
EM78F561N

**8-Bit
Microcontroller**

**Product
Specification**

DOC. VERSION 1.0


ELAN MICROELECTRONICS CORP.
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Specification Revision History

| Doc. Version | Revision Description | Date |
|--------------|--------------------------|------------|
| 0.9 | Preliminary version | 2009/09/11 |
| 1.0 | Initial released version | 2010/01/07 |



1 General Description

The EM78F561N is an 8-bit microprocessor designed and developed with low-power, high-speed CMOS technology and high noise immunity. It has an on-chip 1K×13-bit Electrical Flash Memory. It provides three protection bits to prevent intrusion of user's Flash memory code. Twelve Code option bits are also available to meet user's requirements.

With its enhanced Flash-ROM features, the EM78F561N provides a convenient way of developing and verifying user's programs. Moreover, this Flash-ROM device offers the advantages of easy and effective program updates, using development and programming tools. Users can avail of the ELAN Writer to easily program their development codes.

2 Features

- CPU configuration
 - 1K×13 bits on-chip Flash memory
 - 48×8 bits on-chip registers (SRAM)
 - 8-level stacks for subroutine nesting
 - 3 programmable Level Voltage Reset
LVR : 4.0V, 3.5V, 2.7V
 - Less than 1.5 mA at 5V / 4 MHz
 - Typically 20 μ A, at 3V / 32kHz
 - Typically 1.5 μ A, during sleep mode
- I/O port configuration
 - 3 bidirectional I/O ports: P5, P6 and P8
 - 14 I/O pins
 - Wake-up port : P6
 - High sink port : P6
 - 6 programmable pull-high I/O pins
 - 5 programmable pull-down I/O pins
 - 6 programmable open-drain I/O pins
 - External interrupt with Wake-up : P60
- Operating voltage range
 - 2.4V~5.5V at -40°C~85°C (Industrial)
 - 2.2V~5.5V at 0°C~70°C (Commercial)
- Operating frequency range (base on two clocks)
 - Crystal mode : DC~16MHz @ 4.5V~5.5V ;
DC~8MHz @ 3V~5.5V ;
DC~4MHz @ 2.2V~5.5V
 - ERC mode : DC~16MHz @ 4.5V~5.5V ;
DC~8MHz @ 3V~5.5V ;
DC~4MHz @ 2.2V~5.5V

- IRC mode : DC~16MHz @ 4.5V~5.5V ;
DC~4MHz @ 2.2V~5.5V

| Internal RC Frequency | Drift Rate | | | |
|-----------------------|--------------------------|---------------------|---------|---------|
| | Temperature (-40°C~85°C) | Voltage (2.4V~5.5V) | Process | Total |
| 4 MHz | ± 3% | ± 5% | ± 2.5% | ± 10.5% |
| 16 MHz | ± 3% | ± 5% | ± 2.5% | ± 10.5% |
| 8 MHz | ± 3% | ± 5% | ± 2.5% | ± 10.5% |

- Six available interrupts
 - Internal interrupt : 3
 - External interrupt : 3
- 6 channels Analog-to-Digital Converter with 10-bit resolution
- One set of comparator
Offset voltage: smaller than 5 mV
- One 8-bit Timer/Counter
 - TC3 : Timer/Counter/PDO (programmable divider output)/PWM (pulse width modulation)
- Peripheral configuration
 - 8-bit real time clock only (TCC) with overflow interrupt
 - External interrupt input pin
 - 2/4/8/16 clocks per instruction cycle selected by code option
 - Power down (Sleep) mode
 - High EFT immunity
- Single instruction cycle commands
- Special Features
 - Programmable free running Watchdog Timer
 - Power-on voltage detector available (2.0V ~ 2.1V)
- Package Type:
 - 10-pin MSOP 118mil : EM78F561NMS10J/S
 - 16-pin DIP 300mil : EM78F561NAD16J/S
 - 16-pin SOP 150mil : EM78F561NASO16AJ/S

Note: *These are all Green Products which do not contain hazardous substances.*

3 Pin Assignment

(1) 10-Pin MSOP

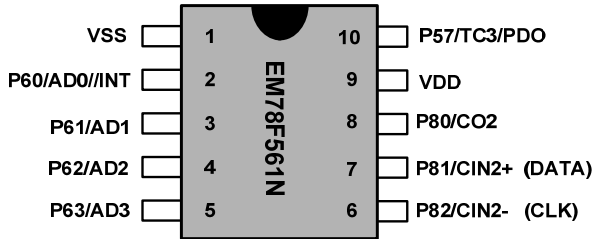


Figure 3-1
 EM78F561NMS10

(2) 16-Pin DIP/SOP

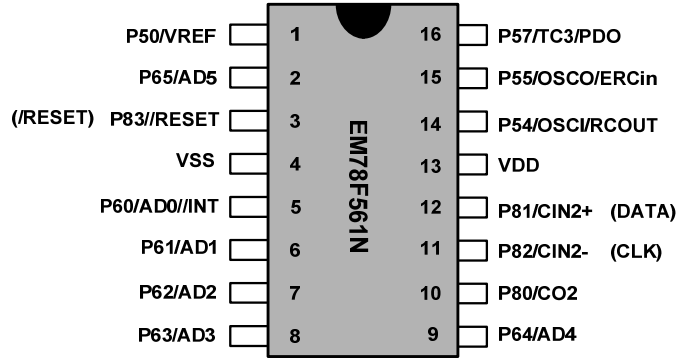


Figure 3-2
 EM78F561NAD16
 EM78F561NASO16A

4 Pin Description

Table 4-1 EM78F561NMS10 -10 Pins

| Symbol | Pin No. | Type | Function |
|----------|---------|------|--|
| P57 | 10 | I/O | Bidirectional 1-bit input/output pins. P57 can be used as 8-bit timer/counter or programmable divider output (PDO). |
| P60 ~P63 | 2~5 | I/O | Bidirectional 4-bit input/output ports. These can be used as pull-high or open drain by software programming. P60~63 can be used as pull-down by software programming. These can be used as 4-channel, 10-bit resolution A/D converter. P60 can be used as external interrupt. |
| P80~P82 | 8~6 | I/O | P80 ~ P82 are bidirectional I/O ports. P80 can act as CO2. P81 can act as CIN2+. P82 can act as CIN2-. * P81 is DATA pin for Writer programming (Required). * P82 is CLK pin for Writer programming (Required). * For ISP (In System Programming) design rules, refer to “EM78F6xxN/5xxN MCU Programming” Application Notes. |
| VDD | 9 | - | Power supply pin |
| VSS | 1 | - | Ground |

Table 4-2 EM78F561NAD16, EM78F561NASO16A -16 Pins

| Symbol | Pin No. | Type | Function |
|--------------------------|---------------------|------|--|
| P50 P54 P55 P57 | 1 14 15 16 | I/O | Bidirectional 4-bit input/output pins. P50 can be used as pull-down by software programming. P50 can be used as external reference voltage for ADC P57 can be used as 8-bit timer/counter or programmable divider output (PDO). |
| P60~ P65 | 5~9, 2 | I/O | Bidirectional 6-bit input/output ports. These can be used as pull-high or open drain by software programming. P60~63 can be used as pull-down by software programming. These can be used as 6-channel, 10-bit resolution A/D converter. P60 can be used as external interrupt. |
| P80~P83 | 10, 12~11, 3 | I/O | P80 ~ P83 are bidirectional I/O ports. P80 can act as CO2. P81 can act as CIN2+. P82 can act as CIN2-. * P81 is DATA pin for Writer programming (Required). * P82 is CLK pin for Writer programming (Required). * For ISP (In System Programming) design rules, refer to "EM78F6xxN/5xxN MCU Programming" Application Notes. |
| OSCO / ERCin | 15 | I/O | Clock output from crystal oscillator. External RC oscillator clock input pin. |
| OSCI / RCOUT | 14 | I/O | External clock crystal resonator oscillator input pin. Clock output from internal RC oscillator. |
| /RESET | 3 | I | Schmitt trigger input pin. If this pin remains at logic low, the controller is reset. * /RESET is /RESET pin for Writer programming (Required). * For ISP (In System Programming) design rules, refer to "EM78F6xxN/5xxN MCU Programming" Application Notes. |
| VDD | 13 | - | Power supply pin |
| VSS | 4 | - | Ground |

5 Block Diagram

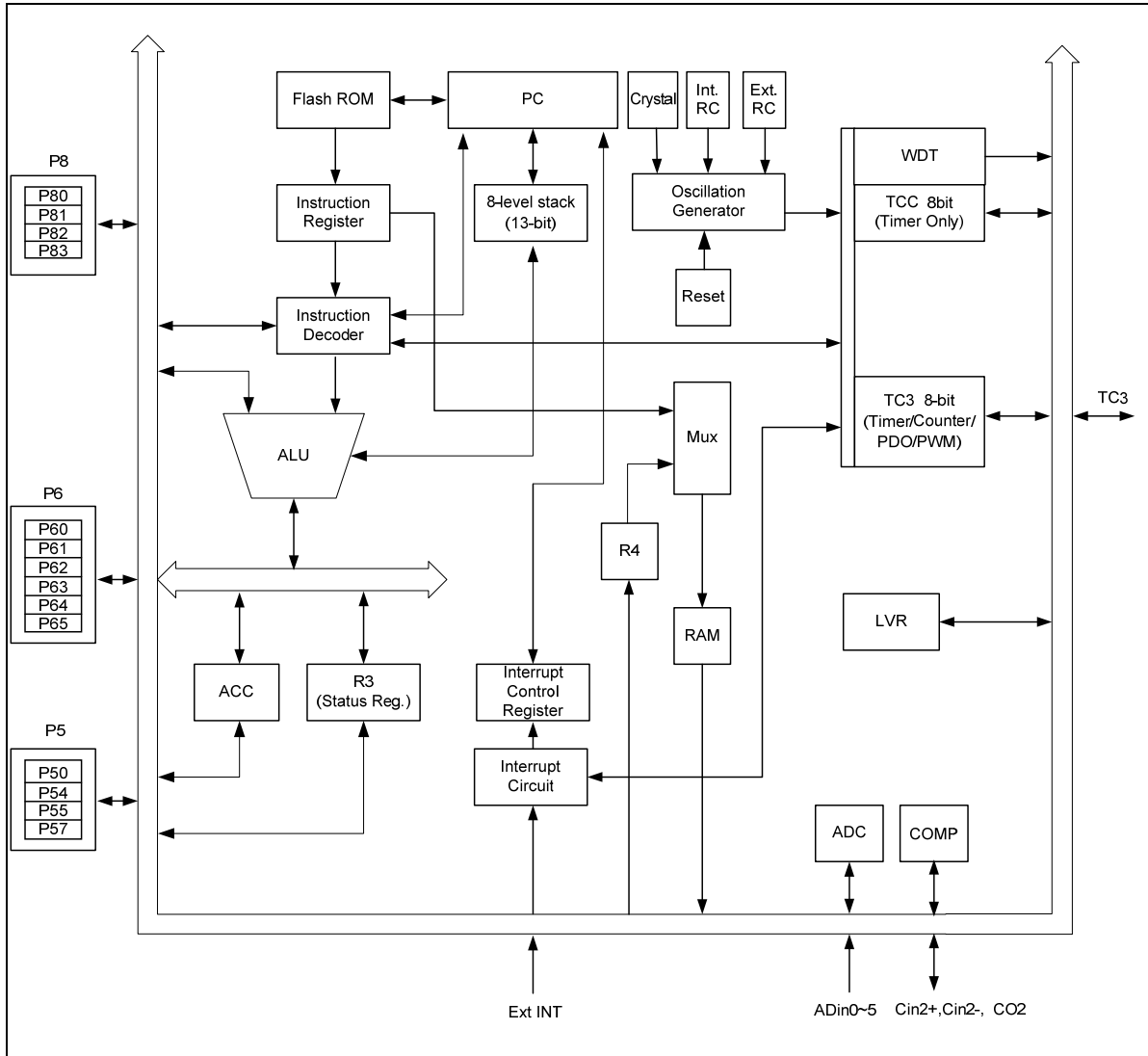


Figure 5-1 Functional Block Diagram

6 Functional Description

6.1 Operational Registers

6.1.1 R0 (Indirect Addressing Register)

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

6.1.2 R1 (Timer Clock)

R1 is incremented by the instruction cycle clock. It is writable and readable as any other registers. It is defined by resetting PSTE (CONT-3).

The prescaler is assigned to TCC, if the PSTE bit (CONT-3) is reset. The content of the prescaler counter is cleared only when the TCC register is written with a value.

6.1.3 R2 (Program Counter and Stack)

Depending on the device type, R2 and hardware stack are 10-bit wide. The structure is depicted in Figure 6-1.

The configuration structure generates 1K×13 bits on-chip Flash ROM addresses to the relative programming instruction codes. One program page is 1024 words long.

R2 is set as all "0"s when under a reset condition.

"JMP" instruction allows direct loading of the lower 10 program counter bits. Thus, "JMP" allows the PC to go to any location within a page.

"CALL" instruction loads the lower 10 bits of the PC, and PC+1 are pushed onto the stack. Thus, the subroutine entry address can be located anywhere within a page.

"RET" ("RETL k", "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 above bits of the PC will increase progressively.

"MOV R2, A" allows loading an address from the "A" register to the lower 8 bits of the PC, and the ninth and tenth bits of the PC 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, fclk/4, fclk/8 or fclk/16) except for the instruction that would change the contents of R2 and "TBRD" instruction. The "TBRD" instructions need two instruction cycles.

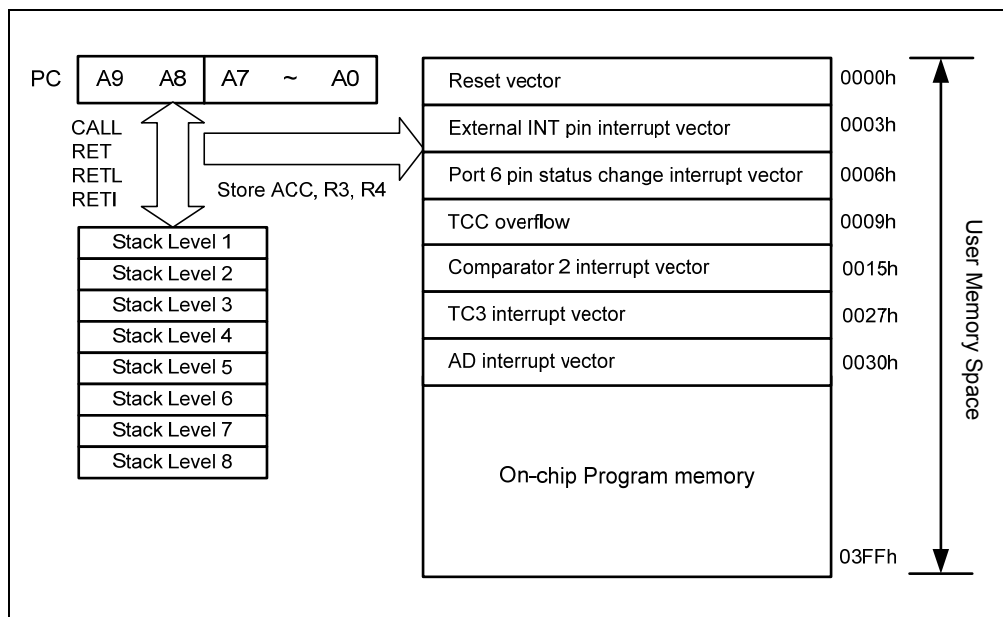


Figure 6-1 Program Counter Organization



| | Register Bank 0 | Register Bank 1 | Register Bank 2 | Register Bank 3 | Control Register |
|----------------|---------------------------------|------------------------------|--------------------------------|------------------------------------|-----------------------------|
| Address | | | | | |
| 01 | R1 (TCC Buffer) | | | | |
| 02 | R2 (PC) | | | | |
| 03 | R3 (STATUS) | | | | |
| 04 | R4 (RSR Bank Select) | R4(7,6) (0,1) | (1,0) | (1,1) | |
| 05 | R5 (Port 5 I/O data) | R5 (Reserved) | R5 (ADC Input Select Register) | R5 (Reserved) | IOC5 (Port 5 I/O Control) |
| 06 | R6 (Port 6 I/O data) | R6 (Reserved) | R6 (ADC Control Register) | R6 (TBHP: Table Point Register) | IOC6 (Port 6 I/O Control) |
| 07 | R7 (Reserved) | R7 (Reserved) | R7 (Reserved) | R7 (Comparator 2 Control Register) | IOC7 (Reserved) |
| 08 | R8 (Port 8 I/O data) | R8 (IRC Select Register) | R8 (AD high 8-bit Data buffer) | R8 (Reserved) | IOC8 (Port 8 I/O Control) |
| 09 | R9 (TBLP: Table Point Register) | R9 (Reserved) | R9 (AD low 2-bit Data buffer) | R9 (Reserved) | IOC9 (Reserved) |
| 0A | RA (Wake Control Register) | RA (Reserved) | RA (Reserved) | RA (Reserved) | IOCA (WDT Control) |
| 0B | RB (Reserved) | RB (Reserved) | RB (Reserved) | RB (Reserved) | IOCB (Pull Down Control 2) |
| 0C | RC (Reserved) | RC (Reserved) | RC (Reserved) | RC (Reserved) | IOCC (Open Drain Control 1) |
| 0D | RD (Reserved) | RD (Reserved) | RD (Reserved) | RD (Timer 3 Control) | IOCD (Pull High Control 2) |
| 0E | RE (Mode Select Register) | RE (Reserved) | RE (Reserved) | RE (Timer 3 data buffer) | IOCE (Interrupt Mask 2) |
| 0F | RF (Interrupt Status Flag 1) | RF (Interrupt Status Flag 2) | RF (Reserved) | RF (Reserved) | IOCF (Interrupt Mask 1) |
| 10 : 1F | 16-Byte Common Register | | | | |
| 20 : 3F | Bank 0 32x8 | | | | |

Figure 6-2 Data Memory Configuration

6.1.4 R3 (Status Register)

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

Bits 7 ~ 5: Not used, set to "0" at all time.

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 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 2 (Z): Zero flag

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

Bit 1 (DC): Auxiliary carry flag

Bit 0 (C): Carry flag

6.1.5 R4 (RAM Select Register)

Bits 7 ~ 6: Used to select Bank 0 ~ Bank 3

Bits 5 ~ 0: Used to select registers (Address: 00~3F) in indirect addressing mode.

See the data memory configuration in Figure 6-2.

6.1.6 Bank 0 R5 ~ R6, R8 (Port 5 ~ Port 6, Port 8)

R5 ~ R6, R8 are I/O registers.

6.1.7 Bank 0 R9 (TBLP: Table Point Register for Instruction TBRD)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| RBit7 | RBit6 | RBit5 | RBit4 | RBit3 | RBit2 | RBit1 | RBit0 |

Bits 7 ~ 0: These are the least 8 significant bits of address for program code.

NOTE

- Bank 0 R9 overflow will carry to Bank 3 R6.
- Bank 0 R9 underflow will borrow from Bank 3 R6.

6.1.8 Bank 0 RA (Wake-up Control Register)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|--------|-------|-------|-------|-------|-------|-------|-------|
| CMP2WE | ICWE | ADWE | EXWE | - | - | - | - |

Bit 7 (CMP2WE): Comparator 2 wake-up enable bit.

- 0 : Disable Comparator 2 wake-up
- 1 : Enable Comparator 2 wake-up

When the Comparator 2 output status change is used to enter an interrupt vector or to wake-up the EM78F561N from sleep mode, the CMP2WE bit must be set to "Enable".

Bit 6 (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

Bit 5 (ADWE): ADC wake-up enable bit

- 0 : Disable ADC wake-up
- 1 : Enable ADC wake-up

When ADC Complete is used to enter an interrupt vector or to wake-up the EM78F561N from sleep with A/D conversion running, the ADWE bit must be set to "Enable".

Bit 4 (EXWE): External /INT wake-up enable bit

- 0 : Disable External /INT pin wake-up
- 1 : Enable External /INT pin wake-up

Bits 3 ~ 0: Not used, set to "0" at all time.

6.1.9 Bank 0 RB ~ RD

These are reserved registers.

6.1.10 Bank 0 RE (Mode Select Register)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|---------|-------|-------|-------|-------|-------|-------|
| - | TIMERSC | CPUS | IDLE | - | - | - | - |

Bit 7: Not used, set to “0” at all time.

Bit 6 (TIMERSC): TCC, TC3 clock source select.

- 0 : Fs is used as Fc
- 1 : Fm is used as Fc

Bit 5 (CPUS): CPU Oscillator Source Select.

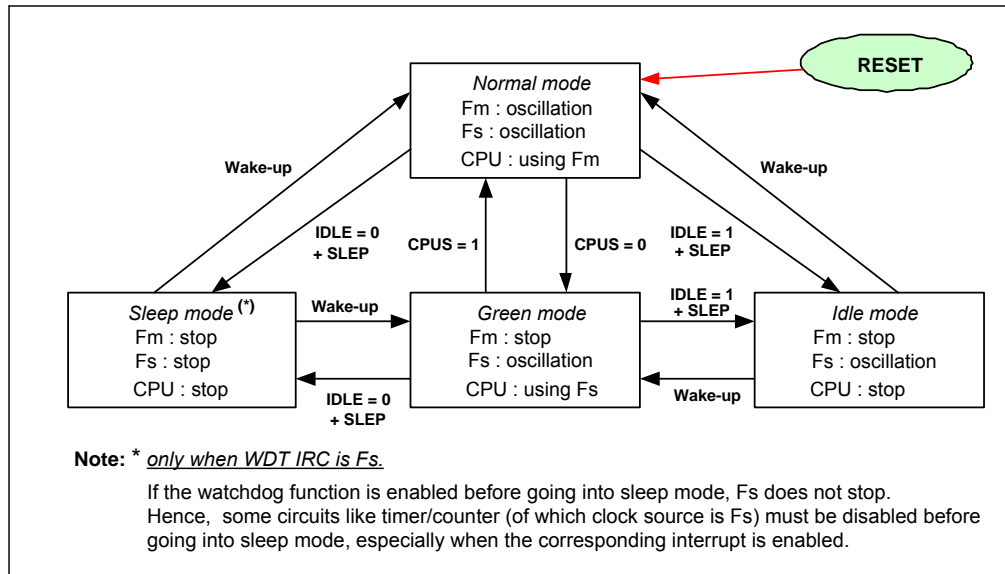
- 0 : Fs : Sub frequency for WDT internal RC time base
- 1 : Fm : Main-oscillator clock

When CPUS=0, the CPU oscillator selects a sub-oscillator and the main oscillator is stopped.

Bit 4 (IDLE): Idle Mode Enable Bit.

- 0 : IDLE=“0” + SLEP instruction → Sleep mode
- 1 : IDLE=“1” + SLEP instruction → Idle mode

CPU Operation Mode



| Oscillator (Normal Mode Source) | CPU Mode Status | Oscillator Stable Time (s) ¹ | Count from Normal/Green (CLK) ² |
|------------------------------------|---------------------|--|---|
| Crystal ; 1M ~ 16 MHz | Sleep/Idle → Normal | 0.5 ms ~ 2 ms | 254 CLK |
| | Green → Normal | | 254 CLK |
| | Sleep/Idle → Green | < 100 μs | 32 CLK |
| ERC ; 3.5 MHz | Sleep/Idle → Normal | < 5 μs | 32 CLK |
| | Green → Normal | | |
| | Sleep/Idle → Green | < 100 μs | |
| IRC ; 4M, 8M, 16 MHz | Sleep/Idle → Normal | < 2 μs | 32 CLK |
| | Green → Normal | | |
| | Sleep/Idle → Green | < 100 μs | |

NOTE

- ¹ Stabilization time for the oscillator depends on the oscillator characteristics.
- ² After the oscillator has stabilized, the CPU will count 254/32 CLK in Normal/Green mode and continue to work in Normal/Green mode.

Ex 1 : When the 4 MHz IRC wakes-up from Sleep mode to Normal mode,
 its total wake-up time is 2 μs + 32 CLK @ 4 MHz.

Ex 2 : When the 4 MHz IRC wakes-up from Sleep mode to Green mode,
 its total wake-up time is 100 μs + 32 CLK @ 16kHz.

Bits 3 ~ 0: Not used, set to "0" at all time.

6.1.11 Bank 0 RF (Interrupt Status Register 1)

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

Note: “ 1 ” means with interrupt request “ 0 ” means no interrupt occurs

Bit 7: Not used, set to “0” at all time

Bit 6 (ADIF): Interrupt flag for analog to digital conversion.

Set when AD conversion is completed, reset by software.

Bits 5 ~ 3: Not used, set to “0” at all time

Bit 2 (EXIF): External interrupt flag. Set by a falling edge on the /INT pin, reset by software.

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

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

NOTE

- RF can be cleared by instruction but cannot be set.
- IOCF is an interrupt mask register.
- The result of reading RF is the "logic AND" of RF and IOCF.

6.1.12 R10 ~ R3F

All of these are 8-bit general-purpose registers.

6.1.13 Bank 1 R5~R7

These are reserved registers.

6.1.14 Bank 1 R8 (IRC Select Register)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| RCM1 | RCM0 | - | - | - | - | - | - |

Bits 7 ~ 6 (RCM1 ~ RCM0): IRC mode select bits. Bank 1 R8<7,6> will be enabled when Word 1<12> COBS0 = "1".

| Writer Trim IRC | Bank 1 R8<7,6> | | Frequency | Operating Voltage Range | Stable Time |
|-----------------|----------------|------|---------------|-------------------------|-------------|
| | RCM1 | RCM0 | | | |
| 4 MHz | 0 | 0 | 4 MHz ± 2.5% | 2.2V ~ 5.5V | < 5 μs |
| | 0 | 1 | 16 MHz ± 10% | 4.5V ~ 5.5V | < 1.5 μs |
| | 1 | 0 | 8 MHz ± 10% | 3.0V ~ 5.5V | < 3 μs |
| | 1 | 1 | x | - | - |
| 16 MHz | 0 | 0 | 4 MHz ± 10% | 2.2V ~ 5.5V | < 6 μs |
| | 0 | 1 | 16 MHz ± 2.5% | 4.5V ~ 5.5V | < 1.25 μs |
| | 1 | 0 | 8 MHz ± 10% | 3.0V ~ 5.5V | < 3 μs |
| | 1 | 1 | x | - | - |
| 8 MHz | 0 | 0 | 4 MHz ± 10% | 2.2V ~ 5.5V | < 6 μs |
| | 0 | 1 | 16 MHz ± 10% | 4.5V ~ 5.5V | < 1.5 μs |
| | 1 | 0 | 8 MHz ± 2.5% | 3.0V ~ 5.5V | < 2.5 μs |
| | 1 | 1 | x | - | - |

NOTE

- The initial values of Bank1 R8<7,6> will be kept the same as Word 1<3,2>.
- If user changes the IRC frequency from A-frequency to B-frequency, the MCU needs to wait for some time for it to work. The waiting time corresponds to the B-frequency.

For Example:

1st step When user selects the 4 MHz at the Writer, the initial values of Bank 1 R8<7,6> would be "00", the same as the value of Word 1<3,2> is "00". If the MCU is free-running, it will work at 4 MHz ± 2.5%. Refer to the table below.

| Writer Trim IRC | Bank 1 R8<7,6> | | Frequency | Operating Voltage Range | Stable Time |
|-----------------|----------------|------|--------------|-------------------------|-------------|
| | RCM1 | RCM0 | | | |
| 4 MHz | 0 | 0 | 4 MHz ± 2.5% | 2.2V ~ 5.5V | < 5 μs |
| | 0 | 1 | 16 MHz ± 10% | 4.5V ~ 5.5V | < 1.5 μs |
| | 1 | 0 | 8 MHz ± 10% | 3.0V ~ 5.5V | < 3 μs |
| | 1 | 1 | x | - | - |

2nd step If it is desired to set Bank 1 R8<7,6> = "01" while the MCU is working at 4 MHz \pm 2.5%, the MCU needs to hold for 1.5 μ s, then it will continue to work at 16 MHz \pm 10%.

| Writer Trim IRC | Bank 1 R8<7,6> | | Frequency | Operating Voltage Range | Stable Time |
|-----------------|----------------|----------|------------------------------------|-------------------------|---------------|
| | RCM1 | RCM0 | | | |
| 4 MHz | 0 | 0 | 4 MHz \pm 2.5% | 2.2V ~ 5.5V | < 5 μ s |
| | 0 | 1 | 16 MHz \pm 10% | 4.5V ~ 5.5V | < 1.5 μ s |
| | 1 | 0 | 8 MHz \pm 10% | 3.0V ~ 5.5V | < 3 μ s |
| | 1 | 1 | x | - | - |

3rd step If it is desired to set Bank 1 R8<7,6> = "10" while the MCU is working at 16 MHz \pm 10%, the MCU needs to hold for 3 μ s, then it will continue to work at 8 MHz \pm 10%.

| Writer Trim IRC | Bank 1 R8<7,6> | | Frequency | Operating Voltage Range | Stable Time |
|-----------------|----------------|----------|-----------------------------------|-------------------------|---------------|
| | RCM1 | RCM0 | | | |
| 4 MHz | 0 | 0 | 4 MHz \pm 2.5% | 2.2V ~ 5.5V | < 5 μ s |
| | 0 | 1 | 16 MHz \pm 10% | 4.5V ~ 5.5V | < 1.5 μ s |
| | 1 | 0 | 8 MHz \pm 10% | 3.0V ~ 5.5V | < 3 μ s |
| | 1 | 1 | x | - | - |

4th step If it is desired to set Bank 1 R8<7,6> = "00" while the MCU is working at 8 MHz \pm 10%, the MCU needs to hold for 5 μ s, then it will continue to work at 4 MHz \pm 2.5%.

| Writer Trim IRC | Bank 1 R8<7,6> | | Frequency | Operating Voltage Range | Stable Time |
|-----------------|----------------|----------|------------------------------------|-------------------------|---------------|
| | RCM1 | RCM0 | | | |
| 4 MHz | 0 | 0 | 4 MHz \pm 2.5% | 2.2V ~ 5.5V | < 5 μ s |
| | 0 | 1 | 16 MHz \pm 10% | 4.5V ~ 5.5V | < 1.5 μ s |
| | 1 | 0 | 8 MHz \pm 10% | 3.0V ~ 5.5V | < 3 μ s |
| | 1 | 1 | x | - | - |

6.1.15 Bank 1 R9~RE

These are reserved registers.

6.1.16 Bank 1 RF (Interrupt Status Register 2)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|--------|-------|-------|-------|-------|-------|-------|-------|
| CMP2IF | - | TC3IF | - | - | - | - | - |

Bit 7 (CMP2IF): Comparator 2 Interrupt Flag. Set when a change occurs in the Comparator 2 output, reset by software.

Bit 6: Not used, set to "0" at all time.

Bit 5 (TC3IF): 8-bit Timer/Counter 3 Interrupt Flag.

Bits 4 ~ 0: Not used, set to "0" at all time.

NOTE

The Interrupt flag is automatically set by hardware. It must be cleared by software.

6.1.17 Bank 2 R5 AISR (ADC Input Select Register)

The AISR register individually defines the Port 6 pins as analog input or digital I/O.

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| - | - | ADE5 | ADE4 | ADE3 | ADE2 | ADE1 | ADE0 |

Bits 7 ~ 6: Not used, set to "0" at all time.

Bit 5 (ADE5): AD converter enable bit of P65 pin

0 : Disable ADC5, P65 functions as I/O pin.

1 : Enable ADC5 to function as analog input pin.

Bit 4 (ADE4): AD converter enable bit of P64 pin

0 : Disable ADC4, P64 act as I/O pin.

1 : Enable ADC4 to act as analog input pin.

Bit 3 (ADE3): AD converter enable bit of P63 pin.

0 : Disable ADC3, P63 act as I/O pin.

1 : Enable ADC3 to act as analog input pin.

Bit 2 (ADE2): AD converter enable bit of P62 pin.

0 : Disable ADC2, P62 act as I/O pin.

1 : Enable ADC2 to act as analog input pin.

Bit 1 (ADE1): AD converter enable bit of P61 pin

0 : Disable ADC1, P61 act as I/O pin

1 : Enable ADC1 to act as analog input pin

Bit 0 (ADE0): AD converter enable bit of P60 pin

0 : Disable ADC0, P60 act as I/O pin.

1 : Enable ADC0 to act as analog input pin.

The following table shows the priority of P60/ADC0//INT.

| P60 / ADC0 // INT Pin Priority | | |
|--------------------------------|--------|-----|
| High | Medium | Low |
| /INT | ADC0 | P60 |

6.1.18 Bank 2 R6 ADCON (A/D Control Register)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| VREFS | CKR1 | CKR0 | ADRUN | ADPD | ADIS2 | ADIS1 | ADIS0 |

Bit 7 (VREFS): Input source of the Vref of the ADC.

0 : Vref of the ADC is connected to Vdd (default value), and the P50/VREF pin carries out the function of P50

1 : Vref of the ADC is connected to P50/VREF

Bit 6 ~ Bit 5 (CKR1 ~ CKR0): Prescaler of ADC oscillator clock rate

00 = 1: 4 (default value)

01 = 1: 1

10 = 1: 16

11 = 1: 2

| CKR1/CKR0 | Operation Mode | Max. Operation Frequency |
|-----------|----------------|--------------------------|
| 00 | $F_{osc}/4$ | 4 MHz |
| 01 | F_{osc} | 1 MHz |
| 10 | $F_{osc}/16$ | 16 MHz |
| 11 | $F_{osc}/2$ | 2 MHz |

Bit 4 (ADRUN): ADC starts to run

0 : reset on completion of AD conversion. This bit cannot be reset by software.

1 : A/D conversion is started. This bit can be set by software.

Bit 3 (ADPD): ADC Power-down mode

0 : switch off the resistor reference to save power even while the CPU is operating.

1 : ADC is operating.

Bits 2 ~ 0 (ADIS2~ADIS0): Analog Input Select

000 = AN0/P60

001 = AN1/P61

010 = AN2/P62

011 = AN3/P63

100 = AN4/P64

101 = AN5/P65

110 = x

111 = x

The following table shows the priority of P50/VREF pin. They can only be changed when the ADIF bit and the ADRUN bit are both low.

| P50/VREF Pin Priority | |
|-----------------------|-----|
| High | Low |
| VREF | P50 |

6.1.19 Bank 2 R7

These are reserved registers.

6.1.20 Bank 2 R8 ADDH (AD High 8-Bit Data Buffer)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| AD9 | AD8 | AD7 | AD6 | AD5 | AD4 | AD3 | AD2 |

When A/D conversion is completed, the result of high 8-bit is loaded into the ADDH. The ADRUN bit is cleared, and the ADIF is set. R8 is read only.

6.1.21 Bank 2 R9 ADDL (AD Low 2-Bit Data Buffer)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| - | - | - | - | - | - | AD1 | AD0 |

Bits 7 ~ 2: Unimplemented, read as '0'

Bits 1 ~ 0 (AD1~AD0): AD low 2-bit data buffer. R9 is read only.

6.1.22 Bank 2 RA~RF

These are reserved registers.

6.1.23 Bank 3 R5

These are reserved registers.

6.1.24 Bank 3 R6 (TBHP : Table Point Register for Instruction TBRD)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| MLB | - | - | - | - | - | RBit9 | RBit8 |

Bit 7 (MLB): Choosing MSB or LSB machine code to be moved to the register.

The machine code is pointed by TBLP and TBHP register.

Bits 6 ~ 2: Not used, set to "0" at all time.

Bits 1 ~ 0: These are the most two significant bits of address for program code.

6.1.25 Bank 3 R7 (CMPCON: Comparator 2 Control Register)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|--------|-------|-------|-------|-------|
| - | - | - | CPOUT2 | COS21 | COS20 | - | - |

Bit 7 ~ Bit 5: Not used, set to "0" at all time.

Bit 4 (CPOUT2): The result of Comparator 2 output.

Bit 3 ~ Bit 2 (COS21: COS20): Comparator 2 Select bits.

| COS21 | COS20 | Function Description |
|-------|-------|---|
| 0 | 0 | Comparator 2 is not used, P80 act as normal I/O pin |
| 0 | 1 | Act as a Comparator 2 and P80 act as normal I/O pin |
| 1 | 0 | Act as a Comparator 2 and P80 act as Comparator 2 output pin (CO) |
| 1 | 1 | Not used |

Bit 1 ~ Bit 0: Not used, set to “0” at all time.

6.1.26 Bank 3 R8 ~ RC

These are reserved registers.

6.1.27 Bank 3 RD TC3CR (Timer 3 Control)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|--------|--------|-------|--------|--------|--------|-------|-------|
| TC3FF1 | TC3FF0 | TC3S | TC3CK2 | TC3CK1 | TC3CK0 | TC3M1 | TC3M0 |

Bits 7 ~ 6 (TC3FF1 ~ TC3FF0): Timer/Counter 3 flip-flop control

| TC3FF1 | TC3FF0 | Operating Mode |
|--------|--------|----------------|
| 0 | 0 | Clear |
| 0 | 1 | Toggle |
| 1 | 0 | Set |
| 1 | 1 | Reserved |

Bit 5 (TC3S): Timer/Counter 3 start control

0 : Stop and clear the counter

1 : Start

Bits 4 ~ 2 (TC3CK2 ~ TC3CK0): Timer/Counter 3 clock source select

| TC3CK2 | TC3CK1 | TC3CK0 | Clock Source | Resolution | Max. Time | Resolution | Max. Time |
|--------|--------|--------|--------------------------|-------------|----------------|--------------|-----------|
| | | | Normal, Idle | Fc=4M | Fc=4M | Fc=16K | Fc=16K |
| 0 | 0 | 0 | $Fc/2^{11}$ | 512 μ s | 131072 μ s | 128 ms | 32768 ms |
| 0 | 0 | 1 | $Fc/2^7$ | 32 μ s | 8192 μ s | 8 ms | 2048 ms |
| 0 | 1 | 0 | $Fc/2^5$ | 8 μ s | 2048 μ s | 2 ms | 512 ms |
| 0 | 1 | 1 | $Fc/2^3$ | 2 μ s | 512 μ s | 500 μ s | 128 ms |
| 1 | 0 | 0 | $Fc/2^2$ | 1 μ s | 256 μ s | 250 μ s | 64 ms |
| 1 | 0 | 1 | $Fc/2^1$ | 500 ns | 128 μ s | 125 μ s | 32 ms |
| 1 | 1 | 0 | Fc | 250 ns | 64 μ s | 62.5 μ s | 16 ms |
| 1 | 1 | 1 | External clock (TC3 pin) | - | - | - | - |

Bits 1 ~ 0 (TC3M1 ~ TC3M0): Timer/Counter 3 operating mode select

| TC3M1 | TC3M0 | Operating Mode |
|-------|-------|-------------------------------|
| 0 | 0 | Timer/Counter |
| 0 | 1 | Reserved |
| 1 | 0 | Programmable Divider Output |
| 1 | 1 | Pulse Width Modulation Output |

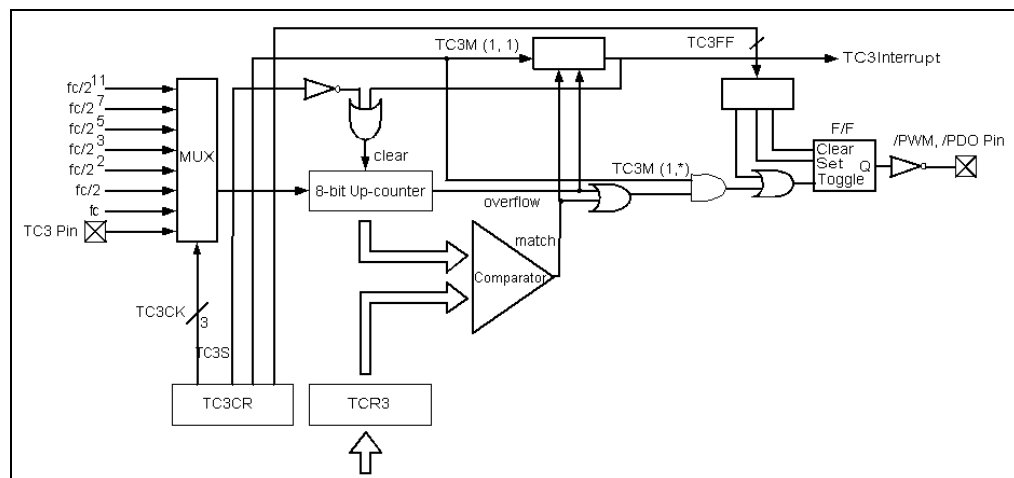


Figure 6-3 Timer / Counter 3 Configuration

In Timer mode, counting up is performed using the internal clock (rising edge trigger). When the contents of the up-counter match the TCR3, then interrupt is generated and the counter is cleared. Counting up resumes after the counter is cleared.

In Counter mode, counting up is performed using the external clock input pin (TC3 pin). When the contents of the up-counter match the TCR3, then interrupt is generated and the counter is cleared. Counting up resumes after the counter is cleared.

In Programmable Divider Output (PDO) mode, counting up is performed using the internal clock. The contents of TCR3 are compared with the contents of the up-counter. The F/F output is toggled and the counter is cleared each time a match is found. The F/F output is inverted and output to /PDO pin. This mode can generate 50% duty pulse output. **The F/F can be initialized by the program and it is initialized to “0” during reset.** A TC3 interrupt is generated each time the /PDO output is toggled.

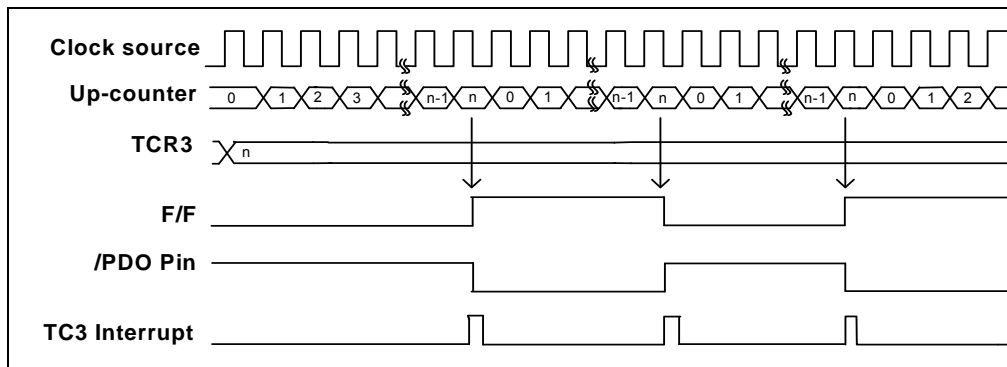


Figure 6-4 PDO Mode Timing Chart

In Pulse Width Modulation (PWM) Output Mode, counting up is performed using the internal clock. The contents of TCR3 are compared with the contents of the up-counter. The F/F is toggled when a match is found. The counter continues counting, the F/F is toggled again when the counter overflows, after which the counter is cleared. The F/F output is inverted and output to /PWM pin. A TC3 interrupt is generated each time an overflow occurs. **TCR3 is configured as a 2-stage shift register and, during output, will not switch until one output cycle is completed even if TCR3 is overwritten.** Therefore, the output can be changed continuously. Also, the first time, TCR3 is shifted by setting TC3S to “1” after data is loaded to TCR3.

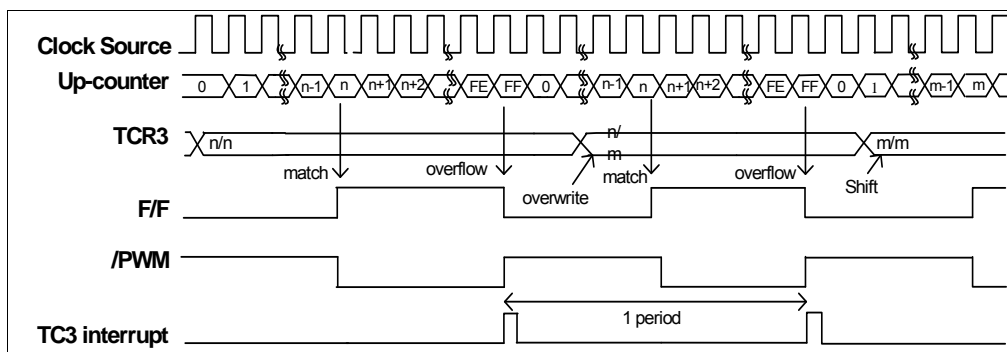


Figure 6-5 PWM Mode Timing Chart

6.1.28 Bank 3 RE TC3D (Timer 3 Data Buffer)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| TC3D7 | TC3D6 | TC3D5 | TC3D4 | TC3D3 | TC3D2 | TC3D1 | TC3D0 |

Bits 7 ~ 0 (TC3D7 ~ TC3D0): Data Buffer of 8-bit Timer/Counter 3.

6.1.29 Bank 3 RF

These are reserved registers.

6.2 Special Function Registers

6.2.1 A (Accumulator)

Internal data transfer operation, or instruction operand holding usually involves the temporary storage function of the Accumulator. The Accumulator is not an addressable register.

6.2.2 CONT (Control Register)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| INTE | /INT | - | - | PSTE | PST2 | PST1 | PST0 |

Bit 7 (INTE): INT signal edge

0 : interrupt occurs at a rising edge of the INT pin

1 : interrupt occurs at a falling edge of the INT pin

Bit 6 (/INT): Interrupt enable flag

0 : masked by DISI or hardware interrupt

1 : enabled by ENI/RETI instructions

Bits 5 ~ 4: Not used, set to "0" at all time

Bit 3 (PSTE): Prescaler enable bit for TCC

0 : prescaler disable bit, TCC rate is 1:1

1 : prescaler enable bit, TCC rate is set at Bit 2~Bit 0.

Bit 2 ~ Bit 0 (PST 2 ~ PST0): TCC prescaler bits

| PST2 | PST1 | PST0 | 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 |

The CONT register is both readable and writable.

6.2.3 IOC5 ~ IOC6, IOC8 (I/O Port Control Register)

A value of "1" sets the relative I/O pin into high impedance, while "0" defines the relative I/O pin as output.

IOC5 ~ IOC6, IOC8 registers are both readable and writable.

6.2.4 IOC7, IOC9

Reserved registers

6.2.5 IOCA (WDT Control Register)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| WDTE | EIS | - | - | 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 used to define the function of P60 (/INT) pin

0 : P60, bidirectional 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 the /INT pin can also be read by way of reading Port 6 (R6).

The EIS is both readable and writable.

Bits 5 ~ 4: Not used, set to "0" at all time.

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 at Bit 0~Bit 2

Bit 2 ~ Bit 0 (PSW2 ~ 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 |

6.2.6 IOCB (Pull-down Control Register 2)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| /PD63 | /PD62 | /PD61 | /PD60 | - | - | - | /PD50 |

Bit 7 (/PD63): Control bit used to enable pull-down of the P63 pin.

- 0 : Enable internal pull-down
- 1 : Disable internal pull-down

Bit 6 (/PD62): Control bit used to enable pull-down of the P62 pin.

Bit 5 (/PD61): Control bit used to enable pull-down of the P61 pin.

Bit 4 (/PD60): Control bit used to enable pull-down of the P60 pin.

Bits 3 ~ 1: Not used, set to "0" at all time.

Bit 0 (/PD50): Control bit used to enable pull-down of the P50 pin.

The IOCB Register is both readable and writable.

6.2.7 IOCC (Open-drain Control Register)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| - | - | OD65 | OD64 | OD63 | OD62 | OD61 | OD60 |

Bits 7 ~ 6: Not used, set to "0" at all time.

Bit 5 (OD65): Control bit used to enable open-drain output of the P65 pin

- 0 : Disable open-drain output
- 1 : Enable open-drain output

Bit 4 (OD64): Control bit used to enable open-drain output of the P64 pin

Bit 3 (OD63): Control bit used to enable open-drain output of the P63 pin

Bit 2 (OD62): Control bit used to enable open-drain output of the P62 pin

Bit 1 (OD61): Control bit used to enable open-drain output of the P61 pin

Bit 0 (OD60): Control bit used to enable open-drain output of the P60 pin

The IOCC Register is both readable and writable.

6.2.8 IOCD (Pull-high Control Register 2)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| - | - | /PH65 | /PH64 | /PH63 | /PH62 | /PH61 | /PH60 |

Bits 7 ~ 6: Not used, set to “0” at all time.

Bit 5 (/PH65): Control bit used to enable pull-high of the P65 pin.

- 0 : Enable internal pull-high
- 1 : Disable internal pull-high

Bit 4 (/PH64): Control bit used to enable pull-high of the P64 pin.

Bit 3 (/PH63): Control bit used to enable pull-high of the P63 pin.

Bit 2 (/PH62): Control bit used to enable pull-high of the P62 pin.

Bit 1 (/PH61): Control bit used to enable pull-high of the P61 pin.

Bit 0 (/PH60): Control bit used to enable pull-high of the P60 pin.

The IOCD Register is both readable and writable.

6.2.9 IOCE (Interrupt Mask Register 2)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|--------|-------|-------|-------|-------|-------|-------|-------|
| CMP2IE | - | TC3IE | - | - | - | - | - |

Bit 7 (CMP2IE): CMP2IF interrupt enable bit.

- 0 : Disable CMP2IF interrupt
- 1 : Enable CMP2IF interrupt

When the Comparator 2 output status changed is used to enter an interrupt vector or enter the next instruction, the CMP2IE bit must be set to “Enable”.

Bit 6: Not used, set to “0” at all time

Bit 5 (TC3IE): Interrupt enable bit

- 0 : Disable TC3IF interrupt
- 1 : Enable TC3IF interrupt

Bits 4 ~ 0: Not used, set to “0” at all time

NOTE

- User must set to “0” Bit 6 of the IOCE register.
- The IOCE register is both readable and writable.

6.2.10 IOCF (Interrupt Mask Register 1)

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

Bit 7: Not used, set to “0” at all time

Bit 6 (ADIE): ADIF interrupt enable bit
0 : Disable ADIF interrupt
1 : Enable ADIF interrupt

When ADC complete status is used to enter an interrupt vector or enter the next instruction, the ADIE bit must be set to “Enable”.

Bits 5 ~ 3: Not used, set to “0” at all time

Bit 2 (EXIE): EXIF interrupt enable bit
0 : Disable EXIF interrupt
1 : Enable EXIF interrupt

Bit 1 (ICIE): ICIF interrupt enable bit
0 : Disable ICIF interrupt
1 : Enable ICIF interrupt

Bit 0 (TCIE): TCIF interrupt enable bit
0 : Disable TCIF interrupt
1 : Enable TCIF interrupt

NOTE

- User must set to “0” Bit 7 of the IOCF register.
- 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.
- The IOCF register is both readable and writable.

6.3 TCC/WDT and Prescaler

There are two 8-bit counters available as prescalers for the TCC and WDT respectively. The PST2~PST0 bits of the CONT register are used to determine the ratio of the prescaler of TCC. Likewise, the PSW2~PSW0 bits of the IOCA register are used to determine the WDT prescaler. The prescaler counter will be cleared by the instructions each time they are written into TCC. The WDT and prescaler will be cleared by the “WDTTC” and “SLEP” instructions. Figure 6-6-1 depicts the EM78F561N circuit diagram of TCC/WDT.

R1 (TCC) is an 8-bit timer. The TCC clock source can be an internal clock only. The TCC signal source is from an internal clock, TCC will be incremented by 1 at Fc clock (without prescaler). **The TCC will stop running when sleep mode occurs.**

The watchdog timer is a free running on-chip RC oscillator. The WDT will keep on running even after 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 the WDTE bit of the IOCA register. With no prescaler, the WDT time-out period is approximately 18 ms¹ (one oscillator start-up timer period).

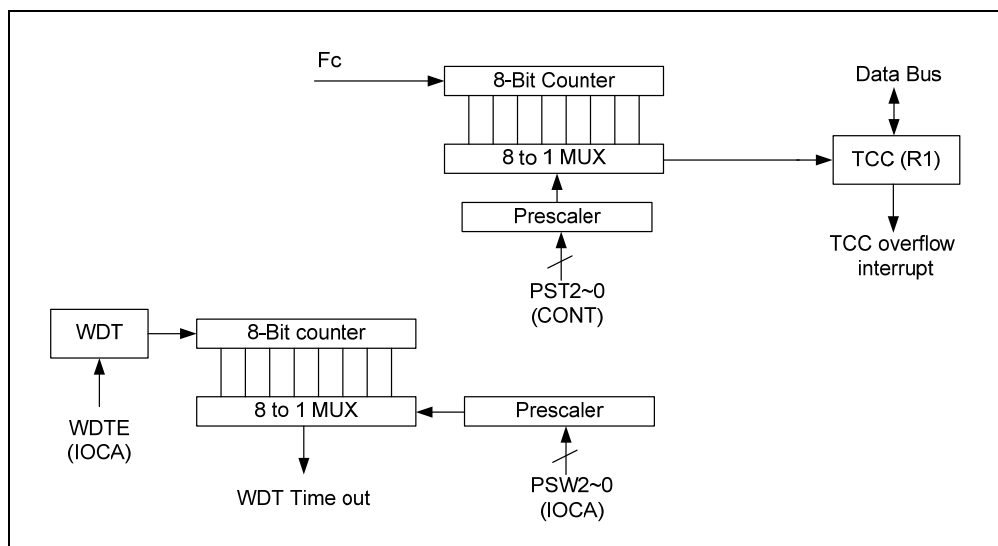


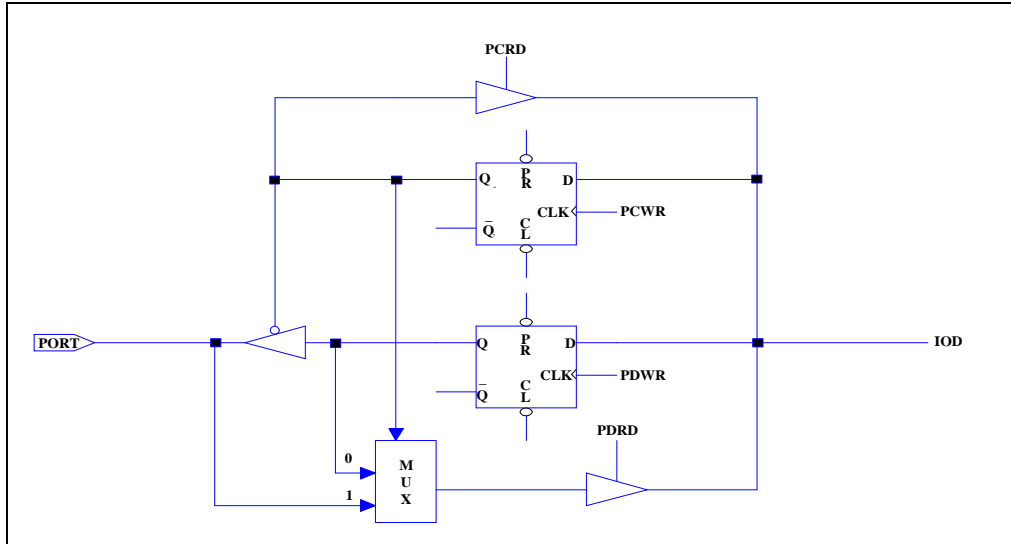
Figure 6-6-1 Block Diagram of TCC and WDT for EM78F561N

6.4 I/O Ports

The I/O registers, Ports 5, 6 and 8, are bidirectional tri-state I/O ports. Port 6 can be pulled-high internally by software. In addition, Port 6 can also have open-drain output by software. Input status change interrupt (or wake-up) function on Port 6, P50, 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, IOC8).

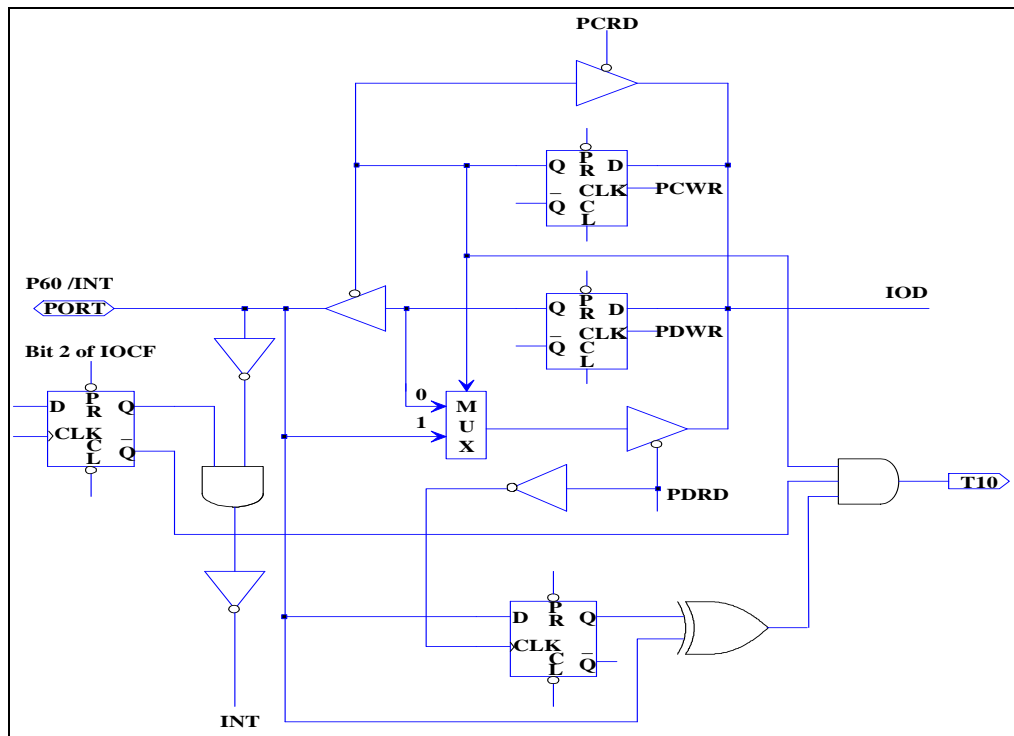
The I/O registers and I/O control registers are both readable and writable. The I/O interface circuits for Ports 5 ~ 6, and Port 8 are shown in the following Figures 6-7, 6-8 (a), 6-8 (b), and Figure 6-9.

¹ **Note:** VDD=5V, WDT time-out period = 16ms ± 7.5%
VDD=3V, WDT time-out period = 18ms ± 7.5%.



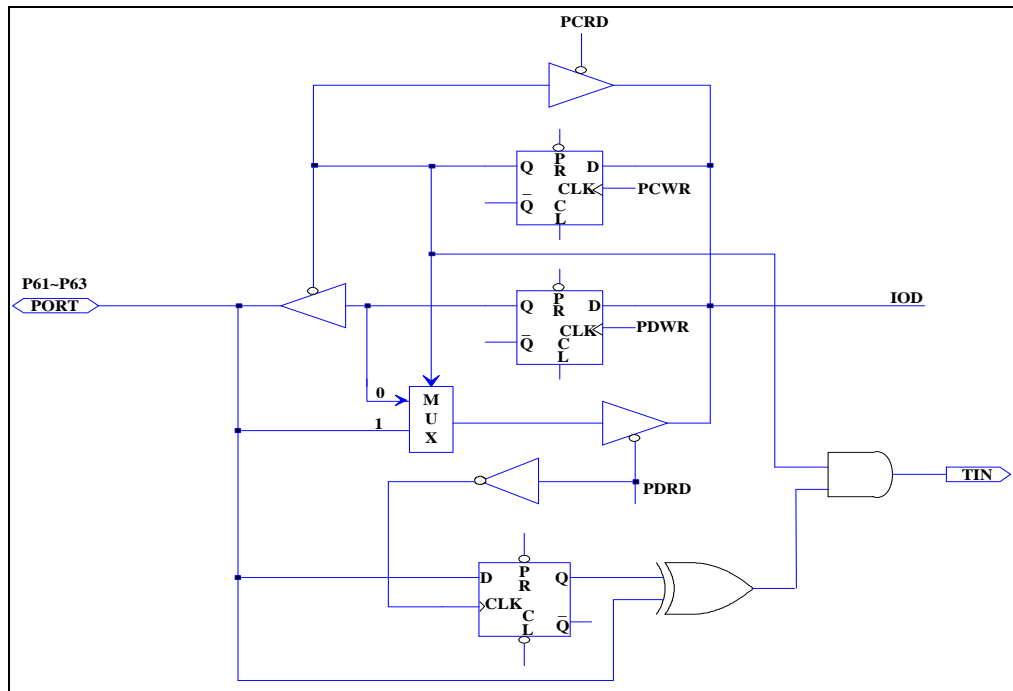
Note: Pull-down is not shown in the figure.

Figure 6-7 I/O Port and I/O Control Register Circuit for Ports 5 ~ 6, Port 8



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

Figure 6-8 (a) I/O Port and I/O Control Register Circuit for P60 (/INT)



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

Figure 6-8 (b) I/O Port and I/O Control Register Circuit for P61~P65

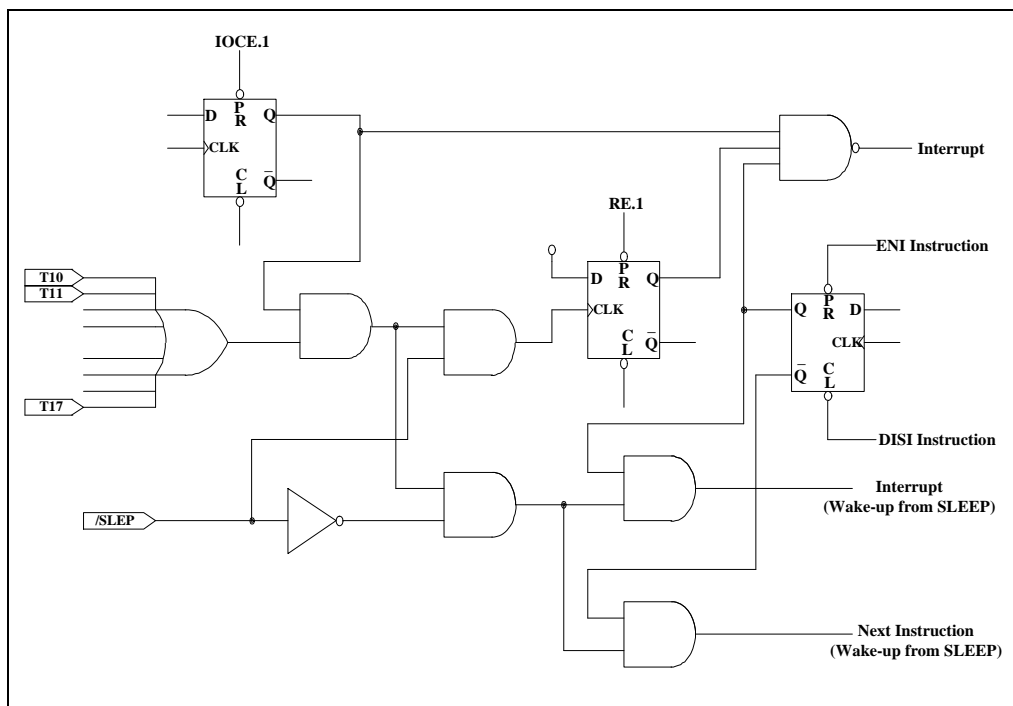


Figure 6-9 Block Diagram of I/O Port 6 with Input Change Interrupt/Wake-up

Table 6.4-1 Usage of Port 6 Input Change Wake-up/Interrupt Function

| Usage of Port 6 Input Status Changed Wake-up/Interrupt | |
|--|--|
| (I) Wake-up from Port 6 Input Status Change (a) Before Sleep 1. Disable WDT ² (use this very carefully) 2. Read I/O Port 6 (MOV R6,R6) 3 a. Enable interrupt (Set IOCF.1), after wake-up if "ENI" switch to interrupt Vector (006H), if "DISI" excute next instruction 3 b. Disable interrupt (Set IOCF.1), always execute next instruction 4. Enable wake-up enable bit (Set RA.6) 5. Execute "SLEP" instruction (b) After Wake-up 1. IF "ENI" → Interrupt Vector (006H) 2. IF "DISI" → Next instruction | (II) Port 6 Input Status Change Interrupt 1. Read I/O Port 6 (MOV R6,R6) 2. Execute "ENI" 3. Enable interrupt (Set IOCF.1) 4. IF Port 6 change (interrupt) → Interrupt Vector (006H) |

6.5 Reset and Wake-up

6.5.1 Reset

A reset is initiated by one of the following events:

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

The device is kept in a reset condition for a period of approximately 18 ms³ (one oscillator start-up timer period) after a reset is detected.

- 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).
- The Watchdog timer and prescaler are cleared.
- When power is switched on, the upper three bits of R3 are cleared.

Note: ² The Software disables the WDT (Watchdog Timer) but the hardware must be enabled before applying Port 6 Change wake-up function. (Code Option Register and Bit 6 (ENWDTB) are set to "1").

³ Vdd = 5V, set up time period = 16ms ± 7.5%
 Vdd = 3V, set up time period = 18ms ± 7.5%

- The bits of the RB, RC, RD registers are set to their previous status.
- The bits of the CONT register are set to all "0".
- The bits of the IOCA register are set to all "0".
- The bits of the IOCB register are set to all "1".
- The bits of the IOCC register are set to all "0".
- The bits of the IOCD register are set to all "1".
- The bits of the IOCE register are set to all "0".
- The bits of the IOCF register are set to all "0".

Sleep (power down) mode is asserted by executing the "SLEP" instruction. While entering sleep mode, the WDT (if enabled) is cleared but keeps on running. After a wake-up, in RC mode the wake-up time is 10 μ s. High crystal mode wake-up time is 800 μ s.

The controller can be awakened by:

- (1) External reset input on /RESET pin
- (2) WDT time-out (if enabled)
- (3) Port 6 input status changes (if enabled)
- (4) Comparator output status change (if CMPWE is enabled)
- (5) A/D conversion completed (if ADWE is enabled)
- (6) External (P60, /INT) pin changes (if EXWE is enabled)

The first two cases will cause the EM78F561N to reset. The T and P flags of R3 can be used to determine the source of the reset (wake-up). Cases 3, 4, 5, 6 are considered the continuation of program execution and the global interrupt ("ENI" or "DISI" being executed) determines whether or not the controller branches to the interrupt vector following a wake-up. If ENI is executed before SLEP, the instruction will begin to execute from the Address 0x6, 0x15, 0x30, 0x3 after wake-up. If DISI is executed before SLEP, the execution will restart from the instruction right next to SLEP after wake-up. After a wake-up, in RC mode the wake-up time is 10 μ s. High crystal mode wake-up time is 800 μ s.

One or more of Cases 2 to 6 can be enabled before entering into sleep mode. That is,

- [a] If WDT is enabled before SLEP, all of the RE bit is disabled. Hence, the EM78F561N can be awakened only by Case 1 or 2. Refer to the Interrupt section for further details.
- [b] If Port 6 Input Status Change is used to wake-up EM78F561N and ICWE bit of RA register is enabled before SLEP, WDT must be disabled. Hence, the EM78F561N can be waken-up only by Case 3.

- [c] If Comparator 2 output status change is used to wake-up EM78F561N and CMPWE bit of RA register is enabled before SLEP, WDT must be disabled by software. Hence, the EM78F561N can be waken-up only by Case 4.
- [d] If AD conversion completed is used to wake-up EM78F561N and ADWE bit of RA register is enabled before SLEP, WDT must be disabled by software. Hence, the EM78F561N can be waken-up only by Case 5.
- [e] If External (P60,/INT) pin change is used to wake-up EM78F561N and EXWE bit of RA register is enabled before SLEP, WDT must be disabled. Hence, the EM78F561N can be waken-up only by Case 6.

If Port 6 Input Status Change Interrupt is used to wake-up the EM78F561N, (as in Case [b] above), the following instructions must be executed before SLEP:

```

MOV          A, @0xxx1000b ; Select WDT prescaler and
                                ; Disable the WDT
IOW          IOCA
WDTC
MOV          R6, R6          ; Clear WDT and prescaler
                                ; Read Port 6
ENI (or DISI)          ; Enable (or disable) global
                                ; interrupt
BC          R4, 7          ; Select Bank0
BC          R4, 6
MOV          A, @0100xxxxb ; Enable Port 6 input change
                                ; wake-up bit
MOV          RA,A
MOV          A, @xxxxxx1xb ; Enable Port 6 input change
                                ; interrupt
IOW          IOCF
SLEP

```

Similarly, if the Comparator 2 Interrupt is used to wake up the EM78F561N (as in Case [c] above), the following instructions must be executed before SLEP:

```

BS          R4, 7          ; Select Bank 3
BS          R4, 6
MOV          A, @xxxx10xxb ; Select a comparator and P80 act
                                ; as CO pin
MOV          R7,A
MOV          A, @0xxx1000b ; Select WDT prescaler and
                                ; Disable the WDT
IOW          IOCA
WDTC
                                ; Clear WDT and prescaler
ENI (or DISI)          ; Enable (or disable) global
                                ; interrupt
BC          R4, 7          ; Select Bank 0
BC          R4, 6
MOV          A, @1000xxxxb ; Enable comparator output status
                                ; change wake-up bit
MOV          RA,A
MOV          A, @10000000b ; Enable comparator output status
                                ; change interrupt
IOW          IOCE
SLEP

```

All kinds of wake-up mode and interrupt mode are shown below:

| Wake-up Signal | Sleep Mode | Idle Mode | Green Mode | Normal Mode |
|--|--|--|--|---|
| External interrupt | If EXWE bit is enabled: Wake-up+ interrupt (if interrupt is enabled)+ next instruction | If EXWE bit is enabled: Wake-up+ interrupt (if interrupt is enabled)+ next instruction | Interrupt (if interrupt is enabled) or next instruction | Interrupt (if interrupt is enabled) or next instruction |
| Port 6 pin change | If ICWE bit is enabled: Wake-up+ interrupt (if interrupt is enabled)+ next instruction | If ICWE bit is enabled: Wake-up+ interrupt (if interrupt is enabled)+ next instruction | Interrupt (if interrupt is enabled) or next instruction | Interrupt (if interrupt is enabled) or next instruction |
| TCC overflow interrupt | × | Wake-up+ interrupt (if interrupt is enabled)+ next instruction | Interrupt (if interrupt is enabled) or next instruction | Interrupt (if interrupt is enabled) or next instruction |
| Comparator 2 (Comparator Output Status Change) | If CMPWE bit is enabled: Wake-up + interrupt (if interrupt is enabled)+ next instruction | If CMPWE bit is enabled: Wake-up + interrupt (if interrupt is enabled)+ next instruction | Interrupt (if interrupt is enabled) or next instruction | Interrupt (if interrupt is enabled) or next instruction |
| TC3 interrupt | × | Wake-up+ interrupt (if interrupt is enabled)+ next instruction | Interrupt (if interrupt is enabled) or next instruction | Interrupt (if interrupt is enabled) or next instruction |
| AD Conversion Complete Interrupt | If ADWE bit is enabled: Wake-up + interrupt (if interrupt is enabled)+ next instruction Fm and Fs don't stop | If ADWE bit is enabled: Wake-up + interrupt (if interrupt is enabled)+ next instruction Fm and Fs don't stop | interrupt (if interrupt is enabled)+ next instruction Fm and Fs don't stop | Interrupt (if interrupt is enabled) or next instruction |
| WDT Time out | RESET | RESET | RESET | RESET |
| Low Voltage Reset | RESET | RESET | RESET | RESET |

After wake up:

1. If interrupt is enabled → interrupt + next instruction
2. If interrupt is disabled → next instruction

Table 6.5-1 Summary of Registers Initialized Values

| 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 | C57 | - | C55 | C54 | - | - | - | C50 |
| | | 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 | IOC6 | Bit Name | - | - | 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 | IOC8 | Bit Name | - | - | - | - | C83 | C82 | C81 | C80 |
| | | 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 | INTE | INT | - | - | PSTE | PST2 | PST1 | PST0 |
| | | 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 |
| 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 | Jump to interrupt vector address or continue to execute next instruction | | | | | | | |

| Address | Name | Reset Type | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|---------|----------------|-------------------------|--------|--------|-------|-------|-------|-------|-------|-------|
| 0x03 | R3 (SR) | Bit Name | - | - | - | T | P | Z | DC | C |
| | | Power-on | 0 | 0 | 0 | 1 | 1 | U | U | U |
| | | /RESET and WDT | 0 | 0 | 0 | t | t | P | P | P |
| | | Wake-up from Pin Change | P | P | P | t | t | P | P | P |
| 0x04 | R4 (RSR) | Bit Name | Bank 1 | Bank 0 | - | - | - | - | - | - |
| | | 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 |
| 0x05 | P5 (Bank 0) | Bit Name | P57 | - | P55 | P54 | - | - | - | P50 |
| | | 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 |
| 0x06 | P6 (Bank 0) | Bit Name | - | - | P65 | P64 | P63 | P62 | P61 | P60 |
| | | 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 |
| 0x08 | P8 (Bank 0) | Bit Name | - | - | - | - | P83 | P82 | P81 | P80 |
| | | 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 |
| 0x09 | R9 (Bank 0) | Bit Name | RBit7 | RBit6 | RBit5 | RBit4 | RBit3 | RBit2 | RBit1 | RBit0 |
| | | 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 |
| 0x0A | RA (Bank 0) | Bit Name | CMP2WE | ICWE | ADWE | EXWE | - | - | - | - |
| | | 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 |



| Address | Name | Reset Type | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|---------|----------------------|-------------------------|-------------|---------|-------|-------|-------|-------|-------|-------|
| 0x0E | RE (Bank 0) | Bit Name | - | TIMERSC | CPUS | IDLE | - | - | - | - |
| | | Power-on | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| | | /RESET and WDT | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| | | Wake-up from Pin Change | P | P | P | P | P | P | P | P |
| 0x0F | RF (ISR) (Bank 0) | Bit Name | - | ADIF | - | - | - | EXIF | ICIF | TCIF |
| | | 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 |
| 0x08 | R8 (Bank 1) | Bit Name | RCM1 | RCM0 | - | - | - | - | - | - |
| | | Power-on | Word 1<3,2> | | 0 | 0 | 0 | 0 | 0 | 0 |
| | | /RESET and WDT | Word 1<3,2> | | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Wake-up from Pin Change | P | P | P | P | P | P | P | P |
| 0x0F | RF (Bank 1) | Bit Name | CMP2IF | - | TC3IF | - | - | - | - | - |
| | | 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 |

| Addr | Name | Reset Type | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|------|----------------|-------------------------|---------|--------|--------|--------|--------|--------|--------|--------|
| 0x05 | R5 (Bank 2) | Bit Name | - | - | ADE5 | ADE4 | ADE3 | ADE2 | ADE1 | ADE0 |
| | | 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 |
| 0x06 | R6 (Bank 2) | Bit Name | VREFS | CKR1 | CKR0 | ADRUN | ADPD | ADIS2 | ADIS1 | ADIS0 |
| | | 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 |
| 0x08 | R8 (Bank 2) | Bit Name | AD9 | AD8 | AD7 | AD6 | AD5 | AD4 | AD3 | AD2 |
| | | 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 |
| 0x09 | R9 (Bank 2) | Bit Name | - | - | - | - | - | - | AD1 | AD0 |
| | | 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 |
| 0x06 | R6 (Bank 3) | Bit Name | MLB | - | - | - | - | - | RBit9 | RBit8 |
| | | 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 |
| 0x07 | R7 (Bank 3) | Bit Name | - | - | - | CPOUT2 | COS21 | COS20 | - | - |
| | | 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 | RD (Bank 3) | Bit Name | TC3FF1 | TC3FF0 | TC3S | TC3CK2 | TC3CK1 | TC3CK0 | TC3M1 | TC3M0 |
| | | 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 |
| 0x0E | RE (Bank 3) | Bit Name | TCR3 D7 | TCR3D6 | TCR3D5 | TCR3D4 | TCR3D3 | TCR3D2 | TCR3D1 | TCR3D0 |
| | | 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 |



| Address | Name | Reset Type | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|----------------|---------|-------------------------|--------|-------|-------|-------|-------|-------|-------|-------|
| 0x0A | IOCA | Bit Name | WDTE | EIS | - | - | PSWE | PSW2 | PSW1 | PSW0 |
| | | 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 |
| 0x0B | IOCB | Bit Name | /PD63 | /PD62 | /PD61 | /PD60 | - | - | - | /PD50 |
| | | 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 | - | - | OD65 | OD64 | OD63 | OD62 | OD61 | OD60 |
| | | 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 | - | - | /PH65 | /PH64 | /PH63 | /PH62 | /PH61 | /PH60 |
| | | 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 | CMP2IE | - | TC3IE | - | - | - | - | - |
| | | 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 |
| 0x0F | IOCF | Bit Name | - | ADIE | - | - | - | EXIE | ICIE | TCIE |
| | | 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 |
| 0x10 ~ 0x3F | R10~R3F | 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 |

Legend: "x" = not used

"P" = previous value before reset

"u" = unknown or don't care

"t" = check Table 6-5-2-1

6.5.2 Status of RST, T, and P of the Status Register

A reset condition is initiated by the following events:

1. Power-on condition
2. High-low-high pulse on /RESET pin
3. Watchdog timer time-out

The values of T and P, listed in Table 6-5-2-1 are used to check how the processor wakes up. Table 6-5-2-2 shows the events that may affect the status of T and P.

Table 6-5-2-1 Values of RST, T and P after Reset

| Reset Type | T | P |
|---|----|----|
| Power on | 1 | 1 |
| /RESET during operation mode | *P | *P |
| /RESET wake-up during Sleep mode | 1 | 0 |
| WDT during operation 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

Table 6-5-2-2 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 |
| SLEP instruction | 1 | 0 |
| Wake-up on pin change during Sleep mode | 1 | 0 |

* P: Previous status before reset

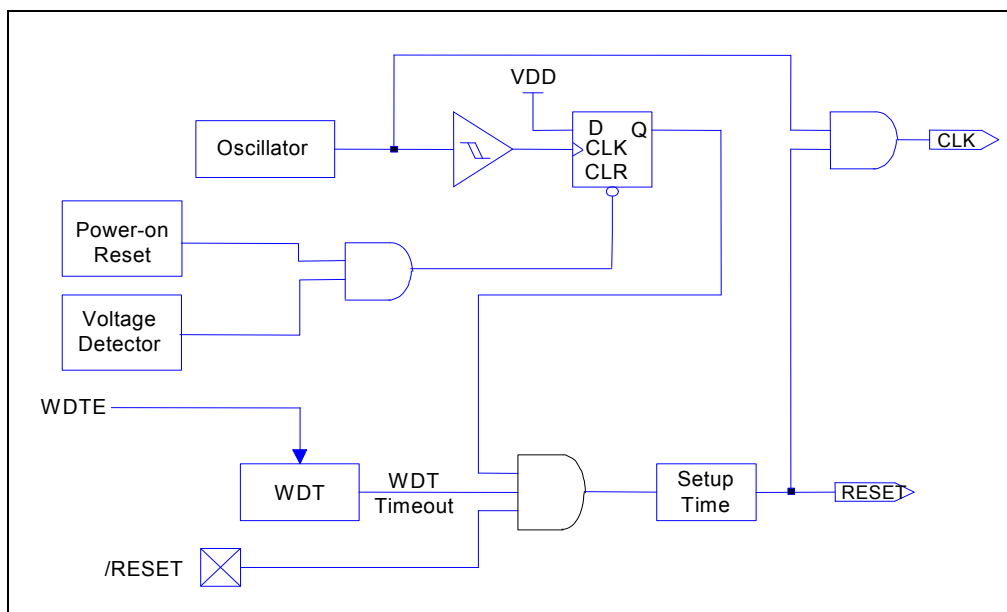


Figure 6-10 Block Diagram of Controller Reset

6.6 Interrupt

The EM78F561N has 6 interrupts (3 external, 3 internal) as listed below:

| Interrupt Source | | Enable Condition | Int. Flag | Int. Vector | Priority |
|---------------------|-------------------|------------------|-----------|-------------|----------|
| Internal / External | Reset | - | - | 0000 | High 0 |
| External | INT | ENI + EXIE=1 | EXIF | 0003 | 1 |
| External | Port 6 pin change | ENI + ICIE=1 | ICIF | 0006 | 2 |
| Internal | TCC | ENI + TCIE=1 | TCIF | 0009 | 3 |
| External | Comparator 2 | ENI+CMP2IE=1 | CMP2IF | 0015 | 4 |
| Internal | TC3 | ENI + TC3IE=1 | TC3IF | 0027 | 5 |
| Internal | AD | ENI+ADIE=1 | ADIF | 0030 | 6 |

RE and RF are the interrupt status registers that record the interrupt requests in the relative flags/bits. IOCE and IOCF are the interrupt mask registers. The global interrupt is enabled by the ENI instruction and is disabled by the DISI instruction. When one of the enabled interrupts occurs, the next instruction will be fetched from their individual address. 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 and RE) is set regardless of the status of its mask bit or the execution of ENI. The RETI instruction ends the interrupt routine and enables the global interrupt (the execution of ENI).

The external interrupt has an on-chip digital noise rejection circuit (input pulse less than **8 system clock time** is eliminated as noise), **but in Low Crystal oscillator (LXT) mode, the noise rejection circuit will be disabled.** When an interrupt (Falling edge) is generated by the External interrupt (when enabled), the next instruction will be fetched from Address 003H.

Before the interrupt subroutine is executed, the contents of ACC and the R3 and R4 register will be saved by hardware. If another interrupt occurred, the ACC, R3 and R4 will be replaced by the new interrupt. After the interrupt service routine is finished, ACC, R3 and R4 will be pushed back.

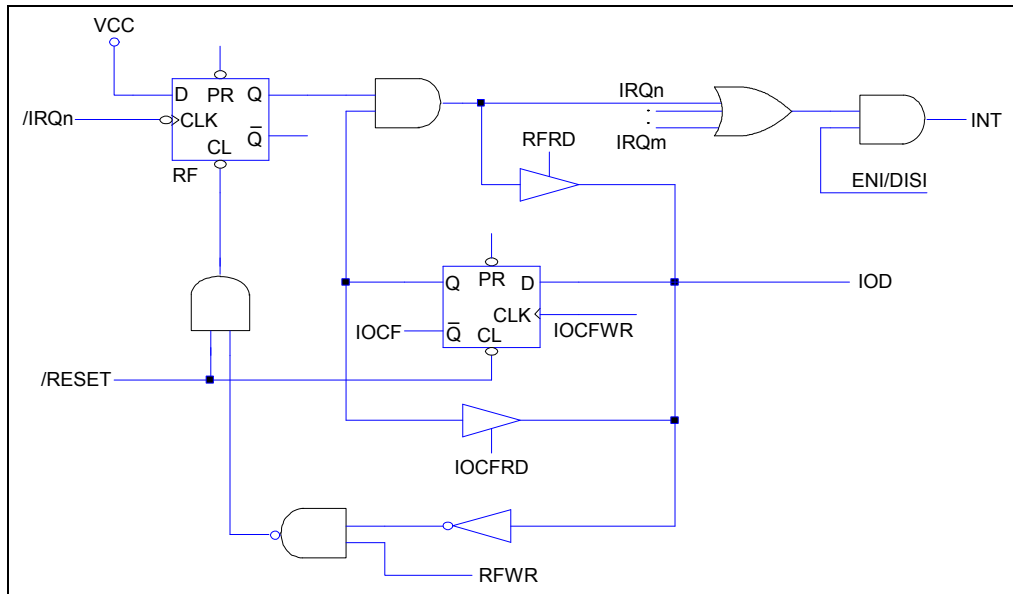


Figure 6-11 Interrupt Input Circuit

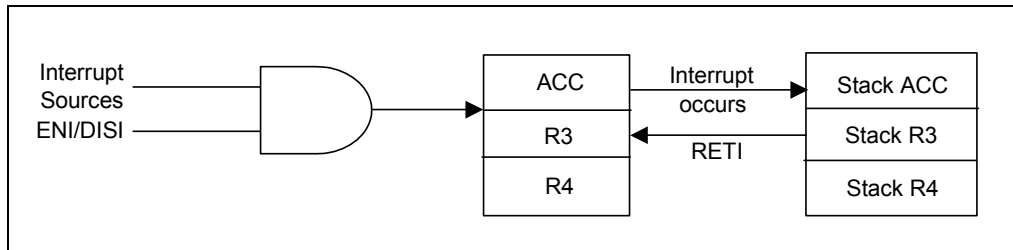


Figure 6-12 Interrupt Back-up Diagram

6.7 Analog-to-Digital Converter (ADC)

The analog-to-digital circuitry consists of a 10-bit analog multiplexer, Two control registers [AISR/R5 (Bank 2), ADCON/R6 (Bank 2), two data registers (ADDH, ADDL/R8, R9) and an ADC with 10-bit resolution. The functional block diagram of the ADC is shown in Figure 6-13. The analog reference voltage (Vref) and analog ground are connected via separate input pins.

The ADC module utilizes successive approximation to convert the unknown analog signal into a digital value. The result is fed to the ADDH and ADDL. Input channels are selected by the analog input multiplexer via the ADCON register Bits ADIS2 ~ ADIS0.

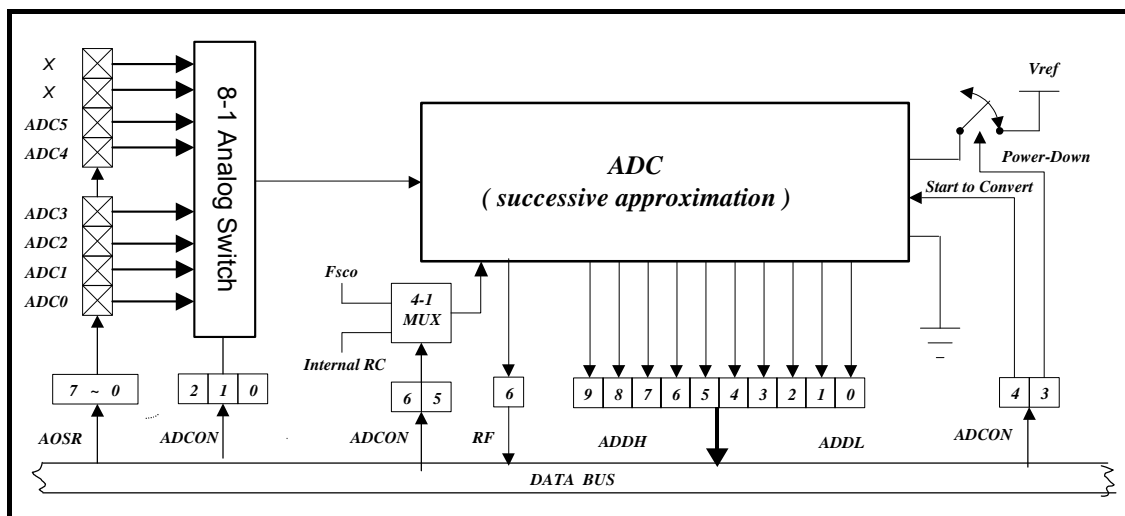


Figure 6-13 Functional Block Diagram of Analog-to-Digital Conversion

6.7.1 ADC Control Register (AISR/R5, ADCON/R6)

6.7.1.1 Bank 2 R5 AISR (ADC Input Select Register)

The AISR register individually defines the Port 6 pins as analog input or as digital I/O.

| Bit | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Symbol | - | - | ADE5 | ADE4 | ADE3 | ADE2 | ADE1 | ADE0 |
| *Init_Value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Bits 7 ~ 6: Not used, set to "0" at all time

Bit 5 (ADE5): AD converter enable bit of P65 pin

0 : Disable ADC5, P65 functions as I/O pin

1 : Enable ADC5 to function as analog input pin

Bit 4 (ADE4): AD converter enable bit of P64 pin.

0 : Disable ADC4, P64 functions as I/O pin

1 : Enable ADC4 to function as analog input pin

Bit 3 (ADE3): AD converter enable bit of P63 pin.

- 0 : Disable ADC3, P63 functions as I/O pin
- 1 : Enable ADC3 to function as analog input pin

Bit 2 (ADE2): AD converter enable bit of P62 pin

- 0 : Disable ADC2, P62 functions as I/O pin
- 1 : Enable ADC2 to function as analog input pin

Bit 1 (ADE1): AD converter enable bit of P61 pin

- 0 : Disable ADC1, P61 functions as I/O pin
- 1 : Enable ADC1 to function as analog input pin

Bit 0 (ADE0): AD converter enable bit of P60 pin.

- 0 : Disable ADC0, P60 functions as I/O pin
- 1 : Enable ADC0 to function as analog input pin

6.7.1.2 Bank 2 R6 ADCON (A/D Control Register)

The ADCON register controls the operation of the A/D conversion and determines which pin should be currently active.

| Bit | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|
| Symbol | VREFS | CKR1 | CKR0 | ADRUN | ADPD | ADIS2 | ADIS1 | ADIS0 |

Bit 7 (VREFS): ADC's Vref input source

- 0 : ADC's Vref is connected to Vdd (default value), and the P50/VREF pin carries out the function of P50
- 1 : ADC's Vref is connected to P50/VREF

Bit 6 ~ Bit 5 (CKR1 ~ CKR0): The prescaler of oscillator clock rate of ADC

- 00 = 1: 4 (default value)
- 01 = 1: 1
- 10 = 1: 16
- 11 = 1: 2

| CKR1/CKR0 | Operation Mode | Max. Operation Frequency |
|-----------|----------------|--------------------------|
| 00 | $F_{osc}/4$ | 4 MHz |
| 01 | F_{osc} | 1 MHz |
| 10 | $F_{osc}/16$ | 16 MHz |
| 11 | $F_{osc}/2$ | 2 MHz |

Bit 4 (ADRUN): ADC starts to run

- 0 : reset on completion of the conversion. This bit cannot be reset by software.
- 1 : an A/D conversion is started. This bit can be set by software.

Bit 3 (ADPD): ADC Power-down mode

0 : Switch off the resistor reference to save power even while the CPU is operating

1 : ADC is operating

Bit 2 ~ Bit 0 (ADIS2 ~ ADIS0): Analog Input Select

000 = AN0/P60

001 = AN1/P61

010 = AN2/P62

011 = AN3/P63

100 = AN4/P64

101 = AN5/P65

110 = X

111 = X

These can only be changed when the ADIF bit and the ADRUN bit are both Low.

6.7.2 ADC Data Buffer (ADDH, ADDL/R8, R9)

When the A/D conversion is completed, the result is loaded to the ADDH, ADDL. The ADRUN bit is cleared, and the ADIF is set.

6.7.3 A/D Sampling Time

The accuracy, linearity, and speed of the successive approximation A/D converter are dependent on the properties of the ADC and the comparator. The source impedance and the internal sampling impedance directly affect the time required to charge the sample holding capacitor. The application program controls the length of the sample time to meet the specified accuracy. Generally speaking, the program should wait for 2 μ s for each K Ω of the analog source impedance and at least 2 μ s for the low-impedance source. The maximum recommended impedance for analog source is 10K Ω at V_{dd}=5V. After the analog input channel is selected, this acquisition time must be done before the conversion can be started.

6.7.4 A/D Conversion Time

CKR1 and CKR0 select the conversion time (T_{ct}), in terms of instruction cycles. This allows the MCU to run at a maximum frequency without sacrificing the AD conversion accuracy. For the EM78F561N, the conversion time per bit is 1 μ s. Table 6-8-4-1 shows the relationship between T_{ct} and the maximum operating frequencies.

Table 6-7-4-1 Tct vs. Maximum Operating Frequency

| CKR1: CKR0 | Operation Mode | Max. Operation Frequency | Max. Conversion Rate/Bit | Max. Conversion Rate |
|------------|----------------|--------------------------|--------------------------|--|
| 00 | Fosc/4 | 4 MHz | 1 MHz (1 μ s) | 16 \times 1 μ s = 16 μ s (62.5kHz) |
| 01 | Fosc | 1 MHz | 1 MHz (1 μ s) | 16 \times 1 μ s = 16 μ s (62.5kHz) |
| 10 | Fosc/16 | 16 MHz | 1 MHz (1 μ s) | 16 \times 1 μ s = 16 μ s (62.5kHz) |
| 11 | Fosc/2 | 2 MHz | 1 MHz (1 μ s) | 16 \times 1 μ s = 16 μ s (62.5kHz) |

NOTE

The pin not used as an analog input can be used as regular input or output pin. During conversion, do not perform output instruction to maintain precision for all the pins.

6.7.5 A/D Operation during Sleep Mode

In order to obtain a more accurate ADC value and reduced power consumption, the A/D conversion remains operational during sleep mode. **As the SLEP instruction is executed, all MCU operations will stop except for the Oscillator, TCC, TC3 and A/D conversion.**

The AD Conversion is considered completed when:

- 1 ADRUN Bit of R6 Register Is Cleared to "0".
- 2 Wake-up from A/D Conversion Remains in Operation during Sleep Mode.

The result is fed to the ADDATA, ADOC when the conversion is completed. If the ADWE is enabled, the device will wake up. Otherwise, the A/D conversion will be shut off, no matter what the status of the ADPD bit is.

6.7.6 Programming Steps/Considerations

6.7.6.1 Programming Steps

Follow these steps to obtain data from the ADC:

1. Write to the four bits (ADE5~ADE0) on the R5 (AISR) register to define the characteristics of R6 (digital I/O, analog channels, or voltage reference pin)

2. Write to the R6/ADCON register to configure the AD module:
 - a) Select AD input channel (ADIS2 : ADIS0)
 - b) Define the AD conversion clock rate (CKR1 ~ CKR0)
 - c) Select the VREFS input source of the ADC
 - d) Set the ADPD bit to 1 to begin sampling
3. Set the ADWE bit, if the wake-up function is employed
4. Set the ADIE bit, if the interrupt function is employed
5. Write "ENI" instruction, if the interrupt function is employed
6. Set the ADRUN bit to 1
7. Wait for wake-up or for ADRUN bit to be cleared to "0"
8. Read the ADDATAH and ADDATAL conversion data registers.
9. Clear the interrupt flag bit (ADIF) when A/D interrupt function has occurred.
10. For the next conversion, go to Step 1 or Step 2 as required. At least two TCT's are required before the next acquisition starts.

NOTE

To obtain an accurate value, it is necessary to avoid any data transition on the I/O pins during AD conversion.

6.7.6.2 Demonstration Programs

```

; To define the general registers
R_0 == 0                ; Indirect addressing register
PSW == 3                ; Status register
PORT5 == 5
PORT6 == 6
RA == 0XA               ; Wake-up control register
RF == 0XF               ; Interrupt status register

; To define the control register
IOC50 == 0X5           ; Control Register of Port 5
IOC60 == 0X6           ; Control Register of Port 6
C_INT == 0XF           ; Interrupt Control Register

;ADC Control Registers
ADDATAH == 0x8         ; The contents are the results of ADC
ADDATAH == 0x9         ; The contents are the results of ADC
AISR == 0x05           ; ADC input select register
ADCON == 0x6           ; 7   6   5   4   3   2   1   0
                        ; (VREFS)(CKR1:0)(ADRUN)(ADPD)(ADIS2:0)
ADOC == 0x07           ; ADC offset calibration register

;To define bits
;In ADCON
ADRUN == 0x4           ; ADC is executed as the bit is set
ADPD == 0x3           ; Power Mode of ADC

```

```

ORG 0 ; Initial address
JMP INITIAL
ORG 0x30 ; Interrupt vector

(User's program) ; Determined by User

BANK 0
CLR RF ; To clear the ADIF bit
BANK 2
BS ADCON , ADRUN ; To start to execute the next AD
; conversion if necessary
RETI

INITIAL:
BANK 2
MOV A , @0B00000001 ; To define P60 as an analog input
MOV AISR , A
MOV A , @0B00001000 ; To select P60 as an analog input
; channel, and AD power on
MOV ADCON , A ; To define P60 as an input pin and
; set clock rate at fosc/4
MOV A , @0B00000000
MOV ADC , A ; To disable calibration

En_ADC:
MOV A , @0BXXXXXXX1 ; To define P60 as an input pin, and
; the others are dependent
IOW PORT6 ; on applications
BANK 0
MOV A , @0BXX1XXXXX ; Enable the ADWE wake-up function
; of ADC, "X" by application
MOV RA , A
MOV A , @0BX1XXXXXX ; Enable the ADIE interrupt function
; of ADC, "X" by application
IOW C_INT

ENI ; Enable the interrupt function
BANK 2
BS ADCON , ADRUN ; Start to run the ADC
; If the interrupt function is
; employed, the following three
; lines may be ignored
SLEP ; Into sleep mode
POLLING:
JBC ADCON , ADRUN ; To check the ADRUN bit
; continuously;
JMP POLLING ; ADRUN bit will be reset as the AD
; conversion is completed
(User's program) ; Read AD convert data from ADDATAH/L

```

6.8 Timer/Counter 3

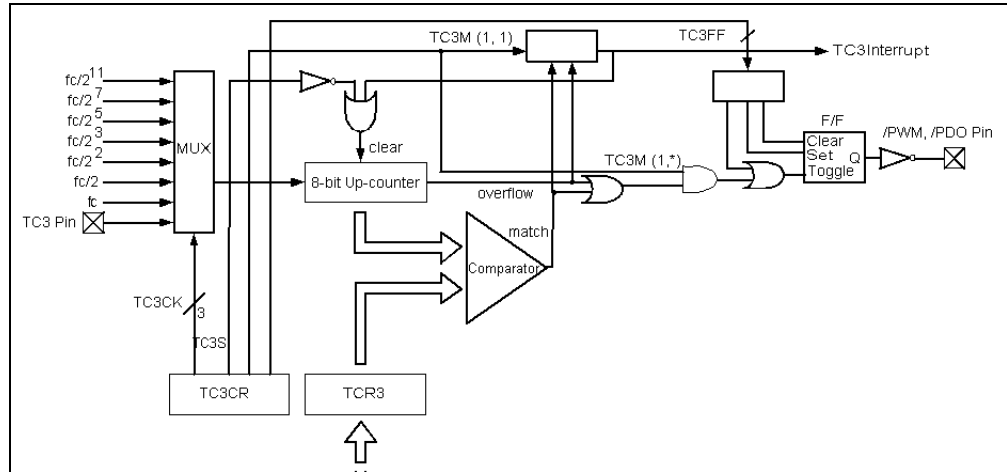


Figure 6-14 Timer/Counter 3 Configuration

In Timer mode, counting up is performed using the internal clock (rising edge trigger). When the contents of the up-counter matched with the contents of TCR3, then interrupt is generated and the counter is cleared. Counting up resumes after the counter is cleared.

In Counter mode, counting up is performed using the external clock input pin (TC3). When the contents of the up-counter matched with the contents of TCR3, then interrupt is generated and the counter is cleared. Counting up resumes after the counter is cleared.

In Programmable Divider Output (PDO) mode, counting up is performed using the internal clock. The contents of TCR3 are compared with the contents of the up-counter. The F/F output is toggled and the counter is cleared each time a match is found. The F/F output is inverted and output to /PDO pin. This mode can generate 50% duty pulse output. **The F/F can be initialized by program and it is initialized to "0" during reset.** A TC3 interrupt is generated each time the /PDO output is toggled.

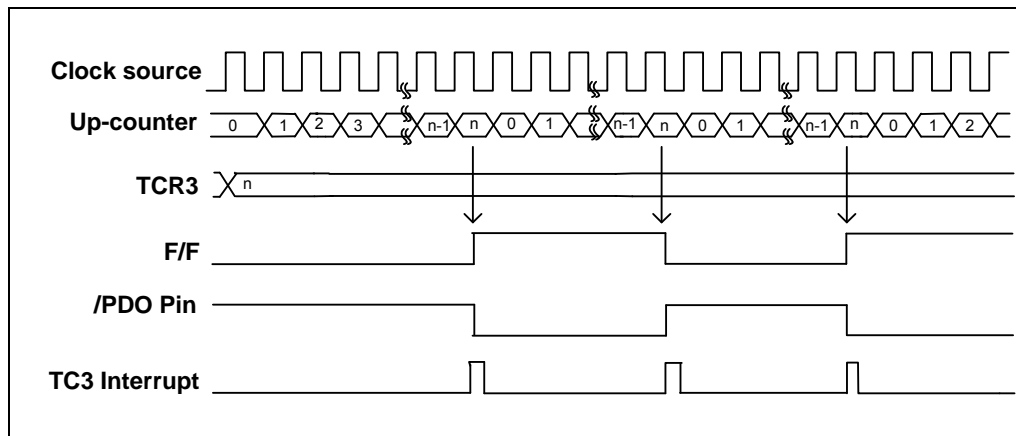


Figure 6-15 PDO Mode Timing Chart

In Pulse Width Modulation (PWM) Output mode, counting up is performed using the internal clock. The contents of TCR3 are compared with the contents of the up-counter. The F/F is toggled when a match is found. While the counter is counting, the F/F is toggled again when the counter overflows, the counter is cleared. The F/F output is inverted and output to the /PWM pin. A TC3 interrupt is generated each time an overflow occurs. **TCR3 is configured as a 2-stage shift register and during output, will not switch until one output cycle is completed even if TCR3 is overwritten.** Hence, the output can be changed continuously. Also, the first time, TCR3 is shifted by setting TC3S to “1” after data is loaded to TCR3.

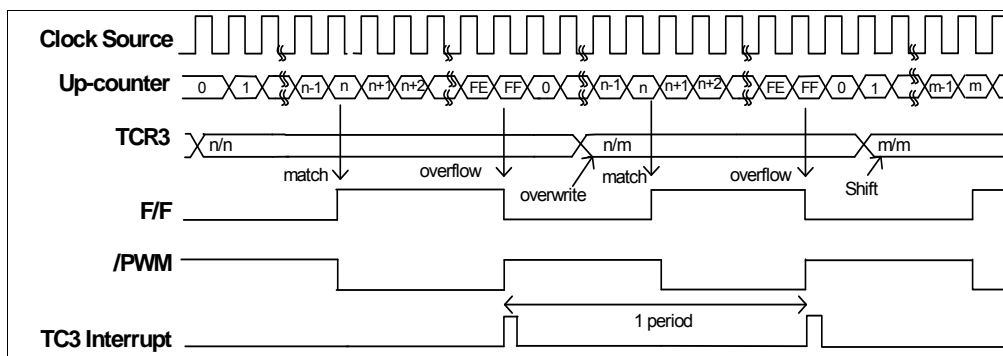


Figure 6-16 PWM Mode Timing Chart

6.9 Comparator

EM78F561N has two comparators, which has two analog inputs and one output. The comparator can be employed to wake up from sleep mode. Figure 6-17 shows the comparator circuit.

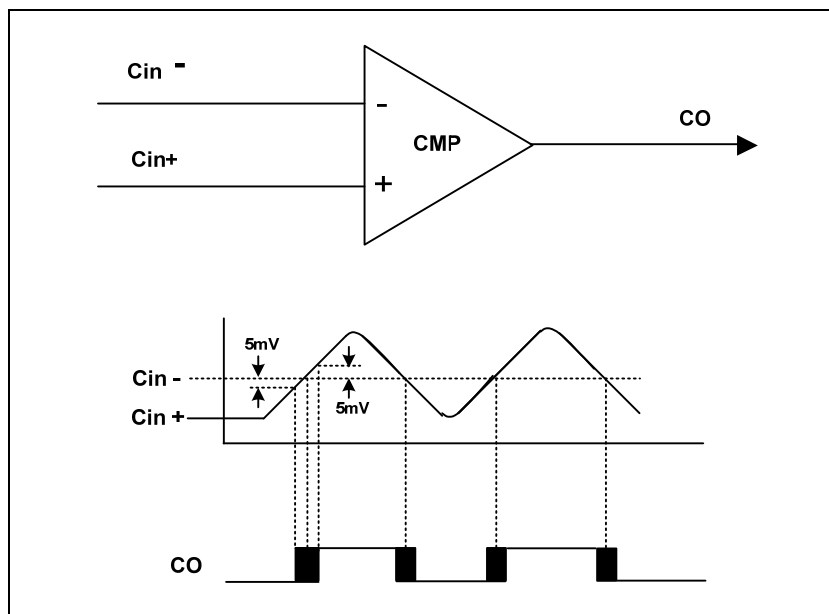


Figure 6-17 Comparator Operating Mode

6.9.1 External Reference Signal

The analog signal that is presented at Cin- is compared to the signal at Cin+, and the digital output (CO) of the comparator is adjusted accordingly.

- The reference signal must be between Vss and Vdd.
- The reference voltage can be applied to either pin of the comparator.
- Threshold detector applications may be of the same reference.
- The comparator can operate from the same or different reference source.

6.9.2 Comparator Outputs

- The compared result is stored in the CPOUT2 of R7 Bit 4 of Bank 3.
- The comparator is output to CO2 (P80) by programming Bit 3, Bit 2 <COS21, COS20> of Register R7 Bank 3.
- Figure 6-18 shows the comparator output block diagram.

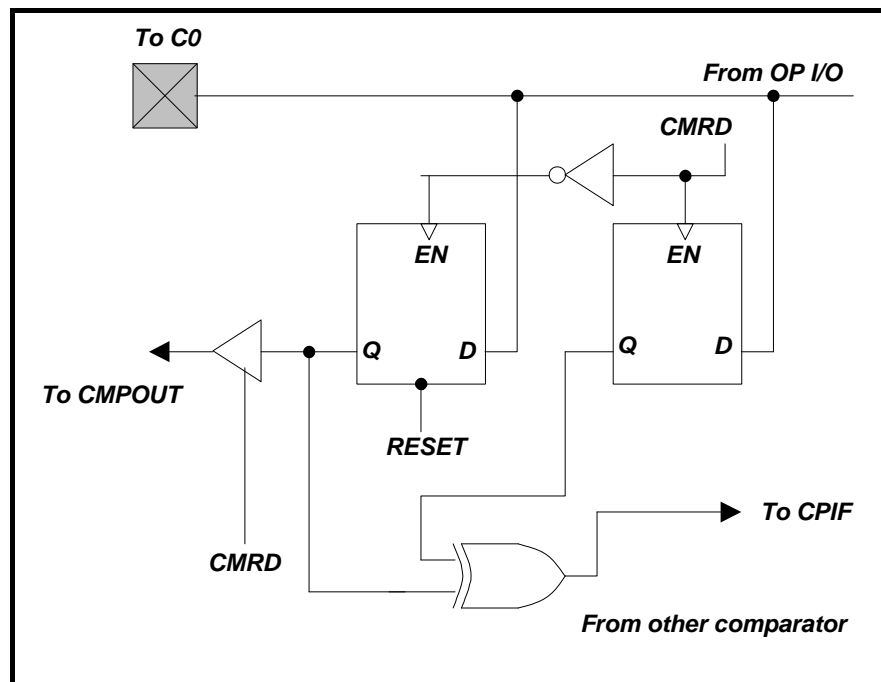


Figure 6-18 Comparator Output Configuration

6.9.3 Interrupt

- CMP2IE (IOCE.7) and the "ENI" instruction execution must be enabled.
- Interrupt occurs whenever a change occurs on the output pin of the comparator.
- The actual change on the pin can be determined by reading the Bit CPOUT2, R7 Bit 4 of Bank 3.
- CMP2IF (RF.7 Bank 1), the comparator interrupt flag, can only be cleared by software.

6.9.4 *Wake-up from Sleep Mode*

- If enabled, the comparator remains active and the interrupt remains functional, even in Sleep mode.
- If a mismatch occurs, the interrupt will wake up the device from Sleep mode.
- The power consumption should be taken into consideration for the benefit of energy conservation.
- If the function is unemployed during Sleep mode, turn off the comparator before entering into sleep mode.

6.10 Oscillator

6.10.1 *Oscillator Modes*

The EM78F561N device can be operated in four different oscillator modes, such as Internal RC oscillator mode (IRC), External RC oscillator mode (ERC), High Crystal oscillator mode (HXT), and Low Crystal oscillator mode (LXT). User can select one of such modes by programming OSC2, OCS1 and OSC0 in the Code Option register. Table 6-16-1 depicts how these four modes are defined.

The up-limited operation frequency of the crystal/resonator on the different VDD is listed in Table 6-10-1:

Table 6-10-1 Oscillator Modes as Defined by OSC2 ~ OSC0

| Mode | OSC2 | OSC1 | OSC0 |
|--|------|------|------|
| XT (Crystal oscillator mode) | 0 | 0 | 0 |
| HXT (High Crystal oscillator mode) | 0 | 0 | 1 |
| LXT1 (Low Crystal 1 oscillator mode) | 0 | 1 | 0 |
| LXT2 (Low Crystal 2 oscillator mode) | 0 | 1 | 1 |
| IRC (Internal RC oscillator mode); P55, P54 act as I/O pin | 1 | 0 | 0 |
| IRC (Internal RC oscillator mode); P55 act as I/O pin P54 act as RCOUT pin | 1 | 0 | 1 |
| ERC (External RC oscillator mode); P55 act as ERCin pin P54 act as I/O pin | 1 | 1 | 0 |
| ERC (External RC oscillator mode); P55 act as ERCin pin P54 act as RCOUT pin with Open-drain | 1 | 1 | 1 |

OSCI and OSC0 are used in LXT2, LXT1, XT, HXT and ERC modes. They cannot be used as normal I/O pins.

In IRC mode, P55 is used as normal I/O pin.

NOTE

- Frequency range of HXT mode is 16 MHz ~ 6 MHz.
- Frequency range of XT mode is 6 MHz ~ 1 MHz.
- Frequency range of LXT1 mode is 1 MHz ~ 100kHz.
- Frequency range of LXT2 mode is 32kHz.

Table 6-10-2 Summary of Maximum Operating Speeds

| Conditions | VDD | Max. Fxt. (MHz) |
|----------------------------|-----|-----------------|
| Two cycles with two clocks | 2.5 | 4.0 |
| | 3.0 | 8.0 |
| | 4.5 | 16.0 |

6.10.2 Crystal Oscillator/Ceramic Resonators (Crystal)

The EM78F561N can be driven by an external clock signal through the OSCI pin as shown in Figure 6-19 below.

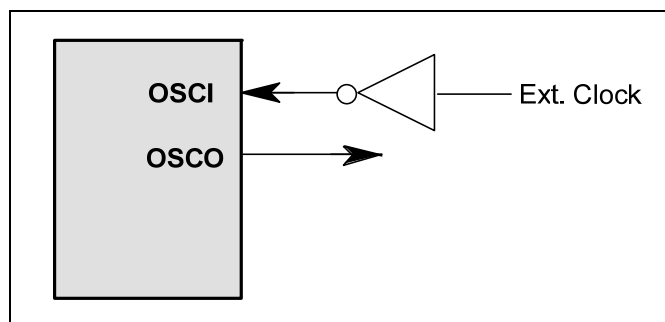


Figure 6-19 Circuit for External Clock Input

In most applications, pin OSCI and pin OSCO can be connected with a crystal or ceramic resonator to generate oscillation. Figure 6-20 depicts such circuit. The same thing applies whether it is in the HXT mode or in the LXT mode. Table 6-14-3 provides the recommended values of C1 and C2. Since each resonator has its own attribute, user 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.

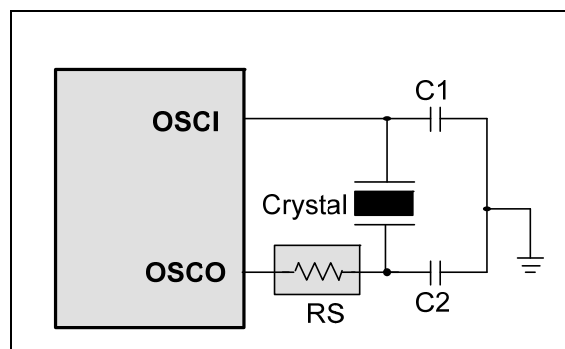


Figure 6-20 Circuit for Crystal/Resonator

Table 6-10-3 Capacitor Selection Guide for Crystal Oscillator or Ceramic Resonator

| Oscillator Type | Frequency Mode | Frequency | C1 (pF) | C2 (pF) |
|--------------------|----------------------|-----------|---------|---------|
| Ceramic Resonators | LXT1 (100K~1 MHz) | 100kHz | 45pF | 45pF |
| | | 200kHz | 20pF | 20pF |
| | | 455kHz | 20pF | 20pF |
| | | 1.0 MHz | 20pF | 20pF |
| | XT (1M~6 MHz) | 1.0 MHz | 25pF | 25pF |
| | | 2.0 MHz | 20pF | 20pF |
| | | 4.0 MHz | 20pF | 20pF |
| Crystal Oscillator | LXT2 (32.768kHz) | 32.768kHz | 40pF | 40pF |
| | LXT1 (100K~1 MHz) | 100kHz | 45pF | 45pF |
| | | 200kHz | 20pF | 20pF |
| | | 455kHz | 20pF | 20pF |
| | | 1.0 MHz | 20pF | 20pF |
| | XT (1~6 MHz) | 455kHz | 30pF | 30pF |
| | | 1.0 MHz | 20pF | 20pF |
| | | 2.0 MHz | 20pF | 20pF |
| | | 4.0 MHz | 20pF | 20pF |
| | | 6.0 MHz | 20pF | 20pF |
| | HXT (6~16 MHz) | 6.0 MHz | 25pF | 25pF |
| | | 8.0 MHz | 20pF | 20pF |
| | | 10.0 MHz | 20pF | 20pF |
| 12.0 MHz | | 20pF | 20pF | |
| 16.0 MHz | | 15pF | 15pF | |

6.10.3 External RC Oscillator Mode

For some applications that do not need a very precise timing calculation, the RC oscillator (Figure 6-21) offers a cost-effective oscillator configuration. 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 manufacturing process variation.

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

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

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, and the PCB layout, will affect the system frequency.

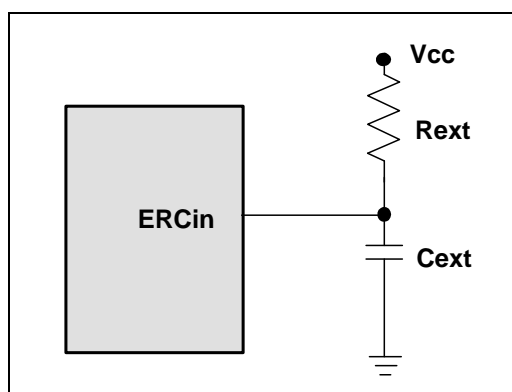


Figure 6-21 Circuit for External RC Oscillator Mode

Table 6-10-4 RC Oscillator Frequencies

| Cext | Rext | Average Fosc 5V, 25°C | Average Fosc 3V, 25°C |
|--------|------|-----------------------|-----------------------|
| 20 pF | 3.3k | 3.5 MHz | 3.2 MHz |
| | 5.1k | 2.5 MHz | 2.3 MHz |
| | 10k | 1.30 MHz | 1.25 MHz |
| | 100k | 140kHz | 140kHz |
| 100 pF | 3.3k | 1.27 MHz | 1.21 MHz |
| | 5.1k | 850kHz | 820kHz |
| | 10k | 450kHz | 450kHz |
| | 100k | 48kHz | 50kHz |
| 300 pF | 3.3k | 560kHz | 540kHz |
| | 5.1k | 370kHz | 360kHz |
| | 10k | 196kHz | 192kHz |
| | 100k | 20kHz | 20kHz |

Note: ¹: Measured based on DIP packages.

²: The values are for design reference only.

6.10.4 Internal RC Oscillator Mode

The EM78F561N offers a versatile internal RC mode with default frequency value of 4 MHz. Internal RC oscillator mode has other frequencies (16 MHz and 8 MHz) that can be set by Code Option Word1<3,2> or switch by Bank1 R8<7,6>, RCM1 and RCM0. All these four main frequencies can be calibrated by programming the Code Option Word1<8~4>, C4~C0 (auto calibration).

Table 6-10-5 Internal RC Drift Rate (Ta=25°C, VDD=5 V± 5%, VSS=0V)

| Internal RC | Drift Rate | | | |
|-------------|--------------------------|---------------------|---------|---------|
| | Temperature (-40°C~85°C) | Voltage (2.4V~5.5V) | Process | Total |
| 4 MHz | ± 3% | ± 5% | ± 2.5% | ± 10.5% |
| 16 MHz | ± 3% | ± 5% | ± 2.5% | ± 10.5% |
| 8 MHz | ± 3% | ± 5% | ± 2.5% | ± 10.5% |

6.11 Code Option Register

The EM78F561N has a Code option word that is not 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 |
|--------------|--------------|--------------|
| Bit 12~Bit 0 | Bit 12~Bit 0 | Bit 12~Bit 0 |

6.11.1 Code Option Register (Word 0)

| Word 0 | | | | | | | | | | | |
|----------|--------|--------|---------|----------|-------|-------|---------|-------|-------|-------|---------------|
| Bit | Bit 12 | Bit 11 | Bit 10 | Bit 9 | Bit 8 | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 ~ Bit 0 |
| Mnemonic | – | NRHL | NRE | RESETENB | CLKS1 | CLKS0 | ENWDTB | OSC2 | OSC1 | OSC0 | Protect |
| 1 | – | 8/fc | Disable | /RESET | High | High | Enable | High | High | High | Enable |
| 0 | – | 32/fc | Enable | P83 | Low | Low | Disable | Low | Low | Low | Disable |

Bit 12: Not used, set to “0” at all time.

Bit 11 (NRHL): Noise rejection high/low pulse define bit. INT pin is a falling edge trigger.

0 : Pulses equal to 32/fc [s] are regarded as signal (default)

1 : Pulses equal to 8/fc [s] are regarded as signal

NOTE

The noise rejection function is turned off in the LXT2 and sleep mode.

Bit 10 (NRE): Noise rejection enable. The INT pin is falling edge triggered.

0 : enable noise rejection (default) but in Low Crystal oscillator (LXT2) mode, the noise rejection circuit is always disabled.

1 : disable noise rejection

Bit 9 (RESETENB): Reset Pin Enable Bit

0 : P83 set to I/O pin (default)

1 : P83 set to /RESET pin

Bit 8 ~ Bit 7 (CLKS1 ~ CLKS0): Instruction period option bit

| Instruction Period | CLKS1 | CLKS0 |
|--------------------|-------|-------|
| 4 clocks (default) | 0 | 0 |
| 2 clocks | 0 | 1 |
| 8 clocks | 1 | 0 |
| 16 clocks | 1 | 1 |

Refer to the Instruction Set section.

Bit 6 (ENWDTB): Watchdog timer enable bit

0 : Disable (default)

1 : Enable

Bit 5 ~ Bit 3 (OSC2 ~ OSC0): Oscillator Mode Selection bits

Oscillator Modes defined by OSC2 ~ OSC0

| Mode | OSC2 | OSC1 | OSC0 |
|--|------|------|------|
| XT (Crystal oscillator mode) (default) | 0 | 0 | 0 |
| HXT (High Crystal oscillator mode) | 0 | 0 | 1 |
| LXT1 (Low Crystal 1 oscillator mode) | 0 | 1 | 0 |
| LXT2 (Low Crystal 2 oscillator mode) | 0 | 1 | 1 |
| IRC (Internal RC oscillator mode); P55, P54 act as I/O pin | 1 | 0 | 0 |
| IRC (Internal RC oscillator mode); P55 act as I/O pin P54 act as RCOUT pin | 1 | 0 | 1 |
| ERC (External RC oscillator mode); P55 act as ERCin pin P54 act as I/O pin | 1 | 1 | 0 |
| ERC (External RC oscillator mode); P55 act as ERCin pin P54 act as RCOUT pin with Open-Drain | 1 | 1 | 1 |

- Note:**
1. Frequency range of HXT mode is 16 MHz ~ 6 MHz.
 2. Frequency range of XT mode is 6 MHz ~ 1 MHz.
 3. Frequency range of LXT1 mode is 1 MHz ~ 100kHz.
 4. Frequency range of LXT2 mode is 32kHz.

Bit 2 ~ Bit 0 (Protect): Protect Bit. Protect type is as follows:

| Protect | Protect |
|---------|---------|
| 1 | Enable |
| 0 | Disable |

6.11.2 Code Option Register (Word 1)

| Word 1 | | | | | | | | | | | | | |
|----------|----------|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Bit | 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 |
| Mnemonic | COBS0 | - | - | - | C4 | C3 | C2 | C1 | C0 | RCM1 | RCM0 | LVR1 | LVR0 |
| 1 | Register | - | - | - | High | High | High | High | High | High | High | High | High |
| 0 | Option | - | - | - | Low | Low | Low | Low | Low | Low | Low | Low | Low |

Bit 12 (COBS0): IRC mode select bit.

0: IRC frequency select from code option (default)

1: IRC frequency select from register.

Bits 11 ~ 10: Not used, set to "0" at all time

Bit 9: Not used, set to "1" at all time.

Bit 8 ~ Bit 4 (C4 ~ C0): Internal RC mode calibration bits. C4 ~ C0 must be set to "0" only (auto-calibration).

Bit 3 ~ Bit 2 (RCM1 ~ RCM0): RC mode select bits

| RCM 1 | RCM 0 | *Frequency (MHz) |
|-------|-------|------------------|
| 0 | 0 | 4 (default) |
| 0 | 1 | 16 |
| 1 | 0 | 8 |
| 1 | 1 | x |

Bit 1 ~ Bit 0 (LVR1 ~ LVR0): Low Voltage Reset Enable bits

| LVR1 | LVR0 | Reset Level | Release Level |
|------|------|-------------|---------------|
| 0 | 0 | NA | NA |
| 0 | 1 | 2.7V | 2.9V |
| 1 | 0 | 3.5V | 3.7V |
| 1 | 1 | 4.0V | 4.2V |

LVR1, LVR0="0, 0" : LVR disable, power-on reset point of EM78F561N is 2.0~2.1V (default)

LVR1, LVR0="0, 1" : If Vdd < 2.7V, the EM78F561N will be reset.

LVR1, LVR0="1, 0" : If Vdd < 3.5V, the EM78F561N will be reset.

LVR1, LVR0="1, 1" : If Vdd < 4.0V, the EM78F561N will be reset.

6.11.3 Customer ID Register (Word 2)

| Word 2 | | | | | | | | | | | | | |
|----------|--------|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Bit | 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 |
| Mnemonic | SC3 | SC2 | SC1 | SC0 | – | – | – | – | ID4 | ID3 | ID2 | ID1 | ID0 |
| 1 | High | High | High | High | – | – | – | – | High | High | High | High | High |
| 0 | Low | Low | Low | Low | – | – | – | – | Low | Low | Low | Low | Low |

Bits 12 ~ 9 (SC3 ~ SC0): Calibrator of sub frequency (WDT frequency, auto calibration).

Bit 8: Not used, set to “0” at all time.

Bit 7: Not used, set to “1” at all time.

Bits 6 ~ 5: Not used, set to “0” at all time.

Bits 4 ~ 0: Customer’s ID code.

6.12 Power-on Considerations

Any microcontroller is not guaranteed to start to operate properly before the power supply has stabilized. The EM78F561N has an on-chip Power-on Voltage Detector (POVD) with a detecting level of 2.0V~2.1V. It will work well if V_{dd} can rise quickly enough (50 ms or less). In many critical applications, however, extra devices are still required to assist in solving power-up problems.

6.13 External Power-on Reset Circuit

The circuit shown in Figure 6-22 uses an external RC to produce a reset pulse. The pulse width (time constant) should be kept long enough for V_{dd} to reach minimum operation voltage. This circuit is used when the power supply has a slow rise time. Since the current leakage from the /RESET pin is $\pm 5 \mu\text{A}$, it is recommended that R should not be greater than 40 K Ω . In this way, the /RESET pin voltage is held below 0.2V. The diode (D) functions as a short circuit at the moment of power down.

The capacitor C will discharge rapidly and fully. R_{in}, the current-limited resistor, will prevent high current or ESD (electrostatic discharge) from flowing to the /RESET pin.

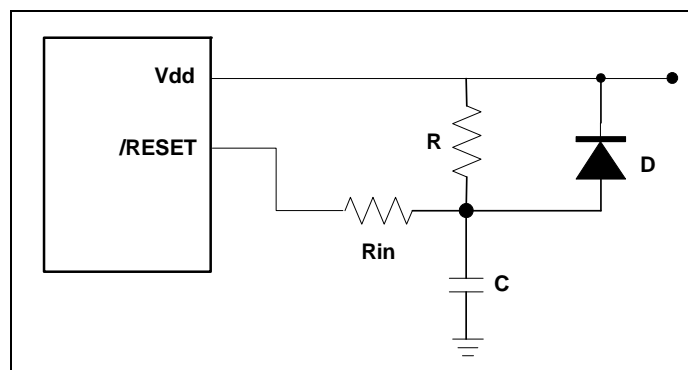


Figure 6-22 External Power-up Reset Circuit

6.14 Residue-Voltage Protection

When battery is replaced, device power (Vdd) is taken off but residue-voltage remains. The residue-voltage may trip below Vdd minimum, but not to zero. This condition may cause a poor power-on reset. Figure 6-23 and Figure 6-24 shows how to make a residue-voltage protection circuit.

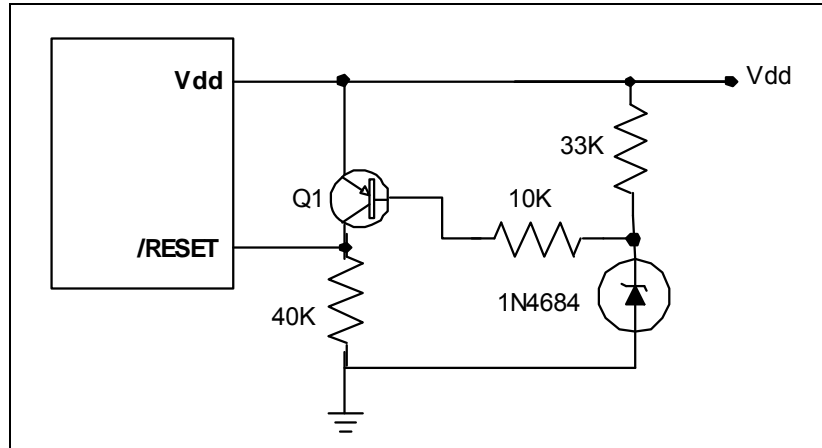


Figure 6-23 Residue Voltage Protection Circuit 1

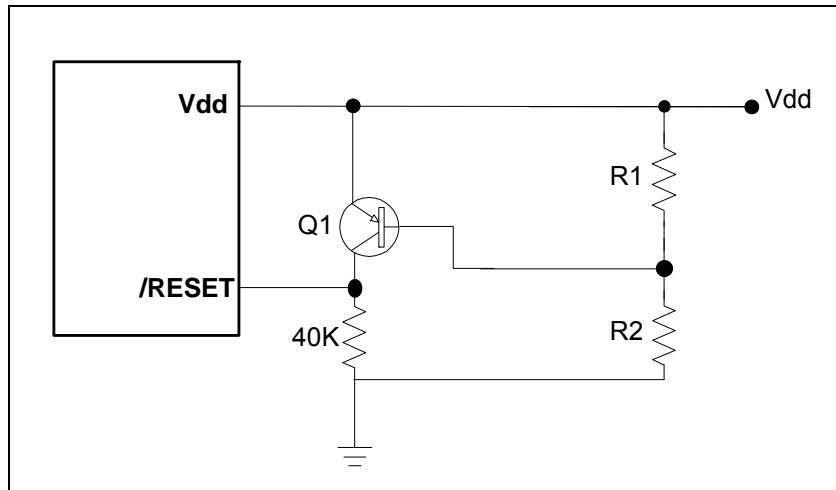


Figure 6-24 Residue Voltage Protection Circuit 2

6.15 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 two oscillator periods), unless the program counter is changed by instructions "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", etc.). 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 to modify the instruction as follows:

- (A) Change one instruction cycle to consist of four oscillator periods.
- (B) "TBRD", "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 CLK1:0. One instruction cycle consists of two oscillator clocks if CLK1:0 is "01", and four oscillator clocks if CLK1:0 is "00".

Note that once the four oscillator periods within one instruction cycle is selected as in Case (A), the internal clock source for TCC should be CLK = Fc as indicated in Figure 6-6-1.

In addition, 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 the I/O register.

Convention:

R = Register designator that specifies which one of the registers (including operation and general purpose registers) is to be utilized by the instruction.

b = Bit field designator that selects the value for the bit located in the register R and which affects the operation.

k = 8 or 10-bit constant or literal value

| Binary Instruction | 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 |

| Binary Instruction | Hex | Mnemonic | Operation | Status Affected |
|--------------------|------|----------|--|-------------------|
| 0 0000 0000 rrrr | 000r | IOW R | A → IOCR | None ¹ |
| 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 ¹ |
| 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 |

Note: ¹ This instruction is applicable to IOC5~IOC7, IOCA ~ IOCF only.

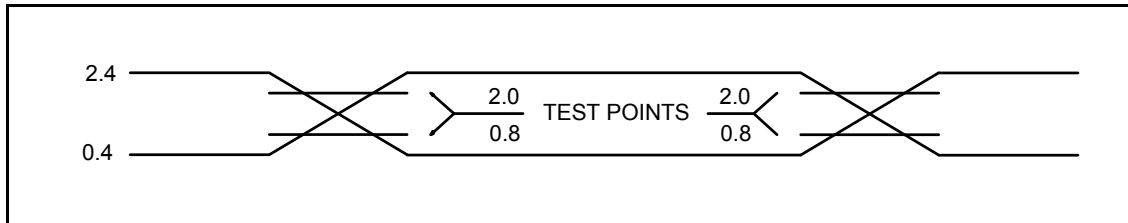
| Binary Instruction | Hex | Mnemonic | Operation | Status Affected |
|--------------------|------|----------|--|-------------------|
| 0 0110 01rr rrrr | 06rr | RRC R | $R(n) \rightarrow R(n-1)$, $R(0) \rightarrow C$, $C \rightarrow R(7)$ | C |
| 0 0110 10rr rrrr | 06rr | RLCA R | $R(n) \rightarrow A(n+1)$, $R(7) \rightarrow C$, $C \rightarrow A(0)$ | 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 brrr rrrr | 0xxx | BC R,b | $0 \rightarrow R(b)$ | None ² |
| 0 101b brrr rrrr | 0xxx | BS R,b | $1 \rightarrow R(b)$ | None ³ |
| 0 110b brrr rrrr | 0xxx | JBC R,b | if $R(b)=0$, skip | None |
| 0 111b brrr 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 1111 kkkk kkkk | 1Fkk | ADD A,k | $k+A \rightarrow A$ | Z, C, DC |
| 1 1110 1001 kkkk | 1E9k | BANK k | $K \rightarrow R4(7:6)$ | None |
| 1 1110 11rr rrrr | 1Err | TBRD R | If Bank 3 $R6.7=0$, machine code (7:0) $\rightarrow R$ Else Bank 3 $R6.7=1$, machine code (12:8) \rightarrow $R(4:0)$, $R(7:5)=(0,0,0)$ | None |

Note: ² This instruction is not recommended for interrupt status register operation.

³ This instruction cannot operate under interrupt status register.

7 Timing Diagram

AC Test Input/Output Waveform



Note: AC Testing: Input are driven at 2.4V for logic "1," and 0.4V for logic "0"
Timing measurements are made at 2.0V for logic "1," and 0.8V for logic "0"

Figure 7-1 AC Test Input/Output Waveform Timing Diagram

Reset Timing (CLK1:0 = "01")

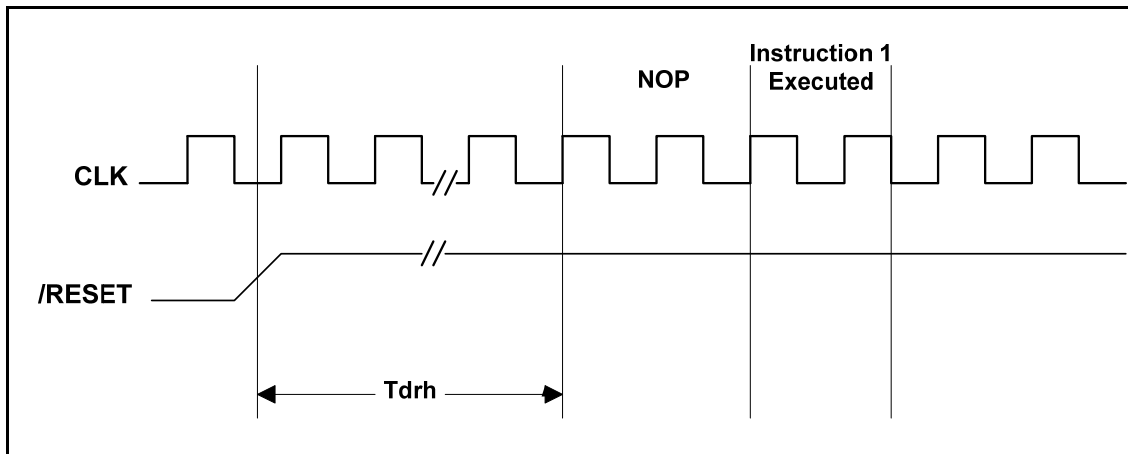


Figure 7-2 Reset Timing Diagram

8 Absolute Maximum Ratings

| Items | Rating | | |
|------------------------|-----------------------|----|-----------------------|
| Temperature under bias | -40°C | to | 85°C |
| Storage temperature | -65°C | to | 150°C |
| Working voltage | 2.2V | to | 5.5V |
| Working frequency | DC | to | 16 MHz |
| Input voltage | V _{ss} -0.3V | to | V _{dd} +0.5V |
| Output voltage | V _{ss} -0.3V | to | V _{dd} +0.5V |

Note: These parameters are theoretical values and have not been tested.

9 DC Electrical Characteristics

T_a=25°C, V_{DD}=5.0V ± 5%, V_{SS}=0V

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|--------|--|---|--------------------|------|------------------------|------|
| Fxt | Crystal: VDD to 3V | Two cycles with two clocks | DC | – | 8 | MHz |
| | Crystal: VDD to 5V | | DC | – | 16 | MHz |
| | ERC: VDD to 5V | R: 5.1KΩ, C: 300 pF | F-30% | 370 | F+30% | kHz |
| | IRC: VDD to 5 V | 4 MHz, 16 MHz, 8 MHz | F-2.5% | F | F+2.5% | Hz |
| IIL | Input Leakage Current for input pins | V _{IN} = V _{DD} , V _{SS} | – | – | ±1 | μA |
| VIHRC | Input High Threshold Voltage (Schmitt Trigger) | OSCI in RC mode | – | 3.5 | – | V |
| IERC1 | Sink current | V _I from low to high, V _I =5V | 21 | 22 | 23 | mA |
| VILRC | Input Low Threshold Voltage (Schmitt Trigger) | OSCI in RC mode | – | 1.5 | – | V |
| IERC2 | Sink current | V _I from high to low, V _I =2V | 16 | 17 | 18 | mA |
| VIH1 | Input High Voltage (Schmitt Trigger) | Ports 5, 6, 8 | 0.7V _{DD} | – | V _{DD} + 0.3V | V |
| VIL1 | Input Low Voltage (Schmitt Trigger) | Ports 5, 6, 8 | -0.3V | – | 0.3V _{DD} | V |
| VIHT1 | Input High Threshold Voltage (Schmitt Trigger) | /RESET | 0.7V _{DD} | – | V _{DD} + 0.3V | V |
| VILT1 | Input Low Threshold Voltage (Schmitt Trigger) | /RESET | -0.3V | – | 0.3V _{DD} | V |

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|--------|--|--|--------|------|----------|------|
| VIHT2 | Input High Threshold Voltage (Schmitt Trigger) | INT | 0.7VDD | - | VDD+0.3V | V |
| VILT2 | Input Low Threshold Voltage (Schmitt Trigger) | INT | -0.3V | - | 0.3VDD | V |
| VIHX1 | Clock Input High Voltage | OSCI in crystal mode | - | 3.0 | - | V |
| VILX1 | Clock Input Low Voltage | OSCI in crystal mode | - | 1.8 | - | V |
| IOH1 | Output High Voltage (Ports 5, 6, 8) | VOH = VDD-0.5V (IOH =3.7mA) | -3.0 | -4.2 | - | mA |
| IOL1 | Output Low Voltage (Ports 5, 8) | VOL = GND + 0.5V | 9 | 11 | - | mA |
| IOL2 | Output Low Voltage (Port 6) | VOL = GND + 0.5V | 15 | 18 | - | mA |
| IPH | Pull-high current | Pull-high active, Input pin at VSS | - | -70 | -80 | μA |
| IPL | Pull-low current | Pull-low active, Input pin at Vdd | - | 20 | 30 | μA |
| ISB1 | Power down current | All input and I/O pins at VDD, Output pin floating, WDT disabled | - | 1.0 | 1.5 | μA |
| ISB2 | Power down current | All input and I/O pins at VDD, Output pin floating, WDT enabled | - | 8 | 10 | μA |
| ICC1 | Operating supply current at two clocks | /RESET= 'High', Fosc=32kHz (Crystal type, CLKS1:0="01"), Output pin floating, WDT disabled. | - | 37 | 40 | μA |
| ICC2 | Operating supply current at two clocks | /RESET= 'High', Fosc=32kHz (Crystal type, CLKS1:0="01"), Output pin floating, WDT enabled. | - | 39 | 43 | μA |
| ICC3 | Operating supply current at two clocks | /RESET= 'High', Fosc=455kHz (Crystal type, CLKS1:0="01"), Output pin floating, WDT enabled. (*VDD = 3V) | - | 110 | 120 | μA |



| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|--------|--|--|------|------|------|------|
| ICC4 | Operating supply current at two clocks | /RESET = 'High', Fosc = 4 MHz (Crystal type, CLKS1:0 = "01"), Output pin floating, WDT enabled | – | 1.1 | 1.5 | mA |
| ICC5 | Operating supply current at two clocks | /RESET = 'High', Fosc = 10 MHz (Crystal type, CLKS1:0 = "01"), Output pin floating, WDT enabled | – | 2.7 | 3 | mA |

Note: 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. These data are for design reference only and are not tested.

Program Flash Memory Electrical Characteristics

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|--------|------------------------|--|------|------|------|--------|
| Tprog | Erase/Write cycle time | Vdd = 5.0V Temperature = -40°C ~ 85°C | – | – | – | ms |
| Treten | Data Retention | | – | 10 | – | years |
| Tendu | Endurance time | | – | 100K | – | cycles |

A/D Converter Characteristics (V_{dd}=2.5V to 5.5V, V_{ss}=0V, T_a=25°C)

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|-------------------|--|---|------------------|------|-------------------|------|
| V _{AREF} | Analog reference voltage | V _{AREF} - V _{ASS} ≥ 2.5V | 2.5 | – | V _{dd} | V |
| V _{ASS} | | | V _{ss} | – | V _{ss} | V |
| V _{AI} | Analog input voltage | – | V _{ASS} | – | V _{AREF} | V |
| IAI1 | I _{vdd} | V _{dd} =V _{AREF} =5.0V, V _{ASS} =0V (V reference from V _{dd}) | 1150 | 1300 | 1450 | μA |
| | I _{vref} | | -10 | 0 | 10 | μA |
| IAI2 | I _{vdd} | V _{dd} =V _{AREF} =5.0V, V _{ASS} =0V (V reference from V _{REF}) | 700 | 800 | 900 | μA |
| | I _{vref} | | 450 | 500 | 550 | μA |
| RN | Resolution | V _{dd} =V _{AREF} =5.0V, V _{ASS} =0V | 8 | 9 | – | Bits |
| LN | Linearity error | V _{dd} = 2.5 to 5.5V T _a =25°C | – | ±2 | ±4 | LSB |
| DNL | Differential nonlinear error | V _{dd} = 2.5 to 5.5V T _a =25°C | – | ±0.5 | ±0.9 | LSB |
| FSE | Full scale error | V _{dd} =V _{AREF} =5.0V, V _{ASS} =0V | – | ±1 | ±2 | LSB |
| OE | Offset error | V _{dd} =V _{AREF} =5.0V, V _{ASS} =0V | – | ±1 | ±2 | LSB |
| ZAI | Recommended impedance of analog voltage source | – | – | 8 | 10 | KΩ |
| TAD1 | A/D clock period | V _{dd} =V _{AREF} =2.5~5.5V, V _{ASS} =0V | 4 | – | – | μs |
| TAD2 | A/D clock period | V _{dd} =V _{AREF} =3.0~5.5V, V _{ASS} =0V | 1 | – | – | μs |
| TCN | A/D conversion time | V _{dd} =V _{AREF} =5.0V, V _{ASS} =0V | 14 | – | 14 | TAD |
| ADIV | A/D OP input voltage range | V _{dd} =V _{AREF} =5.0V, V _{ASS} =0V | 0 | – | V _{AREF} | V |
| PSR | Power Supply Rejection | V _{dd} =5.0V±0.5V | – | – | ±2 | LSB |

Note: ¹ These parameters are theoretical values and have not been tested. Such parameters are for design reference only.

² When A/D is off, no current is consumed other than minor leakage current.

³ The A/D conversion result does not decrease with an increase in the input voltage, and there's no missing code.

⁴ Specifications are subject to change without prior notice.

Comparator Electrical Characteristics

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|--------|----------------------------------|---|------|------|------|------|
| VOS | Input offset voltage | RL = 5.1K (Note ¹) | – | – | 5 | mV |
| Vcm | Input common-mode voltages range | (Note ²) | GND | – | VDD | V |
| ICO | Supply current of Comparator | – | – | 200 | – | μA |
| TRS | Response time | Vin(-)=2.5V, Vdd=5V, CL=15p (comparator output load), overdrive=30mV (Note ³) | – | 0.7 | – | μs |
| TLRS | Large signal response time | Vin(-)=2.5V, Vdd=5V, CL=15p (comparator output load), | – | 300 | – | ns |
| VS | Operating range | – | 2.5 | – | 5.5 | V |

Note: ¹ The output voltage is in the unit gain circuitry and over the full input common-mode range.

² The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is VDD.

³ The response time specified is a 100 mV input step with 30 mV overdrive.

10 AC Electrical Characteristics

EM78F561N, $0 \leq T_a \leq 70^\circ\text{C}$, VDD=5V, VSS=0V

$-40 \leq T_a \leq 85^\circ\text{C}$, VDD=5V, VSS=0V

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|--------|---------------------------------------|---------------|--------------|------|------|------|
| Dclk | Input CLK duty cycle | – | 45 | 50 | 55 | % |
| Tins | Instruction cycle time (CLKS1:0="01") | Crystal type | 100 | – | DC | ns |
| | | RC type | 500 | – | DC | ns |
| Ttcc | TCC input period | – | (Tins+20)/N* | – | – | ns |
| Tdrh | Device reset hold time | – | 14 | 16 | 18 | ms |
| Trst | /RESET pulse width | Ta = 25°C | 2000 | – | – | ns |
| Twdt | Watchdog timer period | Ta = 25°C | 14 | 16 | 18 | ms |
| Tset | Input pin setup time | – | – | 0 | – | ns |
| Thold | Input pin hold time | – | – | 20 | – | ns |
| Tdelay | Output pin delay time | Cload = 20 pF | – | 50 | – | ns |

Note: These parameters are theoretical values and have not been tested. Such parameters are for design reference only. Data in the Minimum, Typical, Maximum ("Min.", "Typ.", "Max.") columns are based on characterization results at 25°C.

*N = selected prescaler ratio.



APPENDIX

A Package Type

| Flash MCU | Package Type | Pin Count | Package Size |
|--------------------|--------------|-----------|--------------|
| EM78F561NMS10J/S | MSOP | 10 | 118 mil |
| EM78F561NAD16J/S | DIP | 16 | 300 mil |
| EM78F561NASO16AJ/S | SOP | 16 | 150 mil |

These are Green products which do not contain hazardous substances and comply with the third edition of Sony SS-00259 standard.

The Pb content is less than 100ppm and complies with Sony specifications.

| Part No. | EM78F561NxJ/xS |
|--|----------------|
| Electroplate type | Pure Tin |
| Ingredient (%) | Sn: 100% |
| Melting point (°C) | 232°C |
| Electrical resistivity ($\mu\Omega$ cm) | 11.4 |
| Hardness (hv) | 8~10 |
| Elongation (%) | >50% |

B Packaging Configuration

B.1 EM78F561NMS10

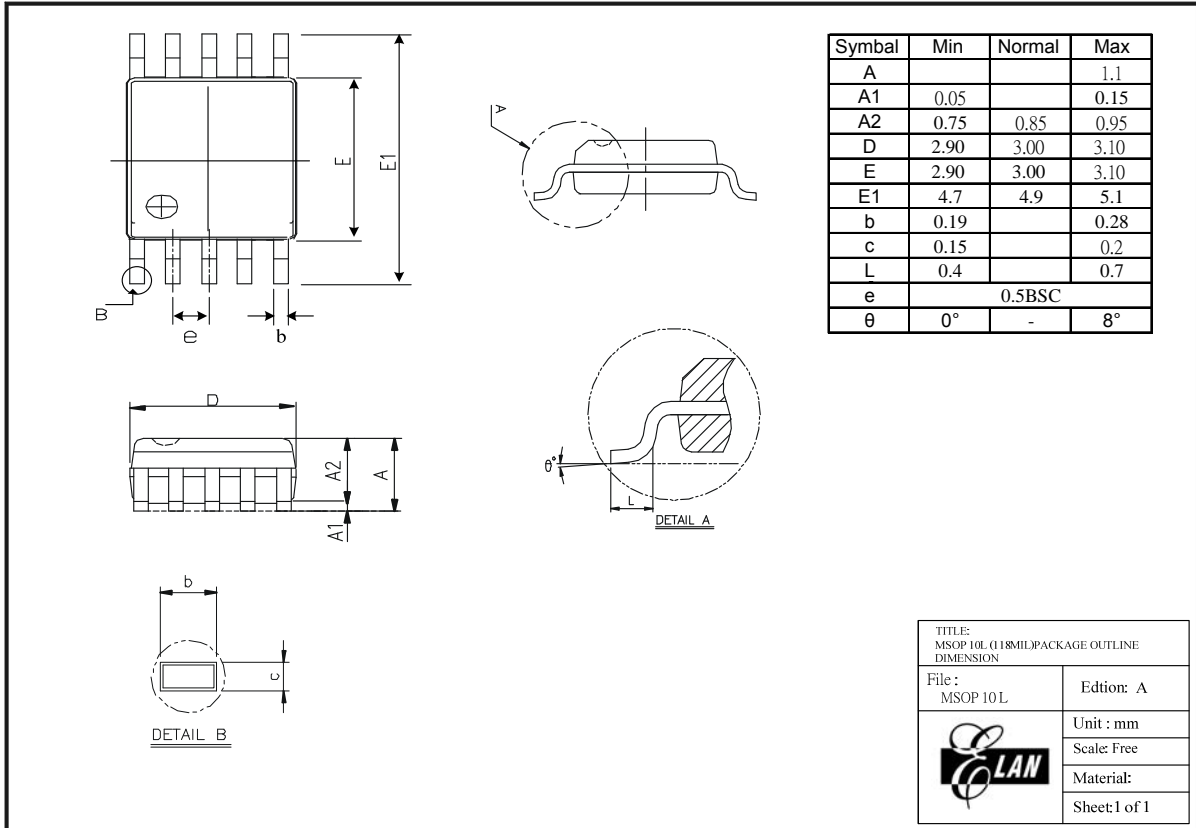


Figure B-1 EM78F561N 10-pin MSOP Package Type

B.2 EM78F561NAD16

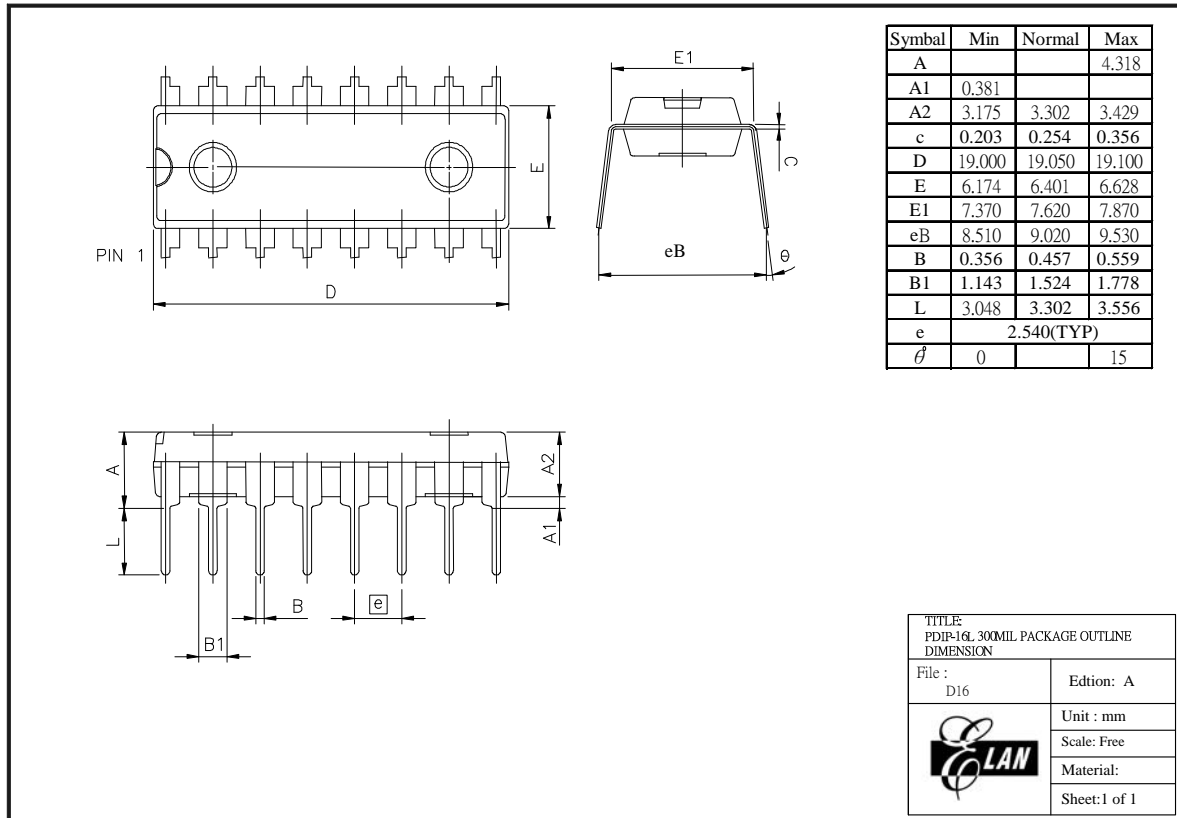


Figure B-2 EM78F561N 16-pin DIP Package Type

B.3 EM78F561NASO16A

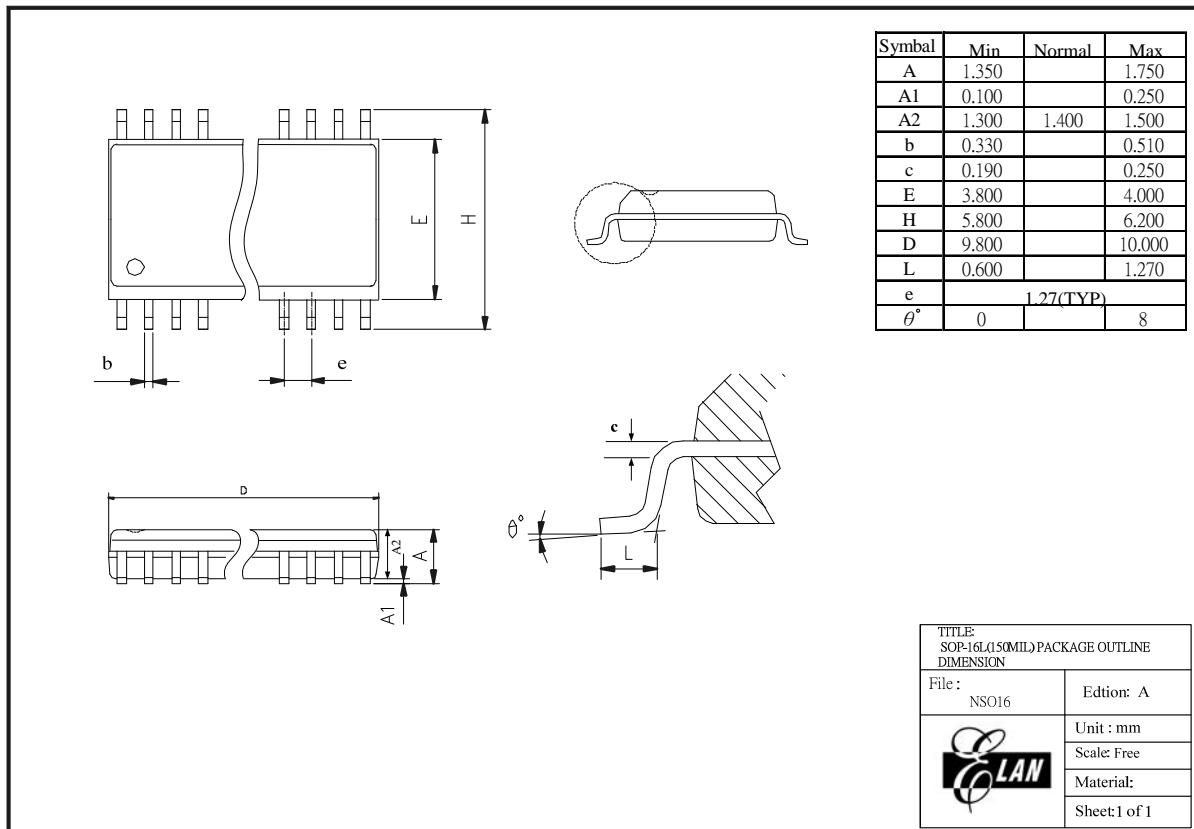


Figure B-3 EM78F561N 16-pin SOP Package Type

C Quality Assurance and Reliability

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

C.1 Address Trap Detect

An address trap detect is one of the MCU embedded fail-safe functions that detects MCU malfunction caused by noise or the like. Whenever the MCU attempts to fetch an instruction from a certain section of ROM, an internal recovery circuit is auto started. If a noise-caused address error is detected, the MCU will repeat execution of the program until the noise is eliminated. The MCU will then continue to execute the next program.