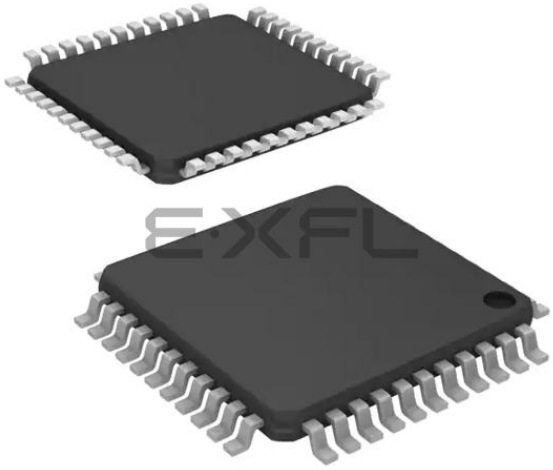


Welcome to E-XFL.COM

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	32MHz
Connectivity	I²C, IrDA, LINbus, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, HLVD, POR, PWM, WDT
Number of I/O	38
Program Memory Size	32KB (11K x 24)
Program Memory Type	FLASH
EEPROM Size	512 x 8
RAM Size	2K x 8
Voltage - Supply (Vcc/Vdd)	2V ~ 5.5V
Data Converters	A/D 16x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	44-TQFP
Supplier Device Package	44-TQFP (10x10)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic24fv32ka304t-i-pt

TO OUR VALUED CUSTOMERS

It is our intention to provide our valued customers with the best documentation possible to ensure successful use of your Microchip products. To this end, we will continue to improve our publications to better suit your needs. Our publications will be refined and enhanced as new volumes and updates are introduced.

If you have any questions or comments regarding this publication, please contact the Marketing Communications Department via E-mail at **docerrors@microchip.com** or fax the **Reader Response Form** in the back of this data sheet to (480) 792-4150. We welcome your feedback.

Most Current Data Sheet

To obtain the most up-to-date version of this data sheet, please register at our Worldwide Web site at:

http://www.microchip.com

You can determine the version of a data sheet by examining its literature number found on the bottom outside corner of any page. The last character of the literature number is the version number, (e.g., DS30000A is version A of document DS30000).

Errata

An errata sheet, describing minor operational differences from the data sheet and recommended workarounds, may exist for current devices. As device/documentation issues become known to us, we will publish an errata sheet. The errata will specify the revision of silicon and revision of document to which it applies.

To determine if an errata sheet exists for a particular device, please check with one of the following:

- Microchip's Worldwide Web site; **http://www.microchip.com**
- Your local Microchip sales office (see last page)

When contacting a sales office, please specify which device, revision of silicon and data sheet (include literature number) you are using.

Customer Notification System

Register on our web site at **www.microchip.com** to receive the most current information on all of our products.

NOTES:

© 2011-2013 Microchip Technology Inc.

TABLE 1-3: PIC24FV32KA304 FAMILY PINOUT DESCRIPTIONS (CONTINUED)

Function	F					FV					I/O	Buffer	Description
	Pin Number					Pin Number							
	20-Pin PDIP/ SSOP/ SOIC	28-Pin SPDIP/ SSOP/ SOIC	28-Pin QFN	44-Pin QFN/ TQFP	48-Pin UQFN	20-Pin PDIP/ SSOP/ SOIC	28-Pin SPDIP/ SSOP/ SOIC	28-Pin QFN	44-Pin QFN/ TQFP	48-Pin UQFN			
RA0	2	2	27	19	21	2	2	27	19	21	I/O	ST	PORTA Pins
RA1	3	3	28	20	22	3	3	28	20	22	I/O	ST	
RA2	7	9	6	30	33	7	9	6	30	33	I/O	ST	
RA3	8	10	7	31	34	8	10	7	31	34	I/O	ST	
RA4	10	12	9	34	37	10	12	9	34	37	I/O	ST	
RA5	1	1	26	18	19	1	1	26	18	19	I/O	ST	
RA6	14	20	17	7	7	—	—	—	—	—	I/O	ST	
RA7	—	19	16	6	6	—	19	16	6	6	I/O	ST	
RA8	—	—	—	32	35	—	—	—	32	35	I/O	ST	
RA9	—	—	—	35	38	—	—	—	35	38	I/O	ST	
RA10	—	—	—	12	13	—	—	—	12	13	I/O	ST	
RA11	—	—	—	13	14	—	—	—	13	14	I/O	ST	
RB0	4	4	1	21	23	4	4	1	21	23	I/O	ST	PORTB Pins
RB1	5	5	2	22	24	5	5	2	22	24	I/O	ST	
RB2	6	6	3	23	25	6	6	3	23	25	I/O	ST	
RB3	—	7	4	24	26	—	7	4	24	26	I/O	ST	
RB4	9	11	8	33	36	9	11	8	33	36	I/O	ST	
RB5	—	14	11	41	45	—	14	11	41	45	I/O	ST	
RB6	—	15	12	42	46	—	15	12	42	46	I/O	ST	
RB7	11	16	13	43	47	11	16	13	43	47	I/O	ST	
RB8	12	17	14	44	48	12	17	14	44	48	I/O	ST	
RB9	13	18	15	1	1	13	18	15	1	1	I/O	ST	
RB10	—	21	18	8	9	—	21	18	8	9	I/O	ST	
RB11	—	22	19	9	10	—	22	19	9	10	I/O	ST	
RB12	15	23	20	10	11	15	23	20	10	11	I/O	ST	
RB13	16	24	21	11	12	16	24	21	11	12	I/O	ST	
RB14	17	25	22	14	15	17	25	22	14	15	I/O	ST	
RB15	18	26	23	15	16	18	26	23	15	16	I/O	ST	

© 2011-2013 Microchip Technology Inc.

TABLE 1-3: PIC24FV32KA304 FAMILY PINOUT DESCRIPTIONS (CONTINUED)

Function	F					FV					I/O	Buffer	Description
	Pin Number					Pin Number							
	20-Pin PDIP/ SSOP/ SOIC	28-Pin SPDIP/ SSOP/ SOIC	28-Pin QFN	44-Pin QFN/ TQFP	48-Pin UQFN	20-Pin PDIP/ SSOP/ SOIC	28-Pin SPDIP/ SSOP/ SOIC	28-Pin QFN	44-Pin QFN/ TQFP	48-Pin UQFN			
T1CK	13	18	15	1	1	13	18	15	1	1	I	ST	Timer1 Clock
T2CK	18	26	23	15	16	18	26	23	15	16	I	ST	Timer2 Clock
T3CK	18	26	23	15	16	18	26	23	15	16	I	ST	Timer3 Clock
T4CK	6	6	3	23	25	6	6	3	23	25	I	ST	Timer4 Clock
T5CK	6	6	3	23	25	6	6	3	23	25	I	ST	Timer5 Clock
$\overline{U1CTS}$	12	17	14	44	48	12	17	14	44	48	I	ST	UART1 Clear-to-Send Input
$\overline{U1RTS}$	13	18	15	1	1	13	18	15	1	1	O	—	UART1 Request-to-Send Output
U1RX	6	6	3	2	2	6	6	3	2	2	I	ST	UART1 Receive
U1TX	11	16	13	3	3	11	16	13	3	3	O	—	UART1 Transmit
$\overline{U2CTS}$	10	12	9	34	37	10	12	9	34	37	I	ST	UART2 Clear-to-Send Input
$\overline{U2RTS}$	9	11	8	33	36	9	11	8	33	36	O	—	UART2 Request-to-Send Output
U2RX	5	5	2	22	24	5	5	2	22	24	I	ST	UART2 Receive
U2TX	4	4	1	21	23	4	4	1	21	23	O	—	UART2 Transmit
ULPWU	4	4	1	21	23	4	4	1	21	23	I	ANA	Ultra Low-Power Wake-up Input
V_{CAP}	—	—	—	—	—	14	20	17	7	7	P	—	Core Power
V_{DD}	20	28,13	25,10	17,28,40	18,30,43	20	28,13	25,10	17,28,40	18,30,43	P	—	Device Digital Supply Voltage
V_{REF+}	2	2	27	19	21	2	2	27	19	21	I	ANA	A/D Reference Voltage Input (+)
V_{REF-}	3	3	28	20	22	3	3	28	20	22	I	ANA	A/D Reference Voltage Input (-)
V_{SS}	19	27,8	24,5	16,29,39	17,31,42	19	27,8	24,5	16,29,39	17,31,42	P	—	Device Digital Ground Return

© 2011-2013 Microchip Technology Inc.

5.5.1 PROGRAMMING ALGORITHM FOR FLASH PROGRAM MEMORY

The user can program one row of Flash program memory at a time by erasing the programmable row. The general process is as follows:

1. Read a row of program memory (32 instructions) and store in data RAM.
2. Update the program data in RAM with the desired new data.
3. Erase a row (see Example 5-1):
   a) Set the NVMOPx bits (NVMCON<5:0>) to '011000' to configure for row erase. Set the ERASE (NVMCON<6>) and WREN (NVMCON<14>) bits.
   b) Write the starting address of the block to be erased into the TBLPAG and W registers.
   c) Write 55h to NVMKEY.
   d) Write AAh to NVMKEY.
   e) Set the WR bit (NVMCON<15>). The erase cycle begins and the CPU stalls for the duration of the erase cycle. When the erase is done, the WR bit is cleared automatically.
4. Write the first 32 instructions from data RAM into the program memory buffers (see Example 5-1).
5. Write the program block to Flash memory:
   a) Set the NVMOPx bits to '011000' to configure for row programming. Clear the ERASE bit and set the WREN bit.
   b) Write 55h to NVMKEY.
   c) Write AAh to NVMKEY.
   d) Set the WR bit. The programming cycle begins and the CPU stalls for the duration of the write cycle. When the write to Flash memory is done, the WR bit is cleared automatically.

For protection against accidental operations, the write initiate sequence for NVMKEY must be used to allow any erase or program operation to proceed. After the programming command has been executed, the user must wait for the programming time until programming is complete. The two instructions following the start of the programming sequence should be NOPs, as shown in Example 5-5.

EXAMPLE 5-1: ERASING A PROGRAM MEMORY ROW – ASSEMBLY LANGUAGE CODE

```
; Set up NVMCON for row erase operation
        MOV     #0x4058, W0                 ;
        MOV     W0, NVMCON                  ; Initialize NVMCON
; Init pointer to row to be ERASED
        MOV     #tblpage(PROG_ADDR), W0     ;
        MOV     W0, TBLPAG                  ; Initialize PM Page Boundary SFR
        MOV     #tbloffset(PROG_ADDR), W0   ; Initialize in-page EA[15:0] pointer
        TBLWTL  W0, [W0]                    ; Set base address of erase block
        DISI    #5                          ; Block all interrupts
                                              for next 5 instructions
        MOV     #0x55, W0
        MOV     W0, NVMKEY                  ; Write the 55 key
        MOV     #0xAA, W1                   ;
        MOV     W1, NVMKEY                  ; Write the AA key
        BSET    NVMCON, #WR                 ; Start the erase sequence
        NOP                                 ; Insert two NOPs after the erase
        NOP                                 ; command is asserted
```


© 2011-2013 Microchip Technology Inc.

EXAMPLE 5-4: LOADING THE WRITE BUFFERS – 'C' LANGUAGE CODE

```
// C example using MPLAB C30

   #define NUM_INSTRUCTION_PER_ROW 64
   int __attribute__ ((space(auto_psv))) progAddr = 0x1234;  // Global variable located in Pgm Memory
   unsigned int offset;
   unsigned int i;
   unsigned int progData[2*NUM_INSTRUCTION_PER_ROW];        // Buffer of data to write

   //Set up NVMCON for row programming
   NVMCON = 0x4001;                                         // Initialize NVMCON

   //Set up pointer to the first memory location to be written
   TBLPAG = __builtin_tblpage(&progAddr);                   // Initialize PM Page Boundary SFR
   offset = __builtin_tbloffset(&progAddr);                 // Initialize lower word of address

   //Perform TBLWT instructions to write necessary number of latches
   for(i=0; i < 2*NUM_INSTRUCTION_PER_ROW; i++)
   {
       __builtin_tblwtl(offset, progData[i++]);             // Write to address low word
       __builtin_tblwth(offset, progData[i]);               // Write to upper byte
       offset = offset + 2;                                 // Increment address
   }
```

EXAMPLE 5-5: INITIATING A PROGRAMMING SEQUENCE – ASSEMBLY LANGUAGE CODE

```
        DISI    #5                      ; Block all interrupts
                                          for next 5 instructions
        MOV     #0x55, W0
        MOV     W0, NVMKEY              ; Write the 55 key
        MOV     #0xAA, W1               ;
        MOV     W1, NVMKEY              ; Write the AA key
        BSET    NVMCON, #WR             ; Start the erase sequence
        NOP                             ; 2 NOPs required after setting WR
        NOP                             ;
        BTSC    NVMCON, #15             ; Wait for the sequence to be completed
        BRA     $-2                     ;
```

EXAMPLE 5-6: INITIATING A PROGRAMMING SEQUENCE – 'C' LANGUAGE CODE

```
// C example using MPLAB C30

asm("DISI #5");               // Block all interrupts for next 5 instructions

__builtin_write_NVM();        // Perform unlock sequence and set WR
```


© 2011-2013 Microchip Technology Inc.

REGISTER 8-5: 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

© 2011-2013 Microchip Technology Inc.

REGISTER 8-11: IEC0: INTERRUPT ENABLE CONTROL REGISTER 0

bit 1 **IC1IE:** Input Capture Channel 1 Interrupt Enable bit
1 = Interrupt request is enabled
0 = Interrupt request is not enabled

bit 0 **INT0IE:** External Interrupt 0 Enable bit
1 = Interrupt request is enabled
0 = Interrupt request is not enabled

REGISTER 8-19: IPC2: INTERRUPT PRIORITY CONTROL REGISTER 2

U-0	R/W-1	R/W-0	R/W-0	U-0	R/W-1	R/W-0	R/W-0
—	U1RXIP2	U1RXIP1	U1RXIP0	—	SPI1IP2	SPI1IP1	SPI1IP0
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
—	SPF1IP2	SPF1IP1	SPF1IP0	—	T3IP2	T3IP1	T3IP0
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 **U1RXIP<2:0>:** UART1 Receiver 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 **SPI1IP<2:0>:** SPI1 Event 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 **SPF1IP<2:0>:** SPI1 Fault 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 **T3IP<2:0>:** Timer3 Interrupt Priority bits
111 = Interrupt is Priority 7 (highest priority interrupt)
•
•
•
001 = Interrupt is Priority 1
000 = Interrupt source is disabled

REGISTER 8-21: IPC4: INTERRUPT PRIORITY CONTROL REGISTER 4

U-0	R/W-1	R/W-0	R/W-0	U-0	R/W-1	R/W-0	R/W-0
—	CNIP2	CNIP1	CNIP0	—	CMIP2	CMIP1	CMIP0
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
—	MI2C1P2	MI2C1P1	MI2C1P0	—	SI2C1P2	SI2C1P1	SI2C1P0
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 **CNIP<2:0>:** Input Change Notification 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 **CMIP<2:0>:** Comparator 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 **MI2C1P<2:0>:** Master I2C1 Event 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 **SI2C1P<2:0>:** Slave I2C1 Event Interrupt Priority bits
111 = Interrupt is Priority 7 (highest priority interrupt)
•
•
•
001 = Interrupt is Priority 1
000 = Interrupt source is disabled

10.3 Ultra Low-Power Wake-up

The Ultra Low-Power Wake-up (ULPWU) on pin, RB0, allows a slow falling voltage to generate an interrupt without excess current consumption.

To use this feature:

1. Charge the capacitor on RB0 by configuring the RB0 pin to an output and setting it to '1'.
2. Stop charging the capacitor by configuring RB0 as an input.
3. Discharge the capacitor by setting the ULPEN and ULPSINK bits in the ULPWCON register.
4. Configure Sleep mode.
5. Enter Sleep mode.

When the voltage on RB0 drops below VIL, the device wakes up and executes the next instruction.

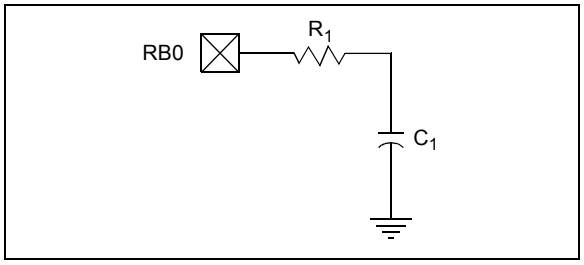
This feature provides a low-power technique for periodically waking up the device from Sleep mode.

The time-out is dependent on the discharge time of the RC circuit on RB0.

When the ULPWU module wakes the device from Sleep mode, the ULPWUIF bit (IFS5<0>) is set. Software can check this bit upon wake-up to determine the wake-up source. See Example 10-3 for initializing the ULPWU module.

A series resistor, between RB0 and the external capacitor, provides overcurrent protection for the RB0/AN0/ULPWU pin and enables software calibration of the time-out (see Figure 10-1).

FIGURE 10-1: SERIES RESISTOR



A timer can be used to measure the charge time and discharge time of the capacitor. The charge time can then be adjusted to provide the desired delay in Sleep. This technique compensates for the affects of temperature, voltage and component accuracy. The peripheral can also be configured as a simple, programmable Low-Voltage Detect (LVD) or temperature sensor.

EXAMPLE 10-3: ULTRA LOW-POWER WAKE-UP INITIALIZATION

```
//******************************
// 1. Charge the capacitor on RB0
//******************************
    TRISBbits.TRISB0 = 0;
    LATBbits.LATB0 = 1;
    for(i = 0; i < 10000; i++) Nop();
//******************************
//2. Stop Charging the capacitor
//   on RB0
//******************************
    TRISBbits.TRISB0 = 1;
//******************************
//3. Enable ULPWU Interrupt
//******************************
IFS5bits.ULPWUIF = 0;
IEC5bits.ULPWUIE = 1;
IPC21bits.ULPWUIP = 0x7;
//******************************
//4. Enable the Ultra Low Power
//   Wakeup module and allow
//   capacitor discharge
//******************************
    ULPWCONbits.ULPEN = 1;
    ULPWCONbit.ULPSINK = 1;
//******************************
//5. Enter Sleep Mode
//******************************
    Sleep();
//for sleep, execution will
//resume here
```

REGISTER 10-3: ULPWCON: ULPWU CONTROL REGISTER

R/W-0	U-0	R/W-0	U-0	U-0	U-0	U-0	R/W-0
ULPEN	—	ULPSIDL	—	—	—	—	ULPSINK
bit 15							bit 8

U-0	U-0	U-0	U-0	U-0	U-0	U-0	U-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 **ULPEN:** ULPWU Module Enable bit
1 = Module is enabled
0 = Module is disabled

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

bit 13 **ULPSIDL:** ULPWU Stop in Idle Select bit
1 = Discontinues module operation when the device enters Idle mode
0 = Continues module operation in Idle mode

bit 12-9 **Unimplemented:** Read as '0'

bit 8 **ULPSINK:** ULPWU Current Sink Enable bit
1 = Current sink is enabled
0 = Current sink is disabled

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

© 2011-2013 Microchip Technology Inc.

REGISTER 15-1: OCxCON1: OUTPUT COMPARE x CONTROL REGISTER 1 (CONTINUED)

bit 2-0 **OCM<2:0>:** Output Compare x Mode Select bits(1)

111 = Center-Aligned PWM mode on OCx
110 = Edge-Aligned PWM mode on OCx
101 = Double Compare Continuous Pulse mode: Initialize OCx pin low; toggle OCx state continuously on alternate matches of OCxR and OCxRS
100 = Double Compare Single-Shot mode: Initialize OCx pin low; toggle OCx state on matches of OCxR and OCxRS for one cycle
011 = Single Compare Continuous Pulse mode: Compare events continuously toggle the OCx pin
010 = Single Compare Single-Shot mode: Initialize OCx pin high; compare event forces the OCx pin low
001 = Single Compare Single-Shot mode: Initialize OCx pin low, compare event forces the OCx pin high
000 = Output compare channel is disabled

Note 1: The comparator module used for Fault input varies with the OCx module. OC1 and OC2 use Comparator 1; OC3 and OC4 use Comparator 2; OC5 uses Comparator 3.

© 2011-2013 Microchip Technology Inc.

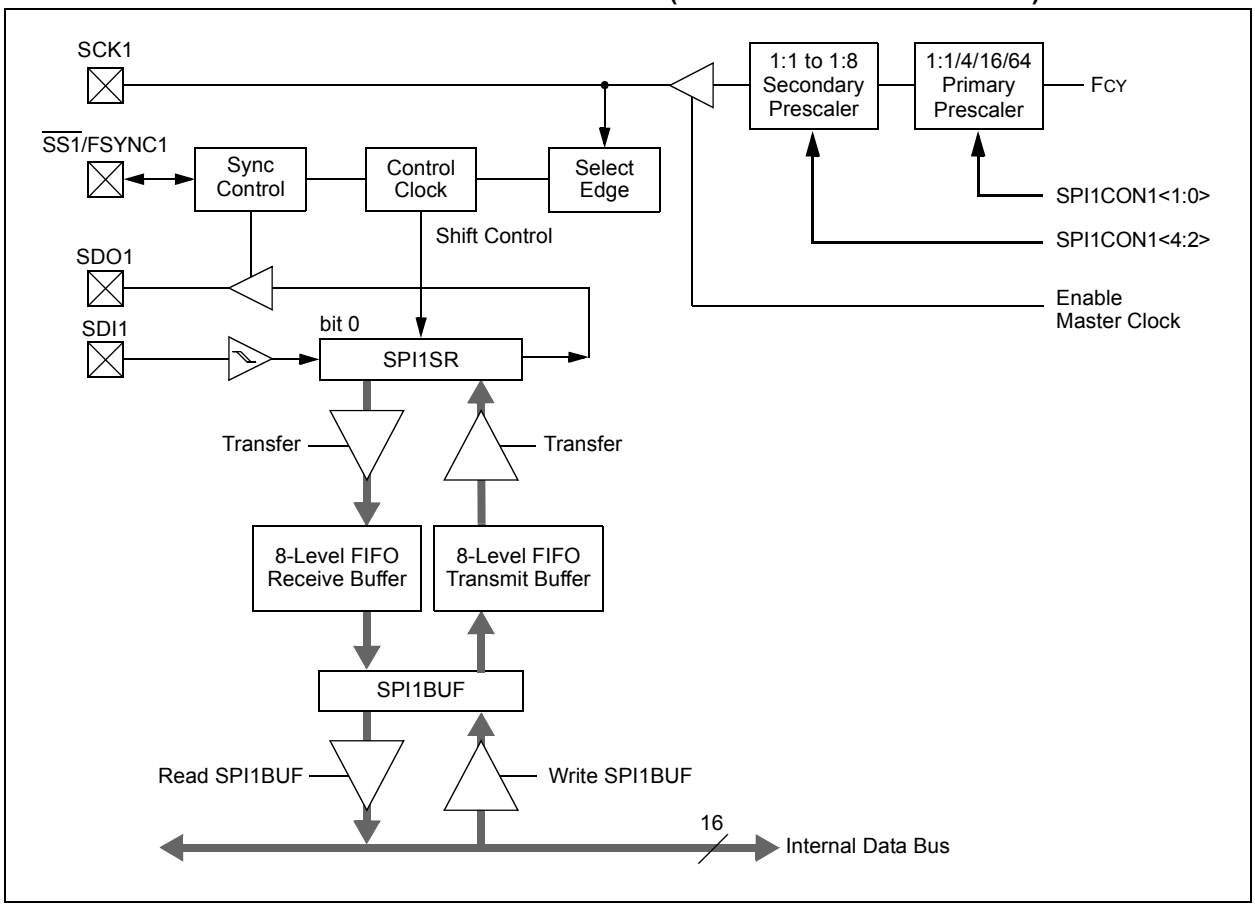
To set up the SPI1 module for the Enhanced Buffer Master (EBM) mode of operation:

1. If using interrupts:
   a) Clear the SPI1IF bit in the IFS0 register.
   b) Set the SPI1IE bit in the IEC0 register.
   c) Write the respective SPI1IPx bits in the IPC2 register.
2. Write the desired settings to the SPI1CON1 and SPI1CON2 registers with the MSTEN bit (SPI1CON1<5>) = 1.
3. Clear the SPIROV bit (SPI1STAT<6>).
4. Select Enhanced Buffer mode by setting the SPIBEN bit (SPI1CON2<0>).
5. Enable SPI operation by setting the SPIEN bit (SPI1STAT<15>).
6. Write the data to be transmitted to the SPI1BUF register. Transmission (and reception) will start as soon as data is written to the SPI1BUF register.

To set up the SPI1 module for the Enhanced Buffer Slave mode of operation:

1. Clear the SPI1BUF register.
2. If using interrupts:
   a) Clear the SPI1IF bit in the IFS0 register.
   b) Set the SPI1IE bit in the IEC0 register.
   c) Write the respective SPI1IPx bits in the IPC2 register to set the interrupt priority.
3. Write the desired settings to the SPI1CON1 and SPI1CON2 registers with the MSTEN bit (SPI1CON1<5>) = 0.
4. Clear the SMP bit.
5. If the CKE bit is set, then the SSEN bit must be set, thus enabling the $\overline{SS1}$ pin.
6. Clear the SPIROV bit (SPI1STAT<6>).
7. Select Enhanced Buffer mode by setting the SPIBEN bit (SPI1CON2<0>).
8. Enable SPI operation by setting the SPIEN bit (SPI1STAT<15>).

FIGURE 16-2: SPI1 MODULE BLOCK DIAGRAM (ENHANCED BUFFER MODE)



22.1 A/D Control Registers

The 12-bit A/D Converter module uses up to 43 registers for its operation. All registers are mapped in the data memory space.

22.1.1 CONTROL REGISTERS

Depending on the specific device, the module has up to eleven control and status registers:

- AD1CON1: A/D Control Register 1
- AD1CON2: A/D Control Register 2
- AD1CON3: A/D Control Register 3
- AD1CON5: A/D Control Register 5
- AD1CHS: A/D Sample Select Register
- AD1CHITH and AD1CHITL: A/D Scan Compare Hit Registers
- AD1CSSL and AD1CSSH: A/D Input Scan Select Registers
- AD1CTMUENH and AD1CTMUENL: CTMU Enable Registers

The AD1CON1, AD1CON2 and AD1CON3 registers (Register 22-1, Register 22-2 and Register 22-3) control the overall operation of the A/D module. This includes enabling the module, configuring the conversion clock and voltage reference sources, selecting the sampling and conversion triggers, and manually controlling the sample/convert sequences. The AD1CON5 register (Register 22-4) specifically controls features of the Threshold Detect operation, including its function in power-saving modes.

The AD1CHS register (Register 22-5) selects the input channels to be connected to the S/H amplifier. It also allows the choice of input multiplexers and the selection of a reference source for differential sampling.

The AD1CHITH and AD1CHITL registers (Register 22-6 and Register 22-7) are semaphore registers used with Threshold Detect operations. The status of individual bits, or bit pairs in some cases, indicate if a match condition has occurred. AD1CHITL is always implemented, whereas AD1CHITH may not be implemented in devices with 16 or fewer channels.

The AD1CSSH/L registers (Register 22-8 and Register 22-9) select the channels to be included for sequential scanning.

The AD1CTMUENH/L registers (Register 22-10 and Register 22-11) select the channel(s) to be used by the CTMU during conversions. Selecting a particular channel allows the A/D Converter to control the CTMU (particularly, its current source) and read its data through that channel. AD1CTMUENL is always implemented, whereas AD1CTMUENH may not be implemented in devices with 16 or fewer channels.

22.1.2 A/D RESULT BUFFERS

The module incorporates a multi-word, dual port RAM, called ADC1BUF. The buffer is composed of at least the same number of word locations as there are external analog channels for a particular device, with a maximum number of 32. The number of buffer addresses is always even. Each of the locations is mapped into the data memory space and is separately addressable. The buffer locations are referred to as ADC1BUF0 through ADC1BUFn (up to 31).

The A/D result buffers are both readable and writable. When the module is active (AD1CON<15> = 1), the buffers are read-only, and store the results of A/D conversions. When the module is inactive (AD1CON<15> = 0), the buffers are both readable and writable. In this state, writing to a buffer location programs a conversion threshold for Threshold Detect operations.

Buffer contents are not cleared when the module is deactivated with the ADON bit (AD1CON1<15>). Conversion results and any programmed threshold values are maintained when ADON is set or cleared.

© 2011-2013 Microchip Technology Inc.

REGISTER 22-6: AD1CHITH: A/D SCAN COMPARE HIT REGISTER (HIGH WORD)(1)

U-0	U-0	U-0	U-0	U-0	U-0	U-0	U-0
—	—	—	—	—	—	—	—
bit 15							bit 8

U-0	U-0	U-0	U-0	U-0	U-0	R/W-0	R/W-0
—	—	—	—	—	—	CHH17	CHH16
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 15-2 **Unimplemented:** Read as '0'.

bit 1-0 **CHH<17:16>:** A/D Compare Hit bits

If CM<1:0> = 11:

1 = A/D Result Buffer x has been written with data or a match has occurred

0 = A/D Result Buffer x has not been written with data

For All Other Values of CM<1:0>:

1 = A match has occurred on A/D Result Channel x

0 = No match has occurred on A/D Result Channel x

Note 1: Unimplemented channels are read as '0'.

REGISTER 22-7: AD1CHITL: A/D SCAN COMPARE HIT REGISTER (LOW WORD)(1)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
CHH15	CHH14	CHH13	CHH12	CHH11	CHH10	CHH9	CHH8
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
CHH7	CHH6	CHH5	CHH4	CHH3	CHH2	CHH1	CHH0
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 15-0 **CHH<15:0>:** A/D Compare Hit bits

If CM<1:0> = 11:

1 = A/D Result Buffer x has been written with data or a match has occurred

0 = A/D Result Buffer x has not been written with data

For all other values of CM<1:0>:

1 = A match has occurred on A/D Result Channel x

0 = No match has occurred on A/D Result Channel x

Note 1: Unimplemented channels are read as '0'.

© 2011-2013 Microchip Technology Inc.

TABLE 28-2: INSTRUCTION SET OVERVIEW (CONTINUED)

Assembly Mnemonic	Assembly Syntax		Description	# of Words	# of Cycles	Status Flags Affected
TBLRDL	TBLRDL	Ws,Wd	Read Prog<15:0> to Wd	1	2	None
TBLWTH	TBLWTH	Ws,Wd	Write Ws<7:0> to Prog<23:16>	1	2	None
TBLWTL	TBLWTL	Ws,Wd	Write Ws to Prog<15:0>	1	2	None
ULNK	ULNK		Unlink Frame Pointer	1	1	None
XOR	XOR	f	f = f .XOR. WREG	1	1	N, Z
	XOR	f,WREG	WREG = f .XOR. WREG	1	1	N, Z
	XOR	#lit10,Wn	Wd = lit10 .XOR. Wd	1	1	N, Z
	XOR	Wb,Ws,Wd	Wd = Wb .XOR. Ws	1	1	N, Z
	XOR	Wb,#lit5,Wd	Wd = Wb .XOR. lit5	1	1	N, Z
ZE	ZE	Ws,Wnd	Wnd = Zero-Extend Ws	1	1	C, Z, N

TABLE 29-20: PLL CLOCK TIMING SPECIFICATIONS

AC CHARACTERISTICS			Standard Operating Conditions: 1.8V to 3.6V PIC24F32KA3XX 2.0V to 5.5V PIC24FV32KA3XX Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended				
Param No.	**Sym**	**Characteristic(1)**	**Min**	**Typ(2)**	**Max**	**Units**	**Conditions**
OS50	FPLLI	PLL Input Frequency Range	4	—	8	MHz	ECPLL, HSPLL modes, -40°C ≤ TA ≤ +85°C
OS51	FSYS	PLL Output Frequency Range	16	—	32	MHz	-40°C ≤ TA ≤ +85°C
OS52	TLOCK	PLL Start-up Time (Lock Time)	—	1	2	ms	
OS53	DCLK	CLKO Stability (Jitter)	-2	1	2	%	Measured over a 100 ms period

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

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

TABLE 29-21: AC CHARACTERISTICS: INTERNAL RC ACCURACY

AC CHARACTERISTICS		Standard Operating Conditions: 1.8V to 3.6V PIC24F32KA3XX 2.0V to 5.5V PIC24FV32KA3XX Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended					
Param No.	**Characteristic**	**Min**	**Typ**	**Max**	**Units**	**Conditions**	
F20	**Internal FRC Accuracy @ 8 MHz(1)**						
	FRC	-2	—	+2	%	+25°C	3.0V ≤ VDD ≤ 3.6V, F device 3.2V ≤ VDD ≤ 5.5V, FV device
		-5	—	+5	%	-40°C ≤ TA ≤ +85°C	1.8V ≤ VDD ≤ 3.6V, F device 2.0V ≤ VDD ≤ 5.5V, FV device
	LPRC @ 31 kHz(2)						
F21		-15	—	15	%		

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

2: The change of LPRC frequency as VDD changes.

TABLE 29-22: INTERNAL RC OSCILLATOR SPECIFICATIONS

AC CHARACTERISTICS			Standard Operating Conditions: 1.8V to 3.6V PIC24F32KA3XX 2.0V to 5.5V PIC24FV32KA3XX Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended				
Param No.	**Sym**	**Characteristic(1)**	**Min**	**Typ**	**Max**	**Units**	**Conditions**
	TFRC	FRC Start-up Time	—	5	—	μs	
	TLPRC	LPRC Start-up Time	—	70	—	μs	

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

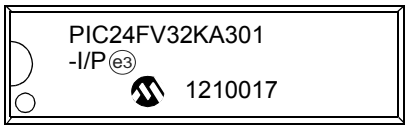
© 2011-2013 Microchip Technology Inc.

31.0 PACKAGING INFORMATION

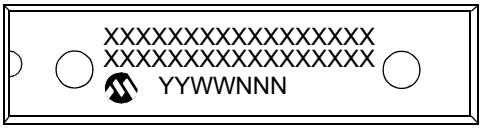
31.1 Package Marking Information

20-Lead PDIP (300 mil)

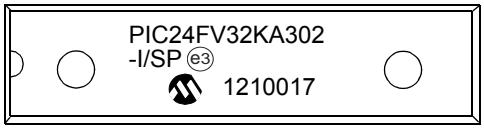
Example



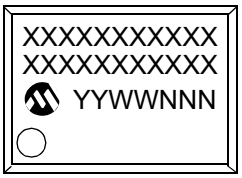
28-Lead SPDIP (.300")



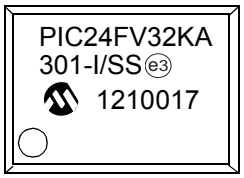
Example



20-Lead SSOP (5.30 mm)



Example



28-Lead SSOP (5.30 mm)

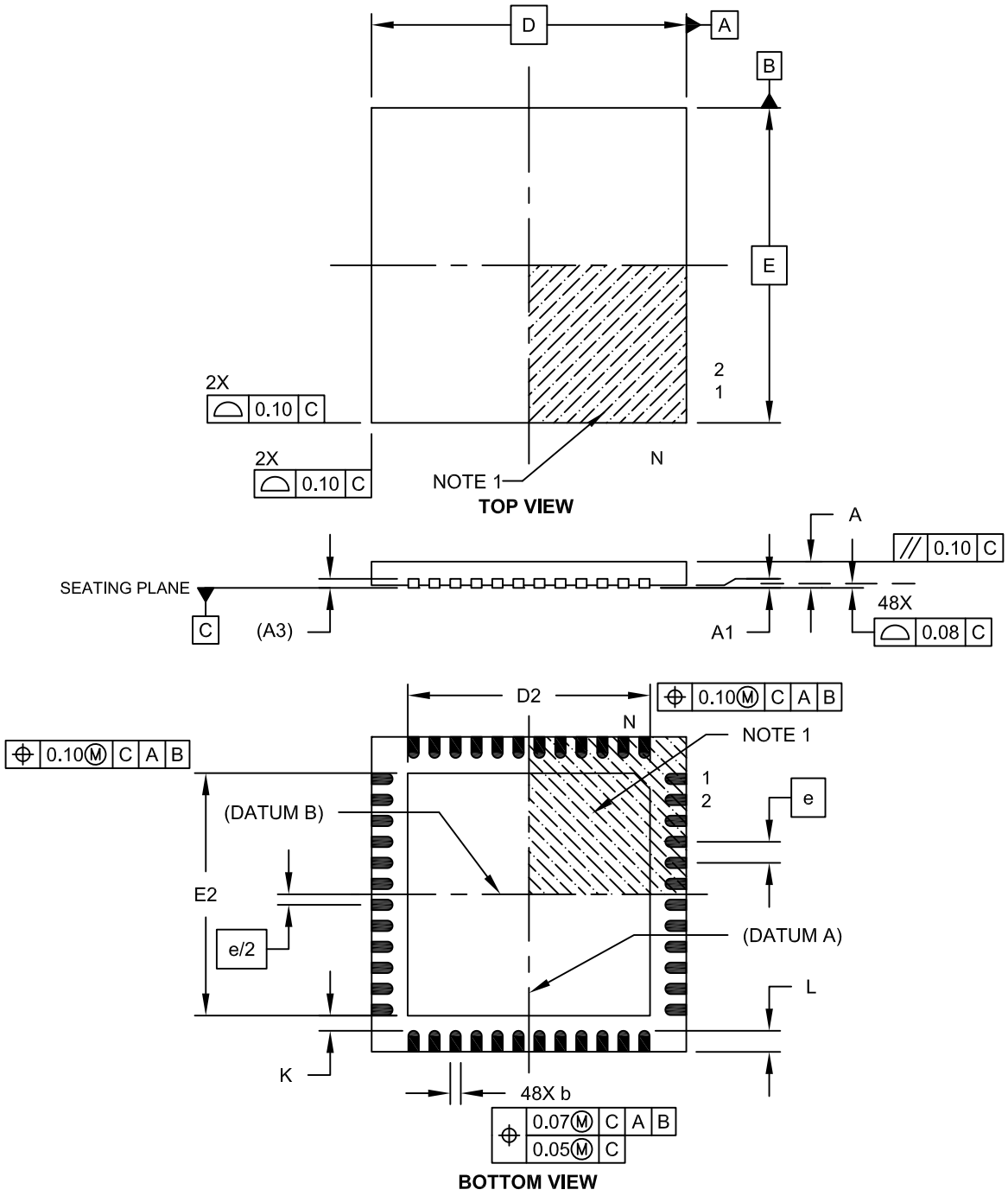
Example

Legend:	XX...X	Product-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

48-Lead Plastic Ultra Thin Quad Flat, No Lead Package (MV) – 6x6x0.5 mm Body [UQFN]

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



Microchip Technology Drawing C04-153A Sheet 1 of 2

© 2011-2013 Microchip Technology Inc.