

## Resistive Touch Panel Technologies

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### Introduction

In most cases an interactive interface is required when working with a display. For example, to select the program on your washing machine, adjust the temperature at an industrial facility or buy a train ticket. However, for most applications the usual interfaces for computers – mouse and keyboard/keypad – are uncomfortable and not necessary.

The easiest and most intuitive way of “user input” is to point with your finger. The interface to do that is a touch panel. The advantages are obvious: you are able to navigate your way through various displayed options or menu screens very easily and quickly.

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## 1. Different technologies

There are different touch panel technologies available in the market today: resistive, capacitive, LED Array, SAW (Surface or Sonar Acoustic Waves) to name the most common. Each have their own advantages as well as disadvantages. Please see below a short explanation of the capacitive, SAW and LED technologies. Because Hitachi uses only the analogue resistive type of Touch Panels, this technology will be explained in detail in chapter 2.

### 1.1 Capacitive

Capacitive Touch Panels consist of a glass plate covered at the bottom with a conductive and transparent layer (usually Indium Tin Oxide – ITO). A low AC voltage is applied at the corners of the Conductive Layer. A finger touch, on the glass panel, will draw a small current from each corner of the electric field. The value of current coming from each corner is directly proportional to the distance to the pressing point. By measuring the current in each corner, the touch location can be calculated.

### 1.2 SAW (Surface Acoustic Waves)

SAW Touch Panels consist of a glass with piezoelectric transducers for both the X and Y axes. The touch panel controller generates a 5 MHz signal. The transmitting transducer converts this electric signal in ultrasonic waves. These waves propagate through the glass. The receiving transducer converts these waves back to electric signals. When pressing on the surface of the glass some waves are absorbed by the finger. Due to wave characteristics a position can be calculated from the measured absorption.

### 1.3 Infrared LED-Array

An array of IR-LEDs is mounted along the top edge and one side of the display. On the opposite side and along the bottom edge are mounted arrays of photo transistors. This results in the creation of a kind of light barrier array. When there is no pressing on the screen, the light is not interrupted. The interruption of the light beams by finger or other pointing device can be measured and the position then calculated.

## 1.4 Comparison between the different technologies

Note: Please keep in mind that the following are only “rules of thumb”. They intend to give a short overview of the different technologies and not actual “datasheet” values.

	<b>Resistive</b>	<b>Capacitive</b>	<b>SAW</b>	<b>LED-Array</b>
<b>Response Speed</b>	10-20 ms	3 ms	20 ms	25-35 ms
<b>Resolution</b>	300/inch	50/inch	30/inch	8/inch
<b>Light Transmission</b>	75%-80%	85%	90%	100%
<b>Durability</b>	Low due to the flexible covering layer	Medium to high due to the covering glass plate	Very High	Very High
<b>Environment</b>	Indoor and with no additional protecting layers in non tough environments.	Outdoors. Relatively insensitive to scratches, dirt and water.	Outdoors. Insensitive against scratches and dirt	Large Touch Panels with low resolution. Flies and dirt can cause false activations.
<b>Lifetime</b>	1-35 Mio. touches (depends if there are additional protection layers.)	> 20 Mio. touches	Over 50 Mio. Touches	Depends on LED-Lifetime
<b>Price</b>	Low	Medium	High	High
<b>Notes</b>	Most popular technology. Can be operated with any pointing device, even with a gloved hand. Can be used to a size of approx. 6 inches and a resolution of approx. QVGA (320*240)	Must be operated with finger or special pointing device	Very high durability, will not function when liquids come into direct contact with surface.  Must be operated with finger.	Very low resolution, adding up to 1cm to the overall thickness of the display.

Table 1: Comparison of different Touch Panel Technologies

## 2 Analogue Resistive Touch Panels

This technology is the most common, due to its simplicity and low cost characteristics. It can be found in various applications including PDAs, office machines, manufacturing facilities.

Analogue resistive technology can be separated into 4-wire, 5-wire, 6-wire, 7-wire, and 8-wire systems where 8-wire is similar to 4-wire and the others are similar among themselves. The most popular are 4-wire and 5-wire systems. Hitachi uses only 4-wire systems.

### 2.1 Structure

Resistive Touch Panels consist of several layers. The first one is a glass plate at the bottom. The top surface of the plate is coated with a transparent conductive layer, usually ITO (Indium Tin Oxide). Above the glass plate there is a polyester film coated on the bottom side with the same conductive and transparent layer. The ITO layers are set up to have a homogeneous resistance per area. To separate the conductive layers transparent and elastic spacers are employed. In the normal state (no press) there is no physical contact between these layers.

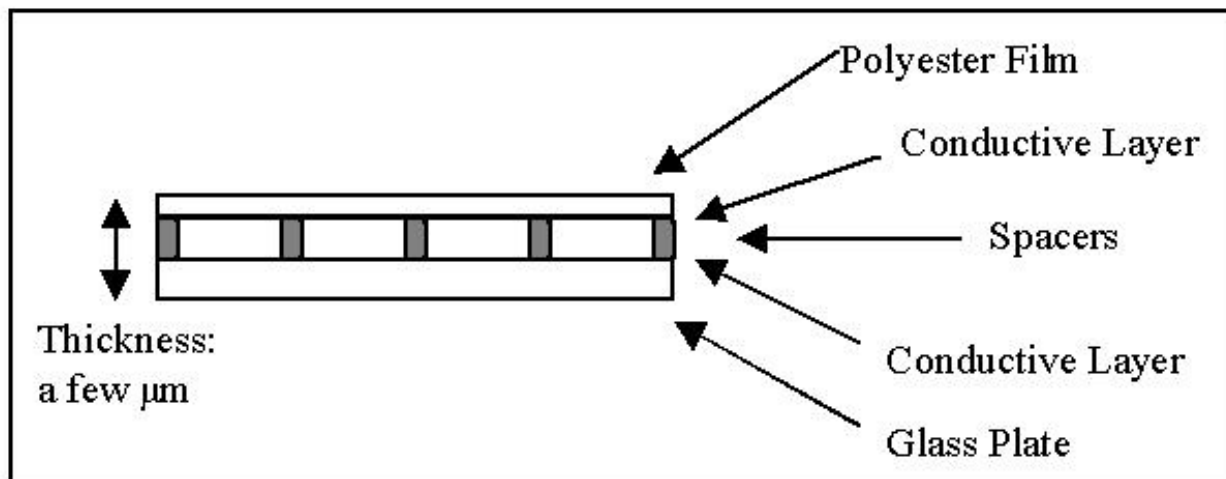
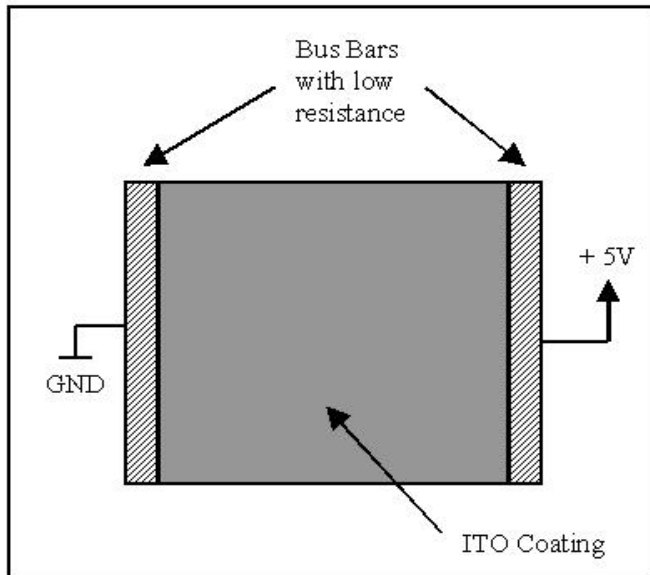


Figure 1: Structure of Resistive Touch Panels

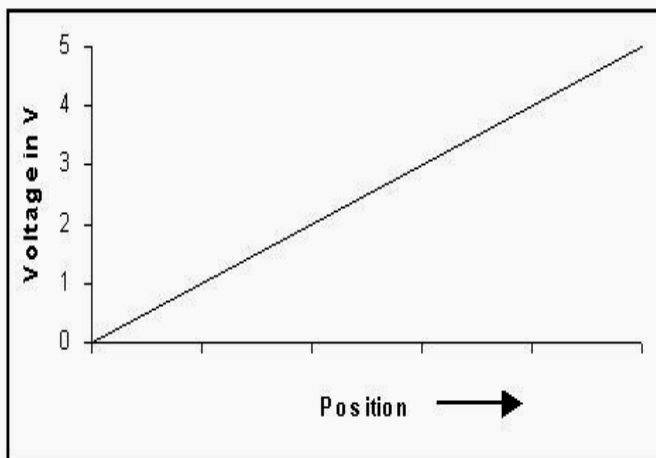
## 2.2 Applying Voltage to the Layers



To measure a contact position on the touch panel, a voltage needs to be applied to the conductive layers. This is done via low resistance bus bars. Typically +5 V and GND are applied and usually the bottom layer has the bus bar on the left and the right side.

Figure 2: Bottom conductive Layer

with voltage



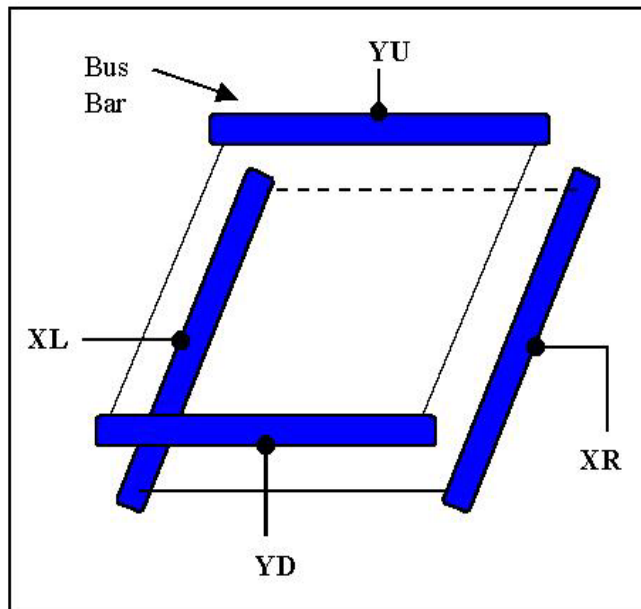
When applying a voltage to e.g. the bottom layer, there is a linear voltage drop from one bus bar to the other bus bar via the conductive ITO coated glass plate.

Figure 3: Linear Voltage drop from one bus bar to

the other bus bar

## 2.3 Typical configuration of 4-wire Touch Panels

The difference between 4-wire, 5-wire technologies is the measurement operation and the way in which the voltage is applied to the conductive layers. In the 4-wire technology there are four connections at the two conductive layers: Two bus bars for each layer.



A 4-wire Touch Panel usually has the following set up (see figure 4): At the bottom layer, the bus bars are on the left side and on the right side. The left connection is called X Left (XL) and the right connection is called X Right (XR). The top layer is rotated 90° horizontally. It has its bus bars on the upper side and on the down side – the Y Upper (YU) and the Y Down (YD).

With this configuration, the bottom Layer is called X-Layer and the Top Layer is called Y-Layer.

Figure 4: Typical configuration of a 4-wire Touch Panel

## 2.4 Getting the position with 4 wires

If there is a press on the touch panel a contact is made between the two conductive layers. When a voltage is applied to one layer the system behaves like a voltage divider. If for example the X-Layer has voltage applied, this voltage can be measured at a bus bar of the Y-Layer. (the actual bus bar does not matter).

This voltage value represents the actual X-Position. Of course, the measurement at the Y-Layer Bus Bar must be taken with a high resistance connection to keep reduce the impact to the voltage. Together with this voltage and some calibration data the X-Position can be calculated using an A-to-D converter.

To get the Y-Position, the voltage must then be switched from the X-Layer to the Y-Layer and the same measurement procedure must be done at the X-Layer.

## 2.5 Important Notes!

- Pay attention on delay times. Before measurement can be done, an appropriate delay time should be used to ensure the associated voltages have stabilised.
- When switching the voltages and A/D converter connections, keep in mind that there shouldn't be high current flows through the conductive layers. Thus, suitable switching sequences should be obeyed – a pressure point is a short-circuit between the ultra thin layers. Good resistive Touch Panels (which includes the design of the control circuit) can be pressed up to 2 Million times.
- To keep A/D conversion errors and measurement errors low, several measurements for one position should be made and a mean value should be calculated. The amount of measurements is only limited by the switching delays and the A/D conversion time.
- Please find an example of controlling a Touch Screen with a Microchip PIC microcontroller in Application Note AN-037

## 3 Digital Resistive Touch Screens

There are also digital touch panels, also known as matrix touch panels. They are used when a very low resolution of touch points is required. For example, when there is a requirement for selecting from a simple display menu. The conductive layers, unlike with analogue touch screens, are prepared as segmented blocks over the touch panel. Interfacing to each block is by way of a wire matrix. One point of intersection represents a touchable point. The position can be measured using a simple voltage divider equation.

## 4 Conclusion

As seen in *Table 1: Comparison of different Touch Panel Technologies*, every technology has its advantages and suitable applications. The most important application of resistive touch panels, especially 4-wire ones, is with small displays in the low-cost sector. With such displays it should be relatively easy to implement a Touch Panel solution. In such cases a low resolution Analogue-to-Digital converter is all that is needed to control and interface to them. This type of peripheral can usually be found in many micro-controller solutions.

The low-cost characteristic and the ease of interfacing are the main reasons why Hitachi has chosen to use 4-wire resistive Touch Panel technologies.

## Cautions

### Keep safety first in your circuit designs!

- Hitachi Europe Ltd. puts the maximum effort into making display products better and more reliable, but there is always the possibility that trouble may occur with them. Trouble with display products may lead to personal injury, fire or property damage.  
Remember to give due consideration to safety when making your circuit designs, with appropriate measures such as (i) placement of substitutive, auxiliary circuits, (ii) use of nonflammable material or (iii) prevention against any malfunction or mishap.

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