VPG Low Voltage Strain Gauge DAQ on a USB Stick Reference Design with Renesas & Foil Resistors

**Introduction**

The reference design presented takes the best products from Intersil, Renesas and Vishay Precision Group (VPG) to make a low voltage, low noise and low power Micro-Measurements (MM) strain gauge reference design. The strain gauge reference design is a precision solution from the sensor to the digital Graphical User Interface (GUI). The design uses Intersil’s precision and power products, the Renesas DAQ on a Stick with the RL78/G1C microprocessor and VPG’s high precision Bulk Metal® Foil resistors. The demo platform consists of two boards as shown in Figure 1.

**Key Components**

- ISL28134 5V, Low Noise, Zero-Drift Op Amp
- ISL26102 Low-Noise 24-bit Delta Sigma ADC
- ISL21010 Micropower Precision Bandgap Voltage Reference
- ISL43741 Differential 4 to 1 Multiplexer
- ISL22316 128 Taps Digital Potentiometer
- R5F10JBC Renesas Integrated USB Controller
- Z201VPG Foil Resistor

validate the consistency of the strain gauge circuit at any time. At the heart of the calibration circuit is a voltage divider formed from Vishay Precision Group 1202 style Bulk Metal Foil trimmers and Z201 fixed resistors.

The strain gauge design is a bridge solution that is able to extract a small sensor signal from a common mode signal of 5V. The Vishay Precision Group calibration box is able to quickly and accurately null out voltage offsets and verify measurement accuracy of commonly used bridge sensors. Vishay Bulk Metal® Foil bridge completion resistors form the backbone of the wheatstone measurement configuration and guarantees that any variations in environmental conditions such as temperature, time, or humidity do not affect the bridge sensor measurement. Additionally, Vishay Bulk Metal® Foil trimming resistors offer an extremely linear response with no backlash for quick and accurate, coarse or fine adjustments to set or remove measurement offsets. After a bridge has been used for a period of time, another precision trimming resistor may be used to verify a known resistance shift that creates the desired output, effectively negating the need to periodically use a weighing standard which may be an inconvenience due to size or a specific weight being required.

**Graphical User Interface (GUI) Software and USB Drivers**

The GUI Software and USB drivers have to be installed on a PC running Windows NT/2000/XP/Vista/Win7 Operation System before connecting the ISLRE-BDGSTKEV2Z evaluation board to the USB port.

**FIGURE 1. INTERSIL, RENESAS AND VPG STRAIN GAUGE AND FOIL RESISTORS DEMO PLATFORM**

The first board is the VPG strain gauge calibration box. The calibration box is a 1/2 bridge configuration and is made up of ultra high precision Bulk Metal® Foil resistors from VPG. The second board is the Renesas DAQ on a Stick. The DAQ on a Stick is a self contained demo showing a complete signal chain solution using Intersil parts and a Renesas microcontroller. The complete reference design is conveniently housed in a USB stick form factor. This compact design draws power through the USB port to power the application and provide a 5V source to power the calibration box.

**FIGURE 2. SIMPLIFIED VISHAY FOIL RESISTORS CALIBRATION BOX SCHEMATIC**

Figure 2 shows the schematic for the Vishay Precision Group strain gauge calibration box. This box makes it easy for anyone measuring two gauges, or with an additional resistor a single gauge, to quickly and accurate make a convenient measurement with meaningful results as well as periodically verify the consistence of the strain gauge circuit at any time. At the heart of the calibration circuit is a voltage divider formed from Vishay Precision Group 1202 style Bulk Metal Foil trimmers and Z201 fixed resistors.

The strain gauge design is a bridge solution that is able to extract a small sensor signal from a common mode signal of 5V. The Vishay Precision Group calibration box is able to quickly and accurately null out voltage offsets and verify measurement accuracy of commonly used bridge sensors. Vishay Bulk Metal® Foil bridge completion resistors form the backbone of the wheatstone measurement configuration and guarantees that any variations in environmental conditions such as temperature, time, or humidity do not affect the bridge sensor measurement. Additionally, Vishay Bulk Metal® Foil trimming resistors offer an extremely linear response with no backlash for quick and accurate, coarse or fine adjustments to set or remove measurement offsets. After a bridge has been used for a period of time, another precision trimming resistor may be used to verify a known resistance shift that creates the desired output, effectively negating the need to periodically use a weighing standard which may be an inconvenience due to size or a specific weight being required.

**FIGURE 3. GUI MEASUREMENT SCREEN**

![GUI Measurement Screen](image-url)
The software and a quick video on the operation of this application demo can be downloaded or viewed from the Intersil website at: http://www.intersil.com/en/tools/referencedesigns/Renesas-DAQ-Vishay-strain-gauge-referencedesign.html.

**Pressure Strain Gauge Signal Conditioning**

The strain gauge design is a bridge solution that is able to extract a small sensor signal from a high voltage common mode signal of 10V or higher. Figure 4 shows a simplified schematic of the Strain Gauge design. The design uses VPG’s Z201 fixed resistor and 1202 trimming potentiometer, Intersil’s ISL28134 chopper amplifier, ISL22316 Digitally Controlled Potentiometer (DCP), ISL43741 differential mux, ISL21010 4.096 voltage reference, the ISL26102 24-bit delta sigma converter and, Renesas’ R5F10JBC microcontroller.

**Design Considerations**

**Vishay Precision Group FRSM Series Bulk Metal® Foil Resistors**

The FRSM series Bulk Metal® Foil (Z1-Foil Technology) ultra-high precision resistors have a tolerance of 0.01% and a temperature coefficient (TCR) of 0.2ppm/°C, giving exceptional gain accuracy that is ideal for high-end applications. The foil resistors are capable of achieving tighter absolute and ratio tolerances than any other technology. The real value of foil resistors is their unmatched stability through temperature excursions, load life and extraordinary thermal and environmental stresses, resulting in far more stable gain ratios. Another important feature of the Bulk Metal® Foil technology is the lowest current noise of any resistor technology (<40dB). The combination of foil resistors’ low current noise and the exceptional low-noise performance of the ISL28134 amplifier make this the perfect solution for noise critical precision applications.

**ISL28134**

The ISL28134 is an ideal choice for the input amplifier for a strain gauge design. The ISL28134 uses auto-correction circuitry to provide ultra-low offset voltage (2.5μV), and low offset temperature drift (15nV/°C). The very low 1/f noise corner <0.1Hz and low input noise voltage (8nV/√Hz @ 100Hz) of the amplifier makes it ideal for low frequency precision applications requiring very high gain and low noise. Other attributes of the ISL28134 are the wide gain bandwidth and rail-to-rail input/output swing.

**ISL26102 24-bit ADC**

The ISL26102 is a complete analog front-end with dual differential multiplexed inputs for high resolution measurements. ISL26102 features a third order modulator providing up to 21.4-bit noise-free performance (10Sps). The 24-bit delta-sigma analog-to-digital converter includes a very low-noise amplifier with programmable gain. Although this application demo uses an input buffer amplifier (ISL28134), the high input impedance of the ISL26102 allows direct connection of sensors, such as load cell bridges to ensure the specified measurement accuracy without a buffer amplifier. In order to initiate a correct power-up reset, diode D1, resistor R3 and capacitor C8 implement a simple RC delay to ensure the PDWN transitions from low to high after both power supplies have settled to specified levels.

**ISL21010 (4.096V)**

The ISL21010CFH341 is a precision 4.096V, low dropout micropower bandgap voltage reference. It provides a ±0.2% accurate reference. The ISL21010 provides up to 25mA output current sourcing with low 150mV dropout voltage. The low supply current and low dropout voltage combined with high accuracy make the ISL21010 ideal for precision low powered applications.

**ISL22316 DCP**

The ISL22316 is a low noise, low power I2C™ bus, 128 tap DCP. The DCP can be used as a three-terminal potentiometer or as a two-terminal variable resistor in a wide variety of applications including control, parameter adjustments, and signal processing.

**ISL43741 Differential 4 to 1 Multiplexer**

The ISL43741 is a precision, bidirectional, differential 4-channel multiplexer/demultiplexer. The mux is designed to operate from a single ±2V to ±12V supply or from ±2V to ±6V supplies. The ISL43741 has low charge injection with 1pC (Max) at V5 = ±5V.

**Reference Documents**

- Vishay Precision Group FRSM Series Bulk Metal® Foil Resistors: http://www.vishaypg.com/docs/49788/10reasns.pdf
- Renesas R5F10JBC Data Sheet
- Slin, “Renesas and VPG Low Voltage Strain Gauge and Foil Resistor Reference Design,” App Note, AN1840
- Intersil ISL21010 Data Sheet “Micropower Voltage Reference,” FSN969
- Intersil ISL21010 Data Sheet “5V Ultra Low Noise, Zero Drift Rail-to-Rail Precision Op Amp,” FSN957
- Intersil ISL26102 Data Sheet “Low-Noise 24-bit Delta Sigma ADC,” FSN766
- Intersil ISL28134 Data Sheet “5V Ultra Low Noise, Zero Drift Rail-to-Rail Precision Op Amp,” FSN957
- Intersil ISL22316 Data Sheet “Low Noise, Low Power I2C® Bus, 128 Taps,” FSN158
- Intersil ISL43741 Data Sheet “4-channel Multiplexer/Demultiplexer,” AN1840
- Intersil ISL22316 Data Sheet “Low Noise, Low Power I2C® Bus, 128 Taps,” FSN158
- Intersil ISL28134 Data Sheet “5V Ultra Low Noise, Zero Drift Rail-to-Rail Precision Op Amp,” FSN957
- Intersil ISL26102 Data Sheet “Low-Noise 24-bit Delta Sigma ADC,” FSN766
- Intersil ISL43741 Data Sheet “Low-Voltage, Single and Dual Supply, 8 to 1 Multiplexer and Differential 4 to 1 Multiplexer,” FSN903
- Intersil ISL22316 Data Sheet “Low Noise, Low Power I2C® Bus, 128 Taps,” FSN158
- Intersil ISL28134 Data Sheet “5V Ultra Low Noise, Zero Drift Rail-to-Rail Precision Op Amp,” FSN957
- Intersil ISL26102 Data Sheet “Low-Noise 24-bit Delta Sigma ADC,” FSN766
- Intersil ISL43741 Data Sheet “Low-Voltage, Single and Dual Supply, 8 to 1 Multiplexer and Differential 4 to 1 Multiplexer,” FSN903
- Intersil ISL22316 Data Sheet “Low Noise, Low Power I2C® Bus, 128 Taps,” FSN158
- Intersil ISL28134 Data Sheet “5V Ultra Low Noise, Zero Drift Rail-to-Rail Precision Op Amp,” FSN957
- Intersil ISL26102 Data Sheet “Low-Noise 24-bit Delta Sigma ADC,” FSN766
- Intersil ISL43741 Data Sheet “Low-Voltage, Single and Dual Supply, 8 to 1 Multiplexer and Differential 4 to 1 Multiplexer,” FSN903
- Intersil ISL22316 Data Sheet “Low Noise, Low Power I2C® Bus, 128 Taps,” FSN158
- Intersil ISL28134 Data Sheet “5V Ultra Low Noise, Zero Drift Rail-to-Rail Precision Op Amp,” FSN957
- Intersil ISL26102 Data Sheet “Low-Noise 24-bit Delta Sigma ADC,” FSN766
- Intersil ISL43741 Data Sheet “Low-Voltage, Single and Dual Supply, 8 to 1 Multiplexer and Differential 4 to 1 Multiplexer,” FSN903
- Intersil ISL22316 Data Sheet “Low Noise, Low Power I2C® Bus, 128 Taps,” FSN158