ANALOG DEVICES

Circuit Note
CN-0175

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Devices Connected/Referenced	
AD7607	8-Channel DAS with 14-Bit, Bipolar Input, Simultaneous Sampling ADC
ADR421	Precision, Low Noise, 2.500 V XFET® Voltage Reference

A Low Cost, 8-Channel, Simultaneously Sampled, Data Acquisition System with 84 dB SNR and Excellent Channel-to-Channel Matching

CIRCUIT FUNCTION AND BENEFITS

Cost sensitive, high channel count applications that require wide dynamic range can effectively use the AD7607 8-channel integrated data acquisition system (DAS) with on-chip 14-bit SAR ADCs to achieve greater than 80 dB dynamic range.

A typical application for the DAS is in power-line measurement and protection equipment, where large numbers of current and voltage channels of multiphase distribution and transmission networks must be sampled simultaneously.

Many low voltage power-line measurement and protection systems do not require full 16-bit ADC resolution (such as provided by the AD7606 DAS); however, they still require more than 80 dB dynamic range to capture the under- and over-voltage/current conditions. Simultaneous sampling is also needed to maintain the phase information between the current and voltage channels on a multiphase power line.

The AD7607 8-Channel DAS with 14-Bit, bipolar input, simultaneous sampling SAR ADC has 84 dB signal-to-noise ratio (SNR) to meet the requirements for these types of low voltage protection and measurement systems. The circuit shown in Figure 1 also uses an external ADR421 precision, low drift, low noise reference for high channel count applications that require absolute accuracy performance.

CIRCUIT DESCRIPTION

The AD7607 is an integrated data acquisition system with input amplifiers, overvoltage protection, analog antialiasing filter, 14-bit SAR ADC, and a digital filter all included on chip. This circuit consists of the AD7607 in conjunction with the ADR421 2.5 V reference. Symmetrical layout around the analog input channels and device decoupling is critical for good channel-to-channel matching.

The following section outlines the recommended layout for the AD7607 and ADR421 to achieve excellent channel-to-channel matching as well as 84 dB SNR performance.

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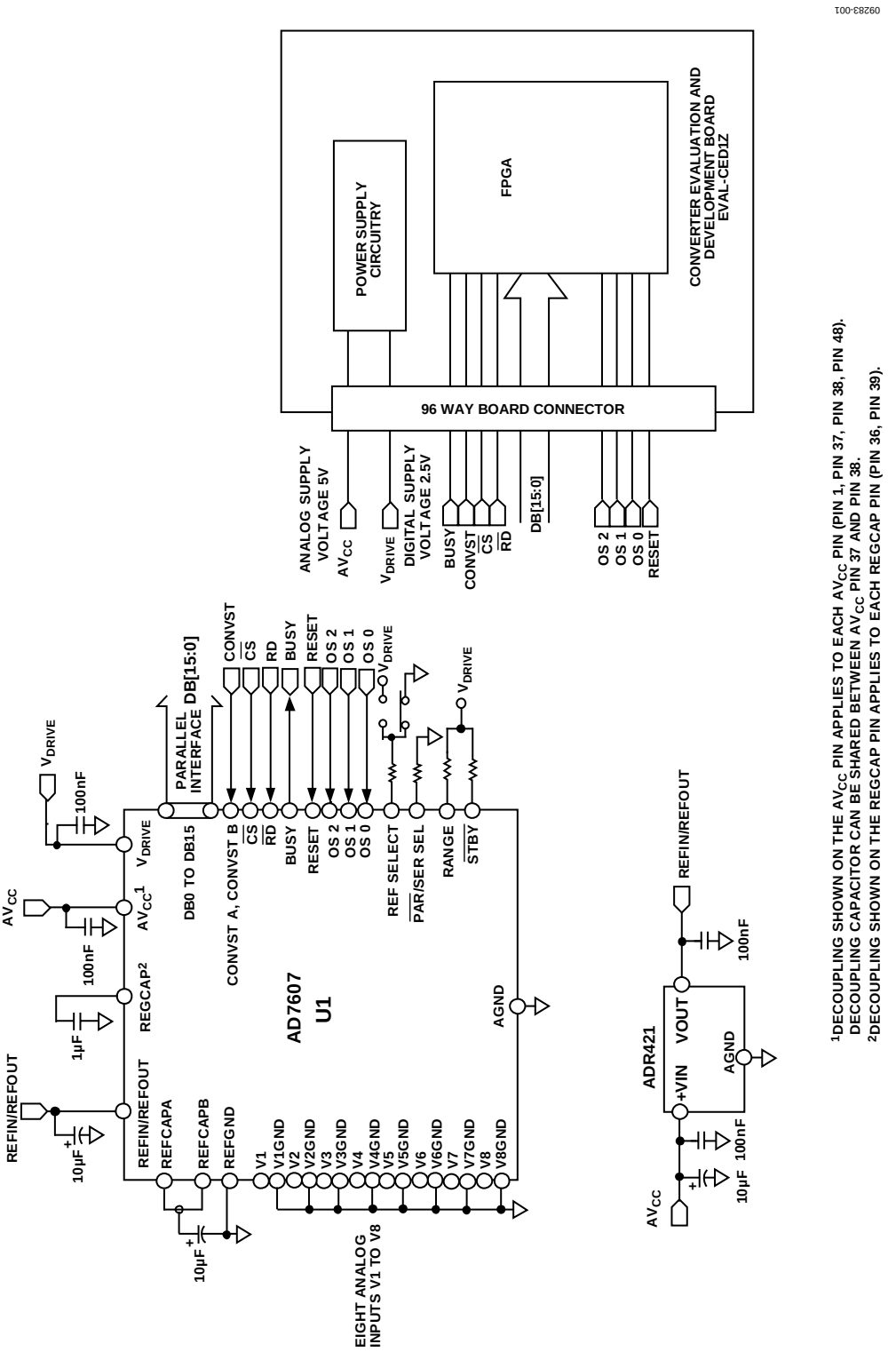

Figure 1. Low Cost, 8-Channel, Simultaneously Sampled, Data Acquisition System (Simplified Schematic: All Connections and Decoupling Not Shown)

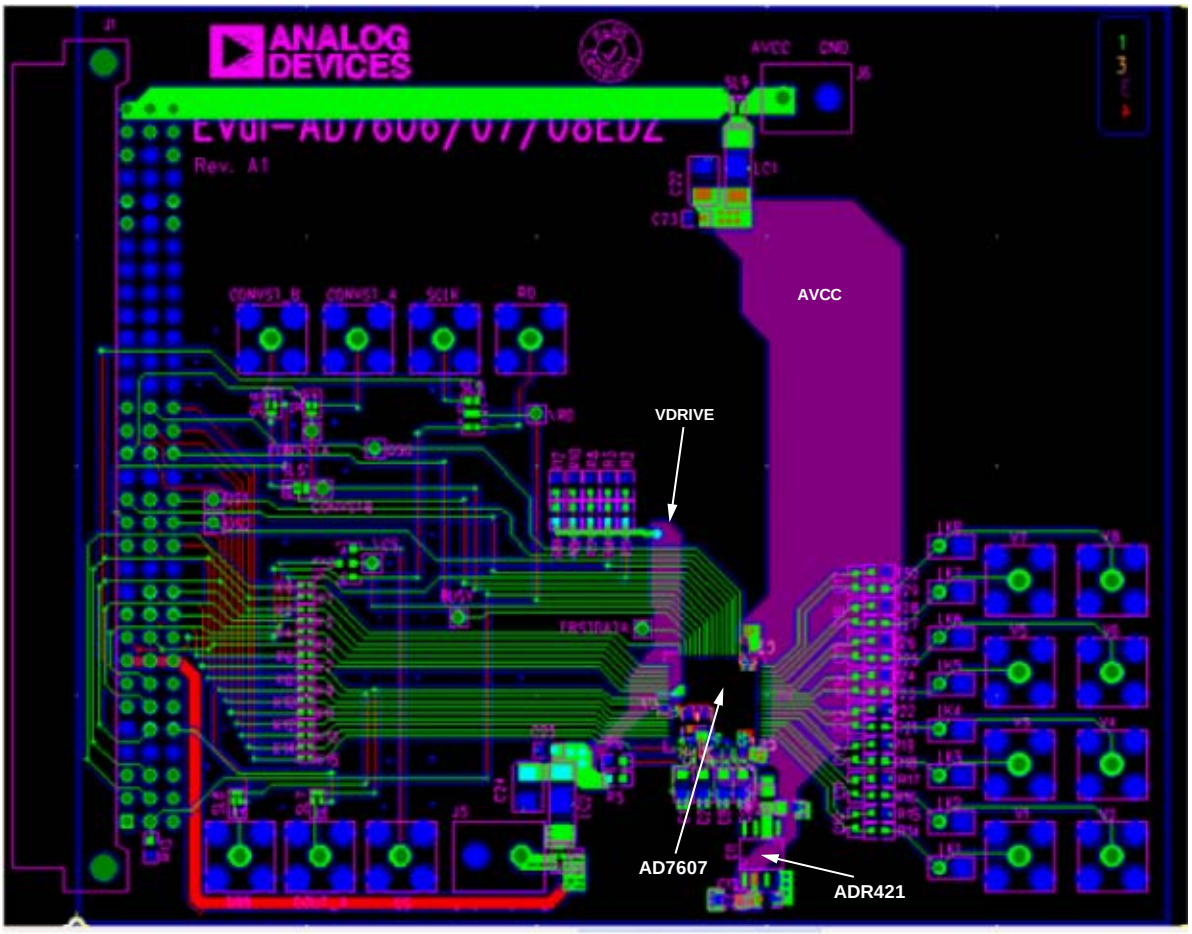

Figure 2. PCB Layout Showing the AD7607 DAS and ADR421 Reference

AD7607 Evaluation Board Layout

To ensure good channel-to-channel matching, a symmetrical layout of the analog input channels is important. In a system that contains multiple AD7607 devices, to ensure good device-to-device performance matching, a symmetrical layout between the AD7607 devices is important.

Figure 2 shows an optimum board layout of the AD7607 and the ADR421. The AVCC supply plane runs to the right of the AD7607. The VDRIVE supply track runs to the left of the AD7607. The ADR421 reference is positioned to the south of the AD7607. A solid ground plane layer is used.

These symmetrical layout principles should also be applied to a system that contains multiple AD7607 devices. The AD7607 devices should be placed in a north-south direction with the reference voltage located midway between the AD7607 devices, and running in the north-south direction similar to Figure 2. Details of a system using multiple AD7606 (16-bit 8-channel DAS) devices can be found in Circuit Note CN-0148.

Good decoupling is also important to lower the supply impedance presented to the AD7607 and to reduce the magnitude of the supply spikes. The decoupling capacitors should be placed as close as possible to the DUT power pins and their corresponding ground pins. The decoupling capacitors for the REFIN/REFOUT pin and the REFCAPA and REFCAPB pins are also critical decoupling capacitors and should be placed as close as possible to their respective AD7607 pins and, where possible, they should be placed on the same side of the board as the AD7607 device. Figure 3 shows the recommended decoupling on the top layer of the AD7607 board.

The four ceramic capacitors on the top layer of the board are the decoupling caps for REFIN/REFOUT pin and the REFCAPA and REFCAPB pins. These capacitors are placed in a north-south direction to get as close to their respective pins as possible. Figure 4shows the bottom layer decoupling which is used for the four AV_{CC} pins and the V_{DRIVE} pin. Multiple vias are used to connect the pins to their respective decoupling capacitors. Symmetrical layout of the decoupling capacitors around the AD7607 devices helps with part-to-part performance matching. Multiple vias are used to connect capacitor pads and pin pads to ground and supply planes and the reference track.

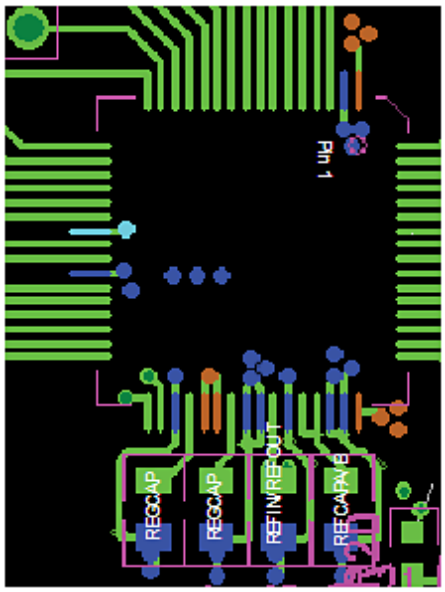

Figure 3. Top Layer Decoupling

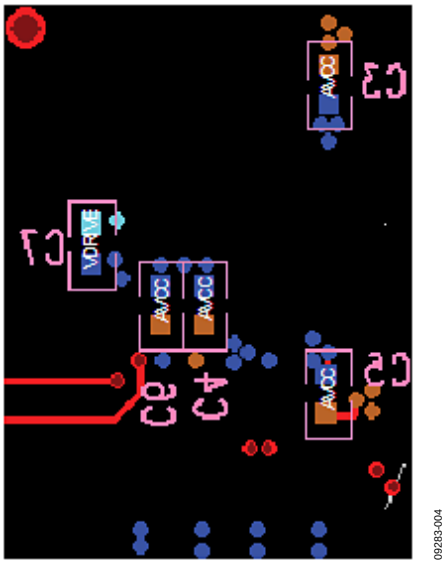

Figure 4. Bottom Layer Decoupling

Channel-to-Channel Matching

In a high channel count system, good channel-to-channel and part-to-part performance matching greatly simplifies calibration routines. Symmetrical layout of the AD7607 devices, the analog input channels, and the decoupling capacitors aids performance matching between multiple devices. The use of a common system reference further enhances matching performance in the system. Figure 5 shows the matching measured for the eight channels on the board when all inputs are grounded. There is a maximum histogram spread of three codes, with each channel histogram centered on Code 1.

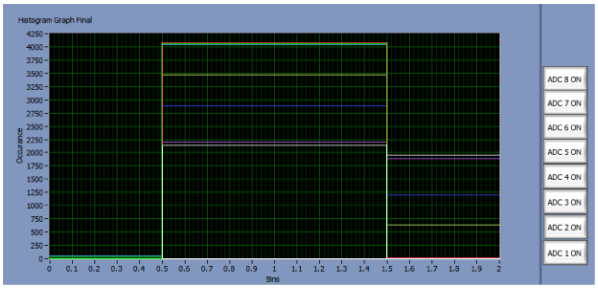

Figure 5. Histogram for Eight Channels with Inputs Grounded

AC Performance

In this circuit, the AD7607 is configured to operate in the external reference mode. The ADR421 provides the 2.5 V reference to the REFIN/REFOUT pin of the AD7607. A 1 kHz signal is applied to Channel 1 of the AD7607. The AD7607 is configured for the ±5 V input range. Sampling at 200 kSPS on all eight channels, the AD7607 achieves 84.12 dB SNR. This performance equates to approximately 13.7 effective number of bits (ENOB), where ENOB = (SNR − 1.76 dB)/6.02.

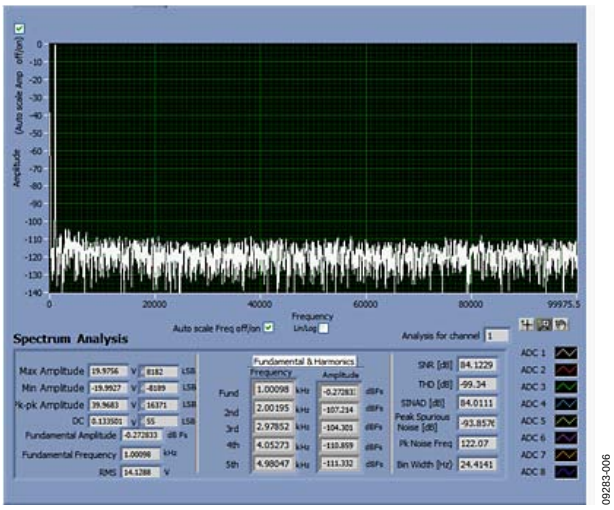

Figure 6. FFT Showing SNR of 84.12 dB, Input = 1 kHz, fs = 200 kSPS

To further increase the SNR performance and increase the ENOB of the system, the AD7607 is configured to operate in an 8× oversampling mode. In this mode, the SNR increases to 85.25 dB, therefore increasing the effective number of bits to 13.9 bits. When using the AD7607 in an 8× oversampling mode, the throughput rate on each channel is reduced to 25 kSPS.

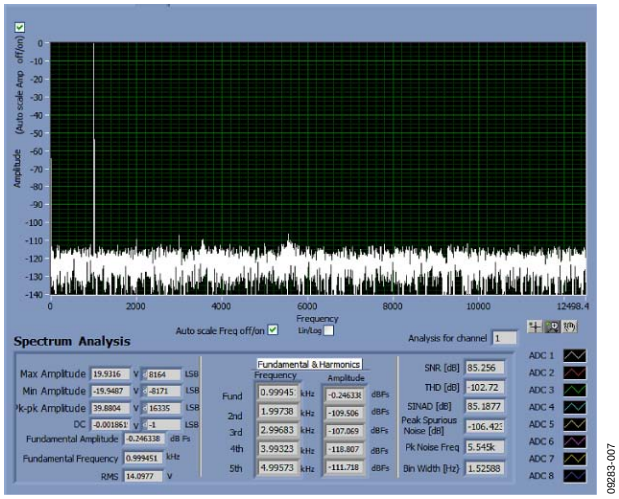

Figure 7. FFT Showing 85.26 dB SNR with Oversampling-by-8 and fs = 25 kSPS

The layout suggested above ensures good channel-to-channel matching on a single AD7607 and also good part-to-part matching between multiple AD7607s on the same PCB board. The AD7607 and ADR421 achieve 84 dB SNR, satisfying the need for greater than 80 dB dynamic range for low voltage protection and measurement applications in substation automation equipment.

COMMON VARIATIONS

The AD7607 is an 8-channel, 14-bit DAS. Also available are the AD7606-6 (6-channel, 16-bit DAS) and AD7606-4 (4-channel, 16-bit DAS). The AD7608 is an 8-channel 18-bit DAS.

Alternate voltage references can be chosen using the Voltage Reference Selection and Evaluation Tool.

For more details on layout and performance issues involving multiple AD7606 16-bit devices on the same board, see Circuit Note CN-0148.

LEARN MORE

MT-021 Tutorial, *Successive Approximation ADCs.* Analog Devices.

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

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

Voltage Reference Selection and Evaluation Tool. Analog Devices.

Data Sheets and Evaluation Boards

AD7606

AD7606 Evaluation Board

AD7607

AD7607 Evaluation Board

AD7608

AD7608 Evaluation Board

EVAL-CED1Z Converter Evaluation and Development Board

ADR421

REVISION HISTORY

11/10—Revision 0: Initial Version