10.2 AI350 / AI375

10.2.1 General information

The AI350 and AI375 are standard analog input modules.

10.2.2 Order Data

Model Number	Short Description	Image
3AI350.6	2005 analog input module, 8 inputs, +/- 10 V, 12-bit. Order terminal block separately.	
3AI375.6	2005 Analog Input Module, 8 inputs, 0 to 10 V, 12-bit. Order TB170 terminal block separately.	
3TB170.9	2005 terminal block, 20-pin, screw clamps	
3TB170.91	2005 terminal block, 20-pin, cage clamps	
3TB170:90-02	2005 terminal block, 20-pin, 20 pcs., screw clamps	
3TB170:91-02	2005 terminal block, 20-pin, 20 pcs., cage clamps	
Terminal blocks not included in the delivery (see "Accessories").		

Table 185: AI350 / AI375 order data

10.2.3 Technical Data

Product ID	AI350	AI375
C-UL-US Listed	Yes	Yes
B&R ID Code	$82	$80
Number of Inputs	8 differential inputs	
Electrical Isolation Input - PLC Input - Input	 Yes No	
Input signal Nominal Min./Max.	 -10 to +10 V -20 to +20 V	 0 to +10 V -20 to +20 V

Table 186: AI350 / AI375 technical data

Product ID	AI350	AI375
Operating Modes Normal Operation Special Operating Mode 1 Special Operating Mode 2	Cyclic measurement with optional averaging Direct software timing Software timing using a default time of 2000 - 65535 µs	
Digital Converter Resolution	12-bit	12-bit
Non-Linearity	±1 LSB	
Output Format	INT $8000 - $7FF0 1 LSB = $0010 = 4.883 mV	INT $0000 - $7FF8 1 LSB = $0008 = 2.441 mV
Conversion Procedure	Successive approximation	
Conversion Time for all Channels Normal and Special Operation Normal Operation with Active Averaging	 < 1 ms < 1.5 ms	
Differential Input Resistance	2 MΩ	
Input Filter	Low pass 1st order / cut-off frequency: 450 Hz	
Basic Accuracy at 25° C	±0.1% 1)	
Offset Drift	Max. ±0.0037% /° C 1)	
Gain Drift	Max. ±0.0075% /° C 2)	
Repeat Precision	±0.025% 1)	
Cross-Talk between Channels	-66 dB	
Common-Mode Rejection DC 50 Hz	 50 dB 45 dB	
Maximum Modulation Compared to Ground Potential	±50 V	
Common Mode Modulation Capability between Two Channels	±5 V	±10 V
Power Consumption 5 V 24 V Total	 Max. 1 W Max. 3.5 W Max. 4.5 W	
Dimensions	B&R 2005 single-width	

Table 186: AI350 / AI375 technical data (cont.)

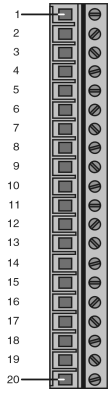
1) Refers to the measurement range.
2) Refers to the current measurement value.

10.2.4 Status LEDs

Image	LED	Description
	RUN	The RUN LED indicates that the analog/digital converter is running.
	MODE	The MODE LED flashes briefly if a start pulse is detected in one of the two special operating modes.

Table 187: AI350 / AI375 status LEDs

10.2.5 Pin Assignments



TB170

Connection	Assignment
1	+ Input 1
2	- Input 1
3	+ Input 2
4	- Input 2
5	+ Input 3
6	- Input 3
7	+ Input 4
8	- Input 4
9	Shield
10	Shield
11	Shield
12	Shield
13	+ Input 5
14	- Input 5
15	+ Input 6
16	- Input 6
17	+ Input 7
18	- Input 7
19	+ Input 8
20	- Input 8

Table 188: AI350 / AI375 pin assignments

Signal Cable Connection

Shielded cables must be used with analog input modules. The ground connection for the shield is made on one of the terminal block shield connections provided for the two inputs.

For EMC reasons, it is recommended to short circuit the inputs which are not used.

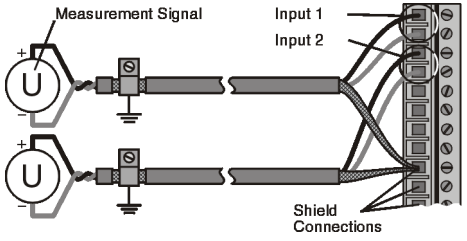


Figure 123: AI350 / AI375 signal cable connection

The four shielded connections are of the same value and each connected via 100 Ω resistors with ground (⏚, that means: a spring contact and a mounting rail).

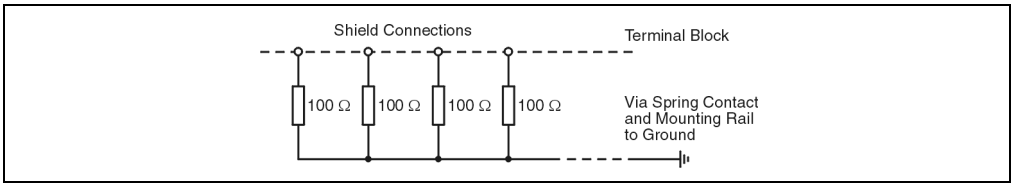


Figure 124: AI350 / AI375 shielded connection

10.2.6 Input Circuit Diagram

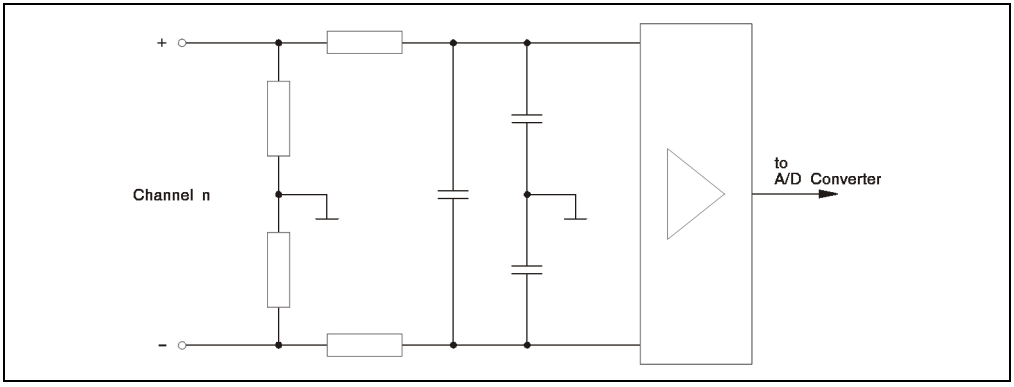


Figure 125: AI350 / AI375 input circuit diagram

10.2.7 Operating Modes

Three operating modes are available:

- Normal operation (default setting)
- Special Operating Mode 1: Direct software timing
- Special Operating Mode 2: Software timing using default time

Change of Operating Mode

- Normal operation is set during power-on or after a reset.
- Changing from normal operation to one of the special operating modes is possible at any time. To do this, the mode register 2 must be set to the respective value. When a change in operating mode is carried out, it is acknowledged in status register 2, the register which displays the current operating mode.
- However changing from one of the special operating modes to another operating mode is not possible.

Normal Operation

Normal operation is set after power-on.

All channels are converted cyclically and data is deposited in the dual ported RAM in the agreed INT format. The conversion time for all channels is <1 ms.

Averaging can only be switched on in cyclic operation, using mode register 1. The conversion time increases slightly to <1.5 ms due to the higher computing time needed.

Special Operating Mode 1: Direct software timing

Mode register 2 must be set to the following value : %00010000

With this type of operation, the measurement cycle is started on the module by the application program, which sets bit 7 from mode register 8 to 0 (start pulse). Conversion of all eight channels is carried out without responding to further start pulses. The end of the cycles is registered by setting bit 7 in the status register 2.

Application example: Data acquisition (without jitter) in high-speed task classes (e.g. for a controller).

Mode Register 8	Analog Input Module	Time
Write access with bit 7 = 0 (start pulse)	Module in delay loop	t_0
	Bit 7 in the status register 2 = 0	t_0 + 20 to 40 µs
	Start measurement channel 1	t_c1 = t_0 + 128 to 130 µs
	Start measurement channel 2	t_c1 + 1 * 85 µs
	Start measurement channel 3	t_c1 +2 * 85 µs
	Start measurement channel 4	t_c1 +3 * 85 µs
	Start measurement channel 5	t_c1 +4 * 85 µs
	Start measurement channel 6	t_c1 +5 * 85 µs
	Start measurement channel 7	t_c1 +6 * 85 µs
	Start measurement channel 8	t_c1 +7 * 85 µs
	Write measurements in the DPR (start up)	1)
	Write measurements in the DPR (end)	1)
	Bit 7 in the status register 2 = 1(cycle end)	t_0 + 900 µs
The next start pulse is possible	Module in delay loop	

Table 189: AI350 / AI375 special operating mode 1: Direct software timing

1) Writing the measurement value in the Dual Ported RAM (DPR) can be interrupted by accessing the module using the bus. Therefore, it is recommended that handling of affected I/O variables in the special operating modes should only be made by the "Direct_IO" FBKs.

Special Operating Mode 2: Software timing using default time

Mode register 2 must be set to the following value : %00110000

The procedure is similar to special operating mode 1. However, in special operating mode 2 there is the option to set the time when the next measurement should be ended. The default time is entered in µs as UINT in mode register 7 + 8. This write access works in the same way as a start pulse (independent of bit 7 in the mode register 8). Further write accesses are ineffective until the end of the cycles. The conversion of all eight channels is not started immediately but rather 1000 µs before the end of the default time. The end of the cycles is registered by setting bit 7 in the status register 2. Unlike special operating mode 1, the time scale is left unchanged.

Value range for default times: 2000 to 65535 µs

Application example: equidistant data acquisition for controllers in normal task classes with the option of calculating the measurement time in the main CPU (e.g. using the timer function "TIM_musec" or "TIM_ticks" -> user program).

Example: Task 1 has a cycle time of 10 ms in task class 1 . At the end of the cycles, current analog values must be available for the next cycle.
The "TIM_musec" function measures the current time period. If the measurement results in 2 ms, then the analog conversion must be completed in 8 ms. Defining the default time carried out with the "IO_data" function. The value 8000 is written in mode registers 7 + 8.
If the time measured in the next cycle results in e.g. 2.2 ms, then the value 7800 must be written in mode registers 7 + 8 .

Mode Registers 7 + 8	Analog Input Module	Time
Default time written in µs as UINT	Module in delay loop	t_0
	Bit 7 in status register 2 = 0	t_0 + 20 to 40 µs
	Delay Loop	Depends on t_pre
	Starting internal cycles	t_St = t_pre - 1000 µs
	Start measurement channel 1	t_c1 = t_St + 128 to 130 µs
	Start measurement channel 2	t_c1 + 1 * 85 µs
	Start measurement channel 3	t_c1 +2 * 85 µs
	Start measurement channel 4	t_c1 +3 * 85 µs
	Start measurement channel 5	t_c1 +4 * 85 µs
	Start measurement channel 6	t_c1 +5 * 85 µs
	Start measurement channel 7	t_c1 +6 * 85 µs
	Start measurement channel 8	t_c1 +7 * 85 µs
	Write measurements in the DPR (start up)	1)
	Write measurements in the DPR (end)	1)
	Bit 7 in status register 2 = 1(cycle end)	t_pre - 100 µs

Table 190: AI350 / AI375 special operating mode 2: Software timing using default time

Mode Registers 7 + 8	Analog Input Module	Time
	Time entry sequence	t_pre
The next start pulse is possible	Module in delay loop	

Table 190: AI350 / AI375 special operating mode 2: Software timing using default time (cont.)

1) Writing the measurement value in the Dual Ported RAM (DPR) can be interrupted by accessing the module using the bus. Therefore, it is recommended that handling of affected I/O variables in the special operating modes should only be made by the "Direct_IO" FBKs.

10.2.8 Relationship between Input Voltage and Converter Value

AI350

The converter value (INT format) changes in increments of 16 (0, 16, 32, etc.).

Voltage	Converter Value	
	Hexadecimal	Decimal
≤-10 V	8000	-32768
-4.883 mV	FFF0	-16
0 V	0000	0
4.883 mV	0010	16
≥10 V	7FF0	32752

Table 191: AI350 Relationship between input voltage and converter value

AI375

The converter value (INT format) changes in increments of 8 (0, 8, 16, etc.).

Voltage	Converter Value	
	Hexadecimal	Decimal
≤0 V	0000	0
2.441 mV	0008	8
≥10 V	7FF8	32760

Table 192: AI375 Relationship between input voltage and converter value

10.2.9 Variable Declarations

The variable declaration is made in B&R Automation Studio™:

Function	Variable Declarations				
	Scope	Data Type	Length	Module Type	Chan.
Single Analog Input (Channel x)	tc_global	INT	1	Analog In	1 ... 8

Table 193: AI350 / AI375 variable declaration

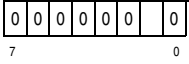
Mode Register 1	tc_global	USINT	1	Status Out	0
Mode Register 2	tc_global	USINT	1	Status Out	1
Mode Registers 7 + 8 Special Operating Mode 2 "Software Timing using Default Values"	tc_global	UINT	1	Status Out	6
Mode Register 8 Start pulse in the special operating mode 1 "Direct Software Timing"	tc_global	USINT	1	Status Out	7
Status Register 1	tc_global	USINT	1	Status In	0
Status Register 2	tc_global	USINT	1	Status In	1

Table 193: AI350 / AI375 variable declaration

Mode Register 1

Bits 0 and 2 - 7 must be assigned with 0.

Mode Register 1	Bit	Description
	7	0
	6	0
	5	0
	4	0
	3	0
	2	0
	1	AV - Averaging switched on
	0	0



Averaging

Averaging can be activated during normal operation. It should be noted that the conversion time increases to <1.5 ms.

AV= 0 ..... Averaging switched off (default setting)
AV = 1 ..... Averaging switched on

When this option is switched on, the average value is generated and transferred to the central unit. The calculation is formulated as follows:

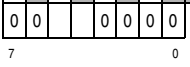
$$\text{New Average Value} = \frac{\text{Old Average Value} + \text{New Value}}{2}$$

The positive final value when averaging is switched on is $7FEF with the AI350 instead of $7FF0 and $7FF7 instead of $7FF8 with the AI375.

Mode Register 2

Bits 0 and -3 as well as 6 and 7 must be assigned with 0.

Mode Register 2	Bit	Description
	7	0
	6	0
	5	SWT_TIM - Software timing using default time
	4	SWT_DIR - Direct software timing
	3	0
	2	0
	1	0
	0	0



SWT_DIR 0 .....Normal operation (default setting)
1 .....Special operating mode 1 (Direct Software Timing)

SWT_TIM SWT_TIM is only active if SWT_DIR is set to 1!
0 .....Operating mode dependent on SWT_DIR (default setting)
1 .....Special operating mode 2 (software timing using default times)

Changing from one of the special operating modes to another operating mode is not possible!

Mode Register 7 + 8 (UINT)

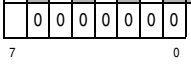
When using special operating mode 2 "Software Timing using Default Times", the time is defined in µs in both of these registers. The measurement of the eight channels must be completed when this time has passed.

Value range: 2000 to 65535 µs

Mode Register 8

Bits 0 - 6 must be assigned with 0.

Mode Register 8	Bit	Description
	7	TRIGn - Start pulse
	6	0
	5	0
	4	0
	3	0
	2	0
	1	0
	0	0



TRIGn TRIGn is only active in "Direct Software Timing" operating mode (SWT_DIR to 1, SWT_TIM to 0)
A write access using TRIGn = 0 triggers the immediate measurement of all eight channels.
A write access with TRIGn = 1 is ignored.

Status Register 1

Status Register 1	Bit	Description
	7	x
	6	x
	5	x
	4	x
	3	x
	2	x
	1	AV - Averaging switched on
	0	I_ERR - Module error

x	x	x	x	x	x		

7 0

I_ERR 0 ..... Data values in the dual ported RAM (DPR) correspond to definitions
1 ..... An internal error exists. That means that the data values in the Dual Ported RAM (DPR) do not correspond to the definitions. Please contact B&R if this occurs.

MW Averaging in normal operation is active (mode register 1 settings are repeated)

Status Register 2

Status Register 2	Bit	Description
	7	SWT_RDY - Software timed measurement is completed
	6	x
	5	SWT_TIM - Software timing using default time
	4	SWT_DIR - Direct software timing
	3	x
	2	x
	1	x
	0	x

	x			x	x	x	x

7 0

SWT_DIR
SWT_TIM SWT_DIR and SWT_TIM indicate the operating mode in which in the module can be found.

SWT_RDY SWT_RDY is only active if a special operating mode is set.
0 ..... Measurement or waiting loop is running
1 ..... The last cycle is completed