SAB 8088
8-Bit Microprocessor

Preliminary

SAB 8088 5 MHz
SAB 8088-2 8 MHz

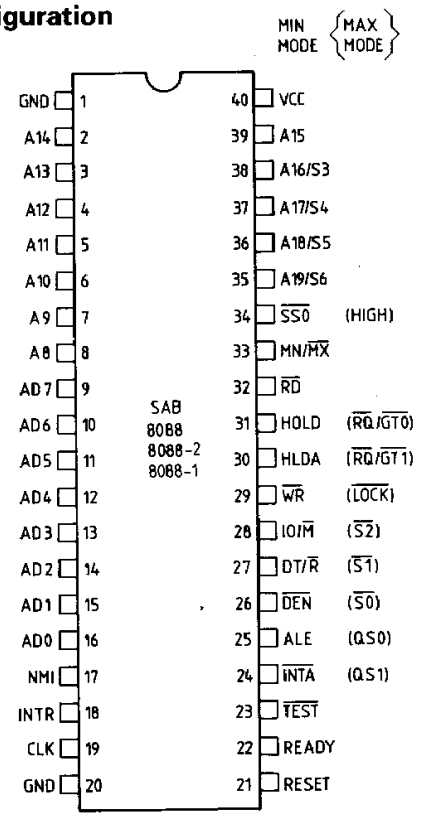
- 8-bit data bus interface
- 16-bit internal architecture
- Direct addressing capability to 1 Mbyte of memory
- Software compatible with SAB 8086
- 14-word by 16-bit register set with symetrical operations
- Byte, word and block operations
- 24 operand addressing modes

SAB 8088-1 10 MHz

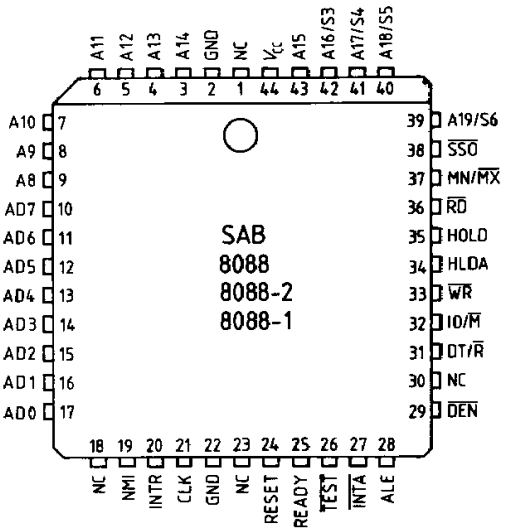
- 8-bit and 16-bit signed and unsigned arithmetic in binary or decimal, including multiply and divide
- Clock rates:
  5 MHz for SAB 8088
  8 MHz for SAB 8088-2
  10 MHz for SAB 8088-1
- Compatible with industry standard 8088
- Available in a 40-pin plastic dual-in-line package (P-DIP-40) or in a plastic leaded chip carrier package (PL-CC-44)

Pin Configuration

P-DIP-40



PL-CC-44



SAB 8088 is a high-performance 8-bit microprocessor implemented in +5V advanced Siemens MYMOS technology, packaged in a 40-pin plastic dual-in-line package (P-DIP-40) or in a 44-pin plastic leaded chip carrier package (PL-CC-44). It is 100 percent compatible with the industry standard 8088. With features like string handling, 16-bit arithmetic with multiply and divide it significantly increases system performance. It is highly suited for multi-processor applications in various configurations.

Pin Definitions and Functions

The following pin definitions are for SAB 8088 systems in **either minimum or maximum mode.** The "local bus" in these descriptions is the direct multiplexed bus interface connection to the SAB 8088 (without regard to additional bus buffers).

<table>
<tr><th>Symbol</th><th>Pin</th><th>Input (I)
Output (O)</th><th>Function</th></tr>
<tr><td>AD7–AD0</td><td>9–16</td><td>I/O</td><td>ADDRESS DATA BUS
These lines constitute the time multiplexed memory I/O address (T1) and data (T2, T3, Tw, and T4) bus. These lines are active high and float to tristate off during interrupt acknowledge and local bus "hold acknowledge".</td></tr>
<tr><td>A15–A8</td><td>39, 2–8</td><td>O</td><td>ADDRESS BUS
These lines provide address bits 8 through 15 for the entire bus cycle (T1–T4). These lines do not have to be latched by ALE to remain valid. A15–A8 are active high and float to tristate off during interrupt acknowledge and local bus "hold acknowledge".</td></tr>
<tr><td>A19/S6, A18/S5,
A17/S4, A16/S3</td><td>34–38</td><td>O</td><td>ADDRESS/STATUS
During T1, these are the four most significant address lines for memory operations. During I/O operations, these lines are low. During memory and I/O operations, status information is available on these lines during T2, T3, TW and T4. S6 is always low. The status of the interrupt enable flag bit (S5) is updated at the beginning of each clock cycle. S4 and S3 are encoded as shown.
<table>
<tr><th>S4</th><th>S3</th><th>Characteristics</th></tr>
<tr><td>0</td><td>0</td><td>Alternate Data</td></tr>
<tr><td>0</td><td>1</td><td>Stack</td></tr>
<tr><td>1</td><td>0</td><td>Code or None</td></tr>
<tr><td>1</td><td>1</td><td>Data</td></tr>
</table>
This information indicates which segment register is presently being used for data accessing.
These lines float to tristate off during local bus "hold acknowledge".</td></tr>
<tr><td>$\overline{RD}$</td><td>32</td><td>O</td><td>$\overline{READ}$
Read strobe indicates that the processor is performing a memory or I/O read cycle, depending on the state of the IO/$\overline{M}$ pin or S2. This signal is used to read devices which reside on the SAB 8088 local bus. $\overline{RD}$ is active low during T2, T3 and TW of any read cycle, and is guaranteed to remain high in T2 until the SAB 8088 local bus has floated.
This signal floats to tristate off in "hold acknowledge".</td></tr>
<tr><td>READY</td><td>22</td><td>I</td><td>READY
This is the acknowledgement from the addressed memory or I/O device that it will complete the data transfer. The RDY signal from memory or I/O is synchronized by the SAB 8284A/8284B clock generator to form READY. This signal is active high. The SAB 8088 READY input is not synchronized. Correct operation is not guaranteed if the setup and hold times are not met.</td></tr>
</table>

Pin Definitions and Functions (cont'd)

Symbol	Pin	Input (I) Output (O)	Function
INTR	18	I	**INTERRUPT REQUEST** This is a level triggered input which is sampled during the last clock cycle of each instruction to determine if the processor should enter into an interrupt acknowledge operation. A subroutine is vectored to via an interrupt vector lookup table located in system memory. It can be internally masked by software resetting the interrupt enable bit. INTR is internally synchronized. This signal is active high.
$\overline{\text{TEST}}$	23	I	**$\overline{\text{TEST}}$** This input is examined by the "wait for test" instruction. If the $\overline{\text{TEST}}$ input is low, execution continues, otherwise the processor waits in an "idle" state. This input is synchronized internally during each clock cycle on the leading edge of CLK.
NMI	17	I	**NON-MASKABLE INTERRUPT** This is an edge triggered input which causes a type 2 interrupt. A subroutine is vectored to via interrupt vector lookup table located in system memory. NMI is not maskable internally by software. A transition from low to high initiates the interrupt at the end of the current instruction. This input is internally synchronized.
RESET	21	I	**RESET** Causes the processor to immediately terminate its present activity. The signal must be active high for at least four clock cycles. It restarts execution, as described in the instruction set description, when RESET returns low. RESET is internally synchronized.
CLK	19	I	**CLOCK** Provides the basic timing for the processor and bus controller. It is asymmetric with a 33% duty cycle to provide optimized internal timing.
V_{CC}	40	–	**POWER SUPPLY** (+5V)
GND	1, 20	–	**GROUND** (0V)
MN/$\overline{\text{MX}}$	33	I	**MINIMUM/$\overline{\text{MAXIMUM}}$** Indicates what mode the processor is to operate in. The two modes are discussed in the following sections.

Pin Definitions and Functions (cont'd)

The following pin descriptions are for the SAB 8088 **minimum mode** (i.e. MN/$\overline{MX}$ = V_{CC}). Only the pin functions which are unique to minimum mode are described; all other pin functions are as already described.

Symbol	Pin	Input (I) Output (O)	Function
IO/$\overline{M}$	28	O	**STATUS LINE** Is an inverted maximum mode $\overline{S2}$. It is used to distinguish a memory access from an I/O access. IO/$\overline{M}$ becomes valid in the T4 preceding a bus cycle and remains valid until the final T4 of the cycle (I/$\overline{O}$ = high, M = low). IO/$\overline{M}$ floats to tristate off in local bus "hold acknowledge".
$\overline{WR}$	29	O	**$\overline{WRITE}$** The write strobe indicates that the processor is performing a write memory or write I/O cycle depending on the state of the IO/$\overline{M}$ signal. $\overline{WR}$ is active for T2, T3, and TW of any write cycle. It is active low, and floats to tristate off in local bus "hold acknowledge".
$\overline{INTA}$	24	O	**$\overline{INTERRUPT\ ACKNOWLEDGE}$** Is used as a read strobe for interrupt acknowledge cycles. It is active low during T2, T3, and TW of each interrupt acknowledge cycle.
ALE	25	O	**ADDRESS LATCH ENABLE** Is provided by the processor to latch the address into the SAB 8282 /8282A/8283/8283A address latch. It is a high pulse active during clock low of T1 of any bus cycle. Note that ALE is never floated.
DT/$\overline{R}$	27	O	**DATA TRANSMIT/$\overline{RECEIVE}$** Is needed in a minimum system that desires to use an SAB 8286/8286A/8287/8287A data bus transceiver. It is used to control the direction of data flow through the transceiver. Logically, DT/$\overline{R}$ is equivalent to $\overline{S1}$ in the maximum mode, and its timing is the same as for IO/$\overline{M}$ (T = high, R = low). This signal floats to tristate off in local "hold acknowledge".
$\overline{DEN}$	26	O	**$\overline{DATA\ ENABLE}$** Is provided as an output enable for the SAB 8286/8286A/ 8287/8287A in a minimum system which uses the transceiver. $\overline{DEN}$ is active low during each memory and I/O access, and for $\overline{INTA}$ cycles. For a read or $\overline{INTA}$ cycle, it is active from the middle of T2 until the middle of T4, while for a write cycle, it is active from the beginning of T2 until the middle of T4. $\overline{DEN}$ floats to tristate off during local bus "hold acknowledge".
HOLD, HLDA	31, 30	I/O	**HOLD** Indicates that another master is requesting a local bus "hold". To be acknowledged, HOLD must be active high. The processor receiving the "hold" request will issue HLDA (high) as an acknowledgement, in the middle of a T4 or T1 clock cycle. Simultaneous with the issuance of HLDA the processor will float the local bus and control lines. After HOLD is detected as being low, the processor lowers HLDA, and when the processor needs to run another cycle, it will again drive the local bus and control lines. HOLD is not an asynchronous input. External synchronization should be provided if the system cannot otherwise guarantee the setup time.

Pin Definitions and Functions (cont'd)

Symbol	Pin	Input (I) Output (O)	Function
$\overline{SS0}$	34	O	**STATUS LINE** It is logically equivalent to $\overline{S0}$ in the maximum mode. The combination of $\overline{SS0}$, IO/$\overline{M}$ and DT/$\overline{R}$ allows the system to completely decode the current bus cycle status.

IO/$\overline{M}$	DT/$\overline{R}$	$\overline{SS0}$	Characteristics
1	0	0	Interrupt Acknowledge
1	0	1	Read I/O Port
1	1	0	Write I/O Port
1	1	1	Halt
0	0	0	Code Access
0	0	1	Read Memory
0	1	0	Write Memory
0	1	1	Passive

Pin Definitions and Functions (cont'd)

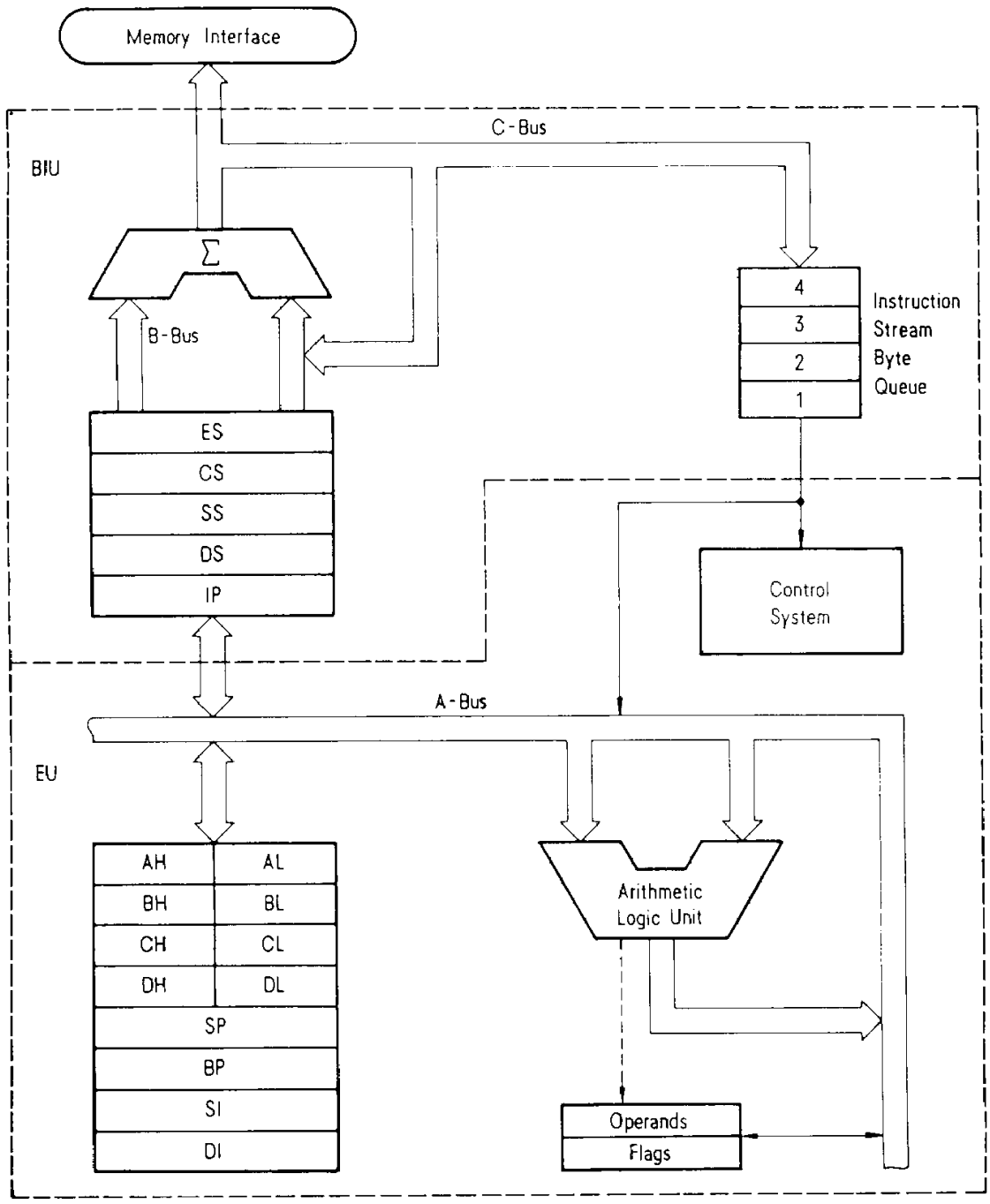
The following pin descriptions are for the SAB 8088/8288 system in **maximum mode** (i.e. MN/$\overline{MX}$ = GND). Only the pin functions which are unique to maximum mode are described. All other pin functions are as already described.

<table>
<tr><th>Symbol</th><th>Pin</th><th>Input (I)
Output (O)</th><th>Function</th></tr>
<tr><td>$\overline{S2}$, $\overline{S1}$, $\overline{S0}$</td><td>28–26</td><td>O</td><td>STATUS
Is active during clock high of T4, T1, and T2, and is returned to the passive state (1,1,1) during T3 or during TW when READY is high. This status is used by the SAB 8288/8288A bus controller to generate all memory and I/O access control signals. Any change by $\overline{S2}$, $\overline{S1}$, or $\overline{S0}$ during T4 is used to indicate the beginning of a bus cycle, and the return to the passive state in T3 or TW is used to indicate the end of a bus cycle.
These signals float to tristate off during "hold acknowledge". During the first clock cycle after RESET becomes active, these signals are active high. After this first clock, they float to tristate off.
<table>
<tr><th>$\overline{S2}$</th><th>$\overline{S1}$</th><th>$\overline{S0}$</th><th>Characteristics</th></tr>
<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 Port</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>Write I/O Port</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>Halt</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>Code Access</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</td></tr>
</table>
</td></tr>
<tr><td>$\overline{RQ}$/$\overline{GT0}$
$\overline{RQ}$/$\overline{GT1}$</td><td>31
30</td><td>I/O
I/O</td><td>$\overline{REQUEST}$/$\overline{GRANT}$
Pins are used by other local bus masters to force the processor to release the local bus at the end of the processor's current bus cycle. Each pin is bidirectional with $\overline{RQ}$/$\overline{GT0}$ having higher priority than $\overline{RQ}$/$\overline{GT1}$. $\overline{RQ}$/$\overline{GT}$ has an internal pullup resistor so may be left unconnected. The request/grant sequence is as follows (see page 38):
1. A pulse of one CLK wide from another local bus master indicates a local bus request ("hold") to the SAB 8088 (pulse 1).
2. During a T4 or T1 clock cycle, a pulse one clock wide from the SAB 8088 to the requesting master (pulse 2), indicates that the SAB 8088 has allowed the local bus to float and that it will enter the "hold acknowledge" state at the next CLK. The CPU's bus interface unit is disconnected logically from the local bus during "hold acknowledge". The same rules as for HOLD/HOLDA apply as for when the bus is released.
3. A pulse one CLK wide from the requesting master indicates to the SAB 8088 (pulse 3) that the "hold" request is about to end and that the SAB 8088 can reclaim the local bus at the next CLK. The CPU then enters T4.
Each master-master exchange of the local bus is a sequence of three pulses. There must be one idle CLK cycle after each bus exchange. Pulses are active low.</td></tr>
</table>

Pin Definitions and Functions (cont'd)

<table>
<tr><th>Symbol</th><th>Pin</th><th>Input (I)
Output (O)</th><th>Function</th></tr>
<tr><td></td><td></td><td></td><td>If the request is made while the CPU is performing a memory cycle, it will release the local bus during T4 of the cycle when all the following conditions are met:
1. Request occurs on or before T2.
2. Current cycle is not the low byte of a word.
3. Current cycle is not the first acknowledge of an interrupt acknowledge sequence.
4. A locked instruction is not currently executing.
If the local bus is idle when the request is made the two possible events will follow:
1. Local bus will be released during the next clock.
2. A memory cycle will start within 3 clocks. Now the four rules for a currently active memory cycle apply with condition number 1 already satisfied.</td></tr>
<tr><td>$\overline{\text{LOCK}}$</td><td>29</td><td>O</td><td>$\overline{\text{LOCK}}$
Indicates that other system bus masters are not to gain control of the system bus while $\overline{\text{LOCK}}$ is active (low). The $\overline{\text{LOCK}}$ signal is activated by the "LOCK" prefix instruction and remains active until the completion of the next instruction. This signal is active low, and floats to tristate off in "hold acknowledge".</td></tr>
<tr><td>QS1, QS0</td><td>24, 25</td><td>O</td><td>QUEUE STATUS
Provide status to allow external tracking of the internal SAB 8088 instruction queue.
The queue status is valid during the CLK cycle after which the queue operation is performed.
<table>
<tr><th>QS1</th><th>QS0</th><th>Characteristics</th></tr>
<tr><td>0</td><td>0</td><td>No Operation</td></tr>
<tr><td>0</td><td>1</td><td>First Byte of Op Code from Queue</td></tr>
<tr><td>1</td><td>0</td><td>Empty the Queue</td></tr>
<tr><td>1</td><td>1</td><td>Subsequent Byte from Queue</td></tr>
</table></td></tr>
<tr><td>–</td><td>34</td><td>O</td><td>Pin 34 is always high in the maximum mode.</td></tr>
</table>

Block Diagram



Functional Description

Memory Organization

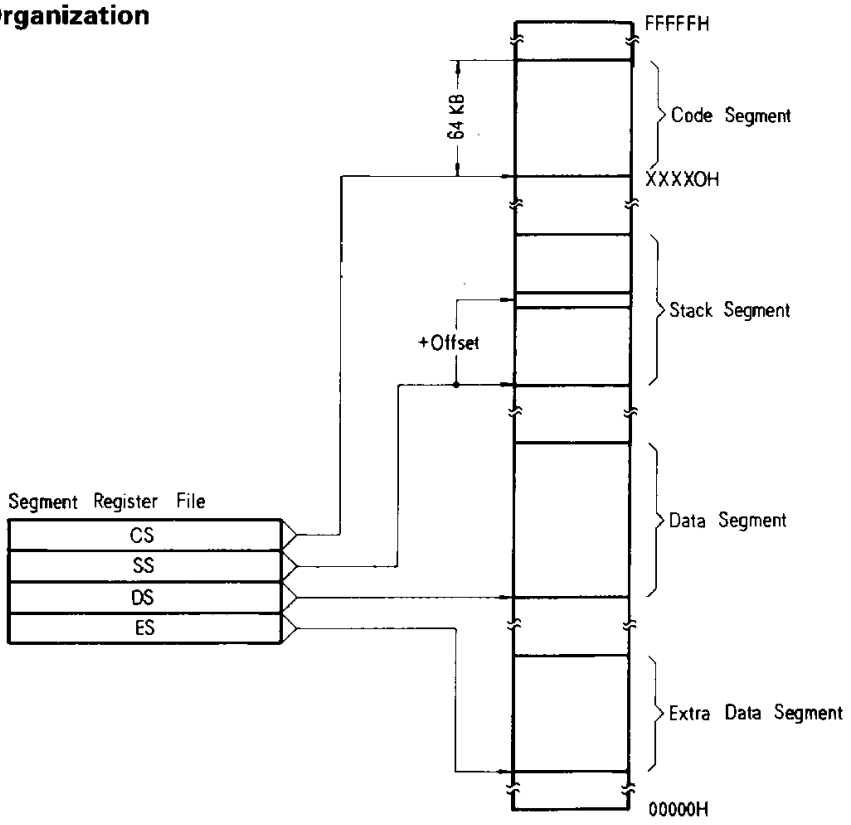
The processor provides a 20-bit address to memory which locates the byte being referenced. The memory is organized as a linear array of up to 1 million bytes, addressed as 00000(H) to FFFFF(H). The memory is logically divided into code, data, extra data, and stack segments of up to 64 Kbytes each, with each segment falling on 16-byte boundaries.

All memory references are made relative to base addresses contained in high-speed segment registers. The segment types were chosen based on the addressing needs of programs. The segment register to be selected is automatically chosen according to the rules of the following table. All information in one segment type shares the same logical attributes (e.g. code or data). By structuring memory into relocatable areas of similar characteristics and by automatically selecting segment registers, programs are shorter, faster, and more structured.

Word (16-bit) operands can be located on even or odd address boundaries. For address and data operands, the least significant byte of the word is stored in the lower valued address location and the most significant byte in the next higher address location. The BIU will automatically execute two fetch or write cycles for 16-bit operands.

Certain locations in memory are reserved for specific CPU operations. Locations from addresses FFFF0H trough FFFFFH are reserved for operations including a jump to the initial system initialization routine. Following RESET, the CPU will always begin execution at location FFFF0H where the jump must be located. Locations 00000H through 003FFH are reserved for interrupt operations. Four-byte pointers consisting of a 16-bit segment address and a 16-bit offset address direct program flow to one of the 256 possible interrupt service routines. The pointer elements are assumed to have been stored at their respective places in reserved memory prior to the occurrence of interrupts.

Memory Organization



Minimum and Maximum Modes

The requirements for supporting minimum and maximum mode in SAB 8088 systems are sufficiently different that they cannot be met efficiently with 40 uniquely defined pins. Consequently, the SAB 8088 is equipped with a strap pin (MN/$\overline{MX}$) which defines the system configuration. The definition of a certain subset of the pins changes, dependent on the condition of the strap pin. When the MN/$\overline{MX}$ pin is strapped to GND, the SAB 8088 defines pins 24 through 31 and 34 in maximum mode. When the MN/$\overline{MX}$ pin is strapped to VCC, the SAB 8088 generates bus control signals itself on pins 24 through 31 and 34.

The minimum mode SAB 8088 can be used with either a multiplexed or demultiplexed bus. The multiplexed bus configuration is compatible with the SAB 8085A multiplexed bus peripherals (e.g. SAB 8155) and provides the user with a minimum chip count system. This architecture provides the SAB 8088 processing power in a highly integrated form.

The demultiplexed mode requires one latch (for 64K addressability) or two latches (for a full megabyte of addressing). A third latch can be used for buffering if the address bus loading requires it. An SAB 8286/8286A or SAB 8287/8287A transceiver can also be used if data bus buffering is required. The SAB 8088 provides $\overline{DEN}$ and DT/$\overline{R}$ to control the transceiver, and ALE to latch the addresses. This configuration of the minimum mode provides the standard demultiplexed bus structure with heavy bus buffering and relaxed bus timing requirements.

The maximum mode employs the SAB 8288/8288A bus controller. The SAB 8288/8288A decodes status lines $\overline{S0}$, $\overline{S1}$, and $\overline{S2}$, and provides the system with all bus control signals. Moving the bus control to the SAB 8288/8288A provides better source and sink current capability to the control lines, and frees the SAB 8088 pins for extended large system features. Hardware lock, queue status, and two request/grant interfaces are provided by the SAB 8088 in maximum mode. These features allow coprocessors in local bus and remote bus configurations.

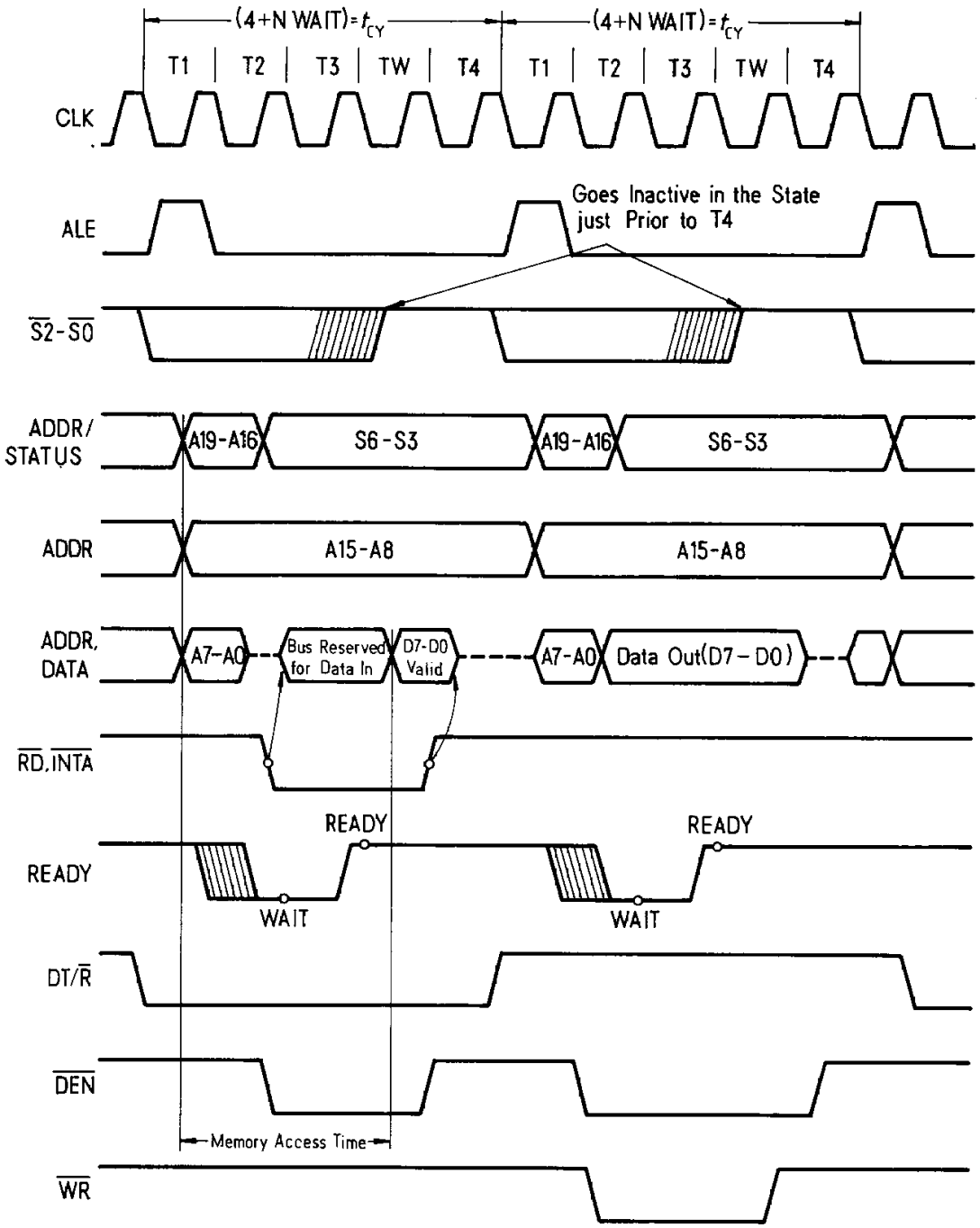
Bus Operation

The SAB 8088 address/data bus is broken into three parts – the lower eight address/data bits (AD0–AD7), the midle eight address bits (A8–A15), and the upper four address bits (A16–A19). The address/data bits and the highest four address bits are time multiplexed. This technique provides the most efficient use of pins on the processor, permitting the use of a standard 40 lead package. The middle eight address bits are not multiplexed, i.e. they remain valid throughout each bus cycle. In addition, the bus can be demultiplexed at the processor with a single address latch if a standard, non-multiplexed bus is desired for the system.

Each processor bus cycle consists of at least four CLK cycles. These are referred to as T1, T2, T3 and T4. The address is emitted from the processor during T1 and data transfer occurs on the bus during T3 and T4. T2 is used primarily for changing the direction of the bus during read operations. In the event that a "NOT READY" indication is given by the addressed device, wait states (TW) are inserted between T3 and T4. Each inserted wait state is of the same duration as a CLK cycle. Periods can occur between SAB 8088 driven bus cycles. These are referred to as "idle" states (Ti), or inactive CLK cycles. The processor uses these cycles for internal housekeeping.

During T1 of any bus cycle, the ALE (address latch enable) signal is emitted (by either the processor or the SAB 8288/8288A bus controller, depending on the MN/$\overline{MX}$ strap). At the trailing edge of this pulse, a valid address and certain status information for the cycle may be latched.

Basic System Timing



Status bits $\overline{S0}$, $\overline{S1}$, and $\overline{S2}$ are used, in maximum mode, by the bus controller to identify the type of bus transaction according to the following table:

$\overline{S2}$	$\overline{S1}$	$\overline{S0}$	Characteristics
0 (Low)	0	0	Interrupt Acknowledge
0	0	1	Read I/O
0	1	0	Write I/O
0	1	1	Halt
1 (High)	0	0	Instruction Fetch
1	0	1	Read Data from Memory
1	1	0	Write Data to Memory
1	1	1	Passive (no bus cycle)

Status bits S3 through S6 are multiplexed with highorder address bits and are therefore valid during T2 through T4. S3 and S4 indicate which segment register was used for this bus cycle in forming the address according to the following table:

S4	S3	Characteristics
0 (Low)	0	Alternate Data (extra segment)
0	1	Stack
1 (High)	0	Code or None
1	1	Data

S5 is a reflection of the PSW interrupt enable bit. S6 is always equal to 0.

I/O Addressing

In the SAB 8088, I/O operations can address up to a maximum of 64 K I/O registers. The I/O address appears in the same format as the memory address on bus lines A15 to A0. The address lines A19 to A16 are zero in I/O operations. The variable I/O instructions, which use register DX as a pointer have full address capability, while the direct I/O instructions directly address one or two of the 256 I/O byte locations in page 0 of the I/O address space. I/O ports are addressed in the same manner as memory locations.

Design engineers familiar with the SAB 8085 or upgrading an SAB 8085 design should observe that the SAB 8085 addresses I/O with an 8-bit address on both halves of the 16-bit address bus. The SAB 8088 uses a full 16-bit address on its lower 16 address lines.

System Components

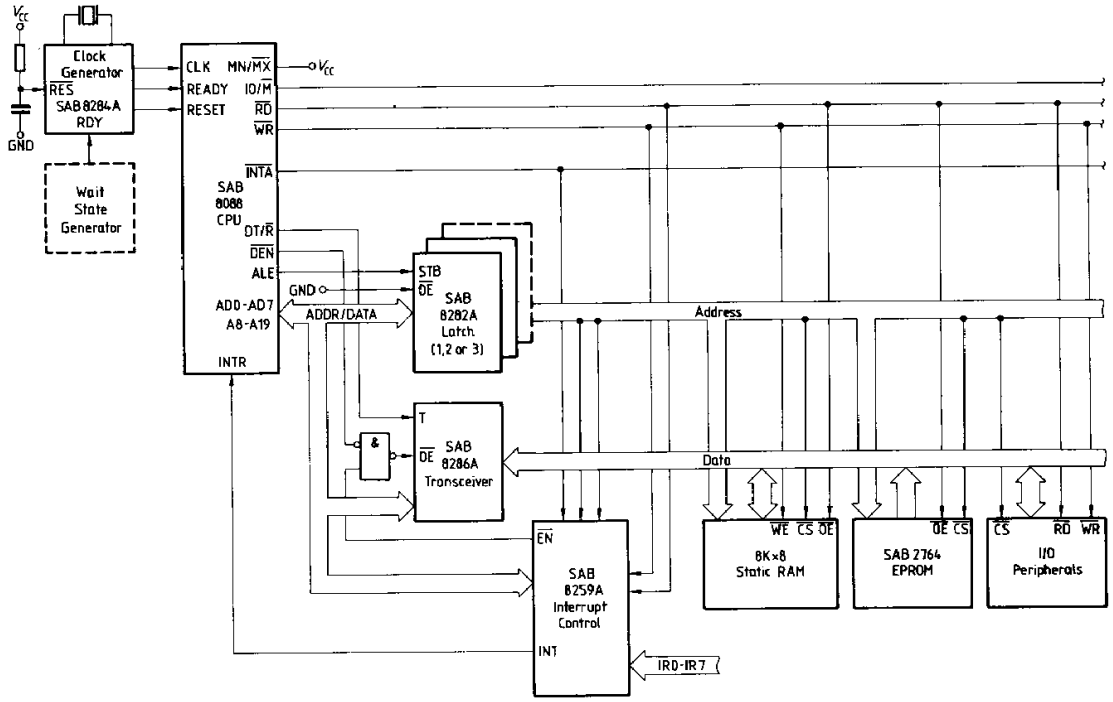
Support Circuits

SAB 8282/8282A	Octal Latch
SAB 8283/8283A	Octal Latch (inverting)
SAB 8284A/8284B	Clock Generator and Driver
SAB 8286/8286A	Octal Bus Transceiver
SAB 8287/8287A	Octal Bus Transceiver (inverting)
SAB 8288/8288A	Bus Controller
SAB 8289	Bus Arbiter
SAB 8259A	Programmable Interrupt Controller

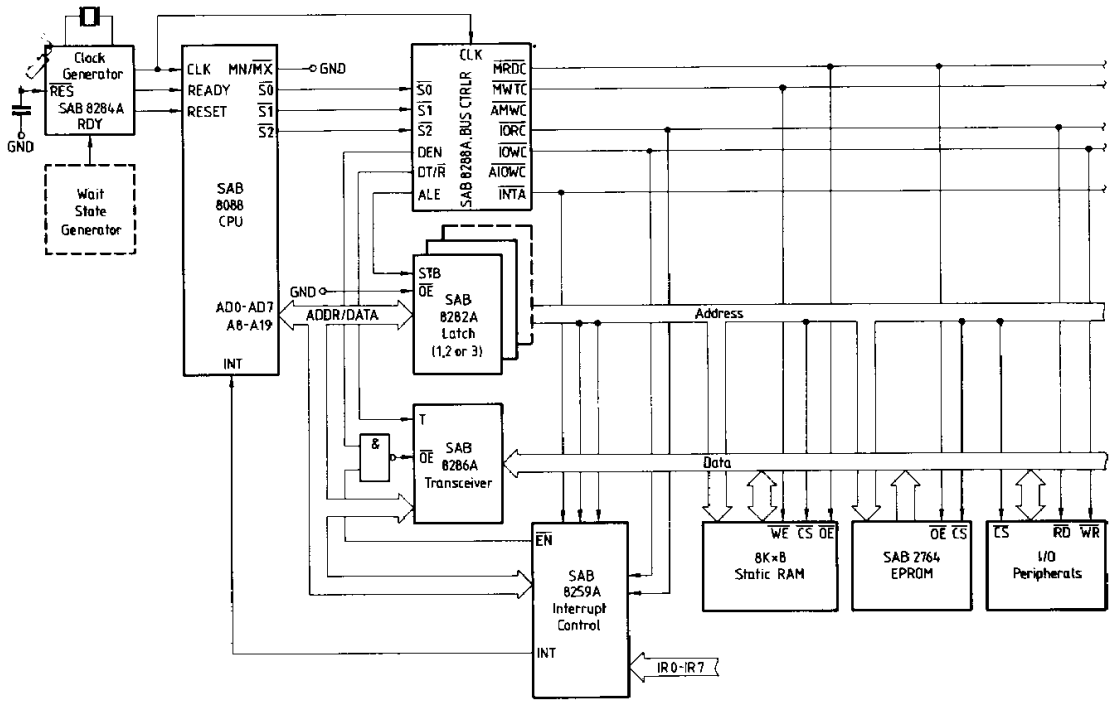
Typical Applications

The SAB 8088 is a general-purpose 8-bit micro processor which can be used for applications ranging from process control to data processing. The next page shows typical system configurations for SAB 8088 familiy components.

Minimum Mode SAB 8088 Typical System Configuration



Maximum Mode SAB 8088 Typical System Configuration



Instruction Set Summary

Data Transfer

MOV = Move:	76543210	76543210	76543210	76543210
Register / memory to / from register	100010dw	mod reg r/m		
Immediate to register/memory	1100011w	mod 000 r/m	data	data if w=1
Immediate to register	1011w reg	data	data if w=1	
Memory to accumulator	1010000w	addr-low	addr-high	
Accumulator to memory	1010001w	addr-low	addr-high	
Register/memory to segment register	10001110	mod 0 reg r/m		
Segment register to register/memory	10001100	mod 0 reg r/m		
PUSH = Push:				
Register/memory	11111111	mod 110 r/m		
Register	01010 reg			
Segment register	000 reg 110			
POP = Pop:				
Register/memory	10001111	mod 000 r/m		
Register	01011 reg			
Segment register	000 reg 111			
XCHG = Exchange:				
Register/memory with register	1000011w	mod reg r/m		
Register with accumulator	10010 reg			
IN = Input from:				
Fixed port	1110010w	port		
Variable port	1110110w			

OUT = Output to:	76543210	76543210	76543210	76543210
Fixed port	1110011w	port		
Variable port	1110111w			
XLAT = Translate byte to AL	11010111			
LEA = Load EA to register	10001101	mod reg r/m		
LDS = Load pointer to DS	11000101	mod reg r/m		
LES = Load pointer to ES	11000100	mod reg r/m		
LAHF = Load AH with flags	10011111			
SAHF = Store AH into flags	10011110			
PUSHF = Push flags	10011100			
POPF =Pop flags	10011101			

Arithmetic
ADD = Add:

Reg./memory with register to either	000000dw	mod reg r/m		
Immediate to register/memory	100000sw	mod 000 r/m	data	data if s:w=01
Immediate to accumulator	0000010w	data	data if w=1	

ADC = Add with carry:

Reg./memory with register to either	000100dw	mod reg r/m		
Immediate to register/memory	100000sw	mod 010 r/m	data	data if s:w=01
Immediate to accumulator	0001010w	data	data if w=1	

INC = Increment:

Register/memory	1111111w	mod 000 r/m
Register	01000reg	
AAA = ASCII adjust for add	00110111	
DAA = Decimal adjust for add	00100111	

SUB = Subtract:	76543210	76543210	76543210	76543210
Reg./memory and register to either	001010dw	mod reg r/m		
Immediate from register/memory	100000sw	mod 101 r/m	data	data if s:w=01
Immediate from accumulator	0010110w	data	data if w=1	

SBB = Subtract with borrow:				
Reg./memory and register to either	000110dw	mod reg r/m		
Immediate from register/memory	100000sw	mod 011 r/m	data	data if s:w=01
Immediate from accumulator	0001110w	data	data if w=1	

DEC = Decrement:	76543210	76543210	76543210	76543210
Register/memory	1111111w	mod 001 r/m		
Register	01001reg			
NEG = Change sign	1111011w	mod 011 r/m		

CMP = Compare:				
Register/memory and register	001110dw	mod reg r/m		
Immediate with register/memory	100000sw	mod 111 r/m	data	data if s:w=01
Immediate with accumulator	0011110w	data	data if w=1	
AAS = ASCII adjust for subtract	00111111			
DAS = Decimal adjust for subtract	00101111			
MUL = Multiply (unsigned)	1111011w	mod 100 r/m		
IMUL = Integer multiply (signed)	1111011w	mod 101 r/m		
AAM = ASCII adjust for multiply	11010100	00001010		
DIV = Divide (unsigned)	1111011w	mod 110 r/m		
IDIV = Integer divide (signed)	1111011w	mod 111 r/m		
AAD = ASCII adjust for divide	11010101	00001010		
CBW = Convert byte to word	10011000			
CWD = Convert word to double word	10011001			

Logic	76543210	76543210	76543210	76543210
NOT = Invert	1111011w	mod 010 r/m		
SHL/SAL = Shift logical/arithmetic left	110100vw	mod 100 r/m		
SHR = Shift logical right	110100vw	mod 101 r/m		
SAR = Shift arithmetic right	110100vw	mod 111 r/m		
ROL = Rotate left	110100vw	mod 000 r/m		
ROR = Rotate right	110100vw	mod 001 r/m		
RCL = Rotate through carry flag left	110100vw	mod 010 r/m		
RCR = Rotate through carry flag right	110100vw	mod 011 r/m		
AND = And:				
Reg./memory and register to either	001000dw	mod reg r/m		
Immediate to register/memory	1000000w	mod 100 r/m	data	data if w=1
Immediate to accumulator	0010010w	data	data if w=1	
TEST = And function to flags, no result:				
Register/memory and register	1000010w	mod reg r/m		
Immediate data and register/memory	1111011w	mod 000 r/m	data	data if w=1
Immediate data and accumulator	1010100w	data	data if w=1	
OR = Or:				
Reg./memory and register to either	000010dw	mod reg r/m		
Immediate to register/memory	1000000w	mod 001 r/m	data	data if w=1
Immediate to accumulator	0000110w	data	data if w=1	
XOR = Exclusive Or:				
Reg./memory and register to either	001100dw	mod reg r/m		
Immediate to register/memory	1000000w	mod 110 r/m	data	data if w=1
Immediate to accumulator	0011010w	data	data if w=1	

String Manipulation	**76543210**	**76543210**	**76543210**
REP = Repeat	1111001z		
MOVS = Move byte/word	1010010w		
CMPS = Compare byte/word	1010011w		
SCAS = Scan byte/word	1010111w		
LODS = Load byte/word to AL/AX	1010110w		
STOS = Store byte/word from AL/A	1010101w		

Control Transfer

CALL = **Call:**

Direct within segment	11101000	disp-low	disp-high
Indirect within segment	11111111	mod 010 r/m	
Direct intersegment	10011010	offset-low	offset-high
		seg-low	seg-high
Indirect intersegment	11111111	mod 011 r/m	

JMP = **Unconditional jump:**

Direct within segment	11101001	disp-low	disp-high
Direct within segment short	11101011	disp	
Indirect within segment	11111111	mod 100 r/m	
Direct intersegment	11101010	offset-low	offset-high
		seg-low	seg-high
Indirect intersegment	11111111	mod 101 r/m	

RET = Return from CALL:	**76543210**	**76543210**	**76543210**
Within segment	11000011		
Within seg. adding immediate to SP	11000010	data-low	data-high
Intersegment	11001011		
Intersegment adding immediate to SP	11001010	data-low	data-high
JE/JZ = Jump on equal/zero	01110100	disp	
JL/JNGE = Jump on less/not greater or equal	01111100	disp	
JLE/JNG = Jump on less or equal/not greater	01111110	disp	
JB/JNAE = Jump on below/not above or equal	01110010	disp	
JBE/JNA = Jump on below or equal/ not above	01110110	disp	
JP/JPE = Jump on parity/parity even	01111010	disp	
JO = Jump on overflow	01110000	disp	
JS = Jump on sign	01111000	disp	
JNE/JNZ = Jump on not equal/not zero	01110101	disp	
JNL/JGE = Jump on not less/greater or equal	01111101	disp	
JNLE/JG = Jump on not less or equal/ greater	01111111	disp	
JNB/JAE = Jump on not below/above or equal	01110011	disp	
JNBE/JA = Jump on not below or equal/above	01110111	disp	
JNP/JPO = Jump on not parity/parity odd	01111011	disp	
JNO = Jump on not overflow	01110001	disp	
JNS = Jump on not sign	01111001	disp	
LOOP = Loop CX times	11100010	disp	
LOOPZ/LOOPE = Loop while zero/equal	11100001	disp	
LOOPNZ/LOOPNE = Loop while not zero/equal	11100000	disp	
JCXZ = Jump on CX zero	11100011	disp	

INT = Interrupt	**76543210**	**76543210**
Type specified	11001101	type
Type 3	11001100	
INTO = Interrupt on overflow	11001110	
IRET = Interrupt return	11001111	

Processor Control

CLC = Clear carry	11111000	
CMC = Complement carry	11110101	
STC = Set carry	11111001	
CLD = Clear direction	11111100	
STD = Set direction	11111101	
CLI = Clear interrupt	11111010	
STI = Set interrupt	11111011	
HLT = Halt	11110100	
WAIT = Wait	10011011	
ESC = Escape (to external device)	11011xxx	mod x x x r/m
LOCK = Bus lock prefix	11110000	

Notes:

AL = 8-bit accumulator
AX = 16-bit accumulator
CX = Count register
DS = Data segment
ES = Extra segment
Above/below refers to unsigned value.
Greater = more positive;
Less = less positive (more negative) signed values
if d = 1 then "to" reg; if d = 0 then "from" reg
if w = 1 then word instruction; if w = 0 then byte instruction
if s:w = 01 then 16-bits of immediate data from the operand
it s:w = 11 then an immediate data byte is sign extended to form the 16-bit operand
if v = 0 then "count" = 1; if v = 1 then "count" in (CL)
x = don't care
z is used for string primitives for comparsion with ZF FLAG

Segment Override Prefix

0 0 1 reg 1 1 0

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.

REG is assigned according to the following table

16-bit (w=1)	8-bit (w=0)	Segment
000 AX	000 AL	00 ES
001 CX	001 CL	01 CS
010 DX	010 DL	10 SS
011 BX	011 BL	11 DS
100 SP	100 AH	
101 BP	101 CH	
110 SI	110 DH	
111 DI	111 BH	

Instruction which reference the flag register file as a 16-bit object use the symbol FLAGS to represent the file:

FLAGS = X:X:X:X:(OF):(DF):(IF):(TF):(SF):(ZF):X:(AF):X:(PF):X:(CF)

Absolute Maximum Ratings

Ambient temperature under bias	0 to 70°C
Storage temperature	−65 to +150°C
Voltage on any pin with respect to ground	−1.0 to +7V
Power dissipation	2.5 W

Note:
Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

DC Characteristics

SAB 8088: T_A = 0 to 70°C, V_{CC} = 5V ±10%
SAB 8088-2: T_A = 0 to 70°C, V_{CC} = 5V ± 5%
SAB 8088-1: T_A = 0 to 70°C, V_{CC} = 5V ± 5%

Parameter	Symbol	Limit values		Unit	Test conditions
		min.	max.		
Input low voltage	V_{IL}	−0.5	+0.8	V	1)
Input high voltage	V_{IH}	2.0	V_{CC}+0.5	V	1) 2)
Output low voltage	V_{OL}	–	0.45	V	I_{OL} = 2.0 mA
Output high voltage	V_{OH}	2.4	–	V	I_{OH} = −400 µA
Power supply current	I_{CC}	–	340	mA	All outputs open T_A = 25°C
Input leakage current	I_{LI}	–	±10	µA	0V ≤ V_{IN} ≤ V_{CC}
Output leakage current	I_{LO}	–	±10	µA	0.45V ≤ V_{OUT} ≤ V_{CC}
Clock input low voltage	V_{CL}	−0.5	+0.6	V	–
Clock input high voltage	V_{CH}	3.9	V_{CC}+1.0	V	–
Capacitance of input buffer (all inputs except AD0 to AD7, RQ/GT)	C_{IN}	–	15	pF	f_c = 1 MHz
Capacitance of I/O buffer (AD0 to AD7, RQ/GT)	C_{IO}	–	15	pF	f_c = 1 MHz

1) V_{IL} tested with MN/$\overline{MX}$ in = 0V
V_{IH} tested with MN/$\overline{MX}$ in = 5V
MN/$\overline{MX}$ pin is a strap pin.

2) Not applicable to $\overline{RG}$/$\overline{GT0}$ and $\overline{RG}$/$\overline{GT1}$ pins (pins 30 and 31)

AC Characteristics for SAB 8088/8088-2

SAB 8088: $T_A = 0$ to 70°C, $V_{CC} = 5\,V \pm 10\%$
SAB 8088-2: $T_A = 0$ to 70°C, $V_{CC} = 5\,V \pm 5\%$

Minimum Complexity System Timing Requirements

Parameter	Symbol	Limit values				Unit	Test conditions
		SAB 8088		SAB 8088-2			
		min.	max.	min.	max.		
CLK cycle period	t_{CLCL}	200	500	125	500	ns	–
CLK low time	t_{CLCH}	118	–	68	–	ns	–
CLK high time	t_{CHCL}	69	–	44	–	ns	–
CLK rise time	t_{CH1CH2}	–	10	–	10	ns	from 1.0 to 3.5V
CLK fall time	t_{CL2CL1}	–	10	–	10	ns	from 3.5 to 1.0V
Data in setup time	t_{DVCL}	30	–	20	–	ns	–
Data in hold time	t_{CLDX}	10	–	10	–	ns	–
RDY setup time into SAB 8284A/8284B [1) 2)]	t_{R1VCL}	35	–	35	–	ns	–
RDY hold time into SAB 8284A/8284B [1) 2)]	t_{CLR1X}	0	–	0	–	ns	–
READY setup time into SAB 8088	t_{RYHCH}	118	–	68	–	ns	–
READY hold time into SAB 8088	t_{CHRYX}	30	–	20	–	ns	–
READY inactive to CLK [3)]	t_{RYLCL}	−8	–	−8	–	ns	–
HOLD setup time	t_{HVCH}	35	–	20	–	ns	–
INTR, NMI, $\overline{\text{TEST}}$ setup time [2)]	t_{INVCH}	30	–	15	–	ns	–
Input rise time (except CLK)	t_{ILIH}	–	20	–	20	ns	from 0.8 to 2.0V
Input fall time (except CLK)	t_{IHIL}	–	12	–	12	ns	from 2.0 to 0.8V

[1)] Signal at SAB 8284A/8284B shown for reference only.
[2)] Setup requirement for asynchronous signal only to guarantee recognition at next CLK.
[3)] Applies only to T2 state (8 ns into T3).

Timing Responses

Parameter	Symbol	Limit values				Unit	Test conditions
		SAB 8088		SAB 8088-2			
		min.	max.	min.	max.		
Address valid delay	t_{CLAV}	10	110	10	60	ns	[1]
Address hold time	t_{CLAX}	10	–	10	–	ns	[1]
Address float delay	t_{CLAZ}	t_{CLAX}	80	t_{CLAX}	50	ns	[1]
ALE width	t_{LHLL}	$t_{CLCH}-20$	–	$t_{CLCH}-10$	–	ns	[1]
ALE active delay	t_{CLLH}	–	80	–	50	ns	[1]
ALE inactive delay	t_{CHLL}	–	85	–	55	ns	[1]
Address hold time to ALE inactive	t_{LLAX}	$t_{CHCL}-10$	–	$t_{CHCL}-10$	–	ns	[1]
Data valid delay	t_{CLDV}	10	110	10	60	ns	[1]
Data hold time	t_{CHDX}	10	–	10	–	ns	[1]
Data hold time after $\overline{WR}$	t_{WHDX}	$t_{CLCH}-30$	–	$t_{CLCH}-30$	–	ns	[1]
Control active delay 1	t_{CVCTV}	10	110	10	70	ns	[1]
Control active delay 2	t_{CHCTV}	10	110	10	60	ns	[1]
Control inactive delay	t_{CVCTX}	10	110	10	70	ns	[1]
Address float to READ active	t_{AZRL}	0	–	0	–	ns	[1]
$\overline{RD}$ active delay	t_{CLRL}	10	165	10	100	ns	[1]
$\overline{RD}$ inactive delay	t_{CLRH}	10	150	10	80	ns	[1]
$\overline{RD}$ inactive to next address active	t_{RHAV}	$t_{CLCL}-45$	–	$t_{CLCL}-40$	–	ns	[1]
HLDA valid delay	t_{CLHAV}	10	160	10	100	ns	[1]
$\overline{RD}$ width	t_{RLRH}	$2\,t_{CLCL}-75$	–	$2\,t_{CLCL}-50$	–	ns	[1]
$\overline{WR}$ width	t_{WLWH}	$2\,t_{CLCL}-60$	–	$2\,t_{CLCL}-40$	–	ns	[1]
Address valid to ALE low	t_{AVAL}	$t_{CLCH}-60$	–	$t_{CLCH}-40$	–	ns	[1]
Output rise time	t_{OLOH}	–	20	–	20	ns	from 0.8 to 2.0V
Output fall time	t_{OHOL}	–	12	–	12	ns	from 2.0 to 0.8V

[1] C_L = 20–100 pF for all SAB 8088 outputs in addition to the internal loads

Maximum Mode System (using SAB 8288/8288A bus controller) Timing Requirements

Parameter	Symbol	Limit values				Unit	Test conditions
		SAB 8088		SAB 8088-2			
		min.	max.	min.	max.		
CLK cycle period	t_{CLCL}	200	500	125	500	ns	–
CLK low time	t_{CLCH}	118	–	68	–	ns	–
CLK high time	t_{CHCL}	69	–	44	–	ns	–
CLK rise time	t_{CH1CH2}	–	10	–	10	ns	from 1.0 to 3.5V
CLK fall time	t_{CL2CL1}	–	10	–	10	ns	from 3.5 to 1.0V
Data in setup time	t_{DVCL}	30	–	20	–	ns	–
Data in hold time	t_{CLDX}	10	–	10	–	ns	–
RDY setup time into SAB 8284A/8284B [1] [2]	t_{R1VCL}	35	–	35	–	ns	–
RDY hold time into SAB 8284A/8284B [1] [2]	t_{CLR1X}	0	–	0	–	ns	–
READY setup time into SAB 8088	t_{RYHCH}	118	–	68	–	ns	–
READY hold time into SAB 8088	t_{CHRYX}	30	–	20	–	ns	–
READY inactive to CLK [3]	t_{RYLCL}	−8	–	−8	–	ns	–
Setup time for recognition (INTR, NMI, $\overline{TEST}$) [2]	t_{INVCH}	30	–	15	–	ns	–
$\overline{RQ}/\overline{GT}$ setup time	t_{GVCH}	30	–	15	–	ns	–
$\overline{RQ}$ hold time into SAB 8088	t_{CHGX}	40	–	30	–	ns	–
Input rise time (except CLK)	t_{ILIH}	–	20	–	20	ns	from 0.8 to 2.0V
Input fall time (except CLK)	t_{IHIL}	–	12	–	12	ns	from 2.0 to 0.8V

[1] Signal at SAB 8284A/8284B or SAB 8288/8288A shown for reference only.
[2] Setup requirement for asynchronous signal only to guarantee recognition at next CLK.
[3] Applies only to T2 state (8 ns into T3).

Timing Responses

Parameter	Symbol	Limit values				Unit	Test conditions
		SAB 8088		SAB 8088-2			
		min.	max.	min.	max.		
Command Active Delay [1]	t_{CLML}	10	35	10	35	ns	[3]
Command Inactive Delay [1]	t_{CLMH}	10	35	10	35	ns	[3]
READY Active to status passive [2]	t_{RYHSH}	–	110	–	65	ns	[3]
Status active delay	t_{CHSV}	10	110	10	60	ns	[3]
Status inactive delay	t_{CLSH}	10	130	10	70	ns	[3]
Address valid delay	t_{CLAV}	10	110	10	60	ns	[3]
Address hold time	t_{CLAX}	10	–	10	–	ns	[3]
Address float delay	t_{CLAZ}	t_{CLAX}	80	t_{CLAX}	50	ns	[3]
Status valid to ALE high [1]	t_{SVLH}	–	20	–	20	ns	[3]
Status valid to MCE high [1]	t_{SVMCH}	–	20	–	20	ns	[3]
CLK low to ALE valid [1]	t_{CLLH}	–	20	–	20	ns	[3]
CLK low to MCE high [1]	t_{CLMCH}	–	20	–	20	ns	[3]
ALE inactive delay [1]	t_{CHLL}	4	15	4	15	ns	[3]
Data valid delay	t_{CLDV}	10	110	10	60	ns	[3]
Data hold time	t_{CHDX}	10	–	10	–	ns	[3]
Control active delay [1]	t_{CVNV}	5	45	5	45	ns	[3]
Control inactive delay [1]	t_{CVNX}	10	45	10	45	ns	[3]

[1] Signal at SAB 8284A/8284B or SAB 8288/8288A shown for reference only.
[2] Applies only to T2 state (8 ns into T3).
[3] C_L = 20–100 pF for all SAB 8088 outputs in addition to the internal loads.

Timing Responses (cont'd)

Parameter	Symbol	Limit values				Unit	Test conditions
		SAB 8088		SAB 8088-2			
		min.	max.	min.	max.		
Address float to READ active	t_{AZRL}	0	–	0	–	ns	[2]
$\overline{RD}$ active delay	t_{CLRL}	10	165	10	100	ns	[2]
$\overline{RD}$ inactive delay	t_{CLRH}	10	150	10	80	ns	[2]
$\overline{RD}$ inactive to next address active	t_{RHAV}	$t_{CLCL}-45$	–	$t_{CLCL}-40$	–	ns	[2]
Direction control active delay [1]	t_{CHDTL}	–	50	–	50	ns	[2]
Direction control inactive delay [1]	t_{CHDTH}	–	30	–	30	ns	[2]
$\overline{GT}$ active delay	t_{CLGL}	–	85	–	50	ns	[2]
$\overline{GT}$ inactive delay	t_{CLGH}	–	85	–	50	ns	[2]
$\overline{RD}$ width	t_{RLRH}	$2\,t_{CLCL}-75$	–	$2\,t_{CLCL}-50$	–	ns	[2]
Output rise time	t_{OLOH}	–	20	–	20	ns	from 0.8 to 2.0V
Output fall time	t_{OHOL}	–	12	–	12	ns	from 2.0 to 0.8V

[1] Signal at SAB 8284A/8284B or SAB 8288/8288A shown for reference only.
[2] C_L = 20–100 pF for all SAB 8088 outputs in addition to the internal loads.

AC Characteristics for SAB 8088-1

SAB 8088-1: $T_A = 0$ to 70°C, $V_{CC} = 5\,V \pm 5\%$

Minimum Complexity System Timing Requirements

Parameter	Symbol	Limit values		Unit	Test conditions
		min.	max.		
CLK cycle period	t_{CLCL}	100	500	ns	–
CLK low time	t_{CLCH}	53	–	ns	–
CLK high time	t_{CHCL}	39	–	ns	–
CLK rise time	t_{CH1CH2}	–	10	ns	from 1.0 to 3.5V
CLK fall time	t_{CL2CL1}	–	10	ns	from 3.5 to 1.0V
Data in setup time	t_{DVCL}	5	–	ns	–
Data in hold time	t_{CLDX}	10	–	ns	–
RDY setup time into SAB 8284A/8284B [1) 2)]	t_{R1VCL}	35	–	ns	–
RDY hold time into SAB 8284A/8284B [1) 2)]	t_{CLR1X}	0	–	ns	–
READY setup time into SAB 8088	t_{RYHCH}	53	–	ns	–
READY hold time into SAB 8088	t_{CHRYX}	20	–	ns	–
READY inactive to CLK [3)]	t_{RYLCL}	−10	–	ns	–
HOLD setup time	t_{HVCH}	20	–	ns	–
INTR, NMI, $\overline{\text{TEST}}$ setup time [2)]	t_{INVCH}	15	–	ns	–
Input rise time (except CLK)	t_{ILIH}	–	20	ns	from 0.8 to 2.0V
Input fall time (except CLK)	t_{IHIL}	–	12	ns	from 2.0 to 0.8V

[1)] Signal at SAB 8284A/8284B shown for reference only.
[2)] Setup requirement for asynchronous signal only to guarantee recognition at next CLK.
[3)] Applies only to T2 state (8 ns into T3).

Timing Responses SAB 8088-1

Parameter	Symbol	Limit values		Unit	Test conditions
		min.	max.		
Address valid delay	t_{CLAV}	10	50	ns	[1]
Address hold time	t_{CLAX}	10	–	ns	[1]
Address float delay	t_{CLAZ}	10	40	ns	[1]
ALE width	t_{LHLL}	$t_{CLCH}-10$	–	ns	[1]
ALE active delay	t_{CLLH}	–	40	ns	[1]
ALE inactive delay	t_{CHLL}	–	45	ns	[1]
Address hold time to ALE inactive	t_{LLAX}	$t_{CHCL}-10$	–	ns	[1]
Data valid delay	t_{CLDV}	10	50	ns	[1]
Data hold time	t_{CHDX}	10	–	ns	[1]
Data hold time after $\overline{WR}$	t_{WHDX}	$t_{CLCH}-25$	–	ns	[1]
Control active delay 1	t_{CVCTV}	10	50	ns	[1]
Control active delay 2	t_{CHCTV}	10	45	ns	[1]
Control inactive delay	t_{CVCTX}	10	50	ns	[1]
Address float to READ active	t_{AZRL}	0	–	ns	[1]
$\overline{RD}$ active delay	t_{CLRL}	10	70	ns	[1]
$\overline{RD}$ inactive delay	t_{CLRH}	10	60	ns	[1]
$\overline{RD}$ inactive to next address active	t_{RHAV}	$t_{CLCL}-35$	–	ns	[1]
HLDA valid delay	t_{CLHAV}	10	60	ns	[1]
$\overline{RD}$ width	t_{RLRH}	$2\,t_{CLCL}-40$	–	ns	[1]
$\overline{WR}$ width	t_{WLWH}	$2\,t_{CLCL}-35$	–	ns	[1]
Address valid to ALE low	t_{AVAL}	$t_{CLCH}-35$	–	ns	[1]
Output rise time	t_{OLOH}	–	20	ns	from 0.8 to 2.0V
Output fall time	t_{OHOL}	–	12	ns	from 2.0 to 0.8V

[1]) $C_L = 20-100$ pF for all SAB 8088 outputs in addition to the internal loads.

Maximum Mode System (using SAB 8288/8288A bus controller)
Timing Requirements SAB 8088-1

Parameter	Symbol	Limit values		Unit	Test conditions
		min.	max.		
CLK cycle period	t_{CLCL}	100	500	ns	–
CLK low time	t_{CLCH}	53	–	ns	–
CLK high time	t_{CHCL}	39	–	ns	–
CLK rise time	t_{CH1CH2}	–	10	ns	from 1.0 to 3.5V
CLK fall time	t_{CL2CL1}	–	10	ns	from 3.5 to 1.0V
Data in setup time	t_{DVCL}	5	–	ns	–
Data in hold time	t_{CLDX}	10	–	ns	–
RDY setup time into SAB 8284A/8284B [1] [2]	t_{R1VCL}	35	–	ns	–
RDY hold time into SAB 8284A/8284B [1] [2]	t_{CLR1X}	0	–	ns	–
READY setup time into SAB 8088	t_{RYHCH}	53	–	ns	–
READY hold time into SAB 8088	t_{CHRYX}	20	–	ns	–
READY inactive to CLK [3]	t_{RYLCL}	−10	–	ns	–
Setup time for recognition (INTR, NMI, $\overline{TEST}$) [2]	t_{INVCH}	15	–	ns	–
$\overline{RQ}/\overline{GT}$ setup time	t_{GVCH}	12	–	ns	–
$\overline{RQ}$ hold time into SAB 8088	t_{CHGX}	20	–	ns	–
Input rise time (except CLK)	t_{ILIH}	–	20	ns	from 0.8 to 2.0V
Input fall time (except CLK)	t_{IHIL}	–	12	ns	from 2.0 to 0.8V

[1] Signal at SAB 8284A/8284B or SAB 8288/8288A shown for reference only.
[2] Setup requirement for asynchronous signal only to guarantee recognition at next CLK.
[3] Applies only to T2 state (8 ns into T3).

Timing Responses SAB 8088-1

Parameter	Symbol	Limit values		Unit	Test conditions
		min.	max.		
Command active delay [1]	t_{CLML}	10	35	ns	[3]
Command inactive delay [1]	t_{CLMH}	10	35	ns	[3]
READY active to status passive [2]	t_{RYHSH}	–	45	ns	[3]
Status active delay	t_{CHSV}	10	45	ns	[3]
Status inactive delay	t_{CLSH}	10	55	ns	[3]
Address valid delay	t_{CLAV}	10	50	ns	[3]
Address hold time	t_{CLAX}	10	–	ns	[3]
Address float delay	t_{CLAZ}	10	40	ns	[3]
Status valid to ALE high [1]	t_{SVLH}	–	20	ns	[3]
Status valid to MCE high [1]	t_{SVMCH}	–	20	ns	[3]
CLK low to ALE valid [1]	t_{CLLH}	–	20	ns	[3]
CLK low to MCE high [1]	t_{CLMCH}	–	20	ns	[3]
ALE inactive delay [1]	t_{CHLL}	4	15	ns	[3]
Data valid delay	t_{CLDV}	10	50	ns	[3]
Data hold time	t_{CHDX}	10	–	ns	[3]
Control active delay [1]	t_{CVNV}	5	45	ns	[3]
Control inactive delay [1]	t_{CVNX}	10	45	ns	[3]

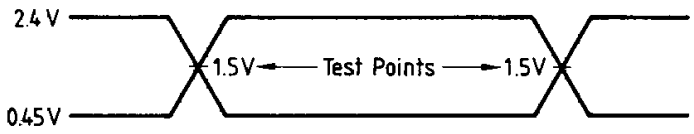
[1] Signal at SAB 8284A/8284B or SAB 8288/8288A shown for reference only.
[2] Applies only to T2 state (8 ns into T3).
[3] C_L = 20–100 pF for all SAB 8088 outputs in addition to the internal loads.

Timing Responses SAB 8088-1 (cont'd)

Parameter	Symbol	Limit values		Unit	Test conditions
		min.	max.		
Address float to READ active	t_{AZRL}	0	–	ns	[2]
$\overline{RD}$ active delay	t_{CLRL}	10	70	ns	[2]
$\overline{RD}$ inactive delay	t_{CLRH}	10	60	ns	[2]
$\overline{RD}$ inactive to next address active	t_{RHAV}	$t_{CLCL}-35$	–	ns	[2]
Direction control active delay [1]	t_{CHDTL}	–	50	ns	[2]
Direction control inactive delay [1]	t_{CHDTH}	–	30	ns	[2]
$\overline{GT}$ active delay	t_{CLGL}	0	45	ns	[2]
$\overline{GT}$ inactive delay	t_{CLGH}	0	45	ns	[2]
$\overline{RD}$ width	t_{RLRH}	$2\,t_{CLCL}-40$	–	ns	[2]
Output rise time	t_{OLOH}	–	20	ns	from 0.8 to 2.0V
Output fall time	t_{OHOL}	–	12	ns	from 2.0 to 0.8V

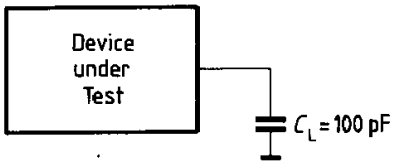
[1] Signal at SAB 8284A/8284B or SAB 8288/8288A shown for reference only.
[2] C_L = 20–100 pF for all SAB 8088 outputs in addition to the internal loads.

Input/Output Waveforms for AC Tests



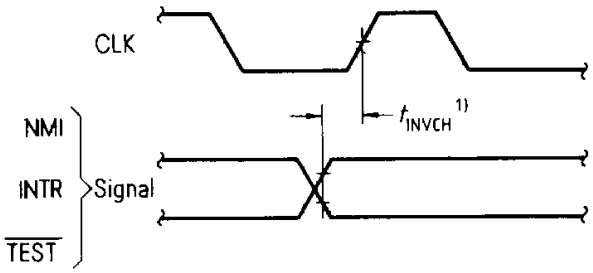
AC Testing: Inputs are driven at 2.4V for a logic "1" and 0.45V for a logic "0". The clock is driven at 4.3V and 0.25V. Timing measurements are made at 1.5V for both a logic "1" and "0".

Load Circuit for AC Tests



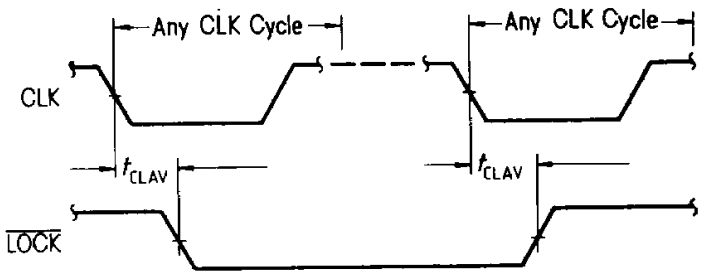
C_L includes Jig Capacitance

Asynchronous Signal Recognition

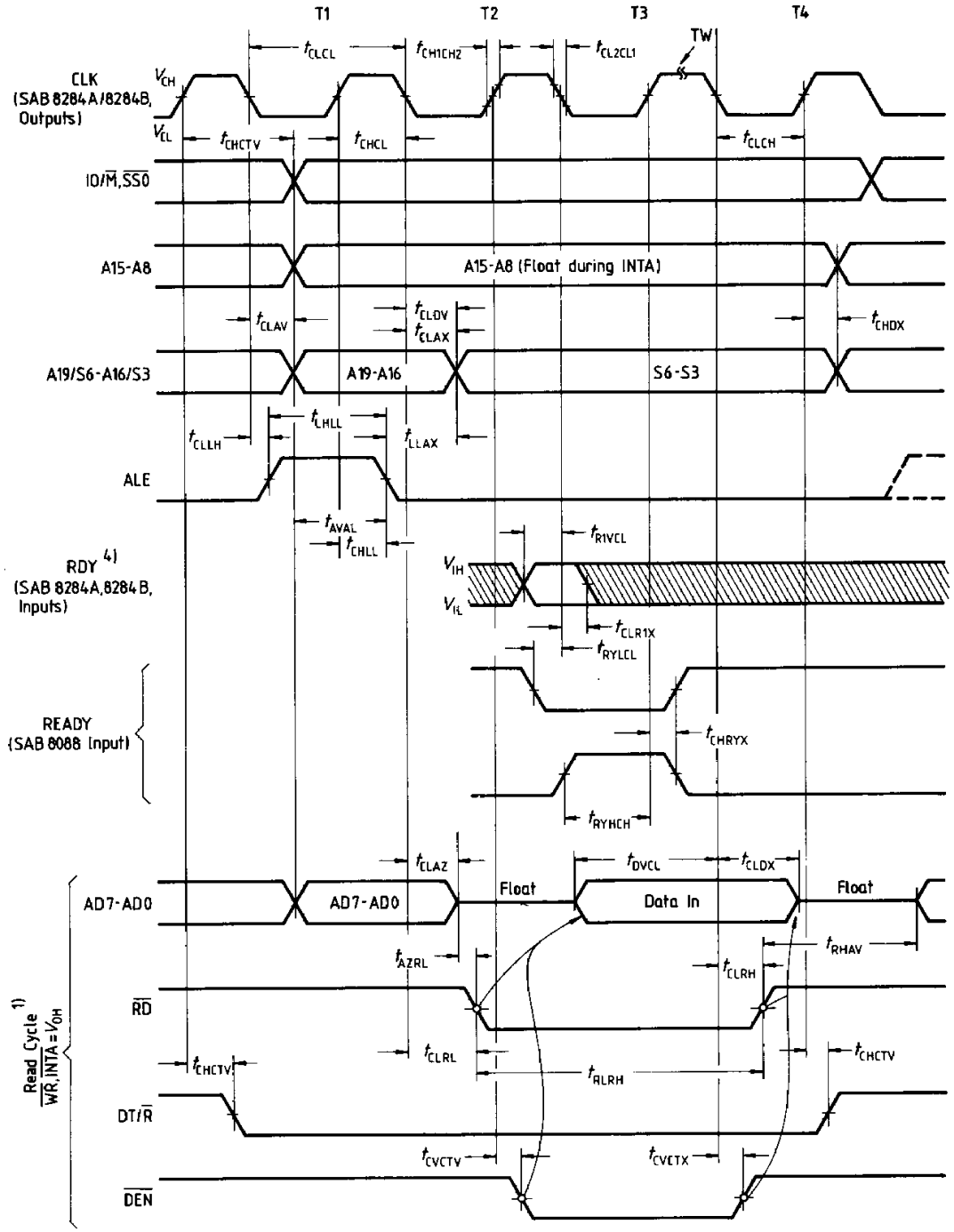


1) Setup requirements for asynchronous signals only to guarantee recognition at next CLK

Bus Lock Signal Timing (Maximum Mode only)

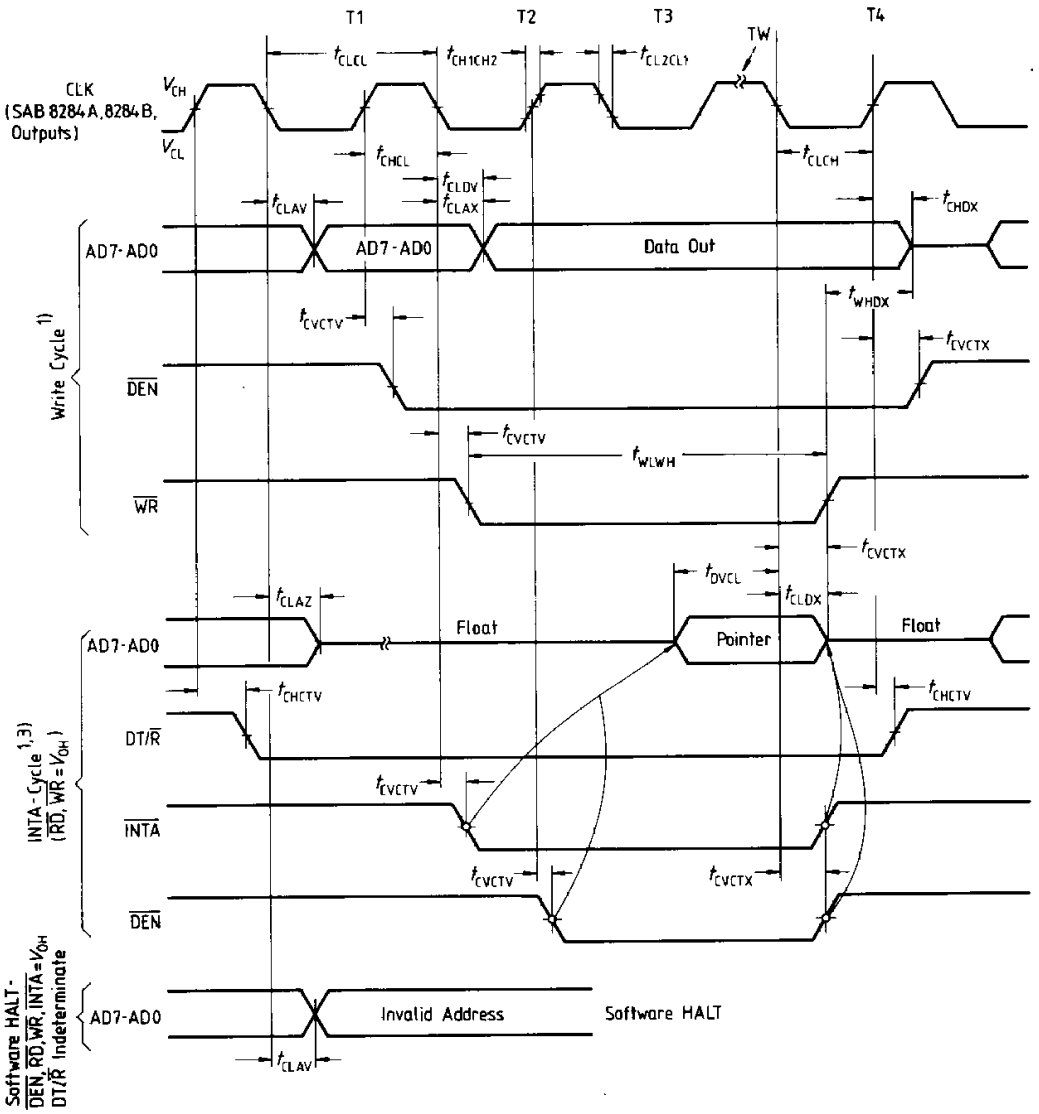


Bus Timing – Minimum Mode System



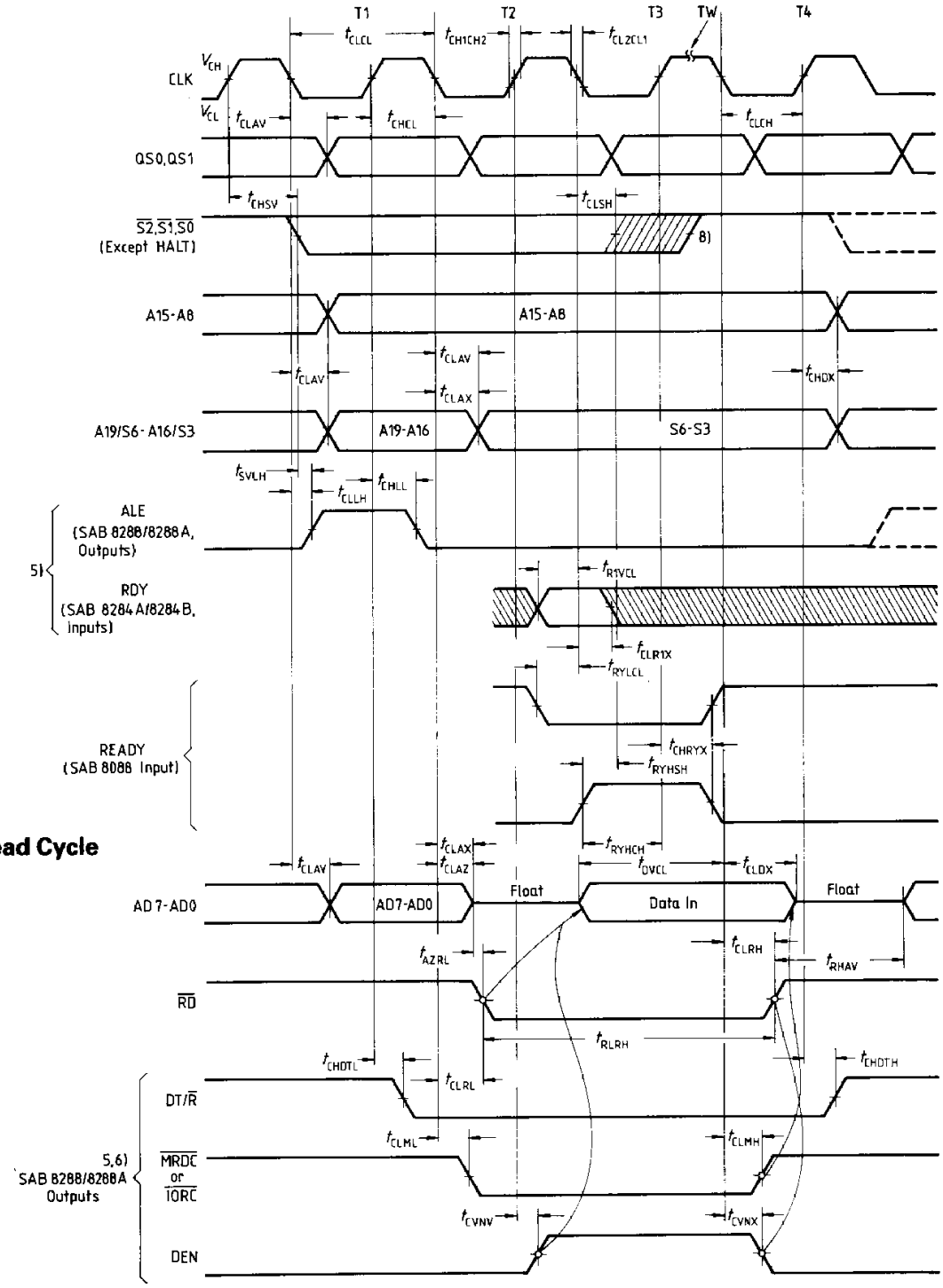
Notes see next page

Bus Timing — Minimum Mode System (cont'd)



1) All signals switch between V_{OH} and V_{OL} unless otherwise specified.
2) RDY is sampled near the end of T2, T3, TW to determine if TW machine states are to be inserted.
3) Two INTA cycles run back to back. The SAB 8088 local ADDR/DATA bus is floating during both INTA cycles. Control signals shown for second INTA cycle.
4) Signals at SAB 8284A/8284B are shown for reference only.
5) All timing measurements are made at 1.5V unless otherwise noted.

Bus Timing – Maximum Mode System (using SAB 8288/8288A)

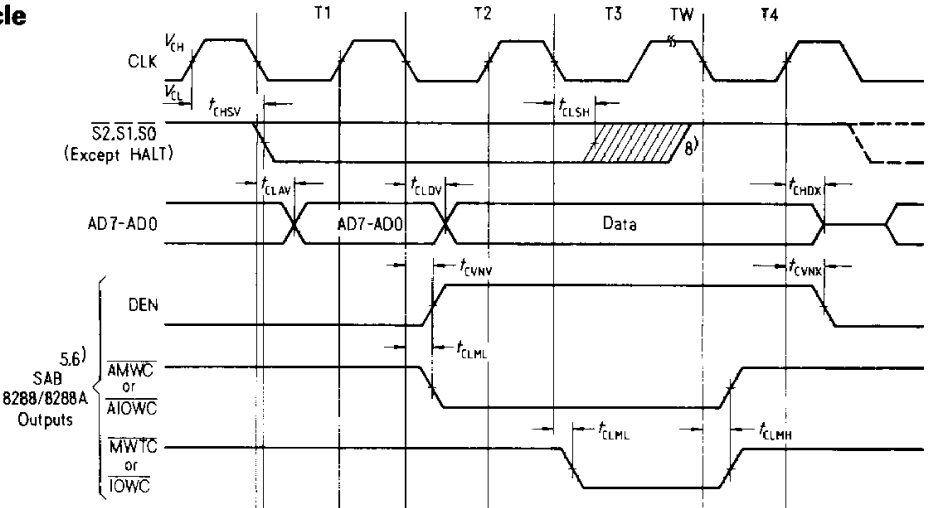


Read Cycle

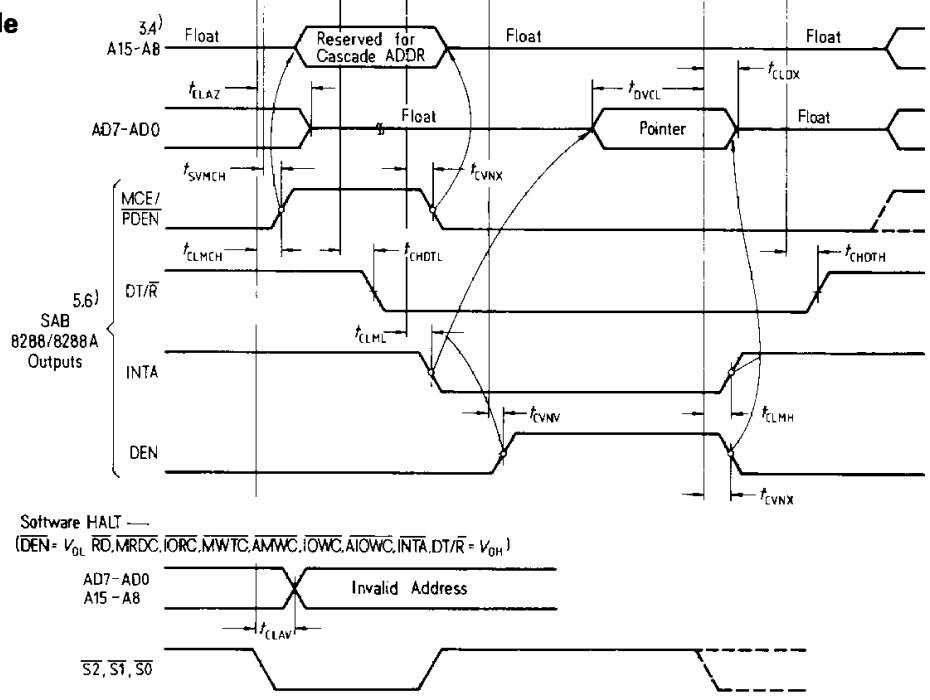
Notes see next page.

Bus Timing – Maximum Mode System (using SAB 8288/8288A)

Write Cycle

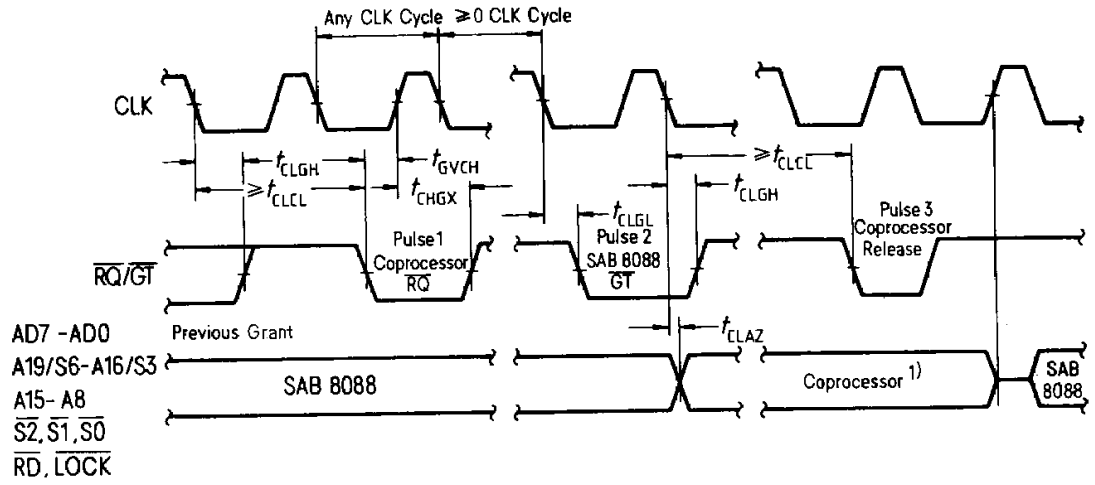


INTA Cycle



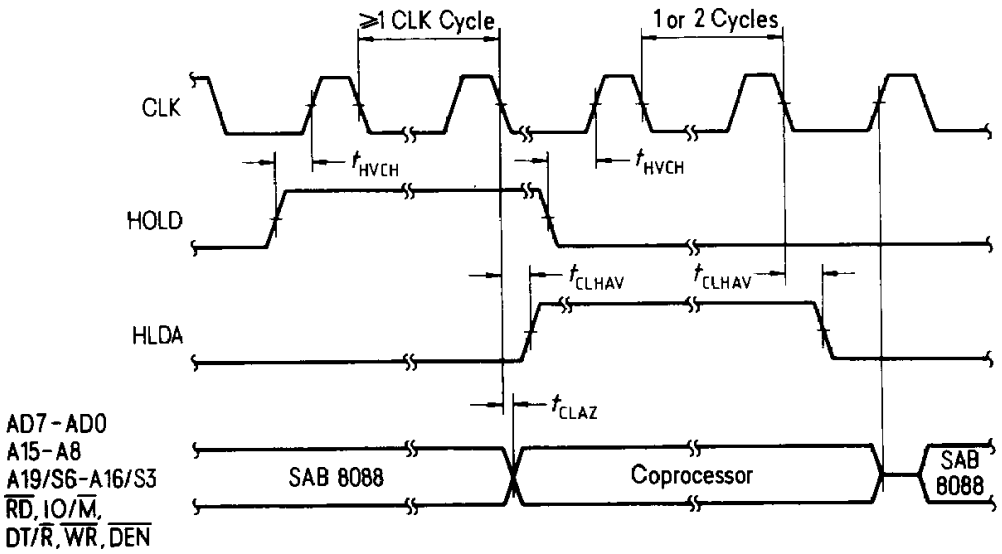
1) All signals switch between V_{OH} and V_{OL} unless otherwise specified.
2) RDY is sampled near the end of T2, T3, TW to determine if TW machine states are to be inserted.
3) Cascade address is valid between first and second INTA cycle.
4) Two INTA cycles run back-to-back. The SAB 8088 local ADDR/DATA bus is floating during both INTA cycles. Control for pointer address is shown for second INTA cycle.
5) Signals at SAB 8284A/8284B or SAB 8288/8288A are shown for reference only.
6) The issuance of the SAB 8288/8288A command and control signals (MRDC, MWTC, AMWC, IORC, IOWC, AIOWC, INTA and DEN) lags the active high SAB 8288/8288A DEN.
7) All timing measurements are made at 1.5 V unless otherwise noted.
8) Status inactive in state just prior to T4.

Request/Grant Sequence Timing (Maximum Mode only)



1) The coprocessor may not drive the buses outside the region shown without risking contention

Hold/Hold Acknowledge Timing (Minimum Mode only)



Ordering Information

Type	Ordering code	Function
SAB 8088-P	Q67120-C106	8-bit microprocessor – 5 MHz (P-DIP-40)
SAB 8088-2-P	Q67120-C213	8-bit microprocessor – 8 MHz (P-DIP-40)
SAB 8088-1-P	Q67120-C249	8-bit microprocessor – 10 MHz (P-DIP-40)
SAB 8088-N	Q67120-C301	8-bit microprocessor – 5 MHz (PL-CC-44)
SAB 8088-2-N	Q67120-C302	8-bit microprocessor – 8 MHz (PL-CC-44)
SAB 8088-1-N	Q67120-C321	8-bit microprocessor – 10 MHz (PL-CC-44)