Analog Expansion Modules Specifications

Table A-15 Analog Expansion Modules Order Numbers

Order Number	Expansion Model	EM Inputs	EM Outputs	Removable Connector
6ES7 231-0HC22-0XA0	EM 231 Analog Input, 4 Inputs	4	-	No
6ES7 232-0HB22-0XA0	EM 232 Analog Output, 2 Outputs	-	2	No
6ES7 235-0KD22-0XA0	EM 235 Analog Combination 4 Inputs/1 Output	4	1[1]	No

1 The CPU reserves 2 analog output points for this module.

Table A-16 Analog Expansion Modules General Specifications

Order Number	Module Name and Description	Dimensions (mm) (W x H x D)	Weight	Dissipation	VDC Requirements +5 VDC	+24 VDC
6ES7 231-0HC22-0XA0	EM 231 Analog Input, 4 Inputs	71.2 x 80 x 62	183 g	2 W	20 mA	60 mA
6ES7 232-0HB22-0XA0	EM 232 Analog Output, 2 Outputs	46 x 80 x 62	148 g	2 W	20 mA	70 mA (with both outputs at 20 mA)
6ES7 235-0KD22-0XA0	EM 235 Analog Combination 4 Inputs/1 Output	71.2 x 80 x 62	186 g	2 W	30 mA	60 mA (with output at 20 mA)

Table A-17 Analog Expansion Modules Input Specifications

General	6ES7 231-0HC22-0XA0	6ES7 235-0KD22-0XA0
Data word format	(See Figure A-14)	(See Figure A-14)
Bipolar, full-scale range	-32000 to +32000	-32000 to +32000
Unipolar, full-scale range	0 to 32000	0 to 32000
DC Input impedance	≥10 MΩ voltage input 250 Ω current input	≥ 10 MΩ voltage input 250 Ω current input
Input filter attenuation	-3 db at 3.1 Khz	-3 db at 3.1 Khz
Maximum input voltage	30 VDC	30 VDC
Maximum input current	32 mA	32 mA
Resolution		
Bipolar	11 bits plus 1 sign bit	
Unipolar	12 bits	
Isolation (field to logic)	None	None
Input type	Differential	Differential
Input ranges		
Voltage	Selectable, see Table A-20 for available ranges	Selectable, see Table A-21 for available ranges
Current	0 to 20 mA	0 to 20 mA
Input resolution	See Table A-20	See Table A-21
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
24 VDC supply voltage range	20.4 to 28.8 VDC (Class 2, Limited Power, or sensor power from PLC)	

Table A-18 Analog Expansion Modules Output Specifications

General	6ES7 232-0HB22-0XA0	6ES7 235-0KD22-0XA0
Isolation (field to logic)	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 plus sign bit 11 bits	 11 bits plus sign bit 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
Setting 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
24 VDC supply voltage range	20.4 to 28.8 VDC (Class 2, Limited Power, or sensor power from PLC)	

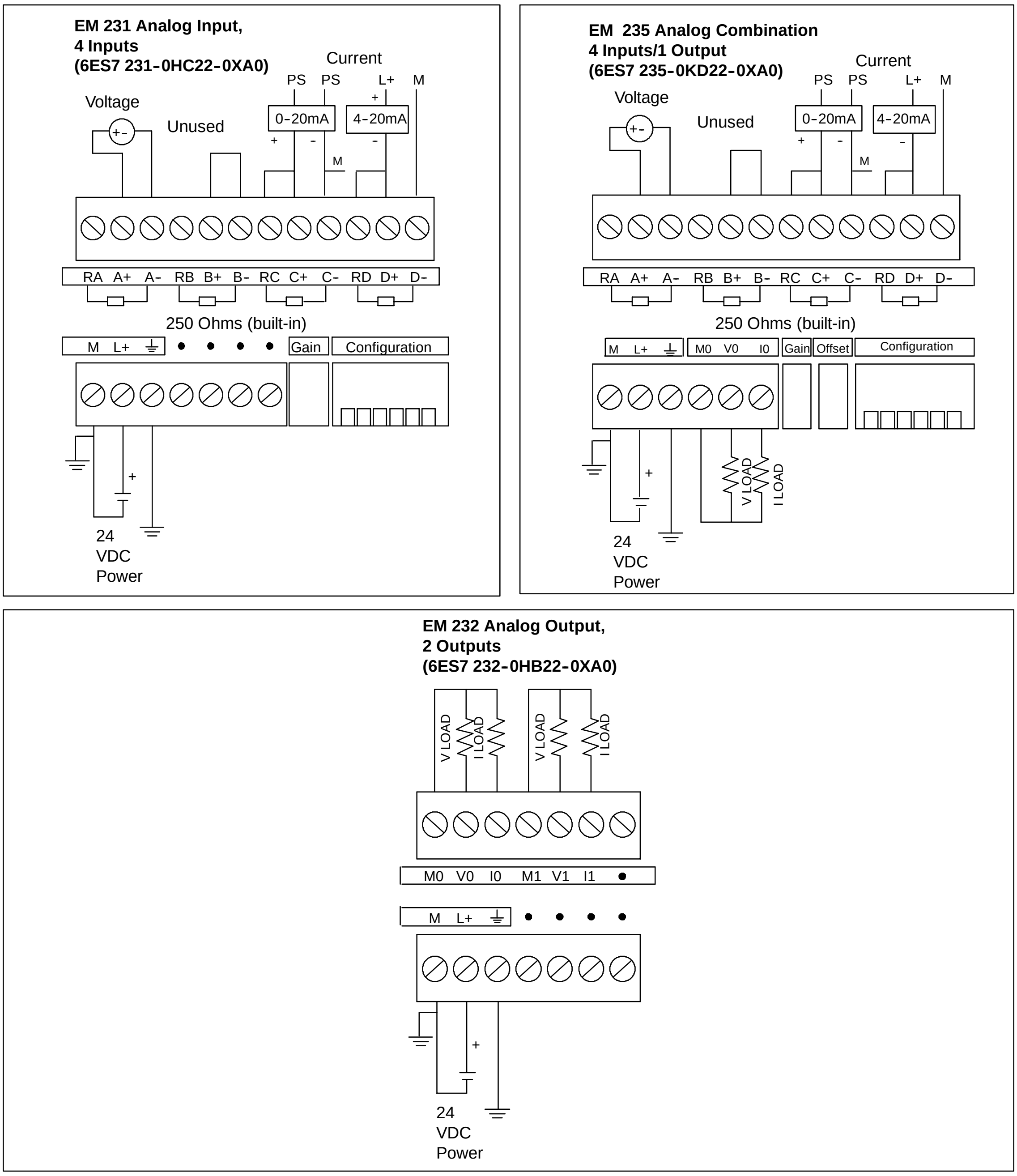

Figure A-12 Wiring Diagrams for Analog Expansion Modules

Analog LED Indicators

The LED indicators for the analog modules are shown in Table A-19.

Table A-19 Analog LED Indicators

LED Indicator	ON	OFF
24 VDC Power Supply Good	No faults	No 24 VDC power

Tip

The state of user power is also reported in Special Memory (SM) bits. For more information, see Appendix D, SMB8 to SMB21 I/O Module ID and Error Registers.

Input Calibration

The calibration adjustments affect the instrumentation amplifier stage that follows the analog multiplexer (see the Input Block Diagram for the EM 231 in Figure A-15 and EM 235 in Figure A-16). Therefore, calibration affects all user input channels. Even after calibration, variations in the component values of each input circuit preceding the analog multiplexer will cause slight differences in the readings between channels connected to the same input signal.

To meet the specifications, you should enable analog input filters for all inputs of the module. Select 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.
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 EM 231 and EM 235

Figure A-13 shows the calibration potentiometer and configuration DIP switches located on the right of the bottom terminal block of the module.

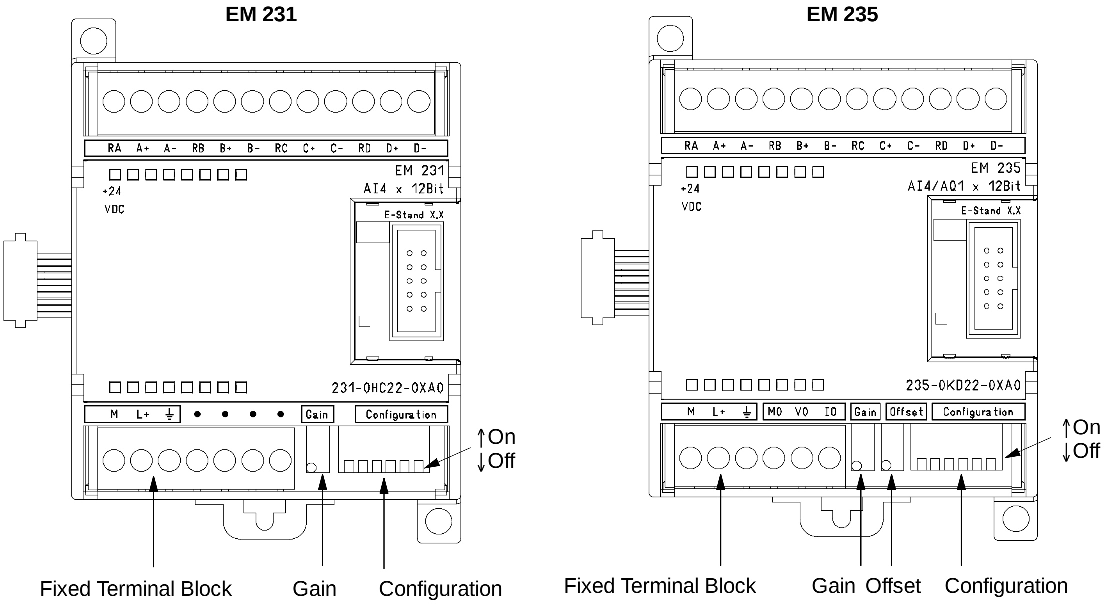

Figure A-13 Calibration Potentiometer and Configuration DIP Switch Location for the EM 231 and EM 235

Configuration for EM 231

Table A-20 shows how to configure the EM 231 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. The switch settings are read only when the power is turned on.

Table A-20 EM 231 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 EM 235

Table A-21 shows how to configure the EM 235 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 A-21 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. The switch settings are read only when the power is turned on.

Table A-21 EM 235 Configuration Switch Table to Select Analog 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

Input Data Word Format for EM 231 and EM 235

Figure A-14 shows where the 12-bit data value is placed within the analog input word of the CPU.

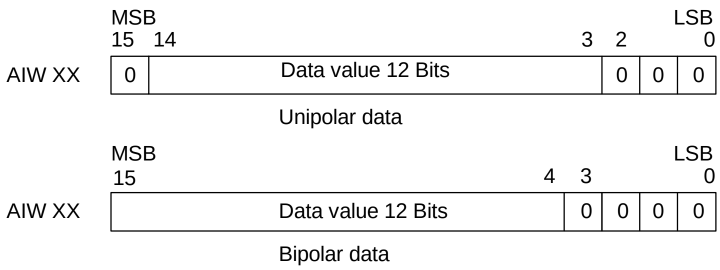

Figure A-14 Input Data Word Format for EM 231 and EM 235

Tip

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 EM 231 and EM 235

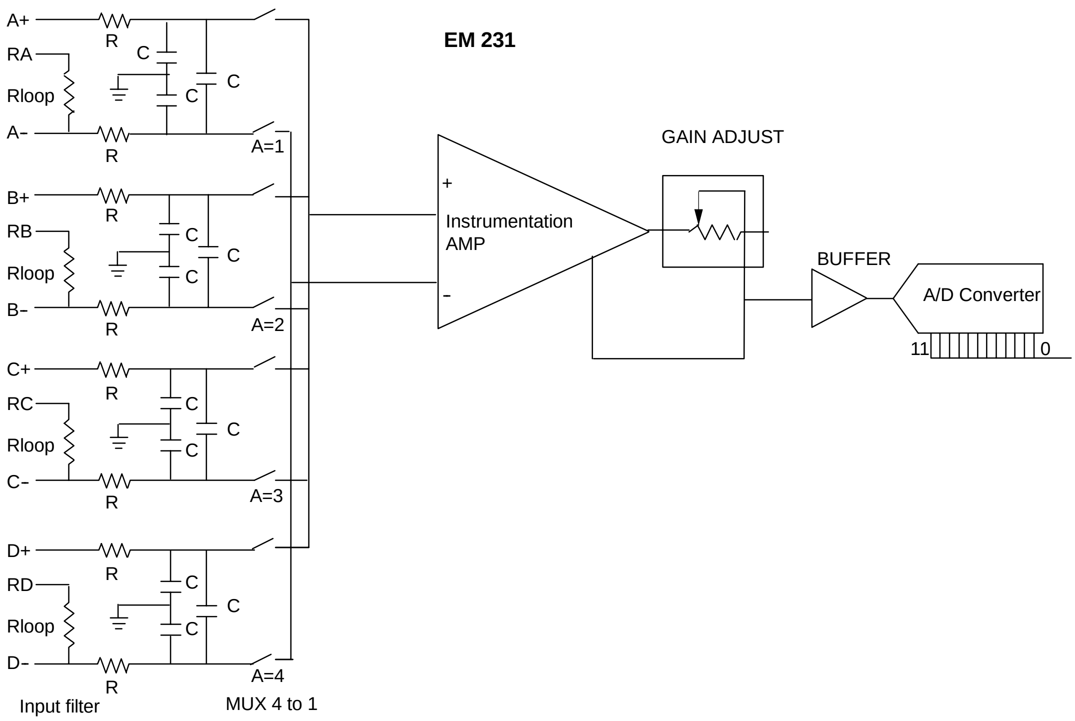

Figure A-15 Input Block Diagram for the EM 231

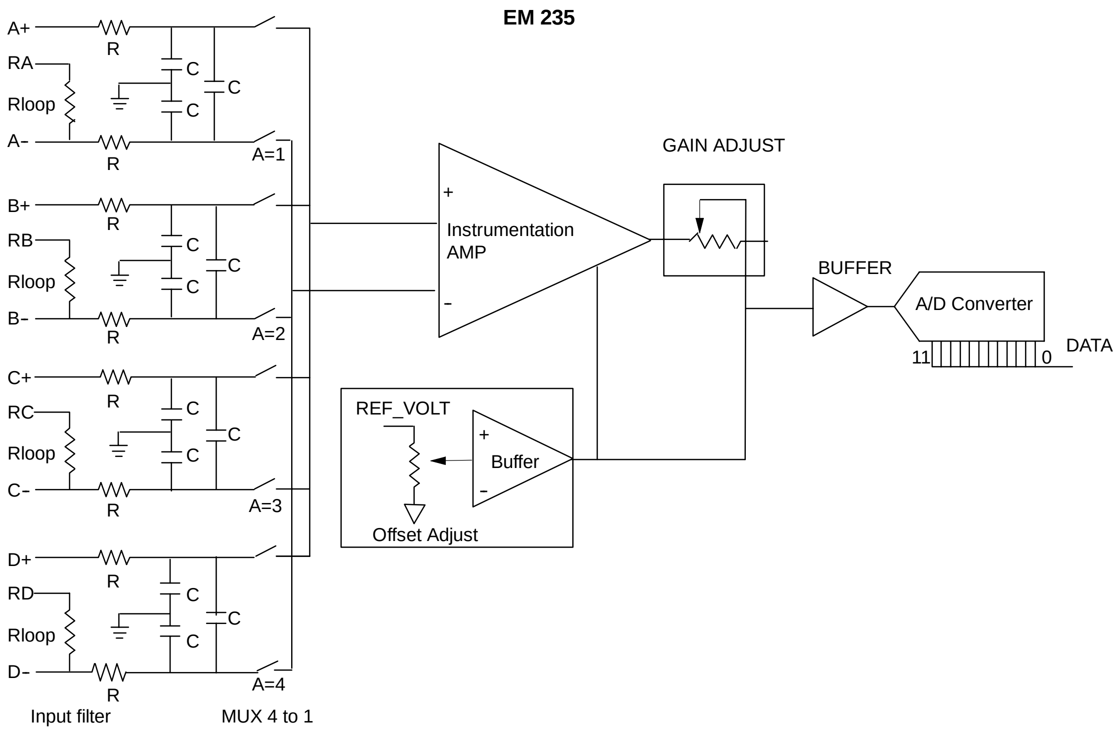

Figure A-16 Input Block Diagram for the EM 235

Output Data Word Format for EM 232 and EM 235

Figure A-17 shows where the 12-bit data value is placed within the analog output word of the CPU.

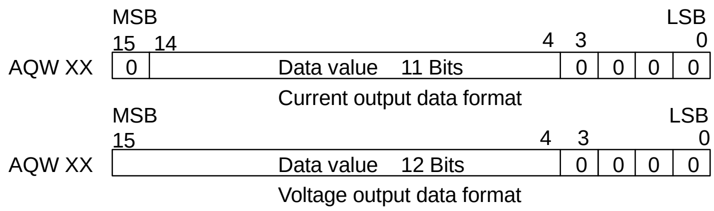

Figure A-17 Output Data Word Format for EM 232 and EM 235

Tip

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 EM 232 and EM 235

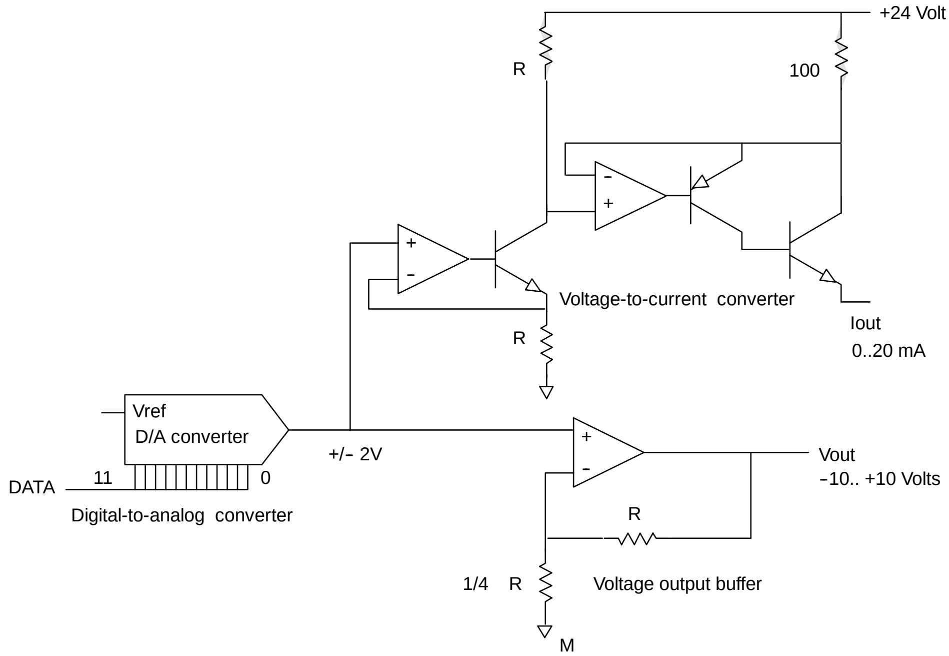

Figure A-18 Output Block Diagram for the EM 232 and EM 235

Installation Guidelines

Use the following guidelines to ensure 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 A-18.
- ❑ 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.

Tip

The EM 231 and EM 235 expansion modules are not recommended for use with thermocouples.

Understanding the Analog Input Module: Accuracy and Repeatability

The EM 231 and EM 235 analog input modules are low-cost, high-speed 12 bit analog input modules. The modules can convert an analog signal input to its corresponding digital value in 149 μsec. The analog signal input is converted each time your program accesses the analog point. These conversion times must be added to the basic execution time of the instruction used to access the analog input.

The EM 231 and EM 235 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).

You can minimize reading-to-reading variations caused by noise for a constant or slowly changing analog input signal by averaging a number of readings. Note that increasing the number of readings used in computing the average value results in a correspondingly slower response time to changes in the input signal.

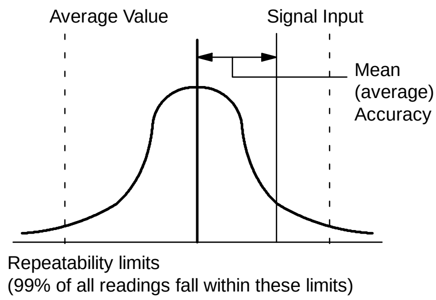

Figure A-19 Accuracy Definitions

Figure A-19 shows the 99% repeatability limits, the mean or average value of the individual readings, and the mean accuracy in a graphical form.

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 repeatability is described in this figure by the bell curve.

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).

Table A-22 gives the repeatability specifications and the mean accuracy as they relate to each of the configurable ranges.

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.

Table A-22 EM 231 and EM 235 Specifications

<table>
<tr><th rowspan="2">Full Scale Input Range</th><th colspan="2">Repeatability[1]</th><th colspan="2">Mean (average) Accuracy[1,2,3,4]</th></tr>
<tr><th>% of Full Scale</th><th>Counts</th><th>% of Full Scale</th><th>Counts</th></tr>
<tr><th colspan="5">EM 231 Specifications</th></tr>
<tr><td>0 to 5 V</td><td rowspan="5">± 0.075%</td><td rowspan="3">± 24</td><td rowspan="3">± 0.1%</td><td rowspan="5">± 32</td></tr>
<tr><td>0 to 20 mA</td></tr>
<tr><td>0 to 10 V</td></tr>
<tr><td>± 2.5 V</td><td rowspan="2">± 48</td><td rowspan="2">± 0.05%</td></tr>
<tr><td>± 5 V</td></tr>
<tr><th colspan="5">EM 235 Specifications</th></tr>
<tr><td>0 to 50 mV</td><td rowspan="7">± 0.075%</td><td rowspan="7">± 24</td><td>± 0.25%</td><td>± 80</td></tr>
<tr><td>0 to 100 mV</td><td>± 0.2%</td><td>± 64</td></tr>
<tr><td>0 to 500 mV</td><td rowspan="5">± 0.05%</td><td rowspan="5">± 16</td></tr>
<tr><td>0 to 1 V</td></tr>
<tr><td>0 to 5 V</td></tr>
<tr><td>0 to 20 mA</td></tr>
<tr><td>0 to 10 V</td></tr>
<tr><td>± 25 mV</td><td rowspan="9">± 0.075%</td><td rowspan="9">± 48</td><td>± 0.25%</td><td>± 160</td></tr>
<tr><td>± 50 mV</td><td>± 0.2%</td><td>± 128</td></tr>
<tr><td>± 100 mV</td><td>± 0.1%</td><td>± 64</td></tr>
<tr><td>± 250 mV</td><td rowspan="6">± 0.05%</td><td rowspan="6">± 32</td></tr>
<tr><td>± 500 mV</td></tr>
<tr><td>± 1 V</td></tr>
<tr><td>± 2.5 V</td></tr>
<tr><td>± 5 V</td></tr>
<tr><td>± 10 V</td></tr>
</table>

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.