INTRODUCTION

This application note discusses the use of the PIC16CXXX Timer1 module as an asynchronous clock. The Timer1 module has its own oscillator circuitry, which allows the timer to keep real-time, even when the device is in SLEEP mode. When the device is in sleep, the oscillator will continue to increment TMR1. An overflow of the TMR1 register causes a TMR1 Overflow Interrupt (if enabled) and will wake the processor from sleep. The interrupt service routine can then perform the desired task.

OVERVIEW

Timer1 is a 16-bit counter with a 2-bit prescaler. Timer1 can be incremented from an internal clock, an external clock, or an external oscillator. Timer1 can be configured to synchronize or not synchronize the external clock sources. Asynchronous operation allows Timer1 to increment when the device is in sleep. Figure 1 is a block diagram of Timer1.

To set up Timer1 for asynchronous operation the Timer1 control register, T1CON, must have the following bits configured:
- TMR1CS set (external clock source)
- T1CKS1:T1CKS0 configured for the desired prescaler
- T1SYNC set (asynchronous operation)
- TMR1ON set (enables Timer1)
- T1OSCEN set, if using an external oscillator

In asynchronous operation, if the clock source is an external clock, it is input on the T1CKI pin. If the clock source is a crystal oscillator, the crystal is connected across the T1OSO and T1OSI pins.

When using Timer1 in Asynchronous mode, the use of an external clock minimizes the operating and sleep currents. This is because the timer’s internal oscillator circuitry is disabled. Though the external clock may give the lower device currents, the use of a crystal oscillator may lead to lower system current consumption and system cost.

System current consumption can also be reduced by having the TMR1 Overflow Interrupt wake the processor from SLEEP at the desired interval. With a 32.768 kHz crystal, Timer1’s overflow rate ranges from 2 to 16 seconds, depending on the prescaler chosen. Table 1 shows Timer1 overflow times for various crystal frequencies and prescaler values.

<table>
<thead>
<tr>
<th>TABLE 1: TIMETER1 OVERFLOW TIMES</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Prescale</th>
<th>Frequency (kHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>32.768</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>16</td>
</tr>
</tbody>
</table>

Overflow times in seconds.

FIGURE 1: TIMER1 BLOCK DIAGRAM

When the T1OSCEN bit is cleared, the inverter and feedback resistor are turned off. This eliminates power drain.
As can be seen the 32 kHz crystal, gives very nice overflow rates. These crystals, referred to as watch crystals, also can be relatively inexpensive. In many applications the 2 second overflow time, of a 32 kHz crystal, is too long. An easy way to reduce the overflow time is to load the TMR1H register with a value, during the interrupt service routine. Table 2 shows the overflow times, depending on the value loaded into the TMR1H register and a prescale of 1.

### TABLE 2: TMR1H LOAD VALUES / TIMER1 OVERFLOW TIMES

<table>
<thead>
<tr>
<th>TMR1H Load Value</th>
<th>Overflow Time (@ 32.768 kHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>80h</td>
<td>1 Second</td>
</tr>
<tr>
<td>C0h</td>
<td>0.5 Second</td>
</tr>
<tr>
<td>E0h</td>
<td>0.25 Second</td>
</tr>
<tr>
<td>F0h</td>
<td>0.125 Second</td>
</tr>
</tbody>
</table>

**Note:** The loading of either TMR1H or TMR1L causes the prescaler to be cleared. When Timer1 is in operation, extreme care should be taken in modifying either the TMR1H or TMR1L registers, since this automatically configures the prescaler to 1.

The code segment shown in Example 1 configures the Timer1 module for asynchronous operation, enables the Timer1 interrupt, and the interrupt service routine loads the TMR1H register with a value.

### CONCLUSION

Timer1 gives designers a powerful time-base function. The asynchronous operation and internal oscillator circuitry gives designers the ability to easily keep real-time, while minimizing power consumption and external logic.
EXAMPLE 1: TIMER1 CODE SEGMENT FOR ASYNCHRONOUS OPERATION

```
org 0x000
Reset_V GOTO START
;
org 0x004
PER_INT_V
BCF STATUS, RP0 ; Bank0
BTFSC PIR1, TMR1IF ; Timer1 overflowed?
GOTO T1_OVRFL ; YES, Service the Timer1 Overflow Interrupt
;
; Should NEVER get here
;
ERROR1
BSF PORTD, 1 ; Toggle a port pin to indicate error
BCF PORTD, 1
GOTO ERROR1
;
T1_OVRFL
BCF PIR1, TMR1IF ; Clear Timer1 Interrupt Flag
MOVlw 0x80 ; Since doing key inputs, clear TMR1
MOVwf TMR1H ; for 1 sec overflow.
:
; Do Interrupt stuff here
:
RETFIE ; Return / Enable Global Interrupts
;
START ; POWER_ON Reset (Beginning of program)
CLRF STATUS ; Do initialization (Bank0)
BCF T1CON, TMR1ON ; Timer1 is NOT incrementing
:
; Do Initialization stuff here
:
MOVlw 0x80 ; TIM1H:TMR1L = 0x8000 gives 1 second
MOVwf TMR1H ; overflow, at 32 KHz.
CLRF TMR1L
;
CLRF INTCON
CLRF PIR1
BSF STATUS, RP0 ; Bank1
CLRF PIE1 ; Disable all peripheral interrupts
;
if ( C74_REV_A ) ; See PIC16C74 Errata
BSF TRISC, T1OSO ; RC0 needs to be input for the oscillator to function
endif
BSF PIE1, TMR1IE ; Enable TMR1 Interrupt
;
; Initialize the Special Function Registers (SFR) interrupts
;
BCF STATUS, RP0 ; Bank0
CLRF PIR1 ;
BSF INTCON, FEIE ; Enable Peripheral Interrupts
BSF INTCON, GIE ; Enable all Interrupts
;
MOVLW 0x0E
MOVWF T1CON ; Enable T1 Oscillator, Ext Clock, Async, prescaler = 1
BSF T1CON, TMR1ON ; Turn Timer1 ON
;
zzz SLEEP
GOTO zzz ; Sleep, wait for TMR1 interrupt
```
Note the following details of the code protection feature on PICmicro® MCUs.

- The PICmicro family meets the specifications contained in the Microchip Data Sheet.
- Microchip believes that its family of PICmicro microcontrollers is one of the most secure products of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the PICmicro microcontroller in a manner operating the specifications contained in the data sheet. The person doing so may be engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable".
- Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our product.

If you have any further questions about this matter, please contact the local sales office nearest to you.

Information contained in this publication regarding device applications and the like is intended through suggestion only and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. No representation or warranty is given and no liability is assumed by Microchip Technology Incorporated with respect to the accuracy or use of such information, or infringement of patents or other intellectual property rights arising from such use or otherwise. Use of Microchip's products as critical components in life support systems is not authorized except with express written approval by Microchip. No licenses are conveyed, implicitly or otherwise, under any intellectual property rights.

Note the following details of the code protection feature on PICmicro® MCUs.

- The PICmicro family meets the specifications contained in the Microchip Data Sheet.
- Microchip believes that its family of PICmicro microcontrollers is one of the most secure products of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the PICmicro microcontroller in a manner operating the specifications contained in the data sheet. The person doing so may be engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable".
- Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our product.

If you have any further questions about this matter, please contact the local sales office nearest to you.

Information contained in this publication regarding device applications and the like is intended through suggestion only and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. No representation or warranty is given and no liability is assumed by Microchip Technology Incorporated with respect to the accuracy or use of such information, or infringement of patents or other intellectual property rights arising from such use or otherwise. Use of Microchip’s products as critical components in life support systems is not authorized except with express written approval by Microchip. No licenses are conveyed, implicitly or otherwise, under any intellectual property rights.

Trademarks

The Microchip name and logo, the Microchip logo, FilterLab, KEELOQ, microID, MPLAB, PIC, PICmicro, PICMASTER, PICSTART, PRO MATE, SEEVAL and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

dsPIC, ECONOMONITOR, FanSense, FlexROM, fuzzyLAB, In-Circuit Serial Programming, ICSP, ICEPIC, microPort, Migratable Memory, MPASM, MPLIB, MPSIM, MXDEV, PICC, PICDEM, PICDEM.net, rfPIC, Select Mode and Total Endurance are trademarks of Microchip Technology Incorporated in the U.S.A.

Serialized Quick Turn Programming (SQTP) is a service mark of Microchip Technology Incorporated in the U.S.A.

All other trademarks mentioned herein are property of their respective companies.

© 2002, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

Printed on recycled paper.
**WORLDWIDE SALES AND SERVICE**

**AMERICAS**

**Corporate Office**
2335 West Chandler Blvd.
Chandler, AZ  85224-6199
Tel: 480-792-7200  Fax: 480-792-7277
Technical Support: 480-792-7627
Web Address: http://www.microchip.com

**Rocky Mountain**
2335 West Chandler Blvd.
Chandler, AZ  85224-6199
Tel: 480-792-7966  Fax: 480-792-7456

**Atlanta**
500 Sugar Mill Road, Suite 200B
Atlanta, GA  30350
Tel: 770-640-0034  Fax: 770-640-0307

**Boston**
2 Lan Drive, Suite 120
Westford, MA  01886
Tel: 978-692-3848  Fax: 978-692-3821

**Chicago**
333 Pierce Road, Suite 180
Itasca, IL  60143
Tel: 630-285-0071  Fax: 630-285-0075

**Dallas**
4570 Westgrove Drive, Suite 160
Addison, TX 75001
Tel: 972-818-7924  Fax: 972-818-2924

**Detroit**
Tri-Aria Office Building
32255 Northwestern Highway, Suite 190
Farmington Hills, MI  48334
Tel: 248-538-2250  Fax: 248-538-2260

**Kokomo**
2767 S. Albright Road
Kokomo, Indiana  46902
Tel: 765-864-8360  Fax: 765-864-8387

**Los Angeles**
18201 Von Karman, Suite 1090
Irvine, CA  92612
Tel: 949-263-1888  Fax: 949-263-1338

**New York**
150 Motor Parkway, Suite 202
Hauppauge, NY  11788
Tel: 631-273-5305  Fax: 631-273-5335

**San Jose**
1681 North First Street, Suite 590
San Jose, CA 95131
Tel: 408-436-7955  Fax: 408-436-7955

**Toronto**
6285 Northam Drive, Suite 108
Mississauga, Ontario L4V 1X5, Canada
Tel: 905-673-0699  Fax: 905-673-6509

**Asia/Pacific**

**Australia**
Microchip Technology Australia Pty Ltd
Suite 22, 41 Rawson Street
Epping 2121, NSW
Australia
Tel: 61-2-9868-6733  Fax: 61-2-9868-6755

**China - Beijing**
Microchip Technology Consulting (Shanghai) Co., Ltd., Beijing Liaison Office
Unit 915
Bei Hai Wan Tai Bldg., No. 6 Chaoyangmen Beidajie
Beijing, 100027, No. China
Tel: 86-10-85282100  Fax: 86-10-85282104

**China - Chengdu**
Microchip Technology Consulting (Shanghai) Co., Ltd., Chengdu Liaison Office
Rm. 2401, 24th Floor,
Ming Xing Financial Tower
No. 88 TIDU Street
Chengdu 610016, China
Tel: 86-28-6766200  Fax: 86-28-6766599

**China - Fuzhou**
Microchip Technology Consulting (Shanghai) Co., Ltd., Fuzhou Liaison Office
Unit 71 Wus Road
Fuzhou 350001, China
Tel: 86-591-7503506  Fax: 86-591-7503521

**China - Shanghai**
Microchip Technology Consulting (Shanghai) Co., Ltd., Shanghai Liaison Office
Room 28F, World Trade Plaza
No. 71 Wus Road
Shanghai, 200051
Tel: 86-21-6275-5700  Fax: 86-21-6275-5060

**China - Shenzhen**
Microchip Technology Consulting (Shanghai) Co., Ltd., Shenzhen Liaison Office
Rm. 1315, 13/F, Shenzhen Kerry Centre,
Renmin Nan Lu
Shenzhen 518001, China
Tel: 86-755-2350361  Fax: 86-755-2366086

**Hong Kong**
Microchip Technology Hongkong Ltd.
Unit 901-6, Tower 2, Metroplaza
223 Hing Fong Road
Kwai Fong, N.T., Hong Kong
Tel: 852-2401-1200  Fax: 852-2401-3431

**India**
Microchip Technology Inc.
India Liaison Office
Divyasree Chambers
1 Floor, Wing A (A3/A4)
No. 11, O'Shaugnessy Road
Bangalore, 560 025, India
Tel: 91-80-2290061  Fax: 91-80-2290062

**Japan**
Microchip Technology Japan K.K.
Benex S-1 1F
3-18-20, Shinyokohama
Kohoku-Ku, Yokohama-shi
Kanagawa, 222-0033, Japan
Tel: 81-45-471-6166  Fax: 81-45-471-6122

**Korea**
Microchip Technology Korea
168-1, Youngbo Bldg. 3 Floor
Samsung-Dong, Kangnam-Ku
Seoul, Korea 135-882
Tel: 82-2-554-7200  Fax: 82-2-558-5934

**Singapore**
Microchip Technology Singapore Pte Ltd.
200 Middle Road
#07-02 Prime Centre
Singapore, 189890
Tel: 65-334-8870  Fax: 65-334-8850

**Taiwan**
Microchip Technology Taiwan
11F-3, No. 207
Tung Hua North Road
Taipei, 105, Taiwan
Tel: 886-2-2717-7175  Fax: 886-2-2545-0139

**Europe**

**Denmark**
Microchip Technology Nordic ApS
Regus Business Centre
Laurup høj 1-3
Ballup DK-2750 Denmark
Tel: 45 4420 9895  Fax: 45 4420 9910

**France**
Microchip Technology SARL
Parc d'Activite du Moulin de Massy
43 Rue du Saule Trapu
Batiment A - Ier Etage
91900 Massy, France
Tel: 33-1-69-53-63-20  Fax: 33-1-69-30-90-79

**Germany**
Microchip Technology GmbH
Gustav-Heinemann Ring 125
D-81739 Munich, Germany
Tel: 49-89-627-144 0  Fax: 49-89-627-144-44

**Italy**
Microchip Technology SRL
Centro Direzionale Colleoni
Palazzo Taurus 1 V. Le Colleoni 1
20041 Agrate Brianza
Milan, Italy
Tel: 39-039-65791-1  Fax: 39-039-6899883

**United Kingdom**
Microchip Technology Ltd.
505 Eskdale Road
Winnersh Triangle
Wokingham
Berkshire, England RG41 5TU
Tel: 44 118 921 5869  Fax: 44-118 921-5820

01/18/02

© 2002 Microchip Technology Inc.