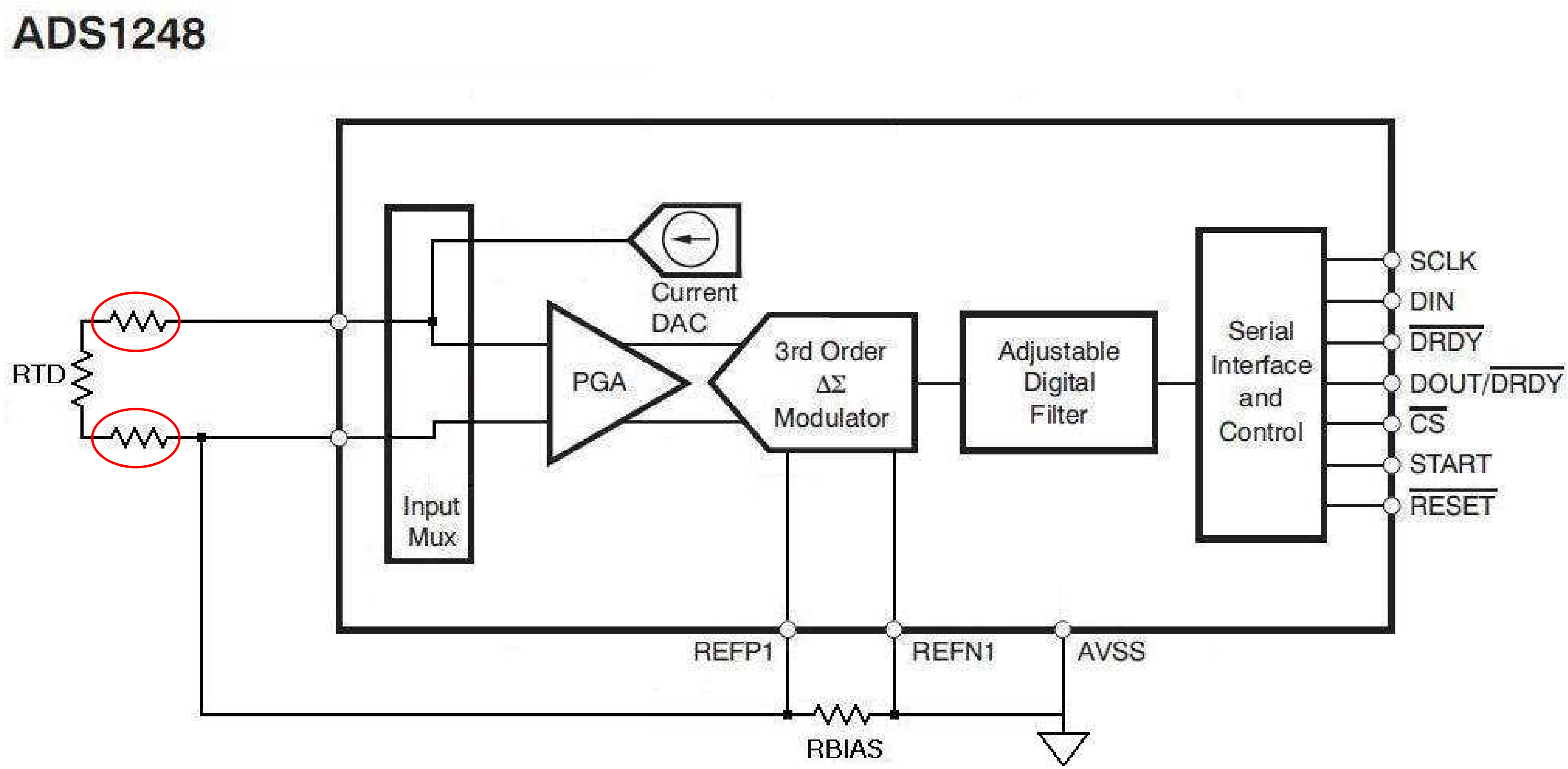
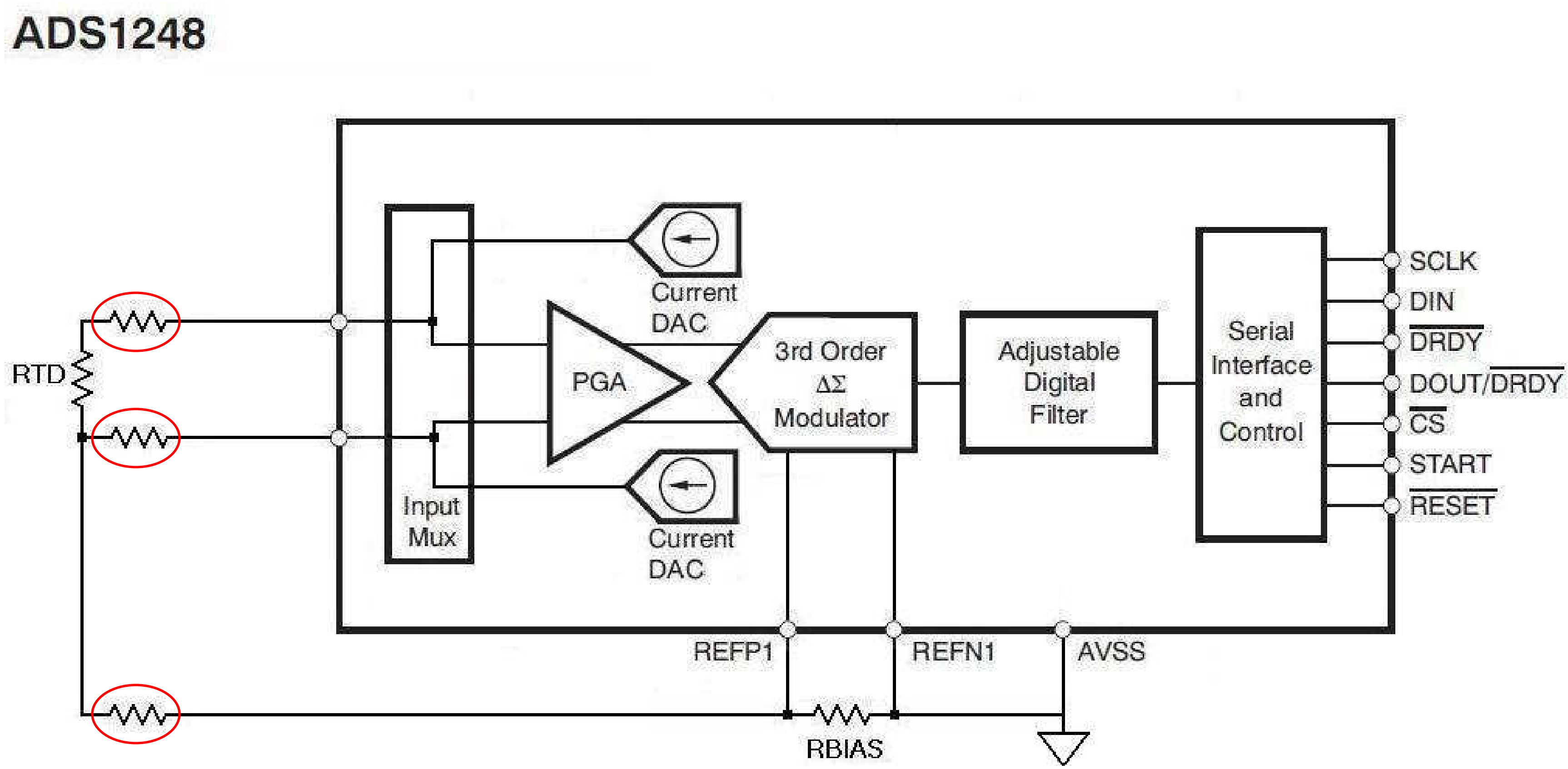
2-Wire RTD Measurement

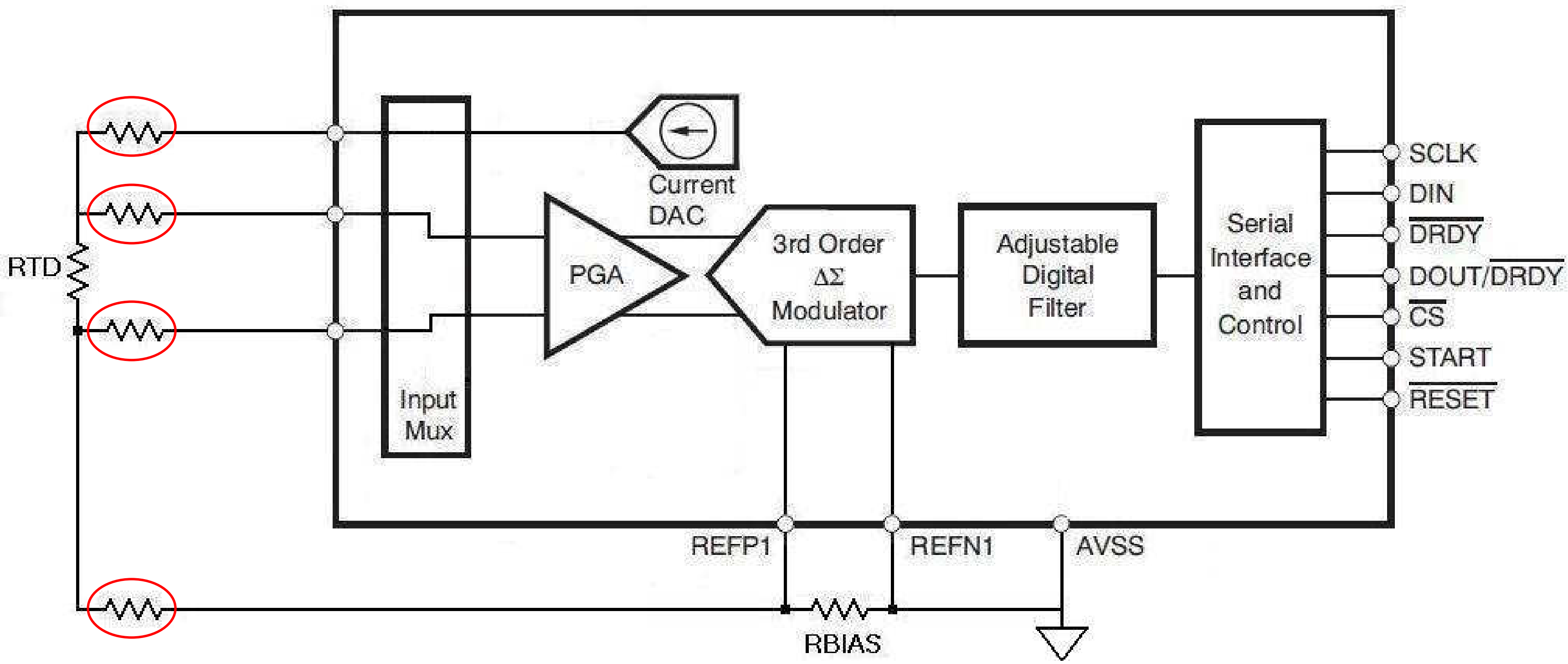


3-Wire RTD Measurement



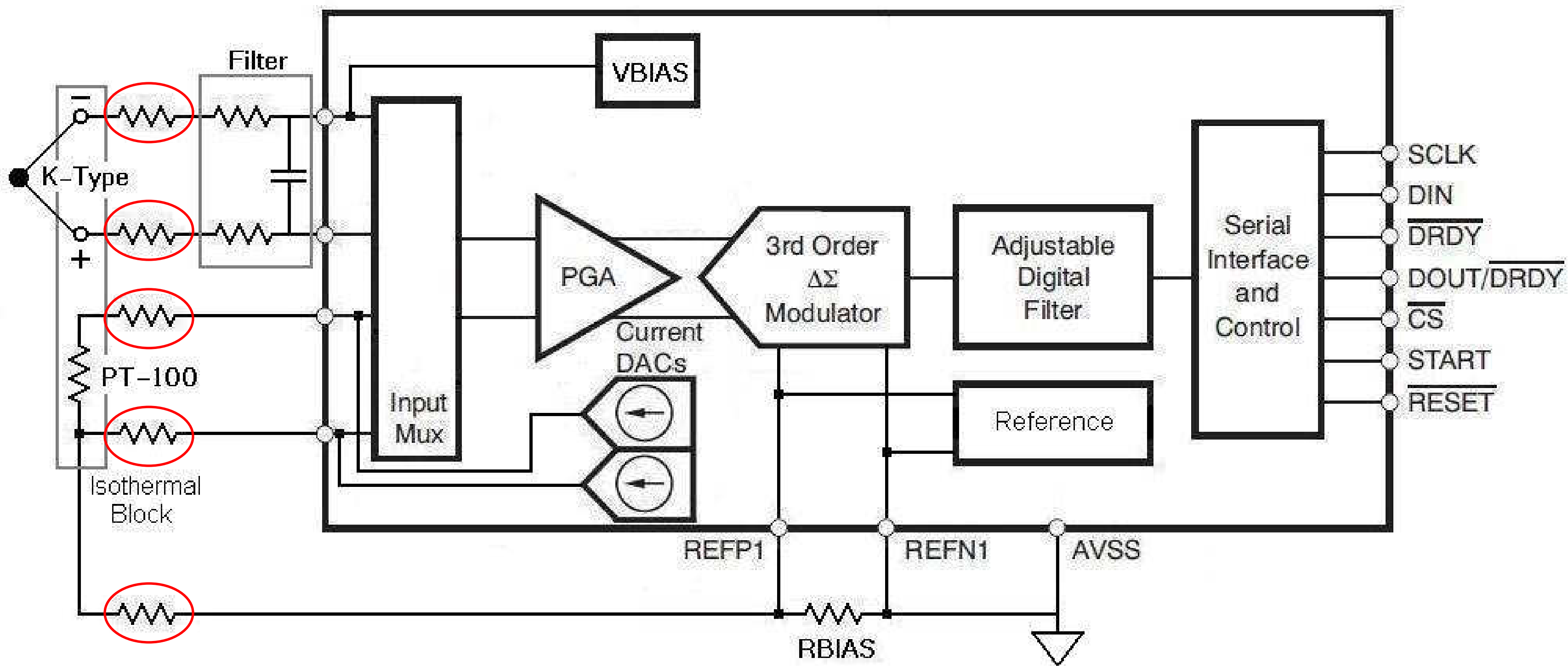
4-Wire RTD Measurement

ADS1248



Thermocouple Measurement with 3-Wire RTD as Cold Junction Compensation

ADS1248



1. 2-Wire RTD Measurement

The 2-wire RTD connection is the simplest method using an RTD for a remote temperature measurement. It is a two-wire measurement because there is a single drive and single return for the RTD connection. The resistors circled in red are the parasitic line resistances. It represents the potential error in the measurement. In many cases the line resistance can be a large contributor for the error, because the sensor is far away from the sensing electronics.

In many cases, the RTD is a low value resistor in the PT100, this is nominally 100ohms at 0C. If the sensor is far away from the ADC, the line resistance may be a significant error, especially because the sensitivity of the device is only 0.384ohms/C.

Shown above, a current from one of the IDACs is sent through the input pins directly into the RTD. The return current goes through RBIAS, which biases the RTD above ground so that the measurement in in the common-mode input range of the ADC. The voltage across RBIAS also acts as a reference voltage.

One of the ADS1247/8 current sources is connected to one of the terminals of the RTD lines by setting the appropriate bits in the IDAC0 register. The value of the current can be chosen by setting the ISELT bits in the IDAC0 register.

The internal band-gap reference MUST be turned on by setting VREFCON bits in the MUX2 register. The internal reference has to be turned on for the IDAC to function even though the reference to the device is supplied externally.

On the EVM we set can measure the RTD with AIN0 and AIN1. IDAC0 is used at AIN0, while IDAC1 is turned off. The reference resistor RBIAS can be read by REF0. A jumper from REFN0 to ground and a wire jumper from REFP0 to AIN1 will connect the reference.

The voltage developed across the RTD is measured by also connecting the RTD through the PGA to the ADC. The voltage measured across the RTD is proportional to temperature (determined by the RTD's characteristics). RBIAS value is selected according to IDAC current source setting. The reference to the device is also derived from the IDAC. The appropriate external reference has to be selected by setting the VREFSELT bits in the MUX2 register. RBIAS determines the reference voltage to the ADC as well as the input common mode of the PGA. The reference as well as the input to the device is a function of the IDAC current in this topology. This ratiometric approach guarantees more Effective Number Of Bits (ENOBs) as the noise in the IDAC reflects in the reference and as well as in the input and hence tends to cancel off. The effect of the IDAC current temperature drift also gets canceled off in this ratiometric topology.

The major limitation of the two wire method is the voltage drop across the line resistances add up to the voltage drop across the RTD and hence the sensor cannot be very far away from the measurement setup. For best performance with the ratio-metric approach no filtering capacitance should be added to either the signal path or the reference path. The IDAC current mismatch drift does not matter since there is only one current path.

2. 3-Wire RTD Measurement

A 3-wire RTD application is shown above. In this 3-wire example two selectable current sources are used to provide symmetry and compensate for the line resistances in the RTD wiring.

The ADS1247/8 current sources are connected to the two channels connecting to the two RTD terminals by setting the appropriate bits in the IDAC1 register. The value of the current can be chosen by setting the ISELT bits in the IDAC0 register. The internal band-gap reference has to be turned on by setting the VREFCON bits in the MUX2 register. The internal reference has to be turned on for the IDAC to function even though an external reference channel is used.

The voltage measured across the RTD is proportional to temperature (determined by the RTD's characteristics). RBIAS value is selected according to IDAC current source setting. RBIAS determines the reference voltage to the ADC as well as the input common mode of the PGA.

The reference as well as the input to the device is a function of the IDAC current in this topology. The noise in the IDAC reflects in the reference and as well as in the input and hence tends to cancel off. This ratio-metric approach guarantees more ENOBs. The effect of the IDAC current temperature drift also gets cancelled off in this approach. Only the IDAC current mismatch drift matters.

The limitation of the two wire method has been avoided in this topology and hence the sensor can be very far away from the measurement setup as long as noise coupling into the wire does not degrade the noise performance. This setup utilizes less than half of the dynamic range of the ADC as the input to the ADC is never negative.

3. 4-Wire RTD Measurement

The 4-wire RTD application provides the highest level of accuracy as it isolates the excitation path of the RTD from the sensing path.

The ADS1247/8 current sources are connected to one of the terminals of the RTD lines by setting the appropriate bits in the IDAC1 register.

Line4 of the RTD has been tied to the IOUT1 terminal of the device since line4 is not a sensing line, thus saving an input channel in the device for other sensors.

The value of the current can be chosen by setting the ISELT bits in the IDAC0 register. The internal band-gap reference has to be turned on by setting VREFCON bits in the MUX2 register. The internal reference has to be turned on for the IDAC to function even though the reference to the device is supplied externally.

The voltage developed across the RTD is measured by also connecting the RTD through the PGA to the ADC. The voltage measured across the RTD is proportional to temperature (determined by the RTD's characteristics). RBIAS value is selected according to IDAC current source setting. The reference to the device is also derived from the IDAC. The appropriate external reference has to be selected by setting the VREFSELT bits in the MUX2 register. RBIAS determines the reference voltage to the ADC as well as the input common mode of the PGA. The reference as well as the input to the device is a function of the IDAC current in this topology. The noise in the IDAC reflects in the reference and as well as in the input and hence tends to cancel off. The IDAC current drift does not matter as we follow the ratio-metric topology. The IDAC current mismatch drift does not matter since there is only one current path. For best performance with the ratio-metric approach no filtering capacitance should be added to either the signal path or the reference path.

This setup utilizes less than half of the dynamic range of the ADC as the input to the ADC is never negative.

4. Thermocouple Measurement with 3-Wire RTD as Cold Junction Compensation

The thermocouple unlike the RTD needs no excitation source and generates a potential difference, across its terminals, which is proportional to the temperature (TJ – TREF).

The thermocouple consists of a two metal junction which produces a voltage difference proportional to TJ, the junction temperature which has to be measured. Since these two metals have to be connected to the copper line two more junctions are created. These two metal junctions have to be placed at the same temperature TREF. Placing them at the same temperature TREF creates a voltage proportional to TREF and opposing that produced by the thermocouple junction.

If the temperature TREF is a known temperature then the temperature TJ can be calculated by adding TREF to it. But if TREF cannot be forced to a known temperature it can be measured with an RTD. A three wire RTD method for the junction temperature compensation is shown above.

When measuring the temperature using the thermocouple, the output of the thermocouple has to be biased. The ADS1247/48 provides a bias voltage generator for this purpose. The bias voltage is equal to the mid-supply voltage i.e. AVSS + (AVDD-AVSS)/2 and has to be tied to one of the terminals of the thermocouple as shown above.

The internal reference is used to measure the voltage from the thermocouple.

A filter may be used to suppress noise in the thermocouple voltage due to noise coupling to the lines. When measuring the temperature of the junction using the RTD, the external reference has to be selected to obtain the best noise performance using the ratio-metric approach.

The three wire RTD section explains this in detail. The three wire RTD measurement with hardware compensation may be used instead of the normal method.