C-DIAS Analogue Conversion Module CAM 011

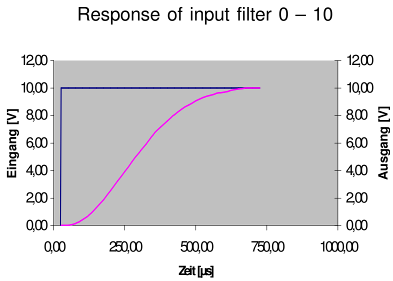
for 3 x 0 - 10V DC inputs
2 x PT100 inputs and
1 x ±10V output

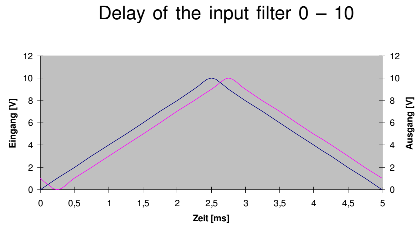
This analogue conversion module is a combination of analogue inputs and outputs. There are three analogue inputs for voltage measurement (0 – 10V / 4 wire), two analogue inputs for temperature measurement (PT100 / 4 wire) and one analogue output for voltage output (±10V). Additionally various states can be displayed via 5 LEDs.

Technical Data

Input channel specifications

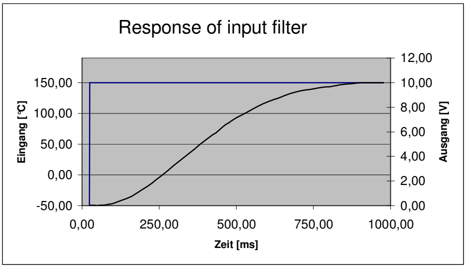
Number of channels	3 (4 wire connection)	
Measuring range	0 – 10V	
Measured value	0 – 16000	Open input delivers value 16383
Resolution	14 bit	
Transformation time per channel	≤1ms	
Input filter	Cut-off frequency 1kHz (1ms)	Low pass class 3
Reference output	+10V / ±1%	
Loading capacity of the reference supply voltage per channel	2.5mA	
Precision of the analogue channel	+/-0.5% of the maximum measured value	

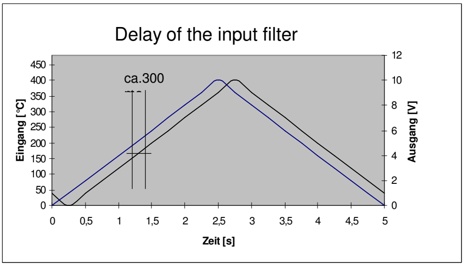




Temperature measurement with thermal resistances

Number of Channels	2
Measuring range	-50 to +150°C
Sensor area	80.31 - 157.31Ω
Measure value	0 to 16000 (open input delivers value16383)
Input resistance	>1MΩ
Common mode area	±20V
Input filter	1s
Suitable sensor	PT 100 DIN IEC 751
Measuring precision	±0.75 %
Reference output	1mA / ±1 %





Output channel specifications

Number of channels	1
Output voltage	-10 to +10V DC
Output value	-2000 to +2000
Resolution	14 bit (1,25mV / bit)
Loading capacity of the output voltage	>100KΩ
Protection against short circuiting	Yes
Transient time	<50µs
Refresh time of all channels	<1ms
Precision of the analogue output	+/-0.4% of the magnitude of the output

Electrical requirements

Supply voltage +24V	18 – 30V DC (is supplied at connectors X1 – X5)	
Bus supply	+5V / +24V internal	
Current consumption on the C-DIAS bus (+5V supply)	Typically 100mA	Maximum 130mA
Current consumption on the C-DIAS bus (+24V supply)	Typically 100mA (without load on reference outputs)	

Voltage supervision

Supply voltage +24V	LED 5 illuminates at supply voltage <18V

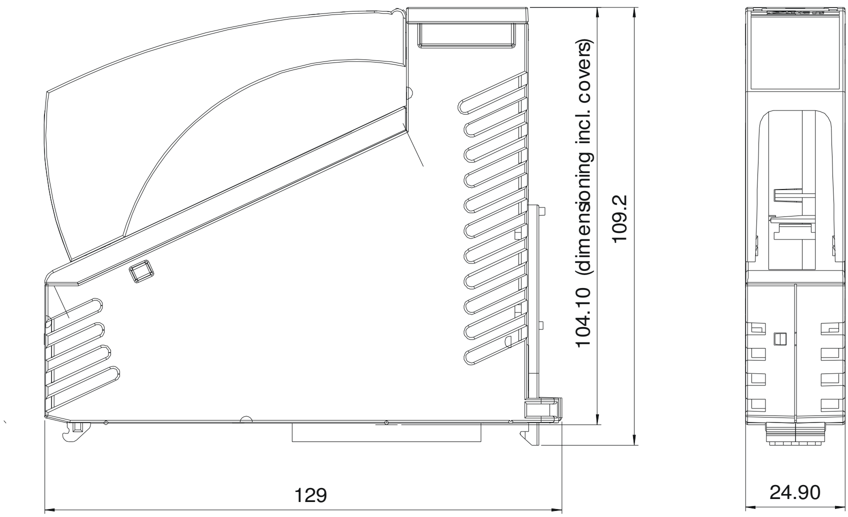
Miscellaneous

Article number	12-017-011
Hardware version	2.x
Standardization	UL (E247993)

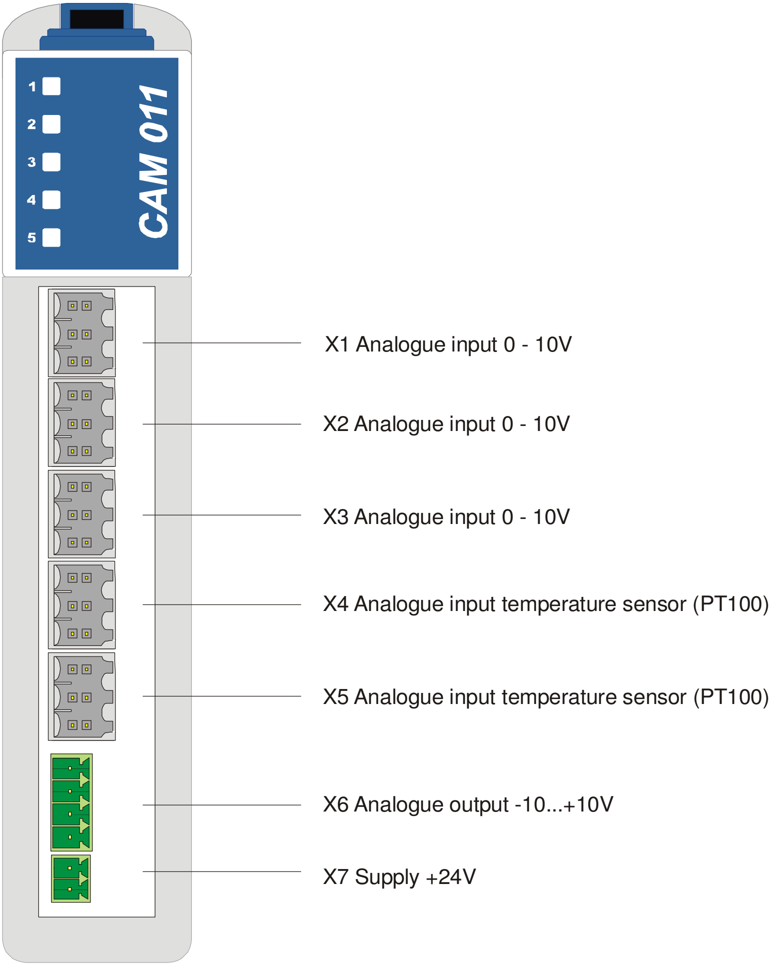
Environmental conditions

Storage temperature	-20 – +85℃	
Operating temperature	0 – +60℃	
Humidity	0 – 95%, without condensation	
EMV stability	In accordance with EN 61000-6-2:2001 (industrial)	
Resistance to shocks	EN 60068-2-27	$150 m/s^2$
Protective system	EN 60529	IP 20

Mechanical dimensions

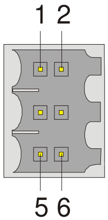


Pin assignment



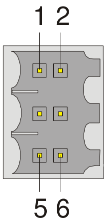
Analogue In Error: When there is not a signal on every input channel or the input voltage at one or more channels is >10V.

X1 – X3: Analogue inputs 0 – 10V



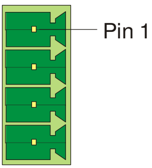
Pin	Function
1	+10V-Ref OUT
2	Analogue IN +
3	AGND-1
4	Analogue IN -
5	GND
6	+24V-OUT

X4, X5: Analogue inputs temperature sensor (PT100)



Pin	Function
1	Reference OUT
2	Analogue IN +
3	AGND-1
4	Analogue IN -
5	GND
6	+24V-OUT

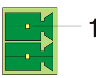
X6: Analogue output



Pin	Function
1	Analogue OUT
2	AGND-2
3	n.c.
4	AGND-2

The connection of the power supply happens with a 2-pole plug assigned as follows:

X7: Supply plug



Pin	Function
1	+24V supply
2	GND

Usable connectors

X1-X5: 6-pole Weidmüller plug B2L3,5/6

X6: **Connector with spring clamp:**
Phoenix Contact: FK-MCP 1,5/ 4-ST-3,5

Connector with screw clamp technique:
Phoenix Contact: MC 1,5/ 4-ST-3,5

X7: **Connector with spring clamp:**
Phoenix Contact: FK-MCP 1,5/ 2-ST-3,5

Connector with screw clamp technique:
Phoenix Contact: MC 1,5/ 2-ST-3,5

The complete C-DIAS plug set CKL 041 with spring clamp is available from Sigmatek with the article number 12-600-041.

Wiring instructions

The signals detected from the analogue module are very small in comparison with the digital signals. In order to guarantee trouble free functioning it is essential to stick to a meticulous wiring arrangement.

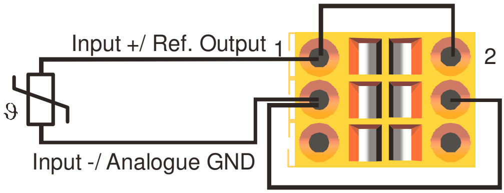
- The 0V supply voltage connection must follow the shortest path the common 0V terminal.
- The connecting wires to the sources of the analogue signals must be as short as possible and avoid lying in parallel to wires carrying digital signals.
- The signal carrying wires should be double or triple pole screened, or at least twisted together.

Temperature measurement with thermistors

2-wire measurement

2-wire measurement is only advisable with short sensor leads since the resistance of the lead influences the measurement.

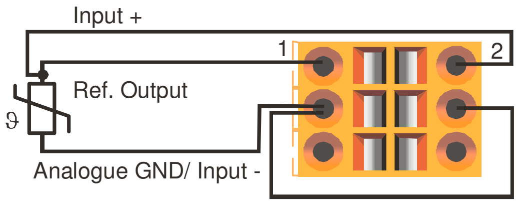
Input + must be connected to the reference output and input – with analogue GND.



3-wire measurement

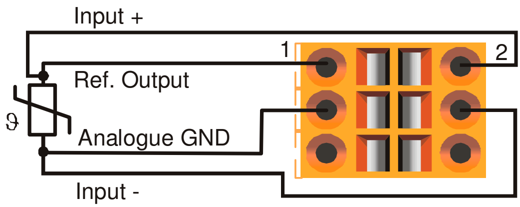
This method can be employed when the earth lead has a large cross-section and therefore a correspondingly low resistance.

Input – must be connected to the analogue GND.



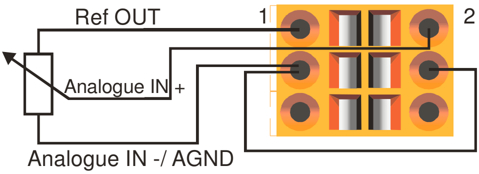
4-wire measurement

This type of connection provides the smallest measuring errors.



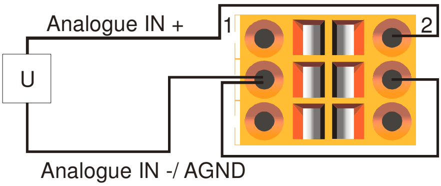
Voltage measurement with potentiometers (odometry)

The input must be connected to the analogue GND connection.



Active voltage source

With **voltage sources, which are not potential free,** no connection must be made between input – and GND or analogue GND.



Status displays

LED no.	LED colour	Meaning
1	green	Sync
2	green	Reference voltage OK
3	green	Reference voltage ON
4	red	Analogue IN error
5	red	+24V Low level error

Addressing

Address	Access		Function
$00, $20, $40, $60, $80, $A0, $C0, $E0	READ	WORD	**Analogue measurement value REFERENCE VOLTAGE**
$02, $22, $42, $62, $82, $A2, $C2, $E2	READ	WORD	**Analogue measurement value CHANNEL1 (0…10V)**
$04, $24, $44, $64, $84, $A4, $C4, $E4	READ	WORD	**Analogue measurement value CHANNEL2 (0...10V)**
$06, $26, $46, $66, $86, $A6, $C6, $E6	READ	WORD	**Analogue measurement value CHANNEL 3 (0...10V)**
$08, $28, $48, $68, $88, $A8, $C8, $E8	READ	WORD	**Analogue measurement value CHANNEL 4 (PT100 / -50..+150℃)**
$0A, $2A, $4A, $6A, $8A, $AA, $CA, $EA	READ	WORD	**Analogue measurement value CHANNEL 5 (PT100 / -50..+150℃)**
$10, $30, $50, $70, $90, $B0, $D0, $F0	WRITE	WORD	**Value analogue output (-10..+10V)**
$16, $36, $56, $76, $96, $B6, $D6, $F6,	WRITE	BYTE	**ADC-DAC configuration: Bit 7 10V-Reference switch on**
$16, $36, $56, $76, $96, $B6, $D6, $F6,	READ	BYTE	**ADC-DAC status: Bit 0 10V-Reference OK** **Bit 7 10V-Reference switched on**
16#18, 16#38, 16#58, 16#78, 16#98, 16#B8, 16#D8, 16#F8	READ	BYTE	**PLL status register** Bit 1 = PLL online Bit 0 = PLL lock (PLL locked)
16#19, 16#39, 16#59, 16#79, 16#99, 16#B9, 16#D9, 16#F9	READ/ WRITE	BYTE	**PLL Configuration register** Bit 2…0: Period duration of PLL time base in ms
16#1A, 16#3A, 16#5A, 16#7A, 16#9A, 16#BA, 16#DA, 16#FA	READ	BYTE	**reserved**
16#1B, 16#3B, 16#5B, 16#7B, 16#9B, 16#BB, 16#DB, 16#FB	READ	BYTE	**Xilinx Version**

16#1C ... 16#1F 16#3C ... 16#3F . . 16#FC ... 16#FF			**reserved for interface module (CIC)**

Matching data (organized byte-wise)

Address	Data	Description
$00	$xx	Check sum
$01	123	Identification
$02	7	Module group 7=AM
$03	1	Module version 1=CAM011
$04	6	Number of channels
$05	$10	Hardware version $10=HW 1.0
$10		Serial number
		AI-Matching data 0 – 10Vref way
$40	$xxxx	Check sum
$42	12345	Identification
$44	19	Length of the following data block in WORD
$46	5	Number of channels
$48	-488	AI1 Offset = 0 – 10Vref way
$4A	16000	AI1 Multiplicand
$4C	15761	AI1 Divisor
$4E	-487	AI2 Offset = 0 – 10Vref way
$50	16000	AI2 Multiplicand
$52	15718	AI2 Divisor
$54	-497	AI3 Offset = 0 – 10Vref way
$56	16000	AI3 Multiplicand
$58	15698	AI3 Divisor
$5A	-8287	AI4 Offset = PT100 –50°C +150°C
$5C	16000	AI4 Multiplicand
$5E	7363	AI4 Divisor
$60	-8220	AI5 Offset = PT100 –50°C +150°C
$62	16000	AI5 Multiplicand
$64	7309	AI5 Divisor

$66	15257	AI6 Offset = Reference voltage value at the moment of matching
$68	0	AI6 Multiplicand not used
$6°	0	AI6 Divisor not used

Address	Data	Description
		AI-Matching data 0 – 10V
$80	$xxxx	Check sum
$82	12345	Identification
$84	19	Length of the following data block in WORD
$86	5	Number of channels
$88	-488	AI1 Offset = 0 – 10V
$8A	16000	AI1 Multiplicand
$8C	15834	AI1 Divisor
$8E	-487	AI2 Offset = 0 – 10V
$90	16000	AI2 Multiplicand
$92	115791	AI2 Divisor
$94	-497	AI3 Offset = 0 – 10V
$96	16000	AI3 Multiplicand
$98	15771	AI3 Divisor
$9A	-8287	AI4 Offset = PT100 –50℃ +150℃
$9C	16000	AI4 Multiplicand
$9E	7360	AI4 Divisor
$A0	-8221	AI5 Offset = PT100 –50℃ +150℃
$A2	16000	AI5 Multiplicand
$A4	7305	AI5 Divisor
$A6	15258	AI6 Offset = Reference voltage value at the moment of matching
$A8	0	AI6 Multiplicand not used
$AA	0	AI6 Divisor not used
		AO-Matching data +/-10V
$C0	$xxxx	Check sum
$C2	12345	Identification
$C4	4	Length of the following data block in WORD
$C6	1	Number of channels
$C8	2054	AO1 Offset
$CA	4040	AO1 Multiplicand
$CC	4000	AO1 Divisor

Check sum calculation of the EEPROM

- The check sum is calculated byte-wise
- It is calculated from the address following the check sum to the last address of the data block (both inclusive)
- This means, the length of the data block of the check sum to be calculated = 5 BYTE fixed.
- Calculation algorithm

1.	Load pointer with address of the matching data	L.DI#		HWKENN
	(without check sum)	ADD.DI		1
2.	Length of data block	L.CX		5
3.	Load check sum with $FF	L.AL		$FF
4.	Rotate check sum 1 bit to the left into Carry	LP	ROL.AL	1
5.	Add up check sum with current WORD and Carry	ADC.AL		(DI)
6.	Increase pointer on next WORD	ADD.DI		1
7.	Finished all addresses? NO ---> 4. YES ---> 8.	LOOP		LP
8.	Check sum is ready			

Calculation AI/AO matching values

AI Matching values (0 – 10Vref way and 0 – 10V absolute)

- Calculation of the matching values e.g.
  0.000 Assigned to ADC 163d
  10.000V or 10Vref assigned to ADC 14614d

- Matching data:

OFFSET:	-163	Value for 0 V at AI (0 – 163)
GAIN Multiplicand:	16000	Delta X of gradient (Debit value of gradient)
GAIN Divisor:	14451	Delta Y of gradient (Actual value of gradient 14614-163)

- Reference voltage matching data:

OFFSET:	15336	Value at the moment of the comparison of the OFFSET (0% values)
GAIN Multiplicand:	00000	Not used
GAIN Divisor:	00000	Not used

ATTENTION: Matching data for GAIN (100% values) must be already subject to a correction of the reference voltage!

AI calculation in the user program

- Read value from ADC
- Control of plausibility (e.g. break-down of sensor)
- Correction of reference voltage (if necessary in case of ramp procedure)
  Value = Value * value of reference voltage from EEPROM / reference voltage value
- Digital filter (if desired)
- Standardization of the measurement value
  Value = (Value + OFFSET) * MULTIPLICAND / DIVISOR (all from EEPROM)
- Scaling of the measurement value (if desired e.g. 0 – 16000d to 0 – 10000mV)
- Cold terminal compensation (only at thermo elements but not in mV and not in °C)
- Linearization (at temperature sensor, thermo elements and the like)

Standardization example:

0.000V amounts at ADC 163d	(163 + -163) * 16000 / 14451 = 0
5.000V amounts at ADC 7555d	(7389 + -163) *16000 / 14451 = 8000
10.000V amounts at ADC 14614d	(14614 + -163) * 16000 / 14451 = 16000

AO matching data (+/-10V)

- Calculation of matching data e.g.:
  8253d amounts 0.000V at analogue output
  192d amounts -10.000V at analogue output
  16313d amounts +10.000V at analogue output

- Matching data:

OFFSET:	8253	Value for 0V at AO
GAIN Multiplicand:	16121	Delta X of gradient (Actual value of gradient 16313-192)
GAIN Divisor:	16000	Delta Y of gradient (Debit value of gradient)

AO calculation in user program

- Bring output value to normed sector
  -10.000V corresponds –8000d
  0.000V corresponds 0d
  +10.000V corresponds +8000d
- DAC writing

Standardization example:

0.000V corresponds 0d amounts at DAC 8253d	(0 * 16121 / 16000) + 8253
-10.000V corresponds –8000d amounts at DAC 192d	(-8000 *16121 / 16000) + 8253
+10.000V corresponds +8000d amounts at DAC 16313d	(8000 * 16121 / 16000) + 8253

Check sum calculation of the matching values

- The check sum is calculated WORD-wise
- It is calculated from the address following the check sum to the last address of the data block (both inclusive).
- This means, the length of the data block of the check sum to be calculated = 2 WORD fixed (Identification and length of the data block) + number of the WORD as defined under the length of the data block.
- Calculation algorithm:

1.	Load pointer with address of the matching data	L.DI#	ABGL	
	(without check sum)	ADD.DI	2	
2.	Calculate length of data block	L.CX	(DI+0002)	
	(+2 WORD identification and data block length)	ADD.CX	2	
3.	Load check sum with $FFFF	L.AX	$FFFF	
4.	Rotate check sum 1 bit to the left into Carry	LP	ROL.AX	1
5.	Add up check sum with current WORD and Carry	ADC.AX	(DI)	
6.	Increase pointer on next WORD	ADD.DI	2	
7.	Finished all addresses? NO ---> 4. YES ---> 8.	LOOP	LP	
8.	Check sum is ready			