How to Use TI’s 4-Wire TSC to Control an 8-Wire Resistive Touch Screen

Wendy X. Fang

ABSTRACT

This application report implements a Texas Instruments 4-wire touch screen controller (TSC) to control an 8-wire touch screen and discusses features and performances for such applications.

Texas Instruments (TI) provides various TSC devices for the 4-wire or 5-wire resistive touch screens (TS). A TI 4-wire TSC device, such as the ADS7843, TSC2003, or TSC2046, is ideal for controlling a 4-wire TS, but it can also be used on an 8-wire TS.

Contents

1 Using 4-Wire TS Technology .................................................................................... 2
2 Using 8-Wire TS Technology ................................................................................ 3
3 Using 4-Wire TSC to Control 8-Wire Screen .......................................................... 3
4 Discussions ........................................................................................................... 5
5 Conclusion ............................................................................................................. 7

List of Figures

1 The 4-Wire Resistive TS Structure ........................................................................... 2
2 Measuring X Touch Location on a 4-Wire Resistive TS ......................................... 2
3 The 8-Wire Resistive TS Structure ........................................................................ 3
4 Touch Measure With Excite + Sense or Excite Only Connection .......................... 4
5 Touch Measure With Sense Only Connection .......................................................... 5
6 TS X-Data Measurement With Differential TSC ..................................................... 6

List of Tables

1 Connection From 8-Wire TSC to 4-Wire TSC ......................................................... 4
1 Using 4-Wire TS Technology

In a 4-wire resistive TS, the two transparent resistive layers, the X and the Y, are assembled one on top of the other and separated by insulating spacers, as shown in Figure 1.

![Figure 1. The 4-Wire Resistive TS Structure](image)

Figure 1 shows the two conductor bars, each at one end of the X- or Y-layer, which lead to 4 wires, named X+, X−, Y+, and Y−, or Left, Right, Top, and Bottom, respectively. Each touch or press on the TS connects the two layers at one point.

When measuring the X-direction touch location, an *excite or force* voltage is applied crossing the X+ to X−, and the voltage gradient on the X resistive layer corresponds to the touch location. At this moment, no voltage is applied in the Y-layer, and the Y+ line is used as the voltage probe or the X touch location detect, from which the TSC obtains divided voltage on the X-layer, or the X touch data (see Figure 2).

![Figure 2. Measuring X Touch Location on a 4-Wire Resistive TS](image)

Measuring the Y-direction touch location is similar to that on the X-direction, except that the excite voltage is applied to the Y-layer and the data is probed at X+.

**Example 1:** Using a 3-V VDD and 12-bit-resolution TSC, such as TSC2046, to control a 4-wire TS. A touch on the TS (1/3 on X-direction and ½ or center at Y-direction) can initialize the following actions:

1. Measure X-data:
Using 8-Wire TS Technology

The 8-wire TS structure and technology is similar to the 4-wire one, previously discussed, but with each edge providing one more sensing or referencing line, as shown in Figure 3.

The four additional wires, located at each end of the X- or Y-layer, provides the additional sense or reference measurements directly off the screen, which can be used to perform a certain auto-calibration to compensate/reduce some errors, such as the resistance error on connecting or pigtail resistance.

Example 2: The same as Example 1, except that both the TSC and TS are 8-wire. So, to measure the X-location:

- The TSC applies a voltage crossing X+ to X–.
- The measured voltage at Y+ is obtained (e.g., 1 V).
- The TSC samples, converts, and stores/transfers the X-data (= 1365 or 1/3 × 4095).

2. Measure Y-data:

- Disconnect the voltage from the X-layer and apply it to the Y-layer.
- A voltage at X+ (e.g., 1.5 V) is measured.
- The TSC samples, converts, and stores/transfers the Y-data (= 2047 or 1.5/3 × 4095).

3 Using 4-Wire TSC to Control 8-Wire Screen

Can a TI 4-wire touch screen controller be used to control an 8-wire touch screen? Yes, and this section shows how.

One way to connect an 8-wire TS to a TI 4-wire TSC is shown by Table 1, where the 8-wire TS’s Excite and Sense wires are shorted and routed to the corresponding wire at the 4-Wire TSC.
Table 1. Connection From 8-Wire TSC to 4-Wire TSC

<table>
<thead>
<tr>
<th>From 8-Wire TS Pin</th>
<th>Connected to 4-Wire TSC Pin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Excite and Sense</td>
<td>X+</td>
</tr>
<tr>
<td>Right Excite and Sense</td>
<td>X–</td>
</tr>
<tr>
<td>Up Excite and Sense</td>
<td>Y+</td>
</tr>
<tr>
<td>Bottom Excite and Sense</td>
<td>Y–</td>
</tr>
</tbody>
</table>

Connecting only the Excites of the 8-wire TS to the corresponding pins at the TSC can also work functionally. But, keeping the 4 sense wires floating may introduce extra noise to the panel.

Figure 4. Touch Measure With Excite + Sense or Excite Only Connection
4 Discussions

Some features and performances of the 8-wire TS + 4-wire TSC system are discussed in this section.

4.1 Resolution

The resolution of the TS measurement is mainly decided by the number of bits of the TSC device. For example, a 12-bit TSC can ideally offer the 4096 × 4096 resolution across the whole screen; for an 8-bit TSC, the resolution is 256 × 256.

Figure 5. Touch Measure With Sense Only Connection

Functionally, connecting only the Sense wires also works, but the accessible range may be reduced. Figure 4 and Figure 5 show examples of some test results in which a TI TSC EVM and a 3M™ MicroTouch™ 15-inch, 8-wire PL resistive touch screen were used. The touch pen was moved crossing the X- or Y-direction on the TS from one end to another. Note the differences at each of the edges under different connections. Obviously, Figure 4 and Figure 5 show that there is more unaccessible area at the edges with the Sense Only connection.
The number of points per square inch depends on the resolution (or bits) of the TSC and the size of the TS. For example, for a 12-bit TSC, the 5-inch TS, typical with width x height = 4×3, has 1024 × 1365 points per square inch; a 15-inch TS (12×9) has 341 × 455 per square inch.

With TI's TSC devices, the resolution is programmable at 8-bit, 10-bit, or 12-bit. The resolution does not change, regardless of whether the TSC is connected to control a 4-wire or an 8-wire TS.

4.2 Accuracy

Touch data accuracy is determined by the TSC’s performance, as well as various other reasons such as circuit noise, power-supply fluctuation, the TS panel’s mechanic vibration, environment effects, whether there is HW/SW filtering/averaging, whether there is HW/SW calibrations, etc.

When using a TI TSC, the patented ratiometric technology from TI provides high-performance measurement. This performance does not change, regardless of whether the TSC is connected to control a 4-wire or an 8-wire TS.

4.3 Connect Effect

For an explanation of the measurement error due to the TS-to-TSC connection, see Figure 6, which shows the X-axis measurement connection effect, as an example.

In Figure 6, the actual TS resistance in full X-axis is within the two points X+’ and X-‘; while the actual TSC reference in full X-axis is within the two points X+ and X-. They are different, which is the connection error. The error is caused mainly by the connection or pigtail resistance on the TS. For example, Figure 6 shows that the X-axis pigtail resistance is that from X+’ to X+ and from X-‘ to X- on the TS connector.

![Figure 6. TS X-Data Measurement With Differential TSC](image)

Thus, the full range of the resolution, from 0 to 4096 on 12-bit TSC, is usually not accessible due to the connection or pigtail resistance (that may be around several ohms to under 50 ohms). For example, from TS end-to-end, the TSC may be able to read only from 200 to 3900, not from 0 to 4096.
Using an 8-wire TS provides the extra 4 end points of reference measurements, which may be used to reduce/calibrate the pigtail resistance and other kind of errors on a TS.

When using a 4-wire TSC on an 8-wire TS, the combined touch system is still a 4-wire one, without the extra sense/reference benefit.

5 Conclusion

- One can use one of TI’s 4-wire resistive TSCs to control a 4-wire or 8-wire TS.
- The performance of a TI 4-wire TSC does not change, whether it controls a 4-wire or an 8-wire TS.
- Because there is no extra Sense/Reference on the 4-wire TSC system, no benefit may be realized due to the extra references in an 8-wire touch system.
IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

<table>
<thead>
<tr>
<th>Products</th>
<th>Applications</th>
<th>URLs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amplifiers</td>
<td>Audio</td>
<td><a href="http://www.ti.com/audio">www.ti.com/audio</a></td>
</tr>
<tr>
<td>Data Converters</td>
<td>Automotive</td>
<td><a href="http://www.ti.com/automotive">www.ti.com/automotive</a></td>
</tr>
<tr>
<td>DSP</td>
<td>Broadband</td>
<td><a href="http://www.ti.com/broadband">www.ti.com/broadband</a></td>
</tr>
<tr>
<td>Interface</td>
<td>Digital Control</td>
<td><a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a></td>
</tr>
<tr>
<td>Logic</td>
<td>Military</td>
<td><a href="http://www.ti.com/military">www.ti.com/military</a></td>
</tr>
<tr>
<td>Power Mgmt</td>
<td>Optical Networking</td>
<td><a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a></td>
</tr>
<tr>
<td>Microcontrollers</td>
<td>Security</td>
<td><a href="http://www.ti.com/security">www.ti.com/security</a></td>
</tr>
<tr>
<td></td>
<td>Telephony</td>
<td><a href="http://www.ti.com/telephony">www.ti.com/telephony</a></td>
</tr>
<tr>
<td></td>
<td>Video &amp; Imaging</td>
<td><a href="http://www.ti.com/video">www.ti.com/video</a></td>
</tr>
<tr>
<td></td>
<td>Wireless</td>
<td><a href="http://www.ti.com/wireless">www.ti.com/wireless</a></td>
</tr>
</tbody>
</table>

Mailing Address: Texas Instruments  
Post Office Box 655303 Dallas, Texas 75265

Copyright © 2006, Texas Instruments Incorporated