PCB Layout Guideline for TI Resistive TSC Devices

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ABSTRACT

This application report provides printed circuit board (PCB) layout guidelines to optimize the performance of touch screen designs that apply TI's resistive touch screen controller (TSC) devices.

Introduction

TI provides users a family of resistive touch screen controller devices, as shown by Table 1, that are applied to control various resistive touch screens on today's market, including 4-wire, 5-wire or more wire touch screens; and single-touch or multi-touch screens.

Table 1. TI Resistive Touch Screen Controller Devices

Part Number	Controlled Touch Screen/Panel/Sensor	Digital Interface	Additional Features
TSC2020 [1]	5x3 array Multi-touch	I2C	Multi-touch
TSC2011 [2]	4-wire Single-touch	I2C	Built-in Haptic Driver
TSC2014 [3]	4-wire Single-touch	I2C	
TSC2004 [4]	4-wire Single-touch	I2C	
TSC2005 [5]	4-wire Single-touch	SPI	
TSC2006 [6]	4-wire Single-touch	SPI	
TSC2017 [7]	4-wire Single-touch	I2C	
TSC2007 [8]	4-wire Single-touch	I2C	
TSC2008 [9]	4-wire Single-touch	SPI	
TSC2046 [10]	4-wire Single-touch	SPI	
TSC2003 [11]	4-wire Single-touch	I2C	
ADS7846 [12]	4-wire Single-touch	SPI	
ADS7845 [13]	5-wire Single-touch	SPI	5-wire touch screen
ADS7843 [14]	4-wire Single-touch	SPI	

Good PCB layout practice can optimize performance in a resistive TSC system, in addition to easing other design restrictions, reducing design and debug costs, reducing exposure to ESD damage, and shortening product development time.

Common Practices

To layout PCB in a touch system that applies a TI's TSC device in Table 1, it is recommended to follow commonly accepted design practices for PCB layout, such as the *Generic Standard on PCB Design* IPC 2221A [15]. Also refer to [16].

Some of the more important and widely accepted points for PCB layout include:

- Use a ground plane where possible, and connect the signal ground through vias to the ground plane rather than printed traces;
- Keep the analog ground and digital ground separate at each power-supply stage, and connect them together at a single point;
- Use large trace for power supply lines to provide low impendence, and Add bypass capacitors to each power supply, located as close as possible to the power pins;
- Avoid wiring digital lines under the device;
- Avoid cross-wiring between analog and digital signals;
- Minimize the area and length of loops for the required analog wiring.

Analog Connection

In the specific case of a resistive touch screen system, additional care should be given to the connection between the TSC and the touch screen. This connection is also known as the *analog interconnection* or *analog interface*. Figure 1 shows a typical connection diagram for a 4-wire TSC device, using TSC2014 as an example, in a touch application. Note the analog connection here.

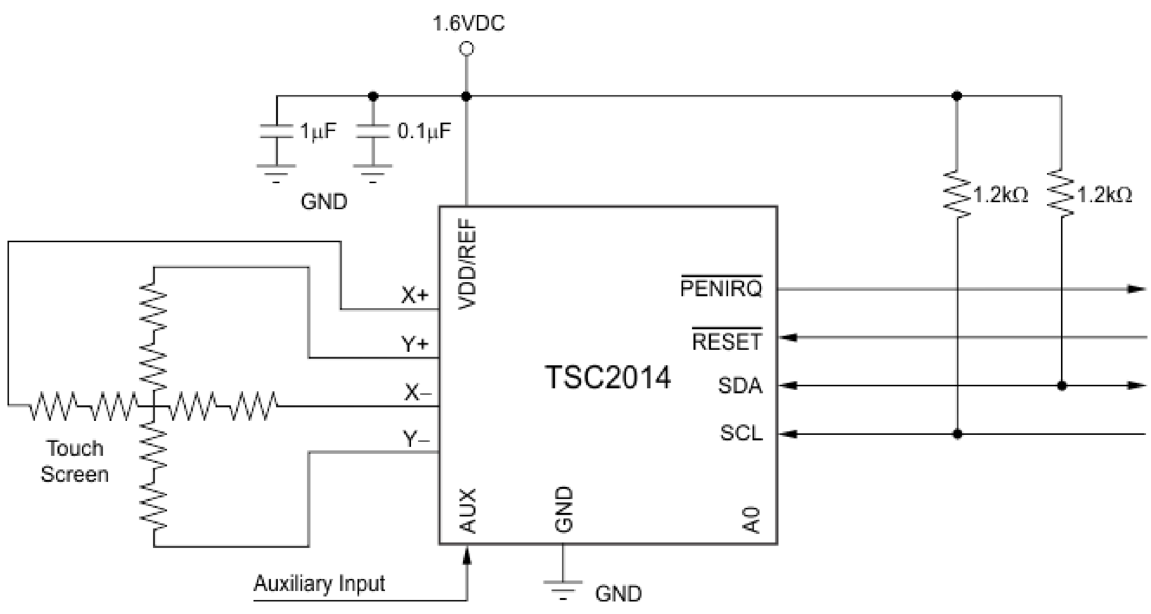

Figure 1. Typical Connection of TSC2014 Touch System [3]

The Analog Interface should be kept as **short**, as **simple**, and as **secure** as possible because resistive touch screens have fairly low resistance (usually several hundred ohms). Longer connections can not only bring in possible pigtail resistance between the TSC and the touch screen, but also increase the chance for noise, ESD and other interferes to affect the analog input lines. Poor connections can be another source of noise and error when the contact resistance changes with flexing or vibrations, and can even cause the entire touch screen system to malfunction or fail.

Electromagnetic interference (EMI) noise can be a major source of error in touch screen applications that require an LCD panel with backlighting. This type of noise can couple through the LCD panel to the touch screen and enter the TSC device through the analog interface, causing the converted ADC data to flicker. To reduce this type of error, use a touch screen with a bottom-side metal layer connected to ground. This configuration couples most of the noise to ground, and has been shown to be very helpful in a range of embedded touch screen applications. Additionally, display interface and touch interface should be separated to avoid crosstalk.

Power and Grounding

Care should be taken with the physical layout on power and grounding of the TSC circuitry.

The analog-to-digital converter (ADC) in a TI TSC device is a successive-approximation-register (AR) architecture ADC. The generic SAR architecture is sensitive to glitches or sudden changes in the power supply, ground connections, and digital inputs that occur before latching the output of the analog comparator. Therefore, during any single conversion for an *n*-bit SAR converter, there are *n* windows in which large external transient voltages can easily affect the conversion result. Such glitches might originate from switching power supplies, nearby digital logic, and high-power devices. The degree of error in the digital output depends on the reference voltage, layout, and the exact timing of the external event. Once the SAR ADC has made a decision to keep or reject a bit-value, the converter cannot go back in time and change the previous decision.

With this consideration in mind, power to the TSC device should be clean and well-bypassed, with bypass capacitors between power and ground. A 0.1μF ceramic bypass capacitor should be added between every TSC power supply pin (which could be named differently with different devices in Table 1, such as +VCC or VDD or VREF or IOVDD) and corresponding ground. A 1μF to 10μF capacitor may also be needed if the impedance of the connection between the TSC's power supply pin and the power supply is high. These bypass capacitors must be placed as close as possible to the TSC's power supply pin, optimally right up against the TSC. From the ESD protection point of view, the traces connecting the TSC power supply pin's bypass capacitors to ground should be as short as possible. The TSC side of the capacitors needs to be placed right on the +VCC/VDD/VREF/IOVDD trace and the other side of the capacitors right on the ground plane. Using flow-through design instead of T-shape connection is recommended for decoupling capacitors to minimize parasitic inductance associated with the connections between capacitors and power supply line.

The ground pins of the TSC device and its analog surrounding circuit should be connected to a clean ground point. In many cases, this point is the analog ground. Avoid connections that are near the grounding point of a microcontroller or digital signal processor. If needed, it is recommended to have a separate ground trace directly from the converter to the power-supply entry or battery connection point. The ideal layout includes an analog ground plane dedicated to the converter and associated analog circuitry. From the ESD protection point of view, provide more ground vias to the ground plane right below the TSC ground and the TSC power supply bypass capacitors. At least one ground via per capacitor is recommended. Sharing a single via among multiple capacitors needs to be avoided. It is important to ensure there is ample ground path to the system ground to allow ESD discharge current if the touch screen subsystem is implemented on a flex.

ESD Protection Considerations

- If possible, place TSC device on the main PCB to mitigate possible ground bouncing problem
- Do not connect resets and interrupts to long traces or cables
- Consider adding a filter (capacitor 1nF to 10nF) right next to the reset pin if there is a noise coupling issue on the reset line.
- If there is a need for filters on the TSC device analog input lines, place filters close to the TSC, right next to the TSC analog input pin. Use flow-through design instead of T-shape connection for filters to minimize parasitic inductance
- Avoid direct connection between the chassis ground (metal frame) and the PCB signal ground near the touch screen device
- Design extra space for ESD protection circuits that might be needed into the original layout (these extra components can be added later when needed)
- Transient voltage suppressor (TVS) selection guidelines
    1. When selecting transient voltage suppressors, consider the maximum capacitance that can be placed on a signal while keeping the intended signal integrity
    2. Select devices with low breakdown voltage and low clamping voltage to reduce voltage/current going to receiver circuits. However breakdown voltage of the TVS component needs to be high enough not to disturb touch line signals
    3. Suppressors need to turn on within 1 ns to be effective against the fast rising ESD currents: IEC ESD current rise time approximately 0.8 ns
    4. Place TVS components close to the ESD entry point. In most cases it would be the touch panel connector side

Additional Notes

- Some package options have pins labeled as NC (no connection). It is recommended that these NC pins be connected to the ground plane.
- Connect the analog input pin AUX (or AUX IN, or IN), or V_{BAT} to ground if not used.
- Avoid any active trace going under the TSC analog pin, unless they are shielded by a ground or power plane.

As the last line of defense, a 1nF to 100nF cap may be added to an analog input line to provide a low-pass filter and extra ESD path for the TSC analog pin (X+, X-, Y+, Y-). As repeatedly mentioned, the cap should be put right next and as close as possible to the TSC pin. Note that the added capacitance on the analog line would increase the settling time of the touch signal, especially under weak touch when the equivalent resistance R there could be in 100K-Ω to M- Ω. Refer to the Section of the application note [17] on the capacitance affect and selection.

Even though the above suggestions are based on the widely accepted PCB design practices for today's resistive touch screen systems, each layout must be carefully reviewed, because touch applications might have conflicting requirements with respect to power, cost, size, and weight, and each application and design is unique.

References

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