
EM78P159N

**8-Bit Microcontroller
with OTP ROM**

Product Specification

DOC. VERSION 1.0

ELAN MICROELECTRONICS CORP.


March 2006



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Specification Revision History

| Doc. Version | Revision Description | Date |
|--------------|-------------------------|------------|
| 1.0 | Initial Release Version | 2006/03/10 |

1 General Description

EM78P159N is an 8-bit microprocessor designed and developed with low-power, high-speed CMOS technology. It is equipped with 1K*13-bits Electrical One Time Programmable Read Only Memory (OTP-ROM). It provides three PROTECTION bits to prevent user's code in the OTP memory from being intruded. 8 OPTION bits are also available to meet user's requirements.

With its OTP-ROM feature, the EM78P159N is able to offer a convenient way of developing and verifying user's programs. Moreover, user can take advantage of ELAN Writer to easily program his development code.

1.1 Comparison between EM78P159N, EM78P154N, and EM78P157N

To find out what similarities and differences are between EM78P159N EM78P154N and EM78P157N, click the following link.

[AN-001 EM78P154N/159N introduction and comparison with EM78P157N](#)

2 Features

- Operating voltage range:
 - 2.1V~5.5V at 0°C~70°C
 - 2.3V~5.5V at 40°C~85°C
- Operating frequency range (base on 2 clocks):
 - Crystal mode: DC~20MHz at 5.0V, DC~8MHz at 3.0V, DC~4MHz at 2.1V
 - ERC mode: DC~4MHz at 5.0~2.1V
 - IRC mode: 4 choices of frequencies available; i.e., 8M, 4M, 1M, & 455kHz
- IRC mode:
 - All these four main frequencies can be trimmed by programming with four calibrated bits in the ICE159N Simulator. OTP is auto trimmed by DWTR.
 - Temperature, Voltage, and Process changes will influence the frequency drift
 - Frequency deviation is only $\pm 4.5\%$ after auto trimming (based on Vdd=5V, Ta=25°C)
- Fast set-up time only requires about 2ms in high XTAL and 32CLKS in IRC mode from wake up to operating mode



- Low power consumption:
 - Less than 2mA at 5V/4MHz
 - Typically 20 μ A at 3V/32kHz
 - Typically 1 μ A during Sleep mode
- 1K \times 13 bits on chip ROM
- One security register to prevent intrusion of OTP memory codes
- One configuration register to accommodate user's requirements
- 48 \times 8 bits on chip registers (SRAM, general purpose register)
- 2 bi-directional I/O ports
- 5 level stacks for subroutine nesting
- 8-bit real time clock/counter (TCC) with selective signal sources, trigger edges, and overflow interrupt
- Two clocks per instruction cycle
- Power down (SLEEP) mode
- Three available interruptions:
 - TCC overflow interrupt
 - Input-port status changed interrupt (wake up from Sleep mode)
 - External interrupt
- Programmable free running watchdog timer
- 8 programmable pull-high pins
- 8 programmable pull-down pins
- 8 programmable open-drain pins
- 2 programmable R-option pins
- Package types:
 - 18 pin DIP 300mil : EM78P159NP
 - 18 pin SOP 300mil : EM78P159NM
 - 20 pin SSOP 209mil : EM78P159NAS
 - 20 pin SSOP 209mil : EM78P159NKM
- 99.9% single instruction cycle commands
- The transient point of system frequency between HXT and LXT is around 400kHz

3 Pin Assignments and Descriptions

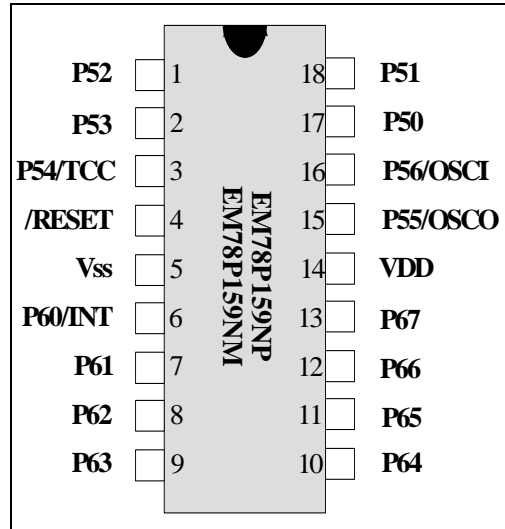


Figure3-1a EM78P159NP/M Pin Assignments

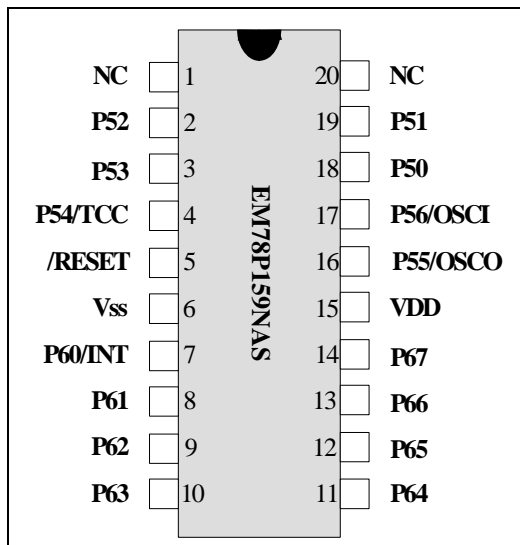


Figure3-1b EM78P159NAS Pin Assignments

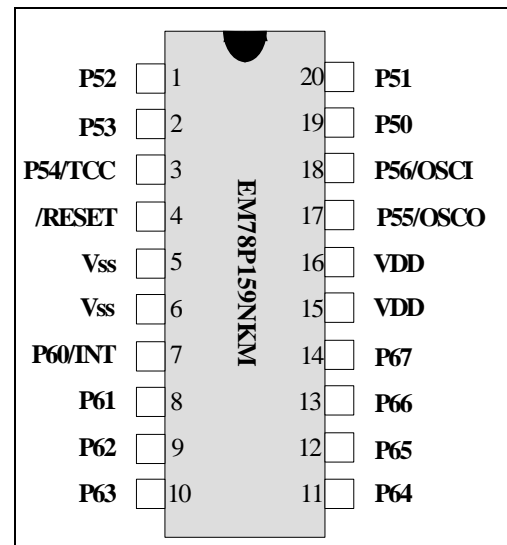


Figure3-1c EM78P159NKM Pin Assignments

3.1 EM78P159NP and EM78P159NM Pin Description

| Symbol | Pin No. | Type | Function |
|-----------|--------------|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| VDD | 14 | - | ■ Power supply |
| P56/OSCI | 16 | I/O | <ul style="list-style-type: none"> ■ General-purpose I/O pin ■ XTAL type: Crystal input terminal or external clock input pin ■ ERC type: RC oscillator input pin |
| P55/OSCO | 15 | I/O | <ul style="list-style-type: none"> ■ General-purpose I/O pin ■ XTAL type: Output terminal for crystal oscillator or external clock input pin ■ RC type: Instruction clock output ■ External clock signal input |
| P54/TCC | 3 | I/O | <ul style="list-style-type: none"> ■ General-purpose I/O pin ■ The real time clock/counter (with Schmitt trigger input pin), must be tied to VDD or VSS if not in use. |
| /RESET | 4 | I | ■ Input pin with Schmitt trigger. If this pin remains at logic low, the controller will also remain in reset condition. |
| P50 ~ P53 | 17, 18, 1, 2 | I/O | <ul style="list-style-type: none"> ■ P50 ~ P53 are bi-directional I/O pins. ■ P50 and P51 can also be defined as the R-option pins ■ P50 ~ P53 can be pulled-down by software |
| P60 ~ P67 | 6 ~ 13 | I/O | <ul style="list-style-type: none"> ■ P60 ~ P67 are bi-directional I/O pins. ■ These can be pulled-high or can be open-drain by software programming ■ P60 ~ P63 can also be pulled-down by software |
| /INT | 6 | I | ■ External interrupt pin triggered by falling edge |
| VSS | 5 | - | ■ Ground |

3-2 EM78P159NAS Pin Description

| Symbol | Pin No. | Type | Function |
|----------|--------------|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| VDD | 15 | - | ■ Power supply. |
| P56/OSCI | 17 | I/O | <ul style="list-style-type: none"> ■ General-purpose I/O pin ■ XTAL type: Crystal input terminal or external clock input pin ■ ERC type: RC oscillator input pin |
| P55/OSCO | 16 | I/O | <ul style="list-style-type: none"> ■ General-purpose I/O pin ■ XTAL type: Output terminal for crystal oscillator or external clock input pin ■ RC type: Instruction clock output ■ External clock signal input |
| P54/TCC | 4 | I/O | <ul style="list-style-type: none"> ■ General-purpose I/O pin ■ The real time clock/counter (with Schmitt trigger input pin), must be tied to VDD or VSS if not in use. |
| /RESET | 5 | I | ■ Input pin with Schmitt trigger. If this pin remains at logic low, the controller will also remain in reset condition. |
| P50~P53 | 18, 19, 2, 3 | I/O | <ul style="list-style-type: none"> ■ P50 ~ P53 are bi-directional I/O pins ■ P50 and P51 can also be defined as the R-option pins ■ P50 ~ P53 can be pulled-down by software |
| P60~P67 | 7~14 | I/O | <ul style="list-style-type: none"> ■ P60 ~ P67 are bi-directional I/O pins. ■ These can be pulled-high or can be open-drain by software programming ■ P60 ~ P63 can also be pulled-down by software |
| /INT | 7 | I | ■ External interrupt pin triggered by falling edge |
| VSS | 6 | - | ■ Ground |

3.3 EM78P159NKM Pin Description

| Symbol | Pin No. | Type | Function |
|----------|-----------------|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| VDD | 15,16 | - | ■ Power supply. |
| P56/OSCI | 18 | I/O | <ul style="list-style-type: none"> ■ General-purpose I/O pin ■ XTAL type: Crystal input terminal or external clock input pin. ■ ERC type: RC oscillator input pin. |
| P55/OSCO | 17 | I/O | <ul style="list-style-type: none"> ■ General-purpose I/O pin ■ XTAL type: Output terminal for crystal oscillator or external clock input pin ■ RC type: Instruction clock output ■ External clock signal input |
| P54/TCC | 3 | I/O | <ul style="list-style-type: none"> ■ General-purpose I/O pin ■ The real time clock/counter (with Schmitt trigger input pin), must be tied to VDD or VSS if not in use. |
| /RESET | 4 | I | ■ Input pin with Schmitt trigger. If this pin remains at logic low, the controller will also remain in reset condition. |
| P50~P53 | 19, 20, 1, 2 | I/O | <ul style="list-style-type: none"> ■ P50 ~ P53 are bi-directional I/O pins. ■ P50 and P51 can also be defined as the R-option pins. ■ P50 ~ P53 can be pulled-down by software. |
| P60~P67 | 7~14 | I/O | <ul style="list-style-type: none"> ■ P60 ~ P67 are bi-directional I/O pins. ■ These can be pulled-high or can be open-drain by software programming. ■ P60 ~ P63 can also be pulled-down by software |
| /INT | 7 | I | ■ External interrupt pin triggered by falling edge |
| VSS | 5, 6 | - | ■ Ground |

4 Function Description

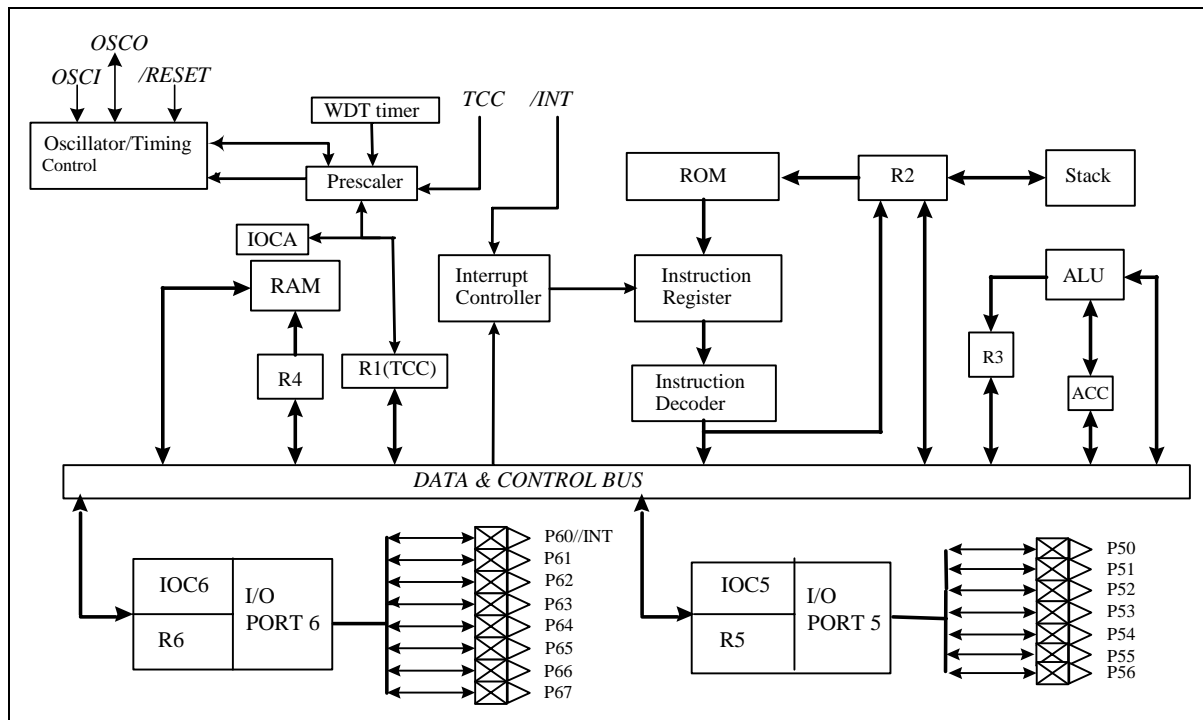


Figure 4-1 Function Block Diagram

4.1 Operational Registers

4.1.1 R0 (Indirect Addressing Register)

R0 is not a physically implemented register. Its major function is to perform as an indirect addressing pointer. Any instruction using R0 as a pointer actually accesses data pointed by the RAM Select Register (R4).

4.1.2 R1 (Time Clock /Counter)

- Increased by an external signal edge, which is defined by TE bit (CONT-4) through the TCC pin, or by the instruction cycle clock.
- Writable and readable as any other registers.
- Defined by resetting PAB(CONT-3).
- The prescaler is assigned to TCC, if the PAB bit (CONT-3) is reset.
- The contents of the prescaler counter will be cleared only when TCC register is written with a value.

4.1.3 R2 (Program Counter) & Stack

- Depending on the device type, R2 and hardware stack are 10-bit wide. The structure is depicted in the following figure.

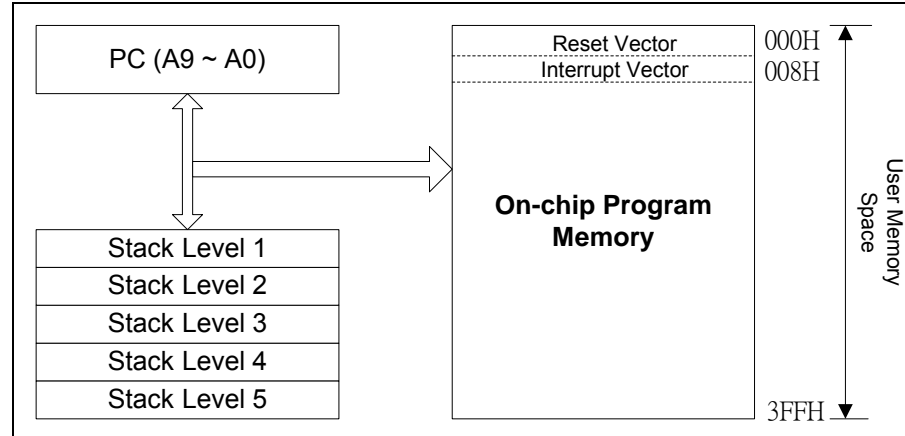


Figure 4-2 Program Counter Organization

- Generating 1024×13 bits on-chip OTP ROM addresses to the relative programming instruction codes. One program page is 1024 words long.
- R2 is set as all "0" when under RESET condition.
- "JMP" instruction allows direct loading of the lower 10 program counter bits. Thus, "JMP" allows PC to go to any location within a page.
- "CALL" instruction loads the lower 10 bits of the PC, and then PC+1 is pushed into the stack. Thus, the subroutine entry address can be located anywhere within a page.
- "RET" ("RETLk", "RETI") instruction loads the program counter with the contents of the top-level stack.
- "ADD R2, A" allows a relative address to be added to the current PC, and the ninth and succeeding bits of the PC will increase progressively.
- "MOV R2, A" allows loading of an address from the "A" register to the lower 8 bits of the PC, and the ninth and tenth bits (A8 ~ A9) of the PC will remain unchanged.
- Any instruction (except "ADD R2,A") that is written to R2 (e.g., "MOV R2, A", "BC R2, 6",.....) will cause the ninth bit and the tenth bit (A8 ~ A9) of the PC to remain unchanged.
- All instructions are single instruction cycle (fclk/2 or fclk/4) except for the instruction that would change the contents of R2. Such instruction will need one more instruction cycle.



- The Data Memory Configuration is as follows:

| Address | R PAGE Registers | IOC PAGE Registers |
|---------------|-------------------------|-----------------------------------|
| 00 | R0 (IAR) | Reserve |
| 01 | R1 (TCC) | CONT (Control Register) |
| 02 | R2 (PC) | Reserve |
| 03 | R3 (Status) | Reserve |
| 04 | R4 (RSR) | Reserve |
| 05 | R5 (Port5) | IOC5 (I/O Port Control Register) |
| 06 | R6 (Port6) | IOC6 (I/O Port Control Register) |
| 07 | Reserve | Reserve |
| 08 | Reserve | Reserve |
| 09 | Reserve | Reserve |
| 0A | Reserve | IOCA (Prescaler Control Register) |
| 0B | Reserve | IOCB (Pull-down Register) |
| 0C | Reserve | IOCC (Open-drain Control) |
| 0D | RD (Only for simulator) | IOCD (Pull-high Control Register) |
| 0E | RE (Wake up control) | IOCE (WDT Control Register) |
| 0F | RF (Interrupt Status) | IOCF (Interrupt Mask Register) |
| 10 : 3F | General Registers | |

4.1.4 R3 (Status Register)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| GP2 | GP1 | GP0 | T | P | Z | DC | C |

Bit 0 (C) Carry flag

Bit 1 (DC) Auxiliary carry flag

Bit 2 (Z) Zero flag.

Set to "1" if the result of an arithmetic or logic operation is zero.

Bit 3 (P) Power down bit.

Set to "1" during power on or by a "WDTC" command; and reset to "0" by a "SLEP" command.

Bit 4 (T) Time-out bit.

Set to "1" with the "SLEP" and "WDTC" commands, or during power up; and reset to "0" by WDT time-out.

Bit 5 ~7 (GP0 ~ 2) General-purpose read/write bits.

4.1.5 R4 (RAM Select Register)

Bits 0~5 are used to select registers (Address: 00~06, 0F~3F) in the indirect addressing mode.

Bits 6~7 Not used (read only). Set these bits to "1" all the time.

The "Z" flag of R3 will set to "1" when the R4 content is equal to "3F." When R4=R4+1, the R4 content will select "R0."

4.1.6 R5 ~ R6 (Port 5 ~ Port 6)

R5 and R6 are I/O registers. Only the lower 7 bits of R5 are available.

4.1.7 RD (Manual Calibration Register)

| | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| EM78P159N | X | X | X | X | X | X | X | X |
| ICE159N Simulator | - | - | - | - | C3 | C2 | C1 | C0 |

In EM78P159N: The register does not exist in real chip.

In ICE159N Simulator: C3 ~ C0 are IRC calibration bits in MCIRC mode.

Bit 3 ~ Bit 0 (C3 ~ C0): are the Calibrators of internal RC mode

| C3 | C2 | C1 | C0 | Cycle Time (ns) | Frequency (MHz) |
|----|----|----|----|-----------------|-----------------|
| 0 | 0 | 0 | 0 | 390.6 | 2.56 |
| 0 | 0 | 0 | 1 | 365.0 | 2.74 |
| 0 | 0 | 1 | 0 | 342.5 | 2.92 |
| 0 | 0 | 1 | 1 | 322.6 | 3.1 |
| 0 | 1 | 0 | 0 | 304.9 | 3.28 |
| 0 | 1 | 0 | 1 | 289.0 | 3.46 |
| 0 | 1 | 1 | 0 | 274.7 | 3.64 |
| 0 | 1 | 1 | 1 | 261.8 | 3.82 |
| 1 | 1 | 1 | 1 | 250.0 | 4.00 |
| 1 | 1 | 1 | 0 | 239.2 | 4.18 |
| 1 | 1 | 0 | 1 | 229.4 | 4.36 |
| 1 | 1 | 0 | 0 | 220.3 | 4.54 |
| 1 | 0 | 1 | 1 | 211.9 | 4.72 |
| 1 | 0 | 1 | 0 | 204.1 | 4.9 |
| 1 | 0 | 0 | 1 | 196.7 | 5.08 |
| 1 | 0 | 0 | 0 | 190.1 | 5.26 |

NOTES:

1. Frequency values shown are theoretical and taken from an instance of a high frequency mode. Hence they are shown for reference only. Definite values will depend on the actual process.
2. Similar way of calculation is also applicable to Low Frequency mode.

Bits 4~7: Not used



4.1.8 RE (Wake Up Control Register)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| - | - | - | - | - | - | ICWE | - |

Bits 0: Not used.

Bit 1 (ICWE): Port 6 input status change wake-up enable bit

0 = Disable Port 6 input status change wake-up

1 = Enable Port 6 input status change wake-up

Bits 2 ~ 7: Not used.

4.1.9 RF (Interrupt Status Register)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| - | - | - | - | - | EXIF | ICIF | TCIF |

"1" means interrupt request, and "0" means no interrupt occurs.

Bit 0 (TCIF): TCC overflow interrupt flag. Set when TCC overflows. Reset by software.

Bit 1 (ICIF): Port 6 input status change interrupt flag. Set when Port 6 input changes. Reset by software.

Bit 2 (EXIF): External interrupt flag. Set by falling edge on /INT pin. Reset by software.

Bits 3 ~ 7: Not used.

RF can be cleared by instruction but cannot be set.

IOCF is the interrupt mask register.

NOTE

The result of reading RF is the "logic AND" of RF and IOCF.

4.1.10 R10 ~ R3F

These are all 8-bit general-purpose registers.

4.2 Special Purpose Registers

4.2.1 A (Accumulator)

- Internal data transfer, or instruction operand holding
- It cannot be addressed.

4.2.2 CONT (Control Register)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| - | /INT | TS | TE | PSRE | PSR2 | PSR1 | PSR0 |

Bit 0 (PSR0) ~ Bit 2 (PSR2): TCC prescaler bits

| PSR2 | PSR1 | PSR0 | TCC Rate |
|------|------|------|----------|
| 0 | 0 | 0 | 1:2 |
| 0 | 0 | 1 | 1:4 |
| 0 | 1 | 0 | 1:8 |
| 0 | 1 | 1 | 1:16 |
| 1 | 0 | 0 | 1:32 |
| 1 | 0 | 1 | 1:64 |
| 1 | 1 | 0 | 1:128 |
| 1 | 1 | 1 | 1:256 |

Bit 3 (PSRE): Prescaler enable bit for TCC.

0 = prescaler disabled bit, TCC rate is 1:1

1 = prescaler enabled bit, TCC rate is set as Bit2~Bit0

Bit 4 (TE): TCC signal edge

0 = increment if the transition from low to high takes place on TCC pin

1 = increment if the transition from high to low takes place on TCC pin

Bit 5 (TS): TCC signal source

0 = internal instruction cycle clock, P54 is a bi-directional I/O PIN

1 = transition on TCC pin

Bit 6 (/INT): Interrupt enable flag

0 = masked by DISI or hardware interrupt

1 = enabled by ENI/RETI instructions

Bit 7: Not used.

CONT register is both readable and writable.

4.2.3 IOC5 ~ IOC6 (I/O Port Control Register)

- "1" put the relative I/O pin into high impedance, while "0" defines the relative I/O pin as output.
- Only the lower 7 bits of IOC5 can be defined.
- IOC5 and IOC6 registers are both readable and writable.

4.2.4 IOCA (Prescaler Counter Register)

- IOCA register is readable.
- The value of IOCA is equal to the contents of Prescaler counter.
- Down counter

4.2.5 IOCB (Pull-Down Control Register)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| /PD7 | /PD6 | /PD5 | /PD4 | /PD3 | /PD2 | /PD1 | /PD0 |

Bit 0 (/PD0): Control bit is used to enable the pull-down of P50 pin.

0 = Enable internal pull-down

1 = Disable internal pull-down

Bit 1 (/PD1): Control bit is used to enable the pull-down of P51 pin.

Bit 2 (/PD2): Control bit is used to enable the pull-down of P52 pin.

Bit 3 (/PD3): Control bit is used to enable the pull-down of P53 pin.

Bit 4 (/PD4): Control bit is used to enable the pull-down of P60 pin.

Bit 5 (/PD5): Control bit is used to enable the pull-down of P61 pin.

Bit 6 (/PD6): Control bit is used to enable the pull-down of P62 pin.

Bit 7 (/PD7): Control bit is used to enable the pull-down of P63 pin.

IOCB Register is both readable and writable.

4.2.6 IOCC (Open-Drain Control Register)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| OD7 | OD6 | OD5 | OD4 | OD3 | OD2 | OD1 | OD0 |

Bit 0 (OD0): Control bit is used to enable the open-drain of P60 pin.

0 = Disable open-drain output

1 = Enable open-drain output

Bit 1 (OD1): Control bit is used to enable the open-drain of P61 pin.

Bit 2 (OD2): Control bit is used to enable the open-drain of P62 pin.

Bit 3 (OD3): Control bit is used to enable the open-drain of P63 pin.

Bit 4 (OD4): Control bit is used to enable the open-drain of P64 pin.

Bit 5 (OD5): Control bit is used to enable the open-drain of P65 pin.

Bit 6 (OD6): Control bit is used to enable the open-drain of P66 pin.

Bit 7 (OD7): Control bit is used to enable the open-drain of P67 pin.

IOCC Register is both readable and writable.

4.2.7 IOCD (Pull-High Control Register)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| /PH7 | /PH6 | /PH5 | /PH4 | /PH3 | /PH2 | /PH1 | /PH0 |

Bit 0 (/PH0): Control bit is used to enable the pull-high of P60 pin.

0 = Enable internal pull-high

1 = Disable internal pull-high

Bit 1 (/PH1): Control bit is used to enable the pull-high of P61 pin.

Bit 2 (/PH2): Control bit is used to enable the pull-high of P62 pin.

Bit 3 (/PH3): Control bit is used to enable the pull-high of P63 pin.

Bit 4 (/PH4): Control bit is used to enable the pull-high of P64 pin.

Bit 5 (/PH5): Control bit is used to enable the pull-high of P65 pin.

Bit 6 (/PH6): Control bit is used to enable the pull-high of P66 pin.

Bit 7 (/PH7): Control bit is used to enable the pull-high of P67 pin.

IOCD Register is both readable and writable.



4.2.8 IOCE (WDT Control Register)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| WDTE | EIS | - | ROC | PSWE | PSW2 | PSW1 | PSW0 |

Bit 7 (WDTE): Control bit used to enable the Watchdog timer.

0 = Disable WDT

1 = Enable WDT

WDTE is both readable and writable.

Bit 6 (EIS): Control bit is used to define the function of P60 (/INT) pin.

0 = P60, bi-directional I/O pin.

1 = /INT, external interrupt pin. In this case, the I/O control bit of P60 (Bit 0 of IOC6) must be set to "1."

When EIS is "0," the path of /INT is masked. When EIS is "1," the status of /INT pin can also be read by way of reading Port 6 (R6). See Figure 4-4a under Section 4.4 for reference.

EIS is both readable and writable.

Bit 5: Not used

Bit 4 (ROC): ROC is used for the R-option.

Setting the ROC to "1" will enable the status of R-option pins (P50~P51) that are read by the controller. Clearing the ROC will disable the R-option function. If the R-option function is selected, you must connect the P51 pin or/and P50 pin to VSS with a 430KΩ external resistor (Rex). If the Rex is connected/disconnected, the status of P50 (P51) is read as "0" / "1." Refer to Figure 4-5 under Section 4.4 for reference.

Bit 3 (PSWE): Prescaler enable bit for WDT

0 = prescaler disable bit, WDT rate is 1:1.

1 = prescaler enable bit, WDT rate is set as Bit4~Bit2.

Bit 2 (PSW2) ~ Bit 0 (PSW0): WDT prescaler bits

| PSW2 | PSW1 | PSW0 | WDT Rate |
|------|------|------|----------|
| 0 | 0 | 0 | 1:2 |
| 0 | 0 | 1 | 1:4 |
| 0 | 1 | 0 | 1:8 |
| 0 | 1 | 1 | 1:16 |
| 1 | 0 | 0 | 1:32 |
| 1 | 0 | 1 | 1:64 |
| 1 | 1 | 0 | 1:128 |
| 1 | 1 | 1 | 1:256 |

4.2.9 IOCF (Interrupt Mask Register)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| - | - | - | - | - | EXIE | ICIE | TCIE |

Bit 0 (TCIE): TCIF interrupt enable bit
0 = disable TCIF interrupt
1 = enable TCIF interrupt

Bit 1 (ICIE): ICIF interrupt enable bit
0 = disable ICIF interrupt
1 = enable ICIF interrupt

Bit 2 (EXIE): EXIF interrupt enable bit
0 = disable EXIF interrupt
1 = enable EXIF interrupt

Bits 3~7: Not used

Individual interrupt is enabled by setting its associated control bit in the IOCF to "1."

Global interrupt is enabled by the ENI instruction and is disabled by the DISI instruction. Refer to Figure 4-7 in Section 4.6 for further reference.

IOCF register is both readable and writable.

4.3 TCC/WDT & Prescaler

There are two 8-bit counters available as prescalers for the TCC and WDT respectively. The PSR0 ~ PSR2 bits of the CONT register are used to determine the ratio of the prescaler of TCC, and the PWR0 ~ PWR2 bits of the IOCE register are used to determine the prescaler of WDT. The prescaler (PSR0 ~ PSR2) will be cleared by the instruction each time it writes to TCC. The WDT and prescaler will be cleared by the "WDTTC" and "SLEP" instructions.

- R1 (TCC) is an 8-bit timer/counter. The clock source of TCC can be internal or external clock input (edge selectable from TCC pin). If TCC signal is sourced from internal clock, TCC will increase by 1 at every instruction cycle (without prescaler). $CLK = F_{osc}/2$ or $CLK = F_{osc}/4$ application is determined by the CODE Option bit CLK status. $CLK = F_{osc}/2$ is used if CLK bit is "0," and $CLK = F_{osc}/4$ is used if CLK bit is "1." If TCC signal source comes from external clock input, TCC is increased by 1 at every falling edge or rising edge of TCC pin.
- The watchdog timer is a free running on-chip RC oscillator. The WDT will keep on running even when the oscillator driver has been turned off (i.e., in Sleep mode). During normal operation or Sleep mode, a WDT time-out (if enabled) will cause the device to reset. The WDT can be enabled or disabled any time during Normal mode by software programming. Refer to WDTE bit of IOCE register in Section 4.2.8. Without prescaler, the WDT time-out period is approximately 18 ms¹ (default).

¹ Vdd = 5V, set up time period = 16.8ms ± 30%
Vdd = 3V, set up time period = 18ms ± 30%

4.4 I/O Ports

The I/O registers, both Port 5 and Port 6, are bi-directional tri-state I/O ports. Port 6 can be pulled high internally by software. In addition, Port 6 can also features an open-drain output through software and an Input status change interrupt (or wake-up) function. P50 ~ P53 and P60 ~ P63 pins can be pulled down by software. Each I/O pin can be defined as "input" or "output" pin by the I/O control register (IOC5 ~ IOC6). P50~P51 are the R-option pins enabled by setting the ROC bit in the IOCE register to "1." When the R-option function is used, it is recommended that P50 ~ P51 are used as output pins. When R-option is in enable state, P50 ~ P51 must be programmed as input pins. Under R-option mode, the current/power consumption by Rex should be taken into the consideration to promote energy conservation.

The I/O registers and I/O control registers are both readable and writable. The I/O interface circuits for Port 5 and Port 6 are shown in the following figures (Figures 4-3, 4-4a, 4-4b, & 4-5).

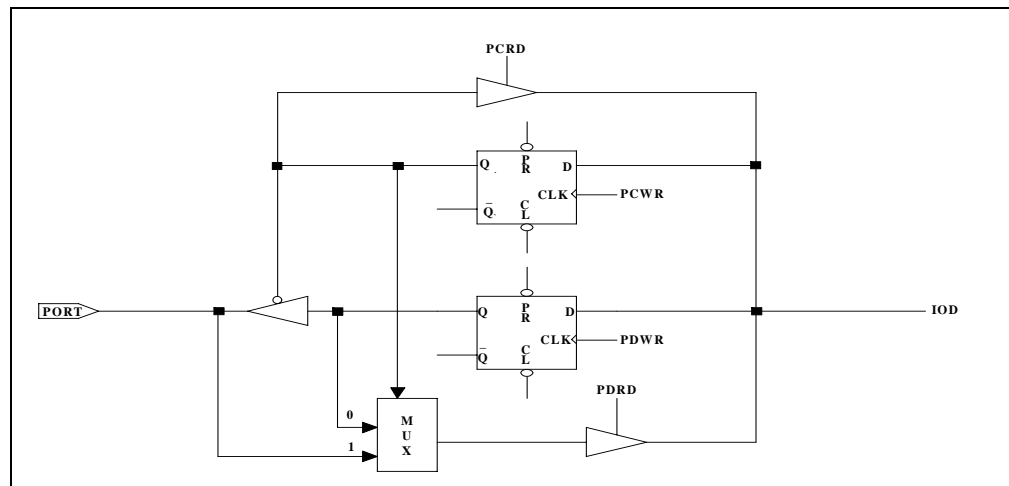


Figure 4-3 I/O Port and I/O Control Register for Port 5 Circuit

NOTE

Pull-down is not shown in the figure.

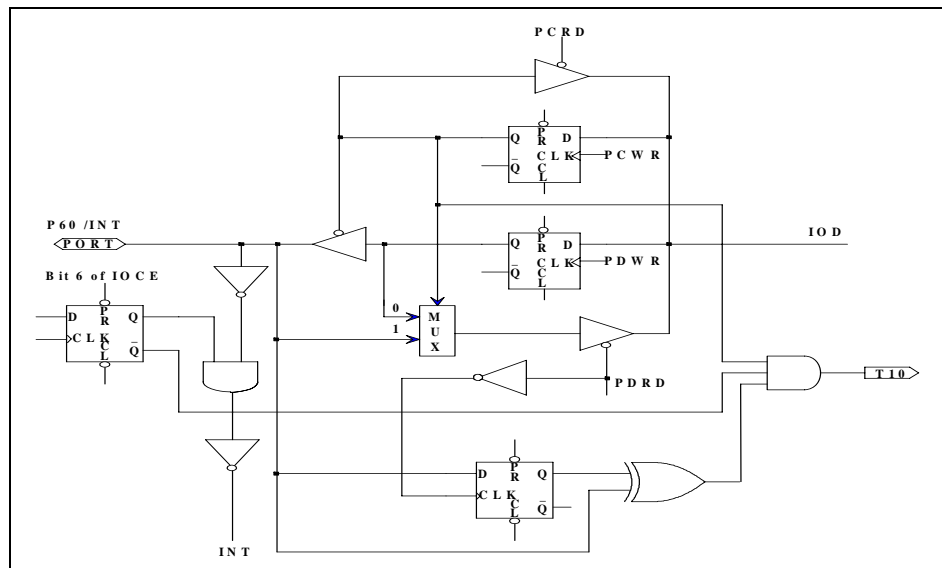


Figure 4-4a I/O Port and I/O Control Register for P60 (/INT) Circuit

NOTE

Pull-high (down) and Open-drain are not shown in the figure.

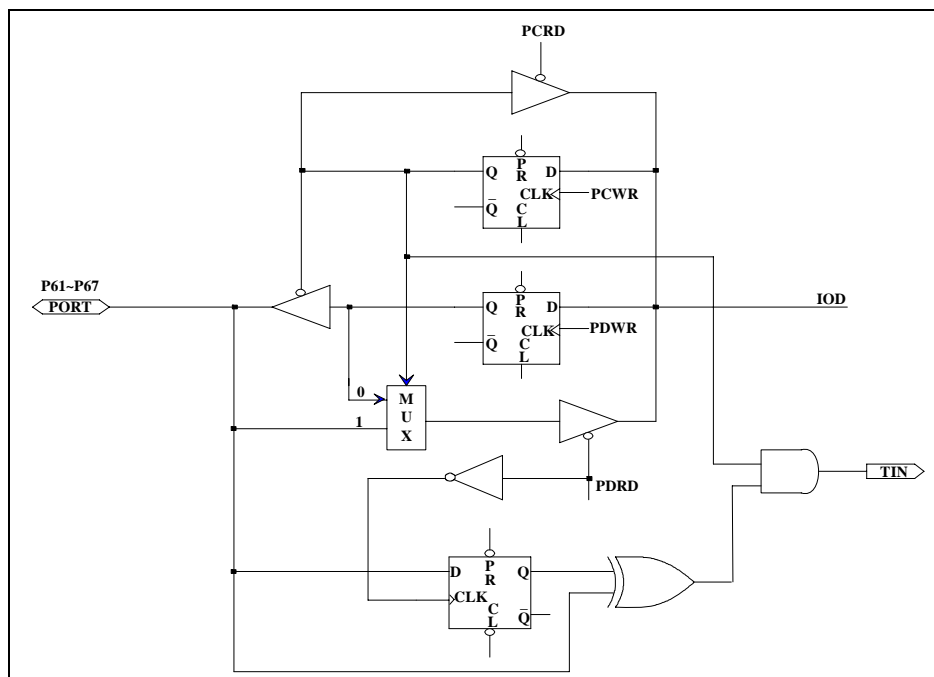


Figure 4-4b I/O Port and I/O Control Register for P61~P67 Circuit

NOTE

Pull-high (down) and Open-drain are not shown in the figure.

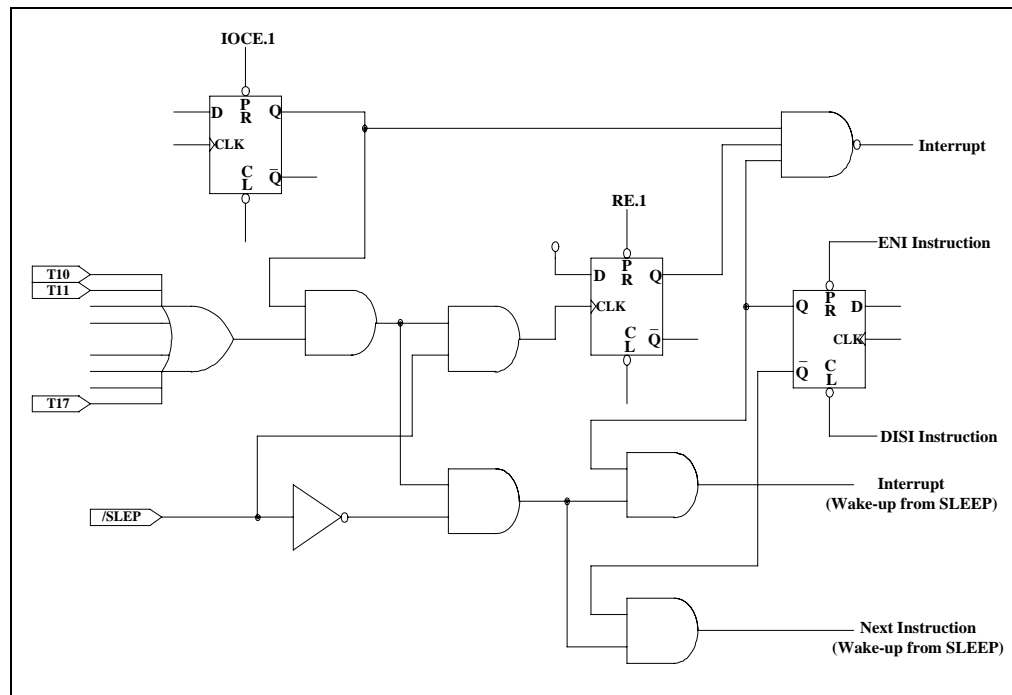


Figure 4-4c I/O Port 6 with Input Change Interrupt/Wake-up Block Diagram

4.4.1 Usage of Port 6 Input Change Wake-up/Interrupt Function

| Usage of Port 6 Input Status Changed Wake-up/Interrupt | |
|--------------------------------------------------------|------------------------------------------------|
| (I) Wake-up | (II) Wake-up and interrupt |
| (a) Before SLEEP | (a) Before SLEEP |
| 1. Disable WDT | 1. Disable WDT |
| 2. Read I/O Port 6 (MOV R6,R6) | 2. Read I/O Port 6 (MOV R6,R6) |
| 3. Execute "ENI" or "DISI" | 3. Execute "ENI" or "DISI" |
| 4. Enable wake-up bit (Set RE ICWE =1) | 4. Enable wake-up bit (Set RE ICWE =1) |
| 5. Execute "SLEP" instruction | 5. Enable interrupt (Set IOCF0 ICIE =1) |
| (b) After wake-up | 6. Execute "SLEP" instruction |
| → Next instruction | (b) After wake-up |
| | 1. IF "ENI" → Interrupt vector (008H) |
| | 2. IF "DISI" → Next instruction |
| (III) Interrupt | |
| (a) Before Port 6 pin change | |
| 1. Read I/O Port 6 (MOV R6,R6) | |
| 2. Execute "ENI" or "DISI" | |
| 3. Enable interrupt (Set IOCF0 ICIE =1) | |
| (b) After Port 6 pin changed (interrupt) | |
| 1. IF "ENI" → Interrupt vector (008H) | |
| 2. IF "DISI" → Next instruction | |

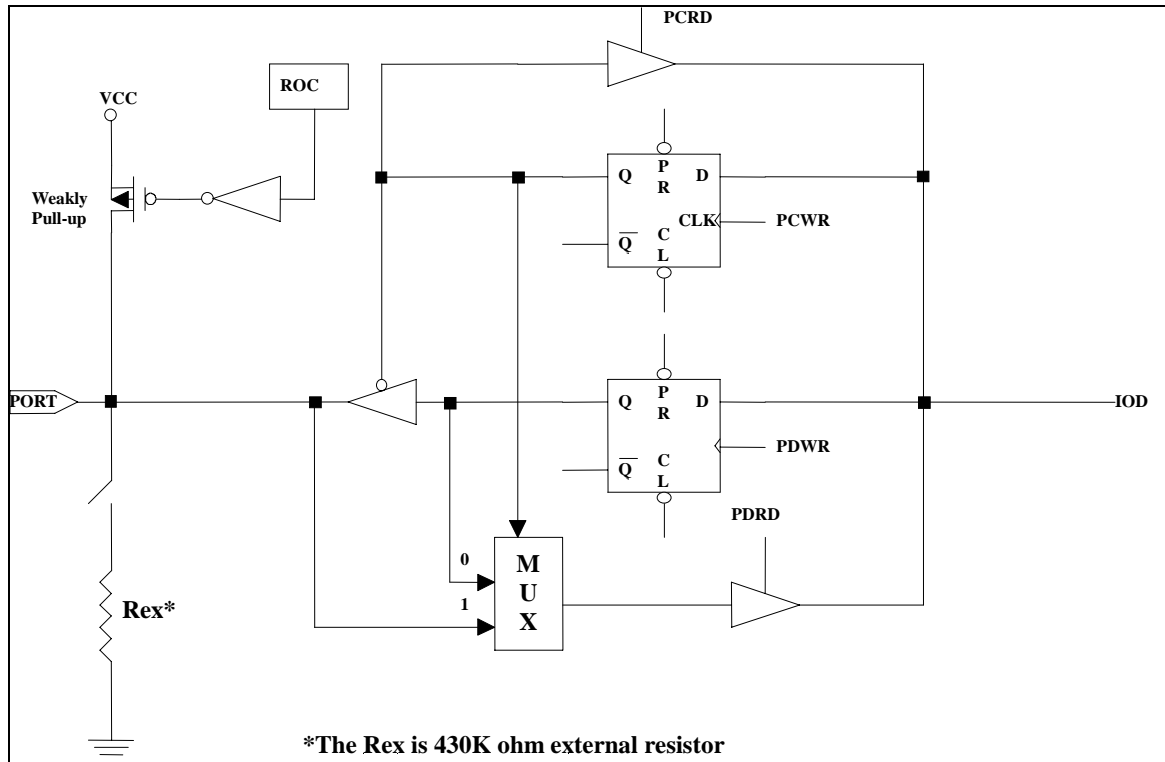


Figure 4-5 I/O Port with R-option (P50,P51) Circuit

4.5 RESET and Wake-up

4.5.1 RESET

A RESET is initiated by one of the following events-

- 1) Power on reset.
- 2) /RESET pin input "low," or
- 3) WDT time-out (if enabled).

The device is kept under RESET condition for a period of approximately 18ms² (one oscillator start-up timer period) after a reset is detected. And if the /Reset pin goes "low" or WDT time-out is active, a reset is generated. Once a RESET occurs, the following functions are performed:

- The oscillator is running, or will be started.
- The Program Counter (R2) is set to all "0."
- All I/O port pins are configured as input mode (high-impedance state).

² Vdd = 5V, set up time period = 16.8ms ± 30%
Vdd = 3V, set up time period = 18ms ± 30%



- The Watchdog timer and prescaler are cleared.
- When power is switched on, the upper 3 bits of R3 are cleared.
- The bits of the CONT register are set to all "1" except for the Bit 6 (INT flag).
- The bits of the IOCA register are set to all "1."
- The bits of the IOCB register are set to all "1."
- The IOCC register is cleared.
- The bits of the IOCD register are set to all "1."
- Bit 7 of the IOCE register is set to "1," and Bits 4 and 6 are cleared.
- Bits 0 ~ 2 of RF and Bits 0 ~ 2 of IOCF registers are cleared.

The Sleep (power down) mode is asserted by executing the "SLEP" instruction. While entering Sleep mode, WDT (if enabled) is cleared but keeps on running. The controller can be awakened by-

- 1) External reset input on /RESET pin,
- 2) WDT time-out (if enabled), or
- 3) Port 6 input status change (if enabled).

The first two cases will cause the EM78P159N to reset. The T and P flags of R3 are used to determine the source of the reset (wake-up). The last case is considered the continuation of program execution and the global interrupt ("ENI" or "DISI" being executed) decides whether or not the controller branches to the interrupt vector following wake-up. If ENI is executed before SLEP, the instruction will begin to execute from the address 008H after wake-up. If DISI is executed before SLEP, the operation will restart from the succeeding instruction right next to SLEP after wake-up.

Wake-up time is dependent on oscillator mode. Under RC mode, the reset time is 32 clocks, and in High XTAL mode, reset time is 2ms and 32clocks. In Low XTAL mode, the reset time is 500ms. The above is applicable only for stable oscillator.

Only one of Cases 2 and 3 can be enabled before going into the Sleep mode. That is,

- [a]** if Port 6 Input Status Change Interrupt is enabled before SLEP, WDT must be disabled by software. However, the WDT bit in the option register remains enabled. Hence, the EM78P159N can be awakened only by Case 1 or 3.
- [b]** if WDT is enabled before SLEP, Port 6 Input Status Change Interrupt must be disabled. Hence, the EM78P159N can be awakened only by Case 1 or 2. Refer to the Section 4.6, *Interrupt* for further details.

If Port 6 Input Status Change Interrupt is used to wake-up the EM78P159N (Case [a] above), the following instructions must be executed before SLEP:

```
MOV A, @xx000110b    ; Select internal TCC clock
CONTW
CLR R1                ; Clear TCC and prescaler
MOV A, @xxxx1110b    ; Select WDT prescaler
CONTW
WDTC                  ; Clear WDT and prescaler
MOV A, @0xxxxxxxxb   ;Disable WDT
IOW RE
MOV R6, R6            ; Read Port 6
BS RE,1              ; Enable wake up control bit
MOV A, @00000x1xb    ; Enable Port 6 input change interrupt
IOW RF
ENI (or DISI)        ; Enable (or disable) global interrupt
SLEP                  ;Sleep
NOP
```

4.5.2 The Summary of the Initialized Values for Registers

| Address | Name | Reset Type | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|---------|---------|-------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| N/A | IOC5 | Bit Name | X | C56 | C55 | C54 | C53 | C52 | C51 | C50 |
| | | Power-On | U | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | /RESET and WDT | U | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | Wake-Up from Pin Change | U | P | P | P | P | P | P | P |
| N/A | IOC6 | Bit Name | C67 | C66 | C65 | C64 | C63 | C62 | C61 | C60 |
| | | Power-On | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | /RESET and WDT | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | Wake-Up from Pin Change | P | P | P | P | P | P | P | P |
| N/A | CONT | Bit Name | X | /INT | TS | TE | PSRE | PSR2 | PSR1 | PSR0 |
| | | Power-On | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | /RESET and WDT | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | Wake-Up from Pin Change | P | P | P | P | P | P | P | P |
| 0x00 | R0(IAR) | Bit Name | - | - | - | - | - | - | - | - |
| | | Power-On | U | U | U | U | U | U | U | U |
| | | /RESET and WDT | P | P | P | P | P | P | P | P |
| | | Wake-Up from Pin Change | P | P | P | P | P | P | P | P |
| 0x01 | R1(TCC) | Bit Name | - | - | - | - | - | - | - | - |
| | | Power-On | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | /RESET and WDT | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Wake-Up from Pin Change | P | P | P | P | P | P | P | P |
| 0x02 | R2(PC) | Bit Name | - | - | - | - | - | - | - | - |
| | | Power-On | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | /RESET and WDT | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Wake-Up from Pin Change | *0/P | *0/P | *0/P | *0/P | *1/P | *0/P | *0/P | *0/P |
| 0x03 | R3(SR) | Bit Name | GP2 | GP1 | GP0 | T | P | Z | DC | C |
| | | Power-On | 0 | 0 | 0 | 1 | 1 | U | U | U |
| | | /RESET and WDT | 0 | 0 | 0 | ** | ** | P | P | P |
| | | Wake-Up from Pin Change | P | P | P | ** | ** | P | P | P |
| 0x04 | R4(RSR) | Bit Name | - | - | - | - | - | - | - | - |
| | | Power-On | 1 | 1 | U | U | U | U | U | U |
| | | /RESET and WDT | 1 | 1 | P | P | P | P | P | P |
| | | Wake-Up from Pin Change | 1 | 1 | P | P | P | P | P | P |
| 0x05 | P5 | Bit Name | X | P56 | P55 | P54 | P53 | P52 | P51 | P50 |
| | | Power-On | 0 | U | U | U | U | U | U | U |
| | | /RESET and WDT | 0 | P | P | P | P | P | P | P |
| | | Wake-Up from Pin Change | 0 | P | P | P | P | P | P | P |
| 0x06 | P6 | Bit Name | P67 | P66 | P65 | P64 | P63 | P62 | P61 | P60 |
| | | Power-On | U | U | U | U | U | U | U | U |
| | | /RESET and WDT | P | P | P | P | P | P | P | P |
| | | Wake-Up from Pin Change | P | P | P | P | P | P | P | P |

| Address | Name | Reset Type | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-----------|---------|-------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| 0x0E | RE(WUE) | Bit Name | X | X | X | X | X | X | ICWE | X |
| | | Power-On | U | U | U | U | U | U | 0 | U |
| | | /RESET and WDT | U | U | U | U | U | U | 0 | U |
| | | Wake-Up from Pin Change | U | U | U | U | U | U | P | U |
| 0x0F | RF(ISR) | Bit Name | X | X | X | X | X | EXIF | ICIF | TCIF |
| | | Power-On | U | U | U | U | U | 0 | 0 | 0 |
| | | /RESET and WDT | U | U | U | U | U | 0 | 0 | 0 |
| | | Wake-Up from Pin Change | U | U | U | U | U | P | P | P |
| 0x0A | IOCA | Bit Name | - | - | - | - | - | - | - | - |
| | | Power-On | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | /RESET and WDT | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | Wake-Up from Pin Change | P | P | P | P | P | P | P | P |
| 0x0B | IOCB | Bit Name | /PD7 | /PD6 | /PD5 | /PD4 | /PD3 | /PD2 | /PD1 | /PD0 |
| | | Power-On | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | /RESET and WDT | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | Wake-Up from Pin Change | P | P | P | P | P | P | P | P |
| 0x0C | IOCC | Bit Name | OD7 | OD6 | OD5 | OD4 | OD3 | OD2 | OD1 | OD0 |
| | | Power-On | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | /RESET and WDT | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Wake-Up from Pin Change | P | P | P | P | P | P | P | P |
| 0x0D | IOCD | Bit Name | /PH7 | /PH6 | /PH5 | /PH4 | /PH3 | /PH2 | /PH1 | /PH0 |
| | | Power-On | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | /RESET and WDT | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | Wake-Up from Pin Change | P | P | P | P | P | P | P | P |
| 0x0E | IOCE | Bit Name | WDTE | EIS | X | ROC | PSWE | PSW2 | PSW1 | PSW0 |
| | | Power-On | 1 | 0 | U | 0 | 0 | 0 | 0 | 0 |
| | | /RESET and WDT | 1 | 0 | U | 0 | 0 | 0 | 0 | 0 |
| | | Wake-Up from Pin Change | 1 | P | U | P | P | P | P | P |
| 0x0F | IOCF | Bit Name | X | X | X | X | X | EXIE | ICIE | TCIE |
| | | Power-On | U | U | U | U | U | 0 | 0 | 0 |
| | | /RESET and WDT | U | U | U | U | U | 0 | 0 | 0 |
| | | Wake-Up from Pin Change | U | U | U | U | U | P | P | P |
| 0x10~0x2F | R10~R2F | Bit Name | - | - | - | - | - | - | - | - |
| | | Power-On | U | U | U | U | U | U | U | U |
| | | /RESET and WDT | P | P | P | P | P | P | P | P |
| | | Wake-Up from Pin Change | P | P | P | P | P | P | P | P |

* Jump to address 0x08, or execute the instruction next to the "SLEP" instruction.

** Refer to tables provided under next section (Section 4.5.3).

Legend:

X: Not used **U:** Unknown or don't care **P:** Previous value before reset

4.5.3 The Status of RST, T, and P of STATUS Register

A RESET condition is initiated by the following events

- 1) A power-on condition,
- 2) A high-low-high pulse on /RESET pin, and
- 3) Watchdog timer time-out.

The values of T and P listed in the table below are used to check how the processor wakes up.

■ The Values of RST, T, and P after RESET

| Reset Type | T | P |
|-----------------------------------------|----|----|
| Power on | 1 | 1 |
| /RESET during Operating mode | *P | *P |
| /RESET wake-up during SLEEP mode | 1 | 0 |
| WDT during Operating mode | 0 | *P |
| WDT wake-up during SLEEP mode | 0 | 0 |
| Wake-Up on pin change during SLEEP mode | 1 | 0 |

* P: Previous status before reset

The following table shows the events that may affect the status of T and P.

■ The Status of T and P Being Affected by Events

| Event | T | P |
|-----------------------------------------|---|----|
| Power on | 1 | 1 |
| WDTC instruction | 1 | 1 |
| WDT time-out | 0 | *P |
| SLEEP instruction | 1 | 0 |
| Wake-Up on pin change during SLEEP mode | 1 | 0 |

* P: Previous status before reset

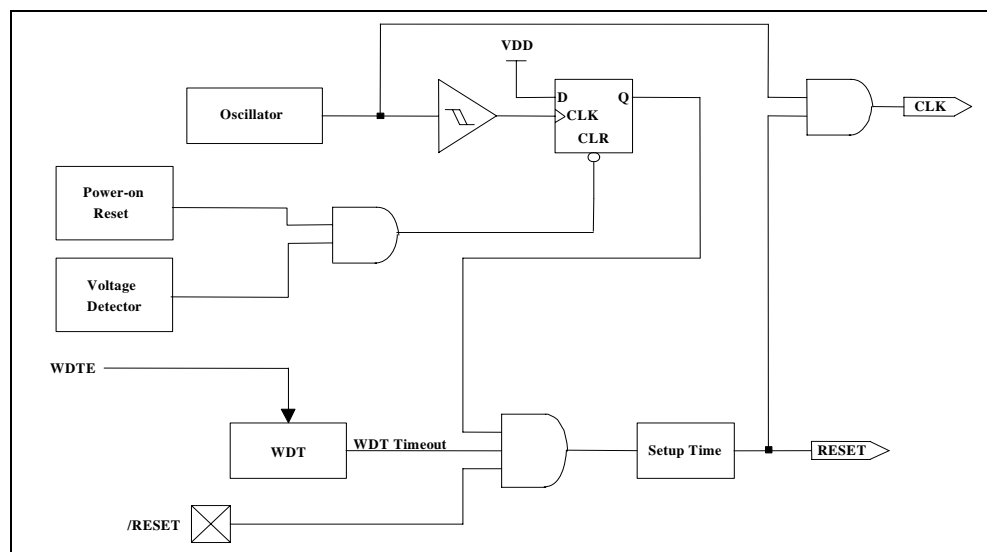


Figure 4-6 Controller Reset Block Diagram

4.6 Interrupt

The EM78P159N has three falling-edge interrupts as listed herewith:

- 1) TCC overflow interrupt
- 2) Port 6 Input Status Change Interrupt
- 3) External interrupt [(P60, /INT) pin].

Before the Port 6 Input Status Change Interrupt is enabled, reading Port 6 (e.g., "MOV R6,R6") is necessary. Each Port 6 pin will have this feature if its status changes. Any pin configured as output or P60 pin configured as /INT is excluded from this function. The Port 6 Input Status Changed Interrupt can wake up the EM78P159N from Sleep mode if Port 6 is enabled prior to going into the Sleep mode by executing SLEEP. When the chip wakes-up, the controller will continue to execute the succeeding address if the global interrupt is disabled or it will branch into the interrupt vector 008H if the global interrupt is enabled.

RF is the interrupt status register that records the interrupt requests in the relative flags/bits. IOCF is an interrupt mask register. The global interrupt is enabled by the ENI instruction and is disabled by the DISI instruction. When one of the interrupts (enabled) occurs, the next instruction will be fetched from address 008H. Once in the interrupt service routine, the source of an interrupt can be determined by polling the flag bits in RF. The interrupt flag bit must be cleared by instructions before leaving the interrupt service routine and before interrupts are enabled to avoid recursive interrupts.

The flag (except ICIF bit) in the Interrupt Status Register (RF) is set regardless of the status of its mask bit or the execution of ENI. Note that the outcome of RF will be the logic AND of RF and IOCF (refer to figure below). The RETI instruction ends the interrupt routine and enables the global interrupt (the execution of ENI).

When an interrupt is generated by the INT instruction (enabled), the next instruction will be fetched from Address 001H.

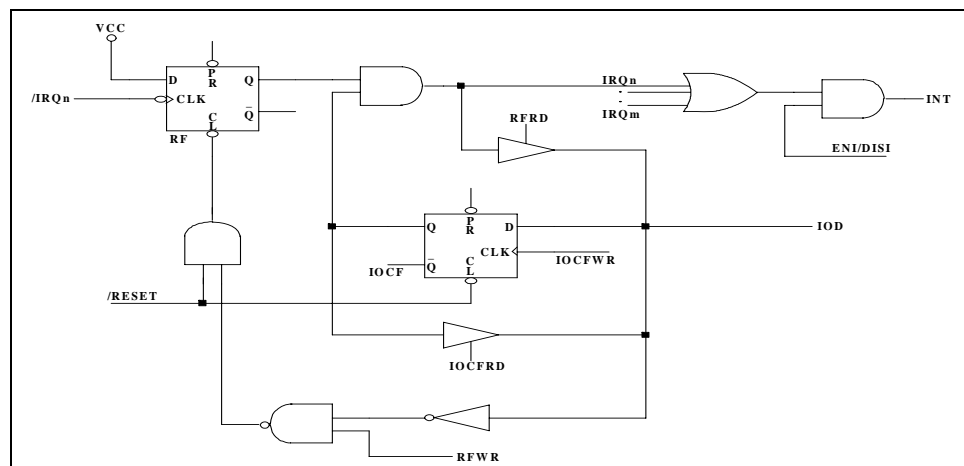


Figure 4-7 Interrupt Input Circuit

4.7 Oscillator

4.7.1 Oscillator Modes

The EM78P159N can be operated in four different oscillator modes, such as External RC oscillator mode (ERC), Internal RC oscillator mode (IRC), High XTAL oscillator mode (HXT), and Low XTAL oscillator mode (LXT). The desired mode can be selected through programming of OSC2, OSC1, and OSC0 in the CODE option register. Table below explains how these 4 oscillator modes are defined with OSC2, OSC1, and OSC0.

■ Oscillator Modes Defined by OSC

| Mode | | OSC2 | OSC1 | OSC0 |
|--------------------------------------------------------|---------------------|------|------|------|
| ERC (External RC oscillator mode); P55/OSCO act P55 | | 0 | 0 | 0 |
| ERC (External RC oscillator mode); P55/OSCO act OSC0 | | 0 | 0 | 1 |
| IRC (Internal RC oscillator mode) ; P55/OSCO act P55 | | 0 | 1 | 0 |
| IRC (Internal RC oscillator mode); P55/OSCO act OSC0 | | 0 | 1 | 1 |
| MCIRC (Manual calibration IRC mode); P55/OSCO act P55 | With Simulator only | 1 | 0 | 0 |
| MCIRC (Manual calibration IRC mode); P55/OSCO act OSC0 | | 1 | 0 | 1 |
| LXT (Low XTAL oscillator mode) | | 1 | 1 | 0 |
| HXT (High XTAL oscillator mode) (default) | | 1 | 1 | 1 |

NOTE

The transient point of system frequency between HXT and LXY is around 400 KHz.

The maximum operational frequency of crystal/resonator under different VDDs is as listed below.

■ Summary of Maximum Operating Speeds

| Conditions | VDD | Max Freq. (MHz) |
|----------------------------|-----|-----------------|
| Two cycles with two clocks | 2.1 | 4.0 |
| | 3.0 | 8.0 |
| | 5.0 | 20.0 |

4.7.2 Crystal Oscillator/Ceramic Resonators (XTAL)

EM78P159N can be driven by an external clock signal through the OSCI pin as shown in the following figure.

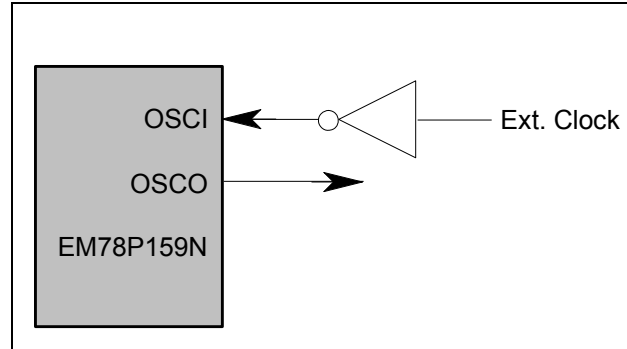


Figure 4-8a External Clock Input Circuit

In the most applications, Pin OSCI and Pin OSCO can be connected with a crystal or ceramic resonator to generate oscillation. Figure below depicts such circuit. The same thing applies whether it is in the HXT mode or in the LXT mode. The following table provides the recommended values of C1 and C2. Since each resonator has its own attribute, you should refer to its specification for appropriate values of C1 and C2. RS, a serial resistor, may be necessary for AT strip cut crystal or low frequency mode.

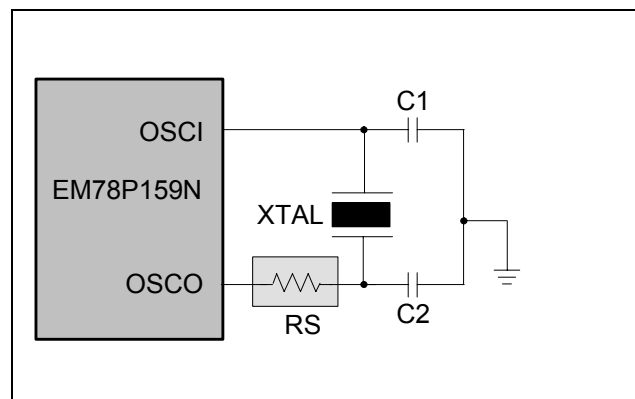


Figure 4-8b Crystal/Resonator Circuit

■ Capacitor Selection Guide for Crystal Oscillator or Ceramic Resonator

| Oscillator Type | Frequency Mode | Frequency | C1(pF) | C2(pF) |
|--------------------|----------------|-----------|---------|---------|
| Ceramic Resonators | HXT | 455 kHz | 100~150 | 100~150 |
| | | 2.0 MHz | 20~40 | 20~40 |
| | | 4.0 MHz | 10~30 | 10~30 |
| Crystal Oscillator | LXT | 32.768kHz | 25 | 15 |
| | | 100KHz | 25 | 25 |
| | | 200KHz | 25 | 25 |
| | HXT | 455KHz | 20~40 | 20~150 |
| | | 1.0MHz | 15~30 | 15~30 |
| | | 2.0MHz | 15 | 15 |
| | | 4.0MHz | 15 | 15 |

NOTE

The values of capacitors C1 & C2 are for reference only.

4.7.3 External RC Oscillator Mode

For some applications that do not need a very precise timing calculation, the RC oscillator (Figure 4-9 below) offers a lot of cost savings. Nevertheless, it should be noted that the frequency of the RC oscillator is influenced by the supply voltage, the values of the resistor (R_{ext}), the capacitor (C_{ext}), and even by the operation temperature. Moreover, the frequency also changes slightly from one chip to another due to the manufacturing process variation.

In order to maintain a stable system frequency, the values of the C_{ext} should not be less than 20pF, and that the value of R_{ext} should not be greater than 1 M Ω . If they cannot be kept in this range, the frequency can be easily affected by noise, humidity, and leakage.

The smaller the R_{ext} in the RC oscillator is, the faster its frequency will be. On the contrary, for very low R_{ext} values, for instance, 1 K Ω , the oscillator becomes unstable because the NMOS cannot discharge the current of the capacitance correctly.

Based on the above reasons, it must be kept in mind that all of the supply voltage, the operation temperature, the components of the RC oscillator, the package types, the way the PCB is layout, will affect the system frequency.

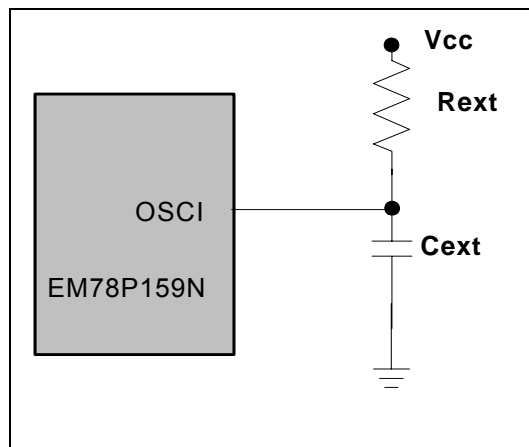


Figure 4-9 External RC Oscillator Mode Circuit

RC Oscillator Frequencies

| Cext | Rext | Average Fosc 5V, 25°C | Average Fosc 3V, 25°C |
|--------|------|--------------------------|--------------------------|
| 20 pF | 3.3k | 3.92 MHz | 3.65 MHz |
| | 5.1k | 2.67 MHz | 2.60 MHz |
| | 10k | 1.39MHz | 1.40 MHz |
| | 100k | 149 kHz | 156 kHz |
| 100 pF | 3.3k | 1.39 MHz | 1.33 MHz |
| | 5.1k | 940 kHz | 920 kHz |
| | 10k | 480 kHz | 475 kHz |
| | 100k | 52 kHz | 50 kHz |
| 300 pF | 3.3k | 595 kHz | 560 kHz |
| | 5.1k | 400 kHz | 390 kHz |
| | 10k | 200 kHz | 200 kHz |
| | 100k | 21 kHz | 20 kHz |

NOTE

1. Measured on DIP packages.
2. The values are for design reference only.
3. The frequency drift is about $\pm 30\%$

4.7.4 Internal RC Oscillator Mode

EM78P159N offers a versatile internal RC mode with default frequency value of 4MHz. The Internal RC oscillator mode has other frequencies (1MHz, 8MHz. & 455kHz) that can be set by CODE OPTION (WORD1), RCM1, and RCM0. All these four main frequencies can be calibrated by programming the OPTION Bits C3 ~ C0. The table below describes a typical instance of the calibration.

Internal RC Drift Rate (Ta=25°C, VDD=3.9V \pm 5%, VSS=0V)

| Internal RC Frequency | Drift Rate | | | |
|--------------------------|--------------------------------|--------------------------|-----------|------------|
| | Temperature (-40°C ~ +85°C) | Voltage (2.3V ~ 5.5V) | Process | Total |
| 4MHz | $\pm 5\%$ | $\pm 5\%$ | $\pm 4\%$ | $\pm 14\%$ |
| 8MHz | $\pm 5\%$ | $\pm 5\%$ | $\pm 4\%$ | $\pm 14\%$ |
| 1MHz | $\pm 5\%$ | $\pm 5\%$ | $\pm 4\%$ | $\pm 14\%$ |
| 455MHz | $\pm 5\%$ | $\pm 5\%$ | $\pm 4\%$ | $\pm 14\%$ |

The above are theoretical values and are provided for reference only. Actual values may vary depending on actual process.

■ Calibration Selection for Internal RC Mode

| C3 | C2 | C1 | C0 | Cycle Time (ns) | Frequency (MHz) |
|----|----|----|----|-----------------|-----------------|
| 0 | 0 | 0 | 0 | 390.6 | 2.56 |
| 0 | 0 | 0 | 1 | 365.0 | 2.74 |
| 0 | 0 | 1 | 0 | 342.5 | 2.92 |
| 0 | 0 | 1 | 1 | 322.6 | 3.1 |
| 0 | 1 | 0 | 0 | 304.9 | 3.28 |
| 0 | 1 | 0 | 1 | 289.0 | 3.46 |
| 0 | 1 | 1 | 0 | 274.7 | 3.64 |
| 0 | 1 | 1 | 1 | 261.8 | 3.82 |
| 1 | 1 | 1 | 1 | 250.0 | 4.00 |
| 1 | 1 | 1 | 0 | 239.2 | 4.18 |
| 1 | 1 | 0 | 1 | 229.4 | 4.36 |
| 1 | 1 | 0 | 0 | 220.3 | 4.54 |
| 1 | 0 | 1 | 1 | 211.9 | 4.72 |
| 1 | 0 | 1 | 0 | 204.1 | 4.9 |
| 1 | 0 | 0 | 1 | 196.7 | 5.08 |
| 1 | 0 | 0 | 0 | 190.1 | 5.26 |

The above are theoretical values and are provided for reference only. Actual values may vary depending on actual process.

4.8 CODE Option Register

The EM78P159N has a CODE option word that is not a part of the normal program memory. The option bits cannot be accessed during normal program execution.

■ Code Option Register and Customer ID Register Arrangement Distribution:

| Word 0 | Word 1 | Word 2 |
|--------------|--------------|--------------|
| Bit12 ~ Bit0 | Bit12 ~ Bit0 | Bit12 ~ Bit0 |

4.8.1 Code Option Register (Word 0)

| WORD 0 | | | | | | | | | | | | |
|--------|--------|--------|-------|-------|--------|-------|-------|-------|-------|-------|-------|-------|
| Bit 12 | Bit 11 | Bit 10 | Bit 9 | Bit 8 | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| - | - | - | - | CLKS0 | ENWDTB | OSC2 | OSC1 | OSC0 | HLP | PR2 | PR1 | PR0 |

Bit 0 ~ Bit 2 (PR0 ~ PR2): Protect bits

PR0 ~ PR2 are protect bits. Protect types are as follows:

| PR2 | PR1 | PR0 | Protect |
|-----|-----|-----|---------|
| 0 | 0 | 0 | Enable |
| 0 | 0 | 1 | Enable |
| 0 | 1 | 0 | Enable |
| 0 | 1 | 1 | Enable |
| 1 | 0 | 0 | Enable |
| 1 | 0 | 1 | Enable |
| 1 | 1 | 0 | Enable |
| 1 | 1 | 1 | Disable |

Bit 3 (HLP): Power selection
0 = Low power
1 = High power

Bit 4 ~ Bit 6 (OSC0 ~ OSC2): Oscillator Modes Selection bits

| Mode | | OSC2 | OSC1 | OSC0 |
|--------------------------------------------------------|------------------------|------|------|------|
| ERC (External RC oscillator mode); P55/OSCO act P55 | | 0 | 0 | 0 |
| ERC (External RC oscillator mode); P55/OSCO act OSC0 | | 0 | 0 | 1 |
| IRC (Internal RC oscillator mode) ; P55/OSCO act P55 | | 0 | 1 | 0 |
| IRC (Internal RC oscillator mode); P55/OSCO act OSC0 | | 0 | 1 | 1 |
| MCIRC (Manual calibration IRC mode); P55/OSCO act P55 | With Simulator only | 1 | 0 | 0 |
| MCIRC (Manual calibration IRC mode); P55/OSCO act OSC0 | | 1 | 0 | 1 |
| LXT (Low XTAL oscillator mode) | | 1 | 1 | 0 |
| HXT (High XTAL oscillator mode) (default) | | 1 | 1 | 1 |

NOTE

The transient point of system frequency between HXT and LXY is around 400 KHz.

Bit 7 (ENWDTB): Watchdog timer enable bit.
0 = Enable
1 = Disable

Bit 8 (CLKS0): Instruction period option bit

| Word 0 | CLK0 |
|--------------------------------------------|------|
| 4 oscillator time periods (default) | 1 |
| 2 oscillator time periods | 0 |

Refer to Section 4.12 *Instruction Set* for further details.

Bit 9 ~ Bit 12: Not used, but need to set to “1” all the time to preclude possible error.

4.8.2 Customer ID Register (Word 1)

| WORD 0 | | | | | | | | | | | | |
|--------|-------|-------|------|------|------|------|------|------|------|------|------|------|
| Bit12 | Bit11 | Bit10 | Bit9 | Bit8 | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
| - | RCOUT | - | - | - | - | CYES | - | - | - | - | RCM1 | RCM0 |

Bit 0 ~ Bit 1 (RCM0 ~ RCM1): IRC mode selection bits

| RCM 1 | RCM 0 | Frequency (MHz) |
|-------|-------|-----------------|
| 1 | 1 | 4 |
| 1 | 0 | 8 |
| 0 | 1 | 1 |
| 0 | 0 | 455kHz |

Bit 2 ~ Bit 5: Not used

- Bit 6 (CYES):** Instruction cycle selection bit
0 = one instruction cycle
1 = two instruction cycles (default)
- Bit 7 ~ Bit 10:** Not used
- Bits 11 (RCOUT):** System clock output enable bit in IRC or ERC mode
0 = OSCO pin is open drain.
1 = OSCO output system clock
- Bit 12:** Not used

4.8.3 Customer ID Register (Word 2)

| WORD 0 | | | | | | | | | | | | |
|--------|-------|-------|------|------|------|------|------|------|------|------|------|------|
| Bit12 | Bit11 | Bit10 | Bit9 | Bit8 | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
| - | - | - | - | - | - | - | - | - | - | - | - | - |

Bit 0 ~ Bit 12: User's ID code

4.9 Power On Considerations

Any microcontroller is not guaranteed to start to operate properly before the power supply stays at its steady state.

EM78P159N POR voltage range is 1.7V~1.9V. Under customer application, when power is OFF, Vdd must drop to below 1.2V and remains OFF for 10μs before power can be switched ON again. This way, the EM78P159N will reset and operates normally. The extra external reset circuit will work well if Vdd can rise at very fast speed (50 ms or less). However, under most cases where critical applications are involved, extra devices are required to assist in solving the power-up problems.

4.10 External Power On Reset Circuit

The circuit shown in the following figure implements an external RC to produce the reset pulse. The pulse width (time constant) should be kept long enough for Vdd to reached minimum operation voltage. This circuit is used when the power supply has a slow rise time. Because the current

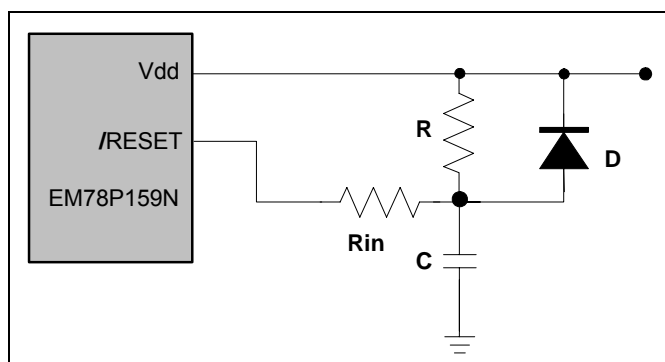


Figure 4-10 External Power-Up Reset Circuit

leakage from the /RESET pin is about ±5μA, it is recommended that R should not be greater than 40K. In this way, the /RESET pin voltage is held below 0.2V. The diode (D) acts as a short circuit at the moment of power down. The capacitor C will discharge rapidly and fully. Rin, the current-limited resistor, will prevent high current or ESD (electrostatic discharge) from flowing to pin /RESET.

4.11 Residue-Voltage Protection

When the battery is replaced, device power (V_{dd}) is cut off but residue-voltage remains. The residue-voltage may trips below minimum V_{dd} , but not to zero. This condition may cause a poor power-on reset. The following figures illustrate two recommended methods on how to build a residue-voltage protection circuit for EM78P159N.

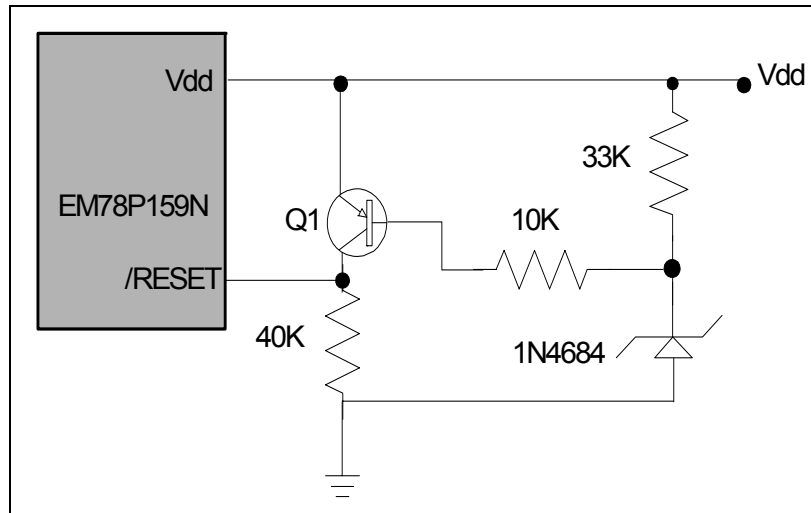


Figure 4-11a Residue Voltage Protection Circuit (1)

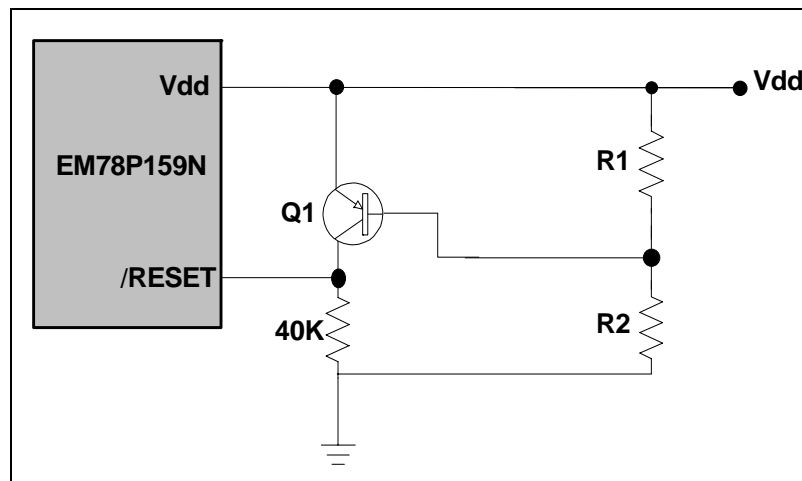


Figure 4-11b Residue Voltage Protection Circuit (2)



4.12 Instruction Set

Each instruction in the instruction set is a 13-bit word divided into an OP code and one or more operands. Normally, all instructions are executed within one single instruction cycle (one instruction consists of 2 oscillator periods), unless the program counter is changed by instruction "MOV R2,A", "ADD R2,A", or by instructions of arithmetic or logic operation on R2 (e.g., "SUB R2,A", "BS(C) R2,6", "CLR R2",). In this case, the execution takes two instruction cycles.

If for some reasons, the specification of the instruction cycle is not suitable for certain applications, try modifying the instruction as follows:

- (A) Change one instruction cycle to consist of 4 oscillator periods.
- (B) "JMP," "CALL," "RET," "RETL," "RETI," or the conditional skip ("JBS," "JBC," "JZ," "JZA," "DJZ," "DJZA") commands which were tested to be true, are executed within two instruction cycles. The instructions that are written to the program counter also take two instruction cycles.

Case (A) is selected by the CODE Option bit, called CLK. One instruction cycle consists of two oscillator clocks if CLK is low, and four oscillator clocks if CLK is high.

Note that once the 4 oscillator periods within one instruction cycle is selected as in Case (A), the internal clock source to TCC should be $CLK = F_{osc}/4$, instead of $F_{osc}/2$.

Moreover, the instruction set has the following features:

- 1) Every bit of any register can be set, cleared, or tested directly.
- 2) The I/O register can be regarded as general register. That is, the same instruction can operate on I/O register.

The following symbols are used in the following Instruction Set table:

- R** represents a register designator that specifies which one of the registers (including operational registers and general purpose registers) is to be utilized by the instruction.
- b** represents a bit field designator that selects the value for the bit which is located in the register "R", and affects operation.
- K** represents an 8 or 10-bit constant or literal value.

| Instruction Binary | Hex | Mnemonic | Operation | Status Affected |
|--------------------|------|----------|---------------------------------------|-----------------|
| 0 0000 0000 0000 | 0000 | NOP | No Operation | None |
| 0 0000 0000 0001 | 0001 | DAA | Decimal Adjust A | C |
| 0 0000 0000 0010 | 0002 | CONTW | A → CONT | None |
| 0 0000 0000 0011 | 0003 | SLEP | 0 → WDT, Stop oscillator | T,P |
| 0 0000 0000 0100 | 0004 | WDTC | 0 → WDT | T,P |
| 0 0000 0000 rrrr | 000r | IOW R | A → IOCR | None <Note1> |
| 0 0000 0001 0000 | 0010 | ENI | Enable Interrupt | None |
| 0 0000 0001 0001 | 0011 | DISI | Disable Interrupt | None |
| 0 0000 0001 0010 | 0012 | RET | [Top of Stack] → PC | None |
| 0 0000 0001 0011 | 0013 | RETI | [Top of Stack] → PC, Enable Interrupt | None |
| 0 0000 0001 0100 | 0014 | CONTR | CONT → A | None |
| 0 0000 0001 rrrr | 001r | IOR R | IOCR → A | None <Note1> |
| 0 0000 01rr rrrr | 00rr | MOV R,A | A → R | None |
| 0 0000 1000 0000 | 0080 | CLRA | 0 → A | Z |
| 0 0000 11rr rrrr | 00rr | CLR R | 0 → R | Z |
| 0 0001 00rr rrrr | 01rr | SUB A,R | R-A → A | Z,C,DC |
| 0 0001 01rr rrrr | 01rr | SUB R,A | R-A → R | Z,C,DC |
| 0 0001 10rr rrrr | 01rr | DECA R | R-1 → A | Z |
| 0 0001 11rr rrrr | 01rr | DEC R | R-1 → R | Z |
| 0 0010 00rr rrrr | 02rr | OR A,R | A ∨ R → A | Z |
| 0 0010 01rr rrrr | 02rr | OR R,A | A ∨ R → R | Z |
| 0 0010 10rr rrrr | 02rr | AND A,R | A & R → A | Z |
| 0 0010 11rr rrrr | 02rr | AND R,A | A & R → R | Z |
| 0 0011 00rr rrrr | 03rr | XOR A,R | A ⊕ R → A | Z |
| 0 0011 01rr rrrr | 03rr | XOR R,A | A ⊕ R → R | Z |
| 0 0011 10rr rrrr | 03rr | ADD A,R | A + R → A | Z,C,DC |
| 0 0011 11rr rrrr | 03rr | ADD R,A | A + R → R | Z,C,DC |
| 0 0100 00rr rrrr | 04rr | MOV A,R | R → A | Z |
| 0 0100 01rr rrrr | 04rr | MOV R,R | R → R | Z |
| 0 0100 10rr rrrr | 04rr | COMA R | /R → A | Z |
| 0 0100 11rr rrrr | 04rr | COM R | /R → R | Z |
| 0 0101 00rr rrrr | 05rr | INCA R | R+1 → A | Z |
| 0 0101 01rr rrrr | 05rr | INC R | R+1 → R | Z |
| 0 0101 10rr rrrr | 05rr | DJZA R | R-1 → A, skip if zero | None |
| 0 0101 11rr rrrr | 05rr | DJZ R | R-1 → R, skip if zero | None |
| 0 0110 00rr rrrr | 06rr | RRCA R | R(n) → A(n-1), R(0) → C, C → A(7) | C |
| 0 0110 01rr rrrr | 06rr | RRC R | R(n) → R(n-1), R(0) → C, C → R(7) | C |

| Instruction Binary | Hex | Mnemonic | Operation | Status Affected |
|--------------------|------|----------|----------------------------------------------------------------------------|-----------------|
| 0 0110 10rr rrrr | 06rr | RLCA R | $R(n) \rightarrow A(n+1)$, $R(7) \rightarrow C$, $C \rightarrow A(0)$ | C |
| 0 0110 11rr rrrr | 06rr | RLC R | $R(n) \rightarrow R(n+1)$, $R(7) \rightarrow C$, $C \rightarrow R(0)$ | C |
| 0 0111 00rr rrrr | 07rr | SWAPA R | $R(0-3) \rightarrow A(4-7)$, $R(4-7) \rightarrow A(0-3)$ | None |
| 0 0111 01rr rrrr | 07rr | SWAP R | $R(0-3) \leftrightarrow R(4-7)$ | None |
| 0 0111 10rr rrrr | 07rr | JZA R | $R+1 \rightarrow A$, skip if zero | None |
| 0 0111 11rr rrrr | 07rr | JZ R | $R+1 \rightarrow R$, skip if zero | None |
| 0 100b bbrr rrrr | 0xxx | BC R,b | $0 \rightarrow R(b)$ | None <Note2> |
| 0 101b bbrr rrrr | 0xxx | BS R,b | $1 \rightarrow R(b)$ | None <Note3> |
| 0 110b bbrr rrrr | 0xxx | JBC R,b | if $R(b)=0$, skip | None |
| 0 111b bbrr rrrr | 0xxx | JBS R,b | if $R(b)=1$, skip | None |
| 1 00kk kkkk kkkk | 1kkk | CALL k | $PC+1 \rightarrow [SP]$, $(Page, k) \rightarrow PC$ | None |
| 1 01kk kkkk kkkk | 1kkk | JMP k | $(Page, k) \rightarrow PC$ | None |
| 1 1000 kkkk kkkk | 18kk | MOV A,k | $k \rightarrow A$ | None |
| 1 1001 kkkk kkkk | 19kk | OR A,k | $A \vee k \rightarrow A$ | Z |
| 1 1010 kkkk kkkk | 1Akk | AND A,k | $A \& k \rightarrow A$ | Z |
| 1 1011 kkkk kkkk | 1Bkk | XOR A,k | $A \oplus k \rightarrow A$ | Z |
| 1 1100 kkkk kkkk | 1Ckk | RETL k | $k \rightarrow A$, $[Top\ of\ Stack] \rightarrow PC$ | None |
| 1 1101 kkkk kkkk | 1Dkk | SUB A,k | $k-A \rightarrow A$ | Z,C,DC |
| 1 1110 0000 0001 | 1E01 | INT | $PC+1 \rightarrow [SP]$, $001H \rightarrow PC$ | None |
| 1 1111 kkkk kkkk | 1Fkk | ADD A,k | $k+A \rightarrow A$ | Z,C,DC |

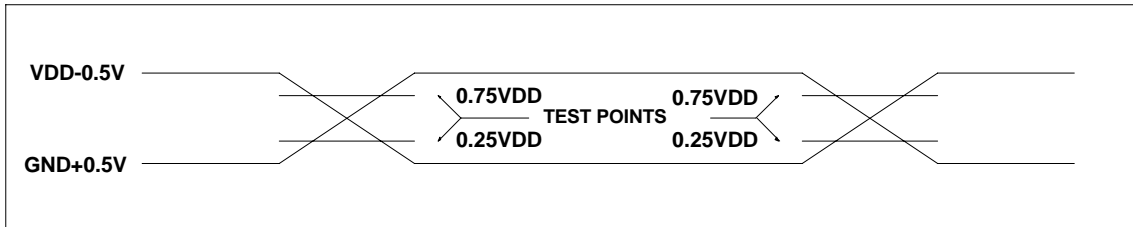
Note 1: This instruction is applicable to IOC5~IOC6, IOCB~IOCF only.

Note 2: This instruction is not recommended for RF operation.

Note 3: This instruction cannot operate under RF.

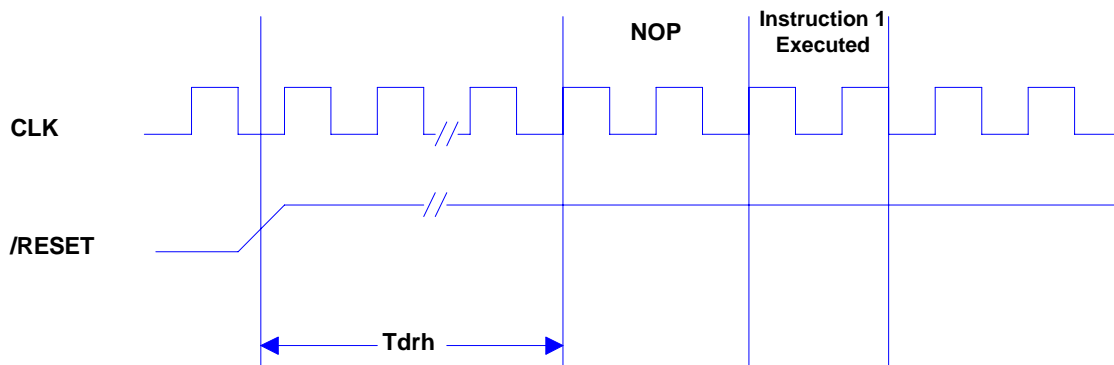
4.13 Timing Diagrams

AC Test Input/Output Waveform



AC Testing : Input is driven at VDD-0.5V for logic "1", and GND+0.5V for logic "0". Timing measurements are made at 0.75VDD for logic "1", and 0.25VDD for logic "0".

RESET Timing (CLK="0")



TCC Input Timing (CLKS="0")

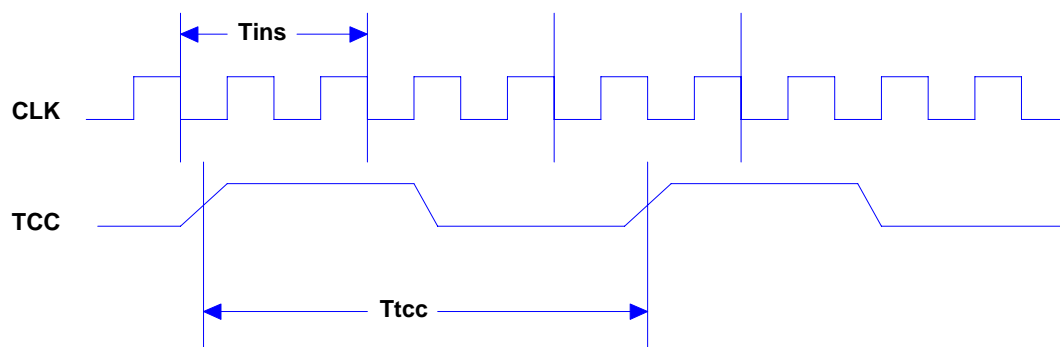


Figure 4-12 EM78P159N Timing Diagrams

5 Absolute Maximum Ratings

■ EM78P159N

| Items | Rating |
|------------------------|----------------------|
| Temperature under bias | -40°C to 85°C |
| Storage temperature | -65°C to 150°C |
| Working voltage | 2.1 to 5.5V |
| Working frequency | DC to 20MHz* |
| Input voltage | Vss-0.3V to Vdd+0.5V |
| Output voltage | Vss-0.3V to Vdd+0.5V |

These parameters are theoretical values and have not been tested.

6 Electrical Characteristics

6.1 DC Electrical Characteristic

■ (Ta=25 °C, VDD=5V±5%, VSS=0V)

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|--------|-------------------------------------------------|------------------------------------|---------|-----|---------|------|
| FXT | XTAL: VDD to 3V | Two cycle with two clocks | DC | | 8.0 | MHz |
| | XTAL: VDD to 5V | Two cycle with two clocks | DC | | 20.0 | MHz |
| ERC | ERC: VDD to 5V | R: 5.1KΩ, C: 100 pF | F±30% | 940 | F±30% | KHz |
| IIL | Input Leakage Current for input pins | VIN = VDD, VSS | | | ±1 | μA |
| VIH1 | Input High Voltage (VDD=5V) | Ports 5, 6 (Schmitt trigger) | 0.75Vdd | | Vdd+0.3 | V |
| VIL1 | Input Low Voltage (VDD=5V) | Ports 5, 6 (Schmitt trigger) | Vdd-0.3 | | 0.25Vdd | V |
| VIHT1 | Input High Threshold Voltage (VDD=5V) | /RESET, TCC (Schmitt trigger) | 0.75Vdd | | Vdd+0.3 | V |
| VILT1 | Input Low Threshold Voltage (VDD=5V) | /RESET, TCC (Schmitt trigger) | Vdd-0.3 | | 0.25Vdd | V |
| VIHX1 | Clock Input High Voltage (VDD=5V) | OSCI (Schmitt trigger) | 0.75Vdd | | Vdd+0.3 | V |
| VILX1 | Clock Input Low Voltage (VDD=5V) | OSCI (Schmitt trigger) | Vdd-0.3 | | 0.25Vdd | V |
| VIH2 | Input High Voltage (VDD=3V) | Ports 5, 6 (Schmitt trigger) | 0.75Vdd | | Vdd+0.3 | V |
| VIL2 | Input Low Voltage (VDD=3V) | Ports 5, 6 (Schmitt trigger) | Vdd-0.3 | | 0.25Vdd | V |
| VIHT2 | Input High Threshold Voltage (VDD=3V) | /RESET, TCC (Schmitt trigger) | 0.75Vdd | | Vdd+0.3 | V |
| VILT2 | Input Low Threshold Voltage (VDD=3V) | /RESET, TCC (Schmitt trigger) | Vdd-0.3 | | 0.25Vdd | V |
| VIHX2 | Clock Input High Voltage (VDD=3V) | OSCI (Schmitt trigger) | 0.75Vdd | | Vdd+0.3 | V |
| VILX2 | Clock Input Low Voltage (VDD=3V) | OSCI (Schmitt trigger) | Vdd-0.3 | | 0.25Vdd | V |
| VOH1 | Output High Voltage (Ports 5) | IOH = -6 mA | 4.5 | | | V |
| VOH1 | Output High Voltage (Ports 6) (Schmitt trigger) | IOH = -6 mA | 4.5 | | | V |
| VOL1 | Output Low Voltage (Port5) | IOL = 16.5 mA | | | 0.5 | V |
| VOL1 | Output Low Voltage (Ports 6) (Schmitt trigger) | IOL = 16.5 mA | | | 0.5 | V |
| IPH | Pull-high current | Pull-high active, input pin at VSS | -50 | -70 | -100 | μA |
| IPD | Pull-down current | Pull-down active, input pin at VDD | 25 | 50 | 120 | μA |

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|--------|---------------------------------------------------------------|----------------------------------------------------------------------------------------|-----|-----|-----|------|
| ISB1 | Power down current (VDD=5.0V) | All input and I/O pins at VDD, output pin floating, WDT disabled | | 1 | 2 | μA |
| ISB2 | Power down current (VDD=5.0V) | All input and I/O pins at VDD, output pin floating, WDT enabled | | 6 | 10 | μA |
| ICC1 | Operating supply current (VDD=3V) at two cycles/four clocks | /RESET= 'High', Fosc=32KHz (Crystal type, CLKS="0"), output pin floating, WDT disabled | | 20 | 30 | μA |
| ICC2 | Operating supply current (VDD=3V) at two cycles/four clocks | /RESET= 'High', Fosc=32KHz (Crystal type, CLKS="0"), output pin floating, WDT enabled | | 22 | 32 | μA |
| ICC3 | Operating supply current (VDD=5.0V) at two cycles/two clocks | /RESET= 'High', Fosc=4MHz (Crystal type, CLKS="0"), output pin floating, WDT enabled | | 1.7 | 2.5 | mA |
| ICC4 | Operating supply current (VDD=5.0V) at two cycles/four clocks | /RESET= 'High', Fosc=10MHz (Crystal type, CLKS="0"), output pin floating, WDT enabled | | 2.7 | 3.5 | mA |

These parameters are theoretical values and have not been tested.

6.2 AC Electrical Characteristic

■ (Ta=25 °C, VDD=5V±5%, VSS=0V)

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--------|-----------------------------------|--------------|--------------|------|------|------|
| Dclk | Input CLK duty cycle | | 45 | 50 | 55 | % |
| Tins | Instruction cycle time (CLKS="0") | Crystal type | 100 | | DC | ns |
| | | RC type | 500 | | DC | ns |
| Ttcc | TCC input period | | (Tins+20)/N* | | | ns |
| Tdrh | Device reset hold time | | 11.8 | 16.8 | 21.8 | ms |
| Trst | /RESET pulse width | Ta = 25°C | 2000 | | | ns |
| Twdt | Watchdog timer period | Ta = 25°C | 11.8 | 16.8 | 21.8 | ms |
| Tset | Input pin setup time | | | 0 | | ns |
| Thold | Input pin hold time | | | 20 | | ns |
| Tdelay | Output pin delay time | Cload=20pF | | 50 | | ns |

* N = selected prescaler ratio.

These parameters are theoretical values and have not been tested.

Data in the Minimum, Typical, Maximum ("Min", "Typ", "Max") columns are based on characterization results at 25°C. This data is for design reference only and has not been tested.

APPENDIX

A Package Types

| OTP MCU | Package Type | Pin Count | Package Size |
|------------|--------------|-----------|--------------|
| EM78P159NP | DIP | 18 | 300 mil |
| EM78P159NM | SOP | 18 | 300 mil |
| EM78159NAS | SSOP | 20 | 209 mil |
| EM78159NKM | SSOP | 20 | 209 mil |

B Package Information

■ 18-Lead Plastic Dual in Line (PDIP) — 300 mil

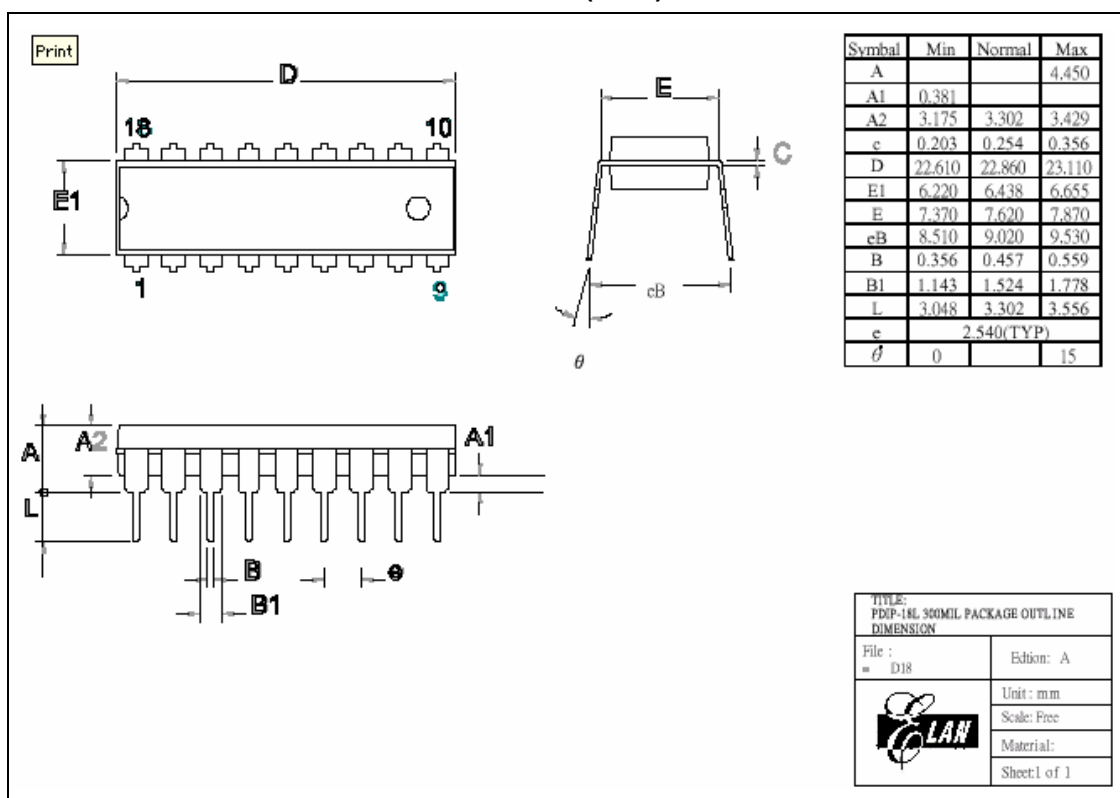


Figure B-1a EM78P159N 18-Lead PDIP Package Type

■ 18-Lead Plastic Small Outline (SOP) — 300 mil

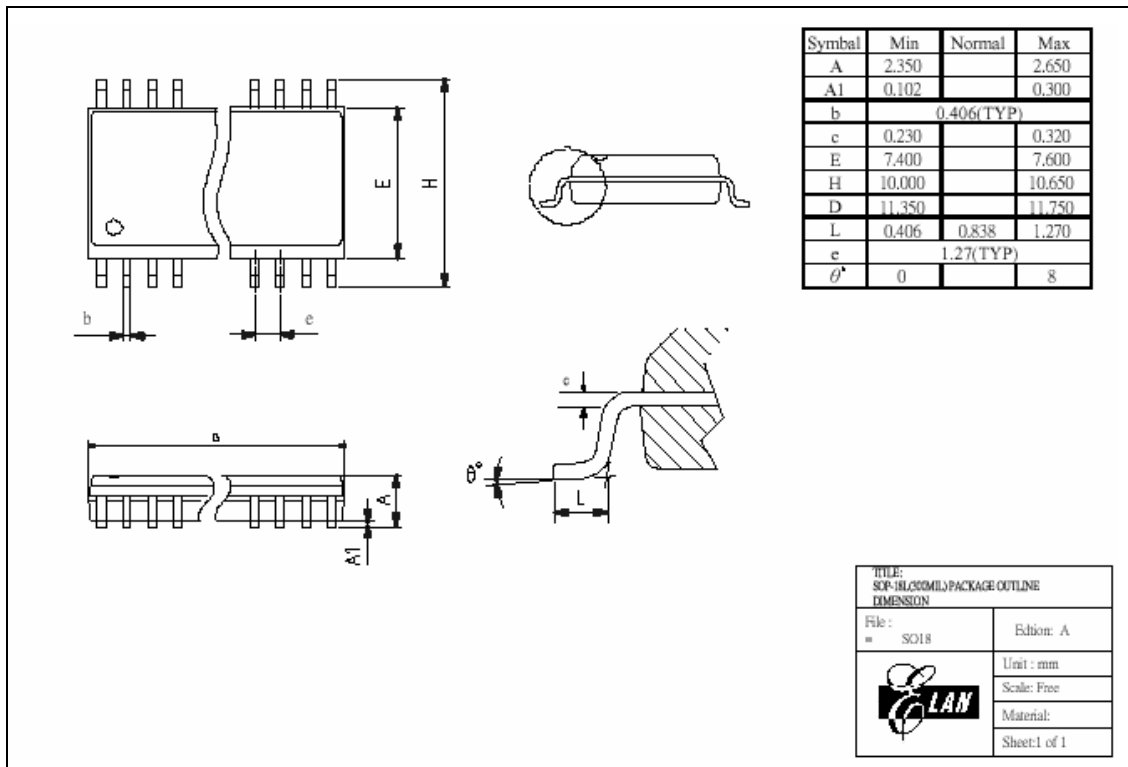


Figure B-1b EM78P159N 18-Lead SOP Package Type

■ 20-Lead Plastic Small Outline (SSOP) — 209 mil

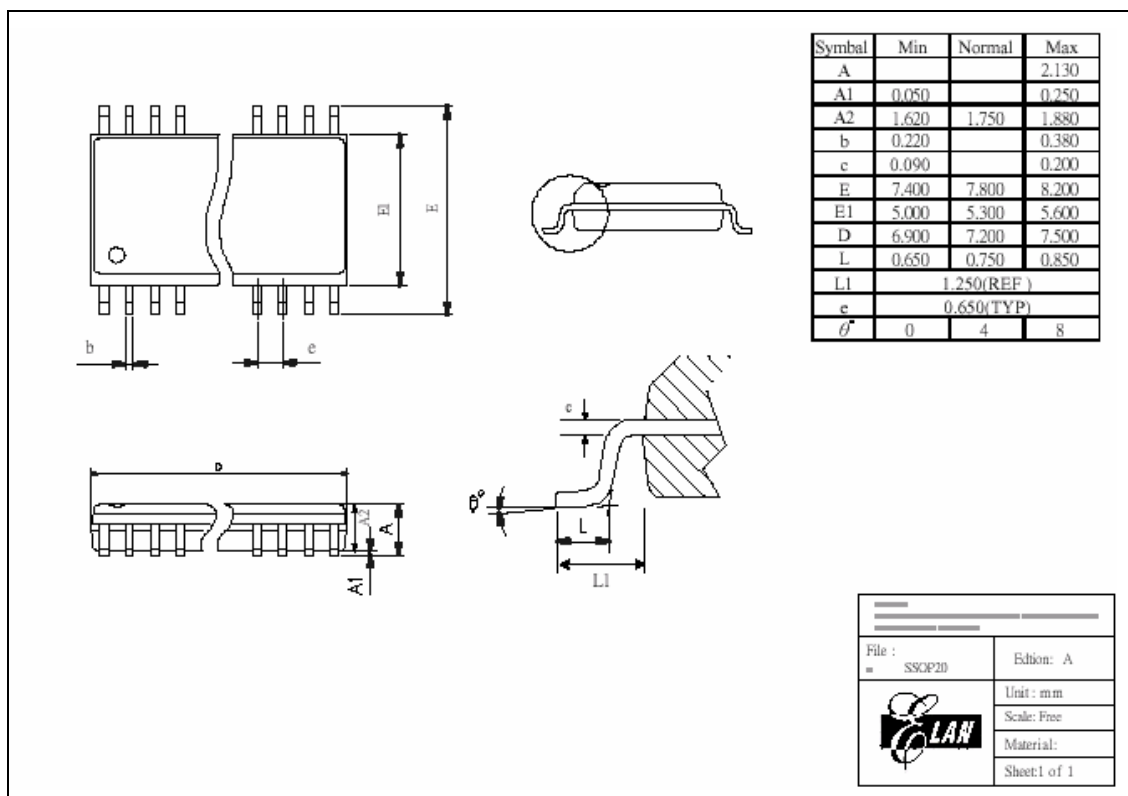


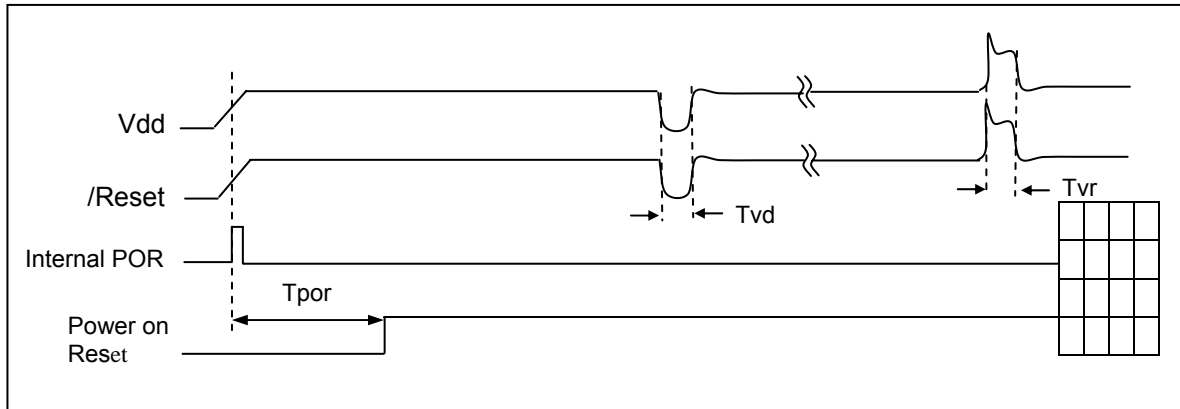
Figure B-1c EM78P159N 20-Lead SSOP Package Type

C Quality Assurance and Reliability

C.1 Reliability Test

| Test Category | Test Conditions | Remarks |
|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Solderability | Solder temperature = $245 \pm 5^{\circ}\text{C}$ for 5 seconds up to the stopper using a rosin-type flux | |
| Pre-condition | Step 1: TCT 65°C (15mins) ~ 150°C (15mins), 10 cycles | For SMD IC (such as SOP, QFP, SOJ, etc.) |
| | Step 2: bake 125°C , TD(endurance) = 24 hrs. | |
| | Step 3: soak 30°C /60%, TD (endurance) = 192hrs. | |
| | Step 4: IR flow 3cycles (Pkg thickness $\geq 2.5\text{mm}$ or Pkg volume $\geq 350\text{mm}^3$ -- $225 \pm 5^{\circ}\text{C}$) (Pkg thickness $\leq 2.5\text{mm}$ or Pkg volume $\leq 350\text{mm}^3$ -- $240 \pm 5^{\circ}\text{C}$) | |
| Temperature cycle test | -65°C (15mins) ~ 150°C (15mins), 200 cycles | |
| Pressure cooker test | TA = 121°C , RH = 100%, pressure = 2atm, TD (endurance) = 96 Hrs. | |
| High temperature /high humidity test | TA = 85°C , RH = 85%, TD (endurance) = 168, 500 Hrs | |
| High-temperature storage life | TA = 150°C , TD (endurance) = 500, 1000Hrs. | |
| High-temperature operating life | TA = 125°C , VCC = Max. operating voltage, TD (endurance) = 168,500, 1000Hrs. | |
| Latch-up | TA = 25°C , VCC = Max. operating voltage, 150mA/20V | |
| ESD (HBM) | TA = 25°C , $\geq \pm 3\text{KV}$ | IP_ND, OP_ND, IO_ND IP_NS, OP_NS, IO_NS |
| ESD (MM) | TA = 25°C , $\geq \pm 300\text{V}$ | IP_PD, OP_PD, IO_PD, IP_PS, OP_PS, IO_PS, VDD-VSS(+), VDD_VSS(-)mode |

C.2 Power-On Reset and Vdd Voltage Drop/Rise Timing Test



| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|--------|-----------------------|-------------------------|------|------|------|------|
| Tpor | Power on reset time | Vdd = 5V, -40°C to 85°C | 10.5 | 16.8 | 22 | ms |
| Tvd* | Vdd Voltage drop time | Vdd = 5V, -40°C to 85°C | - | - | 1 | μs |
| Tvr** | Vdd Voltage rise time | Vdd = 5V, -40°C to 85°C | - | - | 1 | us |
| | | | | | | |

* Tvd is the period of Vdd voltage lower than POR voltage.

** Tvr is the period of Vdd voltage higher than 5.5V.

Figure C-1 EM78P159N Power-On Reset and Vdd Voltage Drop/Rise Timing Test Timing Diagram

C.3 Address Trap Detect

An address trap detect is one of the fail-safe function that detects CPU malfunction caused by noise or the like. If the CPU attempts to fetch an instruction from a part of RAM, an internal recovery circuit will be auto started. Until CPU got the correct function, it will execute the next program.

