AN1268

mTouch™ Capacitive Sensing Using Period Method

Author: *Thomas Perme*
Microchip Technology Inc.

INTRODUCTION

This application note is an addendum to the information in the previous capacitive touch sensing application notes, found on Microchip's web site. It builds specifically on AN1101, "*Introduction to Capacitive Sensing"*. This application note focuses on how to use either an SR latch enabled part, or our new family of parts with a dedicated Cap Sense Module (CSM) to measure changes in capacitance using a period measurement instead of frequency measurement.

Using this new method provides higher resolution than the frequency measurement and permits faster scanning.

THEORY OF OPERATION

The basic principle is that a relaxation oscillator will be created with the microcontroller and the sensing pad's capacitance. This oscillation should be on the order of 200 to 500 kHz (using the CSM module, no work is required but to have a sensor pad, and the oscillations will be in this range when using the high power setting; for the SR latch devices, a 100 kOhm feedback resistor will typically put the sensors in that region - Figure A-1). When a user's finger touches the sensor, it will reduce the relaxation oscillator frequency and increase the period. This increase in period will be detected.

Configuring the Hardware

The period will not be measured as a value, such as 8µsec but, instead, will be a count in Timer1 representing period through some scaling factors. This method will use Timer0 and Timer1, but now the inputs to Timer0 and Timer1 are reversed. The input of Timer1 will be FOSC/4, or a multiple, and the input of Timer0 will be the relaxation oscillator drive signal.

Figure 1 on page 3 shows how to configure the PIC16F727 family of devices to perform this period measurement using the Cap Sense Module (CSM).

Obtaining a Reading

At the beginning of a reading, Timer1 is cleared, and Timer0 may be cleared or preloaded with a fixed value. Preloading a value, other than 0, will make the sampling time shorter. On the interrupt of Timer0, the value of Timer1 is the reading. The internal oscillator of the device will run at 4, 8, or 16 MHz, orders of magnitude faster than the relaxation oscillator. The Timer1 result is a ratio of the frequency of the internal oscillator over the frequency of the relaxation oscillator, and this is multiplied by the number of periods measured (how many times Timer0 counted – 255 periods if starting from 0), as shown in Equation 1 below:

EQUATION 1:

$$\text{reading} = (F_{OSC}/4)/(F_{RELAXOSC}) \bullet N$$

The Timer1 value is a representation of the period of the relaxation oscillator. This value will be watched for an increase, signaling touch.

SOFTWARE DECODING

The software decoding for the period measurement is identical to the frequency measurement methods, except now the reading goes up for a touch, instead of down. Previously, as frequency decreased, the same decrease was seen in the reading.

Also, the period measurement is linear only for small shifts, less than 5-10%. A percentage can still be computed from the value, and is still useful, but for large shifts, since the period is 1/f, it increases exponentially. If you have a large shift, then the signal shift will be extremely large, allowing for plenty of shift in the data to work with.

BENEFITS AND TRADE-OFFS

Faster

The sensor can be sampled in a shorter time for an equal amount of resolution and debouncing, compared to the frequency method. The decrease in sampling time is on the order of 2-5 times. This method can work acceptably with as few as 32 periods of the relaxation oscillator (preload TMR0=255-32). Scanning faster can allow more time for debouncing. The alternative to scanning faster is to have the same sample time, which will increase resolution.

Higher Resolution

This method provides a higher resolution in the same amount of time, compared to the frequency method. The reason is that using frequency directly, a single bit count was a change in 1 period of the relaxation oscillator. Using FOSC/4, as described above, gives sampling points within a single relaxation oscillator period. The end result is that for a 5% shift, you will see 5% shift on both the frequency measurement and period measurement, but you will get more counts of resolution between 0 and 5% using the period measurement.

This increase in resolution is most beneficial when using weaker sensors, since all resolution obtainable is needed, and there is little margin. In stronger sensors, both methods work equally well.

Additional Safety Catch

The frequency method has an automatic time out if a sensor is stuck or grounded. That sensor will naturally be dead (since it is grounded), and then the other sensors will continue to operate. There is a small amount of overhead to add a check on Timer1 to overflow, in order to ensure a sensor is not dead with the period measurement. This is required because Timer0 will not increment if the sensor is grounded, and then could create a potential lockup of all keys, not just one. So, the new period method requires an additional condition to be observed.

Non-constant Sample Time

The period measurement does introduce sample times for sensors which are not constant. Since it depends on the relaxation oscillator to get the reading, as you touch the sensor, it will take longer to read the sensor. For small changes, the time is mostly linear. If a sensor's capacitance changes by 5%, that sensor will take 5% longer to sample. If the sampling time is 1ms, it would then take about 1.05ms. This is good for yielding higher resolution, but is not desirable if you want a constant sampling time.

Code Usage

The memory and RAM usage of both period and frequency measurements are very comparable, and there is not much difference between the two methods here.

CONCLUSIONS

The new period measurement is a good method to use when weak sensors are used, such as cases with thick plastic covers. It is best in situations like that to add the extra resolution, for the same amount of time spent scanning.

This new method allows for flexibility in a trade-off between speed and resolution. If scanning speed is too slow, it can be made to work faster, and if higher resolution is required, it allows for that too. The final user's balance is more flexible in the range of speed and resolution.

Microchip also has other useful application notes about its mTouch™ Capacitive Touch Sensing Solutions. These application notes cover the basics of capacitive touch sensing, as well as different methods for tiny parts, like the PIC10F family, or large parts such as some PIC24F families.

REFERENCES:

AN1101, *"Introduction to Capacitive Sensing"*

AN1102, *"Layout and Physical Design Guidelines for Capacitive Sensing"*

AN1103, *"Software Handling for Capacitive Sensing"*

AN1104, *"Capacitive Multibutton Configurations"*

AN1171, *"Using Capacitive Sensing Module with PIC16F72X"*

AN1202, *"Capacitive Sensing with PIC10F"*

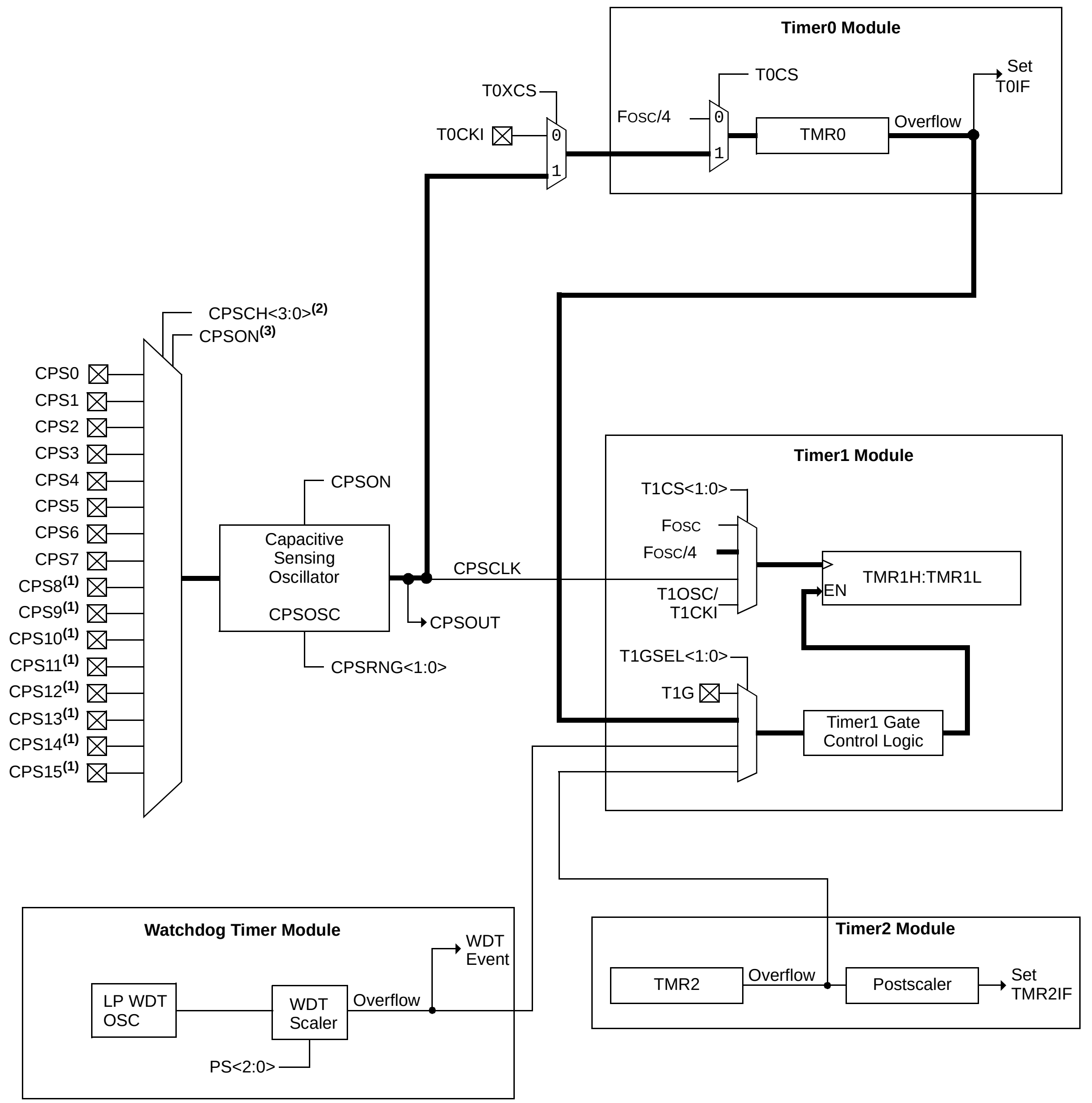
AN1250, *"Microchip CTMU for Capacitive Touch Applications"*

WEBINARS:

Introduction to mTouch™ Capacitive Touch Sensing

Capacitive mTouch™ Sensing Solutions: Design Guidelines.

FIGURE 1: CONFIGURING PIC16F727 FOR PERIOD MEASUREMENT



Note 1: Channels CPS<15:8> are implemented on PIC16F724/727/PIC16LF724/727 only.
2: CPSCH3 is not implemented on PIC16F722/723/726/PIC16LF722/723/726.
3: If CPSON = 0, disabling capacitive sensing, no channel is selected.

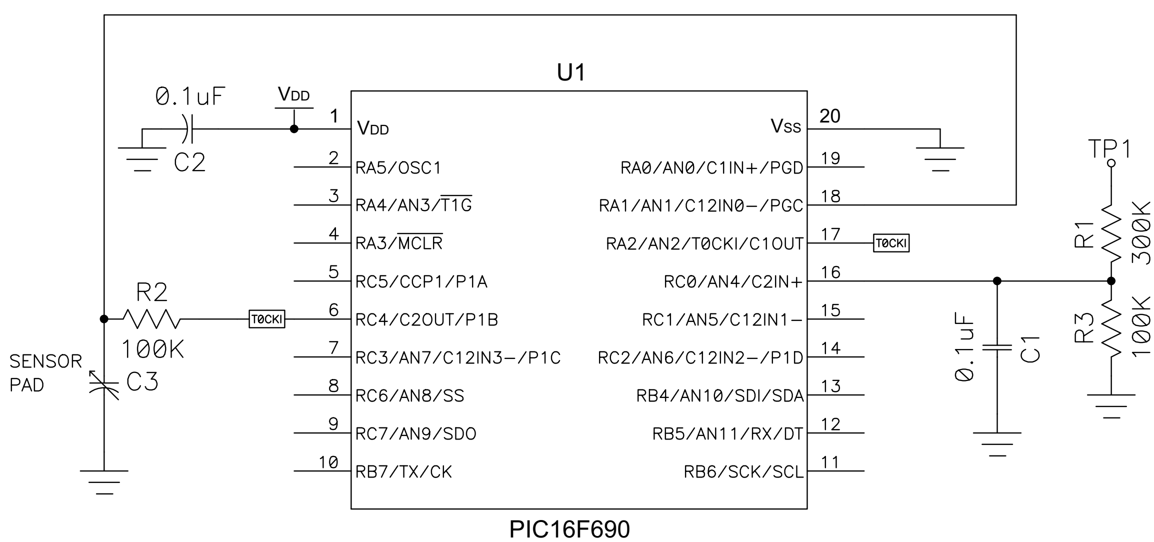
NOTES:

APPENDIX A: SCHEMATICS

The SR Latch schematic, illustrated in Figure A-1, shows how the oscillator drive signal goes into T0CKI, and how the feedback signal goes into C12IN0-.

Using a part with the CSM only requires a wire to a pad for the schematic. The setup is done internally as shown in Figure 1, which configures the CSM to send the CPSOSC (drive signal) to T0CKI, and increment Timer1 from FOSC/4.

FIGURE A-1: SR LATCH SCHEMATIC



NOTES:

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families 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 Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is 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 products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
ISO/TS 16949:2002

Microchip received ISO/TS-16949:2002 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.

WORLDWIDE SALES AND SERVICE

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
http://support.microchip.com
Web Address:
www.microchip.com

Atlanta
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Cleveland
Independence, OH
Tel: 216-447-0464
Fax: 216-447-0643

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Farmington Hills, MI
Tel: 248-538-2250
Fax: 248-538-2260

Kokomo
Kokomo, IN
Tel: 765-864-8360
Fax: 765-864-8387

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608

Santa Clara
Santa Clara, CA
Tel: 408-961-6444
Fax: 408-961-6445

Toronto
Mississauga, Ontario,
Canada
Tel: 905-673-0699
Fax: 905-673-6509

ASIA/PACIFIC

Asia Pacific Office
Suites 3707-14, 37th Floor
Tower 6, The Gateway
Harbour City, Kowloon
Hong Kong
Tel: 852-2401-1200
Fax: 852-2401-3431

Australia - Sydney
Tel: 61-2-9868-6733
Fax: 61-2-9868-6755

China - Beijing
Tel: 86-10-8528-2100
Fax: 86-10-8528-2104

China - Chengdu
Tel: 86-28-8665-5511
Fax: 86-28-8665-7889

China - Hong Kong SAR
Tel: 852-2401-1200
Fax: 852-2401-3431

China - Nanjing
Tel: 86-25-8473-2460
Fax: 86-25-8473-2470

China - Qingdao
Tel: 86-532-8502-7355
Fax: 86-532-8502-7205

China - Shanghai
Tel: 86-21-5407-5533
Fax: 86-21-5407-5066

China - Shenyang
Tel: 86-24-2334-2829
Fax: 86-24-2334-2393

China - Shenzhen
Tel: 86-755-8203-2660
Fax: 86-755-8203-1760

China - Wuhan
Tel: 86-27-5980-5300
Fax: 86-27-5980-5118

China - Xiamen
Tel: 86-592-2388138
Fax: 86-592-2388130

China - Xian
Tel: 86-29-8833-7252
Fax: 86-29-8833-7256

China - Zhuhai
Tel: 86-756-3210040
Fax: 86-756-3210049

ASIA/PACIFIC

India - Bangalore
Tel: 91-80-3090-4444
Fax: 91-80-3090-4080

India - New Delhi
Tel: 91-11-4160-8631
Fax: 91-11-4160-8632

India - Pune
Tel: 91-20-2566-1512
Fax: 91-20-2566-1513

Japan - Yokohama
Tel: 81-45-471- 6166
Fax: 81-45-471-6122

Korea - Daegu
Tel: 82-53-744-4301
Fax: 82-53-744-4302

Korea - Seoul
Tel: 82-2-554-7200
Fax: 82-2-558-5932 or
82-2-558-5934

Malaysia - Kuala Lumpur
Tel: 60-3-6201-9857
Fax: 60-3-6201-9859

Malaysia - Penang
Tel: 60-4-227-8870
Fax: 60-4-227-4068

Philippines - Manila
Tel: 63-2-634-9065
Fax: 63-2-634-9069

Singapore
Tel: 65-6334-8870
Fax: 65-6334-8850

Taiwan - Hsin Chu
Tel: 886-3-6578-300
Fax: 886-3-6578-370

Taiwan - Kaohsiung
Tel: 886-7-536-4818
Fax: 886-7-536-4803

Taiwan - Taipei
Tel: 886-2-2500-6610
Fax: 886-2-2508-0102

Thailand - Bangkok
Tel: 66-2-694-1351
Fax: 66-2-694-1350

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4450-2828
Fax: 45-4485-2829

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

UK - Wokingham
Tel: 44-118-921-5869
Fax: 44-118-921-5820

03/26/09