KAD/ADC/117/EC1

Full-bridge ADC (current excitation, programmable analog gain, configurable FIR/IIR filter, 3.75kHz b/w) - 8ch at 24ksps

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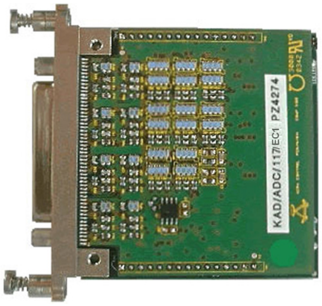


Key Features

- Eight full bridge or differential ended input channels
- Programmable input range (±10mV to ±10V)
- High accuracy (0.08% FSR typical)
- Programmable current excitation per channel
- Short on any channel does not affect others
- 16-bit simultaneous sampling on each channel
- Two filtering mode: IIR and FIR
- Linear bridge operation – constant current

Applications

- Bridge applications with long leads/barriers
- General purpose voltage measurement

Overview

The KAD/ADC/117/EC1 has eight channels of signal conditioning and data acquisition for differential voltages, strain gage and bridge measurements. In addition to the measurement channel, the KAD/ADC/117/EC1 provides independent constant current excitation for up to eight channels. Each differential ended signal has a separate programmable amplifier, filter and A/D converter.

At the heart of the KAD/ADC/117/EC1 is a hard-wired state-machine that over-samples all channels and digitally filters any noise above the user-programmable cutoff frequency. This is achieved using cascaded, half-band, decimate by 2, 15 tap, finite-impulse-response (FIR) filters with 32-bit coefficients followed by an 8^{th} order Butterworth (IIR) filter with a default cutoff point set to 25% of the sampling frequency. The IIR filter is bypassed in FIR mode with samples output directly from the FIR filter. All signals are sampled simultaneously. Thus, when several channels are sampled at different sampling rates, at least at the start of an acquisition cycle all channels will be aligned.

The excitation current is programmable (0mA to 20mA in 5μA steps) and is kept constant. As the resistance changes, the voltage across the bridge (and hence as seen by the amplifier) changes linearly.

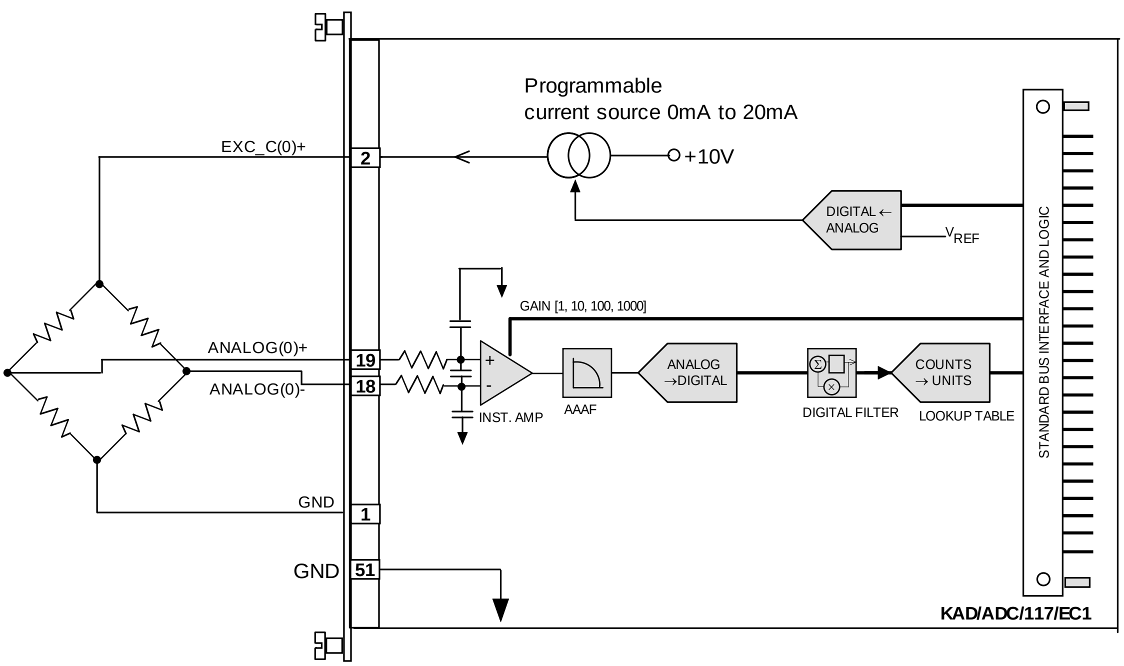


Figure 1: First of eight channels on the KAD/ADC/117/EC1

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.

TABLE 1	General specifications				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Slots	–	–	1	–	Can be placed in any user-slot in any combination.
Mass					
	–	95	–	g	
	–	3.35	–	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	90	–	130	mA	
+7V	80	–	110	mA	Excludes current used by excitation. As a DC/DC converter is used, multiply excitation current by 2.2 to calculate +7V line current.
-7V	0	–	0	mA	
+12V	50	–	60	mA	
-12V	30	–	50	mA	
total power	1.97	–	2.74	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	–	–	8	–	
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[7:0]	2	–	24000	sps	26000sps is allowed in FIR mode.
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.

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, 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 (IIR mode)					
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	9	–	–	bits	$f_c \leq$ 2kHz and secondary gain of 1.
Effective number of bits (FIR mode)					
gain = 1, 10	12	–	–	bits	$f_c \leq$ 2kHz and secondary gain of 1.
gain = 100	11.3	–	–	bits	$f_c \leq$ 2kHz and secondary gain of 1.
gain = 1000	8.5	–	–	bits	$f_c \leq$ 2kHz and secondary gain of 1.
Crosstalk					
gain = 1, 10, 100	–	–	-60	dB	
gain = 1000	–	–	-40	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	3.37	3.75	4.13	kHz	
Digital filter (IIR mode)					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	

TABLE 2	Differential ended analog inputs (continued)				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Digital filter (FIR mode)					Digital filter is cascaded 15 tap FIR.
poles	–	–	–	–	Not applicable for FIR-type filters.
filter cutoff -6dB	0.25	–	16	f_s	The maximum value is limited to 6.5kHz (f_s : sampling frequency).
0.1dB bandwidth	–	0.64	–	f_c	
aliasing to 0.1dB band	–	–	-40	dB	
aliasing to f_c	–	–	-47	dB	
Filter delay					
IIR mode	–	4.08	–	ms	Where f_{in} = f_c = 500Hz (f_{in} : input signal frequency). See “Understanding filter delays (IIR filter mode)” on page 7.
FIR mode	–	9.05	–	ms	Where f_{in} = f_c = 500Hz. See “Understanding filter delays (FIR filter mode)” on page 7.
Input resistance					
between inputs	44	–	–	kΩ	Module powered off.
between inputs	10	–	–	MΩ	Module powered on.
each input to GND	22	–	–	kΩ	Module powered off.
each input to GND	10	–	–	MΩ	Module powered on.

TABLE 3	Single ended DC current excitation outputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Outputs	–	–	8	–	Applied per channel.
Output current					
operating range	0	–	20	mA	
resolution	–	5	–	µA	
compliance	0	–	10	V	
short circuit current	–	–	20	mA	
short circuit duration	∞	–	–	s	
DC error					
error	–	–	0.3	%FSR	With a constant 350Ω load.
noise (gain = 1)	–	–	0.5	mV_{rms}	As measured on analog input.
noise (gain = 10)	–	–	0.05	mV_{rms}	As measured on analog input.
noise (gain = 100, 1000)	–	–	0.01	mV_{rms}	As measured on analog input.

Setting up the KAD/ADC/117/EC1

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

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

XidML Legend

DAU: Data Acquisition Unit (PC: Personal Computer)

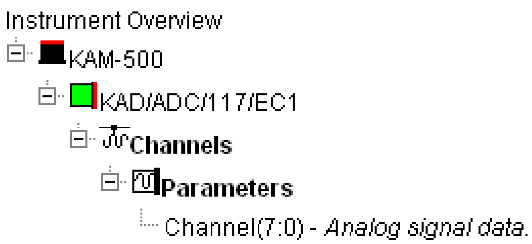
Instrument: Any component or module used in a data acquisition system

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



Setting up the module

The following table lists the setup configurations available for the KAD/ADC/117/EC1.

SETUP DATA	CHOICE	DEFAULT	NOTES
Manufacturer			-
Name	ACRA CONTROL	ACRA CONTROL	-
PartReference	KAD/ADC/117/EC1	KAD/ADC/117/EC1	-
SerialNumber			-
Settings			-
Module-Analog-In-1.2			-
Channel Channel(7:0)			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.
ExcitationAmplitude	0 to 0.02	0	Required excitation current (in A) for the bridge.
FilterType	IIR FIR	IIR	Filtering mode selection.

Setting up parameters

Parameter definitions

The following table lists all parameters that are available for the KAD/ADC/117/EC1.

NAME/DESCRIPTION	BASE UNIT	DATA FORMAT	BITS	REGISTER DEFINITION
Channel(7:0) Analog signal data.	Volt	OffsetBinary	16:4	R[15:0] 0000:FFFF (hex)

Programmable elements

Channel(7:0)

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

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/117/EC1

Bias current return path

As shown in the following figure, the analog inputs can be used as differential inputs (that is, not from a bridge). In this case, 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.

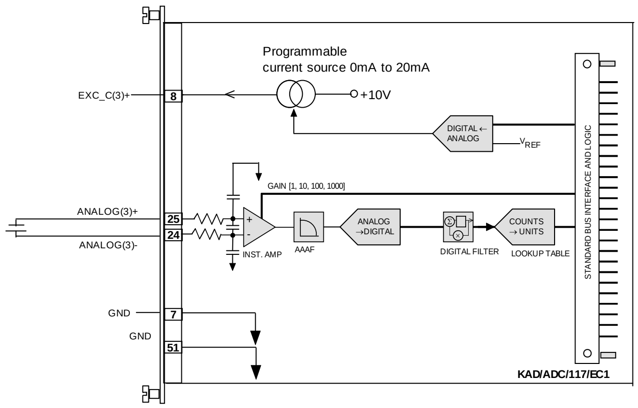


Figure 2: Fourth of 8 independent differential ended channels

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NOTE: When analog inputs are used as differential inputs, setting the excitation to zero reduces quiescent currents of the module.

Using high primary gains

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

Understanding filter delays (FIR filter mode)

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. All filters cause a delay inversely proportional to the filter cutoff frequency (f_C).

The filter delay for this mode is:

$$T_D \approx T_A + \left(19.1 - \frac{20}{2^N}\right) \cdot \frac{1}{4 \cdot f_C}$$

$$N = INT(15.7 - \log_2(4 \cdot f_C))$$

T_D is the filter delay

INT is for the integer part of the value. For example, if x = 13.5, *INT*(x) = 13.

f_C is the filter cutoff frequency.

N cannot be lower than 1. If N is lower than 1, then use 1.

T_A (analog filter delay) ≈ 125μs.

Understanding filter delays (IIR filter mode)

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. The following figure 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.

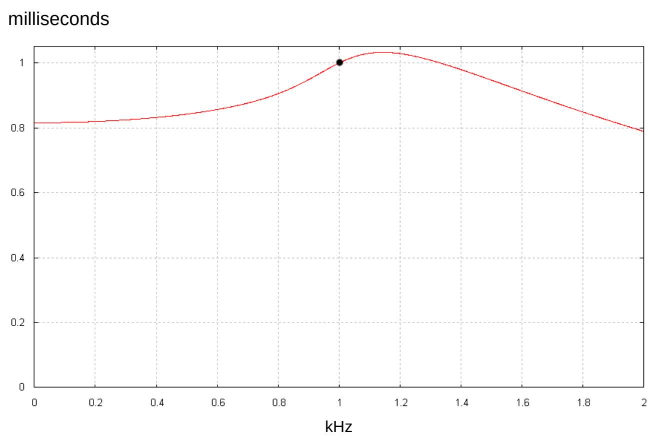

Figure 3: Filter delay for 8th order Butterworth filter where f_c = 1kHz

The filter delay for this mode is:

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

T_D is the filter delay

T_A (analog filter delay) ≈ 82µs

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.

Delay differences to reference modules

The KAD/ADC/117/EC1 was developed to provide configurable filter characteristics similar to the KAD/ADC/117 module (IIR mode) and the KAD/ADC/014/D module (FIR mode). However as the original modules have different AAAF filters, schematics, components and FPGA architectures, a compromise had to be made in achieving this. The KAD/ADC/117/EC1 AAAF filter f_c and order were chosen to follow both reference modules in the closest way, but with slight differences, especially close to the AAAF f_c point.

The delay difference between the KAD/ADC/117/EC1 in FIR mode and the KAD/ADC/014/D is lower than 80µs (or a time equivalent of 2° of phase difference, whichever value is bigger).

The delay difference between the KAD/ADC/117/EC1 in IIR mode and the KAD/ADC/117 is approximately 82µs up to 1.8kHz. However at around f_c of AAAF (3.75kHz) the delay difference will be bigger: about 100us.

Connector pinout of the KAD/ADC/117/EC1

PIN	NAME	SEE SPECIFICATIONS TABLE	COMMENT
1	GND	Internal ground	
2	EXC_C(0)+	Single ended DC current excitation outputs	Excitation to top of bridge
3	GND	Internal ground	
4	EXC_C(1)+	Single ended DC current excitation outputs	Excitation to top of bridge
5	GND	Internal ground	
6	EXC_C(2)+	Single ended DC current excitation outputs	Excitation to top of bridge
7	GND	Internal ground	
8	EXC_C(3)+	Single ended DC current excitation outputs	Excitation to top of bridge
9	GND	Internal ground	
10	EXC_C(4)+	Single ended DC current excitation outputs	Excitation to top of bridge
11	GND	Internal ground	
12	EXC_C(5)+	Single ended DC current excitation outputs	Excitation to top of bridge
13	GND	Internal ground	
14	EXC_C(6)+	Single ended DC current excitation outputs	Excitation to top of bridge
15	GND	Internal ground	
16	EXC_C(7)+	Single ended DC current excitation outputs	Excitation to top of bridge
17	DNC		Do not connect
18	ANALOG(0)-	Differential ended analog inputs	
19	ANALOG(0)+	Differential ended analog inputs	
20	ANALOG(1)-	Differential ended analog inputs	
21	ANALOG(1)+	Differential ended analog inputs	
22	ANALOG(2)-	Differential ended analog inputs	
23	ANALOG(2)+	Differential ended analog inputs	
24	ANALOG(3)-	Differential ended analog inputs	
25	ANALOG(3)+	Differential ended analog inputs	
26	ANALOG(4)-	Differential ended analog inputs	
27	ANALOG(4)+	Differential ended analog inputs	
28	ANALOG(5)-	Differential ended analog inputs	
29	ANALOG(5)+	Differential ended analog inputs	
30	ANALOG(6)-	Differential ended analog inputs	
31	ANALOG(6)+	Differential ended analog inputs	
32	ANALOG(7)-	Differential ended analog inputs	
33	ANALOG(7)+	Differential ended analog inputs	
34	DNC		Do not connect
35	DNC		Do not connect
36	DNC		Do not connect
37	DNC		Do not connect
38	DNC		Do not connect
39	DNC		Do not connect
40	DNC		Do not connect
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/117/EC1	Full-bridge ADC (current excitation, programmable analog gain, configurable FIR/IIR filter, 3.75kHz b/w) - 8ch at 24ksps

By default, the standard mating connector, CON/KAD/002/CP, 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).

The KAD/ADC/117/EC1 uses power from ±7V for excitation and therefore cannot be used with the KAM/CHS/04L, KAM/CHS/05F, KAM/CHS/03F, or KAM/CHS/02F chassis.

Revision history

REVISION	DIFFERENCES	STATUS
KAD/ADC/117/EC1	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	This module is 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/001	Strain gages and ideal bridges
TEC/NOT/016	Power dissipation
TEC/NOT/019	An introduction to digital filtering
TEC/NOT/049	Power estimation