLKIN) frequency. CLKOUT has a 50% duty cycle and transistions every falling edge of CLKIN.
RESIN	I A(L)	<b>RESet IN</b> causes the 80C188EB to immediately terminate any bus cycle in progress and assume an initialized state. All pins will be driven to a known state, and RESOUT will also be driven active. The rising edge (low-to-high) transition synchronizes CLKOUT with CLKIN before the 80C188EB begins fetching opcodes at memory location 0FFFF0H.
RESOUT	O H(0) R(1) P(0)	<b>RESet OUTput</b> that indicates the 80C188EB is currently in the reset state. RESOUT will remain active as long as RESIN remains active.
PDTMR	I/O A(L) H(WH) R(Z) P(1)	<b>Power-Down TIMEr</b> pin (normally connected to an external capacitor) that determines the amount of time the 80C188EB waits after an exit from power down before resuming normal operation. The duration of time required will depend on the startup characteristics of the crystal oscillator.
NMI	I A(E)	<b>Non-Maskable Interrupt</b> input causes a TYPE-2 interrupt to be serviced by the CPU. NMI is latched internally.
TEST	I A(E)	<b>TEST</b> is used during the execution of the WAIT instruction to suspend CPU operation until the pin is sampled active (LOW).
AD7:0	I/O S(L) H(Z) R(Z) P(X)	These pins provide a multiplexed <b>Address</b> and <b>Data</b> bus. During the address phase of the bus cycle, address bits 0 through 7 are presented on the bus and can be latched using ALE. 8-bit data information is transferred during the data phase of the bus cycle.
A15:8	O H(Z) R(Z) P(X)	These pins provide <b>Address</b> information throughout the entire bus cycle.

Table 4. 80C188EB Pin Descriptions (Continued)

Name	Type	Description																																				
A18:16 A19/ $\overline{\text{ONCE}}$	I/O H(Z) R(W1) P(X)	These pins provide multiplexed ADDRESS during the address phase of the bus cycle. Address bits 16 through 19 are presented on these pins and can be latched using ALE. These pins are driven to a logic 0 during the data phase of the bus cycle. During a processor reset ( $\overline{\text{RESIN}}$ active), A19/ $\overline{\text{ONCE}}$ is used to enable ONCE mode. A18:16 must not be driven low during reset or improper 80C188EB operation may result.																																				
$\overline{\text{S2:0}}$	O H(Z) R(Z) P(1)	Bus cycle <b>Status</b> are encoded on these pins to provide bus transaction information. $\overline{\text{S2:0}}$ are encoded as follows: <table border="1"> <thead> <tr> <th><math>\overline{\text{S2}}</math></th> <th><math>\overline{\text{S1}}</math></th> <th><math>\overline{\text{S0}}</math></th> <th>Bus Cycle Initiated</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> <td>Interrupt Acknowledge</td> </tr> <tr> <td>0</td> <td>0</td> <td>1</td> <td>Read I/O</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> <td>Write I/O</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> <td>Processor HALT</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> <td>Queue Instruction Fetch</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> <td>Read Memory</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> <td>Write Memory</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td>Passive (no bus activity)</td> </tr> </tbody> </table>	$\overline{\text{S2}}$	$\overline{\text{S1}}$	$\overline{\text{S0}}$	Bus Cycle Initiated	0	0	0	Interrupt Acknowledge	0	0	1	Read I/O	0	1	0	Write I/O	0	1	1	Processor HALT	1	0	0	Queue Instruction Fetch	1	0	1	Read Memory	1	1	0	Write Memory	1	1	1	Passive (no bus activity)
$\overline{\text{S2}}$	$\overline{\text{S1}}$	$\overline{\text{S0}}$	Bus Cycle Initiated																																			
0	0	0	Interrupt Acknowledge																																			
0	0	1	Read I/O																																			
0	1	0	Write I/O																																			
0	1	1	Processor HALT																																			
1	0	0	Queue Instruction Fetch																																			
1	0	1	Read Memory																																			
1	1	0	Write Memory																																			
1	1	1	Passive (no bus activity)																																			
ALE	O H(0) R(0) P(0)	<b>Address Latch Enable</b> output is used to strobe address information into a transparent type latch during the address phase of the bus cycle.																																				
RFSH	O H(Z) R(Z) P(1)	<b>ReFrESH</b> output signals that a refresh bus cycle is in progress.																																				
$\overline{\text{RD}}$	O H(Z) R(Z) P(1)	<b>ReaD</b> output signals that the accessed memory or I/O device must drive data information onto the data bus.																																				
$\overline{\text{WR}}$	O H(Z) R(Z) P(1)	<b>WRite</b> output signals that data available on the data bus are to be written into the accessed memory or I/O device.																																				
READY	I A(L) S(L)	<b>READY</b> input to signal the completion of a bus cycle. READY must be active to terminate any 80C188EB bus cycle, unless it is ignored by correctly programming the Chip-Select Unit.																																				
$\overline{\text{DEN}}$	O H(Z) R(Z) P(1)	<b>Data ENable</b> output to control the enable of bi-directional transceivers when buffering a 80C188EB system. $\overline{\text{DEN}}$ is active only when data is to be transferred on the bus.																																				

Table 4. 80C188EB Pin Descriptions (Continued)

Name	Type	Description
DT/ $\bar{R}$	O H(Z) R(Z) P(X)	<b>Data Transmit/Receive</b> output controls the direction of a bi-directional buffer when buffering an 80C188EB system. DT/ $\bar{R}$ is only available for the PLCC package (TN80C188EB).
LOCK	I/O H(Z) R(W1) P(1)	<b>LOCK</b> output indicates that the bus cycle in progress is not to be interrupted. The 80C188EB will not service other bus requests (such as HOLD) while LOCK is active. This pin is configured as a weakly held high input while $\bar{RESIN}$ is active and must not be driven low.
HOLD	I A(L)	<b>HOLD</b> request input to signal that an external bus master wishes to gain control of the local bus. The 80C188EB will relinquish control of the local bus between instruction boundaries not conditioned by a LOCK prefix.
HLDA	O H(1) R(0) P(0)	<b>HoLD Acknowledge</b> output to indicate that the 80C188EB has relinquish control of the local bus. When HLDA is asserted, the 80C188EB will (or has) floated its data bus and control signals allowing another bus master to drive the signals directly.
UCS	O H(1) R(1) P(1)	<b>Upper Chip Select</b> will go active whenever the address of a memory or I/O bus cycle is within the address limitations programmed by the user. After reset, UCS is configured to be active for memory accesses between 0FFC00H and 0FFFFFH.
LCS	O H(1) R(1) P(1)	<b>Lower Chip Select</b> will go active whenever the address of a memory bus cycle is within the address limitations programmed by the user. LCS is inactive after a reset.
P1.0/ $\overline{GCS0}$ P1.1/ $\overline{GCS1}$ P1.2/ $\overline{GCS2}$ P1.3/ $\overline{GCS3}$ P1.4/ $\overline{GCS4}$ P1.5/ $\overline{GCS5}$ P1.6/ $\overline{GCS6}$ P1.7/ $\overline{GCS7}$	O H(X)/H(1) R(1) P(X)/P(1)	These pins provide a multiplexed function. If enabled, each pin can provide a <b>Generic Chip Select</b> output which will go active whenever the address of a memory or I/O bus cycle is within the address limitations programmed by the user. When not programmed as a Chip-Select, each pin may be used as a general purpose output <b>Port</b> . As an output port pin, the value of the pin can be read internally.
T0OUT T1OUT	O H(Q) R(1) P(Q)	<b>Timer OUTput</b> pins can be programmed to provide a single clock or continuous waveform generation, depending on the timer mode selected.
T0IN T1IN	I A(L) A(E)	<b>Timer INput</b> is used either as clock or control signals, depending on the timer mode selected.



Table 4. 80C188EB Pin Descriptions (Continued)

Name	Type	Description
INT0 INT1 INT4	I A(E,L)	Maskable <b>INTerrupt</b> input will cause a vector to a specific Type interrupt routine. To allow interrupt expansion, INT0 and/or INT1 can be used with INTA0 and INTA1 to interface with an external slave controller.
INT2/INTA0 INT3/INTA1	I/O A(E,L) /H(1) R(Z) /P(1)	These pins provide a multiplexed function. As inputs, they provide a maskable <b>INTerrupt</b> that will cause the CPU to vector to a specific Type interrupt routine. As outputs, each is programmatically controlled to provide an INTERRUPT ACKNOWLEDGE handshake signal to allow interrupt expansion.
P2.7 P2.6	I/O A(L) H(X) R(Z) P(X)	BI-DIRECTIONAL, open-drain <b>Port</b> pins.
CTS0 P2.4/CTS1	I A(L)	<b>Clear-To-Send</b> input is used to prevent the transmission of serial data on their respective TXD signal pin. CTS1 is multiplexed with an input only port function.
TXD0 P2.1/TXD1	O H(X)/H(Q) R(1) P(X)/P(Q)	<b>Transmit Data</b> output provides serial data information. TXD1 is multiplexed with an output only <b>Port</b> function. During synchronous serial communications, TXD will function as a clock output.
RXD0 P2.0/RXD1	I/O A(L) R(Z) H(Q) P(X)	<b>Receive Data</b> input accepts serial data information. RXD1 is multiplexed with an input only <b>Port</b> function. During synchronous serial communications, RXD is bi-directional and will become an output for transmission or data (TXD becomes the clock).
P2.5/BCLK0 P2.2/BCLK1	I A(L)/A(E)	<b>Baud Clock</b> input can be used as an alternate clock source for each of the integrated serial channels. BCLKx is multiplexed with an input only <b>Port</b> function, and cannot exceed a clock rate greater than one-half the operating frequency of the 80C188EB.
P2.3/SINT1	O H(X)/H(Q) R(0) P(X)/P(Q)	<b>Serial Interrupt</b> output will go active to indicate serial channel 1 requires service. SINT1 is multiplexed with an output only <b>Port</b> function.

**80C188EB PINOUT**

Tables 5 and 6 list the 80C188EB pin names with package location for the 84-pin Plastic Leaded Chip Carrier (PLCC) component. Figure 8 depicts the complete 80C188EB pinout (PLCC package) as viewed from the top side of the component (i.e., contacts facing down).

Tables 7 and 8 list the 80C188EB pin names with package location for the 80-pin Quad Flat Pack (QFP) component. Figure 9 depicts the complete 80C188EB (QFP package) as viewed from the top side of the component (i.e., contacts facing down).

**Table 5. PLCC Pin Names with Package Location**

Address/Data Bus		Bus Control		Processor Control		I/O	
Name	Location	Name	Location	Name	Location	Name	Location
AD0	61	ALE	6	RESIN	37	UCS	30
AD1	66	$\overline{RFSH}$	7	RESOUT	38	LCS	29
AD2	68	$\overline{S0}$	10	CLKIN	41	P1.0/ $\overline{GCS0}$	28
AD3	70	$\overline{S1}$	9	OSCOUT	40	P1.1/ $\overline{GCS1}$	27
AD4	72	$\overline{S2}$	8	CLKOUT	44	P1.2/ $\overline{GCS2}$	26
AD5	74	$\overline{RD}$	4	$\overline{TEST}$	14	P1.3/ $\overline{GCS3}$	25
AD6	76	$\overline{WR}$	5	NC	60	P1.4/ $\overline{GCS4}$	24
AD7	78	READY	18	NC	39	P1.5/ $\overline{GCS5}$	21
A8	62	$\overline{DEN}$	11	NC	3	P1.6/ $\overline{GCS6}$	20
A9	67	$\overline{DT/\overline{R}}$	16	PDTMR	36	P1.7/ $\overline{GCS7}$	19
A10	69	$\overline{LOCK}$	15	NMI	17	T0OUT	45
A11	71	HOLD	13	INT0	31	T0IN	46
A12	73	HLDA	12	INT1	32	T1OUT	47
A13	75			INT2/ $\overline{INTA0}$	33	T1IN	48
A14	77			INT3/ $\overline{INTA1}$	34	RXD0	53
A15	79			INT4	35	TXD0	52
A16	80					P2.5/ $\overline{BCLK0}$	54
A17	81					$\overline{CTS0}$	51
A18	82					P2.0/RXD1	57
A19/ $\overline{ONCE}$	83					P2.1/TXD1	58
						P2.2/ $\overline{BCLK1}$	59
						P2.3/SINT1	55
						P2.4/ $\overline{CTS1}$	56
						P2.6	50
						P2.7	49

Power	
Name	Location
V <sub>SS</sub>	2, 22, 43, 63, 65, 84
V <sub>CC</sub>	1, 23, 42, 64

Table 6. PLCC Package Locations with Pin Name

Location	Name	Location	Name	Location	Name	Location	Name
1	V <sub>CC</sub>	22	V <sub>SS</sub>	43	V <sub>SS</sub>	64	V <sub>CC</sub>
2	V <sub>SS</sub>	23	V <sub>CC</sub>	44	CLKOUT	65	V <sub>SS</sub>
3	NC	24	P1.4/ $\overline{\text{GCS4}}$	45	T0OUT	66	AD1
4	$\overline{\text{RD}}$	25	P1.3/ $\overline{\text{GCS3}}$	46	T0IN	67	A9
5	$\overline{\text{WR}}$	26	P1.2/ $\overline{\text{GCS2}}$	47	T1OUT	68	AD2
6	ALE	27	P1.1/ $\overline{\text{GCS1}}$	48	T1IN	69	A10
7	$\overline{\text{RFSH}}$	28	P1.0/ $\overline{\text{GCS0}}$	49	P2.7	70	AD3
8	$\overline{\text{S2}}$	29	$\overline{\text{LCS}}$	50	P2.6	71	A11
9	$\overline{\text{S1}}$	30	$\overline{\text{UCS}}$	51	$\overline{\text{CTS0}}$	72	AD4
10	$\overline{\text{S0}}$	31	INT0	52	TXD0	73	A12
11	$\overline{\text{DEN}}$	32	INT1	53	RXD0	74	AD5
12	HLDA	33	INT2/ $\overline{\text{INTA0}}$	54	P2.5/BCLK0	75	A13
13	HOLD	34	INT3/ $\overline{\text{INTA1}}$	55	P2.3/SINT1	76	AD6
14	$\overline{\text{TEST}}$	35	INT4	56	P2.4/ $\overline{\text{CTS1}}$	77	A14
15	$\overline{\text{LOCK}}$	36	PDTMR	57	P2.0/RXD1	78	AD7
16	DT/ $\overline{\text{R}}$	37	$\overline{\text{RESIN}}$	58	P2.1/TXD1	79	A15
17	NMI	38	RESOUT	59	P2.2/BCLK1	80	A16
18	READY	39	NC	60	NC	81	A17
19	P1.7/ $\overline{\text{GCS7}}$	40	OSCOU	61	AD0	82	A18
20	P1.6/ $\overline{\text{GCS6}}$	41	CLKIN	62	A8	83	A19/ $\overline{\text{ONCE}}$
21	P1.5/ $\overline{\text{GCS5}}$	42	V <sub>CC</sub>	63	V <sub>SS</sub>	84	V <sub>SS</sub>

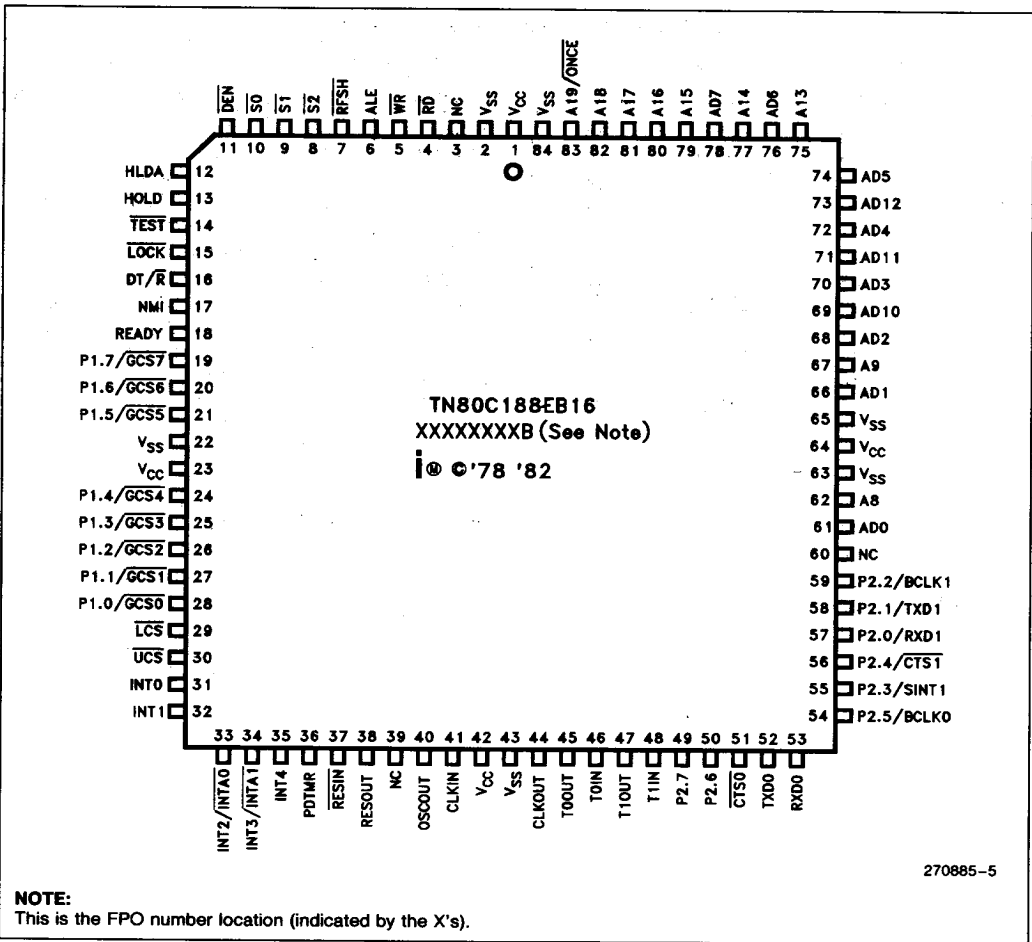


Figure 8. 84-Pin Plastic Leaded Chip Carrier Pinout Diagram

Table 7. QFP Pin Name with Package Location

Address/Data Bus		Bus Control		Processor Control		I/O	
Name	Location	Name	Location	Name	Location	Name	Location
AD0	10	ALE	38	RESIN	68	UCS	61
AD1	15	RFSH	39	RESOUT	69	LCS	60
AD2	17	S0	42	CLKIN	71	P1.0/GCS0	59
AD3	19	S1	41	OSCOU	70	P1.1/GCS1	58
AD4	21	S2	40	CLKOUT	74	P1.2/GCS2	57
AD5	23	RD	36	TEST	46	P1.3/GCS3	56
AD6	25	WR	37	PDTMR	67	P1.4/GCS4	55
AD7	27	READY	49	NMI	48	P1.5/GCS5	52
A8	11	DEN	43	INT0	62	P1.6/GCS6	51
A9	16	LOCK	47	INT1	63	P1.7/GCS7	50
A10	18	HOLD	45	INT2/INTA0	64	T0OUT	75
A11	20	HLDA	44	INT3/INTA1	65	T0IN	76
A12	22			INT4	66	T1OUT	77
A13	24					T1IN	78
A14	26					RXD0	3
A15	28					TXD0	2
A16	29					P2.5/BCLK0	4
A17	30					CTS0	1
A18	31					P2.0/RXD1	7
A19/ONCE	32					P2.1/TXD1	8
						P2.2/BCLK1	9
						P2.3/SINT1	5
						P2.4/CTS1	6
						P2.6	80
						P2.7	79

Power	
Name	Location
V <sub>SS</sub>	12, 14, 33, 35, 53, 73
V <sub>CC</sub>	13, 34, 54, 72

Table 8. QFP Package Location with Pin Names

Location	Name	Location	Name	Location	Name	Location	Name
1	CTS0	21	AD4	41	ST	61	UCS
2	TXD0	22	A12	42	S0	62	INT0
3	RXD0	23	AD5	43	DEN	63	INT1
4	P2.5/BCLK0	24	A13	44	HLDA	64	INT2/INTA0
5	P2.3/SINT1	25	AD6	45	HOLD	65	INT3/INTA1
6	P2.4/CTS1	26	A14	46	TEST	66	INT4
7	P2.0/RXD1	27	AD7	47	LOCK	67	PDTMR
8	P2.1/TXD1	28	A15	48	NMI	68	RESIN
9	P2.2/BCLK1	29	A16	49	READY	69	RESOUT
10	AD0	30	A17	50	P1.7/GCS7	70	OSCOU
11	A8	31	A18	51	P1.6/GCS6	71	CLKIN
12	Vss	32	A19/ONCE	52	P1.5/GCS5	72	Vcc
13	Vcc	33	Vss	53	Vss	73	Vss
14	Vss	34	Vcc	54	Vcc	74	CLKOUT
15	AD1	35	Vss	55	P1.4/GCS4	75	T0OUT
16	A9	36	RD	56	P1.3/GCS3	76	T0IN
17	AD2	37	WR	57	P1.2/GCS2	77	T1OUT
18	A10	38	ALE	58	P1.1/GCS1	78	T1IN
19	AD3	39	RFSH	59	P1.0/GCS0	79	P2.7
20	A11	40	S2	60	LCS	80	P2.6

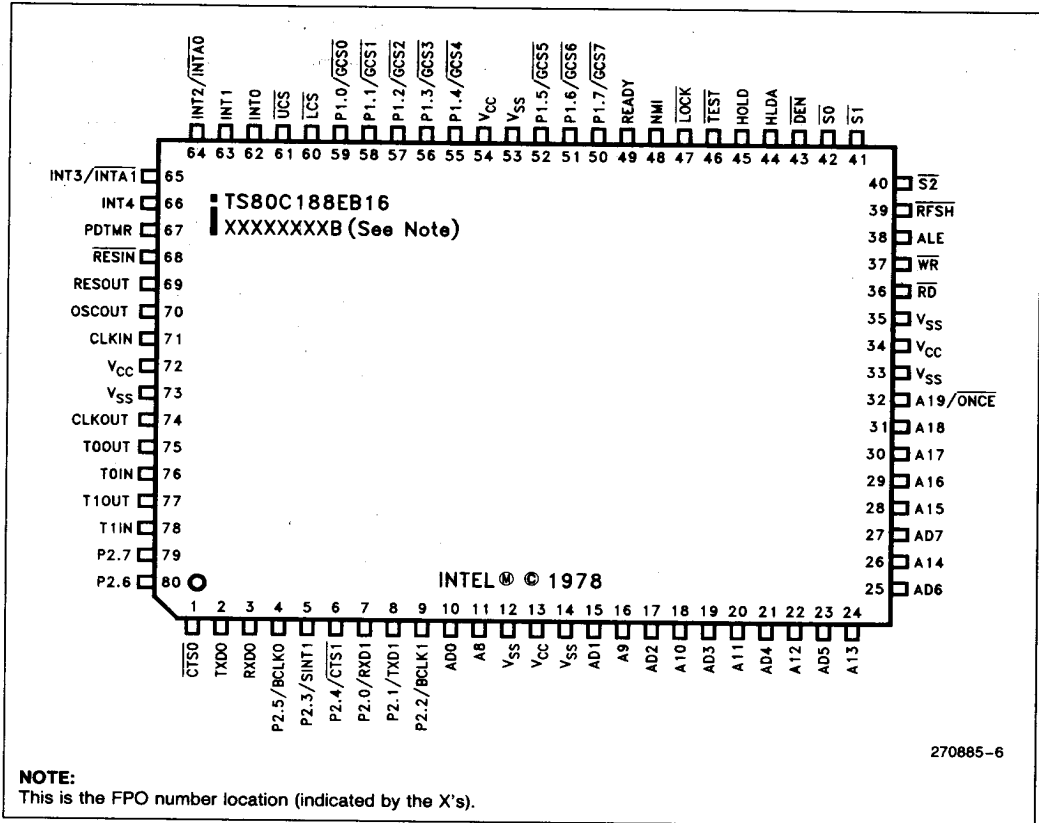


Figure 9. Quad Flat Pack Pinout Diagram

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**PACKAGE THERMAL SPECIFICATIONS**

The 80C188EB is specified for operation when  $T_C$  (the case temperature) is within the range of  $-40^{\circ}\text{C}$  to  $+100^{\circ}\text{C}$  (PLCC package) or  $-40^{\circ}\text{C}$  to  $+114^{\circ}\text{C}$  (QFP package).  $T_C$  may be measured in any environment to determine whether the 80C188EB is within the specified operating range. The case temperature must be measured at the center of the top surface.

$T_A$  (the ambient temperature) can be calculated from  $\theta_{CA}$  (thermal resistance from the case to ambient) with the following equation:

$$T_A = T_C - P \cdot \theta_{CA}$$

Typical values for  $\theta_{CA}$  at various airflows are given in Table 9 for the 84-pin Plastic Leaded Chip Carrier (PLCC) package.

Table 10 shows the maximum  $T_A$  allowable (without exceeding  $T_C$ ) at various airflows and operating frequencies.  $P$  (the maximum power consumption, specified in watts) is calculated by using the maximum ICC as tabulated in the DC specifications and  $V_{CC}$  of 5V.

**Table 9. Thermal Resistance ( $\theta_{CA}$ ) at Various Airflows (in  $^{\circ}\text{C}/\text{Watt}$ )**

	Airflow Linear ft/min (m/sec)					
	0 (0)	200 (1.01)	400 (2.03)	600 (3.04)	800 (4.06)	1000 (5.07)
$\theta_{CA}$ (PLCC)	30	24	21	19	17	16.5
$\theta_{CA}$ (QFP)	58	47	43	40	38	36

**Table 10. Maximum  $T_A$  at Various Airflows (in  $^{\circ}\text{C}$ )**

	$T_F$ (MHz)	Airflow Linear ft/min (m/sec)					
		0 (0)	200 (1.01)	400 (2.03)	600 (3.04)	800 (4.06)	1000 (5.07)
$T_A$ (PLCC)	16	91.5	93.5	94	94.5	95.5	95.5
	26	88.5	91	92	92.5	93.5	93.5
	32	85	87.5	89.5	90.5	91.5	92
$T_A$ (QFP)	16	98	101	102	103	103.5	104
	26	92	96	97.5	99	99.5	100
	32	85	90.5	92.5	94	95	96



**ELECTRICAL SPECIFICATIONS**

**Absolute Maximum Ratings**

Parameter	Maximum Rating
Storage Temperature .....	- 65°C to + 150°C
Case Temp Under Bias .....	- 65°C to + 120°C
Supply Voltage with respect to V <sub>SS</sub> .....	- 0.5V to + 6.5V
Voltage on other Pins with respect to V <sub>SS</sub> .....	- 0.5V to V <sub>CC</sub> + 0.5V

NOTICE: This data sheet contains information on products in the sampling and initial production phases of development. It is valid for the devices indicated in the revision history. The specifications are subject to change without notice.

*\*WARNING: Stressing the device beyond the "Absolute Maximum Ratings" may cause permanent damage. These are stress ratings only. Operation beyond the "Operating Conditions" is not recommended and extended exposure beyond the "Operating Conditions" may affect device reliability.*

**OPERATING CONDITIONS**

Symbol	Parameter	Min	Max	Units
V <sub>CC</sub>	Supply Voltage	4.5	5.5	V
T <sub>F</sub>	Input Clock Frequency			
	80C188EB-16	0	32	MHz
	80C188EB-13	0	26.08	MHz
	80C188EB	0	16	MHz
T <sub>C</sub>	Case Temperature Under Bias			
	TN80C188EB-XX (PLCC)	- 40	+ 100	°C
	TS80C188EB-XX (QFP)	- 40	+ 114	°C

**RECOMMENDED CONNECTIONS**

Power and ground connections must be made to multiple V<sub>CC</sub> and V<sub>SS</sub> pins. Every 80C188EB-based circuit board should include separate power (V<sub>CC</sub>) and ground (V<sub>SS</sub>) planes. Every V<sub>CC</sub> pin must be connected to the power plane, and every V<sub>SS</sub> pin must be connected to the ground plane. Pins identified as "NC" must not be connected in the system. Liberal decoupling capacitance should be placed near the 80C188EB. The processor can cause transient power surges when its output buffers transition, particularly when connected to large capacitive loads.

Low inductance capacitors and interconnects are recommended for best high frequency electrical performance. Inductance is reduced by placing the decoupling capacitors as close as possible to the 80C188EB V<sub>CC</sub> and V<sub>SS</sub> package pins.

Always connect any unused input to an appropriate signal level. In particular, unused interrupt inputs (INT0:4) should be connected to V<sub>CC</sub> through a pull-up resistor (in the range of 50 KΩ). **Leave any unused output pin or any NC pin unconnected.**

## TARGETED DC SPECIFICATIONS

Symbol	Parameter	Min	Max	Units	Notes
V <sub>IL</sub>	Input Low Voltage	-0.5	0.3*V <sub>CC</sub>	V	
V <sub>IH</sub>	Input High Voltage	0.7*V <sub>CC</sub>	V <sub>CC</sub> + 0.5	V	
V <sub>OL</sub>	Output Low Voltage		0.45	V	I <sub>OL</sub> = 3 mA (Min)
V <sub>OH</sub>	Output High Voltage	V <sub>CC</sub> - 0.5		V	I <sub>OH</sub> = -2 mA (Min)
V <sub>HYS</sub>	Input Hysteresis on $\overline{\text{RESIN}}$	0.50		V	
I <sub>LI1</sub>	Input Leakage Current for pins: AD7:0, READY, HOLD, $\overline{\text{RESIN}}$ , CLKIN, $\overline{\text{TEST}}$ , NMI, INT4:0, T0IN, T1IN, RXD0, BCLK0, CTS0, RXD1, BCLK1, CTST, P2.6, P2.7		± 15	μA	0V ≤ V <sub>IN</sub> ≤ V <sub>CC</sub>
I <sub>LI2</sub>	Input Leakage Current for pins: A19/ $\overline{\text{ONCE}}$ , A18:16, LOCK	-0.275	-5.0	mA	V <sub>IN</sub> = 0.7 V <sub>CC</sub> (Note 1)
I <sub>LO</sub>	Output Leakage Current		± 15	μA	0.45 ≤ V <sub>OUT</sub> ≤ V <sub>CC</sub> (Note 2)
I <sub>CC</sub>	Supply Current Cold (RESET) 80C188EB-16		90	mA	(Note 3)
	80C188EB-13		73	mA	(Note 3)
	80C188EB-8		45	mA	(Note 3)
I <sub>ID</sub>	Supply Current Idle 80C188EB-16		63	mA	(Note 4)
	80C188EB-13		48	mA	(Note 4)
	80C188EB-8		31	mA	(Note 4)
I <sub>PD</sub>	Supply Current Powerdown 80C188EB-16		100	μA	(Note 5)
	80C188EB-13		100	μA	(Note 5)
	80C188EB-8		100	μA	(Note 5)
C <sub>IN</sub>	Input Pin Capacitance	0	15	pF	T <sub>F</sub> = 1 MHz
C <sub>OUT</sub>	Output Pin Capacitance	0	15	pF	T <sub>F</sub> = 1 MHz (Note 6)

## NOTES:

- These pins have an internal pull-up device that is active while  $\overline{\text{RESIN}}$  is low and ONCE Mode is not active. Sourcing more current than specified (on any of these pins) may invoke a factory test mode.
- Tested by outputs being floated by invoking ONCE Mode or by asserting HOLD.
- Measured with the device in RESET and at worst case frequency, V<sub>CC</sub>, and temperature with ALL outputs loaded as specified in AC Test Conditions, and all floating outputs driven to V<sub>CC</sub> or V<sub>SS</sub>.
- Measured with the device in HALT (IDLE Mode active) and at worst case frequency, V<sub>CC</sub>, and temperature with ALL outputs loaded as specified in AC Test Conditions, and all floating outputs driven to V<sub>CC</sub> or V<sub>SS</sub>.
- Measured with the device in HALT (Powerdown Mode active) and at worst case frequency, V<sub>CC</sub>, and temperature with ALL outputs loaded as specified in AC Test Conditions, and all floating outputs driven to V<sub>CC</sub> or V<sub>SS</sub>.
- Output Capacitance is the capacitive load of a floating output pin.

**I<sub>CC</sub> VERSUS FREQUENCY AND VOLTAGE**

The current (I<sub>CC</sub>) consumption of the 80C188EB is essentially composed of two components; I<sub>PD</sub> and I<sub>CCS</sub>.

I<sub>PD</sub> is the **quiescent** current that represents internal device leakage, and is measured with all inputs or floating outputs at GND or V<sub>CC</sub> (no clock applied to the device). I<sub>PD</sub> is equal to the Powerdown current and is typically less than 50 μA.

I<sub>CCS</sub> is the **switching** current used to charge and discharge parasitic device capacitance when changing logic levels. Since I<sub>CCS</sub> is typically much greater than I<sub>PD</sub>, I<sub>PD</sub> can often be ignored when calculating I<sub>CC</sub>.

I<sub>CCS</sub> is related to the voltage and frequency at which the device is operating. It is given by the formula:

$$\text{Power} = V \times I = V^2 \times C_{DEV} \times f$$

$$\therefore I = I_{CC} = I_{CCS} = V \times C_{DEV} \times f$$

Where: V = Device operating voltage (V<sub>CC</sub>)  
 C<sub>DEV</sub> = Device capacitance  
 f = Device operating frequency  
 I<sub>CCS</sub> = I<sub>CC</sub> = Device current

Measuring C<sub>DEV</sub> on a device like the 80C188EB would be difficult. Instead, C<sub>DEV</sub> is calculated using the above formula by measuring I<sub>CC</sub> at a known V<sub>CC</sub> and frequency (see Table 11). Using this C<sub>DEV</sub> value, I<sub>CC</sub> can be calculated at any voltage and frequency within the specified operating range.

EXAMPLE: Calculate the typical I<sub>CC</sub> when operating at 10 MHz, 4.8V.

$$I_{CC} = I_{CCS} = 4.8 \times 0.583 \times 10 \approx 28 \text{ mA}$$

**Table 11. Device Capacitance (C<sub>DEV</sub>) Values**

Parameter	Typ	Max	Units	Notes
C <sub>DEV</sub> (Device in Reset)	0.583	1.02	mA/V*MHz	1, 2
C <sub>DEV</sub> (Device in Idle)	0.408	0.682	mA/V*MHz	1, 2

1. Max C<sub>DEV</sub> is calculated at -40°C, all floating outputs driven to V<sub>CC</sub> or GND, and all outputs loaded to 50 pF (including CLKOUT and OSCOUT).
2. Typical C<sub>DEV</sub> is calculated at 25°C with all outputs loaded to 50 pF except CLKOUT and OSCOUT, which are not loaded.

**PDTMR PIN DELAY CALCULATION**

The PDTMR pin provides a delay between the assertion of NMI and the enabling of the internal clocks when exiting Powerdown. A delay is required only when using the on-chip oscillator to allow the crystal or resonator circuit time to stabilize.

**NOTE:**

The PDTMR pin function does not apply when RESIN is asserted (i.e., a device reset during Powerdown is similar to a cold reset and RESIN must remain active until after the oscillator has stabilized).

To calculate the value of capacitor required to provide a desired delay, use the equation:

$$440 \times t = C_{PD} \quad (5V, 25^\circ C)$$

Where: t = desired delay in **seconds**

C<sub>PD</sub> = capacitive load on PDTMR in **microfarads**

EXAMPLE: To get a delay of 300 μs, a capacitor value of C<sub>PD</sub> = 440 × (300 × 10<sup>-6</sup>) = 0.132 μF is required. Round up to standard (available) capacitive values.

**NOTE:**

The above equation applies to delay times greater than 10 μs and will compute the **TYPICAL** capacitance needed to achieve the desired delay. A delay variance of +50% or -25% can occur due to temperature, voltage, and device process extremes. In general, higher V<sub>CC</sub> and/or lower temperature will decrease delay time, while lower V<sub>CC</sub> and/or higher temperature will increase delay time.

## AC SPECIFICATIONS

## AC Characteristics—80C188EB-16

Symbol	Parameter	Min	Max	Units	Notes
<b>INPUT CLOCK</b>					
$T_F$	CLKIN Frequency	0	32	MHz	1
$T_C$	CLKIN Period	31.25	$\infty$	ns	1
$T_{CH}$	CLKIN High Time	10	$\infty$	ns	1, 2
$T_{CL}$	CLKIN Low Time	10	$\infty$	ns	1, 2
$T_{CR}$	CLKIN Rise Time	1	8	ns	1, 3
$T_{CF}$	CLKIN Fall Time	1	8	ns	1, 3
<b>OUTPUT CLOCK</b>					
$T_{CD}$	CLKIN to CLKOUT Delay	0	20	ns	1, 4
$T$	CLKOUT Period		$2 \cdot T_C$	ns	1
$T_{PH}$	CLKOUT High Time	$(T/2) - 5$	$(T/2) + 5$	ns	1
$T_{PL}$	CLKOUT Low Time	$(T/2) - 5$	$(T/2) + 5$	ns	1
$T_{PR}$	CLKOUT Rise Time	1	6	ns	1, 5
$T_{PF}$	CLKOUT Fall Time	1	6	ns	1, 5
<b>OUTPUT DELAYS</b>					
$T_{CHOV1}$	ALE, S2:0, DEN, DT/R, RFSH, LOCK, A19:16	3	22	ns	1, 4, 6, 7
$T_{CHOV2}$	GCS0:7, LCS, UCS, RD, WR	3	27	ns	1, 4, 6, 8
$T_{CLOV1}$	RFSH, DEN, LOCK, RESOUT, HLDA, T0OUT, T1OUT, A19:16	3	22	ns	1, 4, 6
$T_{CLOV2}$	RD, WR, GCS7:0, LCS, UCS, AD7:0, NCS, INTA1:0, S2:0, A15:8	3	27	ns	1, 4, 6
$T_{CHOF}$	RD, WR, RFSH, DT/R, LOCK, S2:0, A19:8	0	25	ns	1
$T_{CLOF}$	DEN, AD7:0, A15:8	0	25	ns	1
<b>SYNCHRONOUS INPUTS</b>					
$T_{CHIS}$	TEST, NMI, INT4:0, BCLK1:0, T1:0IN, READY, CTST:0, P2.6, P2.7	10		ns	1, 9
$T_{CHIH}$	TEST, NMI, INT4:0, BCLK1:0, T1:0IN, READY, CTST:0	3		ns	1, 9
$T_{CLIS}$	AD7:0, READY	10		ns	1, 10
$T_{CLIH}$	READY, AD7:0	3		ns	1, 10
$T_{CLIS}$	HOLD	10		ns	1, 9
$T_{CLIH}$	HOLD	3		ns	1, 9

## NOTES:

1. See **AC Timing Waveforms**, for waveforms and definition.
2. Measure at  $V_{IH}$  for high time,  $V_{IL}$  for low time.
3. Only required to guarantee  $I_{CC}$ . Maximum limits are bounded by  $T_C$ ,  $T_{CH}$  and  $T_{CL}$ .
4. Specified for a 50 pF load, see Figure 16 for capacitive derating information.
5. Specified for a 50 pF load, see Figure 17 for rise and fall times outside 50 pF.
6. See Figure 17 for rise and fall times.
7.  $T_{CHOV1}$  applies to RFSH, LOCK and A19:8 only after a HOLD release.
8.  $T_{CHOV2}$  applies to RD and WR only after a HOLD release.
9. Setup and Hold are required to guarantee recognition.
10. Setup and Hold are required for proper 80C188EB operation.

**AC SPECIFICATIONS** (Continued)

**AC Characteristics—80C188EB-13**

Symbol	Parameter	Min	Max	Units	Notes
<b>INPUT CLOCK</b>					
$T_F$	CLKIN Frequency	0	26.08	MHz	1
$T_C$	CLKIN Period	38.34	$\infty$	ns	1
$T_{CH}$	CLKIN High Time	12	$\infty$	ns	1, 2
$T_{CL}$	CLKIN Low Time	12	$\infty$	ns	1, 2
$T_{CR}$	CLKIN Rise Time	1	8	ns	1, 3
$T_{CF}$	CLKIN Fall Time	1	8	ns	1, 3
<b>OUTPUT CLOCK</b>					
$T_{CD}$	CLKIN to CLKOUT Delay	0	23	ns	1, 4
$T$	CLKOUT Period		$2 \cdot T_C$	ns	1
$T_{PH}$	CLKOUT High Time	$(T/2) - 5$	$(T/2) + 5$	ns	1
$T_{PL}$	CLKOUT Low Time	$(T/2) - 5$	$(T/2) + 5$	ns	1
$T_{PR}$	CLKOUT Rise Time	1	6	ns	1, 5
$T_{PF}$	CLKOUT Fall Time	1	6	ns	1, 5
<b>OUTPUT DELAYS</b>					
$T_{CHOV1}$	ALE, $\overline{S2:0}$ , DEN, DT/ $\overline{R}$ , RFSH, LOCK, A19:16	3	25	ns	1, 4, 6, 7
$T_{CHOV2}$	GCS0:7, LCS, UCS, RD, WR	3	30	ns	1, 4, 6, 8
$T_{CLOV1}$	RFSH, DEN, LOCK, RESOUT, HLDA, T0OUT, T1OUT, A19:16	3	25	ns	1, 4, 6
$T_{CLOV2}$	RD, WR, GCS7:0, LCS, UCS, AD7:0, NCS, INTA1:0, $\overline{S2:0}$ , A15:8	3	30	ns	1, 4, 6
$T_{CHOF}$	RD, WR, RFSH, DT/ $\overline{R}$ , LOCK, $\overline{S2:0}$ , A19:16	0	25	ns	1
$T_{CLOF}$	DEN, AD7:0, A15:8	0	25	ns	1
<b>SYNCHRONOUS INPUTS</b>					
$T_{CHIS}$	$\overline{TEST}$ , NMI, INT4:0, BCLK1:0, T1:0IN, READY, CTS1:0, P2.6, P2.7	10		ns	1, 9
$T_{CHIH}$	$\overline{TEST}$ , NMI, INT4:0, BCLK1:0, T1:0IN, READY, CTS1:0	3		ns	1, 9
$T_{CLIS}$	AD7:0, READY	10		ns	1, 10
$T_{CLIH}$	READY, AD7:0	3		ns	1, 10
$T_{CLIS}$	HOLD	10		ns	1, 9
$T_{CLIH}$	HOLD	3		ns	1, 9

**NOTES:**

1. See **AC Timing Waveforms**, for waveforms and definition.
2. Measure at  $V_{IH}$  for high time,  $V_{IL}$  for low time.
3. Only required to guarantee  $I_{CC}$ . Maximum limits are bounded by  $T_C$ ,  $T_{CH}$  and  $T_{CL}$ .
4. Specified for a 50 pF load, see Figure 16 for capacitive derating information.
5. Specified for a 50 pF load, see Figure 17 for rise and fall times outside 50 pF.
6. See Figure 17 for rise and fall times.
7.  $T_{CHOV1}$  applies to RFSH, LOCK and A8:0 only after a HOLD release.
8.  $T_{CHOV2}$  applies to RD and WR only after a HOLD release.
9. Setup and Hold are required to guarantee recognition.
10. Setup and Hold are required for proper 80C188EB operation.

**AC SPECIFICATIONS** (Continued)

**AC Characteristics—80C188EB-8**

Symbol	Parameter	Min	Max	Units	Notes
<b>INPUT CLOCK</b>					
T <sub>F</sub>	CLKIN Frequency	0	16	MHz	1
T <sub>C</sub>	CLKIN Period	62.5	∞	ns	1
T <sub>CH</sub>	CLKIN High Time	15	∞	ns	1, 2
T <sub>CL</sub>	CLKIN Low Time	15	∞	ns	1, 2
T <sub>CR</sub>	CLKIN Rise Time	1	8	ns	1, 3
T <sub>CF</sub>	CLKIN Fall Time	1	8	ns	1, 3
<b>OUTPUT CLOCK</b>					
T <sub>CD</sub>	CLKIN to CLKOUT Delay	0	27	ns	1, 4
T	CLKOUT Period		2•T <sub>C</sub>	ns	1
T <sub>PH</sub>	CLKOUT High Time	(T/2) - 5	(T/2) + 5	ns	1
T <sub>PL</sub>	CLKOUT Low Time	(T/2) - 5	(T/2) + 5	ns	1
T <sub>PR</sub>	CLKOUT Rise Time	1	6	ns	1, 5
T <sub>PF</sub>	CLKOUT Fall Time	1	6	ns	1, 5
<b>OUTPUT DELAYS</b>					
T <sub>CHOV1</sub>	ALE, S2:0, DEN, DT/R, RFSH, LOCK, A19:16	3	30	ns	1, 4, 6, 7
T <sub>CHOV2</sub>	GCS0:7, LCS, UCS, RD, WR	3	35	ns	1, 4, 6, 8
T <sub>CLOV1</sub>	RFSH, DEN, LOCK, RESOUT, HLDA, T0OUT, T1OUT, A19:16	3	30	ns	1, 4, 6
T <sub>CLOV2</sub>	RD, WR, GCS7:0, LCS, UCS, AD7:0, NCS, INTA1:0, S2:0, A15:8	3	35	ns	1, 4, 6
T <sub>CHOF</sub>	RD, WR, RFSH, DT/R, LOCK, S2:0, A19:16	0	30	ns	1
T <sub>CLOF</sub>	DEN, AD7:0, A15:8	0	35	ns	1
<b>SYNCHRONOUS INPUTS</b>					
T <sub>CHIS</sub>	TEST, NMI, INT4:0, BCLK1:0 T1:0IN, READY, CTS1:0, P2.6, P2.7	10		ns	1, 9
T <sub>CHIH</sub>	TEST, NMI, INT4:0, BCLK1:0 T1:0IN, READY, CTS1:0	3		ns	1, 9
T <sub>CLIS</sub>	AD7:0, READY	10		ns	1, 10
T <sub>CLIH</sub>	READY, AD7:0	3		ns	1, 10
T <sub>CLIS</sub>	HOLD	10		ns	1, 9
T <sub>CLIH</sub>	HOLD	3		ns	1, 9

**NOTES:**

1. See **AC Timing Waveforms**, for waveforms and definition.
2. Measure at V<sub>IH</sub> for high time, V<sub>IL</sub> for low time.
3. Only required to guarantee I<sub>CC</sub>. Maximum limits are bounded by T<sub>C</sub>, T<sub>CH</sub> and T<sub>CL</sub>.
4. Specified for a 50 pF load, see Figure 16 for capacitive derating information.
5. Specified for a 50 pF load, see Figure 17 for rise and fall times outside 50 pF.
6. See Figure 17 for rise and fall times.
7. T<sub>CHOV1</sub> applies to RFSH, LOCK and A19:8 only after a HOLD release.
8. T<sub>CHOV2</sub> applies to RD and WR only after a HOLD release.
9. Setup and Hold are required to guarantee recognition.
10. Setup and Hold are required for proper 80C188EB operation.

## AC SPECIFICATIONS (Continued)

## Relative Timings (80C188EB-16, -13, -8)

Symbol	Parameter	Min	Max	Unit	Notes
<b>RELATIVE TIMINGS</b>					
$T_{LHLL}$	ALE Rising to ALE Falling	$T - 15$		ns	
$T_{AVLL}$	Address Valid to ALE Falling	$\frac{1}{2}T - 10$		ns	
$T_{PLLL}$	Chip Selects Valid to ALE Falling	$\frac{1}{2}T - 10$		ns	1
$T_{LLAX}$	Address Hold from ALE Falling	$\frac{1}{2}T - 10$		ns	
$T_{LLWL}$	ALE Falling to $\overline{WR}$ Falling	$\frac{1}{2}T - 15$		ns	1
$T_{LLRL}$	ALE Falling to $\overline{RD}$ Falling	$\frac{1}{2}T - 15$		ns	1
$T_{WHLH}$	$\overline{WR}$ Rising to ALE Rising	$\frac{1}{2}T - 10$		ns	1
$T_{AFRL}$	Address Float to $\overline{RD}$ Falling	0		ns	
$T_{RLRH}$	$\overline{RD}$ Falling to $\overline{RD}$ Rising	$(2 \cdot T) - 5$		ns	2
$T_{WLWH}$	$\overline{WR}$ Falling to $\overline{WR}$ Rising	$(2 \cdot T) - 5$		ns	2
$T_{RHAV}$	$\overline{RD}$ Rising to Address Active	$T - 15$		ns	
$T_{WHDX}$	Output Data Hold after $\overline{WR}$ Rising	$T - 15$		ns	
$T_{WHPH}$	$\overline{WR}$ Rising to Chip Select Rising	$\frac{1}{2}T - 10$		ns	1
$T_{RHPPH}$	$\overline{RD}$ Rising to Chip Select Rising	$\frac{1}{2}T - 10$		ns	1
$T_{PHPL}$	$\overline{CS}$ Inactive to $\overline{CS}$ Active	$\frac{1}{2}T - 10$		ns	1
$T_{OVRH}$	$\overline{ONCE}$ Active to $\overline{RESIN}$ Rising	$T$		ns	3
$T_{RHGX}$	$\overline{ONCE}$ Hold from $\overline{RESIN}$ Rising	$T$		ns	3

**NOTES:**

1. Assumes equal loading on both pins.
2. Can be extended using wait states.
3. Not tested.

## AC SPECIFICATIONS (Continued)

## Serial Port Mode 0 Timings (80C188EB-16, -13, -8)

Symbol	Parameter	Min	Max	Unit	Notes
T <sub>XLXL</sub>	TXD Clock Period	T (n + 1)		ns	1, 2
T <sub>XLXH</sub>	TXD Clock Low to Clock High (n > 1)	2T - 35	2T + 35	ns	1
T <sub>XLXH</sub>	TXD Clock Low to Clock High (n = 1)	T - 35	T + 35	ns	1
T <sub>XHXL</sub>	TXD Clock High to Clock Low (n > 1)	(n - 1) T - 35	(n - 1) T + 35	ns	1, 2
T <sub>XHXL</sub>	TXD Clock High to Clock Low (n = 1)	T - 35	T + 35	ns	1
T <sub>QVXH</sub>	RXD Output Data Setup to TXD Clock High (n > 1)	(n - 1) T - 35		ns	1, 2
T <sub>QVXH</sub>	RXD Output Data Setup to TXD Clock High (n = 1)	T - 35		ns	1
T <sub>XHQX</sub>	RXD Output Data Hold after TXD Clock High (n > 1)	2T - 35		ns	1
T <sub>XHQX</sub>	RXD Output Data Hold after TXD Clock High (n = 1)	T - 35		ns	1
T <sub>XHQZ</sub>	RXD Output Data Float after Last TXD Clock High		T + 20	ns	1
T <sub>DVXH</sub>	RXD Input Data Setup to TXD Clock High	T + 20		ns	1
T <sub>XHDX</sub>	RXD Input Data Hold after TXD Clock High	0		ns	1

## NOTES:

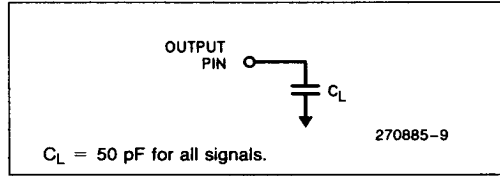
1. See Figure 15 for waveforms.
2. n is the value of the BxCMP register ignoring the iCLK bit (i.e., ICLK = 0).



**AC TEST CONDITIONS**

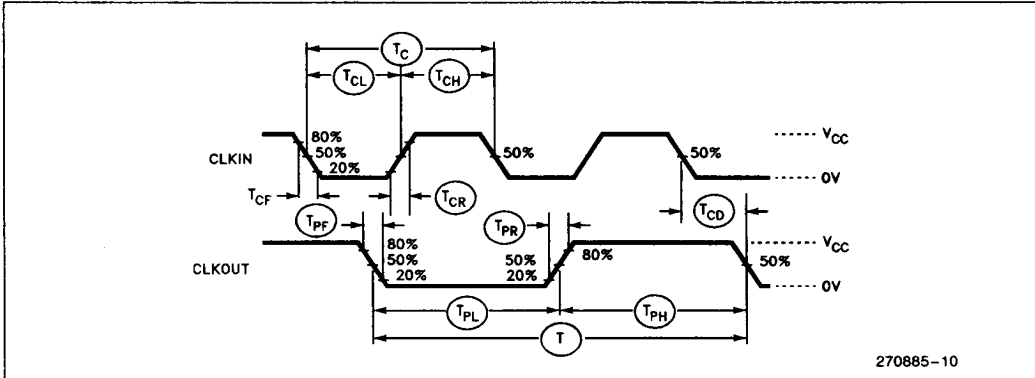
The AC specifications are tested with the 50 pF load shown in Figure 10. See the Derating Curves section to see how timings vary with load capacitance.

Specifications are measured at the  $V_{CC}/2$  crossing point, unless otherwise specified. See AC Timing Waveforms, for AC specification definitions, test pins, and illustrations.



**Figure 10. AC Test Load**

**AC TIMING WAVEFORMS**



**Figure 11. Input and Output Clock Waveform**

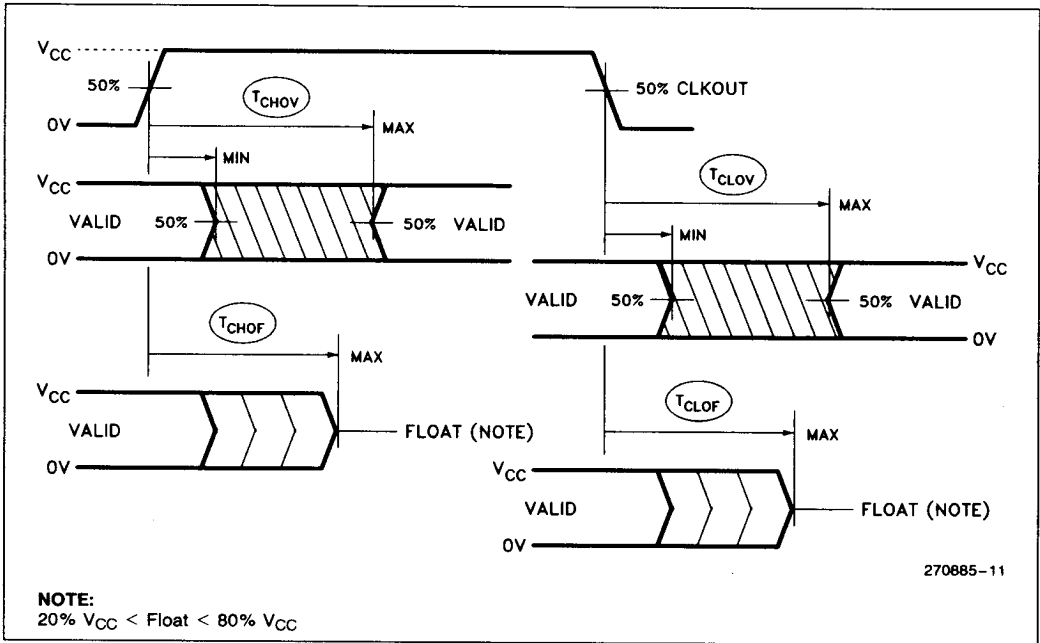


Figure 12. Output Delay and Float Waveform

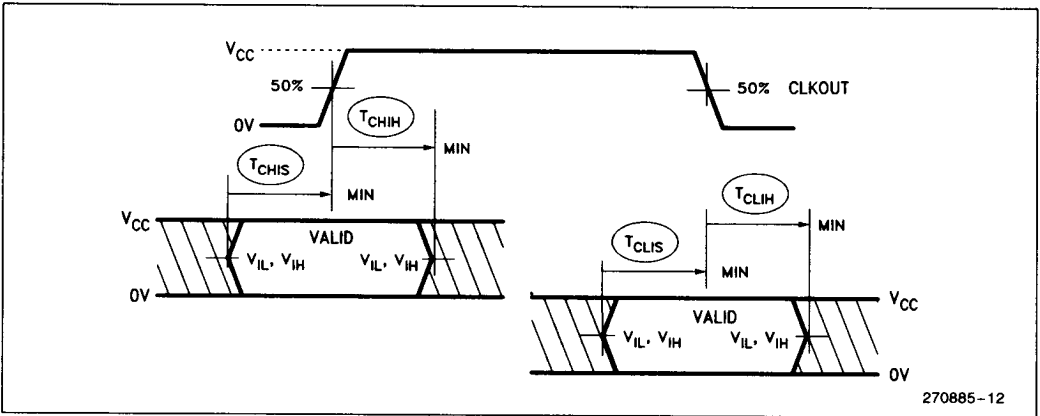


Figure 13. Input Setup and Hold

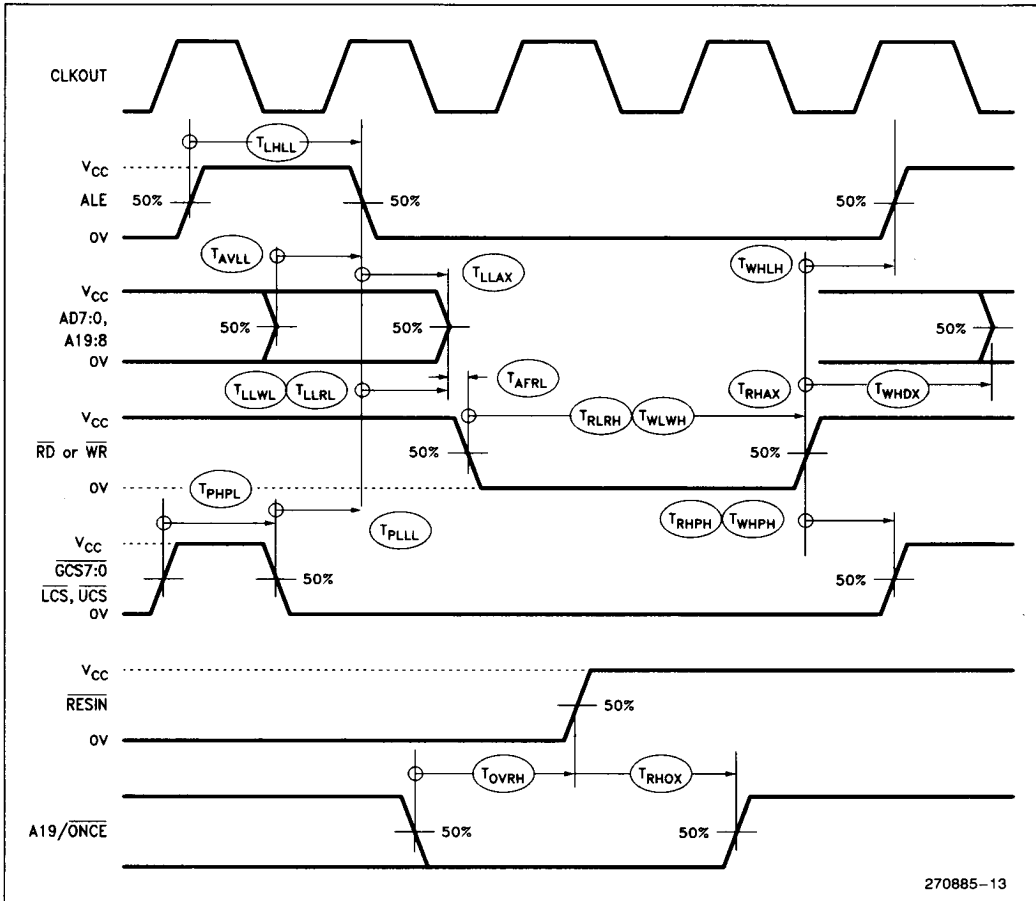


Figure 14. Relative Signal Waveform

270885-13

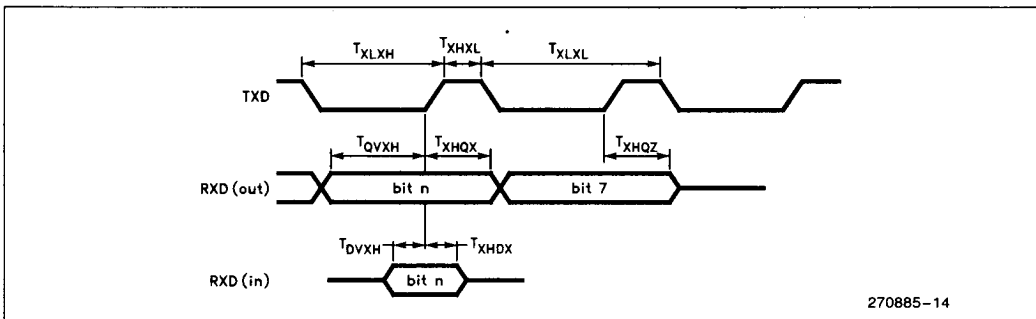
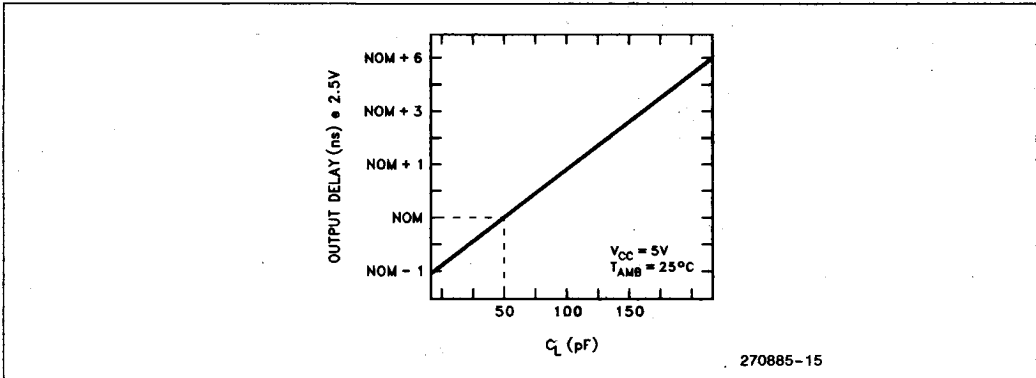


Figure 15. Serial Port Mode 0 Waveform

270885-14

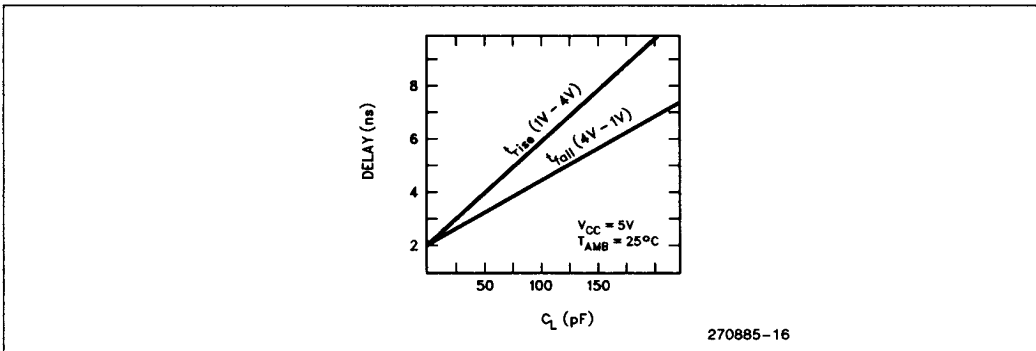
**DERATING CURVES**

**TYPICAL OUTPUT DELAY VARIATIONS VERSUS LOAD CAPACITANCE**



**Figure 16**

**TYPICAL RISE AND FALL VARIATIONS VERSUS LOAD CAPACITANCE**



**Figure 17**

## RESET

The 80C188EB will perform a reset operation any time the  $\overline{\text{RESIN}}$  pin active. The  $\overline{\text{RESIN}}$  pin is actually synchronized before it is presented internally, which means that the clock must be operating before a reset can take effect. From a power-on state,  $\overline{\text{RESIN}}$  must be held active (low) in order to guarantee correct initialization of the 80C188EB. **Failure to provide  $\overline{\text{RESIN}}$  while the device is powering up will result in unspecified operation of the device.**

Figure 18 shows the correct reset sequence when first applying power to the 80C188EB. An external clock connected to CLKIN must not exceed the  $V_{CC}$  threshold being applied to the 80C188EB. This is normally not a problem if the clock driver is supplied with the same  $V_{CC}$  that supplies the 80C188EB. When attaching a crystal to the device,  $\overline{\text{RESIN}}$  must remain active until both  $V_{CC}$  and CLKOUT are stable (the length of time is application specific and depends on the startup characteristics of the crystal circuit). The  $\overline{\text{RESIN}}$  pin is designed to operate correctly using an RC reset circuit, but the designer

must ensure that the ramp time for  $V_{CC}$  is not so long that  $\overline{\text{RESIN}}$  is never really sampled at a logic low level when  $V_{CC}$  reaches minimum operating conditions.

Figure 19 shows the timing sequence when  $\overline{\text{RESIN}}$  is applied after  $V_{CC}$  is stable and the device has been operating. Note that a reset will terminate all activity and return the 80C188EB to a known operating state. Any bus operation that is in progress at the time  $\overline{\text{RESIN}}$  is asserted will terminate immediately (note that most control signals will be driven to their inactive state first before floating).

While  $\overline{\text{RESIN}}$  is active, bus signals  $\overline{\text{LOCK}}$ , A19/ $\overline{\text{ONCE}}$ , and A18:16 are configured as inputs and weakly held high by internal pullup transistors. Only 19/ $\overline{\text{ONCE}}$  can be overdriven to a low and is used to enable  $\overline{\text{ONCE}}$  Mode. Forcing  $\overline{\text{LOCK}}$  or A18:16 low at any time while  $\overline{\text{RESIN}}$  is low is prohibited and will cause unspecified device operation.

COLD RESET WAVEFORMS

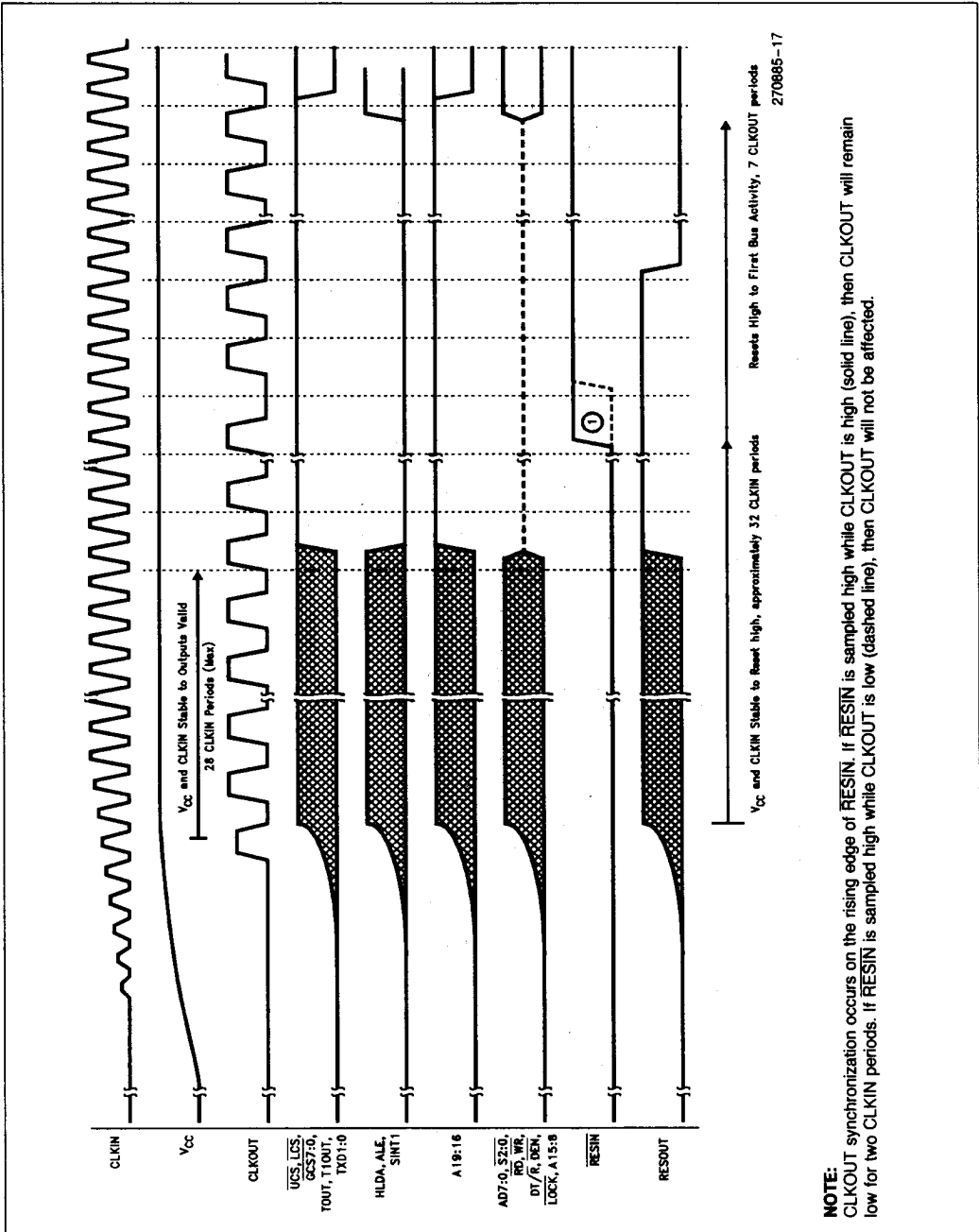


Figure 18

24-795

WARM RESET WAVEFORMS

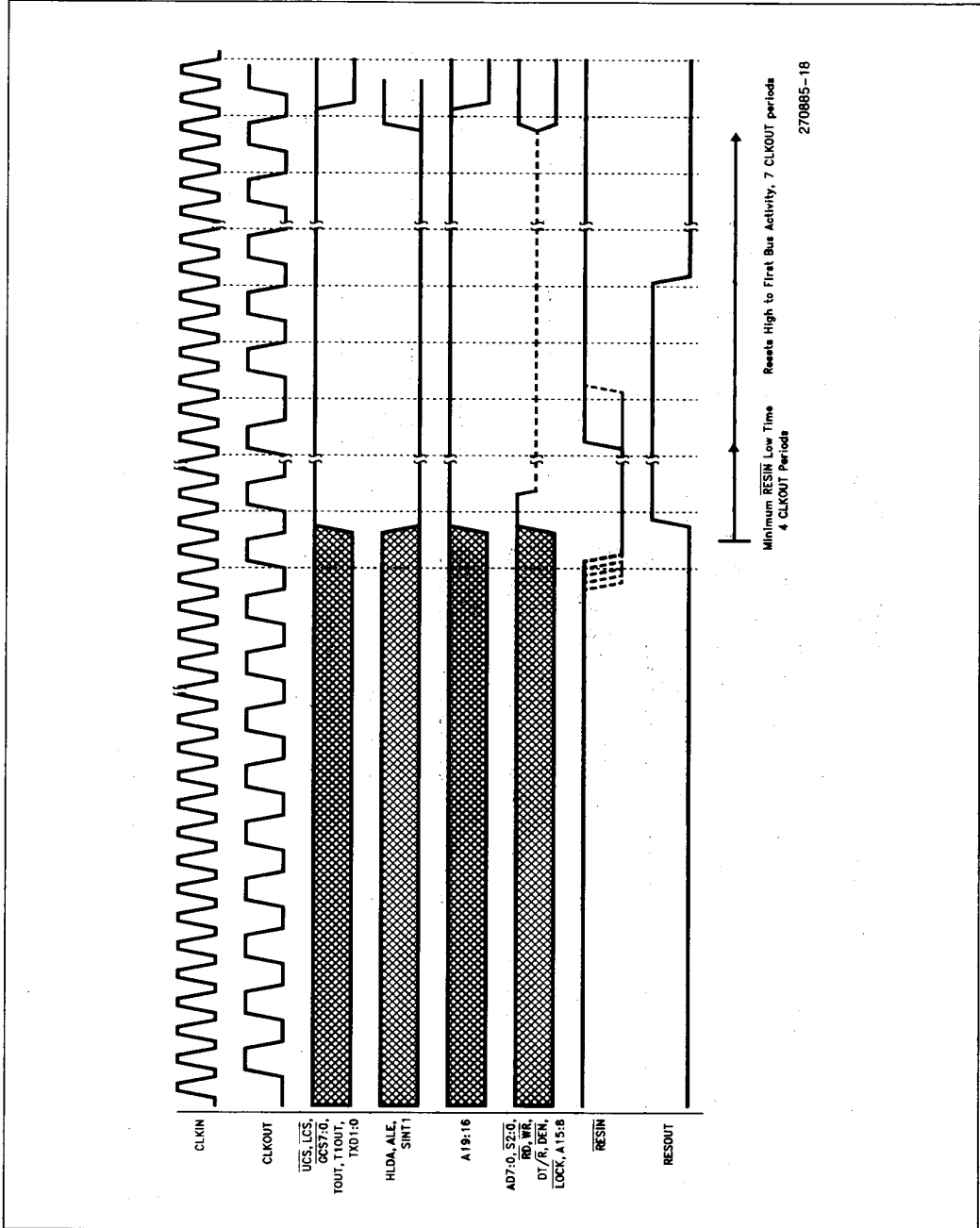


Figure 19

**BUS CYCLE WAVEFORMS**

Figures 20 through 26 present the various bus cycles that are generated by the 80C188EB. What is shown in the figure is the relationship of the various bus signals to CLKOUT. These figures along with the information present in **AC Specifications** allow the user to determine all the critical timing analysis needed for a given application.

Figure 20 shows the 80C188EB bus state diagram. A typical bus cycle will consist of four consecutive states labeled T1, T2, T3, and T4. A T1 state exists when no bus cycle is pending. A T1 state can occur if the pre-fetch queue is full, the BIU is waiting for the completion of an effective address calculation, or the BIU is told to wait for a pending EU bus operation. The latter case will occur most often during the sequencing of an interrupt acknowledge.

Aside from T1 states, multiple T3 states can occur during a bus cycle if READY is not returned in time (or the CSU has been programmed to automatically insert wait-states). A T3 state will be followed by either a T4 state (if a bus cycle is pending), or a T1 state (if no bus cycle is pending). Only multiple T3 or T1 states can exist (i.e., there is no way to extend the T1, T2, or T4 states).

Figures 21 and 22 present a typical bus read and write operation respectively. Bus read operations include memory, I/O, instruction fetch, and refresh bus cycles. Bus write operations include memory and I/O bus cycles. The only variation among the

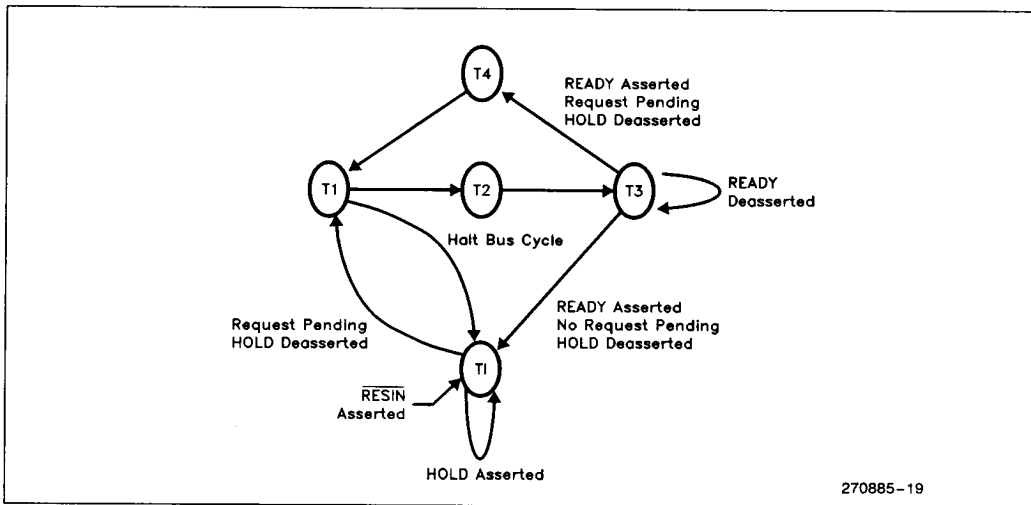
different bus cycles would be the range of address generated and the state of the status signals.

The Halt bus cycle is shown in Figure 23. Note that the condition of the AD7:0 pin can be either floating or driving depending on the operation of the bus cycle that preceded the Halt. The pins will float if the previous bus cycle was a read, otherwise they will drive. None of the control signals (e.g.,  $\overline{RD}$ ,  $\overline{WR}$ , DEN, etc.) will be activated, however.

Figure 24 shows the sequence of bus cycles run when an interrupt is acknowledged and the ICU has been programmed for Cascade Mode. Note the address information is not valid for the two bus cycles run, however, also note that  $\overline{RD}$  and  $\overline{WR}$  are not generated. Vector information needs to be returned during the second bus cycle.

Figures 25 and 26 present the operation of bus HOLD. Figure 25 shows how bus HOLD is entered and exited under normal operating conditions. Figure 26 shows the effect specific bus signals have when a refresh bus cycle request has been generated and the bus is currently unavailable due to a bus HOLD.

The effects of READY on bus operation is shown in Figure 27. READY is useful in extending the bus cycle to meet the various access requirements for memory and peripheral devices in the system. Additional T3 states added to the bus cycle have been appropriately labeled Tw.

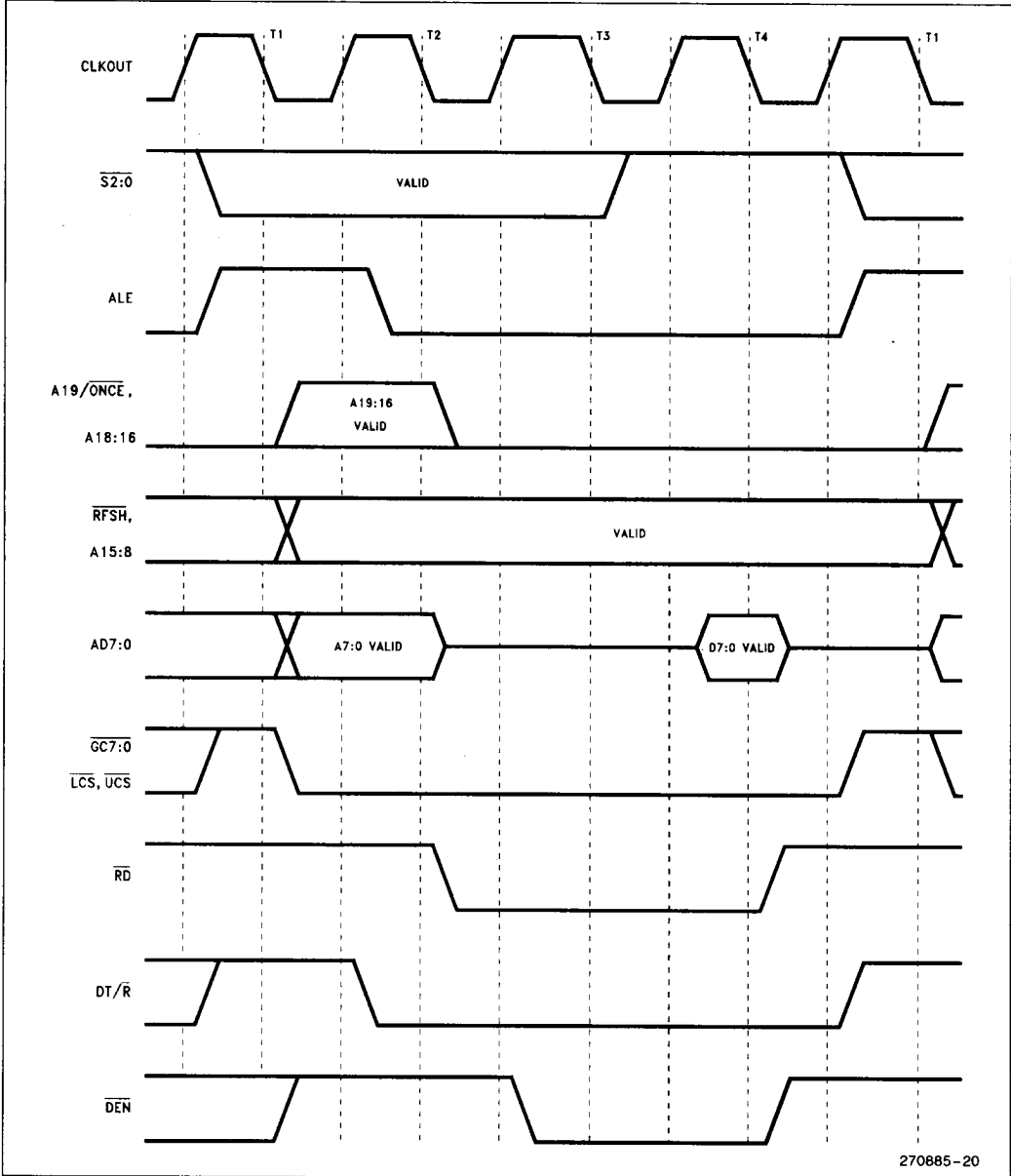


**Figure 20. 80C188EB Bus States**



**BUS CYCLE WAVEFORMS**

**MEMORY READ, I/O READ, INSTRUCTION FETCH, AND REFRESH WAVEFORM**



**Figure 21**

MEMORY WRITE AND I/O WRITE CYCLE WAVEFORM

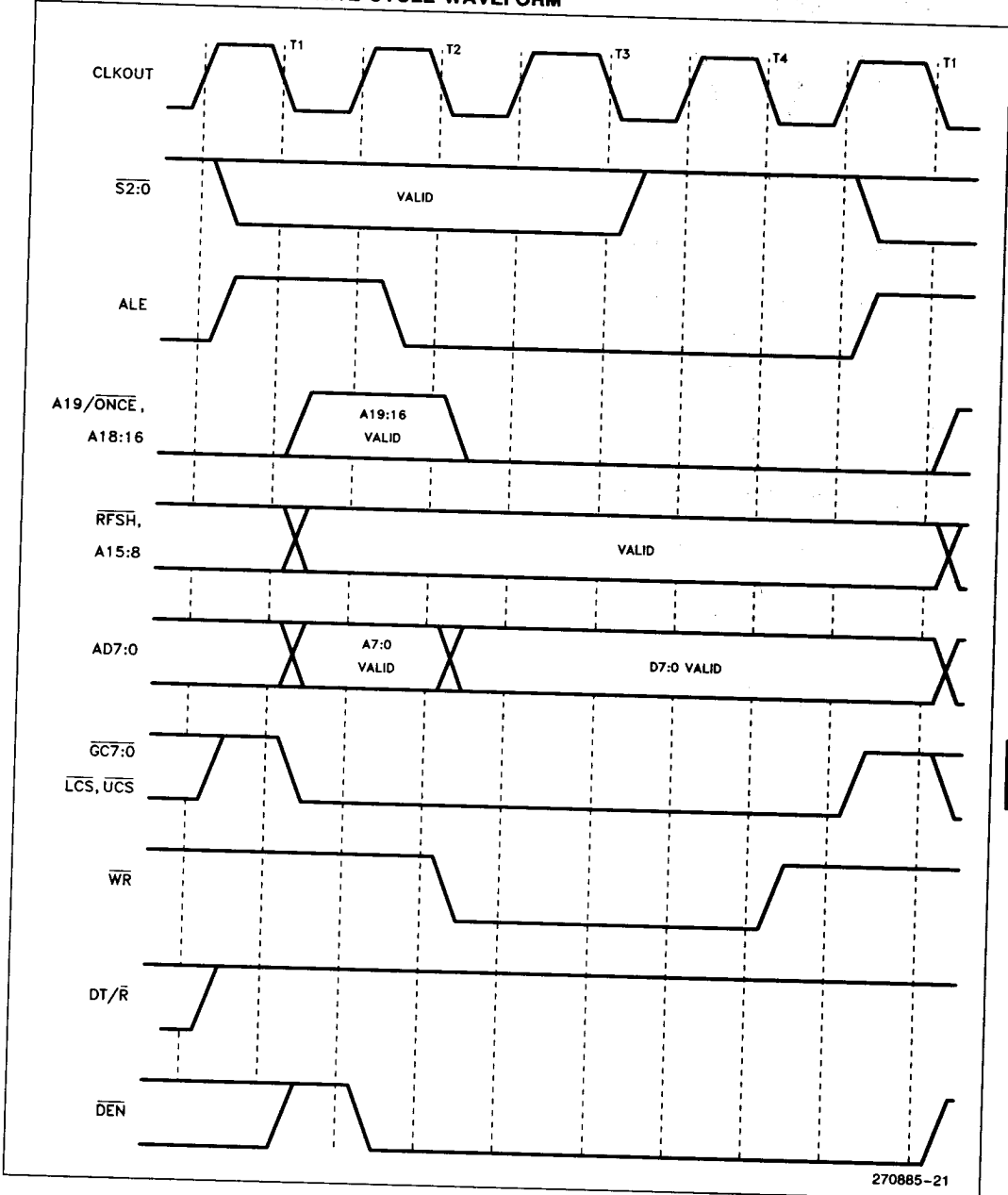


Figure 22

HALT CYCLE WAVEFORM

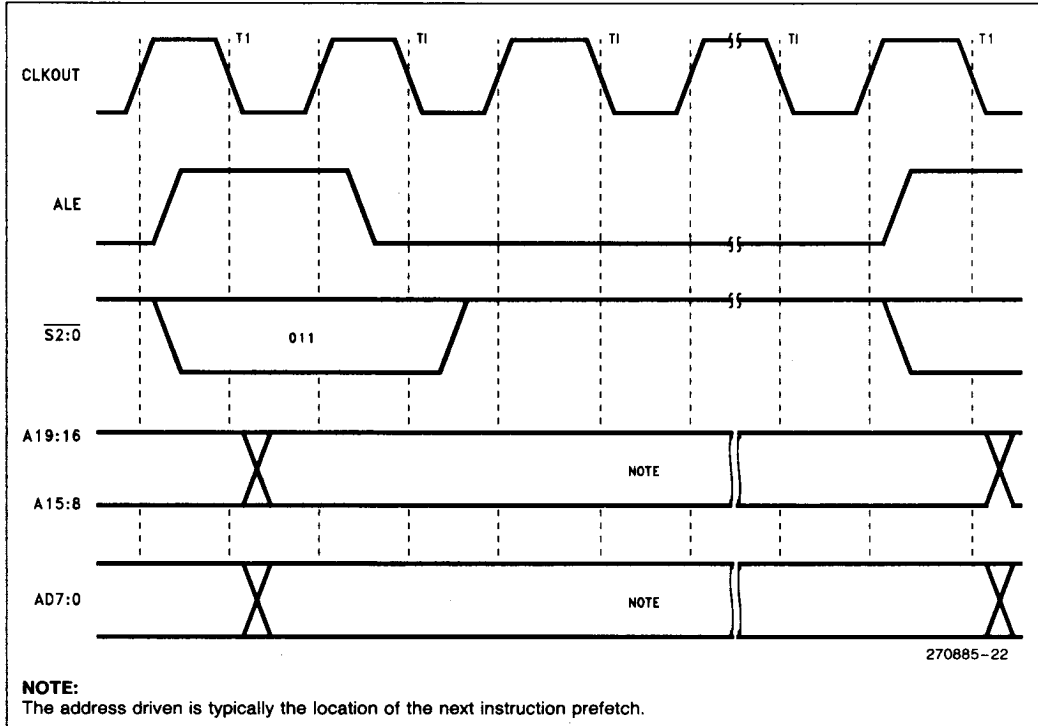


Figure 23

CASCADE MODE INTERRUPT ACKNOWLEDGE CYCLE WAVEFORM

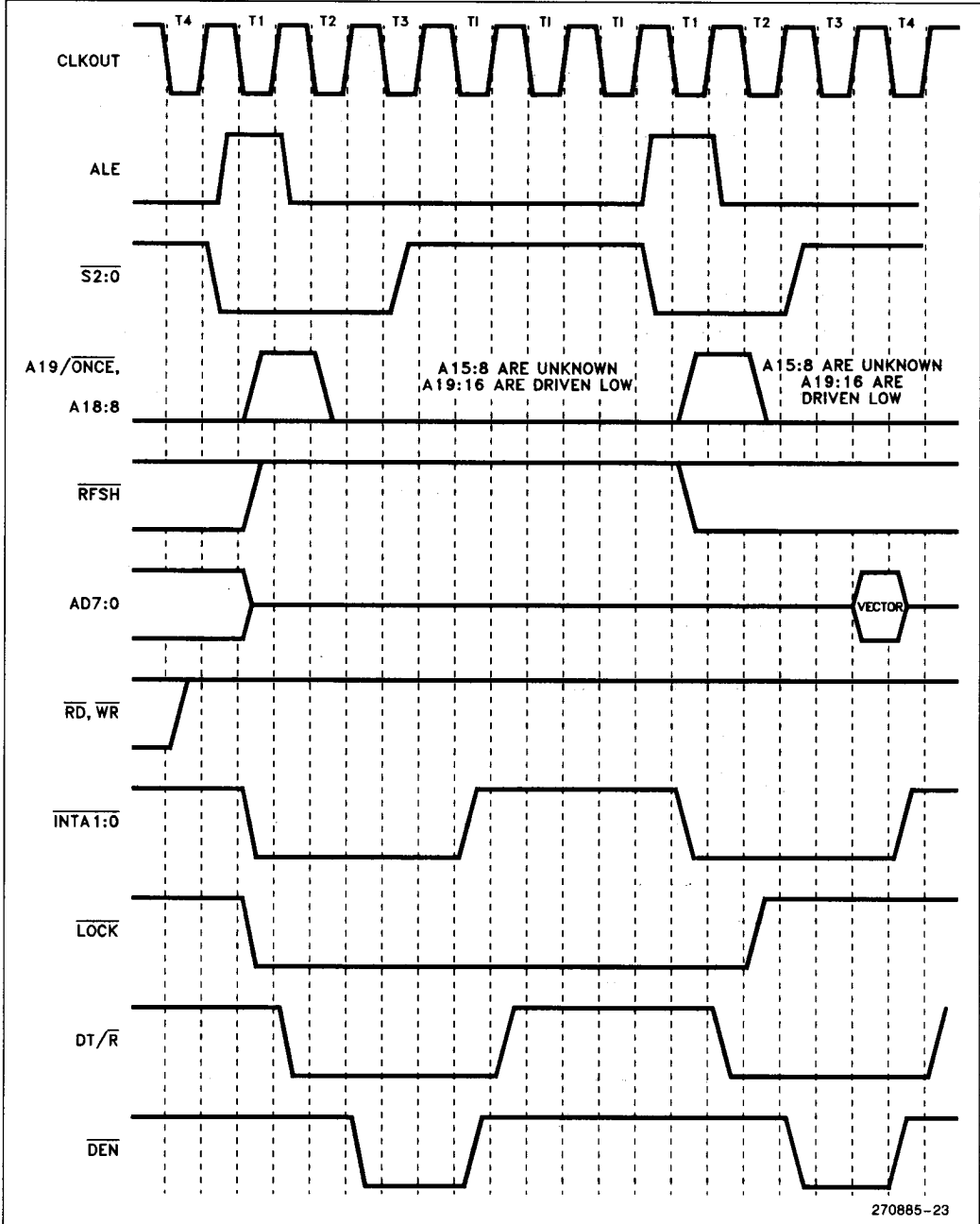
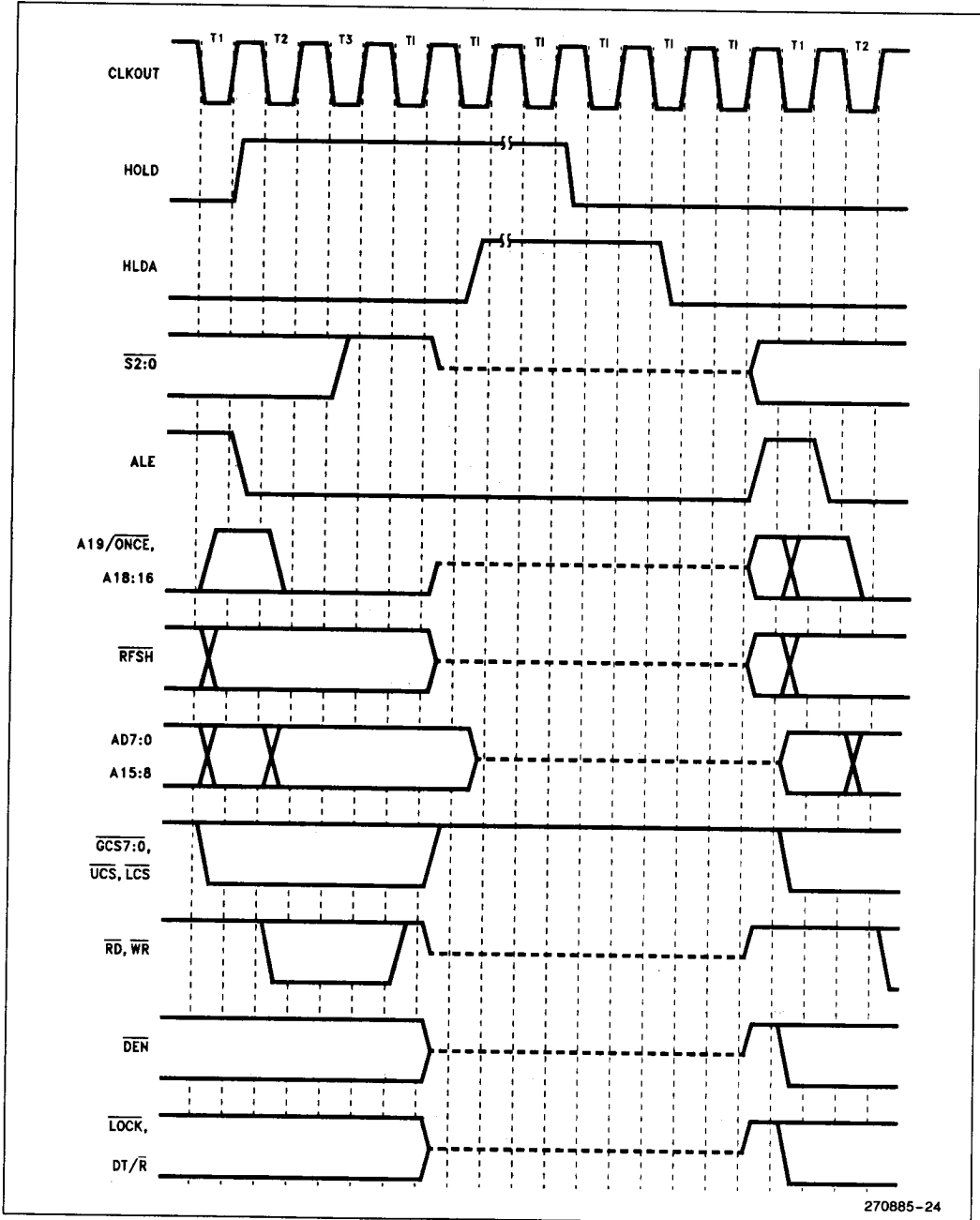


Figure 24

24-801

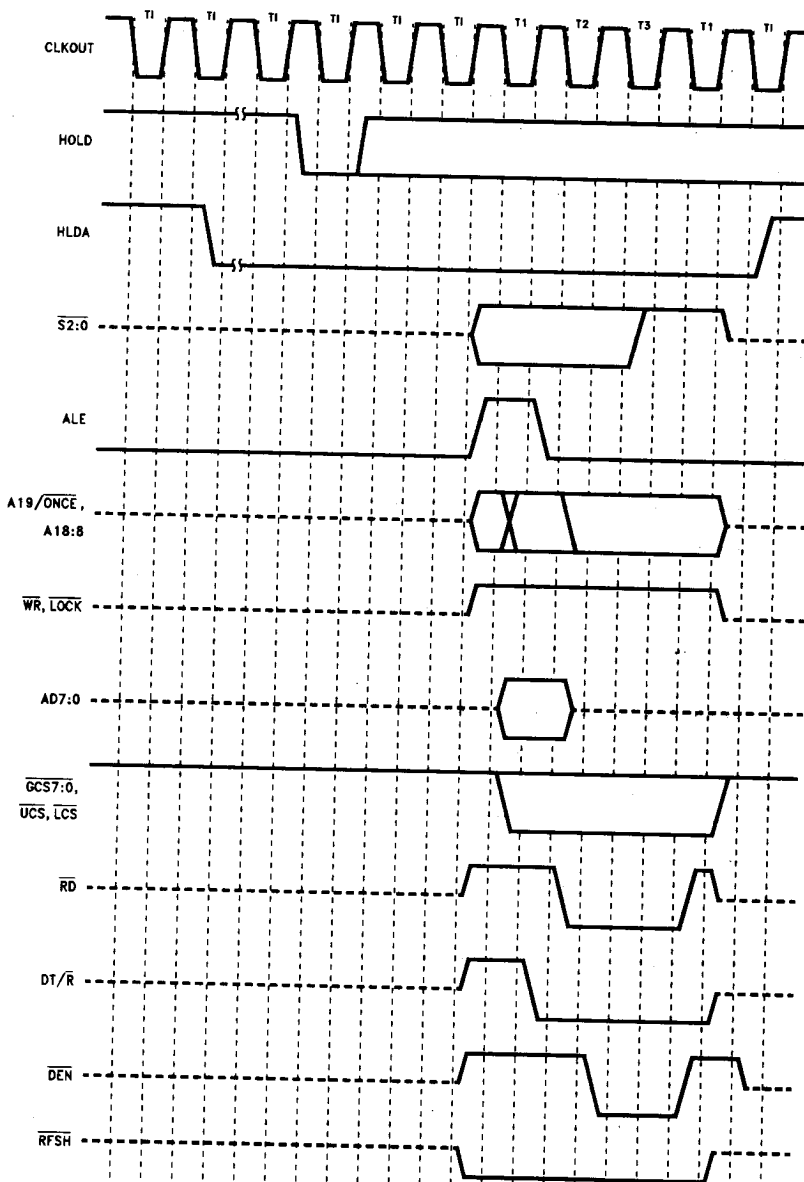
HOLD/HLDA CYCLE WAVEFORMS



270885-24

Figure 25

REFRESH DURING HLDA CYCLE WAVEFORM



270885-25

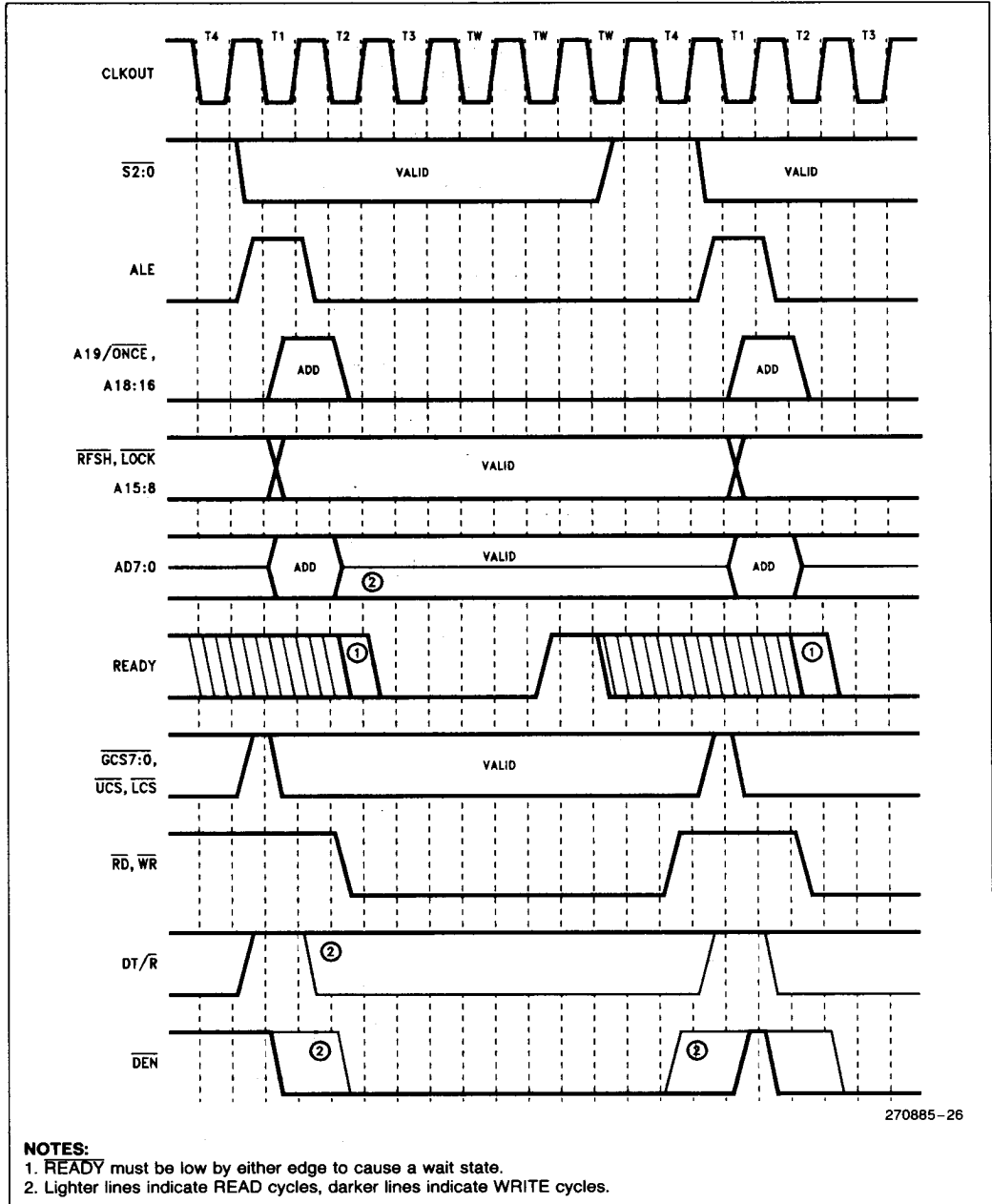
NOTES:

1. READY must be low by either edge to cause a wait state.
2. Lighter lines indicate READ cycles, darker lines indicate WRITE cycles.

Figure 26

24-803

READY CYCLE WAVEFORM



270885-26

Figure 27

## REGISTER BIT SUMMARY

Figures 28 through 35 present the bit definition of each register that is active (not reserved) in the Peripheral Control Block (PCB). Each register can be thought to occupy one word (16-bits) of either memory or I/O space, although not all bits in the register necessarily have a function. A register bit is **not** guaranteed to return a specific logic value if an "X" appears for the bit definition (i.e., if a zero was written to the register bit it may not be returned as a zero when read). Furthermore, a 0 must be written to any bit that is indicated by an "X" to ensure compatibility with future products or potential product changes.

Not all defined register bits can be read and/or written, although most registers are read/write. Some registers, like the P1DIR register, exist but do not have any effect on the operation of the 80C188EB. For example, the Port1 pins are output only and cannot be changed by programming the P1DIR register. However, the P1DIR register can still be read and written—which allows the P1DIR register to be used as a temporary 8-bit data register.

Reads and writes to any of the PCB registers will cause a bus cycle to be run externally, however, none of the chip selects will go active (even if they overlap the PCB address range). Data read back from the AD7:0 bus is ignored, and all cycles will take zero wait states (except accesses to the Timer/Counter registers which take one wait state due to internal synchronization).

Figures 28 and 29 present the registers associated with the Interrupt Control Unit (ICU). A write to the MASK (08H) register will also effect the corresponding MSK bit in each of the control registers (e.g., setting the TMR bit in the MASK register will also set the MSK bit in the TMRCON register).

The Timer/Counter Unit registers are presented in Figure 30. The compare and count registers are **not** initialized after reset and must be set correctly during initialization to ensure the timer operates correctly the first time it is enabled.

Figure 31 presents the I/O Port UNIT (IPU) registers. Only PD6 and PD7 of the P2DIR register have any effect on the direction of the port pins (P2.6 and P2.7 respectively). The unused bits of P2DIR and all the bits of P1DIR can be thought of having latches that can be read and written. The two PxLTCH registers have all 8-bits implemented, however, only those port pins which can function as outputs actually use the value programmed into the latch. Otherwise (like the P1DIR register), the registers can be thought of being an 8-bit data register.

Figure 32 presents the register bit definitions of the Serial Communications Unit (SCU). The transmit and receive buffer registers are both readable and writable. Note that a read from SxSTS register will clear all of the status information (except for CTS, which actually is derived from the pin itself).

The Chip-Select Unit (CSU) registers are presented in Figure 33 and the Refresh Control Unit (RCU) registers are presented in Figure 34. The RFADDR register will indicate the current refresh address when read, and a write to the register will change the next refresh address generated.

Figure 35 presents the PWRCON register and STEPID register. The STEPID register contains a stepping identifier that may or may not change any time there is a change to the 80C188EB silicon die. The STEPID is for Intel use and can change at any time.



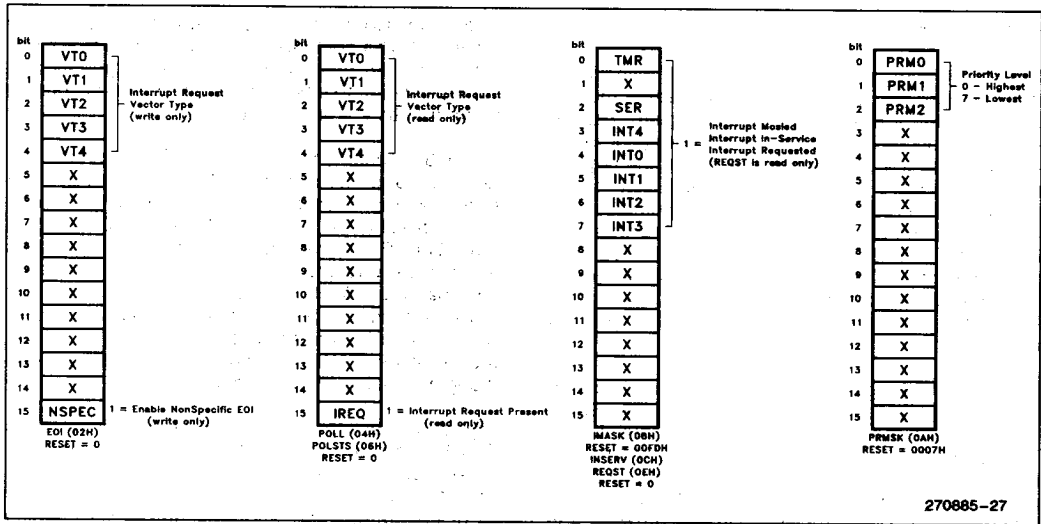


Figure 28. Interrupt Control Unit Registers

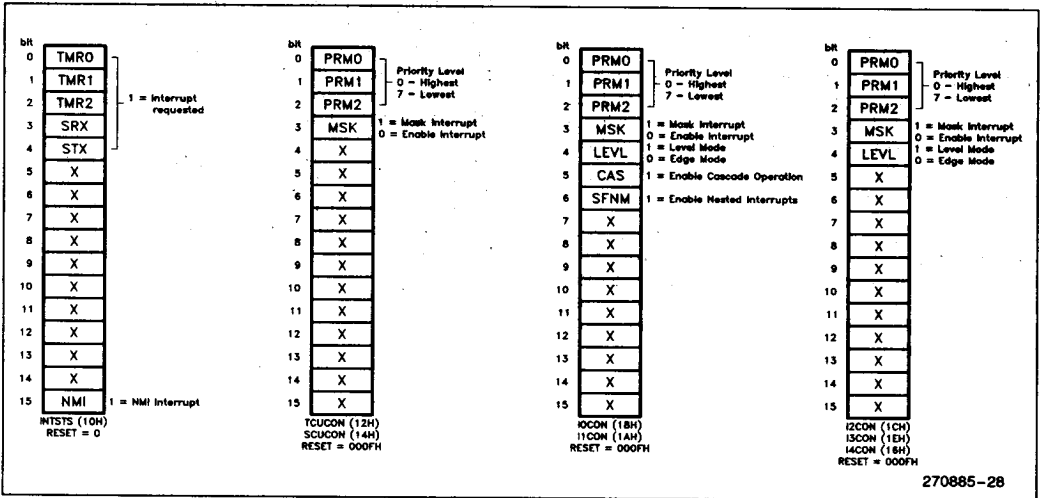


Figure 29. Interrupt Control Unit Registers

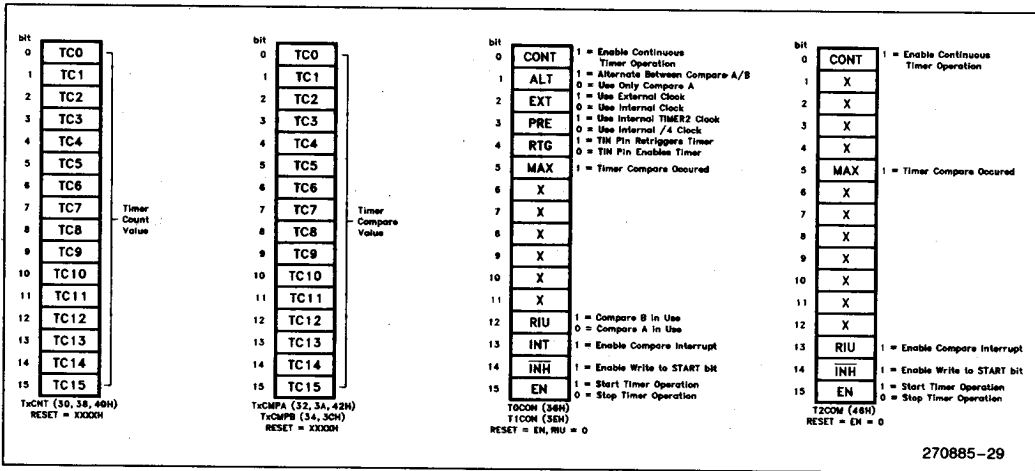


Figure 30. Timer Control Unit Registers

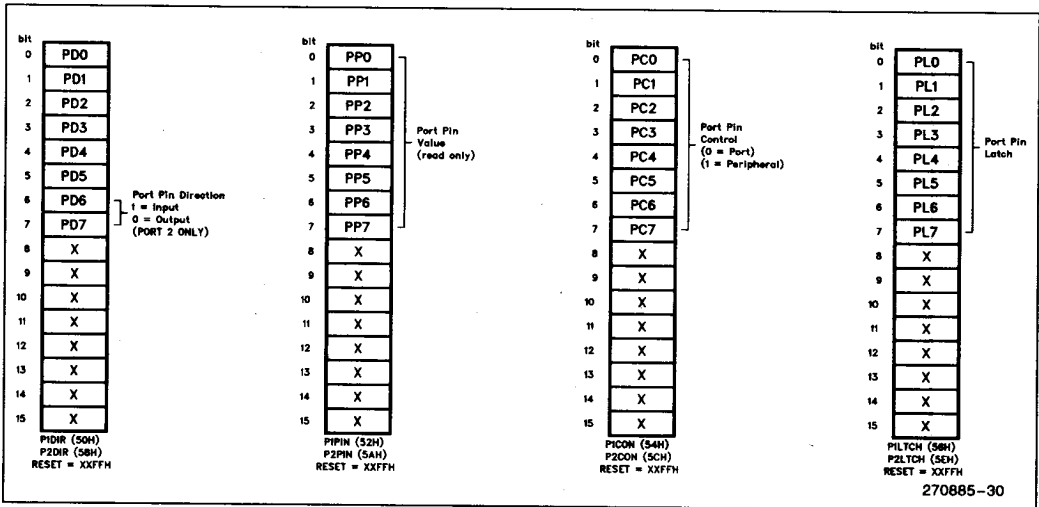


Figure 31. I/O Port Unit Registers

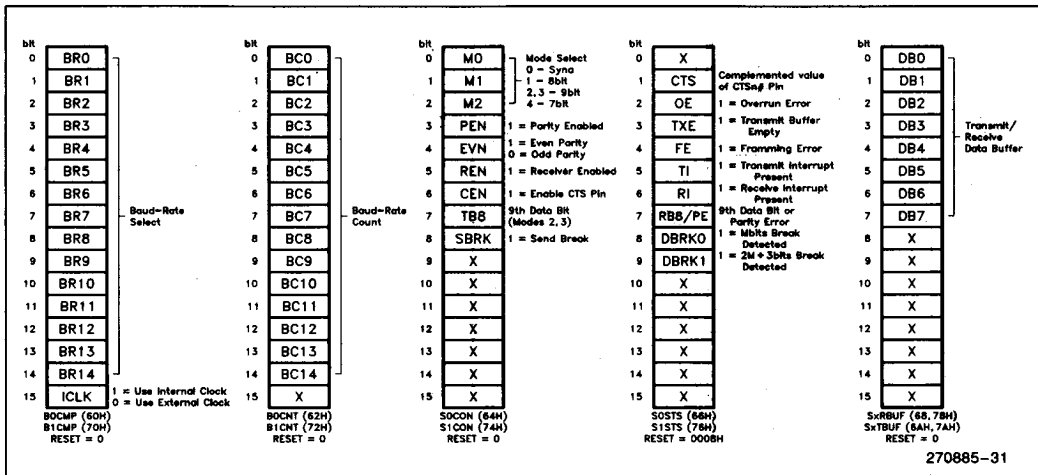


Figure 32. Serial Communications Unit Registers

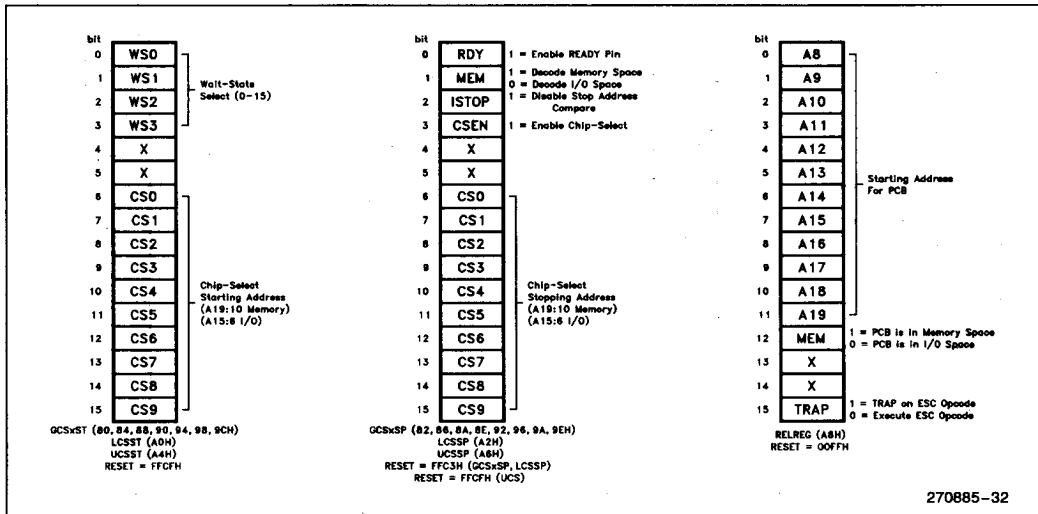


Figure 33. Chip-Select Unit Registers

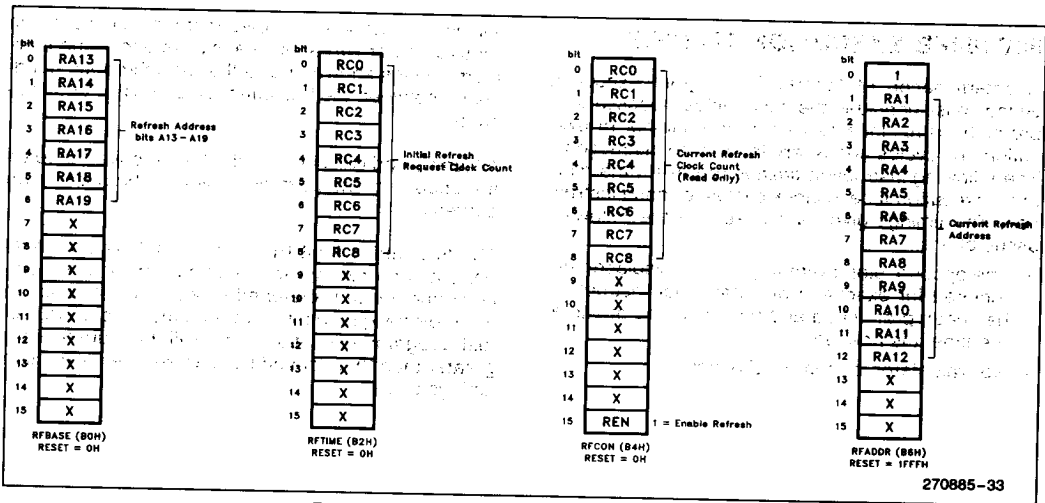


Figure 34. Refresh Control Unit Registers

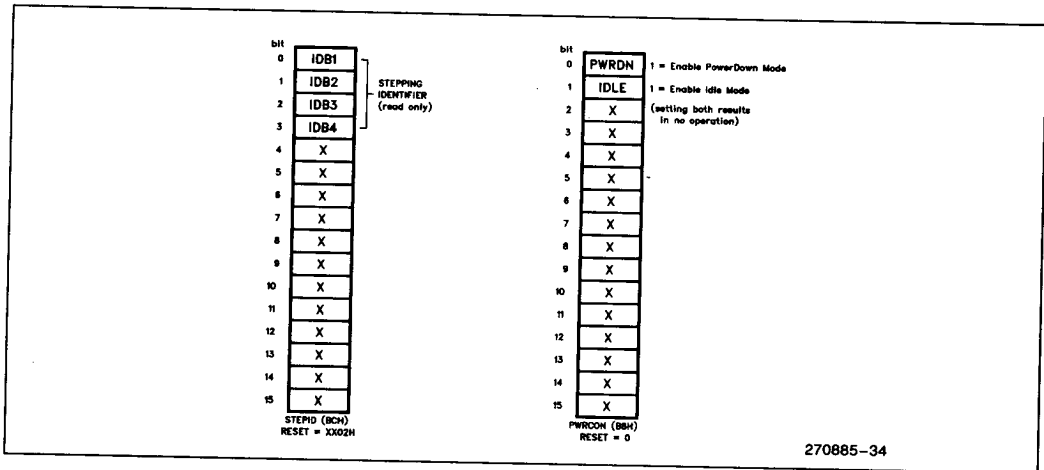


Figure 35. Power Management Unit Registers

## 80C188EB EXECUTION TIMINGS

A determination of 80C188EB program execution timing must consider the bus cycles necessary to prefetch instructions as well as the number of execution unit cycles necessary to execute instructions. The following instruction timings represent the minimum execution time in clock cycles for each instruction. The timings given are based on the following assumptions:

- The opcode, along with any data or displacement required for execution of a particular instruction, has been prefetched and resides in the queue at the time it is needed.
- No wait states or bus HOLDs occur.

All instructions which involve memory accesses can require one or two additional clocks above the minimum timings shown due to the asynchronous handshake between the bus interface unit (BIU) and execution unit.

All jumps and calls include the time required to fetch the opcode of the next instruction at the destination address.

The 80C188EB 8-bit BIU is noticeably limited in its performance relative to the execution unit. A sufficient number of prefetched bytes may not reside in the prefetch queue much of the time. Therefore, actual program execution time will be substantially greater than that derived from adding the instruction timings shown.

**INSTRUCTION SET SUMMARY**

Function	Format	Clock Cycles	Comments
<b>DATA TRANSFER</b>			
<b>MOV = Move:</b>			
Register to Register/Memory	1 0 0 0 1 0 0 w mod reg r/m	2/12	
Register/memory to register	1 0 0 0 1 0 1 w mod reg r/m	2/9	
Immediate to register/memory	1 1 0 0 0 1 1 w mod 000 r/m data data if w = 1	12-13	8/16-bit
Immediate to register	1 0 1 1 w reg data data if w = 1	3-4	8/16-bit
Memory to accumulator	1 0 1 0 0 0 0 w addr-low addr-high	8	
Accumulator to memory	1 0 1 0 0 0 1 w addr-low addr-high	9	
Register/memory to segment register	1 0 0 0 1 1 1 0 mod 0 reg r/m	2/9	
Segment register to register/memory	1 0 0 0 1 1 0 0 mod 0 reg r/m	2/11	
<b>PUSH = Push:</b>			
Memory	1 1 1 1 1 1 1 1 mod 1 1 0 r/m	16	
Register	0 1 0 1 0 reg	10	
Segment register	0 0 0 reg 1 1 0	9	
Immediate	0 1 1 0 1 0 s 0 data data if s = 0	10	
<b>PUSHA = Push All</b>			
	0 1 1 0 0 0 0 0	36	
<b>POP = Pop:</b>			
Memory	1 0 0 0 1 1 1 1 mod 0 0 0 r/m	20	
Register	0 1 0 1 1 reg	10	
Segment register	0 0 0 reg 1 1 1 (reg ≠ 01)	8	
<b>POPA = Pop All</b>			
	0 1 1 0 0 0 0 1	51	
<b>XCHG = Exchange:</b>			
Register/memory with register	1 0 0 0 0 1 1 w mod reg r/m	4/17	
Register with accumulator	1 0 0 1 0 reg	3	
<b>IN = Input from:</b>			
Fixed port	1 1 1 0 0 1 0 w port	10	
Variable port	1 1 1 0 1 1 0 w	8	
<b>OUT = Output to:</b>			
Fixed port	1 1 1 0 0 1 1 w port	9	
Variable port	1 1 1 0 1 1 1 w	7	
<b>XLAT = Translate byte to AL</b>			
	1 1 0 1 0 1 1 1	11	
<b>LEA = Load EA to register</b>			
	1 0 0 0 1 1 0 1 mod reg r/m	6	
<b>LDS = Load pointer to DS</b>			
	1 1 0 0 0 1 0 1 mod reg r/m (mod ≠ 11)	18	
<b>LES = Load pointer to ES</b>			
	1 1 0 0 0 1 0 0 mod reg r/m (mod ≠ 11)	18	
<b>LAHF = Load AH with flags</b>			
	1 0 0 1 1 1 1 1	2	
<b>SAHF = Store AH into flags</b>			
	1 0 0 1 1 1 1 0	3	
<b>PUSHF = Push flags</b>			
	1 0 0 1 1 1 0 0	9	
<b>POPF = Pop flags</b>			
	1 0 0 1 1 1 0 1	8	

Shaded areas indicate instructions not available in 8086/8088 microsystems.

**INSTRUCTION SET SUMMARY (Continued)**

Function	Format	Clock Cycles	Comments
<b>DATA TRANSFER (Continued)</b>			
<b>SEGMENT = Segment Override:</b>			
CS	00101110	2	
SS	00110110	2	
DS	00111110	2	
ES	00100110	2	
<b>ARITHMETIC</b>			
<b>ADD = Add:</b>			
Reg/memory with register to either	00000dw mod reg r/m	3/10	
Immediate to register/memory	10000sw mod 000 r/m data data if sw=01	4/16	
Immediate to accumulator	0000010w data data if w=1	3/4	8/16-bit
<b>ADC = Add with carry:</b>			
Reg/memory with register to either	000100dw mod reg r/m	3/10	
Immediate to register/memory	10000sw mod 010 r/m data data if sw=01	4/16	
Immediate to accumulator	0001010w data data if w=1	3/4	8/16-bit
<b>INC = Increment:</b>			
Register/memory	1111111w mod 000 r/m	3/15	
Register	01000 reg	3	
<b>SUB = Subtract:</b>			
Reg/memory and register to either	001010dw mod reg r/m	3/10	
Immediate from register/memory	10000sw mod 101 r/m data data if sw=01	4/16	
Immediate from accumulator	0010110w data data if w=1	3/4	8/16-bit
<b>SBB = Subtract with borrow:</b>			
Reg/memory and register to either	000110dw mod reg r/m	3/10	
Immediate from register/memory	10000sw mod 011 r/m data data if sw=01	4/16	
Immediate from accumulator	0001110w data data if w=1	3/4	8/16-bit
<b>DEC = Decrement</b>			
Register/memory	1111111w mod 001 r/m	3/15	
Register	01001 reg	3	
<b>CMP = Compare:</b>			
Register/memory with register	0011101w mod reg r/m	3/10	
Register with register/memory	0011100w mod reg r/m	3/10	
Immediate with register/memory	10000sw mod 111 r/m data data if sw=01	3/10	
Immediate with accumulator	0011110w data data if w=1	3/4	8/16-bit
<b>NEG = Change sign register/memory</b>			
	1111011w mod 011 r/m	3/10	
<b>AAA = ASCII adjust for add</b>			
	00110111	8	
<b>DAA = Decimal adjust for add</b>			
	00100111	4	
<b>AAS = ASCII adjust for subtract</b>			
	00111111	7	
<b>DAS = Decimal adjust for subtract</b>			
	00101111	4	
<b>MUL = Multiply (unsigned):</b>			
	1111011w mod 100 r/m		
Register-Byte		26-28	
Register-Word		35-37	
Memory-Byte		32-34	
Memory-Word		41-43	

Shaded areas indicate instructions not available in 8086/8088 microsystems.

**INSTRUCTION SET SUMMARY** (Continued)

Function	Format	Clock Cycles	Comments
<b>ARITHMETIC</b> (Continued)			
<b>IMUL</b> = Integer multiply (signed):	1 1 1 1 0 1 1 w    mod 1 0 1 r/m		
Register-Byte		25-28	
Register-Word		34-37	
Memory-Byte		31-34	
Memory-Word		40-43	
<b>IMUL</b> = Integer Immediate multiply (signed)	0 1 1 0 1 0 s 1    mod reg r/m    data    data if s = 0	22-25/ 29-32	
<b>DIV</b> = Divide (unsigned):	1 1 1 1 0 1 1 w    mod 1 1 0 r/m		
Register-Byte		29	
Register-Word		38	
Memory-Byte		35	
Memory-Word		44	
<b>IDIV</b> = Integer divide (signed):	1 1 1 1 0 1 1 w    mod 1 1 1 r/m		
Register-Byte		44-52	
Register-Word		53-61	
Memory-Byte		50-58	
Memory-Word		59-67	
<b>AAM</b> = ASCII adjust for multiply	1 1 0 1 0 1 0 0    0 0 0 0 1 0 1 0	19	
<b>AAD</b> = ASCII adjust for divide	1 1 0 1 0 1 0 1    0 0 0 0 1 0 1 0	15	
<b>CBW</b> = Convert byte to word	1 0 0 1 1 0 0 0	2	
<b>CWD</b> = Convert word to double word	1 0 0 1 1 0 0 1	4	
<b>LOGIC</b>			
<b>Shift/Rotate Instructions:</b>			
Register/Memory by 1	1 1 0 1 0 0 0 w    mod TTT r/m	2/15	
Register/Memory by CL	1 1 0 1 0 0 1 w    mod TTT r/m	5 + n/17 + n	
Register/Memory by Count	1 1 0 0 0 0 0 w    mod TTT r/m    count	5 + n/17 + n	
	<b>TTT Instruction</b>		
	0 0 0    ROL		
	0 0 1    ROR		
	0 1 0    RCL		
	0 1 1    RCR		
	1 0 0    SHL/SAL		
	1 0 1    SHR		
	1 1 1    SAR		
<b>AND</b> = And:			
Reg/memory and register to either	0 0 1 0 0 0 d w    mod reg r/m	3/10	
Immediate to register/memory	1 0 0 0 0 0 0 w    mod 1 0 0 r/m    data    data if w = 1	4/16	
Immediate to accumulator	0 0 1 0 0 1 0 w    data    data if w = 1	3/4	8/16-bit
<b>TEST</b> = And function to flags, no result:			
Register/memory and register	1 0 0 0 0 1 0 w    mod reg r/m	3/10	
Immediate data and register/memory	1 1 1 1 0 1 1 w    mod 0 0 0 r/m    data    data if w = 1	4/10	
Immediate data and accumulator	1 0 1 0 1 0 0 w    data    data if w = 1	3/4	8/16-bit
<b>OR</b> = Or:			
Reg/memory and register to either	0 0 0 0 1 0 d w    mod reg r/m	3/10	
Immediate to register/memory	1 0 0 0 0 0 0 w    mod 0 0 1 r/m    data    data if w = 1	4/16	
Immediate to accumulator	0 0 0 0 1 1 0 w    data    data if w = 1	3/4	8/16-bit

Shaded areas indicate instructions not available in 8086/8088 microsystems.



**INSTRUCTION SET SUMMARY** (Continued)

Function	Format	Clock Cycles	Comments
<b>LOGIC</b> (Continued)			
<b>XOR = Exclusive or:</b>			
Reg/memory and register to either	0 0 1 1 0 0 d w    mod reg r/m	3/10	8/16-bit
Immediate to register/memory	1 0 0 0 0 0 w    mod 1 1 0 r/m    data    data if w = 1	4/16	
Immediate to accumulator	0 0 1 1 0 1 0 w    data    data if w = 1	3/4	
<b>NOT</b> = Invert register/memory	1 1 1 1 0 1 1 w    mod 0 1 0 r/m	3/10	
<b>STRING MANIPULATION</b>			
<b>MOVS</b> = Move byte/word	1 0 1 0 0 1 0 w	14	
<b>CMPS</b> = Compare byte/word	1 0 1 0 0 1 1 w	22	
<b>SCAS</b> = Scan byte/word	1 0 1 0 1 1 1 w	15	
<b>LODS</b> = Load byte/wd to AL/AX	1 0 1 0 1 1 0 w	12	
<b>STOS</b> = Store byte/wd from AL/AX	1 0 1 0 1 0 1 w	10	
<b>INS</b> = Input byte/wd from DX port	0 1 1 0 1 1 0 w	14	
<b>OUTS</b> = Output byte/wd to DX port	0 1 1 0 1 1 1 w	14	
Repeated by count in CX (REP/REPE/REPZ/REPNE/REPNZ)			
<b>MOVS</b> = Move string	1 1 1 1 0 0 1 0    1 0 1 0 0 1 0 w	8 + 8n	
<b>CMPS</b> = Compare string	1 1 1 1 0 0 1 z    1 0 1 0 0 1 1 w	5 + 22n	
<b>SCAS</b> = Scan string	1 1 1 1 0 0 1 z    1 0 1 0 1 1 1 w	5 + 15n	
<b>LODS</b> = Load string	1 1 1 1 0 0 1 0    1 0 1 0 1 1 0 w	6 + 11n	
<b>STOS</b> = Store string	1 1 1 1 0 0 1 0    1 0 1 0 1 0 1 w	6 + 9n	
<b>INS</b> = Input string	1 1 1 1 0 0 1 0    0 1 1 0 1 1 0 w	8 + 8n	
<b>OUTS</b> = Output string	1 1 1 1 0 0 1 0    0 1 1 0 1 1 1 w	8 + 8n	
<b>CONTROL TRANSFER</b>			
<b>CALL</b> = Call:			
Direct within segment	1 1 1 0 1 0 0 0    disp-low    disp-high	15	
Register/memory indirect within segment	1 1 1 1 1 1 1 1    mod 0 1 0 r/m	13/19	
Direct intersegment	1 0 0 1 1 0 1 0    segment offset    segment selector	23	
Indirect intersegment	1 1 1 1 1 1 1 1    mod 0 1 1 r/m    (mod ≠ 11)	38	
<b>JMP</b> = Unconditional jump:			
Short/long	1 1 1 0 1 0 1 1    disp-low	14	
Direct within segment	1 1 1 0 1 0 0 1    disp-low    disp-high	14	
Register/memory indirect within segment	1 1 1 1 1 1 1 1    mod 1 0 0 r/m	11/17	
Direct intersegment	1 1 1 0 1 0 1 0    segment offset    segment selector	14	
Indirect intersegment	1 1 1 1 1 1 1 1    mod 1 0 1 r/m    (mod ≠ 11)	26	

Shaded areas indicate instructions not available in 8086/8088 microsystems.

**INSTRUCTION SET SUMMARY** (Continued)

Function	Format	Clock Cycles	Comments	
<b>CONTROL TRANSFER</b> (Continued)				
<b>RET = Return from CALL:</b>				
Within segment	11000011	16		
Within seg adding immed to SP	11000010    data-low    data-high	18		
Intersegment	11001011	22		
Intersegment adding immediate to SP	11001010    data-low    data-high	25		
<b>JE/JZ = Jump on equal/zero</b>	01110100    disp	4/13	JMP not taken/JMP taken	
<b>JL/JNGE = Jump on less/not greater or equal</b>	01111100    disp	4/13		
<b>JLE/JNG = Jump on less or equal/not greater</b>	01111110    disp	4/13		
<b>JB/JNAE = Jump on below/not above or equal</b>	01110010    disp	4/13		
<b>JBE/JNA = Jump on below or equal/not above</b>	01110110    disp	4/13		
<b>JP/JPE = Jump on parity/parity even</b>	01111010    disp	4/13		
<b>JO = Jump on overflow</b>	01110000    disp	4/13		
<b>JS = Jump on sign</b>	01111000    disp	4/13		
<b>JNE/JNZ = Jump on not equal/not zero</b>	01110101    disp	4/13		
<b>JNL/JGE = Jump on not less/greater or equal</b>	01111101    disp	4/13		
<b>JNLE/JG = Jump on not less or equal/greater</b>	01111111    disp	4/13		
<b>JNB/JAE = Jump on not below/above or equal</b>	01110011    disp	4/13		
<b>JNBE/JA = Jump on not below or equal/above</b>	01110111    disp	4/13		
<b>JNP/JPO = Jump on not par/par odd</b>	01111011    disp	4/13		
<b>JNO = Jump on not overflow</b>	01110001    disp	4/13		
<b>JNS = Jump on not sign</b>	01111001    disp	4/13		
<b>JCXZ = Jump on CX zero</b>	11100011    disp	5/15		
<b>LOOP = Loop CX times</b>	11100010    disp	6/16		LOOP not taken/LOOP taken
<b>LOOPZ/LOOPE = Loop while zero/equal</b>	11100001    disp	6/16		
<b>LOOPNZ/LOOPNE = Loop while not zero/equal</b>	11100000    disp	6/16		
<b>ENTER = Enter Procedure</b>	11001000    data-low    data-high    L			
L = 0		15		
L = 1		25		
L > 1		22 + 16(n - 1)		
<b>LEAVE = Leave Procedure</b>	11001001	8		
<b>INT = Interrupt:</b>				
Type specified	11001101    type	47		
Type 3	11001100	45	if INT. taken/ if INT. not taken	
<b>INTO = Interrupt on overflow</b>	11001110	48/4		
<b>IRET = Interrupt return</b>	11001111	28		
<b>BOUND = Detect value out of range</b>	01100010    mod reg r/m	33-35		

Shaded areas indicate instructions not available in 8086/8088 microsystems.

**INSTRUCTION SET SUMMARY (Continued)**

Function	Format	Clock Cycles	Comments
<b>PROCESSOR CONTROL</b>			
CLC = Clear carry	1 1 1 1 1 0 0 0	2	
CMC = Complement carry	1 1 1 1 0 1 0 1	2	
STC = Set carry	1 1 1 1 1 0 0 1	2	
CLD = Clear direction	1 1 1 1 1 1 0 0	2	
STD = Set direction	1 1 1 1 1 1 0 1	2	
CLI = Clear interrupt	1 1 1 1 1 0 1 0	2	
STI = Set interrupt	1 1 1 1 1 0 1 1	2	
HLT = Halt	1 1 1 1 0 1 0 0	2	
WAIT = Wait	1 0 0 1 1 0 1 1	6	if TEST = 0
LOCK = Bus lock prefix	1 1 1 1 0 0 0 0	2	
NOP = No Operation	1 0 0 1 0 0 0 0	3	
(TTT LLL are opcode to processor extension)			

Shaded areas indicate instructions not available in 8086/8088 microsystems.

**FOOTNOTES**

The Effective Address (EA) of the memory operand is computed according to the mod and r/m fields:

- if mod = 11 then r/m is treated as a REG field
- if mod = 00 then DISP = 0\*, disp-low and disp-high are absent
- if mod = 01 then DISP = disp-low sign-extended to 16-bits, disp-high is absent
- if mod = 10 then DISP = disp-high: disp-low
- if r/m = 000 then EA = (BX) + (SI) + DISP
- if r/m = 001 then EA = (BX) + (DI) + DISP
- if r/m = 010 then EA = (BP) + (SI) + DISP
- if r/m = 011 then EA = (BP) + (DI) + DISP
- if r/m = 100 then EA = (SI) + DISP
- if r/m = 101 then EA = (DI) + DISP
- if r/m = 110 then EA = (BP) + DISP\*
- if r/m = 111 then EA = (BX) + DISP

DISP follows 2nd byte of instruction (before data if required)

\*except if mod = 00 and r/m = 110 then EA = disp-high: disp-low.

EA calculation time is 4 clock cycles for all modes, and is included in the execution times given whenever appropriate.

**Segment Override Prefix**

0	0	1	reg	1	1	0
---	---	---	-----	---	---	---

reg is assigned according to the following:

reg	Segment Register
00	ES
01	CS
10	SS
11	DS

REG is assigned according to the following table:

16-Bit (w = 1)	8-Bit (w = 0)
000 AX	000 AL
001 CX	001 CL
010 DX	010 DL
011 BX	011 BL
100 SP	100 AH
101 BP	101 CH
110 SI	110 DH
111 DI	111 BH

The physical addresses of all operands addressed by the BP register are computed using the SS segment register. The physical addresses of the destination operands of the string primitive operations (those addressed by the DI register) are computed using the ES segment, which may not be overridden.

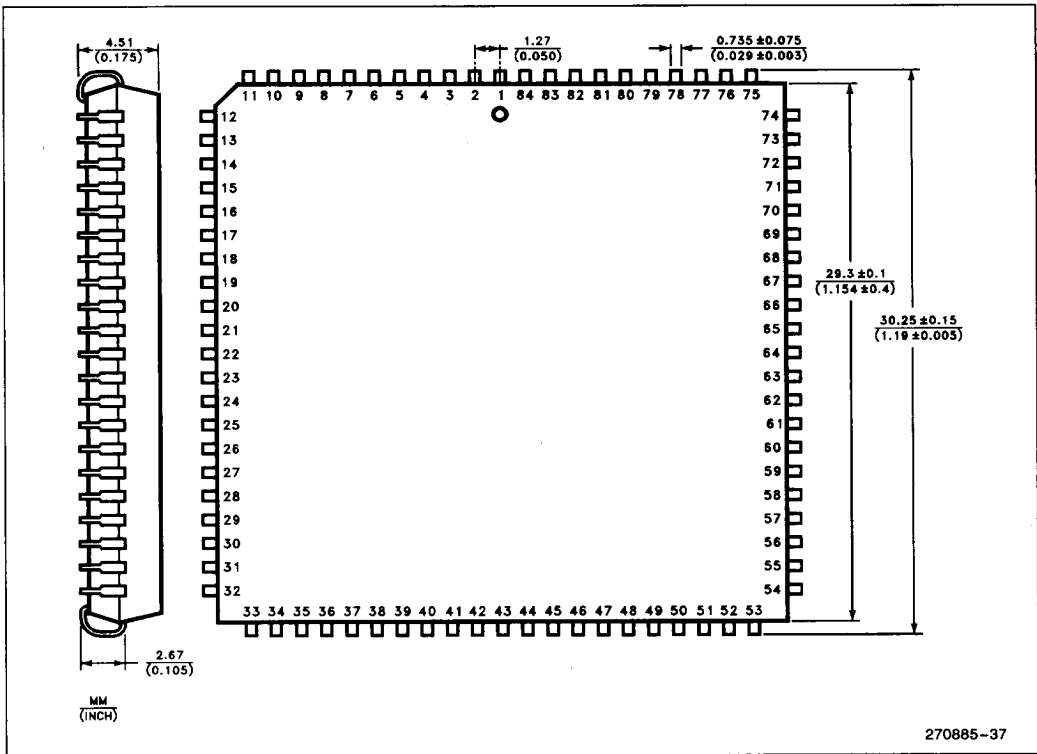
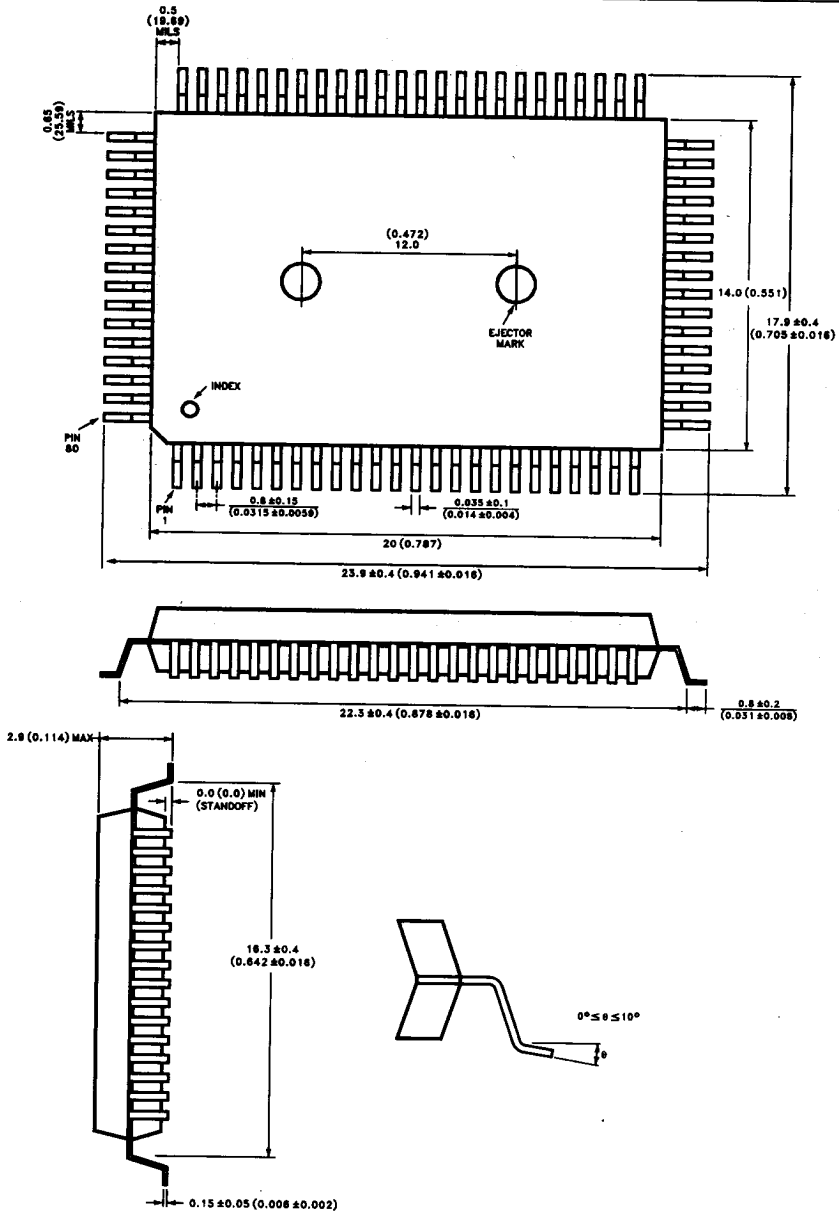


Figure 36. PLCC Principal Dimensions



270885-38

**NOTE:**  
Units are mm (inches) unless specified.

**Figure 37. QFP Principal Dimensions**

## ERRATA

An 80C188EB with a STEPID value of 0001H has the following known errata. A device with a STEPID of 0001H can be visually identified by noting the **absence** of an alpha character next to the FPO number or by the **presence** of an "A" alpha character next to the FPO number. The FPO number location is shown in Figures 8 and 9.

1.  $\overline{A19}/\overline{ONCE}$  is not latched by the rising edge of  $\overline{RESIN}$ .  $\overline{A19}/\overline{ONCE}$  must remain active (LOW) at all times to remain in the  $\overline{ONCE}^{\text{TM}}$  Mode. Removing  $\overline{A19}/\overline{ONCE}$  after  $\overline{RESIN}$  is high will return all output pins to a driving state, however, the 80C188EB will remain in a reset state.
2. During interrupt acknowledge (INTA) bus cycles, the bus controller will ignore the state of the READY pin if the previous bus cycle ignored the state of the READY pin. This errata can only occur if the Chip-Select Unit is being used. All active chip-selects must be programmed to use READY (RDY bit must be programmed to a 1) if wait-states are required for INTA bus cycles.
3. CLKOUT will transition off the **rising** edge of CLKIN rather than the falling edge of CLKIN. This does not affect any bus timings other than  $T_{CICO}$ .
4.  $\overline{RESIN}$  has a hysteresis of only 130 mV. It is recommended that  $\overline{RESIN}$  be driven with a Schmitt triggered device to avoid processor lockup during reset when using an RC circuit.
5. SINT1 will only go active for one clock period when a receive or transmit interrupt is pending (i.e., it does not remain active until the S1STS register is read). If SINT1 is to be connected to any of the 80C188EB interrupt lines (INT0-INT4), then it must be latched by user logic.

An 80C188EB with a STEPID value of 0002H has no known errata (as of this publication). A device with a STEPID value of 0002H can be visually identified by locating the "B" alpha character next to the FPO number. The FPO number location is shown in Figures 8 and 9.

## REVISION HISTORY

The following changes have been made between the -001 version and this (-002) version of the 80C188EB data sheet. This -002 data sheet applies to any 80C188EB with a "B" alpha character after the FPO number. The FPO number location is shown in Figures 8 and 9.

1. The data sheet was changed from a Product Preview version to an Advanced Information version.
2. Figures 1, 8, 9, 11, 15, 21, 23, 24, 25, 26, 27, 33, and 35 and Table 4 were updated to correct for errors.
3. The DC specifications table has changed. Also, notes 3, 4 and 5 have been changed/added.
4. Graphs for  $I_{CC}$  versus Frequency have been changed to equations with supporting text.
5. Graphs for PDTMR pin capacitance have been changed to equations with supporting text.
6. AC Hold timings have been changed from 0 ns to 3 ns.
7. READY input setup time has been changed from 13 ns to 10 ns.
8. Serial port MODE 0 timings have been changed.
9. Various typing errors have been corrected throughout the document.