Analog Touch Screens

PURPOSE:
This application note will describe the theory of operation, construction and use of the three types of analog resistive touch screens used on Hantronix LCD displays. It will also suggest ways of interfacing to a host processor and provide some guidelines on selecting the type of analog touch screen for use in various applications.

GENERAL:
Analog touch screens supplied with Hantronix LCDs are available in three types, 4-wire, 5-wire and 8-wire. Each type has advantages and disadvantages and is optimized for a specific type of application. Selecting the appropriate type will be discussed later in this paper.

All analog touch screens consist of a ridged layer and a flexible layer with a separation layer between them. The flexible layer is exposed to the outside, towards the user. The inside surfaces of the ridged and flexible layers are coated with a resistive coating, usually ITO (indium tin oxide). When the flexible layer is pushed its conductive surface will make contact with the conductive surface of the ridged layer making an electrical connection between the two layers at the point of contact. Measurements are then made to determine the point of contact.

4-WIRE ANALOG RESISTIVE TOUCH SCREEN:
The active layers of a 4-wire type touch screen consist of a partially conductive (resistive) coating applied uniformly to the panel. Conductive bus bars are screened with silver ink across opposing edges of the panel. The ridged and flexible panels are mounted with the bus bars perpendicular to each other.

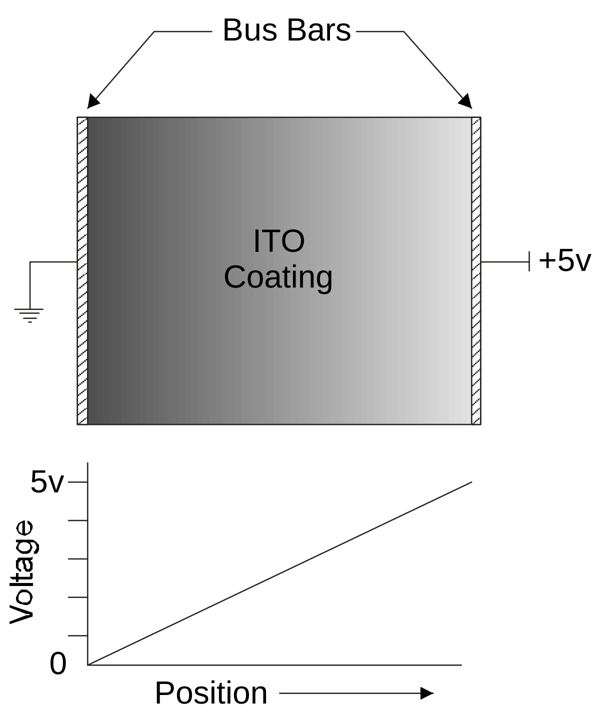

Figure 1

Measurements are made by applying a voltage gradient across one of the layers and measuring the voltage on the other layer. This measurement is made twice, once with the gradient across the ridged layer and the measurement taken from the flexible layer and again with the gradient applied to the flexible layer and the measurement taken from the ridged layer.

The gradient is usually produced by grounding one bus bar and applying +5v to the other bus bar. This will produce a smooth voltage gradient in one axis across the panel. Figure 1 shows the electrical connections and a graph of the applied voltage gradient.

With a 4-wire touch screen two separate setups and measurements are required, one in the X-axis (left-right) and one in the Y-axis (up-down) to define the touch point. Figure 2 illustrates the setup for making the two measurements. The actual switching of the 4 touch screen connections is done using an array of low on-resistance FET transistors and the voltage measurements are made with an A/D converter. The host micro controller controls both these elements. When a layer is being used as a sens layer all other connections to that layer must be left floating.

The resistance of the bus bars and the connection circuitry introduces an error (offset) in the voltage measurements. These offsets can also drift with changes in temperature, humidity and time. If the touch screen is to be used only with a finger the offsets will constitute a small percentage of the voltage represented by the large size of the finger and can be ignored. If, however, the touch screen is to be used with a stylus for drawing or signature capture then these offsets should be taken into account. This can be done by calibrating the screen periodically or by utilizing an 8-wire touch screen.

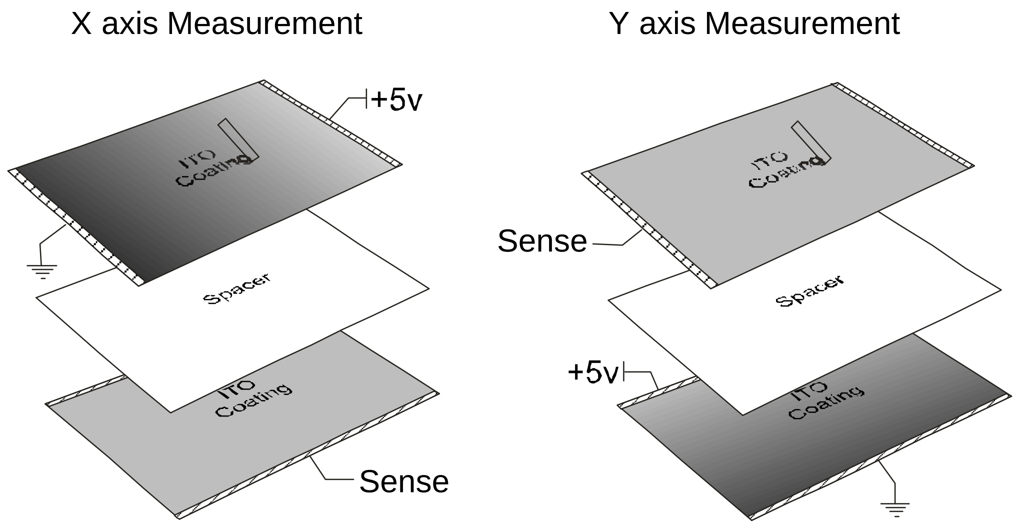

Figure 2

8-WIRE ANALOG RESISTIVE TOUCH SCREEN:
8-wire touch screens compensate for drift by adding 4 additional reference lines. This allows the voltage to be measured directly at the touch screen bus bars. Note: you can use an 8-wire touch screen in 4-wire mode by connecting the drive and reference lines together. Use of this type of touch screen won't eliminate the need for an initial calibration of the touch screen but should eliminate the need for any subsequent calibrations.

The simplest way to connect an 8-wire touch screen and take advantage of its benefits is to use a ratio-metric A/D converter supplying the reference voltages from the touch screen directly into the references of the A/D converter. Figure 3 shows the setup for making the measurements.

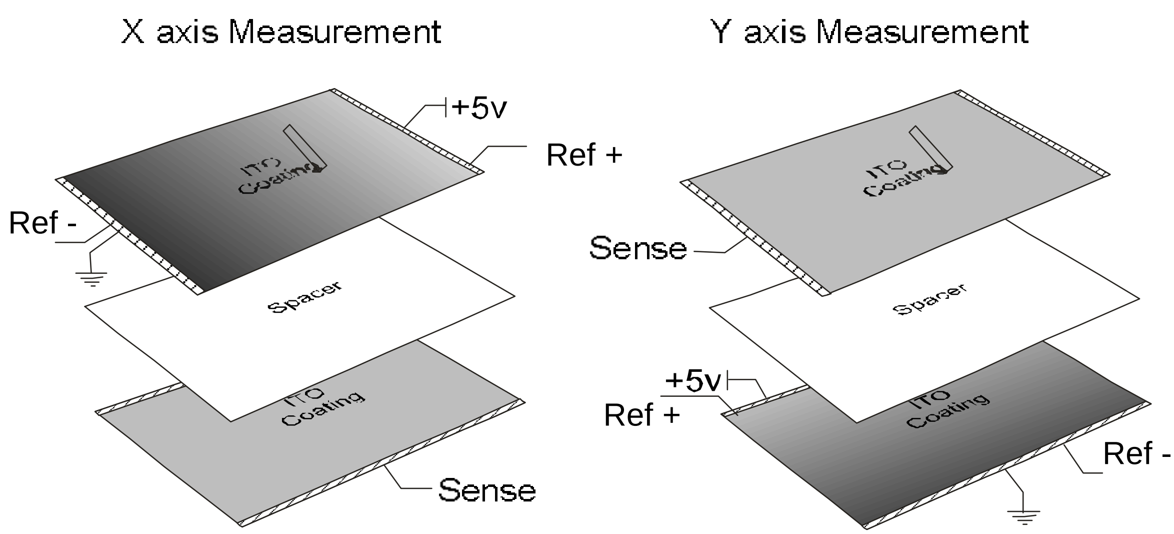

Figure 3

5-WIRE ANALOG RESISTIVE TOUCH SCREEN:
The 5-wire touch screen differs from the 4-wire type mainly in that the voltage gradient is applied only to one layer, the ridged layer, while the other layer is the sense layer for both measurements. Figure 4 shows the setup for making the measurements.

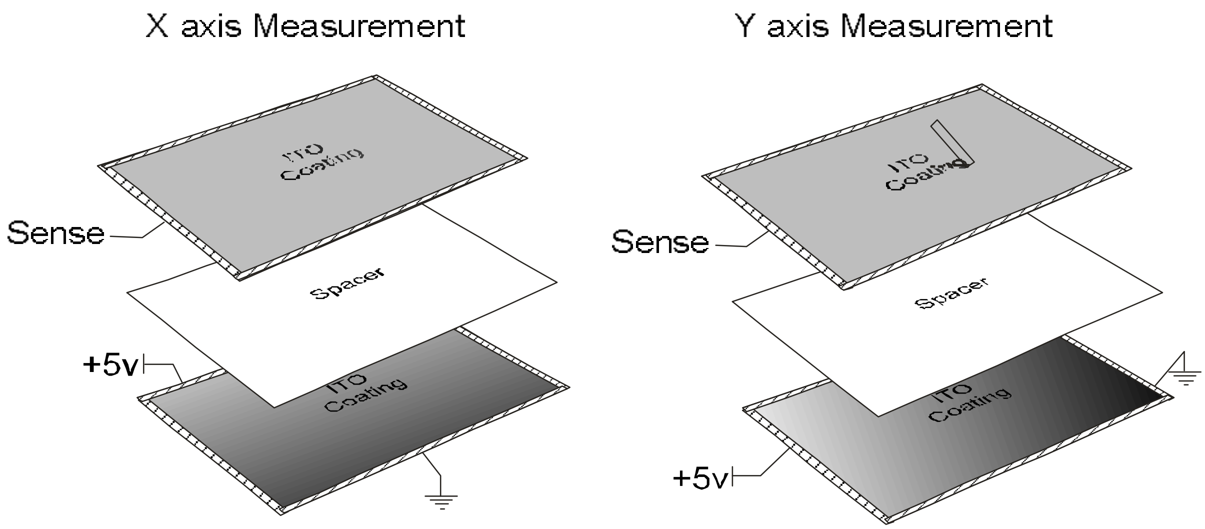

Figure 4

The sequence of events during the measurements is this. The voltage gradient is set up on the x-axis and a voltage measurement is taken from the sens layer. The voltage gradient is then switched to the y-axis and another voltage measurement is taken from the same sense layer.

TOUCH SCREEN CONTROLLER:
The touch screen controller is responsible for:

- Switching of the drive and sense voltage to the proper layer/axis
- Routing the sense voltage to the A/D converter input
- Converting the analog voltage from the sense layer into a digital word
- Interfacing to the host processor

Each of these tasks will be discussed separately.

Switching. This stage is used to apply the drive voltage and ground to the proper layer (4 and 8-wire) or axis (5-wire).

Routing. This task is usually accomplished by a multiplexer in the case of the 4 and 8-wire types. The 5-wire type does not need a multiplexer since there is only one sense line.

Converting. The voltage level from the sense layer is then converted to a digital word by an analog to digital converter (ADC).

Interface. The output of the ADC is then conditioned and perhaps latched by this element. It may also be converted to a serial stream if that is the type of interface desired. Figure 5 shows a block diagram of a typical touch screen controller.

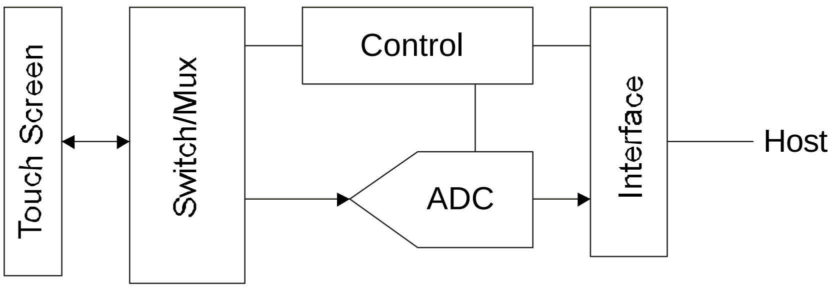

Figure 5

TOUCH SCREEN CONTROLLER DESIGN ISSUES:
There are some design issues to be considered as well as choices to be made in the design of the touch screen controller. These will be discussed next.

ESD and noise. Electro Static Discharge (ESD) is not usually a problem since the flexible layer of the touch screen is a good dielectric. Noise can be an issue so some consideration should be paid to its elimination. The flexible cable connection from the touch screen should be routed well away from noise sources such as a CCFL or EL back light inverter. Noise suppression capacitors can be added between the touch screen connections and ground to suppress noise.

Bit depth of the A/D converter. This choice is dictated mainly by the application. If the Touch screen is to be used as a human interface where the contact will be a finger then the resolution need not be very high. If the long dimension of the panel is 6" for example and the touch resolution is .2" (fine for a finger) then the A/D must resolve 30 points. 32 points can be represented in only 5 binary bits so this is sufficient for the A/D converter in this example. A sampling rate of 10 samples per second is enough for this application.

In another example the application requires capturing a signature. The display is to draw the signature as it is traced on the touch screen. The display is to be a quarter VGA (320x240) LCD. In order to achieve the most accurate representation on the display of the user's signature the touch screen should have a resolution that at least matches that of the LCD display, 320 points. This would dictate an A/D converter of at least 9 bits depth (2^9 = 512 levels).

The sampling rate of the Touch screen controller in this example must be rather high so that the displayed image doesn't lag behind the movement of the stylus and so that all of the movements of the stylus are captured. A rate of perhaps 100 samples per second would suffice.

De-bounce. As contact between the layers of the touch screen are made there maybe some contact bounce. This can be eliminated in either the controller hardware or by the software in the host processor. The most economical way is to do it in the software. Usually, the touch screen is being sampled continuously for the first indication of a touch. This is done on one axis only to simplify the process. When a touch is sensed a short delay is used before the full 2-axis measurement is taken. Alternately, several measurements can be taken and averaged.

CONTROLLER CALIBRATION:
The bulk resistance of the coatings on a touch screen will vary slightly from unit to unit and can change under some environmental conditions and over time. Environmental factors such as temperature and humidity can alter the resistance characteristics of the coating which will affect the position measurements from the touch screen. Changes over time (drift) in the touch screen coating and in the calibration of the touch screen controller can also affect measurement accuracy. Finally, the physical position of the touch screen relative to the LCD display may vary slightly from unit to unit.

Because of these factors an initial calibration of the touch screen is usually necessary, and in critical applications subsequent calibrations may be required periodically to maintain accuracy. The type of application will dictate the calibration requirements.

For example, a touch screen application that requires finger touch accuracy on a small LCD may require only about 10% accuracy of the touch measurement relative to a screen location. The combined amount of drift over time and initial variations in characteristics of the touch screen system typically amount to a total of about 5%. In this application calibration would not be necessary.

In a second example, an application such as signature capture on a 5" LCD with a resolution of 320 x 240, an accuracy of better than one pixel is necessary over the life of the product. This amounts an accuracy of the position measurement relative to the LCD screen of better than 0.3%. In this application calibration would be required.

A typical calibration procedure would be to first display a single pixel near one corner of the display and request the user to place a stylus at that point. A measurement is taken and stored. Next, the procedure is repeated near the opposite corner of the display. These two readings now represent the accurate positions of two points on the LCD display. A scaling factor can now be computed for each axis and all subsequent positional measurements can be adjusted using this factor.

Initial calibration is still required with an 8-wire touch screen is critical applications but periodic re-callibration is usually not required.

CONTROLLER IMPLEMENTATION:
Implementing a touch screen controller can be done is a number of ways. The most popular methods are discussed below.

One chip controllers are available and are popular for systems with embedded processors. They require a minimum of support components and will deliver a position measurement directly to the micro controller.

A low cost, high volume, application may be implemented by using a micro controller with a built-in A/D converter. The switching array is implemented with FET transistors controlled directly by the micro controller. This scheme requires only a few, inexpensive, external components with most of the "work" being done by the software in the micro controller. This is the technique used in most hand held PDA type devices.

If the application consists of an embedded PC running an operating system such as Windows there are complete touch screen controller cards available. These cards typically deliver a stream of position measurements to the computer as serial data to a Comm or USB port. An accompanying software driver emulates a mouse so the touch screen/display becomes a complete touch driven user interface for the computer. This system is popular with industrial control applications.

CONCLUSION:
Analog resistive is the most common and the most versatile touch screen technology available. It is applicable to almost any device or instrument using an LCD display where intuitive human interaction is needed.