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Filter - Analog-to-Digital Converter Card

Description

The Filter-ADC board is a 15-channel, 16-bit high-speed converter that accepts analog input voltages in the range of ±2.5V. Through careful design and using the latest true-differential, charge-distribution, successive-approximation converters, the ADC achieves unprecedented performance and low-power consumption. Each unit is tested to confirm its 10 ppm linearity and sampling standard-deviation of less than 0.5 samples rms.

Each of the 15 input channels has an 8-pole Butterworth low-pass filter. The cut-off frequency is set to 98 Hz and 6 Hz for fast and slow channels respectively. These values guarantee that there is no aliasing of signals for the standard sampling rate of 512 per second for fast channels and 32 samples per second for slow channels. Other cut-off frequencies are available by request. Channel 0 (the 16^{th} addressable channel) always samples the analog ground and does not have a filter.

The Filter ADC board is designed to work with the other analog and digital boards available from RSI. Analog input voltages are applied via a 20-pin ribbon cable connector (the Analog Bus) and digital signals are transferred in and out via a 14-pin ribbon connector (the Serial Instrument Bus).

A programmable logic chip continually monitors requests for data on the Serial Instrument Bus, selects the requested channel, controls the conversion process and presents the digital result to the Instrument Bus. The base address of the ADC board is set with 4 jumpers and can be set to any value between 0 and 240 in steps of 16. Up to 16 ADC converters can be operated simultaneously for a total of 256 channels.

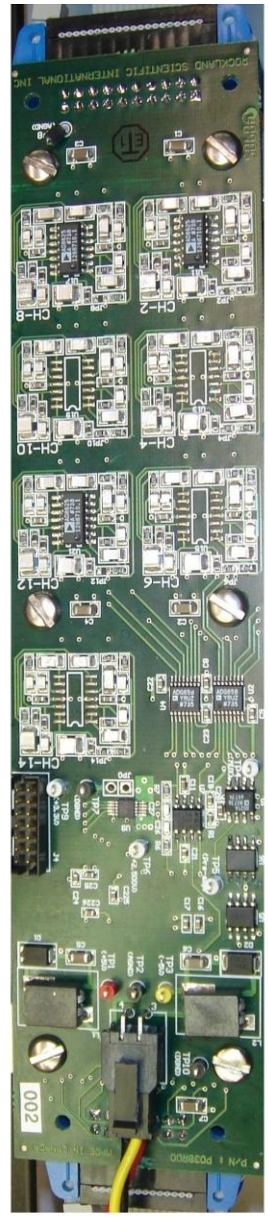
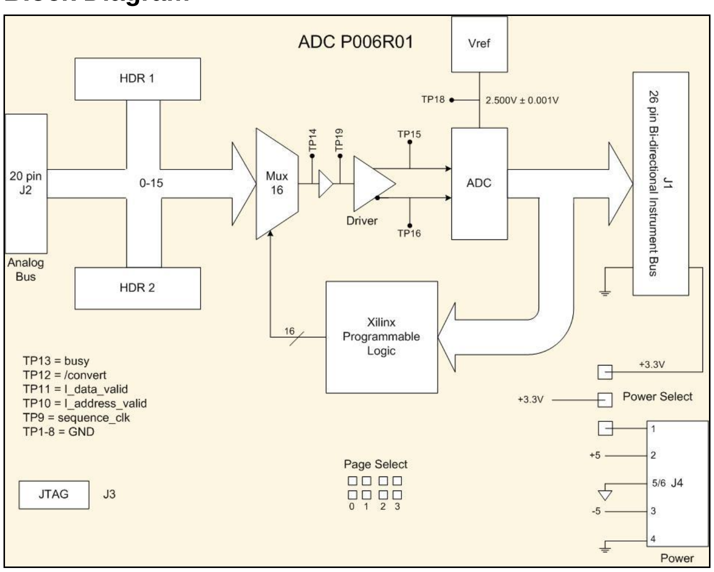


Figure 1. The Filter-AD Converter board.

Block Diagram



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Specifications

Input Range	±2.5V
Output Range	16 bits, no missing codes
Input Channels	16
Linearity	$10x\ 10^{-6}$
Sampling Standard Deviation	0.5 counts typical, 1.0 counts max.
Conversion Time	10 µs, full cycle, 2 µs on request
Filter Type	8-pole Butterworth
Filter cut-off	98 Hz for fast channels, 6 Hz for slow channels
Power	±5V DC, 3.3V DC
Current	±24 mA, 1mA
Dimensions	8.7 X 1.750 X 0.70 inches 221 X 45 X 18 mm

Performance Test Results

Each ADC is tested for linearity and sampling noise. Linearity is tested by sampling a “pure” sine wave with frequency of 5.000 Hz and 10 parts per million (ppm) harmonic distortion. This signal is generated by a SigLab 20-22 digital signal synthesizer. Spurious aliased signals may exist to 100 ppm but will not be at harmonic frequencies. Data are recorded on a single channel for 120 seconds and its spectrum is computed. Distortion is gauged by looking at exact harmonics of 5 Hz. The sample spectrum (Figure 2) shows that all harmonics are almost indistinguishable from the broad back-ground noise of the output from the signal generator. The harmonic at 10 Hz, is the strongest and probably generated by the signal source rather than the AD converter. The worst case linearity is derived by assuming that the 1st harmonic is generated by the converter. In this case, the linearity of the converter is at least

$$D = \sqrt{\frac{0.13}{1.8\times10^{9}}} = 8\times10^{-6}\,.$$

Signals that are exact harmonics (marked with red triangles) are due to the distortion of the AD Converter or the signal source itself. These are summarized in the inset table within Figure 2.

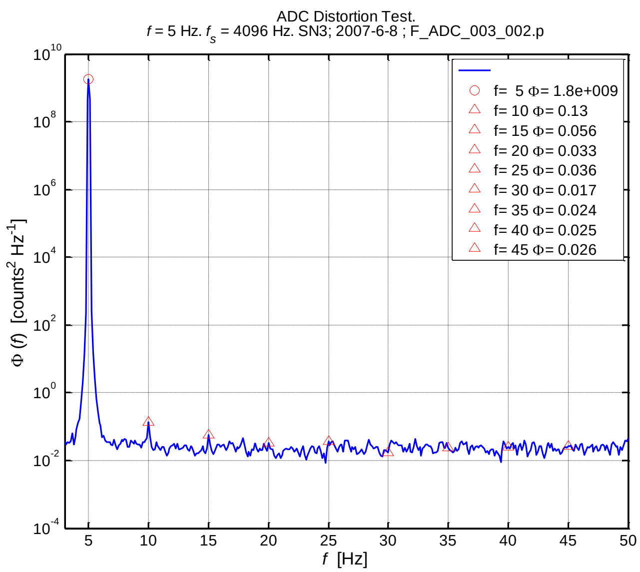

Figure 2. Spectrum of a 5000 Hz, nearly-pure sign wave generated by a SigLab digital synthesizer. Exact harmonics are marked by red triangles and the fundamental is marked by a circle.

Sampling Noise

The sampling or quantization noise of an ideal AD Converter is

$$\sqrt{\frac{1}{12}} = 0.29 \text{ counts}.$$

The spectral level of this quantization noise is

$$\frac{1}{12 f_N}$$

where f_N is the Nyquist frequency of the sampling. For the noise spectrum shown in Figure 3, the Nyquist frequency is 2048 Hz. Therefore, the ideal spectral level is 0.41×10^{-4}. The observed noise variance is only 2 times higher and corresponds to a sample standard deviation of 0.36 counts rms.

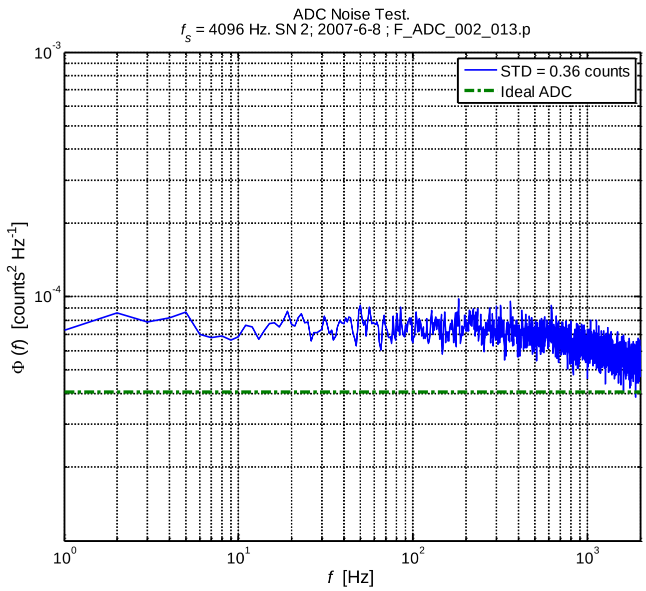

Figure 3. Spectrum of sampling noise with AD Converter input shorted to ground. Similar results are obtained when the source is a 1.5V battery.

Dimensional Information

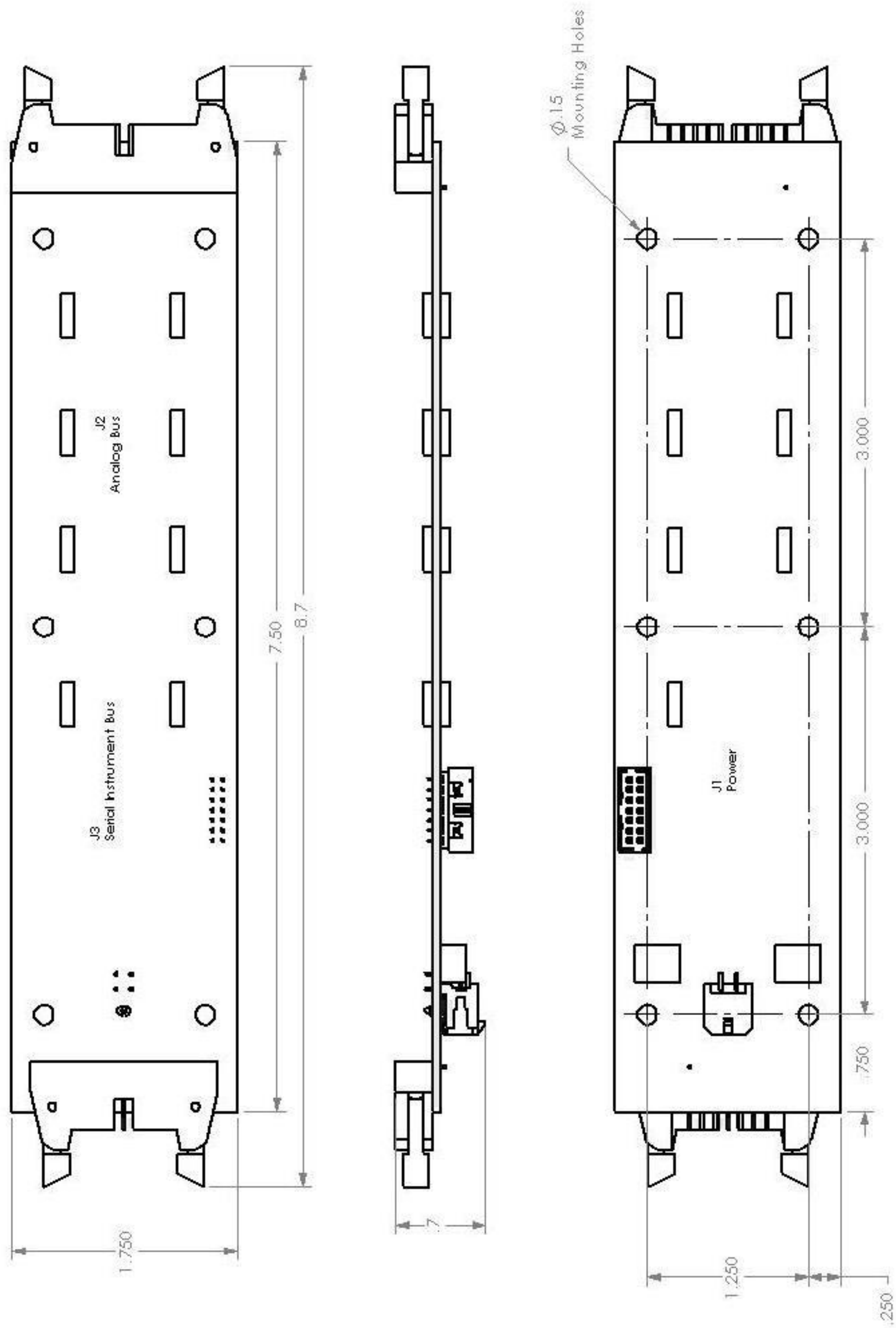

Figure 4. Outline of the Filter-ADC board.

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Connector List

J3 3 Serial Instrument Bus, IDC 0.1”		J2 Analog Bus, IDC 0.1”	
1	Ground	1	Channel 0
2	Seq_Clk +	2	Channel 1
3	Seq_Clk -	3	Channel 2
4	Ground	4	Channel 3
5	Add_Clk	5	Channel 4
6	Add_En	6	Channel 5
7	Add	7	Channel 6
8	Data_Rdy	8	Channel 7
9	Data_En	8	Channel 8
10	Data	9	Channel 9
11	Data_Clk	10	Channel 10
12	Ground	11	Channel 11
13	+3.3V DC	12	Channel 12
14	+3.3V DC	13	Channel 13
		15	Channel 14
		Ground	Channel 15
		Seq_Clk +	Analog Ground
		Seq_Clk -	Analog Ground
		Ground	Analog Ground
		20	Analog Ground

J1, Power Molex Micro-Fit 3”	
1	+5VDC
2	Analog Ground
3	-5VDC
4	NC

J4 JTAG	
2	+3.3VDC
4	TMS
6	TCK
8	TDO
10	TDI
12	NC
14	NC
1:2:13	Digital Ground