Application Report

New Approach to Protect 4–20 mA, ±20-mA Analog Input

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ABSTRACT

This document shows how the TPS26610 device protects 4- to 20-mA current loop and ±20-mA current inputs in an *Analog Input Module* and the advantages compared to traditional discrete solutions.

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1 Introduction

In industrial applications, the equipment must operate reliably in harsh environments. In an analog IO module, input power and analog signal protections are needed to operate in harsh environments, fulfilling various standards. Field transmitters set the current loop based on the value of physical quantities such as temperature and pressure. The set current is then converted into voltage using a burden resistor inside the analog input module. The goal of the design is to ensure that the precision burden resistor and the analog-to-digital converter (ADC) front end are well protected.

Focusing on analog signal protections, it is important to be compliant with mandatory standards to protect the module from surges (IEC61000-4-5) and electrical fast transients (EFT). It is also necessary to consider and manage accidental events such as mis-wiring during installation and wire-short, the unwanted connection between two cables which causes a short circuit during operations that can occur in a factory.

2 Discrete Solution With PTC

Figure 2-1 shows a typical discrete solution based on a positive temperature coefficient device (PTC) used to protect the current input of an analog input module.

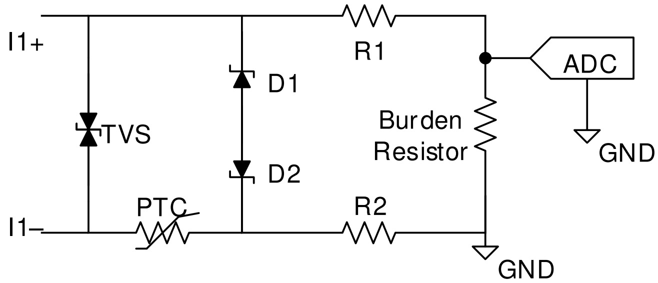

Figure 2-1. Discrete Solution With PTC

The downsides of a typical solution are:

- System size due to the BOM in terms of size and count of the components (see Figure 2-1)
- Constraint of high-power dissipation of the burden resistor in overcurrent condition reduces the choice of selection
- Temperature dependency of the front end (mainly from PTC)
- Higher voltage drop at the analog input limits the length of the current loop
- Lack of status (overcurrent versus normal operation)

3 TPS26610 Advantages to a Typical Solution

The traditional discrete solution with the PTC (Figure 2-1) can be replaced by an optimized solution as Figure 3-1 shows.

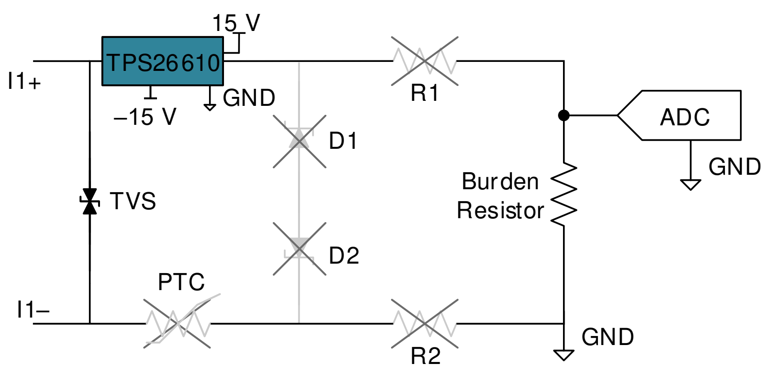

Figure 3-1. Current-Loop Protector for AIN – Integrated Protection With TPS26610

3.1 BOM and Size Reduction

The BOM of the analog front end (ADC excluded) is reduced from eight components to three components. This not only simplifies the logistic but also reduces the board space. This is an important advantage in the space-constraints of IO modules.

3.2 Burden Resistor and Power Dissipation

The 30-mA current limit granted by the TPS26610 allows the choice of a burden resistor with less constraints on maximum power dissipation. In overcurrent conditions the TPS26610 limits the current faster than the PTC in the typical solution.

Figure 3-2 shows that in the traditional solution the burden resistor has to dissipate more than 1.7 W in about four seconds until the PTC stabilizes to around 120 mW. Figure 3-3 shows the auto-retry feature of the TPS26610 decreasing the power dissipation on the burden resistor (less than 10 mW).

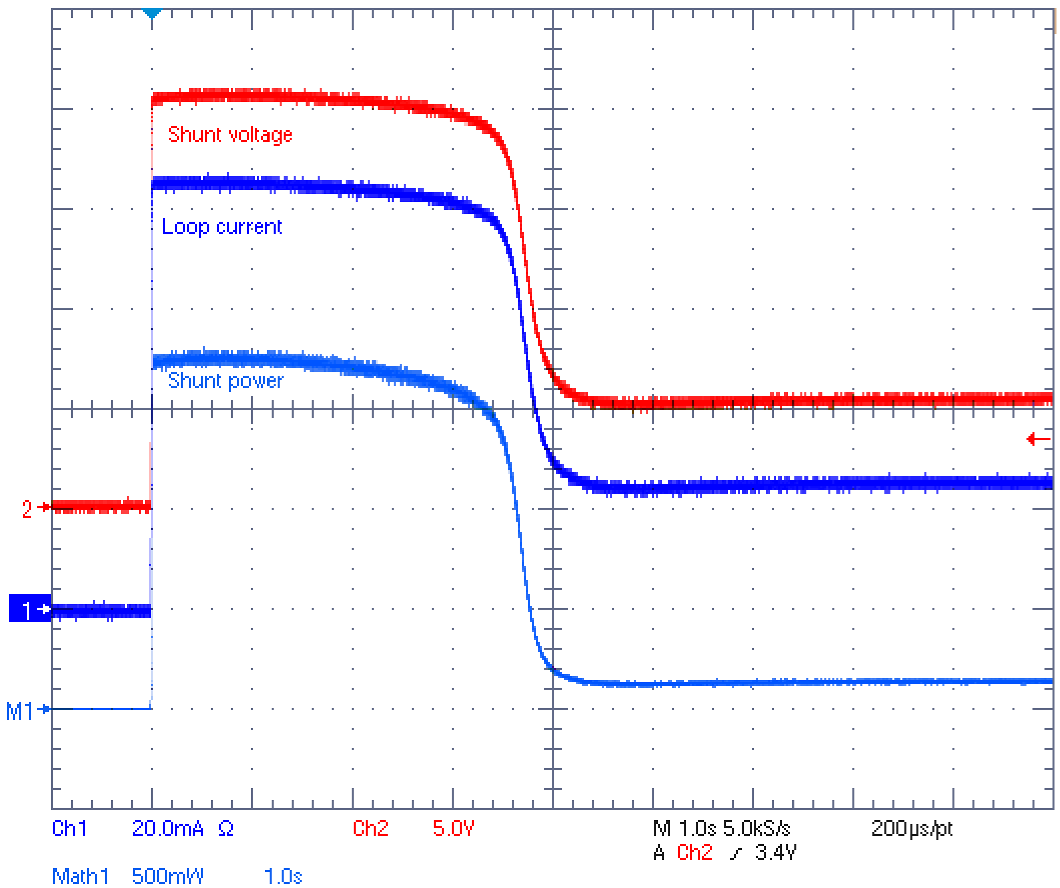

Figure 3-2. PTC Overcurrent Response With V_{IN} = 24 V (1 s/div) — 250-Ω Burden Resistor

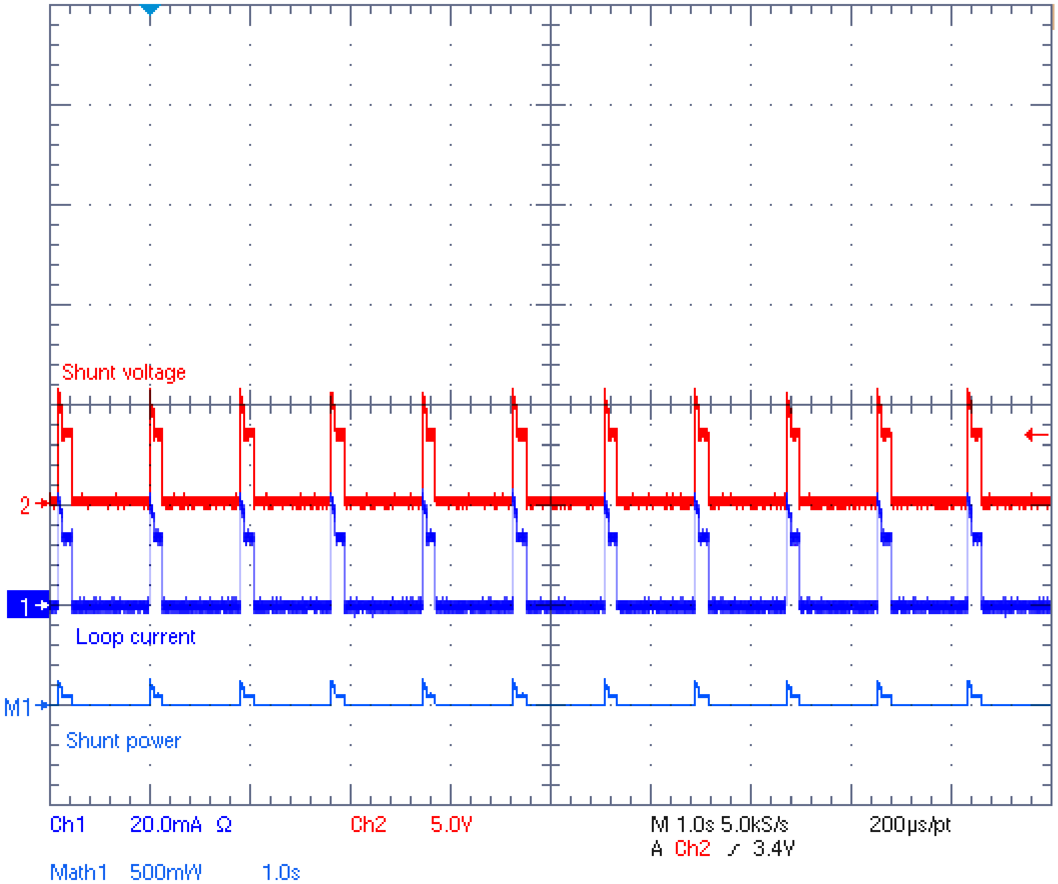

Figure 3-3. TPS26610 Overcurrent Response With V_{IN} = 24 V (1 s/div) — 250-Ω Burden Resistor

Figure 3-5 and Figure 3-4 show the temperature of the two components during the same overcurrent condition. The temperature of the TPS26610 - Figure 3-5 is 37°C while the temperature of the PTC - Figure 3-4 is more than three times higher, specifically 120°C.

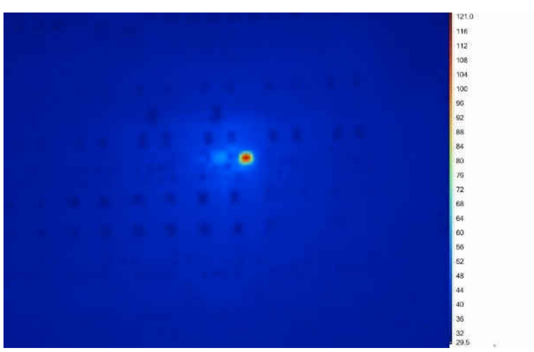

Figure 3-4. PTC Thermal Image

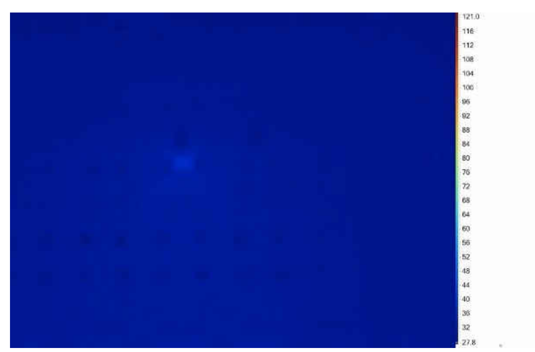

Figure 3-5. TPS26610 Thermal Image

3.3 Voltage Drop

The overall voltage drop at the analog input is composed by the drop across the burden resistance and the TPS26610 voltage drop of about 250 mV. The decrease of this voltage-drop compared to the typical solution allows you to increase the length of the current loop.

3.4 Signal Good

The TPS26610 also features a signal good (SGOOD) output to indicate if the component is working in normal operating conditions. The SGOOD pin goes high in the event of overcurrent, overvoltage and undervoltage, and thermal shutdown.

3.5 Additional TPS26610 Features

3.5.1 Miswiring

The TPS26610 provides protection from miswiring to ±50 V. This tolerates miswiring of the programmable logic controller (PLC) power supply (+24-V DC) at the inputs. If the module (and the TPS26610) is not powered, the TPS26610 limits the current to a maximum of 43 mA.

3.5.2 Surge

In combination with the TVS3301 that clamps the surge at 40 V, using both the TVS3301 and the TPS26610 protects against surge (IEC61000-4-5).

3.5.3 Current-Loop Test During Installation (Unpowered)

Independent of the power state of the module, the current loop is closed as the TPS26610 can flow the current in both the powered and unpowered condition. This allows testing of the current loop during the installation.

3.5.4 High Accuracy For Current Measurements

When the TPS26610 is powered through the supply pin, it draws 100-nA maximum current from the current loop across temperature and load conditions. This leakage current does not affect the result of a 16-bit ADC ($1 \text{ LSB} = 20 \text{ mA} / 2^{16} = 305 \text{ nA} > 100 \text{ nA}$).

4 Conclusion

Considering the schematics in Figure 2-1 and Figure 3-1, the pros of the current-loop protector TPS26610 over the discrete solution with the PTC are summarized in Table 4-1.

Table 4-1. Comparison of Current-Loop Protector TPS26610 Over the Discrete Solution With the PTC

	TPS26610	Discrete Solution With PTC
Number of components	3	8
Solution size	Reduced up to 85%	100%
Burden resistor properties	Lower size and value	Power dissipation constraints (higher size and value)
Signal Good	Yes	No
Voltage drop at the terminals	Burden resistor + 200 mV (TPS26610)	Burden resistor + PTC + protection resistors
Surge protection	Yes	Yes
Miswiring protection	Yes	Yes
Protection in powered and unpowered module	Yes	Yes

In conclusion, the TPS26610 is the integrated solution to both meet the technical specifications required in a current loop protector for AIN and the increasingly-restrictive space conditions.