KAD/ADC/112

Differential ended ADC (3kHz b/w) - 24ch at 12ksps

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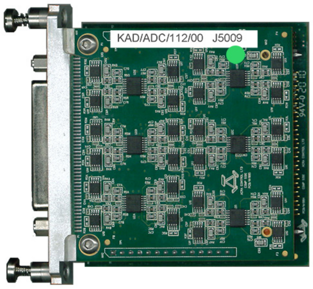

Key Features

- 24 differential ended input channels
- Ordering input range from ±100mV to ±40V
- High accuracy (0.01% FSR typical)
- High input resistance (>1MΩ) when on/off for /100mV, /1V, and /10V variant
- 16-bit simultaneous sampling on each channel

Applications

- Differential voltage measurement

Overview

The KAD/ADC/112 is used to condition and digitize up to 24 differential ended analog channels using a 16-bit A/D per channel. At the heart of the KAD/ADC/112 is a hard-wired state-machine that over-samples all channels at a rate between 48ksps and 96ksps and digitally filters any noise above the user-programmable cutoff frequency.

This is achieved using cascaded, half-band, finite-impulse-response (FIR) filters followed by an 8th order Butterworth IIR filter with a default cutoff point set at one quarter of the sampling frequency ($f_c = f_s / 4$). All signals are sampled simultaneously. Thus, when several channels are sampled at different sampling rates, at the start of an acquisition cycle all channels are aligned.

The KAD/ADC/112 is available with four different input ranges (±40V, ±10V, ±1V, ±100mV). The input range must be specified when ordering.

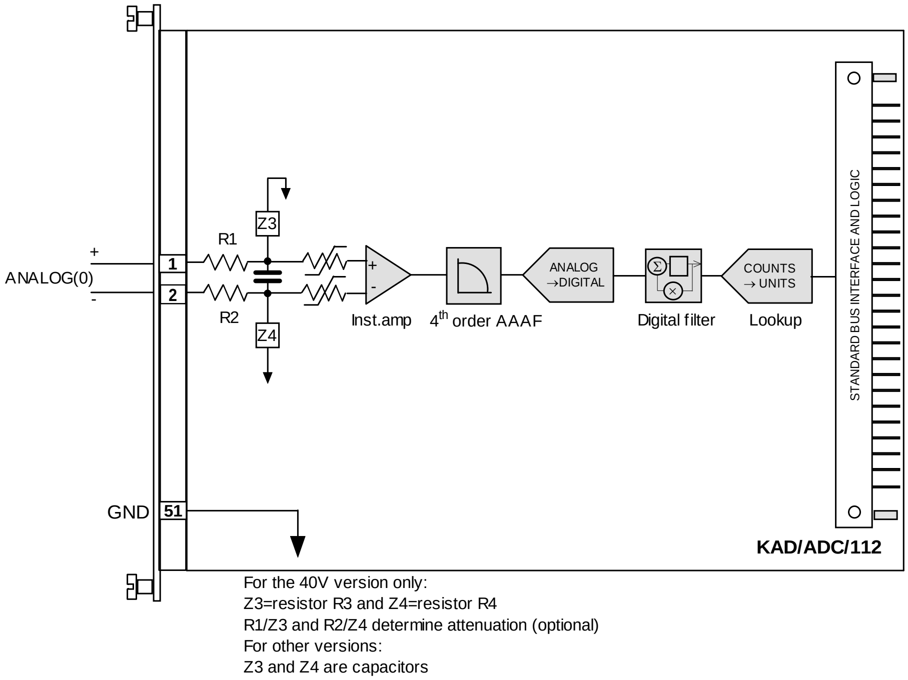

Figure 1: First of 24 channels on the KAD/ADC/112

Specifications

All values provided in the following specification tables are valid within the operating temperature range specified under "Environmental ratings" in the "General specifications" table. Module specifications are met for up to 97% of Full Scale Range (FSR).

TABLE 1	General specifications				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Slots	–	–	1	–	Can be placed in any user-slot in any combination.
Mass					
	–	86	–	g	
	–	3.03	–	oz	Design metric is grams.
Height above chassis					For recommended clearance requirements see the *CON/KAD/002/CP* data sheet.
bare connector	–	–	11	mm	
bare connector	–	–	0.43	in.	Design metric is millimeters.
Access rate	–	–	2	Msps	Maximum combined access rate for read and write.
Power consumption					
+5V	100	–	200	mA	
±7V	0	–	0	mA	
±12V	50	–	100	mA	
total power	1.7	–	3.4	W	Particular combinations of chassis and Acra KAM-500 modules may have power or current limitations. For details, see *TEC/NOT/016 - Power dissipation, TEC/NOT/049 - Power estimation*, and the relevant chassis data sheet.
Environmental ratings					See *Environmental Qualification Handbook*.
operating temperature	-40	–	85	°C	Chassis base/side plate temperature.
storage temperature	-55	–	105	°C	

TABLE 2	Differential ended analog inputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Inputs	–	–	24	–	
Sampling rate					While the sampling rate can be set individually, each must have a power of two times any other (¼, ½ ...2, 4).
Channel[23:0]	0.5	–	12,000	sps	
Input voltage					
operating range (KAD/ADC/112/40V)	-40	–	40	V	Primary gain = 0.25.
operating range (KAD/ADC/112/10V)	-10	–	10	V	Primary gain = 1.
operating range (KAD/ADC/112/1V)	-1	–	1	V	Primary gain = 10.
operating range (KAD/ADC/112/100M)	-100	–	100	mV	Primary gain = 100.
overvoltage protection	-40	–	40	V	Voltages outside of this range can damage input.

TABLE 2	Differential ended analog inputs (continued)				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
DC error					DC signal averaged over 200 samples without excitation.
gain = 1	–	0.01	0.05	%FSR	KAD/ADC/112/10V, KAD/ADC/112/1V.
gain = 2	–	0.02	0.08	%FSR	KAD/ADC/112/10V, KAD/ADC/112/1V.
gain = 4	–	0.04	0.14	%FSR	KAD/ADC/112/10V, KAD/ADC/112/1V.
gain = 8	–	0.08	0.25	%FSR	KAD/ADC/112/10V, KAD/ADC/112/1V.
gain = 1	–	0.02	0.08	%FSR	KAD/ADC/112/100M.
gain = 2	–	0.04	0.14	%FSR	KAD/ADC/112/100M.
gain = 4	–	0.08	0.25	%FSR	KAD/ADC/112/100M.
gain = 8	–	0.16	0.44	%FSR	KAD/ADC/112/100M.
gain = 1,2,4	–	0.05	0.35	%FSR	KAD/ADC/112/40V.
gain = 8	–	0.1	0.5	%FSR	KAD/ADC/112/40V.
AC gain error					
for 0Hz < $f_{in} \leq$ 300Hz	–	0.02	0.1	%FSR	Gain = 1, f_s = 12kHz, f_c = f_s / 4 (f_{in} : input signal frequency; f_s : sampling frequency; f_c : filter cutoff frequency).
for 300Hz < $f_{in} \leq$ 1kHz	–	0.1	0.2	%FSR	Gain = 1, f_s = 12kHz, f_c = f_s / 4.
for 1kHz < $f_{in} \leq$ 2kHz	–	0.2	0.6	%FSR	Gain = 1, f_s = 12kHz, f_c = f_s / 4.
Effective number of bits					
	11.5	13	–	bits	$f_c \leq$ 1kHz or $f_{in} \leq$ 0.5kHz. Secondary gain of 1.
	10.5	12	–	bits	f_c > 1kHz and f_{in} > 0.5kHz. Secondary gain of 1.
Crosstalk					
	–	-86	-74	dB	$f_{in} \leq$ 0.5kHz.
Common mode					
voltage range	-40	–	40	V	Operational voltage range (KAD/ADC/112/40V).
voltage range	-10	–	10	V	Operational voltage range (KAD/ADC/112/10V, KAD/ADC/112/1V, KAD/ADC/112/100M).
rejection ratio (KAD/ADC/112/40V)	62	70	–	dB	Applies within the above common mode voltage range, $0 \leq f \leq$ 100Hz.
rejection ratio (KAD/ADC/112/10V)	70	74	–	dB	Applies within the above common mode voltage range, $0 \leq f \leq$ 100Hz.
rejection ratio (KAD/ADC/112/1V)	80	90	–	dB	Applies within the above common mode voltage range, $0 \leq f \leq$ 100Hz.
rejection ratio (KAD/ADC/112/100M)	80	90	–	dB	Applies within the above common mode voltage range, $0 \leq f \leq$ 100Hz.
Analog filter					Analog filter is Butterworth.
poles	–	–	4	–	
filter cutoff -3dB	5.7	6	6.3	kHz	
Digital filter					Digital filter is Butterworth.
poles	–	–	8	–	
filter cutoff -3dB	0.25	–	16	f_s	The maximum value is limited to 3kHz.
0.1dB bandwidth	–	0.8	–	f_c	
aliasing to 0.1dB band	–	–	-72	dB	
aliasing to f_c	–	–	-74	dB	

TABLE 2	Differential ended analog inputs (continued)				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Filter delay	–	0.66	–	ms	Measured for $f_{in} = f_c$ = 3kHz (f_{in} : input signal frequency). See “Understanding filter delays” on page 6.
Input resistance					
between inputs	10	–	–	MΩ	Module powered off (KAD/ADC/112/10V, KAD/ADC/112/1V, KAD/ADC/112/100M).
between inputs	10	–	–	MΩ	Module powered on (KAD/ADC/112/10V, KAD/ADC/112/1V, KAD/ADC/112/100M).
each input to GND	10	–	–	MΩ	Module powered off (KAD/ADC/112/10V, KAD/ADC/112/1V, KAD/ADC/112/100M).
each input to GND	10	–	–	MΩ	Module powered on (KAD/ADC/112/10V, KAD/ADC/112/1V, KAD/ADC/112/100M).
between inputs	150	160	–	kΩ	Module powered off (KAD/ADC/112/40V).
between inputs	150	160	–	kΩ	Module powered on (KAD/ADC/112/40V).
each input to GND	75	80	–	kΩ	Module powered off (KAD/ADC/112/40V).
each input to GND	75	80	–	kΩ	Module powered on (KAD/ADC/112/40V).
Input impedance					
each input to ground	–	300	–	kΩ	Module powered on (measured at 3kHz; KAD/ADC/112/10V, KAD/ADC/112/1V, KAD/ADC/112/100M).
between inputs	–	300	–	kΩ	Module powered on (measured at 3kHz; KAD/ADC/112/10V, KAD/ADC/112/1V, KAD/ADC/112/100M).
each input to GND	–	80	–	kΩ	Module powered on (measured at 3kHz; KAD/ADC/112/40V).
between inputs	–	160	–	kΩ	Module powered on (measured at 3kHz; KAD/ADC/112/40V).

Setting up the KAD/ADC/112

All module setup can be defined in XML using XidML® schemas (see http://www.xidml.org).

Instrument settings

SETUP DATA	CHOICE	DEFAULT	NOTES
Manufacturer	-	-	-
Name	ACRA CONTROL	ACRA CONTROL	Name of manufacturer.
PartReference	KAD/ADC/112/10V	KAD/ADC/112/10V	The instrument part reference.
SerialNumber	AB1234	AB1234	Unique name for each module.
Channels	-	-	-
Analog(23:0) Analog Input	-	-	Settings for this channel.
Settings	-	-	-
Filter Cutoff	0.25 0.5 1 2 4 8 16	0.25	Required cutoff point for the filter is the chosen value multiplied by the user sampling frequency. 0.25 is recommended as any higher may lead to aliasing. 1 is the sampling rate.

Parameter definitions

NAME/DESCRIPTION	BASE UNIT	DATA FORMAT	BITS	REGISTER DEFINITION
Analog(23:0) Parameters				
Analog Analog signal data.	Volt	OffsetBinary	16	R[15:0]

Configurable parameters

Analog(23:0)

SETUP DATA	CHOICE	DEFAULT	NOTES
Range Maximum	-10 to 10	10	Range maximum for analog channel
Range Minimum	-10 to 10	-10	Range minimum for analog channel

NOTE: It is recommended that names are less than 20 characters, have no white space or contain any of the following five characters "/><\.

Getting the most from the KAD/ADC/112

Bias current return path

If the signal source is isolated with respect to the Acra KAM-500 (for example a battery), a common-mode resistance between the negative input and ground (GND) should be used to provide a return for bias currents and reduce common-mode noise pick-up. Because the bias currents are in the order of nA, resistors up to 10kΩ can be used. In most cases a short (0Ω) is recommended.

NOTE: The KAD/ADC/112/40V input divider provides a return path to GND, so no additional return path is required. The divider input series resistor for KAD/ADC/112/40V is the order of 60kΩ. It is still beneficial to provide an external return path to GND so that the crosstalk picked up by an external cable will be minimized.

Unused differential ended inputs

Unused inputs should not be left floating, as this may increase current consumption from the ±12V backplane lines. Floating inputs may cause the output voltage of the instrumentation amplifier to approach one of the supply rails, which causes increased quiescent currents within specific channel circuits. Each unused differential ended input should be shorted together within its pair or connected to GND.

NOTE: The KAD/ADC/112/40V input divider pulls both inputs to GND so the inputs can be left floating.

Understanding filter delays

The Acra KAM-500 uniquely samples all signals at the start of an acquisition cycle and at equal intervals of time thereafter. Signals sampled at the same sample rate will always be sampled at the same time independently of how they are stored or transmitted. (This has significant advantages for issues such as time correlation.) However, before signals are sampled they are filtered to remove noise components that might alias. The recommended cutoff point is one quarter the sampling frequency, as this results in the maximum filtering of aliasing frequencies.

The Acra KAM-500 filters signals using over-sampling signal processing techniques. Figure 2 shows a delay for an 8^{th} order filter where f_c = 1kHz. All filters cause a delay inversely proportional to the filter cutoff frequency (f_c), so to calculate the delay for other f_c values, multiply the delay by (1kHz / f_c). The frequency axis then needs to be rescaled to the new f_c by dividing the frequency values by (1kHz / f_c). For example, an 8^{th} order Butterworth filter with an f_c of 1kHz delays a 1kHz signal by 1ms; a filter with an f_c of 10Hz delays a 10Hz signal by 0.1s. The delay for IIR filters (for example Butterworth) varies with the input frequency.

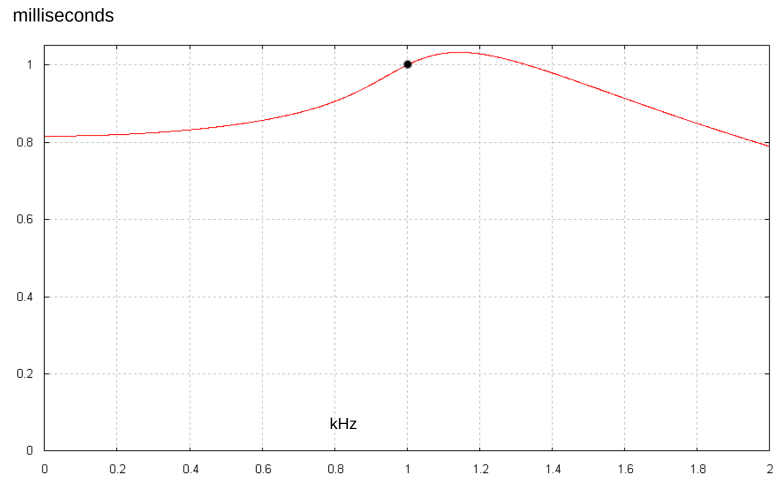

Figure 2: Filter delay for 8^{th} order Butterworth filter where f_c = 1kHz

The filter delay for the KAD/ADC/112 is:

$$T_D \approx T_A + \frac{1}{f_C} + T_{Butterworth8}(f)$$

T_D is the filter delay

T_A (analog filter delay) ≈ 0

Additional delay sources

Modelling an 8th order Butterworth filter with an IIR digital filter causes small phase and amplitude errors as shown in Figure 3 and Figure 4.

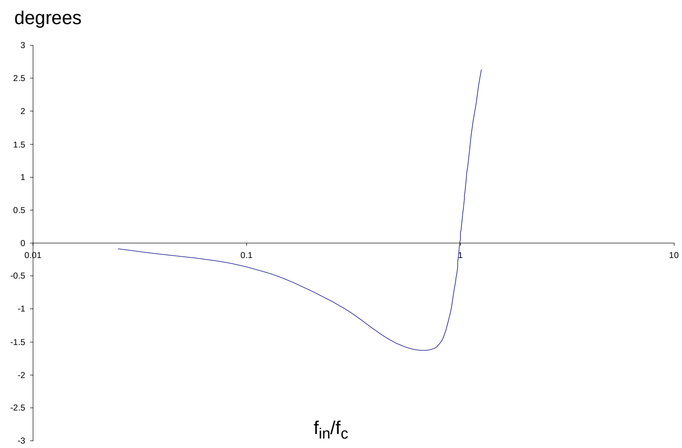

Figure 3: Delay error (ideal minus actual delay)

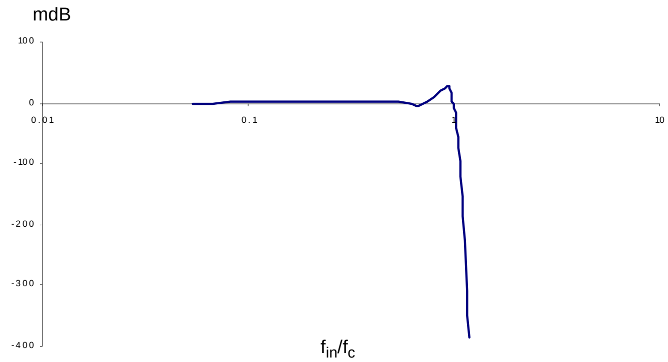

Figure 4: Amplitude error (ideal minus actual attenuation)

Connector pinout of the KAD/ADC/112

PIN	NAME	SEE SPECIFICATIONS TABLE	COMMENT
1	ANALOG(0)+	Differential ended analog inputs	Analog input
2	ANALOG(0)-	Differential ended analog inputs	Analog input
3	ANALOG(1)+	Differential ended analog inputs	Analog input
4	ANALOG(1)-	Differential ended analog inputs	Analog input
5	ANALOG(2)+	Differential ended analog inputs	Analog input
6	ANALOG(2)-	Differential ended analog inputs	Analog input
7	ANALOG(3)+	Differential ended analog inputs	Analog input
8	ANALOG(3)-	Differential ended analog inputs	Analog input
9	ANALOG(4)+	Differential ended analog inputs	Analog input
10	ANALOG(4)-	Differential ended analog inputs	Analog input
11	ANALOG(5)+	Differential ended analog inputs	Analog input
12	ANALOG(5)-	Differential ended analog inputs	Analog input
13	ANALOG(6)+	Differential ended analog inputs	Analog input
14	ANALOG(6)-	Differential ended analog inputs	Analog input
15	ANALOG(7)+	Differential ended analog inputs	Analog input
16	ANALOG(7)-	Differential ended analog inputs	Analog input
17	ANALOG(8)+	Differential ended analog inputs	Analog input
18	ANALOG(8)-	Differential ended analog inputs	Analog input
19	ANALOG(9)+	Differential ended analog inputs	Analog input
20	ANALOG(9)-	Differential ended analog inputs	Analog input
21	ANALOG(10)+	Differential ended analog inputs	Analog input
22	ANALOG(10)-	Differential ended analog inputs	Analog input
23	ANALOG(11)+	Differential ended analog inputs	Analog input
24	ANALOG(11)-	Differential ended analog inputs	Analog input
25	ANALOG(12)+	Differential ended analog inputs	Analog input
26	ANALOG(12)-	Differential ended analog inputs	Analog input
27	ANALOG(13)+	Differential ended analog inputs	Analog input
28	ANALOG(13)-	Differential ended analog inputs	Analog input
29	ANALOG(14)+	Differential ended analog inputs	Analog input
30	ANALOG(14)-	Differential ended analog inputs	Analog input
31	ANALOG(15)+	Differential ended analog inputs	Analog input
32	ANALOG(15)-	Differential ended analog inputs	Analog input
33	ANALOG(16)+	Differential ended analog inputs	Analog input
34	ANALOG(16)-	Differential ended analog inputs	Analog input
35	ANALOG(17)+	Differential ended analog inputs	Analog input
36	ANALOG(17)-	Differential ended analog inputs	Analog input
37	ANALOG(18)+	Differential ended analog inputs	Analog input
38	ANALOG(18)-	Differential ended analog inputs	Analog input
39	ANALOG(19)+	Differential ended analog inputs	Analog input
40	ANALOG(19)-	Differential ended analog inputs	Analog input
41	ANALOG(20)+	Differential ended analog inputs	Analog input
42	ANALOG(20)-	Differential ended analog inputs	Analog input
43	ANALOG(21)+	Differential ended analog inputs	Analog input
44	ANALOG(21)-	Differential ended analog inputs	Analog input
45	ANALOG(22)+	Differential ended analog inputs	Analog input
46	ANALOG(22)-	Differential ended analog inputs	Analog input
47	ANALOG(23)+	Differential ended analog inputs	Analog input
48	ANALOG(23)-	Differential ended analog inputs	Analog input
49	DNC		Do not connect
50	GND	Internal ground	
51	GND	Internal ground	
52	CHASSIS	Chassis	Double-density connector only

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Ordering information

PART NUMBER	DESCRIPTION
KAD/ADC/112/40V	Differential ended ADC (3kHz b/w, ±40V) - 24ch at 12ksps (52-way double-density module top connector)
KAD/ADC/112/10V	Differential ended ADC (3kHz b/w, ±10V) - 24ch at 12ksps (52-way double-density module top connector)
KAD/ADC/112/1V	Differential ended ADC (3kHz b/w, ±1V) - 24ch at 12ksps (52-way double-density module top connector)
KAD/ADC/112/100M	Differential ended ADC (3kHz b/w, ±100mV) - 24ch at 12ksps (52-way double-density module top connector)
KAM/ADC/112/40V	Differential ended ADC (3kHz b/w, ±40V) - 24ch at 12ksps (with 51-way micro-miniature module top connector)
KAM/ADC/112/10V	Differential ended ADC (3kHz b/w, ±10V) - 24ch at 12ksps (with 51-way micro-miniature module top connector)

By default, the standard mating connector (CON/KAD/002/CP for KAD modules; or ACC/CON/008/04 for KAM modules) is included with each module in the shipment. Its part number will be added to the Confirmation of Order unless an alternative option is specified (see the *Cables* data sheet). In this data sheet, KAD/ADC/112 refers to both the KAD and KAM version of the module.

Revision history

REVISION	DIFFERENCES	STATUS
KAD/ADC/112	First release	Recommended for new programs

Supporting software

SOFTWARE	DETAILS
DAS Studio 3	User interface for setup and management of data acquisition, network switches, recorders and ground stations in an integrated environment
KSM-500	These modules are supported by the KSM-500 suite of software tools

Related documentation

DOCUMENT	DETAILS
DOC/DBK/001	Acra KAM-500 Databook
DOC/HBK/002	Environmental Qualification Handbook
DOC/MAN/018	KSM-500 Databook
DOC/MAN/030	DAS Studio 3 User Manual
TEC/NOT/016	Power dissipation
TEC/NOT/049	Power estimation

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