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 isoPower™ 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 parts can add to a PLC system. The demo
board contains four fully isolated ADC channels, a micro-
processor 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
8/10—Revision 0: Initial Version
Figure 3. PLC Block Diagram
DEMO SYSTEMS HARDWARE

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

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's circuitry. Figure 5 shows a diagram of these switches, and Table 1 lists the required switch configurations for each input range.

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.

Table 2. Ranges Allowed in PLC Demo Software

<table>
<thead>
<tr>
<th>Input Channel</th>
<th>Input Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>JA1—voltage and current (unipolar)</td>
</tr>
<tr>
<td>2</td>
<td>JB2—thermocouple</td>
</tr>
<tr>
<td>3</td>
<td>JC1—voltage and current (bipolar)</td>
</tr>
<tr>
<td>4</td>
<td>JD3—RTD</td>
</tr>
</tbody>
</table>

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 choose 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](image)

**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](image)

**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.

**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 IOUT, which may need to be changed/removed if an external supply is used.

![Figure 10. +32VDC Connection on the Output Channels](image)
POWER SUPPLIES

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](image1)

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](image2)

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](image3)
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.

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.

ADC Stats Tab

The ADC Stats tab can be used to 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, p-p noise, standard deviation, and p-p resolution).
**ADC Configure Tab**

Use the **ADC Configure** tab to alter ADC register settings. Some of these settings 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.

**DAC Configure Tab**

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

**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.

<table>
<thead>
<tr>
<th>Test Item</th>
<th>Description</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN55022</td>
<td>Radiated emission Class A, 3-meter anechoic chamber</td>
<td>Passed and met −6 dB margin.</td>
</tr>
<tr>
<td>EN and IEC 61000-4-2</td>
<td>Electrostatic discharge (ESD) ±8 kV VCD</td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>Electrostatic discharge (ESD) ±8 kV HCD</td>
<td>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.</td>
</tr>
<tr>
<td>EN and IEC 61000-4-3</td>
<td>Radiated immunity 80 MHz to 1 GHz 18 V/m, vertical antenna polarization</td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>Radiated immunity 80 MHz to 1 GHz 18 V/m, horizontal antenna polarization</td>
<td>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.</td>
</tr>
<tr>
<td>EN and IEC 61000-4-4</td>
<td>Electrically fast transient (EFT) ±4 kV power port</td>
<td>Passed Class B</td>
</tr>
<tr>
<td></td>
<td>Electrically fast transient (EFT) ±2 kV analog I/O ports</td>
<td>Passed Class B</td>
</tr>
<tr>
<td>EN and IEC 61000-4-5</td>
<td>Power line surge, ±2 kV</td>
<td>No board or part damage occurred, no performance degrade, passed with Class A.</td>
</tr>
<tr>
<td>EN and IEC 61000-4-6</td>
<td>Conducted immunity test on power cord, 10 V/m for 30 minutes</td>
<td>Maximum deviations in Input Channel 2, Input Channel 3, and Input Channel 4 are respectively 9.3%, 11%, 3.4%. Passed Class B.</td>
</tr>
<tr>
<td></td>
<td>Conducted immunity test on I/O cable 10 V/m for 30 minutes</td>
<td>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.</td>
</tr>
</tbody>
</table>
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 CN-0067.

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 CN-0067.
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 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 CN-0065.
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
By using the evaluation board discussed herein (together with any tools, components documentation or support materials, the “Evaluation Board”), you are agreeing to be bound by the terms and conditions set forth below (“Agreement”) unless you have purchased the Evaluation Board, in which case the Analog Devices Standard Terms and Conditions of Sale shall govern. Do not use the Evaluation Board until you have read and agreed to the Agreement. Your use of the Evaluation Board shall signify your acceptance of the Agreement. This Agreement is made by and between you (“Customer”) and Analog Devices, Inc. (“ADI”), with its principal place of business at One Technology Way, Norwood, MA 02062, USA. Subject to the terms and conditions of the Agreement, ADI hereby grants to Customer a free, limited, personal, temporary, non-exclusive, non-sublicensable, non-transferable license to use the Evaluation Board FOR EVALUATION PURPOSES ONLY. Customer understands and agrees that the Evaluation Board is provided for the sole and exclusive purpose referenced above, and agrees not to use the Evaluation Board for any other purpose. Furthermore, the license granted is expressly made subject to the following additional limitations: Customer shall not (i) rent, lease, display, sell, transfer, assigns, sublicense, or distribute the Evaluation Board; and (ii) permit any Third Party to access the Evaluation Board. As used herein, the term “Third Party” includes any entity other than ADI, Customer, their employees, affiliates and in-house consultants. The Evaluation Board is NOT sold to Customer; all rights not expressly granted herein, including ownership of the Evaluation Board, are reserved by ADI. CONFIDENTIALITY. This Agreement and the Evaluation Board shall all be considered the confidential and proprietary information of ADI. Customer may not disclose or transfer any portion of the Evaluation Board to any other party for any reason. Upon discontinuation of use of the Evaluation Board or termination of this Agreement, Customer agrees to promptly return the Evaluation Board to ADI. ADDITIONAL RESTRICTIONS. Customer may not disassemble, decompile or reverse engineer chips on the Evaluation Board. Customer shall inform ADI of any occurred damages or any modifications or alterations it makes to the Evaluation Board, including but not limited to soldering or any other activity that affects the material content of the Evaluation Board. Modifications to the Evaluation Board must comply with applicable law, including but not limited to the RoHS Directive. TERMINATION. ADI may terminate this Agreement at any time upon giving written notice to Customer. Customer agrees to return to ADI the Evaluation Board at that time. LIMITATION OF LIABILITY. THE EVALUATION BOARD PROVIDED HEREUNDER IS PROVIDED “AS IS” AND ADI MAKES NO WARRANTIES OR REPRESENTATIONS OF ANY KIND WITH RESPECT TO IT. ADI SPECIFICALLY DISCLAIMS ANY REPRESENTATIONS, ENDORSEMENTS, WARRANTIES, OR WARRANTIES, EXPRESS OR IMPLIED, RELATED TO THE EVALUATION BOARD INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, TITLE, FITNESS FOR A PARTICULAR PURPOSE OR NONINFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS. IN NO EVENT WILL ADI AND ITS LICENSORS BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES RESULTING FROM CUSTOMER'S POSSESSION OR USE OF THE EVALUATION BOARD, INCLUDING BUT NOT LIMITED TO LOSSES, DELAY COSTS, COSTS OR LOSS OF REVENUE, ADI'S TOTAL LIABILITY FROM ANY AND ALL CAUSES SHALL BE LIMITED TO THE AMOUNT OF ONE HUNDRED US DOLLARS ($100.00). EXPORT. Customer agrees that it will not directly or indirectly export the Evaluation Board to another country, and that it will comply with all applicable United States federal laws and regulations relating to exports. GOVERNING LAW. This Agreement shall be governed by and construed in accordance with the substantive laws of the Commonwealth of Massachusetts (excluding conflict of law rules). Any legal action regarding this Agreement will be heard in the state or federal courts having jurisdiction in Suffolk County, Massachusetts, and Customer hereby submits to the personal jurisdiction and venue of such courts. The United Nations Convention on Contracts for the International Sale of Goods shall not apply to this Agreement and is expressly disclaimed.