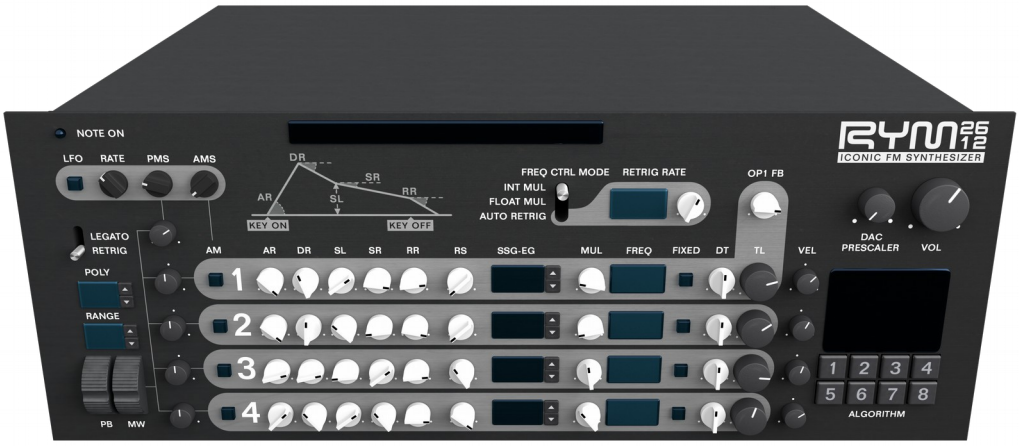


User Manual

1.0.4

Foreword

The RYM2612 is the result of several years of hard work to reproduce almost “genetically” the sound of the mighty YM2612 discrete chip which once equipped the Sega Genesis/Megadrive video game consoles and went instantly timeless with its success, as people fell in love with the FM tones as much as they loved the fantastic games available for the console.

The RYM2612 can be seen as a tribute to these early years of home arcade gaming, as well as an opportunity to bring those tones back to present days, more proudly than ever.

To achieve this, a brand new emulation core has been written from scratch with cycle accuracy in mind as well as extensibility and low CPU usage.

This allows the RYM2612 to behave exactly as the original chip in the way it creates sound but also to push back some of its original limits.

We thus hope to revive the urge to play with these operators and to make tremendously vibrant music with this iconic synth recreation.

Short Introduction to FM Synthesis

Frequency Modulation (or FM) synthesis is a method for producing electronic sound made popular by Yamaha in the 80s with their legendary DX line of synthesizers.

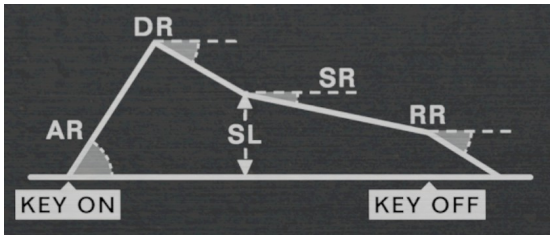
In FM synthesis, everything starts with sine waves. Simple oscillators produce a single sine wave at a given frequency with an amplitude envelope applied to it. These basic components are called *operators*. Each operator output can either be mixed with others (and thus be audible) or can be used to actually *modulate* another operator's frequency. The different ways to organize operators are called *algorithms*.

Detailed Operation

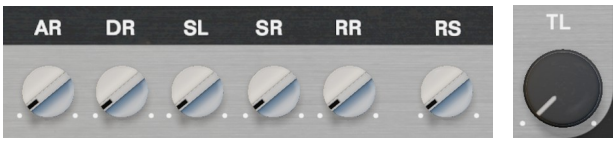
Operator Controls

Each operator has an equal set of controls to sculpt its sound.

Envelope Generator



The Envelope Generator (or EG) controls the amplitude of the operator's sine wave through time. Internally, the EG is responsible to compute an *attenuation* value which will be applied to the operator's output. Note that this is how Sustain Level and Total Level are expressed in the original YM2612: from 127 to 0, where 0 means *minimum attenuation* thus maximal amplitude. However, for the sake of intuitiveness, in the RYM2612, Sustain and Total Levels are expressed as is, “levels”, and are internally converted.



The main parameters of the EG are the *rates* which can be represented by the angles determining the speed of each slope.

Sustain Level represents the amplitude level at which the EG will switch from the decay phase to the sustain phase. Total Level represents the overall amplitude of the EG.

The Rate Scaling parameter will affect the overall EG speed depending on the pitch of the played note. The higher Rate Scaling, the faster EG rate.

SSG-EG

The SSG (Software-Controlled Sound Generator) is a reminiscence of higher grade YM chip models which the 2612 inherited in a quite special and incomplete way. It can alter the original operation of the base EG by combining different behaviors.

- **Repeat:** while a key is being pressed, this behavior will make the EG loop through its attack, decay and sustain phases when the EG's amplitude hits zero. To enable this behavior, ensure that the decay and sustain phases will actually allow the EG to reach zero, by setting their rate to a high enough value. Also note that if Sustain Level is set to zero, the loop will be triggered at the end of the decay phase.
- **Hold:** the EG will only run once and will then hold its amplitude to either zero or Total Level (depending on the next behavior).
- **Alternate:** each motif of the SSG will be alternatively played forward then backward (or more precisely *inverted*).
- **Inverted first:** the SSG begins with an inverted motif.

When SSG is enabled, it will also double the base EG rate except for the attack phase. The release phase is only entered after a key off (as usual) and will make the current amplitude decrease at the desired rate. Finally, note that the SSG was not even intended to be an official feature of the YM2612 (hence its poor implementation and the potentially resulting quirks) but it eventually proved to be an exotic feature which can be used creatively and offers a lot of sonic potential.

Phase Generator

The Phase Generator is in charge of computing the operator's sine wave phase depending on several parameters.

When a key is pressed, the absolute pitch of the note gives a base frequency which is common to each operator. The Multiplier parameter represents a factor which the base frequency is then multiplied by. Integer multipliers produce natural higher harmonics of the base frequency (value ½ results in an octave lower frequency).

The Detune parameter (as its names involves) will apply a small positive or negative detune amount to the final frequency.

Feedback

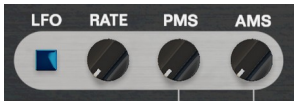
Operator 1 is able to feed its output back into itself to produce even more timbres. Use the OP1 FB knob to adjust the feedback amount. Note that with a high Total Level on operator 1, this can leads to digital saturation (which can be used creatively for percussive sounds, for example).

Algorithm

The Algorithm selector allows to choose between eight combinations of operators with a clear graphical representation. Operators with inverted colors are output operators (also called *slots*) and require adequate EG settings (Total Level notably) in order to obtain audible sounds.

LFO Section

The YM2612 comes with a minimalistic Low Frequency Oscillator (LFO) with variable pre-defined rates and can independently modulate a voice's pitch or an operator's amplitude.



Use the toggle button to enable the LFO and adjust the Rate parameter to the desired value.

Pitch Modulation Sensitivity (PMS) determines the impact of the LFO on pitch while Amplitude Modulation Sensitivity (AMS) determines the impact of the LFO on operators' amplitude.

Note that an additional individual Amplitude Modulation toggle button on each operator allows to control if the operator's amplitude will be affected by the LFO.

Additional Modulation Controls

The Total Level of each operator can be modulated by a desired amount of either velocity, modulation wheel or CV.

Use the different MW and Vel knobs to control the impact of these modulation sources to each operator's amplitude.

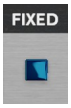
CV inputs are available for each operator on the back of the device for external modulation of Total Levels.

There's also a MW knob which allows to modulate the LFO's PMS setting and thus rapidly create a vibrato effect controlled by the modulation wheel.

Special Features

Special Mode

As stated below, the frequency Multiplier of each operator is, by default, an integer number (or ½) and the base frequency which it'll multiply is common to all operators. However, the original YM2612 also has a so-called “Special Mode” in which each operator can have its own independent base frequency. This allowed programmers and musicians to obtain dissonant harmonics (for the purpose of creating SFX, mainly). The RYM2612 faithfully reproduce this feature and gives it even finer control. Since the base frequency can be independent for each operator, the RYM2612 offers the ability to either use a *floating* (decimal) frequency Multiplier (while still using the original note's absolute pitch) or a *fixed* absolute frequency.



To enable this feature, set the Frequency Control Mode switch to Float Mul. In this mode, you can use the Fixed toggle button of each operator to use a fixed frequency. The Freq display is thus showing different values depending on the current Frequency Control Mode and current state of the Fixed toggle button:

- Int Mul: the Freq display shows ½ and integer multiplier values (Fixed toggle button has no effect)
- Float Mul w/o Fixed: the Freq display shows floating multiplier values
- Float Mul w/ Fixed on: the Freq display shows the absolute operator's frequency (in Hz)

CSM Mode

In addition to this “Special Mode”, the YM2612 also has an even more secret feature referred to as “CSM Mode” (as for Composite Sinusoidal Modeling) or “Illegal Mode” (because of the absence of official documentation on this feature). In this mode, the chip uses a built-in interval timer (TimerA) which value can be user-defined and automatically triggers key on/off events each time the timer overflows. This gives a very fast repetition effect of a note which sound is then perceived as a tone rather than a repeating note. Combined with the remaining “regular” settings of the tone, this allows to create formants and some kind of rudimentary speech synthesis (as well as creative sound effects).

To enable this feature, set the Frequency Control Mode switch to Auto Retrig and adjust the Retrig Rate value (which internally corresponds to the real TimerA value) and ensure that operators have significant release time in order to hear any result (as each note is automatically “keyed on” then *immediately* “keyed off”). Also note that this mode implies the Float Mul Frequency Control Mode (or “Special Mode”), just as with the real YM2612.

PCM Playback

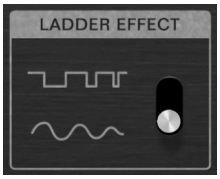
A last well known feature of the YM2612 is its ability to output PCM samples. This feature is provided in the form of an audio input on the back of the device. Once fed with audio, the RYM2612 will convert the signal to 8bit so it can be treated just as the YM2612 would do.

An extra Prescaler parameter allows to hard divide the sample rate of incoming audio to produce a characteristic decimation effect.

Output Filtering

Circuit analysis of a real Model 1 Sega Genesis allowed to recreate an accurate simulation of the filtering induced by the external electronic components used alongside the YM2612. This simulation can to toggled on and off, from the back of the device, to either get the real frequency response of the legacy hardware or to obtain a purer, digital-only sound.

Ladder Effect



The original YM2612 is equipped with a built-in digital-to-analog converter which has a noticeable (not to say famous) defect which creates a somewhat unique sound distortion called the “Ladder Effect” which is mostly audible at low amplitudes. It can also be toggled on and off from the back of the device.

For the Purists

The RYM2612 has been developed from the ground-up to be 100% respectful of the intrinsic constraints of its hardware counterpart. Video game music history has always proved that constraints forced composers and programmers to exceed the boundaries of their hardware specifications, and to create revolutionary techniques in order to outcome their potential of musical expression through devices like the YM2612. Even though the RYM2612 has extended capabilities compared to the original YM2612, one can deliberately choose to adhere to the real constraints of the chip while composing, thus turning the RYM2612 into an ideal prototyping tool for the purists and musical aesthetics like the so-called *chiptune* music scene. Here's how:

- At any given moment, do not exceed a total polyphony of 6 voices. The YM2612 had only 6 channels.
- DAC mode for PCM playback counts for one voice. It replaced the FM tone on channel 6 when enabled on the YM2612.
- Special Mode or CSM Mode (Float Mul and Auto Retrig on the RYM2612) were only available on channel 3. Do not use more than one voice with these modes enabled.
- Each channel could be panned left, right or both. Nothing in between. This is actually the only parameter from the original YM2612 which is not exposed to the user in the RYM2612 because of its redundancy with Reason's Mixer.
- Output filtering and ladder effect must be enabled. That's how the YM2612 sounds on a Model 1 Sega Genesis!

Acknowledgements

For ages, the YM2612 retained attention and efforts of one of the most skilled and passionate reverse-engineering community ever. Many thanks go to Jarek Burczynski, Tatsuyuki Satoh, Stéphane Dallongeville, Nemesis, Shiru, TmEE, Eke-Eke, AamirM, Charles McDonald, Aly James and all the regular people at spritesmind.net and smspower.org.

Special thanks to William “willbe” Lamy, for being such a wonderful teammate.

Many thanks also go to all testers who helped making the RYM2612 a better product and also showed invaluable support during development.