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PLC Demo System, Industrial Process Control Demo System

FEATURES

EMC performance tested
Inputs selectable: 0 mA to 20 mA, 4 mA to 20 mA, 0 V to 5 V, 0 V to 10 V, ±5 V, ±10 V, RTD, TC
Outputs programmable: 0 mA to 20 mA, 0 mA to 24 mA, 4 mA to 20 mA, 0 V to 5 V, 0 V to 10 V, ±5 V, ±10 V
Four isolated 24-bit analog input channels
- **AD7793 24-bit sigma-delta (Σ-Δ) ADC, 40 nV noise**
- **AD8220 instrumentation amplifier, >80 dB CMRR**
- **ADuM5401 *iso*Power® integrated, isolated dc-to-dc converter, 500 mW output power**
- **ADR441 precision 2.5 V reference**

4 isolated 16-bit analog output channels
- **AD5422 single-channel, 16-bit, serial input, current source and voltage output DAC**
- **0.01% typical total unadjusted error (TUE)**
- **Single chip solution**
- **Output fault detection and protection**

Power/interface/control
- **Analog Devices, Inc., ARM7 ADuC7027**
- **ADP1715 500 mA low-dropout CMOS linear regulator**
- **ADM3251E isolated single-channel RS-232 line driver/receiver**

APPLICATIONS

Process control
Transmitters
Actuator control
PLC/DCS systems

GENERAL DESCRIPTION

The PLC demonstration system is aimed at demonstrating the value Analog Devices devices can add to a PLC system. The demo board contains four fully isolated ADC channels, a microprocessor with RS-232 interface and four fully isolated DAC output channels.

Input ranges are hardware programmable and include 0 V to 5 V, 0 V to 10 V, ±5 V, ±10 V, 4 mA to 20 mA, 0 mA to 20 mA, ±20 mA, thermocouple and RTD. Output ranges are software programmable and include 0 V to 5 V, 0 V to 10 V, ±5 V, ±10 V, 4 mA to 20 mA, 0 mA to 20 mA, and 0 mA to 24 mA.

The PLC demo system features the AD5422 (a single-chip 16 bit DAC solution with ±0.05% TUE) and AD7793 (low noise, low power, 24-bit Σ-Δ ADC). Isolation is achieved using the ADuM5401 (quad-channel isolator with integrated dc-to-dc converter), ADuM1401 (quad-channel isolator), or ADM3251E (fully isolated RS-232 transceiver).

Input signal conditioning is performed by the AD8220 (>80 dB CMRR, JFET in-amp). Voltage references include the ADR441, ADR445 (ultralow noise, XFET® voltage reference), and ADP1720 (50 mA, high voltage, micropower linear regulator).

Communications with the ADC and DAC channels take place using the ADuC7027 microcontroller, which can be connected to a PC via an isolated RS-232 interface.

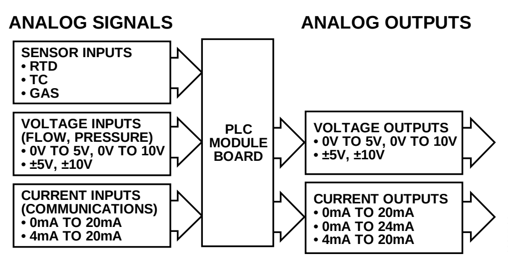

Figure 1. PLC System Level Diagram

Figure 2. PLC Demo Board

TABLE OF CONTENTS

Features 1
Applications 1
General Description 1
Revision History 2
PLC Total Solution Diagram 3
Demo Systems Hardware 4
Inputs 4
Outputs 5
Power Supplies 6
RS-232 Communications 6
Demo System Software 7
Software Installation 7
Software Operation 7
Firmware 9
EMC Test Results 10
Simplified Input/Output circuit Diagrams 11

REVISION HISTORY

8/2016—Rev. 0 to Rev. A

Changes to Figure 21 11

8/2010—Revision 0: Initial Version

PLC TOTAL SOLUTION DIAGRAM

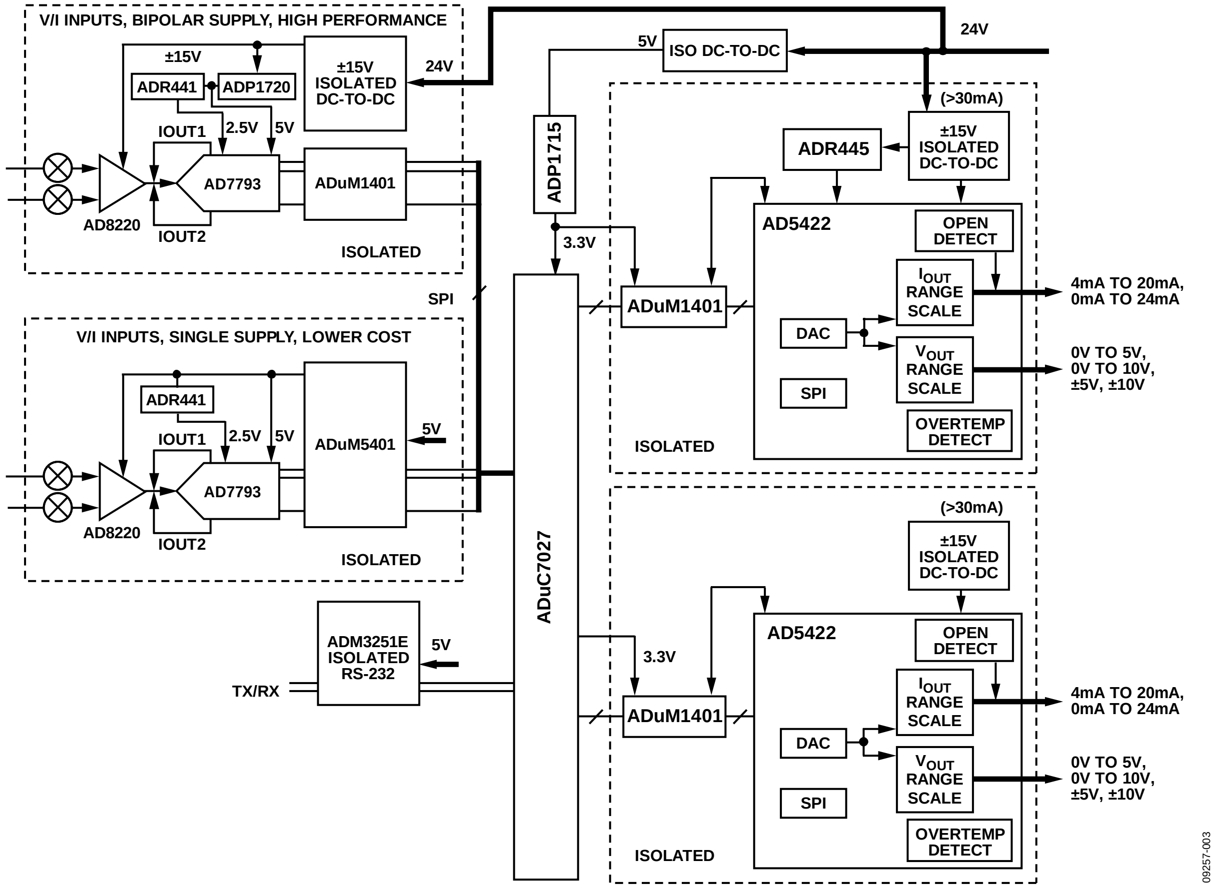

Figure 3. PLC Block Diagram

DEMO SYSTEMS HARDWARE

Figure 4 shows the locations of the various functional blocks of the PLC demo system.

Figure 4. Channel Locations

INPUTS

DIP switches on the PLC demo board must be set to configure each input channel to the required input range. These switches are found to the left of each input channel circuitry. Figure 5 shows a diagram of these switches, and Table 1 lists the required switch configurations for each input range.

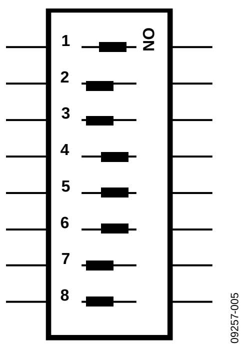

Figure 5. Input Channel Switches

Table 1. Input Channel Switch Settings

Switch No.	Range		Current	Thermo-couple	RTD
	0 V to 5 V, ±5 V	0 V to 10 V, ±10 V			
1	On	Off	On	Off	Off
2	Off	Off	Off	Off	Off
3	Off	Off	On	Off	Off
4	On	On	On	Off	Off
5	On	On	On	Off	Off
6	On	On	On	Off	Off
7	Off	Off	Off	On	Off
8	Off	Off	Off	On	Off

Input Connectors

Each input channel contains three sets of connectors; Jx1 connectors for voltage and current inputs, Jx2 connectors for thermocouple inputs, and Jx3 for RTD inputs (see Figure 6). Although all the channels allow for all three input types, the PLC demo software limits the inputs as described in Table 2.

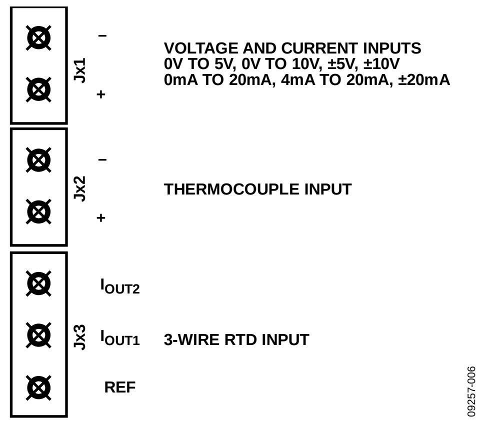

Figure 6. Input Connectors

Table 2. Ranges Allowed in PLC Demo Software

Input Channel	Input Type
1	JA1—voltage and current (unipolar)
2	JB2—thermocouple
3	JC1—voltage and current (bipolar)
4	JD3—RTD

Voltage and Current

The JA1 and JC1 connectors allow for various signaling inputs (see Figure 6). JA1 (Channel 1) allows for single-ended unipolar inputs: 0 V to 5 V, 0 V to 10 V, 4 mA to 20 mA, and 0 mA to 20 mA. Figure 20 shows a circuit diagram of this input. JC1 (Channel 3) allows for differential inputs: 0 V to 5 V, 0 V to 10 V, ±5 V, ±10 V, 4 mA to 20 mA, 0 mA to 20 mA, and ±20 mA. Figure 21 shows a circuit diagram of this input. To set the input range switches, see Table 1.

The 250 Ω current sensing resistor on the input channels has a 25 ppm/°C drift specification. The user can observe the drift from this resistor and can chose to replace this with a lower drift resistor if greater performance is desired.

Thermocouple

JB2 (Channel 2) is for thermocouple inputs (see Figure 6). Figure 22 shows a circuit diagram of this input. The PLC software allows the user to connect many different thermocouple types including J-, K-, and T-types. To set the input range switches for thermocouple inputs, see Table 1.

The PLC demo system hardware comes with a T-type thermocouple. Figure 7 shows how to connect this thermocouple to the PLC demo board.

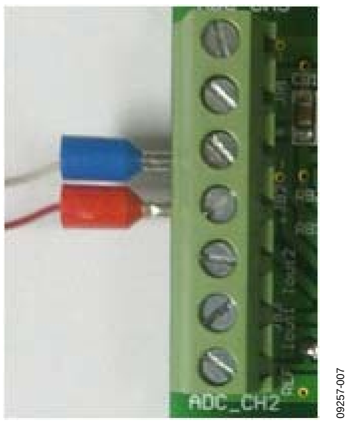

Figure 7. Thermocouple Connector

RTD

JD3 (Channel 4) is for 3-wire RTD inputs (see Figure 6). Figure 23 shows a circuit diagram for these inputs. To set the input range switches for 3-wire RTD inputs, see Table 1.

The PLC demo system hardware comes with a PT1000 RTD temperature sensor. Figure 8 shows how to connect this RTD to the PLC demo board.

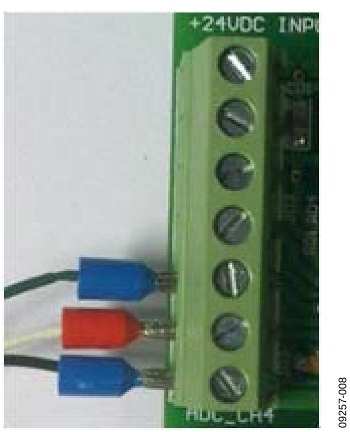

Figure 8. RTD Connection

OUTPUTS

Each output channel contains both a current and a voltage output connector. The relevant connectors are +VOUT/GND and IOUT/GND (Figure 9). The available output ranges are 0 V to 5 V, 0 V to 10 V, ±5 V, ±10 V, 4 mA to 20 mA, 0 mA to 20 mA, and 0 mA to 24 mA. On each channel, either the voltage or the current output can be enabled. The output that is not in use is tristated. If neither channel is enabled both are tristated. Figure 24 shows a circuit diagram of the output channels.

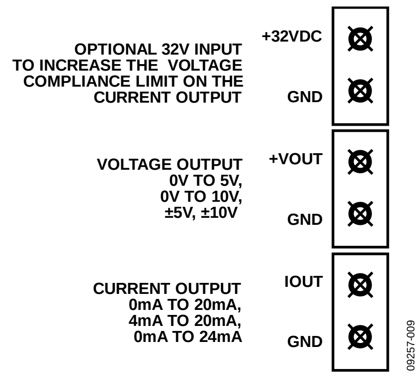

Figure 9. Output Connectors

Increasing the Output Compliance

The voltage compliance limit on the current output is 12.5 V. A connector is available to externally provide 32 V dc, which increases the output compliance to 29.5 V. The relevant connectors are labeled +32VDC and GND (see Figure 9). Figure 10 shows how +32VDC is connected to the channel supply of the AD5422. There is a 20 V TVS on the I_{OUT}, which may need to be changed/ removed if an external supply is used.

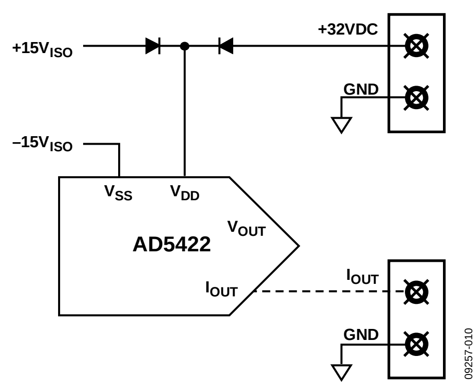

Figure 10. +32VDC Connection on the Output Channels

POWER SUPPLIES

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Figure 11. Power Connections

The demo board should be powered by a 24 V dc, ±10%, 500 mA supply. This should be connected via the +24VDC INPUT (JP2) socket. All other supplies on the PLC demo board are derived from this 24 V dc supply.

RS-232 COMMUNICATIONS

The PLC demo system uses an RS-232 straight through DB-9 connector. This connector is supplied with the PLC demo system board. The RS-232 signal can be connected straight to the RS-232 port of the PC. If the PC being used does not have an RS-232 port, a RS-232-to-USB converter can be used.

The RS-232 connection between the PLC demo board and PC is fully isolated using the ADM3251E isolated single-channel RS-232 line driver/receiver.

DEMO SYSTEM SOFTWARE

SOFTWARE INSTALLATION

The demonstration kit includes self-installing software. The software is compatible with Windows® 2000 and Windows XP. Run the **setup.exe** file to begin the installation.

After the installation has completed, connect the demo board to the computer serial port using a serial cable and power the board using a 24 V dc supply as described in the Power Supplies section.

SOFTWARE OPERATION

1. To run the software, click **Start** > **All Programs** > **Analog Devices** > **PLC Demo System** > **PLC EVALUATION SW V3.x**. The window in Figure 12 should appear.

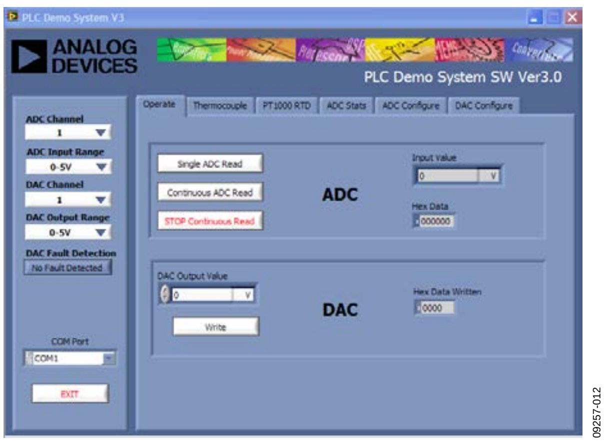

Figure 12. Main Window

2. The menu bar on the left of the main window (see Figure 13) allows the user to select the ADC/DAC channel and range. It also allows the user to set the RS-232 communication port of the PC.

To set up an input channel, see the Demo Systems Hardware section. Ensure the ADC range switches are set correctly for the selected channel. Then, use the correct connector for the specified channel and range.

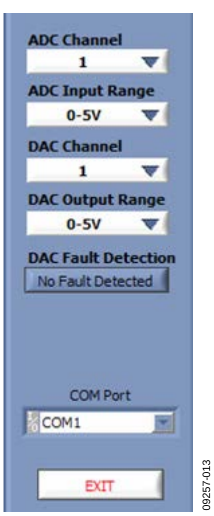

Figure 13. Menu Bar

The following tabs are available in the software:

- **Operate** tab
- **Thermocouple** tab
- **PT1000 RTD** tab
- **ADC Stats** tab
- **ADC Configure** tab
- **DAC Configure** tab

Operate Tab

The **Operate** tab can be used with Input Channel 1 and Input Channel 3 as well as all the output channels. In the **Operate** tab of the software window, you can

- Perform an ADC conversion(s).
- Write to an output channel. To do this, enter a value in the **DAC Output Value** box and click **Write**. The hex value written to the DAC is displayed to the right of these controls.

Figure 14. Operate Tab

Thermocouple Tab

The **Thermocouple** tab allows for thermocouple measurement on Output Channel 2. See the Demo Systems Hardware section for setting up a thermocouple channel. Click **Run** to start the measurement (see Figure 15).

The measurement is performed by executing a thermocouple voltage reading (the bias voltage generator for the AD7793 is used for this) followed by a cold-junction reading from the on-board thermistor (using the excitation current sources of the AD7793).

See the AN-880 Application Note, *ADC Requirements for Temperature Measurement Systems*, for information on thermocouple measurements using the AD7793.

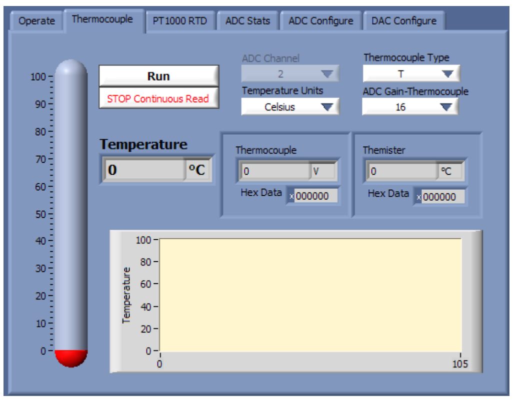

Figure 15. Thermocouple Tab

PT1000 RTD Tab

The **PT1000 RTD** tab allows for RTD measurement on ADC Channel 4. See the Demo Systems Hardware section for setting up an RTD channel. Click **Run** to start the measurement (see Figure 16).

See the AN-880 Application Note, *ADC Requirements for Temperature Measurement Systems*, and the AD7793 data sheet, for information on RTD measurements using the AD7793.

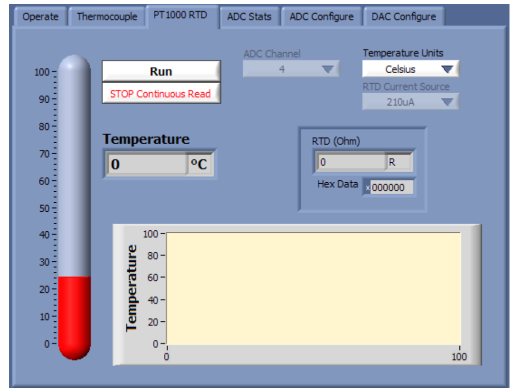

Figure 16. PT1000 RTD Tab

ADC Stats Tab

The **ADC Stats** tab can perform statistical analysis on channel input. To carry out this analysis, complete the following steps:

1. Connect the input channel to the desired source.
2. Select the number of samples to be taken from the **No. of Samples** box.
3. Click **Measure**.
4. The sampling can be stopped at any stage by clicking **STOP**.

Once the sampling is complete, the histogram is updated as well as the statistical information (mean, RMS value, peak-to-peak noise, standard deviation, and peak-to-peak resolution).

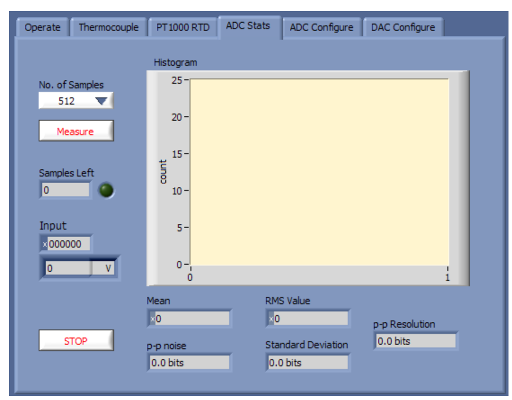

Figure 17. ADC Stats Tab

ADC Configure Tab

Use the **ADC Configure** tab to alter ADC register settings. Some of these setting are automatically altered when using the **Thermocouple** or **PT1000 RTD** tab (see Figure 18).

The **ADC Configure** tab also displays the current calibration values. The ADC can be recalibrated using the following procedure:

1. Connect a (precision) dc source to the system voltage input (Jx3 connector).
2. Ensure that the correct input range is set in both the hardware and the software.
3. Click **New Calibration** and follow the on-screen instructions.

To revert to the default calibration values, click Load Original Values. These default calibration values were created using the DAC outputs. To generate more accurate calibration values, use a precision dc source as previously outlined in this section.

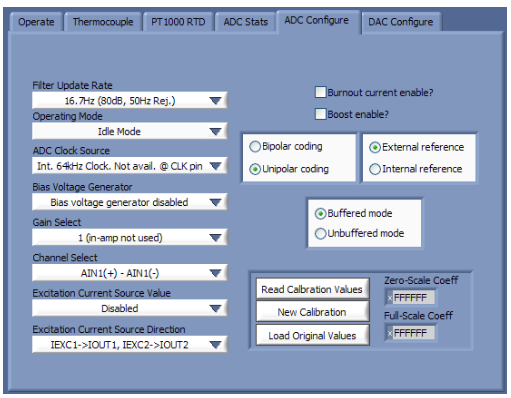

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Figure 18. ADC Configure Tab

DAC Configure Tab

Use the **DAC Configure** tab to alter the control register of a DAC (see Figure 19).

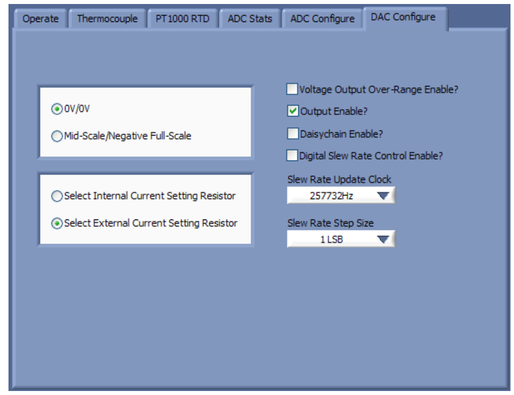

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Figure 19. DAC Configure Tab

FIRMWARE

The firmware on the ADuC7027 is designed to perform basic communications between the on-board data converters and a PC. This basic firmware is available on the PLC website. The firmware that comes on the PLC demo board also has functions to store calibration data for the PLC demo software.

EMC TEST RESULTS

A sample was tested during initial release and met the following test compliances. These results should be viewed as typical data taken at 25°C. For these tests, the DAC outputs were connected to the DAC inputs, that is, DAC2 to ADC2, DAC3 to ADC3, and DAC4 to ADC4. The DAC outputs were set to 5 V, 6 V, and 10 mA, respectively.

Table 3.

Test Item	Description	Result
EN55022	Radiated emission Class A, 3 meter anechoic chamber	Passed and met −6 dB margin.
EN and IEC 61000-4-2	Electrostatic discharge (ESD) ±8 kV VCD	Maximum deviations in Input Channel 2, Input Channel 3, and Input Channel 4 are respectively −8 ppm, 10 ppm, 13 ppm when there is interference.
	Electrostatic discharge (ESD) ±8 kV HCD	Maximum deviations in Input Channel 2, Input Channel 3, and Input Channel 4 are respectively −8 ppm, 10 ppm, 13 ppm when there is interference.
EN and IEC 61000-4-3	Radiated immunity 80 MHz to 1 GHz 18 V/m, vertical antenna polarization	Maximum deviations in Input Channel 2, Input Channel 3, and Input Channel 4 are 0.05%, 0.004%, −0.13%. Performance automatically resorted to ≤0.05% after interference. Class B.
	Radiated immunity 80 MHz to 1 GHz 18 V/m, horizontal antenna polarization	Maximum deviations in Input Channel 2, Input Channel 3, and Input Channel 4 are −0.09%, 0.003%, −0.02%. Performance automatically resorted to ≤0.05% after interference. Class B.
EN and IEC 61000-4-4	Electrically fast transient (EFT) ±4 kV power port	Passed Class B.
	Electrically fast transient (EFT) ±2 kV analog input/output ports	Passed Class B.
EN and IEC 61000-4-5	Power line surge, ±2 kV	No board or device damage occurred, no performance degrade, passed with Class A.
EN and IEC 61000-4-6	Conducted immunity test on power cord, 10 V/m for 30 minutes	Maximum deviations in Input Channel 2, Input Channel 3, and Input Channel 4 are respectively 9.3%, 11%, 3.4%. Passed Class B.
	Conducted immunity test on input/output cable 10 V/m for 30 minutes	Maximum deviations in Input Channel 2, Input Channel 3, and Input Channel 4 are respectively 4.5%, 4.7%, 1.4%. Performance automatically resorted to ≤0.05% when interference stopped.

SIMPLIFIED INPUT/OUTPUT CIRCUIT DIAGRAMS

Figure 20 shows a simplified circuit diagram for Input Channel 1 (Input Channel 2 follows the same format). On the input side, the precision current setting resistor can be switched in and out selecting either current or voltage mode. Resistors R_A and R_B divide down the input signal into the range of the AD7793. The AD8226 output is biased with a common-mode signal connected to the REF pin so that the signal meets the input requirements of the AD7793.

For more information on this circuit, see Circuit Note CN0067.

Figure 21 shows a simplified circuit diagram for Input Channel 3 (Input Channel 4 follows the same format). On the input side, the precision current setting resistor can be switched in and out selecting either current or voltage mode. Resistors R_A and R_B divide down the pseudodifferential input signal into the range of the AD7793. The AD8226 output is biased with a common-mode signal connected to the REF pin so that the signal meets the input requirements of the AD7793. This circuit has bipolar supplies and, thus, allows bipolar inputs.

For more information on a similar circuit, see Circuit Note CN0067.

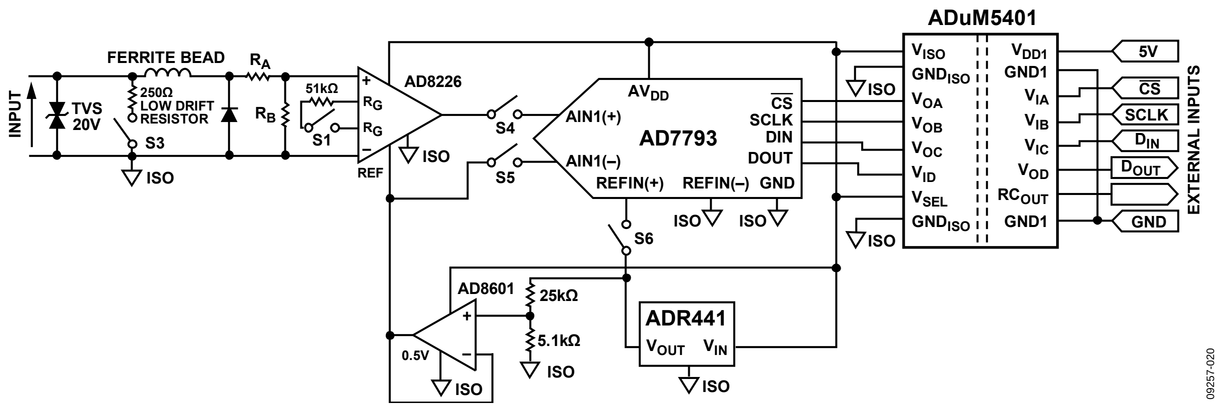

Figure 20. Input Channel 1 and Input Channel 2—Voltage and Current Input

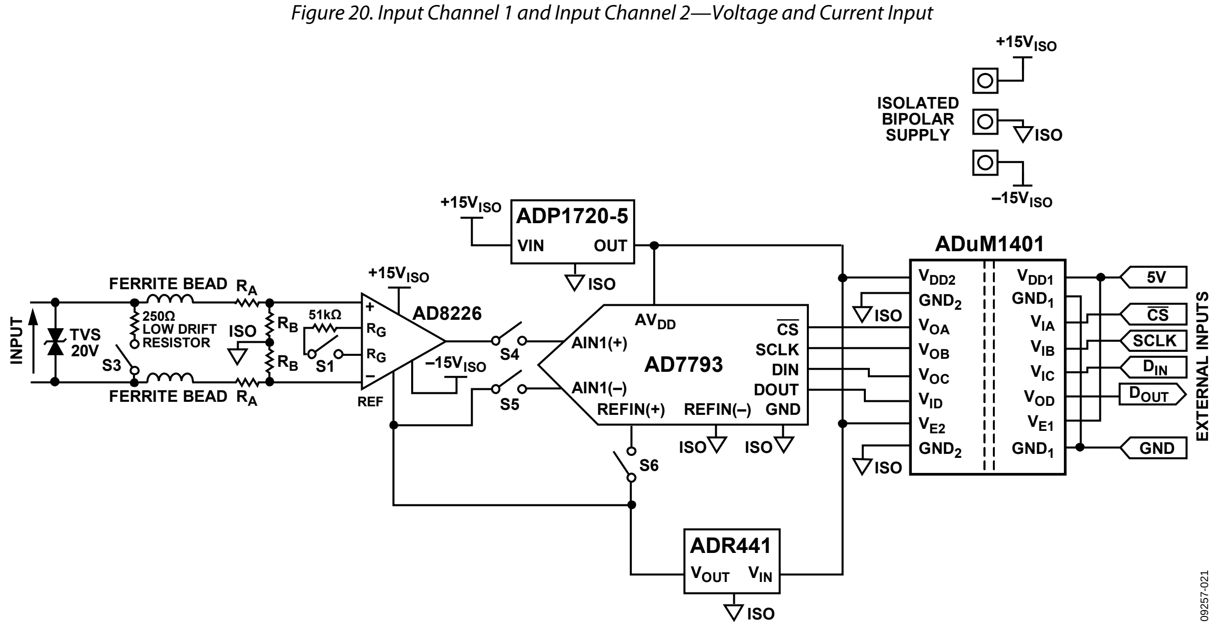

Figure 21. Input Channel 3 and Input Channel 4—Voltage and Current Input

Figure 22 shows a simplified circuit diagram for the thermocouple inputs. The ADC includes an on-chip PGA and can, therefore, accept small signal inputs from sensors directly. The PGA gains can be set for 1, 2, 4, 8, 16, 32, 64, or 128. The PLC demo board also includes an on-board thermistor for the cold-junction compensation measurement.

See the AN-880 Application Note, *ADC Requirements for Temperature Measurement Systems*, and the AD7793 data sheet for information on thermocouple measurements using the AD7793.

Figure 23 shows a simplified circuit diagram for the 3-wire RTD inputs. The AD7793 contains two matched excitation current sources for 3-wire RTD measurements. See the AN-880 Application Note, *ADC Requirements for Temperature Measurement Systems*, and the AD7793 data sheet, for information on RTD measurements using the AD7793.

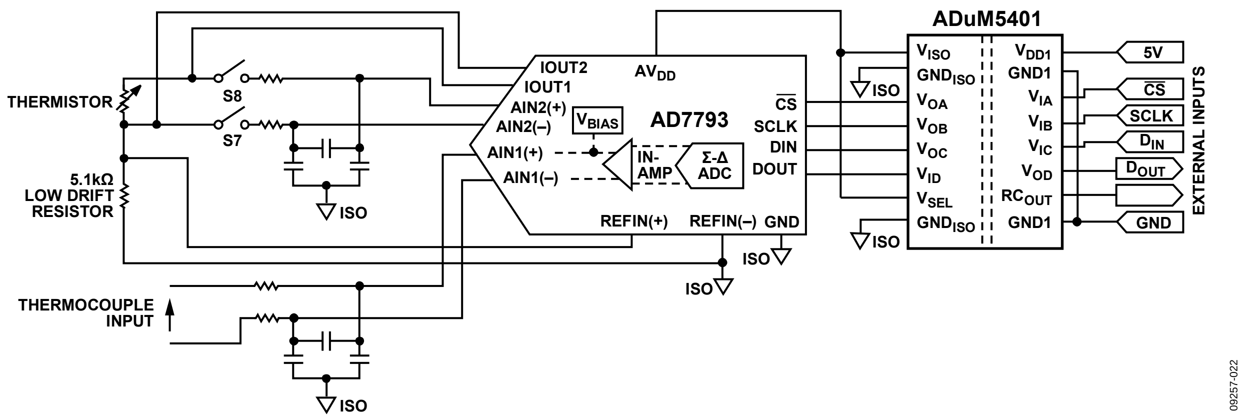

Figure 22. Thermocouple Inputs

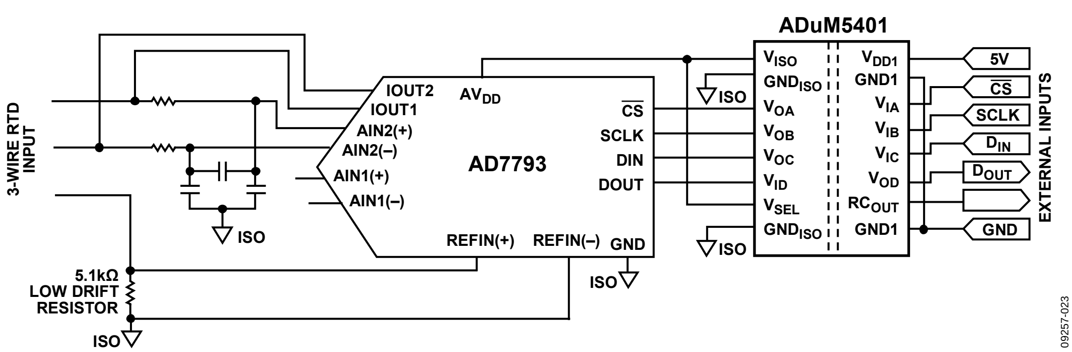

Figure 23. 3-Wire RTD Inputs

Figure 24 shows a simplified circuit diagram for Output Channel 3 and Output Channel 4. Output Channel 1 and Output Channel 2 are the same except they use the AD5422 internal 10 ppm/°C (maximum) reference.

An internal boost transistor is available on-chip though an external boost transistor has been used for those who may wish to operate at the extremes of the supply voltage, load current, and temperature range.

For more information on this circuit, see Circuit Note CN0065.

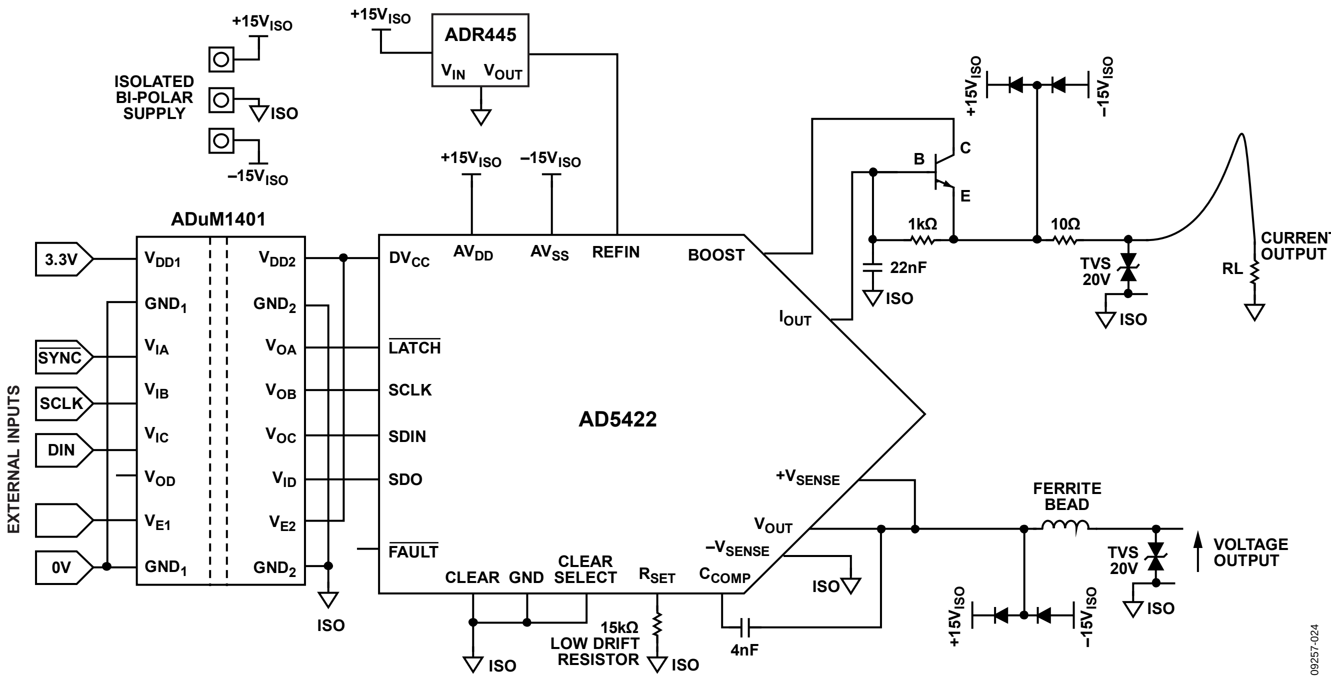

Figure 24. Output Channel 3 and Output Channel 4—Voltage and Current Output

NOTES

NOTES

NOTES

ESD Caution

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

Legal Terms and Conditions

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