

## 16-Bit, Fully Isolated Output Module Using the AD5422 Single-Chip Voltage and Current Output DAC and the ADuM1401 Digital Isolator

### CIRCUIT FUNCTION AND BENEFITS

The circuit shown in Figure 1 provides a complete solution for an industrial control output module. This design is suitable for process control programmable logic controllers (PLCs) and distributed control system (DCS) modules that require standard 4 mA to 20 mA current outputs, and unipolar or bipolar output voltage ranges. The AD5422 16-bit, digital-to-analog converter (DAC) is software-configurable to provide all necessary outputs,

and has integrated diagnostic features that are useful in an industrial environment. The ADuM1401 provides the necessary signal isolation between the microcontroller and the DAC. The circuit also includes standard external protection and has been tested and verified to be fully compliant with IEC 61000 specifications.

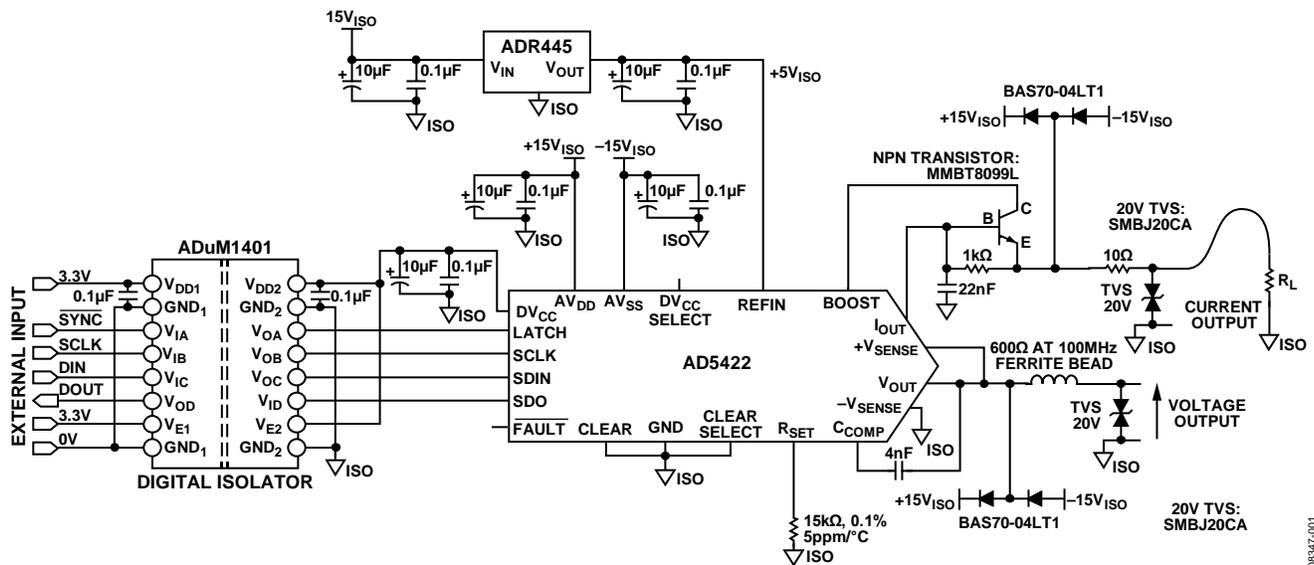


Figure 1. 16-Bit Industrial Control Output Module, Integrated Diagnostics, Output Protection (Simplified Schematic)

08347-001

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**REVISION HISTORY**

**2/2018—Rev. B to Rev. C**

Document Title Changed from CN0065 to AN-1519 ..... Universal	
Changes to Figure 1.....	1
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**5/2011—Rev. A to Rev. B**

Changes to Circuit Function and Benefits Section .....	1
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**8/2009—Rev. 0 to Rev. A**

Updated Figure 1 .....	1
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**7/2009—Revision 0: Initial Version**

**CIRCUIT DESCRIPTION**

For industrial control modules, standard analog output voltage and current ranges include  $\pm 5$  V,  $\pm 10$  V, 0 V to +5 V, 0 V to +10 V, 4 mA to 20 mA, and 0 mA to 20 mA. The AD5422 is a precision, fully integrated, 16-bit DAC offering a programmable current source and programmable voltage output, designed to meet the requirements of industrial process control applications.

The output current range of the circuit shown in Figure 1 is programmable from 4 mA to 20 mA, or 0 mA to 20 mA, and has an overrange function of 0 mA to 24 mA. Voltage output is provided from a separate pin ( $V_{OUT}$ ) that can be configured to provide 0 V to +5 V, 0 V to +10 V,  $\pm 5$  V, or  $\pm 10$  V output ranges. An overrange feature of 10% is available on all ranges. Analog outputs are short-circuit and open-circuit protected and can drive capacitive loads of 1  $\mu$ F and inductive loads of 50 mH.

By default, the  $DV_{CC}$  pin on the AD5422 accepts a power supply of 2.7 V to 5.5 V. Alternatively, the  $DV_{CC}$  SELECT pin can be used to connect an internal 4.5 V power supply to the  $DV_{CC}$  pin for use as a digital power supply for other devices in the system or as a termination for pull-up resistors. The maximum current available from the  $DV_{CC}$  pin in this mode is 5 mA. In this design, the  $DV_{CC}$  output is used to supply the field side of the ADuM1401 digital isolator.

The ADuM1401 is a quad-channel digital isolator based on Analog Devices, Inc., iCoupler® technology. It is used to provide isolation between the AD5422 and the system microcontroller, with an isolation rating of 2500 V rms. All four wires are used to connect the standard serial peripheral interface (SPI) to the AD5422: three wires transmit (LATCH, SCLK, and SDIN) and one wire receives (SDO).

The AD5422 has a maximum on-chip reference of 10 ppm/°C. For high performance over temperature, this design uses an external ADR445 5 V reference. The ADR445 has a 0.04% maximum initial accuracy error and a 3 ppm/°C maximum temperature drift (B grade devices, only). This drift contributes approximately 0.02% error across the industrial temperature range.

Figure 2 shows an accuracy plot of the output error of the AD5422 when used with the ADR435 external reference. The data is shown as output voltage error in % FSR across a nominal 0 V to 10 V output range.

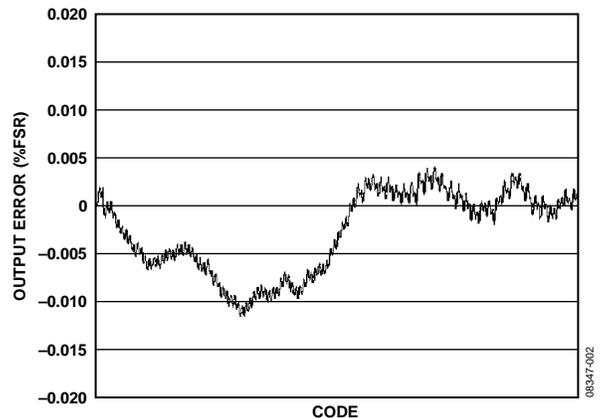


Figure 2. Integral Nonlinearity (INL) Accuracy Plot for a 0 V to 10 V Output Range

This circuit is from a portion of the PLC Demo System. The PLC Demo System successfully tests to the IEC 61000 standards, as shown in Table 1 (see the Analog Dialogue article, *PLC Evaluation Board Simplifies Design of Industrial Process-Control systems* for full details).

Table 1. Conformance to IEC Specifications<sup>1</sup>

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) $\pm 8$ kV vertical coupling plane (VCP) Electrostatic discharge (ESD) $\pm 8$ 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. 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	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 $\leq 0.05\%$ 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 respectively -0.09%, +0.003%, and -0.02%. Performance automatically resorted to $\leq 0.05\%$ after interference. Class B.
EN and IEC 61000-4-4	Electrically fast transient (EFT) $\pm 4$ kV power port	Passed Class B.
	Electrically fast transient (EFT) $\pm 2$ kV analog input/output ports	Passed Class B.
EN and IEC 61000-4-5	Power line surge, $\pm 2$ kV	No board or part damage occurred, no performance degrade, passed with Class A.

Test Item	Description	Result
EN and IEC 61000-4-6	Immunity test on power cord, 10 V/m for 30 minutes 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 9.3%, 11%, and 3.4%. Passed Class B. 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 $\leq 0.05\%$ when interference stopped.

<sup>1</sup> A sample was tested during initial release of the [PLC Demo System \(V07\)](#) and met the test compliances listed in this table. View these results as typical data taken at 25°C. For these tests, the DAC outputs were connected to the analog-to-digital converter (ADC) inputs, that is, DAC\_CH2 to ADC\_CH2, DAC\_CH3 to ADC\_CH3, and DAC\_CH4 to ADC\_CH4. The DAC outputs were set to 5 V, 6 V, and 10 mA, respectively. The ADC channels correspond to the circuit as in [AN-1522](#).

## REFERENCES

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