Introduction

The "DAQ on a Stick, Thermocouple" is a reference design highlighting Intersil’s precision products with different microcontrollers. This reference design 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 enables the user to power the application through the USB port and monitor the temperature through the GUI interface on a computer. Figure 1 shows the Data Acquisition on a Stick reference design with the thermocouple attached.

![Figure 1. DAQ on a stick with thermocouple](image)

Figure 2 shows a simplified schematic of the thermocouple design. The design uses Intersil’s ISL28134 chopper amplifier, ISL21010 4.096V voltage reference, ISL22317 DCP, ISL26102 24-bit delta sigma converter and Renesas’s R5F10JBC microcontroller.

![Figure 2. ISLRE-TCSTKEV1Z Simplified Evaluation Board Schematic](image)

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 ISLEM-TCSTKEV1Z evaluation board to the USB port.

The software and a quick video on the operation of this application demo can be downloaded or viewed from the Intersil website [http://www.intersil.com/en/tools/referencedesigns/Renesas-thermo-reference-design.html](http://www.intersil.com/en/tools/referencedesigns/Renesas-thermo-reference-design.html). Details of the software can be found in app note AN1833.

Accuracy of Reference Design

The application circuit is calibrated at 25°C to within +/-0.1°C using a Fluke 54II Thermometer. The application accuracy of this design is within the achievable accuracy of the K-type thermocouple for temperatures above 0°C. Table 1 shows the limits of error for the K-type thermocouple.

<table>
<thead>
<tr>
<th>THERMOCOUPLE</th>
<th>TEMPERATURE RANGE (°C)</th>
<th>LIMITS OF ERROR</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>0 to 1250</td>
<td>±2.2°C or ±0.75%</td>
</tr>
<tr>
<td>K</td>
<td>-200 to 0</td>
<td>±2.2°C or ±2.0%</td>
</tr>
</tbody>
</table>

Table 2 shows the measured accuracy across -40°C to 125°C.

<table>
<thead>
<tr>
<th>TEMPERATURE RANGE (°C)</th>
<th>MEASURED ERROR (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+25 to +125</td>
<td>0.7</td>
</tr>
<tr>
<td>0 to +125</td>
<td>0.7</td>
</tr>
<tr>
<td>-20 to +25</td>
<td>1.7</td>
</tr>
<tr>
<td>-40 to +25</td>
<td>3.5</td>
</tr>
</tbody>
</table>
Design Considerations

Temperature Calculation

The temperature displayed on the GUI is calculated using the formula in Equation 1. $V_{out}$ in Equation 1 is the output voltage of the ISL28134 Chopper amplifier when set for a gain of 100.

$$\text{Temperature} = \frac{(V_{out} - 1.1092)}{4.14 mV/°C}$$

(EQ. 1)

ISL28134: Chopper Op Amp

The ISL28134 is an ideal choice for the input amplifier for a thermocouple 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, rail-to-rail input/output swing and low power consumption.

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 $D_1$, resistor $R_3$ and capacitor $C_8$ 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): Voltage Reference

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.

ISL22317 DCP

The highly precise ISL22317 features a low end-to-end temperature coefficient of $T_{Ref} ±10ppm/°C$ and precise resistance selection. It maintains less than ±1% typical variance from the ideal resistance at each wiper position providing 99% accuracy of selected resistance value. This highly accurate DCP eliminates the need for complex algorithms to guarantee precision. The ISL22317 operates from a single supply between 2.7V to 5.5V.

Reference Documents

- Intersil “DAQ on a Stick, Renesas Thermocouple” App Note: AN1833
- Intersil ISL28134 Data Sheet, FN6957
- Intersil ISL21010 Data Sheet, FN7896
- Intersil ISL26102 Data Sheet, FN7608
- Intersil ISL22317 Datasheet, FN6912
- Renesas’s R5F10JBC

### Ordering Information

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>DESCRIPTION</th>
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<tbody>
<tr>
<td>ISLRE-TCSTKEV1Z</td>
<td>Evaluation Board</td>
</tr>
</tbody>
</table>

Sensor: Thermocouple, temperature sensor, K-type, thermoelectric sensors

Applications: Sensor signal conditioning, process control, industrial control, medical, small signal gain, precision analog, mixed signal analog to digital, USB; thermometers, temperature monitors, HVAC, alternative energy, wind power, energy meters, patient monitors, data acquisition, smart metering, automotive, aerospace

Performance: Cold junction compensation, 16-bit to 24-bit sensor signal conditioning, low noise, low offset drift, less than <1%, RL78/G1C, chopper stabilized, 21.6 noise-free bits, ENOB, USB 2.0, DMIPS, true low power MCU, 16-bit CISC architecture, USB BC 1.2 standard for Fast Battery Charging

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