Micro Motion® Modbus Interface Tool
Integer Scaling

IS 1   Overview

Integer scaling is used to represent process variable data as integer values, rather than floating-point values, without losing resolution. Integer scaling may be required for Modbus hosts that do not support floating-point.

Note: Integer scaling is not necessary if the host controller has IEEE 754 floating-point capability.

Integer scaling may also be used to apply an offset to the process data so that it falls within a valid or convenient range. For example, negative values may be offset so that they can be read as positive values.

The scaled integer value is accurate to one part in 65535.

Example 1

Problem: The quality of the process varies widely unless density remains between 1.0000 and 1.2000 grams per cubic centimeter (g/cm^3). Because the Modbus host does not have floating-point capability, it interprets both values as 1 g/cm^3.

Solution: Implement integer scaling for density, so that the integer 10000 represents a density of 1.0000 g/cm^3, and the integer 12000 represents a density of 1.2000 g/cm^3.

As a result, a change of 1 in the value of the scaled integer represents a 0.0001 g/cm^3 change in temperature. For example, a density value of 10001 represents a density of 1.0001 g/cm^3.

Figures IS-1 and IS-2 provide two illustrations of integer scaling. These figures show how a floating-point value is represented as an integer value, given the user-specified values for the high end and low end of the range. Scale factor and offset are calculated from this information.

Section IS-2 provides integer scaling calculation and configuration instructions.

Section IS-3 provides information on using scaled integer data.

Section IS-4 provides detailed examples of scaled integer setup.

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Integer scaling illustration

Scale factor = 1000
Offset = 31268

Process variable values
- Floating-point range: −1.50 to +3.50
- Scaled integer range: 0 to 5000

Unscaled values   −2.00   −1.00   0   1.00   2.00   3.00   4.00   5.00

Scaled integer values   0   1500   3000   4000   5000

Integer scaling illustration

Scale factor = 6
Offset = 30868

Process variable values
- Floating-point range: −150 to +500
- Scaled integer range: 1000 to 4900

Unscaled values   −200   −100   0   100   200   300   400   500

Scaled integer values   1000   1900   2500   3100   3700   4300   4900
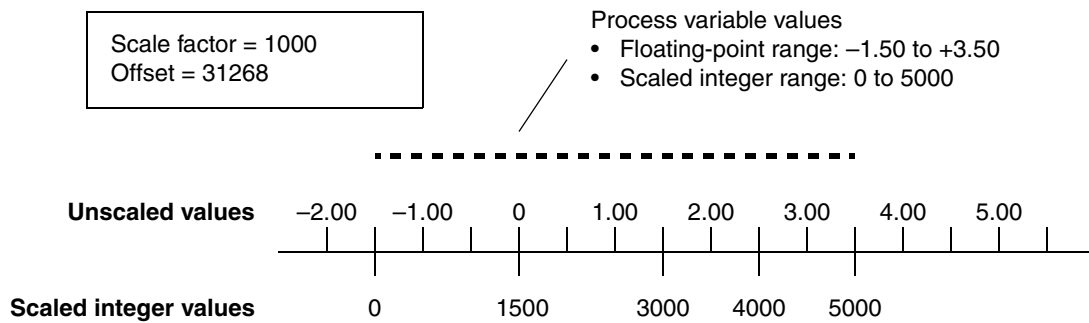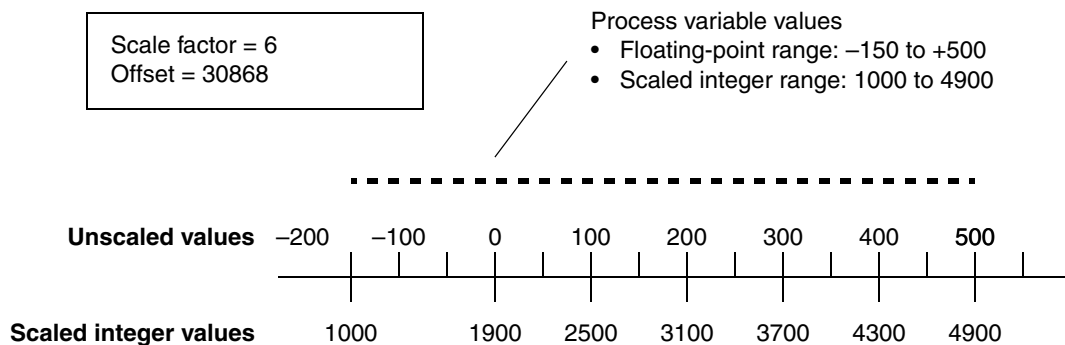
IS 2   Configuring integer scaling

Note: If you configure integer scaling for more than one process variable, the same maximum integer applies to all scaled process variables. Each scaled process variable can have its own offset and scale factor.

A scaled integer value is calculated using the following equation:

$$y = Ax - (B - 32768)$$

where:

y = Scaled integer to be returned by transmitter

A = Scale factor

x = Measured value of process variable

B = Offset

Step 1   **Calculate scale factor**

The scale factor is the value of **A** in the preceding equation. The scale factor is a ratio that converts the process variable range to the scaled integer range. The default scale factor is 1.

1. Use the following equation to calculate the scale factor:

$$A = \frac{y_2 - y_1}{x_2 - x_1}$$

where:

- **x1** = Lower range value (LRV) of process variable. Typically, but not necessarily, the LRV is the lowest value that the process variable can take in the application.

- **x2** = Upper range value (URV) of process variable. Typically, but not necessarily, the URV is the highest value that the process variable can take in the application.

- **y1** = Scaled integer that will represent **x1**. **y1** must be equal to or greater than 0 and less than or equal to the maximum integer.

- **y2** = Scaled integer that will represent **x2**. **y2** must be equal to or greater than 0 and less than or equal to the maximum integer.

2. The scale factor must be an integer. If necessary, round the calculated scale factor down to the nearest integer. As a result, the scaled integer range will slightly exceed the process variable range.

Example 2	Refer to Figure IS-1. The mass flow rate ranges from −1.50 to +3.50 g/min. The integer 0 will be used to represent −1.50 g/min, and the integer 5000 will be used to represent a mass flow rate of 3.50 g/min. Calculate the scale factor as follows: $$A = \frac{y_2 - y_1}{x_2 - x_1}$$ $$A = \frac{5000 - 0}{3.50 - (-1.50)}$$ $$A = 1000$$ Refer to Figure IS-2. The mass flow rate ranges from −150 to +500 g/min. The integer 1000 will be used to represent −150 g/min, and the integer 5000 will be used to represent a mass flow rate of 500 g/min. Calculate the scale factor as follows, rounding down as required: $$A = \frac{y_2 - y_1}{x_2 - x_1}$$ $$A = \frac{5000 - 1000}{500 - (-150)}$$ $$A = 6.15 = 6$$

Step 2   **Calculate offset**

The offset for scaled integers is the value of **B** in the preceding equation. The default offset is 0.

Use the following equation to calculate the offset:

$$B = (\text{ScaleFactor} \times x_1) - y_1 + 32768$$

Note: This equation is a simple transformation of the equation used to calculate scaled integers.

Example 3	Refer to Figure IS-1.
	Calculate the offset as follows:
	$B = (\text{ScaleFactor} \times x_1) - y_1 + 32768$
	$B = [1000 \times (-1.50)] - 0 + 32768$
	$B = (-1500) - 0 + 32768$
	$B = 31268$
	Refer to Figure IS-2.
	Calculate the offset as follows:
	$B = (\text{ScaleFactor} \times x_1) - y_1 + 32768$
	$B = [6 \times (-150)] - 1000 + 32768$
	$B = (-900) - 1000 + 32768$
	$B = 30868$

The offset determines the intercept, which is the value of the process variable that will be reported as the scaled integer 0.

Step 3   **Determine maximum integer**

The maximum integer is the highest value of the scaled integer that you want to read. It may or may not be equivalent to the highest value that is possible or desirable for your application.

The overflow integer is the value that the transmitter will report for the process variable if the scaled integer value goes above the maximum integer or below 0. The overflow integer is automatically set to the maximum integer + 1.

The maximum integer and overflow integer values are shared by all scaled integers. Set the maximum integer so that both it and the overflow integer are in the range of integers supported by the Modbus host, and they will be appropriate for all process variables for which you will implement scaled integers.

The valid range for the maximum integer is 0 to 65534; the default value is 65534. Accordingly, the default value for the overflow integer is 65535.

Example 4	Integer scaling for density has been implemented, so that the integer 10000 represents a density of 1.0000 g/cm^3, and the integer 12000 represents a density of 1.2000 g/cm^3.
	The maximum integer is set to 12000. Therefore, the overflow integer is 12001. Whenever the density scaled integer goes above 12000 (density goes above 1.2000 g/cm^3), the transmitter reports the overflow integer (12001) for the density process variable, which the Modbus host is programmed to recognize as an alarm condition.

The transmitter also returns the overflow integer for all scaled integers if any of the following alarm conditions exists:

- Sensor failure
- Input overrange
- Density outside sensor limits
- Temperature outside sensor limits
- Transmitter electronics failure

Note: Events can be used to show out-of-range conditions, just as the overflow integer does. However, these two functions are independent and can be programmed independently.

Step 4   Write the values to the transmitter

Write the following values to the transmitter:

- Maximum integer – Register 18
- For each process variable:
    - Scale factor – Registers 29–38
    - Offset – Registers 19–28

IS 3   Using scaled integers

To read scaled integer values, read the appropriate integer registers (Registers 2–11). To reset scaled integer totals or inventories, write 0 to the appropriate register (Registers 8–11).

IS 4   Scaled integer examples

Example 5	The transmitter is connected to a Honeywell TDC3000 control system using a PLC Gateway. The transmitter's volume flow measurement will be reported to the control system via an analog input point.

On the control system, an analog input point has limits of 0 and 4095. Any input greater than 4095 indicates a "bad" process variable.

The lowest expected value for volume flow is –100 barrels/day; the highest expected value is 300 barrels/day.

1. Choose the scaled integers that will represent the LRV and URV. They must be in the range 0–4095. This example will use 0 and 4095.

2. Determine the scale factor.

$$= \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{4095 - 0}{300 - (-100)}$$

$$= \frac{4095}{400}$$

$$= 10.2375$$

Because the scale factor must be an integer, round down to 10.

3. Determine the offset.

$$= (\text{Scale factor} \times x) - y + 32,768$$

$$= [10(-100)] - 0 + 32,768$$

$$= -1000 + 32,768$$

$$= 31,768$$

4. Because the calculated scale factor of 10.2375 was rounded down to 10, calculate the actual process variable values that correspond to scaled integer values of 0 and 4095. This will allow correct scaling of the analog input at the control system.

Scaled integer = 0

$$0 = 10x - (31768 - 32768)$$
$$x = -100$$

Scaled integer = 4095

$$4095 = 10x - (31768 - 32768)$$
$$x = 309.5$$

5. Set the maximum integer, if desired. It should be 300 or greater.

Example 6	Scale the mass flow rate so 0 represents −100 lb/min and 30,000 represents 200 lb/min.
	Scale factor $= \dfrac{y_2 - y_1}{x_2 - x_1}$
	$= \dfrac{30,000 - 0}{200 - (-100)}$
	$= \dfrac{30,000}{300}$
	$= 100$
	Offset $= (\text{Scale factor} \times x_1) - y_1 + 32,768$
	$= [100 - (-100)] - 0 + 32,768$
	$= 22,768$

Example 7	The mass flow rate needs to remain between 30 and 40 g/min. Scale the mass flow rate so 0 represents a flow rate less than or equal to 30.000 g/min, 10,000 represents a flow rate of 40.000 g/min, and 10,001 represents any flow rate greater than 40.000 g/min.
	Scale factor $= \dfrac{y_2 - y_1}{x_2 - x_1}$
	$= \dfrac{10000 - 0}{40 - 30}$
	$= \dfrac{10000}{10}$
	$= 1000$
	Offset $= (\text{Scale factor} \times x_1) - y_1 + 32,768$
	$= [1000 \times 30] - 0 + 32,768$
	$= 62768$
	Maximum integer $= 10000$

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