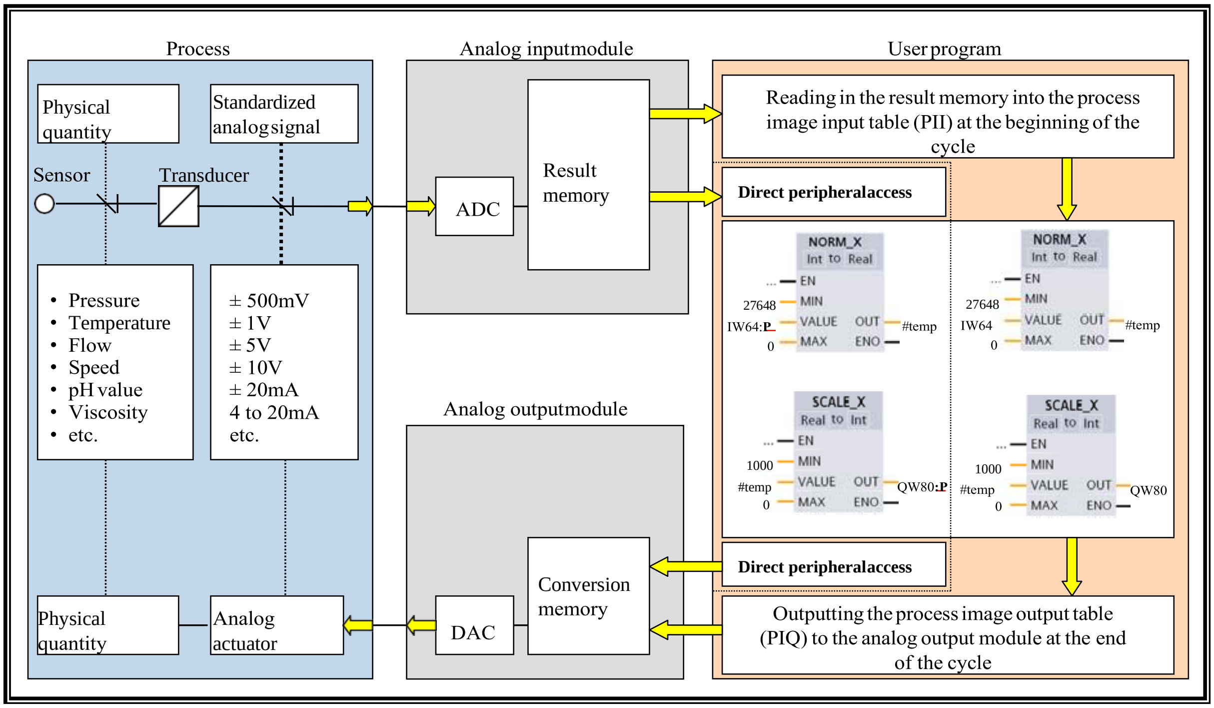
Analog Value Processing with an application

Principle of Analog Value Processing



Principle of Analog Value Processing

In a production process, there are a variety of physical quantities (such as pressure, temperature, speed, rotational speed, pH value, and viscosity) that need to be processed in the PLC for automation purposes.

Sensor

Measuring sensors respond to changes in the quantity to be measured by such things as linear expansion, angular distortion, and alteration of electrical conductivity.

Transducer

Measuring transducers convert these above-mentioned changes into standard analog signals, such as: ± 500mV, ± 10V, ± 20mA, 4 to 20mA.

These signals are supplied to the analog input modules.

ADC

Before these analog values can be processed in the CPU, they must be converted to digital form. The ADC (Analog-to-Digital Converter) on the analog input module handles this conversion.

The analog-to-digital conversion is performed sequentially. This means the signals are converted for each analog input channel in turn.

Result Memory

The result of the conversion is stored in the result memory and remains there until it is overwritten by a new value.

You can use the "L PIW..." load instruction to read the converted analog value.

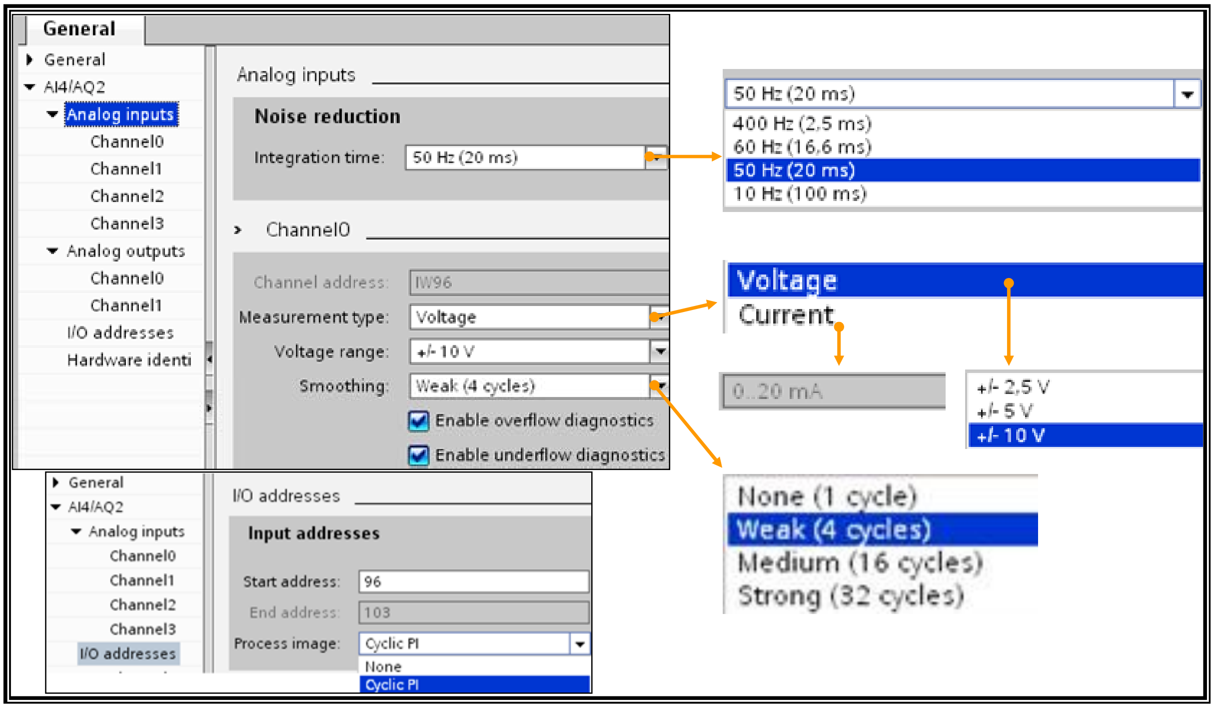
Analog Output

The (MOVE) transfer instruction is used to write the analog values the user program calculated to an analog output module, where a DAC (Digital-to-Analog Converter) converts them to standard analog signals.

Analog Actuators

Standardized actuators can be connected directly to the analog output modules.

Analog Input Modules



Analog Input Modules

Analog input modules are configured and parameterized in STEP7 in the device configuration of the respective PLC. The settings or parameters of all modules are downloaded into the CPU which must be in the STOP state to do this. When a subsequent (warm) restart is carried out, the CPU distributes the parameters to the appropriate modules.

Parameters

For the respective module, differentiation is made between module parameters and channel parameters.

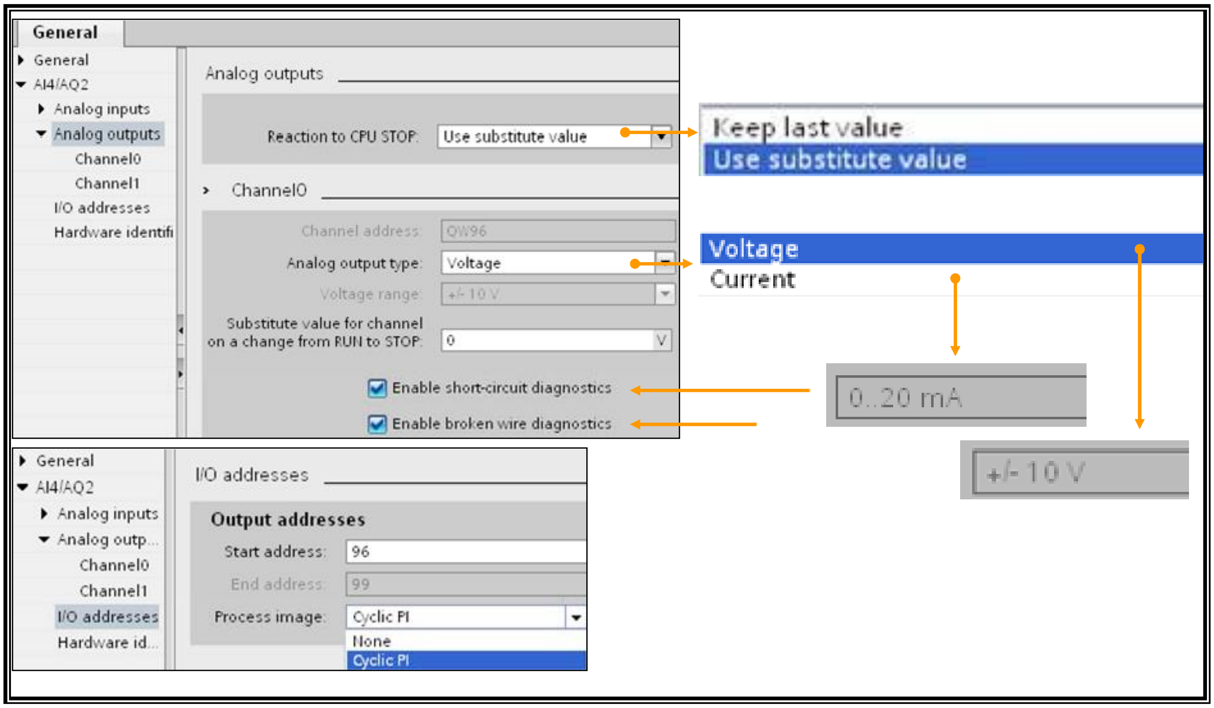
Module Parameters

- General
  Name and comment for the integrated analog inputs of the CPU.
- Noise reduction
  In the noise reduction, the noise frequencies of the specified frequency (in Hz) are suppressed by the integration time which is set.
- I/O addresses and Hardware identifier
  The address space of the entry addresses as well as the process image is defined. The hardware identity of the device is displayed.

Channel Parameters

- Measurement type
  With this parameter, the type of measurement is set, for example, voltage. An unused channel must then be deactivated since it is otherwise also converted thus making the total conversion time for the module worse.
- Measurement range (in the picture – Voltage range)
  With this parameter, the range of measurement for the selected type of measurement is set.
- Smoothing
  The smoothing of analog values generates a stable analog signal for further processing. Smoothing the analog values is recommended in case of fast signal changes (measured value changes), for example, in the level measurement of fluctuating liquids.
- Overflow diagnostics
  Through this parameter, the overflow diagnostics is activated. If the measured value exceeds the overflow range of the channel, a diagnostic interrupt is triggered.
- Underflow diagnostics
  Through this parameter, the underflow diagnostics is activated. If the measured value falls below the underflow range of the channel, a diagnostic interrupt is triggered.

Analog Output Modules



Analog Output Modules

Analog output modules are configured and parameterized in STEP7 in the device configuration of the respective PLC. The settings or parameters of all modules are downloaded into the CPU which must be in the STOP state to do this. When a subsequent (warm) restart is carried out, the CPU distributes the parameters to the appropriate modules.

Parameters

For the respective module, differentiation is made between module parameters and channel parameters.

Module Parameters

- General
  Name and comment for the integrated analog outputs of the CPU.
- Reaction to CPU STOP
  - Switch off
    The peripheral device goes into safe mode. The process image output table is deleted (=0).
  - Substitute value
    The peripheral device outputs the value previously set for the channel.
  - Keep last value
    The peripheral device retains the value last put out before STOP.

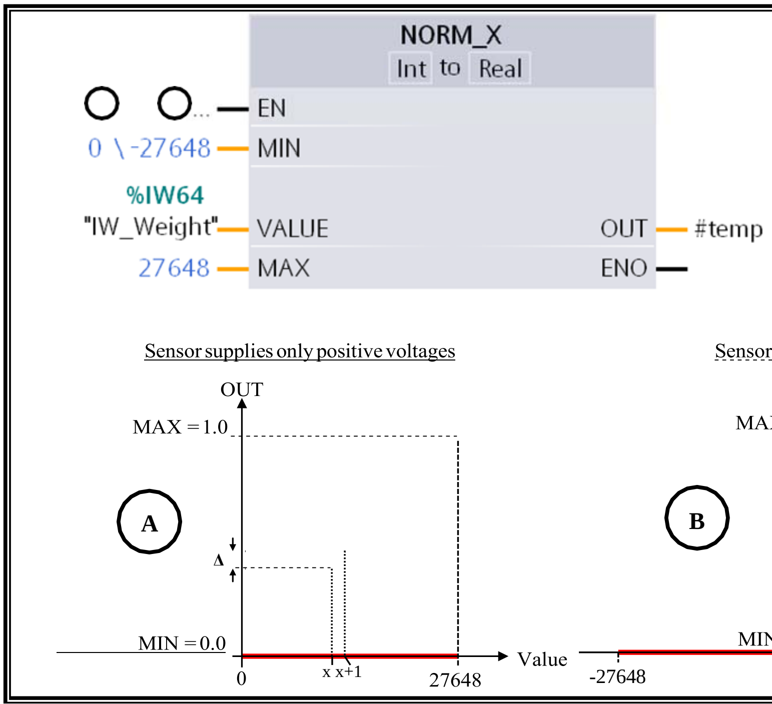
Attention!
Make sure that the system is always in safe mode in the case of "Keep last value"!

- I/O addresses and Hardware identifier
  The address space of the entry addresses as well as the process image is defined. The hardware identity of the device is displayed.

Channel Parameters

- Analog output type
  With this parameter, the type of output is set, for example, voltage. Unused outputs have to be deactivated since they are otherwise also converted thus making the total conversion time for the module worse.
- Output range (in the picture - Voltage range)
  With this parameter, the output range of the selected type of output is set.
- Broken wire diagnostics (in Current mode)
  With this parameter, the diagnostic Wire break is generated when there is a wire break. This diagnostic is not noticeable in the zero range.
- Short-circuit diagnostics (in Voltage mode)
  With this parameter, a diagnostic is generated when there is a short-circuit of the output wire. This diagnostic is not noticeable in the zero range.
- Substitute value
  With this parameter, a substitute value is specified which the module is to output when the CPU goes into STOP. The substitute value must be in the rated range, the overrange or the underran

Scaling Analog Inputs with NORM_X and SCALE_X (1)



NORM_X normalizes the input signal at input "Value" in the limits "MIN and MAX" to the signal range 0.0 to 1.0.

Norm_X

The analog module encrypts the voltage range of -10V to +10V in the value range of -27648 to +27648. The "Normalize" operation normalizes a value by mapping it to a linear scale. You can use the MIN and MAX parameters to define the limits of a value range that is applied to the scale. The result at the OUT output is calculated and stored as a floating-point number depending on the location of the normalized value in this value range. If the value to be normalized is equal to the value at the MIN input, the OUT output returns the value "0.0". If the value to be normalized is equal to the value at the MAX input, the OUT output has the value "1.0".

Resolution

In example **B,** the measurement occurs with twice the resolution or with half as much measuring tolerance **Δ**, since the measured value is mapped to the greater units range of -27648 to +27648.

Data Types

- The parameters on the input-side can be one of the following data types: SINT, INT, DINT, USINT, UINT, UDINT or REAL
- The parameter OUT can be one of the following data types: REAL or LREAL

Sensor

In the following it is assumed that a sensor is used which has a measuring range of 0 to 10V (case A) or -10V to 10V (case B).

Example **A** shows the normalization when a sensor is used that supplies a measured voltage of 0V as the smallest measured value and +10V for the maximum measured value. Example **B** shows the mapping when a sensor is used that supplies -10V as the smallest measured value and 10V as the largest measured value.

Parameters

- VALUE: value which is normalized.
- MIN: lower limit of the value range
- MAX: upper limit of the value range
- OUT: normalized signal 0.0 to 1.0

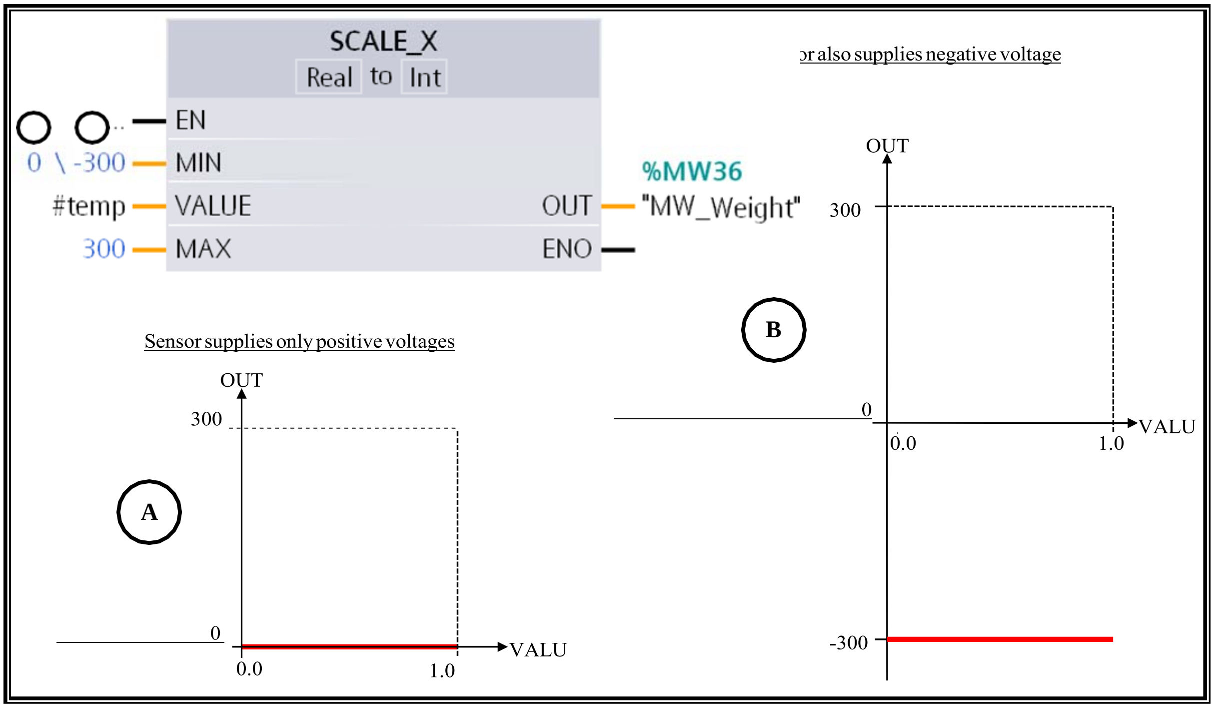
EN / ENO

The "Normalize" operation is only executed if the signal state is "1" at the enable input EN. In this case, the enable output ENO has signal state "1".

The enable output ENO returns signal state "0" if one of the following conditions applies:

- The EN input has signal state "0".
- The value at the MIN input is greater than or equal to the value at the MAX input.
- The value of a specified floating-point number is outside of the range of the normalized numbers according to IEEE-754.
- The value at input VALUE is NaN (Not a number = result of an invalid arithmetic operation).

Scaling Analog Input with NORM_X and SCALE_X (2)



SCALE_X

The "Scale" operation scales the value at the VALUE input linearly by mapping it to a specified value range. When the "Scale" operation is executed, the floating-point value at the VALUE input is scaled to the value range, which is defined by the MIN and MAX parameters. The result of the scaling is an integer, which is stored at the OUT output.

Examples

In the example shown, the value at the VALUE input is scaled within the limits 0 to 300 for case A. In case B, VALUE is scaled to the limits -300 to 300.

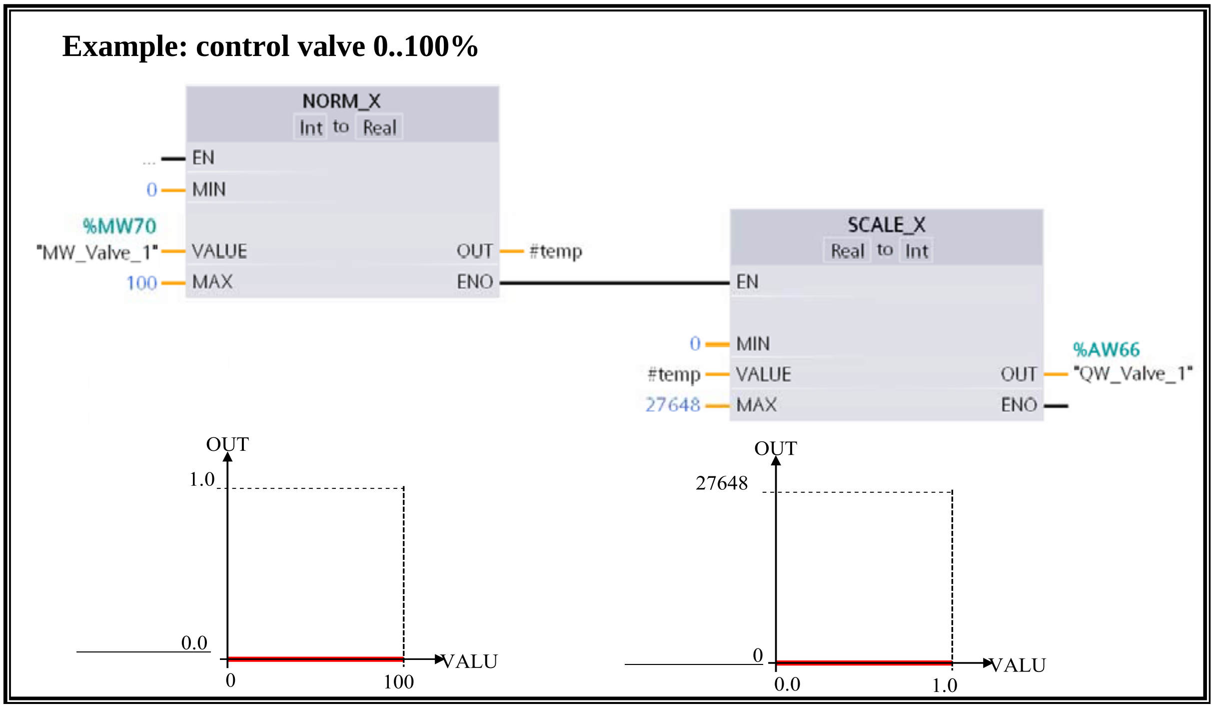
☞ The VALUE input may only be within the limits 0.0 to 1.0 !

Parameters

- VALUE: value which is scaled.
- MIN: lower limit of the value range
- MAX: upper limit of the value range
- OUT: result of scaling.

- The value at the MIN input is greater than or equal to the value at the MAX input.
- The value of a specified floating-point number is outside of the range of the normalized numbers according to IEEE-754.
- An overflow occurs.
- The value at input VALUE is NaN (Not a number = result of an invalid arithmetic operation).

Controlling Analog Outputs with NORM_X and SCALE_X



Controlling Analog Outputs (Example)

An analog value (valve position) calculated by the user program in the range 0 to 100% is converted to the range 0 to +27648 through the combination of NORM_X and SCLAE_X. In outputting the descaled value to an analog output module, it will control the analog actuator (for example, a servo valve) with, for example, 0V to +10V (depending on the output range set).

The example shows the normalization for an actuator that is to be controlled with the value 0 (0V or 0mA) when the program value is 0%, and with the maximum value (for example, +10V or 20mA) when it is 100%.