Framework Manual
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1 Anatomy of a Block

Whatever the function, all REAKTOR Blocks are built in the same way. Three distinct Macros each carry out a particular task. The Panel Macro contains all front end elements of the Block. The System Info Macro houses all elements which provide the necessary system and project information. Both the Panel and System Info Macros feed into the process Core Cell. This Core Cell is where all of the actual processing happens, making use of the signals provided to it by both system and user.

On either side of these three Macros are the Block’s inputs and outputs. In order to maintain a degree of familiarity for the user, these ports should always be found in the same order.

Audio inputs are always in first position, followed by Pitch/Frequency inputs, Gate/Reset inputs, and finally modulation bus inputs. Outputs are also ordered in the same way.
The inputs and outputs in the Block Structure
1.1 System Info Macro

The System Info Macro serves to provide the Block with all necessary information from the system and project in which it resides. This might include system clocks, song position, tempo information, random seeds, and so on.

In this example, the System Info Macro is providing the Process Core Cell with 3 signals. Audio song position (SPos), display clock (DClk), and the master start/stop gate (S/S). These signals are then connected directly to the Process Core Cell, where they are distributed as required.
1.2 Panel Macro

While the System Info Macro is providing the Process Core Cell with all system signals, the Panel Macro deals with all user signals. This includes panel elements such as knobs, buttons, text, displays, and anything else pertaining to how the Block looks and how the user can interact with it.
In this example, the Panel Macro contains a number of different panel elements. The outputs from all of these elements are connected directly to the Process Core Cell. The Panel Macro also receives signals from the Process Core Cell. These signals are sent into the various panel elements, where they are used to display any modulation that has been applied to that particular parameter.

In addition to all panel elements, the Panel Macro also contains 2 further Macros, A/B Buttons and a size Macro.

1.2.1 Size Macro

Inside every Panel Macro is a size Macro. The size Macro does not contain any modules, but instead serves to determine that Block’s panel size.

In order for all Blocks to line up correctly in panel view, all panels are made to particular dimensions. Panels should always be 252 pixels in height, but width will vary depending on the complexity of the panel. Never the less, width should still adhere to specific values for correct alignment.

Block widths are calculated on a grid where 1 ‘unit’ is 60 pixels, and panel widths are multiples thereof. The 4 pixel gap between instruments should also be taken into account when calculating panel width.

- Panel width in pixels = number of units * 60 - 4 pixel gap.
- The smallest available width is 2 units or 116 pixels: 2 * 60 - 4 = 116

The size Macro is in fact an empty stacked Macro, and setting its width and height in the view properties menu will determine the size of the Block’s panel. REAKTOR always creates an additional border around any panel elements, which must be taken into consideration when setting the height and width. This border will always be 8 pixels on either side, and 6 pixels at the top and bottom, and these values should be subtracted accordingly.
This example shows a 3 unit wide size Macro. The panel should be 176 pixels wide, and 252 pixels tall. To adjust for the border added by REAKTOR, the correct dimensions for the stacked Macro should be Width (Pixels) = 160, and Height (Pixels) = 240.

1.2.2 A/B Buttons Macro

The A/B Buttons Macro serves two purposes. When a signal is connected to a modulation bus input, the buttons on the panel will illuminate to display the signal’s strength and polarity. The A/B Buttons Macro also determines when the modulation sliders are visible on the panel, and so its output should be directly connected to the A/B Buttons input of all panel elements inside of that Block.
1.2.3 Panel Elements

There is a wide variety of panel elements provided with the template, all of which are covered in more detail in the “Panel Widgets” section. However, the most commonly found element is the modulatable knob.

The modulatable knob should be placed inside of the Panel Macro, while the right image shows the inside of the modulatable knob itself. The Mod Knob Macro is comprised of a number of different elements. Most important are the main control, and the A and B modulation sliders. The main control is found in the first level of the Mod Knob Macro, while the modulation sliders are to be found in the Mod A/B stacked Macro, the panel index of which is connected to the A/B Buttons Macro as discussed in the previous section.

Other elements found in the Mod Knob Macro are the Label & Value Macro, the Ctrl Pack Macro the Mod Ring display, and the Scale picture.
The *Label & Value* Macro contains a label for displaying the parameter name, a value display, as well as some additional modules which determine what is currently visible on the panel. Here you are able to change parameter names or use a different type of value display, depending on what the knob is controlling. A variety of different *Label & Value* Macros are already provided with the template which can be used to replace the default one, should a different value display be required.

The *Ctrl Pack* Macro packages the signals from the main control, and both modulation faders into a single signal which is then connected directly to the *Process Core Cell*. These signals are then unpacked and used to control modulation depths and so on. Further information on this can be found in the “Smooth + A/B Mod” section.

### 1.2.4 Mod Ring and Mod Return

The *Mod Knob* Macro sends all parameter values and modulation amounts into the process Core Cell, where the actual modulation signals are scaled and summed accordingly. The result of this summing will then be sent to wherever it is needed within the *Process Core Cell*. In addition, it is also routed back to the *Panel Macro*, and to the original panel element, where it is displayed by the *Mod Ring* display.

![Connections between the Panel Macro and the Process Core Cell](image)

Connections between the Panel Macro and the Process Core Cell

The left image shows the connections between the *Panel Macro* and the *Process Core Cell*. Parameter values are sent from the panel element via the {C0} output. All scaling of modulation signals occur within the Core Cell, and the result is returned to the panel element via the {C0}
input. The right image shows how the *Knob* panel element is connected inside of the ‘Panel’ Macro. Again, parameter values are sent via the {CO} output, and the resulting modulation is returned via the {C0} input.
1.3 Process Core Cell

Both the System Info and Panel Macros are connected to the Process Core Cell, where all of the actual signal processing occurs. The template includes several starter instruments, each of which contains an empty Process Core Cell.

The left side of the image shows the connections between the System Info and Panel Macros, and the Process Core Cell. The right side of the image shows the inside of the Core Cell itself. By default, the template Core Cell will already contain many of the ports and elements required to receive signals from the System Info and Panel Macros.

1.3.1 Display Clk Distributor

The Display Clk distribution bus sends the display rate clock, as provided by the System Info Macro, to the Display Latch Macros. This is where ‘modulation return’ signals are clocked before being routed back to their associated panel elements. Within Blocks, modulation signals...
are audio rate, however this is a far higher rate than can be displayed on the panel. Attempting to display audio rate signals would be inefficient. Instead, before leaving the Process Core Cell ‘modulation return’ signals are latched by the display rate clock, resulting in a noticeable increase in efficiency.

1.3.2 A and B Distributors

The A and B buses distribute all signals arriving at the A and B modulation buses throughout the entire Core Cell, where they can be used as a modulation source. Typically, a completed block will have a number of modulatable parameters. By distributing the signals arriving at the A and B modulation buses in this way, it helps to keep structures cleaner and more organized.

1.3.3 Smoother Attributes

Any connection between two Blocks will be at audio rate, however the connection between a panel element and the Process Core Cell within a Block will be control rate. Therefore, some degree of smoothing is required in order to avoid potential discontinuity in signals, audible ‘pops’, and other such undesirable results. The Smoother Attributes Macro provides the various signals required for smoothing parameters at 2 different clock rates; 1K and 15K. These attributes can be picked up anywhere within the Process Core Cell. In addition, the template also provides a selection of different smoothers, which will automatically pick up all relevant information provided by the Smoother Attributes Macro.

1.3.4 Smooth + A/B Mod

The Smooth + A/B Mod Macro is one of the most important Macros within the Blocks framework. This Macro serves a variety of purposes. As mentioned in the “Panel elements” section, before being sent to the Process Core Cell the 3 values inside of a modulatable parameter are packaged together into a single connection. The first thing the Smooth + A/B Mod Macro does is to unpack this connection into its individual components, the main control, and the 2 modulation sliders.

The second task of the Smooth + A/B Mod Macro is to apply smoothing to the 3 signals, before receiving, scaling, and summing any modulation signals.
The DMux and Prep Macros

The *DMux* Macro is responsible for unpacking the arriving signal, while the *Prep* Macro deals with smoothing of parameters, and scaling/summing of modulation signals.

Having been unpacked by the *DMux* Macro, the 3 signals provided by the panel element are routed to the *Prep* Macro and smoothed. In addition, signals connected to the A and B modulation buses are also received here before being scaled, summed with the main control value, and clipped to ensure the result remains within the [0, 1] range.
1.4 A Completed Block

The left image shows the connections between the System Info Macro, Panel Macro, and the Process Core Cell. The right image shows the inside of the Process Core Cell.

The packaged signals from the panel elements are routed into the Process Core Cell, where they are unpacked, smoothed, and summed with any modulation received via the A and B distribution buses inside of the Smooth + A/B Mod Macros. The summed signals are then routed to wherever they are needed within the Core Cell. They are also routed to Display Latch Macros, where they are latched at display rate by the clock received from the System Info Macro via the Display Clk distribution bus. Finally, the signals are returned to the Panel Macro, where they are used to display modulation.
2 Connections and Signals

The most important aspect of the Blocks framework is the universal connectivity between each Block. A user should be able to connect any output to any input and achieve predictable results, regardless of what modules they are connecting together.

In order to achieve this, all Blocks have been designed to interpret signals within a particular range, in a particular way. It is important that any additional Blocks are built to the same criteria to ensure compatibility with already existing Blocks.
2.1 Audio Rate Connections

Ensuring that all connections between Blocks are audio rate signals serves 2 main purposes. Primarily, using audio rate signals results in total interconnectivity across the entire framework, meaning that the user is always able to make any connection they wish. Furthermore, using audio rate signals ensures that any modulation within a patch is as smooth as possible and very rapid modulations can be achieved with no detriment to audio quality.

LFO signal at control rate

The first image shows the signal from an LFO at control rate. The second image shows the same signal at audio rate. The higher clocking frequency results in a much smoother waveform.

All Blocks have been designed to function at a standard sample rate of 44.1kHz. Higher sample rates are also supported, but it is inadvisable to use a sample rate lower than 44.1kHz, as this would have an adverse affect on audio quality.
2.2 Value Range

Just as all connections between Blocks should be audio rate signals, the value range of those signals should always remain within a range of \([-1, 1]\). Again, this serves to ensure compatibility across the entire framework.

There remains still the possibility to exceed that range, either by mixing multiple signals together, or by simply applying excessive amounts of gain to a signal. Never the less, the \([-1, 1]\) range should be considered the standard operating range at all inputs and outputs.

Signal polarity or bias is less of a concern, and it is perfectly acceptable for signals between Blocks to be offset or entirely unipolar. It is however inadvisable to connect a biased signal directly to the main output, as this could potentially cause damage to monitoring equipment in the case where the audio interface used does not have an AC coupled output.
2.3 Pitch Scaling

As all connections between Blocks are audio rate signals within the [-1, 1] range, on occasion some scaling may be required to convert the signals patched between modules into standard MIDI note values. To this end, Blocks adopts a scaling system similar to the volts per octave scheme as found in Eurorack format modular systems.

In the Blocks framework, signals connected to a Pitch input are scaled up by a factor of 120, so that a value of 0 results in a MIDI note of 0, a value of 0.5 results in a MIDI note of 60, and a value of 1 results in a MIDI note of 120.

![Pitch input scaling](image)

Likewise, MIDI notes received from a host software or MIDI device are scaled down by the same amount, so that they can be freely patched throughout the Framework.

![MIDI note scaling](image)

This scaling scheme means that an increase of 0.1 in a signal connected to a Pitch input will result in a 1 octave increase in pitch, and an increase of 0.00833333 results in a 1 semitone increase in pitch.
2.4 Gate Signals

Various types of Blocks will have a Gate or Reset input, and while the result may be different depending on the type of Block, a gate signal is always detected in the same way. Once again, this is to ensure total interconnectivity across the entire framework.

Gate signal detection

The Gate input of any Block will be looking for a positive zero crossing in the signal connected to it. This is the point at which a signal increases from a value of zero or less, to a value greater than zero. When this positive zero crossing occurs, it is considered a ‘Gate on’ event, and when the signal returns to a value of zero or less, it is considered a ‘Gate off’ event.

Gate detection for a sine wave

The actual result of the gate on and off messages will differ, depending on the type of module. In a sequencer, the gate on event will cause the sequencer to advance 1 step. In an envelope generator, the gate on event will trigger the envelope, while the gate off event will allow it to continue into the release stage.

Whatever the type of module, detecting gate events in this way allows for any number of different sources to be used as a gate signal.
2.5  Gate Signals and Velocity

Blocks such as envelope generators can also be made to respond to gate velocity, rather than just simple gate on/off messages. Velocity is determined in a manner similar to a typical gate signal.

Once again, the Gate input will be looking for a positive zero crossing in the signal connected to it. When the positive zero crossing occurs it is again considered a ‘Gate on’ event, however the amount by which the signal has exceeded zero is used to determine the velocity value. Once the signal has returned to a value of 0 or less, it is considered a ‘Gate off’ message.

When using a triangle wave as a gate signal for a velocity sensitive Block, the resulting gate signal has a very low velocity since the value at the initial positive zero crossing is very small:

When using a saw wave as a gate signal for a velocity sensitive Block, the value at the initial positive zero crossing is very large, which results in a gate signal with a very high velocity:
Velocity detection for a saw wave
3 Panel Widgets

The template contains a wide selection of panel widgets, which can be used when building a new Block. Widgets are provided in both Light on Dark and Dark on Light color schemes so that they are always visible, whatever the chosen panel color might be.
All widgets can be easily customized, making tasks such as renaming parameters, setting knob color, or changing the type of value readout quick and simple to achieve.
3.1 Color Schemes

The template contains a wide selection of panel widgets, which can be used when building a new Block. Widgets are provided in both Light on Dark and Dark on Light color schemes so that they are always visible, whatever the chosen panel color might be.

All widgets can be easily customized, making tasks such as renaming parameters, setting knob color, or changing the type of value readout quick and simple to achieve.
3.1.1  Additional Knob Colors

The template contains a wide selection of panel widgets, which can be used when building a new Block. Widgets are provided in both *Light on Dark* and *Dark on Light* color schemes so that they are always visible, whatever the chosen panel color might be.

All widgets can be easily customized, making tasks such as renaming parameters, setting knob color, or changing the type of value readout quick and simple to achieve.
3.2 Template Blocks

Also included with the template is a selection of empty Blocks. These have already been set to the correct dimensions to ensure they fit with existing Blocks. In addition, each empty Block also contains the most essential Macros needed to begin building. The most commonly used sizes have been provided, however it is a very simple process to set different sizes too. More information on this can be found in section 1.2.1, Size Macro.
3.3 Process Macros

As well as the various panel widgets, the template also includes a wide selection of Macros for use inside of a Block’s Process Core Cell. Primarily, these are the Macros required to utilize the various widgets most effectively, or to interpret any signals connected to a Block such as Pitch and Gate.
3.4 Knobs

3.4.1 Basic Knobs

Available in three different sizes, the signal provided by the basic knob requires no additional Macros after entering a Core Cell, except for smoothing when necessary.

Output value range is \([0, 1]\).

Inside of the basic knob Macro is another Macro named \(Label \& Value\). This contains the text modules used for displaying parameter name and value, as well as additional modules used to determine which is visible at any particular time. Here the parameter name can be changed, and value display adjusted as needed. Alternatively, more complex \(Label \& Value\) Macros have been provided for more specific cases, and can be used as a replacement if desired.
3.4.2 Basic Knobs (Bipolar)

Bipolar knobs

Similar to the basic knob, with the only difference being that the bipolar knob includes a center point indicator, and a bipolar value display.

Output value range is [0, 1].

Customization of both label and value can be carried out in the exact same way as described for the basic knob.

3.4.3 Modulation Knobs

Modulation knobs
More complex than the basic knob, the modulation knob Macro also includes the two sliders used for defining modulation depth, and an additional modulation ring which displays any modulation currently assigned to that parameter. Connecting the output from the A/B Buttons Macro to the A/B Buttons input gives control over when the modulation sliders are visible. Signals connected to the Mod Return input will be displayed by the modulation ring.

The signal sent from the modulation knob output is a multiplexed signal comprised of the main knob as well as the two modulation depth sliders. Therefore, a Smooth + A/B Mod Macro should be used inside of the Process Core Cell in order to correctly demultiplex the signal, smooth, and apply modulation before routing the signal to its final destination.

Modulation knob parameter names and values can be customized inside of the Label & Value Macro, or alternatively, the Label & Value Macro can be replaced with one of the others included with the template.

### 3.4.4 Modulation Knobs (Bipolar)

Similar to the modulation knob, with the only difference being that the bipolar knob includes a center point indicator, and a bipolar value display. Just like the modulation knob, the bipolar modulation knob also outputs a multiplexed signal, and so a Smooth + A/B Mod Macro should be used inside of the Process Core Cell.

Customization of both label and value can be carried out in the exact same way as described for the modulation knob.
### 3.4.5 OSC Tuning

The OSC tuning Macro contains all the parameters commonly used when building oscillator Blocks. A switch to enable/disable key tracking, a modulatable coarse tuning control which switches between note value or frequency value depending on whether key tracking is enabled, and a fine tuning control.

The coarse tuning control output is a multiplexed signal as described in the *Modulation Knob* section, the fine tuning control is a simple knob with an output value range of [0, 1], and the key tracking switch is a simple on/off switch with an output value range of [0 .. 1].

Since each parameter has its own output, these signals can all be treated separately if desired. For ease of use however, the template also includes a Core Cell Macro specifically designed for the purpose of receiving these values, along with any pitch signals patched into the Block.

The left image shows the three signals sent from the OSC tuning Macro, as well as the modulation return needed to display modulation of the ‘Coarse’ parameter. The right image shows the same three signals arriving in the *Process* Core Cell. Note that since the coarse parameter {C1} is multiplexed, a *Smooth + A/B Mod* Macro is used to demultiplex and apply any modulation.
before connection to the *OSC Tuning* Core Macro. In addition, the output from the *Smooth + A/B Mod* Macro is also connected to a ‘Display latch’ Macro before being routed back to the *Panel* Macro so that modulation can be displayed.

### 3.4.6 Multiplex Knobs

The multiplex knobs Macro contains eight separate basic knobs, which are multiplexed into a single output. While there are eight by default, additional knobs can be added, or removed as required. Since the output from all knobs is multiplexed into a single connection, demultiplexing is required inside of the *Process* Core Cell. The template includes two suitable demultiplexing Core Macros. One will simply unpack the multiplexed input into its constituent signals, while the other writes the signals into an array.

The output value range of each knob is \([0, 1]\), and the label and value displays of each knob can be customized as needed.
3.5 Customizing Knobs

3.5.1 Color

The multiplex knobs Macro contains eight separate basic knobs, which are multiplexed into a single output. While there are eight by default, additional knobs can be added, or removed as required. Since the output from all knobs is multiplexed into a single connection, demultiplexing is required inside of the Process Core Cell. The template includes two suitable demultiplexing Core Macros. One will simply unpack the multiplexed input into its constituent signals, while the other writes the signals into an array.

The output value range of each knob is \([0, 1]\), and the label and value displays of each knob can be customised as needed.

![Changing the knob color](image-url)
### 3.5.2 Labels

Changing the label displayed underneath a knob is a quick process. The text module used to display the parameter name can always be found in the *Label & Value* Macro found in every knob module.

Simply locate the *Label* Macro, and edit the text module inside.

### 3.5.3 Values

Changing the knob values
By default, all panel widgets come with a basic $[0, 100]$ value display, or $[-100, 100]$ if the parameter is bipolar. The value display is found in the same location as the label, and can be edited in much the same way.

In cases where more complex value displays are required, such as frequency or envelope times, the generic *Label & Value* Macro can be replaced in its entirety with one of the more specialized Macros included in the ‘Value Displays’ Macro.
3.6 Buttons

3.6.1 Basic Button

Available in three different sizes, the signal sent by the basic button requires no additional Macros after entering a Core Cell, except for smoothing if necessary.

Output value range is [0 .. 1].

By default, the basic button text display will switch between “OFF” and “ON”. This can be changed by editing the multtext module found inside of the Macro.

3.6.2 Basic Color Button

Essentially the same as the basic button, with the only difference being that the color button switches between grey when off, and a selectable color when on, allowing for easy panel customization. Integer values between 0 and 15 at the Color input select different colors.
Output value range is \([0 .. 1]\).

By default, the basic color button will switch between “OFF” and “ON”. This can be changed by editing the multitext module found inside of the Macro.

### 3.6.3 Multistate Button

![Multistate button](image)

While the basic button only provides two possible values, 0 and 1, the multistate button can provide a definable number of values. The output value begins at 0, and increases by 1 every time the button is clicked. Once the maximum value is reached, the output value returns to 0.

By default, the multistate button has 4 states and an output range of \([0 .. 3]\). The number of states can be changed by editing the constant value found inside of the Macro. Similarly the text displayed for each state can also be modified, by editing the multitext module inside of the Macro.

### 3.6.4 Multistate Color Button

![Multistate color button](image)
The multistate color button offers the same functionality as the multistate button, with the only difference being that the color button switches between grey when 0, and a selectable color for all other values. Integer values between 0 and 15 at the Color input will select different colors.

By default, the multistate color button has 4 states and an output range of [0 .. 3]. The number of states can be changed by editing the constant value found inside of the Macro. Similarly the text displayed for each state can also be modified, by editing the multitext module inside of the Macro.

### 3.6.5 Radio Buttons

![Radio buttons](image)

Similar to the multistate button Macro, the radio buttons Macro also provides a definable number of values. The difference being that rather than a using a single button, the different states are selected via several on screen buttons.

By default, the radio buttons Macro has six states with an output range of [0 .. 5] however, states can be added or removed as required. In addition, the text display for each button can also be modified by editing the text modules inside of the Macro.

### 3.6.6 Radio Color Buttons

![Radio color buttons](image)
With the same functionality as the radio buttons, the Radio Color Buttons switch between grey when off, and a selectable color when on, allowing for easy panel customization. Integer values between 0 and 15 at the Color input select different colors.

By default, the radio color buttons Macro has six states with an output range of [0 .. 5] however, states can be added or removed as required. In addition, the text display for each button can also be modified by editing the text modules inside of the Macro.

### 3.6.7 Multiplex Buttons

![Multiplex Buttons](image)

The multiplex buttons Macro contains eight separate basic buttons, which are multiplexed into a single output. While there are eight by default, additional buttons can be added or removed as required. Since the output from all buttons is multiplexed into a single connection, demultiplexing is required inside of the Process Core Cell. The template includes two suitable demultiplexing Core Macros. One will simply unpack the multiplexed input into its constituent signals, while the other writes the signals into an array.

The output value range of each button is [0 .. 1], and the text display of each button can be customized as needed, by editing the text modules inside of the Macro.

### 3.6.8 Multiplex Color Buttons

![Multiplex Color Buttons](image)

Functionally the same as the Multiplex Buttons, but with the additional option to quickly select a different color for the on states. Integer values between 0 and 15 at the Color input select between the sixteen available colors.
The output value range of each button is [0 .. 1], and the text display of each button can be customized as needed, by editing the text modules inside of the Macro.

### 3.6.9 A/B Buttons

The A/B Buttons Macro does not connect to the Process Core Cell. Instead, its output should be connected to the A/B Buttons input found on any modulatable panel widget, such as the Modulation Knob. Clicking the A/B Buttons will then determine when that panel widget’s modulation sliders are visible.

The A/B Buttons Macro also has two inputs, A and B. These inputs should be connected to the Block’s A and B modulation bus inputs in order to display the signal strength and polarity of any incoming modulation.

The A/B Buttons Macro output range is [0 .. 2]. When neither button is active, output value is 0 and no modulation faders are visible. When button A is active, output value is 1 and modulation bus A sliders are visible. When button B is active, output value is 2 and modulation bus B sliders are visible.
3.7 Meters

3.7.1 Meter Mono

The Meter Mono Macro is a simple level meter, useful for displaying mono signal levels in dB. It is comprised of several different elements. As well as the main level meter, there is also a peak level meter, and numeric readout which will change color when the input signal exceeds 0dB.

Integer values between 0 and 15 at the Color input will set the meter to one of the sixteen available color options.

3.7.2 Meter Stereo
Stereo version of the Meter widget. As before, meter color can be selected at the color input. An integer value between 0 and 15 will select one of the 16 available color options.
In addition to the wide selection of Panel Widgets, the template also includes several Macros for use inside of a Block’s Process Core Cell. Primarily, these Core Macros are designed to work in conjunction with the various panel elements available, or to interpret incoming signals such as pitch, gate, and modulation.
4.1 Inputs

Display Clk

The $DClk$ input and the attached $Display Clk$ distributor receive a clocking signal sent from the $System Info$ Macro, and distribute it throughout the $Process Core Cell$. This clocking signal is used to clock signals being returned to the Block’s panel, which are to be used for displaying modulation. Modulation signals are audio rate, and it would be inefficient to connect them directly to any form of display. Clocking these signals at display rate results in a noticeable increase in efficiency.

Random Seed

The $RS$ input and the attached $Random Seed$ distributor receive a value sent from the $System Info$ Macro, and distribute it throughout the $Process Core Cell$. A new random value is sent every time the patch is re-initialized. This value can be used as a seed wherever a degree of randomization is required, such as noise generators or random sequences.

Pitch / Pitch Mult

Signals between Blocks should always remain within the $[-1, +1]$ range. Typically a pitch signal will have a range of $[0, 1]$, but on occasion it may be preferable to scale this up to typical MIDI note values. The $Pitch$ input will receive any signals connected to the Block’s $Pitch$ input, while the $Pitch Mult$ Macro scales this signal up to MIDI note values.
Gate / Int Gate / Vel Gate

Signals connected to the Block’s Gate input are passed on to the Gate input of the Process Core Cell. The Int Gate and Vel Gate Macros will convert the incoming audio rate signal into a usable gate.

They both function in much the same way, by looking for a positive zero crossing in the input signal. When the signal rises above 0 it is considered a gate on, and when the signal returns to 0 or less it is considered a gate off.

The Int Gate Macro effectively acts as an audio to logic converter, only outputting either 0 or 1. This can be used for any gated functions where velocity information is not required, such as restarting an LFO or advancing a sequencer.

The Vel Gate also sends velocity information. Velocity is determined by the value of the input signal, immediately after a positive zero crossing. This can be used for any gated function where velocity information is required, such as an envelope generator.

Reset

The Reset input and Macro function in much the same way as the Gate input. Signals connected to the Block’s reset input are passed on to the Reset input of the Process Core Cell which is in turn connected to the Reset Core Macro.

Like the Gate Macro, the Reset Macro is also looking for positive zero crossings in the input signal. However, every time a positive zero crossing occurs the Reset Macro will output a value of 0. This can be used to reset any counters within the Block, as might be found in a sequencer or clock divider.
**A and B**

The $A$ and $B$ inputs are where signals connected to the Mod A and Mod B inputs of the Block are received inside of the *Process Core Cell*. Both inputs are connected directly to distributors, so that incoming modulation can be picked up wherever needed within the *Process Core Cell*.

Macros such as the *Smooth + A/B Mod* are already designed to pick up signals distributed by the $A$ and $B$ buses, so that no additional patching is required.
4.2 Smoothing and Modulation

**Smoother Attributes**

The Smoother Attributes Macro is responsible for creating the various signals needed for the smoothing of parameter inputs i.e. smoothing time and rate. These attributes are distributed throughout the Process Core Cell by the two distributors. Two different smoothing rates are provided, 1 kHz and 15 kHz.

Macros such as the Smooth + A/B Mod are already designed to pick up signals distributed by the Smoother Attributes Macro, so that no additional patching is required.

**Smother**

The smoother Macro serves to smooth the event rate signals arriving from the Panel Macro, in order to avoid discontinuity in signals, audible ‘pops’ and other such undesirable artifacts. It can be used after to smooth the signals received from knobs, buttons or any other non multiplexed input signal.

The smoother is available at either 1 kHz or 15kHz rate. Both Macros are already designed to pick up the necessary signals, as distributed by the Smoother Attributes Macro.

For multiplexed signals, such as those sent by a Modulation Knob panel widget, the Smooth + A/B Mod Macro should be used instead.
Smooth + A/B Mod

As the signal sent from the Modulation knobs a multiplexed signal, comprised of the main knob as well as the two modulation depth sliders, a Smooth + A/B Mod Macro should be used inside of the Process Core Cell in order to correctly demultiplex the signal, smooth, and apply modulation.

The Smooth + A/B Mod is available at either 1 kHz or 15kHz rate. Both versions are already designed to pick up the signals distributed from the A and B modulation buses, as well as the appropriate signals distributed by the Smoother Attributes Macro.

A/B Mod Q

The A/B Mod Q Macro can also be used for demultiplexing signals arriving from Modulation Knob panel elements, and applying modulation. The difference between this Macro and the Smooth + A/B Mod Macro, is that the A/B Mod Q will quantize the resulting signal into a determined number of steps. This can be particularly useful when creating modulatable parameters with only a small number of possible values, such as the length parameter of a sequencer.

The X input sets the number of steps. The *X output sends integer values ranging from 0 to X, while the 1/X output scales the final value, so that it remains within the [0, 1] range. Typically the *X output would be routed to wherever it is needed within the Core Cell, while the 1/X output should be routed back to the panel element to display modulation.

Uni 2 Bi
All signals arriving in the Process Core Cell from the various panel widgets will be unipolar, with a linear value range of [0, 1]. In some instances it may be preferable to convert these signals to a bipolar value range. These two simple Macros can be used to achieve just that.

A unipolar [0, 1] signal arriving at the input will be converted into a bipolar [-1, 1] signal at the output. The *Uni 2 Bi (lin)* module output will have a linear control shape, while the *Uni 2 Bi (Para)* module output will have a parabolic (x^2) control shape.

Both modules should be placed after any modulation or smoothing Macros, such as the *Smooth + A/B Mod*.

**OSC Tuning**

The *OSC Tuning* Macro is designed specifically to work in conjunction with the *OSC Tuning* panel widget.

In the case of the Coarse parameter, the signal should be first connected to a *Smooth + A/B Mod* Macro, in order to apply smoothing and modulation. The Fine parameter should be connected to a *Smother* Macro, before being connected to the *OSC Tuning* Core Cell.

The KTrack parameter requires no additional processing, and the input signal can be connected directly to the Core Macro.

The Pitch input accepts values in the range of [0, 1] meaning signal received from other Blocks can be connected directly, without the need for any scaling.

The *OSC Tuning* Macro has two outputs. The Pitch output provides MIDI note values, while the Freq output provides frequency values in Hertz.
4.3 Select and Distribute

Clk Select

The Clk Select Macro can be used to select between different input signals. By default it has four inputs, but more can be added or removed if needed.

The input signals are connected to latches within the Macro. A Clock signal is then sent to the latch of the desired input, allowing it to pass to the output. The sample rate clock (SR.C) is connected by default, although a different clock can be connected to the Clk input if needed.

The Sel input accepts integer values for selecting which input is to be clocked.

Clk Distro

The Clk Distro Macro can be used to distribute a clock signal between several different outputs. By default it has four outputs, but further outputs can be added or removed if needed.

In particularly complex structures, it is often preferential to distribute clocking signals only to the sections of a structure which are currently in use. By distributing the clock exclusively to where it is needed at that particular moment, structures can be made to be considerably more efficient.

By default, the Clk Distro Macro will distribute the sample rate clock (SR.C) signal. A different clock can be used by connecting it to the Clk input.
The *Sel* input accepts integer values, selecting which output to send the clock signal from.

A typical application of the *Clk Distro* Macro. In this example, the clock signal is distributed between the various different waveforms produced by an LFO. Only the shape currently selected receives a clock, while the remaining shapes are inactive, resulting in a significant increase in efficiency.
4.4 Counting

**Clk Count**

![Clk Count](image)

The *Clk Count* Macro is a simple counter, ideal for counting gate events or button presses.

![Clk Count in use](image)

A typical application of the *Clk Count* Macro. Every positive zero crossing in the signal arriving at the *Gate* input results in a value of 1 being sent from the *Int Gate* Macro output. This causes the value at the *Clk Count* output to increase by 1.

A positive zero crossing in the signal arriving at the *Reset* input results in a value of 0 being sent from the *Reset* Macro output. This causes the *Clk Count* Macro to reset to zero, and begin counting again.

**Clk Count / Wrap**

![Clk Count / Wrap](image)

The *Clk count/Wrap* Macro is similar to the *Clk Count* Macro, and both Clk and Rst inputs function in exactly the same way. The *Clk Count/Wrap* Macro however also includes a Max input.

While the *Clk Count* Macro will advance indefinitely until it receives a reset signal, the *Clk Count/Wrap* Macro will only count as far as the value provided at the Max input, after which it will return to 0 and begin counting again.
4.5 Demultiplex

**Button DMux**

The *Button DMux* is a simple demultiplexer, designed to be used in conjunction with the *Multiplex Buttons* panel widget. The signal arriving from the panel widget should be connected directly to the *Button DMux* input. The values sent by the eight buttons will then available at the eight outputs.

If additional buttons have been added to the *Multiplex Buttons* panel widget, then the *Button DMux* Macro should also be suitably modified.

**Knob DMux**

Similar to the *Button DMux* Macro, the *Knob DMux* Macro is also a simple demultiplexer, however it is designed for use in conjunction with the *Multiplex Knobs* panel widget. The signal arriving from the panel widget should be connected directly to the *Knob DMux* input. The values sent from the eight knobs will then be available at the eight outputs.
If additional buttons have been added to the *Multiplex Knobs* panel widget, then the *Knob DMux* Macro should also be suitably modified.

**Button DMux/Seq**

The *Button DMux/Seq* Macro is another type of demultiplexer, designed to be used in conjunction with the *Multiplex Buttons* panel widget. How it differs from the basic *Button DMux* Macro is that rather than simply routing each constituent button to a dedicated output, the state of each button is written to an array within the Macro.

The Idx input accepts integer values, and specifies which index of the array is to be sent to the Macro’s output. The *Button DMux/Seq* is especially suitable for making sequencers, by connecting the sequencer position to the Idx input.

If additional buttons have been added to the *Multiplex Buttons* panel widget, then the *Button DMux/Seq* Macro should also be suitably modified.

**Knob DMux/Seq**

Similar in concept to the *Button DMux/Seq* Macro, the *Knob DMux/Seq* Macro is also a demultiplexer and array Macro, but designed for use with a multiplexed float signal, specifically that provided by the *Multiplex Knobs* Macro.

As on the *Button DMux/Seq* Macro, the Idx input accepts integer values to determine which index of the array is sent to the Macro’s output. Again, this is particularly useful when making sequencers.

If additional buttons have been added to the *Multiplex Knobs* panel widget, then the *Knob DMux/Seq* Macro should also be suitably modified.
Using the **Knob DMux/Seq** Macro as part of a basic sequencer. The output from the **Multiplex Knobs** panel widget is connected to the input of the **Knob DMux/Seq** Macro. A positive zero crossing in the signal arriving at the **Gate** input is converted to a value of 1 by the **Int Gate** Macro. This will increase the output value of the **Clk Count/Wrap** Macro by 1, which in turn selects the next index value from the **Knob DMux/Seq** Macro.
4.6 Outputs

**Pitch Div**

Pitch Div

Essentially the opposite of the *Pitch Mult* Macro. The function of the *Pitch Div* Macro is to scale pitch signals back to the \([0, 1]\) range, in the case where they had been previously scaled up to standard MIDI note values.

**Display Latch**

Display Latch

The *Display Latch* Macro should be used before routing modulation signals back to the *Panel* Macro for display. The *Display Latch* is designed to pick up the display clock signal distributed within the Core Cell by the *Display Clk* distribution bus. Signals connected to the *Display Latch* are then clocked at display rate, resulting in increased efficiency.

**Display iLatch**

Display iLatch

The *Display iLatch* Macro is essentially the same as the *Display Latch* Macro, with the only difference being that while the *Display Latch* is designed for use with float signals, the *Display iLatch* Macro should be used with integer signals.