A.35 Expansion Module EM235 Analog Combination AI 3/AQ 1 x 12 Bits

Order Number: 6ES7 235-0KD00-0XA0

General Features	
Physical size (L x W x D)	90 x 80 x 62 mm (3.54 x 3.15 x 2.44 in.)
Weight	0.2 kg (0.4 lbs.)
Power dissipation	2 W
Points[1]	3 analog inputs 1 analog output
Standards compliance	UL 508 CSA C22.2 142 FM Class I, Division 2 VDE 0160 compliant CE compliant
Output Points	
Signal range	
Voltage output	± 10 V
Current output	0 to 20 mA
Resolution, full-range	
Voltage	12 bits
Current	11 bits
Data word format[2]	
Bipolar range[3]	-32000 to +32000
Unipolar range[2]	0 to + 32000
Accuracy	
Worst case, 0 to 60° c	
Voltage output	± 2% of full-scale
Current output	± 2% of full-scale
Typical, 25° c	
Voltage output	± 0.5% of full-scale
Current output	± 0.5% of full-scale
Settling time	
Voltage output	100 µs
Current output	2 ms
Maximum drive @ 24 V user supply	
Voltage output	5000Ω minimum
Current output	500Ω maximum

Input Points	
Input type	Differential
Input impedance	≥ 10 MΩ
Input filter attenuation	-3db @ 3.1 kHz
Maximum input voltage	30 V
Maximum input current	32 mA
Resolution	12 bit A/D converter
Isolation	Non-isolated
Analog-to-digital conversion time	< 250 µsec
Analog step response	1.5 ms to 95%
Common mode voltage	Signal voltage plus common mode voltage, less than or equal to 12 V
Common mode rejection	40 dB, DC to 60 Hz
Data word format[2]	
Bipolar range[3]	-32000 to +32000
Unipolar range[2]	0 to + 32000
Current Requirements	
5 VDC logic current	70 mA from Base Unit
External power supply	60 mA, plus output current of 20 mA, from Base Unit or External Supply (24 VDC nominal, Class 2 or DC Sensor Supply)
Indicator LED, EXTF	
Power supply fault	Low voltage, on external 24 VDC

1 The CPU reserves 4 analog input points and 2 analog output points for this module.
2 Data word increments in 16 count steps, left justified ADC values. See Figure A-43 and Figure A-45.
3 Data word increments in 8 count steps, left justified ADC values. See Figure A-43.

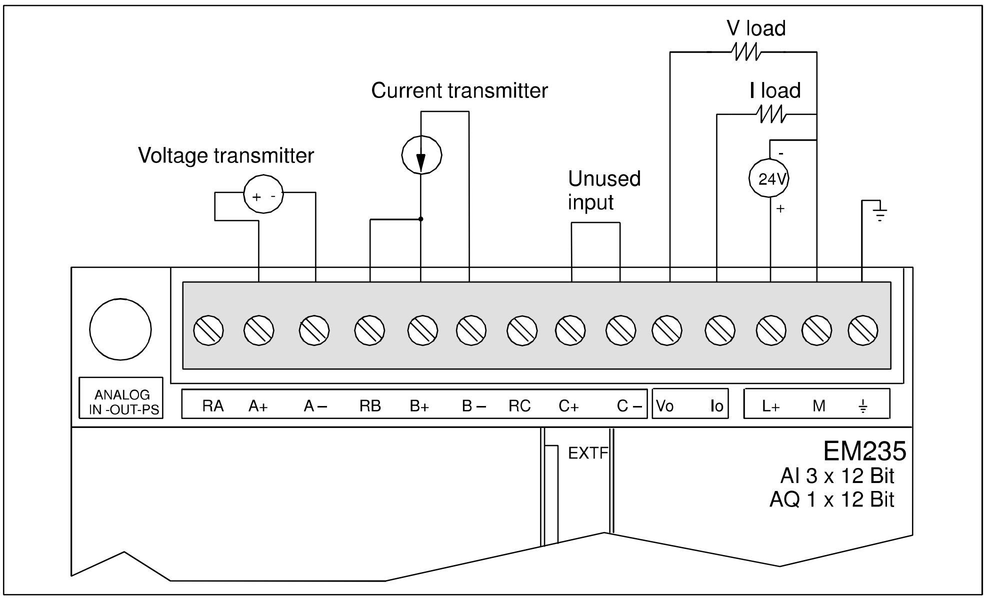

Figure A-41 Connector Terminal Identification for Expansion Module EM235 Analog Combination AI 3/AQ 1 x 12 Bits

Calibration and Configuration Location

The calibration potentiometers and configuration DIP switches are accessed through the ventilation slots of the module, as shown in Figure A-42.

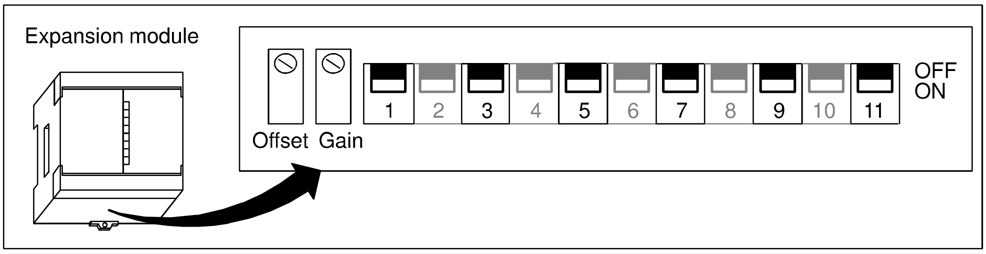

Figure A-42 Calibration Potentiometers and Configuration DIP Switches

Configuration

Table A-4 shows how to configure the module using the configuration DIP switches. Switches 1, 3, 5, 7, 9, and 11 select the analog input range and data format. All inputs are set to the same input range and format.

Table A-4 Configuration Switch Table for EM235 Analog Combination

Configuration Switch						Full-Scale Input	Resolution
1[1]	3	5	7	9	11		
ON	ON	OFF	ON	OFF	OFF	0 to 50 mV	12.5 μV
ON	ON	OFF	OFF	ON	OFF	0 to 100 mV	25 μV
ON	OFF	ON	ON	OFF	OFF	0 to 500 mV	125 μV
ON	OFF	ON	OFF	ON	OFF	0 to 1 V	250 μV
ON	OFF	OFF	ON	OFF	OFF	0 to 5 V	1.25 mV
ON	OFF	OFF	ON	OFF	OFF	0 to 20 mA[2]	5 μA
ON	OFF	OFF	OFF	ON	OFF	0 to 10 V	2.5 mV
OFF	ON	OFF	ON	OFF	OFF	±25 mV	12.5 μV
OFF	ON	OFF	OFF	ON	OFF	±50 mV	25 μV
OFF	ON	OFF	OFF	OFF	ON	±100 mV	50 μV
OFF	OFF	ON	ON	OFF	OFF	±250 mV	125 μV
OFF	OFF	ON	OFF	ON	OFF	±500 mV	250 μV
OFF	OFF	ON	OFF	OFF	ON	±1 V	500 μV
OFF	OFF	OFF	ON	OFF	OFF	±2.5 V	1.25 mV
OFF	OFF	OFF	OFF	ON	OFF	±5 V	2.5 mV
OFF	OFF	OFF	OFF	OFF	ON	±10 V	5 mV

1 Switch 1 selects the input polarity: ON for unipolar and OFF for bipolar. CPU power cycle required when switching between unipolar and bipolar data formats. Switches 3, 5, 7, 9 and 11 select voltage range.

2 0 to 20 mA measurements were made using the internal 250 current-sense resistor.

Input Calibration

The calibration affects all three input channels, and there may be a difference in the readings between the channels after calibration.

To calibrate the module accurately, you must use a program designed to average the values read from the module. Use the Analog Input Filtering wizard provided in STEP 7-Micro/WIN to create this program (see Section 5.3). Use 64 or more samples in calculating the average value.

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.

Input Data Word Format

Figure A-43 shows where the 12-bit data value is placed within the analog input word of the CPU.

A variance in repeatability of only ±0.50% of full scale can give a variance of ±160 counts in the value read from the analog input.

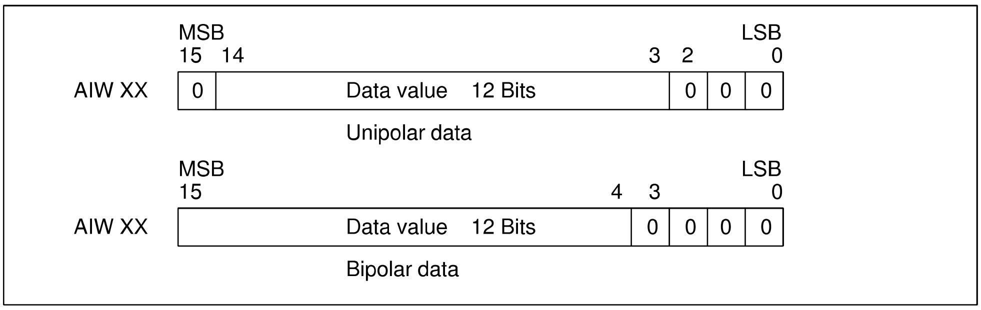

Figure A-43 Input Data Word Format

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

Figure A-44 shows the EM235 input block diagram.

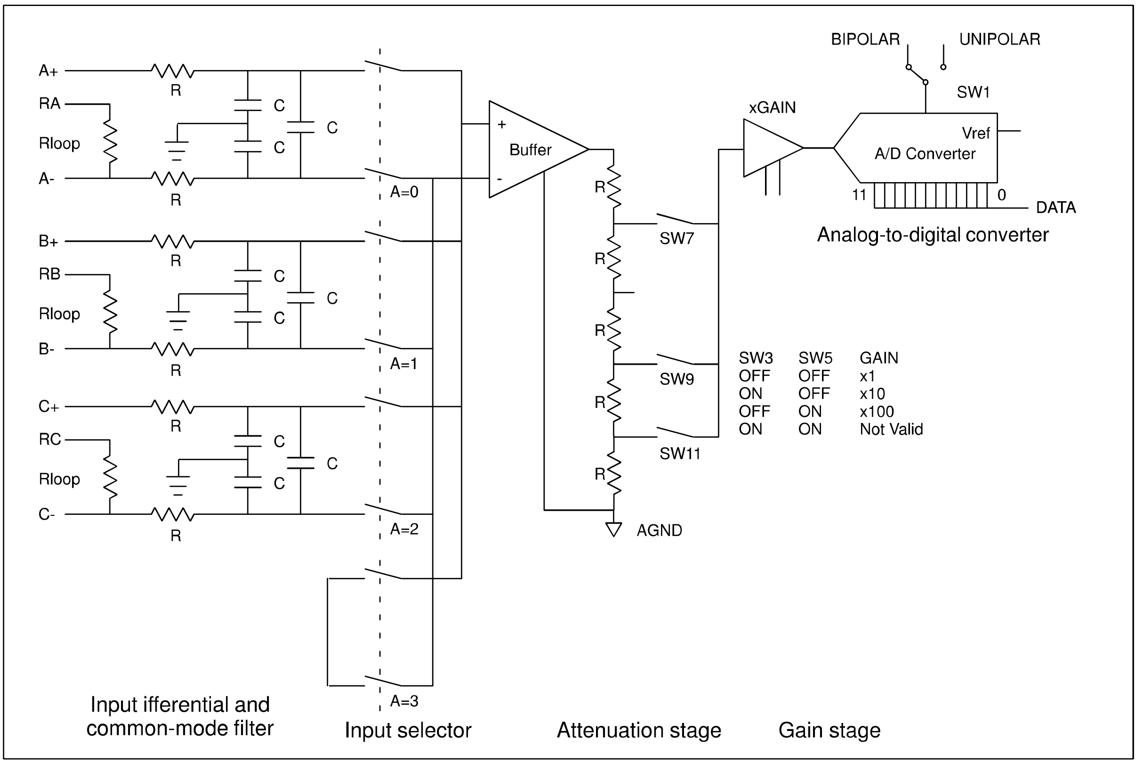

Figure A-44 EM235 Input Block Diagram

Output Data Word Format

Figure A-45 shows where the 12-bit data value is placed within the analog output word of the CPU. Figure A-46 shows the EM235 output block diagram.

Current output data format (MSB = bit 15, LSB = bit 0):

	15	14 … 4	3	2	1	0
AQW XX	0	Data value 11 Bits	0	0	0	0

Voltage output data format (MSB = bit 15, LSB = bit 0):

	15 … 4	3	2	1	0
AQW XX	Data value 12 Bits	0	0	0	0

Figure A-45 Output Data Word Format

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

Figure A-46 shows the EM235 output block diagram.

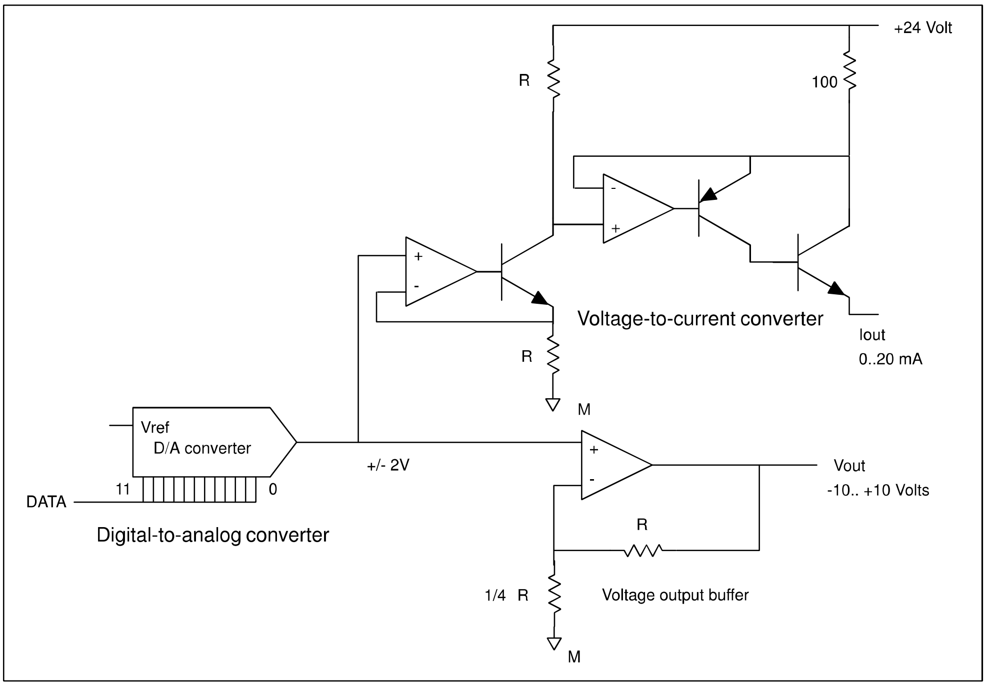

Figure A-46 EM235 Output Block Diagram

Installation Guidelines for EM235

Use the following guidelines to ensure good accuracy and repeatability:

- Ensure that the 24-VDC Sensor Supply is free of noise and is stable.
- Calibrate the module.
- 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 A-41.
- 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 floating, or referenced to the external 24V common of the analog module.

Note
This expansion module is not recommended for use with thermocouples.

Understanding and Using the Analog Inputs: Accuracy and Repeatability

The EM235 combination input/output module is a low-cost, high-speed 12 bit analog input module. The module is capable of converting an analog input to its corresponding digital value in 171 µsec for the CPU 212, and 139 µsec for all other S7-200 CPUs. Conversion of the analog signal input is performed each time the analog point is accessed by the user program. These times must be added to the basic execution time of the instruction used to access the analog input.

The EM235 provides an unprocessed digital value (no linearization or filtering) that corresponds to the analog voltage or current presented at the modules input terminals. Since the module is a high-speed module, it 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 will be observed.

You may use the STEP 7-Micro/WIN Analog Input Filtering wizard to add an averaging routine to your program. Remember that an average value computed from a large number of samples will stabilize the reading while slowing down its response to changes in the input signal. For slowly changing analog input signals, a sample size of 64 or greater is recommended for the averaging routine.

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 A-47 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 A-5 gives the repeatability specifications and the mean accuracy as they relate to each of the configurable ranges.

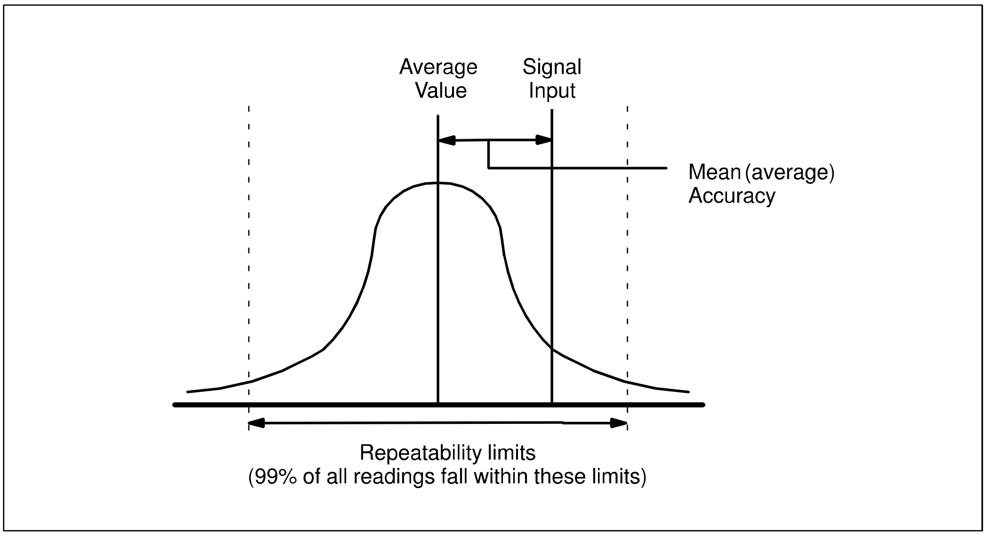

Figure A-47 Accuracy Definitions

Table A-5 Specifications for DC and AC Powered S7-200 CPUs

Full Scale Input Range	Repeatability[1]		Mean (average) Accuracy[1, 2, 3, 4]	
	% of Full Scale	Counts	% of Full Scale	Counts
Specifications for DC Powered S7-200 CPUs				
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				
Specifications for AC Powered S7-200 CPUs				
0 to 50 mV	± 0.15%	± 48	± 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	± 0.15%	± 96	± 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.