Cycle Time Calculation

S7-1500 Analog Input Module AI 8xU/I/R/RTD BA

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1 Introduction

The universal analog module AI 8xU/I/R/RTD BA of the S7-1500 (article number 6ES7531-7QF00-0AB0) is a multiplexed module that converts all the activated channels one after the other. In this way the module's cycle time, that is the time interval in which the module receives new values, depends on the type and number of activated channels.

Furthermore, at the end of each cycle the module performs an offset calibration to ensure sustained high precision. This corresponds to the longest basic conversion time of an activated channel.

This entry will explain the basic terms and take you through a sample calculation.

Figure 2-1 and Figure 3-1 show the times specified in the module's data sheet which are needed to calculate the conversion time of a channel and the cycle time of the module.

2 Conversion Time of a Channel

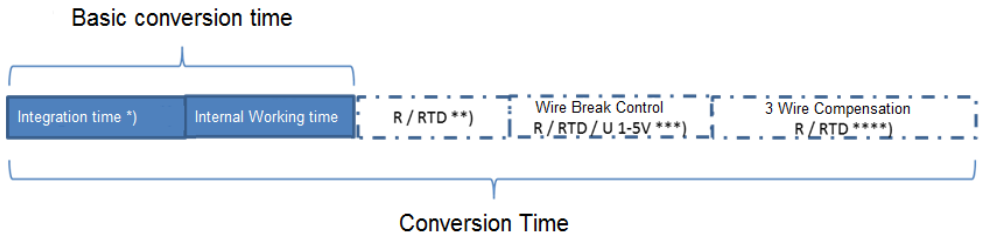
The conversion time of an individual channel consists of

- The basic conversion time (all measurement modes)
- The time for an activated wire-break control (only for R, RTD and U 1-5V)
- An additional time for the resistance measurement (R / RTD)
- The time for the 3-conductor compensation (only for R, RTD 3-conductor)

If QI is activated (Quality Information; value status), the wire-break control is always activated and is executed even if the diagnosis is deselected.

Figure 2-1 shows how to calculate the conversion time of a channel.

Figure 2-1



*) The integration time depends on the interference frequency suppression you set; example: 2.5ms@400Hz; 20ms@50Hz.
**) Additional conversion time for resistance measurement.
***) Additional conversion time for wire-break control.
****) The conductor compensation is done for R/RTD 3-conductor measurement. It corresponds to the basic conversion time of the channel.

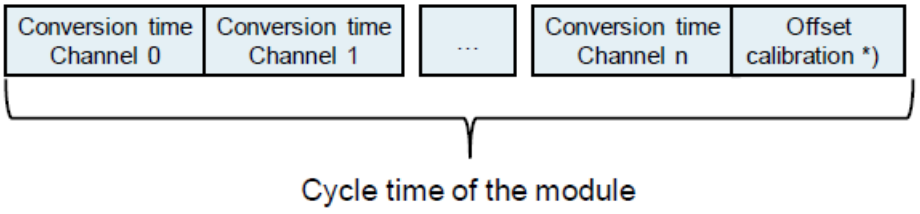
3 Cycle Time of the Module

To calculate the cycle time you must calculate the conversion time for each channel separately and then add these separate conversion times together.

Furthermore, the module performs an offset calibration for each cycle. The time required for this corresponds to the longest basic conversion time of a channel.

Figure 3-1 shows how to calculate the cycle time of the module.

Figure 3-1



*) The offset calibration is done once for each module cycle. It corresponds to the basic conversion time of the slowest channel.

The figure below shows an excerpt from the technical data of the analog module AI 8xU/I/R/RTD BA.

Figure 3-2

Analog value generation for the inputs	
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Integration time, parameterizable	Yes
• Integration time (ms)	2,5 / 16,67 / 20 / 100 ms
• Basic conversion time, including integration time (ms)	10 / 24 / 27 / 107 ms
— additional conversion time for wire break control	4 ms (consider to R/RTD/U 1-5 V-Measurement)
— additional conversion time for resistance measurement	8 ms
• Interference voltage suppression for interference frequency f1 in Hz	400 / 60 / 50 / 10 Hz

The technical data of the analog module AI 8xU/I/R/RTD BA is available at this link:

https://support.industry.siemens.com/cs/ww/en/pv/6ES7531-7QF00-0AB0

4 Sample Calculations of Conversion Time and Cycle Time

4.1 Channels Have Different Parameters

Channel parameters

In this example the channels have completely different parameters.

Table 4-1

Channel	Measurement mode	Wire-break control
Channel 0	Current	Not applicable
Channel 1	Voltage +/- 10V	Not applicable
Channel 2	PT100	Selected
Channel 3	PT100	Disabled
Channel 4	PTC	Not applicable
Channel 5	Voltage 1-5V	Selected
Channel 6	Disabled	Not applicable
Channel 7	Disabled	Not applicable

An interference frequency suppression of 50 Hz is set for all channels.

Calculation

You calculate the cycle time of the module by adding together the conversion times of the single channels plus the conversion time for the offset calibration. The cycle time of the module in this example is 275ms.

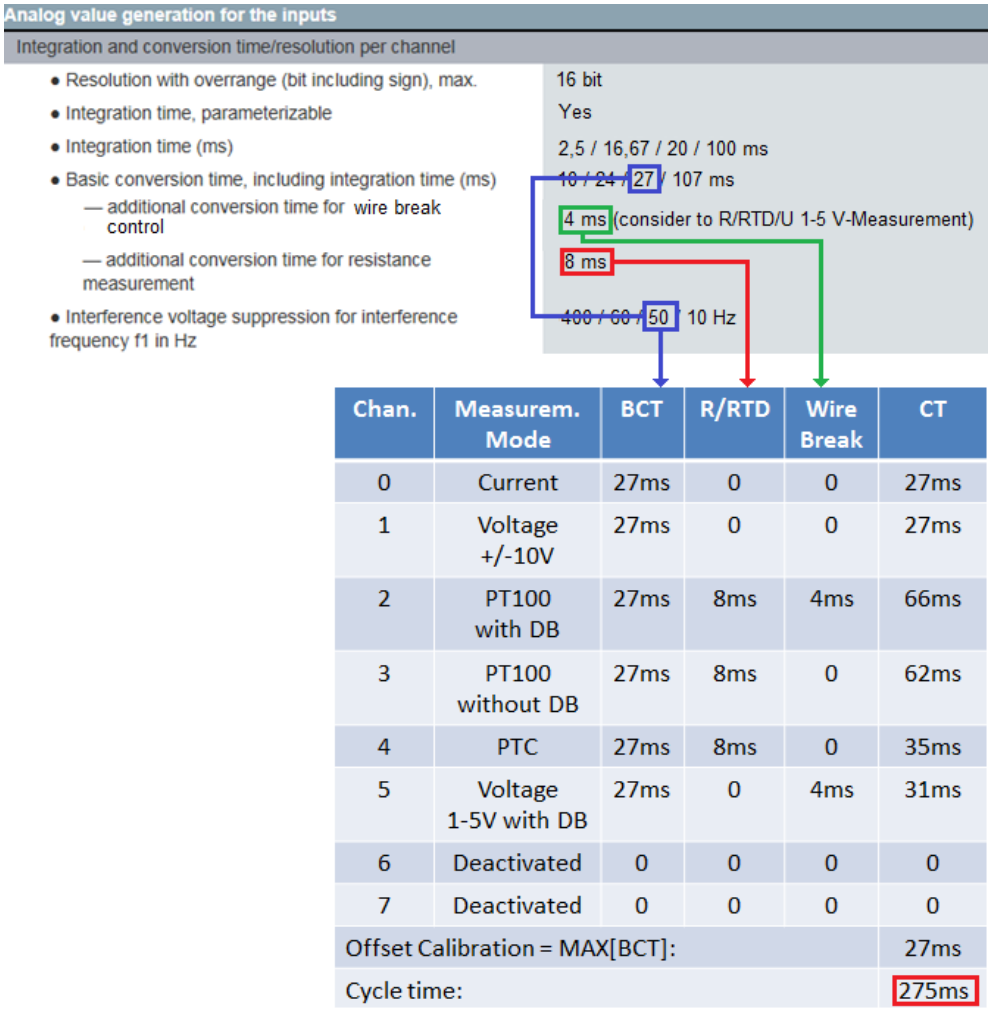
Table 4-2

Channel	Description	Conversion time
Channel 0	Only the basic conversion time has to be taken into account.	27ms
Channel 1	Only the basic conversion time has to be taken into account.	27ms
Channel 2	In addition to the basic conversion you must take into account the following: Additional conversion time for • resistance measurement (8ms) • activated wire-break control (4ms) • 3-conductor compensation Conversion time = 27ms + 8ms + 4ms + 27ms = 66ms	66ms
Channel 3	In addition to the basic conversion you must take into account the following: Additional conversion time • resistance measurement (8ms) • 3-conductor compensation Conversion time = 27ms + 8ms + 27ms = 62ms	62ms
Channel 4	In addition to the basic conversion you must take into account the following: • resistance measurement (8ms)	35ms

Channel	Description	Conversion time
	Conversion time = 27ms + 8ms = 35ms	
Channel 5	In addition to the basic conversion you must take into account the following: Additional conversion time for the activated wire-break control (4ms). Conversion time = 27ms + 4ms = 31ms	31ms
Offset calibration	The basic conversion time of the slowest channel is 27ms. You must take this into account in the offset calibration.	27ms

Figure 4-1 and Figure 4-2 show the calculation of the cycle time of the module when the channels have different parameters.

Figure 4-1

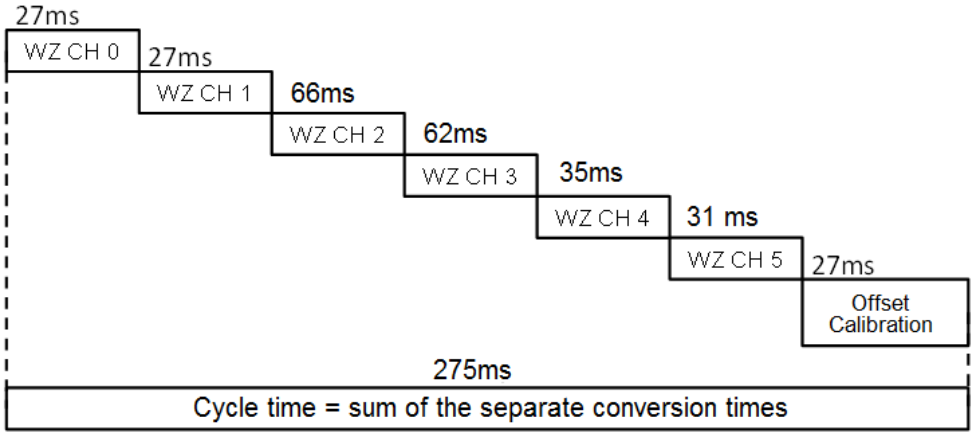


Chan.	Measurem. Mode	BCT	R/RTD	Wire Break	CT
0	Current	27ms	0	0	27ms
1	Voltage +/-10V	27ms	0	0	27ms
2	PT100 with DB	27ms	8ms	4ms	66ms
3	PT100 without DB	27ms	8ms	0	62ms
4	PTC	27ms	8ms	0	35ms
5	Voltage 1-5V with DB	27ms	0	4ms	31ms
6	Deactivated	0	0	0	0
7	Deactivated	0	0	0	0
Offset Calibration = MAX[BCT]:					27ms
Cycle time:					275ms

Number of activated channels: 6
Measurement mode: see table
Interference frequency suppression: 50Hz

The longest basic conversion time provides the time for the offset calibration: 27ms

Figure 4-2



CT CH: Conversion time of the channel

4.2 All Channels Have Identical Parameters

Channel parameters

The analog module AI 8xU/I/R/RTD BA is used for current measurement in a range of 4…20mA with all channels. Wire-break control is activated for all channels. An interference frequency suppression of 400 Hz is set.

Calculation

You calculate the cycle time of the module by adding together the conversion times of the single channels plus the conversion time for the offset calibration. The cycle time of the module in this example is 90ms.

Although wire-break control is enabled, you do not have to take any other times into consideration for current measurement. Here the basic conversion time of the channel is the conversion time.

Since all 8 channels are configured identically, you simply take the product of the number of activated channels and the conversion time. You must also add the time for the offset calibration. The basic conversion time of the slowest channel is 10ms. You must take this into account in the offset calibration.

Cycle time = number of activated channels * conversion time + offset calibration
= 8 * 10ms + 10ms = 90ms

Figure 4-3 and Figure 4-4 show the calculation of the cycle time of the module when the channels have identical parameters.

Figure 4-3

Analog value generation for the inputs

Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Integration time, parameterizable	Yes
• Integration time (ms)	2,5 / 16,67 / 20 / 100 ms
• Basic conversion time, including integration time (ms)	10 / 24 / 27 / 107 ms
— additional conversion time for wire break control	4 ms (consider to R/RTD/U 1-5 V-Measurement)
— additional conversion time for resistance measurement	8 ms
• Interference voltage suppression for interference frequency f1 in Hz	400 / 60 / 50 / 10 Hz

Chan.	Measurem. Mode	BCT	R/RTD	Wire Break	CT
0	Current	10ms	0	0	10ms
1	Current	10ms	0	0	10ms
2	Current	10ms	0	0	10ms
3	Current	10ms	0	0	10ms
4	Current	10ms	0	0	10ms
5	Current	10ms	0	0	10ms
6	Current	10ms	0	0	10ms
7	Current	10ms	0	0	10ms
Offset Calibration = MAX[BCT]:					10ms
Cycle time:					90ms

Number of activated channels: 8
Measurement mode: Current (I) for all channels; diagnostics activated
Interference frequency suppression: 400Hz

The longest basic conversion time provides the time for the offset calibration: 90ms

Figure 4-4