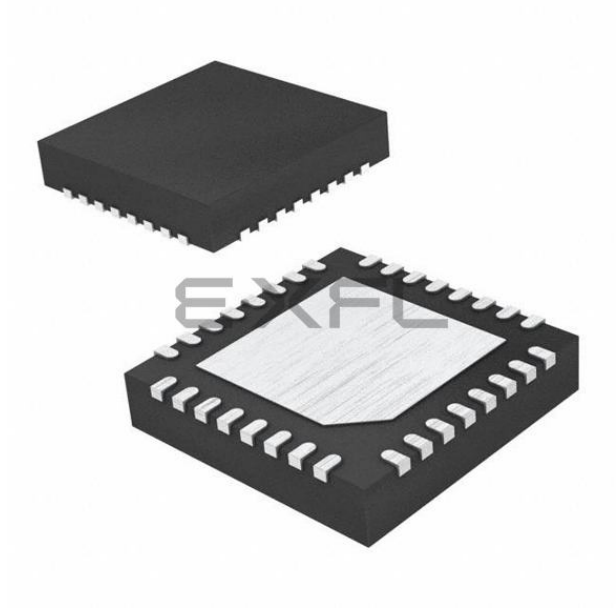
Microchip Technology - PIC24HJ64GP502T-I/MM Datasheet



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What is "Embedded - Microcontrollers"?

"Embedded - Microcontrollers" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable input/output peripherals. They are called "embedded" because they are embedded within electronic devices to control various functions, rather than serving as standalone computers. Microcontrollers are crucial in modern electronics, providing the intelligence and control needed for a wide range of applications.

Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	PIC
Core Size	16-Bit
Speed	40 MIPs
Connectivity	CANbus, I²C, IrDA, LINbus, PMP, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, DMA, POR, PWM, WDT
Number of I/O	21
Program Memory Size	64KB (22K x 24)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	8K x 8
Voltage - Supply (Vcc/Vdd)	3V ~ 3.6V
Data Converters	A/D 10x10b/12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	28-VQFN Exposed Pad
Supplier Device Package	28-QFN-S (6x6)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic24hj64gp502t-i-mm

1.0 DEVICE OVERVIEW

Note 1: This data sheet summarizes the features of the PIC24HJ32GP302/304, PIC24HJ64GPX02/X04 and PIC24HJ128GPX02/X04 families of devices. It is not intended to be a comprehensive reference source. To complement the information in this data sheet, refer to the *"dsPIC33F/PIC24H Family Reference Manual"*. Please see the Microchip web site (www.microchip.com) for the latest dsPIC33F/PIC24H Family Reference Manual sections.

2: Some registers and associated bits described in this section may not be available on all devices. Refer to **Section 4.0 "Memory Organization"** in this data sheet for device-specific register and bit information.

This document contains device specific information for the PIC24HJ32GP302/304, PIC24HJ64GPX02/X04 and PIC24HJ128GPX02/X04 devices.

Figure 1-1 shows a general block diagram of the core and peripheral modules in the PIC24HJ32GP302/304, PIC24HJ64GPX02/X04 and PIC24HJ128GPX02/X04 families of devices.

Table 1-1 lists the functions of the various pins shown in the pinout diagrams.

TABLE 4-10: UART2 REGISTER MAP

SFR Name	SFR Addr	Bit 15	Bit 14	Bit 13	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	All Resets
U2MODE	0230	UARTEN	—	USIDL	IREN	RTSMD	—	UEN1	UEN0	WAKE	LPBACK	ABAUD	URXINV	BRGH	PDSEL<1:0>		STSEL	0000
U2STA	0232	UTXISEL1	UTXINV	UTXISEL0	—	UTXBRK	UTXEN	UTXBF	TRMT	URXISEL<1:0>		ADDEN	RIDLE	PERR	FERR	OERR	URXDA	0110
U2TXREG	0234	—	—	—	—	—	—	—	UTX8	UART Transmit Register								xxxx
U2RXREG	0236	—	—	—	—	—	—	—	URX8	UART Receive Register								0000
U2BRG	0238	Baud Rate Generator Prescaler																0000

Legend: x = unknown value on Reset, — = unimplemented, read as '0'. Reset values are shown in hexadecimal.

TABLE 4-11: SPI1 REGISTER MAP

SFR Name	SFR Addr	Bit 15	Bit 14	Bit 13	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	All Resets
SPI1STAT	0240	SPIEN	—	SPISIDL	—	—	—	—	—	—	SPIROV	—	—	—	—	SPITBF	SPIRBF	0000
SPI1CON1	0242	—	—	—	DISSCK	DISSDO	MODE16	SMP	CKE	SSEN	CKP	MSTEN	SPRE<2:0>			PPRE<1:0>		0000
SPI1CON2	0244	FRMEN	SPIFSD	FRMPOL	—	—	—	—	—	—	—	—	—	—	—	FRMDLY	—	0000
SPI1BUF	0248	SPI1 Transmit and Receive Buffer Register																0000

Legend: x = unknown value on Reset, — = unimplemented, read as '0'. Reset values are shown in hexadecimal.

TABLE 4-12: SPI2 REGISTER MAP

SFR Name	SFR Addr	Bit 15	Bit 14	Bit 13	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	All Resets
SPI2STAT	0260	SPIEN	—	SPISIDL	—	—	—	—	—	—	SPIROV	—	—	—	—	SPITBF	SPIRBF	0000
SPI2CON1	0262	—	—	—	DISSCK	DISSDO	MODE16	SMP	CKE	SSEN	CKP	MSTEN	SPRE<2:0>			PPRE<1:0>		0000
SPI2CON2	0264	FRMEN	SPIFSD	FRMPOL	—	—	—	—	—	—	—	—	—	—	—	FRMDLY	—	0000
SPI2BUF	0268	SPI2 Transmit and Receive Buffer Register																0000

Legend: x = unknown value on Reset, — = unimplemented, read as '0'. Reset values are shown in hexadecimal.

5.6 Flash Memory Control Registers

REGISTER 5-1: NVMCON: FLASH MEMORY CONTROL REGISTER

R/SO-0(1)	R/W-0(1)	R/W-0(1)	U-0	U-0	U-0	U-0	U-0
WR	WREN	WRERR	—	—	—	—	—
bit 15							bit 8

U-0	R/W-0(1)	U-0	U-0	R/W-0(1)	R/W-0(1)	R/W-0(1)	R/W-0(1)
—	ERASE	—	—	NVMOP<3:0>(2)			
bit 7							bit 0

Legend:	SO = Settable only bit		
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 **WR:** Write Control bit
1 = Initiates a Flash memory program or erase operation. The operation is self-timed and the bit is cleared by hardware once operation is complete
0 = Program or erase operation is complete and inactive

bit 14 **WREN:** Write Enable bit
1 = Enable Flash program/erase operations
0 = Inhibit Flash program/erase operations

bit 13 **WRERR:** Write Sequence Error Flag bit
1 = An improper program or erase sequence attempt or termination has occurred (bit is set automatically on any set attempt of the WR bit)
0 = The program or erase operation completed normally

bit 12-7 **Unimplemented:** Read as '0'

bit 6 **ERASE:** Erase/Program Enable bit
1 = Perform the erase operation specified by NVMOP<3:0> on the next WR command
0 = Perform the program operation specified by NVMOP<3:0> on the next WR command

bit 5-4 **Unimplemented:** Read as '0'

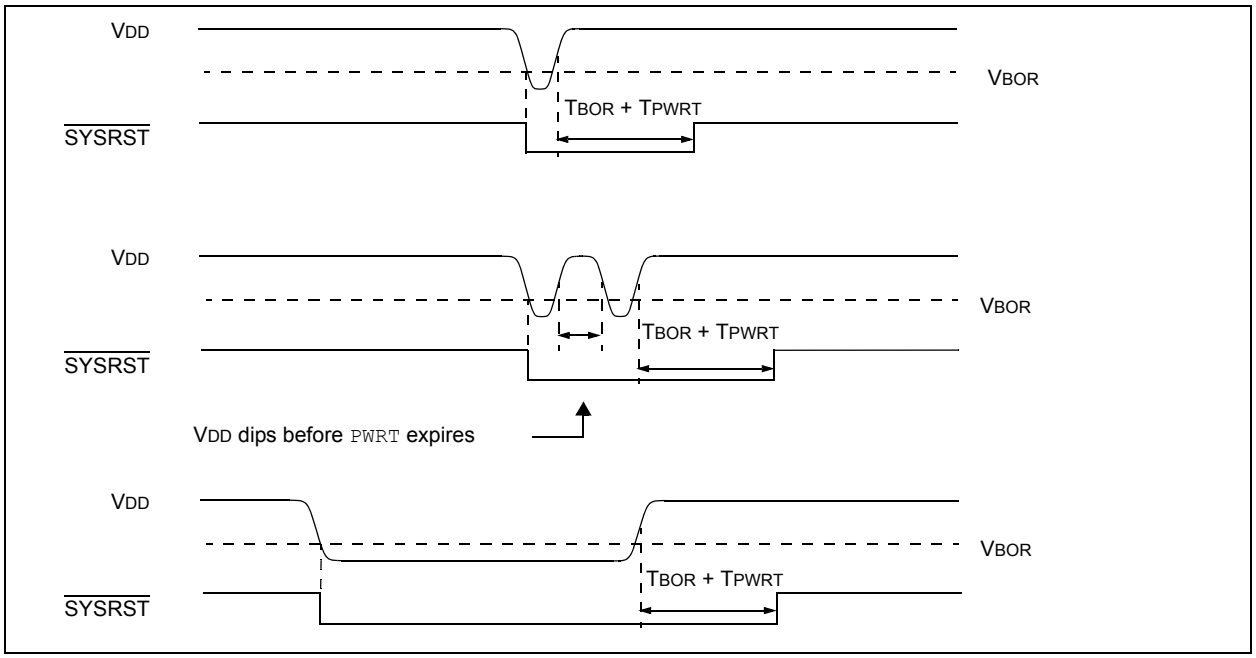
bit 3-0 **NVMOP<3:0>:** NVM Operation Select bits(2)

If ERASE = 1:
1111 = Memory bulk erase operation
1110 = Reserved
1101 = Erase General Segment
1100 = Erase Secure Segment
1011 = Reserved
0011 = No operation
0010 = Memory page erase operation
0001 = No operation
0000 = Erase a single Configuration register byte

If ERASE = 0:
1111 = No operation
1110 = Reserved
1101 = No operation
1100 = No operation
1011 = Reserved
0011 = Memory word program operation
0010 = No operation
0001 = Memory row program operation
0000 = Program a single Configuration register byte

Note 1: These bits can only be reset on a POR.
2: All other combinations of NVMOP<3:0> are unimplemented.

FIGURE 6-3: BROWN-OUT SITUATIONS



6.5 External Reset (EXTR)

The external Reset is generated by driving the $\overline{MCLR}$ pin low. The $\overline{MCLR}$ pin is a Schmitt trigger input with an additional glitch filter. Reset pulses that are longer than the minimum pulse width will generate a Reset. Refer to **Section 28.0 "Electrical Characteristics"** for minimum pulse width specifications. The External Reset ($\overline{MCLR}$) Pin (EXTR) bit in the Reset Control (RCON) register is set to indicate the $\overline{MCLR}$ Reset.

6.5.1 EXTERNAL SUPERVISORY CIRCUIT

Many systems have external supervisory circuits that generate reset signals to reset multiple devices in the system. This external Reset signal can be directly connected to the $\overline{MCLR}$ pin to reset the device when the rest of system is Reset.

6.5.2 INTERNAL SUPERVISORY CIRCUIT

When using the internal power supervisory circuit to reset the device, the external reset pin ($\overline{MCLR}$) should be tied directly or resistively to VDD. In this case, the $\overline{MCLR}$ pin will not be used to generate a Reset. The external reset pin ($\overline{MCLR}$) does not have an internal pull-up and must not be left unconnected.

6.6 Software RESET Instruction (SWR)

Whenever the RESET instruction is executed, the device will assert $\overline{SYSRST}$, placing the device in a special Reset state. This Reset state will not re-initialize the clock. The clock source in effect prior to the RESET instruction will remain. $\overline{SYSRST}$ is released at the next instruction cycle, and the reset vector fetch will commence.

The Software Reset (Instruction) Flag bit (SWR) in the Reset Control register (RCON<6>) is set to indicate the software Reset.

6.7 Watchdog Time-out Reset (WDTO)

Whenever a Watchdog time-out occurs, the device will asynchronously assert $\overline{SYSRST}$. The clock source will remain unchanged. A WDT time-out during Sleep or Idle mode will wake-up the processor, but will not reset the processor.

The Watchdog Timer Time-out Flag bit (WDTO) in the Reset Control register (RCON<4>) is set to indicate the Watchdog Reset. Refer to **Section 25.4 "Watchdog Timer (WDT)"** for more information on Watchdog Reset.

6.8 Trap Conflict Reset

If a lower-priority hard trap occurs while a higher-priority trap is being processed, a hard trap conflict Reset occurs. The hard traps include exceptions of priority level 13 through level 15, inclusive. The address error (level 13) and oscillator error (level 14) traps fall into this category.

The Trap Reset Flag bit (TRAPR) in the Reset Control register (RCON<15>) is set to indicate the Trap Conflict Reset. Refer to **Section 7.0 "Interrupt Controller"** for more information on trap conflict Resets.

6.9 Configuration Mismatch Reset

To maintain the integrity of the peripheral pin select control registers, they are constantly monitored with shadow registers in hardware. If an unexpected change in any of the registers occur (such as cell disturbances caused by ESD or other external events), a configuration mismatch Reset occurs.

The Configuration Mismatch Flag bit (CM) in the Reset Control register (RCON<9>) is set to indicate the configuration mismatch Reset. Refer to **Section 11.0 "I/O Ports"** for more information on the configuration mismatch Reset.

Note:	The configuration mismatch feature and associated reset flag is not available on all devices.

6.10 Illegal Condition Device Reset

An illegal condition device Reset occurs due to the following sources:

- Illegal Opcode Reset
- Uninitialized W Register Reset
- Security Reset

The Illegal Opcode or Uninitialized W Access Reset Flag bit (IOPUWR) in the Reset Control register (RCON<14>) is set to indicate the illegal condition device Reset.

6.10.1 ILLEGAL OPCODE RESET

A device Reset is generated if the device attempts to execute an illegal opcode value that is fetched from program memory.

The illegal opcode Reset function can prevent the device from executing program memory sections that are used to store constant data. To take advantage of the illegal opcode Reset, use only the lower 16 bits of each program memory section to store the data values. The upper 8 bits should be programmed with 3Fh, which is an illegal opcode value.

6.10.2 UNINITIALIZED W REGISTER RESET

Any attempts to use the uninitialized W register as an address pointer will Reset the device. The W register array (with the exception of W15) is cleared during all resets and is considered uninitialized until written to.

6.10.3 SECURITY RESET

If a Program Flow Change (PFC) or Vector Flow Change (VFC) targets a restricted location in a protected segment (Boot and Secure Segment), that operation will cause a security Reset.

The PFC occurs when the Program Counter is reloaded as a result of a Call, Jump, Computed Jump, Return, Return from Subroutine, or other form of branch instruction.

The VFC occurs when the Program Counter is reloaded with an Interrupt or Trap vector.

Refer to **Section 25.8 "Code Protection and CodeGuard™ Security"** for more information on Security Reset.

6.11 Using the RCON Status Bits

The user application can read the Reset Control register (RCON) after any device Reset to determine the cause of the reset.

Note:	The status bits in the RCON register should be cleared after they are read so that the next RCON register value after a device Reset will be meaningful.

Table 6-3 provides a summary of the reset flag bit operation.

TABLE 6-3: RESET FLAG BIT OPERATION

Flag Bit	Set by:	Cleared by:
TRAPR (RCON<15>)	Trap conflict event	POR, BOR
IOPWR (RCON<14>)	Illegal opcode or uninitialized W register access or Security Reset	POR, BOR
CM (RCON<9>)	Configuration Mismatch	POR, BOR
EXTR (RCON<7>)	$\overline{\text{MCLR}}$ Reset	POR
SWR (RCON<6>)	`RESET` instruction	POR, BOR
WDTO (RCON<4>)	WDT time-out	`PWRSAV` instruction, `CLRWDT` instruction, POR, BOR
SLEEP (RCON<3>)	`PWRSAV #SLEEP` instruction	POR, BOR
IDLE (RCON<2>)	`PWRSAV #IDLE` instruction	POR, BOR
BOR (RCON<1>)	POR, BOR	—
POR (RCON<0>)	POR	—

Note: All Reset flag bits can be set or cleared by user software.

REGISTER 7-5: IFS0: INTERRUPT FLAG STATUS REGISTER 0 (CONTINUED)

bit 2 **OC1IF:** Output Compare Channel 1 Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 1 **IC1IF:** Input Capture Channel 1 Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 0 **INT0IF:** External Interrupt 0 Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

8.3 DMA Control Registers

REGISTER 8-1: DMAxCON: DMA CHANNEL x CONTROL REGISTER

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	U-0	U-0	U-0
CHEN	SIZE	DIR	HALF	NULLW	—	—	—
bit 15							bit 8

U-0	U-0	R/W-0	R/W-0	U-0	U-0	R/W-0	R/W-0
—	—	AMODE<1:0>		—	—	MODE<1:0>	
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 **CHEN:** Channel Enable bit
1 = Channel enabled
0 = Channel disabled

bit 14 **SIZE:** Data Transfer Size bit
1 = Byte
0 = Word

bit 13 **DIR**: Transfer Direction bit (source/destination bus select)
1 = Read from DMA RAM address, write to peripheral address
0 = Read from peripheral address, write to DMA RAM address

bit 12 **HALF:** Early Block Transfer Complete Interrupt Select bit
1 = Initiate block transfer complete interrupt when half of the data has been moved
0 = Initiate block transfer complete interrupt when all of the data has been moved

bit 11 **NULLW:** Null Data Peripheral Write Mode Select bit
1 = Null data write to peripheral in addition to DMA RAM write (DIR bit must also be clear)
0 = Normal operation

bit 10-6 **Unimplemented:** Read as '0'

bit 5-4 **AMODE<1:0>:** DMA Channel Operating Mode Select bits
11 = Reserved (acts as Peripheral Indirect Addressing mode)
10 = Peripheral Indirect Addressing mode
01 = Register Indirect without Post-Increment mode
00 = Register Indirect with Post-Increment mode

bit 3-2 **Unimplemented:** Read as '0'

bit 1-0 **MODE<1:0>:** DMA Channel Operating Mode Select bits
11 = One-Shot, Ping-Pong modes enabled (one block transfer from/to each DMA RAM buffer)
10 = Continuous, Ping-Pong modes enabled
01 = One-Shot, Ping-Pong modes disabled
00 = Continuous, Ping-Pong modes disabled

12.2 Timer1 Control Register

REGISTER 12-1: T1CON: TIMER1 CONTROL REGISTER

R/W-0	U-0	R/W-0	U-0	U-0	U-0	U-0	U-0
TON	—	TSIDL	—	—	—	—	—
bit 15							bit 8

U-0	R/W-0	R/W-0	R/W-0	U-0	R/W-0	R/W-0	U-0
—	TGATE	TCKPS<1:0>		—	TSYNC	TCS	—
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 **TON:** Timer1 On bit
1 = Starts 16-bit Timer1
0 = Stops 16-bit Timer1

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

bit 13 **TSIDL:** Stop in Idle Mode bit
1 = Discontinue module operation when device enters Idle mode
0 = Continue module operation in Idle mode

bit 12-7 **Unimplemented:** Read as '0'

bit 6 **TGATE:** Timer1 Gated Time Accumulation Enable bit
When TCS = 1:
This bit is ignored.
When TCS = 0:
1 = Gated time accumulation enabled
0 = Gated time accumulation disabled

bit 5-4 **TCKPS<1:0>:** Timer1 Input Clock Prescaler Select bits
11 = 1:256
10 = 1:64
01 = 1:8
00 = 1:1

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

bit 2 **TSYNC:** Timer1 External Clock Input Synchronization Select bit
When TCS = 1:
1 = Synchronize external clock input
0 = Do not synchronize external clock input
When TCS = 0:
This bit is ignored.

bit 1 **TCS:** Timer1 Clock Source Select bit
1 = External clock from pin T1CK (on the rising edge)
0 = Internal clock (FCY)

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

The Timer2/3 and Timer4/5 modules can operate in one of the following modes:

- Timer mode
- Gated Timer mode
- Synchronous Counter mode

In Timer and Gated Timer modes, the input clock is derived from the internal instruction cycle clock (FCY). In Synchronous Counter mode, the input clock is derived from the external clock input at TxCK pin.

The timer modes are determined by the following bits:

- TCS (TxCON<1>): Timer Clock Source Control bit
- TGATE (TxCON<6>): Timer Gate Control bit

Timer control bit settings for different operating modes are given in the Table 13-1.

TABLE 13-1: TIMER MODE SETTINGS

Mode	TCS	TGATE
Timer	0	0
Gated timer	0	1
Synchronous counter	1	x

13.1 16-Bit Operation

To configure any of the timers for individual 16-bit operation:

1. Clear the T32 bit corresponding to that timer.
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. Load the timer period value into the PRx register.
5. If interrupts are required, set the interrupt enable bit, TxIE. Use the priority bits, TxIP<2:0>, to set the interrupt priority.
6. Set the TON bit.

Note: Only Timer2 and Timer3 can trigger a DMA data transfer.

13.2 32-Bit Operation

A 32-bit timer module can be formed by combining a Type B and a Type C 16-bit timer module. For 32-bit timer operation, the T32 control bit in the Type B Timer Control register (TxCON<3>) must be set. The Type C timer holds the most significant word (msw) and the Type B timer holds the least significant word (lsw) for 32-bit operation.

When configured for 32-bit operation, only the Type B Timer Control register (TxCON) bits are required for setup and control. Type C timer control register bits are ignored (except TSIDL bit).

For interrupt control, the combined 32-bit timer uses the interrupt enable, interrupt flag and interrupt priority control bits of the Type C timer. The interrupt control and status bits for the Type B timer are ignored during 32-bit timer operation.

The Type B and Type C timers that can be combined to form a 32-bit timer are listed in Table 13-2.

TABLE 13-2: 32-BIT TIMER

TYPE B Timer (lsw)	TYPE C Timer (msw)
Timer2	Timer3
Timer4	Timer5

A block diagram representation of the 32-bit timer module is shown in Figure 13-3. The 32-timer module can operate in one of the following modes:

- Timer mode
- Gated Timer mode
- Synchronous Counter mode

To configure the features of Timer2/3 or Timer4/5 for 32-bit operation:

1. Set the T32 control bit.
2. Select the prescaler ratio for Timer2 or Timer4 using the TCKPS<1:0> bits.
3. Set the Clock and Gating modes using the corresponding TCS and TGATE bits.
4. Load the timer period value. PR3 or PR5 contains the most significant word of the value, while PR2 or PR4 contains the least significant word.
5. If interrupts are required, set the interrupt enable bits, T3IE or T5IE. Use the priority bits, T3IP<2:0> or T5IP<2:0> to set the interrupt priority. While Timer2 or Timer4 controls the timer, the interrupt appears as a Timer3 or Timer5 interrupt.
6. Set the corresponding TON bit.

The timer value at any point is stored in the register pair, TMR3:TMR2 or TMR5:TMR4, which always contains the most significant word of the count, while TMR2 or TMR4 contains the least significant word.

14.1 Input Capture Resources

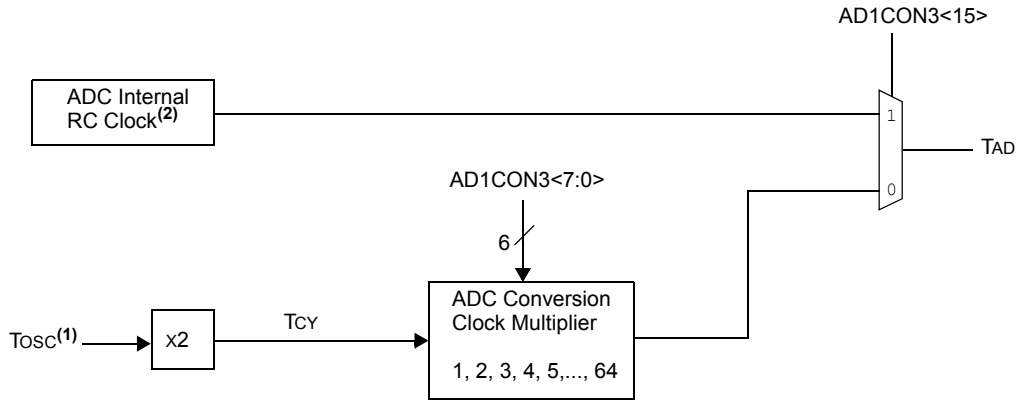
Many useful resources related to Input Capture are provided on the main product page of the Microchip web site for the devices listed in this data sheet. This product page, which can be accessed using this link, contains the latest updates and additional information.

Note:	In the event you are not able to access the product page using the link above, enter this URL in your browser: http://www.microchip.com/wwwproducts/Devices.aspx?dDocName=en532315

14.1.1 KEY RESOURCES

- **Section 12. "Input Capture"** (DS70198)
- Code Samples
- Application Notes
- Software Libraries
- Webinars
- All related dsPIC33F/PIC24H Family Reference Manuals Sections
- Development Tools

FIGURE 20-3: ADC CONVERSION CLOCK PERIOD BLOCK DIAGRAM



Note 1: Refer to Figure 9-2 for the derivation of Fosc when the PLL is enabled. If the PLL is not used, Fosc is equal to the clock source frequency. Tosc = 1/Fosc

2: See the ADC electrical characteristics for the exact RC clock value.

22.2 RTCC Resources

Many useful resources related to RTCC are provided on the main product page of the Microchip web site for the devices listed in this data sheet. This product page, which can be accessed using this link, contains the latest updates and additional information.

Note:	In the event you are not able to access the product page using the link above, enter this URL in your browser: http://www.microchip.com/wwwproducts/Devices.aspx?dDocName=en534555

22.2.1 KEY RESOURCES

- **Section 37. "Real-Time Clock and Calendar (RTCC)"** (DS70301)
- Code Samples
- Application Notes
- Software Libraries
- Webinars
- All related dsPIC33F/PIC24H Family Reference Manuals Sections
- Development Tools

TABLE 25-4: CODE FLASH SECURITY SEGMENT SIZES FOR 64 KB DEVICES

CONFIG BITS	BSS<2:0> = x11 0K	BSS<2:0> = x10 1K	BSS<2:0> = x01 4K	BSS<2:0> = x00 8K
SSS<2:0> = x11 0K	VS = 256 IW GS = 21760 IW	VS = 256 IW BS = 768 IW GS = 20992 IW	VS = 256 IW BS = 3840 IW GS = 17920 IW	VS = 256 IW BS = 7936 IW GS = 13824 IW
SSS<2:0> = x10 4K	VS = 256 IW SS = 3840 IW GS = 17920 IW	VS = 256 IW BS = 768 IW SS = 3072 IW GS = 17920 IW	VS = 256 IW BS = 3840 IW GS = 17920 IW	VS = 256 IW BS = 7936 IW GS = 13824 IW
SSS<2:0> = x01 8K	VS = 256 IW SS = 7936 IW GS = 13824 IW	VS = 256 IW BS = 768 IW SS = 7168 IW GS = 13824 IW	VS = 256 IW BS = 3840 IW SS = 4096 IW GS = 13824 IW	VS = 256 IW BS = 7936 IW GS = 13824 IW
SSS<2:0> = x00 16K	VS = 256 IW SS = 16128 IW GS = 5632 IW	VS = 256 IW BS = 768 IW SS = 15360 IW GS = 5632 IW	VS = 256 IW BS = 3840 IW SS = 12288 IW GS = 5632 IW	VS = 256 IW BS = 7936 IW SS = 8192 IW GS = 5632 IW

0x000000h
0x0001FEh
0x000200h
0x0007FEh
0x000800h
0x001FFEh
0x002000h
0x003FFEh
0x004000h
0x007FFEh
0x008000h
0x00ABFEh
0x0157FEh

27.0 DEVELOPMENT SUPPORT

The PIC® microcontrollers and dsPIC® digital signal controllers are supported with a full range of software and hardware development tools:

- Integrated Development Environment
  - MPLAB® IDE Software
- Compilers/Assemblers/Linkers
  - MPLAB C Compiler for Various Device Families
  - HI-TECH C for Various Device Families
  - MPASM™ Assembler
  - MPLINK™ Object Linker/ MPLIB™ Object Librarian
  - MPLAB Assembler/Linker/Librarian for Various Device Families
- Simulators
  - MPLAB SIM Software Simulator
- Emulators
  - MPLAB REAL ICE™ In-Circuit Emulator
- In-Circuit Debuggers
  - MPLAB ICD 3
  - PICkit™ 3 Debug Express
- Device Programmers
  - PICkit™ 2 Programmer
  - MPLAB PM3 Device Programmer
- Low-Cost Demonstration/Development Boards, Evaluation Kits, and Starter Kits

27.1 MPLAB Integrated Development Environment Software

The MPLAB IDE software brings an ease of software development previously unseen in the 8/16/32-bit microcontroller market. The MPLAB IDE is a Windows® operating system-based application that contains:

- A single graphical interface to all debugging tools
  - Simulator
  - Programmer (sold separately)
  - In-Circuit Emulator (sold separately)
  - In-Circuit Debugger (sold separately)
- A full-featured editor with color-coded context
- A multiple project manager
- Customizable data windows with direct edit of contents
- High-level source code debugging
- Mouse over variable inspection
- Drag and drop variables from source to watch windows
- Extensive on-line help
- Integration of select third party tools, such as IAR C Compilers

The MPLAB IDE allows you to:

- Edit your source files (either C or assembly)
- One-touch compile or assemble, and download to emulator and simulator tools (automatically updates all project information)
- Debug using:
  - Source files (C or assembly)
  - Mixed C and assembly
  - Machine code

MPLAB IDE supports multiple debugging tools in a single development paradigm, from the cost-effective simulators, through low-cost in-circuit debuggers, to full-featured emulators. This eliminates the learning curve when upgrading to tools with increased flexibility and power.

TABLE 28-11: ELECTRICAL CHARACTERISTICS: BOR

DC CHARACTERISTICS			Standard Operating Conditions: 3.0V to 3.6V (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended				
Param No.	**Symbol**	**Characteristic**	**Min(1)**	**Typ**	**Max(1)**	**Units**	**Conditions**
BO10	VBOR	BOR Event on VDD transition high-to-low	2.40	—	2.55	V	VDD

Note 1: Parameters are for design guidance only and are not tested in manufacturing.

TABLE 28-12: DC CHARACTERISTICS: PROGRAM MEMORY

DC CHARACTERISTICS			Standard Operating Conditions: 3.0V to 3.6V (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended				
Param No.	**Symbol**	**Characteristic**	**Min**	**Typ(1)**	**Max**	**Units**	**Conditions**
		Program Flash Memory					
D130a	EP	Cell Endurance	10,000	—	—	E/W	-40° C to +125° C
D131	VPR	VDD for Read	VMIN	—	3.6	V	VMIN = Minimum operating voltage
D132B	VPEW	VDD for Self-Timed Write	VMIN	—	3.6	V	VMIN = Minimum operating voltage
D134	TRETD	Characteristic Retention	20	—	—	Year	Provided no other specifications are violated
D135	IDDP	Supply Current during Programming	—	10	—	mA	—
D136a	TRW	Row Write Time	1.32	—	1.74	ms	TRW = 11064 FRC cycles, TA = +85°C, See **Note 2**
D136b	TRW	Row Write Time	1.28	—	1.79	ms	TRW = 11064 FRC cycles, TA = +125°C, See **Note 2**
D137a	TPE	Page Erase Time	20.1	—	26.5	ms	TPE = 168517 FRC cycles, TA = +85°C, See **Note 2**
D137b	TPE	Page Erase Time	19.5	—	27.3	ms	TPE = 168517 FRC cycles, TA = +125°C, See **Note 2**
D138a	TWW	Word Write Cycle Time	42.3	—	55.9	µs	TWW = 355 FRC cycles, TA = +85°C, See **Note 2**
D138b	TWW	Word Write Cycle Time	41.1	—	57.6	µs	TWW = 355 FRC cycles, TA = +125°C, See **Note 2**

Note 1: Data in "Typ" column is at 3.3V, 25°C unless otherwise stated.

2: Other conditions: FRC = 7.37 MHz, TUN<5:0> = `b'011111` (for Min), TUN<5:0> = `b'100000` (for Max). This parameter depends on the FRC accuracy (see Table 28-19) and the value of the FRC Oscillator Tuning register (see Register 9-4). For complete details on calculating the Minimum and Maximum time see **Section 5.3 "Programming Operations"**.

TABLE 28-13: INTERNAL VOLTAGE REGULATOR SPECIFICATIONS

Standard Operating Conditions (unless otherwise stated): Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended							
Param No.	**Symbol**	**Characteristics**	**Min**	**Typ**	**Max**	**Units**	**Comments**
—	CEFC	External Filter Capacitor Value(1)	4.7	10	—	µF	Capacitor must be low series resistance (< 5 Ohms)

Note 1: Typical VCAP voltage = 2.5V when VDD ≥ VDDMIN.

TABLE 28-17: PLL CLOCK TIMING SPECIFICATIONS (V_{DD} = 3.0V TO 3.6V)

AC CHARACTERISTICS			Standard Operating Conditions: 3.0V to 3.6V (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended				
Param No.	**Symbol**	**Characteristic**	**Min**	**Typ(1)**	**Max**	**Units**	**Conditions**
OS50	FPLLI	PLL Voltage Controlled Oscillator (VCO) Input Frequency Range	0.8	—	8	MHz	ECPLL, HSPLL, XTPLL modes
OS51	FSYS	On-Chip VCO System Frequency	100	—	200	MHz	—
OS52	TLOCK	PLL Start-up Time (Lock Time)	0.9	1.5	3.1	mS	—
OS53	DCLK	CLKO Stability (Jitter)	-3	0.5	3	%	Measured over 100 ms period

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

2: These parameters are characterized by similarity, but are not tested in manufacturing. This specification is based on clock cycle by clock cycle measurements. To calculate the effective jitter for individual time bases or communication clocks use this formula:

$$Peripheral\ Clock\ Jitter = \frac{DCLK}{\sqrt{\left(\frac{FOSC}{Peripheral\ Bit\ Rate\ Clock}\right)}}$$

For example: Fosc = 32 MHz, DCLK = 3%, SPI bit rate clock, (i.e., SCK) is 2 MHz.

$$SPI\ SCK\ Jitter = \left[\frac{DCLK}{\sqrt{\left(\frac{32\ MHz}{2\ MHz}\right)}}\right] = \left[\frac{3\%}{\sqrt{16}}\right] = \left[\frac{3\%}{4}\right] = 0.75\%$$

TABLE 28-18: AC CHARACTERISTICS: INTERNAL RC ACCURACY

AC CHARACTERISTICS		Standard Operating Conditions: 3.0V to 3.6V (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended					
Param No.	**Characteristic**	**Min**	**Typ**	**Max**	**Units**	**Conditions**	
	Internal FRC Accuracy @ 7.3728 MHz(1)						
F20	FRC	-2	—	+2	%	-40°C ≤ TA ≤ +85°C	VDD = 3.0-3.6V
	FRC	-5	—	+5	%	-40°C ≤ TA ≤ +125°C	VDD = 3.0-3.6V

Note 1: Frequency calibrated at 25°C and 3.3V. TUN bits can be used to compensate for temperature drift.

TABLE 28-19: INTERNAL RC ACCURACY

AC CHARACTERISTICS		Standard Operating Conditions: 3.0V to 3.6V (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended					
Param No.	**Characteristic**	**Min**	**Typ**	**Max**	**Units**	**Conditions**	
	LPRC @ 32.768 kHz(1)						
F21	LPRC	-20	±6	+20	%	-40°C ≤ TA ≤ +85°C	VDD = 3.0-3.6V
	LPRC	-30	—	+30	%	-40°C ≤ TA ≤ +125°C	VDD = 3.0-3.6V

Note 1: Change of LPRC frequency as VDD changes.

FIGURE 28-8: OC/PWM MODULE TIMING CHARACTERISTICS

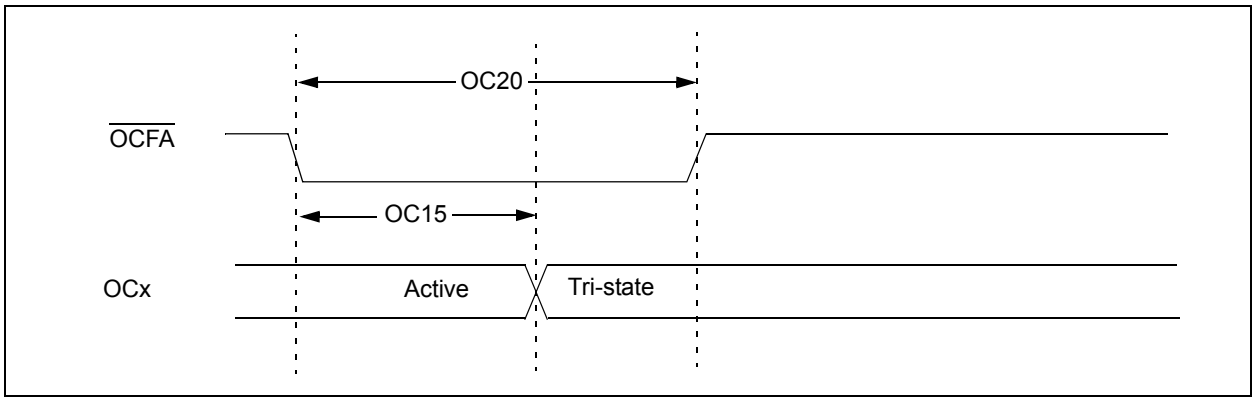


TABLE 28-27: SIMPLE OC/PWM MODE TIMING REQUIREMENTS

AC CHARACTERISTICS			Standard Operating Conditions: 3.0V to 3.6V (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended				
Param No.	**Symbol**	**Characteristic(1)**	**Min**	**Typ**	**Max**	**Units**	**Conditions**
OC15	TFD	Fault Input to PWM I/O Change	—	—	TCY + 20	ns	—
OC20	TFLT	Fault Input Pulse Width	TCY + 20	—	—	ns	—

Note 1: These parameters are characterized but not tested in manufacturing.

FIGURE 28-27: PARALLEL MASTER PORT WRITE TIMING DIAGRAM

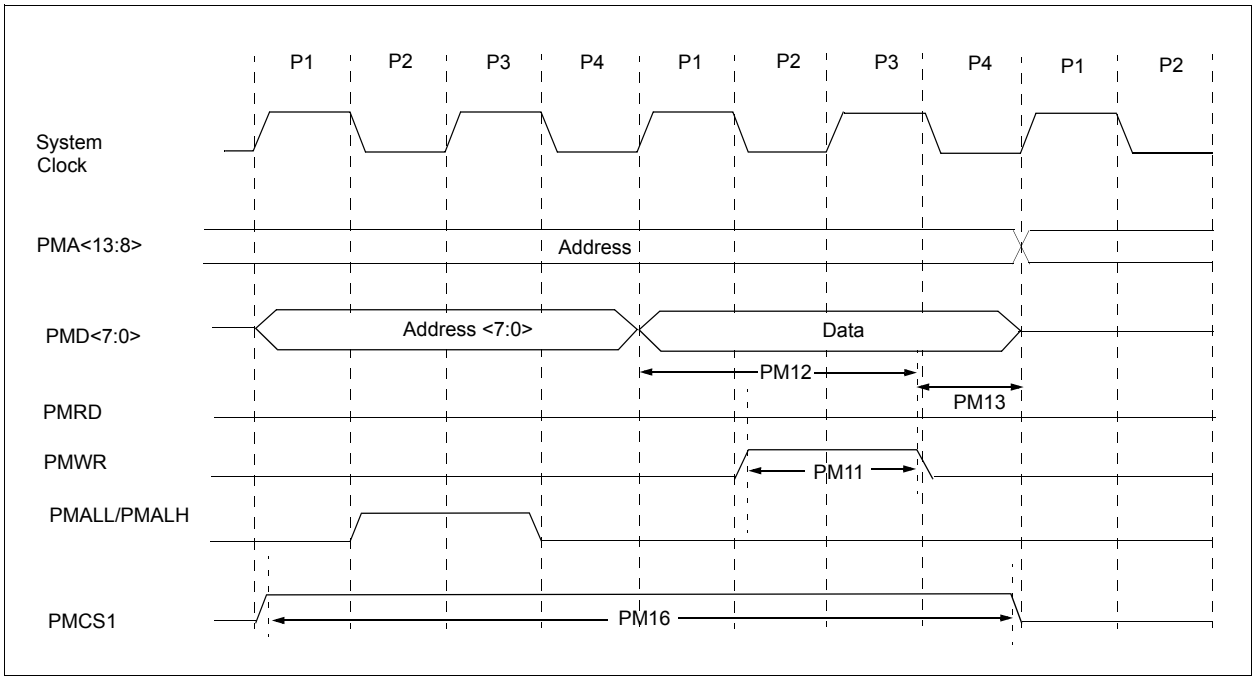


TABLE 28-50: PARALLEL MASTER PORT WRITE TIMING REQUIREMENTS

AC CHARACTERISTICS		Standard Operating Conditions: 3.0V to 3.6V (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended				
Param No.	**Characteristic**	**Min.**	**Typ**	**Max.**	**Units**	**Conditions**
PM11	PMWR Pulse Width	—	0.5 TCY	—	ns	—
PM12	Data Out Valid before PMWR or PMENB goes Inactive (data setup time)	—	—	—	ns	—
PM13	PMWR or PMEMB Invalid to Data Out Invalid (data hold time)	—	—	—	ns	—
PM16	PMCSx Pulse Width	TCY - 5	—	—	ns	—

TABLE 28-51: DMA READ/WRITE TIMING REQUIREMENTS

AC CHARACTERISTICS		Standard Operating Conditions: 3.0V to 3.6V (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended				
Param No.	**Characteristic**	**Min.**	**Typ**	**Max.**	**Units**	**Conditions**
DM1	DMA Read/Write Cycle Time	—	—	1 TCY	ns	—

TABLE A-4: MAJOR SECTION UPDATES (CONTINUED)

Section Name	Update Description
Section 28.0 "Electrical Characteristics"	Updated the maximum value for Extended Temperature Devices in the Thermal Operating Conditions (see Table 28-2). Removed Note 4 from the DC Temperature and Voltage Specifications (see Table 28-4). Updated all typical and maximum Operating Current (I_{DD}) values (see Table 28-5). Updated all typical and maximum Idle Current (I_{IDLE}) values (see Table 28-6). Updated the maximum Power-Down Current (I_{PD}) values for parameters DC60d, DC60a, and DC60b (see Table 28-7). Updated all typical Doze Current (Idoze) values (see Table 28-8). Updated the maximum value for parameter DI19 and added parameters DI28, DI29, DI60a, DI60b, and DI60c to the I/O Pin Input Specifications (see Table 28-9). Added Note 2 to the PLL Clock Timing Specifications (see Table 28-17) Removed Note 2 from the AC Characteristics: Internal RC Accuracy (see Table 28-18). Updated the Internal RC Accuracy minimum and maximum values for parameter F21b (see Table 28-19). Updated the characteristic description for parameter DI35 in the I/O Timing Requirements (see Table 28-20). Updated *all* SPI specifications (see Table 28-28 through Table 28-35 and Figure 28-10 through Figure 28-16) Updated the ADC Module Specification minimum values for parameters AD05 and AD07, and updated the maximum value for parameter AD06 (see Table 28-41). Updated the ADC Module Specifications (12-bit Mode) minimum and maximum values for parameter AD21a (see Table 28-42). Updated all ADC Module Specifications (10-bit Mode) values, with the exception of Dynamic Performance (see Table 28-43). Updated the minimum value for parameter PM6 and the maximum value for parameter PM7 in the Parallel Master Port Read Timing Requirements (see Table 28-49). Added DMA Read/Write Timing Requirements (see Table 28-51).

TABLE A-4: MAJOR SECTION UPDATES (CONTINUED)

Section Name	Update Description
Section 29.0 "High Temperature Electrical Characteristics"	Updated all ambient temperature end range values to +150ºC throughout the chapter. Updated the storage temperature end range to +160ºC. Updated the maximum junction temperature from +145ºC to +155ºC. Updated the maximum values for High Temperature Devices in the Thermal Operating Conditions (see Table 29-2). Updated the ADC Module Specifications (12-bit Mode), removing all parameters with the exception of HAD33a (see Table 29-14). Updated the ADC Module Specifications (10-bit Mode), removing all parameters with the exception of HAD33b (see Table 29-16).
"Product Identification System"	Updated the end range temperature value for H (High) devices.