SIEMENS

Product Information

SIMATIC S7-200

EM231, EM232, EM235 Analog Input and Output Modules **Release** $\frac{X|2}{3|4}$

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New Expansion Modules Available

The following expansion modules have been added to the S7-200 family. The order numbers for these expansion modules are shown below:

- EM231 Analog Input AI 4 x 12 Bits
  (order number 6ES7 231–0HC20–0XA0)
- EM232 Analog Output AQ 2 x 12 Bits
  (order number 6ES7–232–0HB20–0XA0)
- EM235 Analog Combo AI 4/AQ 1 x 12 Bits
  (order number 6ES7 235–0KD20–0XA0)

The technical specifications for the expansion modules are included in this product information document. You can refer to the *S7-200 Programmable Controller System Manual* for more information about the S7-200 product family.

Additional Assistance

For assistance in answering technical questions, for training on this product, or for ordering, contact your Siemens distributor or sales office.

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Description Order Number	EM231 Analog Input AI 4 x 12 Bits 6ES7 231–0HC20–0XA0	EM232 Analog Output AQ 2 x 12 Bits 6ES7 232–0HB20–0XA0	EM235 Analog Combo AI 4/AQ 1 x 12 Bits 6ES7 235–0KD20–0XA0	
	Input Specifications	**Output Specifications**	**Input Specifications**	**Output Specifications**
General Specifications				
Dimensions (W x H x D) Weight Power loss (dissipation)	71.2 mm x 80 mm x 62 mm 183 g 2 W	46 mm x 80 mm x 62 mm 148 g 2 W	71.2 mm x 80 mm x 62 mm 186 g 2 W	
Number of physical I/O	4 analog input points	2 analog output points	4 analog input points, 1 analog output point	
Power Consumption From +5 VDC (from I/O bus) From L+ L+ voltage range, Class 2 or DC sensor supply	 20 mA 60 mA 20.4 to 28.8	 20 mA 70 mA (with both outputs at 20 mA) 20.4 to 28.8	 30 mA 60 mA (with output at 20 mA) 20.4 to 28.8	
LED indicator	24 VDC Power Supply Good, ON = no fault, OFF = no 24 VDC power	24 VDC Power Supply Good, ON = no fault, OFF = no 24 VDC power	24 VDC Power Supply Good, ON = no fault, OFF = no 24 VDC power	
Analog Input Specifications				
No. of Analog Input Points	4		4	
Isolation (Field side to logic circuit)	None		None	
Input type	Differential		Differential	
Input ranges Voltage (unipolar) Voltage (bipolar) Current	 0 to 10 V, 0 to 5 V ±5 V, ± 2.5 V 0 to 20 mA		 0 to 10 V, 0 to 5 V, 0 to 1 V, 0 to 500 mV, 0 to 100 mV, 0 to 50 mV ± 10 V, ± 5 V, ± 2.5 V, ± 1 V, ± 500 mV, ± 250 mV, ± 100 mV, ± 50 mV, ± 25 mV 0 to 20 mA	
Input Resolution Voltage (unipolar) Voltage (bipolar) Current	see Table 1		see Table 2	
Analog to digital conversion time	< 250 µs		< 250 µs	
Analog input step response	1.5 ms to 95%		1.5 ms to 95%	
Common mode rejection	40 dB, DC to 60 Hz		40 dB, DC to 60 Hz	
Common mode voltage	Signal voltage plus common mode voltage (must be ≤ 12 V)		Signal voltage plus common mode voltage (must be ≤ 12 V)	
Data word format Bipolar, full-scale range Unipolar, full-scale range	(see Figure 3) –32000 to +32000 0 to 32000		(see Figure 3) –32000 to +32000 0 to 32000	
Input impedance	≥10 MΩ		≥ 10 MΩ	
Input filter attenuation	–3 db @ 3.1 Khz		–3 db @ 3.1 Khz	
Maximum input voltage	30 VDC		30 VDC	
Maximum input current	32 mA		32 mA	
Resolution	12 bit A/D converter		12 bit A/D converter	

Description Order Number	EM231 Analog Input AI4x12 Bits 6ES7 231–0HC20–0XA0	EM232 Analog Output AQ2x12 Bits 6ES7 232–OHB20–0XA0	EM235 Analog Combo AI4/AQ 1 x 12 Bits 6ES7 235–0KD20–0XA0	
	Input Specifications	**Output Specifications**	**Input Specifications**	**Output Specifications**
Analog Output Specifications				
No. of Analog Output Points		2		1
Isolation (Field side to logic circuit)		None		None
Signal range Voltage output Current output		 ± 10 V 0 to 20 mA		 ± 10 V 0 to 20 mA
Resolution, full-scale Voltage Current		 12 bits 11 bits		 12 bits 11 bits
Data word format Voltage Current		 –32000 to +32000 0 to +32000		 –32000 to +32000 0 to +32000
Accuracy Worst case, 0° to 55° C Voltage output Current output Typical, 25° C Voltage output Current output		 ± 2% of full-scale ± 2% of full-scale ± 0.5% of full-scale ± 0.5% of full-scale		 ± 2% of full-scale ± 2% of full-scale ± 0.5% of full-scale ± 0.5% of full-scale
Settling time Voltage output Current output		 100 µS 2 mS		 100 µS 2 mS
Maximum drive Voltage output Current output		 5000 Ω minimum 500 Ω maximum		 5000 Ω minimum 500 Ω maximum

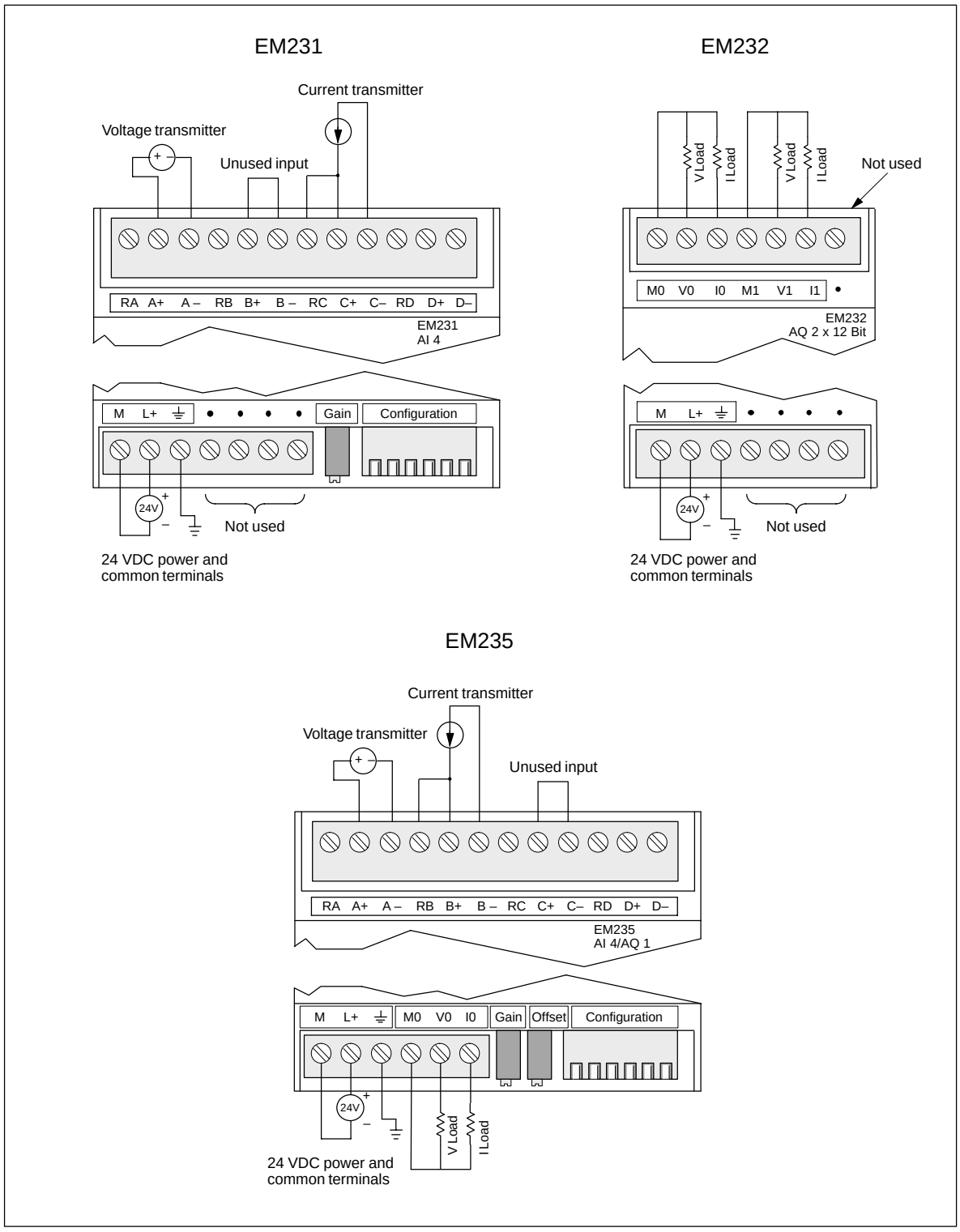

Figure 1 Connector Terminal Identification for Expansion Modules EM231, EM232, and EM235

Input Calibration

The calibration adjustments affect the instrumentation amplifier stage that follows the analog multiplexer (see Figure 4). Therefore, calibration affects all user input channels. Variations in the component values of each input circuit preceeding the analog multiplexer will cause slight differences in the readings between channels connected to the same input signal even after calibration.

To meet the specifications contained in this data sheet, you should enable analog input filters for all inputs of the module. Select 64 or more samples in calculating the average value. For more information about analog input filters, see the *S7-200 Programmable Controller System Manual.*

To calibrate the input, use the following steps.

1. Turn off the power to the module. Select the desired input range.
2. Turn on the power to the CPU and module. Allow the module to stabilize for 15 minutes.
3. Using a transmitter, a voltage source, or a current source, apply a zero value signal to one of the input terminals.
4. Read the value reported to the CPU by the appropriate input channel.
5. Adjust the OFFSET potentiometer until the reading is zero, or the desired digital data value.
6. Connect a full-scale value signal to one of the input terminals. Read the value reported to the CPU.
7. Adjust the GAIN potentiometer until the reading is 32000, or the desired digital data value.
8. Repeat OFFSET and GAIN calibration as required.

Calibration and Configuration Location for EM231 and EM235

The calibration potentiometer and configuration DIP switches are located on the right of the bottom terminal block of the module, as shown in Figure 2.

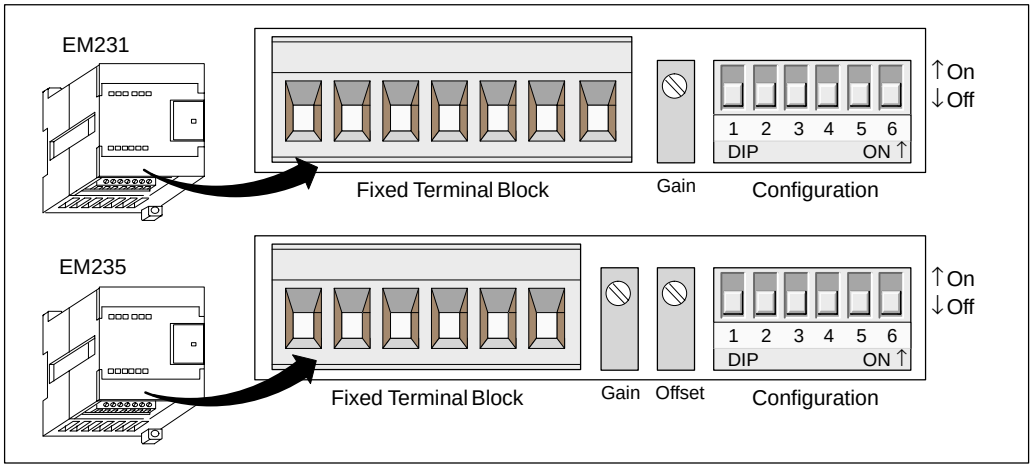

Figure 2 Calibration Potentiometer and Configuration DIP Switches for EM231 and EM235

Configuration for EM231

Table 1 shows how to configure the EM231 module using the configuration DIP switches. Switches 1, 2, and 3 select the analog input range. All inputs are set to the same analog input range. In this table, ON is closed, and OFF is open.

Table 1 EM231 Configuration Switch Table to Select Analog Input Range

Unipolar			Full-Scale Input	Resolution
SW1	**SW2**	**SW3**		
ON	OFF	ON	0 to 10 V	2.5 mV
	ON	OFF	0 to 5 V	1.25 mV
			0 to 20 mA	5 µA
Bipolar			**Full-Scale Input**	**Resolution**
SW1	**SW2**	**SW3**		
OFF	OFF	ON	± 5 V	2.5 mV
	ON	OFF	± 2.5 V	1.25 mV

Configuration for EM235

Table 2 shows how to configure the EM235 module using the configuration DIP switches. Switches 1 through 6 select the analog input range and resolution. All inputs are set to the same analog input range and format. Table 3 shows how to select for unipolar/bipolar (switch 6), gain (switches 4 and 5), and attenuation (switches 1, 2, and 3). In these tables, ON is closed, and OFF is open.

Table 2 EM235 Configuration Switch Table to Select Analog Input Range and Resolution

Unipolar						Full-Scale Input	Resolution
SW1	**SW2**	**SW3**	**SW4**	**SW5**	**SW6**		
ON	OFF	OFF	ON	OFF	ON	0 to 50 mV	12.5 μV
OFF	ON	OFF	ON	OFF	ON	0 to 100 mV	25 μV
ON	OFF	OFF	OFF	ON	ON	0 to 500 mV	125 μV
OFF	ON	OFF	OFF	ON	ON	0 to 1 V	250 μV
ON	OFF	OFF	OFF	OFF	ON	0 to 5 V	1.25 mV
ON	OFF	OFF	OFF	OFF	ON	0 to 20 mA	5 μA
OFF	ON	OFF	OFF	OFF	ON	0 to 10 V	2.5 mV
Bipolar						**Full-Scale Input**	**Resolution**
SW1	**SW2**	**SW3**	**SW4**	**SW5**	**SW6**		
ON	OFF	OFF	ON	OFF	OFF	±25 mV	12.5 μV
OFF	ON	OFF	ON	OFF	OFF	±50 mV	25 μV
OFF	OFF	ON	ON	OFF	OFF	±100 mV	50 μV
ON	OFF	OFF	OFF	ON	OFF	±250 mV	125 μV
OFF	ON	OFF	OFF	ON	OFF	±500 mV	250 μV
OFF	OFF	ON	OFF	ON	OFF	±1 V	500 μV
ON	OFF	OFF	OFF	OFF	OFF	±2.5 V	1.25 mV
OFF	ON	OFF	OFF	OFF	OFF	±5 V	2.5 mV
OFF	OFF	ON	OFF	OFF	OFF	±10 V	5 mV

Table 3 EM235 Configuration Switch Table to Select Unipolar/Bipolar, Gain, and Attenuation

EM235 Configuration Switches						Unipolar/Bipolar Select	Gain Select	Attenuation Select
SW1	**SW2**	**SW3**	**SW4**	**SW5**	**SW6**			
					ON	Unipolar		
					OFF	Bipolar		
			OFF	OFF			x1	
			OFF	ON			x10	
			ON	OFF			x100	
			ON	ON			invalid	
ON	OFF	OFF						0.8
OFF	ON	OFF						0.4
OFF	OFF	ON						0.2

Input Data Word Format for EM231 and EM235

Figure 3 shows where the 12-bit data value is placed within the analog input word of the CPU.

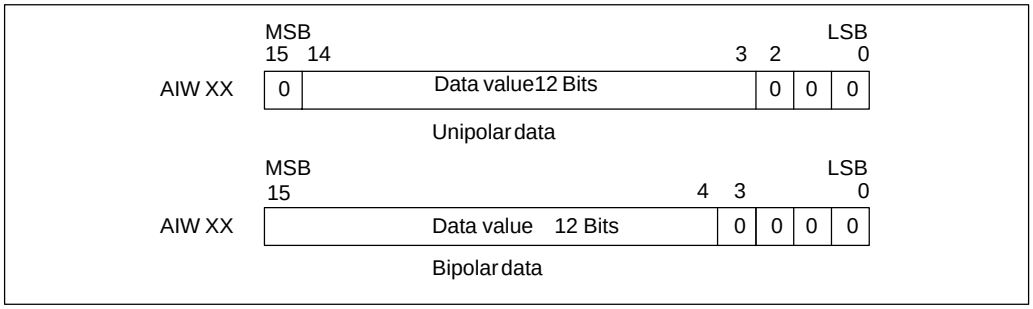

Figure 3 Input Data Word Format for EM231 and EM235

Note

The 12 bits of the analog-to-digital converter (ADC) readings are left-justified in the data word format. The MSB is the sign bit: zero indicates a positive data word value. In the unipolar format, the three trailing zeros cause the data word to change by a count of eight for each one-count change in the ADC value. In the bipolar format, the four trailing zeros cause the data word to change by a count of sixteen for each one count change in the ADC value.

Input Block Diagram for EM231 and EM235

Figure 4 shows the EM231 and EM235 input block diagrams.

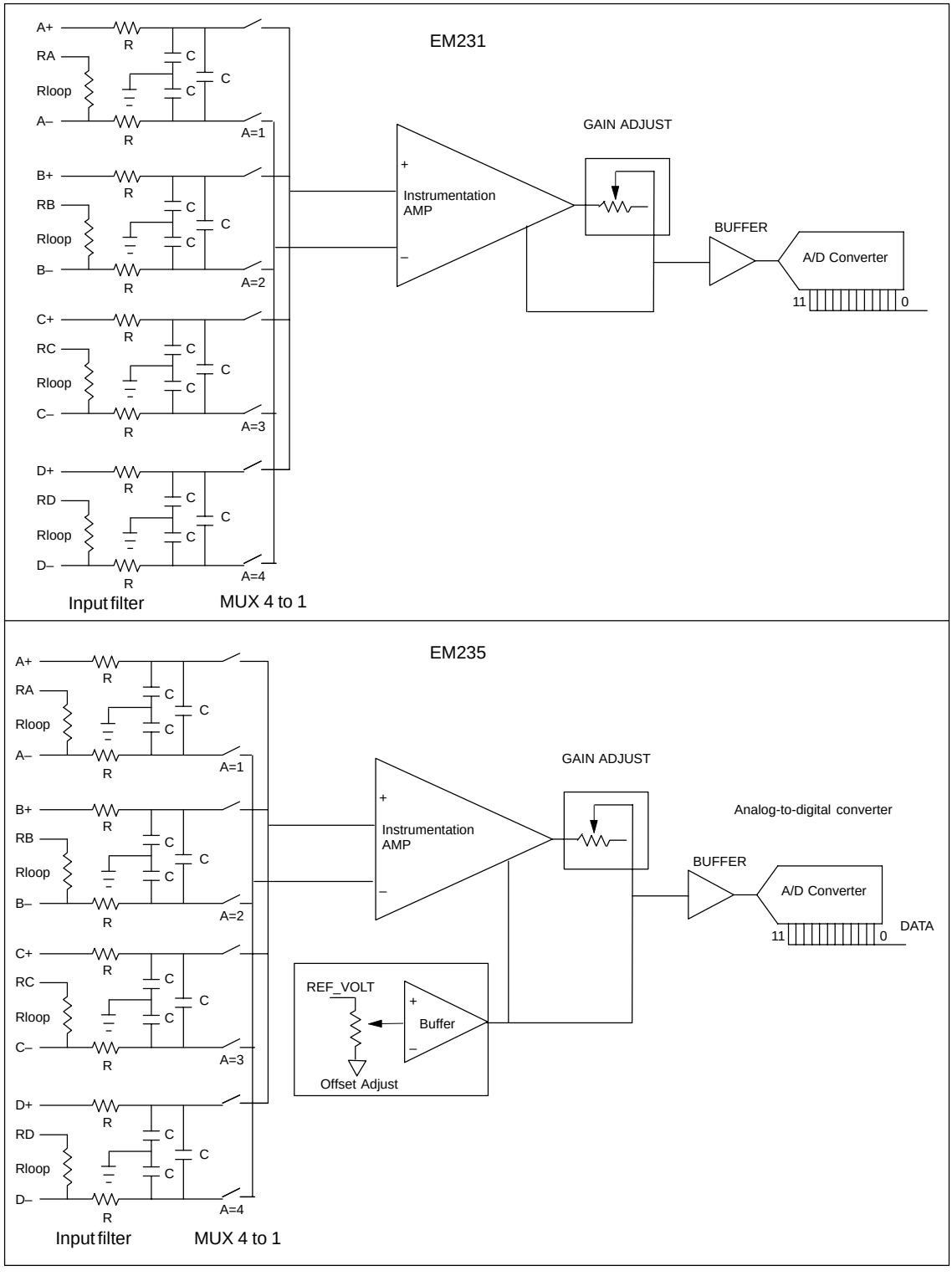

Figure 4 EM231 and EM235 Input Block Diagram

Output Data Word Format for EM232 and EM235

Figure 5 shows where the 12-bit data value is placed within the analog output word of the CPU.

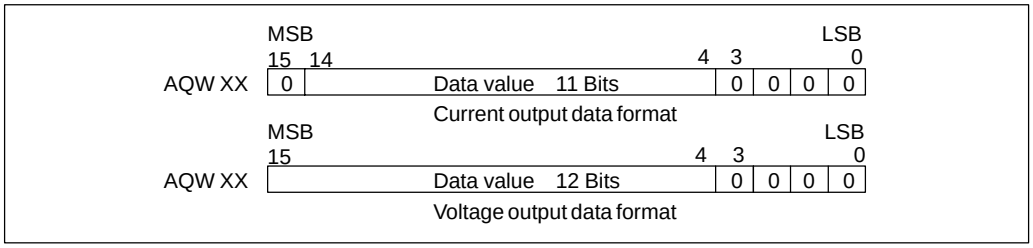

Figure 5 Output Data Word Format for EM232 and EM235

Note

The 12 bits of the digital-to-analog converter (DAC) readings are left-justified in the output data word format. The MSB is the sign bit: zero indicates a positive data word value. The four trailing zeros are truncated before being loaded into the DAC registers. These bits have no effect on the output signal value.

Output Block Diagram for EM232 and EM235

Figure 6 shows the EM232 and EM235 output block diagrams.

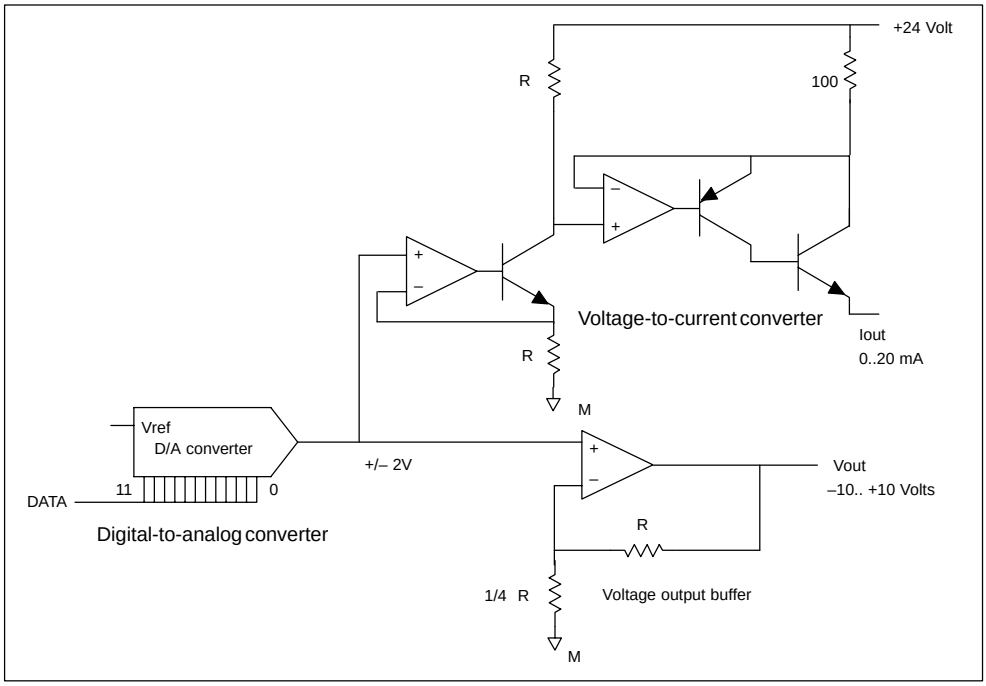

Figure 6 EM232 and EM235 Output Block Diagram

Installation Guidelines

Use the following guidelines to ensure good accuracy and repeatability:

- Ensure that the 24-VDC Sensor Supply is free of noise and is stable.
- Use the shortest possible sensor wires.
- Use shielded twisted pair wiring for sensor wires.
- Terminate the shield at the Sensor location only.
- Short the inputs for any unused channels, as shown in Figure 1.
- Avoid bending the wires into sharp angles.
- Use wireways for wire routing.
- Avoid placing signal wires parallel to high-energy wires. If the two wires must meet, cross them at right angles.
- Ensure that the input signals are within the common mode voltage specification by isolating the input signals or referencing them to the external 24V common of the analog module.

Note
The EM231 and EM235 expansion modules are not recommended for use with thermocouples.

Understanding and Using the Analog Input Module: Accuracy and Repeatability

The EM231 and EM235 analog input modules are low-cost, high-speed 12 bit analog input modules. The modules are capable of converting an analog input to its corresponding digital value in 149 μsec. Conversion of the analog signal input is performed each time the analog point is accessed by your program. These times must be added to the basic execution time of the instruction used to access the analog input.

The EM231 and EM235 provide an unprocessed digital value (no linearization or filtering) that corresponds to the analog voltage or current presented at the module's input terminals. Since the modules are high-speed modules, they can follow rapid changes in the analog input signal (including internal and external noise). Reading-to-reading variations caused by noise for a constant or slowly changing analog input signal can be minimized by averaging a number of readings. As the number of readings used in computing the average value increases, a correspondingly slower response time to changes in the input signal can be observed.

The specifications for repeatability describe the reading-to-reading variations of the module for an input signal that is not changing. The repeatability specification defines the limits within which 99% of the readings will fall. The mean accuracy specification describes the average value of the error (the difference between the average value of individual readings and the exact value of the actual analog input signal). The repeatability is described in Figure 7 by the bell curve. This figure shows the 99% repeatability limits, the mean or average value of the individual readings, and the mean accuracy in a graphical form. Table 4 gives the repeatability specifications and the mean accuracy as they relate to each of the configurable ranges.

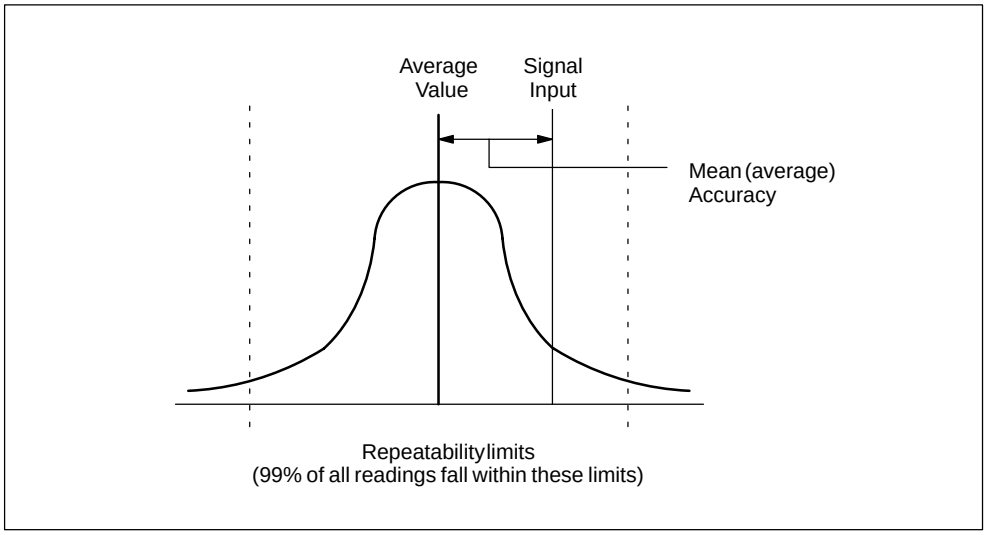

Figure 7 Accuracy Definitions

Table 4 EM231 and EM235 Specifications

Full Scale Input Range	Repeatability[1]		Mean (average) Accuracy[1,2,3,4]	
	% of Full Scale	Counts	% of Full Scale	Counts
EM231 Specifications				
0 to 5 V	± 0.075%	± 24	± 0.01%	± 32
0 to 20 mA				
0 to 10 V				
± 2.5 V		± 48	± 0.05%	
± 5 V				
EM235 Specifications				
0 to 50 mV	± 0.075%	± 24	± 0.25%	± 80
0 to 100 mV			± 0.2%	± 64
0 to 500 mV			± 0.05%	± 16
0 to 1 V				
0 to 5 V				
0 to 20 mA				
0 to 10 V				
± 25 mV	± 0.075%	± 48	± 0.25%	± 160
± 50 mV			± 0.2%	± 128
± 100 mV			± 0.1%	± 64
± 250 mV			± 0.05%	± 32
± 500 mV				
± 1 V				
± 2.5 V				
± 5 V				
± 10 V				

1 Measurements made after the selected input range has been calibrated.
2 The offset error in the signal near zero analog input is not corrected, and is not included in the accuracy specifications.
3 There is a channel-to-channel carryover conversion error, due to the finite settling time of the analog multiplexer. The maximum carryover error is 0.1% of the difference between channels.
4 Mean accuracy includes effects of non-linearity and drift from 0 to 55 degrees C.

Definitions of the Analog Specifications

- Accuracy: deviation from the expected value on a given point.
- Resolution: the effect of an LSB change reflected on the output.

Agency Standards

These modules adhere to the following agency standards: UL 508 Listed (Industrial Control Equipment); CSA C22.2 Number 142 Certified (Process Control Equipment); FM Class I, Division 2, Groups A, B, C, & D Hazardous Locations, T4A; VDE 0160: Electronic equipment for use in electrical power installations; European Community (CE) Low Voltage Directive 73/23/EEC, EN 61131–2: Programmable controllers – Equipment requirements; European Community (CE) EMC Directive 89/336/EEC.

For more information about these standards, refer to the *S7-200 Programmable Controller System Manual.*