

TMP8085AP-2/TMP8085AHP-2 8-BIT MICROPROCESSOR

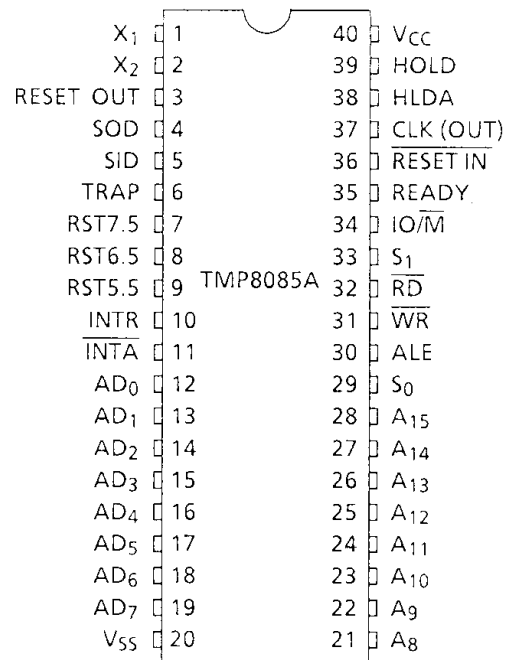
1. GENERAL DESCRIPTION

The TMP8085AP-2/TMP8085AHP-2, hereafter on referred to as TMP8085A, is a 8 bit micro processing unit (MPU). TMP8085A uses a multiplexed data bus. The address is split between the 8 bit address bus and the 8 bit data bus. The on-chip address latches of TMP8155P-2/TMP8156P-2 allow a direct interface with TMP8085A.

2. FEATURES

- 0.8 μ Sec Instruction Cycle (CLK Cycle Period @200nSec)
 - Single +5V Power Supply
(TMP8085AP-2: 5V \pm 5%, TMP8085AHP-2: 5V \pm 10%)
 - On-Chip Clock Generator (with External Crystal or RC Network)
 - On-Chip System Controller; Cycle status information available for Large System Control
 - 4 Vectored Interrupts (One is Non-Maskable)
 - Decimal, Binary and Double Precision Arithmetic
 - Serial In/Serial Out Port
 - Direct Addressing Capability up to 64K Byte Memory Space
 - Compatible with Intel's 8085A
 - Low Power Consumption (TMP8085AHP-2: Icc max = 135mA)
- 

3. PIN CONNECTION (TOP VIEW)



050489

Figure 3.1

4. BLOCK DIAGRAM

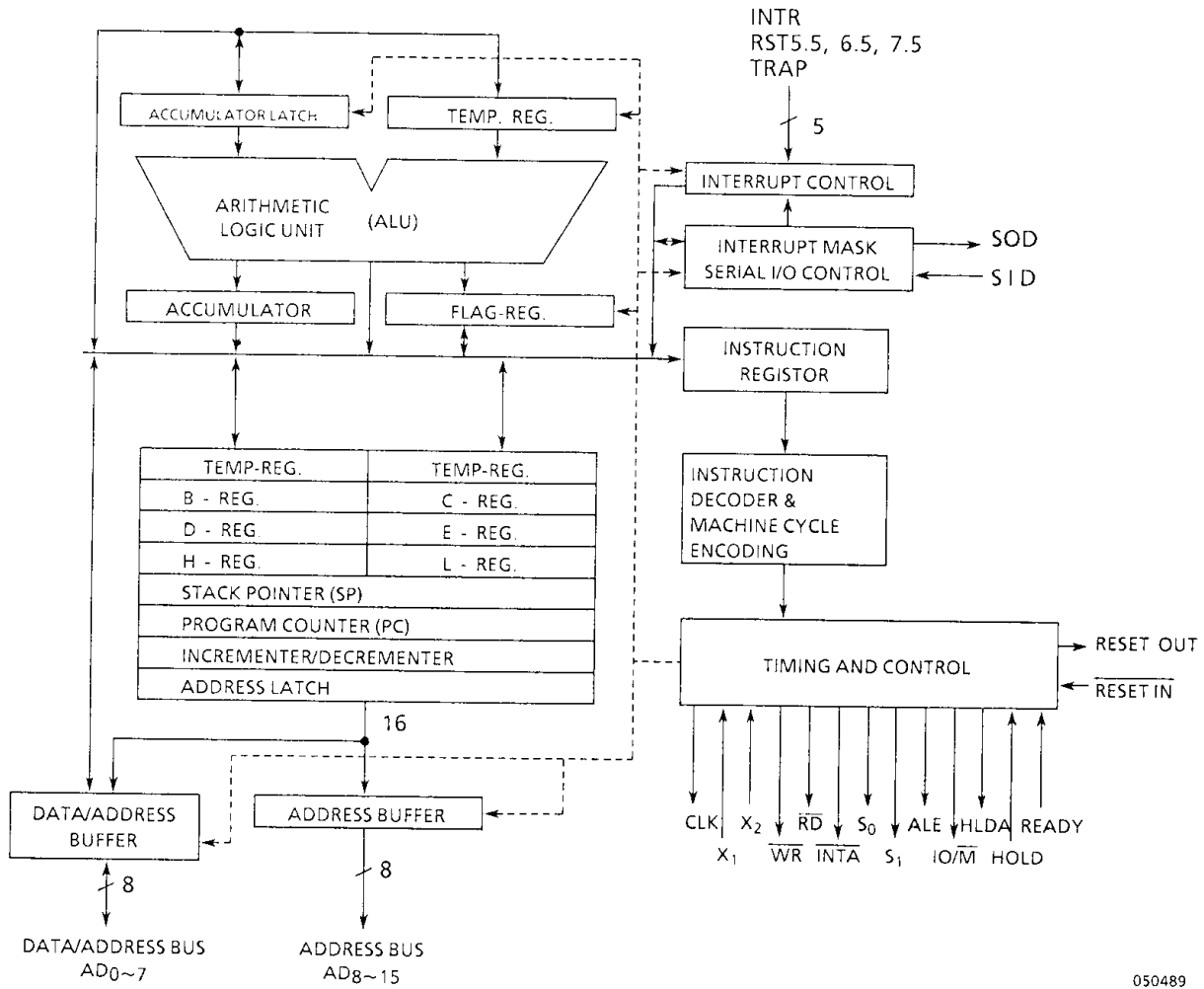


Figure 4.1

050489

5. PIN NAME AND PIN DESCRIPTION

- X_1, X_2 (Input)

Crystal, LC, or RC network are connected to X_1 and X_2 to drive the internal clock generator. X_1 and X_2 can also be driven by an external clock source. The input frequency is divided by 2 to give the processor's internal operating frequency.

- CLK(Output)

Clock Output for use as a system clock. The period of CLK is twice the X_1, X_2 input period.

- $\overline{\text{RESETIN}}$ (Input)

The $\overline{\text{RESETIN}}$ Input initializes the processor by clearing the program counter, instruction register, SOD latch, Interrupt Enable flip-flop and HLDA flip-flop. The address and data buses and the control lines are 3-stated during RESET and because of the asynchronous nature of RESET, the processor's internal registers and flags may be altered by RESET with unpredictable results. $\overline{\text{RESETIN}}$ is a Schmitttriggered input, allowing connection to an RC network for power on RESET delay. The TMP8085A is held in the reset condition as long as $\overline{\text{RESETIN}}$ is applied.

- RESET OUT (Output)

The RESET OUT signal indicates that the TMP8085A is being reset. It can be used as a system reset. It is synchronized to the processor clock and lasts an integral number of clock periods.

- SOD (Output)

Serial output data line. The output SOD is set or reset as specified by the SIM instruction.

- SID (Input)

Serial input data line. The data on this line is loaded into accumulator bit 7 whenever a RIM instruction is executed.

- INTR (Input)

INTERRUPT REQUEST signal provides a mechanism for external devices to modify the instruction flow of the program in progress. It is sampled only during the next to the last clock cycle of an instruction and during Hold and Halt states. If it is recognized, the processor will complete the execution of the current instruction, and then the Program Counter (PC) will be inhibited from incrementing and an $\overline{\text{INTA}}$ will be issued. During this cycle a RESTART or CALL instruction can be inserted to jump to the interrupt service routine. The INTR is enabled and disabled by software. It is disabled by RESET and immediately after an interrupt is accepted.

- $\overline{\text{INTA}}$ (Output)

INTERRUPT ACKNOWLEDGE: Occurs in response to an Interrupt input and indicates that the processor will be ready for an interrupt instruction on the data bus. It is used instead of (and has the same timing as) $\overline{\text{RD}}$ during the instruction cycle after an INTR is accepted.

| | |
|---------|------------|
| RST 5.5 | } (Inputs) |
| RST 6.5 | |
| RST 7.5 | |

RESTART INTERRUPTS: These three inputs have the same timing as INTR except they cause an internal RESTART to be automatically inserted. These interrupts have a higher priority than INTR. The priority of these interrupts is ordered as shown Table 1. These interrupts are maskable using the SIM instruction.

- TRAP (Input)

Trap interrupt is a nonmaskable RESTART interrupt. It is sampled at the same timing as INTR or RST 5.5-7.5. It is unaffected by SIM or Enable/Disable Interrupt instruction. It has the highest priority of any interrupt.

- AD₀-AD₇ (Input/Output, 3-state)

Lower 8 bits of the memory address (or I/O address) appear on the bus during the first clock cycle (T₁ state) of a machine cycle. It then becomes the data bus during the second and third clock cycles.

- A₈-A₁₅ (Output, 3-state)

Upper 8 bits of the memory address or the 8 bits of the I/O address, 3-stated during Hold and Halt modes and during RESET.

- $S_0, S_1,$ and IO/\overline{M} (Output)

Machine cycle status:

| IO/\overline{M} | S_1 | S_0 | Status |
|-------------------|-------|-------|-----------------------|
| 0 | 1 | 1 | Opcode fetch |
| 0 | 1 | 0 | Memory read |
| 0 | 0 | 1 | Memory write |
| 1 | 1 | 0 | I/O read |
| 1 | 0 | 1 | I/O write |
| 1 | 1 | 1 | Interrupt Acknowledge |
| TS | 0 | 0 | Halt |
| TS | X | X | Hold |
| TS | X | X | Reset |

Note : TS=3-state (high impedance)
X=unspecified

- ALE (Output)

Address Latch Enable: It occurs during the first clock state of a machine cycle and enables the address to get latched into the external latch or the on-chip latch of peripherals. The falling edge of ALE can be used to strobe the status information. ALE never goes 3-stated.

- \overline{WR} (Output, 3-state)

WRITE control: A low level on \overline{WR} indicates the data on the Data Bus is to be written into the selected memory or I/O location. Data is set up at the trailing edge of \overline{WR} . It is 3-stated during Hold and Halt modes and during RESET.

- \overline{RD} (Output, 3-state)

READ control: A low level on \overline{RD} indicates the selected memory or I/O device to be read and that the Data Bus is available for the data transfer, 3-stated during Hold and Halt modes and during RESET.

- READY (Input)

When READY is inactive (low), indicating the external operation has not been complete yet, the processor will enter the Wait state. It will wait for an integral number of clock cycles until READY goes high before completing the read or write cycle.

- HOLD (Input)

The HOLD input cause TMP8085A to release the control over the address bus and the data bus. When HOLD goes active, the processor completes its current operation, activates the HLDA output, and puts the Address, Data, \overline{RD} , \overline{WR} , and IO/\overline{M} lines into high-impedance state. Internal processing can continue. The Holding device can then utilize the address and data buses instead of TMP8085A. TMP8085A can regain the bus only after the HOLD goes inactive (low).

- HLDA (Output)

The Hold Acknowledge output, HLDA signal is a response to a HOLD input. It indicates that TMP8085A has received the HOLD request and HOLD will release the bus control in the next cycle. HLDA goes low after the HOLD goes inactive (low). TMP8085A takes over the bus control one half clock after HDLA goes low.

- V_{CC}

+5 volt supply

- V_{SS}

Ground Reference

6. FUNCTIONAL DESCRIPTION

TMP8085A is a 8-bit central processor.

TMP8085A is provided with internal 8-bit registers and 16-bit registers. TMP8085A has eight addressable 8-bit registers. Six of them can be used either as 8-bit registers or as 16-bit register pairs. In addition to the register pairs, the TMP8085A contains two additional 16-bit registers. TMP8085A register set is as follows:

- The accumulator (A Register) is the focus of all of the accumulator instructions, which include arithmetic, logic, load and store, and I/O instructions.
- The program counter (PC) always points to the memory location of the next instruction to be executed.
- General-purpose registers BC, DE, and HL may be used as 8-bit registers or as three 16-bit registers, interchangeably, depending on the instruction being performed.
- The stack pointer (SP) is a special data pointer that always points to the stack top (next available stack address).
- The flag register contains five one-bit flags, each of which records processor status information and may also control processor operation.

The five flags in TMP8085A are shown below:

(MSB)

| | | | | | | | |
|----|----|----|----|----|----|----|----|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
| S | Z | | AC | | P | | C |

- The carry flag (C) is set and reset by arithmetic operations. An additional operation that results in an overflow out of the high-order bit of the accumulator sets the carry flag. The carry flag also acts as a “borrow” flag for subtract instruction.
- The auxiliary carry flag (AC) indicates overflow out of bit 3 of the accumulator in the same way that C flag indicates overflow out of bit 7. This flag is commonly used in BCD arithmetic.
- The sign flag (S) is set to the condition of the most significant (MSB) bit of the accumulator following the execution of arithmetic or logic instructions.
- The zero flag (Z) is set if the result generated by certain instructions is zero. The zero flag is cleared if the result is not zero.
- The parity flag (P) is set to 1 if the parity (number of 1-bits) of the accumulator is even. If odd, it is cleared. TMP8085A offers the functions of clock generation,

system bus control, and interrupt priority selection as well as execution of the instruction set. TMP8085A uses a multiplexed Data Bus. The address is split between the higher 8-bit Address Bus and the lower 8-bit Address/Data Bus. During the first T state (T_1 clock cycle) of a machine cycle the lower order address is sent out on the Address/Data Bus. These lower 8 bits may be latched externally by the Address Latch Enable signal (ALE). During the rest of the machine cycle, the data bus is used for memory or I/O data transferring.

7. INTERRUPT AND SERIAL I/O

TMP8085A has 5 interrupt inputs: INTR, RST 5.5, RST 6.5, RST 7.5, and TRAP. INTR is identical in function to 8080A INT. Each of three RESTART inputs 5.5, 6.5, 7.5, has a programmable mask. TRAP is also one of RESTART interrupts but it is nonmaskable.

The three RESTART interrupts cause the internal execution of RESTART if the interrupts are enabled and if the corresponding interrupt mask is not set. The nonmaskable TRAP always causes internal interrupt execution whether INTR, RST 5.5, RST 6.5 and RST 7.5 interrupts are enable or not.

There are two different types of inputs in the restart interrupts. RST 5.5 and RST 6.5 are high-level sensitive like INTR and are recognized with the same timing as INTR. RST 7.5 is rising edge-sensitive.

For RST 7.5, only a pulse is required to set an internal flip-flop which generates the interrupt request. The RST 7.5 request flip-flop remains set until the request is serviced. Then it is reset automatically. This flip-flop may also be reset by using the SIM instruction or by issuing a $\overline{\text{RESETIN}}$ to TMP8085A. The RST 7.5 internal flip-flop will be set by a pulse on the RST 7.5 pin even when the RST 7.5 interrupt is masked.

The interrupts are arranged in a fixed priority that determines which interrupt is to be recognized if more than one is pending: TRAP-highest priority. RST 7.5, RST 6.5, RST 5.5, INTR-lowest priority. This priority scheme does not take into account the priority of a routine that was started by a higher priority interrupt. RST 5.5 can interrupt a RST 7.5 routine if the interrupts were reenabled before the end of the RST 7.5 routine.

The TRAP interrupt is useful for catastrophic errors such as power failure or bus error. It is not affected by any flag or mask. The TRAP input is both edge and level sensitive. The TRAP input must go high and remain high until it is acknowledged. It will not be recognized again until it goes low, then high again. This avoids any false triggering due to noise or logic glitches.

Table 7.1 Interrupt Priority, Restart Address, and Sensitivity

| Name | Priority | Address branched to When Interrupt Occurs | Type Trigger |
|---------|----------|--|---|
| TRAP | 1 | 24 (Hex.) | Rising edge and high level until sampled. |
| RST 7.5 | 2 | 3C (Hex.) | Rising edge (latched) . |
| RST 6.5 | 3 | 34 (Hex.) | High level until sampled. |
| RST 5.5 | 4 | 2C (Hex.) | High level until sampled. |
| INTR | 5 | See Note (2) | High level until sampled. |

050489

- Notes : (1) The processor pushes the PC on the stack before branching to the indicated address.
 (2) The address branched to depends on the instruction provided to TMP8085A when the interrupt is acknowledged.

The TRAP interrupt is special in that it disables all other interrupts, but preserves the previous interrupt enable status. Performing the first RIM instruction following a TRAP interrupt allows you to determine whether interrupts were enabled or disabled prior to the TRAP. All subsequent RIM instruction provide current interrupt enable status. Performing a RIM instruction following INTR, or RST 5.5-7.5 will provide current interrupt enable status, revealing that interrupts are disabled.

The serial I/O system is also controlled by the RIM and SIM instructions. SID is read by RIM, and SIM sets the SOD date.

8. BASIC TIMING

The execution of each instruction by the TMP8085A consists of a sequence of from one to five machine cycles, and each machine cycle consists of a minimum of from three to six clock cycles. Most machine cycles consist of three T states, (cycles of the CLK output) with the exception of opcode fetch, which normally has either four or six T states (unless WAIT or HOLD states are forced by the receipt of READY or HOLD inputs). Any T state must be one of ten possible states, shown in Table 3.

At the beginning of every machine cycle, TMP8085A sends out three status signals ($\overline{IO/\overline{M}}$, S_1 , S_0) that define what type of machine cycle is about to take place. TMP8085A also sends out a 16-bit address at the beginning of every machine cycle to identify the particular memory location or I/O port that the machine cycle applies to.

The special timing signal, ADDRESS LATCH ENABLE (ALE), is used as a strobe to sample the lower 8-bits of address on the AD_0 - AD_7 lines. ALE is present during T_1 of every machine cycle. Control lines \overline{RD} (\overline{INTA}) and \overline{WR} become active later, at the time when the transfer of data is to take place.

Figure 3 shows an instruction fetch, memory read and I/O write cycle (as would occur during processing of the OUT instruction).

Table 8.1 TMP8085 Machine Cycle Chart

| MACHINE CYCLE | $\overline{IO/\overline{M}}$ | S_1 | S_0 | \overline{RD} | \overline{WR} | \overline{INTA} |
|----------------------|------------------------------|-------|-------|-----------------|-----------------|-------------------|
| OPCODE FETCH | 0 | 1 | 1 | 0 | 1 | 1 |
| MEMORY READ | 0 | 1 | 0 | 0 | 1 | 1 |
| MEMORY WRITE | 0 | 0 | 1 | 1 | 0 | 1 |
| I/O READ | 1 | 1 | 0 | 0 | 1 | 1 |
| I/O WRITE | 1 | 0 | 1 | 1 | 0 | 1 |
| ACKNOWLEDGE OF INTR | 1 | 1 | 1 | 1 | 1 | 0 |
| BUS IDLE: DAD | 0 | 1 | 0 | 1 | 1 | 1 |
| ACK. OF RST, TRAP | 1 | 1 | 1 | 1 | 1 | 1 |
| HALT | TS | 0 | 0 | TS | TS | 1 |

050489

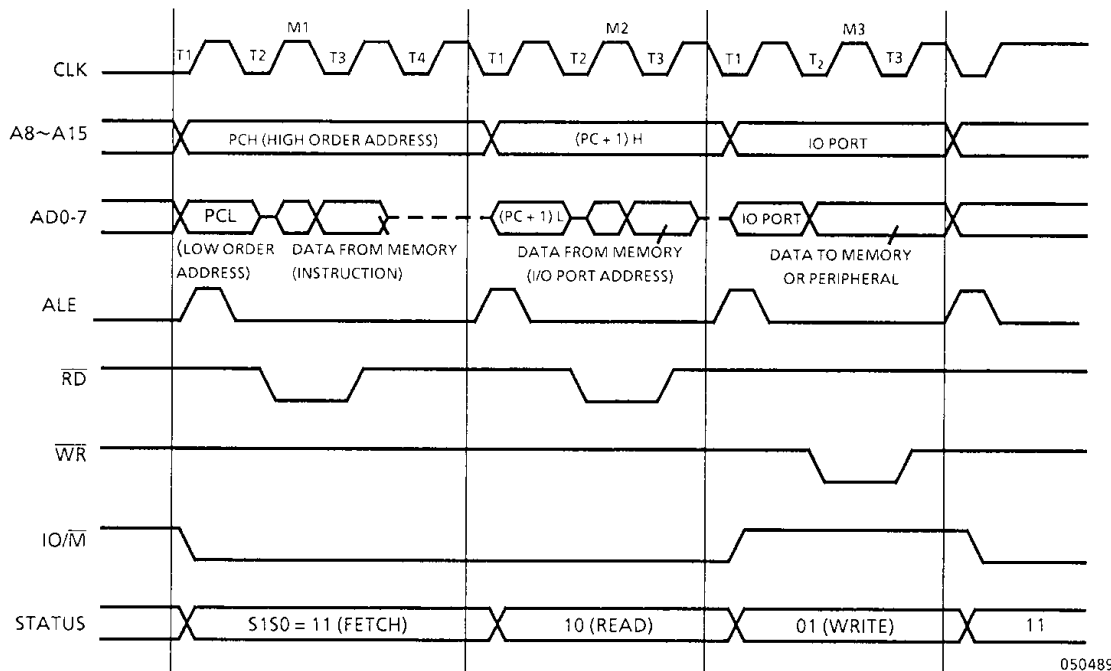
Notes: 0=Logic "0", 1=Logic "1", TS=High Impedance

Table 8.2 TMP8085 Machine State Chart

| MACHINE STATE | S ₁ , S ₀ | IO/ \overline{M} | A ₈ -A ₁₅ | AD ₀ -AD ₇ | \overline{RD} , \overline{WR} | \overline{INTA} | ALE |
|--------------------|---------------------------------|--------------------|---------------------------------|----------------------------------|-----------------------------------|-------------------|-----|
| T ₁ | X | X | X | X | 1 | 1 | 1° |
| T ₂ | X | X | X | X | X | X | 0 |
| T _{WAIT} | X | X | X | X | X | X | 0 |
| T ₃ | X | X | X | X | X | X | 0 |
| T ₄ | 1 | 0+ | X | TS | 1 | 1 | 0 |
| T ₅ | 1 | 0+ | X | TS | 1 | 1 | 0 |
| T ₆ | 1 | 0+ | X | TS | 1 | 1 | 0 |
| T _{RESET} | X | TS | TS | TS | TS | 1 | 0 |
| T _{HALT} | 0 | TS | TS | TS | TS | 1 | 0 |
| T _{HOLD} | X | TS | TS | TS | TS | 1 | 0 |

050489

- Notes : (1) 0 = LOGIC "0", 1 = Logic "1", TS = High Impedance, X = Unspecified
 (2) °ALE not generated during 2nd and 3rd machine cycles of DAD instruction
 (3) +IO/ \overline{M} = 1 during T₄-T₆ of INA machine cycle



050489

Figure 8.1 TMP8085A Basic System Timing

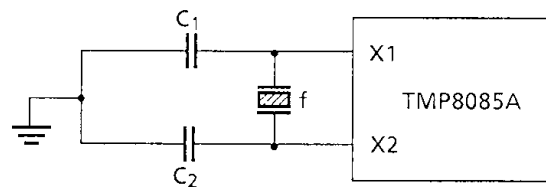
9. DRIVING THE X1 AND X2 INPUTS

The clock inputs of TMP8085A may be driven by a crystal oscillator, an LC tuned circuit, an RC network or an external clock source. The Minimum driving frequency must be 1 MHz, and must be twice as much as the desired internal clock frequency.

(1) Quartz Crystal Clock Driver

If a crystal used, it must have the following characteristics.

- Parallel resonance at twice the clock frequency desired
- C_S (shunt capacitance) ≤ 7 pF
- R_S (equivalent shunt resistance) ≤ 75 Ohms



050489

Figure 9.1

Note : A value of the external capacitors C_1 and C_2 between X1, X2 and ground.

The following values are recommended

$1\text{MHz} \leq f < 4\text{MHz}$: $C_1 = 20\text{pF}$, $C_2 = 20\text{pF}$

$4\text{MHz} \leq f \leq 8\text{MHz}$: $C_1 = 10\text{pF}$, $C_2 = 10\text{pF}$

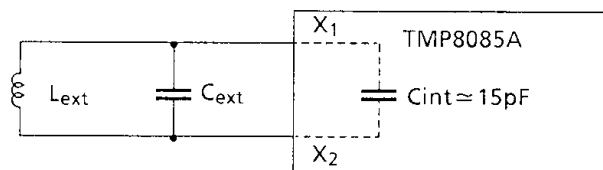
$8\text{MHz} < f \leq 10\text{MHz}$: $C_1 = 0$, $C_2 = 0$

(2) LC Turned Circuit Clock Driver

A parallel-resonant LC circuit may be used as the frequency-determining network for TMP8085A, providing that its frequency tolerance of approximately 10% is acceptable. The components are chosen from the formula.

$$f = \frac{1}{2\pi\sqrt{L(C_{\text{ext}} + C_{\text{int}})}}$$

The use of an LC circuit is not recommended for frequencies higher than approximately 5 MHz.

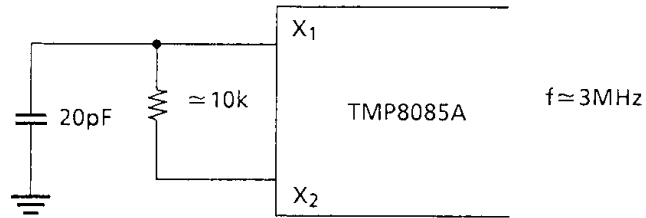


050489

Figure 9.2

(3) RC Circuit Clock Driver

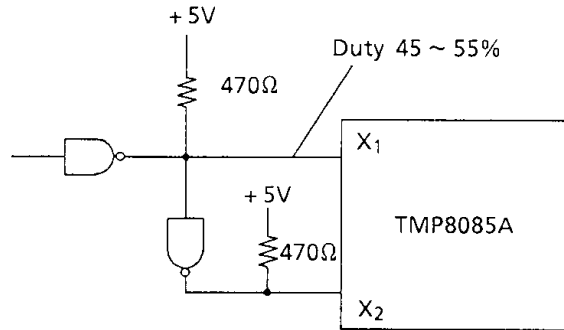
An RC circuit may be used in the case without precise clock frequency stability. Variations in the on-chip timing generation can cause a wide variation in frequency when using RC circuit. The driving frequency generated by the circuit shown is approximately 3 MHz. It is not recommended that frequencies greatly higher or lower than this be attempted.



050489

Figure 9.3

(4) External clock Driver Circuit



050489

Figure 9.4

10. POWER-ON-RESET

The TMP8085A is not guaranteed to work until 10 ms after V_{CC} reaches 4.75V. It is suggested that $\overline{\text{RESETIN}}$ be kept low during this period. Note that the 10 ms period does not include the time it takes for the power supply to reach its 4.75V level.

For the TMP8085AHP-2, Power-on-reset can be performed when the supply voltage reaches 4.50V.

11. INSTRUCCION SET

The code and function of machine instructions are shown as following table. In this table the symbols and abbreviated symbols are used for describing the instructions. However, the symbols required for special attention are explained on the page using them.

Explanation of Symbols

| Division | Symbol | Description |
|------------------|----------------------------|--|
| Register | r, g | Register B, C, D, E, H, L, A |
| | t | Register pair BC, DE, HL |
| | . | Stack pointer SP |
| | q | Register pair BC, DE, HL |
| | | Program status word PSW |
| Memory | mn | Memory address or immediate data indicated by 16 bits m expresses higher 8 bits and n expresses lower 8 bits |
| | (mn) | Contents of memory address indicated by mn |
| | (HL) | Contents of memory address indicated by register pair Contents of memory address indicated by register pair BC, DE and SP |
| Flag status | 0 | Be reset to 0 |
| | 1 | Be set to 1 |
| | - | No change |
| | * | Be affected by operation (be set to 0 or 1.) |
| Operation symbol | ← | Transfer |
| | ↕ | Exchange |
| | + | Addition |
| | - | Subtraction |
| | ∧ | Logical AND for every bit |
| | ∨ | Logical OR for every bit |
| ⊕ | Exclusive OR for every bit | |
| Other | IM | Interrupt mask register |
| | CY | Carry flag |

050489

TLCS-85 List of Machine Instruction (1/2)

| CLAS | ITEM | ASSEMBLER MNEMONIC | OBJECT CODE | | FUNCTION | FLAGS | | | | | CYCL | STAT | |
|-----------------------------|------------|-----------------------|---------------------------|--------------------|----------|-------|---|---|---|----|------|----------|----------|
| | | | BIN | HEX | | CY | Z | S | P | AC | | | |
| | | | 76 543 210 | | | | | | | | | | |
| 8bit load | MOV g, r | 01 ggg rrr | 40+g×8+r | g←r | - | - | - | - | - | 1 | 4 | rrr | |
| | MOV g, M | 01 ggg 110 | 46+g×8 | g←(HL) | - | - | - | - | - | 2 | 7 | 999 | Register |
| | MOV M, r | 01 110 rrr | 70+r | (HL)←r | - | - | - | - | - | 2 | 7 | 000 | B |
| | MVI g, n | 00 ggg 110 | 06+g×8 | g←n | - | - | - | - | - | 2 | 7 | 001 | C |
| | MVI M, n | 00 110 110 | 36 | (HL)←n | - | - | - | - | - | 3 | 10 | 010 | D |
| | | nn nnn nnn | n | | | | | | | | | 011 | E |
| | LDAX B | 00 001 010 | 0A | A←(BC) | - | - | - | - | - | 2 | 7 | 100 | H |
| | LDAX D | 00 011 010 | 1A | A←(DE) | - | - | - | - | - | 2 | 7 | 101 | L |
| | LDA mn | 00 111 010 | 3A | A←(mn) | - | - | - | - | - | 4 | 13 | 111 | A |
| | | nn nnn nnn | n | | | | | | | | | | |
| | | mmmmmmmm | m | | | | | | | | | | |
| | STAX B | 00 000 010 | 02 | (BC)←A | - | - | - | - | - | 2 | 7 | | |
| STAX D | 00 010 010 | 12 | (DE)←A | - | - | - | - | - | 2 | 7 | | | |
| STA mn | 00 110 010 | 32 | (mn)←A | - | - | - | - | - | 4 | 13 | | | |
| | nn nnn nnn | n | | | | | | | | | | | |
| | mmmmmmmm | m | | | | | | | | | | | |
| 16bit load | LXI t, mn | 00 tt0 001 | 01+t×16 | t←mn | - | - | - | - | - | 3 | 10 | 00 | BC |
| | | nn nnn nnn | n | | | | | | | | | 01 | DE |
| | | mmmmmmmm | m | | | | | | | | | 10 | HL |
| | LHLD mn | 00 101 010 | 2A | H←(mn+1) L←(mn) | - | - | - | - | - | 5 | 16 | 11 | SP |
| | | nn nnn nnn | n | | | | | | | | | | |
| | | mmmmmmmm | m | | | | | | | | | | |
| SHLD mn | 00 100 010 | 22 | (mn+1)←H (mn)←L | - | - | - | - | - | 5 | 16 | | | |
| | nn nnn nnn | n | | | | | | | | | | | |
| | mmmmmmmm | m | | | | | | | | | | | |
| SPHL | 11 111 001 | F9 | SP←HL | - | - | - | - | - | 1 | 6 | | | |
| PUSH q | 11 qq0 101 | C5+q×6 | (SP-1)(SP-2)←q SP←SP-2 | - | - | - | - | - | 3 | 12 | qq | Register | |
| | nn nnn nnn | n | | | | | | | | | 00 | BC | |
| POP q | 11 qq0 001 | C1+q×6 | q←(SP+1)(SP) SP←SP+2 | - | - | - | - | - | 3 | 10 | 01 | DE | |
| | nn nnn nnn | n | | | | | | | | | 10 | HL | |
| | mmmmmmmm | m | | | | | | | | | 11 | PSW | |
| (a) | XCHG | 11 101 011 | EB | DE↔HL | - | - | - | - | - | 1 | 4 | | |
| | XTHL | 11 100 011 | E3 | H↔(SP+1),L↔(SP) | - | - | - | - | - | 5 | 16 | | |
| 8bit arithmetic and logical | ADD r | 10 000 rrr | 80+r | A←A+r | * | * | * | * | * | 1 | 4 | | |
| | ADD M | 10 000 110 | 86 | A←A+(HL) | * | * | * | * | * | 2 | 7 | | |
| | ADI n | 11 000 110 | C6 | A←A+n | * | * | * | * | * | 2 | 7 | | |
| | | nn nnn nnn | n | | | | | | | | | | |
| | ADC r | 10 001 rrr | 88+r | A←A+r+CY | * | * | * | * | * | 1 | 4 | | |
| | ADC M | 10 001 110 | 8E | A←A+(HL)+CY | * | * | * | * | * | 2 | 7 | | |
| | ACI n | 11 001 110 | CE | A←A+n+CY | * | * | * | * | * | 2 | 7 | | |
| | | nn nnn nnn | n | | | | | | | | | | |
| | SUB r | 10 010 rrr | 90+r | A←A-r | * | * | * | * | * | 1 | 4 | | |
| | SUB M | 10 010 110 | 96 | A←A-(HL) | * | * | * | * | * | 2 | 7 | | |
| | SUI n | 11 010 110 | D6 | A←A-n | * | * | * | * | * | 2 | 7 | | |
| | | nn nnn nnn | n | | | | | | | | | | |
| | SBB r | 10 011 rrr | 98+r | A←A-r-CY | * | * | * | * | * | 1 | 4 | | |
| | SBB M | 10 011 110 | 9E | A←A-(HL)-CY | * | * | * | * | * | 2 | 7 | | |
| | SBI n | 11 011 110 | DE | A←A-n-CY | * | * | * | * | * | 2 | 7 | | |
| | | nn nnn nnn | n | | | | | | | | | | |
| | ANA r | 10 100 rrr | A0+r | A←A∧r | 0 | * | * | * | * | 1 | 4 | | |
| | ANA M | 10 100 110 | A6 | A←A∧(HL) | 0 | * | * | * | * | 2 | 7 | | |
| | ANI n | 11 100 110 | E6 | A←A∧n | 0 | * | * | * | * | 2 | 7 | | |
| | | nn nnn nnn | n | | | | | | | | | | |
| ORA r | 10 110 rrr | B0+r | A←A∨r | 0 | * | * | * | * | 0 | 1 | 4 | | |
| ORA M | 10 110 110 | B6 | A←A∨(HL) | 0 | * | * | * | * | 0 | 2 | 7 | | |
| ORI n | 11 110 110 | F6 | A←A∨n | 0 | * | * | * | * | 0 | 2 | 7 | | |
| | nn nnn nnn | n | | | | | | | | | | | |
| XRA r | 10 101 rrr | A8+r | A←A⊖r | 0 | * | * | * | * | 0 | 1 | 4 | | |
| XRA M | 10 101 110 | AE | A←A⊖(HL) | 0 | * | * | * | * | 0 | 2 | 7 | | |

TLCS-85 List of Machine Instruction (2/2)

| CLASS | ITEM | ASSEMBLER MNEMONIC | OBJECT CODE | | FUNCTION | FLAGS | | | | | CYCL | STAT |
|-----------------------------|------|-----------------------|-------------|------------------------|--|-------|---|---|---|----|------|------|
| | | | BIN | HEX | | CY | Z | S | P | AC | | |
| | | | 76 543 210 | | | | | | | | | |
| 8bit arithmetic and logical | XRI | n | 11 101 110 | EE | $A \leftarrow A \oplus n$ | 0 | * | * | * | 0 | 2 | 7 |
| | CMP | r | 10 111 rrr | B8+r | A-r | * | * | * | * | * | 1 | 4 |
| | CPM | M | 10 111 110 | BE | A-(HL) | * | * | * | * | * | 2 | 7 |
| | CPI | n | 11 111 110 | FE | A-n | * | * | * | * | * | 2 | 7 |
| | INR | g | 00 999 100 | 04+g×8 | $g \leftarrow g+1$ | - | * | * | * | * | 1 | 4 |
| | INR | M | 00 110 100 | 34 | (HL) \leftarrow (HL)+1 | - | * | * | * | * | 3 | 10 |
| | DCR | g | 00 999 101 | 05+g×8 | $g \leftarrow g-1$ | - | * | * | * | * | 1 | 4 |
| | DCR | M | 00 110 101 | 35 | (HL) \leftarrow (HL)-1 | - | * | * | * | * | 3 | 10 |
| | DAA | | 00 100 111 | 27 | Decimal adjust accumulator | * | * | * | * | * | 1 | 4 |
| | CMA | | 00 101 111 | 2F | A \leftarrow NOT A | - | - | - | - | - | 1 | 4 |
| CMC | | 00 111 111 | 3F | CY \leftarrow NOT CY | * | - | - | - | - | 1 | 4 | |
| STC | | 00 110 111 | 37 | CY \leftarrow 1 | 1 | - | - | - | - | 1 | 4 | |
| NOP | | 00 000 000 | 00 | no operation | - | - | - | - | - | 1 | 4 | |
| HLT | | 01 110 110 | 76 | MPU halt | - | - | - | - | - | 1 | 5 | |
| DI | | 11 110 011 | F3 | INTE F/F Reset | - | - | - | - | - | 1 | 4 | |
| EI | | 11 111 011 | FB | INTE F/F Set | - | - | - | - | - | 1 | 4 | |
| (c) | DAD | t | 00 tt1 001 | 09+t×10 | HL \leftarrow HL+t | * | - | - | - | - | 3 | 10 |
| | INX | t | 00 tt0 011 | 03+t×10 | t \leftarrow t+1 | - | - | - | - | - | 1 | 6 |
| | DCX | t | 00 tt1 011 | 0B+t×10 | t \leftarrow t-1 | - | - | - | - | - | 1 | 6 |
| Rotate and sift | RLC | | 00 000 111 | 07 | | * | - | - | - | - | 1 | 4 |
| | RAL | | 00 010 111 | 17 | | * | - | - | - | - | 1 | 4 |
| | RRC | | 00 001 111 | 0F | | * | - | - | - | - | 1 | 4 |
| | RAR | | 00 011 111 | 1F | | * | - | - | - | - | 1 | 4 |
| Jump and call and return | JMP | mn | 11 000 011 | C3 | PC \leftarrow mn | - | - | - | - | - | 3 | 10 |
| | Jc | mn | 11 ccc 010 | C2+C×8 | IF cc is true, PC \leftarrow mn otherwise, PC \leftarrow PC+3 | - | - | - | - | - | 3 | 10 |
| | PCHL | | 11 101 001 | E9 | PC \leftarrow HL | - | - | - | - | - | 1 | 6 |
| | CALL | mn | 11 001 101 | CD | (SP-1)(SP-2) \leftarrow PC, SP \leftarrow SP-2, PC \leftarrow mn | - | - | - | - | - | 5 | 18 |
| | Cc | mn | 11 ccc 100 | C4+c×8 | IF c is true, (SP-1)(SP-2) \leftarrow PC, SP \leftarrow SP-2, PC \leftarrow mn otherwise, PC \leftarrow PC+3 | - | - | - | - | - | 5 | 18 |
| | RET | | 11 001 001 | C9 | PC \leftarrow (SP+1)(SP), SP \leftarrow SP+2 | - | - | - | - | - | 2 | 9 |
| | Rc | | 11 ccc 000 | C0+C×8 | IF c is true, PC \leftarrow (SP+1)(SP), SP \leftarrow SP+2 otherwise, PC \leftarrow PC+1 | - | - | - | - | - | 3 | 12 |
| | RST | j | 11 kkk 111 | C7+k×8 | (SP-1)(SP-2) \leftarrow PC, SP \leftarrow SP-2, PC \leftarrow kkk×8 | - | - | - | - | - | 3 | 12 |
| (d) | IN | n | 11 011 011 | DB | A \leftarrow (n) | - | - | - | - | - | 3 | 10 |
| | OJT | n | 11 010 011 | D3 | (n) \leftarrow A | - | - | - | - | - | 3 | 10 |
| | | | nn nnn nnn | n | | - | - | - | - | - | 100 | 4 |
| | | | nn nnn nnn | n | | - | - | - | - | - | 101 | 5 |
| | | | nn nnn nnn | n | | - | - | - | - | - | 110 | 6 |
| | | | nn nnn nnn | n | | - | - | - | - | - | 111 | 7 |
| | | | nn nnn nnn | n | | - | - | - | - | - | 100 | 4 |
| (e) | RIM | | 00 100 000 | 20 | A \leftarrow IM | - | - | - | - | - | 1 | 4 |
| | SIM | | 00 110 000 | 30 | IM \leftarrow A | - | - | - | - | - | 1 | 4 |

Note: "POP PSW" instruction changes state of flags.

(a) Exchange (b) General purpose arithmetic and MPU control
(c) 16bit arithmetic (d) Input and output (e) Interrupt

050489

12. ELECTRICAL CHARACTERISTICS

12.1 ABSOLUTE MAXIMUM RATINGS

| Symbol | Item | Ratings | Units |
|---------|-----------------------|--------------|-------|
| VCC | VCC Supply voltage | -0.5 to +7.0 | V |
| PD | Power Dissipation | 1.5 | W |
| Tsolder | Soldering Temperature | 260 (10 sec) | °C |
| Tstg | Storage Temperature | -55 to 150 | °C |
| Topr | Operating Temperature | 0 to 70 | °C |

050489

12.2 DC CHARACTERISTICS

TA = 0°C to 70°C, VCC = 5V ± 5% : TMP8085AP-2

VCC = 5V ± 10% : TMP8085AHP-2

| Symbol | Parameter | Test Conditions | Min. | Max. | Units |
|--------|--------------------------|-------------------|------|-----------|-------|
| VIL | Input Low Voltage | | -0.5 | 0.8 | V |
| VIH | Input High Voltage | | 2.0 | VCC + 0.5 | V |
| VOL | Output Low Voltage | IOL = 2mA | | 0.45 | V |
| VOH | Output High Voltage | IOH = -400µA | 2.4 | | V |
| ICC | Power Supply Current | TMP8085AP/AP-2 | | 170 | mA |
| | | TMP8085AHP/AHP-2 | | 135 | |
| IIL | Input Leakage | 0 ≤ VIN ≤ VCC | | ± 10 | µA |
| ILO | Output Leakage | 0.45 ≤ VOUT ≤ VCC | | ± 10 | µA |
| VILR | Input Low Level (RESET) | | -0.5 | 0.8 | V |
| VIHR | Input High Level (RESET) | | 2.4 | VCC + 0.5 | V |
| VHY | Hysteresis (RESET) | | 0.25 | | V |

050489

12.3 AC CHARACTERISTICS

TA = 0°C to 70°C, V_{CC} = 5V ± 5% : TMP8085AP-2
 V_{CC} = 5V ± 10% : TMP8085AHP-2
 V_{SS} = 0V, unless otherwise noted.

| Symbol | Parameter | Min. | Max. | Units |
|--------|--|------|------|-------|
| tCYC | CLK Cycle Period | 200 | 2000 | ns |
| tL | CLK Low Time | 40 | | ns |
| | | 50* | | ns |
| tH | CLK High Time | 70 | | ns |
| | | 80* | | ns |
| tr, tf | CLK Rise and Fall Time | | 30 | ns |
| tXKR | X1 Rising to CLK Rising | 30 | 100 | ns |
| tXKF | X1 Rising to CLK Falling | 30 | 110 | ns |
| tAC | A8-15 Valid to Leading Edge of Control [1] | 115 | | ns |
| tACL | A0-7 Valid to Leading of Control | 115 | | ns |
| tAD | A0-15 Valid to Valid Data In | | 350 | ns |
| tAFR | Address Float after Leading Edge of ALE READ (INT) | | 0 | ns |
| tAL | A8-15 Valid before Trailing Edge of ALE [1] | 50 | | ns |
| tALL | A0-7 Valid before Trailing Edge of ALE | 50 | | ns |
| tARY | READY Valid from Address Valid | | 100 | ns |
| tCA | Address (A8-15) Valid after Control | 60 | | ns |
| tCC | Width of Control Low (RD, WR, INTA) Edge of ALE | 230 | | ns |
| tCL | Trailing Edge of Control to Leading Edge of ALE | 25 | | ns |
| tDW | Data Valid to Trailing Edge of WRITE | 230 | | ns |
| tHABE | HLDA to Bus Enable | | 150 | ns |
| tHABF | Bus Float after HLDA | | 150 | ns |
| tHACK | HLDA Valid to Trailing Edge of CLK | 40 | | ns |
| tHDH | HOLD Hold Time | 0 | | ns |
| tHDS | HOLD Setup Time to Trailing Edge of CLK | 120 | | ns |
| tINH | INTR Hold Time | 0 | | ns |
| tINS | INTR, RST and TRAP Setup Time to Falling | 150 | | ns |
| tLA | Edge of CLK Address Hold Time after ALE | 50 | | ns |
| tLC | Trailing Edge of ALE to Leading Edge of Control | 60 | | ns |

050489

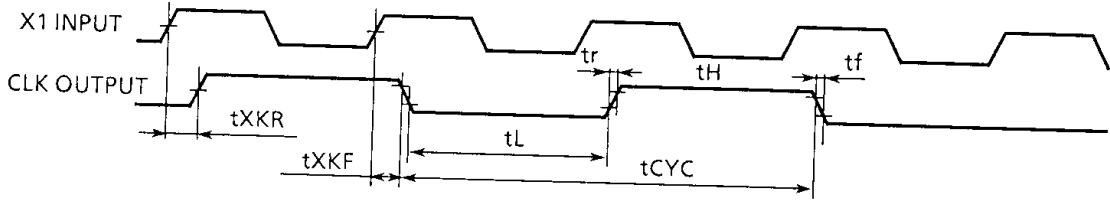
| Symbol | Parameter | Min. | Max. | Units |
|--------|---|------|------|-------|
| tLCK | ALE Low during CLK High | 50 | | ns |
| tLDR | ALE to Valid Data during Read | | 270 | ns |
| tLDW | ALE to Valid Data during Write | | 120 | ns |
| tLL | ALE Width | 80 | | ns |
| tLRY | ALE to READY Stable | | 30 | ns |
| tRAE | Trailing Edge of READ to Re-Enabling of Address | 90 | | ns |
| tRD | READ (or INTA) to Valid Data | | 150 | ns |
| tRV | Control Trailing Edge of Leading Edge of Next Control | 220 | | ns |
| tRDH | Data Hold Time After READ INTA | 0 | | ns |
| tRYH | READY Hold Time | 0 | | ns |
| tRYS | READY Setup Time to Leading Edge of CLK | 100 | | ns |
| tWD | Data Valid After Trailing Edge of WRITE | 60 | | ns |
| tWDL | LEADING Edge of WRITE to Data Valid | | 20 | ns |

050489

Test conditions CL = 150pF (*: CL = 50pF + 1TTL)
t_{cy} = 200ns

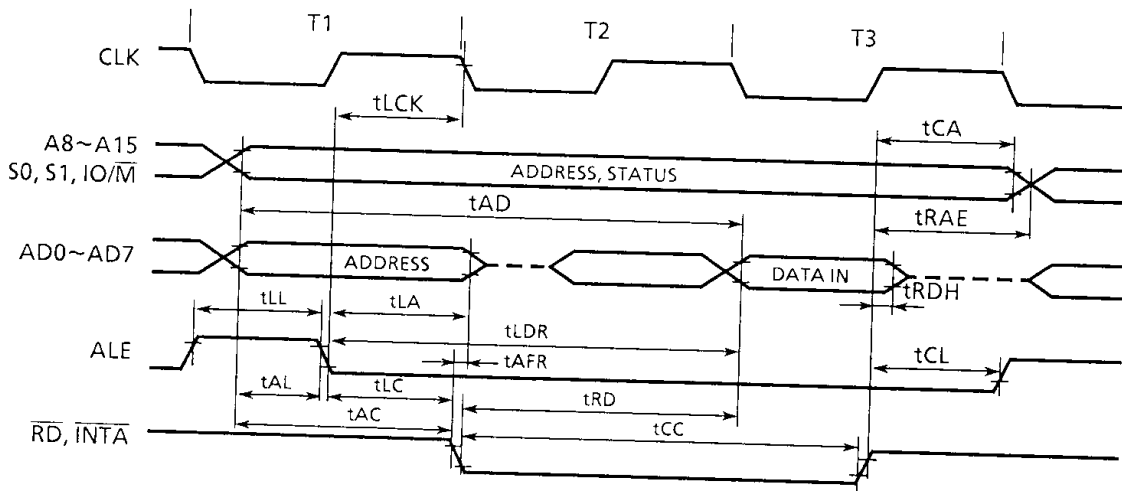
- Notes :
1. A8-15 address specs apply to IO/M, S0 and S1 expect A8-15 are undifiend during T4-T6 of Cycle whereas IO/M, S0, and S1 are stable.
 2. Timing defining signal voltage are;
Output High level = 2.0V, Low level = 0.8V
 3. To calculate timing specifications at other value of t_{CYC} use Table 12.1.

12.4 TIMING WAVEFORMS



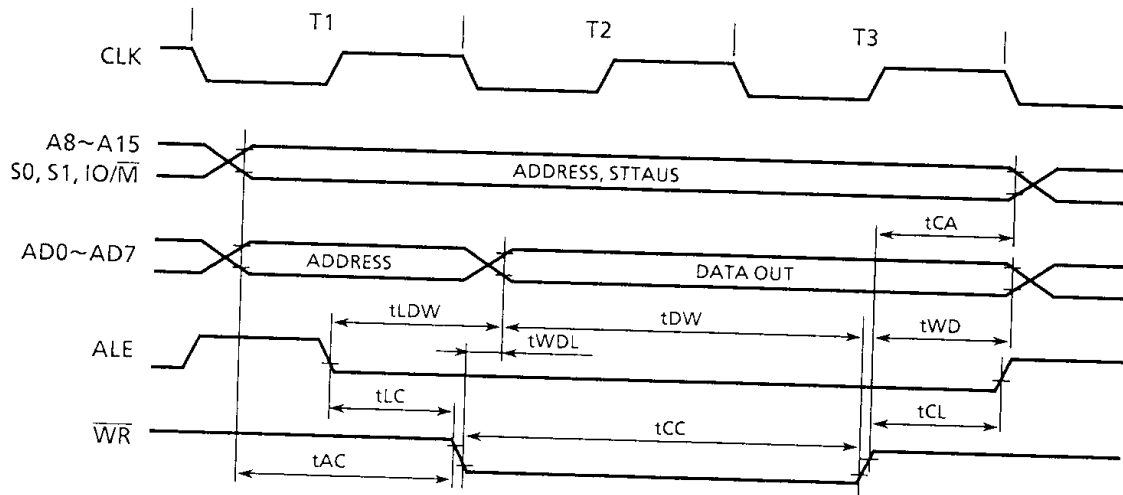
050489

Figure 12.1 Clock Timing Waveform



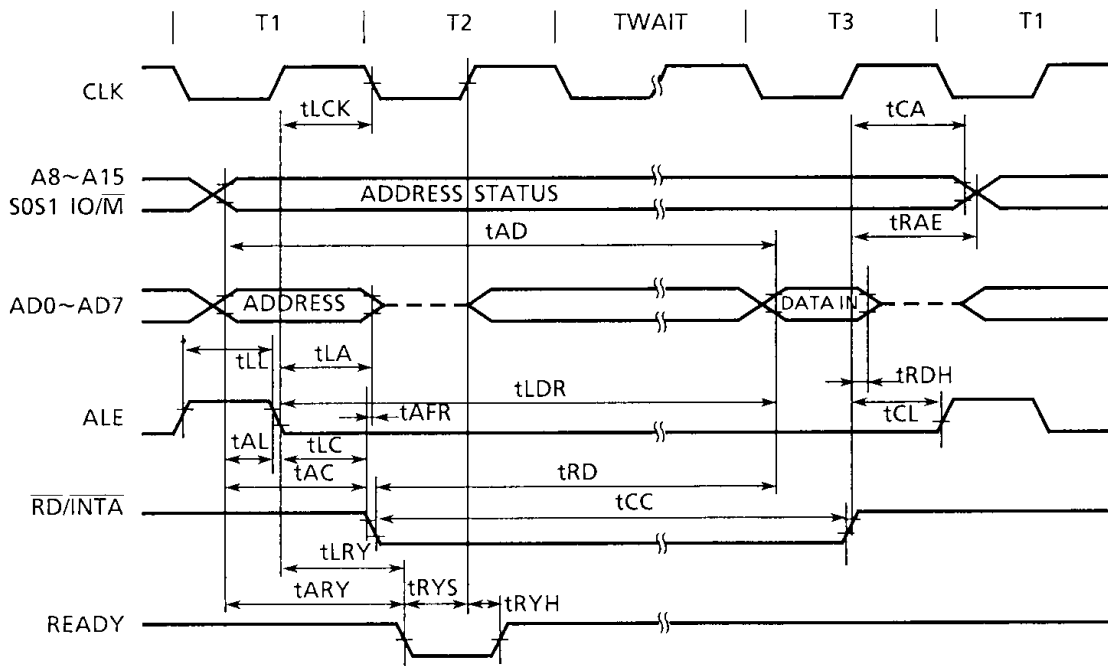
050489

Figure 12.2 Read Operation



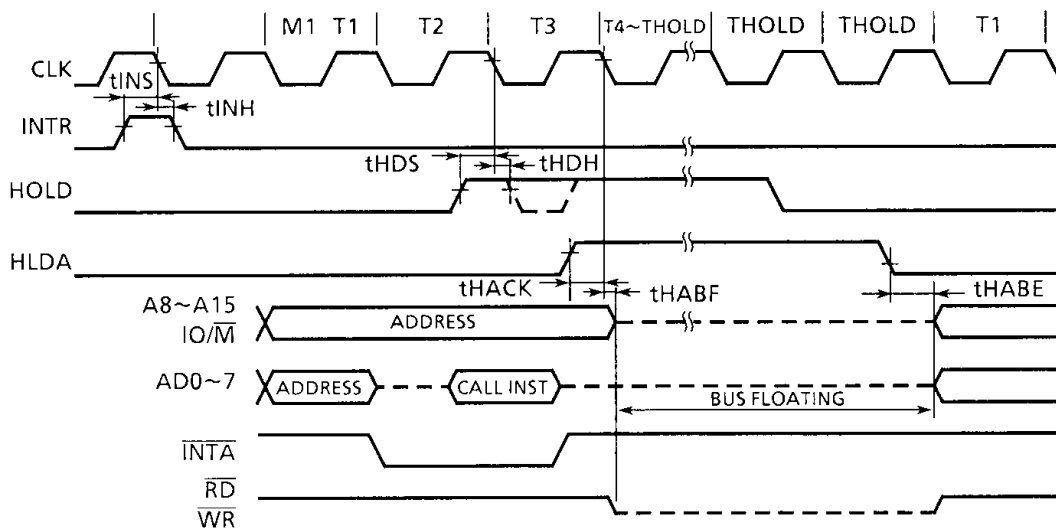
050489

Figure 12.3 Write Operation



050489

Figure 12.4 Read Operation with Wait Cycle (Typical)
- Same Ready Timing Applied to Write Operation

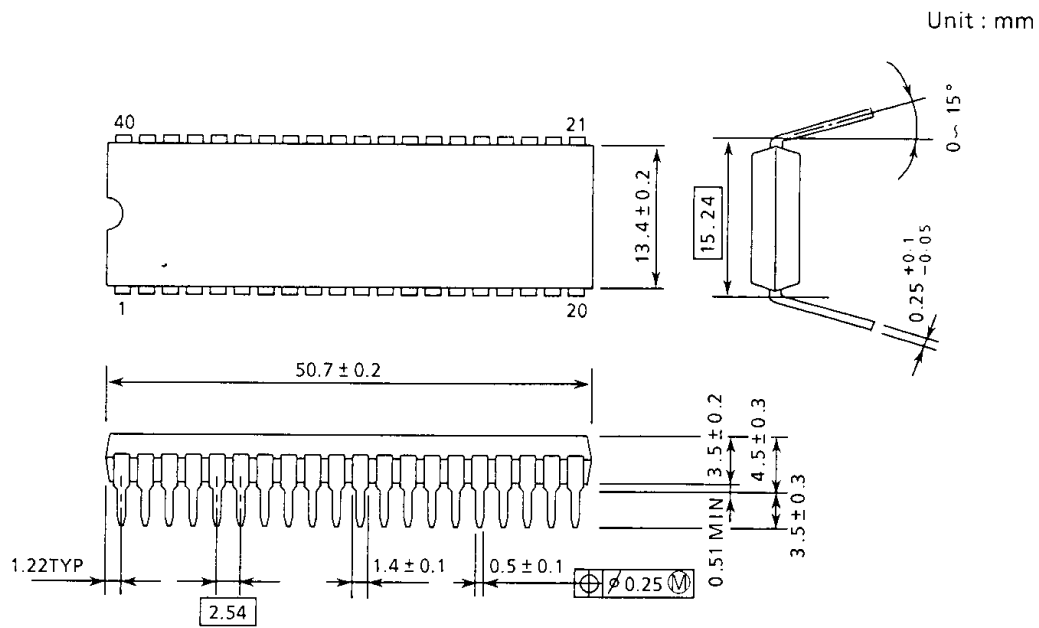


050489

Figure 12.5 Interrupt and Hold Timing

13. OUTLINE DRAWING (40PINS PLASTIC PACKAGE)

DIP40-P-600



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Note: Each lead pitch is 2.54mm, and all the leads are located within ± 0.25 mm from their theoretical positions with respect to No.1 and No.40 leads.