# KAD/ADC/141

¼-bridge ADC (current excitation, RTD temp. sensors, 3.125kHz b/w) - 16ch at 12.5ksps

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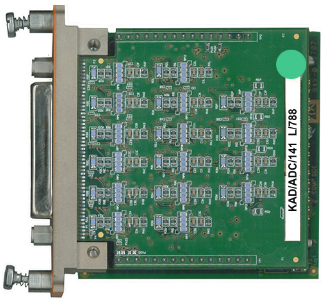


## Key Features

- 16 × ¼-bridge 3-wire input channels for PT50/PT100 RTD sensors
- Input range -200°C to 750°C
- High accuracy (0.87°C between -50 and 200°C @ 2mA for PT100; 2.6°C between -200 and 750°C @ 2mA for PT50)
- Programmable constant current excitation per group of four channels
- Short on any channel does not affect others
- 16-bit simultaneous sampling on each channel

## Applications

- Temperature measurements with PT50 or PT100 RTD sensors

## Overview

The KAD/ADC/141 provides independent excitation for up to 16 channels and is intended for RTD type sensors.

Each channel has a separate programmable digital filter and A/D converter.

At the heart of the KAD/ADC/141 is a hard-wired state-machine that oversamples all channels at a rate between 50ksps and 100ksps and digitally filters any noise above the user-programmable cutoff frequency. This is achieved using cascaded, half-band, finite-impulse-response filters followed by an 8$^{th}$ order Butterworth infinite-impulse-response 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 excitation current through the RTD is kept constant. As the resistance changes, the voltage across the RTD (and hence as seen by the amplifier) changes linearly.

A linearization table for each channel can be used to compensate for non-linear sensors or to fine-tune gain and offset.

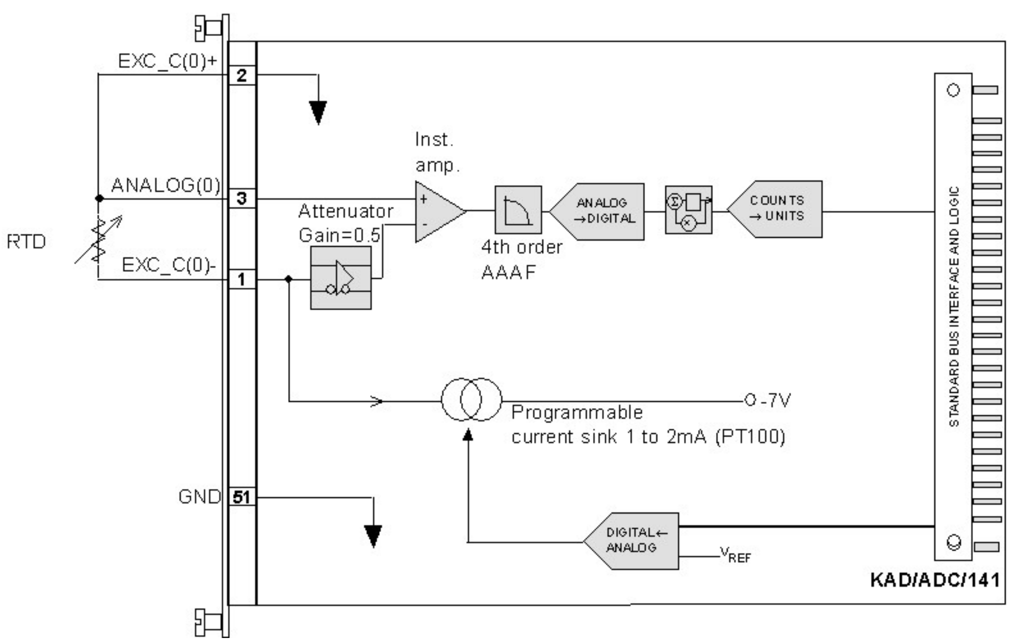


Figure 1: First of 16 channels on the KAD/ADC/141

# 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 | | | | | |
| | – | 90 | – | g | |
| | – | 3.07 | – | 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 | 145 | – | 160 | mA | |
| +7V | 45 | – | 50 | mA | |
| -7V | 40 | – | 45 | mA | Excludes current used by excitation. |
| +12V | 10 | – | 10 | mA | |
| -12V | 0 | – | 0 | mA | |
| total power | 1.44 | – | 1.6 | 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 | Single ended DC current excitation outputs | | | | |
|---|---|---|---|---|---|
| PARAMETER | MIN. | TYP. | MAX. | UNITS | CONDITION/DETAILS |
| Outputs | – | – | 16 | – | Applied in groups of four channels. |
| Output current | | | | | |
| operating range | 1 | – | 2 | mA | |
| resolution | – | 0.5 | – | µA | |
| compliance | -4 | – | – | V | The product of the sensor resistance and the excitation current must not exceed -1V (values exceeding this level will overdrive the devices inputs). |
| short circuit current | – | – | 2 | mA | Depends on user setting. |
| short circuit duration | – | – | ∞ | s | |
| DC error | | | | | |
| error (PT50) | – | – | – | – | Error included within channel accuracy, see DC error in “RTD inputs” on page 3. |
| error (PT100) | – | – | – | – | Error included within channel accuracy, see DC error in “RTD inputs” on page 3. |
| noise (PT50) | – | – | 1 | $°C_{rms}$ | Measured as rms noise visible on read values with and without excitation used. |
| noise (PT100) | – | – | 0.5 | $°C_{rms}$ | Measured as rms noise visible on read values with and without excitation used. |

| TABLE 3 | RTD inputs | | | | |
|---|---|---|---|---|---|
| PARAMETER | MIN. | TYP. | MAX. | UNITS | CONDITION/DETAILS |
| Inputs | – | – | 16 | – | |
| 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(x) | 0.5 | – | 12,500 | sps | |
| Input temperature | | | | | |
| full scale range (PT100) | -200 | – | 750 | °C | |
| DC error | | | | | Temperature averaged over 200 measurement points. |
| for FSR of -200°C to 750°C (PT50) | – | 0.20 | 0.27 | %FSR | When excitation current set to 2mA. |
| for FSR of -200°C to 750°C (PT100) | – | 0.20 | 0.27 | %FSR | When excitation current set to 1mA. |
| for FSR of -50°C to 200°C (PT100) | – | 0.15 | 0.35 | %FSR | When excitation current set to 2mA. |
| Effective number of bits | 12 | – | – | bits | $0 \leq f \leq f_C$ ($f_C$: filter cutoff frequency) |
| Crosstalk | – | – | -72 | dB | Between channels on the same module. |

| TABLE 3 | RTD inputs (continued) (continued) | | | | |
|---|---|---|---|---|---|
| PARAMETER | MIN. | TYP. | MAX. | UNITS | CONDITION/DETAILS |
| Analog filter cutoff | | | | | Analog filter is Butterworth. |
| poles | – | – | 4 | – | |
| filter cutoff -3dB | 5.82 | 6.125 | 6.43 | kHz | |
| Digital filter | | | | | Digital filter is Butterworth. |
| poles | – | – | 8 | – | |
| filter cutoff -3dB | 0.25 | – | 16 | $f_s$ | The maximum value is limited to 3.125kHz ($f_s$: sampling frequency). |
| 0.1dB bandwidth | – | 0.8 | – | $f_c$ | |
| aliasing to 0.1dB band | – | – | -72 | dB | |
| aliasing to $f_c$ | – | – | -74 | dB | |
| Filter delay | 1.99 | 2 | 2.01 | ms | $f_{in} = f_c$ = 1kHz (see “Understanding filter delays” on page 6). |

# Setting up the KAD/ADC/141

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/141 | KAD/ADC/141 | The instrument part reference. |
| SerialNumber | AAA1234 | AAA1234 | Unique name for each module. |
| Channels | - | - | - |
| Temperature(15:0) Analog Input | - | - | 1/4-bridge A/D converter with excitation and signal conditioning for PT50/PT100. |
| Settings | - | - | - |
| Filter Cutoff | 0.25<br>0.5<br>1<br>2<br>4<br>8<br>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. |
| Linearization Algorithm Reference | UTF-8 String | .\LookupFiles\RTD\PT_385.LU | URL algorithm describing a PT50/100 RTD-type sensor for this channel. |
| Excitation Amplitude | 1E-3 to 2E-3 | 1E-3 | Required excitation current (in 0.5µA steps). Applied to each group of four channels. |

## Parameter definitions

| NAME/DESCRIPTION | BASE UNIT | DATA FORMAT | BITS | REGISTER DEFINITION |
|---|---|---|---|---|
| Temperature(15:0) Parameters | | | | |
| Temperature<br>Temperature signal data | Celsius | OffsetBinary | 16 | R[15:0] |

## Configurable parameters

### Temperature(15:0)

| SETUP DATA | CHOICE | DEFAULT | NOTES |
|---|---|---|---|
| Range Maximum | -200 to 750 | 350 | - |
| Range Minimum | -200 to 750 | 0 | - |

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/141

## Lead error compensation

The feedback line ANALOG(x) carries no current. Ideally it should be connected close to the gage to help compensate for lead resistances (assuming that both EXC_C(x)+ and EXC_C(x)- lead resistances are the same). If operating with two wires, and the ANALOG(x) and excitation lines (EXC_C(x)+) are connected close to the module (not the gage), the error introduced is primarily an offset error (because the circuit is linear with respect to resistance) and can be adjusted for.

Use two-wire operation carefully. Estimation of cable resistance should consider temperature drift over the temperature range the cable operates (copper temperature coefficient is approximately 0.4%/°C). Depending on the wire length and diameter, the drift may cause noticeable error of measurement. In general, it may become an issue for thinner and longer cables.

## Setting the range and excitation

For any temperature range required, errors can be minimized by using as much as possible of the 0 to 1V input range of the A/D. For the best accuracy, use 2mA excitation, as the card calibration was optimized using this excitation during manufacture. An excitation current of 2mA is recommended for all input temperature ranges. The 1mA excitation current is provided for applications where it is necessary to reduce the RTD sensor self-heating temperature error by a factor of four of the 2mA excitation error.

The KAD/ADC/141 has been verified for PT100 sensors at 2mA between -50 and 200°C and at 1mA between -200 and 750°C. It has been verified for PT50 sensors at 2mA between -200 and 750°C.

## Settings for unused channels

For each unused channel, the three pins of each channel should be shorted together and, where possible, each channel's excitation current set to 1mA.

## Pinout compatibility

The KAD/ADC/141 is pin compatible with the KAD/ADC/113.

## 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 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.

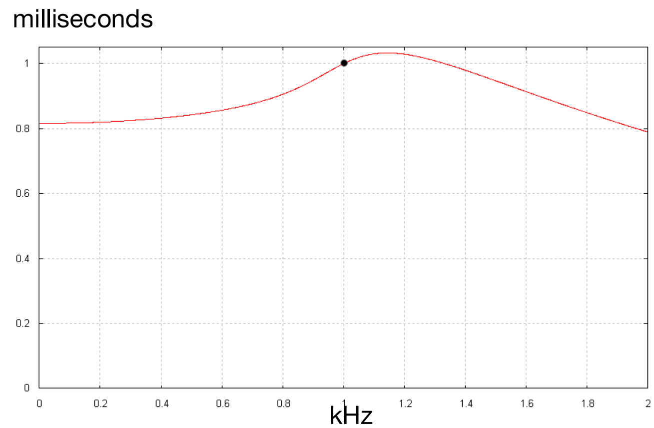


Figure 2: Filter delay for 8th order Butterworth filter where $f_c$ = 1kHz

The filter delay for the KAD/ADC/141 is:

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

$T_A$ (analog filter delay) ≈ 0

$T_D$ is the filter delay

# Connector pinout of the KAD/ADC/141

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

# Ordering information

| PART NUMBER | DESCRIPTION |
|---|---|
| KAD/ADC/141 | ¼-bridge ADC (current excitation, RTD temp. sensors, 3.125kHz b/w) - 16ch at 12.5ksps |

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/141 uses power from the ±7V power lines for excitation and therefore can not be used with KAM/CHS/04L, KAM/CHS/05F, KAM/CHS/03F, or KAM/CHS/02F.

# Revision history

| REVISION | DIFFERENCES | STATUS |
|---|---|---|
| KAD/ADC/141 | Supports both PT50 and PT100 sensors | Recommended for new programs |
| KAD/ADC/141/PT100 | 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 |

# Related documentation

| DOCUMENT | DETAILS |
|---|---|
| DOC/DBK/001 | Acra KAM-500 Databook |
| DOC/HBK/002 | Environmental Qualification Handbook |
| DOC/MAN/030 | DAS Studio 3 User Manual |
| TEC/NOT/016 | Power dissipation |
| TEC/NOT/023 | Resistance temperature detectors |
| TEC/NOT/049 | Power estimation |