

How to Protect a Multi-Channel RTD System using Fault Protected Multiplexers



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Introduction

The resistance temperature detector (RTD) is an excellent device to measure the signal transition of the temperature with extreme accuracy, more accurate than the thermocouple, and being able to handle higher temperature than the thermistor, help to reduce external noise. There are various types that use two, three, or four-wire measuring systems, depending upon the accuracy level that is desired, and the expected cost. In all of the wire measuring systems, the voltage across RRTD is measured, which is converted to digital format using an analog-to-digital converter (ADC).

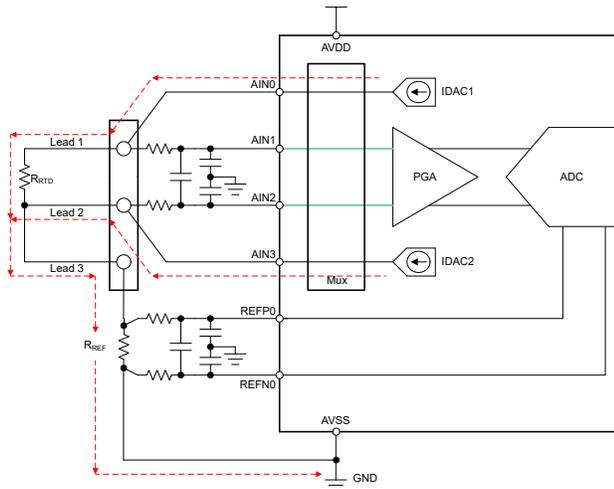


Figure 1. Three-Wire RTD Ratio Metric Measurement Using $\Delta\Sigma$ ADC

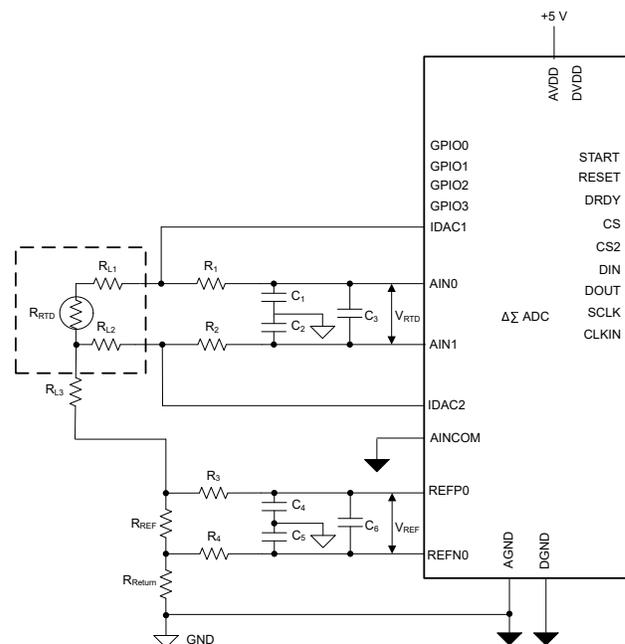
Integrated circuits in industrial environments are liable to damage as a result of a variety of fault cases. Such fault conditions may include, but are not limited to, human error from miswiring connections, EOS (transient conditions above the standard MUX rating), latch-up failures, and so forth. Overvoltage protection is a desirable specification for an RTD module which provides protection to the entire signal conditioning circuit.

This article discusses the overvoltage protection solution for the RTD input systems using the fault-protected multiplexers and channel protectors.

RTD Input Module Using the High-Resolution ADC

The RTD sensor requires an excitation current to produce an output voltage. The excitation current is provided by the ADC, containing the multiplexer, PGA, and internal reference. The two-wire system has one wire from each end and the three-wire system has one wire from each end and another wire from any end that goes to the measuring circuit.

Figure 2 shows the basic block diagram for the RTD input system with the $\Delta\Sigma$ ADC and protection using discrete components. As the figure shows, the excitation current is provided by the IDAC1/2 for the RTD Sensors.



Generally, the discrete components are used in the arrangement in [Figure 2](#) between the source or sense, and the ADC. For overvoltage protection, various solutions are employed:

- Using series resistors in front of the pins of an ADC helps to protect the ADC pins. These pins include analog input and excitation output pins, but the resistors limit compliance voltage.
- The protection of current source are realized by discrete components. The current-limiting resistors and the clamping diodes provide protection against some levels of positive and negative voltage.
- Reference resistors for ratio metric measurements becomes damaged because of voltages that are too high. Here, a limiting resistor and TVS is also required, so that the resistor cannot be overloaded.
- Limit the voltage drop to a safe level for the ADC or an additional filter network is required with an impedance high enough so that the ADC internal steering diode can handle the current caused by the overvoltage.
- Use fault-protected multiplexers like [TMUX7412F](#) and [TMUX7462F](#) to protect the source pins and the analog input channels against the overvoltage events. These parts provide $\pm 60V$ fault voltage protection in powered and unpowered modes.

[Figure 3](#) illustrates the RTD circuit configuration with the multiplexer.

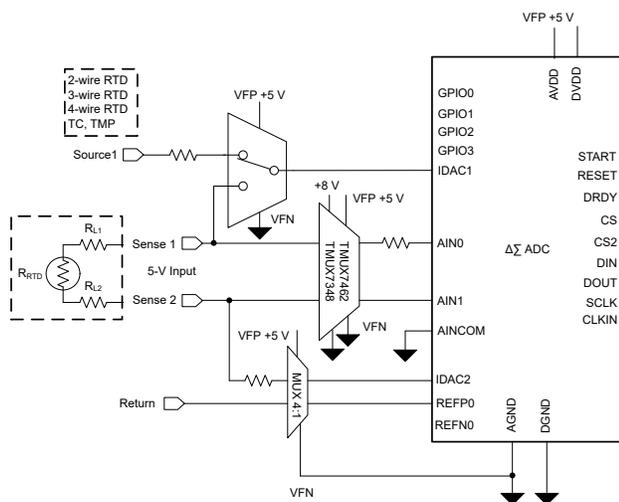


Figure 3. RTD Circuit Configuration With the Multiplexer

The [TMUX7462F](#) is a four-channel protector with an adjustable fault threshold, that can be placed on the front end of a signal path to protect analog input pins, downstream from damages caused by overvoltage faults. Each of the four channels has an internal switch that is turned-off autonomously upon

occurrence of an overvoltage fault without the need of external controls. A lack of external controls simplifies robust system-level protection designs by removing the need for control signals for each channel of the device. The overvoltage protection is available in powered and powered-off conditions, making the [TMUX7462F](#) suitable for applications with multiple channels that must be simultaneously protected in an application. For a higher number of channels and multiplexing requirements, use the [TMUX7348F](#), an 8:1, 1-channel multiplexer with the adjustable fault threshold (secondary supplies), as an input multiplexer.

These multiplexers accept input signals in the range of $\pm 5V$ to $\pm 22V$ and protect the circuit against high voltage due to potential miswiring risk (outside the VFN, VFP range) up to the $\pm 60V$ protection level of the MUX.

Using the Secondary Rails for the Protection

V_{FP} and V_{FN} provide the much-needed protection to the ADC in the event that the input RTD is operating at a voltage level higher than the ADC and the high voltage gets exposed to the AIN pin during an overvoltage event. V_{FP} and V_{FN} can be configured to match the ADC supply voltage and can help clamp down the voltage to the supply voltage of the ADC.

Two secondary power supplies on the device, V_{FP} and V_{FN} , are the required secondary power supplies that set the level at which the overvoltage protection comes into play. V_{FP} can be supplied from 3V up to VDD and V_{FN} can be supplied from VSS to 0V.

Some of the ADC can have $\pm 15V$ (HV_AVDD, HV_AVSS) for the HV inputs. It has a +5/GND (AVDD, AGND) domain for the REF circuitry and the internal current sources. Introducing fault-protected multiplexers for the IDACs connecting the V_{FP} , V_{FN} to the AVDD/GND domain will work as protection to the IDAC pins and REF inputs.

The switch channels remain in the high-impedance state (regardless of switch input conditions) when the devices power supplies are floating, grounded, or at a level that is below the undervoltage (UV) threshold. If the signal level on any Sx pin exceeds the fault supply (V_{FP} or V_{FN}) by a threshold voltage (VT), then the Sx pin becomes high impedance and an output fault flag is asserted low to indicate a fault condition under normal operation. The drain pin (Dx) is either pulled to the fault supply voltage that was exceeded or left floating depending on the DR control logic.

Summary

The [TMUX7412F](#) and [TMUX7462F](#) is part of the fault-protected switches and multiplexers family of devices. The ability to protect downstream components from overvoltage events up to $\pm 60V$ and latch-up immunity features makes these switches and multiplexers suitable for harsh environments. Using analog switches and multiplexers in an RTD input system creates ease-of-use and have many advantages including making RTD modules secure from fault voltage, offering low noise and fast settling time.

Reference

- Texas Instruments E2E™ Forum, [How to design for precision RTD measurements with ADCs](#)
- Texas Instruments, [A Basic Guide to RTD Measurements](#) application note
- Texas Instruments, [Introduction To RTDs](#) precision labs video

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