Analog Engineer's Circuit

Digitally-Isolated ADS8689 Circuit Design

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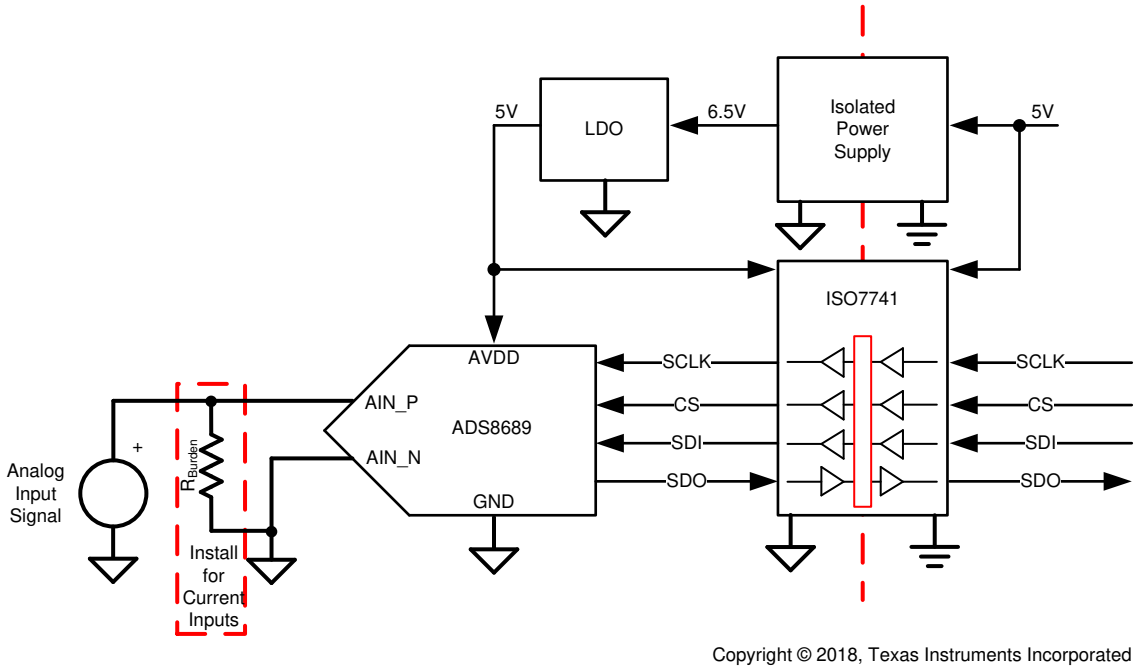
Input	ADC Input	Digital Output ADS7042
VinMin = –12.288V	AIN_P = –12.288V, AIN_N = 0V	8000_H or -32768_{10}
VinMax = 12.288V	AIN_P = 12.288V, AIN_N = 0V	$7FFF_H$ or 32767_{10}

Power Supplies		
AVDD	**Vee**	**Vdd**
5V	6.5V	5V

Design Description

This design shows a digitally isolated high-voltage SAR ADC that is capable of full AC performance at maximum throughput. This design is intended for channel-to-channel isolated analog input modules as well as measuring a signal with a very large common mode. Programmable logic controller, analog input modules, and many 4- to 20-mA signal applications benefit from this design. See *Isolated Power Supply Low-Noise, 5V, 100mA* for details on the isolated power supply design for these applications. This cookbook includes links to design files.

This circuit implementation is applicable in applications such as *Analog Input Modules*, *Electrocardiogram (ECG)*, *Pulse Oximeter*, and *Bedside Patient Monitors*.



Specifications

Specification	Calculated	Measured
SCLK Frequency	6.66MHz	6.67MHz
Sampling Rate	100ksps	100ksps
Signal-to-Noise Ratio (SNR)	92dB	Min: 92.29dB Max: 92.46dB
Total Harmonic Distortion (THD)	–112dB	Min: –108.8dB Max: –111.38dB

Design Notes

1. Select a SAR ADC that meets the input voltage range, sampling rate, and resolution for the system. This is covered in the *component selection* section.
2. Select a digital isolator that allows for the required isolation specification as well as the correct number of channels and channel directions. This is covered in the *component selection* section.
3. Install the burden resistor for current inputs. This design removes any common mode limitation of the inputs due to the channel-to-channel isolation. Select the burden resistor so that the maximum current input stays within the full scale range of the SAR ADC.

Component Selection

1. Select a SAR ADC that meets the input voltage range, sampling rate, and resolution for the system:
   - Desired input range: ±12V
   - Desired effective number of bits (ENOB): 14 bits
   - Desired sampling rate: 100ksps
   - ADS8689 input range: ±12.228V
   - ADS8689 ENOB: 14.8 bits
   - ADS8689 maximum sampling rate: 100ksps

   Note

   There is a wide selection of TI SAR ADCs that match the specifications in the previous list.
2. Select a digital isolator that allows for the required isolation specification as well as the correct number of bidirectional channels:
   - TI offers digital isolators with isolation rating ranging from 2.5kV_{RMS} to 5.7kV_{RMS}.
   - Choose isolation ratings based on the system requirements.
   - For a standard SPI interface, the digital isolator needs to be 4-channels with 3 channels in the same direction and 1 channel in the opposite direction.
   - The ISO774x is a digital isolator family for 4-channel devices with all combinations of channel directions and the ability to select a 2.5kV_{RMS} or a 5.0kV_{RMS} isolation rating.
3. Understand the expected delays to the digital signal from the digital isolator:
   - The ISO7741 has a typical propagation delay of 10.7ns with a maximum of 16ns.
   - Round trip isolation delay is 21.4ns typical or 32ns maximum.
   - SCLK is running at 6.66MHz resulting in a period of 150ns.
   - The typical round trip delay is 14% of the SCLK period.
   - The maximum round trip delay is 21% of the SCLK period.

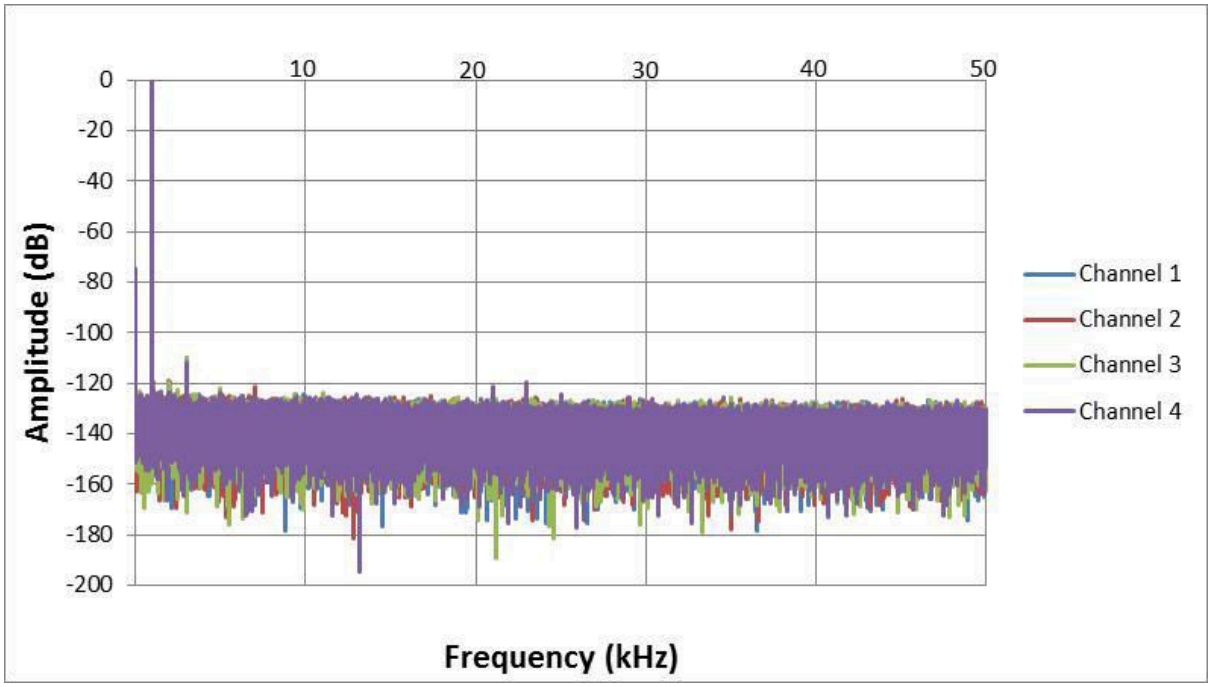
   Note

   The delay from the isolator results in a delay between the optimal SDO read relative to SCLK and the actual SDO read. This delay can be adjusted for by adding an SCLK return signal that travels through the digital isolator to all for the SDO to be read at exactly the correct time. Adding a return clock requires another channel of isolation.

Measured FFT

This performance was measured on a custom 4-channel, channel-to-channel isolated ADS8689 PCB. The input signal is a 24Vpp, 1-kHz sine wave. The AC performance indicates minimum SNR = 92.2dB and minimum THD = –108.8dB, which matches well with the specified performance of the ADC of SNR = 92dB and THD = –112dB.

Channel	SNR(dB)	THD (dB)
1	92.29	–109.95
2	92.38	–108.82
3	92.46	–109.53
4	92.42	–111.38



TVS Diode Performance Degradation

A 14-V bidirectional TVS diode was used in this design to protect the input of the SAR ADC. The TVS diode actually degrades total harmonic distortion (THD) due to the added capacitance. The THD was seen to be around 6dB worse with the TVS diode installed versus uninstalled.

Design Featured Devices

Device	Key Features	Link	Similar Devices
ADS8689 (1)	16 bit resolution, SPI, 100-ksps sample rate, single-ended input, and ±12.288-V input range.	16-Bit, 100-kSPS, 1-Ch SAR ADC with programmable (±12/±10/±6/±5/±2.5V) input ranges on +5V supply	Precision ADCs
ISO7741 (2)	High-speed, robust-EMC reinforced quad-channel digital isolator	Robust EMC, quad-channel, 3/1, reinforced digital isolator	Isolation

(1) The ADS8689 has in internal attenuator and programmable gain amplifier that allows for a wide input voltage range.
(2) The ISO7741 is used to isolate the digital input signals.

Link to Key Files

Texas Instruments, Source files for SBAA269, software support.

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision A (March 2019) to Revision B (September 2024)	Page
• Updated the format for tables, figures, and cross-references throughout the document	1

Changes from Revision * (February 2018) to Revision A (March 2019)	Page
• Downstyle the title and changed title role to 'Data Converters'. Added link to circuit cookbook landing page	1

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