Using a touch-screen controller's auxiliary inputs

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Introduction

Texas Instruments (TI) touch-screen controllers (TSCs), including the ADS7843/45/46, TSC2046, and TSC2003/4/5/6/7, have touch-screen input pins and one or more non-touch-screen or auxiliary analog input pins, such as the battery-voltage-monitoring pin (V_{BAT}) of the TSC2046 or the AUX pin of the TSC2007. These auxiliary inputs make it possible to monitor the system's battery level or other voltage signals by sharing time with touch-screen inputs or using time periods when the touch screen is not touched.

The auxiliary analog inputs of different TI TSCs may have different input ranges and different levels of electrostatic-discharge (ESD) protection, so certain requirements or limitations should be considered when they are used. This article discusses the general and specific features and limitations of the TSC auxiliary (including battery-voltage) inputs.

Auxiliary analog inputs

Table 1 lists auxiliary analog input pins of TI's current TSCs. Inside a TSC, a MUX selects and connects one of the analog inputs to the ADC via commands sent through the SPI or I²C ports. Figure 1 shows an example.

Auxiliary input mode

TI's TSCs can be operated in either differential or single-ended (SE) input mode, but auxiliary analog inputs can be measured and converted only in SE mode (see Figure 2).

Table 1. Auxiliary analog input(s) of TI TSC devices

TSC	AUXILIARY ANALOG INPUTS		V_{REF}	MAIN FEATURES[1]
	NUMBER OF INPUTS	PIN NAMES		
ADS7843	2	IN3, IN4	External	4-wire, SPI, command-based
ADS7845	1	AUXIN	External	5-wire, SPI, command-based
ADS7846	2	V_{BAT}, AUX	Internal	4-wire, SPI, command-based
TSC2046	2	V_{BAT}, AUX	Internal	4-wire, SPI, command-based
TSC2003	4	V_{BAT1}, IN1, V_{BAT2}, IN2	Internal	4-wire, I²C, command-based
TSC2004	1	AUX	External	4-wire, I²C, register-based
TSC2005	1	AUX	External	4-wire, SPI, register-based
TSC2006	1	AUX	External	4-wire, SPI, register-based
TSC2007	1	AUX	Shared with V_{DD}	4-wire, I²C, command-based

Figure 1. Block diagram of TSC's internal input circuit

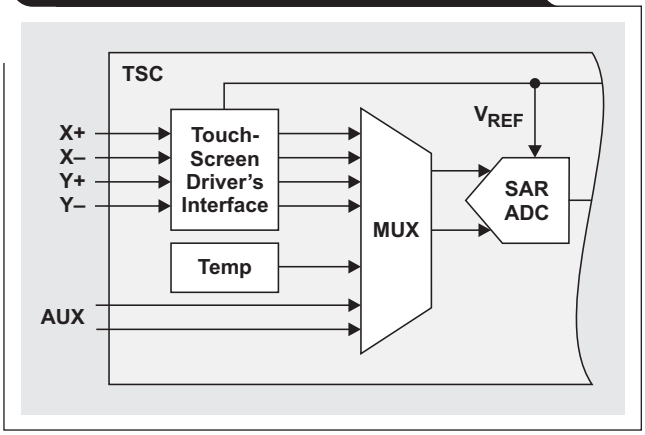
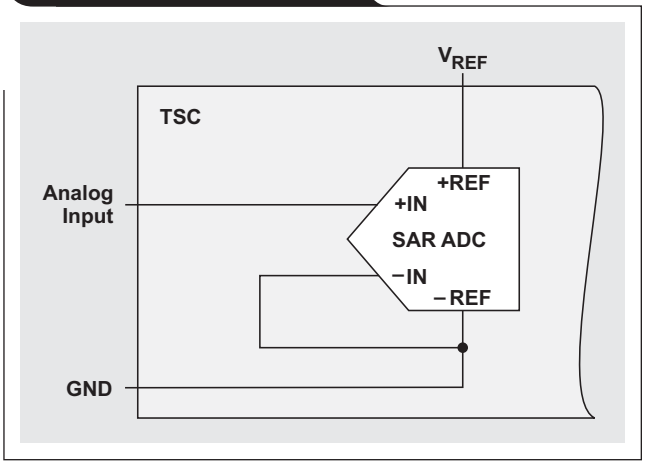


Figure 2. SE mode of a TSC



A TSC in differential mode does not need any reference, since the signal's driver is connected to +REF and –REF directly. However, the reference voltage, V_{REF}, is a must for SE operation and thus is always needed when an auxiliary input, such as the AUX or V_{BAT}, is measured.

The reference voltage can be provided to the TSC's ADC externally or internally for the ADS7846, TSC2046, and TSC2003. When an external reference is used, these devices can be powered up at the V_{CC} pin with a supply voltage between 2.2 and 5.25 V, and an external V_{REF} ranging from 1.0 V to V_{CC} can be provided. When the TSC's internal reference is used, the ADS7846, TSC2046, or TSC2003 should be powered up with a 2.7- to 5.25-V supply to guarantee that the internal V_{REF} will be around 2.5 V (2.45 V ~ 2.55 V). Other TI TSCs do not have the built-in voltage reference. In practical applications, one can simply route the same TSC power supply to the reference.

Auxiliary-input voltage range

The signal range for an auxiliary input should always be within 0 V to V_{REF}. Signals beyond this range will saturate the ADC and can even increase the temperature, damaging the input circuitry.

The signal range for a battery-monitor input, say V_{BAT}, can greatly exceed the V_{REF} level, since there is a voltage divider with each V_{BAT} pin (see Figure 3). The input divider circuit limits the range of the signal to the ADC to within 0 V to V_{REF}. Figure 3 shows that the signal to the ADC is only 25% of the signal at the V_{BAT} pin.

As shown in Table 1, the ADS7846, TSC2046, and TSC2003 have one or two battery-monitor input(s) designed to monitor/measure signals of up to 6.0 V while the device is powered with much lower voltage, down to 2.7 VDC.

TSC auxiliary-input features

The main features of TSC auxiliary (including battery) inputs can be summarized as follows:

- Auxiliary input signals can be measured only in SE mode.
- A reference voltage, V_{REF}, must be provided to the ADC when an auxiliary input is measured.
- The signal range of an auxiliary input must be within 0 V to V_{REF}.
- The battery input, V_{BAT}, can range from 0 V to as high as 4 × V_{REF}, up to 6.0 V.

Special applications

The following discussion focuses on the special applications of the auxiliary analog input pins of TSCs.

Unused input pins

If the TSC's analog input pins are not used, it is recommended that they be connected directly to an analog ground.

Using AUX input pin to monitor V_{BAT}

As Table 1 shows, several TI TSCs are not furnished with a battery-voltage-monitoring pin (V_{BAT}). A regular auxiliary input cannot be used directly for monitoring the battery,

Figure 3. Voltage divider reduces input to ADC

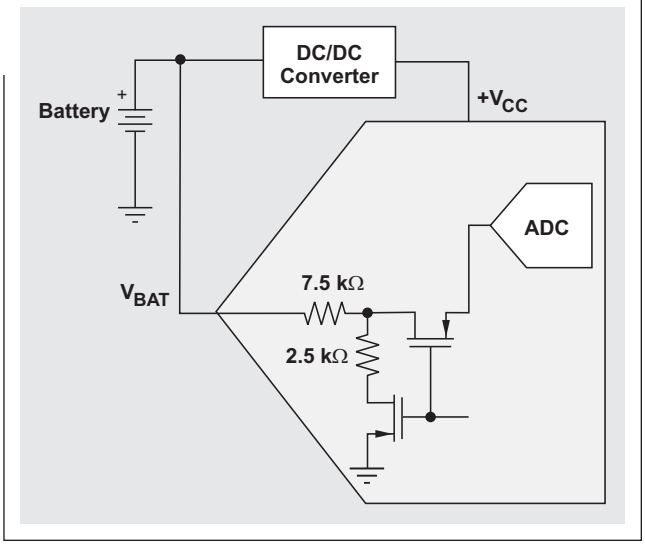
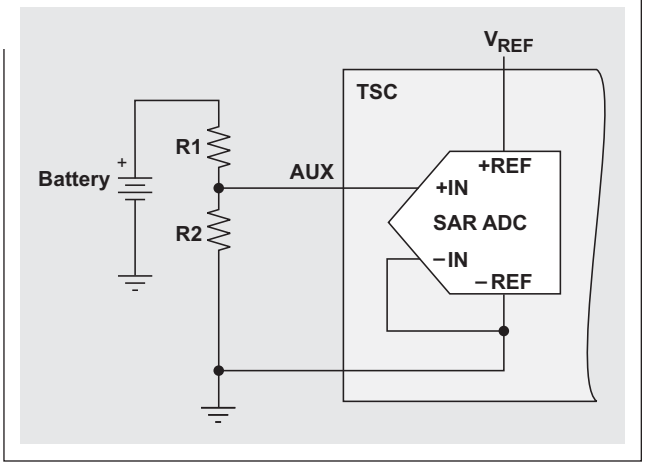


Figure 4. Using AUX with external voltage divider to monitor battery voltage



since the battery's voltage is normally higher than that of the TSC's power supply (and thus that of the V_{REF}).

A TSC auxiliary pin such as AUX can still be used to measure/monitor the battery voltage if an external voltage divider is added between the battery and the AUX, as shown in Figure 4. R1 and R2 values should be selected with wide enough margins to ensure that the signal at the AUX pin is within 0 V to V_{REF}. Note that the voltage divider shown in Figure 4 consumes extra power since a current of V_{CC}/(R1 + R2) continuously drains the battery. Larger resistance can reduce power consumption.

The V_{BAT} input circuit of TI TSCs does not consume extra power from the battery since there is a switcher between the divider and the power (ground) (see Figure 3), and the internal divider is powered up only during the short period of battery measurement.

Figure 5. Using TSC AUX pin to monitor battery with controllable switch

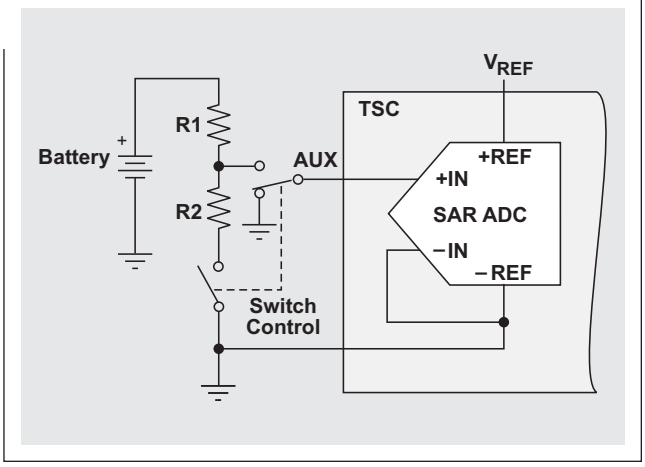
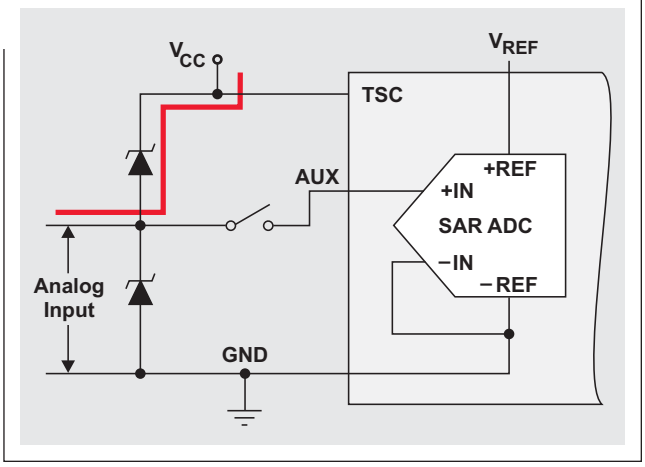


Figure 6. External ESD-protection circuit may supply pseudo power to TSC



Similarly, while a TSC's AUX pin is used to monitor battery voltage, adding a controllable switcher like that shown in Figure 5 can reduce power consumption and ensure disconnection of the signal from the AUX pin while the TSC is powered down.

ESD protection and auxiliary-input requirements during power down

It is very common in practical applications to power down a TSC when it is not in use to reduce system power consumption. A question then arises: Can the analog signal stay connected to the TSC when the TSC's power source is removed?

Figure 6 shows one case in which the analog input should be removed before the TSC is powered down. If the analog input signal is active (AUX is nonzero) when the TSC is powered down (V_{CC} = 0), the analog signal may be routed to the V_{CC} through the ESD-protection diode (see the red line in Figure 6). This may partially or fully power up the TSC, depending upon the amplitude of the input signal, consuming more power and possibly causing the TSC to malfunction. Thus the circuit configuration in Figure 6 should be avoided.

An alternative is to simply use ESD-protection circuitry as shown in Figure 7. Under extremely large electrostatic voltages, the circuit in Figure 7a may not be as efficient as that in Figure 7b due to the limited current flow through the ESD-protection diodes. On the other hand, the circuit in Figure 7b is not symmetric and therefore does not provide equal protection for positive and negative ESD bursts.

Figure 7. ESD-protection circuits for TSC analog input pin

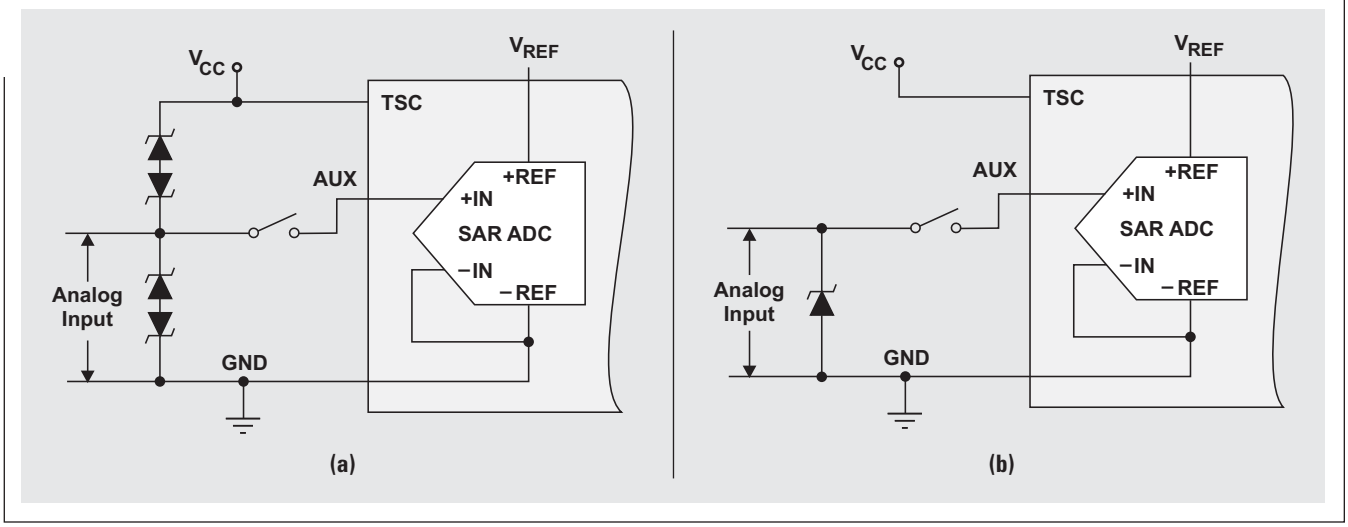


Figure 8. TSC2004/5/6/7 internal ESD protection for AUX input

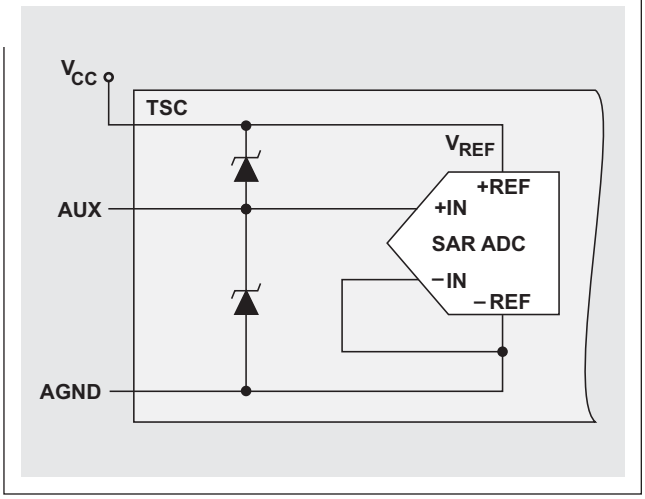
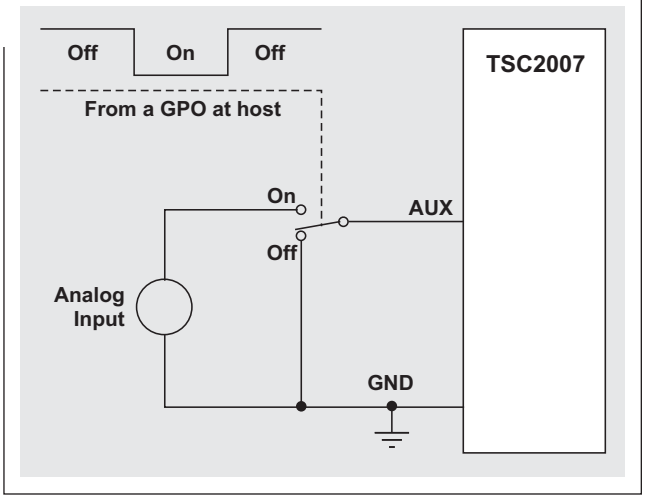


Figure 9. Switching off TSC2004/5/6/7 AUX before TSC is powered down



Some of TI's new TSCs, including the TSC2004/5/6/7, were designed with the enhanced, on-chip ESD protection shown by the simplified circuit in Figure 8. Obviously, for these devices, the input signal to the TSC's AUX should be removed before the TSC's V_{CC} power is shut down. An example of removing the AUX signal is shown in Figure 9.

Special applications summary

- An unused analog input pin should be connected directly to the analog ground.
- Pay attention to the divider's resistance values and power consumption when using an AUX to monitor the battery voltage.
- Before removing the TSC's power, always use software commands to disable the TSC's auxiliary functions.
- For the ADS7846, TSC2046, and TSC2003, the nonzero signal to the AUX or V_{BAT} pin can stay connected while the TSC's power source is removed.
- For the TSC2004/5/6/7, the nonzero signal to AUX should be removed from the analog input pin before the TSC power is removed.

Reference

For more information related to this article, you can download an Acrobat Reader file at www-s.ti.com/sc/techlit/*litnumber* and replace *"litnumber"* with the **TI Lit. #** for the materials listed below.

Document Title **TI Lit. #**

1. Wendy Fang, "Operation Schemes of Touch Screen Controllers," Application Report slaa359

Related Web sites

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Replace *partnumber* with ADS7843, ADS7845, ADS7846, TSC2003, TSC2004, TSC2005, TSC2006, TSC2007, or TSC2046

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