One Technology Way • P.O. Box 9106 • Norwood, MA 02062-9106, U.S.A. • Tel: 781.329.4700 • Fax: 781.461.3113 • www.analog.com

# Fully Isolated Input Module Based on the AD7793 24-Bit, Σ-Δ ADC and the ADuM5401 Digital Isolator

## CIRCUIT FUNCTION AND BENEFITS

The circuit shown in Figure 1 provides a complete solution for a single-supply, input circuit design that requires isolation. The AD7793 is a 24-bit, Σ-Δ analog-to-digital converter (ADC). The ADC includes an on-chip, programmable gain amplifier (PGA) and can accept small signal inputs directly from sensors. The PGA gains can be set for 1, 2, 4, 8, 16, 32, 64, or 128. The ADuM5401 provides all necessary signal isolation and power between the microcontroller and the input.

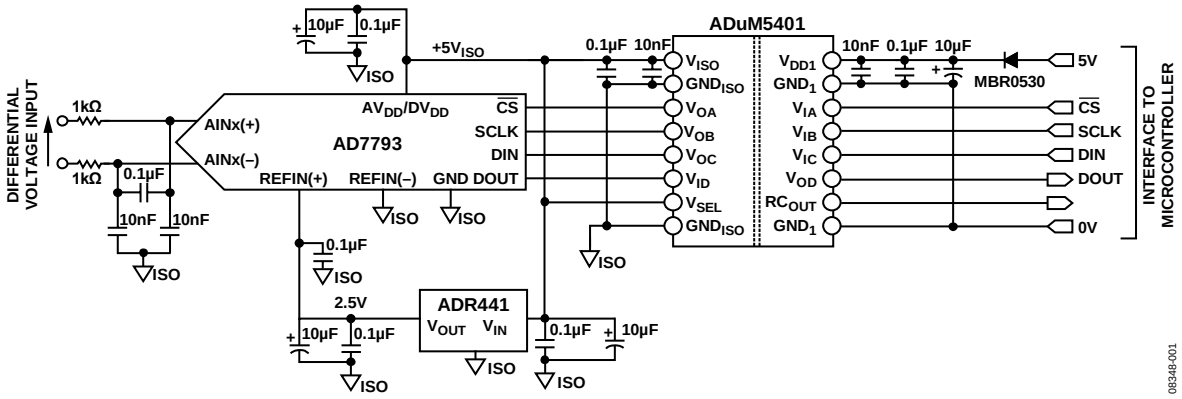


*Figure 1. 24-Bit, Isolated, Single-Supply Input Circuit*

# TABLE OF CONTENTS



## REVISION HISTORY

**7/2018—Rev. A to Rev. B**

Document Title Changed from CN0066 to AN-1521 ....Universal
Changes to Circuit Description Section and Table 1 ..... 3

**5/2011—Rev. 0 to Rev. A**

Changes to Circuit Function and Benefits Section ..... 1
Changes to Figure 1 ..... 1
Changes to Circuit Description Section ..... 2
Changes to Table 1 ..... 2
Changes to Learn More Section ..... 3

**7/2009—Revision 0: Initial Version**

## CIRCUIT DESCRIPTION

Sensor outputs are commonly small signal, for example, thermocouple or resistance temperature detectors (RTDs). This design allows these small signal inputs to be directly connected to the AD7793 input, which has an internal PGA with a maximum gain of 128. The design can be used as a complete solution to a nonloop powered smart transmitter.

The ADR441 is the chosen reference for this circuit. The ADR441 has initial accuracy specifications of 0.04% and a temperature drift of 3 ppm/°C maximum (B grade device).

The ADuM5401 is a quad-channel isolator with integrated *iso*Power® technology, based on Analog Devices, Inc., *i*Coupler® technology. The ADuM5401 is used to provide isolation between the field side and the system microcontroller, with an isolation rating of 2.5 kV/rms. The ADuM5401 also has an integrated dc-to-dc converter, which can provide 500 mW of regulated isolated output power at either 5.0 V or 3.3 V. This design uses the 5.0 V provided from the ADuM5401 to supply all the analog circuitry on the input module. Four data wires connect the ADuM5401 to the standard serial peripheral interface (SPI): three for transmission ($\overline{CS}$, SCLK, DIN) and one for receiving (DOUT).

The AD7793 is specified for an $AV_{DD}$ of 2.7 V to 5.25 V under normal operation. In lighter load conditions (<10 mA), it is possible for the ADuM5401 setpoint voltage to go from 4.7 V to 5.4 V. Under these conditions, the maximum voltage is too high for the $AV_{DD}$ input of the AD7793. To ensure that the circuit draws enough current during operation, place a diode in series with the $AV_{DD}$ supply of the AD7793.

Figure 2 shows a histogram plot of the AD7793 output performance when a 2.5 V reference is connected to its inputs. The output noise is measured in peak-to-peak resolution. The 20.4-bit peak-to-peak resolution figure means there are 3.6 bits of noise flicker on the output of the ADC with respect to the 24-bit resolution of the ADC. Therefore, the noise-free code resolution of the ADC is 20.4 bits. In terms of contribution to the overall system error, the measured noise of 3.6 bits contributes ~0.00007% error with respect to the full-scale range of the ADC. The integral nonlinearity (INL) error of the AD7793 is 0.0015%.

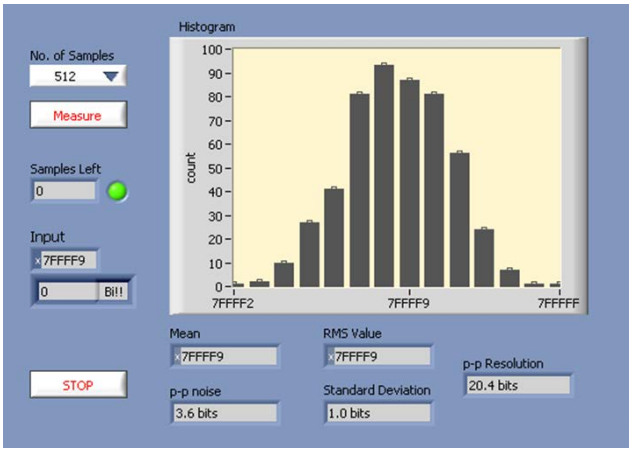


*Figure 2. Input Module Histogram Plot of the AD7793, 512 Samples, 4.17 Hz Data Rate, Gain = 1, Input = 2.5 V Reference*

This circuit is from a portion of the PLC Demo System. The PLC Demo System has been successfully tested to the IEC 61000 standards shown in Table 1 (see the AnalogDialogue article, *PLC Evaluation Board Simplifies Design of Industrial Process Control systems* for more discussion of external protection techniques).

A sample was tested during initial release of the PLC Demo System and met the test compliances listed in this table. These results should be viewed as typical data taken at 25°C. For these tests, the digital-to-analog converter (DAC) outputs were connected to the ADC inputs. The DAC outputs were set to 5 V, 6 V, and 10 mA. The ADC channels correspond to the circuit as described in Application Note AN-1522.

**Table 1. Conformance to IEC Specifications**

| 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 vertical coupling place (VCP)<br>ESD ±8 kV horizontal coupling plane (HCP) | Maximum deviations in Input Channel 2, Input Channel 3, and Input Channel 4 are respectively −8 ppm, 10 ppm, and 13 ppm when there is interference.<br>Maximum deviations in Input Channel 2, Input Channel 3, and Input Channel 4 are respectively −8 ppm, 10 ppm, and 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<br>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 respectively 0.05%, 0.004%, and −0.13%. Performance automatically resorted to ≤0.05% after interference. Class B.<br>Maximum deviations in Input Channel 2, Input Channel 3, and Input Channel 4 are respectively −0.09%, 0.003%, and −0.02%. Performance automatically resorted to ≤0.05% after interference. Class B. |

| Test Item | Description | Result |
|---|---|---|
| EN and IEC 61000-4-4 | Electrically fast transient (EFT) ±4 kV power port | Passed Class B. |
| | EFT ±2 kV analog input/output ports | Passed Class B. |
| EN and IEC 61000-4-5 | Power line surge, ±2 kV | No board or part damage occurred, no performance degrade, passed with Class A. |
| EN and IEC 61000-4-6 | 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%, and 3.4%. Passed Class B. |
| | 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%, and 1.4%. Performance automatically resorted to ≤0.05% when interference stopped. |

## REFERENCES


Cantrell, Mark. AN-0971 Application Note, *Recommendations for Control of Radiated Emissions with isoPower Devices.* Analog Devices.

Chen, Baoxing. 2006. *iCoupler Products with isoPower Technology: Signal and Power Transfer Across Isolation Barrier Using Microtransformers.* Analog Devices.

MT-004 Tutorial. *The Good, the Bad, and the Ugly Aspects of ADC Input Noise—Is No Noise Good Noise?.* Analog Devices.

MT-022 Tutorial, *ADC Architectures III: Sigma-Delta ADC Basics.* Analog Devices.

MT-023 Tutorial, *ADC Architectures IV: Sigma-Delta ADC Advanced Concepts and Applications.* Analog Devices.

Slattery, Colm, Derrick Hartmann, and Li Ke. *PLC Evaluation Board Simplifies Design of Industrial Process Control systems.* AnalogDialogue. April 2009.

Wayne, Scott. *iCoupler Digital Isolators protect RS-232, RS-485, and CAN Buses.* AnalogDialogue. October 2005.



AN08348-0-7/18(B)