12.5 AM374

12.5.1 General Information

The AM374 is a standard analog mixed module. Two channels at a time are combined into a group. There are two input and output groups. The signal can be configured for each group (voltage or current).

12.5.2 Order Data

Model Number	Short Description	Image
3AM374.6	2005 analog mixed module, 4 inputs, 0-10 V / 0-20 mA, 12-bit, 4 outputs, +/- 10 V / 0-20 mA, 12-bit, signals can be switched in groups of 2. Order TB170 terminal blocks 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 255: AM374 order data

12.5.3 Technical Data

Product ID	AM374
General information	
C-UL-US Listed	Yes
B&R ID Code	$8A
Slot Main Rack Expansion Rack	 Yes Yes
Inputs Input signal Group 1 Group 2	4 0 - 10 V / 0 - 20 mA, can be switched in groups of 2 Channel 1 +2 Channel 3 + 4
Outputs Output signal Group 1 Group 2	4 ±10 V / 0 - 20 mA, can be switched in groups of 2 Channel 1 +2 Channel 3 + 4
Electrical Isolation Channel - PLC Channel - Channel	 Yes No
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
Conversion Time for all Channels Normal and Special Operation Normal Operation with Active Averaging	 < 1 ms < 1.5 ms
Power Consumption 5 V 24 V Total	 Max. 1.5 W Max. 5 W Max. 6.5 W
Analog Inputs Voltage	
Input signal Nominal Min./Max.	 0 to +10 V -20 to +20 V
Conversion Procedure	Successive approximation
Digital Converter Resolution	12-bit
Output Format	INT $0000 - $7FFF (1 LSB = $0008 = 2.441 mV)
Non-Linearity	±1 LSB
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. ±0.0025% /° C 1)
Gain Drift	Max. ±0.0075% /° C 2)
Repeat Precision	±0.025% 1)

Table 256: AM374 technical data

Product ID	AM374
Cross-Talk between Channels	-66 dB
Common-Mode Rejection DC 50 Hz	 50 dB 45 dB
Maximum Modulation Compared to Ground Potential	±50 VDC
Common Mode Modulation Capability between Two Channels	±10 VDC
Analog Inputs - Current	
Input Signal Nominal Min./Max.	 0 to 20 mA -50 to +50 mA
Conversion Procedure	Successive approximation
Digital Converter Resolution	12-bit
Output Format	INT $0000 - $7FFF (1 LSB = $0008 = 4.883 µA)
Non-Linearity	±1 LSB
Load	50 Ω
Voltage Drop at 20 mA	1 V
Input Filter	Low pass 1st order / cut-off frequency: 450 Hz
Basic Accuracy at 25° C	±0.1% 1)
Offset Drift	Max. ±0.0025% /° C 1)
Gain Drift	Max. ±0.01% /° C 2)
Repeat Precision	±0.05% 1)
Cross-Talk between Channels	-66 dB
Common-Mode Rejection DC 50 Hz	 60 dB 55 dB
Maximum Modulation Compared to Ground Potential	±50 VDC
Common Mode Modulation Capability between Two Channels	±15 VDC
Analog Outputs - Voltage	
Output Signal	±10 V
Digital Converter Resolution	12-bit
Output Format	INT $8080 - $7F80 (1 LSB = $0010 = 4.90 mV)
Non-Linearity	±1 LSB
Load	Min. 1 kΩ
Short-circuit-proof	Current limit -15 mA to -30 mA / +15 mA to +30 mA
Output Filter	Low pass 1st order / cut-off frequency: 1 kHz

Table 256: AM374 technical data (cont.)

Product ID	AM374
Basic Accuracy at 25° C Offset Total	 ±0.025% 1) ±0.15% 1)
Offset Drift	Max. ±0.0015% /° C 1)
Gain Drift	Max. ±0.0050% /° C 2)
Error caused by Load Change	Max. 0.013% (from 10 MΩ -> 1 kΩ, resistive)
Repeat Precision	±0.025% 1)
Switch On/Off Behavior	Internal enable relay, default setting: Short circuit
Analog Outputs Current	
Output signal	0 - 20 mA
Digital Converter Resolution	12-bit
Output Format	INT $0000 - $7F80 (1 LSB = $0080 = 4.90 µA)
Non-Linearity	±1 LSB
Load	Max. 600 Ω
Output Filter	Low pass 1st order / cut-off frequency: 1 kHz
Basic Accuracy at 25° C Offset Total	 -0.013% to +0.039% 1) ±0.15% 1)
Offset Drift	Max. ±0.0025% /° C 1)
Gain Drift	Max. ±0.008% /° C 2)
Error caused by Load Change	Max. 0.075% (from 1 Ω -> 600 kΩ, resistive)
Repeat Precision	±0.025% 1)
Switch On/Off Behavior	Internal enable relay, default setting: Short circuit
Mechanical Characteristics	
Dimensions	B&R 2005 single-width

Table 256: AM374 technical data (cont.)

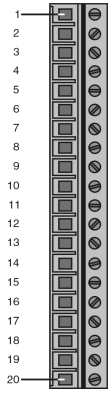
1) Refers to the measurement range.
2) Referring to the current measurement value.

12.5.4 Status LEDs

Image	LED	Description
	RUN	A slow blinking RUN LED indicates that the module has not yet been configured. A lit RUN LED indicates the analog/digital converter and digital/analog converter are running according to the configuration made.
	MODE	The MODE LED flashes briefly if a start pulse is detected in one of the two special operating modes.
	AI1, AI2	The LEDs AI1, AI2 indicate that input channels 1 and 2 are configured as current inputs.
	AI3, AI4	The LEDs AI3, AI4 indicate that input channels 3 and 4 are configured as current inputs.
	AO1, AO2	The LEDs AO1, AO2 indicate that output channels 1 and 2 are configured as current outputs.
	AO3, AO4	The LEDs AO3, AO4 indicate that output channels 3 and 4 are configured as current outputs.

Table 257: AM374 status LEDs

12.5.5 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	+ Output 1
14	- Output 1
15	+ Output 2
16	- Output 2
17	+ Output 3
18	- Output 3
19	+ Output 4
20	- Output 4

Table 258: AM374 pin assignment

Signal Cable Connection

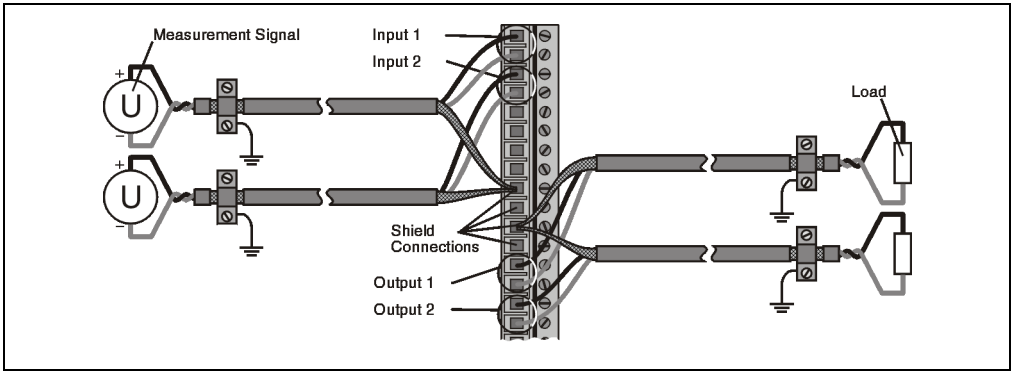


Figure 157: AM374 signal cable connection

Shielded cabling should be used for the mixed module's analog input and output signal cables. The shield is grounded for two inputs/outputs using one of the terminal block shield connections provided.

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

Minus connections for the analog outputs are switched over 22 Ω to the internal ground. A floating connection is recommended for large cable lengths. The potential displacement between minus connections is allowed to be a maximum of 4 V.

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).

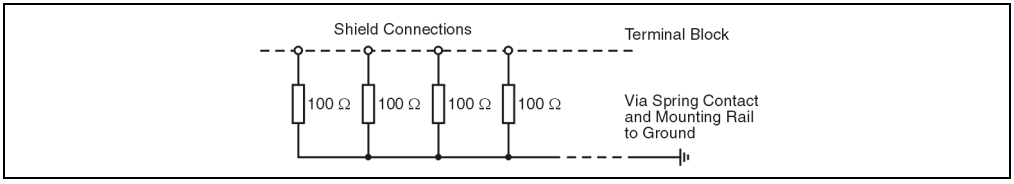


Figure 158: AM374 shielded connection

12.5.6 Input Circuit Diagram

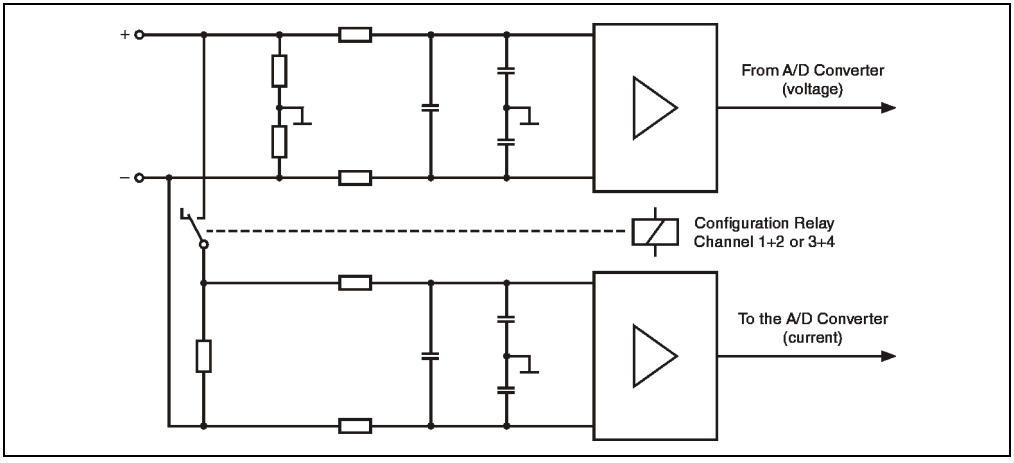


Figure 159: AM374 input circuit diagram

12.5.7 Output Circuit Diagram

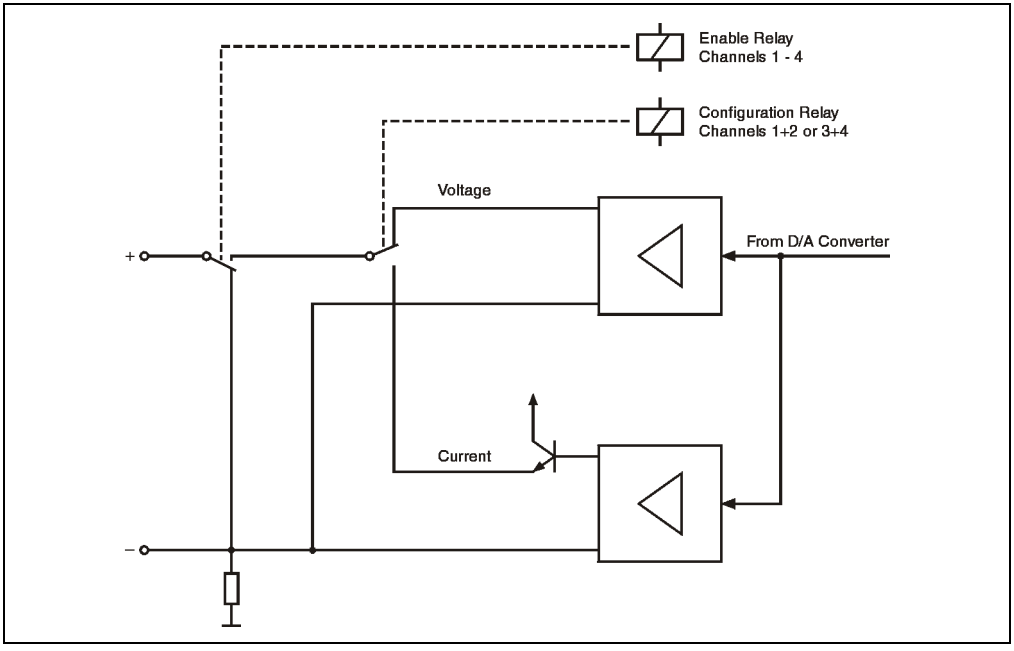


Figure 160: AM374 output circuit diagram

12.5.8 Configuration

The signal for analog inputs and analog outputs channels can be configured using the configuration register. The analog/digital and digital/analog converter begins to work after the configuration has been made.

There is no standby status! Without valid configuration, analog inputs remain highly resistive and the analog outputs are short circuited with the internal enable relay. The RUN LED blinks slowly. The error value $8000 (-32768) is returned as data value for the analog inputs.

The configuration remains in effect until the next start up or a reset is carried out in all operating modes. Changing during the operation is not possible. Configuration ideally takes place during the initialization sub-program (INIT SP). If PLC software ≥ V1.90 is used, then analog input values are already valid when the main program is started.

12.5.9 Operating Modes

Three operating modes are available:

- Normal operation: is set after configuration takes place
- Special Operating Mode 1: Direct software timing
- Special Operating Mode 2: Software timing using default time

Change of Operating Mode

- The module must be configured after the start up or after a reset. Normal operation is then active.
- 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 start up and after configuration has been carried out.

Analog Inputs

All channels are converted cyclically and data is transferred to 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.

Analog Outputs

All values are read, and written on the analog output channels. The update time for the analog outputs should be considered in the above listed conversion times for the analog inputs.

Special Operating Mode 1: Direct software timing

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

In this operating mode, the conversion cycle is started on the module by the application program, which sets bit 7 from mode register 8 to 0 (start pulse).

All analog output values are then immediately read and written on the output channels. Finally, the conversion of all four input channels is carried out so that it does not react to another start pulse. The end of the cycles is registered by setting bit 7 in status register 2.

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

Mode Register 8	Analog Mixed 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
	Analog output values read from the DPR (start)	1)
	Analog output values read from the DPR (end)	1)
	Update analog outputs 1 - 4	t_ao = t_0 + 328.5 to 330 µs
	Start measurement input channel 1	t_ao + 1 * 85 µs
	Start measurement input channel 2	t_ao +2 * 85 µs
	Start measurement input channel 3	t_ao +3 * 85 µs
	Start measurement input channel 4	t_ao +4 * 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 259: AM374 Special Operating Mode 1: Direct software timing

1) Bus accesses on the module can lead to interruptions in the reading of analog output values from the dual ported RAM (DPR) and/or the writing of the measurements in the dual ported RAM. 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

The 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 conversion cycle 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 reading of analog output values and 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 reported by setting bit 7 in the status register 2. Unlike special operating mode 1, the time scale is left unchanged.

Value range for the 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 Mixed Module	Time
Default time written in µs as UINT	Module in delay loop	t_0
	Bit 7 in the 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
	Analog output values read from the DPR (start)	1)
	Analog output values read from the DPR (end)	1)
	Update analog outputs 1 - 4	t_ao = t_St + 328.5 to 330 µs
	Start measurement input channel 1	t_ao + 1 * 85 µs
	Start measurement input channel 2	t_ao +2 * 85 µs
	Start measurement input channel 3	t_ao +3 * 85 µs
	Start measurement input channel 4	t_ao +4 * 85 µs
	Write measurements in the DPR (start up)	1)
	Write measurements in the DPR (end)	1)

Table 260: AM374 Special Operating Mode 2: Software timing using default time

Mode Registers 7 + 8	Analog Mixed Module	Time
	Bit 7 in the status register 2 = 1(cycle end)	t_pre - 100 µs
	Time entry sequence	t_pre
The next start pulse is possible	Module in delay loop	

Table 260: AM374 Special Operating Mode 2: Software timing using default time (cont.)

1) Bus accesses on the module can lead to interruptions in the reading of analog output values from the dual ported RAM (DPR) and/or the writing of the measurements in the dual ported RAM. 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.

12.5.10 Relationship between Converter Value and Input / Output Signals

Input Voltage 0 - 10 V

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

Input Voltage	Converter Value	
	Hexadecimal	Decimal
Error Status[1)]	$8000	-32768
≤0 V	$0000	0
2.441 mV	$0008	8
9.997 V	$7FF0	32752
≥10 V	$7FFF	32767

Table 261: AM374 Relationship between input voltage and converter value

1) For example, configuration that still has not been carried out.

Input Current 0 - 20 mA

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

Input Current	Converter Value	
	Hexadecimal	Decimal
Error Status[1)]	$8000	-32768
≤0 A	$0000	0
4.883 µA	$0008	8
19.995 mA	$7FF0	32752
≥20 mA	$7FFF	32767

Table 262: AM374 Relationship between input current and converter value

1) For example, configuration that still has not been carried out.

Output Voltage ±10 V

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

Converter Value		Output Voltage
Hexadecimal	Decimal	
≤$8080	-32640	-10 V
$FFF0	-16	-4.901 mV
$0000	0	0 V
$0010	16	4.901 mV
≥$7F80	32640	10 V

Table 263: AM374 Relationship between output voltage and converter value

Output Current 0 - 20 mA

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

Converter Value		Output Current
Hexadecimal	Decimal	
≤$0000	0	0 A
$0008	8	4.883 µA
≥$7F80	32640	20 mA

Table 264: AM374 relationship between output current and converter value

12.5.11 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 ... 4
Single Analog Output (channel x)	tc_global	INT	1	Analog Out	1 ... 4
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
Configuration Register 1	tc_global	USINT	1	Status Out	2
Configuration Register 2	tc_global	USINT	1	Status Out	3
Status Register 1	tc_global	USINT	1	Status In	0

Table 265: AM374 variable declaration

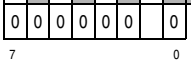
Function	Variable Declarations				
	Scope	Data Type	Length	Module Type	Chan.
Status Register 2	tc_global	USINT	1	Status In	1
Status Register 3 (Reproduction of the configuration register 1)	tc_global	USINT	1	Status In	2
Status Register 4 (Reproduction of the configuration register 2)	tc_global	USINT	1	Status In	3

Table 265: AM374 variable declaration (cont.)

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

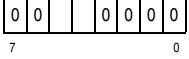
When this option is switched on, the average value is generated and transferred to the central unit. The calculation is formulated as follows:

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

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 conversion cycle of all analog inputs and analog outputs 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

	0	0	0	0	0	0	0
7							0

TRIGn TRIGn is only active in "Direct Software Timing" operating mode (SWT_DIR to 1, SWT_TIM to 0)
A write access with TRIGn = 0 triggers a conversion cycle.
A write access with TRIGn = 1 is ignored.

Configuration Register 1

Bits 4 - 6 must be assigned with 0.

Configuration Reg. 1	Bit	Description
	7	VAL_AI
	6	0
	5	0
	4	0
	3	AI_ CONF4
	2	AI_CONF3
	1	AI_CONF2
	0	AI_CONF1
0 0 0		
7		0

AI_CONF1, AI_CONF2 Input signal definition for analog inputs 1 and 2

AI_CONF2	AI_CONF1	Input Signal for Inputs 1 + 2
0	0	Voltage 0 - 10 V
0	1	Voltage 0 - 10 V
1	0	Voltage 0 - 10 V
1	1	Current 0 - 20 mA

Table 266: AM374 Input signal definition for analog inputs 1 and 2

AI_CONF3, AI_CONF4 Input signal definition for analog inputs 3 and 4

AI_CONF4	AI_CONF3	Input Signal for Inputs 3 +4
0	0	Voltage 0 - 10 V
0	1	Voltage 0 - 10 V
1	0	Voltage 0 - 10 V
1	1	Current 0 - 20 mA

Table 267: AM374 Input signal definition for analog inputs 3 and 4

VAL_AI 0 ..... Configuration is not valid
1 ..... Configuration is valid but only accepted if VAL_AO is also 1 in configuration register 2

Configuration Register 2

Bits 4 - 6 must be assigned with 0.

Configuration Reg. 2	Bit	Description
	7	VAL_AO
	6	0
	5	0
	4	0
	3	AO_CONF4
	2	AO_CONF3
	1	AO_CONF2
	0	AO_CONF1
0 0 0		

7 0

AO_CONF1, AO_CONF2 Output signal definition for analog outputs 1 and 2

AO_CONF2	AO_CONF1	Output Signal for Outputs 1 + 2
0	0	Voltage ±10 V
0	1	Voltage ±10 V
1	0	Voltage ±10 V
1	1	Current 0 - 20 mA

Table 268: AM374 Output signal definition for analog outputs 1 and 2

AO_CONF3, AO_CONF4 Output signal definition for analog outputs 3 and 4

AO_CONF4	AO_CONF3	Output Signal for Outputs 3 +4
0	0	Voltage ±10 V
0	1	Voltage ±10 V
1	0	Voltage ±10 V
1	1	Current 0 - 20 mA

Table 269: AM374 Output signal definition for analog outputs 3 and 4

VAL_AO 0 ..... Configuration is not valid
1 ..... Configuration is valid, but only accepted if VAL_AI is also 1 in configuration register 1

Status Register 1

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

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 or the configuration has still not been carried out. If this bit has still not been deleted after the configuration has been made, please contact B&R.

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

CONF_RDY 0 .....No valid configuration exists
1 .....Configuration of analog input and output is terminated

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

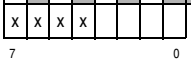
SWT_DIR
SWT_TIM SWT_DIR and SWT_TIM indicate the operating mode in which in the module can be found.

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

Status Register 3

Status register 3 indicates the configuration of analog inputs . The content of the status register is valid if the CONF_RDY bit is set in status register 1.

Status Register 3	Bit	Description
	7	x
	6	x
	5	x
	4	x
	3	AI_CONF4
	2	AI_CONF3
	1	AI_CONF2
	0	AI_CONF1



AI_CONF1, AI_CONF2 Input signal for analog inputs 1 and 2

AI_CONF2	AI_CONF1	Input Signal for Inputs 1 + 2
0	0	Voltage 0 - 10 V
1	1	Current 0 - 20 mA

Table 270: AM374 input signal for analog inputs 1 and 2

AI_CONF3, AI_CONF4 Input signal for analog inputs 3 and 4

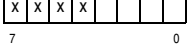
AI_CONF4	AI_CONF3	Input Signal for Inputs 3 +4
0	0	Voltage 0 - 10 V
1	1	Current 0 - 20 mA

Table 271: AM374 input signal for analog inputs 3 and 4

Status Register 4

Status register 4 indicates the configuration of analog outputs. The content of the status register is valid if the CONF_RDY bit is set in the status register 1.

Status Register 4	Bit	Description
	7	x
	6	x
	5	x
	4	x
	3	AO_CONF4
	2	AO_CONF3
	1	AO_CONF2
	0	AO_CONF1



AO_CONF1, AO_CONF2 — Output signal for analog outputs 1 and 2

AO_CONF2	AO_CONF1	Output Signal for Outputs 1 + 2
0	0	Voltage ±10 V
1	1	Current 0 - 20 mA

Table 272: AM374 output signal for analog outputs 1 and 2

AO_CONF3, AO_CONF4 — Output signal for analog outputs 3 and 4

AO_CONF4	AO_CONF3	Output Signal for Outputs 3 +4
0	0	Voltage ±10 V
1	1	Current 0 - 20 mA

Table 273: AM374 output signal for analog outputs 3 and 4