

Product Group: Vishay Foil Resistors

Measurement accuracy and stability over time and temperature

intersil™

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Intersil Corporation based in Milpitas, CA developed a high performance instrumentation amplifier circuit with high gain accuracy over a wide temperature range (-40C to 125C).

Industry/Application Area Industrial, Instrumentation, and Medical Applications

Product Used

- Intersil's ISL28617 (40V Instrumentation Amplifier)
- VPG's FRSM Foil Resistors® 2512 (120 kΩ, 30 kΩ, 12 kΩ, 1.2 kΩ)

The Challenge

Design a high performance instrumentation amplifier circuit with high gain accuracy over a wide temperature range (-40°C to +125°C). Verification of best solution was accomplished by measuring the performance of the ISL28617 instrumentation amplifier with high-performance thin film resistors vs. Vishay Foil Resistors brand Bulk Metal® Foil resistors.

The ISL28617 is a high-performance, differential input, differential output instrumentation amplifier. It can operate over a supply range of 8 V (± 4 V) to 40 V (± 20 V) and features a differential input voltage range up to ± 34 V. The output stage has a rail-to-rail output drive capability optimized for differential ADC driver applications and the outputs can be clamped to ADC supply voltages as low as 3 V (± 1.5 V). Its versatility and small package makes it suitable for a variety of general-purpose applications. Fig 1 is a simplified diagram of the ISL28617, showing where the gain of the ISL28617 can be programmed from 0.1 to 10,000 via two external resistors, R_{IN} and R_{FB} .

The gain accuracy is determined by the matching of R_{IN} and R_{FB} . The gain resistors have Kelvin sensing, which removes gain error due to PC board trace resistance. The input and output stages have individual power supply pins, which enable input signals riding on a high common-

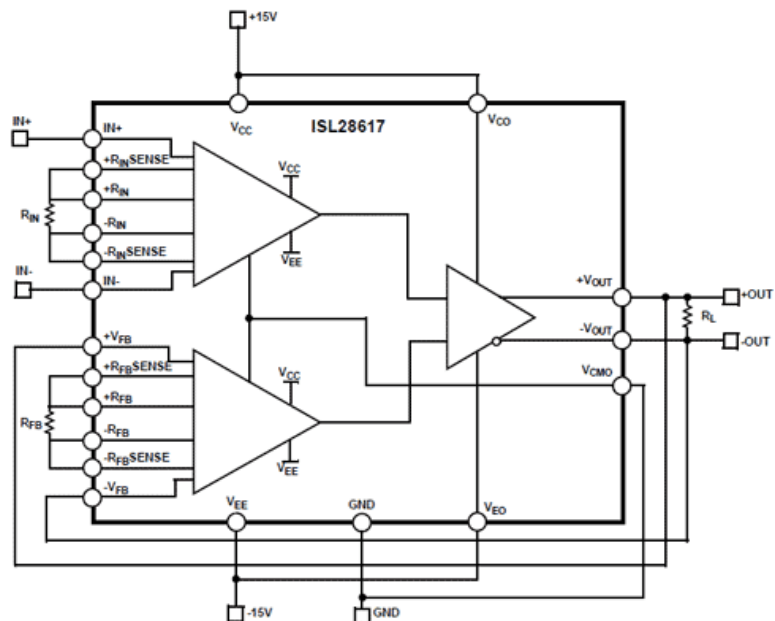


Figure 1 - ISL28617 simplified block diagram

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mode voltage to be level-shifted to a low-voltage device, such as an A/D converter. The rail-to-rail output stage can be powered from the same supplies as the ADC, preserving the ADC maximum input dynamic range and eliminates ADC input overdrive.

The ISL28617 Instrumentation amplifier was developed to accomplish the following:

- Provide a fully differential, rail-to-rail output for optimally driving ADCs
- Limit the output swing to prevent output overdrive
- Allow any gain (<10,000), including attenuation (>0.1)
- Maximize gain accuracy by removing on-chip component tolerances and external PC board parasitic resistance
- Maintain CMRR >100dB and remove CMRR sensitivity to gain resistor tolerance
- Provide a level shift interface from bipolar analog input signal sources to unipolar, and bipolar ADC output terminations
- Enable user control of amplifier precision level with choice of external resistor tolerance

The problem:

Since the gain of the instrumentation amplifier is set by the resistor ratio R_{FB} / R_{IN} , resistor temperature drift and instability create gain errors and ultimately limit system accuracy. Even with perfectly matched resistors, board-level environmental conditions may force the resistors to different temperatures, so a low temperature coefficient of resistance (TCR) is desired. For high gains where the resistors are subject to different voltages, resistor voltage coefficients and unequal self-heating can add additional error.

The Solution

The combination of Intersil's new ISL28617 in-amp with VPG's Bulk Metal Z-Foil resistors provided the ideal high performance solution circuit. These resistors, built on a revolutionary technology, deliver an absolute temperature coefficient of resistance (TCR) of ± 0.2 ppm/ $^{\circ}\text{C}$ (-55°C to $+125^{\circ}\text{C}$, $+25^{\circ}\text{C}$ ref.) and ± 0.05 ppm/ $^{\circ}\text{C}$ (0°C to $+60^{\circ}\text{C}$, $+25^{\circ}\text{C}$ ref.). By taking advantage of the following features of the overall stability and reliability of Vishay Foil Resistors products, designers can significantly reduce circuit errors and greatly improve overall circuit performance.

- Temperature coefficient of resistance (TCR)
- Power coefficient of resistance (PCR)
- Thermal stabilization
- Resistance tolerance
- Load life stability
- High speed and response time
- Noise
- Thermal EMF
- Electrostatic discharge (ESD)
- Non-measurable voltage coefficient

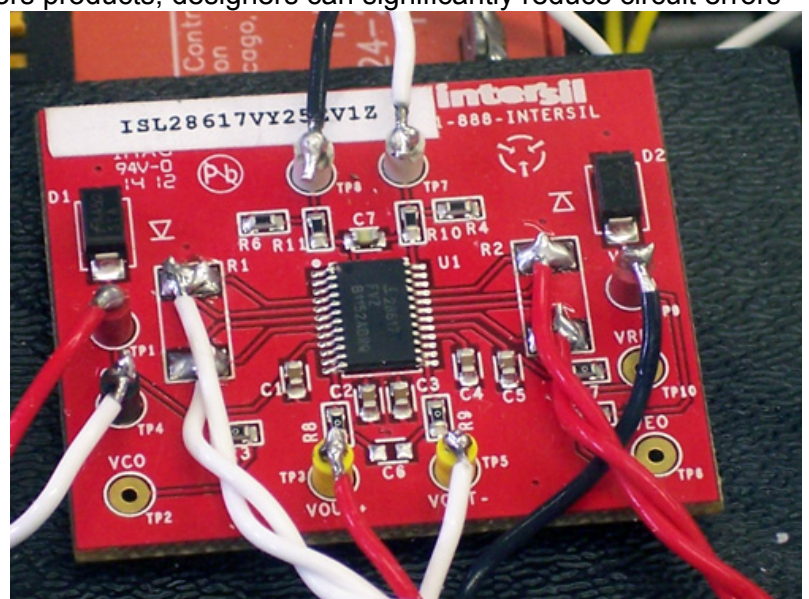


Figure 2 - Intersil's ISL28617 Amplifier

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The User Explains

To test the performance, the ISL28617 (Fig 2) was tested with both the high-performance thin film resistors and Bulk Metal Foil resistors from VPG. See Fig 3 for the test setup.

As can be seen from Fig 4, the thin film resistor (yellow line) performance is very good at room temperature. But as the ambient temperature changes, the performance degrades very quickly. The foil resistors (white line) performance at room temperature is also very good at room temperature, but as shown it also keeps the same level of performance even with the change in ambient temperature.

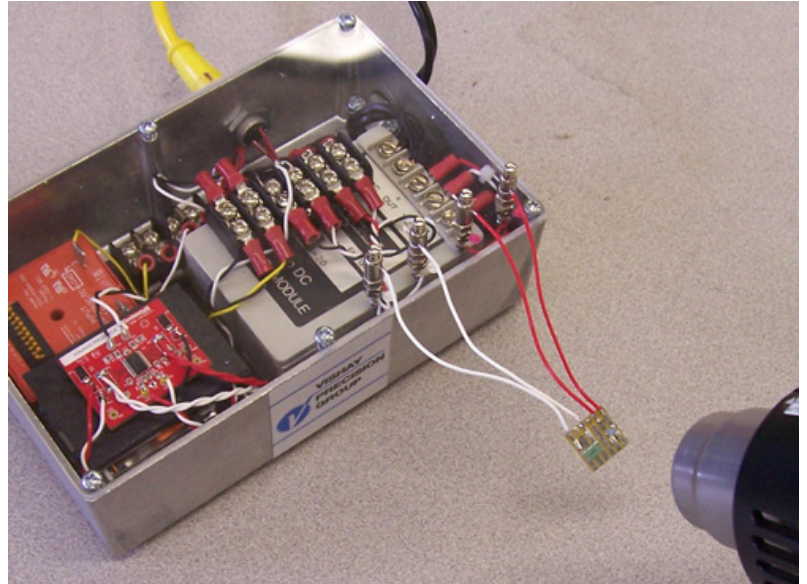


Figure 3 - Intersil's ISL28617 Amplifier inside a test fixture where R1 and R2 are connected externally to a PCB including thin film or foil resistors. The heat gun is facing the resistors and changing the ambient temperature up to +125°C.

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Intersil At a Glance:

Intersil Corporation is a leader in the design and manufacture of high-performance analog, mixed signal, and power management semiconductors. Intersil's products simplify the design process by integrating functions design engineers need to make their products the best in their markets in a more efficient way: By leveraging reliable solutions with the highest level of quality, performance, integration and embedded intelligence, in compact, space-efficient packaging.



Figure 4 – Graph showing the resistance change in ppm from initial value of the resistors (R1 and R2) due to the rise of the ambient change caused by the heat gun

White graph = VFR Z-Foil resistor
Yellow graph = thin film resistor