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Devices Connected/Referenced

AD7124-4/ AD7124-8	4-Channel/8-Channel, Low Noise, Low Power, 24-Bit, Sigma-Delta ADCs with PGA and Reference
ADP1720	50 mA, High Voltage, Micropower Linear Regulator

Completely Integrated 4-Wire RTD Measurement System Using a Low Power, Precision, 24-Bit, Sigma-Delta ADC

EVALUATION AND DESIGN SUPPORT

Circuit Evaluation Boards

AD7124-4 Evaluation Board (EVAL-AD7124-4SDZ) or
AD7124-8 Evaluation Board (EVAL-AD7124-8SDZ)
System Demonstration Platform (EVAL-SDP-CB1Z)

Design and Integration Files

Schematics, Layout Files, Bill of Materials

CIRCUIT FUNCTION AND BENEFITS

The circuit shown in Figure 1 is an integrated 4-wire, resistance temperature detector (RTD) system based on the AD7124-4/ AD7124-8 low power, low noise, 24-bit Σ-Δ ADC optimized for high precision measurement applications. With a two-point calibration and linearization, the overall 4-wire system accuracy is better than ±1°C over a temperature range of −50°C to +200°C. Typical noise free code resolution of the system is 17.9 bits for full power mode, sinc^4 filter selected, at an output data rate of 50 SPS, and 17.3 bits for low power mode, post filter selected, and at an output data rate of 25 SPS.

The AD7124-4 can be configured for 4 differential or 7 pseudo differential input channels, while the AD7124-8 can be configured for 8 differential or 15 pseudo differential input channels. The on-chip programmable gain array (PGA) ensures that signals of small amplitude can be interfaced directly to the ADC.

The AD7124-4/AD7124-8 establishes the highest degree of signal chain integration, which include programmable low drift excitation current sources. Therefore, the design of an RTD system is greatly simplified because most of the required RTD measurement system building blocks are included on-chip.

The AD7124-4/AD7124-8 gives the user the flexibility to employ one of three integrated power modes, where the current consumption, range of output data rates, and rms noise are tailored with the power mode selected. The current consumed by the AD7124-4/AD7124-8 is only 255 µA in low power mode and 930 µA in full power mode. The power options make the device suitable for non-power critical applications, such as input/output modules, and also for low power applications such as loop powered smart transmitters where the complete transmitter must consume less than 4 mA.

The device also has a power-down option. In power-down mode, the complete ADC along with its auxiliary functions are powered down so that the device consumes 1 µA typical. The AD7124-4/AD7124-8 also has extensive diagnostic functionality integrated as part of its comprehensive feature set.

Rev. B

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Fax: 781.461.3113   ©2015–2019 Analog Devices, Inc. All rights reserved.
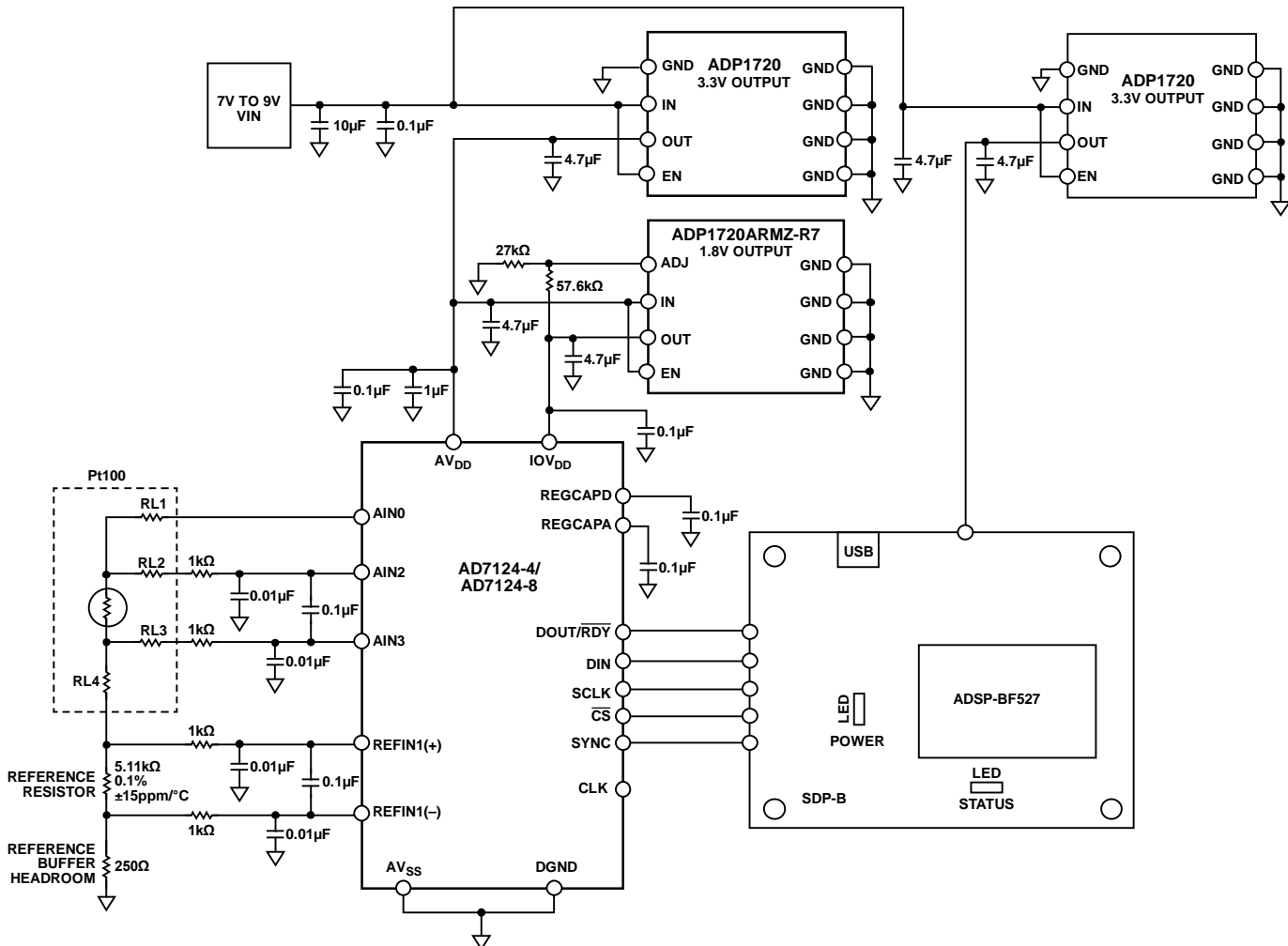www.analog.com

Figure 1. 4-Wire RTD Measurement Configuration

CIRCUIT DESCRIPTION

RTD Temperature Measurement Introduction

RTDs are frequently used sensors for temperature measurements in industrial applications. An RTD is made from a pure metal (examples include platinum, nickel, or copper), which has a predictable change in resistance as the temperature changes. The most widely used RTDs are platinum Pt100 and Pt1000. RTDs are capable of high accuracy and good stability when compared with other types of temperature sensors. The error due to the resistance of long wire lengths can be eliminated using the 4-wire connection.

To accurately measure the resistance, a voltage is generated across the RTD by a constant current source. The AD7124-4/AD7124-8 offers two such excitation current sources that are register programmable from 50 μA to 1 mA. Errors in the current source can be easily cancelled by referring the measurement to the voltage across a precision reference resistor that is driven with the same current source, resulting in a ratiometric measurement.

For the circuit in Figure 1, a Pt100 RTD Class B sensor was used. Pt100 RTDs measure temperature from −200°C to +600°C. The resistance of a Class B RTD is typically 100 Ω at 0°C and has a typical temperature coefficient of ~0.385 Ω/°C (see Figure 2). Using this information, the voltage generated across the Pt100 RTD can easily be calculated based on the current source selected.
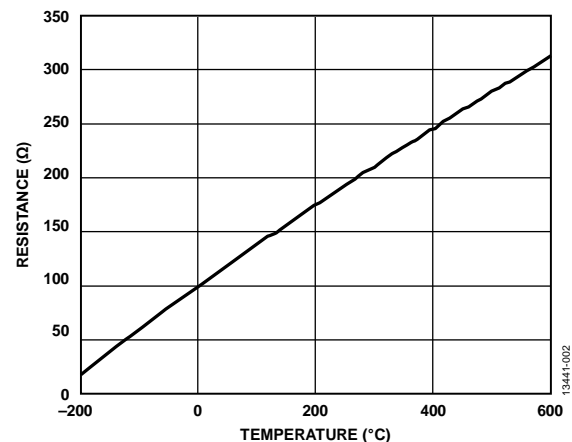

Figure 2. Pt100 RTD Resistance vs. Temperature

How the Circuit Works

The AD7124-4/AD7124-8 provides an integrated solution for RTD measurements; it can achieve high resolution, low non-linearity, and low noise performance as well as very high 50 Hz and 60 Hz rejection. The AD7124-4/AD7124-8 consists of an on-chip, low noise PGA that amplifies the small signal from the RTD with a gain programmable from 1 to 128, thus allowing direct interface with the sensor. The gain stage has high input impedance and limits the input leakage current to 3.3 nA typical for full power mode and 1 nA typical for low power mode. The following sections explain the different elements that make up the 4-wire RTD temperature measurement system.

Power Supplies

The AD7124-4/AD7124-8 has separate analog and digital power supplies. The digital power supply, IOV_{DD}, is independent of the analog power supply and can be 1.65 V to 3.6 V referenced to DGND. The analog power supply, AV_{DD}, is referred to AV_{SS} and has a range of 2.7 V to 3.6 V for low and mid-power modes, and 2.9 V to 3.6 V for full power mode. The circuit shown in Figure 1 operates on a single supply; therefore, AV_{SS} and DGND are connected together, and only one ground plane is used. The AV_{DD} and IOV_{DD} voltages are generated separately using ADP1720 low dropout voltage regulators. The AV_{DD} voltage is set to 3.3 V, and the IOV_{DD} voltage is set to 1.8 V, using the ADP1720 regulators. Using separate regulators ensures lowest noise.

Serial Peripheral Interface (SPI)

SPI communications to the AD7124-4/AD7124-8 are handled by the Blackfin® ADSP-BF527 on the EVAL-SDP-CB1Z board, as shown in Figure 1. To access the registers of the AD7124-4/AD7124-8, use the AD7124_Eval+ Software. Figure 3 shows the main window of this software. Clicking the **4-WIRE RTD** button configures the software for the 4-wire RTD measurement.
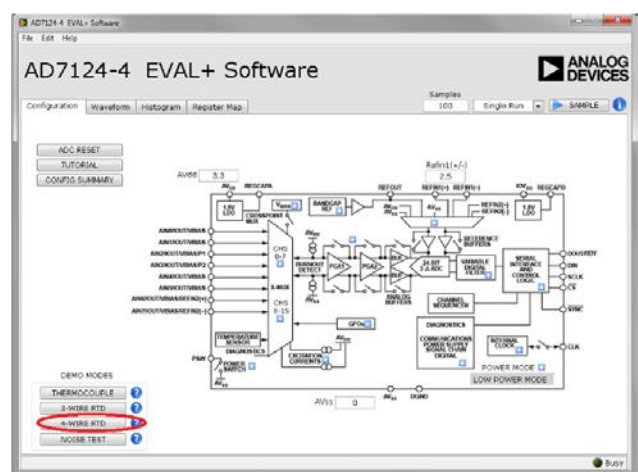
Figure 3. AD7124_Eval+ Software Configuration Window

The AD7124-4/AD7124-8 has diagnostic functions on-chip that can be used to detect faults in the SPI communication. These diagnostics include checks on the SPI read and write operations, ensuring that only valid registers are accessed. An SCLK counter ensures that the correct number of SCLK pulses is used, while the CRC functionality checks for changes in bit values during transmission. When any of these SPI communication diagnostic functions are enabled and an associated error occurs, the corresponding flag is set in the error register. All enabled flags are OR'ed together and control the ERR flag in the status register. This functionality is particularly useful if the status bits are appended to the ADC conversions.

Analog Inputs and Reference

The AD7124-4 can be configured for 4 differential or 7 pseudo differential input channels, while the AD7124-8 can be configured for 8 differential or 15 pseudo differential input channels.

The AD7124-4/AD7124-8 has on-chip diagnostics that can be used to check that the voltage level on the analog pins are within the specified operating range. The positive (AINP) and negative (AINM) analog inputs can be separately checked for overvoltages and undervoltages, as well as ADC saturation. An overvoltage is flagged when the voltage on the analog input exceeds AV_{DD}, while an undervoltage is flagged when the voltage on the analog input goes below AV_{SS}.

For the circuit in Figure 1, three analog pins of the AD7124-4/AD7124-8 are used to implement the 4-wire measurement: AIN0, AIN2, and AIN3. AIN2 and AIN3 are configured as a fully differential input channel and are used for sensing the voltage across the RTD. The excitation current source used to excite the RTD is generated from AV_{DD} and is directed to AIN0. The analog pins and their configuration are shown in greater detail in Figure 4.
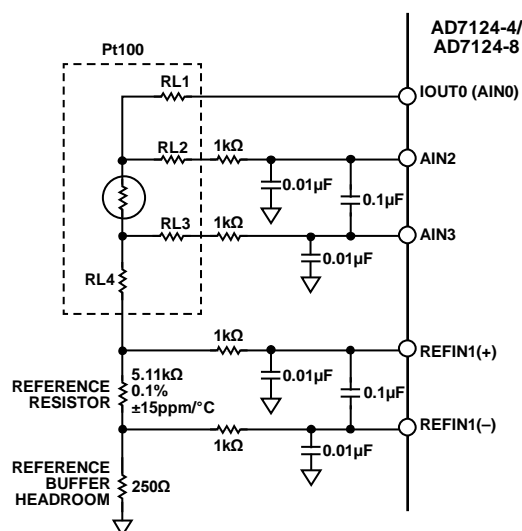
Figure 4. Analog Input Configuration for 4-Wire RTD Measurement

For the circuit in Figure 1, the reference input used is REFIN1(±). The current through the RTD also flows through the precision reference resistor that generates the reference voltage. The voltage generated across this precision reference resistor is ratiometric to the voltage across the RTD; therefore, any variations seen in the excitation current are removed. Because the reference buffers are enabled, it is necessary to ensure that the headroom required for correct operation is met ($AV_{DD} - 0.1$ V and $AV_{SS} + 0.1$ V). The headroom of 0.125 V (500 µA × 250 Ω) is provided by the 250 Ω resistor to ground, as shown in Figure 4.

Digital and Analog Filtering

Differential (~800 Hz cutoff) and common-mode (~16 kHz cutoff) filters are implemented at the analog inputs, as well as at the reference inputs. This filtering is required to reject any interference at the modulator frequency and also any multiples of this frequency.

The AD7124-4/AD7124-8 offers a great deal of on-chip digital filtering flexibility. Several filter options are available; the filter option selected has an effect on the output data rate, settling time, as well as 50 Hz and 60 Hz rejection. For this circuit note, the sinc^4 filter and the post filter are implemented. The sinc^4 filter is used because it has excellent noise performance across the range of output data rates, as well as having excellent 50 Hz and 60 Hz rejection. The post filter provide simultaneous 50 Hz and 60 Hz rejection, with a 40 ms settling time.

Calibration

The AD7124-4/AD7124-8 provides different calibration modes that can be used to eliminate offset and gain errors. For this circuit note, internal zero-scale calibration as well as internal full-scale calibrations were used.

4-Wire RTD Configuration

The circuit shown in Figure 1 is designed for precision 4-wire RTD measurements using the AD7124-4/AD7124-8. For the 4-wire RTD measurement, one excitation current source is required. The AD7124-4/AD7124-8 provides two matched current sources; therefore, either one of these current sources can be used to excite the RTD. The RTD produces a low-level voltage signal, which can then be amplified by the on-board PGA of the AD7124-4/AD7124-8. The amplified voltage is then converted to a precision digital representation using the 24-bit Σ-Δ ADC.

For this 4-wire RTD circuit, a Class B RTD is used. If the on-chip excitation current is programmed to 500 µA, at a maximum temperature of 600°C, the voltage generated across the RTD is approximately 156.85 mV. To ensure that the maximum range of the AD7124-4/AD7124-8 is used, the PGA gain is programmed to a gain of 16. The PGA amplifies the maximum RTD sensor output voltage to 2.5096 V.

The value of the external precision resistor is chosen so that the maximum voltage generated across the RTD equals the reference voltage divided by the PGA gain.

$$R_{REF} = V_{RTD\,MAX}/I_{EXC} = 2.5096 \text{ V}/500 \text{ µA} = 5020 \text{ Ω}$$

Therefore, a 5.11 kΩ resistor is used, which gives a reference voltage of

$$5.11 \text{ kΩ} \times Excitation\ Current = 5.11 \text{ kΩ} \times 500 \text{ µA} = 2.555 \text{ V}$$

The output compliance of the excitation current source must also be considered when making 4-wire RTD measurements using the AD7124-4/AD7124-8. The output compliance is dependent on the excitation current selected. For this circuit, 500 µA is selected, which has an output compliance voltage of $AV_{DD} - 0.37$ V. The AV_{DD} supply voltage for this circuit is 3.3 V; therefore, the output compliance level for the excitation current source must be less than 2.93 V. From the previous calculations, this specification is met, because the maximum voltage on the AIN0 pin is the voltage across the precision reference resistor plus the voltage across the RTD plus the voltage across the headroom resistor.

$$V_{REF} + V_{RTD} + V_{HEADROOM} = 2.555 \text{ V} + 156.8\ 5 \text{ mV} + 125 \text{ mV}$$
$$= 2.83685 \text{ V}$$

The AD7124-4/AD7124-8 configuration for 4-wire RTD measurements is as follows:

- Differential input: AINP = AIN2, AINM = AIN3
- Excitation current: IOUT0 = AIN0 = 500 µA
- Gain = 16
- Precision reference resistor: 5.11 kΩ
- Digital filtering:
    o Sinc^4 filter (full power mode)
    o Post filter (low power mode)

The general expression to calculate the RTD resistance, R_{RTD}, when the ADC is operating in bipolar differential mode is given by

$$R_{RTD} = \frac{(CODE - 2^{N-1}) \times R_{REF}}{G \times 2^{N-1}} \qquad (1)$$

where:
CODE is the ADC code output.
N is the resolution of the ADC (24, in this case).
R_{REF} is the reference resistor.
G is the selected gain.

From the specification of the Class B RTD, the resistance changes by approximately 0.385 Ω/°C. This relationship can be used as a quick method to obtain an approximate temperature of the RTD. This method has inaccuracies due to the temperature coefficient of the RTD changing slightly over the temperature range; however, it can be a useful method to check the temperature quickly.

To calculate the approximate temperature, use Equation 2.

$$Temperature\ (°C) = \frac{R_{RTD} - 100}{0.385} \qquad (2)$$

The RTD transfer function known as the Callender-Van Dusen equation is made up of two distinct polynomial equations to provide a more accurate result. Equation 3 is used for temperatures less than 0°C, and Equation 4 is for temperatures greater than 0°C.

The equation for temperature $t \leq 0°C$ is

$$R_{RTD}(t) = R_0[1 + At + Bt^2 + C(t - 100°C)t^3] \quad (3)$$

The equation for temperature $t \geq 0°C$ is

$$R_{RTD}(t) = R_0(1 + At + Bt^2) \quad (4)$$

where:
t is the RTD temperature (°C).
$R_{RTD}(t)$ is the RTD resistance (Ω).
R_0 is the RTD resistance at 0°C (in this case, $R_0 = 100$ Ω).
$A = 3.9083 \times 10^{-3}$.
$B = -5.775 \times 10^{-7}$.
$C = -4.183 \times 10^{-12}$.

There are many different ways to determine the temperature as a function of the RTD resistance given the transfer function in Equation 3 and Equation 4. The direct mathematical method is chosen, due to its accuracy. Taking Equation 3, the temperature can be calculated as

$$T_{RTD} \ (°C) = \frac{-A + \sqrt{A^2 - 4B\left(1 - \dfrac{r}{R_0}\right)}}{2B} \quad (5)$$

where r is the RTD resistance, and the other variables are as defined previously.

This method works well for temperatures greater than or equal to 0°C. To calculate the RTD temperature for temperatures below 0°C, a best fit polynomial expression is required, and the polynomial used in this circuit note is a fifth-order polynomial shown in Equation 6.

$$T_{RTD} \ (°C) = -242.02 + 2.2228 \times r + (2.5859 \times 10^{-3})r^2 - \\ (-4.8260 \times 10^{-6})r^3 - (2.8183 \times 10^{-3})r^4 + \\ (1.5243 \times 10^{-10})r^5 \quad (6)$$

As an example, if the code read back from the AD7124-4/ AD7124-8 with the temperature set to 25°C is 11270065, converting this code to a resistance using Equation 1 gives

$$R_{RTD} = \frac{(11270065 - 2^{23}) \times R_{REF}}{G \times 2^{23}} = 109.704 \ \Omega$$

Linearization using Equation 5 gives a temperature of 24.921°C.

As a second example, if the code read back from the AD7124-4/ AD7124-8 with the temperature set to −25°C is 10757779, converting this code to a resistance gives

$$R_{RTD} = \frac{(10757779 - 2^{23}) \times R_{REF}}{G \times 2^{23}} = 90.200 \ \Omega$$

Linearization using Equation 6 gives a temperature of −24.982°C.

4-Wire RTD Measurements and Results

For the circuit shown in Figure 1, data was gathered for different digital filter and power mode configurations of the AD7124-4/AD7124-8, with the sinc⁴ filter operating in full power mode, and the post filter operating in low power mode.

Choosing the configuration for sinc⁴ filter, full power mode, and 50 SPS allows the user to operate the AD7124-4/AD7124-8 for best performance relative to speed and noise. Figure 5 shows the noise distribution when a 4-wire RTD is connected as shown in Figure 1 at ambient temperature. The corresponding rms noise is typically 199.37 nV, which is approximately 17.9 noise free bits. The noise performance of the AD7124-4/AD7124-8 for inputs shorted using the same filter, gain, power mode, and output data rate was 100 nV rms or 18.7 noise free bits. The increase in the noise comes directly from the RTD connection across the input channel (AIN2, AIN3).
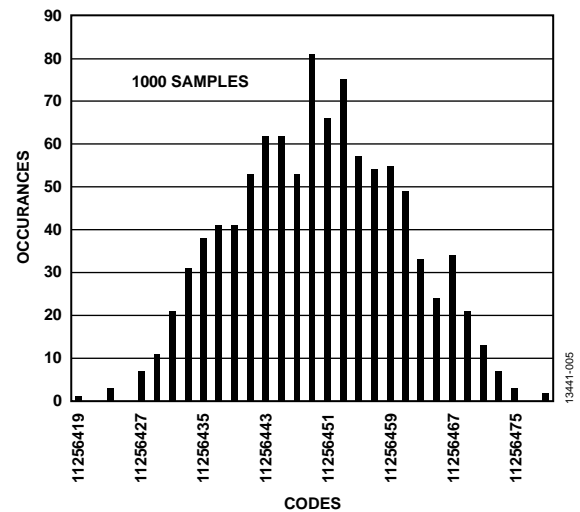

Figure 5. Histogram of Codes for RTD at Ambient Temperature, Sinc⁴ Filter, Full Power Mode, 50 SPS

For the 4-wire RTD configuration where the sinc⁴ filter and full power mode were selected, the temperature of the RTD was swept from −50°C to +200°C. For each temperature, the corresponding voltage across the RTD was measured using the AD7124-4/ AD7124-8 as described previously. This voltage was then converted to a resistance, which was then linearized, and converted to a temperature as described in the 4-Wire RTD Configuration section. Figure 6 shows the resulting error between the set temperature and the measured temperatures of the RTD after linearization. For each RTD temperature setting, the AD7124-4/ AD7124-8 is kept at 25°C. As shown in Figure 6, the error of the RTD temperature measured is well within the error window of the Pt100 Class B RTD after linearization. Figure 6 also shows the deviation of the RTD error across different AD7124-4/AD7124-8 temperature settings. For each AD7124-4/AD7124-8 temperature setting, an internal zero-scale and full-scale calibration is carried out. As shown in Figure 6, the error of the RTD is well within the expected error of the Class B RTD for all temperature settings of the AD7124-4/AD7124-8.
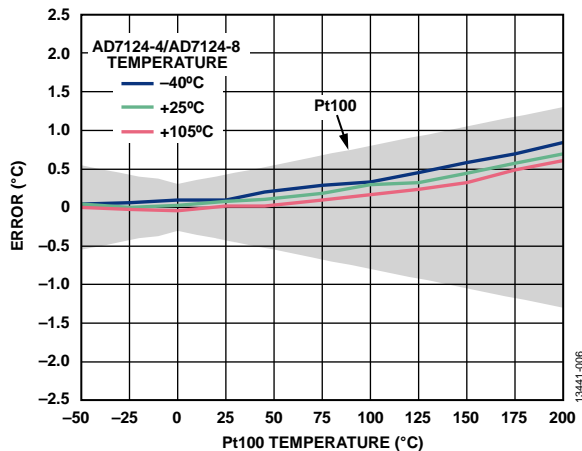
Figure 6. Temperature Accuracy Measurement, Sinc⁴ Filter, Full Power Mode, 50 SPS

Figure 7 shows the error in measured RTD temperature for a one time, internal zero-scale and full-scale calibration carried out at 25°C. From the plot, it can be seen that carrying out a one time calibration at 25°C or calibrating at each individual temperature of the AD7124-4/AD7124-8 gives the same performance.
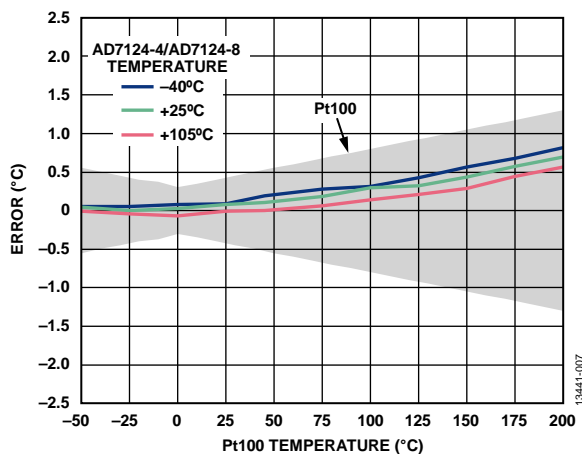

Figure 7. Temperature Accuracy Measurement, Sinc⁴ Filter, Full Power Mode, 50 SPS, One Time 25°C Calibration Only

The second AD7124-4/AD7124-8 configuration tested was the low power mode, where the post filter and 25 SPS output data rate were selected. The 25 SPS filter provides simultaneous 50 Hz and 60 Hz rejection and allows the user to trade off settling time with power supply rejection. Figure 8 shows the resulting noise distribution when a 4-wire RTD is connected as shown in Figure 1 at ambient temperature. The corresponding rms noise is typically 774 nV, equating to approximately 16.8 noise free bits. The noise performance of the AD7124-4/AD7124-8 for inputs shorted with the same filter, gain, power mode, and output data rate is typically 360 nV rms or 17.3 noise free bits. The increase in the noise between the two measurements comes directly from the RTD connection across the input channel (AIN2, AIN3).
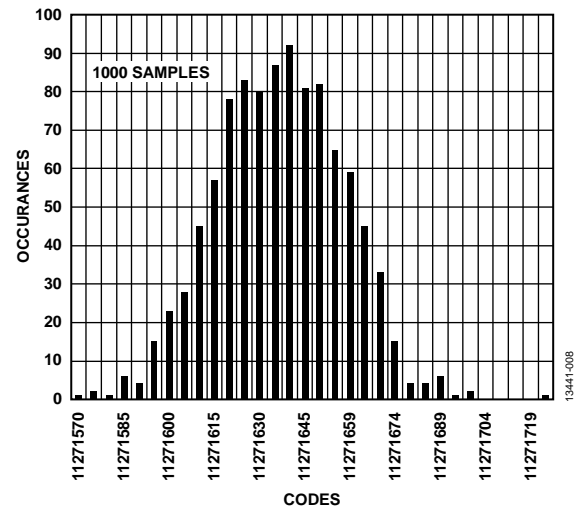

Figure 8. Histogram of Codes for RTD at Ambient Temperature, Post Filter, Low Power Mode, 25 SPS

The temperature of the RTD was swept from −50°C to +200°C. For each of the set RTD temperatures, the corresponding voltage across the RTD was measured using the AD7124-4/AD7124-8 as described previously. The voltage was then converted to a resistance, which was then linearized and converted to a temperature as described in the 4-Wire RTD Configuration section. Figure 9 shows the resulting error between the set and measured temperatures of the RTD after linearization. For each RTD temperature setting, the AD7124-4/AD7124-8 is kept at 25°C. As shown in Figure 9, the error of the RTD temperature measured is well within the error window of the Pt100 Class B RTD. Figure 9 also shows the deviation of the RTD error across different AD7124-4/AD7124-8 temperature settings. For each AD7124-4/AD7124-8 temperature setting, an internal zero-scale and full-scale calibration was carried out. As shown in Figure 9, the error of the RTD is well within the expected error of the Class B RTD for all temperature settings of the AD7124-4/AD7124-8.
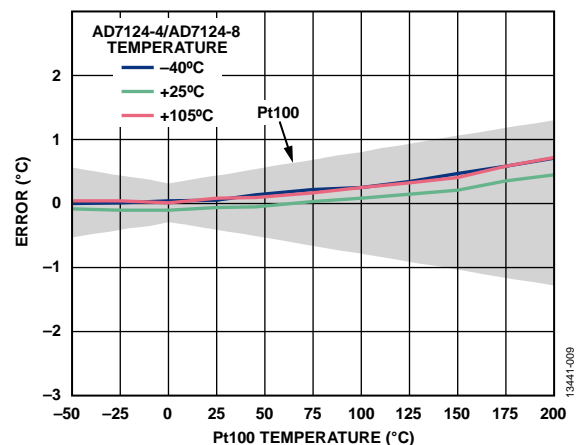

Figure 9. Temperature Accuracy Measurement, Post Filter, Low Power Mode, 25 SPS

Figure 10 shows the error in measured RTD temperature for a one time, internal zero-scale and full-scale calibration carried out at 25°C. From the plot, it can be seen that carrying out a one time calibration at 25°C or calibrating at each individual temperature of the AD7124-4/AD7124-8 gives similar performance.
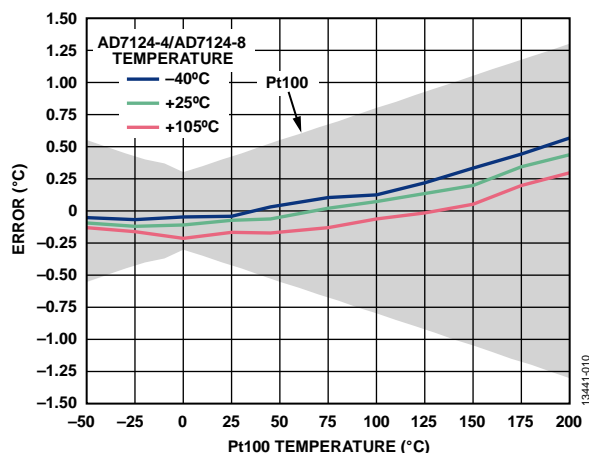

Figure 10. Temperature Accuracy Measurement, Post Filter, Low Power Mode, 25 SPS, 25°C One Time Calibration Only

COMMON VARIATIONS

Multiple 4-Wire RTDs

The AD7124-4/AD7124-8 can be used as a measurement system for multiple 4-wire RTDs. The AD7124-4 can be used to connect two 4-wire RTDs, while the AD7124-8 can be used to connect up to five 4-wire RTDs. The same reference input can be used for all the RTDs, and one current source can be used to excite all the RTDs. The current is directed to the top side of each of the RTDs in turn when the RTD temperature measurement is required. The cross multiplexer on the AD7124-4/AD7124-8 allows multiple channels to be configured separately, where each channel can be configured for different setups.

The steps needed to measure an RTD voltage are

1. Set the external reference to REFIN1±.
2. Enable the IOUT0 current to the RTD to be measured.
3. Enable the analog input channel that has the RTD connected across its input.

As an example, two 4-wire RTDs were connected to the AD7124-4 as shown in Figure 11. One 4-wire RTD is connected across the AIN2 and AIN3 analog input pins (Channel 0 configuration), where the excitation current comes from AIN0, and a second 4-wire RTD is also shown connected across the AIN6 and AIN7 analog input pins (Channel 1 configuration), where AIN1 is used for the excitation current. Temperature measurements were then carried out on each RTD in turn using the following steps:

1. IOUT0 is directed to AIN0. The voltage is measured on Channel 0 (AIN2, AIN3); therefore, Channel 0 must be enabled. All other channels are disabled for this measurement.
2. Disable Channel 0, enable Channel 1, and direct the IOUT0 current to AIN1. The voltage is then measured on Channel 1 (AIN6, AIN7).
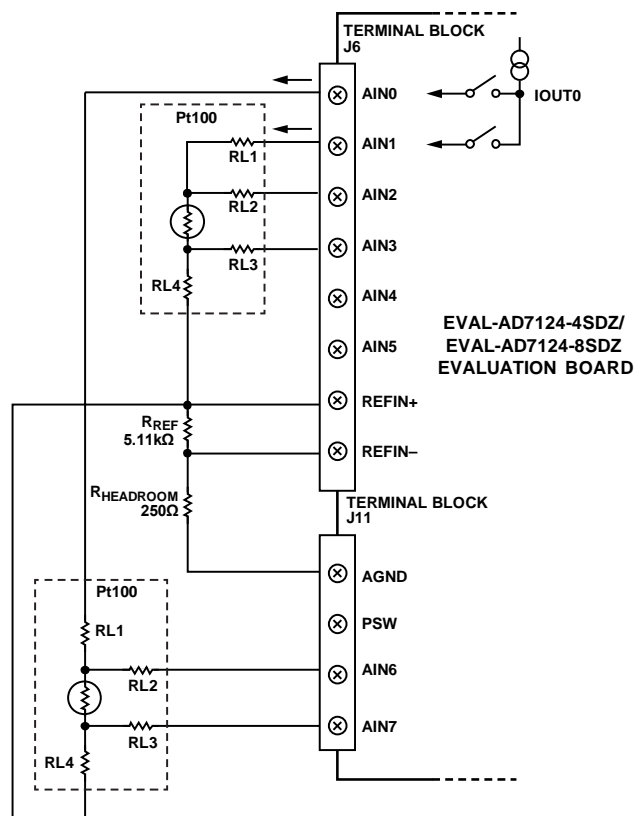

Figure 11. AD7124-4 4-Wire RTD Configuration Using Two 4-Wire RTDs

The performance of the 4-wire RTD configuration shown in Figure 11 was evaluated to ensure that the expected performance was achieved when more than one RTD was connected. For this measurement, the temperature of both 4-wire RTDs were swept from −50°C to +200°C. For each temperature setting, the voltage across each RTD was recorded. Figure 12 shows the error in each. As shown in the results, switching the same current from Channel 0 to Channel 1 has no effect on settling; both RTDs are well within the expected error window for the Class B RTD.
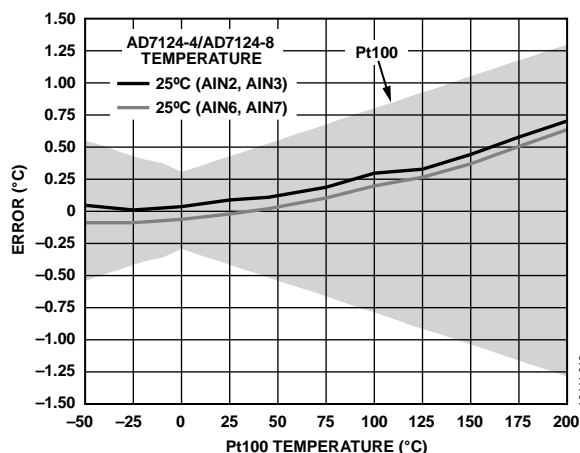

Figure 12. RTD Temperature Error Recorded for Two Different RTD Measurement Configurations

CIRCUIT EVALUATION AND TEST

Equipment Needed

The following equipment is needed for the 4-wire RTD measurement system:

- EVAL–AD7124-4SDZ or EVAL-AD7124-8SDZ evaluation board
- EVAL-SDP-CB1Z System Demonstration Platform (SDP)
- AD7124_Eval+ Software
- Power supply: 7 V or 9 V wall wart
- Class B Pt100 4-wire RTD
- A PC running Windows® XP (SP2), Windows Vista, or Windows 7 (32-bit or 64-bit)

Software Installation

A complete software user guide for the AD7124-4/AD7124-8 and the SDP board can be found in the EVAL–AD7124-4SDZ/EVAL-AD7124-8SDZ user guide and the SDP User Guide.

Software is required to interface with the hardware. This software can be downloaded from ftp://ftp.analog.com/pub/evalcd/AD7124. If the setup file does not automatically run, double click **setup.exe** from the file. Install the evaluation software before connecting the evaluation board and SDP board to the USB port of the PC to ensure that the evaluation system is correctly recognized when connected to the PC.

After the evaluation software installation is complete, connect the EVAL-SDP-CB1Z (via Connector B) to the EVAL-AD7124-4SDZ/EVAL-AD7124-8SDZ and then connect the EVAL-SDP-CB1Z to the USB port of the PC using the supplied cable. When the evaluation system is detected, proceed through any dialog boxes that appear to complete the installation.

Setup and Test

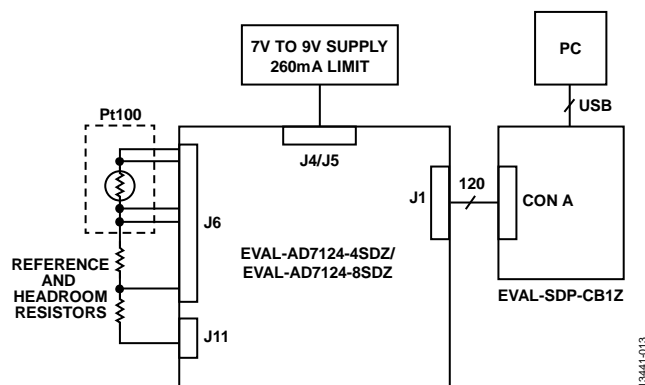Figure 13 shows a functional block diagram of the test setup.

Figure 13. Test Setup Functional Diagram

The EVAL-AD7124-4SDZ/EVAL-AD7124-8SDZ evaluation board is required to test the circuit. In addition, the following sensor and resistors are required to ensure proper operation:

- 4-wire Pt100 RTD, Class B
- 5.11 kΩ precision resistor
- 250 Ω resistor needed for buffer headroom

Configuring the Hardware

To configure the hardware, take the following steps:

1. Set all links on the EVAL-AD7124-4SDZ/EVAL-AD7124-8SDZ evaluation board to the default positions, as described in the EVAL-AD7124-4SDZ/EVAL-AD7124-8SDZ user guide.
2. Power the board with a 7 V or 9 V power source connected to J5.
3. Connect the RTD, the precision reference resistor, and the resistor for headroom, as shown in Figure 14.
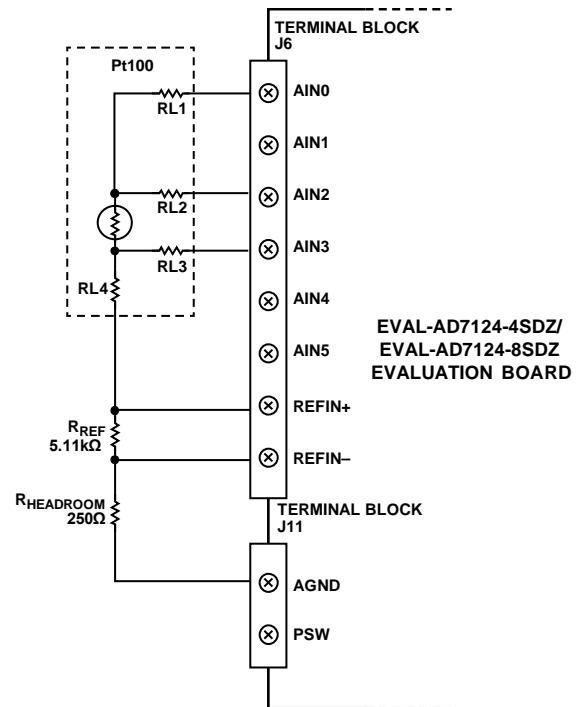

Figure 14. EVAL–AD7124-4SDZ/EVAL-AD7124-8SDZ Evaluation Board Connector for 4-Wire RTD Measurement

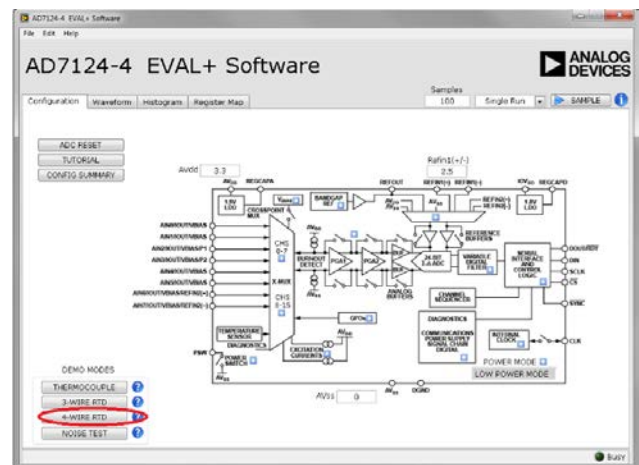Run the AD7124_Eval+ Software, and the window shown in Figure 15 appears.

Figure 15. AD7124_Eval+ Software Window

To configure the AD7124-4/AD7124-8 for 4-wire RTD measurements, click the **4-WIRE RTD** demo mode button (see Figure 15). Clicking the **4-WIRE RTD** button configures the ADC software as follows:

- Channel_0
  - AINP_0 = AIN2
  - AINM_0 = AIN3
  - Setup0
  - Enabled = TRUE
- Setup_0
  - PGA_0 = 16
  - AIN_BUFP, AIN_BUFM both = ENABLED
  - BIPOLAR = ENABLED
  - FS_0 = 384
  - FILTER_MODE_0 = SINC4
- ADC_Control
  - MODE = Continuous Conversion
  - POWER_MODE = FULL
- IO_CONTROL_1
  - IOUT0 Channel Enable = AIN1
  - IOUT0 Select = 500 µA

One additional step is required before the AD7124-4/AD7124-8 is configured for 4-wire RTD measurements: an internal full-scale and zero-scale calibration of the AD7124-4/AD7124-8. This calibration can be performed via the **Register Map** tab, as shown in Figure 16.

1. Click the **ADC_Control** register.
2. Select **Low Power** mode.
3. Perform an internal full-scale calibration.
   a. Click the **Mode** bitfield of the ADC control register
   b. In the **Mode** bitfield, select the internal full scale calibration option.
   c. Check the calibration performed by clicking the **Gain0** register from the register tree, and check that the coefficients have changed.
4. Perform an internal zero-scale calibration.
   a. Click the **Mode** bitfield of the ADC control register.
   b. In the **Mode** bitfield, select the internal zero-scale calibration option.
   c. Check the calibrations performed by clicking the **Offset0** register in the register tree, and check that the coefficients have changed.
5. When calibrations are complete, change the power mode to the required mode of operation, and ensure that the ADC is set to continuous conversion mode by selecting **Continuous** from the drop-down box in the **Mode** bit field of the **ADC_Control** register.
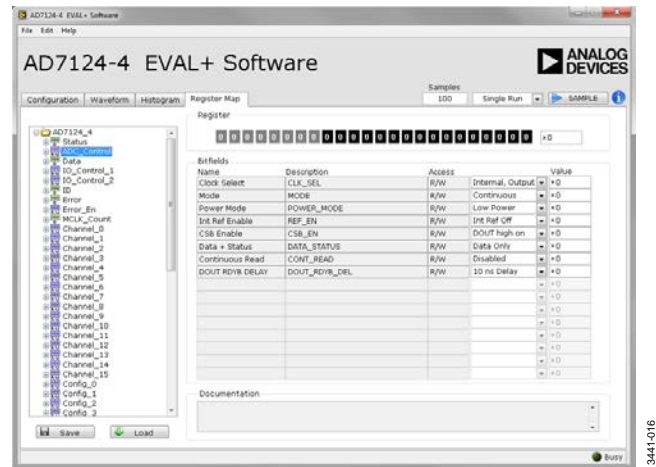

Figure 16. Register Map Internal Full-Scale and Zero-Scale Calibration

The board and device are now configured for 4-wire RTD measurements. Click **SAMPLE** to start gathering samples from the AD7124-4/AD7124-8. The **Waveform** tab and the **Histogram** tab show the data gathered from the AD7124-4/AD7124-8.

LEARN MORE

CN-0381 Design Support Package:
www.analog.com/CN0381-DesignSupport

EVAL-AD7124-4 User Guide (UG-855)

EVAL-AD7124-8 User Guide (UG-856)

SDP User Guide

Kester, Walt. "Temperature Sensors," Chapter 7 in *Sensor Signal Conditioning*. Analog Devices, 1999.

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MT-031 Tutorial. *Grounding Data Converters and Solving the Mystery of "AGND" and "DGND"*. Analog Devices.

MT-101 Tutorial. *Decoupling Techniques*. Analog Devices.

Circuit Note CN-0376. *Channel-to-Channel Isolated Temperature Input (Thermocouple/RTD) for PLC/DCS Applications*. Analog Devices.

Circuit Note CN-0382. *Ultralow Power Industrial Temperature and Pressure, 4 mA to 20 mA/HART Transmitter*. Analog Devices.

Circuit Note CN-0383. *Completely Integrated 3-Wire RTD Measurement System Using a Low Power, Precision, 24-Bit, Sigma-Delta ADC*. Analog Devices.

Circuit Note CN-0384. *Completely Integrated Thermocouple Measurement System Using a Low Power, Precision, 24-Bit, Sigma-Delta ADC*. Analog Devices.

Data Sheets and Evaluation Boards

EVAL-AD7124-4SDZ

EVAL-AD7124-8SDZ

System Demonstration Platform (EVAL-SDP-CB1Z)

AD7124-4 Data Sheet

AD7124-8 Data Sheet

ADP1720 Data Sheet

REVISION HISTORY

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