# KAD/ADC/105

Differential ended ADC (programmable analog gain, 6kHz b/w) - 8ch at 24ksps

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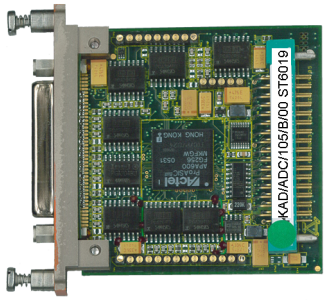


## Key Features

- Eight differential ended input channels
- Programmable input range (±10mV to ±10V)
- High impedance (>10MΩ/44kΩ) when on/off
- Short on any channel does not affect others
- 16 bit simultaneous sampling on each channel

## Applications

- Differential voltage measurement

## Overview

The KAD/ADC/105 is used to condition and digitize up to eight differential ended analog channels.

At the heart of the KAD/ADC/105 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 25% of the sampling frequency.

All signals are sampled simultaneously. Thus, when several channels are sampled at different sampling rates, at the start of an acquisition cycle all channels will be aligned.

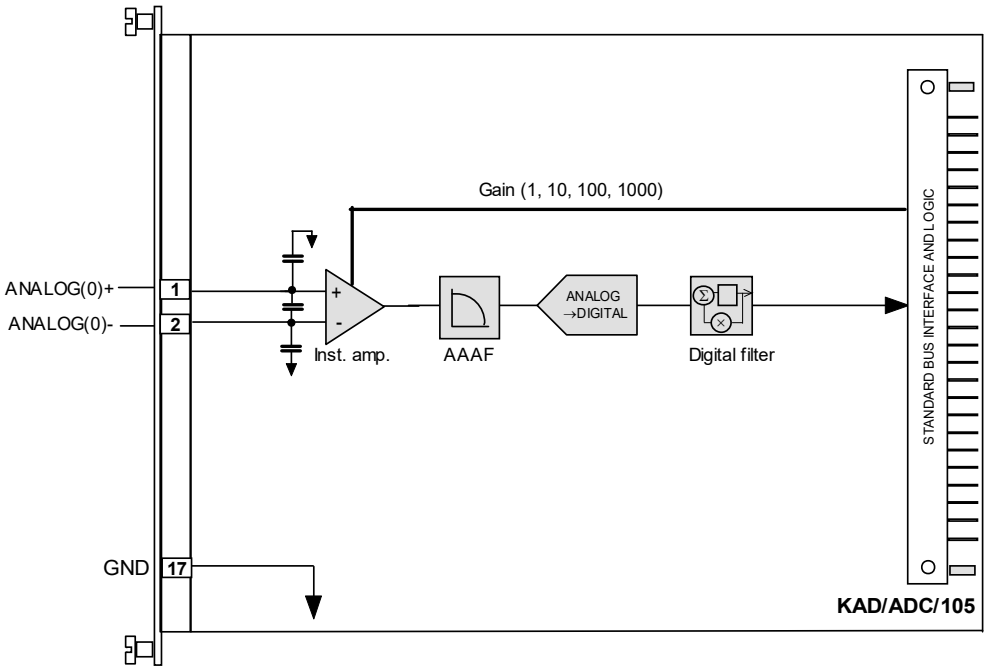


Figure 1: First of eight channels on the KAD/ADC/105

# 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 | | | | | |
| | – | 80 | – | g | |
| | – | 2.82 | – | 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 | – | 175 | mA | |
| ±7V | 0 | – | 0 | mA | |
| +12V | 45 | – | 65 | mA | |
| -12V | 40 | – | 55 | mA | |
| total power | 1.52 | – | 2.31 | 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 | |
| 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 | | | | | |
| 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 | – | – | -60 | dB | |
| gain = 1000 | – | – | -57 | 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. |
| 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 6. |
| 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. |

# Setting up the KAD/ADC/105

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

## Setting up the module

The following table lists the setup configurations available for the KAD/ADC/105/B.

| SETUP DATA | CHOICE | DEFAULT/EXAMPL | NOTES |
|---|---|---|---|
| Manufacturer | | | - |
| Name | ACRA CONTROL | ACRA CONTROL | Name of manufacturer |
| PartReference | KAD/ADC/105/B | KAD/ADC/105/B | ACRA CONTROL part number |
| SerialNumber | | | Unique name for each module |
| Settings | - | - | - |
| Module-Analog-In-1.2 | | | - |
| Channel<br>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. |

## Setting up parameters

### Parameter definitions

The following table lists all parameters that are available for the KAD/ADC/105/B.

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

### Programmable elements

Channel(7:0)

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

# Getting the most from the KAD/ADC/105

## 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.

## 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 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.

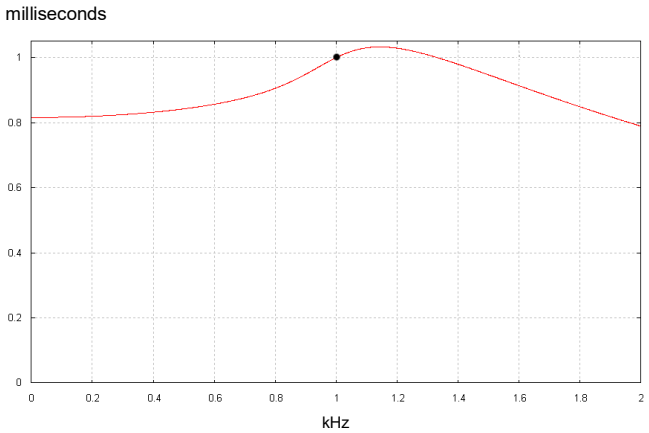


Figure 2: Filter delay for 8$^{th}$ order Butterworth filter where $f_c$ = 1kHz

The filter delay for the KAD/ADC/105 is:

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

$T_A$ (analog filter delay) ≈ 0

$f_c$ is the filter cutoff frequency.

## Additional delay sources

Primary gains higher than 1 cause an additional delay from 1$^{st}$ 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/105

| 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 | 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 |
| 29 | DNC | | Do not connect |
| 30 | DNC | | Do not connect |
| 31 | DNC | | Do not connect |
| 32 | DNC | | Do not connect |
| 33 | DNC | | Do not connect |
| 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 | DNC | | Do not connect |
| 52 | CHASSIS | Chassis | Double-density connector only |

# Ordering information

| PART NUMBER | DESCRIPTION |
|---|---|
| KAD/ADC/105/B | Differential ended ADC (programmable analog gain, 6kHz b/w) - 8ch at 24ksps (with 52-way connector) |
| KAM/ADC/105/B | Differential ended ADC (programmable analog gain, 6kHz b/w) - 8ch at 24ksps (with 51-way 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/105 refers to both the KAD and KAM version of the module.

# Revision history

| REVISION | DIFFERENCES | STATUS |
|---|---|---|
| KAD/ADC/105/B | Improved format switching | Recommended for new programs |
| KAD/ADC/105 | 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 |
|---|---|
| TEC/NOT/016 | Power dissipation |
| TEC/NOT/049 | Power estimation |
| DOC/MAN/018 | KSM-500 Databook |
| DOC/HBK/002 | Environmental Qualification Handbook |
| DOC/MAN/030 | DAS Studio 3 User Manual |
| DOC/DBK/001 | Acra KAM-500 Databook |