A.33 Expansion Module EM231 Analog Input AI 3 x 12 Bits

Order Number: 6ES7 231-0HC00-0XA0

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
Standards compliance	UL 508 CSA C22.2 142 FM Class I, Division 2 VDE 0160 compliant CE compliant
Input Points	
Input type	Differential
Input impedance	≥ 10 MΩ
Input filter attenuation	-3 db @ 3.1 kHz
Maximum input voltage	30 V
Maximum input current	32 mA
Resolution	12 bit A/D converter
Isolation	Non-isolated

Input Points (continued)	
Analog-to-digital conversion time	< 250 μs
Analog step response	1.5 ms to 95%
Common mode rejection	40 dB, DC to 60 Hz
Common mode voltage	Signal voltage plus common mode voltage, less than or equal to 12 V
Data word format[2] Unipolar, full-scale range	0 to 32000
Current Requirements	
5 VDC logic current	70 mA from base unit
External power supply	60 mA from base unit or external power 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 for this module.
2 Data Word increments in 8 count steps, left justified values. See Figure A-35.

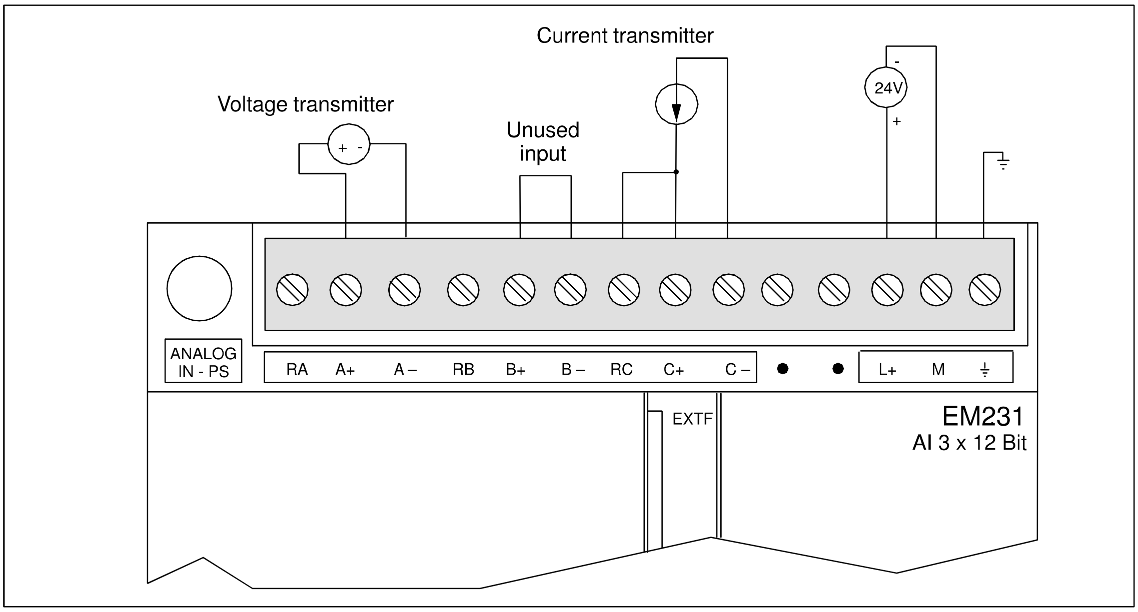

Figure A-33 Connector Terminal Identification for Expansion Module EM231 Analog Input AI 3 x 12 Bits

Calibration and Configuration Location

The calibration potentiometer and configuration DIP switches are accessed through the ventilation slots of the module, as shown in Figure A-34.

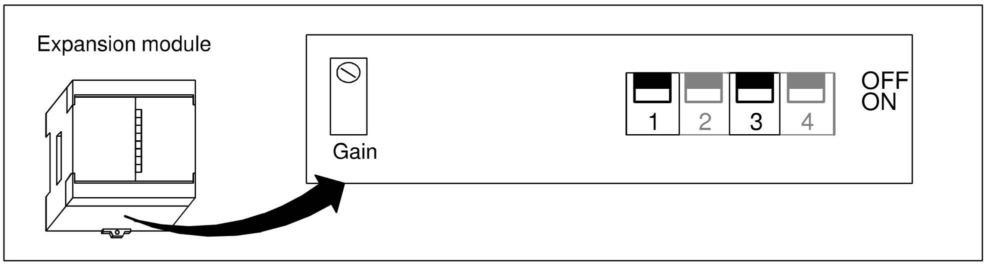

Figure A-34 Calibration Potentiometer and Configuration DIP Switches

Configuration

Table A-2 shows how to configure the module using the configuration DIP switches. Switches 1 and 3 select the analog input range. All inputs are set to the same analog input range.

Table A-2 Configuration Switch Table for EM231 Analog Input

Configuration Switch		Full-Scale Input	Resolution
1	3		
ON	OFF	0 to 5 V	1.25 mV
ON	OFF	0 to 20 mA[1]	5 µA
OFF	ON	0 to 10 V	2.5 mV

1 0 to 20 mA measurements were made using the internal 250-Ω current-sense resistor.

Input Calibration

The module calibration is used to correct the gain error at full scale. Offset error is not compensated. The calibration affects all three input channels, and there may be a difference in the readings between 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 to calculate 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. The reading with a zero value input indicates the magnitude of the offset error. This error cannot be corrected by calibration.
5. Connect a full-scale value signal to one of the input terminals. Read the value reported to the CPU.
6. Adjust the GAIN potentiometer until the reading is 32,000, or the desired digital data value.

Data Word Format

Figure A-35 shows where the 12-bit data value is placed within the analog input word of the CPU.

A variance in repeatability of only ±0.45% of full scale can give a variance of ±144 counts in the value read from the analog input.

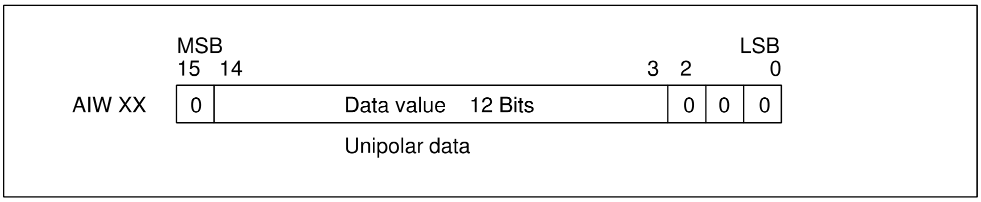

Figure A-35 Data Word Format

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. The three trailing zeros cause the data word to change by a count of eight for each one count change in the ADC value.

Input Block Diagram

Figure A-36 shows the EM231 input block diagram.

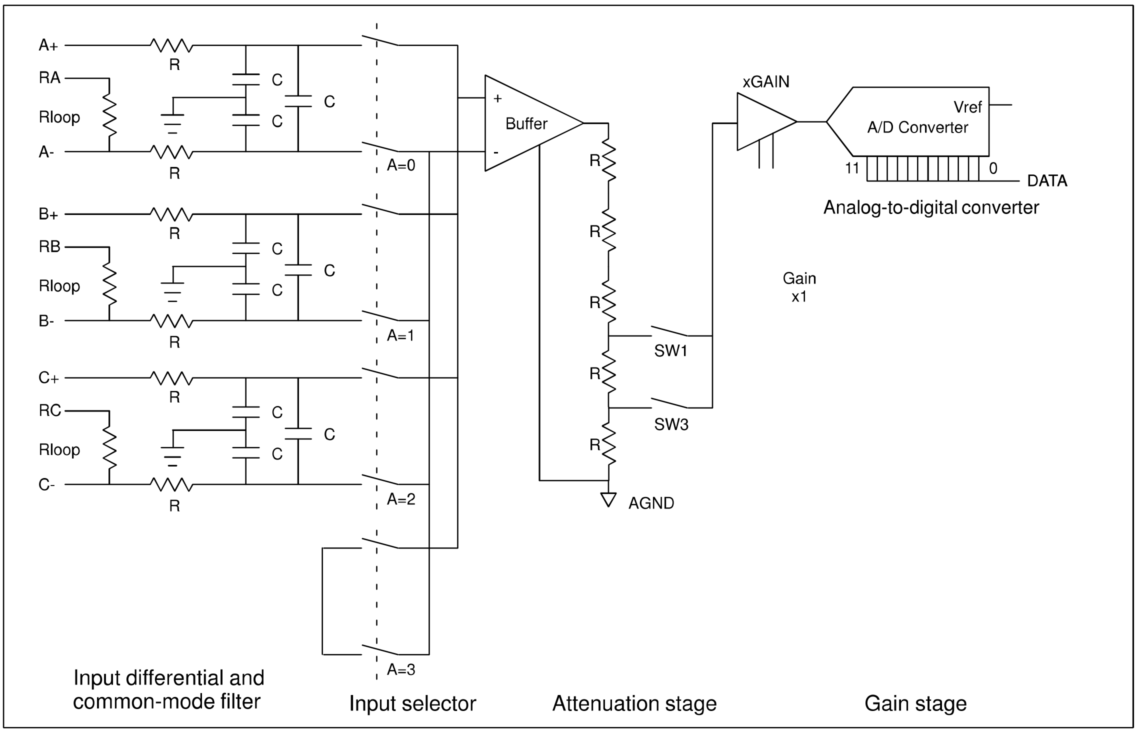

Figure A-36 EM231 Input Block Diagram

Installation Guidelines for EM231

Use the following guidelines to ensure 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-33.
- Avoid bending the wires into sharp angles.
- Use wireways for wire routing.
- Ensure that input signals are floating or referenced to the external 24V common of the analog module.

Understanding and Using the Analog Input Module: Accuracy and Repeatability

The EM231 analog input 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 your program. These times must be added to the basic execution time of the instruction used to access the analog input.

The EM231 provides 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 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 can be observed.

You can use the STEP 7-Micro/WIN Analog Input Filtering wizard (see Section 5.3). to add an averaging routine to your program. Remember that an average value computed from a large number of samples stabilizes 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 the Figure A-37 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-3 gives the repeatability specifications and the mean accuracy as they relate to each of the configurable ranges.

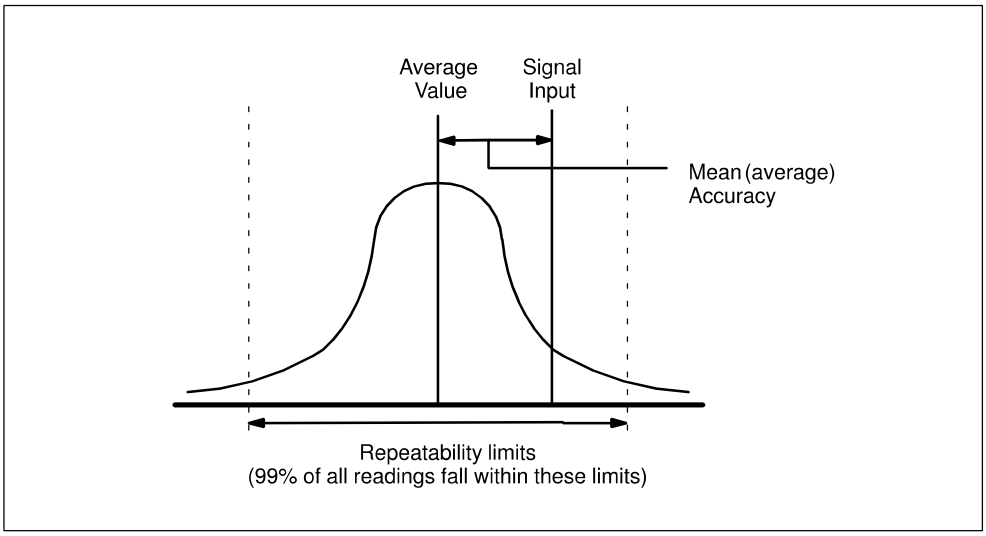

Figure A-37 Accuracy Definitions

Table A-3 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 5 V	± 0.075%	± 24	± 0.1%	± 32
0 to 20 mA				
0 to 10 V				
Specifications for AC Powered S7-200 CPUs				
0 to 5 V	± 0.15%	± 48	± 0.1%	± 64
0 to 20 mA				
0 to 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.