KAM/CDC/101

Charge-to-digital converter (piezoelectric sensors) - 4ch at 24ksps

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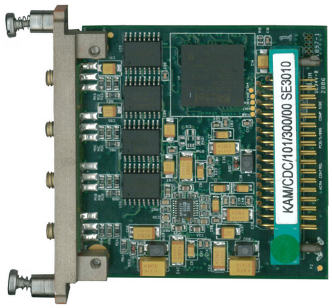


Features

- 4 channel charge-to-digital converter for piezoelectric devices
- Programmable Input range (±100mV, ±10V)
- Accuracy 3% FSR error from all sources typical (for 3Hz on 1kHz on 6kHz version; and 3Hz to 100Hz for 300Hz version)
- High bandwidth with programmable filters (0.5Hz to 6kHz)
- 2nd order Butterworth 0.5Hz high pass filter
- Standard SMC (10-32) sockets per channel
- 16-bit simultaneous sampling on each channel

Applications

- Measurement using piezoelectric devices

Overview

The KAM/CDC/101 is used to digitize signals from charge-based sensors such as piezoelectric devices used for accelerometers. Each is independent and consists of a charge-to-voltage converter (charge-mode amplifier) followed by a second order high pass filter, sixth order low pass filter, programmable gain amplifier, a second order low pass filter and a separate A/D as illustrated in the diagram below.

At the heart of the KAM/CDC/101 is a hard-wired state-machine that over-samples 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, decimate by 2, 15 tap, Finite-Impulse-Response (FIR) filters with 32-bit coefficients followed by an 8th order Butterworth IIR filter with a default cutoff point set at a quarter of the sampling frequency.

Unlike most Acra KAM-500 modules, the input connectors are SMC (10-32) sockets for each channel.

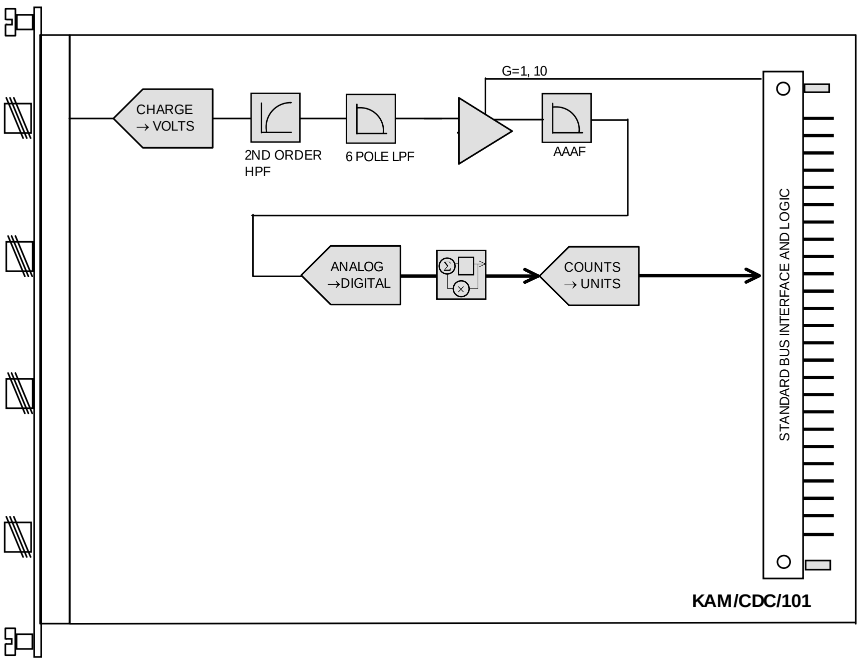


Figure 1: First of four independent charge channels

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					
	–	70	–	g	
	–	2.47	–	oz	Design metric is grams.
Height above chassis					
bare connector	–	–	2.6	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	130	–	135	mA	
±7V	0	–	0	mA	
+12V	42	–	64	mA	
-12V	30	–	50	mA	
total power	1.514	–	2.043	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	Charge converter analog inputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Inputs	–	–	4	–	
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	2	–	24000	sps	
Input charge					
operating range (G_p = 1)	-10	–	10	nC	Primary gain = 1.
operating range (G_p = 10)	-1	–	1	nC	Primary gain = 10.
overvoltage protection	-40	–	40	V	Voltages outside of this range can damage input.

TABLE 2	Charge converter analog inputs (continued)				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
AC gain error					
gain = 1, 10	–	–	3	%FSR	Within 3Hz - 1kHz for 6kHz version; within 3Hz - 100Hz for 300Hz version.
gain = 2, 20	–	–	3	%FSR	Within 3Hz - 1kHz for 6kHz version; within 3Hz - 100Hz for 300Hz version.
gain = 4, 40	–	–	3	%FSR	Within 3Hz - 1kHz for 6kHz version; within 3Hz - 100Hz for 300Hz version.
gain = 8, 80	–	–	3	%FSR	Within 3Hz - 1kHz for 6kHz version; within 3Hz - 100Hz for 300Hz version.
Effective number of bits					
gain = 1	12.5	–	–	bits	For 10Hz < f_{in} < f_c (f_{in}: input signal frequency, f_c: filter cutoff frequency)
gain = 10	10.5	–	–	bits	For 10Hz < f_{in} < f_c
Crosstalk					
gain = 1	–	–	-72	dB	For f_{in} < 200Hz on 300Hz version; f_{in} < 1kHz on 6kHz version.
gain = 10	–	–	-60	dB	For f_{in} < 200Hz on 300Hz version; f_{in} < 1kHz on 6kHz version.
Analog filter					Analog filter is Butterworth.
High pass filter					
poles	–	–	2	–	
filter cutoff -3dB	–	0.5	–	Hz	
Low pass filter					
poles	–	–	6	–	
filter cutoff -3dB	–	300	–	Hz	For 300Hz version.
	–	6	–	kHz	For 6kHz version.
Anti aliasing filter					
poles	–	–	2	–	
filter cutoff -3dB	–	1.5	–	kHz	For 300Hz version.
	–	24	–	kHz	For 6kHz version.
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	–	–	-72	dB	
Filter delay					See "Understanding filter delays" on page 6.
300Hz	–	22.2	–	ms	Where f_{in} = f_c = 100Hz for 300Hz version.
6kHz	–	2.08	–	ms	Where f_{in} = f_c = 1kHz for 6kHz version.
Input resistance					
each input to GND	140	–	–	kΩ	Module powered off.
each input to GND	5	–	–	MΩ	Module powered on.

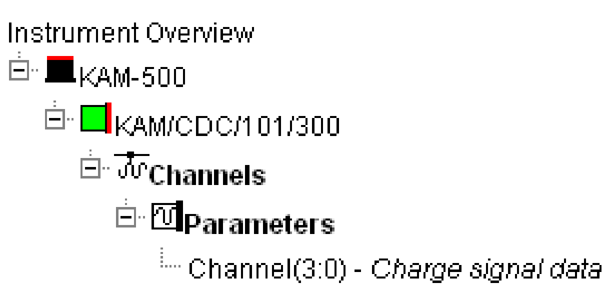
Setting up the KAM/CDC/101

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

NOTE: Ordering options
The PartReference settings are specific to each module variant. Only one variant is shown below.



Setting up the module

The following table lists the setup configurations available for the KAM/CDC/101/300.

SETUP DATA	CHOICE	DEFAULT/EXAMPLE	NOTES
Manufacturer			-
Name	ACRA CONTROL	ACRA CONTROL	Name of manufacturer
PartReference	KAM/CDC/101/300	KAM/CDC/101/300	ACRA CONTROL part number
SerialNumber			Unique name for each module
Settings	-	-	-
Module-Analog-In-1.2			-
Channel Channel(3:0)			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 KAM/CDC/101/300.

NAME/DESCRIPTION	BASE UNIT	DATA FORMAT	BITS	REGISTER DEFINITION
Channel(3:0) Charge signal data	Coulomb	OffsetBinary	16:4	R[15:0] 0000:FFFF (hex)

Programmable elements

Channel(3:0)

SETUP DATA	CHOICE	DEFAULT/EXAMPLE	NOTES
SizeInBits	16:4	16	R[15:0] 0000:FFFF (hex)
RangeMaximum	-10e-9 to 10e-9	10e-9	-
RangeMinimum	-10e-9 to 10e-9	-10e-9	-

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 KAM/CDC/101

It is important to use the shielded coaxial cable type as recommended by the sensor manufacturer. For an introduction to piezoelectric sensors, see *TEC/NOT/012 - Introducing force and pressure measurement using piezoelectric devices*.

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. 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.

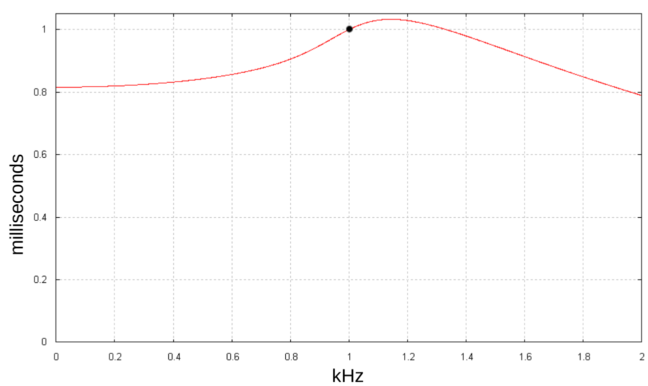


Figure 2: Filter delay for 8^{th} order Butterworth filter where f_C = 1kHz

The filter delay for the KAM/CDC/101 is:

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

T_A (analog filter delay) ≈ 2200µs for KAM/CDC/101/300

T_A (analog filter delay) ≈ 80µs for KAM/CDC/101/6k

f_C is the filter cutoff frequency.

Accuracy

Accuracy is quoted as 3% FSR from all sources over the operating temperature range. This value includes potential gain error of a module (lower than ±2%) and the high pass and low pass analog filter roll-off characteristics within the specified bandwidth. In addition, the potential gain variations caused by limited component accuracies were included in the accuracy specification.

The following figure and Figure 4 on page 7 show possible gain characteristics (expressed in a gain error sense) of analog filters used on KAM/CDC/101/300 and KAM/CDC/101/6K modules. They contain multiple plots, each simulated with varied component values within tolerance (a Monte Carlo analysis of the circuit). They can be used to approximate potential gain error for input signals from outside the specified bandwidth.

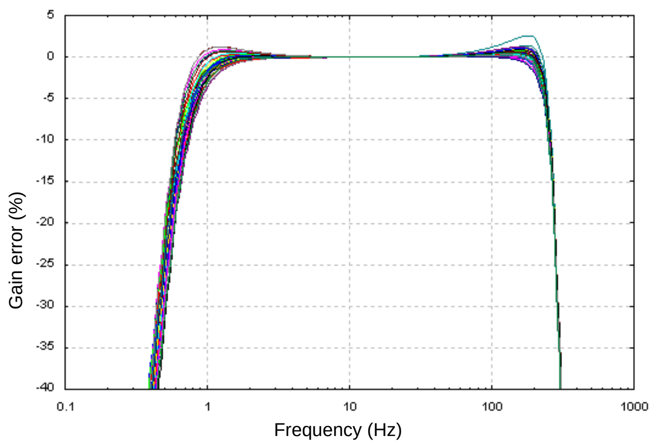


Figure 3: Analog filters on KAM/CDC/101/300 - magnitude variations chart

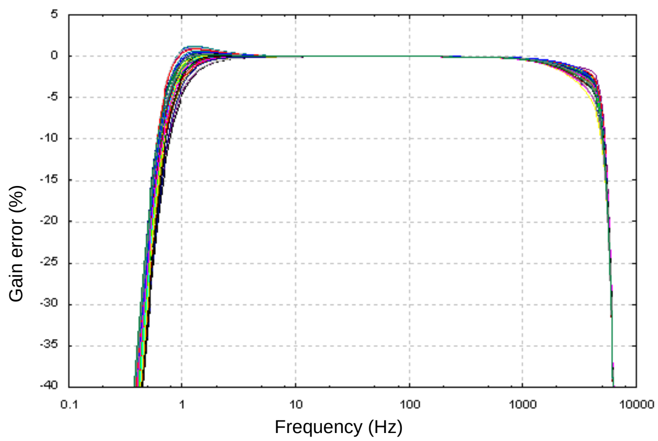


Figure 4: Analog filters on KAM/CDC/101/6k - magnitude variations chart

Calibration of the module gain within the pass band is possible, where required to achieve higher accuracy for certain applications. Contact Curtiss-Wright support (acra-support@curtisswright.com) for details.

Connector pinout of the KAM/CDC/101

There are four SMC (10-32) connectors, one for each channel labeled 0 to 3

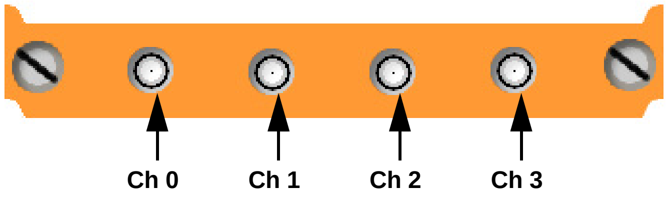


Figure 5: SMC connectors

Ordering information

PART NUMBER	DESCRIPTION
KAM/CDC/101/6k	Charge-to-digital converter (piezoelectric sensors, 6kHz b/w) - 4ch at 24ksps
KAM/CDC/101/300	Charge-to-digital converter (piezoelectric sensors, 300Hz b/w) - 4ch at 24ksps

The standard mating connector, ACC/CON/016, must be ordered separately.

Revision history

REVISION	DIFFERENCES	STATUS
KAM/CDC/101	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/MAN/018	KSM-500 Databook
DOC/HBK/002	Environmental Qualification Handbook
DOC/MAN/030	DAS Studio 3 User Manual
TEC/NOT/012	Piezoelectric effect and charge amplifiers
TEC/NOT/016	Power dissipation
TEC/NOT/049	Power estimation