KAD/TDC/107

Thermocouple ADC (reference compensation, high accuracy, 4Hz b/w) - 12ch at 8sps

CURTISSWRIGHTDS.COM

ACD/CJB/002

Key Features

- 15 isolated thermocouple input channels and compensation block (ADC/CJB/002) measurement
- Ordering input range (±100mV) with digital reference junction compensation and programmable thermocouple type per module, includes cold junction block (ADC/CJB/002)
- Accuracy (0.55°C typical for K-type in -50 to 150°C range; 1.1°C typical outside this range)
- Short on any channel does not affect others
- 16-bit simultaneous sampling on each channel

Applications

- Thermocouple temperature measurements

Overview

Together the KAD/TDC/107 and the ACD/CJB/002 are used to digitize up to 12 thermocouple channels and 3 channels of module junction temperature.

The module junction temperature is a signal indicating the temperature of the ACD/CJB/002; the temperature is measured by PT100 sensors, which are built into the ACD/CJB/002.

Each compensation block signal is digitized and put to 2 x 65536 point linearization tables. One table is used to produce a compensation value to add to the other 12 channels (this table is thermocouple type specific) and the other table is used to scale the compensation block temperature between -55°C and 125°C.

Thermocouple channels are sampled and then scaled to the voltage range, which covers the selected temperature range for the chosen thermocouple type. The junction offset is removed from each of the thermocouple channels. Finally, each thermocouple channel voltage is linearized to engineering units using a 65536 point linearization table specific to the thermocouple type and range selected.

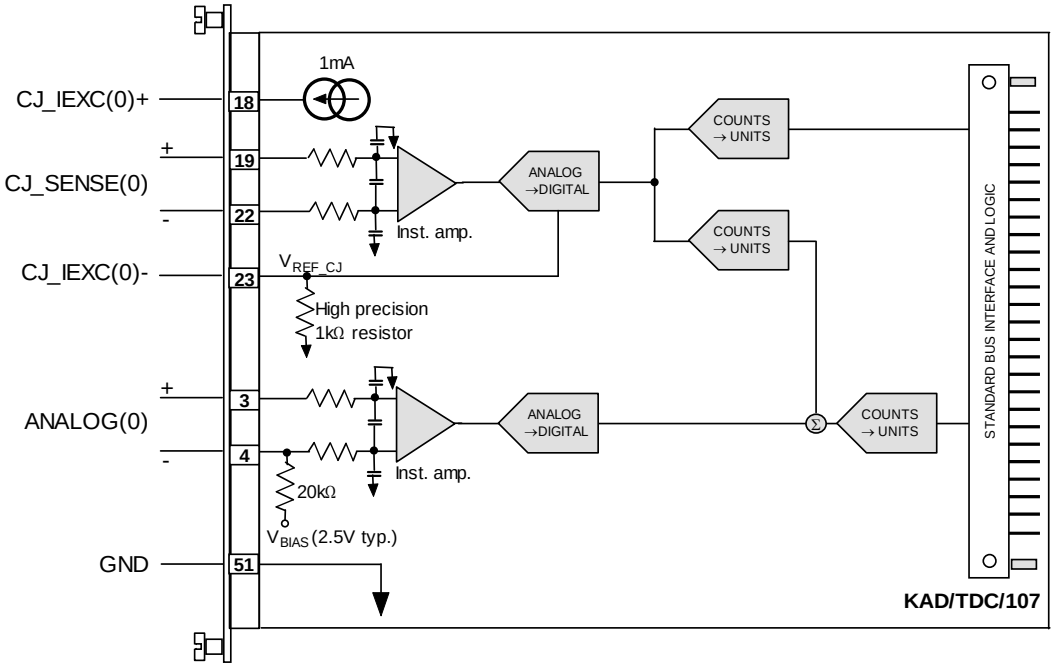


Figure 1: First of 3 reference junction channels plus first of 12 thermocouple channels

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					For recommended clearance requirements see the *ACD/BAC/005* 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	50	–	80	mA	
±7V	0	–	0	mA	
+12V	5	–	20	mA	
-12V	0	–	0	mA	
total power	0.31	–	0.64	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	Cold junction				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Inputs	–	–	3	–	From PT100 sensors provided within the CON/KAD/010 connector. Resistive PT100 sensors are supplied from 1mA current source (typical value). The resistance measurement is ratiometric, compared with the embedded, high precision 1kΩ resistor.
Sampling rate					While the sampling rate can be set individually, each must have a power of two times any other (¼, ½ ...2, 4).
JUNCTION[2:0]	1	–	8	sps	If the sampling rate is set faster, then the module outputs the same sample a number of times; therefore, the real output rate is a maximum of 8sps.
Input temperature					

TABLE 2	Cold junction (continued)				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
full scale range	-55	–	125	°C	
Input voltage					
operating range	0	–	250	mV	
overvoltage protection	-10	–	10	V	Voltages outside of this range can damage input.
DC error	–	–	0.2	%FSR	Temperature averaged over 200 samples.
Effective number of bits	–	13	–	bits	$0 < f_{in} < 4Hz$ (f_{in} : input signal frequency).
Crosstalk	–	–	-80	dB	$0 < f_{in} < 4Hz$.
Analog filter					Analog filter is Butterworth.
poles	–	–	1	–	
filter cutoff -3dB	–	70	–	kHz	±5% error.
Digital filter					Digital filter is embedded in the A/D converter. See “Signal filtering” on page 9.
filter cutoff -3dB	–	4	–	Hz	
0.1dB bandwidth	–	0.1	–	f_c	(f_c : filter cutoff frequency).
Filter delay	–	63	–	ms	Where f_s = 8sps (f_s : sampling frequency). See “Understanding filter delays” on page 8.

TABLE 3	Thermocouple inputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Inputs	–	–	12	–	
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[11:0]	1	–	8	sps	If the sampling rate is set faster, then the module outputs the same sample a number of times; therefore, the real output rate is a maximum of 8sps.
Input temperature					The input temperature range is limited by the input voltage range of ±78.125mV and depends on the specific thermocouple type and the required cold junction temperature range.
full scale range K-type thermocouple	-270	–	1372	°C	
full scale range B-type thermocouple	0	–	1820	°C	
full scale range J-type thermocouple	-210	–	1200	°C	
full scale range E-type thermocouple	-270	–	980	°C	
full scale range R-type thermocouple	-50	–	1767	°C	
full scale range S-type thermocouple	-50	–	1767	°C	
full scale range T-type thermocouple	-270	–	400	°C	

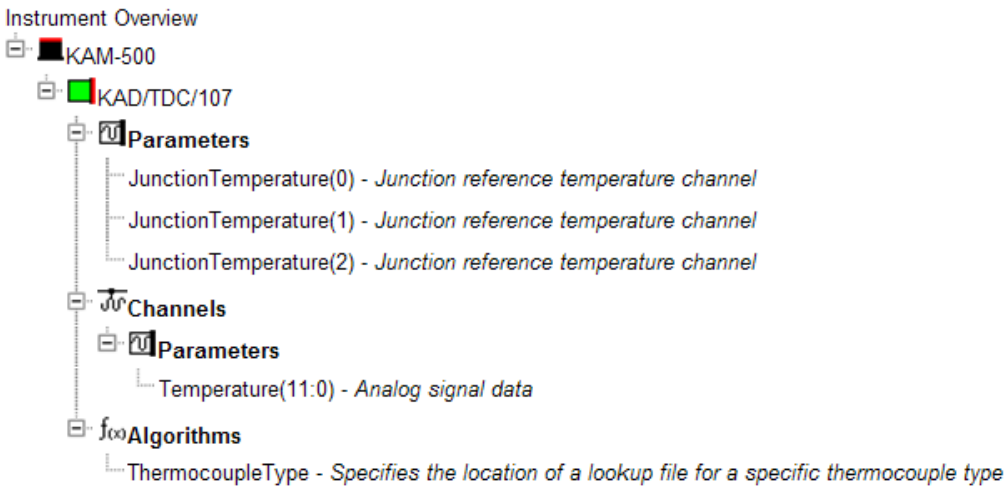
TABLE 3	Thermocouple inputs (continued)				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
full scale range T99-type thermocouple	-59	–	229	°C	
overvoltage protection	-40	–	40	V	Voltages outside of this range can damage input.
Input voltage					
operating range	-78.12	–	78.12	mV	
overvoltage protection	-40	–	40	V	Voltages outside of this range can damage input.
DC error	–	–	0.55	°C	Temperature averaged over 200 samples for thermocouple K-type measured for FSR of -50°C to 150°C. This error includes the cold junction measurement error, and is met for an ambient temperature change rate of up to 4°C per minute using an ACD/CJB/002.
DC error	–	–	1.1	°C	Temperature averaged over 200 samples for thermocouple K-type measured outside -50°C to 150°C temperature range. This error includes the cold junction measurement error, and is met for an ambient temperature change rate of up to 4°C per minute using an ACD/CJB/002.
Effective number of bits	–	13	–	bits	$0 < f_{in} < 4Hz$ (f_{in} : input signal frequency).
Crosstalk	–	–	-100	dB	$0 < f_{in} < 4Hz$.
Common mode					
voltage range	0.5	–	4	V	Operational voltage range.
rejection ratio	80	–	–	dB	Applies within the above common mode voltage range, $0 \leq f_{in} < 4Hz$.
Analog filter					Analog filter is Butterworth.
poles	–	–	1	–	
filter cutoff -3dB	–	130	–	kHz	±5% error.
Digital filter					Digital filter is embedded in the A/D converter. See “Signal filtering” on page 9.
filter cutoff -3dB	–	4	–	Hz	
0.1dB bandwidth	–	0.1	–	f_c	
Filter delay	–	63	–	ms	Where f_s = 8sps (f_s: sampling frequency). See “Understanding filter delays” on page 8.
Input resistance					
between inputs (off)	1	–	–	MΩ	Module powered off. Within ±78.125mV input range.
between inputs (on)	1	–	–	MΩ	Module powered on. Within ±78.125mV input range.

Setting up the KAD/TDC/107

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/TDC/107.

SETUP DATA	CHOICE	DEFAULT	NOTES
Manufacturer	-	-	-
Name	ACRA CONTROL	ACRA CONTROL	Name of manufacturer.
PartReference	KAD/TDC/107	KAD/TDC/107	ACRA CONTROL part number.
SerialNumber	-	-	Unique name for each module.
Settings	-	-	-
Module-Analog-In-1.2	-	-	-
Channel Temperature(11:0)	-	-	Settings for this channel.
Linearization	No character limit	Not Specified	Specifies a URL where a specific thermocouple type lookup file can be found.

Setting up parameters

Parameter definitions

The following table lists all parameters that are available for the KAD/TDC/107.

NAME/DESCRIPTION	BASE UNIT	DATA FORMAT	BITS	REGISTER DEFINITION
JunctionTemperature(0) Junction reference temperature channel	Celsius	OffsetBinary	16:4	R[15:0] 0000:FFFF (hex)
JunctionTemperature(1) Junction reference temperature channel	Celsius	OffsetBinary	16:4	R[15:0] 0000:FFFF (hex)
JunctionTemperature(2) Junction reference temperature channel	Celsius	OffsetBinary	16:4	R[15:0] 0000:FFFF (hex)
Temperature(11:0) Analog signal data	Celsius	OffsetBinary	16:4	R[15:0] 0000:FFFF (hex)

Programmable elements

JunctionTemperature(0)

SETUP DATA	CHOICE	DEFAULT	NOTES
RangeMaximum	-55 to 125	125	-
RangeMinimum	-55 to 125	-55	-
SizeInBits	16:4	16	R[15:0] 0000:FFFF (hex)

JunctionTemperature(1)

SETUP DATA	CHOICE	DEFAULT	NOTES
RangeMaximum	-55 to 125	125	-
RangeMinimum	-55 to 125	-55	-
SizeInBits	16:4	16	R[15:0] 0000:FFFF (hex)

JunctionTemperature(2)

SETUP DATA	CHOICE	DEFAULT	NOTES
RangeMaximum	-55 to 125	125	-
RangeMinimum	-55 to 125	-55	-
SizeInBits	16:4	16	R[15:0] 0000:FFFF (hex)

Temperature(11:0)

SETUP DATA	CHOICE	DEFAULT	NOTES
RangeMaximum	-270 to 1820	1372	-
RangeMinimum	-270 to 1820	-270	-
SizeInBits	16:4	16	R[15:0] 0000:FFFF (hex)

Setting up algorithms

An algorithm describes how data should be processed. The following are algorithms supported by the KAD/TDC/107.

ThermocoupleType

Specifies the location of a lookup file for a specific thermocouple type

SETUP DATA	CHOICE	DEFAULT	NOTES
URL	TYPEB.LU TYPEE.LU TYPEJ.LU TYPEK.LU TYPER.LU TYPES.LU TYPET99.LU TYPET.LU	Not Specified	-

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/TDC/107

Bias current return path

The KAD/TDC/107 should not be used with external bias returns. It provides the return for bias currents internally via 20kΩ to 2.5V bias voltage. As a result, both input terminals are shifted to the middle of the operational voltage range supported by input stage circuits (0.5 to 4V).

NOTE: The KAD/TDC/107 is not a suitable module to support grounded thermocouples, as such connections force input terminals to operate outside of supported voltage range.

Accuracy

The accuracy of the KAD/TDC/107 is specified for K-type thermocouples. It is also met for J and E-type thermocouples. For thermocouples with a lower sensitivity (R, S, and T type), the accuracy figure is lower. Accuracy in that case, can be estimated by scaling the accuracy claimed for K-type thermocouple by the ratio of its sensitivity (K-type thermocouple), to the sensitivity of the considered thermocouple.

Mating connector

Because the compensation sensors are in the CON/KAD/010 mating connector (that ships with the module as part of the ACD/CJB/002), we recommend that only this mating connector is used (see “Specifications” on page 2).

The CON/KAD/010 connector has three built-in PT100, high accuracy (1/3 of class B, DIN/IEC 60751 specification) sensors. This connector provides a compact accurate solution for the cold junction block, and with the ACD/BAC/005 (also part of the ACD/CJB/002) guarantees the specified accuracy for an ambient temperature change rate of up to 4°C per minute.

The following table indicates which PT100 sensor is associated with which KAD/TDC/107 channel.

TABLE 4 CON/KAD/010 built-in PT100 sensor for each KAD/TDC/107 channel

KAD/TDC/107 CHANNEL (TEMPERATURE(X))	CON/KAD/010 BUILT-IN PT100 SENSOR (JUNCTIONTEMPERATURE(X))
0	0
1	0
2	0
3	2
4	2
5	2
6	0
7	0
8	0
9	2
10	2
11	2

For complete mechanical and electrical specifications, refer to the *ACD/CJB/002, ACD/BAC/005,* and *CON/KAD/010* data sheets.

If an external cold junction block other than the ACD/CJB/002 is required, contact Curtiss-Wright support (acra-support@curtisswright.com).

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 filter delay for the KAD/TDC/107 is approximately:

$T_D \approx 1 / f_p - 0.062$; where $4Hz < f_p \leq 8Hz$; $f_p = 2^N \times f_s$

N is integer number

The f_p value is always bigger than 4Hz and lower or equal to 8Hz. The relationship between any channel f_s and f_p is to the power of 2. For example, if f_s = 1sps, f_p = 8Hz.

Sample rates higher than 8sps

For cases when f_s > 8sps, f_p is the greatest value within the range of 4sps to 8sps, which is the result of dividing f_s by the power of 2. Input signals are sampled at a rate of f_p only, so when f_s > 8sps, the output stream contains repeated samples

(specific power of 2 times each). For example, if f_s is 40sps then the actual sampling frequency f_p is 5sps, and each sample is repeated eight times. This functionality is implemented in order to avoid limitations to the acquisition cycle maximum frequency.

Signal filtering

As well as an RF filter on the thermocouple inputs and cold junction channels, the KAD/TDC/107 provides a digital filter, which is built into the analog-to-digital converter. This means—unlike other Curtiss-Wright analog modules—the filter characteristics of the KAD/TDC/107 are fixed. The cutoff frequency (-3dB) point is approximately at 4Hz and is not dependant on the sampling rate that is used.

The built-in digital filter has 50Hz and 60Hz attenuation (> 65dB) and similar attenuation for frequencies above 90Hz.

The following figure shows the magnitude characteristic of the filter.

(Image used with permission of Analog Devices, Inc.)

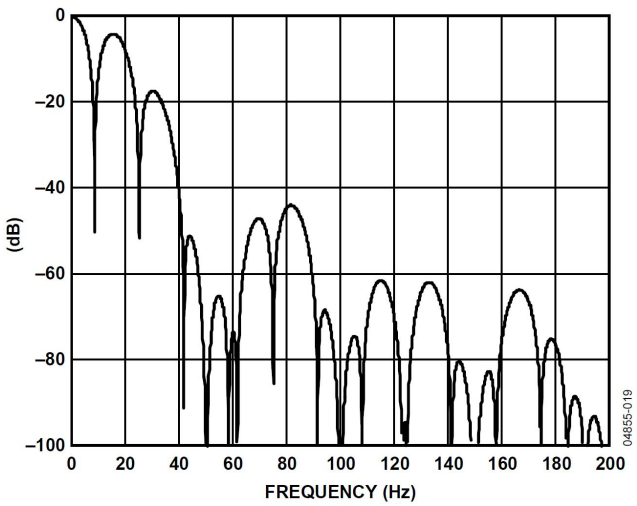


Figure 2: Magnitude characteristic of built-in A/D digital filter

NOTE: If a different type of digital filtering or higher sample rates are required, contact Curtiss-Wright support (acra-support@curtisswright.com).

Connector pinout of the KAD/TDC/107

PIN	NAME	SEE SPECIFICATIONS TABLE	COMMENT
1	DNC		Do not connect
2	DNC		Do not connect
3	ANALOG(0)+	Thermocouple inputs	
4	ANALOG(0)-	Thermocouple inputs	
5	ANALOG(1)+	Thermocouple inputs	
6	ANALOG(1)-	Thermocouple inputs	
7	ANALOG(2)+	Thermocouple inputs	
8	ANALOG(2)-	Thermocouple inputs	
9	ANALOG(3)+	Thermocouple inputs	
10	ANALOG(3)-	Thermocouple inputs	
11	ANALOG(4)+	Thermocouple inputs	
12	ANALOG(4)-	Thermocouple inputs	
13	ANALOG(5)+	Thermocouple inputs	
14	ANALOG(5)-	Thermocouple inputs	
15	DNC		Do not connect
16	DNC		Do not connect
17	DNC		Do not connect
18	CJ_IEXC(0)+	Cold junction	Excitation current to cold junction channel 0
19	CJ_SENSE(0)+	Cold junction	Sense line for cold junction channel 0
20	DNC		Do not connect
21	DNC		Do not connect
22	CJ_SENSE(0)-	Cold junction	Sense line for cold junction channel 0
23	CJ_IEXC(0)-	Cold junction	Excitation current from cold junction channel 0
24	CJ_IEXC(1)+	Cold junction	Excitation current to cold junction channel 1
25	CJ_SENSE(1)+	Cold junction	Sense line for cold junction channel 1
26	DNC		Do not connect
27	DNC		Do not connect
28	CJ_SENSE(1)-	Cold junction	Sense line for cold junction channel 1
29	CJ_IEXC(1)-	Cold junction	Excitation current from cold junction channel 1
30	CJ_IEXC(2)+	Cold junction	Excitation current to cold junction channel 2
31	CJ_SENSE(2)+	Cold junction	Sense line for cold junction channel 2
32	DNC		Do not connect
33	DNC		Do not connect
34	CJ_SENSE(2)-	Cold junction	Sense line for cold junction channel 2
35	CJ_IEXC(2)-	Cold junction	Excitation current from cold junction channel 2
36	DNC		Do not connect
37	DNC		Do not connect
38	ANALOG(6)+	Thermocouple inputs	
39	ANALOG(6)-	Thermocouple inputs	
40	ANALOG(7)+	Thermocouple inputs	
41	ANALOG(7)-	Thermocouple inputs	
42	ANALOG(8)+	Thermocouple inputs	
43	ANALOG(8)-	Thermocouple inputs	
44	ANALOG(9)+	Thermocouple inputs	
45	ANALOG(9)-	Thermocouple inputs	
46	ANALOG(10)+	Thermocouple inputs	
47	ANALOG(10)-	Thermocouple inputs	
48	ANALOG(11)+	Thermocouple inputs	
49	ANALOG(11)-	Thermocouple inputs	
50	GND	Internal ground	
51	GND	Internal ground	
52	CHASSIS	Chassis	

Ordering information

PART NUMBER	DESCRIPTION
KAD/TDC/107	Thermocouple ADC (reference compensation, high accuracy, 4Hz b/w) - 12ch at 8sps
ACD/CJB/002	Cold junction block for KAD/TDC/107 (built in sensors, straight-through heavy thermal mass backshell) - 12ch

By default, an ACD/CJB/002 (which includes an ACD/BAC/005 and a CON/KAD/010) is included with each module in the shipment.

Revision history

REVISION	DIFFERENCES	STATUS
KAD/TDC/107	First release	Recommended for new programs

Supporting software

SOFTWARE	DETAILS
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
TEC/NOT/010	Thermocouples
TEC/NOT/016	Power dissipation
TEC/NOT/049	Power estimation
TEC/NOT/059	Cable assembly using ACD/CJB/002 reference junction block

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