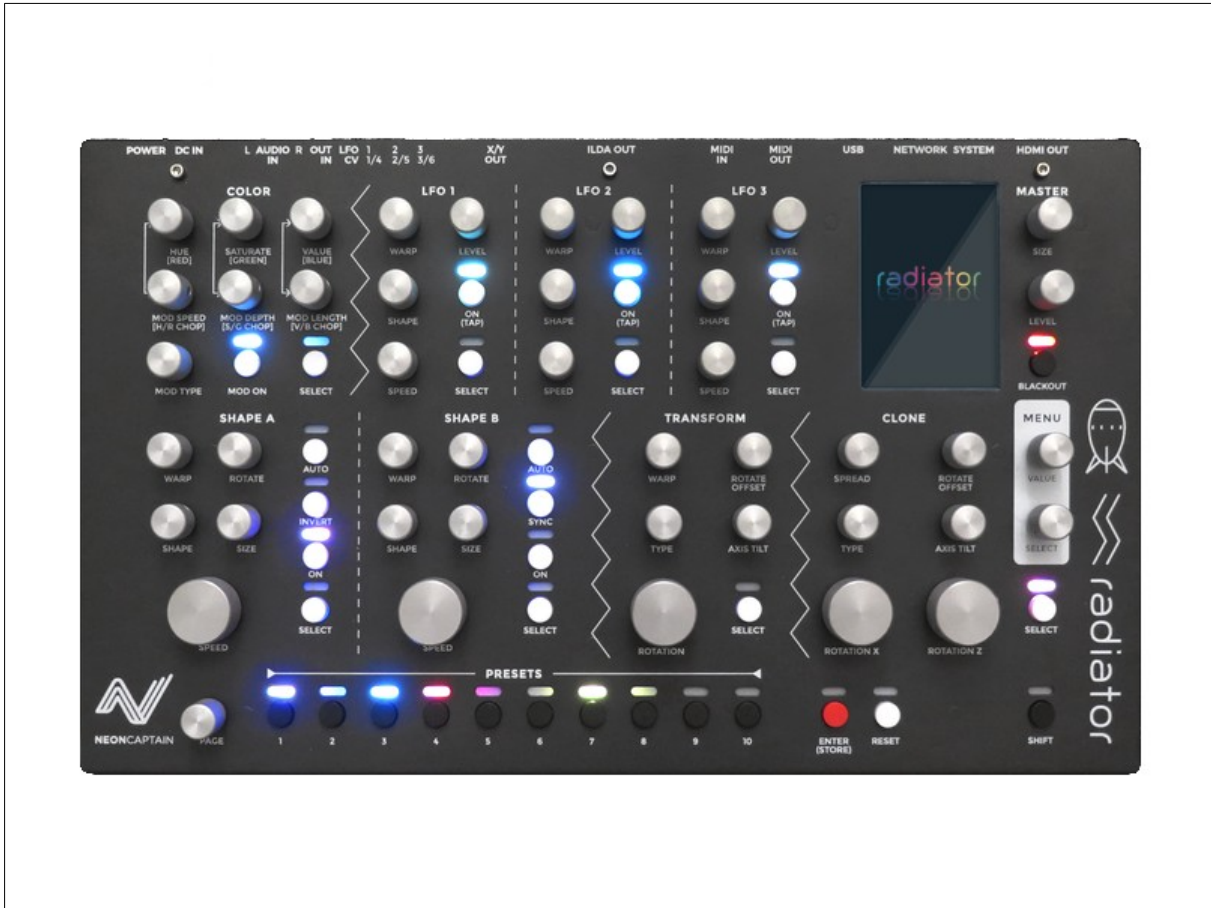# Introduction

Thank you for purchasing Radiator by Neon Captain! Radiator is a powerful and expandable laser synthesizer capable of creating dynamic abstract and beam patterns. It contains a built-in high-performance processor which works as a complete stand-alone system and requires no computer or equipment other than a laser projector or HDMI monitor to operate.

The system is expandable through software updates to add additional content and features. Please check with Neon Captain for updates. Content you create in the form of presets or ILDA stream recordings can be backed up to external USB memory. You can store up to 1000 presets in a show and access them at the touch of a button so you can always have interesting content on-hand or store your unique discoveries for later use.

In addition to being a powerful laser synthesizer, Radiator can also create laser-like visuals using the internal real-time laser raster engine which creates a laser simulation and outputs an HD resolution video signal over HDMI. Use this for live performances where it is not practical or legal to use a laser projector, or for video production via the use of an HDMI recorder or capture card.

The complete set of front-panel controls offers direct knob-per-function control of most parameters in the system so you can play Radiator live just like a DJ controller or electronic instrument. In addition to the front panel controls, all functions of the system can be controlled via MIDI from a computer, keyboard or sequencer. Both the panel controls as well as internal parameters can be controlled. The panel protocol can also be controlled via Ethernet. Please contact Neon Captain for more information.

Table of Contents

Hardware Overview

System

The Radiator is a stand-alone laser synthesizer system housed in a sturdy aluminum enclosure. It is based around a powerful quad-core ARM System-on-Module running the Linux operating system. The system requires 12-24VDC regulated input to operated and consumes less than 6W when operating. It can provide power to up to two connected USB devices. Power is controlled via a hard power switch so there is no power usage when the unit is switched off.

Front Panel

The front panel is divided into sections in the same way that internal laser processing blocks are organized. Each block will be explained in more detail later in this document.
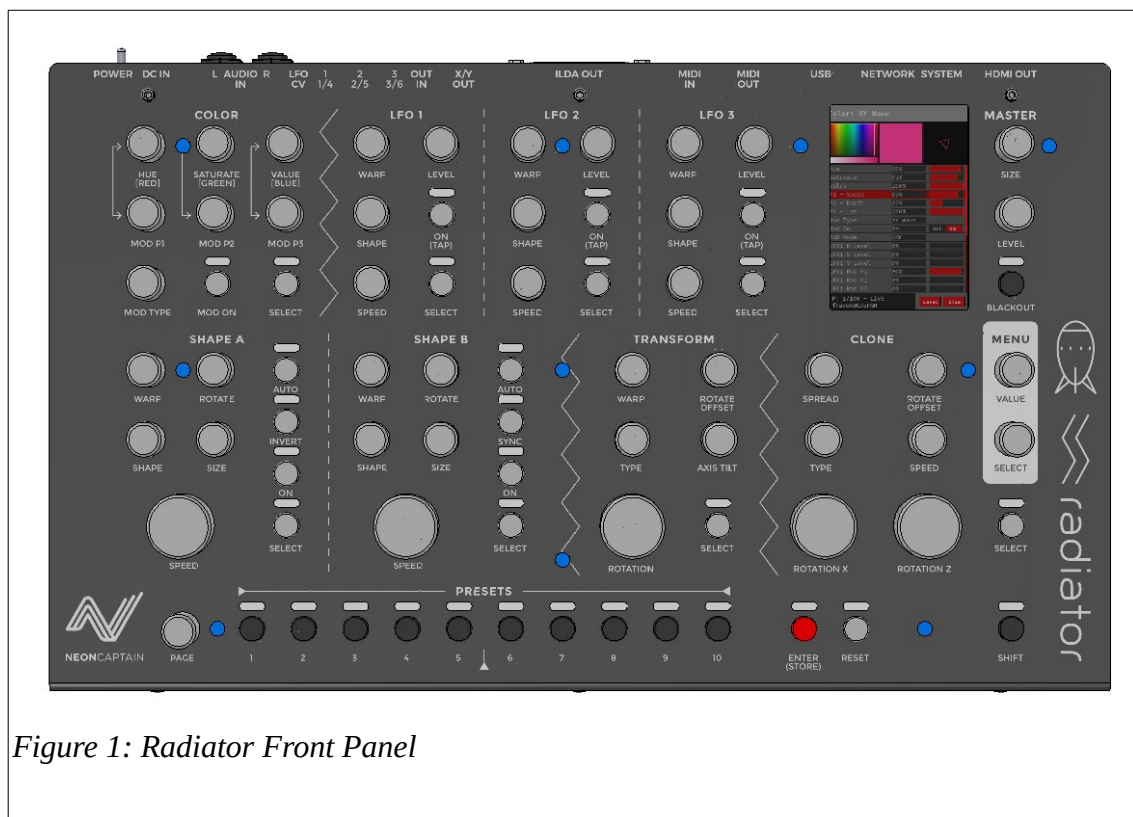

Figure 1: Radiator Front Panel

Control Panel Sections

- **COLOR** – Controls the color processor module which generates the final output color
- **LFO1, 2 and 3** – Three LFOs generate signals to modulate other parameters in real-time.
- **MASTER** – Hard control of the size and output power level as well as a blackout control.
- **SHAPE A** – Controls the main shape generator to create shapes.
- **SHAPE B** – Controls the second shape generate to create shapes.
- **TRANSFORM** – The transform module can distort and transform shapes in 2D and 3D.
- **CLONE** – The clone module can replicate and animate shapes as well as perform 3D rotations.
- **MENU** – These controls are used to navigate menus on the internal LCD screen.
- **PRESETS** – Preset buttons are used to call up and store presets.

Rear Panel

Figure 2: Radiator Rear Panel

Rear Panel Jacks and Controls

- **POWER** – Main power switch. Make sure to shut down the system before turning off.
- **DC IN** – Power input for 12-24VDC. Please only use the included power supply.
- **AUDIO IN** (L and R) – Audio inputs on 1/4" TRS connections for sound-reactive effects.
- **LFO OUT** (1, 2 and 3) – LFO CV outputs on TS minijacks. Output range is -5V to +5V.
- **CV IN** (1-6) – CV inputs on TRS minijacks used to for LFO control and ILDA input.
- **X/Y OUT** – The laser X/Y output on TRS stereo minijack for listening to the laser output.
- **ILDA OUT** – ILDA analog output on DB-25 pin connector for use with ILDA projectors.
- **MIDI IN** – MIDI input on standard 5-pin DIN jack.
- **MIDI OUT** – MIDI output on standard 5-pin DIN jack.
- **USB** – Dual USB host ports. Use for USB storage and LaserDock/LaserCube only.
- **NETWORK** – 10/100BASE-T Ethernet port for Ether Dream support.
- **SYSTEM** – Micro-USB device port for system upgrade or restore.
- **HDMI OUT** – HDMI full-size output port for laser visualizations. Outputs 1080p60 signal.

System Operation

Radiator is easy to use due to its unified control layout. Except for the master LEVEL and SIZE controls, all rotary controls on Radiator use endless encoders. This means that any parameter can be adjusted up or down from its current value. Since there are no end-stops, on-screen displays are used to view the value of each parameter as it is controlled. Both continuously variable parameters like levels, as well as indexed parameters like lists of shapes or effects use the same type of controls.

Pushbuttons are used for momentary or on/off settings. Each button has a full RGB LED located above it which shines through an opening above the button cap. As presets are changed these LEDs indicate the current setting of each button control. Preset buttons show the preset color or black if no preset is stored on the button. The last-recalled preset is also indicated by the preset button flashing.

All parameters including those which have a dedicated control on the front panel can be edited on the LCD screen using the master controls. This allows easier access to some settings. The SELECT and VALUE knobs are used to navigate the menu and change values. By default, adjusting a control will cause the LCD screen to display the parameters for that module. A module can also be called up by preset the SELECT button for that module. If you prefer the adjust the controls without the screen display changing, this function can be turned off in the Util menu.

Some operations in the screens require confirmation, such as loading or deleting a file. For these operations the ENTER button is used to confirm the action. Settings can be selectively reset by using the RESET button as explained later. Finally the SHIFT button can be held down to allow fine control of a function. It can also be used to exit a menu or screen by double-tapping.

Starting up and Shutting Down

To start up Radiator just flip on the power switch at the rear. The system will start up in less than a minute or so. For safety it is recommended to turn down the LEVEL and SIZE knobs to make sure that the laser output does not emit in an unsafe way upon startup. Radiator will always start up in the Blackout mode. To activate laser output, press the BLACKOUT button. You might want to start with the LEVEL and SIZE controls reduced as well to make sure you project in a safe area.

When you are finished using Radiator choose the Shutdown option from the main screen and wait until the system shuts down before switching off the power.

Laser Safety

Laser safety is important for everyone. Safe use of entertainment lasers will ensure that they continue to be legal to own and operate. The major safety hazard of entertainment lasers is eye damage. Even a small laser projector of only a few tens of milliwatts can generate enough concentrated laser energy to permanently damage the eyesight of a human or animal. For more detailed information about laser safety we recommend that you contact the International Laser Display Association (ILDA) at www.ilda.com. The ILDA is a trade organization made up of both amateur and professional laserists and laser companies and works to promote laser safety. This manual should not be used as official safety instructions and Neon Captain is not responsible for your use of our products. Contact ILDA or consult with a trained laser safety expert if you are not sure. We cannot provide advice on safety or legal aspects of using lasers in your country or region. However, the following are some good common-sense tips that we use when operate lasers.

Non-exhaustive list of safety tips:

- Never allow humans or animals to be in the direct path of a laser beam.

- Do not look directly into a laser projector or at the beam reflected off a shiny object like a mirror.

- When setting up a projector in a live performance environment make sure that the laser beam will never be less than 10 feet above the floor.

- Never direct laser beams into an audience. (audience scanning) This requires engineering calculations and approvals and tightly controlled lasers. Radiator is not intended or suitable for use as a controller in this type of situation.

- If you are unsure whether lasers would be safe to use in a particular situation, consider using the HDMI output from Radiator and projecting from a video projector instead.

Prolonging the Life of your Projector

WARNING: Radiator is capable of outputting signals with amplitudes and frequencies that may damage some projectors. This is usually caused by the scanning systems (galvos) mechanically breaking or burning out. Neon Captain cannot be held responsible for projector damage.

More info: Certain types of laser patterns may cause permanent damage to your laser hardware. Squealing or whining noises from your laser projector or distorted shapes indicate that your laser's scanner system is being over-driven. Think of it like a loudspeaker playing too hard. It might work for a while but eventually something will overheat or mechanically fail. The best way to avoid damage is to turn down the SIZE control and reduce the frequency of shape generators to put less stress on the scanners in your projector.

Synthesizer Signal Path

The heart of Radiator is of course the synthesizer blocks that make up the system. These each serve a unique function and are wired together internally in a specific way. Some routing options can be changed but the overall signal path is fixed by design.

Signals generally flow in the following way:

> **Shape Generators → Transformer → Clone → Color → Master**

Several modules such as the Transformer and Clone allow for different combinations of inputs, so it is possible for instance to pass one shape generator through the transformer while the second shape generator goes directly into the clone section.

The LFOs are the most flexible modules and can not only feed into each other, but can feed their signals into almost any variable control in any other module. You can choose as many simultaneous destinations you wish, making for incredible modulation capabilities.

Creating and Exploring

The best way to get started learning about Radiator is to just explore each module. Start off with a clean slate by holding SHIFT and pressing RESET. This restores all controls to their defaults. Turn on the SHAPE A module and get something simple coming out of the laser output. Adjust the COLOR controls. Now turn on SHAPE B and adjust the frequency to make some cycloid or Lissajous patterns. Once you have something interesting try adjusting the other controls and see what happens. All presets in Radiator are made by building things up from basic elements.

Saving your Work

There is no need to explicitly save your work in Radiator. As you make changes the current state of the system is automatically stored. When starting up the system all settings you had in use previously are restored and the currently used show file is loaded automatically.

Read-only Files

It is possible to lock a file so that presets cannot be written to it by accident. This is useful in a live show situations where you want to preserve your presets in a particular order. When the current show is set as read-only it will not be possible to activate preset storage via the front panel or perform store operations via the preset screen.

How Shows and Live Presets Work

When adjusting controls, all settings are always saved to disk automatically. This means that shutting down and restarting Radiator will always bring back the current state of the system. When editing the live preset, changes are stored to a special file so that the current state can be retained between power ons. Show files are used to store presets. The only actions that affect show files are storing or clearing a preset itself. Live changes to an existing preset are not stored unless you choose to write over the existing preset slot.

Importing and Exporting Data

Keeping your data safe is important. Radiator uses reliable eMMC memory internally to store the operating system, software and your settings. However hardware or software failure may cause the data to become lost. Therefore we recommend exporting your show data regularly to an external USB memory stick. Neon Captain will help you with hardware problems but we are not liable for data loss or recovery. Please use the USB Storage menu within the File screen to export your important data.

Updating the System

Radiator has a built-in update system which can update most of the core radiator components without any need to download or manually install anything. Bug fixes and feature enhancements can be updated through this system. To perform an update, power down the Radiator and make sure it is connected to an Ethernet connection which has access to the internet. A spare port on your router or LAN should work fine. Make sure DHCP is enabled on your network.

After booting up, go to the Util menu and scroll down to the System Version option. This will show the current version that is updated. Press ENTER to start the update process. Some status messages will be displayed on the Update button. Please do not operate Radiator while this process is happening. It could take 5-10 minutes or longer to perform a full update so please leave the system powered and connected.

Possible outcomes:

- The status area beside the System Version option changes back to "Update" - No new updates are available.

- The status area beside the System Version option displays "NET ERR" - There was a problem connecting to the Internet or the update server.

- The system reboots automatically - The update was installed successfully.

Special Key Functions

It is possible to perform some handy shortcuts through the use of special key combinations. These are as follows:

- **Select a module on the LCD** - Press the SELECT button for a module to bring up its controls on the LCD screen. When Follow Control mode is turned on in the Util menu, touching any control on a module will cause the screen display to select the module automatically.

- **Exit a Screen Display** - To exit any screen and go back to the main screen double-tap SHIFT.

- **Fine-tune a control** – Hold SHIFT and turn a control to adjust it with finer resolution. This can be particularly useful for frequencies of shape and LFO generators.

- **Assign an LFO destination** – Hold an LFO select button and turn the control on another module to assign the LFO. Adjusting the control affects the LFO depth into this control.

- **Store a preset** – Hold SHIFT and press STORE to arm the presets for storing. Select the page you wish to use and tap the preset button where the preset should be stored.

- **Adjust which modules are stored in a preset** – It is possible to store only some modules in a preset. After arming to store, hold SHIFT and press module SELECT buttons to choose which modules are stored.

- **Display the Preset screen when *Follow Control* mode is off** – Hold SHIFT while turning the PAGE knob to bring up the preset screen.

- **Reset a module** – Hold RESET and press a module SELECT button to reset the module to the default settings.

- **Reset a single control** – Hold RESET and turn a control to reset it to the default settings.

- **Reset the shape autorotate phase** – Reset the single control or turn off Autorotate twice using the shape screen.

- **Reset all LFO inputs on a module** – Select a module and then hold RESET and tap the LFO SELECT button to reset inputs from that LFO to the selected module.

- **Reset the entire preset** – Hold SHIFT and press RESET to reset all modules to default settings.

Radiator Modules and Screens

This section covers each of the modules in Radiator in more detail. This includes a description of all functions and how you might use them in your designs. Common to all module screen is the integrated output preview display in the top right corner. This shows the master output display prior to the SIZE, LEVEL and BLACKOUT controls being applied. Module screens display custom information in the top left section of the screen. This is usually a preview of the particular effect or output they are generating.

Screen Sections

On most screen displays the user interface is laid out in a consistent manner as follows:

- **Top Bar** - Name of the current screen and possibly other information.
- **Preview Bar** - Preview of the current module mode as well as a small output preview.
- **Menu** - Options and controls for the currently selected module or screen.
- **Status Bar** - Shows the currently loaded show, preset number, and master size/level knobs.

General Screen Navigation

Screens are navigated and controlled using the controls in the bottom right corner of the Radiator panel. Parameters with dedicated controls will respond to those at all times, but every parameter and setting can also be adjusted using the screen navigation controls.

- **SELECT** - This knob moves through menu options.

- **VALUE** - This knob adjusts the value of the currently selected parameter. In some modes the Value knob will adjust the currently selected action.

- **ENTER** - This button will confirm the selected action.

- **SHIFT** - Double-tapping SHIFT will back out of certain modes.

Color
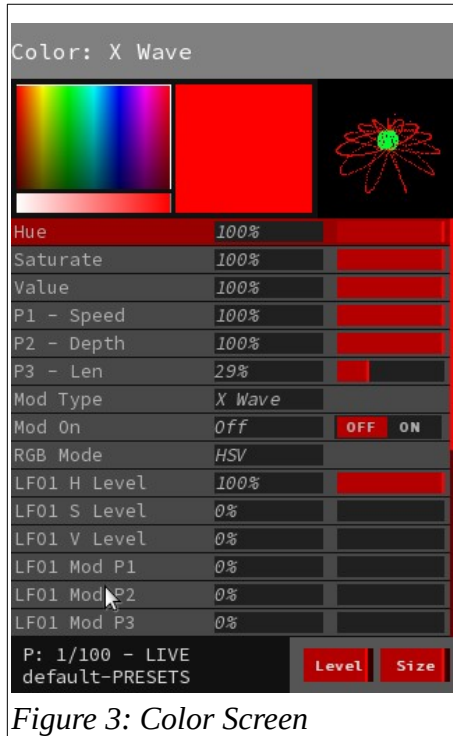
Figure 3: Color Screen

The Color screen is used to add color to shapes. It is the last module in the signal path before it reaches the master section. Color can be taken either from the shape generators themselves if the original shapes contain color, or a unique color can be generated using either RGB or HSV color mixing. A number of color "mod" effects can be used to alter the selected color. The top left of the color screen shows a color picker and preview of the selected color. Color mod types are listed in Appendix C.

Color Selection

Unless the mod type is selected to use the original color from a shape generator, the color selected by using the HSV or RGB controls. It is possible to mix colors using either an HSV or RGB colorspace. By using LFOs and the mod effects the basic chosen color can be modified to create multi-color effects. By selecting the mod types which support original color input from the shape generators, it is possible to use the original color from a selected shape.

Mod Types

To allow more variations of color than just using the LFO inputs, the mod types apply complex color manipulation to the chosen color signal. Some mod types also pass through the original shape colors as well. Since each mod effect has different types of controls the mod P1, 2 and 3 controls will change names in the menu to reflect the available parameters for each mod type.

Color Parameters

Parameter	Description
Hue / Red	Adjusts the hue (red) level.
Saturate / Green	Adjusts the saturation (green) level.
Value / Blue	Adjusts the value (blue) level.
P1	Adjusts the mod P1 parameter.
P2	Adjusts the mod P2 parameter.
P3	Adjusts the mod P3 parameter.
Mod Type	Selects the mod type.
Mod On	Turns the mod effect on and off.
RGB Mode	Switches between RGB and HSV modes.
LFO1 H/R Level	Adjusts the LFO1 to hue / red level.
LFO1 S/G Level	Adjusts the LFO1 to saturation / green level.
LFO1 V/B Level	Adjusts the LFO1 to value / blue level.
LFO1 Mod P1	Adjusts the LFO1 to mod P1 level.
LFO1 Mod P2	Adjusts the LFO1 to mod P2 level.
LFO1 Mod P3	Adjusts the LFO1 to mod P3 level.
LFO2 H/R Level	Adjusts the LFO2 to hue / red level.
LFO2 S/G Level	Adjusts the LFO2 to saturation / green level.
LFO2 V/B Level	Adjusts the LFO2 to value / blue level.
LFO2 Mod P1	Adjusts the LFO2 to mod P1 level.
LFO2 Mod P2	Adjusts the LFO2 to mod P2 level.
LFO2 Mod P3	Adjusts the LFO2 to mod P3 level.

LFO3 H/R Level	Adjusts the LFO3 to hue / red level.
LFO3 S/G Level	Adjusts the LFO3 to saturation / green level.
LFO3 V/B Level	Adjusts the LFO3 to value / blue level.
LFO3 Mod P1	Adjusts the LFO3 to mod P1 level.
LFO3 Mod P2	Adjusts the LFO3 to mod P2 level.
LFO3 Mod P3	Adjusts the LFO3 to mod P3 level.

LFO1, 2 and 3
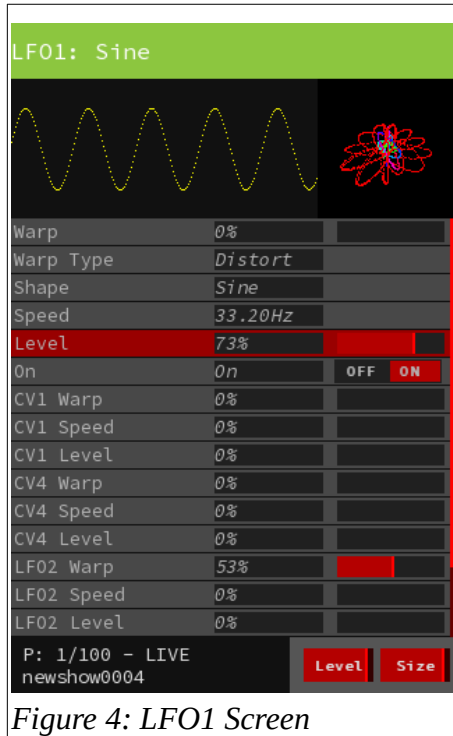
Figure 4: LFO1 Screen

The LFOs enable you to generate modulation signals to be used elsewhere in the system. You can generate signals from a number of built-in waveforms or you can input your own signals using the external CV jacks. This lets you use an analog or modular synthesizer to either control the level and speed of the LFOs, or bypass the internal waveforms completely and use your own modulation voltages to modulate parameters within Radiator. The top left section of the LFO screen shows an oscilloscope view of the currently generated waveform. The sweep speed of the waveform is adjusted automatically. Note that very low amplitude signals may not trigger the scope consistently. Available shapes and warp types are listed in Appendix D.

Note: CV and LFO inputs depend on the LFO module in use. The table below uses "x" and "y" to represent the two possible CV and LFO inputs for each LFO.

Warp Types

Warp types allow the basic waveform to be modified through various linear and non-linear transformations. The LFO warp modes also enough audio control of the LFO from the audio inputs.

LFO Parameters

Parameter	Description
Warp	Adjusts the amount of warp effect applied to the signal.
Warp Type	Selects the warp type.
Shape	Selects the LFO waveform shape.
Speed	Adjusts the LFO frequency.
Level	Adjusts the LFO output level.
On	Turns on and off the LFO.
CVx Warp	Control the warp level with the CV tip signal.
CVx Speed	Control the speed with the CV tip signal.
CVx Level	Control the level with the CV tip signal.
CVy Warp	Control the warp level with the CV ring signal.
CVy Speed	Control the speed with the CV ring signal.
CVy Level	Control the level with the CV ring signal.
LFOx Warp	Control the warp level from another LFO input.
LFOx Speed	Control the speed from another LFO input.
LFOx Level	Control the level from another LFO input.
LFOy Warp	Control the warp level from another LFO input.
LFOy Speed	Control the speed from another LFO input.
LFOy Level	Control the level from another LFO input.

CV Inputs

There are six CV inputs in Radiator. These are input on three stereo 3.5mm minijacks. The signals are input as CV1/4, 2/5 and 3/6. The connections are as follows:

CV Input	Tip Signal	Ring Signal	LFO
CV1/4	CV1	CV4	1
CV2/5	CV2	CV5	2
CV3/6	CV3	CV6	3

The CV inputs are hard-wired to LFOs as shown above. Normally if you are using mono minijacks the tip signal can be used. If you want multiple control over the LFO you can use a stereo cable possibly with a dual mono to stereo adapter to allow two CV signals to be input at once.

Mapping of CV Input Signals

When using built-in LFO waveforms, the CV tip and ring signals can be used to modulate the oscillator speed, warp and level controls. When using the LFO input as an external waveform input the tip signal is always used as the signal source.

ILDA Input

It is possible to use the CV input jacks for ILDA input. This allows Radiator to input content from an external ILDA source like a PC with DAC or another Radiator and process it within Radiator. ILDA signals are input on the Shape generators. Neon Captain offers a special ILDA DB-25 to triple minijack cable that can be used to input the signals. The mapping of signals from ILDA to CV are shown below.

CV Input	Signal	Voltage Level
CV1	ILDA X+	-5.0V to +5.0V
CV2	ILDA I+	-2.5V to +2.5V
CV3	ILDA G+	-2.5V to +2.5V
CV4	ILDA Y+	-5.0V to +5.0V
CV5	ILDA R+	-2.5V to +2.5V
CV6	ILDA B+	-2.5V to +2.5V

LFO Outputs

The signal generated by each LFO is available as a dedicated 3.5mm minijack output from Radiator. This can be used to drive external synthesizers or analog gear. The maximum output level is 10Vpp (+/- 5V and the output impedance is 1K. The signal is exactly the same waveform that is applied to the internal modulation matrix. Each LFO has a dedicated output jack which is always active.

Audio Inputs

The LFO can be driven by audio signals input on the two 1/4" audio input jacks. The audio controls are mapped via the warp functions, and some of the warp types modify the LFO signal in response to audio inputs. Audio inputs are hard-wired to the three LFOs as follows:

- **LFO1**   - audio in L and R
- **LFO2**   - audio in L
- **LFO3**   - audio in R

Shape A and B
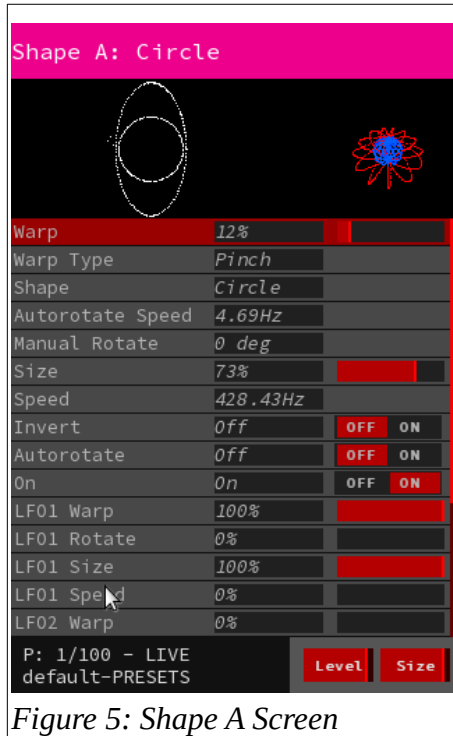
Figure 5: Shape A Screen

Shape generators form the basis of most laser output created by Radiator. Although it is possible generate output signal directly from LFOs, most effects start with one or more of the shape generators. There are many built-in shapes to choose from ranging from simple geometric shape to very complex shapes complete with animation. The top left section of the shape screens show the currently output shape. This will include any color information from the shape. Shape warp and shape types are listed in Appendix E.

Shape Types

The shape generator system outputs 3D data plus RGB color information. It is possible to have 3D shapes with depth that becomes visible when the shape is tilted or rotated using the Transformer or Clone module. The speed of a shape playback is set via the Speed knob. The quality of the final output as well as how the shape interacts with other effects is determined by the speed of playback. It is recommended to use a speed between 30Hz and 60Hz to start with. High speed playback can put more stress on your laser projector and also reduce the detail and resolution of the final projected image.

Shape Rotation

Shapes can be internally rotated using a built-in autorotation oscillator. Both clockwise and counter-clockwise rotation directions can be selected. A manual rotation position can also be selected to allow a static shape to be position in a certain orientation.

Inversion and Sync Modes

The Shape A generator allows the shape playback to be inverted. This can be used, for instance, to switch between generating Lissajous and cycloid patterns with basic circle shapes. You may also find other uses for this especially when mixing Shape A and Shape B outputs together.

The Shape B generator has a Sync mode which causes the speed of Shape B to be tied to Shape A speed. Using the Sync mode simplifies finding harmonic relationships between Shape A and Shape B.

Shape Parameters

Parameter	Description
Warp	Adjusts the amount of warp effect applied to the signal.
Warp Type	Selects the warp type.
Shape	Selects the shape.
Autorotate Speed	Adjusts the autorotation speed.
Manual Rotate	Adjusts the manual rotation offset.
Size	Adjusts the shape size.
Speed	Adjusts the shape drawing speed.
Invert (Shape A only)	Inverts the drawing direction.
Sync (Shape B only)	Syncs the speed of Shape B to a multiple of Shape A.
Autorotate	Turns on and off the autorotation mode.
On	Turns on and off the shape generator.
LFO1 Warp	Adjusts the LFO1 to warp level.
LFO1 Rotate	Adjusts the LFO1 to rotate level.
LFO1 Size	Adjusts the LFO1 to size level.
LFO1 Speed	Adjusts the LFO1 to speed level.
LFO2 Warp	Adjusts the LFO2 to warp level.

LFO2 Rotate	Adjusts the LFO2 to rotate level.
LFO2 Size	Adjusts the LFO2 to size level.
LFO2 Speed	Adjusts the LFO2 to speed level.
LFO3 Warp	Adjusts the LFO3 to warp level.
LFO3 Rotate	Adjusts the LFO3 to rotate level.
LFO3 Size	Adjusts the LFO3 to size level.
LFO3 Speed	Adjusts the LFO3 to speed level.

Transformer
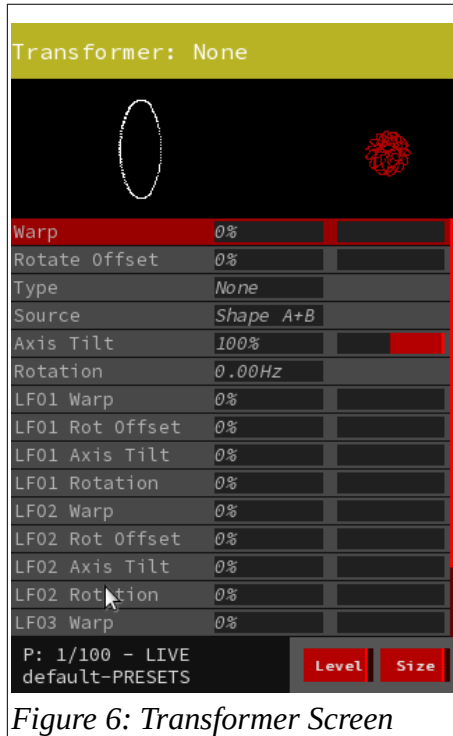
Figure 6: Transformer Screen

The transformer is used to process the output from one or both shape generators. Warp effects act on the X, Y and Z channels of the shape generators. The rotation and axis tilt controls allow 3D manipulation of the shapes. The top left section of the screen displays the processed output form the Transformer. Transform types are listed in Appendix F.

Warp Types

The warp mode allows the X, Y and Z channels from the shape generators to be processed in unique and interesting ways. By setting the Source control to None, it is possible to generate shapes directly with the Transformer by using LFOs to drive the various controls. Warp types can be used to change the frequency response of the shape waveforms, add 3D effects, quantize and distort the images, and so on.

Axis Tilt and Rotation

The Axis Tilt and Rotation controls allow the output from the Transformer to be spun along different

axis. The rotation control affects rotation of the overall Transformer output. The Axis Tilt control moves the axis of rotation so it can be seen from different perspectives.

Transformer Source

The transformer source is used to select which sources are used for transforming. You can select one or both shape generators, or none. In the None mode it is possible to generate patterns using LFOs and other techniques. Please note that the source chosen affects how shape blanking is processed. Shape A is used for blanking in all cases unless only Shape B is selected. Source selections are as follows:

- **ShA+B** - Shape A and B added together
- **ShA** - Shape A
- **ShB** - Shape B
- **None** - No input

Transformer Parameters

Parameter	Description
Warp	Adjusts the amount of warp affect applied.
Rotate Offset	Adjusts the offset center of rotation.
Type	Selects the tranform type.
Source	Selects the source of input for the transformer.
Axis Tilt	Adjusts the amount of axis tilt for the rotation effect.
Rotation	Adjusts the rotation speed.
LFO1 Warp	Adjusts the LFO1 to warp level.
LFO1 Rot Offset	Adjusts the LFO1 to rotate offset level.
LFO1 Axis Tilt	Adjusts the LFO1 to axis tilt level.
LFO1 Rotation	Adjusts the LFO1 to rotation level.
LFO2 Warp	Adjusts the LFO2 to warp level.
LFO2 Rot Offset	Adjusts the LFO2 to rotate offset level.
LFO2 Axis Tilt	Adjusts the LFO2 to axis tilt level.
LFO2 Rotation	Adjusts the LFO2 to rotation level.
LFO3 Warp	Adjusts the LFO3 to warp level.

LFO3 Rot Offset	Adjusts the LFO3 to rotate offset level.
LFO3 Axis Tilt	Adjusts the LFO3 to axis tilt level.
LFO3 Rotation	Adjusts the LFO3 to rotation level.

Clone

Figure 7: Clone Screen
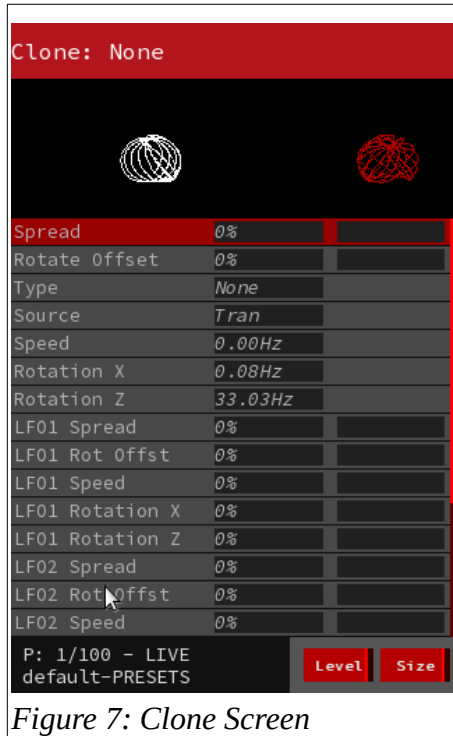
The Clone generator can create duplicates of the incoming shapes in various ways. By using the Source selector it is possible to make clones of composite shapes (Shape A and B together, the Transfomer output, etc.) or clones can be made using multiple inputs at the same time. For instance, Shape A and Shape B can be displayed in different areas of the screen at the same time. The top left section of the screen shows the output from the Clone prior to it feeding into the Color module. Clone types are listed in Appendix G.

Clone Controls

The Source and Type affect which inputs will be cloned and the actual clone type to use. The Spread control affects the distance between clones and the Speed control is used when selected a type that includes built-in animation. An animated clone can move each of the clone elements individually in complex ways to create complex motions.

Rotation Controls

The final stage of clone processing involves two more rotation processors similar to the one found in the Transfomer. These allow the final cloned output to be spun around multiple axes at the same time. The final output from the 3D information from shapes, the Transformer and the Clone generator are projected using a camera projector in 3D space to create depth and perspective distortion so that objects in the foreground appear larger than those in the background. This can be used to create very immersive 3D laser images that appear to have depth even if the source shapes are 2D.

Clone Source

The clone source is used to select which sources are used for choosing the source for clones. You can select one or both shape generators or the transformer in different combinations as follows:

- **Tran** - Transformer
- **ShA** - Shape A
- **ShB** - Shape B
- **ShA+B** - Shape A and B added together
- **ShA|B** - Shape A or B - alternating clones
- **ShA|Tr** - Shape A or Transformer - alternating clones

The "OR" modes are used with clones that offer alternating inputs. Some clones will allow two inputs to be used at the same time but shown at different places on the screen. Please note that the source chosen affects how shape blanking is processed. Shape A is preferred on any setting which includes Shape A as an input, otherwise the other source is used.

Clone Parameters

Parameter	Description
Spread	Adjusts the spacing between clones.
Rotate Offset	Adjusts the offset center of rotation.
Type	Selects the clone type.
Source	Selects the source of input for the clone.
Speed	Adjusts the speed of animated clone playback.
Rotation X	Adjusts the rotation speed about the X axis.
Rotation Z	Adjusts the rotation speed about the Z axis.
LFO1 Spread	Adjusts the LFO1 to spread level.

LFO1 Rot Offset	Adjusts the LFO1 to rotate offset level.
LFO1 Speed	Adjusts the LFO1 to speed level.
LFO1 Rotation X	Adjusts the LFO1 to rotate X level.
LFO1 Rotation Z	Adjusts the LFO1 to rotate Z level.
LFO2 Spread	Adjusts the LFO2 to spread level.
LFO2 Rot Offset	Adjusts the LFO2 to rotate offset level.
LFO2 Speed	Adjusts the LFO2 to speed level.
LFO2 Rotation X	Adjusts the LFO2 to rotate X level.
LFO2 Rotation Z	Adjusts the LFO2 to rotate Z level.
LFO3 Spread	Adjusts the LFO3 to spread level.
LFO3 Rot Offset	Adjusts the LFO3 to rotate offset level.
LFO3 Speed	Adjusts the LFO3 to speed level.
LFO3 Rotation X	Adjusts the LFO3 to rotate X level.
LFO3 Rotation Z	Adjusts the LFO3 to rotate Z level.

Main Screen
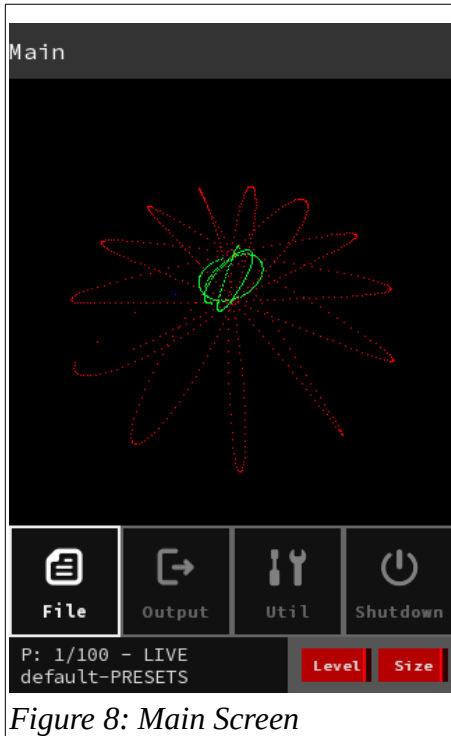
Figure 8: Main Screen

The main screen is the default display when you start up the system, or when another screen times out. When in any other screen double-tapping SHIFT will back out to the main screen. This shows a larger preview of the main output. Please note that the master SIZE and LEVEL knobs do not affect the preview.

Main Screen Ribbon

Below the large preview display is the ribbon which allows access to additional modes not accessible through dedicated buttons on the front panel. To enter one of these modes use the SELECT knob to move the selected item and press ENTER. To enable the Shutdown mode ENTER must be pressed twice to activate it.

Additional Screens and Controls

Preset Manager

Figure 9: Preset Screen
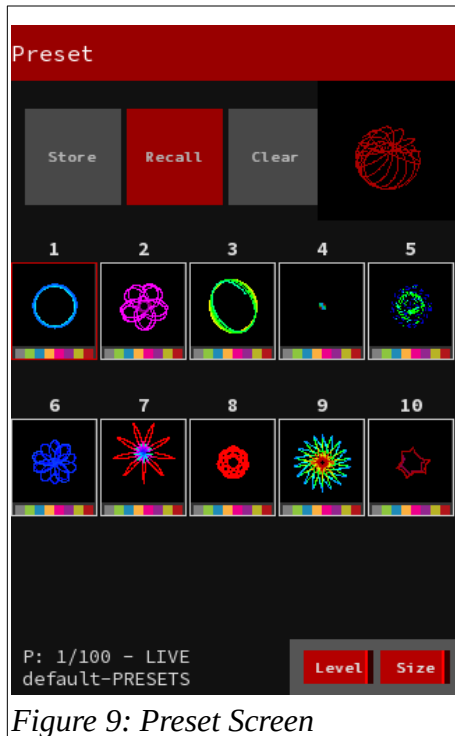
The preset screen allows presets in the currently loaded show to be stored, recalled and cleared. Previews are generated on the fly using the same rendering pipeline used by the actual laser output. A static image is captured of each preview to give some sense of what it will look like.

Calling up the Preset Screen

To call up the preset screen when Follow Control is on, simply turn the preset PAGE knob. When Follow Control is off, simply hold SHIFT while turning the PAGE knob to bring up the Preset screen.

Storing a Preset

Presets can contain all or some combination of module parameters. Presets and shows do not save any parameters related to the Output or Util screens, or the master size, level or blackout state. By storing parameters from only some modules it is possible to make presets which only change portions of the

current running state. For instance a number of color presets could be used to change colors without affecting the shape. By default the parameters of all modules are stored.

To store a preset at any time, hold SHIFT and press STORE. This will cause all module SELECT buttons to flash indicating that those modules will be included in the preset. Hold SHIFT and press SELECT buttons to toggle them on and off to select which modules will be included in the preset. Once all modules to be stored are flashing, press the desired preset button to store the preset in that preset slot. Any information already stored in the preset will be replaced.

Below each preset preview image in the Preset screen a row of colored squares is shown. These squares indicate which if the 8 modules are included in the particular preset: Color, LFO1, LFO2, LFO3, Shape A, Shape B, Transformer, Clone

Recalling a Preset

To recall a preset using the Preset screen, select the page and preset to load by using the SELECT knob. Turn the VALUE knob to select the Recall option and press ENTER. To recall a preset without using the screen controls simply select the page containing the preset to load using the PAGE knob and press the preset button corresponding to the preset to load.

Preset buttons show a preview of the preset color. This is an average of the color at the time when the preset image (shown on the Preset screen) was generated. Generally a preset button with no color displayed on its LED indicates a blank preset slot. Due to the way that preset previews are generated, some presets may not show any color on the LED. A gray background in the Preset screen indicates a blank preset slot.

File

Figure 10: File Screen

The File screen is used to manage shows, backup and restore data, and manage ILDA output recordings. Files are normally stored directly on Radiator but can be backed up and restored from an external USB mass storage device like a USB memory stick. Up to 1000 shows and 24 ILDA recordings can be stored in the internal memory at once. It should be noted that some types of software updates or hardware failure may cause the internal memory to become corrupted or erased. Therefore back up your shows regularly to prevent data loss.

Quickly Creating a New Show

A show is always loaded when the system is operating. If a show has not previously been loaded, a new show will be created automatically. Any live changes made to a preset are retained upon power off, but must be explicitly stored to a preset to be part of a show. To create a new show simply choose the New Show option from the File menu and press ENTER.

Managing Shows

To manage shows enter the Manage Shows submenu by selecting it and pressing ENTER. Within this submenu it is possible to clone, write protect, edit the name or delete a show. Use the SELECT knob to select the show to act on, and the VALUE knob to select the desired action. Press ENTER to perform the action.

Cloning a Show

To clone a show use the Clone option within Manage Shows. Use the SELECT knob to choose which show to clone. Use the VALUE knob to select the Clone option and press ENTER to clone.

Write Protecting / Unprotecting a Show

A show can be write protected to prevent unwanted or accidental writing over presets. When a show is write protected a lock icon will be displayed beside the filename. Choose the file to write protect or unprotect using the SELECT knob and choose the Write Protect option with the VALUE knob. Press ENTER to toggle write protect on or off.

Editing the Name of a Show

To edit the name of a show, select the show with the SELECT knob. Choose the EDIT NAME option with the VALUE knob and press ENTER. A cursor will appear on the name of the file. Use the SELECT knob to move the cursor and the VALUE knob to adjust the letter.

Deleting a Show

To delete a show from the internal memory, select the show to delete with the SELECT knob. Choose the Delete option with the VALUE knob. Press ENTER to delete the show. Note that files which are write protected cannot be deleted until they have been unprotected.

USB Storage

The USB Storage submenu allows shows to be copied to and from a USB mass storage device. Plug a FAT32 formatted USB mass storage device into one of the two rear panel USB ports. Valid disks will be mounted automatically. Only one USB mass storage device can be used at a time. Files must be placed in the root directory of the USB disk to be found.

Import All

To import all show files from the USB memory into Radiator use the Import All option. Any files already on Radiator containing the same name will be overwritten. A list of shows found on the USB disk will be shown in the submenu. Press ENTER to import all shows.

Export All

To export all show files from Radiator onto an external USB disk, use the Export All option. Any files already on the USB disk with the same name will be overwritten. A list of all shows on the internal disk will be shown. Press ENTER to export all shows.

Import Show

To import a single show file from a USB disk, use the Import Show option. A list of shows on the USB disk will be shown in the submenu. Use the SELECT knob to choose which show to import and press ENTER to import it.

Export Show

To export a single show file from the internal disk to a USB disk, use the Export Show option. A list of shows on the internal disk will be shown in the submenu. Use the SELECT knob to choose which show to export and press ENTER to export it.

ILDA Record

The ILDA recording function allows the output of the system to be recorded to an ILDA file to be used by other systems or software. Recordings are made at a fixed point rate and frame rate and there is a limitation on the length of a recordings. However this feature should be useful to export interesting effects discovered on Radiator for use in timeline-based shows and so on. To record, play and manage ILDA recordings use the ILDA Record submenu in the File screen.

ILDA Recording Specifications:

- **Point rate:** 48Kpps fixed
- **Frame rate:** 60fps fixed
- **Max recording length:** 20s
- **Max recordings:** 24

ILDA recordings can only be made when there is a valid USB disk mounted on the system. Recordings are automatically copied to the disk when the recording is finished.

Recording an ILDA File

To record an ILDA file use the Record option and press ENTER to start recording. To stop recording either wait for the recording to automatically time out or press ENTER again to stop it. The recorded file will automatically be copied to the disk and shown in the file list within the ILDA Record submenu.

Playing Back an ILDA Recording

To play back an ILDA recording, select the file to play using the SELECT knob and choose the Play option with the VALUE knob. Press ENTER to start playback. Please note that playback will take over the main output of Radiator for the duration of playback. Please do not attempt to play ILDA files not created with Radiator as they may not play correctly and could damage your laser projector.

Deleting an ILDA Recordings

To delete an ILDA recording, select the file to delete using the SELECT knob and choose the Delete option with the VALUE knob. Press ENTER to delete the file.

Output
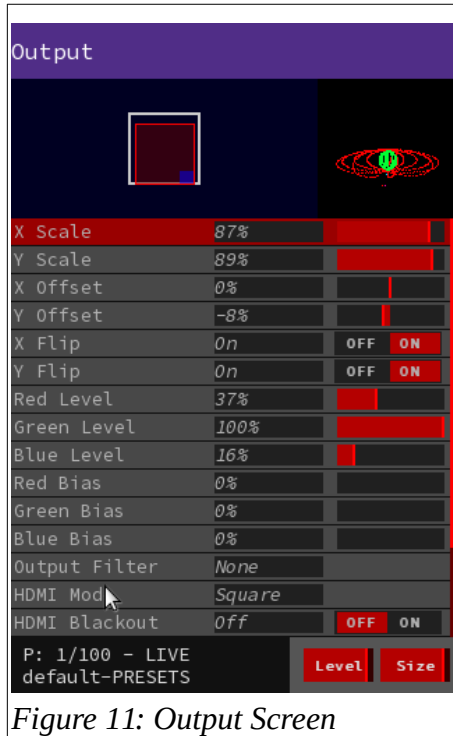
Figure 11: Output Screen

The Output screen allows the adjustment of parameters related to the laser output. These settings are stored globally on the system and are applied to all shows.

Laser Output Settings

HDMI Settings

The HDMI settings allow the rendered image to be adjusted to suit the particular use case. The HDMI Mode allows different aspect ratios to be selected. Since laser signals are generally square, this allows a typical 1920x1080 image to either contain a square or widescreen type of image.

Normally the HDMI output shows a preview similar to that on the built-in LCD screen. As such the Master controls do not affect the HDMI signal. When using the HDMI output as a program feed for recording or performance it might be desirable to have the SIZE, LEVEL and BLACKOUT controls affect it just as they do the laser output. The HDMI Blackout and HDMI Pots settings allow the blackout and master pots to affect the HDMI output.

Note: Settings related to scaling, offset, flipping and laser level and bias are applied to the laser output only and do not affect the HDMI output. Only the SIZE, LEVEL and BLACKOUT controls (if configured) will affect both the laser and HDMI outputs.

Laser Blanking and Dwell

Depending on the specifications of the connected laser projector, clones generated by the Clone module may not look correct. This is due to the speed at which the galvos can be re-positioned, and the speed of the laser diode drivers. To create clones which are free of artifacts these settings are provided. The Laser Blanking setting affects how much time to leave between each clone. This allows time for the laser to move to a new location before drawing starts. The Laser Dwell setting affects the minimum amount of time spent on each clone. This affects the maximum draw rate of clones. These parameters interact with the frequency of shapes being produced by the Shape generators to create the clone effects. When the clone generator is disabled by selecting one clone, these settings are not used.

External DAC

Radiator supports several types of external DACs. The Ether Dream is the most useful as it allows lasers to be located far away from Radiator and connected with Ethernet cable. The Laser Dock / Laser Cube is a USB-connected interface mainly used for low-cost laser projectors which lack a proper ILDA port. Only one external DAC is supported at a time and can be selected with the External DAC option.

The status of the external DAC is shown beside the setting. Status is determined as follows:

- **Ether Dream** - Online means the device is detected on the network, prepared and streaming.
- **LaserDock** - Online means the device is detected on the USB and is receiving points.

Output Parameters

Parameter	Description
X Scale	Adjusts the X size of the output. Preview is shown.
Y Scale	Adjusts the Y size of the output. Preview is shown.
X Offset	Adjusts the X offset of the output. Preview is shown.
Y Offset	Adjusts the Y offset of the output. Preview is shown.
X Flip	Flips the X output polarity. Preview is shown.
Y Flip	Flips the Y output polarity. Preview is shown.
Red Level	Adjusts the gain of the red output.

Green Level	Adjusts the gain of the green output.
Blue Level	Adjusts the gain of the blue output.
Red Bias	Adjusts the bias (offset) of the red output.
Green Bias	Adjusts the bias (offset) of the green output.
Blue Bias	Adjusts the bias (offset) of the blue output.
Output Filter	Selects the output filter to protect laser galvos.
HDMI Mode	Selects the HDMI crop mode and aspect ratio.
HDMI Blackout	Selects whether the HDMI output observes blackout state.
HDMI Pots	Selects whether the HDMI output observes size and level pots.
Laser Blanking	Adjusts the amount of blanking used between clones.
Laser Dwell	Adjusts the amount of dwell time used between clones.
External DAC	Selects the external DAC type and displays its connection status.

Util
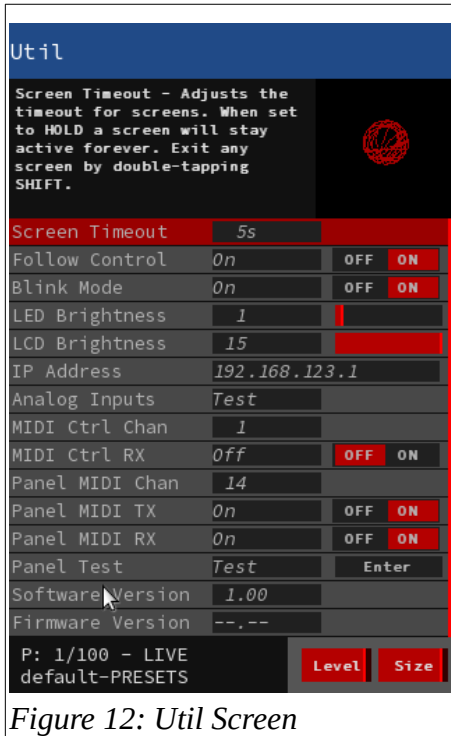
Figure 12: Util Screen

The Util screen has settings for all system settings not related to presets or output. These settings are stored globally on the system and are applied to all shows and presets.

Screen Timeout

Depending on preference, the screen timeout feature causes screens to exit back to the Main screen automatically after a timeout. The timeout can be set from 1-60 seconds of inactivity. To disable the screen timeout feature, turn the setting to the maximum: HOLD to cause the screen to hold indefinitely. Screens can be dismissed at any time by double-tapping the SHIFT button.

Follow Controls

When first learning Radiator, the use of the Follow Controls option might be helpful. This will cause the screen display to switch to whatever module is being adjusted. This can help to see the value of parameters being edited without having to manually navigate. For more advanced users, this option is probably less desirable as it can become distracting when multiple controls are adjusted quickly.

Blink Mode

The blink mode affects whether a SELECT button will blink when a module is selected. This is completely for personal preference.

LED and LCD Brightness

The LEDs on the panel as well as the LCD backlight can be adjusted in overall brightness. This can be useful for operating in very dark rooms.

IP Address

The IP address of the unit is displayed in the IP Address line of the screen. Please note that currently Radiator supports DHCP and Link-Local address setting only. It may be necessary to restart Radiator after a DHCP lease has been acquired to cause it to be reset for use with Link-Local networks.

Analog Inputs

To check for proper audio and CV input levels the Analog Inputs item can be selected. This will cause a levelmeter display to appear at the top of the screen indicating the audio input levels (Audio in L and R) and the CV input DC levels. (CV in 1-6) Please note that the CV inputs are filtered to show bi-polar signals. Use a DC voltage or slow LFO to properly check the full input range.

MIDI Control

The MIDI control parameters affect the MIDI control of parameters using CC and Program Change messages. Make sure to set the MIDI control channel differently than the Panel MIDI channel to avoid conflicts. (see Appendix B)

Panel MIDI

The Panel MIDI parameters affect the MIDI control over panel knobs and buttons via MIDI. The channel sets the base channel and can be set from channel 1-14 because LED values require 3 channels to send the R, G and B values. (see Appendix A) The Panel MIDI TX option affects whether LED values will be sent. The Panel MIDI RX option affects whether panel MIDI knobs and button events will be received.

Panel Test

To confirm proper operation of the panel knobs and buttons, the Panel Test mode can be used. SELECT the Panel Test option in the menu and press ENTER. All LEDs will flash. Knob and button actions will be shown at the top of the screen. Press ENTER again to stop the panel test mode.

Parameter	Description
Screen Timeout	Adjusts timeout for screen to revert to Main screen.
Follow Control	Selects whether screen display follows controls on a module.
Blink Mode	Selects whether SELECT buttons blink when active.
LED Brightness	Adjusts the overall panel LED brightness.
LCD Brightness	Adjusts the LCD backlight brightness.
IP Address	Displays the system IP address detected by DHCP.
Analog Inputs	Shows the level of audio and CV signals at the analog inputs.
MIDI Ctrl Chan	Selects the MIDI channel used for remote control over MIDI.
MIDI Ctrl RX	Selects whether MIDI control is received.
Panel MIDI Chan	Selects the base MIDI channel for panel control over MIDI.
Panel MIDI TX	Selects whether panel MIDI messages are transmitted.
Panel MIDI RX	Selects whether panel MIDI messages are received.
Panel Test	Allows the panel controls to be tested for proper operation.
System Version	Displays the current Radiator system version with update option.
Software Version	Displays the current software version.
Firmware Version	Displays the current firmware version.

Features and Specifications

Laser synthesizer

- Powerful self-contained laser synthesizer and controller
- Generates abstracts and beams with a large library of content
- Dual shape generators can generate separate or complex blended shapes
- Transformer module for processing shapes with unique filters
- Clone module for replicating shapes including clone animations
- Color module with powerful modifier section for dynamic reactive color
- Work in HSV or RGB color-spaces
- Three LFOs for generating modulation signals
- LFO routing includes any variable controls on the system
- Preset storage and recall with quick access to up to 1000 presets
- Preset previews show thumbnails and preset color on preset buttons
- Quick storage of preset with one hand while operating
- Store all or some module parameters in a preset
- Quick reset of modules and LFO routing
- Dedicated master controls for size, output level and blackout for safety
- Internal LCD screen for preview, module control, file and system management
- Fast screen navigation and context-sensitive display switching optional
- Informative full-color LED indicators on every button
- Audio inputs for audio-reactive shape effects
- CV inputs and outputs for control and interaction with modular synthesizers
- ILDA input can be used to process laser signals from another source
- Full MIDI control allows remote panel and parameter control
- Full file manager for backup and restore, duplicating and protecting files
- Internal storage for thousands of shows
- ILDA recording function produces ILDA files from live laser output
- Abstract laser visualizer renders real-time laser output on HDMI
- Adjustable laser output filter to protect galvos
- ILDA and USB or Ethernet DAC support simultaneously
- External DAC support: Ether Dream and LaserDock/LaserCube

Rear panel

- DC input - 12-24VDC on 2.1mm DC coaxial jack - power consumption 6W
- Power switch - hardware power switch

- CV inputs - six CV inputs on 3.5mm minijacks (-5V to +5V range)
- CV outputs - three CV outputs on 3.5mm minijacks (-5V to +5V range)
- Audio input - stereo audio input on dual TRS 1/4" jacks
- Audio output - stereo audio output (X/Y signals) on 3.5mm minijack
- ILDA output - DB-25 connector outputs standard ILDA laser signals
- MIDI I/O - MIDI IN and OUT ports on standard 5 pin DIN jacks
- USB ports - dual USB ports for file storage and USB laser DAC support
- Ethernet port - 10/100 Ethernet port for Ethernet DAC support
- USB system port - Micro-USB port for system restore and upgrade
- HDMI output - Full-size HDMI port generates 1080p60 laser visualizer output

Hardware and enclosure

- Solid rotary encoders and metal knobs and pots on all controls
- Pushbuttons with positive feel and noiseless operation
- Integrated 3.5 inch LCD screen (320x480) with hardware accelerated graphics
- Passive cooling for long life and noiseless operation
- Rugged metal powder-coated enclosure
- Power requirement: 12-24VDC approx. 8W
- Power supply: external AC/DC adapter provided
- Overall dimensions: 15" x 9" x 2.5" (38cm x 23cm x 6cm) (approx)
- Weight: approx. 3.3lbs (1.5kg)

Appendix A - MIDI / TCP Panel Protocol

The panel can be remotely controlled via MIDI or TCP. All encoders, buttons and pots can be controlled, and LEDs are sent back to be used on the remote panel for indication.

Features:

- panel controls can be sent over MIDI using CC messages
- panel controls can be sent over TCP using the same CC numbers
- LED controls are sent over MIDI if enabled
- panel controls are accepted on channels 14-16
- panel LEDs are sent out on channels 14, 15 and 16 (R, G and B)
- all LEDs are RGB and are mapped to the same controllers as buttons

Note: For safety reasons the the blackout button, size and level pots are ignored on TCP or MIDI receive.

MIDI Protocol

All MIDI messages are sent via control change (CC) messages. Encoders, buttons and pots are sent to Radiator, and LEDs are sent from Radiator. MIDI is available via the 5-pin DIN MIDI ports only, and not over USB. The base MIDI channel defaults to 14 but can be changed. In this case the LED channels always go sequentially up from the base channel.

CC message data format:

- encoders   - 1-63 = increment, 127-64 = decrement
- buttons   - 0-63 = not pressed, 64-127 = pressed
- pots   - 0-127 = 0-100% rotation
- LEDs   - 0-127 = 0-100% brightness
  - channel 14 = red
  - channel 15 = green
  - channel 16 = blue (sent last)

TCP Protocol

The TCP protocol is a simple string-based protocol which mimics the same features as the MIDI protocol but over a network socket. A bi-directional connection is made to Radiator on TCP port 4815. Radiator will send in-band "ping" messages (not to be confused with ICMP pings) so that the remote software knows it is still connected. A maximum of 4 connections can be maintained at one time.

TCP message format:

- all messages as sent as ASCII text strings
- all strings must be newline terminated ('\n')

Message format:

Command	Format	Notes
ping	`"p\n"`	sent every 500ms by Radiator
encoder	`"e XX Y\n"`	encoder message
`XX` - encoder number as decimal string (same as CC mapping) `Y` - step amount as decimal string - e.g. `"e 59 -2\n"` - decrement control 59 by 2 - e.g. `"e 45 1\n"` - increment control 45 by 1		
button	`"s XX YYYY\n"`	button message
`XX` - button number as decimal string (same as CC mapping) `YYYY` - "true" = pressed, "false" = released - e.g. `"s 16 true\n"` - button 16 pressed - e.g. `"s 16 false\n"` - button 16 released		
pot	`"r XX Y.YYY\n"`	pot message
`XX` - pot number as decimal string (same as CC mapping) `Y.YYY` - value from 0.000 to 1.000 as decimal float - e.g. `"r 91 0.50\n"` - pot 91 at 50%		
LED	`"l XX YY\n"`	LED message
`XX` - LED number as decimal string (same as CC button mapping) `YY` - color as RRGGBB int value encoded as a decimal number - e.g. `"l 16 16711680\n"` - button 16 LED at full red (0xff0000)		

Control Mapping

Control	**Type**	**CC**
Color Hue	encoder	40
Color Saturate	encoder	41
Color Value	encoder	42
Color Mod P1	encoder	49
Color Mod P2	encoder	50
Color Mod P3	encoder	51
Color Mod Type	encoder	55
Color Mod On	button	4
Color Mod Select	button	5
LFO1 Warp	encoder	43
LFO1 Shape	encoder	52
LFO1 Speed	encoder	56
LFO1 Level	encoder	44
LFO1 On	button	1
LFO1 Select	button	6
LFO2 Warp	encoder	45
LFO2 Shape	encoder	53
LFO2 Speed	encoder	57
LFO2 Level	encoder	46
LFO2 On	button	2
LFO2 Select	button	7
LFO3 Warp	encoder	47
LFO3 Shape	encoder	54
LFO3 Speed	encoder	58
LFO3 Level	encoder	48

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LFO3 On	button	3
LFO3 Select	button	8
Shape A Warp	encoder	59
Shape A Rotate	encoder	60
Shape A Shape	encoder	68
Shape A Size	encoder	69
Shape A Speed	encoder	77
Shape A Invert	button	12
Shape A Autorotate	button	10
Shape A On	button	14
Shape A Select	button	16
Shape B Warp	encoder	61
Shape B Rotate	encoder	62
Shape B Shape	encoder	70
Shape B Size	encoder	71
Shape B Speed	encoder	78
Shape B Invert	button	13
Shape B Autorotate	button	11
Shape B On	button	15
Shape B Select	button	17
Transformer Warp	encoder	63
Transformer Rotate Offset	encoder	64
Transformer Type	encoder	72
Transformer Axis Tilt	encoder	73
Transformer Rotation	encoder	79
Transformer Select	button	18
Clone Spread	encoder	65

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Clone Rotate Offset	encoder	66
Clone Type	encoder	74
Clone Size	encoder	75
Clone Rotation X	encoder	80
Clone Rotation Z	encoder	81
Clone Select	button	19
~~Master Size~~	~~pot~~	~~91~~
~~Master Level~~	~~pot~~	~~92~~
~~Master Blackout~~	~~button~~	~~9~~
Preset Page	encoder	82
Preset P1	button	20
Preset P2	button	21
Preset P3	button	22
Preset P4	button	23
Preset P5	button	24
Preset P6	button	25
Preset P7	button	26
Preset P8	button	27
Preset P9	button	28
Preset P10	button	29
Menu Value	encoder	67
Menu Select	encoder	76
Global Enter	button	30
Global Reset	button	31
Global Shift	button	32

Appendix B - MIDI Control Protocol

All live preset functions of Radiator can be controlled via MIDI just as if the settings were edited from the front panel and menus. However unlike the panel protocol, instead of simulating button and knob input the absolute value of controls can be set. Certain functions cannot be controlled via MIDI, for instance:

- Util settings and system settings
- Output settings and level / tuning parameters
- Manual pot parameters for size and level
- File management functions
- System shutdown function

MIDI Bank and Program Change

Presets within the currently loaded show can be accessed via MIDI Program Change and Bank Change messages. Presets are organized into 10 banks of 100 presets each. Program change values 0-99 can be used to select presets in the current bank. Banks are selected using the standard MIDI Bank LSB CC message. Send value of 0-9 to access one of 10 banks.

MIDI CC Parameters

MIDI control change messages can be used to control all aspects of the current live preset and also trigger other events such as storing presets. For safety reasons the blackout button, level and size controls can only be controlled via the panel.

Due to the number of parameters, some controls must be accessed via NRPN. Many useful parameters are available via normal CC messages but all controls are available via NRPN messages also. The use of NRPN also allows more resolution to be used for controls. When using NRPN with the MSB and LSB data entry CCs to send 14 bit resolution values, send the LSB first. If only using 7 bit values, send only the MSB. Data increment and decrement act on the MSB value only.

MIDI CC / NRPN Controls

Control Name	Type	CC	NRPN MSB	NRPN LSB	Value
Color					
Hue	variable	1	1	0	0-127 = 0-100%
Saturate	variable	2	1	1	0-127 = 0-100%
Value	variable	3	1	2	0-127 = 0-100%
Mod P1	variable	4	1	3	0-127 = 0-100%
Mod P2	variable	5	1	4	0-127 = 0-100%
Mod P3	variable	6	1	5	0-127 = 0-100%
Mod Type	index	7	1	6	selects index
Mod On	boolean	8	1	7	0-63 = off, 64-127 = on
RGB Mode	boolean	9	1	8	0-63 = HSV, 64-127 = RGB
LFO1 H Level	variable		1	9	0-127 = 0-100%
LFO1 S Level	variable		1	10	0-127 = 0-100%
LFO1 V Level	variable		1	11	0-127 = 0-100%
LFO1 Mod P1 Level	variable		1	12	0-127 = 0-100%
LFO1 Mod P2 Level	variable		1	13	0-127 = 0-100%
LFO1 Mod P3 Level	variable		1	14	0-127 = 0-100%
LFO2 H Level	variable		1	15	0-127 = 0-100%

Control Name	**Type**	**CC**	**NRPN MSB**	**NRPN LSB**	**Value**
LFO2 S Level	variable		1	16	0-127 = 0-100%
LFO2 V Level	variable		1	17	0-127 = 0-100%
LFO2 Mod P1 Level	variable		1	18	0-127 = 0-100%
LFO2 Mod P2 Level	variable		1	19	0-127 = 0-100%
LFO2 Mod P3 Level	variable		1	20	0-127 = 0-100%
LFO3 H Level	variable		1	21	0-127 = 0-100%
LFO3 S Level	variable		1	22	0-127 = 0-100%
LFO3 V Level	variable		1	23	0-127 = 0-100%
LFO3 Mod P1 Level	variable		1	24	0-127 = 0-100%
LFO3 Mod P2 Level	variable		1	25	0-127 = 0-100%
LFO3 Mod P3 Level	variable		1	26	0-127 = 0-100%
LFO1					
Warp	variable	10	2	0	0-127 = 0-100%
Warp Type	index	11	2	1	selects index
Shape	variable	12	2	2	selects index
Speed	variable	13	2	3	0-127 = 0-100%
Level	variable	14	2	4	0-127 = 0-100%
On	boolean	15	2	5	0-63 = off, 64-127 = on
CV1 Warp	variable		2	6	0-127 = 0-100%
CV1 Speed	variable		2	7	0-127 = 0-100%
CV1 Level	variable		2	8	0-127 = 0-100%
CV4 Warp	variable		2	9	0-127 = 0-100%
CV4 Speed	variable		2	10	0-127 = 0-100%
CV4 Level	variable		2	11	0-127 = 0-100%
LFO2 Warp	variable		2	12	0-127 = 0-100%
LFO2 Speed	variable		2	13	0-127 = 0-100%

Control Name	Type	CC	NRPN MSB	NRPN LSB	Value
LFO2 Level	variable		2	14	0-127 = 0-100%
LFO3 Warp	variable		2	15	0-127 = 0-100%
LFO3 Speed	variable		2	16	0-127 = 0-100%
LFO3 Level	variable		2	17	0-127 = 0-100%
LFO2					
Warp	variable	16	3	0	0-127 = 0-100%
Warp Type	index	17	3	1	selects index
Shape	variable	18	3	2	selects index
Speed	variable	19	3	3	0-127 = 0-100%
Level	variable	20	3	4	0-127 = 0-100%
On	boolean	21	3	5	0-63 = off, 64-127 = on
CV2 Warp	variable		3	6	0-127 = 0-100%
CV2 Speed	variable		3	7	0-127 = 0-100%
CV2 Level	variable		3	8	0-127 = 0-100%
CV5 Warp	variable		3	9	0-127 = 0-100%
CV5 Speed	variable		3	10	0-127 = 0-100%
CV5 Level	variable		3	11	0-127 = 0-100%
LFO1 Warp	variable		3	12	0-127 = 0-100%
LFO1 Speed	variable		3	13	0-127 = 0-100%
LFO1 Level	variable		3	14	0-127 = 0-100%
LFO3 Warp	variable		3	15	0-127 = 0-100%
LFO3 Speed	variable		3	16	0-127 = 0-100%
LFO3 Level	variable		3	17	0-127 = 0-100%
LFO3					
Warp	variable	22	4	0	0-127 = 0-100%
Warp Type	index	23	4	1	selects index

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Control Name	Type	CC	NRPN MSB	NRPN LSB	Value
Shape	variable	24	4	2	selects index
Speed	variable	25	4	3	0-127 = 0-100%
Level	variable	26	4	4	0-127 = 0-100%
On	boolean	27	4	5	0-63 = off, 64-127 = on
CV3 Warp	variable		4	6	0-127 = 0-100%
CV3 Speed	variable		4	7	0-127 = 0-100%
CV3 Level	variable		4	8	0-127 = 0-100%
CV6 Warp	variable		4	9	0-127 = 0-100%
CV6 Speed	variable		4	10	0-127 = 0-100%
CV6 Level	variable		4	11	0-127 = 0-100%
LFO1 Warp	variable		4	12	0-127 = 0-100%
LFO1 Speed	variable		4	13	0-127 = 0-100%
LFO1 Level	variable		4	14	0-127 = 0-100%
LFO2 Warp	variable		4	15	0-127 = 0-100%
LFO2 Speed	variable		4	16	0-127 = 0-100%
LFO2 Level	variable		4	17	0-127 = 0-100%
Shape A					
Warp	variable	28	5	0	0-127 = 0-100%
Warp Type	index	29	5	1	selects index
Shape	index	30	5	2	selects index
Autorotate Speed	variable	31	5	3	0-127 = -100% to +100% (64 = 0%)
Manual Rotate	variable	65	5	4	0-127 = -100% to +100% (64 = 0%)
Size	variable	66	5	5	0-127 = 0-100%
Speed	variable	67	5	6	0-127 = 0% to +100%
Invert	boolean	68	5	7	0-63 = normal, 64-127 = invert
Autorotate	boolean	69	5	8	0-63 = off, 64-127 = on

Control Name	**Type**	**CC**	**NRPN MSB**	**NRPN LSB**	**Value**
On	boolean	70	5	9	0-63 = off, 64-127 = on
LFO1 Warp	variable		5	10	0-127 = 0-100%
LFO1 Rotate	variable		5	11	0-127 = 0-100%
LFO1 Size	variable		5	12	0-127 = 0-100%
LFO1 Speed	variable		5	13	0-127 = 0-100%
LFO2 Warp	variable		5	14	0-127 = 0-100%
LFO2 Rotate	variable		5	15	0-127 = 0-100%
LFO2 Size	variable		5	16	0-127 = 0-100%
LFO2 Speed	variable		5	17	0-127 = 0-100%
LFO3 Warp	variable		5	18	0-127 = 0-100%
LFO3 Rotate	variable		5	19	0-127 = 0-100%
LFO3 Size	variable		5	20	0-127 = 0-100%
LFO3 Speed	variable		5	21	0-127 = 0-100%
Shape B					
Warp	variable	71	6	0	0-127 = 0-100%
Warp Type	index	72	6	1	selects index
Shape	index	73	6	2	selects index
Autorotate Speed	variable	74	6	3	0-127 = -100% to +100% (64 = 0%)
Manual Rotate	variable	75	6	4	0-127 = -100% to +100% (64 = 0%)
Size	variable	76	6	5	0-127 = 0-100%
Speed	variable	77	6	6	0-127 = 0% to +100%
Invert	boolean	78	6	7	0-63 = normal, 64-127 = invert
Autorotate	boolean	79	6	8	0-63 = off, 64-127 = on
On	boolean	80	6	9	0-63 = off, 64-127 = on
LFO1 Warp	variable		6	10	0-127 = 0-100%
LFO1 Rotate	variable		6	11	0-127 = 0-100%

Control Name	Type	CC	NRPN MSB	NRPN LSB	Value
LFO1 Size	variable		6	12	0-127 = 0-100%
LFO1 Speed	variable		6	13	0-127 = 0-100%
LFO2 Warp	variable		6	14	0-127 = 0-100%
LFO2 Rotate	variable		6	15	0-127 = 0-100%
LFO2 Size	variable		6	16	0-127 = 0-100%
LFO2 Speed	variable		6	17	0-127 = 0-100%
LFO3 Warp	variable		6	18	0-127 = 0-100%
LFO3 Rotate	variable		6	19	0-127 = 0-100%
LFO3 Size	variable		6	20	0-127 = 0-100%
LFO3 Speed	variable		6	21	0-127 = 0-100%
Transformer					
Warp	variable	81	7	0	0-127 = 0-100%
Rotate Offset	variable	82	7	1	0-127 = 0-100%
Type	index	83	7	2	selects index
Source	index	84	7	3	selects index
Axis Tilt	variable	85	7	4	0-127 = 0-100%
Rotation	variable	86	7	5	0-127 = -100% to +100% (64 = 0%)
LFO1 Warp	variable		7	6	0-127 = 0-100%
LFO1 Rotate Offset	variable		7	7	0-127 = 0-100%
LFO1 Axis Tilt	variable		7	8	0-127 = 0-100%
LFO1 Rotation	variable		7	9	0-127 = 0-100%
LFO2 Warp	variable		7	10	0-127 = 0-100%
LFO2 Rotate Offset	variable		7	11	0-127 = 0-100%
LFO2 Axis Tilt	variable		7	12	0-127 = 0-100%
LFO2 Rotation	variable		7	13	0-127 = 0-100%
LFO3 Warp	variable		7	14	0-127 = 0-100%

Control Name	Type	CC	NRPN MSB	NRPN LSB	Value
LFO3 Rotate Offset	variable		7	15	0-127 = 0-100%
LFO3 Axis Tilt	variable		7	16	0-127 = 0-100%
LFO3 Rotation	variable		7	17	0-127 = 0-100%
Clone					
Spread	variable	87	8	0	
Rotate Offset	variable	88	8	1	
Type	index	89	8	2	
Source	index	90	8	3	
Speed	variable	91	8	4	
Rotation X	variable	92	8	5	
Rotation Z	variable	93	8	6	
LFO1 Spread	variable		8	7	
LFO1 Rotate Offset	variable		8	8	
LFO1 Speed	variable		8	9	
LFO1 Rotation X	variable		8	10	
LFO1 Rotation Z	variable		8	11	
LFO2 Spread	variable		8	12	
LFO2 Rotate Offset	variable		8	13	
LFO2 Speed	variable		8	14	
LFO2 Rotation X	variable		8	15	
LFO2 Rotation Z	variable		8	16	
LFO3 Spread	variable		8	17	
LFO3 Rotate Offset	variable		8	18	
LFO3 Speed	variable		8	19	
LFO3 Rotation X	variable		8	20	
LFO3 Rotation Z	variable		8	21	

Control Name	Type	CC	NRPN MSB	NRPN LSB	Value
Master					
Blackout	boolean	94	9	0	0-63 = normal, 64-127 = blackout
Presets					
bank change MSB	index	0			unused
bank change LSB	index	32			0-9 = bank 1-10 (100 programs each)
NRPN Control					
NRPN Select LSB	NRPN	98			select NRPN LSB
NRPN Select MSB	NRPN	99			select NRPN MSB
Data Entry MSB	NRPN	6			set MSB of a data value
Data Entry LSB	NRPN	38			set LSB of a data value
Data Increment	NRPN	96			increment NRPN value
Data Decrement	NRPN	97			decrement NRPN value

Appendix C - Color Mod Types

Mod Type	Description	Param 1	Param 2	Param 3
X Wave	Level modulation on the X axis	Speed	Depth	Wave Length
Y Wave	Level modulation on the Y axis	Speed	Depth	Wave Length
XY Wave	Level Modulation across X/Y axis	Speed	Depth	Wave Length
X Hue	Hue shift based on X position	Distance	Fade	Hue Length
Y Hue	Hue shift based on Y position	Distance	Fade	Hue Length
Radial Hue	Hue shift based on radial distance	Distance	Fade	Hue Length
Source 1	Color from source input with bias	R Bias	G Bias	B Bias
Source 2	Color from source input with level	R Level	G Level	B Level
Envelope	Envelope type chopping	Attack	Release	Delay
Sine Chop	Since type chopping	R Speed	G Speed	B Speed

Appendix D - LFO and Shape Warp Types

LFO Warp Types

Warp Type	Description
Distort	Hard clipping of the waveform
ABS	Absolute value
Fold	Wavefolder
VU Fast	Audio VU meter with fast response
VU Slow	Audio VU meter with slow response
VU Size	Audio VU meter modulating waveform size

LFO Shapes

Shape	Description
Sine	Sine wave
Triangle	Triangle wave
Ramp Up	Ramp (Sawtooth) wave up
Ramp Down	Ramp (Sawtooth) wave down
Square	Square wave
Log	Log-shaped wave
Exp	Exp-shaped wave

Appendix F - Transform Types

Warp Type	Description
None	None
LPF	Low-pass filter
HPF	High-pass filter
Quantize	Positional quantize
Decimate	Time-based point decimation
Multiply	Four-quadrant multiplier
Swap XY	Swap X and Y
Size	Modulate size
X Warp	Generate X by warp
Y Warp	Generate Y by warp
Z Warp	Generate Z by warp
3Dize	Add 3D to XY input
3Dize 2	Add 3D to XY input (another way)

Appendix G - Clone Types

Clone Types

Clone Type	Description
None	None
Line 2	Two lines
Line 3	Three lines
Line 4	Four lines
Cross 2	Cross 2
Cross 3	Cross 3
Cross 3A	Cross 3A
Cross 3B	Cross 3B
Alt 1	Alternating 1
Alt 2	Alternating 2
Alt 2A	Alternating 2A
Rot 1	Rotating 1
2 Clones	2 Radial Clones
3 Clones	3 Radial Clones
4 Clones	4 Radial Clones
5 Clones	5 Radial Clones
2a Clones	2 Animated Clones crossing
2a Clones 3	2 Radial clones moving horizontally then vertically
3a Clones	3 Radial clones moving in and out in turns
4a Clones	4 Clones cross in pairs

Appendix E - Shape Warp and Shape Types

Shape Warp Types

Warp Type	Description
None	None
Pinch	X or Y pinch to zero
Exp X	Exponential curve on X
Exp Y	Exponential curve on Y
Exp XY	Exponential curve on X and Y
LFP	Low-pass filter
HPF	High-pass filter
Scale X	Scale X axis
Scale Y	Scale Y axis
Scale X-Y	Scale X and Y axis (Y axis scale inverted)

Shape Types

Static Shapes

Shape Type	Description
ILDA In	External ILDA Input from CV1-6 Jacks
Circle	Circle
Square	Square
Pinch	Plus Sign
Vee	V- Shape
Zee	Hourglass
Line	Single Horizontal Line

Shape Type	Description
Lines	Three Horizon Lines
Triangle	Triangle
Pyramid	3D Pyramid
Spiral 3	3 Turn Spiral
Spiral 15	15 Turn Spiral
1 Spiral	1 Coil Spiral
2 Spiral	2 Coil Spiral
3 Spiral	3 Coil Spiral
4 Spiral	4 Coil Spiral
5 Coil	5 Coil Spiral
Con Circ	2 Concentric Circles
Con Tri	2 Concentric Triangles
Half Circ	2 Half Circles
Not Square	2 Vertical Rectangles
Broken Arc	3 Broken Arcs
3 Circ	3 Circles arranged in a triangle
3 Con Circ	3 Concentric Circles
3 points	3 Points in a Line
3 lines	3 Horizontal Lines with a long center
3 Squares	3 Squares Rotated
4 Point	4 Pointed Star
5 Lines	5 Vertical Line
5 Points	5 points in a Line
5 Star	5 pointed star
6 Points	6 points in a line
6 Star	6 pointed star

Shape Type	Description
10 Point Star	10 pointed star
Hexagon	Hexagon
Hallway	Hexagon inside a Hexagon with connecting lines
Nest Hex	Concentric Hexagons
Brk Spiral	Broken Spiral
C & S	Circle with a Sine Wave inside
2 Circ	2 Diagonal Circles
2Con Box	2 Concentric Boxes
2Con Tri	2 Concentric Triangles
3 Pt Circle	3 Points inside a Circle
4 Circles	4 Circles
6 Pt Circle	6 Points inside a Circle
120d lines	Circle with Radial 120 Degree lines
120D Lines	Triangle with Radial 120 Degree lines
Concave Square	Square with Concave sides
Concave Tri	Triangle with Concave sides
Crmp Tri	Sine Wave Triangle
Pt Array	3 Concentric Circles of Points
Fade Sq	Square with fading Sides
Fallout	Danger Radiation!
Wavy	Sine Wave
I Con Tri 3	Nested Triangles
Laser	Danger Laser!
Notch Wheel	Circle With Notches
120 Lines	3 Radial 120 Degree lines
Seg Circ	Segmented Circle

Shape Type	Description
Shrink Circ	3 Shrinking Circles
Square Wave	Square Wave
Squareception	3 Concentric Squares
Eye	The eye!
T Star	Throwing Star
Smiles	Happy Face
Quackers	Quackers the Duck

Animated Shapes

Shape Type	Description
Rnd Tri	Rotating Triangles in Random Positions
Star	8 dots morphing from Square to Diamond
Exp Cir	Expanding circles in a linear array
Lines 01	4 Radial Lines rotating in place
Pt Circ	4 points counter rotating from center
Pt Swarm	4 groups of points swarming from center
X	4 lines rotating and forming an X
4 Exp	2 groups of four points expanding and contracting
5 lines	5 Radial lines rotating in and out of center
Exp Cir	5 Expanding circles in a linear array
4 Arcs	4 Arcs Rotating and moving in and out from center
Line Bnc	2 pairs of radial lines from in and out from center
Circ Dnc	4 Circles Square dancing
Pt Cir 01	3 Point Triangle and 6 Point Hexagon counter rotating
Pt Cir 02	4 Point Square and 6 Point Hexagon Rotating and Bouncing
Pt Cir 03	Circle with slowly fading points

Pt Cir 04	2 Point Circles counter rotating with fading points
Pt Cir 05	2 Point Circles counter rotating
Pt Cir 07	2 groups of 4 points moving and changing size
Pt Cir 08	2 point circles rotating and bouncing
Pt Dance	2 pairs of points rotating awkwardly
Simp Tri	4 Triangles rotating and moving in and out
Swim Cir	4 Circles in a lazy swarm
Swim Line	4 Lines Rotating off axis
Pt Circ	Point circles appearing in random positions
Rot Lines	Rotating lines appearing in random positions
Line Array	Lines rotating in a linear array
Circ Cross	3 Circles crossing in the center
Cir Jug	3 Circles in a lazy swarm
Rnd Tri	Rotating triangles appearing in random positions
Jug Cir	2 juggling circles
2 Lines	2 lines rotating and orbiting

Shapes are created by Andrew Kilpatrick, Christopher Short with contributions courtesy of X-Laser.