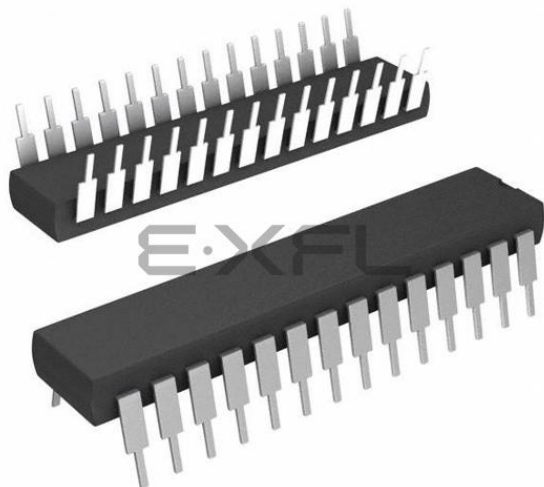




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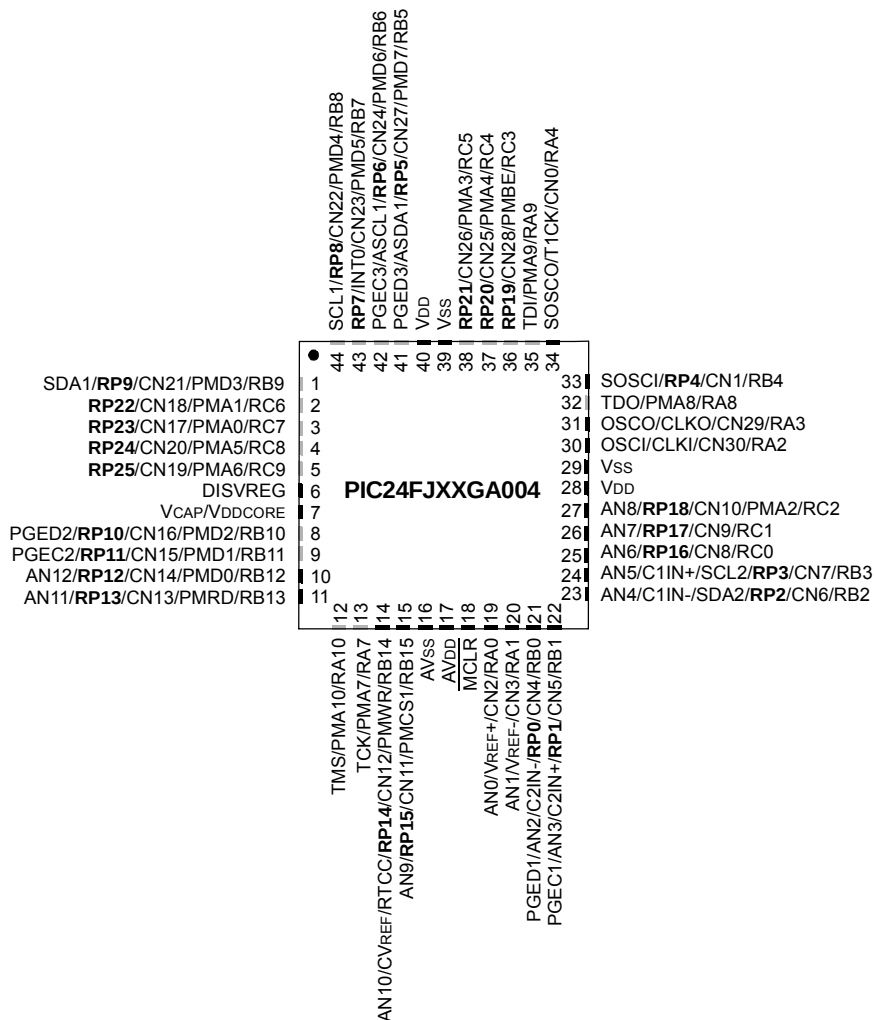
Details

Product Status	Active
Core Processor	PIC
Core Size	16-Bit
Speed	32MHz
Connectivity	I ² C, PMP, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, LVD, POR, PWM, WDT
Number of I/O	21
Program Memory Size	16KB (5.5K x 24)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	4K x 8
Voltage - Supply (Vcc/Vdd)	2V ~ 3.6V
Data Converters	A/D 10x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 125°C (TA)
Mounting Type	Through Hole
Package / Case	28-DIP (0.300", 7.62mm)
Supplier Device Package	28-SPDIP
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic24fj16ga002-e-sp

PIC24FJ64GA004 FAMILY

Pin Diagrams (Continued)

44-Pin QFN⁽¹⁾



Legend: RPn represents remappable peripheral pins. Gray shading indicates 5.5V tolerant input pins.

Note 1: Back pad on QFN devices should be connected to Vss.

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2.0 GUIDELINES FOR GETTING STARTED WITH 16-BIT MICROCONTROLLERS

2.1 Basic Connection Requirements

Getting started with the PIC24FJ64GA004 family of 16-bit microcontrollers requires attention to a minimal set of device pin connections before proceeding with development.

The following pins must always be connected:

- All VDD and VSS pins (see **Section 2.2 “Power Supply Pins”**)
- All AVDD and AVSS pins, regardless of whether or not the analog device features are used (see **Section 2.2 “Power Supply Pins”**)
- MCLR pin (see **Section 2.3 “Master Clear (MCLR) Pin”**)
- ENVREG/DISVREG and VCAP/VDDCORE pins (PIC24F J devices only) (see **Section 2.4 “Voltage Regulator Pins (ENVREG/DISVREG and VCAP/VDDCORE)”**)

These pins must also be connected if they are being used in the end application:

- PGECx/PGEDx pins used for In-Circuit Serial Programming™ (ICSP™) and debugging purposes (see **Section 2.5 “ICSP Pins”**)
- OSCI and OSCO pins when an external oscillator source is used (see **Section 2.6 “External Oscillator Pins”**)

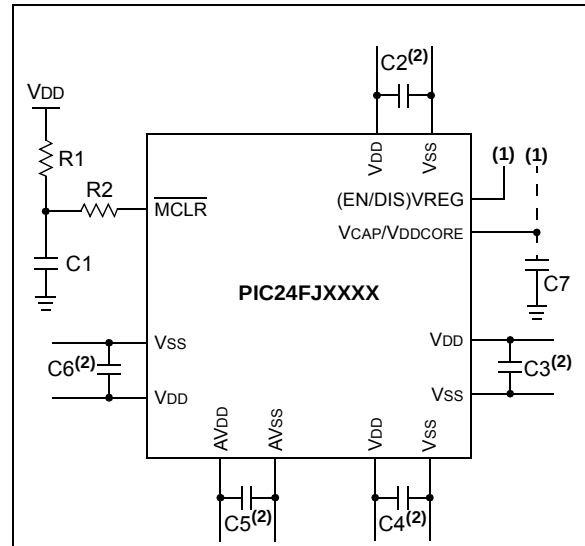
Additionally, the following pins may be required:

- VREF+/VREF- pins used when external voltage reference for analog modules is implemented

Note: The AVDD and AVSS pins must always be connected, regardless of whether any of the analog modules are being used.

The minimum mandatory connections are shown in Figure 2-1.

FIGURE 2-1: RECOMMENDED MINIMUM CONNECTIONS



Key (all values are recommendations):

C1 through C6: 0.1 μ F, 20V ceramic

C7: 10 μ F, 6.3V or greater, tantalum or ceramic

R1: 10 k Ω

R2: 100 Ω to 470 Ω

Note 1: See **Section 2.4 “Voltage Regulator Pins (ENVREG/DISVREG and VCAP/VDDCORE)”** for an explanation of the ENVREG/DISVREG pin connections.

2: The example shown is for a PIC24F device with five VDD/VSS and AVDD/AVSS pairs. Other devices may have more or less pairs; adjust the number of decoupling capacitors appropriately.

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2.4 Voltage Regulator Pins (ENVREG/DISVREG and VCAP/VDDCORE)

Note: This section applies only to PIC24F J devices with an on-chip voltage regulator.

The on-chip voltage regulator enable/disable pin (ENVREG or DISVREG, depending on the device family) must always be connected directly to either a supply voltage or to ground. The particular connection is determined by whether or not the regulator is to be used:

- For ENVREG, tie to VDD to enable the regulator, or to ground to disable the regulator
- For DISVREG, tie to ground to enable the regulator or to VDD to disable the regulator

Refer to **Section 24.2 “On-Chip Voltage Regulator”** for details on connecting and using the on-chip regulator.

When the regulator is enabled, a low-ESR ($< 5\Omega$) capacitor is required on the VCAP/VDDCORE pin to stabilize the voltage regulator output voltage. The VCAP/VDDCORE pin must not be connected to VDD and must use a capacitor of 10 μF connected to ground. The type can be ceramic or tantalum. Suitable examples of capacitors are shown in Table 2-1. Capacitors with equivalent specification can be used.

Designers may use Figure 2-3 to evaluate ESR equivalence of candidate devices.

The placement of this capacitor should be close to VCAP/VDDCORE. It is recommended that the trace length not exceed 0.25 inch (6 mm). Refer to **Section 27.0 “Electrical Characteristics”** for additional information.

When the regulator is disabled, the VCAP/VDDCORE pin must be tied to a voltage supply at the VDDCORE level. Refer to **Section 27.0 “Electrical Characteristics”** for information on VDD and VDDCORE.

FIGURE 2-3: FREQUENCY vs. ESR PERFORMANCE FOR SUGGESTED VCAP

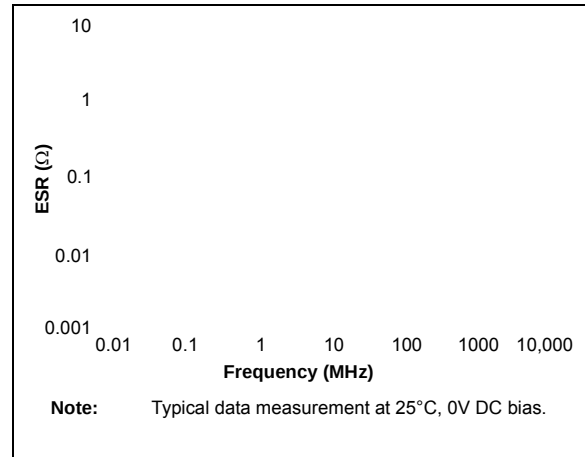


TABLE 2-1: SUITABLE CAPACITOR EQUIVALENTS

Make	Part #	Nominal Capacitance	Base Tolerance	Rated Voltage	Temp. Range
TDK	C3216X7R1C106K	10 μF	$\pm 10\%$	16V	-55 to +125°C
TDK	C3216X5R1C106K	10 μF	$\pm 10\%$	16V	-55 to +85°C
Panasonic	ECJ-3YX1C106K	10 μF	$\pm 10\%$	16V	-55 to +125°C
Panasonic	ECJ-4YB1C106K	10 μF	$\pm 10\%$	16V	-55 to +85°C
Murata	GRM32DR71C106KA01L	10 μF	$\pm 10\%$	16V	-55 to +125°C
Murata	GRM31CR61C106KC31L	10 μF	$\pm 10\%$	16V	-55 to +85°C

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REGISTER 6-1: RCON: RESET CONTROL REGISTER⁽¹⁾

R/W-0	R/W-0	U-0	U-0	U-0	U-0	R/W-0	R/W-0
TRAPR	IOPUWR	—	—	—	—	CM	PMSLP
bit 15						bit 8	

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-1	R/W-1
EXTR	SWR	SWDTEN ⁽²⁾	WDTO	SLEEP	IDLE	BOR	POR
bit 7							bit 0

Legend:

R = Readable bit

W = Writable bit

U = Unimplemented bit, read as '0'

-n = Value at POR

'1' = Bit is set

'0' = Bit is cleared

x = Bit is unknown

- bit 15 **TRAPR:** Trap Reset Flag bit
1 = A Trap Conflict Reset has occurred
0 = A Trap Conflict Reset has not occurred
- bit 14 **IOPUWR:** Illegal Opcode or Uninitialized W Access Reset Flag bit
1 = An illegal opcode detection, an illegal address mode or Uninitialized W register used as an Address Pointer caused a Reset
0 = An illegal opcode or Uninitialized W register Reset has not occurred
- bit 13-10 **Unimplemented:** Read as '0'
- bit 9 **CM:** Configuration Word Mismatch Reset Flag bit
1 = A Configuration Word Mismatch Reset has occurred
0 = A Configuration Word Mismatch Reset has not occurred
- bit 8 **PMSLP:** Program Memory Power During Sleep bit
1 = Program memory bias voltage remains powered during Sleep
0 = Program memory bias voltage is powered down during Sleep and voltage regulator enters Standby mode
- bit 7 **EXTR:** External Reset ($\overline{\text{MCLR}}$) Pin bit
1 = A Master Clear (pin) Reset has occurred
0 = A Master Clear (pin) Reset has not occurred
- bit 6 **SWR:** Software Reset (Instruction) Flag bit
1 = A RESET instruction has been executed
0 = A RESET instruction has not been executed
- bit 5 **SWDTEN:** Software Enable/Disable of WDT bit⁽²⁾
1 = WDT is enabled
0 = WDT is disabled
- bit 4 **WDTO:** Watchdog Timer Time-out Flag bit
1 = WDT time-out has occurred
0 = WDT time-out has not occurred
- bit 3 **SLEEP:** Wake from Sleep Flag bit
1 = Device has been in Sleep mode
0 = Device has not been in Sleep mode

Note 1: All of the Reset status bits may be set or cleared in software. Setting one of these bits in software does not cause a device Reset.

2: If the FWDTEN Configuration bit is '1' (unprogrammed), the WDT is always enabled, regardless of the SWDTEN bit setting.

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REGISTER 7-4: INTCON2: INTERRUPT CONTROL REGISTER 2

R/W-0	R-0	U-0	U-0	U-0	U-0	U-0	U-0
ALTIVT	DISI	—	—	—	—	—	—
bit 15							bit 8

U-0	U-0	U-0	U-0	U-0	R/W-0	R/W-0	R/W-0
—	—	—	—	—	INT2EP	INT1EP	INT0EP
bit 7							bit 0

Legend:

R = Readable bit

W = Writable bit

U = Unimplemented bit, read as '0'

-n = Value at POR

'1' = Bit is set

'0' = Bit is cleared

x = Bit is unknown

- bit 15 **ALTIVT:** Enable Alternate Interrupt Vector Table bit
 1 = Uses Alternate Interrupt Vector Table
 0 = Uses standard (default) Interrupt Vector Table
- bit 14 **DISI:** DISI Instruction Status bit
 1 = DISI instruction is active
 0 = DISI instruction is not active
- bit 13-3 **Unimplemented:** Read as '0'
- bit 2 **INT2EP:** External Interrupt 2 Edge Detect Polarity Select bit
 1 = Interrupt on negative edge
 0 = Interrupt on positive edge
- bit 1 **INT1EP:** External Interrupt 1 Edge Detect Polarity Select bit
 1 = Interrupt on negative edge
 0 = Interrupt on positive edge
- bit 0 **INT0EP:** External Interrupt 0 Edge Detect Polarity Select bit
 1 = Interrupt on negative edge
 0 = Interrupt on positive edge

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REGISTER 7-15: IPC0: INTERRUPT PRIORITY CONTROL REGISTER 0

U-0	R/W-1	R/W-0	R/W-0	U-0	R/W-1	R/W-0	R/W-0
—	T1IP2	T1IP1	T1IP0	—	OC1IP2	OC1IP1	OC1IP0
bit 15				bit 8			

U-0	R/W-1	R/W-0	R/W-0	U-0	R/W-1	R/W-0	R/W-0
—	IC1IP2	IC1IP1	IC1IP0	—	INT0IP2	INT0IP1	INT0IP0
bit 7				bit 0			

Legend:

R = Readable bit

W = Writable bit

U = Unimplemented bit, read as '0'

-n = Value at POR

'1' = Bit is set

'0' = Bit is cleared

x = Bit is unknown

bit 15 **Unimplemented:** Read as '0'

bit 14-12 **T1IP<2:0>:** Timer1 Interrupt Priority bits

111 = Interrupt is Priority 7 (highest priority interrupt)

•
•
•

001 = Interrupt is Priority 1

000 = Interrupt source is disabled

bit 11 **Unimplemented:** Read as '0'

bit 10-8 **OC1IP<2:0>:** Output Compare Channel 1 Interrupt Priority bits

111 = Interrupt is Priority 7 (highest priority interrupt)

•
•
•

001 = Interrupt is Priority 1

000 = Interrupt source is disabled

bit 7 **Unimplemented:** Read as '0'

bit 6-4 **IC1IP<2:0>:** Input Capture Channel 1 Interrupt Priority bits

111 = Interrupt is Priority 7 (highest priority interrupt)

•
•
•

001 = Interrupt is Priority 1

000 = Interrupt source is disabled

bit 3 **Unimplemented:** Read as '0'

bit 2-0 **INT0IP<2:0>:** External Interrupt 0 Priority bits

111 = Interrupt is Priority 7 (highest priority interrupt)

•
•
•

001 = Interrupt is Priority 1

000 = Interrupt source is disabled

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11.0 TIMER1

Note: This data sheet summarizes the features of this group of PIC24F devices. It is not intended to be a comprehensive reference source. For more information, refer to the “PIC24F Family Reference Manual”, “Timers” (DS39704).

The Timer1 module is a 16-bit timer which can serve as the time counter for the Real-Time Clock (RTC), or operate as a free-running, interval timer/counter. Timer1 can operate in three modes:

- 16-Bit Timer
- 16-Bit Synchronous Counter
- 16-Bit Asynchronous Counter

Timer1 also supports these features:

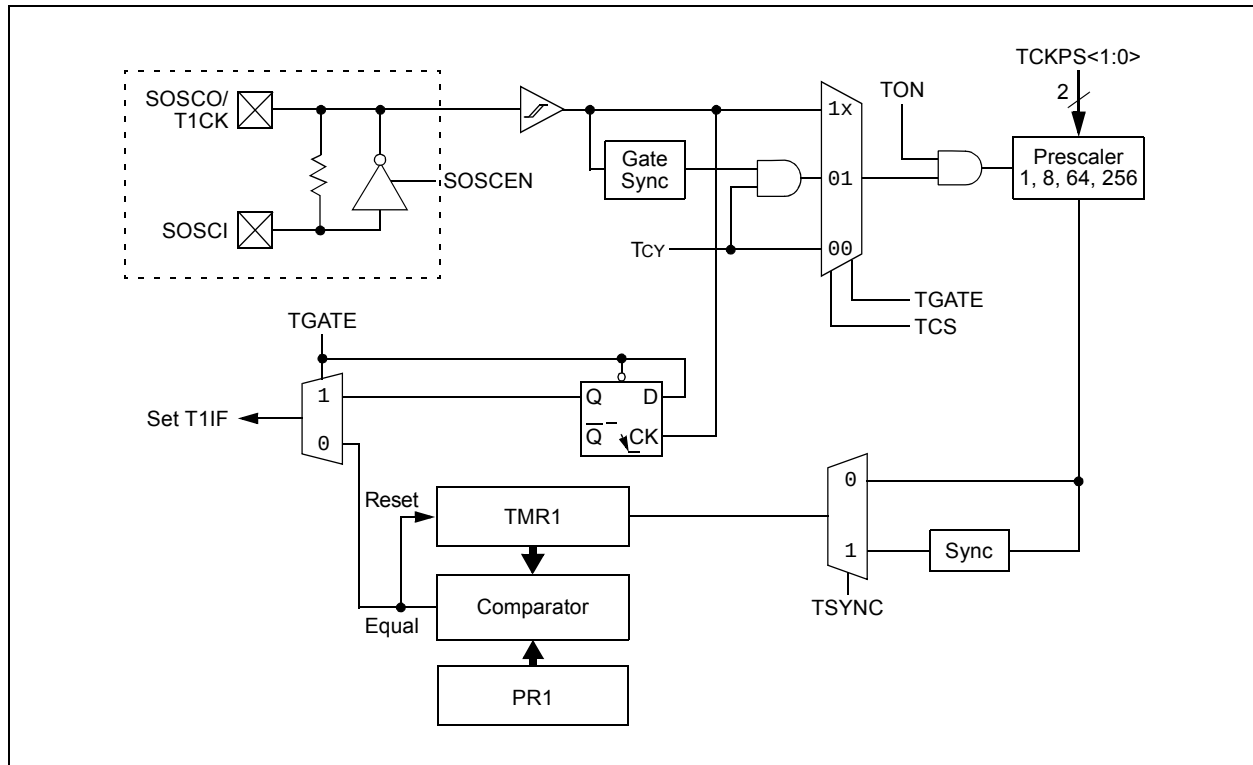
- Timer Gate Operation
- Selectable Prescaler Settings
- Timer Operation During CPU Idle and Sleep modes
- Interrupt on 16-Bit Period Register Match or Falling Edge of External Gate Signal

Figure 11-1 presents a block diagram of the 16-bit timer module.

To configure Timer1 for operation:

1. Set the TON bit (= 1).
2. Select the timer prescaler ratio using the TCKPS<1:0> bits.
3. Set the Clock and Gating modes using the TCS and TGATE bits.
4. Set or clear the TSYNC bit to configure synchronous or asynchronous operation.
5. Load the timer period value into the PR1 register.
6. If interrupts are required, set the Timer1 Interrupt Enable bit, T1IE. Use the priority bits, T1IP<2:0>, to set the interrupt priority.

FIGURE 11-1: 16-BIT TIMER1 MODULE BLOCK DIAGRAM



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NOTES:

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EXAMPLE 14-1: PWM PERIOD AND DUTY CYCLE CALCULATIONS⁽¹⁾

- Find the Timer Period register value for a desired PWM frequency of 52.08 kHz, where FOSC = 8 MHz with PLL (32 MHz device clock rate) and a Timer2 prescaler setting of 1:1.

$$T_{CY} = 2 \cdot T_{OSC} = 62.5 \text{ ns}$$

$$\text{PWM Period} = 1/\text{PWM Frequency} = 1/52.08 \text{ kHz} = 19.2 \text{ } \mu\text{s}$$

$$\text{PWM Period} = (\text{PR2} + 1) \cdot T_{CY} \cdot (\text{Timer2 Prescale Value})$$

$$19.2 \text{ } \mu\text{s} = (\text{PR2} + 1) \cdot 62.5 \text{ ns} \cdot 1$$

$$\text{PR2} = 306$$
- Find the maximum resolution of the duty cycle that can be used with a 52.08 kHz frequency and a 32 MHz device clock rate:

$$\text{PWM Resolution} = \log_{10}(\text{FCY}/\text{FPWM})/\log_{10}(2) \text{ bits}$$

$$= (\log_{10}(16 \text{ MHz}/52.08 \text{ kHz})/\log_{10}(2)) \text{ bits}$$

$$= 8.3 \text{ bits}$$

Note 1: Based on $T_{CY} = 2 \cdot T_{OSC}$; Doze mode and PLL are disabled.

TABLE 14-1: EXAMPLE PWM FREQUENCIES AND RESOLUTIONS AT 4 MIPS (FCY = 4 MHz)⁽¹⁾

PWM Frequency	7.6 Hz	61 Hz	122 Hz	977 Hz	3.9 kHz	31.3 kHz	125 kHz
Timer Prescaler Ratio	8	1	1	1	1	1	1
Period Register Value	FFFFh	FFFFh	7FFFh	0FFFh	03FFh	007Fh	001Fh
Resolution (bits)	16	16	15	12	10	7	5

Note 1: Based on $\text{FCY} = \text{FOSC}/2$; Doze mode and PLL are disabled.

TABLE 14-2: EXAMPLE PWM FREQUENCIES AND RESOLUTIONS AT 16 MIPS (FCY = 16 MHz)⁽¹⁾

PWM Frequency	30.5 Hz	244 Hz	488 Hz	3.9 kHz	15.6 kHz	125 kHz	500 kHz
Timer Prescaler Ratio	8	1	1	1	1	1	1
Period Register Value	FFFFh	FFFFh	7FFFh	0FFFh	03FFh	007Fh	001Fh
Resolution (bits)	16	16	15	12	10	7	5

Note 1: Based on $\text{FCY} = \text{FOSC}/2$; Doze mode and PLL are disabled.

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REGISTER 18-3: PMADDR: PARALLEL PORT ADDRESS REGISTER

U-0	R/W-0	U-0	U-0	U-0	R/W-0	R/W-0	R/W-0
—	CS1	—	—	—	ADDR10 ⁽¹⁾	ADDR9 ⁽¹⁾	ADDR8 ⁽¹⁾
bit 15							bit 8

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
ADDR7 ⁽¹⁾	ADDR6 ⁽¹⁾	ADDR5 ⁽¹⁾	ADDR4 ⁽¹⁾	ADDR3 ⁽¹⁾	ADDR2 ⁽¹⁾	ADDR1 ⁽¹⁾	ADDR0 ⁽¹⁾
bit 7							bit 0

Legend:

R = Readable bit

W = Writable bit

U = Unimplemented bit, read as '0'

-n = Value at POR

'1' = Bit is set

'0' = Bit is cleared

x = Bit is unknown

bit 15 **Unimplemented:** Read as '0'

bit 14 **CS1:** Chip Select 1 bit

1 = Chip Select 1 is active

0 = Chip Select 1 is inactive

bit 13-11 **Unimplemented:** Read as '0'

bit 10-0 **ADDR<10:0>:** Parallel Port Destination Address bits⁽¹⁾

Note 1: PMA<10:2> bits are not available on 28-pin devices.

REGISTER 18-4: PMAEN: PARALLEL PORT ENABLE REGISTER

U-0	R/W-0	U-0	U-0	U-0	R/W-0	R/W-0	R/W-0
—	PTEN14	—	—	—	PTEN10 ⁽¹⁾	PTEN9 ⁽¹⁾	PTEN8 ⁽¹⁾
bit 15							bit 8

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
PTEN7 ⁽¹⁾	PTEN6 ⁽¹⁾	PTEN5 ⁽¹⁾	PTEN4 ⁽¹⁾	PTEN3 ⁽¹⁾	PTEN2 ⁽¹⁾	PTEN1	PTEN0
bit 7							bit 0

Legend:

R = Readable bit

W = Writable bit

U = Unimplemented bit, read as '0'

-n = Value at POR

'1' = Bit is set

'0' = Bit is cleared

x = Bit is unknown

bit 15 **Unimplemented:** Read as '0'

bit 14 **PTEN14:** PMCS1 Strobe Enable bit

1 = PMCS1 pin functions as chip select

0 = PMCS1 pin functions as port I/O

bit 13-11 **Unimplemented:** Read as '0'

bit 10-2 **PTEN<10:2>:** PMP Address Port Enable bits⁽¹⁾

1 = PMA<10:2> function as PMP address lines

0 = PMA<10:2> function as port I/O

bit 1-0 **PTEN<1:0>:** PMALH/PMALL Strobe Enable bits

1 = PMA1 and PMA0 function as either PMA<1:0> or PMALH and PMALL

0 = PMA1 and PMA0 pads functions as port I/O

Note 1: PMA<10:2> bits are not available on 28-pin devices.

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19.1 RTCC Module Registers

The RTCC module registers are organized into three categories:

- RTCC Control Registers
- RTCC Value Registers
- Alarm Value Registers

19.1.1 REGISTER MAPPING

To limit the register interface, the RTCC Timer and Alarm Time registers are accessed through corresponding register pointers. The RTCC Value register window (RTCVALH and RTCVALL) uses the RTCPTR<1:0> bits (RCFGCAL<9:8>) to select the desired Timer register pair (see Table 19-1).

By writing the RTCVALH byte, the RTCC Pointer value (the RTCPTR<1:0> bits) decrements by one until the bits reach '00'. Once they reach '00', the MINUTES and SECONDS value will be accessible through RTCVALH and RTCVALL until the pointer value is manually changed.

TABLE 19-1: RTCVAL REGISTER MAPPING

RTCPTR <1:0>	RTCC Value Register Window	
	RTCVAL<15:8>	RTCVAL<7:0>
00	MINUTES	SECONDS
01	WEEKDAY	HOURS
10	MONTH	DAY
11	—	YEAR

The Alarm Value register window (ALRMVALH and ALRMVALL) uses the ALRMPTR bits (ALCFG RPT<9:8>) to select the desired Alarm register pair (see Table 19-2).

By writing the ALRMVALH byte, the Alarm Pointer value (the ALRMPTR<1:0> bits) decrements by one until the bits reach '00'. Once they reach '00', the ALRMMIN and ALRMSEC value will be accessible through ALRMVALH and ALRMVALL until the pointer value is manually changed.

EXAMPLE 19-1: SETTING THE RTCWREN BIT

```
asm volatile("push w7");
asm volatile("push w8");
asm volatile("disi #5");
asm volatile("mov #0x55, w7");
asm volatile("mov w7, _NVMKEY");
asm volatile("mov #0xAA, w8");
asm volatile("mov w8, _NVMKEY");
asm volatile("bset _RCFGCAL, #13"); //set the RTCWREN bit
asm volatile("pop w8");
asm volatile("pop w7");
```

TABLE 19-2: ALRMVAL REGISTER MAPPING

ALRMPTR <1:0>	Alarm Value Register Window	
	ALRMVAL<15:8>	ALRMVAL<7:0>
00	ALRMMIN	ALRMSEC
01	ALRMWD	ALRMHR
10	ALRMMNTH	ALRMDAY
11	—	—

Considering that the 16-bit core does not distinguish between 8-bit and 16-bit read operations, the user must be aware that when reading either the ALRMVALH or ALRMVALL, the bytes will decrement the ALRMPTR<1:0> value. The same applies to the RTCVALH or RTCVALL bytes with the RTCPTR<1:0> being decremented.

Note: This only applies to read operations and not write operations.

19.1.2 WRITE LOCK

In order to perform a write to any of the RTCC Timer registers, the RTCWREN bit (RCFGCAL<13>) must be set (refer to Example 19-1).

Note: To avoid accidental writes to the timer, it is recommended that the RTCWREN bit (RCFGCAL<13>) is kept clear at any other time. For the RTCWREN bit to be set, there is only 1 instruction cycle time window allowed between the 55h/AA sequence and the setting of RTCWREN; therefore, it is recommended that code follow the procedure in Example 19-1.

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REGISTER 21-3: AD1CON3: A/D CONTROL REGISTER 3

R/W-0	U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
ADRC	—	—	SAMC4	SAMC3	SAMC2	SAMC1	SAMC0
bit 15							bit 8

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
ADCS7	ADCS6	ADCS5	ADCS4	ADCS3	ADCS2	ADCS1	ADCS0
bit 7							bit 0

Legend:

R = Readable bit

W = Writable bit

U = Unimplemented bit, read as '0'

-n = Value at POR

'1' = Bit is set

'0' = Bit is cleared

x = Bit is unknown

bit 15 **ADRC:** A/D Conversion Clock Source bit

1 = A/D internal RC clock

0 = Clock derived from system clock

bit 14-13 **Unimplemented:** Read as '0'

bit 12-8 **SAMC<4:0>:** Auto-Sample Time bits

11111 = 31 TAD

.....

00001 = 1 TAD

00000 = 0 TAD (not recommended)

bit 7-0 **ADCS<7:0>:** A/D Conversion Clock Select bits

11111111

..... = Reserved

01000000

00111111 = 64 • T_{CY}

.....

00000001 = 2 • T_{CY}

00000000 = T_{CY}

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REGISTER 24-1: CW1: FLASH CONFIGURATION WORD 1

U-1	U-1	U-1	U-1	U-1	U-1	U-1	U-1
—	—	—	—	—	—	—	—
bit 23							bit 16

r-x	R/PO-1	R/PO-1	R/PO-1	R/PO-1	r-1	R/PO-1	R/PO-1
r	JTAGEN	GCP	GWRP	DEBUG	r	ICS1	ICS0
bit 15							bit 8

R/PO-1	R/PO-1	r	R/PO-1	R/PO-1	R/PO-1	R/PO-1	R/PO-1
FWDTEN	WINDIS	r	FWPSA	WDTPS3	WDTPS2	WDTPS1	WDTPS0
bit 7							bit 0

Legend: r = Reserved bit
R = Readable bit PO = Program Once bit U = Unimplemented bit, read as '0'
-n = Value when device is unprogrammed '1' = Bit is set '0' = Bit is cleared

- bit 23-16 **Unimplemented:** Read as '1'
- bit 15 **Reserved:** The value is unknown; program as '0'
- bit 14 **JTAGEN:** JTAG Port Enable bit
1 = JTAG port is enabled
0 = JTAG port is disabled
- bit 13 **GCP:** General Segment Program Memory Code Protection bit
1 = Code protection is disabled
0 = Code protection is enabled for the entire program memory space
- bit 12 **GWRP:** General Segment Code Flash Write Protection bit
1 = Writes to program memory are allowed
0 = Writes to program memory are disabled
- bit 11 **DEBUG:** Background Debugger Enable bit
1 = Device resets into Operational mode
0 = Device resets into Debug mode
- bit 10 **Reserved:** Always maintain as '1'
- bit 9-8 **ICS<1:0>:** Emulator Pin Placement Select bits
11 = Emulator EMUC1/EMUD1 pins are shared with PGC1/PGD1
10 = Emulator EMUC2/EMUD2 pins are shared with PGC2/PGD2
01 = Emulator EMUC3/EMUD3 pins are shared with PGC3/PGD3
00 = Reserved; do not use
- bit 7 **FWDTEN:** Watchdog Timer Enable bit
1 = Watchdog Timer is enabled
0 = Watchdog Timer is disabled
- bit 6 **WINDIS:** Windowed Watchdog Timer Disable bit
1 = Standard Watchdog Timer is enabled
0 = Windowed Watchdog Timer is enabled; FWDTEN must be '1'
- bit 5 **Reserved**
- bit 4 **FWPSA:** WDT Prescaler Ratio Select bit
1 = Prescaler ratio of 1:128
0 = Prescaler ratio of 1:32

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24.2 On-Chip Voltage Regulator

All of the PIC24FJ64GA004 family devices power their core digital logic at a nominal 2.5V. This may create an issue for designs that are required to operate at a higher typical voltage, such as 3.3V. To simplify system design, all devices in the PIC24FJ64GA004 family incorporate an on-chip regulator that allows the device to run its core logic from VDD.

The regulator is controlled by the DISVREG pin. Tying VSS to the pin enables the regulator, which in turn, provides power to the core from the other VDD pins. When the regulator is enabled, a low-ESR capacitor (such as ceramic) must be connected to the VDDCORE/VCAP pin (Figure 24-1). This helps to maintain the stability of the regulator. The recommended value for the filter capacitor is provided in **Section 27.1 “DC Characteristics”**.

If DISVREG is tied to VDD, the regulator is disabled. In this case, separate power for the core logic at a nominal 2.5V must be supplied to the device on the VDDCORE/VCAP pin to run the I/O pins at higher voltage levels, typically 3.3V. Alternatively, the VDDCORE/VCAP and VDD pins can be tied together to operate at a lower nominal voltage. Refer to Figure 24-1 for possible configurations.

24.2.1 VOLTAGE REGULATOR TRACKING MODE AND LOW-VOLTAGE DETECTION

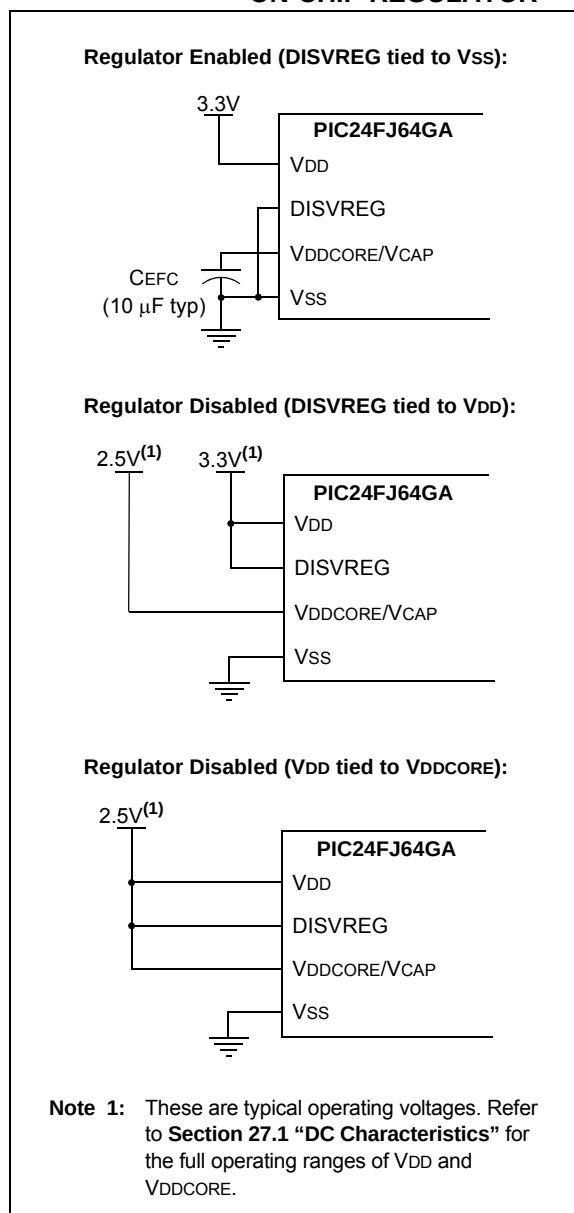
When it is enabled, the on-chip regulator provides a constant voltage of 2.5V nominal to the digital core logic.

The regulator can provide this level from a VDD of about 2.5V, all the way up to the device's VDDMAX. It does not have the capability to boost VDD levels below 2.5V. In order to prevent “brown out” conditions, when the voltage drops too low for the regulator, the regulator enters Tracking mode. In Tracking mode, the regulator output follows VDD, with a typical voltage drop of 100 mV.

When the device enters Tracking mode, it is no longer possible to operate at full speed. To provide information about when the device enters Tracking mode, the on-chip regulator includes a simple, Low-Voltage Detect (LVD) circuit. When VDD drops below full-speed operating voltage, the circuit sets the Low-Voltage Detect Interrupt Flag, LVDIF (IFS4<8>). This can be used to generate an interrupt and put the application into a low-power operational mode or trigger an orderly shutdown.

Low-Voltage Detection is only available when the regulator is enabled.

FIGURE 24-1: CONNECTIONS FOR THE ON-CHIP REGULATOR



24.2.2 ON-CHIP REGULATOR AND BOR

When the on-chip regulator is enabled, PIC24FJ64GA004 family devices also have a simple brown-out capability. If the voltage supplied to the regulator is inadequate to maintain the tracking level, the regulator Reset circuitry will generate a Brown-out Reset. This event is captured by the BOR flag bit (RCON<1>). The brown-out voltage levels are specified in **Section 27.1 “DC Characteristics”**.

26.0 INSTRUCTION SET SUMMARY

Note: This chapter is a brief summary of the PIC24F Instruction Set Architecture (ISA) and is not intended to be a comprehensive reference source.

The PIC24F instruction set adds many enhancements to the previous PIC® MCU instruction sets, while maintaining an easy migration from previous PIC MCU instruction sets. Most instructions are a single program memory word. Only three instructions require two program memory locations.

Each single-word instruction is a 24-bit word divided into an 8-bit opcode, which specifies the instruction type and one or more operands, which further specify the operation of the instruction. The instruction set is highly orthogonal and is grouped into four basic categories:

- Word or byte-oriented operations
- Bit-oriented operations
- Literal operations
- Control operations

Table 26-1 shows the general symbols used in describing the instructions. The PIC24F instruction set summary in Table 26-2 lists all the instructions, along with the status flags affected by each instruction.

Most word or byte-oriented W register instructions (including barrel shift instructions) have three operands:

- The first source operand which is typically a register 'Wb' without any address modifier
- The second source operand which is typically a register 'Ws' with or without an address modifier
- The destination of the result which is typically a register 'Wd' with or without an address modifier

However, word or byte-oriented file register instructions have two operands:

- The file register specified by the value, 'f'
- The destination, which could either be the file register 'f' or the W0 register, which is denoted as 'WREG'

Most bit-oriented instructions (including simple rotate/shift instructions) have two operands:

- The W register (with or without an address modifier) or file register (specified by the value of 'Ws' or 'f')
- The bit in the W register or file register (specified by a literal value or indirectly by the contents of register, 'Wb')

The literal instructions that involve data movement may use some of the following operands:

- A literal value to be loaded into a W register or file register (specified by the value of 'k')
- The W register or file register where the literal value is to be loaded (specified by 'Wb' or 'f')

However, literal instructions that involve arithmetic or logical operations use some of the following operands:

- The first source operand which is a register 'Wb' without any address modifier
- The second source operand which is a literal value
- The destination of the result (only if not the same as the first source operand) which is typically a register 'Wd' with or without an address modifier

The control instructions may use some of the following operands:

- A program memory address
- The mode of the table read and table write instructions

All instructions are a single word, except for certain double-word instructions, which were made double-word instructions so that all the required information is available in these 48 bits. In the second word, the 8 MSBs are '0's. If this second word is executed as an instruction (by itself), it will execute as a NOP.

Most single-word instructions are executed in a single instruction cycle, unless a conditional test is true or the Program Counter (PC) is changed as a result of the instruction. In these cases, the execution takes two instruction cycles, with the additional instruction cycle(s) executed as a NOP. Notable exceptions are the BRA (unconditional/computed branch), indirect CALL/GOTO, all table reads and writes, and RETURN/RETFIE instructions, which are single-word instructions but take two or three cycles.

Certain instructions that involve skipping over the subsequent instruction require either two or three cycles if the skip is performed, depending on whether the instruction being skipped is a single-word or two-word instruction. Moreover, double-word moves require two cycles. The double-word instructions execute in two instruction cycles.

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TABLE 27-6: DC CHARACTERISTICS: POWER-DOWN CURRENT (IPD)

DC CHARACTERISTICS			Standard Operating Conditions: 2.0V to 3.6V (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended			
Parameter No.	Typical ⁽¹⁾	Max	Units	Conditions		
Power-Down Current (IPD): PMD Bits are Set, PMSLP Bit is '0' ⁽²⁾						
DC60	0.1	1	μA	-40°C	2.0V ⁽³⁾	Base Power-Down Current ⁽⁵⁾
DC60a	0.15	1	μA	+25°C		
DC60m	2.2	7.4	μA	+60°C		
DC60b	3.7	12	μA	+85°C		
DC60j	15	50	μA	+125°C		
DC60c	0.2	1	μA	-40°C	2.5V ⁽³⁾	
DC60d	0.25	1	μA	+25°C		
DC60n	2.6	15	μA	+60°C		
DC60e	4.2	25	μA	+85°C		
DC60k	16	100	μA	+125°C		
DC60f	3.3	9	μA	-40°C	3.3V ⁽⁴⁾	
DC60g	3.5	10	μA	+25°C		
DC60o	6.7	22	μA	+60°C		
DC60h	9	30	μA	+85°C		
DC60l	36	120	μA	+125°C		
DC61	1.75	3	μA	-40°C	2.0V ⁽³⁾	Watchdog Timer Current: ΔI _{WDT} ⁽⁵⁾
DC61a	1.75	3	μA	+25°C		
DC61m	1.75	3	μA	+60°C		
DC61b	1.75	3	μA	+85°C		
DC61j	3.5	6	μA	+125°C		
DC61c	2.4	4	μA	-40°C	2.5V ⁽³⁾	
DC61d	2.4	4	μA	+25°C		
DC61n	2.4	4	μA	+60°C		
DC61e	2.4	4	μA	+85°C		
DC61k	4.8	8	μA	+125°C		
DC61f	2.8	5	μA	-40°C	3.3V ⁽⁴⁾	
DC61g	2.8	5	μA	+25°C		
DC61o	2.8	5	μA	+60°C		
DC61h	2.8	5	μA	+85°C		
DC61l	5.6	10	μA	+125°C		

Note 1: Data in the Typical column is at 3.3V, +25°C unless otherwise stated. Parameters are for design guidance only and are not tested.

2: Base IPD is measured with all peripherals and clocks shut down. All I/Os are configured as inputs and pulled high. WDT, etc., are all switched off.

3: On-chip voltage regulator is disabled (DISVREG tied to VDD).

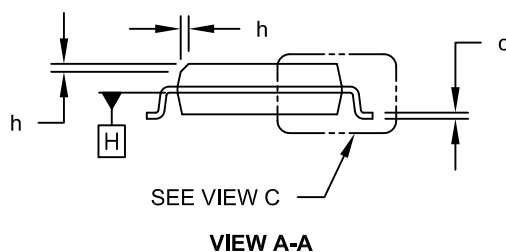
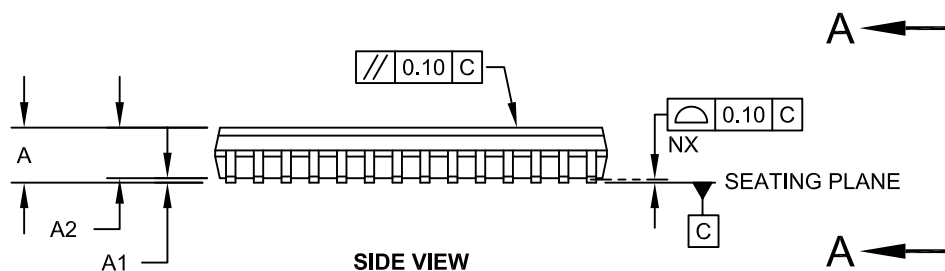
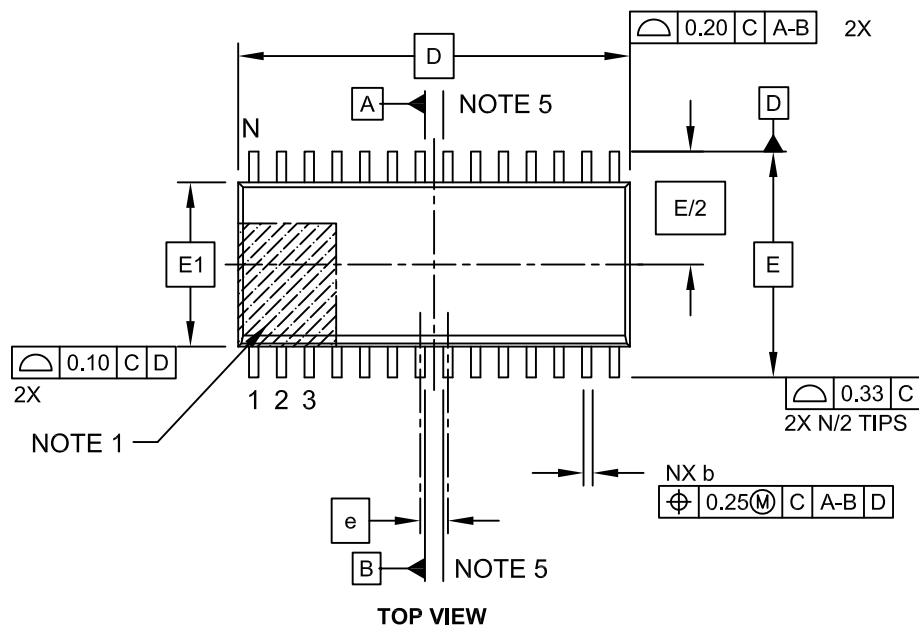
4: On-chip voltage regulator is enabled (DISVREG tied to VSS). Low-Voltage Detect (LVD) and Brown-out Detect (BOD) are enabled.

5: The Δ current is the additional current consumed when the module is enabled. This current should be added to the base IPD current.

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28-Lead Plastic Small Outline (SO) - Wide, 7.50 mm Body [SOIC]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



Microchip Technology Drawing C04-052C Sheet 1 of 2

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