Circuit Note

CN-0201

Devices Connected/Referenced	
ADAS3022	16-Bit, 1 MSPS, 8 Channel Data Acquisition System Acquisition System
ADP1613	650 kHz/1.3 MHz Step-Up PWM DC-to-DC Switching Converter
AD8031/ AD8032	2.7 V, 800 µA per Amp, 80 MHz, Single/Dual, Rail-to-Rail I/O Amplifiers
ADR434	Ultralow Noise XFET Voltage References with Current Sink and Source Capability

Circuits from the Lab™ Reference Circuits

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Complete 5 V, Single-Supply, 8-Channel Multiplexed Data Acquisition System with PGIA for Industrial Signal Levels

EVALUATION AND DESIGN SUPPORT

Circuit Evaluation Boards

- **ADAS Circuit Evaluation Board (EVAL-ADAS3022EDZ)**
- **ADP1613 Evaluation Board Not Included**
- **Converter Evaluation and Development Board (EVAL-CED1Z)**

Design and Integration Files

- **Schematics, Layout Files, Bill of Materials**

CIRCUIT FUNCTION AND BENEFITS

The circuit shown in Figure 1 is a highly integrated 16-bit, 1 MSPS, multiplexed 8-channel flexible data acquisition system (DAS) with a programmable gain instrumentation amplifier (PGIA) capable of handling the full range of industrial signal levels.

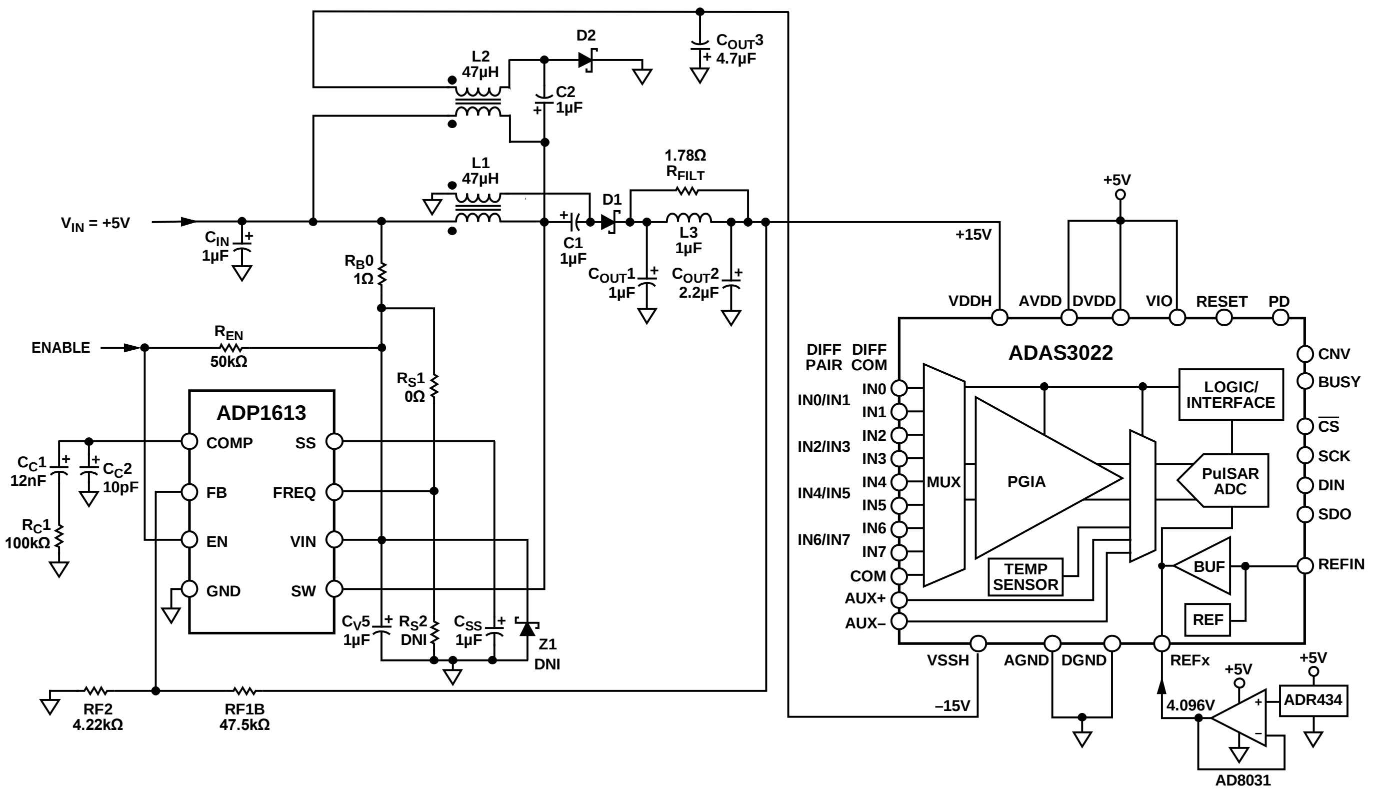

Figure 1. Complete 5 V, Single-Supply, 8-Channel Data Acquisition Solution with Integrated PGIA (Simplified Schematic: All Connections and Decoupling Not Shown)

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A single +5 V supply powers the circuit, and a high efficiency, low ripple boost converter generates the ±15 V that allows processing differential input signals up to ±24.576 V with ±2 LSB INL (maximum), and ±0.5 LSB DNL (typical). For high accuracy applications, this compact and cost-effective circuit offers high precision, as well as low noise.

The successive approximation register (SAR)-based data acquisition system includes true high impedance differential input buffers; therefore, there is no need for additional buffering, as is usually required to reduce kickback in capacitive digital-to-analog converter (DAC)-based SAR analog-to-digital converters (ADCs). In addition, the circuit has high common-mode rejection, eliminating the need for external instrumentation amplifiers, which are typically required in applications where common-mode signals are present.

The ADAS3022 is a complete 16-bit, 1 MSPS data acquisition system that integrates an 8-channel, low leakage multiplexer; a programmable gain instrumentation amplifier stage with a high common-mode rejection; a precision low drift 4.096 V reference; a reference buffer; and a high performance, no latency, 16-bit SAR ADC. The ADAS3022 reduces its power at the end of each conversion cycle; therefore, the operating currents and power scale linearly with throughput make it ideal for the low sampling rates in battery-powered applications.

The ADAS3022 has eight inputs and a COM input that can be configured as eight single-ended channels, eight channels with a common reference, four differential channels, or various combinations of single-ended and differential channels.

In the circuit shown in Figure 1, the reference is supplied by the ADR434 low noise reference buffered by an AD8031 op amp. The AD8031 is ideally suited as a reference buffer because of its ability to drive dynamic loads with fast recovery.

The ADP1613 is a dc-to-dc boost converter with an integrated power switch and provides the ADAS3022 high voltage ±15 V supplies required for the on-chip input multiplexer and the programmable gain instrumentation amplifier without compromising the performance of the ADAS3022.

This circuit offers high precision, as well as low noise, which is ensured by the combination of the ADAS3022, ADP1613, ADR434, and AD8031 precision components.

CIRCUIT DESCRIPTION

The ADAS3022 is the first complete DAS on a single chip that is capable of converting up to 1 MSPS and can accept differential analog input signals up to ±24.576 V. The ADAS3022 requires high voltage bipolar supplies: ±15 V (VDDH and VSSH), +5 V (AVDD and DVDD), and +1.8 V to +5 V (VIO).

The ADAS3022 simplifies the design challenges of building a precision 16-bit, 1 MSPS DAS by eliminating the need for signal buffering, level shifting, amplification, rejection of noise, and other analog signal conditioning required in standard solutions. In addition, the ADAS3022 offers optimized timing and noise performance at higher data rates, a smaller form factor, faster time to market, and lower costs.

The ADAS3022 has an internal PGIA that can be set for gains of 0.16, 0.2, 0.4, 0.8, 1.6, 3.2, and 6.4, and it can handle fully differential input ranges of ±24.576 V, ±20.48 V, ±10.24 V, ±5.12 V, ±2.56 V, ±1.28 V, and ±0.64 V, respectively. The input ranges are referenced to an internal 4.096 V reference voltage.

Pseudo-differential, unipolar, and bipolar input ranges are also allowed where the input voltage is measured with respect to the voltage on the COM pin.

In the circuit shown in Figure 1, the 4.096 V ADR434 provides the external reference voltage. The ADR434 features high accuracy, low power (800 μA operating current), low noise, ±0.12% maximum initial error, and excellent temperature stability. The low power AD8032 op amp is used to buffer the external reference, making it ideal for a wide range of applications from battery-operated systems with large bandwidth requirements to high speed systems where component density requires lower power dissipation.

The ADAS3022 digital interface consists of asynchronous inputs (CNV, RESET, PD, and BUSY) and a 4-wire serial interface ($\overline{CS}$, SDO, SCK, and DIN) compatible with SPI, FPGA, or DSP for conversion result readback and configuration register programming.

ADP1613 Power Design

The ADP1613 is used as the single-ended, primary inductance (SEPIC) Cuk converter, which is an ideal candidate for providing the ADAS3022 with the necessary high voltage ±15 V supplies (at 20 mA) and low output ripple (3 mV maximum) from an external 5 V supply. The switching frequency of the ADP1613 in this application is 1.3 MHz. The ADP1613 satisfies the specification requirements of the ADAS3022 with a minimum of external components, and the efficiency is greater than 86%, as shown in Figure 2. The main advantage of using the low cost ADP1613 in this topology is its excellent tracking between the two supply rails, while creating the ±15 V using off-the-shelf coupled inductors. In addition, it can be quickly and easily designed and built using the ADIsimPower design tool.

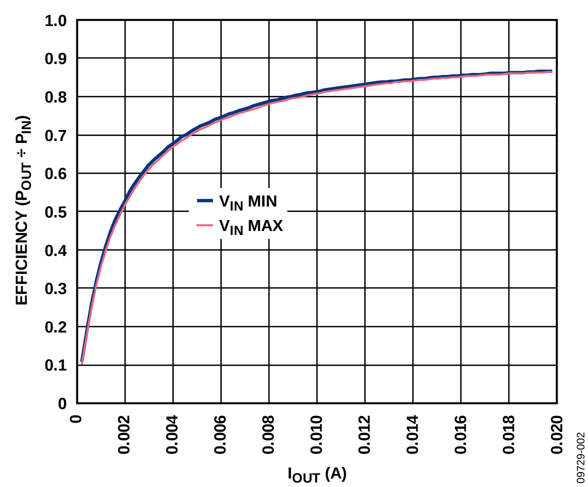

Figure 2. ADP1613 Efficiency (P_{OUT}/P_{IN}) vs. Output Current (I_{OUT})

The circuit shown in Figure 1 was designed using the following inputs within the ADP161x SEPIC-Cuk Downloadable Design Tool, which is available at ADIsimPower:

- V_{INMIN} = 4.75 V
- V_{INMAX} = 4.99 V
- V_{OUT} = 15 V
- V_{RIPPLE} = 0.02%
- Ambient temperature = 55°C
- Optimized for lowest cost
- External filter option

Note that the maximum voltage on the SW pin of the ADP1613 is equal to V_{IN} + V_{OUT} = 20 V, which is less than its absolute maximum voltage specification of 21 V. For input voltages greater than or equal to 5 V, the design tool suggests an additional cascode N-channel MOSFET driven by the SW pin. Because of the 1 V safety margin, this FET is not required in the circuit for input voltages up to 5.25 V with a 15 V output. Therefore, the input voltage used in the design tool was set to 4.99 V. The design results for the ADP1613 SEPIC-Cuk converter are located in the CN0201-Design Support package.

Dynamic Performance

Figure 3 shows the typical dynamic performance of the ADAS3022 with an ac input signal. Experiments were conducted with the ADAS3022 driven from linear ±15 V bench supplies and driven from the ±15 V output of the ADP1613 evaluation board. No difference in ac or dc performance was observed.

COMMON VARIATIONS

Other external 4.096 V references can be used with the ADAS3022 such as the ADR444 and ADR4540. The AD8031 or AD8605 op amps can be used as external reference buffers, if desired.

The ADAS3022 data sheet should be consulted for further recommendations regarding the use of internal or external references and reference buffers.

The ADP1612/ADP1613/ADP1614 are step-up, dc-to-dc converters with an integrated power switch that is capable of providing an output voltage up to 20 V. When used as a SEPIC-Cuk converter, the current output capability of the ADP1613 is up to 60 mA. The ADP1614 supplies up to 120 mA. The ADIsimPower design tool allows complete customization of the design and to quickly create the robust dual rails from one controller using an inexpensive SEPIC-Cuk topology.

CIRCUIT EVALUATION AND TEST

This circuit was tested using an Analog Devices ADP1613 evaluation board, the EVAL-ADAS3022EDZ evaluation board, and the EVAL-CED1Z converter evaluation and development board connected as shown in Figure 4. The 7 V wall wart was connected to the EVAL-CED1Z, and the external 5 V supply was connected to the ADP1613 evaluation board.

The EVAL-ADAS3022EDZ is a customer evaluation board intended to ease standalone testing of performance and functionality for the 16-bit ADAS3022 complete DAS. The ADP1613 evaluation board was built using the ADP161x SEPIC-Cuk Downloadable Design Tool available at ADIsimPower.

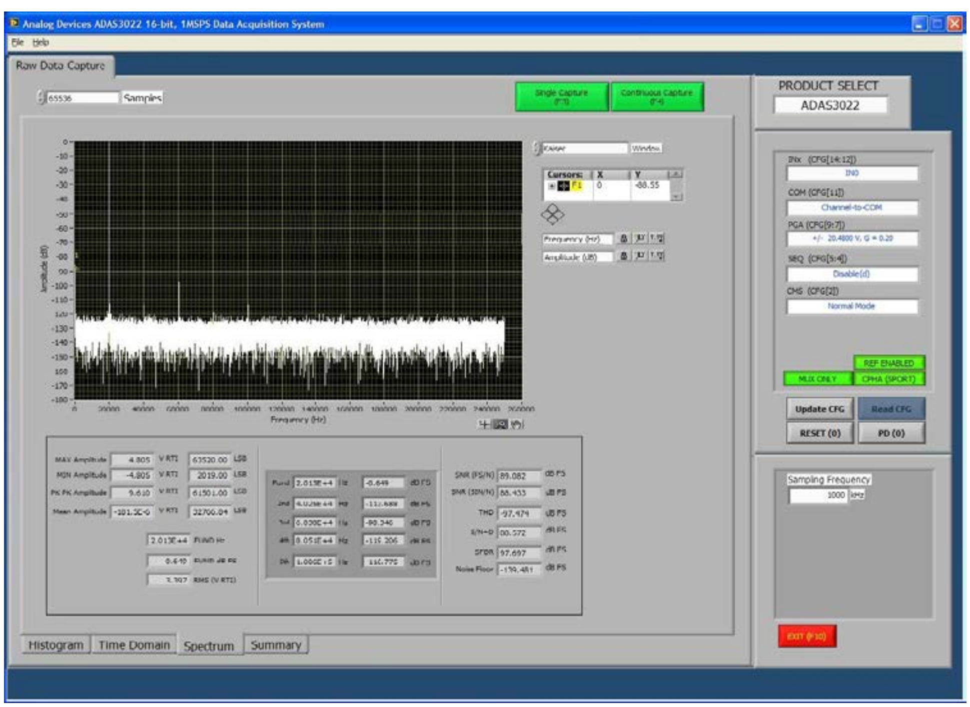

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Figure 3. FFT Output of the ADAS3022 Using the EVAL-CED1Z Evaluation Board and Software

The EVAL-CED1Z board is a platform intended for use in evaluation, demonstration, and development of systems using Analog Devices precision converters. It provides the necessary communications between the converter and the PC, programming or controlling the device, and transmitting or receiving data over a USB link.

Equipment Required

The following equipment is required:

- The ADAS circuit evaluation board and software (EVAL-ADAS3022EDZ)
- The converter evaluation and development board (EVAL-CED1Z)
- The ADP1613 evaluation board from ADIsimPower
- Audio Precision SYS-2702
- PC/laptop (Windows 32-bit or 64-bit)
- USB interface Cable (1) and AP cable (1)
- 7 V at 2 A dc wall wart supply for EVAL-CED1Z board.
- 5 V at 100 mA dc power supply for ADP1613 evaluation board.

Functional Block Diagram

A functional block diagram of the test setup is shown in Figure 4. The ADP1613 evaluation board is driven with an external +5 V supply to generate the ±15 V required by the ADAS3022 board. A 7 V dc wall wart supplies the EVAL-CED1Z board. The 5 V required by the ADAS3022 board is supplied by regulators on the EVAL-CED1Z board. An Audio Precision SYS-2702 is used to generate a low distortion input signal when running ac tests.

Software Installation

The ADAS3022 evaluation kit includes self-installing software on a CD. The software is compatible with Windows XP and Windows 7 (32-bit and 64-bit). If the setup file does not run automatically, run the **setup.exe** file from the CD.

To install the software, take the following steps:

1. Install the evaluation software before connecting the ADAS3022 evaluation board and EVAL-CED1Z board to the USB port of the PC to ensure that the evaluation system is correctly recognized when connected to the PC.
2. After installation from the CD is complete, connect the EVAL-CED1Z board to the ADAS3022 evaluation board and power up the EVAL-CED1Z as described in the Power Supplies section of UG-484 and then to the USB port of the PC using the supplied cable.
3. When the evaluation system is detected, proceed through any dialog boxes that appear. This completes the installation.

The software allows the collection and processing of FFT data as previously shown in Figure 3. Refer to the UG-484 User Guide for complete information on the EVAL-ADAS3022EDZ test setup.

For more details on the definitions and how to calculate the signal-to-noise ratio (SNR), total harmonic distortion (THD), and signal-to-(noise + distortion) ratio (SINAD), see the Terminology section of the ADAS3022 data sheet and the *Data Conversion Handbook*, "Testing Data Converters," Chapter 5, Analog Devices.

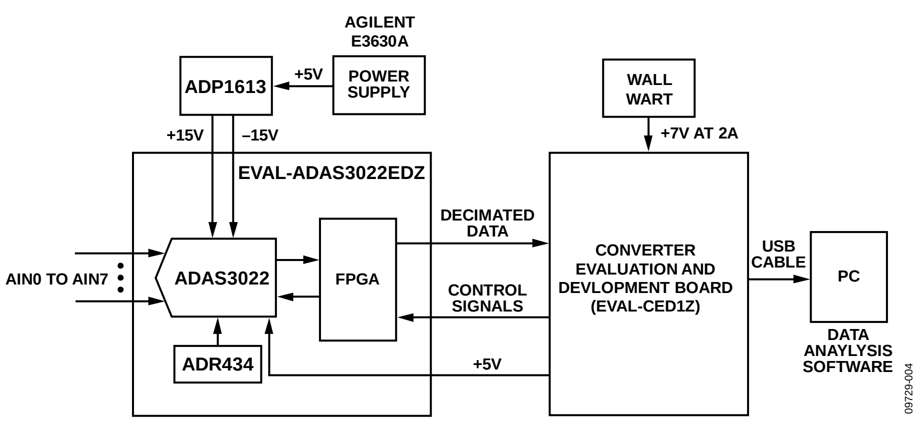

Figure 4. Test Setup Functional Block Diagram

LEARN MORE

CN-0201 Design Support Package: www.analog.com/CN0201-DesignSupport.

AN-1106 Application Note, *An Improved Topology for Creating Split Rails from a Single Input Voltage.*

CN-0105 Circuit Note, *Single-Ended-to-Differential High Speed Drive Circuit for 16-Bit, 10 MSPS AD7626 ADC.*

CN-0237 Circuit Note, *Ultralow Power, 18-Bit, Differential PulSAR ADC Driver.*

Kester, Walt. 2005. The Data Conversion Handbook. Analog Devices. Chapter 3, Chapter 5, and Chapter 7.

MT-021 Tutorial, *ADC Architectures II: Successive Approximation ADCs.* Analog Devices.

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

MT-035 Tutorial, *Op Amp Inputs, Outputs, Single-Supply, and Rail-to-Rail Issues.* Analog Devices.

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

User Guide UG-484 for EVAL-ADAS3022EDZ.

Voltage Reference Wizard Design Tool.

Data Sheets and Evaluation Boards

ADAS3022 Data Sheet and Evaluation Board

ADP1613 Data Sheet

ADR434 Data Sheet

AD8031 Data Sheet

REVISION HISTORY

8/13—Rev. A to Rev. B

4/13—Rev. 0 to Rev. A

10/12—Revision 0: Initial Version

CN09729-0-8/13(B)