

# Using Offset and Gain Technical Note

## Introduction

This technical note shows you how to calculate and set offset and gain for Opto 22 analog input modules. It includes instructions for the following Opto 22 hardware:

- Modules attached to SNAP PAC brains and Ethernet-based I/O units such as the SNAP-PAC-R1 and SNAP-B3000-ENET (page 1)
- Analog modules for *mistic* brains and bricks, such as the B3000 and B3000-HA (page 2)
- Analog cards (such as the G4AIVA) for *mistic* high-density analog bricks (such as the G4HDAR) (page 3)

## What Are Offset and Gain?

Offset and gain commands are used for calibration. Offset and gain commands make adjustments so that the actual readings more accurately match the expected readings.

**Offset** is the adjustment needed to make the actual reading match the expected reading when at the low scale for the module.

Offset calculations are done with the input being at the low scale of the module. For example, with a 4 – 20 mA module, offset is calculated at 4 mA.

Subtract the actual reading from the expected reading to find the offset needed to make the readings match:

Expected Reading – Actual Reading = Offset needed to correct the reading.

*Example:*

Expected reading = 4.000 mA

Actual reading = 4.003 mA

$4.000 - 4.003 = -0.003$  mA

Offset needed to correct the reading is  $-0.003$  mA

**Gain** calculations are done with the input being at the high scale for the module. For example, with a 4 – 20 mA module, gain is calculated at 20 mA.

Gain is the adjustment of the slope needed to make the actual reading match the expected reading when at the high scale for the point.

Divide the span of the Expected Reading by the span when using the Actual (high scale) Reading to get the gain adjustment:

$(\text{Expected high scale reading} - \text{Expected low scale reading})$

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$(\text{Actual high scale reading} - \text{Expected low scale reading})$

*Example:*

Expected reading = 20.0 mA

Actual reading = 20.4 mA

$(20.0 - 4.0) / (20.4 - 4.0) = 16.0 / 16.4 = 0.9756$

Gain = 0.9756

## Calculating and Setting Offset and Gain on SNAP PAC and Ethernet-Based I/O Units

**IMPORTANT:** On SNAP PAC and Ethernet-based I/O units, offset and gain values affect engineering units. For a temperature input, engineering units are in degrees C or F, depending on how the I/O unit is configured.

*Always set offset before setting gain.*

Offset and gain can be manually set or automatically calculated for you by an Ethernet-based I/O unit (any model except digital-only I/O units, which do not handle analog inputs).

Use PAC Manager software to set offset and gain, following the steps in the *PAC Manager User's Guide* (Opto 22 form #1704).

**IMPORTANT:** When you send the PAC Manager configuration file to the brain, make sure you save the configuration to flash memory. If you do not save to flash, the calibration you have set will be lost if the I/O unit is turned off.

Although PAC Manager is the preferred tool, it is also possible to calibrate the point in a PAC Control or OptoControl strategy using the commands Calculate & Set Analog Offset and Calculate & Set Analog Gain (or Set Analog Offset and Set Analog Gain). If you use PAC Control or OptoControl commands, first read details about them in the Command Reference or online

Command Help. (PAC Control Command Reference is form #1701; OptoControl Command Reference is form #725.)

## Calculating and Setting Offset and Gain on *mistic* Brains and Bricks

On *mistic* brains and bricks, such as the SNAP-B3000 or the B3000-HA, use OptoControl™ commands (or PAC Control™ Professional commands with a serial brain) for setting offset and gain.

**IMPORTANT:** *On these non-Ethernet brains, offset and gain values affect raw counts.*

*Always set offset before setting gain.*

**If you know the offset and gain values**, you can use the commands Set Analog Offset and Set Analog Gain in an OptoControl or PAC Control strategy to set the values. Before using these commands in your strategy, read the information on them in the *OptoControl Command Reference* (Opto 22 form #725) or *PAC Control Command Reference* (form #1701), or in online command help.

**To have the brain calculate offset and gain**, follow these steps.

1. In OptoControl or PAC Control, create a strategy using the commands Calculate and Set Analog Offset and Calculate and Set Analog Gain.
 

You can use breakpoints or stepping to allow time between commands for setting the minimum and maximum scale on the input point.
2. Verify that the points you intend to set are properly configured in OptoControl.
3. Choose one of the following:
  - a. For points on a SNAP thermocouple analog module, use the sensor attached to the input or a calibrator to input 0 degrees C (or 32 degrees F) on the input point.
  - b. For points on a SNAP-AIRTD module, use the sensor attached to the input or a calibrator to input –200 degrees C (or –328 degrees F) on the input point.

- c. For points on other modules, use the sensor or a calibrator to input the module's minimum scale.

Note that minimum scale on a bipolar module is a negative number. For example, minimum scale on a SNAP-AIV is –10 V, not 0 V.

4. Run the strategy and execute the Calculate and Set Analog Offset command.
5. Choose one of the following:
  - a. For points on a SNAP thermocouple module, use a calibrator to input the value shown in the chart below.

Module	Thermo-couple	Gain Temp in ° C	Gain Temp in ° F
SNAP-AITM	E	981.75	1799.15
SNAP-AITM	J	673.50	1244.30
SNAP-AITM	K	904.30	1659.74
SNAP-AITM-2	B	1705.75	3102.35
SNAP-AITM-2	C	1399.75	2551.55
SNAP-AITM-2	D	1352.20	2465.96
SNAP-AITM-2	G	2140.50	3884.90
SNAP-AITM-2	N	712.00	1313.60
SNAP-AITM-2	R	1147.40	2097.32
SNAP-AITM-2	S	1451.80	2645.24
SNAP-AITM-2	T	258.80	497.84

- b. For points on a SNAP-AIRTD module, use the sensor attached to the input or a calibrator to input 266.5 degrees C (or 511.7 degrees F).
- c. For points on other modules, use a calibrator to input the module's maximum scale.
6. Execute the Calculate and Set Gain command.
 

Offset and gain are now set. These values will be used until power is lost on the brain.
7. To store offset and gain values permanently, make sure you are in Debug mode. On the Strategy Tree, double-click the I/O unit to open the View I/O Unit dialog box. Click the Set button next to EEPROM.
 

The values are stored to flash memory.

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## Calculating and Setting Offset and Gain on Analog Cards (such as the G4AIVA) for *mistic* High-Density Analog Bricks (such as the G4HDAR)

For analog cards (such as the G4AIVA) for *mistic* high-density analog bricks (such as the G4HDAR), you must calculate offset and gain manually and set them using the OptoControl commands Set Analog Offset and Set Analog Gain.

**IMPORTANT:** *On mistic high-density analog bricks, offset and gain values affect raw counts."*

*Always set offset before setting gain.*

1. Set the input to zero scale (or as close as practical).  
Example: On a 4–20 mA module, the zero scale is 4 mA.
2. Determine the error as a fraction of the span. Invert its sign.  
Example: The span on the 4–20 mA module is 16 (20 – 4). For a reading of 3.9 mA, the error is –0.1.  $-0.1 / 16 = -0.00625$ . Inverted sign = 0.00625.
3. Multiply the error by 65,535 to produce the offset value. Round up or down to the nearest integer.  
Example:  $0.00625 \times 65,535 = 409.59$ . Use 410 as the offset value.

4. Send the offset value to the point using the Set Analog Offset command.
5. Set the input to full scale (or as close as practical).
6. Subtract zero scale from full scale. Then subtract zero scale from the current reading. Divide the first value by the second to produce the gain value.  
Example: If the full-scale reading is 19, the gain value is:  $(20 - 4) / (19 - 4) = 1.0666$ .
7. Send the gain value to the point using the Set Analog Gain command.  
Offset and gain values are now set.
8. Send the offset and gain values to the point each time the strategy is run. (Values are usually sent in the Powerup chart.)

## For Help

If you have problems setting offset and gain that are not answered in this technical note and in the product user's guides, contact Opto 22 Product Support Monday through Friday, 7 a.m. to 5 p.m. Pacific Time.

### Opto 22 Product Support

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