KAD/ADC/106

Accelerometer ADC (current excitation, programmable analog gain, 6kHz b/w) - 6ch ICP and 2ch D/E at 24ksps

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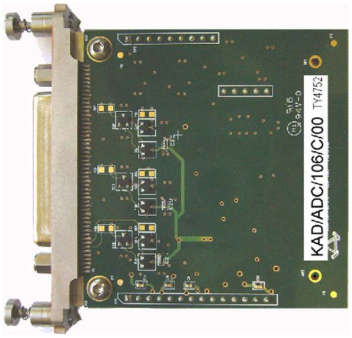


Key Features

- Six accelerometer input channels with DC reject and two differential ended input channels
- Accelerometer input programmable range (±1V, ±10V)
- Differential ended input programmable range (±10mV to ±10V)
- Constant current source excitation on each accelerometer input channel (3.6mA typical)
- Short on any channel does not affect others
- 16 bit simultaneous sampling on each channel

Applications

- Accelerometer signal conditioning/digitalization and differential voltage measurement

Overview

The KAD/ADC/106 is used to condition and digitize up to eight differential ended analog channels. Six of these channels have a constant current source and high-pass (DC-reject) filter for use with ICP accelerometer devices.

At the heart of the KAD/ADC/106 is a hard-wired state-machine that oversamples all channels at a rate between 96ksps and 192ksps 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 (isochronously). Thus, when several channels are sampled at different sampling rates, at the start of an acquisition cycle all channels are aligned.

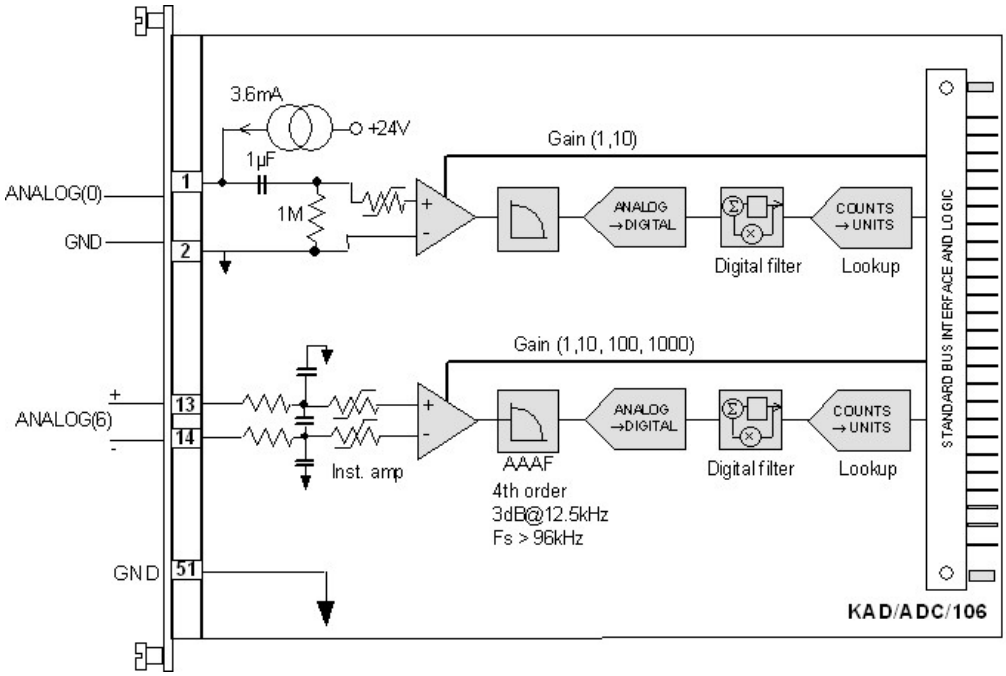


Figure 1: First of six accelerometer channels and first differential ended channel on the KAD/ADC/106

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					
	–	100	–	g	
	–	3.53	–	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	–	80	mA	Excludes current used by excitation. As a DC/DC converter is used, multiply excitation current by 1.5 to calculate +12V and -12V line currents.
total power	1.7	–	2.92	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	AC analog inputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Inputs	–	–	6	–	
Sampling rate					While the sampling rate can be set individually, each must have a power of two times any other (¼, ½ ...2, 4).
ANALOG[5:0]	2	–	24,000	sps	
Input voltage					
operating range (G_p = 1)	-10	–	10	V	Primary gain = 1.
operating range (G_p = 10)	-1	–	1	V	Primary gain = 10.
overvoltage protection	-40	–	40	V	Voltages outside of this range can damage input.

TABLE 2	AC analog inputs (continued)				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
AC gain error					
gain = 1, 2, 4, 8, 10, 20, 40, 80	–	–	0.4	%FSR	For $f_{in} < 0.6f_c$ and 10Hz < f_{in} < 2kHz, note that the first limitation is mostly due to the natural attenuation of the IIR digital filter. The second limitation is due to the attenuation of analog filters in the signal path (f_{in} : input signal frequency; f_c : filter cutoff frequency).
Effective number of bits					
gain = 1, 10	13	–	–	bits	$f_c \leq$ 2kHz and secondary gain of 1.
Crosstalk					
gain = 1, 10	–	-72	-60	dB	The maximum crosstalk value given here represents the worst case scenario for f_{in} close to 6kHz; the typical value is met below 3kHz.
Analog filter					Analog filter is Butterworth.
High pass filter					
poles	–	–	1	–	
filter cutoff -3dB	–	0.16	–	Hz	±15% error.
Anti aliasing filter					
poles	–	–	4	–	
filter cutoff -3dB	–	12.5	–	kHz	±15% error.
Digital filter					Digital filter is Butterworth.
poles	–	–	8	–	
filter cutoff -3dB	0.25	–	16	f_s	The maximum value is limited to 6kHz (f_s : sampling frequency).
0.1dB bandwidth	–	0.8	–	f_c	
aliasing to 0.1dB band	–	–	-72	dB	
aliasing to f_c	–	–	-74	dB	
Filter delay	–	0.33	–	ms	Where $f_{in} = f_c$ = 6kHz. See “Understanding filter delays” on page 8.
Input impedance					
each input to GND	0.8	1	–	MΩ	Module powered off (measured at 3kHz).
each input to GND	250	300	–	kΩ	Module powered on (measured at 3kHz).

TABLE 3	Differential ended analog inputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Inputs	–	–	2	–	
Sampling rate					While the sampling rate can be set individually, each must have a power of two times any other (¼, ½ ...2, 4).
ANALOG [7:6]	2	–	24000	sps	
Input voltage					
operating range (G_p = 1)	-10	–	10	V	Primary gain = 1.
operating range (G_p = 10)	-1	–	1	V	Primary gain = 10.
operating range (G_p = 100)	-100	–	100	mV	Primary gain = 100.
operating range (G_p = 1000)	-10	–	10	mV	Primary gain = 1000.
overvoltage protection	-40	–	40	V	Voltages outside of this range can damage input.
DC error					DC signal averaged over 200 samples without excitation.
gain = 1, 10, 100	–	–	0.08	%FSR	
gain = 2, 20, 200	–	–	0.14	%FSR	
gain = 4, 40, 400	–	–	0.25	%FSR	
gain = 8, 80, 800	–	–	0.44	%FSR	
gain = 1000	–	–	0.3	%FSR	
gain = 2000	–	–	0.6	%FSR	
gain = 4000	–	–	1.2	%FSR	
Effective number of bits					
gain = 1, 10	13.5	–	–	bits	$f_c \leq$ 2kHz and secondary gain of 1 (f_c : filter cutoff frequency).
gain = 100	11.3	–	–	bits	$f_c \leq$ 2kHz and secondary gain of 1.
gain = 1000	8	–	–	bits	$f_c \leq$ 1kHz and secondary gain of 1.
Crosstalk					
gain = 1, 10, 100	–	-72	-60	dB	The maximum crosstalk value given here represents the worst case scenario for f_{in} close to 6kHz; the typical value is met below 3kHz (f_{in} : input signal frequency).
gain = 1000	–	–	-45	dB	
Common mode					
voltage range	-10	–	10	V	Operational voltage range.
rejection ratio	50	–	–	dB	Applies within the above common mode voltage range, $0 \leq f \leq f_c$.
Analog filter					Analog filter is Butterworth.
poles	–	–	4	–	
filter cutoff -3dB	–	12.5	–	kHz	±15% error.

TABLE 3	Differential ended analog inputs (continued)				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Digital filter					Digital filter is Butterworth.
poles	–	–	8	–	
filter cutoff -3dB	0.25	–	16	f_s	The maximum value is limited to 6kHz (f_s : sampling frequency).
0.1dB bandwidth	–	0.8	–	f_c	
aliasing to 0.1dB band	–	–	-72	dB	
aliasing to f_c	–	–	-74	dB	
Filter delay	–	0.33	–	ms	Where $f_{in} = f_c = 6kHz$ (f_{in} : input signal frequency). See “Understanding filter delays” on page 8.
Input resistance					
between inputs	10	–	–	MΩ	Module powered off.
between inputs	10	–	–	MΩ	Module powered on.
each input to GND	10	–	–	MΩ	Module powered off.
each input to GND	10	–	–	MΩ	Module powered on.

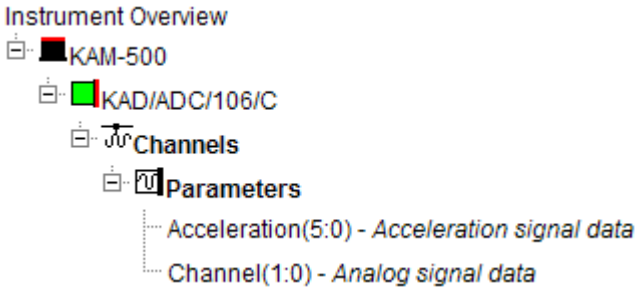
TABLE 4	Single ended DC current excitation outputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Outputs	–	–	6	–	Applied per channel.
Output current					
operating range	–	3.6	–	mA	
compliance	–	–	24	V	
short circuit current	–	–	4.9	mA	
short circuit duration	∞	–	–	s	
DC error					
error	–	–	1.6	mA	With a constant 2.2kΩ load.
noise	–	3	–	mV_{rms}	As measured on analog input.

Setting up the KAD/ADC/106

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

The following treeview provides an overview of setup configurations available for this module:

Treeview icons legend	
DAU: Data Acquisition Unit PC: Personal Computer Instrument: Any component or module used in a data acquisition system DataLink: Connection for transmitting or receiving (defines both the data link and the physical layer) Package: Used to describe how data is transmitted or stored Parameter: Any register that can be read from an instrument Algorithm: Defines processing to be performed on data InterConnect: Represents a physical connection on an instrument PCI card: Circuit board that plugs into the PCI bus on a PC	Indicator: Indicates the firing of an event based on specific conditions Parser slot: Area of memory reserved for storing parsed data Snarfer: Captures all data transmitted on a bus and selectively stores it Bridge: Electrical circuit usually used for measuring purposes PCMCIA card: Peripheral interface device usually for use in laptop computers Multiplexer: Selects one of many input signals and outputs that signal on a signal line Channels: Defines settings for input or output channels on an instrument



Setting up the module

The following table lists the setup configurations available for the KAD/ADC/106/C.

SETUP DATA	CHOICE	DEFAULT/EXAMPLE	NOTES
Manufacturer			-
Name	ACRA CONTROL	ACRA CONTROL	Name of manufacturer.
PartReference	KAD/ADC/106/C	KAD/ADC/106/C	ACRA CONTROL part number.
SerialNumber			Unique name for each module.
Settings	-	-	-
Module-Analog-In-1.2			-
Channel Acceleration(5:0)			Settings for this channel.
FilterCutoff	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.
Channel Channel(1:0)			Settings for this channel.
FilterCutoff	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.

Setting up parameters

Parameter definitions

The following table lists all parameters that are available for the KAD/ADC/106/C.

NAME/DESCRIPTION	BASE UNIT	DATA FORMAT	BITS	REGISTER DEFINITION
Acceleration(5:0) Acceleration signal data	Volt	OffsetBinary	16:4	R[15:0] 0000:FFFF (hex)
Channel(1:0) Analog signal data	Volt	OffsetBinary	16:4	R[15:0] 0000:FFFF (hex)

Programmable elements

Acceleration(5:0)

SETUP DATA	CHOICE	DEFAULT/EXAMPLE	NOTES
SizeInBits	16:4	16	R[15:0] 0000:FFFF (hex)
RangeMinimum	-10 to 10	-10	-
RangeMaximum	-10 to 10	10	-

Channel(1:0)

SETUP DATA	CHOICE	DEFAULT/EXAMPLE	NOTES
SizeInBits	16:4	16	R[15:0] 0000:FFFF (hex)
RangeMinimum	-10 to 10	-10	-
RangeMaximum	-10 to 10	10	-

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/106

Signal return path

For channels 0 to 5, each signal is single ended so a return (GND) for the constant current must be provided. Return path effects are minimized if a GND pin on the module is used. These channels are band-pass filtered (that is, the DC component is also removed) so that when a sensor is first connected or powered on, it takes about 60 seconds to settle.

Bias current return path

For channels 6 and 7, 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 nAs, resistors up to 10kΩ can be used. In most cases a short (0Ω) is recommended.

Using high primary gains

For gains above 1,000, the gain-bandwidth product of the amplifier reduces the bandwidth to 1,000 Hz.

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 are always 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 8th 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 8th 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.

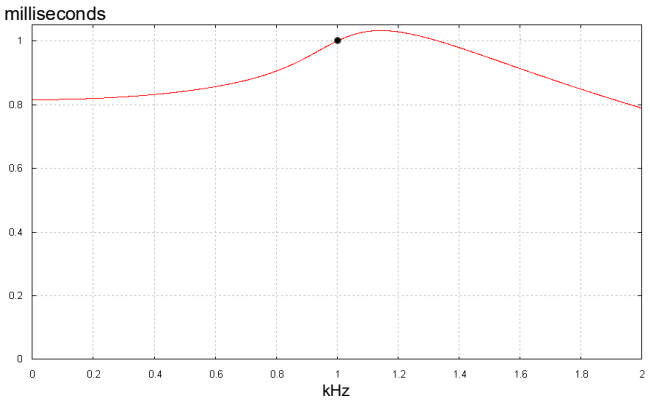


Figure 2: Filter delay for 8th order Butterworth filter where f_c = 1kHz

The filter delay for the KAD/ADC/106 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

f_c is the filter cutoff frequency.

Additional delay sources

Primary gains higher than 1 cause an additional delay from 1st order filters in the instrumentation amplifier. That additional delay is 2µs for a gain of 10, 15µs for a gain of 100, and 150µs for a gain of 1,000. In applications where time correlation is more important than suppression of aliasing, set the same cutoff point on all channels, even if the sampling rates are different.

Connector pinout of the KAD/ADC/106

PIN	NAME	SEE SPECIFICATIONS TABLE	COMMENT
1	ANALOG(0)	AC analog inputs	Constant current output
2	GND	Internal ground	
3	ANALOG(1)	AC analog inputs	Constant current output
4	GND	Internal ground	
5	ANALOG(2)	AC analog inputs	Constant current output
6	GND	Internal ground	
7	ANALOG(3)	AC analog inputs	Constant current output
8	GND	Internal ground	
9	ANALOG(4)	AC analog inputs	Constant current output
10	GND	Internal ground	
11	ANALOG(5)	AC analog inputs	Constant current output
12	GND	Internal ground	
13	ANALOG(6)+	Differential ended analog inputs	
14	ANALOG(6)-	Differential ended analog inputs	
15	ANALOG(7)+	Differential ended analog inputs	
16	ANALOG(7)-	Differential ended analog inputs	
17	GND	Internal ground	
18	DNC		Do not connect
19	DNC		Do not connect
20	DNC		Do not connect
21	DNC		Do not connect
22	DNC		Do not connect
23	DNC		Do not connect
24	DNC		Do not connect
25	DNC		Do not connect
26	DNC		Do not connect
27	DNC		Do not connect
28	DNC		Do not connect
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41	DNC		Do not connect
42	DNC		Do not connect
43	DNC		Do not connect
44	DNC		Do not connect
45	DNC		Do not connect
46	DNC		Do not connect
47	DNC		Do not connect
48	DNC		Do not connect
49	DNC		Do not connect
50	DNC		Do not connect
51	GND	Internal ground	
52	CHASSIS	Chassis	

Ordering information

PART NUMBER	DESCRIPTION
KAD/ADC/106/C	Accelerometer ADC (current excitation, programmable analog gain, 6kHz b/w) - 6ch ICP and 2ch D/E at 24ksps (with 52-way double-density connector)
KAM/ADC/106/C	Accelerometer ADC (current excitation, programmable analog gain, 6kHz b/w) - 6ch ICP and 2ch D/E at 24ksps (with 51-way micro-miniature 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/106 refers to both the KAD and KAM version of the module.

Revision history

REVISION	DIFFERENCES	STATUS
KAD/ADC/106/C	High impedance per channel when powered off, enhanced mechanical strength and higher compliance voltage for current excitations	Recommended for new programs
KAD/ADC/106/B	Reduced power consumption on the ±7V power lines	Not recommended for new programs
KAD/ADC/106	First release	Not 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	This module is supported by the KSM-500 suite of software tools

Related documentation

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