ANALOG DEVICES

AN-766
APPLICATION NOTE

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Using the Noise Reduction Feature on the AD7877

by Susan Pratt

INTRODUCTION

The AD7877 touch screen controller is a 12-bit successive approximation ADC with a synchronous serial interface and low on resistance switches for driving touch screens. The AD7877 features direct battery measurement on two inputs, temperature and touch-pressure measurement.

The AD7877 has many user-programmable conversion controls, which include variable acquisition time, first conversion delay, and averaging. It is ideal for battery-powered systems such as personal digital assistants, smart phones, and other portable equipment with resistive touch screens.

One of the AD7877's key features is the STOPACQ input pin, which can be used to reduce the effects of noise on the touch screen measurements. This application note explains in detail how noise can affect the touch screen measurements, where this noise comes from, and how to use the AD7877's STOPACQ feature to reduce or eliminate this noise in an application.

TOUCH SCREENS AND NOISE

A 4-wire touch screen consists of two flexible, transparent, resistive coated layers. The two resistive layers act like a potential divider, and X and Y positional measurements on the screen are proportional to the voltage that is sensed from these layers. A touch screen is essentially a large resistor, so external noise can be coupled onto it and distort its measurements. Adding capacitors to the touch screen pins will reduce the effect of noise, but this does not eliminate the noise completely. These capacitors also have the effect of increasing the touch screen settling time, and in many cases, this is not desirable.

Noise in touch screen systems can come from the display. In most applications, the touch screen sits on a display, such as an LCD. Because the touch screen is in such close proximity to the LCD, noise is coupled from the display onto the touch screen's resistive layers, causing errors in the positional measurements. This noise issue can be a significant factor in the accuracy of resistive touch screens, particularly for such end-user applications as handwriting recognition. In the future, as touch screens become thinner, the effects of noise from the LCD will become more pronounced.

LCD NOISE

An LCD has many control signals, including display refresh control, clock, and drive signals. During the display refresh cycle in particular, noise is present in the system. As the LCD horizontal lines are written, the noise is most prominent. It has been shown that the noise in the system is framed by an LCD control signal. This signal is related to the LCD horizontal refresh phase, and may be the LCD synchronization pulse or some other system-generated signal that is active during the noisy period. Two typical control signals on different types of LCD are the HSYNC signal and the V_{COM} signal.

The frequency of the HSYNC signal can vary significantly, depending on the type of LCD. The signal is normally only asserted for a small fraction of its period, that is, its duty cycle is not 50-50. The majority of the noise coupled onto the touch screen occurs while this LCD signal is asserted. Some residual noise may occur outside the HSYNC signal's active period.

A typical V_{COM} signal is show in Figure 2. It has a frequency of 10 kHz, and a 50-50 duty cycle. In this case, noise may be most prominent in the system at the signal transitions.

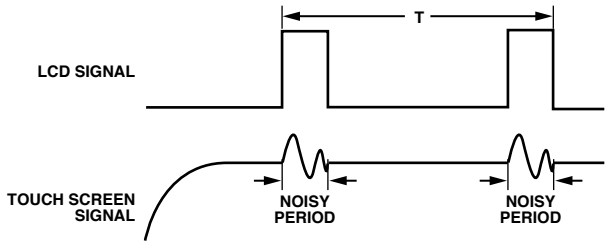

Figure 1. Noise from the LCD Interferes with the Touch Screen Measurements

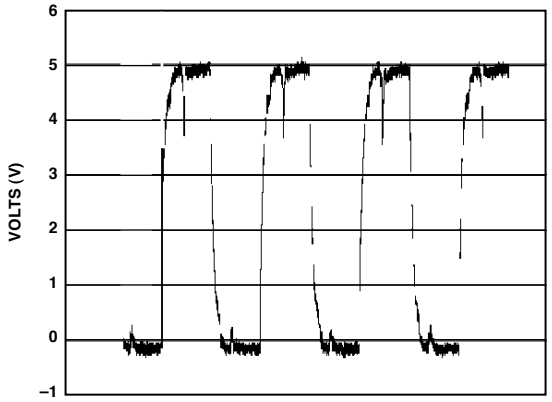

Figure 2. Typical V_{COM} Signal

THE AD7877 STOPACQ FEATURE

The AD7877 includes a feature to reduce the impact of LCD noise on touch screen measurements. The AD7877 has an ADC with sample-and-hold architecture. It is only during the sample, or acquisition phase, of the ADC's operation that noise from the LCD screen has an effect on the ADC's measurements. During the hold, or conversion phase, the noise has no effect, as the voltage at the input of the ADC has already been acquired. The noise is present when the LCD signal is active. So, no acquisitions should take place during the LCD signal active period.

The LCD control signal should be connected to the AD7877 via the external STOPACQ pin. The AD7877 then monitors this signal and ensures that no input signal to the ADC is acquired during the noisy period.

While the STOPACQ pin is being monitored, the user can drive the pin with a signal such as V_{COM} or HSYNC, or with some other suitable control signal. When the signal is active, acquisitions on all input channels on the AD7877 are disabled, irrespective of the programmed mode of the device. When the signal on the STOPACQ pin deasserts, the ADC will reset to the start of the acquisition phase for the next channel to be measured. By programming the acquisition time, any noise from the LCD that is not framed by the signal at STOPACQ can also be avoided. (For more information on AD7877 modes and programming the acquisition time, see the AD7877 data sheet.)

To cater for signals of different polarities on the STOPACQ pin, there is a user-programmable register bit to indicate whether the signal is active high or low. The POL bit is Bit 3 in Control Register 2, address 02h. See Table I for more information.

To disable monitoring of STOPACQ, the pin should be tied low if the signal polarity is active high, or tied high if the signal polarity is active low. If the STOPACQ pin functionality is disabled, then any signal applied to the STOPACQ pin is disregarded by the AD7877. The polarity bit defaults to 0 on power-up. The user must ensure that this bit contains the correct value for the type of signal on STOPACQ.

Table I. STOPACQ POL Bit Description

POL Bit Value	STOPACQ Functionality
0	Input signal is active low: Low signal level frames noise
1	Input signal is active high: High signal level frames noise

STOPACQ TIMING DETAILS

If the STOPACQ signal becomes active during an acquisition cycle, the current acquisition is aborted. Any acquisition data received up to this point is discarded. When STOPACQ deasserts, the acquisition period is restarted from the beginning. The acquisition time on the AD7877 can be programmed by the user to be 2 μs, 4 μs, 8 μs, or 16 μs.

If the STOPACQ signal becomes active while the AD7877 is in a conversion phase, then the conversion goes ahead as normal. However, the next acquisition phase does not begin until the STOPACQ signal deasserts.

There is a first conversion delay before the first acquisition period in a sequence, and before every touch screen measurement, to allow the touch screen to settle. This delay is programmable by the user and can be 500 ns, 128 ms, 1.024 ms, or 8.19 ms. If the STOPACQ signal becomes active during the first conversion delay time, nothing happens. The STOPACQ signal is ignored since noise from the LCD screen will not impact the screen settling time. This is illustrated in Figure 3.

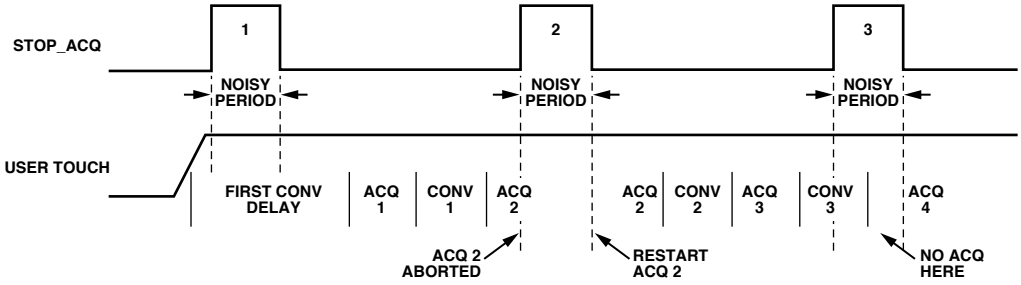

Figure 3. Operation of the AD7877 when STOPACQ is Active

The STOPACQ monitoring function is implemented on all input channels to the ADC: X+, Y+, Y–, AUX1, AUX2, AUX3, BAT1, BAT2, TEMP1, and TEMP2 channels. The acquisition phase for any of these channels will be affected by the STOPACQ signal.

TESTING THE STOPACQ FEATURE

The STOPACQ feature was tested using an HP iPAQ Pocket PC. The iPAQ's touch screen lies directly over the LCD, and so it is reasonable to assume that noise is coupled from the LCD onto the touch screen itself.

Both the touch screen connections and the V_{COM} signals were extracted from the iPAQ and connected to an AD7877 evaluation board. The touch screen contacts were connected to the AD7877's X+, Y+, X–, and Y– pins, while V_{COM} was connected to the STOPACQ pin via a resistor-divider circuit. The AD7877's conversion controls were then set up as follows:

- Averaging: None
- First Conversion Delay: 1.024 ms
- Acquisition Time: 2 μs
- Conversion Type: Differential
- STOPACQ Polarity: Active High

EXPERIMENTAL RESULTS

Figure 4 shows the results read back from the AD7877 for a single point touched on the touch screen. A stylus was held at one point on the touch screen while STOPACQ was tied to ground, and again while STOPACQ was tied to V_{COM}.

When STOPACQ is tied to ground (and therefore the acquisition phase is not interrupted), there is a much wider spread of results from the AD7877. For the same point, the values read back were as different as (838, 3128) and (842, 4142). It is presumed that this spread in the results is due to noise being coupled onto the touch screen from the LCD.

When STOPACQ is tied to V_{COM}, the AD7877 is not acquiring new data during that signal's high time. The spread of data values read back from the ADC is much smaller in this situation. The largest difference between samples is just 3 LSBs, for an error rate of 0.07%. It is clear that most of the noise from the LCD is now being filtered by the STOPACQ function.

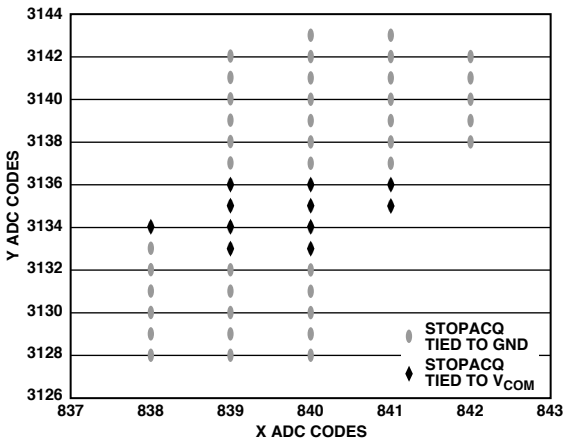

Figure 4. ADC Codes when STOPACQ is Tied to GND and V_{COM}

EXPERIMENTAL RESULTS: A CLOSER LOOK AT THE READ-BACK DATA

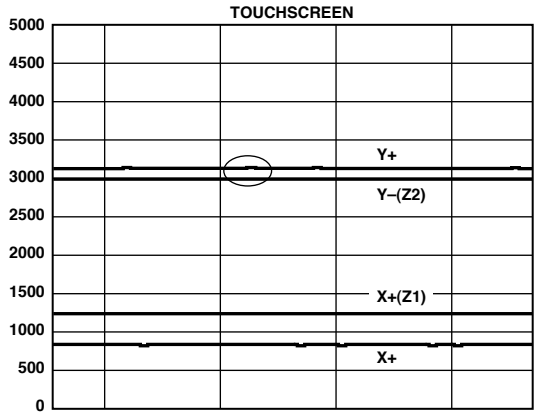

Figure 5. Noisy Data

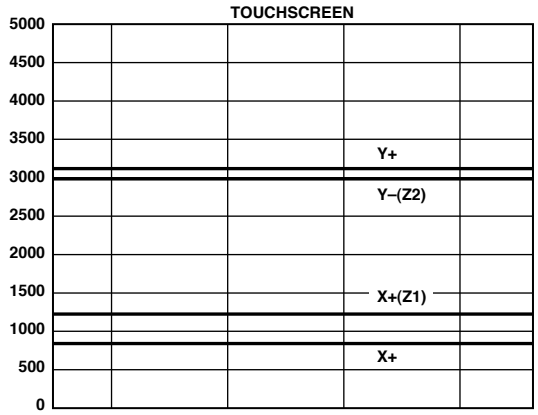

Figure 6. Result Data with V_{COM} Tied to STOPACQ

Figure 5 shows a graph of the data being read back from the AD7877 with STOPACQ tied to ground. Noise is causing small variations to occur in the read-back data at regular intervals. In comparison, Figure 6 shows read-back data from the AD7877 when STOPACQ is tied to V_{COM}. There is no noise visible in the data.

CONCLUSION

The STOPACQ feature on the AD7877 is useful in eliminating noise from a touch screen system. In a real-world application, such as an iPAQ personal digital assistant, the STOPACQ feature reduced the noise present in the touch screen measurements, giving more accurate results. It should be noted that even more noise can be eliminated from the system by using the AD7877's automatic averaging and programmable acquisition times in conjunction with STOPACQ. These features combine to reduce the total noise in the system significantly, and thereby also reduce the effort required by the host to get accurate positional measurements. The AD7877 is the perfect fit for consumer devices that require high accuracy touch screen measurements while keeping host interaction with the part to a minimum.

REFERENCES

AD7877 Data Sheet. Analog Devices, Inc. 2004. http://www.analog.com/UploadedFiles/Data_Sheets/59289336AD7877_a.pdf

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