AN1298

Capacitive Touch Using Only an ADC ("CVD")

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INTRODUCTION

This application note describes a new hardware sensing method called Capacitive Voltage Divider (CVD) which uses no external components. It requires only the ADC to perform capacitive touch sensing. The principle is simple, and can be applied to nearly any Microchip PIC® device with an ADC.

THEORY OF OPERATION

Sensor construction is the same as a typical sensor; a sensor is an area of copper on a PCB or similar conductive pad for sensing. The sensor will be tied directly to an ADC channel. The rest of the process is done by configuring the ADC and I/O in a specific manner. Sensing requires two ADC channels, but they may both be sensors. While one channel is actively scanning, the other sensor may be reused for a secondary line that's required while scanning the first channel. While sensors are not being scanned, they should be kept at ground or V_{DD}.

Sensing Steps

To perform the sensing, do the following:

1. Drive secondary channel to V_{DD} as digital output.
2. Point ADC to the secondary V_{DD} pin (charges C_{HOLD} to V_{DD}).
3. Ground sensor line.
4. Turn sensor line as input (TRISx = `1`).
5. Point ADC to sensor channel (voltage divider from sensor to C_{HOLD}).
6. Begin ADC conversion.
7. Reading is in `ADRESH:ADRESL`.

Sensing Steps Description

The basic principle begins with one ADC channel charging the internal sample-and-hold cap for the ADC to V_{DD}. The sensor channel is then prepared to a known state by grounding it. In Figure 1, it is shown floating to illustrate why it is important to ground it. After the sensor is grounded, it must be made an input again. Finally, immediately after it is made an input, the ADC channel is switched to the sensor. This puts the sample and hold cap, Chold, in parallel with the sensor capacitor, creating a voltage divider between the two. Thus, the voltage on the sensor capacitor is the same on the sample and hold capacitor (see Figure 2). After this step, the ADC should be sampled, and the reading represents an amount of capacitance on the external sensor. With the addition of a finger touching the sensor, the capacitance will increase, and the voltage on step 5 will be lower.

FIGURE 1: WAVEFORMS WHILE PERFORMING SENSING SEQUENCE

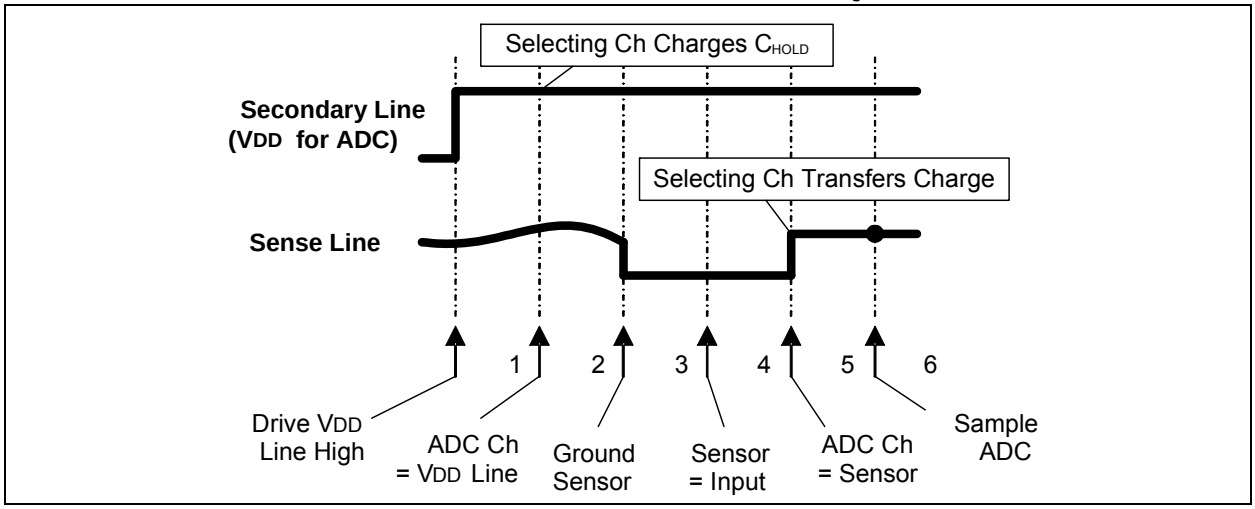
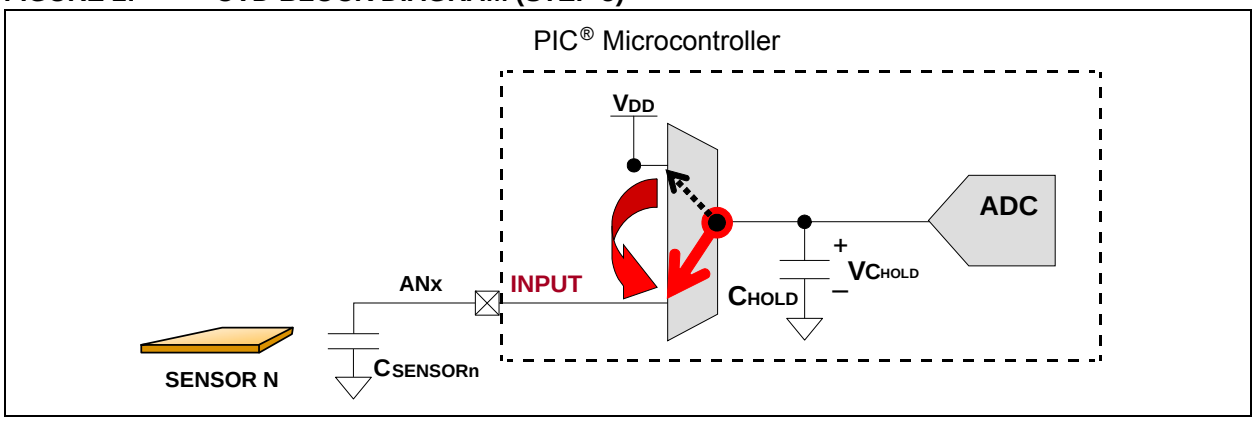


FIGURE 2: CVD BLOCK DIAGRAM (STEP 5)



Detecting a Touch

A touch will cause the ADC reading to decrease. So, an average stable value will be created for an unpressed condition, and then a deviation less than that will be what is detected as a press. This is shown in Figure 3 and Figure 4.

FIGURE 3: COMPARING TOUCHED AND UNTOUCHED WAVEFORM

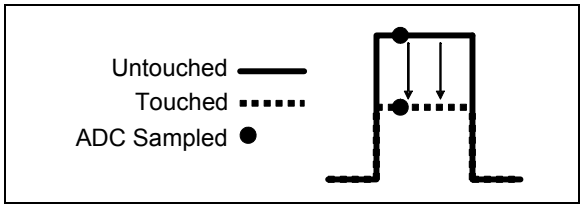
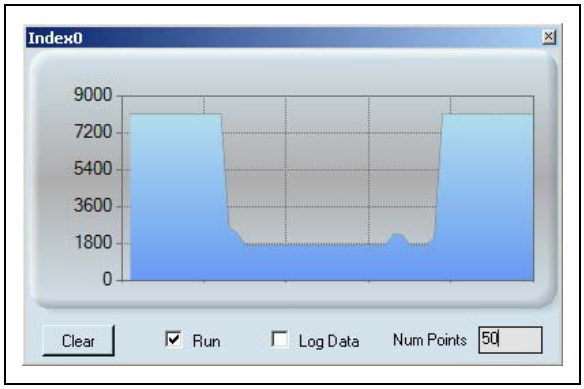


FIGURE 4: A SENSOR'S SCALED READING OVER TIME



BENEFITS OF THIS SOLUTION

This solution may be used with almost any Microchip PIC device that has an ADC. The sensor design is very simple and straightforward, and this method also samples very quickly (10-20 µs). But be mindful not to exceed the ADC's TACQ. At the same time, multiple samples should be taken to filter the data against a single false reading.

INCREASING RESOLUTION

This method is suggested for devices with 10-bit ADCs or better, since the amount of resolution obtainable is directly related to the ADC resolution. It will work on a device with an 8-bit ADC, but there will be less resolution available, and this poses harsher constraints on the physical design – specifically the thickness of any covering material.

If the PIC microcontroller has an optional positive reference voltage. This reference voltage may be used to increase the resolution. Setting VREF+ of the ADC lower will make a smaller voltage range over which the 8 or 10 bits are converted. This applies to both 8-bit and 10-bit ADCs. However, be cautious not to lower VREF+ below the resulting voltage after step 5 of the scanning sequence, or else the ADC reading will saturate. Also, oversampling a sensor 4, 8, or 16 times can improve the resolution via software.

CONCLUSION

The Capacitive Voltage Divider method provides an easy way to add capacitive touch sensing to Microchip PIC devices which do not have touch sensing peripherals, like the CSM or CTMU. It also allows for very fast sampling times. The key peripheral required is an ADC and I/O to perform the touch sensing function.

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03/26/09