RADIUS

Ring Modulator / Frequency Shifter

Owner's Manual

Firmware version 1.0

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Red Panda®

www.redpandalab.com

Contents

Introduction

Thank you for purchasing the Radius. My goal was to create a musical, adaptable ring modulator and frequency shifter that can cover a wide range of sounds while being usable on stage. Its range spans from adding subtle depth and movement to broken alien transmitter sounds, complex harmonic structures, bell-like tones, and metallic textures. Classic ring mod sounds, frequency shifting, soft tremolo and bubbly phaser sounds are available, along with new sounds and techiques.

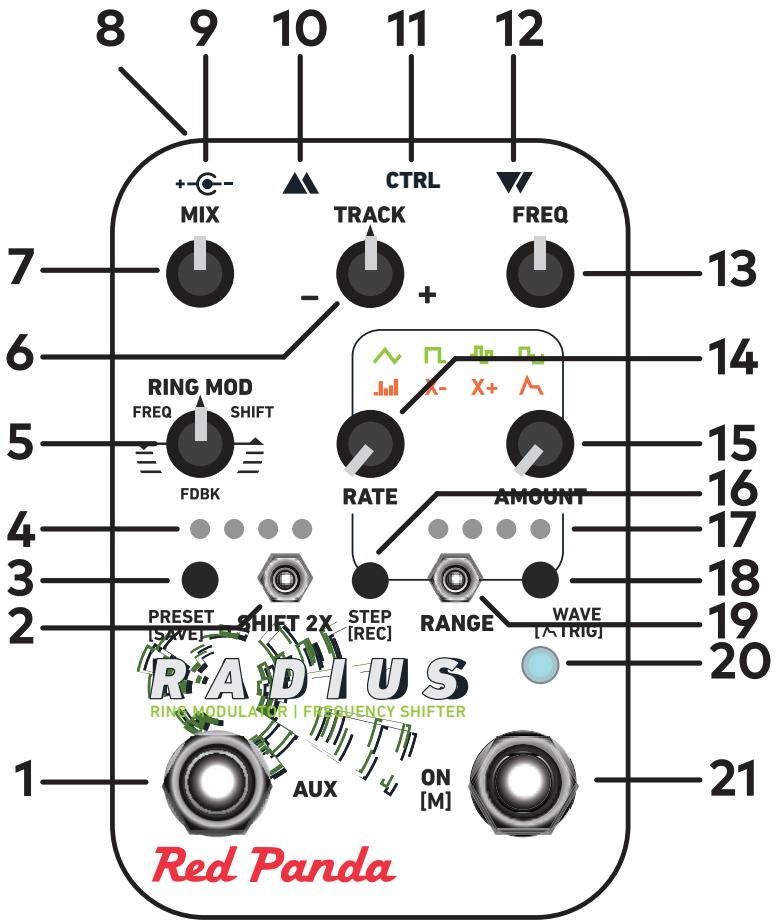
The Radius uses a novel algorithm that combines frequency shifting and ring modulation and seamlessly morph between them. I call it an “eight-quadrant multiplier”, but it is basically the result of unpacking the math behind ring modulation and frequency shifting, adding a few new paths, and combining it into a cohesive structure that is flexible and efficient. The levels of the upper and lower side bands can be adjusted, and they can be set to 2x frequency ratios for more tonal variation than a standard ring modulator. Pitch tracking, a push-to-tune footswitch, and a stepped frequency setting make it responsive and predictable in concert. A multi-waveform LFO, step modulator, and MIDI-playable carrier oscillator modernize classic electronic music techniques for the future.

The Radius is not a model of an analog ring modulator. The algorithms are informed by both analog and digital ring modulator and frequency shifter designs, then tweaked to keep the desirable artifacts while suppressing the undesirable artifacts. There is virtually no carrier oscillator bleed through and the multiplier has low harmonic distortion, which means the Radius pairs well with overdrive and fuzz.

The inspiration for the Radius was Chick Corea’s and Pete Cosey’s work with Miles Davis. My goal was to create ring modulator that could be clean enough to thicken up your instrument without sounding like it was added on top, predictable enough to play on stage, and deep enough to use as a harmonic enhancer or spectral destroyer. Dan Elkan suggested the name.

-curt

Front panel



1. AUX switch (default push-to-tune): configurable using the web editor.
2. SHIFT 2X (lower/off/upper): doubles frequency ratio of upper or lower sidebands.
3. PRESET select, hold to save preset.
4. Preset indicator.
5. RING MOD / FREQ SHIFT mix: adjusts balance between upper and lower harmonics, adds feedback.
6. Carrier frequency TRACK input pitch (monophonic): -100% to +100, off at center.
7. Dry/wet mix.
8. USB mini B receptacle for MIDI and firmware updates.
9. Power jack: 9V DC, center negative, use a power supply rated 200 mA or higher.
10. Stereo output (TRS): tip left/mono, ring right channel.
11. CTRL input: expression, TRS MIDI in, tap tempo, Remote 4 (configure using web editor)
12. Stereo input (TRS): tip left/mono, ring right channel.
13. Carrier oscillator frequency.
14. Modulation rate.
15. Modulation amount.
16. Step modulator pattern record.
17. Modulation wave indicator.
18. Modulation wave select, hold for envelope trigger.
19. Carrier oscillator range (low/high/stepped).
20. On / tap / status indicator.
21. ON switch, hold for momentary on.

LED status indicator

Color	Meaning
Off	bypass
Blue	effect is active
Green (solid)	push-to-tune is active, carrier oscillator will tune to played note
Green (blink)	preset or configuration setting saved
Yellow (blink)	blinks at quarter notes when tap tempo or MIDI clock is active
Red (blink)	an error occurred
Red (blink on startup)	no firmware found, reinstall firmware from https://redpandalab.com/downloads

Inputs and outputs

The Radius has stereo (TRS) inputs and outputs with the left channel on the tip and right channel on the ring. The input/output configuration can be configured using the web editor:

- Mono in / mono out
- Mono in / stereo out
- Stereo in / stereo out (default).

A TS (mono) plug can be used for mono input or output, even if the pedal is configured for stereo.

Power

Use a 9V center negative (Boss-style) regulated power supply that can provide 250 mA or more of current. The plug should have 2.1mm inside diameter and 5.5mm outside diameter. This is the type of power supply used by almost all guitar pedals, and we recommend using one designed specifically for effects. If you have a few pedals, we recommend a multi-pedal power supply with independent regulated outputs (not daisy chained).

If our pedals detect a problem with the power supply, the bypass LED with change to magenta (or pink), the pedal will switch to bypass and enter a low power mode. After a few seconds, the pedal will restart. The most common reasons are that the power supply is not providing enough current, or it is an unregulated voltage converter. Note that some multi-pedal supplies are rated at 100 mA except for a couple of high-current outputs. Some multi-pedal power supplies also share current across multiple outputs. You need to make sure the total current required for all connected pedals is within the power supply's limits.

For additional information, please see our knowledge base.

Bypass mode

Radius supports buffered analog or DSP bypass. DSP bypass gives a smooth fade in and out. With buffered analog bypass, your signal does not go through A/D or D/A conversion when the effect is off. The bypass signal turns on/off using low-distortion analog switches, which may cause a click if the input signal is loud (but less noisy than a 3PDT switch or relay). The click is due to the signal level changing (almost) instantaneously, and will usually be inaudible if you are not playing or using some distortion, but may be noticeable with sounds such as clean guitar or bass.

In mono in/stereo out mode, the analog dry signal is routed from the left input to both outputs.

ON footswitch

The **ON** (right) footswitch switches the effect between active and bypass.

To engage the effect momentarily, start from bypass and hold the footswitch for 400 ms or more. When you release the footswitch, the pedal will return to bypass.

AUX footswitch

The **AUX** (left) footswitch is configurable using the web editor or MIDI. The LED will blink green to confirm that the mode is changed, and it will be remembered when power is off. The mode is global, so that footswitch behavior is consistent between presets.

Tap / tune

Use quick taps to set tempo. Tap multiple times for more accurate measurement. To disable tap tempo, adjust the **RATE** control.

Hold (400 ms) until the LED changes to green to tune the carrier frequency to a played note.

The LED blinks yellow to indicate tap tempo (if active) and is green when push-to-tune is active.

Note: if the envelope follower is active, the AUX switch will not register taps and only do push-to-tune.

Tap tempo

Tap to set tempo (quarter notes). The note division can be set using the web editor or MIDI.

To cancel tap tempo, hold the **AUX** footswitch for 2 seconds or adjust the **RATE** control.

Push-To-Tune (default)

Hold the **AUX** footswitch to tune the carrier frequency to a played note.

See “Pitch tracking” on page 11 for more information.

Push-To-Tune On/Off

Press the **AUX** footswitch to turn push-to-tune mode on or off.

Preset

Pressing the AUX footswitch cycles through the presets, from 1-4 and the live knob settings.

Preset Shift

Pressing the AUX footswitch will momentarily jump to the next preset (1-4), jumping back when you release the switch.

This is a unique and powerful feature, especially useful for emphasis or blasts of chaos. Save a preset in slot 1-3, then save an extreme version of the same sound in the next slot. You can increase the carrier frequency, increase the modulation rate, or any combination. Start on the first preset, then punch the AUX switch to add chaos.

Of course, you can also shift to a more mellow sound, or totally different sound.

Modulation On/Off

Pressing the AUX footswitch turns modulation on and off. The LED blinks green when turned on and red when turned off.

LFO Hold

Press and hold the AUX footswitch to momentarily stop the LFO at its current value. Release the footswitch to let the waveform continue.

LFO Hold On/Off

Pressing the AUX footswitch turns LFO hold on and off. The LED blinks green when turned on and red when turned off.

The difference between LFO hold and turning modulation off is that LFO hold freezes the LFO in its current position, while modulation on/off sets the modulation amount to zero with the LFO still running.

LFO Trigger

If the modulation envelope triggering is active, pressing the **AUX** footswitch will trigger the waveform.

Presets

The Radius stores 100 presets. Presets 1-4 are selectable via the PRESET button, and all are available via MIDI. Preset 101 will revert to the pedal's current knob and switch settings.

Saving presets

To save a preset:
1. press the **PRESET** button until the desired preset (1-4) is selected
2. hold the **PRESET** button for 2 seconds to save the preset

The LED will blink green to confirm that the preset is saved. If the LED blinks red, preset data is locked (see below).

To save a preset using a MIDI controller, hold the **PRESET** button while sending a MIDI program change message. When you release the **PRESET** button, the last program change number will be saved. That allows you to select a preset on MIDI controllers that scroll through program changes. This works best if there is not a preset currently selected, so first press the **PRESET** button until none of the preset LEDs are on (live settings).

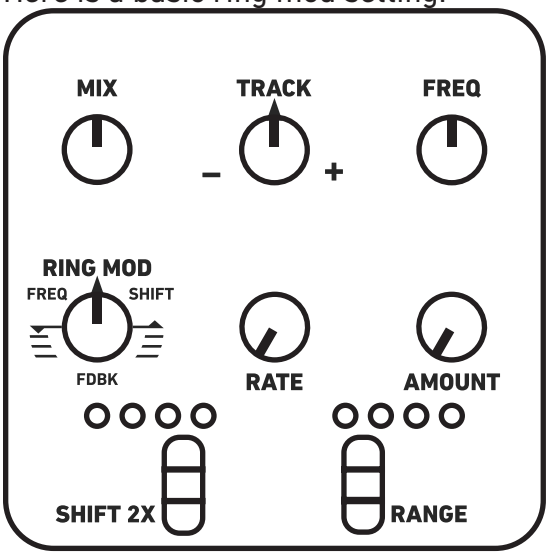
Locking presets

Use the **Lock Presets** setting in the web editor to prevent any of the current presets from being over-written and new presets from being saved. This is useful for tour rigs (or trade shows).

To unlock presets without using the editor, do a factory reset (the presets will not be affected).

Ring modulation

Here is a basic ring mod setting:



The **MIX** control adjusts the wet/dry blend, from 100% dry to 100% wet.

The carrier oscillator frequency can be set in 3 ranges. There is some overlap, but in general, low range is good for tremolo and phases shifter sounds, high is traditional ring modulation, and quantized makes it easier to dial in musical settings.

In its simplest form, ring modulation is the multiplication of one signal by another to create new frequencies. Consider two sine waves:

- An input signal at 1,000 Hz, which we call the modulator. We'll refer to its frequency as f_m
- A second oscillator at 100 Hz, which we call the carrier. We'll refer to its frequency as f_c

Multiplying the two sine waves, $f_m \times f_c$, generates two new sine waves with frequencies $f_m \pm f_c$ = 900 Hz, 1,100 Hz. Those new frequencies are called sidebands – if you view them on a spectrum analyzer, they are on the left (lower) and right (upper) side of the modulator.

Why the names carrier and modulator? For telecommunications, you can use carriers at different frequencies to transmit different radio signals or conversations. Each carrier frequency is modulated by a different signal and they can travel in parallel on the airwaves or a wire. A receiver demodulates one of the signals and filters out everything else to extract (something close to) the original signal.

Why a ring modulator? Mathematically, we are talking about a balanced modulator or four-quadrant multiplier. Four quadrants because the modulator and carrier can both be positive or negative (versus a VCA, where the control signal is non-negative). Early balanced modulators were implemented using rings of diodes, and the name has stuck. Diode ring modulators have a lot of distortion (think Daleks), which is not ideal for communications. Analog ring modulators use either matched transistors, or more commonly, special balanced modulator integrated circuits. The Radius uses DSP algorithms, but it is more complex than simply multiplying the carrier and modulator signals.

Increasing the carrier frequency spreads out the upper and lower sidebands, while decreasing the carrier frequency makes them move closer to the input signal. Negative frequencies reflect back to positive frequencies, causing the sidebands to overlap and mix like waves in a pool.

Shift 2X

The **SHIFT 2X** control adjusts the frequency ratio between the upper and lower sideband.

Up	The upper sideband is shifted by twice as much as the lower sideband
Middle	Both sidebands are shifted by the same amount, set by the **FREQ** control
Down	The lower sideband is shifted by twice as much as the upper sideband

Frequency shifting

Adjusts the balance between frequency shifting and ring modulation. Using the **MIX** and **SHIFT MIX** controls, you can set the relative levels of the original signal, upper and lower sidebands.

The **SHIFT MIX** control morphs the output from frequency shift down to ring modulation to frequency shift up.

below 9:00	frequency shift down with feedback
9:00	frequency shift down
12:00	ring modulation
3:00	frequency shift up
above 3:00	frequency shift up with feedback

Ring modulation creates new upper and lower sidebands at $f_m \pm f_c$. Frequency shifting creates one new frequency, either the upper ($f_m + f_c$) or lower ($f_m - f_c$) sideband. Mathematically, an operation called the Hilbert transform is used to generated a 90˚ phase-shifted versions of the carrier and modulator. In real-world implementations, the carrier is a quadrature (sine/cosine) oscillator and the Hilbert transform is approximated using digital or analog filters to generate an approximately 90˚ phase-shifted version of the input signal.

The Radius generates the phase-shifted input signal in a way that enables phase-shifted sounds at low carrier frequencies, while providing strong carrier suppression for larger shifts.

When the frequency shift carrier frequency is small compared to the input frequency, the result sounds like detuning or phase shifting. A 1 Hz shift at middle C is 6.6 cents. For the second harmonic (880 Hz), 1 Hz is 3.3 cents, and so on. Each harmonic is detuned by a different amount.

Pitch tracking

The **TRACK** control enables the carrier oscillator to track the pitch of your instrument. The center frequency is C4 (middle C, approx 261.63 Hz) and tracking is monophonic. When pitch tracking is 100%, the upper and lower sidebands will move up and down harmonically, which gives a more consistent sound as you play up and down the scale.

Negative pitch tracking will make the upper and lower sidebands farther apart at lower pitches, which gives a stronger effect on lower notes.

Push-to-tune

Hold the **AUX** footswitch and play a note to tune the carrier oscillator to that frequency. That allows you to easily tune the Radius on stage.

Once it is tuned to a note, you can play other notes in the scale and mess around with the harmonics.

Latching push-to-tune

Using the web editor, you can configure the **AUX** footswitch for latching push-to-tune. In this mode, pressing the **AUX** footswitch will turn push-to-tune mode on or off. This can be interesting with modulation, complex harmonies, and chords, creating glitchy tracking. More conventionally, you can keep tracking on for part of a solo, then turn it off to jump off the tuning of the last note.

Play carrier via MIDI

If the **Play Carrier via MIDI** setting is enabled, the carrier oscillator frequency can be set by playing a MIDI note. It uses last note priority, so each time a new note is played, the carrier frequency will update. Adjusting the FREQ control will override the MIDI note, until the next note is received.

Play Carrier via MIDI can be set globally using the **Config** tab of the editor. For each preset, it can be set on, off, or use the global setting (default).

Why is this useful? You can play the carrier oscillator from a sequencer while soloing through the Radius on guitar. Or, connect a MIDI controller to your synth and a Radius. Use MIDI routing software or a plugin to transpose the note sent to the radius up a fourth, or some other interval. Or simply send a synth's audio and MIDI output to the Radius and transpose the synth's oscillator up or down. Or add some glide to the synth oscillator, so the carrier changes immediately but the notes glide in.

Modulation

The Radius' modulation section has 4 LFO waveforms, 2 x-modulators, and an envelope follower. The **RATE** control adjusts the LFO speed (or modulation rate). The modulation wave LED will blink at the modulation rate if modulation is active. The **AMOUNT** control adjusts the range of carrier frequency changes.

Triangle	triangle wave LFO, useful for smooth changes or slow, subtle modulation
Square	square wave LFO, useful for trills or siren sounds
Random	new random value each modulation cycle
Random 2	randomly jumps between the minimum, maximum, and zero values
Step Mod	eight-step sequencer
Xmod -	multi-octave carrier oscillators that sweep downwards
Xmod +	multi-octave carrier oscillators that sweep upwards
Env Follower	envelope follower (**RATE** controls release time)

Envelope trigger

Select any of the modulation waveforms (except for random 2 and the envelope follower). Hold the **WAVE/[TRIG]** button to turn envelope triggering on. The envelope follower LED will turn on (red), and blink green to indicate each time the envelope is triggered. Note that it might not trigger reliably on legato notes, and if the input signal has strong tremolo it may trigger multiple times on sustained notes.

Holding the **WAVE/[TRIG]** button again will turn it off.

When envelope trigger is active, you can press the **STEP** button to trigger the envelope. You can also configure the **AUX** switch to trigger the LFO using the web editor.

The triangle and square LFO waveforms will play in one-shot mode. The Triangle wave will sweep from maximum to zero, creating a fixed-length frequency sweep (with the length controlled by RATE). The square wave will create a fixed-length step at the beginning of each note.

Step modulator

To record a step modulator pattern:

1. Select the step modulator
2. Hold the STEP button until the LED turns red, then release to enter step record mode
3. Adjust the AMOUNT control to set the level at each step
4. Press the STEP button to advance to the next step in the sequence (maximum 8)
5. To finish writing the pattern, hold the STEP button until the LED blinks green
6. Set the AMOUNT knob to its maximum to play the modulation sequence at full scale

Using the web editor or MIDI, you can change the last step and ramp between values.

The step modulator settings are stored in presets. When you program a pattern on the pedal, it is re-

membered when power is off.

Note that it is a step modulator, it is not a sequencer and does not replay knob movements. You can scale the modulation amount and change the base frequency.

You can dynamically change the last step by assigning it to the expression pedal.

X-mod (X- / X+)

The x-mod settings use multiple carrier oscillators that fade in and out while sweeping down (X-) or up (X+). RATE controls the speed of the sweep and AMOUNT controls the width of the sweep, up to ±3 octaves above and below the FREQ control setting. Technically, AMOUNT controls the width of the frequency window for fading in and out. Smaller amounts create unstable warbling or pulsing, while higher settings create endless glissando similar to Shepard-Risset tones.

X-mod is a unique effect that takes some experimentation for best results. Note that increasing the carrier frequency spreads out the upper and lower sidebands, while decreasing the carrier frequency makes them move towards the input signal. Also recall that negative frequencies are reflected back as positive frequencies. That means that the new tones might move in a direction opposite from what you expect.

Sound design with the Radius

Endless glissando

Endless glissando creates tones that seem to rise or fall infinitely. Start with these settings:

MIX 5:00
TRACK: 12:00
FREQ: 11:30
RM/FS: 3:00
RATE: 7:00
AMOUNT: 5:00
MOD WAVE: X+

The slow **RATE** and wide **AMOUNT** give multiple octaves of sidebands that fade in and out. The **FREQ** control sets the center of the sweep.

Frequency shifting up (3:00) or down (9:00) will give the purest glissando. For machine "start up" sounds, try the **RING MOD/FREQ SHIFT** control between 12:00 and 3:00, mixing in some of the lower sideband to create dissonance.

Faster rates will create synth-like tones.

Gliss tremolo

With the **RANGE** switch in the low (down) position, you can create off-balance or frantic tremolo:
MIX 12:00
TRACK 12:00
FREQ: 10:30
RM/FS: 12:00
RATE 10:30
AMOUNT 1:30
MOD WAVE: X+

With envelope triggering on, the sweep happens once.

Fattening

Using frequency shifting to slightly detune harmonic partials so they are in-harmonic can fatten up sounds, especially synths that have a static oscillator waveform. Since each harmonic is detuned my the same number of cycles (Hz), higher harmonics will be detuned less than lower harmonics. That sounds different than regular chorus or detuning and creates a nice fat sound that does not get blurred or hazy [confirm].

Use low (down) range the **RING MOD/FREQ SHIFT** control at 9:00 or 3:00 for pure frequency shifting. They will sound similar, since the shift is small, but the harmonics will be nudged down (9:00) or up (3:00). Set the **FREQ** control to a lower setting, so the sound is thickened but not phasey. Set the **MIX** between 9:00 and 12:00 for a detuned or chorused sound.

Variations:

- Use a triangle or random LFO with a slow **RATE** and low to medium AMOUNT to add some drift to the detuned voice.
- Use a random LFO or step modulator with envelope triggering to detune each note by a different amount.
- Use the envelope follower so that the attack of each note has more detuning, and it becomes more in tune as it decays.
- Use pitch track to keep the detuning consistent as you play different notes (monophonic). With **TRACK** at 100% (5:00), each harmonic will be detuned by the same pitch ratio (cents) on all notes.

Harmonic stretching

To stretch (or compress) harmonics so that they are no longer pure harmonics, use low (down) **RANGE** with **MIX** at 100% and RM/FS to 9:00 or 3:00 for pure frequency shifting. The **FREQ** knob will add or subtract a small fixed frequency (in Hz) from each harmonic, making them slightly out of tune.

Note that your fundamental will also be detuned.

Adding feedback (**RING MOD/FREQ SHIFT** below 9:00 or above 3:00) will add some metallic character and a barberpole frequency shifting effect at low **FREQ** settings.

Overdrive before ring mod

Placing an overdrive in front of the Radius can create new harmonics that generate new sum and difference frequencies, similar to the drive (input gain) control on some ring mods

Ring mod into fuzz

Ring modulation and frequency shifting create new frequencies that are not harmonically related to the input signal. Placing the Radius in front of a fuzz will create new frequencies for the fuzz to work with.

Web Editor

The web editor can be used to configure your pedal, access hidden parameters, and fine-tune presets. It is intended for "offline" configuration and editing. For live performance editing, we recommend using dedicated MIDI hardware or software and MIDI control change messages.

Connect your pedal to a computer using a USB cable and go to the web editor URL using Chrome:

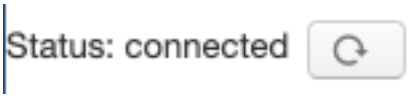
https://www.redpandalab.com/content/apps/radius-editor/index.html

Note the **https** in the URL. **http** will not allow the browser to acess your MIDI devices.

The editor uses Web MIDI, which is not supported by all browsers. We officially support Chrome.

Pedal Status

The web editor indicates whether the pedal is connected. If the status is "not found", ensure that the pedal is turned on and connected to your computer. Click the refresh button to refresh the status.



Edit

The Edit tab shows all of the pedal's realtime parameters. The on-screen controls are updated to match the current state of the pedal, but hidden parameters are not updated. Press the **Refresh** button to update all of the parameters. The web editor's controls allow higher resolution changes than MIDI continuous controller messages.

Sliders can be dragged using the mouse or you can click on a position to change the value. The following key combinations are available for sliders:

Tab	Change focus to next control
Shift-Tab	Change focus to previous control
Left/right arrow	Change value in small increments
Shift-left arrow Shift-right arrow	Change value in larger increments

Ctrl Port

The Ctrl Port tab allows you to configure the pedal's **CTRL** port for an expression pedal or remote switch. The control port mode (expression or remote) is stored globally, but expression pedal assignment and remote switch configuration are stored in each preset.

To store the **CTRL Port Mode** and global expression mapping, scroll to the bottom of the page and click the **Save** button. The pedal's LED will blink green. You can set the expression pedal mapping for a preset by configuring the expression pedal destinations and then saving a preset (without clicking the Save button on the Ctrl Port page).

The expression pedal can be assigned to up to 6 parameters, with a minimum/maximum range for each.

Preset

The Preset tab allows you to send MIDI program change messages and save presets to the pedal's on-board memory. Presets 1-4 are also available via the pedal's **PRESET** footswitch.

Prests can be named, copied, and transferred to/from a computer.

# (Load)		Shows the preset number (1-based). Click the box to load the preset. If there is no preset in the memory location, the column is grayed out.
Name		Displays the preset name. By default, the presets have generic names like Preset 1, Preset 2, etc. If there is no preset in the memory location, the name is grayed out.
Rename		Renames the selected preset. Preset names can be up to 15 UTF-8 characters. When creating a new preset, write the preset first, then rename it.
Write		Writes the current settings to the selected preset.
Copy		Copies the selected preset. You can then paste it into one or more memory slots to duplicate or reorganize presets.
Paste		Pastes the preset into the selected memory location.
From Pedal		Downloads the selected preset to your computer. The location depends on your browser settings, but is typically your Downloads folder. The filename will be the preset name with a ".syx" extension.
To Pedal		Uploads a preset file from your computer to the pedal. A dialog box allows you to select the file (with ".syx" extension.

Config

The Config tab shows your pedal's current firmware version and allows you to configure global pedal settings for your setup. Settings are saved when power is off.

If the pedal detects an error condition, a diagnostic code will be displayed on this tab.

AUX Switch	Sets the AUX (left) footswitch function. See "AUX footswitch" on page 6 for more information.
Input/Output Configuration	Selects stereo or mono audio input/output.
Bypass Mode	Selects analog or DSP bypass.
MIDI Channel	Sets the MIDI channel (default: channel 1).
Play Carrier via MIDI	Enables global MIDI note reception for the carrier oscillator. Can be overridden by presets.

Receive MIDI Clock	Turns MIDI clock reception on/off. To disable MIDI clock sync for specific presets, set their note division parameters to “Off”.
Lock Presets	Locks preset data to avoid accidental changes.

Help

The Help tab provides links to our knowledge base, user manual, and firmware updates.

Show MIDI Devices

This button shows all USB MIDI input and output devices. Your pedal should show up in this list. If not, see our knowledge base or contact us for additional troubleshooting information.

Log to JavaScript Console

Logs debugging information to the JavaScript console. We may ask you to turn this on to help troubleshoot complex problems, but generally you can ignore it.

Control Input

The **CTRL** (control) input supports different methods of remotely controlling the pedal:
- Expression pedal
- Control voltage (CV) with 0-3.3V range
- Tap Tempo
- TRS MIDI in (tip active)
- Remote switch

To configure a expression pedal or remote switch, hold down the right footswitch while plugging it in. The pedal will detect which device is connected using the steps below. You can also use our web editor to configure the port (see "Web Editor").

The configuration is remembered when power is turned off. Expression pedal assignments and remote switch settings are stored in presets and remembered when power is turned off.

Expression Pedal

An expression pedal can be assigned to any combination of knob settings at the heel and toe position (up to 6 parameters). Moving the expression pedal will morph between the settings.

You can also calibrate the range of the expression pedal, to ensure that its full travel is used.

Calibrating Expression Pedal Range (no knob assignments):
1. Start with the pedal powered on and nothing plugged into the **CTRL** port.
2. Hold the right footswitch while plugging in the expression pedal. The right LED will blink yellow three times to indicate it is in **CTRL** configuration mode. You can release the right footswitch and begin configuration immediately.
3. Move the expression pedal to the heel down position.
4. Move the expression pedal to the toe down position.
5. Hold the right footswitch for 3 seconds to save the configuration. The right LED will blink green to indicate that the configuration has been saved.

Configuring Expression Pedal Knob Assignments
1. Start with the pedal powered on and nothing plugged into the **CTRL** port.
2. Hold the right footswitch while plugging in the expression pedal. The right LED will blink yellow 3 times to indicate it is in **CTRL** configuration mode. You can release the right footswitch and begin configuration immediately.
3. Move the expression pedal to the heel down position.
4. Adjust the knobs for the desired sound.
5. Move the expression pedal to the toe down position.
6. Adjust the knobs for the desired sound.
7. Hold the right footswitch for 3 seconds to save the configuration. The right LED will blink green to indicate that the configuration has been saved.

Knobs that are not adjusted during configuration will not be affected by the expression pedal. Expression pedal assignments are stored in presets and when the expression pedal is unplugged or power is turned off. Expression pedals with 5-25 kΩ linear potentiometers work best.

Control Voltage

Control voltage input is configured the same way as an expression pedal.

CV Range: 0-3.3V (with over/under-voltage protection)
Tip: 0-3.3V input
Ring: 3.3V output (with current limiting)
Sleeve: ground

The expression input has current limiting in case you use a TS cable, but it is preferable to use a 1/4" TRS cable with the ring unconnected. We sell a suitable cable at our web site, and the Expert Sleepers 'floating ring' cable is another option. Instructions for building your own cable are available on our Knowledge Base.

Tap Tempo

Uses a normally open momentary switch. Configure it using the web editor.

TRS MIDI

Select **MIDI (TRS)** in the web editor to use the control port as a MIDI input. This is a non-standard MIDI interface, because there is no optocoupler on the input to prevent current loops, but it is used by many guitar pedals. You will need a converter or a MIDI controller with 1/4" TRS outputs, which are available from Empress Effects, Disaster Area Designs, and others.

Remote Switch

A remote switch has up to 4 modes of 4 switches that can access presets and pedal functions. It works with our remote switches, some third-party switches, and is DIY friendly for different control interfaces. See our Knowledge Base for infomation on building a compatible switch. Note that the switch uses parallel resistors, and switches with shorting contacts will not work without an adapter (most tap-tempo switches and the Roland FS-6, for example).

1, 2, 3, and 4-button switches are supported. The modes and functions accessible will depend on the number of buttons. A single-button switch can load or save your favorite sound.

To save a preset, hold the corresponding button for two seconds. The right LED will blink green to indicate that the preset has been stored. Presets are also accessible via the **PRESET** button and MIDI program change messages.

Configuring a Remote Switch:

1. Start with the pedal powered on and nothing plugged into the **CTRL** port.
2. Hold the right footswitch while plugging in the remote switch. The right LED will blink yellow 3 times to indicate it is in **CTRL** configuration mode. You can release the right footswitch and begin configuration immediately.
3. Press one of the buttons on the remote switch to select a mode.
4. Hold the right footswitch for 2 seconds to save the configuration. The right LED will blink green to indicate that the configuration has been saved.

Remote Modes

Mode	Switch	Function	LED Indication
1	A	Preset 1 Double tap: manual settings Hold (4 sec): save	Blinks green when saved
	B	Preset 2 Double tap: manual settings Hold (4 sec): save	Blinks green when saved
	C	Preset 3 Double tap: manual settings Hold (4 sec): save	Blinks green when saved
	D	Preset 4 Double tap: manual settings Hold (4 sec): save	Blinks green when saved
2	A	Left footswitch	
	B	Right footswitch	
	C	Preset down	
	D	Preset up	

Reset to factory defaults

Use the following procedure to reset the Radius' configuration data to factory default settings. This will erase any advanced configuration and control port settings, but presets will not be affected. Note that this is rarely useful for troubleshooting problems with your pedal.

1. Start with the pedal unplugged.
2. Set the **SHIFT 2X** and **RANGE** toggle switches to their down positions.
3. Press and hold the **ON** footswitch while plugging in power. The right LED will be solid blueish white.
4. Move the **SHIFT 2X** and **RANGE** toggle switches to their up positions.
5. Release the ON footswitch.
6. When the factory reset is complete, the LEDs will cycle through different colors.
7. Power cycle the pedal to continue.

Using MIDI

Your pedal supports USB MIDI (in/out) and 1/4" TRS MIDI (input only).

USB MIDI

Your pedal is a class-compliant USB device, which allows you to:
- Control all parameters
- Access additional hidden parameters

The pedal can work with any USB MIDI host, including:
- Macintosh and Windows computers. The pedal shows up as a MIDI device and is available to all programs.
- Apple iPad, iPod touch, and iPhone using the Lightning to USB 3 Camera Adapter.
- Standalone USB MIDI hosts allow you to connect the Tensor to hardware with 5-pin DIN MIDI connectors without the use of a computer. Examples include:
  iConnectivity iConnectMIDI4+
  iConnectivity mio4
  Disaster Area Designs Gen3 MIDI controllers with their gHOST option
  Kenton MIDI USB Host MkII
  MidiPlus USB MIDI Host
  See our Knowledge Base for up-to-date information

The pedal sends and receives on MIDI channel 1 by default. You can change the MIDI channel using MIDI System Exclusive messages or our web-based editor. The MIDI channel is remembered when power is off. See "System Exclusive (SysEx)" for more information.

TRS MIDI Input

See "Control Input" for information about configuring TRS MIDI. Only MIDI input is supported, so you can use the web editor to change parameters and configuration settings, but it will not show the current state of the pedal.

MIDI Continuous Controller Messages

CC Num	Destination	Notes	
4	Expression	Sending CC 4 is the same as having an expression pedal connected to the CTRL input (which does not have to be configured for “expression”).	
14	Mix		
15	Ring mod/freq shift mix		
16	Carrier frequency		
18	Carrier pitch tracking	0 ... 64 ... 127	-100% Off +100%
22	Modulation rate		
24	Modulation depth		
70	Step modulator step 1		
71	Step modulator step 2		
72	Step modulator step 3		
73	Step modulator step 4		
74	Step modulator step 5		
75	Step modulator step 6		
76	Step modulator step 7		
77	Step modulator step 8		
78	Step mod last step	1-8	
79	Step mod ramp	0-63 64-127	Off (step) On (ramp)
80	AUX footswitch	Use gated (momentary) mode to send 127 on press and 0 on release. Matches footswitch behavior.	
		0-63 64-127	Release Press
81	ON footswitch	Use gated (momentary) mode to send 127 on press and 0 on release. Matches footswitch behavior.	
		0-63 64-127	Release Press
82	Mod envelope trigger	0-63 64-127	Off On
85	Modulation waveform	0 1 2 3 4 5 6 7	Triangle Square Random step Random 2 Step modulator X- X+ Envelope follower

CC Num	Destination	Notes	
86	Shift 2X	0 1 2	Down Off Up
87	Shift range	0 1 2	Low High Stepped
88	Bypass (receive only)	0-63 64-127	Bypass Effect on
89	Tap (receive only)	64-127	Tap
109	Modulation note division	See “Note Divisions” table	
110	Receive MIDI clock (global)	0-63 64-127	Off Receive MIDI clock
111	Play carrier by MIDI note	0 1 2	Off On Use global setting

Note division continuous controller values

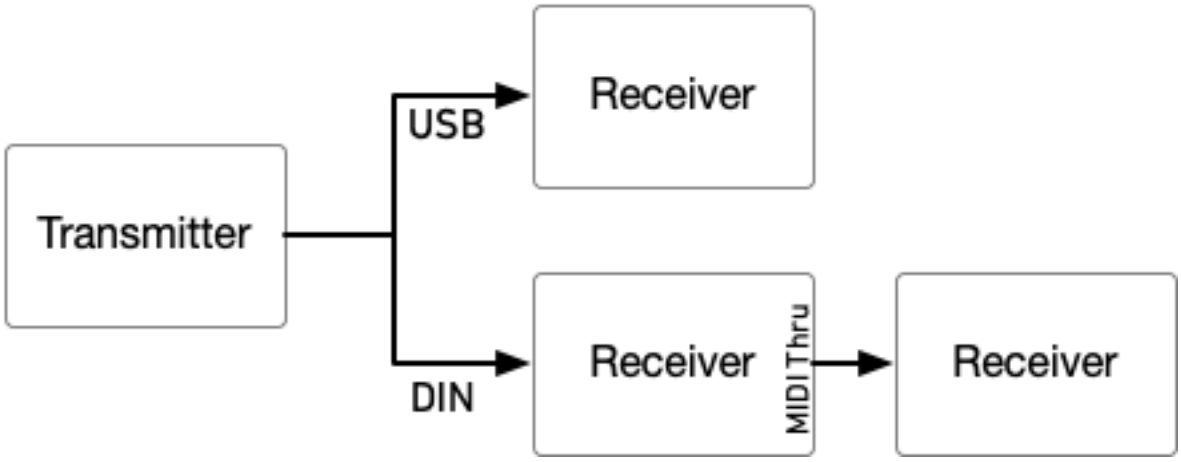
CC Value	Note Division
0	Off (tap tempo disabled)
1	8 measure
2	7 measures
3	6 measures
4	5 measures
5	4 measures
6	3 measures
7	2 measures
8	2 measure triplet
9	Dotted whole note
10	Whole note
11	Whole note triplet
12	Dotted half note
13	Half note
14	Half note triplet
15	Dotted quarter note
16	Quarter note
17	Quarter note triplet
18	Dotted eighth note
19	Eighth note
20	Eighth note triplet
21	Dotted 16th note
22	16th note
23	16th note triplet
24	Dotted 32nd note
25	32nd note
26	32nd note triplet

MIDI Timing Clock

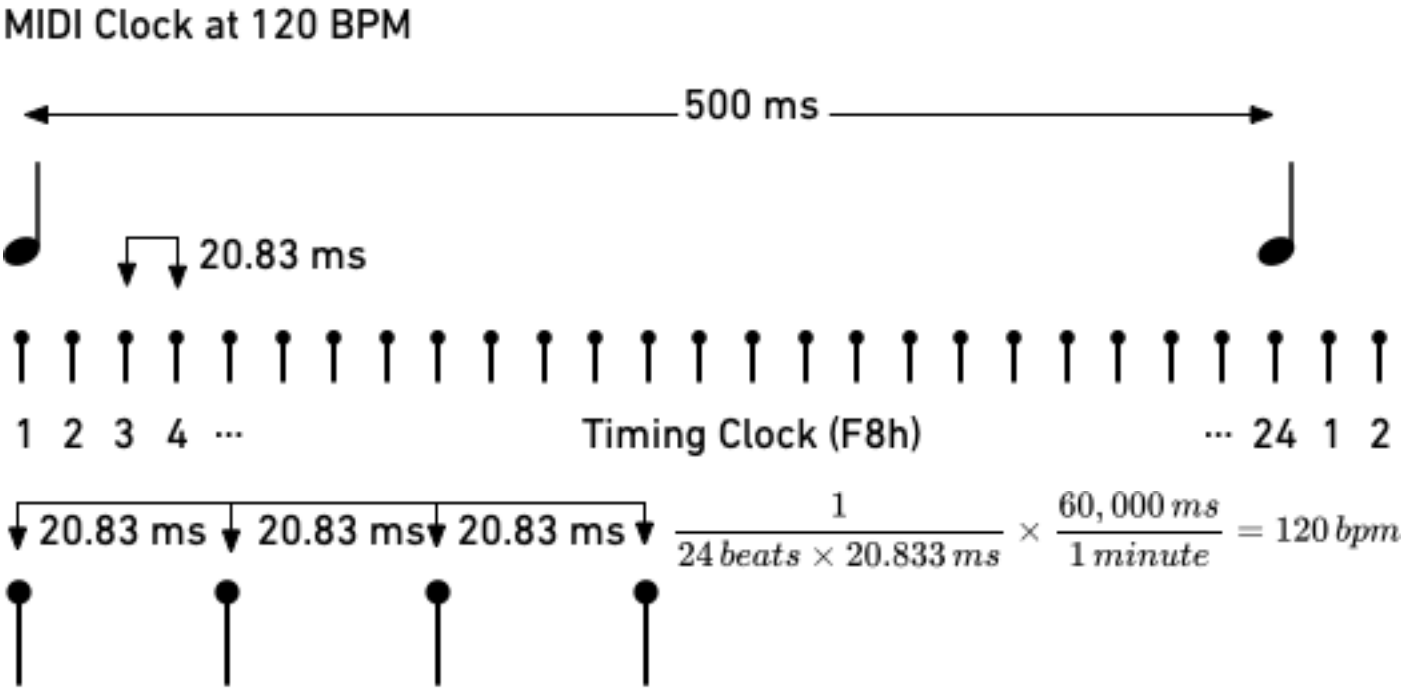
MIDI timing clock messages are used to synchronize multiple MIDI devices to a single clock transmitter. The clock is typically provided by a DAW in computer-based setups and a sequencer or drum machine in hardware-only setups. Dedicated MIDI clock generators are available for more complicated setups that need tight synchronization, and some devices can convert between MIDI clock, DIN sync, and taps.

How MIDI clock works

MIDI clocks are sent out at regular intervals by a clock *transmitter* to one or more *receivers*. The transmitter controls playback and sets the tempo.
The transmitter never tells the receivers the actual tempo. Instead it sends 24 timing clock messages



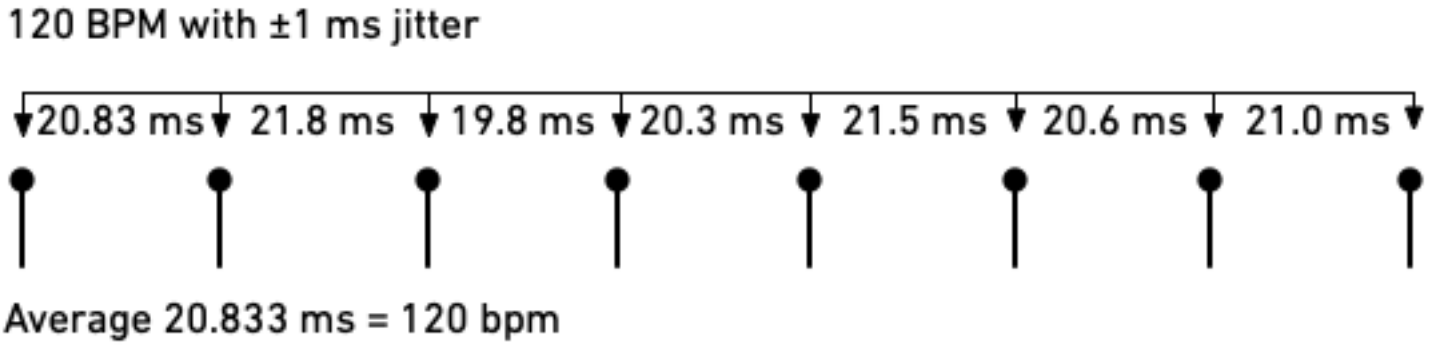
every quarter note (24 PPQ) and the receivers each calculate the tempo independently.
Start, stop, and continue messages are used to synchronize playback between devices. The transmitter



continues sending timing clocks when it is stopped so that receivers can be ready when playback starts or continues. A start message will reset playback to the first beat, and a continue message will pick up where playback left off.

MIDI real time messages are high-priority messages that can interrupt other MIDI messages to ensure

the best possible syncronization timing. However, the accuracy of the clock depends on the transmitter and any devices it passes through. It is common to have +/-1 milliseconds of *jitter*, with is irregular timing due to individual clock ticks arriving too early or too late. All equipment that receives MIDI clock needs to smooth out the timing to maintain a stable tempo. The smoothing algorithm needs to handle jitter, but also track sudden or gradual tempo changes accurately and naturally. Different manufacturers use different synchronization algorithms, which can lead to sloppy timing. This was more of a problem with older MIDI equipment that had slower processors and complex setups with long MIDI chains and routers. It can also be a useful technique, synchronizing multiple hardware sequencers to give each musical part a slightly different timing and feel.
Some devices do not transmit start, stop, and continue messages, so the pedal will begin synchronizing



if it receives a MIDI timing clock message without a start or stop message first.

Comparison to tap tempo

Tap tempo is set by tapping quarter notes on a footswitch. It is simpler to set up, but is not synchronized to other equipment unless you are using a multi-pedal tap tempo controllers. Tap tempo controllers have an electronic switch on each output that simulates a footswitch press.

Neither tap tempo nor MIDI timing clock sends tempo information. The pedal calculates the tempo from the input and adjusts to tempo changes. Because MIDI timing clock sends 24 clock ticks per quarter note instead of 1 tap per quarter note, it enables tighter synchronization between equipment.

Note divisions for the pedal's parameters are configured the same way for tap tempo and MIDI clock, so you can switch between methods for recording and live use.

Configuring your pedal for MIDI clock

In the web editor's **Config** tab, set **Receive MIDI Clock** to On. You can also send MIDI continuous controller #110 to the pedal with a value of 64-127. The MIDI clock setting is remembered when power is turned off.

Setting note divisions

Configure note divisions using the pedal's "shift" mode, or using the web editor. See "Tap Tempo" for information about note divisions for each parameter.

Pitch vs frequency shifting

To understand why ring mod sounds atonal and how you can use it musically, it might help to think about the difference between frequency and pitch. To play a ring mod or frequency shifter musically, you need to map between linear frequency and exponential pitch. This applies to both ring modulation and frequency shifting, and harmonically you can think of ring mod as frequency shifting up and down at the same time. This is also a fundamental discussion that involves some math, so feel free to skip it.

Most musical sounds are made up of a fundamental frequency – the note you play – and the harmonics. Harmonics are at multiples of the fundamental frequency. A 100 Hz tone has harmonics at 200 Hz, 300 Hz, 400 Hz, and so on.

Pitch shifting works with pitch ratios (octaves, semitones, cents). Each harmonic is shifted by the same pitch ratio, which means we are multiplying each harmonic's frequency by the same amount. For example, 17 cents is a ratio of approximately 1.01 (2^(17/1200) = 1.00987). If we pitch shift our 100 Hz tone up by 17 cents, the harmonics will be approximately 101 Hz, 202 Hz, 303 Hz, and 404 Hz. They keep their harmonic relationship (404 / 101 = 4).

Frequency shifting and ring modulation work in terms of linear frequencies (Hz), not pitch. Addition and subtraction instead of multiplication. If we frequency shift our 100 Hz tone by 1 Hz, the harmonics will be 101 Hz, 201 Hz, 301 Hz, and 401 Hz. They are no longer harmonics – higher harmonics get increasingly flat. the 401 Hz harmonic is 13 cents flat.

Input	Pitch shift +17 cents	Frequency shift + 1 Hz	Frequency shift Harmonic detuning
100 Hz	101 Hz	101 Hz	+17 cents
200 Hz	202 Hz	201 Hz	+9 cents
300 Hz	303 Hz	301 Hz	+6 cents
400 Hz	404 Hz	401 Hz	+4 cents

If we shift by a larger amount, it becomes atonal. Here are the output frequencies from frequency shifting the 100 Hz tone up and down by 50 Hz:

Getting more extreme, we can frequency shift the 100 Hz tone up and down by 500 Hz:
Reflected frequencies in italics

The frequencies in italics are negative frequencies that get reflected back as positive frequencies. This happens with both digital and analog ring mods. 100 – 500 = -400 Hz. Real signals cannot have negative frequencies, but it gets reflected back as a 400 Hz frequency.

Specifications

Carrier frequency: 0.65 - 4,000 Hz
LFO frequency: 0.1 - 55 Hz
Input impedance: 1 MΩ
Output impedance: 470 Ω
Max. input: +8 dBu
Power: 9V DC, center negative
Current: 200 mA
Dimensions: 3.1" x 4.75" x 2.5"
Weight: 0.73 lbs.

Credits

Design and engineering	Curt Malouin
Web editor	Curt Malouin
Documentation	Curt Malouin
Name	Dan Elkan
Graphics	Sylvie Demers
Testing	Eric Iverson
	Curt Malouin
	Randy Molina

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