Industrial Music Electronics

HERTZ DONUT DIGITAL OSCILLATOR
PHASE DISTORTION AND FREQUENCY MODULATION SYNTHESIS

PRIMARY OSCILLATOR

PRESET 1
104 Hz
A: x1 B: /4

PDIST

EXT IN

FOLD SELECT

PRESET CV
+/-10V

SYNC
0-5V

FOLD CV
+/-10V

MOD CV
+/-10V

1V/OCT
0-8V

CV
+/-10V

FOLD

MOD

OP A

OP B

EXT

MAIN OSC FREQUENCY

OPERATOR FREQUENCY

PHASE DISTORTION

UMBRAGE

AUX

MIX

MAIN

1V/OCT
0-8V

OP A FREQ
+/-10V

OP B FREQ
+/-10V

EXT FM
AC 10VPP

OUTPUTS

MODULATION OPERATORS

INDUSTRIAL MUSIC ELECTRONICS MODEL 9791 MARK III
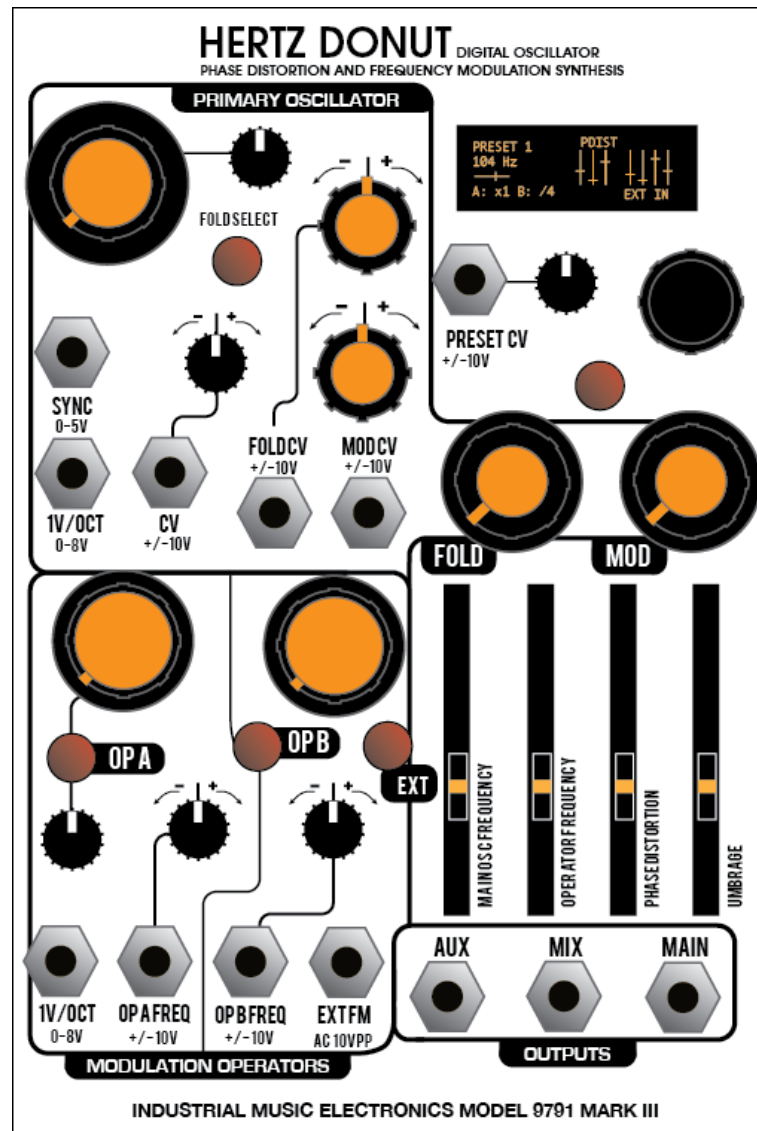
HERTZ DONUT MARK III
OPERATIONS MANUAL · FIRMWARE V1.0

FUNDAMENTALS

The Hertz Donut Mark III is a complex oscillator utilizing the finest digital sound synthesis techniques from the mid-1980s. It uses a combination of phase distortion and thru-zero frequency modulation (FM), and the synthesis algorithm provides access to an auxiliary oscillator/output as well as a simplified control for the total effect of the modulation bus. An audio input acts as a full-bandwidth source for more complicated modulations involving external devices. The unison detune function offers beautiful glass chorus voicing, and the phase distortion parameters have been chosen to provide coherent timbre warping even under heavy frequency modulation. The module contains the Mark III morphing preset manager which facilitates storage and performance of all module parameters.

GETTING STARTED

When the coarse tune is set to its minimum position and the fine tune is set to the middle position, the generated frequency will be 16.35hz (note C0) with no external voltages applied. Patching a 1 volt per octave tuned sequencer, quantizer, or keyboard voltage into this jack (such as the STILLSON HAMMER or ARGOS BLEAK) will change the oscillator's frequency to the desired note. If the control voltage is set so that C0 is equivalent to a value of 0 volts, then the note names shown on the Hertz Donut's display (and the generated frequency) will match the input voltage. Listen to the results of your patch programming at any of the jacks in the OUTPUT section. The MAIN output will contain the most straightforward example of your programming. The AUX output behavior is selectable in a menu. The MIX output is a simple analog combination of both outputs.

SCREEN SAVER

The Hertz Donut's display is an OLED. It is set to a brightness to provide the best balance between visibility and long life. To preserve the life of the OLED, it will turn off if a button or encoder is not used for 10 minutes. To turn it back on, press a button or turn the encoder.

MK III MENU SYSTEM

Most function blocks in Industrial Music Electronics modules have hidden menus associated with them. To access them, hold down the rotary encoder button and push the associated button. The menu will appear on the display. Turn the encoder to select the desired menu item. Push the encoder to select the item, and turn the encoder to change the selected item. Push the encoder button again to enter your selection. Exit the menu by pressing any of the other buttons. If a button does not have a menu associated with it, then the button press combination will usually invoke another shortcut function.

CV INPUTS

Most CV inputs on the Hertz Donut accept full-scale, bipolar control voltages with a range of +/-10v. The response of the various inputs are scaled to provide a musically useful range of motion within the typical range of +/-5V, with additional reactivity far outside of this range. The attenuverters use a nonlinear curve to allow a typical control voltage to subtly modulate a small range of the parameter, or full-swing travel without the use of external amplification.
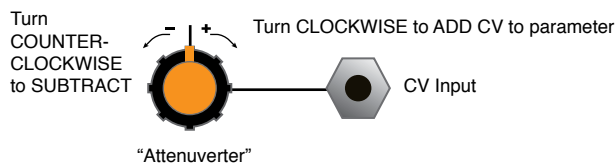
PRIMARY OSCILLATOR

The two frequency controls set the coarse and fine tuning frequencies of the oscillator. Their specific functions may be reversed in the MAIN "GLOBAL" OPTIONS menu by pressing the Encoder and EXT button, scroll down to
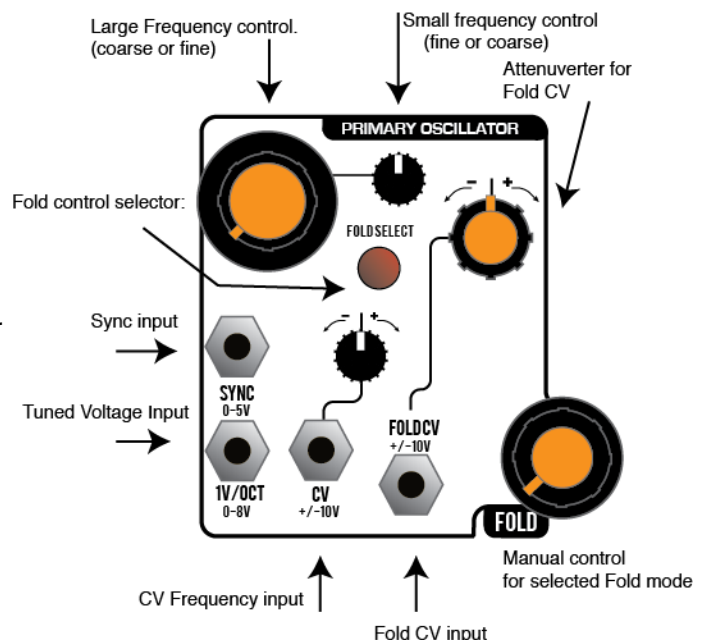
the "Freq Knob Mode" item. "Normal" assigns the large orange knob to Coarse Tune and the small knob to Fine Tune. "Reverse" assigns the large knob to Fine Tune and the small knob to Coarse Tune.

The frequency of the oscillator is set as a combination of the coarse and fine manual tuning controls, the voltage present at the "1V/Oct" and "CV" jacks, the OCTAVE SHIFT parameter (in the menu), and the loaded preset data (if ALL PARAMS is enabled.) The "CV" jack accepts a bipolar control voltage, such as a vibrato LFO. It is attenuated by the nearby "attenuverter" knob.

PHASE DISTORTION

The primary oscillator produces a sine wave with no harmonic content that is modified by the "FOLD" control to create a more complicated waveform. There are three waveform parameters that may be modified by this control. The "FOLD SELECT" button chooses which parameter is modified by the FOLD knob (the current selection is shown on the display). In the oscillator menu, the "CV Destination" parameter chooses which parameter is affected by the Fold CV input. When you change the FOLD SELECT, the current knob position for the previously selected parameter is "frozen", and you can then use the same knob to enter the value for the currently selected parameter. All three waveform parameters are stored in a preset and can be morphed continuously by the preset manager for a mode-less, 3-dimensional timbre space. The display shows a group of three "virtual sliders" in the center that communicates the current setting of all three parameters. When all three parameters are set to zero, a sine wave is produced.

The first and default FOLD setting is the Phase Distortion, shown as "PDist" on the display. This modifies the "ramp" that is used to generate the sine wave, adding breakpoints and reversals. This causes a smooth linear outgrowth of additional harmonics, reminiscent of the synthesis of simple brass instrument tones. Past the 12 o'clock position on the knob, the first harmonic in the signal becomes very strong, and creates a perceived "octave-up" effect. The restrained yet characterful nature of this parameter means that it performs with exceptional clarity even under heavy frequency modulation.

UMBRAGE

This is the second parameter of the FOLD SELECT setting. When selected, the display will read "Umbr" on the top line. It is based on the "fractal" waveform distortion from previous versions of the Hertz Donut. It causes small leaf- and branch-like structures to grow out from the slopes of the waveform. This creates a "fuzz" type of distortion with a bias towards higher frequencies, consonant with the base frequency of the waveform.
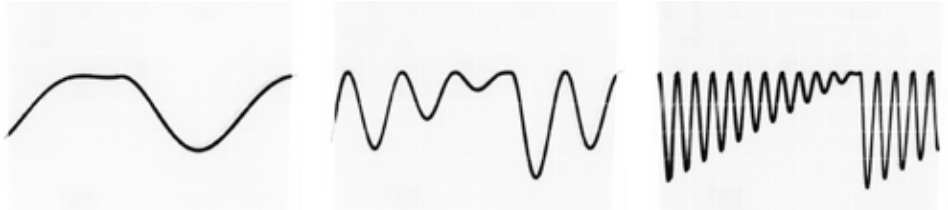
RESONANCE

This is the third parameter of the FOLD SELECT setting. When selected, the display will read "Reso" on the top line. It is inspired by the "virtual resonance" waveforms of historical Phase Distortion synthesizers. It causes a series of resonant peaks to rise throughout the waveform as the control is increased. When your original waveform is closer to a simple sine wave, the effect sounds just like a resonant filter sweep. With more complicated waveforms, the resonance effect sounds closer to classic oscillator sync sweeps. This effect is less stable under heavy frequency modulation.

OSCILLATOR MENU OPTIONS

Access the Oscillator Menu by holding down the encoder button and pressing the FOLD SELECT button.

OCTAVE

Shifts the oscillator frequency up to 2 octaves in either direction. If the Modulation operators are not set to "Free" mode, they will follow.

UNISON

The oscillator and operators may be set to a Unison mode that runs a slightly detuned copy of the oscillator alongside the original. The intervals available range from slight detune, to octaves and fifths. This parameter also adds unison to the selected signal of the AUX output.

CV DEST

This option assigns the incoming FOLD CV signal to one of the three waveform parameters.

SHORTCUTS

To increment the UNISON parameter without using the menu, hold down the encoder button and press the OP B button.

FREQUENCY MODULATION

The signature timbral evolution of the Hertz Donut is achieved by thru-zero frequency modulation. This means that the instantaneous value of an audio signal is used to modulate the frequency of the CARRIER oscillator. This causes a predictable outgrowth of sideband frequencies, determined by the relative frequencies of both carrier and modulator, compounded by any harmonic content those signals may have. Hertz Donut contains several facilities to manage the harmonic content and frequency ratios of the carrier and modulators, to expedite the creation of predictable and controllable complex modulations.

MODULATION SOURCES

Hertz Donut has three modulation sources: two operators and an external input. The operators can be thought of as simplified oscillators. They generate sine waves. By default, they are locked to the frequency of the main oscillator. The large tuning knob of each operator adjusts the frequency multiplication or division of each operator. Several ratios are available. The ratio (or note) of the modulation operators are always visible on the lower line of the display.
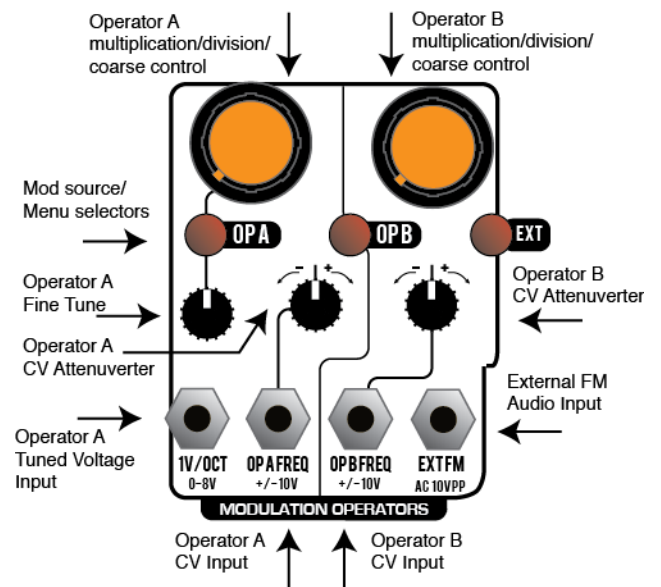
OPERATOR MENU OPTIONS

Access the Operator Menu by holding down the encoder button and pressing the OP A button. Changes to the Operator menu are stored as part of a preset. They are not global options.

A/B QUANT MENU

QUANTIZE

This is the default setting for the operator frequency mode. When enabled, this mode will set the base frequency of the operator to be equal to that of the main oscillator. The large tuning knob will manipulate the frequency multiplication or division ratio. The fine tune knob (Operator A only) allows offset of the frequency after the quantization, which manifests as "beating" in the modulation signal. The display shows the multiplication or division factor of the operator's signal.

FOLLOW

This mode is similar to Quantize, but the frequency multiplications and divisions are eliminated. The large tuning knob now adjusts the coarse frequency in a continuous manner, while the operator frequency still follows the main oscillator frequency. The display shows the approximate note number of the generated frequency.

FREE

This is similar to Follow, but the operator does not track the main oscillator frequency and is completely independent. The display shows the approximate note number of the generated frequency.

A-B LINK

This menu option causes Operator B to follow the frequency of Operator A, for easy 2-operator usage when the A/B operators are used independently of the Main Oscillator.

MODULATION OPERATOR B

Modulation Operator B is identical to Modulation Operator A, without the 1v/octave input or fine tune control.

EXTERNAL INPUT

The external input interface consists of a single jack and button. It accepts a modular-level (10 volts peak-to-peak) audio signal. When selected with the "EXT" button, the sliders route this signal through to each destination as if it were another modulation operator. This input is the key to more elaborate modulation algorithms that require more than a single point of modulation index like the internal Hertz Donut bus: simply patch your desired modulation into this input, going through a VCA.

MODULATION CONTROL

The MASTER MODULATION control manages the total level of modulation applied within the Hertz Donut. A single CV input and knob provides easy performance control of modulation amount. Try patching a snappy envelope into this input for classic FM bassline effects. If the MOD control is at zero, you will not hear any effect while changing the slider positions.

MODULATION MIXER

The four sliders on the panel represent the modulation mixer. It is a 3 * 4 matrix mixer that routes the three modulation sources to the four destinations. To use the mixer, first press the button of the modulation source you wish to select (OP A, OP B, or EXT). The LEDs on the four sliders should turn off. Now, adjust the large "MOD" knob to maximum. Adjust the sliders to add modulation to each destination. The slider's LED will light as it is changed for the first time. This means that the LED, if lit, shows that the physical slider position matches the programmed mix value for the currently selected modulation source.

Use care when manipulating the OPERATOR FREQUENCY slider when it is active on both OP A and OP B sources. Circular modulation of this type often results in unpleasant, less useful sounds. Use small amounts of OPERATOR FREQUENCY modulation for best results.
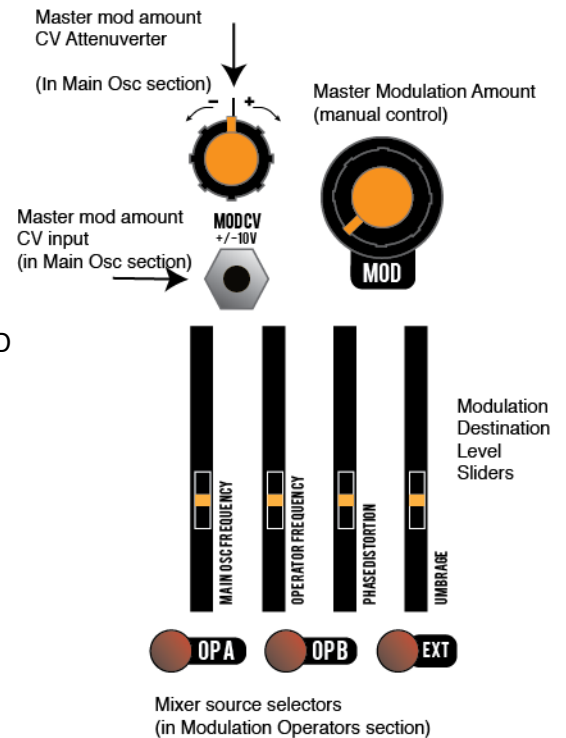
DESTINATION LIST

OP A:
Slider 1 -> Main Oscillator Frequency
Slider 2 -> Operator B Frequency
Slider 3 -> Phase Distortion amount
Slider 4 -> Umbrage amount

OP B:
Slider 1 -> Main Oscillator Frequency
Slider 2 -> Operator A Frequency
Slider 3 -> Phase Distortion amount
Slider 4 -> Umbrage amount

EXT:
Slider 1 -> Main Oscillator Frequency
Slider 2 -> Operator A Frequency
Slider 3 -> Operator B Frequency
Slider 4 -> Phase Distortion amount

AUXILIARY OUTPUT TECHNIQUES

The AUX output has a user-selectable behavior in the OPTIONS menu. You can select either operator A or B, the sum of them both, or the digital XOR of them (resulting in a harsh sound similar to ring modulation.)

DUAL OSCILLATOR SETUP

You can use the Hertz Donut as a dual oscillator by restricting your usage of certain features. Use the MAIN OSCILLATOR on its own, modulating the FOLD parameters as necessary. Do not use the MOD bus to affect the MAIN OSC FREQUENCY. Use Operator A as the second oscillator, using the FINE TUNE and 1V/OCT controls. Use the Operator menu to set Operators A and B to "Free". You can use the MOD bus to have operators A and B modulate each other in some way. When configured this way you have two tone generators with a different type of timbral modulations: Phase Modulation (on the main oscillator) and Frequency Modulation (on the Operators A/B block) each with their own output. Set the AUX OUT MODE to your desired setting. Operator A only is suggested for a "series" FM algorithm. Operator A+B gives a "parallel" algorithm. Use the "A-B LINK" option in the Operator Menu to have operator B correctly follow Operator A in this arrangement.

PARALLEL FM ALGORITHMS

Consider the AUX OUT MODE menu setting carefully. The "Op A + Op B" setting is a clean mix of the two operators. If you use this in conjunction with the MAIN OSCILLATOR set to a simple sine wave as well, the MIX output represents the sum of all three sine generators and is useful for additive synthesis. Small amounts of frequency modulation or Main Oscillator resonance are good additions to these types of sounds, which also respond very well to the Unison setting.
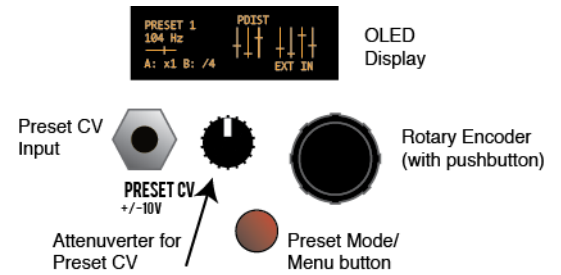
PRESET MANAGER

The Preset Manager provides an easy way to manage the entire state of the control panel and menu system from a single set of controls. Eight presets are available and they may be stored to nonvolatile memory within the Hertz Donut. To enable the Preset Manager, push the PRESET button to the immediate left of the display. It will light up red and the display will change to say "PRESET" followed by the currently selected preset number. Managed controls will be locked and set to the values stored in that preset slot. To change the preset, rotate the encoder. The settings will change according to the stored data in memory. The "Preset scope" setting in the GLOBAL OPTIONS menu will determine if all panel settings are affected by the preset change, or just the waveform selection controls. The CV input and attenuator knob just below the display also changes the active preset. The behavior of the CV and knob is defined in the GLOBAL OPTIONS menu with the CTL option.

EDITING PRESETS

To write your own data into the preset slot, press the rotary encoder button while the preset manager is active. The EDITING indicator will appear on the screen. Any controls that you move while the editing indicator is active will be written into that preset slot. Any changes you make to the oscillator menu will be written to the preset whether the EDITING indicator is present or not. To exit EDITING mode, press the rotary encoder again. IMPORTANT: You must choose "Save Presets" from the PRESET menu to write your changes to memory. They will not be stored permanently unless you do this. The "Save to Preset" command will also commit the edited data to your preset of choice.

PRESET MORPH

When in PRESET mode, press the preset button again to enter MORPH mode. All controls under the scope of the preset manager are locked and unable to move (the CV inputs will still respond). Set the "base" preset for the morph by turning the rotary encoder to select. The base preset will determine the state of unison, octave and other button/menu settings that cannot be smoothly morphed. When the base preset is changed, these menu-based settings may change depending on the preset data. . Next, apply a CV to the preset CV input. The presets will smoothly morph from one to another.

PRESET CONFIGURATION (in GLOBAL OPTIONS MENU):

Access the Global Options Menu by holding down the encoder button and pressing the EXT button.

PRESET SCOPE

This parameter controls which elements (or functions) are managed by the preset manager.
"Mod/Fold" will only change the attenuverters as well as the mod/fold controls on the main oscillator. "M/F/Ops" will change all of the above, in addition to the frequency settings of the modulation operators. If the operators are set to the "Quantize" mode, then when the preset manager is in Morph mode, there will be a hard transition to the next preset's operator frequency setting at the midpoint of the inter-preset morph. "All Params" will also control the main oscillator frequency. This is useful if you wish to use the preset slots to create a sequence of notes, or a strictly defined basic pitch for each segment of a live performance. It is less useful in Preset Morph mode if you are using this feature to constrain the oscillator settings to musically identifiable pitches, as the morph will destroy that illusion by smoothly gliding through all of the intermediate frequencies between presets.

CTL
This menu option determines the behavior of the Preset CV input and attenuator.

CV+OFFSET
Allows the CV input to directly cycle through the bank of 8 presets. The attenuator knob will act as a manual offset. This is useful if you need a manual control to smoothly morph the preset data in Morph mode.

CV+ATTEN
Works like CV+Offset, but the knob becomes an attenuator for the incoming CV. This mode is useful for changing presets within a strictly controlled range, or subtly morphing within a narrow range of preset data.

TRIG + OFFSET
Treats the CV input as a trigger input instead. When a trigger or gate event is received, it will advance the preset number by one. The attenuator knob will manually scan through the presets.

TRIG RANDOM
Randomizes all parameters subject to Preset Scope when a trigger event is received at the CV input. Note that random patch results must be written to memory using the PRESET menu's "Save Presets" command for permanent storage of these changes.

STARTUP:
This menu item allows you to enable the preset manager when the modular system is powered on. You may choose to leave PRESET OFF or select either PRESET or MORPH mode ON. This parameter is used when you have several Mark III modules in a live performance setup, to avoid setting the preset state on each one at startup.

PRESET MENU

Access the Preset Menu by holding down the encoder button and pressing the button closest to the display.

RANDOMIZE CURRENT
When selected, the random preset generator will create a new sound setting. The parameters to be changed are subject to the "Preset Scope" setting. This function works even if Preset Mode is not active. NOTE: Randomized presets are NOT automatically saved to memory. You must use the "Save Presets" or "Save to Preset" menu command to write the data to memory.

SAVE TO PRESET
If you are designing a sound and modulation setup and want to save it to the preset memory, choose this menu option. You must select the preset slot number to activate the save. This feature also works if the preset manager isn't active. The preset will automatically be stored in nonvolatile memory.

SAVE PRESETS
This option writes the current state of all preset slots to nonvolatile memory. Presets are stored on a nonremovable EEPROM inside the module, and will survive firmware upgrades.

Note: This will overwrite all of the preset memory with the new data, so subsequent uses of the "Reload Presets" command will recall that data instead of what was there before.

RELOAD PRESETS
This option reloads the saved memory contents of the Preset Manager to active memory. Use this if you have mistakenly initialized or randomized saved data that you would like to keep. Note: You cannot reload presets after initiating "Save Presets."

INIT ALL PRESETS
Initializes all preset slots and replaces the data with a simple sound. This function does not automatically clear the saved data in memory. You must use the "Save Presets" command to make your changes permanent.

INIT CURRENT:
Initializes the currently playing sound and replaces it with a simple sound This function works even if the Preset Manager is not active.

Note: After initializing the current preset, the frequency of the main oscillator will be set to the minimum (14 hz). Adjust the frequency controls to hear an audible signal once again.

UPGRADING FIRMWARE:

You will need an inexpensive "Pickit3" programmer device and a computer with a USB connection to install any available upgrades for this module. You may download new firmware and detailed upgrade instructions from http://www.industrialmusicelectronics.com on the relevant product page. Note that upgrading the firmware will not disturb your presets or user settings.
The Pickit3 is available from your local electronics distributor, Microchip part number PG164130. The new Pickit4 programmer will also work, part number PG164140.

TEST AND CALIBRATION:

Your oscillator comes from the factory with a fresh calibration job. It may need periodic adjustment, especially when placed into a permanent configuration with other oscillators and CV sources - calibrate your module so it is in tune with the rest of your setup.

1. Prepare two control voltages measuring exactly 1V and 7V.
2. Turn the coarse tune on the Main Oscillator to the minimum position, and turn the fine tune control to center position.
3. Insert the 1V voltage into the Main Oscillator CV input (1v/oct), and adjust the oscillator's fine tune until the tuning display is entered on note C1.
4. Replace the 1V input voltage with 7V. Adjust the trimmer on the rear of the module (labeled OSC1SCALE) until the display is centered on note C7.

Repeat steps 3 and 4 until no further adjustment is needed.
The second calibration is for Operator A's 1v/oct CV input. You will need to use a tuner.

1. Prepare two control voltages measuring exactly 1V and 7V. Plug your tuner into the AUX output.
2. Use the OPTIONS menu to assign Operator A to the AUX OUT.
3. Use the OPERATOR MENU to change Operator A to Free mode.
4. Turn the coarse tune on Operator A to the minimum position, and turn the fine tune control to center position

5. Insert the 1V voltage into the Operator A CV input (1v/oct), and adjust the oscillator's fine tune until the tuner displays note C1.
6. Replace the 1V input voltage with 7V. Adjust the trimmer on the rear of the module (labeled OSC2SCALE) until the tuner displays note C7.

Repeat steps 5 and 6 until no further adjustment is needed.

FACTORY RESET:

To perform a factory reset, make sure that NO patch cables are plugged into the module. Turn the module on while holding the Preset Mode button. The menu settings, CV input calibrations, and preset data will be reset.

MORE INFORMATION:

Find the latest firmware, waveforms, and other information:
http://www.industrialmusicelectronics.com/products/22

Need more help?
 Write to support@industrialmusicelectronics.com.