NOVA

Control Function Block Reference

Cutting Edge Software · October 2026

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Introduction

A Nova control program may be drawn as a diagram, in a style that combines ladder logic with function blocks. Blocks are placed on a grid, connected by wires that run from the outputs on the right of one block to the inputs on the left of the next, and the whole diagram is solved once on every scan of the program. On each scan the program reads the tags that it names, solves its blocks in the order in which the diagram reads, and writes back the values that it has produced, so nothing that it calculates is ever a scan out of date with anything else that it calculates.

This reference describes each of the blocks offered by the visual control editor. The blocks are grouped as they are in the editor's block picker, which is opened from the group buttons on the editor's toolbar, and are listed in the order in which the picker shows them.

Reading the Entries

Each entry begins with a picture of the block as the editor draws it. Where one block is offered on the picker in several forms, such as the normally open and normally closed contacts, each form is shown. The name under each picture is the name used on the picker, and a letter or symbol in brackets is the key that starts placing that block directly, either on the diagram or with the picker open.

The short grey leads on each picture mark the terminals, which is to say the points at which wires attach. They are drawn here to make the terminals easy to see, and do not appear in the editor itself. Most blocks take their inputs on the left and drive their outputs on the right, but a few take an input from below, as the second operand of an arithmetic block does.

The picture is followed by a description of the block's inputs, its outputs and its options. Each terminal has one of three types:

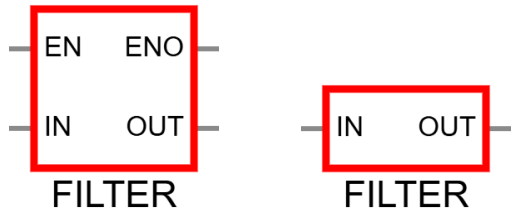
Type	Meaning
Digital	An on or off signal, such as the power flowing along a rung of ladder logic.
Value	A number.
Any	Either of the above, passed through without change.

A wire may also carry no data at all. A tag that is not answering, a sensor that has failed or a block that has been disabled produces no value rather than a zero, and most blocks that are handed no data produce none in turn, so that a missing reading passes down the chain rather than being replaced by a figure that looks real. The descriptions say where a block behaves otherwise.

The options are set in the dialog that opens when a block is double clicked, or when Enter is pressed with the block selected. Every block also has a Name option, which is for information only. Nothing in a program refers to a block by its name, and it may be left empty wherever the purpose of a block is clear from the diagram.

The Enable Pair

Many of the larger blocks carry an enable input, labelled EN, in the top row on their left, and most of those carry a matching enable output, labelled ENO, in the top row on their right.



EN and ENO shown EN and ENO folded away

The EN input decides whether the block runs. While it is set, the block does its work; while it is clear, the block is disabled, and typically produces no value on its outputs. An EN input that is not wired is treated as set, so a block whose enable is left alone simply runs. The ENO output follows the enable, which allows several blocks to be placed along one rung so that a single condition enables them all. A few blocks give the enable a meaning of its own, as the Hold block does in using it as its trigger, and the entry for each block says so where that is the case.

On most diagrams neither terminal is wired, and the pair then takes up a row of the block for no purpose. A block that carries an enable may therefore have the pair **folded away**:

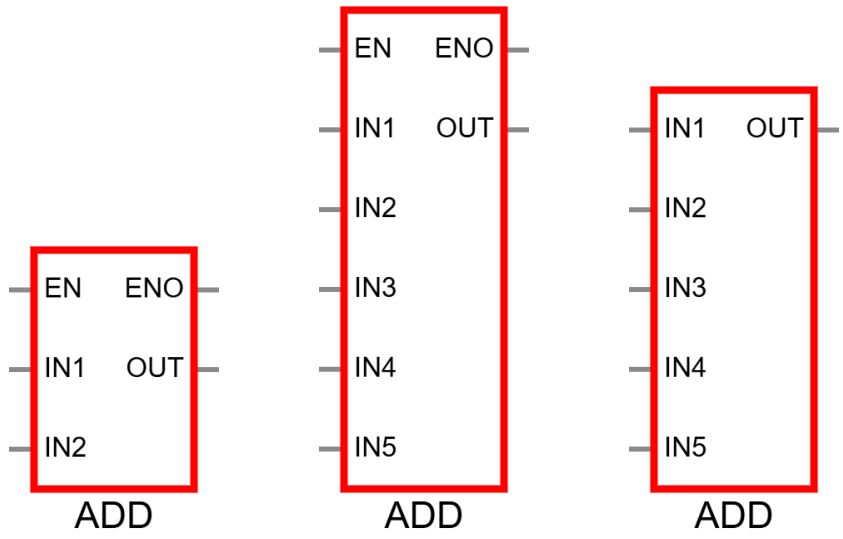
1. Select the block. A small grab handle appears at the middle of its top edge.
2. Drag the handle down by one grid cell. The EN and ENO terminals are removed from the drawing, and the block becomes one row shorter.
3. To bring the pair back, drag the handle up again by one cell.

When the pair is folded away, the block behaves exactly as it does with its enable unwired, and so always runs. The block moves down by a cell as it folds, so that the terminals below the enable stay where they were and no other wire on the diagram has to move. The editor will not fold the pair away while either of its terminals is wired, as this would leave a wire attached to a terminal that could no longer be seen, and will not do so where the shortened block would overlap another. Folding the pair away is a single step that may be undone like any other edit.

Each entry in this reference that carries an enable pair is marked **Enable: EN/ENO** in its summary, and its picture shows the pair in place.

Resizable Blocks and N-ary Operations

Most blocks have a fixed number of terminals. Some, however, perform an operation that is not limited to a fixed number of operands, and may be grown or shrunk to carry as many as are needed. Such an operation is called **n-ary**, meaning that it takes any number, *n*, of operands. A sum of eight values is a single n-ary addition rather than seven separate additions, and it is drawn as one block with eight inputs rather than as a chain of seven blocks.



Sum with two operands | Sum resized to five operands | Five operands

A resizable block is sized by dragging:

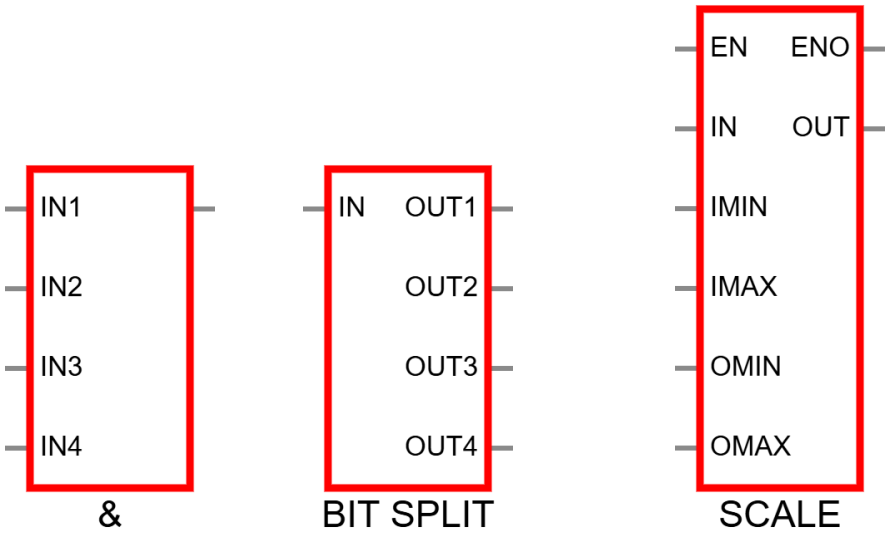
1. Select the block. A small grab handle appears at the middle of its bottom edge.
2. Drag the handle down to add terminals, or up to remove them. The block changes by one terminal for each grid cell, and follows the pointer as it moves.

The editor will not shrink a block past a terminal that is wired, as this would leave the wire attached to nothing. Disconnect the terminal first, and the block may then be shrunk. Nor will it grow a block over one that is already placed beneath it. A wire refers to a terminal by its number, so resizing a block never alters the meaning of a wire that is already drawn to it. Resizing is a single step that may be undone like any other edit.

Unless an entry says otherwise, a terminal that is not wired takes no part in the operation. A block may therefore be sized for connections that are to be made later, and an AND gate with four inputs and three wires is an AND of three conditions.

Resizing is offered by three kinds of block:

Kind	Blocks	What the size controls
N-ary operations	AND, OR and XOR Gates, Sum, Product and Box Op, Selector	The number of operands, from two to eight.
Packing	Bit Pack, Bit Split, Byte Pack, Byte Split	The number of places, from two to eight bits or from two to four bytes.
Parameter terminals	Scale, Limit, Range	How many of the block's parameters are brought out as inputs of their own, from none to all of them.



AND gate with four inputs

Bit Split with four places

Scale with all four parameters brought out

A parameter brought out as a terminal takes its value from the wire connected to it, and the corresponding option in the block's dialog is disabled to say so. A parameter that has been brought out but left unwired continues to take its value from the dialog, so the two may be mixed freely. The parameters are brought out in the order in which they are listed, so a Scale block with two parameter terminals carries the input minimum and maximum.

Each entry in this reference for a resizable block is marked **Resizable** in its summary, with the range of sizes that it accepts. A few other blocks change shape according to their options rather than by being dragged. The Stats block shows a terminal for each figure that is selected, and the Call block shows a terminal for each pin of the subprogram that it calls.

Junctions

A junction is not placed from the picker. The editor inserts one when a wire is started from the middle of an existing wire, so that one output may feed several inputs. Where several wires are joined into a single junction, it is drawn as a circle containing a cross, and acts as an OR.

Junction Merging junction

Every leg out of a junction carries the same value. Where one leg into it is driven, that value passes through unchanged. Where several are driven, the largest is taken, which for digital signals is an OR, and which for values does not depend on the order in which the legs were wired. A leg into a junction that is not driven contributes nothing rather than a zero.

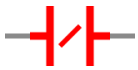
Ladder

Contacts, Coils, Edges and Pulses.

Block	Key	Description
NO Contact	`C`	Normally open contact.
NC Contact	`X`	Normally closed contact.
Coil	`O`	Output coil.
Not Coil		Coil driven by the inverse of its input.
Set Coil	`L`	Latches its tag on.
Reset Coil	`U`	Clears a latched tag.
Inverter	`I`	Output is high when its input is low.
Debounce	`D`	Passes a change once the input settles.
Rising Edge	`P`	Passes one scan when its input goes high.
Falling Edge	`N`	Passes one scan when its input goes low.
Pulse On		Pulses high when its input goes high.
Pulse Off		Drops low when its input goes high.
Latch		Set input latches on, reset clears it.
AND Gate	`&`	Set while every wired input is set.
OR Gate	`|`	Set while any wired input is set.
XOR Gate	`^`	Set on odd parity of the wired inputs.

Contacts

NO Contact (C)



NC Contact (X)

- **NO Contact** — Normally open contact.
- **NC Contact** — Normally closed contact.

INPUTS

Terminal	Type	Meaning
Left	Digital	The incoming signal. Defaults to on.

OUTPUTS

Terminal	Type	Meaning
Right	Digital	The incoming signal, passed on while the tag satisfies the contact, and withheld while it does not.

OPTIONS

Tag Reference

Enter the tag, or an expression over tags, to be read by the contact. Any non-zero value will be treated as true. The expression is displayed above the element on the diagram.

Contact Type

Select the manner in which the contact responds to its tag:

- *Normally Open* will pass the incoming signal while the tag is true; and
- *Normally Closed* will pass it while the tag is false.

A normally closed contact and a normally open contact followed by an inverter are equivalent.

Coils

Coil (O) Not Coil Set Coil (L) Reset Coil (U)

- **Coil** — Output coil.
- **Not Coil** — Coil driven by the inverse of its input.
- **Set Coil** — Latches its tag on.
- **Reset Coil** — Clears a latched tag.

INPUTS

Terminal	Type	Meaning
Left	Digital	The incoming signal. Defaults to on.

OUTPUTS

Terminal	Type	Meaning
Right	Digital	The incoming signal, passed on unchanged, so that several coils may be driven from the same line.

OPTIONS

Tag Reference

Enter the tag to be driven by the coil. The name is displayed above the element on the diagram.

Coil Type

Select the manner in which the coil drives its tag:

- *Normal* will set the tag true while the signal is present, and false while it is not;
- *Inverted* will do the reverse;
- *Set* will set the tag true while the signal is present, and will leave it unchanged otherwise; and
- *Reset* will set the tag false in the same manner.

A set coil and a reset coil are typically used as a pair, with the tag holding its state between them. Where the state need not be held in a tag, use the latch element instead.

Inverter

Inverter (I)

Output is high when its input is low.

INPUTS

Terminal	Type	Meaning
Left	Digital	The signal to be inverted. Defaults to on.

OUTPUTS

Terminal	Type	Meaning
Right	Digital	The inverse of the incoming signal.

Debounce

Debounce (D)

Passes a change once the input settles.

INPUTS

Terminal	Type	Meaning
Left	Digital	The signal to be filtered. Defaults to on.

OUTPUTS

Terminal	Type	Meaning
Right	Digital	The last state accepted by the element. The output will follow the input only once the input has held its new state for the settling time, so that contact bounce and transients shorter than that period are not passed on.

OPTIONS

Make Time

Enter the period for which the input must remain on before the output will follow it. This period should be long enough to cover the expected bounce, but no longer than the application can tolerate.

Break Time

Enter the period for which the input must remain off before the output will follow it. Leave this setting unset to use the same period in both directions, which is the usual case, and which is displayed as a single figure beneath the element.

Edge Detect

Rising Edge (P) Falling Edge (N) First Scan

- **Rising Edge** — Passes one scan when its input goes high.
- **Falling Edge** — Passes one scan when its input goes low.
- **First Scan** — Passes on the first scan after the program starts.

INPUTS

Terminal	Type	Meaning
Left	Digital	The signal to be watched. Defaults to on, in which case no edge will ever occur, but the first scan still will.

OUTPUTS

Terminal	Type	Meaning
Right	Digital	A pulse of one scan, produced each time the selected transition occurs.

OPTIONS

Edge Type

Select the transition to be detected:

- *Rising Edge* will produce a pulse when the signal appears;
- *Falling Edge* will produce one when it is removed; and
- *First Scan* will produce one on the first scan after the program starts, provided the signal is present.

Neither edge is produced on the first scan after the program starts, whatever the state of the signal at that point, since nothing has yet been seen to change.

A single scan is the appropriate input for those elements that act once, such as a counter, an edge triggered store, or the set input of a latch.

The first scan is the place to put a program's initialisation, such as resetting machine states or clearing counters. Place it at the start of a rung and that rung will run once each time the program starts, such as when the device starts or a new configuration is applied. A program that is held off by its *Execute* condition starts when that condition first allows it to scan. In a subprogram, each call has its own first scan.

Pulse

Pulse On

Pulse Off

- **Pulse On** — Pulses high when its input goes high.
- **Pulse Off** — Drops low when its input goes high.

INPUTS

Terminal	Type	Meaning
Left	Digital	The signal to be watched. A rising transition will start a pulse. Defaults to on.

OUTPUTS

Terminal	Type	Meaning
Right	Digital	The pulse itself. This element shapes the signal that passes through it, so the output is the pulse and not the incoming signal.

OPTIONS

Output

Select the sense of the pulse:

- *Positive* will idle in the off state and pulse on; and
- *Negative* will idle in the on state and pulse off.

Only a rising transition will start a pulse. Where the falling transition is required, place an inverter in front of the element.

Pulse Time

Enter the period for which the pulse will be held.

Duration

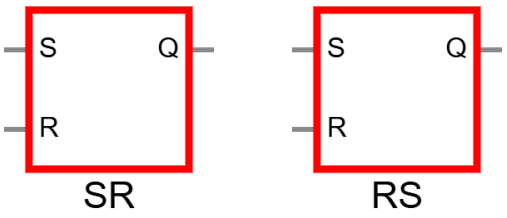
Select the manner in which this period is applied:

- *Fixed* will hold the pulse for the specified time, whatever the input does in the meantime;
- *Minimum* will hold the pulse for at least the specified time, and for longer if the input persists; and
- *Maximum* will hold the pulse for no longer than the specified time, ending it early if the input is removed.

Retrigger

Select whether a further transition will restart a pulse that is still running. If retriggering is not enabled, such transitions will be ignored until the pulse has completed. This setting has no effect where the duration is a maximum, as the pulse will already have been ended by the removal of the input.

Latch



Latch

Latch, reset wins

Set input latches on, reset clears it.

INPUTS

Terminal	Type	Meaning
S	Digital	Sets the output, which will then remain set. This input is a level, and defaults to off.
R	Digital	Resets the output in the same manner.

OUTPUTS

Terminal	Type	Meaning
Q	Digital	The state of the latch. This state is not retained across a restart.

OPTIONS

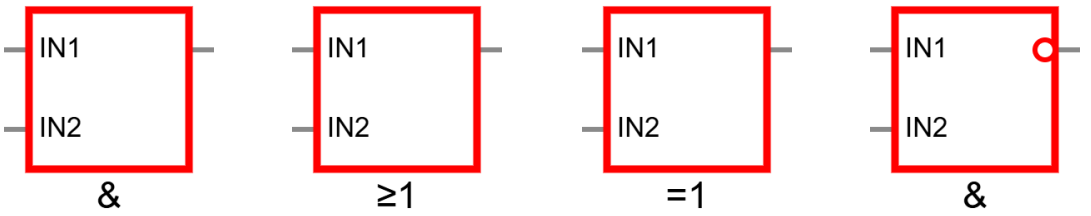
Dominance

Select which input will prevail when both are present on the same scan:

- *Set Wins* implements the IEC SR function; and
- *Reset Wins* implements the IEC RS function.

Where one of the two inputs represents a trip, an interlock or a stop, that input should be the one to prevail.

Logic Gates



AND Gate (&) OR Gate (|) XOR Gate (^) NAND, an inverted form

- **AND Gate** — Set while every wired input is set.
- **OR Gate** — Set while any wired input is set.
- **XOR Gate** — Set on odd parity of the wired inputs.

> **Resizable:** 2 to 8 inputs

INPUTS

Terminal	Type	Meaning
IN1 to IN8	Digital	The conditions to be combined. Only those terminals that are wired take part, so an element given more terminals than it is handed connections answers about the connections that exist.

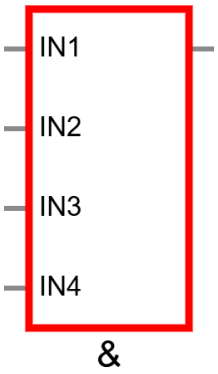
OUTPUTS

Terminal	Type	Meaning
Right	Digital	The result. An element to which nothing has been wired holds its output clear, whichever operation has been selected.

RESIZING

Drag the handle at the foot of the block to set the number of inputs, from 2 to 8. The block cannot be shrunk past a terminal that is wired; disconnect the terminal first, and the block may then be shrunk.

Series contacts already form an and, and parallel branches already form an or, so this element is not required in order to express either. It is offered because a wide and written as a run of contacts reads as a sequence of separate conditions rather than as one, and because an exclusive or has no convenient ladder form at all.



Resized to four inputs

OPTIONS

Operation

Select the operation to be performed:

- *And* sets the output while every input is set;
- *Or* sets it while any input is set;
- *Exclusive Or* sets it while an odd number of inputs are set; and
- the *Not* forms of each of the above invert that result.

An exclusive or over more than two inputs reports odd parity. This is the result of applying the operation in turn to each input, and is not the same as exactly one input being set.

The symbol drawn on the element is the IEC one for the operation selected: `&` for and, `≥1` for or, and `=1` for exclusive or. An inverting form carries the same symbol with a bubble on its output, so that a gate and its inverse read as one gate taken two ways. This also distinguishes the element from the box operation, which spells its operation out in full and works upon bit patterns rather than upon digital conditions.

Values

Tag Reads, Tag Writes and Constants.

Block	Key	Description
Read Tag	`R`	Puts the value of a tag on a wire.
Write Tag	`W`	Writes the value on its wire to a tag.
Zero Tag		Zeroes its tag while enabled.
Set Tag		Writes a fixed value while enabled.
Store	`S`	Writes a value while enabled, passes on.
Increment		Increments a tag when its input goes high.
Decrement		Decrements a tag when its input goes high.
Constant	`K`	A fixed number, drawn small.
Call		Runs a subprogram, with its variables bound here.
On	`1`	A signal permanently on.
Off	`0`	A signal permanently off.
First Scan		Passes on the first scan after the program starts.

Read Tag

Read Tag (R)

Puts the value of a tag on a wire.

OUTPUTS

Terminal	Type	Meaning
Right	Any	The value of the tag or expression. A tag that is not answering will present no value at all, which will pass down the chain of elements that follow, rather than being replaced by a zero.

OPTIONS

Tag Reference

Enter the tag, or an expression over tags, whose value is to be placed on the wire. An expression is evaluated once per scan along with the rest of the program, and will often save several elements. The expression is displayed above the element on the diagram.

Write Tag

Write Tag (W)

Writes the value on its wire to a tag.

INPUTS

Terminal	Type	Meaning
Left	Any	The value to be written. If no value is present, the tag will be left unchanged, so that a value already held is not replaced by one that the program was unable to produce.

OUTPUTS

Terminal	Type	Meaning
Right	Any	The value as it arrived, passed straight through, so that one source may feed a line of writes.

OPTIONS

Tag Reference

Enter the tag to which the value is to be written. The name is displayed above the element on the diagram, and the value last written is displayed beneath it.

Tag Operations

Zero Tag Set Tag Increment Decrement

- **Zero Tag** — Zeroes its tag while enabled.
- **Set Tag** — Writes a fixed value while enabled.
- **Increment** — Increments a tag when its input goes high.
- **Decrement** — Decrements a tag when its input goes high.

INPUTS

Terminal	Type	Meaning
Left	Digital	The incoming signal, applied as a level for the zero and set operations, and as a rising transition for the two steps. Defaults to on.

OUTPUTS

Terminal	Type	Meaning
Right	Digital	The incoming signal, passed on unchanged.

OPTIONS

Tag Reference

Enter the tag on which the element operates. The name is displayed above the element, and its value beneath.

Operation

Select the operation to be performed on the tag:

- *Zero* will clear the tag while the signal is present;
- *Set* will write the configured value while the signal is present; and
- *Increment* and *Decrement* will step the tag by one on each rising transition.

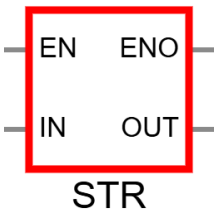
A tag that holds no value yet will be stepped from zero, so that the first transition is not lost.

The count is held in the tag itself, so that any part of the configuration may read it, and so that a coil writing to the same tag will serve as a reset.

Value

Enter the value to be written by a set. This figure is displayed within the element on the diagram.

Store



Store (S)

Writes a value while enabled, passes on.

> **Enable:** EN/ENO, may be folded away

INPUTS

Terminal	Type	Meaning
EN	Digital	Enables the store. Defaults to on.
IN	Value	The value to be written. If no value is present, the tag will be left unchanged.

OUTPUTS

Terminal	Type	Meaning
ENO	Digital	Follows the enable, so that several stores may be placed along the same line.
OUT	Value	The value as it arrived, passed straight through. If no value was present, none will be passed on, so that a later element is not handed the value that the tag happens to hold.

OPTIONS

Tag Reference

Enter the tag to which the value is to be written. The name is displayed above the element on the diagram.

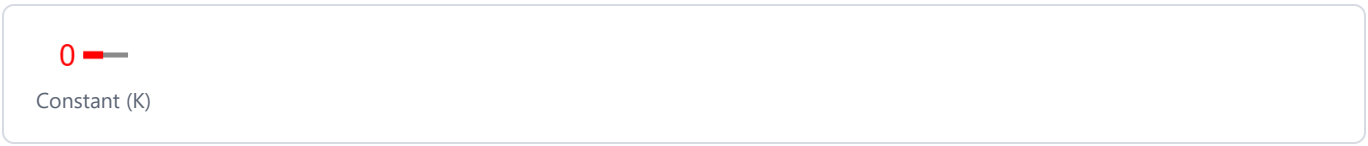
Trigger

Select the manner in which the enable is applied:

- *Level* will write for as long as the enable is present; and
- *Edge* will write once, on the rising transition of the enable.

A level is the usual choice. An edge is used to capture a value into a tag and then to leave it to whatever else may write to it.

Constant



A fixed number, drawn small.

OUTPUTS

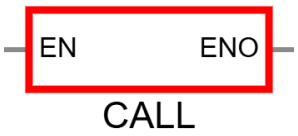
Terminal	Type	Meaning
Right	Value	The configured number, presented on every scan.

OPTIONS

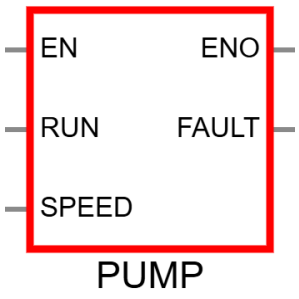
Value

Enter the number that this element places on its wire. The figure is displayed on the diagram, so that it may be read without opening this dialog. Where the figure is to be obtained from elsewhere in the configuration, use an input element instead.

Call



Call



Calling PUMP, with two inputs and one output

Runs a subprogram, with its variables bound here.

> **Enable:** EN/ENO, may be folded away

This element runs a subprogram or a subscript within the scan of the program that contains it, and supplies the variables that it was written against.

A sheet that is worth drawing is usually worth drawing only once. A program that watches an engine is the same logic whichever engine it is pointed at, and the difference between one engine and the next is a handful of tag names. Those names are the subprogram's variables, and this is where they are given.

Each call keeps a copy of the subprogram to itself. What a program holds between one scan and the next is as much a part of it as what it does within a scan, so two calls that shared a timer would be sharing one stopwatch between two machines. Anything that the subprogram keeps outside itself is named against the call rather than against the sheet, for the same reason.

A call that is not enabled does not run its subprogram at all. Nothing is read, nothing is calculated and nothing is written, so whatever the subprogram last wrote is left where it was. This is what stopping a program means everywhere else in this module, and stopping one is not the same as running one whose outputs all happen to be off.

The rung passes through, so a call may sit in the middle of one.

A call of a subscript keeps a copy of the script in the same way, with its own variables. The script reads and writes its tags directly as it runs, rather than when the program writes its outputs at the end of the scan, so a tag is best written either by the script or by the diagram and not by both. A run that is stopped by a fault, such as a loop that runs out of time, turns the enable output off for that scan and leaves the output terminals as they were. A call whose script faults on ten scans in a row is stopped until the program's statistics are reset, and the program's status says so.

The terminals shown are those that the subprogram names on its Pins tab, and they carry its names and appear in the order it lists them. A subprogram that names none is drawn as a plain enable.

A terminal is identified by a number that belongs to the pin rather than to its place in the subprogram's list, so a wire drawn to one is not disturbed by pins being added, removed or reordered on the sheet that is called. Only removing the pin itself takes a terminal away, and the wire is then left plainly attached to nothing.

INPUTS

Terminal	Type	Meaning
EN	Digital	Enables the call. Defaults to on. While it is removed the subprogram is not run at all, and whatever it last wrote is left in place.
Input pins	Any	One terminal for each input pin that the subprogram names on its Pins tab, carrying that pin's name, in the order in which the subprogram lists them. Up to eight may be shown.

OUTPUTS

Terminal	Type	Meaning
ENO	Digital	Follows the enable, so that the rung passes through the call. It is cleared for a scan on which a called script is stopped by a fault.
Output pins	Any	One terminal for each output pin that the subprogram names, in the order in which it lists them. Up to eight may be shown. An output that a subprogram did not drive on this scan carries no value.

OPTIONS

Subprogram

Enter the name of the subprogram or subscript that this element is to run. The program named must be one whose kind is set to Subprogram or Subscript; a program that runs on a thread of its own already has a scan, and running it a second time inside somebody else's would give it two.

Variables

Give a value to each of the variables that the subprogram declares. The name is the subprogram's, and the binding is read in the program that contains the call, so a program that has variables of its own may pass one of them straight through rather than naming the same tag again at every call site.

Whether a binding is to name a place or a figure is decided by the subprogram rather than here. A variable that the subprogram declared as a reference must be given something that can be written to, since its elements may drive it.

A variable that is not named here keeps whatever the subprogram bound it to itself, which is what makes it worth declaring a variable with a sensible default.

On and Off

- **On** — A signal permanently on.
- **Off** — A signal permanently off.

OUTPUTS

Terminal	Type	Meaning
Right	Digital	The configured state, presented on every scan.

OPTIONS

State

Select whether the element presents the on or the off state:

- *Off* will hold the output clear; and
- *On* will hold it set.

Both forms are offered on the palette, so this setting is normally used only to reverse an element that has already been placed. The state is displayed on the face of the element.

Math

Arithmetic, Comparison and Selection.

Block	Key	Description
Add	`+`	Adds two values.
Subtract	`-`	Takes the second value from the first.
Multiply	`*`	Multiplies two values.
Divide	`/`	Divides the first value by the second.
Binary Op		Two values, one chosen operation.
Unary Op		Absolute, negate, truncate, round or root.
Comparison	`=`	Compares two values, drives a signal.
Gate	`G`	Passes a value while its condition holds.
Sum		Adds as many operands as are wired.
Product		Multiplies as many operands as are wired.
Box Op		One operation over the wired operands.
Box Unary		One value in, one out, while enabled.
Bit Pack		Gathers digital inputs into one value.
Bit Split		Splits a value into digital places.
Byte Pack		Gathers bytes into one wide value.
Byte Split		Splits a wide value into bytes.

Binary Operations

Add (+) · Binary Op Subtract (-) Multiply (*) Divide (/)

- **Add** — Adds two values.
- **Subtract** — Takes the second value from the first.
- **Multiply** — Multiplies two values.
- **Divide** — Divides the first value by the second.
- **Binary Op** — Two values, one chosen operation.

INPUTS

Terminal	Type	Meaning
A	Value	The first operand. For those operations that distinguish between them, this is the value that is acted upon.
B	Value	The second operand.

OUTPUTS

Terminal	Type	Meaning
Right	Value	The result of the operation. If either operand is not available, no result will be produced.

OPTIONS

Operation

Select the operation to be performed:

- *Add*, *Subtract*, *Multiply*, *Divide* and *Modulus* will perform the corresponding arithmetic on the two operands;
- *Minimum* and *Maximum* will select the smaller or the larger of them;
- *And*, *Or*, *Xor*, *Shift Left* and *Shift Right* will perform the corresponding bitwise operation;
- *Power* will raise the first operand to the power of the second; and
- *Arc Tangent 2* will take the angle, in radians, of the point whose coordinates are the two operands.

The bitwise operations round their operands to whole numbers before they are applied. Where more than two operands are required, use the box operation element, which offers those operations that accept any number of them.

Arc tangent 2 takes the first operand as the vertical coordinate and the second as the horizontal, and is the form to use wherever an angle is recovered from a pair of coordinates. The single operand arc tangent offered by the unary element cannot tell one half turn from the other, and folds the two together.

Where the operation has no answer for the operands it is given, no result is produced rather than one that is not a number. This applies to a negative raised to a fractional power, and to any result too large to be carried.

Unary Op

Unary Op

Absolute, negate, truncate, round or root.

INPUTS

Terminal	Type	Meaning
Left	Value	The value on which the operation is performed.

OUTPUTS

Terminal	Type	Meaning
Right	Value	The result of the operation. If no value is present at the input, no result will be produced.

OPTIONS

Operation

Select the operation to be performed.

The arithmetic operations are:

- *Absolute* will discard the sign, converting a signed error into a distance;
- *Negate* will reverse the sign;
- *Square* will multiply the value by itself; and
- *Square Root* will take the square root.

The rounding operations are:

- *Truncate* will discard the fractional part, rounding toward zero;
- *Round* will round to the nearest whole number;
- *Ceiling* will round upward; and
- *Floor* will round downward.

Truncate, ceiling and floor differ for negative values, and round differs from all three for those values that fall exactly halfway, so the choice should be made deliberately where the result is a count.

The trigonometric operations are *Sine*, *Cosine*, *Tangent*, and their inverses *Arc Sine*, *Arc Cosine* and *Arc Tangent*. These work in radians, as does the arithmetic that lies behind them. Where a value is held in degrees, the *Degrees* and *Radians* operations convert between the two, which places the unit on the diagram where it can be seen rather than inside an element where it cannot.

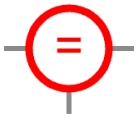
Where an angle is to be recovered from a pair of coordinates, use the arc tangent of the binary operation element rather than the one offered here, as only that form can tell which quadrant the angle lies in.

The exponential operations are:

- *Exp* and *Exp 10* will raise e or ten to the power of the value;
- *Natural Log* and *Log 10* will take the corresponding logarithm; and
- *Reciprocal* will divide one by the value.

Where the operation has no answer for the value it is given, no result is produced rather than one that is not a number. This applies to the square root and the logarithms of a negative value, the logarithms of zero, the reciprocal of zero, the inverse sine and cosine of a value beyond plus or minus one, and the tangent of a quarter turn. A result too large to be carried is treated the same way.

Comparison



Comparison (=)

Compares two values, drives a signal.

INPUTS

Terminal	Type	Meaning
Left	Value	The first value, forming the left side of the comparison.
Bottom	Value	The second value, forming the right side.

OUTPUTS

Terminal	Type	Meaning
Right	Digital	Set while the comparison holds. If either value is not available, the comparison has no answer and the output will be clear.

OPTIONS

Comparison

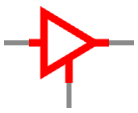
Select the comparison to be performed:

- *Equal* and *Not Equal* will test the two values for exact equality;
- *Less* and *Less or Equal* will test whether the first value falls below the second; and
- *Greater* and *Greater or Equal* will test whether it rises above it.

An exact comparison is rarely appropriate for a value that has been through any arithmetic. Where the values are computed, a band formed from a greater and a less will give a more dependable result.

This element provides the only route from the value plane back to the digital plane, as the wiring rules allow a digital signal to be taken as a value but never the reverse.

Gate



Gate (G)

Passes a value while its condition holds.

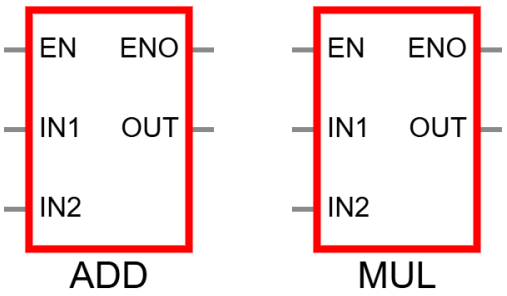
INPUTS

Terminal	Type	Meaning
Left	Any	The value offered to the gate, entering at the flat face.
Bottom	Digital	The condition, arriving at the underside. Defaults to on, so a gate whose condition is not wired will pass its value.

OUTPUTS

Terminal	Type	Meaning
Right	Any	The value while the condition is present, and no value at all while it is not. This is not the same as a zero, which would be stored and acted upon like any other result.

Box Operations



Sum · Box Op

Product

- **Sum** — Adds as many operands as are wired.
- **Product** — Multiplies as many operands as are wired.
- **Box Op** — One operation over the wired operands.

> **Enable:** EN/ENO, may be folded away · **Resizable:** 2 to 8 operands

INPUTS

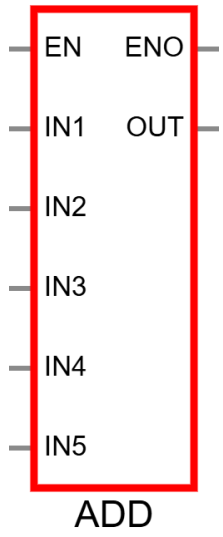
Terminal	Type	Meaning
EN	Digital	Enables the operation. Defaults to on.
IN1 - IN8	Value	The operands. Only those terminals that are wired will take part, so an element may be sized for the connections that are to be made later.

OUTPUTS

Terminal	Type	Meaning
ENO	Digital	Follows the enable, so that several operations may be placed along the same line.
OUT	Value	The result of the operation. While the element is disabled, no result will be produced, and any element that depends upon it will be unable to produce one either.

RESIZING

Drag the handle at the foot of the block to set the number of operands, from 2 to 8. The block cannot be shrunk past a terminal that is wired; disconnect the terminal first, and the block may then be shrunk.



Resized to five operands

OPTIONS

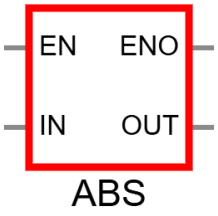
Operation

Select the operation to be performed:

- *Add* and *Multiply* will combine the operands arithmetically;
- *Minimum* and *Maximum* will select the smallest or the largest of them; and
- *And*, *Or* and *Xor* will perform the corresponding bitwise operation, rounding the operands to whole numbers before they are applied.

Subtraction, division and the remainder are not offered here, and are available on the compact operation element.

Box Unary



Box Unary

One value in, one out, while enabled.

> **Enable:** EN/ENO, may be folded away

INPUTS

Terminal	Type	Meaning
EN	Digital	Enables the operation. Defaults to on.
IN	Value	The value on which the operation is performed.

OUTPUTS

Terminal	Type	Meaning
ENO	Digital	Follows the enable, so that several operations may be placed along the same line.
OUT	Value	The result. While the element is not enabled no result is produced, rather than the last one being held.

OPTIONS

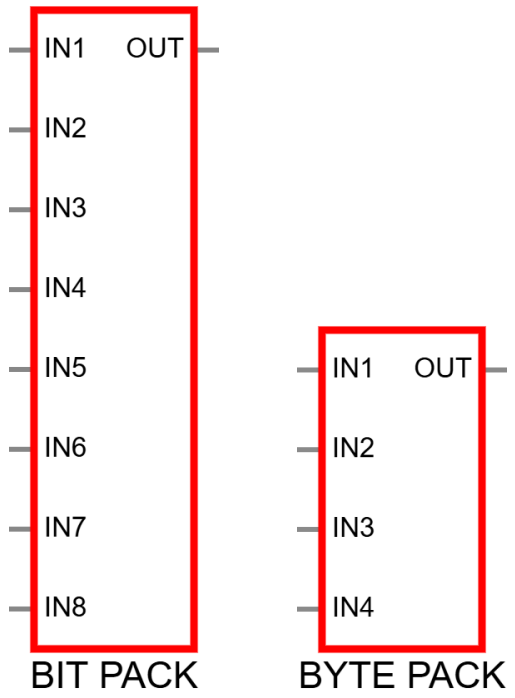
Operation

Select the operation to be performed. These are the same operations offered by the unary element, and are described under that element.

This element differs only in its shape. The unary element is a symbol on a wire, and is the right answer wherever the value plane stands on its own. This form is for the case where the operation belongs to a rung: where it should be performed only while something holds, and where what follows should be able to tell that it was.

Where the operation has no answer for the value it is given, no result is produced rather than one that is not a number.

Bit Pack and Byte Pack



Bit Pack Byte Pack

- **Bit Pack** — Gathers digital inputs into one value.
- **Byte Pack** — Gathers bytes into one wide value.

> **Resizable:** 2 to 8 bits or 2 to 4 bytes

INPUTS

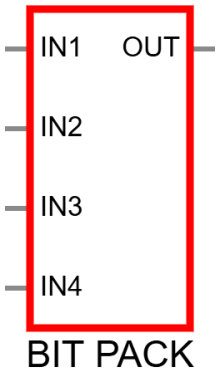
Terminal	Type	Meaning
IN1 to IN8	Any	The places to be gathered, IN1 taking the least significant. Only those terminals that are wired take part, and a place left unwired is gathered as clear.

OUTPUTS

Terminal	Type	Meaning
OUT	Any	The assembled value. If any wired place carries no value, none is produced, rather than a word with a hole in it being sent to a device.

RESIZING

Drag the handle at the foot of the block to set the number of places, from 2 to 8 bits or 2 to 4 bytes. The block cannot be shrunk past a terminal that is wired; disconnect the terminal first, and the block may then be shrunk.



Bit Pack resized to four places

OPTIONS

Width

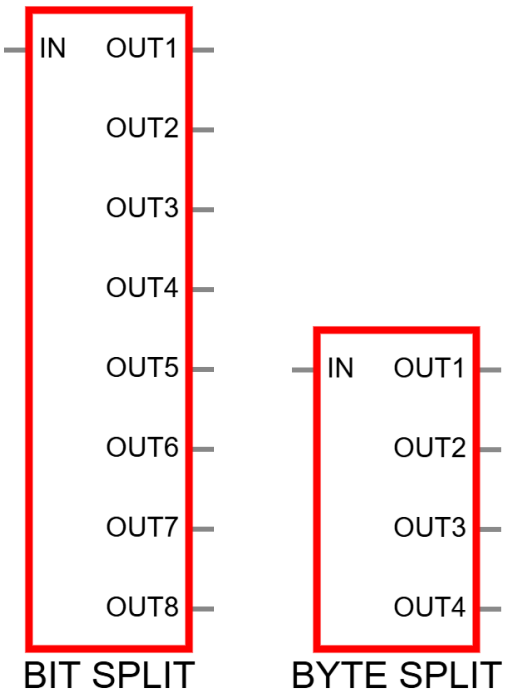
Select the width of each place:

- *Bits* takes one bit from each input, assembling as many as eight into a byte; and
- *Bytes* takes eight bits from each input, assembling as many as four into a thirty two bit value.

Each input is rounded to a whole number and then masked to the width selected, so a place handed more than it can hold contributes only what it can.

Wider assemblies are made by stacking. A pack of bytes fed from packs of bits reaches thirty two places without either element having to know that is what it is being used for.

Bit Split and Byte Split



Bit Split Byte Split

- **Bit Split** — Splits a value into digital places.
- **Byte Split** — Splits a wide value into bytes.

> **Resizable:** 2 to 8 bits or 2 to 4 bytes

INPUTS

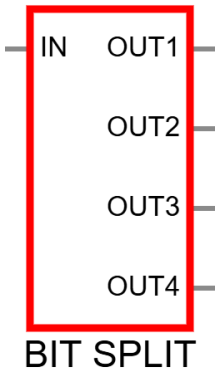
Terminal	Type	Meaning
IN	Any	The value to be split. If no value is present, none is produced at any place.

OUTPUTS

Terminal	Type	Meaning
OUT1 to OUT8	Any	The places, OUT1 carrying the least significant. Every place is driven whether or not anything is connected to it.

RESIZING

Drag the handle at the foot of the block to set the number of places, from 2 to 8 bits or 2 to 4 bytes. The block cannot be shrunk past a terminal that is wired; disconnect the terminal first, and the block may then be shrunk.



Bit Split resized to four places

OPTIONS

Width

Select the width of each place:

- *Bits* splits the value one bit at a time, into as many as eight places; and
- *Bytes* splits it eight bits at a time, into as many as four.

The value is rounded to a whole number before it is split.

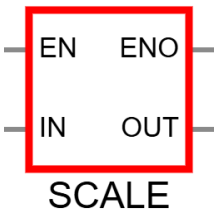
Where the input carries no value, no value is produced at any place. The places are not driven clear, as that would have every rung reading them take a genuine set of zeroes from a source that had in fact gone away.

Signals

Scaling, Limits, Filters and Statistics.

Block	Key	Description
Scale		Maps a value from one range onto another.
Limit		Holds a value between two bounds.
Range		Tests a reading against a band, with hysteresis.
Select		Chooses between two values on a signal.
Hold		Tracks while enabled, or samples an edge.
Selector		Highest, lowest, average or middle.
Stat		One figure over a rolling window.
Stats		Several figures over a rolling window.
Filter		Smooths a reading, by any of five methods.
Integrate		Totals a rate over time, with bounds.
Derive		The rate a reading is moving at.
Lookup		Maps a reading through a curve given as points.
Polynomial		Maps a reading through a formula given as terms.

Scale



Scale

Maps a value from one range onto another.

> **Enable:** EN/ENO, may be folded away · **Resizable:** 0 to 4 parameter terminals

INPUTS

Terminal	Type	Meaning
EN	Digital	Enables the element. Defaults to on.
IN	Value	The value to be scaled.
IMIN, IMAX, OMIN, OMAX	Value	The input and output ranges, where the element has been asked to bring them out. A terminal left unwired takes the setting on the form.

OUTPUTS

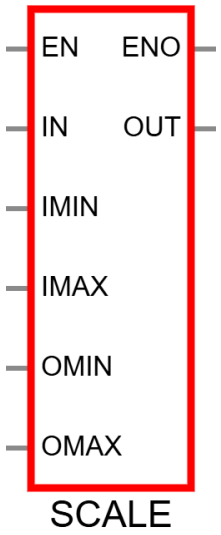
Terminal	Type	Meaning
ENO	Digital	Follows the enable.
OUT	Value	The scaled value, held at the ends of the output range. While the element is disabled, no value will be produced.

RESIZING

Drag the handle at the foot of the block to set the number of parameter terminals, from 0 to 4. The block cannot be shrunk past a terminal that is wired; disconnect the terminal first, and the block may then be shrunk.

They are taken in the order in which they are listed, so asking for two of four gives the first two rather than an arbitrary pair.

A parameter that has been brought out and wired takes what its connection carries, and its setting below is disabled to say so. One that has been brought out but left unwired continues to take its setting, so the two may be mixed freely.



All four parameters brought out

OPTIONS

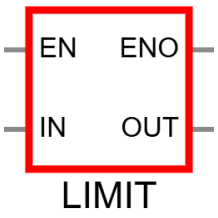
Input Minimum
Enter the input value that corresponds to the output minimum.

Input Maximum
Enter the input value that corresponds to the output maximum. If the input range has no width, or is entered the wrong way round, there is no proportion to be calculated and the value will be passed through unchanged.

Output Minimum
Enter the value that the input minimum becomes.

Output Maximum
Enter the value that the input maximum becomes. The result is held at these ends, as a reading beyond its stated range is out of range and not proportionally further along. To reverse the sense of a reading, enter the output values the other way round.

Limit



Limit

Holds a value between two bounds.

> **Enable:** EN/ENO, may be folded away · **Resizable:** 0 to 2 parameter terminals

INPUTS

Terminal	Type	Meaning
EN	Digital	Enables the element. Defaults to on.
IN	Value	The value to be bounded.
MIN, MAX	Value	The bounds, where the element has been asked to bring them out. A terminal left unwired takes the setting on the form.

OUTPUTS

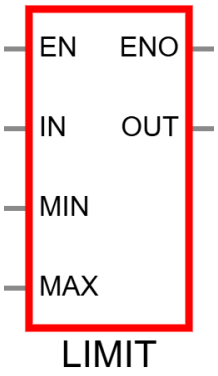
Terminal	Type	Meaning
ENO	Digital	Follows the enable.
OUT	Value	The value, held at whichever bound it exceeded. While the element is disabled, no value will be produced.

RESIZING

Drag the handle at the foot of the block to set the number of parameter terminals, from 0 to 2. The block cannot be shrunk past a terminal that is wired; disconnect the terminal first, and the block may then be shrunk.

They are taken in the order in which they are listed, so asking for two of four gives the first two rather than an arbitrary pair.

A parameter that has been brought out and wired takes what its connection carries, and its setting below is disabled to say so. One that has been brought out but left unwired continues to take its setting, so the two may be mixed freely.



Both limits brought out

OPTIONS

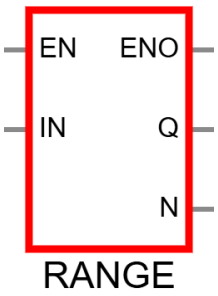
Minimum

Enter the lowest value that may leave the element.

Maximum

Enter the highest value that may leave the element. If the two bounds are entered the wrong way round, the value will be passed through unchanged, so that a range that has yet to be configured will not silently flatten the signal.

Range



Range

Tests a reading against a band, with hysteresis.

> **Enable:** EN/ENO, may be folded away · **Resizable:** 0 to 3 parameter terminals

INPUTS

Terminal	Type	Meaning
EN	Digital	Enables the element. Defaults to on.
IN	Value	The reading to be tested. If no reading is present, the output is cleared and the element begins afresh when one returns.
MIN, MAX, HYST	Value	The band and its hysteresis, where the element has been asked to bring them out. A terminal left unwired takes the setting on the form.

OUTPUTS

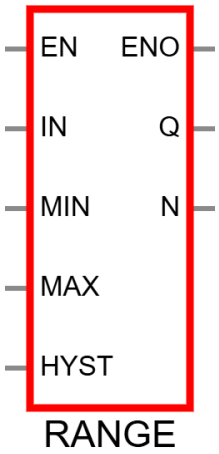
Terminal	Type	Meaning
ENO	Digital	Follows the enable, so that several elements may be placed along the same line.
Q	Digital	Set while the reading is inside the band.
N	Digital	Set while it is outside. Both answers are brought out, so one element serves a rung that wants either, and the diagram says which is being used rather than the setting having to be looked up.

RESIZING

Drag the handle at the foot of the block to set the number of parameter terminals, from 0 to 3. The block cannot be shrunk past a terminal that is wired; disconnect the terminal first, and the block may then be shrunk.

They are taken in the order in which they are listed, so asking for two of four gives the first two rather than an arbitrary pair.

A parameter that has been brought out and wired takes what its connection carries, and its setting below is disabled to say so. One that has been brought out but left unwired continues to take its setting, so the two may be mixed freely.



All three parameters brought out

OPTIONS

Lower Bound

Enter the lower bound of the band. Where the bounds are given the wrong way round they enclose nothing, and a reading is never held to be within them.

Upper Bound

Enter the upper bound of the band.

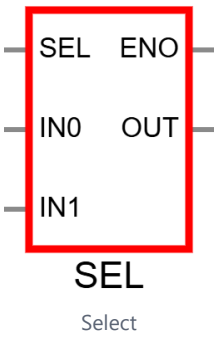
Hysteresis

Enter the amount by which a reading must leave the band before the element accepts that it has done so.

The hysteresis is applied on the way out only. A reading must be within the configured band before the element reports it as such, and must then pass beyond the band by the hysteresis before the element takes that back. Were it applied on the way in as well, the band being reported would be narrower at both ends than the one that had been configured.

Leave this setting at zero where the reading is steady enough not to require it.

Select



Select

Chooses between two values on a signal.

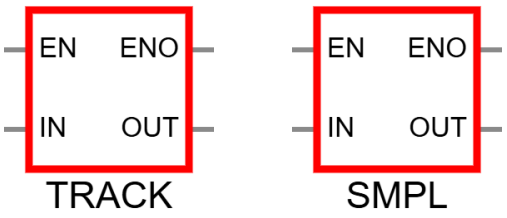
INPUTS

Terminal	Type	Meaning
SEL	Digital	Selects between the two values. Defaults to on, in which case IN1 will be passed.
IN0	Value	Passed while the selector is clear.
IN1	Value	Passed while the selector is set.

OUTPUTS

Terminal	Type	Meaning
ENO	Digital	Follows the selector, so that the choice made by the element is also available as a digital signal.
OUT	Value	The value that was chosen. Only the chosen side is read, so the other may carry anything at all, including no value.

Hold



Hold

Hold, sampling

Tracks while enabled, or samples an edge.

> **Enable:** EN/ENO, may be folded away

INPUTS

Terminal	Type	Meaning
EN	Digital	The condition. When tracking, the output follows the input while this input is present and freezes when it is removed. When sampling, a rising transition takes a single reading. Defaults to on.
IN	Value	The value being watched. A value that is not available will not be captured, so that the element retains the last good figure.

OUTPUTS

Terminal	Type	Meaning
ENO	Digital	Follows the enable.
OUT	Value	The value being held.

OPTIONS

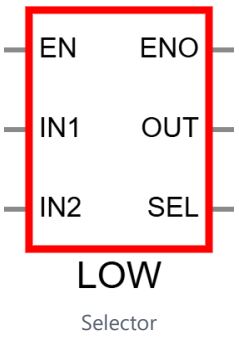
Trigger
Select the manner in which the value is captured:

- *Track* will follow the input while the enable is present, and will hold the value standing there when it is removed; and
- *Sample* will take a single reading on each rising transition of the enable.

Track is used to hold a setpoint where it stood when control was passed to manual. Sample is used to capture a weight at the end of a fill, or a flow at the moment of a trip.

The value is held within the element, and is not retained across a restart.

Selector



Selector

Highest, lowest, average or middle.

Enable: EN/ENO, may be folded away · **Resizable:** 2 to 8 readings

INPUTS

Terminal	Type	Meaning
EN	Digital	Enables the element. Defaults to on.
IN1 - IN8	Value	The readings. Only those terminals that are wired and that carry a value will take part in the selection, so that a failed sensor will drop out of the group of its own accord.

OUTPUTS

Terminal	Type	Meaning
ENO	Digital	Set while there was a selection to be made. This output will clear when the element is disabled, and also when every reading has been lost, so that the elements that follow will not produce a value either.
OUT	Value	The reading that was selected, or the average where that operation is chosen.
SEL	Value	The number of the terminal from which the answer was taken, counting the readings from one. This output is zero where there is nothing to name, which is to say when the element is disabled, when every reading has been lost, or when the operation is an average.

OPTIONS

Operation

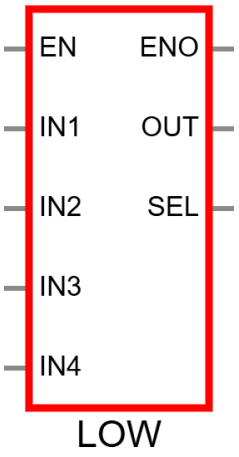
Select the manner in which the reading is chosen:

- *Highest* and *Lowest* will select the largest or the smallest of the readings;
- *Average* will calculate the mean of those present; and
- *Middle* will select the middle reading, which for an even number of readings is one of the two and not their mean.

The terminal number reported by the SEL output is used for override control. Where two controllers drive one actuator through a low selector, the controller that was not selected must be told, or its integral will wind up against an output that is not in use. Compare this output against the number of the loop in question, and use the result to drive that loop into manual with the selected value as its manual demand. The losing controller will then track the winner, and will take over without a bump when it is next selected.

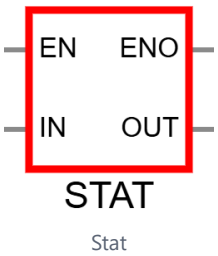
Where an input is to be named, the average is not suitable, as its result is not one of the readings.

Readings
Enter the number of reading terminals to be provided. The element may also be resized by dragging the handle at the foot of its body. Terminals that are not wired take no part in the selection, and the count may not be reduced past a terminal that is still connected.



Resized to four readings

Stat



Stat

One figure over a rolling window.

> **Enable:** EN/ENO, may be folded away

INPUTS

Terminal	Type	Meaning
EN	Digital	Enables the element. Defaults to on.
IN	Value	The reading to be watched. While no reading is present the window is discarded, as what it holds describes a stretch that no longer joins up with the one about to begin.

OUTPUTS

Terminal	Type	Meaning
ENO	Digital	Follows the enable, so that several elements may be placed along the same line.
OUT	Value	The figure selected below.

OPTIONS

Figure

Select the figure the element reports. Where more than one is wanted, use the multiple form, which offers any combination of them:

- *Minimum* and *Maximum* are the extremes within the window;
- *Span* is the difference between them;
- *Mean* is the average;
- *Variance* is the mean of the squared deviations from that average; and
- *Standard Deviation* is its square root, and is in the same units as the reading.

The variance and the standard deviation are taken over the window as a whole rather than as a sample drawn from something larger, so no correction is applied for a sample size.

Sample Period

Enter the interval between samples. The element cannot sample faster than the program runs, so a period shorter than the scan time yields one sample per scan and no more.

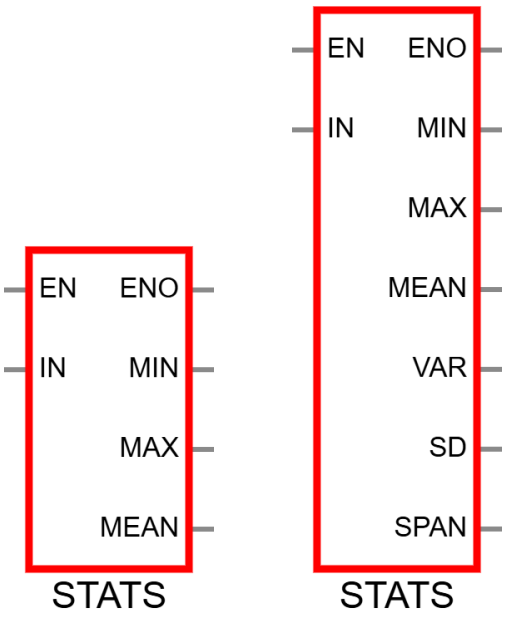
The first reading is taken as soon as the element is enabled rather than after a full period has passed, so that it has something to report immediately.

Window

Enter the length of the window. The number of samples held is this divided by the sample period, to a limit of 8192; a window asking for more than that is held at the limit.

The window is stated as a time rather than as a count of samples so that the figure on the form means what an operator means by it. Were it a count, altering the sample period would silently alter the length of history the element reported upon.

Stats



Stats — Every figure selected

Several figures over a rolling window.

> **Enable:** EN/ENO, may be folded away

INPUTS

Terminal	Type	Meaning
EN	Digital	Enables the element. Defaults to on.
IN	Value	The reading to be watched. While no reading is present the window is discarded, as what it holds describes a stretch that no longer joins up with the one about to begin.

OUTPUTS

Terminal	Type	Meaning
ENO	Digital	Follows the enable.
MIN, MAX, MEAN, VAR, SD, SPAN	Value	The figures selected below. Only those asked for are shown, and the rows close up around the rest.

OPTIONS

Figures
Select which figures the element is to present. Any combination may be chosen.

The window must be walked in order to answer any one of these questions, so a walk that has visited every sample answers all of them at no further cost. Choosing fewer therefore saves terminals rather than work.

Every figure keeps a terminal number of its own whether or not it is being shown, so turning one on or off cannot move the number another one sits at, and a connection already made survives the choice being changed around it. A figure that is wired cannot be turned off; disconnect it first.

Sample Period

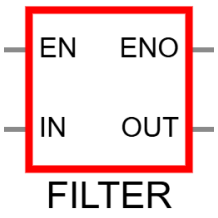
Enter the interval between samples. The element cannot sample faster than the program runs, so a period shorter than the scan time yields one sample per scan and no more.

Window

Enter the length of the window. The number of samples held is this divided by the sample period, to a limit of 8192.

The window is stated as a time rather than as a count of samples so that the figure on the form means what an operator means by it, and so that altering the sample period does not silently alter the length of history reported upon.

Filter



Filter

Smooths a reading, by any of five methods.

> **Enable:** EN/ENO, may be folded away

INPUTS

Terminal	Type	Meaning
EN	Digital	Enables the element. Defaults to on.
IN	Value	The reading to be filtered. While no reading is present the filter is discarded, and the first reading to return is passed as it stands rather than being climbed towards.

OUTPUTS

Terminal	Type	Meaning
ENO	Digital	Follows the enable, so that several elements may be placed along the same line.
OUT	Value	The filtered reading.

OPTIONS

Method

Select the method to be used. These do genuinely different things, and none of them is the general answer:

- *First Order (IIR)* smooths everything in proportion to how fast it moves, and is what is usually meant by a filter. It delays the reading by roughly its time constant, which is the price paid for it.
- *Moving Average* smooths a fixed stretch of history equally. Against noise that repeats at a known rate this is the better choice, as a window of exactly one period removes that period entirely.
- *Median* removes occasional wild readings and does almost nothing else. No amount of averaging removes a spike, as averaging spreads it instead, so this is the only answer where the noise is the occasional bad sample rather than a general fuzz.
- *Rate Limit* bounds how fast the output may move. Not a filter in the ordinary sense, as it passes small noise untouched, but the right answer where what matters is that whatever follows is never asked to jump.
- *Deadband* ignores movement below a threshold. The answer where a reading is steady but jitters in its last digit, and where what follows is a push to a remote system that should not fire for that.

Time Constant
Enter the time constant of the first order filter. The coefficient is worked out from the interval between scans, so the filter behaves the same whatever rate the program runs at, and remains correct if that rate is later changed.

Sample Period
Enter the interval at which the moving average and the median take their samples. The element cannot sample faster than the program runs, so a period shorter than the scan time yields one sample per scan and no more.

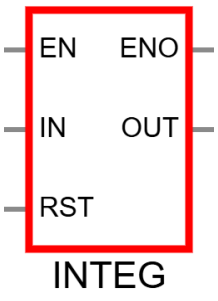
Window
Enter the length of history these methods work over. The number of samples held is this divided by the sample period.

The window is stated as a time rather than as a count of samples so that nothing here changes behaviour when the scan rate is altered. That holds for the whole element: the first order coefficient is worked out from the measured interval rather than fixed, and the rate limit is stated per second. A filter tuned at one scan rate behaves the same at another.

Rate Limit
Enter the greatest rate at which the output may move, in units per second. A rate of zero reads as no limit rather than as a total block.

Deadband
Enter the distance the reading must move before the output follows it. Once it has moved that far the output takes the reading whole, rather than moving only to the edge of the band, which would otherwise leave it trailing by the band for as long as the reading went on moving one way.

Integrate



Integrate

Totals a rate over time, with bounds.

> **Enable:** EN/ENO, may be folded away

INPUTS

Terminal	Type	Meaning
EN	Digital	Enables the element. Defaults to on. While it is removed the total stands but nothing is added to it.
IN	Value	The rate to be totalled, in units per second.
RST	Digital	Returns the total to its preset. A level rather than an edge, so an element held in reset stays at its preset however hard its input works.

OUTPUTS

Terminal	Type	Meaning
ENO	Digital	Follows the enable.
OUT	Value	The total. This is presented whether or not the element is enabled, as a total is a quantity that happened rather than a reading that has gone away.

OPTIONS

Gain

Enter a factor applied to the rate before it is totalled. This converts the units of the input into the units of the total, so a flow in litres per minute is totalled into litres by a gain of one sixtieth.

Minimum

Enter the lower bound of the total.

Maximum

Enter the upper bound of the total. Where the bounds are given the wrong way round, or are both left at zero, they are taken as no bounds at all.

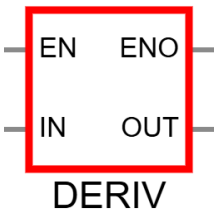
An integrator with nothing to stop it runs away the moment its input carries a standing offset, and having run away takes as long to come back as it took to leave. The bounds are not an optional refinement.

Preset
Enter the value the total takes when the program starts and whenever the element is reset.

Total Tag
Enter a tag in which the total is to be kept. On a restart the total is read back from this tag before anything further is added, so that a quantity continues rather than beginning again. The tag must itself be marked as retained if the total is to survive a power cycle.

The tag is written only when the total moves, so an element that is not running costs nothing.

Derive



Derive

The rate a reading is moving at.

> **Enable:** EN/ENO, may be folded away

INPUTS

Terminal	Type	Meaning
EN	Digital	Enables the element. Defaults to on.
IN	Value	The reading whose rate of change is wanted.

OUTPUTS

Terminal	Type	Meaning
ENO	Digital	Follows the enable.
OUT	Value	The rate of change, in units per second. No value is produced for the first reading, as there is nothing behind it to measure against, nor across a gap in the signal, as the step back is not a rate of change.

OPTIONS

Gain

Enter a factor applied to the rate. This converts the units of the answer, so a level in metres differentiated into metres per hour takes a gain of three thousand six hundred.

Filter

Enter the time constant of the filter applied to the rate.

This should not be left at zero. A raw derivative is the difference between two consecutive samples divided by the time between them, which on any real measurement is largely the noise on the last sample multiplied by the scan rate. The loop element carries a derivative filter for this reason, and an element whose entire output is a derivative needs one more, not less.

The filter is applied to the rate rather than to the reading. Filtering the reading first would delay the signal as well as smooth the rate, where this leaves the reading alone and smooths only the answer.

Lookup

Lookup

Maps a reading through a curve given as points.

This element maps a reading through a curve given as a table of points, joining each point to the next with a straight line. It is the element to use for a sensor whose response is not a straight line, for a tank whose volume does not rise evenly with its level, or for any relationship that is easier to state as a set of measured pairs than as a formula.

INPUTS

Terminal	Type	Meaning
Left	Value	The reading to be mapped.

OUTPUTS

Terminal	Type	Meaning
Right	Value	The value read from the curve. If no reading is present, no value will be produced.

OPTIONS

Points

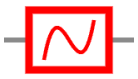
Enter the points that define the curve, each as an input value and the output value that it corresponds to. The points may be entered in any order, as they are sorted by their input values before they are used. A reading that falls between two points is interpolated along the straight line joining them.

Two points with the same input value form a step rather than a slope, and the later of the two is used. A table with fewer than two points does not describe a curve, and the reading is then passed through unchanged.

Clip to Limits

Select whether a reading beyond the first or the last point is held at the output of that point, or is extended along the line through the two outermost points at that end. Holding the output is the safer choice where the curve describes the whole of a device's range, and extending it is appropriate where the end segments are known to continue.

Polynomial



Polynomial

Maps a reading through a formula given as terms.

This element maps a reading through a polynomial, given as a list of terms each with a coefficient and a power. It is the element to use where a sensor's manufacturer states its characteristic as a formula, as is common for thermocouples and for flow elements.

INPUTS

Terminal	Type	Meaning
Left	Value	The reading, which is the variable of the polynomial.

OUTPUTS

Terminal	Type	Meaning
Right	Value	The sum of the terms. If no reading is present, no value will be produced.

OPTIONS

Terms

Enter the terms of the polynomial. Each term is a coefficient multiplied by the reading raised to a whole power between 0 and 32, so a term with a power of zero is a constant offset and one with a power of one is a gain. The terms are added together, and may be entered in any order.

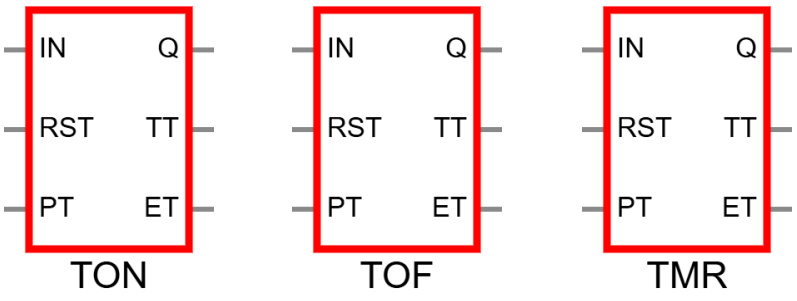
The powers are calculated by repeated multiplication rather than by way of logarithms, so a formula with exact coefficients gives exact results. An element with no terms is the zero polynomial and produces zero.

Timers & Counters

Timers, Oscillators and Counters.

Block	Key	Description
On Delay	`T`	Goes high once held for the preset.
Off Delay	`F`	Goes low once released for the preset.
Timer		Totals the time held, until reset.
Oscillator		Free running square, saw, triangle, sine.
Count Up	`#`	Counts up to a preset, with reset.
Count Down		Counts down from a preset, with load.
Count U/D		Counts both ways to a preset.

Timers



- **On Delay** — Goes high once held for the preset.
- **Off Delay** — Goes low once released for the preset.
- **Timer** — Totals the time held, until reset.

INPUTS

Terminal	Type	Meaning
IN	Digital	The condition to be timed. An on delay times while this input is present, and an off delay times while it is absent.
PT	Value	The preset time in milliseconds. If this terminal is not wired, the configured preset will be used.
RST	Digital	Clears the timer. This input is required only for a retentive timer, as the remaining forms clear themselves when their condition is removed.

OUTPUTS

Terminal	Type	Meaning
Q	Digital	The result of the timer, as described under Timer Type below.
ET	Value	The elapsed time in milliseconds. This value is held at the preset once the time has been served.
TT	Digital	Set while the timer is running and its time has not yet been served. Read together with Q, this distinguishes a timer that is working from one that has finished, without the elapsed time having to be examined.

OPTIONS

Timer Type

Select the form of timer to be provided:

- *On Delay* will set the output once its input has been present for the preset time;
- *Off Delay* will hold the output set until its input has been absent for the preset time; and
- *Retentive* will total the time for which its input has been present, over as many separate periods as it takes, and will set the output once that total reaches the preset.

A retentive timer holds its total, and its output, until it is reset.

Preset Time

Enter the preset time to be served. A value wired to the PT terminal will override this setting, which is disabled while such a connection exists.

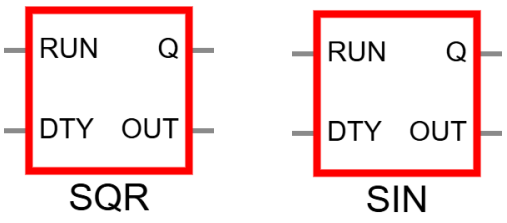
Elapsed Tag

Enter a tag in which the accumulated time is to be kept. This setting applies only to a retentive timer, as the remaining forms hold a delay that means nothing once the condition being delayed has passed.

On a restart the total is read back from this tag before any further time is added, so that a record of running hours continues rather than beginning again. The total that is kept includes the period in progress, so a restart during a run does not lose that run. The tag must itself be marked as retained if the total is to survive a power cycle.

The tag is written only while the timer runs, so an idle timer costs nothing.

Oscillator



Oscillator | Oscillator, sine

Free running square, saw, triangle, sine.

INPUTS

Terminal	Type	Meaning
RUN	Digital	Runs the generator. Defaults to on. While the generator is stopped, both outputs will rest in the off state, and the cycle will begin again from the start when it is next run.
DTY	Value	The duty as a percentage, overriding the configured value. If this terminal is not wired, the configured duty will be used.

OUTPUTS

Terminal	Type	Meaning
Q	Digital	The waveform in its on and off form. For a square wave, this output is set for the duty portion of each cycle. For a pulse, it is set for a single scan at the start of each cycle. For the remaining waveforms, it is set for the first half of each cycle.
OUT	Value	The level of the waveform, between zero and one. Use a scale element to convert this to engineering units.

OPTIONS

Waveform

Select the waveform to be generated:

- *Square* will alternate between the two states according to the duty, and may be used as a flasher, as a mark space output, or as a pulse width output;
- *Pulse* will produce a single scan at the start of each cycle, and is intended for triggering a periodic action; and
- *Sawtooth*, *Triangle* and *Sine* will produce the corresponding analog waveform.

Period

Enter the period of one complete cycle. Whole cycles are removed from the clock as they complete, so that the period will not drift as a result of the scan rate.

Duty

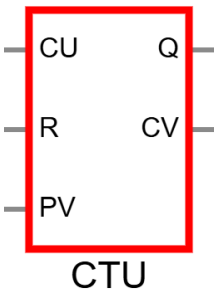
Enter the percentage of each cycle for which the output is to be on. This setting applies to a square wave only, as the remaining waveforms use a half cycle as their reference. A value wired to the DTY terminal will override this

setting.

Phase Shift

Enter the phase shift in degrees, which sets how far into its cycle the waveform starts each time the generator is run. A shift of 90 degrees starts a quarter of the way through the cycle, so two oscillators with the same period that are run together, one shifted by 90 degrees, will remain a quarter cycle apart. A negative shift is a lag, and is the same as the corresponding lead, so that -90 degrees has the same effect as 270 degrees. For a pulse, the shift moves the scan in which the output is set to the point at which the shifted cycle begins again.

Count Up



Count Up (#)

Counts up to a preset, with reset.

INPUTS

Terminal	Type	Meaning
CU	Digital	Increments the count on each rising transition. Defaults to off.
R	Digital	Holds the count at zero. This input is a level, and takes precedence over the count input, so a counter held in reset will not count.
PV	Value	The preset, overriding the configured value. If this terminal is not wired, the configured preset will be used.

OUTPUTS

Terminal	Type	Meaning
Q	Digital	Set while the count has reached the preset. Where the counter is set to wrap, this output instead reports the carry, and is set for the single scan on which the count came round.
CV	Value	The current count.

OPTIONS

At Limit

Select the behavior of the counter at the preset:

- *Continue* will count on past the preset, which is the IEC behavior, and which keeps any overrun visible;
- *Hold* will stop the count at the preset; and
- *Wrap* will return the count to zero and begin again.

A wrapping counter has as many states as its preset, and never shows the preset itself. Its output becomes a carry of one scan, so that several counters may be chained to divide a count.

Preset

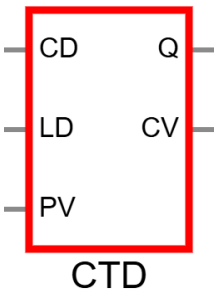
Enter the count at which the output will be set. A value wired to the PV terminal will override this setting, which is disabled while such a connection exists.

Count Tag

Enter a tag in which the count is to be kept. On a restart the count is read back from this tag before anything is counted against it, so that a tally continues rather than beginning again. The tag must itself be marked as retained if the count is to survive a power cycle. Leave this setting empty where the count is not required to outlive the program.

The tag is written only when the count moves, so an idle counter costs nothing.

Count Down



Count Down

Counts down from a preset, with load.

INPUTS

Terminal	Type	Meaning
CD	Digital	Decrements the count on each rising transition. Defaults to off.
LD	Digital	Loads the count with the preset. This input is a level, and takes precedence over the count input.
PV	Value	The preset, overriding the configured value. If this terminal is not wired, the configured preset will be used.

OUTPUTS

Terminal	Type	Meaning
Q	Digital	Set while the count has reached zero. Where the counter is set to wrap, this output instead reports the carry, and is set for the single scan on which the count came round.
CV	Value	The current count.

OPTIONS

At Limit

Select the behavior of the counter at zero:

- *Continue* will count on below zero, which is the IEC behavior, and which keeps any overrun visible;
- *Hold* will stop the count at zero; and
- *Wrap* will return the count to the preset and begin again.

This form provides no reset, as returning a down counter to its starting point is performed by the load input.

Preset

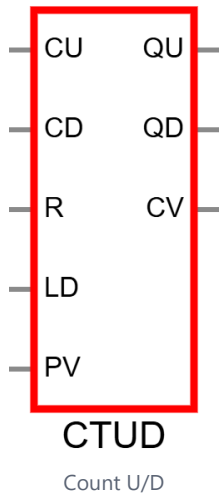
Enter the count that will be loaded, and from which the counter will count down. A value wired to the PV terminal will override this setting, which is disabled while such a connection exists.

Count Tag

Enter a tag in which the count is to be kept. On a restart the count is read back from this tag before anything is counted against it, so that a tally continues rather than beginning again. The tag must itself be marked as retained if the count is to survive a power cycle. Leave this setting empty where the count is not required to outlive the program.

The tag is written only when the count moves, so an idle counter costs nothing.

Count U/D



Count U/D

Counts both ways to a preset.

INPUTS

Terminal	Type	Meaning
CU	Digital	Increments the count on each rising transition. Defaults to off.
CD	Digital	Decrements the count on each rising transition. Both inputs on the same scan will cancel, leaving the count unchanged.
R	Digital	Holds the count at zero. This input is a level, and takes precedence over all others.
LD	Digital	Loads the count with the preset. This input is a level, and takes precedence over the count inputs.
PV	Value	The preset, overriding the configured value. If this terminal is not wired, the configured preset will be used.

OUTPUTS

Terminal	Type	Meaning
QU	Digital	Set while the count has reached the preset, or the carry of one scan where the counter is set to wrap.
QD	Digital	Set while the count has reached zero, or the borrow of one scan where the counter is set to wrap.
CV	Value	The current count.

OPTIONS

At Limit

Select the behavior of the counter at either end of its range:

- *Continue* will count on past the preset and below zero;

- *Hold* will stop the count at both; and
- *Wrap* will come round at both, turning each output into a carry of one scan.

Preset
Enter the count at which the up output will be set, and to which a load will charge the counter. A value wired to the PV terminal will override this setting, which is disabled while such a connection exists.

Count Tag
Enter a tag in which the count is to be kept. On a restart the count is read back from this tag before anything is counted against it, so that a tally continues rather than beginning again. The tag must itself be marked as retained if the count is to survive a power cycle. Leave this setting empty where the count is not required to outlive the program.

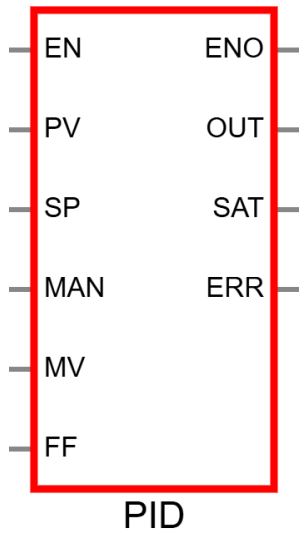
The tag is written only when the count moves, so an idle counter costs nothing.

Control

Closed Loop Control.

Block	Key	Description
PID		Closed loop control with manual mode.
Auto PID		Closed loop controls with auto-tune.
Split		Splits a demand into heat and cool.
TPO		Drives a contact to follow a demand using PWM.
HCM		Checks load current against the drive.
Lead / Lag		Adds lag, lead and dead time to a signal.
Process		Simulated heated mass, for testing loops.

PID



PID

Closed loop control with manual mode.

> **Enable:** EN/ENO, may be folded away

INPUTS

Terminal	Type	Meaning
EN	Digital	Enables the loop. Defaults to on. When the enable is removed, the demand will present no value at all, and the loop will make a clean start when it is restored.
PV	Value	The process reading, in its own units. If no reading is available, the loop is blind, and will behave as it does when a sensor has failed.
SP	Value	The setpoint, in the units of the reading. There is no configured setpoint, so a loop with nothing wired here will not run. Where the setpoint is fixed, use a value element to supply it.
MAN	Digital	Places the loop in manual. Defaults to off. The integral is back calculated against the demand actually issued on every scan, so that the return to automatic will not bump.
MV	Value	The demand to be held while the loop is in manual. If this terminal is not wired, the loop will hold the demand at which it was last operating.
FF	Value	A feedforward term, added to the demand within the output limits so that the integral is not left with further to travel. If this terminal is not wired, nothing is added.

OUTPUTS

Terminal	Type	Meaning
ENO	Digital	Set while the loop is in service and able to see its reading. It will clear when the loop is disabled or blind, so that a store placed after this element will decline to write and the actuator will retain what it has.
OUT	Value	The demand, between the output limits. While the loop is disabled this output presents no value. While it is blind but still in service, it will hold or fall back according to the On Reading Loss setting below.
SAT	Digital	Set while the demand is being held short of the figure the loop called for, whether by an output limit or by the rate limit. The integral is held while the demand is limited, so that the loop will leave the limit on the scan on which the error changes sign.
ERR	Value	The setpoint less the filtered reading, in the units of the reading. This is the error on which the loop is working, and not the difference between the raw terminals.

OPTIONS

Control Mode

Select the direction in which the loop drives:

- *Heat* will increase the demand as the reading falls;
- *Cool* will increase it as the reading rises; and
- *Heat & Cool* will drive in both directions about zero, using the output maximum on either side.

Heat and cool is the mode to select where one loop is responsible for two actuators that oppose one another. Use the split element to separate the signed demand into a figure for each of them.

Reading Minimum

Enter the bottom of the range against which the reading is measured, in the units of the reading. This is the range by which the error is normalized, and not a limit on the reading, so a reading outside it will be processed as usual.

Reading Maximum

Enter the top of that range. Everything the loop calculates is expressed as a fraction of the span between the two, which is what allows the gains to be dimensionless and the same tuning figures to be carried from one loop to another. The setpoint is measured against the same range.

Proportional Gain

Enter the proportional gain. As the error is measured as a fraction of the reading range, a gain of one will call for full output at an error of one full range, and the figure therefore means the same thing on every loop. The integral and derivative terms are calculated from this gain, so a change here will move all three.

Integral Time

Enter the integral time, being the period in which the integral term will repeat the contribution of the proportional term. A loop with no integral term will settle short of its setpoint and remain there. The figure should be compared against the time constant of the process, as a much shorter time will cause the loop to hunt, and a much longer one will leave it slow to close the remaining gap.

Derivative Time

Enter the derivative time, being the distance ahead of the reading that the loop is asked to look. Leaving this setting off is the correct answer for any noisy reading, and for most loops that are not thermal. The derivative is taken from the reading and not from the error, so that a change of setpoint will not deliver a step to the actuator.

Derivative Filter

Enter the ratio between the derivative time and the filter that precedes it. A larger value gives less filtering. Unfiltered derivative will amplify whatever noise is present on a real reading. The filter is expressed as a ratio so that it follows the derivative time as the tuning is changed.

Integral Tag

Enter the tag in which the integral is to be held, or leave this setting empty for a loop that starts from zero on every run. On a slow process, rebuilding the integral takes real time. A named tag may also be trended, alarmed and cleared by a store. The Startup Value of that tag must be set to Retained for the integral to survive a restart.

Setpoint Ramp

Enter the rate at which the setpoint is permitted to move, in the units of the reading per second. A setpoint that is allowed to step will be answered with everything the loop has available, which on a slow process is a disturbance that serves no purpose. Leave this setting at zero to allow the setpoint to move immediately.

Setpoint Weight

Enter the proportion of the setpoint that is seen by the proportional term. A value of one gives the classic controller. A value below one will soften the response to a change of setpoint without affecting the response to a disturbance, as the integral term always sees the whole of the error. This setting is a ratio, and therefore has no units.

Spike Rejection

Select the size of the median window:

- *Off* will pass the reading through;
- *3 Samples* will reject an isolated bad reading; and
- *5 Samples* will reject two of them in succession.

A median discards a bad reading outright, whereas the input filter below will spread one bad sample over those that follow. Use the median where a reading occasionally drops a sample, and the filter where it is noisy.

Input Filter

Enter the time constant of the filter applied to the reading. This will smooth broadband noise at the cost of introducing that much lag within the loop, so the figure should be kept well below the time constant of the process, or the tuning will be working against the filter instead of the plant.

Output Minimum

Enter the lowest demand that the loop may call for. The integral will not be permitted to wind past this limit. A loop driving in both directions has no separate minimum, as the maximum describes both halves of the range.

Output Maximum

Enter the highest demand that the loop may call for. The integral will not be permitted to wind past this figure, so that the loop will leave the limit on the scan on which the error changes sign, and not some minutes later.

Output Rate Limit

Enter the rate at which the demand may move, as a fraction of the output per second. A demand that is held back by the rate limit will raise the SAT output and hold the integral still, as an output limit does. Leave this setting at zero to allow the demand to move as far as required in a single scan.

On Reading Loss

Select the action to be taken when the reading is lost while the loop remains in service:

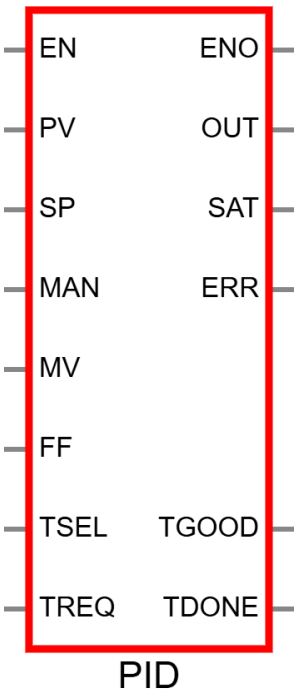
- *Hold Last Output* will leave the demand where it was, which suits a slow process that will not run away; and
- *Output Fixed Value* will fall back to a configured demand, which suits a process that will.

The ENO output is cleared in either case, so a store placed after this element will decline to write, and an actuator driven through one will retain the value it already holds.

Failure Output

Enter the demand to be issued when the reading is lost, expressed in the same terms as the output limits.

Auto PID



Auto PID

Closed loop controls with auto-tune.

> **Enable:** EN/ENO, may be folded away

INPUTS

Terminal	Type	Meaning
EN	Digital	Enables the loop. Defaults to on. When the enable is removed, the demand will present no value at all, and the loop will make a clean start when it is restored.
PV	Value	The process reading, in its own units. If no reading is available, the loop is blind, and will behave as it does when a sensor has failed.
SP	Value	The setpoint, in the units of the reading. There is no configured setpoint, so a loop with nothing wired here will not run. Where the setpoint is fixed, use a value element to supply it.
MAN	Digital	Places the loop in manual. Defaults to off. The integral is back calculated against the demand actually issued on every scan, so that the return to automatic will not bump.
MV	Value	The demand to be held while the loop is in manual. If this terminal is not wired, the loop will hold the demand at which it was last operating.
FF	Value	A feedforward term, added to the demand within the output limits so that the integral is not left with further to travel. If this terminal is not wired, nothing is added.

Terminal	Type	Meaning
TSEL	Digital	Calls for the tuned gains in place of the configured ones. Defaults to off, so that a result obtained on an earlier run cannot be brought into use by a restart alone. Where no tune has yet been obtained, the configured gains will continue to be used.
TREQ	Digital	Requests a tune. Raising this input will start one and will clear whatever the previous tune reported. Lowering it will withdraw the result, and will abandon a tune that is still in progress.

OUTPUTS

Terminal	Type	Meaning
ENO	Digital	Set while the loop is in service and able to see its reading.
OUT	Value	The demand, between the output limits. While a tune is in progress the tuner has control of this output, and the controller continues to be solved behind it against the demand actually issued, so that the loop will resume without a bump when the tuner releases it.
SAT	Digital	Set while the demand is being held short of the figure the loop called for, whether by an output limit or by the rate limit.
ERR	Value	The setpoint less the filtered reading, in the units of the reading.
TDONE	Digital	Set once the request has been dealt with, whatever the outcome.
TGOOD	Digital	Set where the result obtained is usable. The two outputs are provided separately so that a program may wait on the first and decide on the second.

OPTIONS

Control Mode

Select the direction in which the loop drives:

- *Heat* will increase the demand as the reading falls;
- *Cool* will increase it as the reading rises; and
- *Heat & Cool* will drive in both directions about zero, using the output maximum on either side.

Heat and cool is the mode to select where one loop is responsible for two actuators that oppose one another. Use the split element to separate the signed demand into a figure for each of them.

Reading Minimum

Enter the bottom of the range against which the reading is measured, in the units of the reading. This is the range by which the error is normalized, and not a limit on the reading, so a reading outside it will be processed as usual.

Reading Maximum

Enter the top of that range. Everything the loop calculates is expressed as a fraction of the span between the two, which is what allows the gains to be dimensionless and the same tuning figures to be carried from one loop to another. The setpoint is measured against the same range.

Proportional Gain
Enter the proportional gain. As the error is measured as a fraction of the reading range, a gain of one will call for full output at an error of one full range, and the figure therefore means the same thing on every loop. The integral and derivative terms are calculated from this gain, so a change here will move all three.

Integral Time
Enter the integral time, being the period in which the integral term will repeat the contribution of the proportional term. A loop with no integral term will settle short of its setpoint and remain there. The figure should be compared against the time constant of the process, as a much shorter time will cause the loop to hunt, and a much longer one will leave it slow to close the remaining gap.

Derivative Time
Enter the derivative time, being the distance ahead of the reading that the loop is asked to look. Leaving this setting off is the correct answer for any noisy reading, and for most loops that are not thermal. The derivative is taken from the reading and not from the error, so that a change of setpoint will not deliver a step to the actuator.

Derivative Filter
Enter the ratio between the derivative time and the filter that precedes it. A larger value gives less filtering. Unfiltered derivative will amplify whatever noise is present on a real reading. The filter is expressed as a ratio so that it follows the derivative time as the tuning is changed.

Integral Tag
Enter the tag in which the integral is to be held, or leave this setting empty for a loop that starts from zero on every run. On a slow process, rebuilding the integral takes real time. A named tag may also be trended, alarmed and cleared by a store. The Startup Value of that tag must be set to Retained for the integral to survive a restart.

Setpoint Ramp
Enter the rate at which the setpoint is permitted to move, in the units of the reading per second. A setpoint that is allowed to step will be answered with everything the loop has available, which on a slow process is a disturbance that serves no purpose. Leave this setting at zero to allow the setpoint to move immediately.

Setpoint Weight
Enter the proportion of the setpoint that is seen by the proportional term. A value of one gives the classic controller. A value below one will soften the response to a change of setpoint without affecting the response to a disturbance, as the integral term always sees the whole of the error. This setting is a ratio, and therefore has no units.

Spike Rejection
Select the size of the median window:

- *Off* will pass the reading through;
- *3 Samples* will reject an isolated bad reading; and
- *5 Samples* will reject two of them in succession.

A median discards a bad reading outright, whereas the input filter below will spread one bad sample over those that follow. Use the median where a reading occasionally drops a sample, and the filter where it is noisy.

Input Filter
Enter the time constant of the filter applied to the reading. This will smooth broadband noise at the cost of introducing that much lag within the loop, so the figure should be kept well below the time constant of the process,

or the tuning will be working against the filter instead of the plant.

Output Minimum
Enter the lowest demand that the loop may call for. The integral will not be permitted to wind past this limit. A loop driving in both directions has no separate minimum, as the maximum describes both halves of the range.

Output Maximum
Enter the highest demand that the loop may call for. The integral will not be permitted to wind past this figure, so that the loop will leave the limit on the scan on which the error changes sign, and not some minutes later.

Output Rate Limit
Enter the rate at which the demand may move, as a fraction of the output per second. A demand that is held back by the rate limit will raise the SAT output and hold the integral still, as an output limit does. Leave this setting at zero to allow the demand to move as far as required in a single scan.

On Reading Loss
Select the action to be taken when the reading is lost while the loop remains in service:

- *Hold Last Output* will leave the demand where it was, which suits a slow process that will not run away; and
- *Output Fixed Value* will fall back to a configured demand, which suits a process that will.

The ENO output is cleared in either case, so a store placed after this element will decline to write, and an actuator driven through one will retain the value it already holds.

Failure Output
Enter the demand to be issued when the reading is lost, expressed in the same terms as the output limits.

Response
Select the manner in which the gains are derived from the result:

- *Fast* applies the Ziegler-Nichols rule, which was derived for quarter amplitude decay and which will overshoot more than most plants require;
- *Normal* applies a moderate rule; and
- *Slow* applies a conservative one.

Slow is the setting with which to begin on any plant where an overshoot would matter.

Relay Step
Enter the distance either side of the settled demand through which the relay will drive. The figure should be large enough to move the reading clear of its noise, and small enough not to disturb the plant unduly.

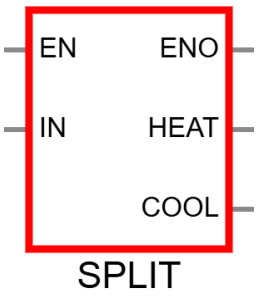
Safety Band
Enter the band about the setpoint within which the reading must remain. The tune will be abandoned if the reading leaves this band.

Time Limit
Enter the period after which a tune that has not produced a result will be abandoned. Where a process requires longer than this, raise the setting.

A tune is performed as a relay test. The demand is stepped either side of the point at which the loop had settled, the resulting oscillation of the reading is observed, and its period and amplitude are used to derive the gains. The

plant is disturbed for the duration of the test. The result is recorded in a file that survives a restart, and the TDONE and TGOOD outputs report that a result is available.

Split



Split

Splits a demand into heat and cool.

> **Enable:** EN/ENO, may be folded away

INPUTS

Terminal	Type	Meaning
EN	Digital	Enables the element. Defaults to on.
IN	Value	The signed demand, nominally between minus one and one. A positive demand drives the heating leg, and a negative demand the cooling leg.

OUTPUTS

Terminal	Type	Meaning
ENO	Digital	Follows the enable.
HEAT	Value	The demand for the heating leg, expressed in its own range.
COOL	Value	The demand for the cooling leg, expressed in its own range. While the element is disabled, neither output will produce a value, leaving the actuators to whatever the elements driving them have been configured to do in that event.

OPTIONS

Crossover

Enter the crossover point. A value of zero will hand over at zero demand, so that one leg stops as the other starts. A negative value will leave a dead band about zero in which neither leg drives, which prevents a plant from working against itself over a small error. A positive value will overlap the two, so that both legs drive through the middle of the range.

Heat Minimum

Enter the demand at which the heating leg will sit when it first comes on. Where this value is above zero it represents a minimum firing rate, and a demand of zero will still leave the leg off, so that the step up to this figure is taken deliberately.

Heat Maximum

Enter the demand at which the heating leg will sit at full output.

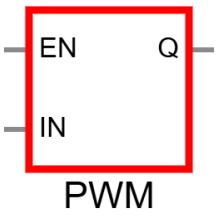
Cool Minimum

Enter the demand at which the cooling leg will sit when it first comes on, in the same manner as the heating leg.

Cool Maximum

Enter the demand at which the cooling leg will sit at full output. The two ranges will differ where the capacities of the two actuators differ.

TPO



TPO

Drives a contact to follow a demand using PWM.

> **Enable:** EN only, may be folded away

INPUTS

Terminal	Type	Meaning
EN	Digital	Enables the element. Defaults to on.
IN	Value	The demand, from zero to one. Values outside this range are held at its ends.

OUTPUTS

Terminal	Type	Meaning
Q	Digital	The output. This will be set for the demanded portion of each cycle, and will be cleared while the element is disabled or while no demand is available.

OPTIONS

Cycle Time

Enter the time for one complete cycle, comprising one on period and one off period. A short cycle will follow the demand more closely at the cost of increased wear on the contactor, and a long cycle will do the reverse. The period should be short enough that the process cannot respond to the switching, and long enough that the switchgear will tolerate it.

The demand is read once at the start of each cycle and is then held for the whole of it.

Minimum On Time

Enter the shortest pulse for which it is worth operating the contactor. A demand calling for less than this will produce no pulse at all, rather than a pulse stretched to the minimum.

Minimum Off Time

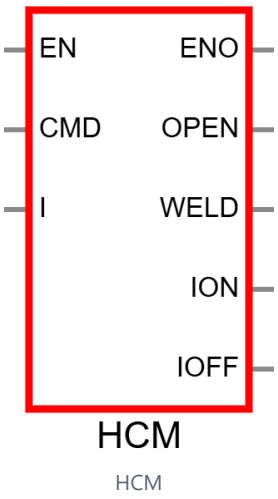
Enter the shortest gap for which it is worth releasing the contactor. A demand leaving less than this will hold the output on through the gap.

Phase Offset

Enter the point in the cycle at which this element starts, as a percentage. Where a device drives several heaters, the outputs should be spread across the cycle, two of them half a cycle apart or four of them a quarter, so that they do

not all operate at the same instant and load the supply.

HCM



HCM

Checks load current against the drive.

> **Enable:** EN/ENO, may be folded away

INPUTS

Terminal	Type	Meaning
EN	Digital	Puts the element in service. Defaults to on. Releasing it forgets every reading and clears both faults.
CMD	Digital	The drive being watched, taken from whatever closes the contact - usually the output of the time proportioning element.
I	Value	The measured load current.

OUTPUTS

Terminal	Type	Meaning
ENO	Digital	Follows the enable.
OPEN	Digital	The on current fell short of its limit, so the element or the contact is open.
WELD	Digital	Current was flowing while the drive was off, so the contact has welded.
ION	Value	The last accepted on reading, or no value at all until one has been taken.
IOFF	Value	The last accepted off reading, the same way.

OPTIONS

Turn On Setup

Enter how long the drive has to have been on before a reading means anything. It covers the output reaching the contactor, the contactor closing and the inrush settling, so it is normally the longer of the two.

Turn Off Setup

Enter the same for the drive going off. Opening has no inrush to settle, so this is usually shorter. It is a separate figure because one field would let the slower case dictate both and narrow the range of duty cycles that can be tested at all, for no reason.

Hold Time

Enter how long the drive has to stay put after the sample. This is what stops the next transition reaching the sample through an input that reads on its own poll rather than ours. It is not a measurement window, and it guards a signal that does not know which way the drive went, so one figure serves both directions.

Averaging Window

Enter how long to average the current over, or leave it off for a single reading. The window opens once the setup time has passed and closes before the hold time begins, so adding one lengthens the shortest pulse that can be tested. Reach for it when the current signal is noisy, not for synchronisation, which is what the setup and hold times are for.

Minimum On Current

Enter the least current the load should draw while it is on. A reading below this raises the open fault. Nothing at all is no test rather than the strictest one, since no load draws nothing while it is on.

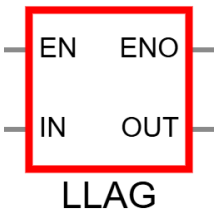
Maximum Off Current

Enter the most current that can be flowing while the drive is off. A reading above this raises the welded fault. Nothing at all is no test rather than the strictest one, since no analogue input reads exactly nothing.

Confirmations

Enter how many readings in a row have to agree before a fault is raised, and how many have to agree before it is cleared again. Counted consecutively in both directions, so neither a contactor bouncing nor a dip on the supply is enough on its own, and one good reading is not enough to say a fault went away.

Lead / Lag



Lead / Lag

Adds lag, lead and dead time to a signal.

> **Enable:** EN/ENO, may be folded away

INPUTS

Terminal	Type	Meaning
EN	Digital	Enables the element. Defaults to on.
IN	Value	The signal to be shaped.

OUTPUTS

Terminal	Type	Meaning
ENO	Digital	Follows the enable.
OUT	Value	The shaped signal. While the element is disabled, no value will be produced.

OPTIONS

Lag Time

Enter the lag time in seconds, which will slow the signal down. A value of zero will pass the signal through, and will also disable the lead, as a lead has nothing to act against without a lag.

Lead Time

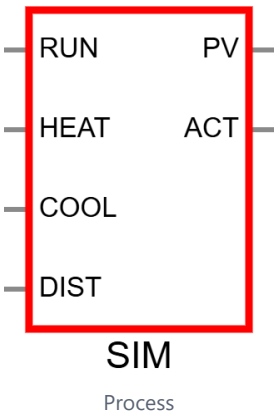
Enter the lead time in seconds, which will cause the signal to arrive early. A lead equal to the lag will cancel it exactly, which is a useful starting point when the two are being set. A lead is applied only where a lag is present.

Dead Time

Enter the dead time in seconds, which will cause the signal to arrive late. This setting represents the transport delay of a pipe, a belt or a duct between the point at which something acts and the point at which it is felt.

These settings are used principally with feedforward. A disturbance reaches the process by a different path from the valve, and with different dynamics, so a measured disturbance that is scaled and passed directly to a controller will be correct only once everything has settled. Use a lead where the disturbance acts more slowly than the valve, a lag where it acts more quickly, and a dead time for the transport between them.

Process



Simulated heated mass, for testing loops.

INPUTS

Terminal	Type	Meaning
RUN	Digital	Runs the simulation. Defaults to on.
HEAT	Value	The heating demand, from zero to one.
COOL	Value	The cooling demand, from zero to one. Leave this terminal unwired to simulate a plant that can only be heated.
DIST	Value	A load on the mass, expressed in the units of the measurement, such as an opened door or a cold feed.

OUTPUTS

Terminal	Type	Meaning
PV	Value	The reading as an instrument would report it, delayed by the dead time and carrying whatever noise and spikes have been configured. This is the output that should be connected to the controller.
ACT	Value	The actual state of the mass, undelayed and free of noise. No real plant offers both of these, but having the two side by side is what allows the behavior of a loop to be understood.

OPTIONS

Ambient

Enter the value at which the mass will settle when nothing is driving it.

Full Drive Rise

Enter the rise above ambient that full heating will eventually produce.

Cooling Capacity

Enter the cooling effect relative to the heating effect. A value of one gives two legs of equal authority, and a value below one is the more usual case, in which a plant sheds heat more slowly than it takes it on.

Time Constant

Enter the time constant in seconds, being the time taken to cover about two thirds of the distance to the value toward which the mass is heading.

Dead Time

Enter the dead time in seconds before a change reaches the instrument. This figure determines how difficult the loop is to tune. A loop that is straightforward at a tenth of the time constant presents a very different problem at half of it.

Noise

Enter the peak to peak noise on the reading, in its own units. This is the disturbance that an input filter is intended to address.

Spike Size

Enter the size of the occasional single bad reading. An input filter will spread such a reading over those that follow it, whereas a median will discard it.

Spike Interval

Enter the average interval between spikes in seconds.

The model is a first order lag with a dead time, which is the form assumed by the published tuning rules. The noise and the spikes are produced by a generator that is seeded identically on every run, so that a test may be repeated exactly.

Notify

Events, Troubles and Outward Notifications.

Block	Key	Description
Event		Records an alarm when its rung goes live, and again when it clears.
Trouble		Marks the device in trouble while its rung is live.

Event

Event

Records an alarm when its rung goes live, and again when it clears.

This element records an event when its rung goes live, and records another when the rung drops again. The events are posted to the device's event system under the name of the program that contains the element, from where they may be sent onward by any connection that subscribes to the channel on which they were posted.

The rung passes through the element unchanged, so it may sit in the middle of a rung rather than having to end it. An element whose input is not wired never fires.

INPUTS

Terminal	Type	Meaning
Left	Digital	The condition to be reported. The event fires when this becomes set and resets when it clears.

OUTPUTS

Terminal	Type	Meaning
Right	Digital	Follows the input, so that the rung may continue past the element.

OPTIONS

Event Channel

Enter the name of the event channel to which the events should be posted, or leave this setting empty to use the default channel. A connection that forwards events selects them by channel, so giving related events a channel of their own is a convenient way to route them separately.

Fired Text

Enter the text to be recorded when the event fires.

Fired Code

Enter a number to be recorded with the text when the event fires, for the benefit of a system that sorts events by code rather than by wording. If both the text and the code are left empty, nothing is recorded when the event fires.

Reset Text

Enter the text to be recorded when the event resets.

Reset Code

Enter a number to be recorded with the text when the event resets. If both the text and the code are left empty, nothing is recorded when the event resets, which is the way to report the onset of a condition without reporting its end.

Data Items

Add any values that are to be recorded along with each event. Each item has a name, under which it appears in the event, a tag or expression whose value is taken at the moment the event is recorded, and a type that says whether the value is to be recorded as a real number, an integer, a boolean or a string. A value that is not available is recorded as null, so that every event from the element has the same shape.

Trouble

Trouble

Marks the device in trouble while its rung is live.

This element places the device in a trouble state while its rung is live, and takes it out again when the rung drops. A trouble is reported to the device management system as a fault with the device itself, rather than as an event of the process, and is the way for a program to say that something needs attention.

The trouble is held for as long as the condition is present, whether or not any text has been entered. It is cleared when the program stops, as a program that is not running can no longer say whether the condition has gone, and is established afresh from the condition on the program's first scan after it starts.

The rung passes through the element unchanged, so it may sit in the middle of a rung rather than having to end it. An element whose input is not wired never fires.

INPUTS

Terminal	Type	Meaning
Left	Digital	The trouble condition. The device is in trouble while this is set.

OUTPUTS

Terminal	Type	Meaning
Right	Digital	Follows the input, so that the rung may continue past the element.

OPTIONS

Severity
Select the severity of the trouble. *Warning* indicates a minor issue, and *Error* indicates a more serious problem.

Fired Text
Enter the text to be shown in the device management system when the trouble fires. If this is left empty, the trouble is still raised but nothing is announced.

Reset Text
Enter the text to be shown in the device management system when the trouble resets.