

SEGA<sup>®</sup>  
**GENESIS<sup>®</sup>**

ALY JAMES LAB  
**F-DRIVE**

**YM 2612 EXTENDED  
VST EMULATION**



**USER MANUAL**

WINDOWS 32BIT

**1.2**



# **FM-DRIVE 2612 VST**

**USER MANUAL 1.2**

BY

Aly James



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# INTRODUCTION

My name is Aly James;

French steam funky musician, composer and creator of strange musical DIY devices and software.

Normally I am more inclined to make some guitar & bass oriented devices but I am also a fan of the SEGA GENESIS/MEGADRIVE sound, it was my first console and it opens up my imagination and lot.

I was not very used to tracker music making or MML programming, which is why I needed an YM2612 Vst Instrument, for personal use. Also I needed a way to control the real hardware via MIDI.

I learn a lot from documentations and hardware tests and from all the nice people who documented the YM2612 on the web. You know who you are.

It turns out to be quite nice so I decided to make it public in exchange for a small donation for the large amount of work I put into this.

This emulation uses a totally new core that I started from scratch a few months ago and was almost fine-tuned by ear so minors differences with the hardware could appears sometimes.

The goal was on one hand to reproduce the hardware distortion "ladder effect" of the Sega Megadrive model 1 and the features of the YM2612 chip and on the other hand to expand further the original capabilities and create a high resolution processing mode for perfect sound quality.

I needed a toy to have best of both world and an inspiring FM synth.

I tested the not well known CSM "illegal mode" usage, designing custom ROMS to investigate further and finally include a way in FMDRIVE 2612 to use CSM for modern music production.

All and all the SEGA MEGADRIVE EXTENDED emulation turns out to be a fantastic FM synth suitable for chip music and Sega nostalgic pleasure and also a powerful tool for modern music production.

The product has been crafted through the SYNTHEDIT engine using the very last version, custom C++ coding and third party licensed code. It may be ported to OSX at some point in the future.

Thanks to all the nice people that started to use FMDrive and support my projects.

A special thanks to Sebastian Tomczak who designed the GENMDM midi hardware interface and provide great sources of inspiration and to Yuzo Koshiro for his FM music and support on FMDrive.

Credits can be accessed on the FMDrive GUI panel.

Mainly,

FMDRIVE can act either as the YM2612 CH1, 2, 3(with special mode or CSM) 4, 5 or 6 (FM or DAC).

It can be either polyphonic (up to 6 voices) or mono like the real chip and can act as 6 YM2612 channels at once with the same patch when in poly mode...

However you have to **load 6 instances of the VST** to have the YM2612 six channels original setup.

This particular implementation allows getting over the original six channels limit if ones need it.

Like **15 instances of FMDrive** for example for a massive FM wall of sound!

However you can still have a lot of control on **only one instance**, as everything can **be MIDI automated in a DAW**, you can have a maximum of control over the chip, for example you can change the algorithm and others registers via MIDI CC on the same instance and same MIDI track. Every registers can be automated or recorded via the GUI and his will change the sound.

#### Basic MIDI implementation:

##### MIDI IN:

FMDrive receive MIDI CH1 as main source for notes and key on/off.

However when in SPECIAL MODE FMDrive can optionally receive MIDI CH 11, 12, 13 to control operators key on/off and frequency separately and MIDI CH 14 to control CSM timer period by note (*this is explained in detail later*).

##### MIDI OUT:

FMDrive can send MIDI CC data over any MIDI channels.

For example if you assign MIDI CC#15 to the LFO speed register, when it is changed, FMDrive will also send CC#15 DATA over the chosen MIDI Channel allowing to control another instance of FMDrive or another Vsti.

*Imagine that on another FMDrive instance you assign the same MIDI CC#15 to the Frequency of an operator in SPECIAL MODE...Then, when the LFO change on the first instance, the second instance will change the Frequency of the operator following the LFO speed change! Now imagine what it is capable of...*



# INSTALLATION

## COMPATIBILITY

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FMDRIVE is a Windows 32Bit VST Instrument for use with MIDI capable DAWs.

RUN on 32/64 Bit Systems.

If you want to use it with a 64bit DAW you can use JBridge.

## INSTALL VST

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1. Decompress the downloaded archive file
2. Copy the entire Folder **AJLAB** to your VST PLUGINS folder
3. Load it in your DAW

## INSTALL STANDALONE

---

1. Decompress the downloaded archive file
2. Copy the entire Folder **FMDRIVE** where you want
3. Simply RUN **FMDRIVE.exe**

# State of FMDRIVE 2612 current features

**WIN 32 VST runs on 32/64Bit Systems and it is multicore compatible**

## **HIGH QUALITY GUI**

(Different panels for controls etc...)

## **INSTANT UPDATE FOR ALL CONTROLS**

## **FULL MIDI AUTOMATION**

With midi learn (right click to assign MIDI)

## **POLY & MONO MODE** with Glide Control

## **DIRECT OUTPUT OR MD1** Headphone Out filtering

## **TWO AUDIO MODELS:** HQ and MD1

(Crystal clear and high resolution processing) and MD1 (emulate distortion and low resolution of MD1 model)

# YM2612 classic features

## **4 OP FM SYNTHESIS**

## **PARAMETRIC Envelope Generator**

## **SSG EG**

## **LFO AM & PM**

## **CH3 SPECIAL MODE**

(Different frequencies for each OP) also different key on off by External Midi channels

## **CSM MODE**

(Kind of early vocal synthesis)

## **CH6 DAC MODE**

(4 slots to load any PCM WAV files/ auto converted to mono 8/4bit 22/11/8Khz) with selectable start/end points, loop and pitch control.



# YM2612 extended switchable features

## **OVERDRIVE LADDER EFFECT CONTROL**

(Works only in MD1 MODE, adjust to taste)

## **RATE RATIO CONTROL**

(Change the global EG RATE/SPEED from \*0.1 to \*4 for rapid tweaking/adjustment of the envelopes)

## **GRAPHIC EG**

Up to 8 stages /8 stage shapes/custom loop point (aka custom SSG) and sustain point.

## **CUSTOM LFO RATE** (for low modulation...)

## **6 LFO SHAPE**

Including noise

## **ATTACK & RELEASE** Time for the LFO

## **DT2 PARAMETER** from YM2151

## **UNSYNC PMS**

(Different settings for each OP)

## **OP FILTER** aka PHASE MODULATION FILTERING

(Reduce the modulation at high frequencies according to the amount of filtering)

## **GLOBAL FM SAMPLE RATE CONTROL**

(Skip audio samples)

## **POLYPHONIC REDUCER**

(Kind of increasing the FMbit crushing audio effect according to the number of voice/keys played..)

## **DAC CUSTOM GRAPHIC WAVEFORM** (14 bytes)

## **DRAW MODE** or LFSR

(Random bytes generated, clock divider, sync with host tempo)

## **CSM Timer A Control by MIDI notes**

(Shortest period limit is 1.13636ms note A5)

## **LOADS & SAVE TFI PATCHES**

(Manual or auto load for fast selection)

**LOAD & SAVE FULL PATCH & BANKS** in FXB/FXP

**CONTROLS THE REAL MEGADRIVE HARDWARE VIA MIDI**

(Needed Little Scale GENMDM Midi Device)

# CONTROL PANELS

FMDRIVE GUI INTERFACE stores the different parameters on different panels

The central visual interface can be opened or closed **clicking on the led next to power on.**

These are:

**1 VU METER** (only when the central panel is closed)

**1 TL panel** (allows control over each operator volume, M1 feedback, global velocity sensitivity, velocity enable for each operator and number of polyphonic voices, fixed frequencies for SPECIAL MODE and Model1 Overdrive Ladder effect level)

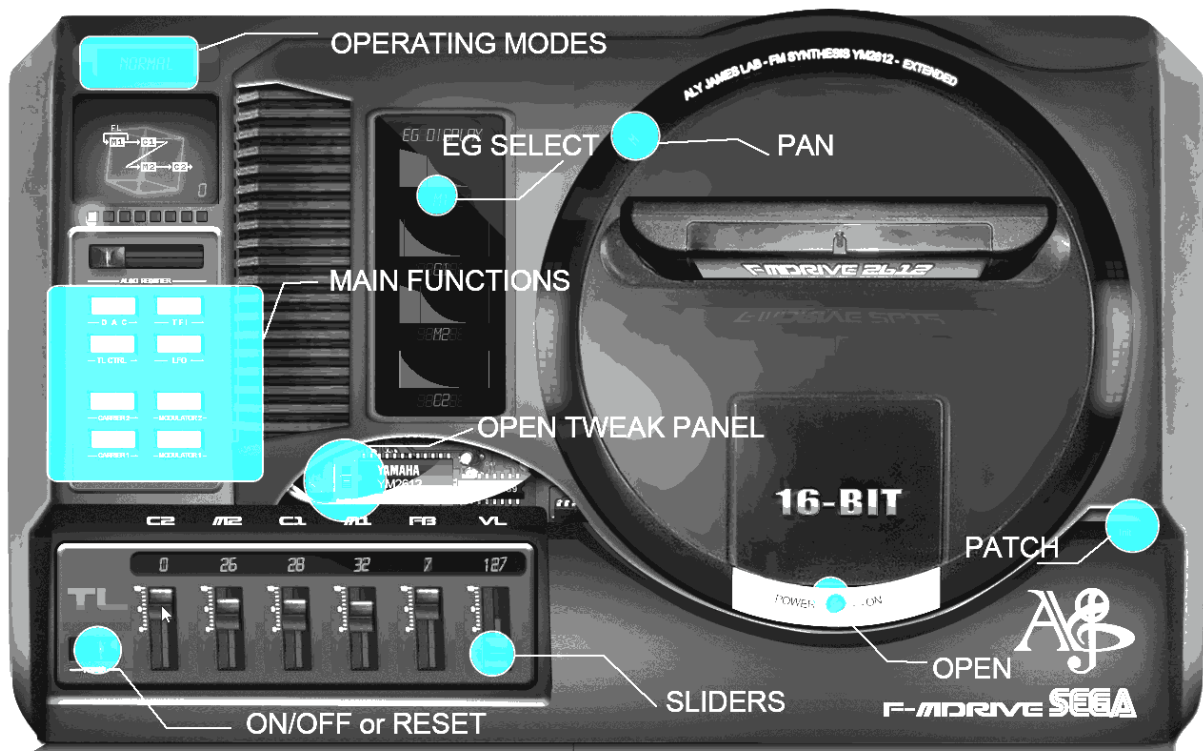
**4 Operators panels** (one for each operator, access via left white buttons or clicking on the operator name on the envelope generators display)

**1 DAC panel** (with one sub panel for the DAC custom waveform)

**1 LFO panel**

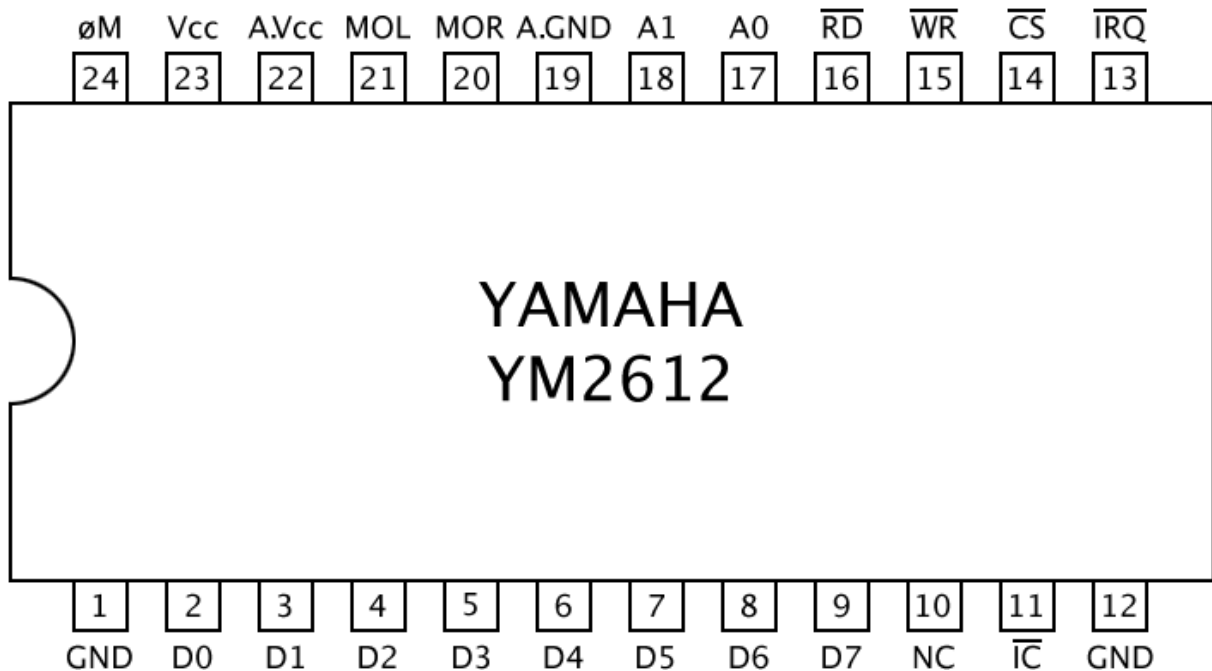
**1 TFI control panel** for loading and saving (allows browsing for tfi patches via internal browser or windows explorer)

**1 Tweak control panel** (for circuit bending and additional control)



Right click on a knob, button or slider will open a midi learn assign menu. Ctrl click + move allow fine tuning.

# THE YAMAHA YM2612 FM CHIP



The **YM2612**, aka **OPN2**, is a six-channel sound chip developed by Yamaha. It belongs to Yamaha's OPN family of FM synthesis chips used in several game and computer systems.

It was most notably used in the **Sega Mega Drive/Sega Genesis** game console.

**The YM2612 has the following features:**

- Six concurrent FM Channel (Voice)
- Four operators per channel
- Two interval timers
- A sine-wave low frequency oscillator
- Analogue stereo output (most other contemporary Yamaha FM chips require a separate external digital-to-analog converter chip)
- For channel three, operator frequencies can be set independently, making dissonant harmonics possible. (Normally, they would have a simple relation relative to a common base frequency.)
- For channel six 8Bit PCM samples can be played instead of FM sound
- Per-channel programmable stereo sound (Left, Right, or both Left and Right)

The particular implementation of the DAC produces some noticeable artifacts on the Sega Megadrive sound output, similar to distortion, the sound can clip at high levels and the sine wave output start to change at low volume, mixed with a squared signal.

The chip was also stripped of its predecessor's (YM2608) SSG component, although its vestigial SSG envelope generator is still functional.

## OPERATOR CORE



Each Operator is switchable Mask on/off to receive note on/off commands. Doing this also disable the envelope generator saving system memory resources when not in use.

## LIST OF PARAMETERS:

---

**TL:** Operator general volume (on MD1 Mode TL below 0X67 (104) will produce no audible output.

**KS:** Key Scaling/ change the timing of the EG according to the pitch of the notes, the higher the pitch the shorter is the envelope. KS affects AR, DR, D2R and RR in the same way. KS is the degree to which the envelope becomes narrower as the frequency becomes higher.

**MUL:** Frequency Multiplier/ \*0.5 to \*15 where 1 is the actual ROOT frequency, 0 is an octave below. This follows harmonic relation to the root frequency.

**DT1:** Fine detune/ following this table (frequency is a small number) small detuning can create movement on the sound.

DT1	0	1	2	3	4	5	6	7
FREQUENCY DETUNE	0	1	2	3	0	-1	-2	-3

**DT2:** Coarse detune/ Large frequency detune (modeled after YM2151 chip)

DT2	0	1	2	3
F-DETUNE HZ	0	19.4	21.58	23.77

**AM:** Enable LFO Amplitude Modulation (AMS) for that Operator. Relevant only if both the LFO is enabled and AMS (amplitude modulation sensitivity) is non-zero.

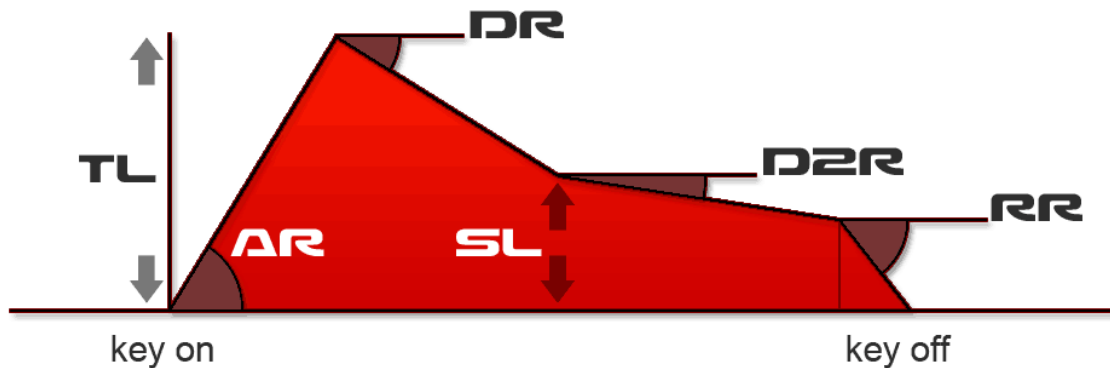
**PMS:** Pitch Modulation Sensitivity

AM	EFFECT ON VOLUME	PMS	EFFECT ON PITCH
0	No effect	0	No effect
1	Enable AMS	1	Displacement of $\pm 3.4\%^*$
		2	Displacement of $\pm 6.7\%^*$
		3	Displacement of $\pm 10\%^*$
		4	Displacement of $\pm 14\%^*$
		5	Displacement of $\pm 20\%^*$
		6	Displacement of $\pm 40\%^*$
		7	Displacement of $\pm 80\%^*$

\* % of a half tone.

---

# ENVELOPE GENERATORS



## PARAMETRIC ENVELOPES

The type used for naming the envelope stages varies with documentations, FMDRIVE uses:

AR, DR, SL, D2R and RR for Attack, First Decay, Sustain Level, Secondary Decay and Release.



The sound starts when the key is depressed, a process called 'key on'. The sound has an attack, a strong primary decay, followed by a slow secondary decay. The sound continues this secondary decay until the key is released, a process called 'key off'. The sound then begins a rapid final decay, representing for example a piano note after the key has been released and the damper has come down on the strings.

The envelope is represented by the above amplitudes and angles, and a few supplementary registers. Used in the above diagram are:

TL	Total level, the highest amplitude of the waveform.
AR	Attack rate, the angle of initial amplitude increase. This can be made very steep if desired. The problem with slow attack rates is that if the notes are short, the release (called 'key off') occurs before the note has reached a reasonable level.
DR	The angle of initial amplitude decrease.
SL	The amplitude at which the slower amplitude decrease starts.
D2R	The angle of secondary amplitude decrease. This will continue indefinitely unless 'key off' occurs.
RR	The final angle of amplitude decrease, after 'key off'.

**IMPORTANT NOTE ON EG BEHAVIOR:**

The Volume value is an **ATTENUATION VALUE** (ex TL = 127 means that the attenuation is MAX so volume is = MIN, TL = 0 means that there is no attenuation so volume = MAX)

IF AR = 0, The YM2612 consider the Attack stage as Infinite, so no sound would be produced. Setting AR to 0 in PARAMETRIC EG will also disable GRAPHIC EG output regardless of the graphic settings.

IF DR = 0, DR stage is off and the Envelope switch directly to D2R stage, however if SL is non-zero D2R will have no effect and the envelope will sustain at TL volume, whatever value SL is.

IF D2R = 0 = off, the envelope will sustain at SL volume.

**USING HIGH Release Time (close to 0) is more CPU hungry in poly mode; avoid using high release time when not needed.**

*GRAPHIC representation of the envelope helps to understand the behavior. It can be changed with a small knob at the top to a solid or a line view.*







# SSG ENVELOPES MODE


When activated SSG mode will loop the envelope from AR to D2R (included) following 8 defined shapes and behavior. The envelope time is also shorter than normal and will never reach MIN volume except when HELD. If an Attack stage is set, AR is > 31 or 30, the behavior of the SSG is changed. (Graphic representation of the envelope on the SSG panel will show the effect.)

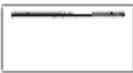


SSG envelopes are combination of these following behaviors:

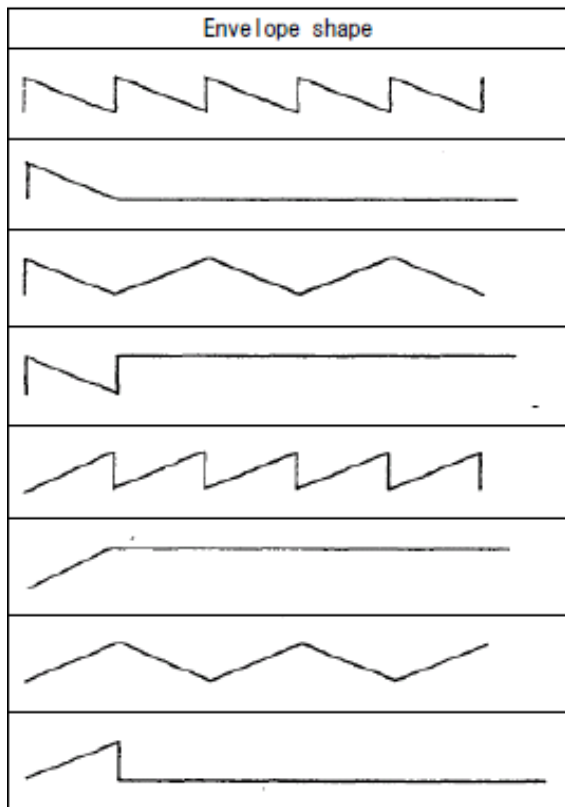
 NORMAL: the envelope plays normally

 INV: The envelope is inverted

 HELD: The envelope is held at Max attenuation value

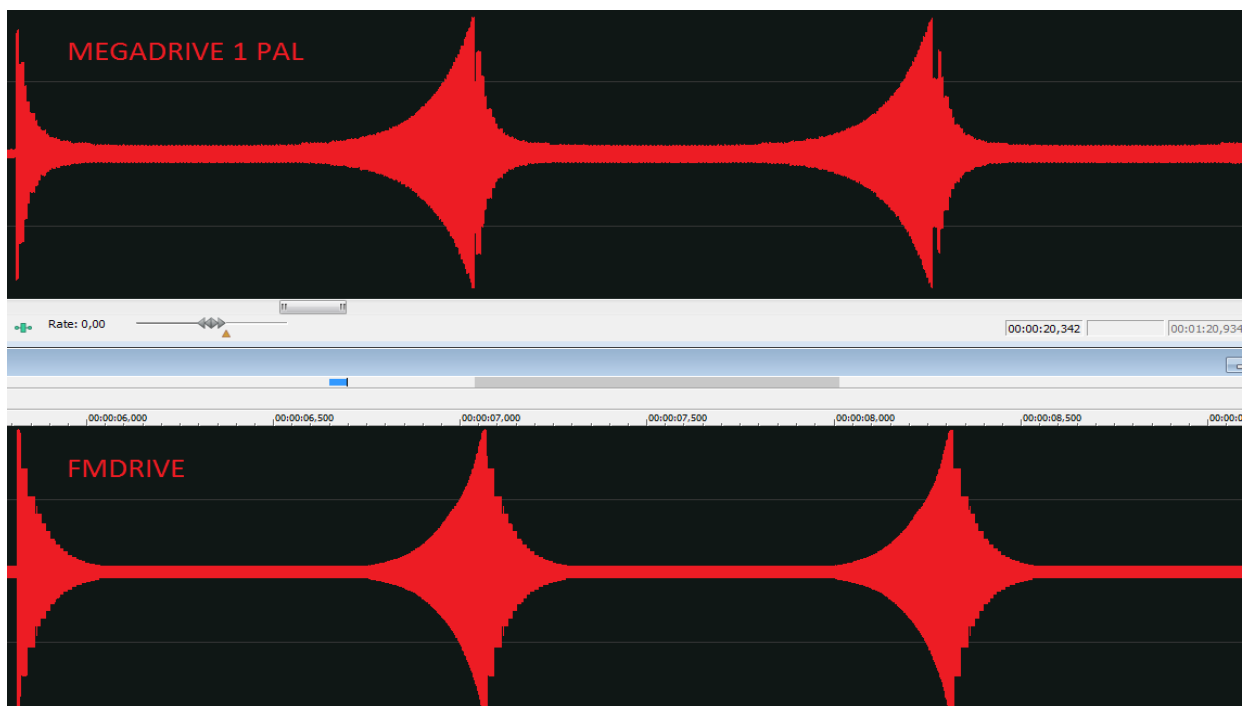
 INVERTED HELD: The envelope is held at Max volume

ALT: The envelope alternates between NORMAL & INV ant each pass



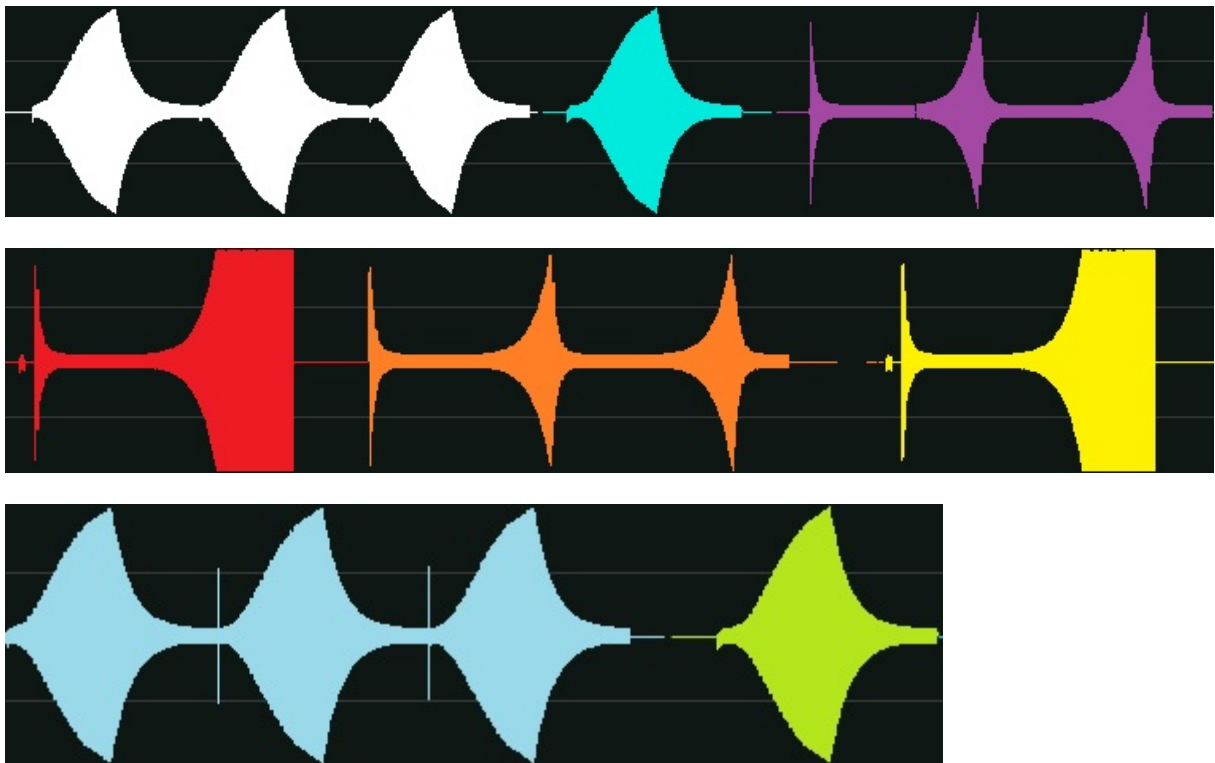
The phase is also reset in SSG mode at the beginning of each repetition of the waveform in cases where both the HLD and ALT bits are unset. This produces different harmonic results when the envelope is very short.

SSG part comes from YM2608 and where not implemented for use with an attack phase on the Sega Megadrive. When the Attack phase is inverted, this can create an attack curve which makes several extremely large audible steps from 0db

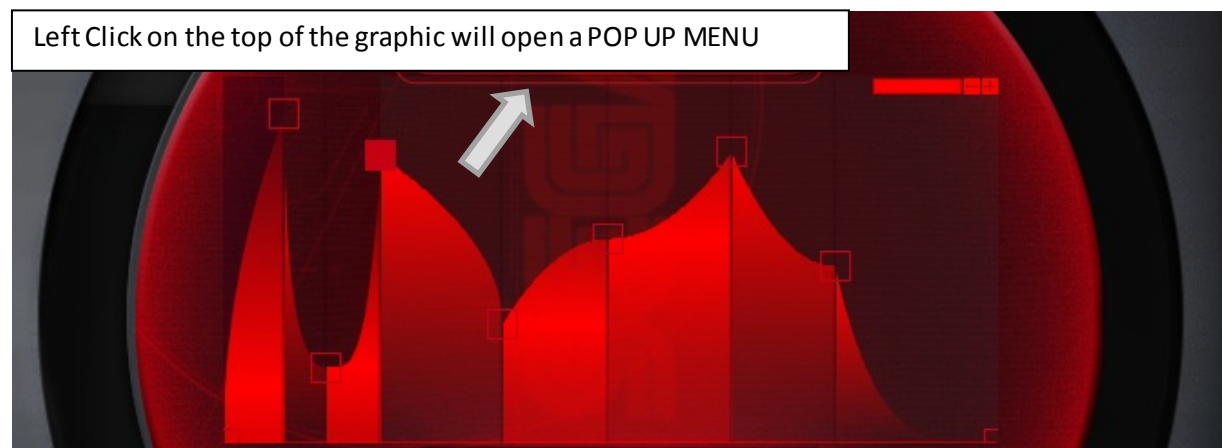


Technical manuals claim that AR should be 31 (no attack) when using SSG...however setting an attack phase and producing this behavior can be used in a creative way.

Here is an example of SSG behavior with an attack phase AR of 8 and D2R of 10. SSG from 0 to 6



## GRAPHIC ENVELOPES



Extended feature of FMDRIVE allows the use of custom complex envelopes instead of the original parametric. (can be done on a real YM2612 by sending software envelope data to TL register)

Left Clicking on a stage will change the shape.

**A click at the top of the graphic envelope opens a pop up menu allowing full control.**

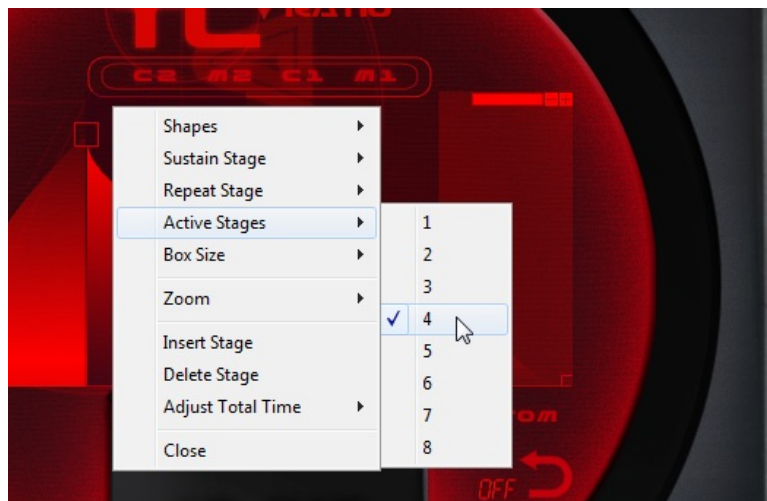
Zoom from 100% to 1000% and SHIFT/CTRL for fine & ultra-fine mouse control.

- GUI CONTROL (zoom, handle box size etc...)
- CHANGE STAGE SHAPE
- ADD OR REMOVE UP to 8 STAGES
- DEFINE CUSTOM LOOP POINT AND SUSTAIN POINT
- ADJUST GLOBAL TIME

### GRAPHIC CONTROL

Initially YM2612 has 4 Stages EG.  
With FM DRIVE, the user can add up to 8 Stages to improve control.  
Also the original SSG EG part was fixed on the chip like shown on fig1.

With FM DRIVE, the user can control the SSG part **by selecting from witch stage the loop occurs** until it reaches custom sustain stage point.  
So you got complete control over a custom SSG Mode.



**POP UP MENU** allows changing the **global time** using a percent of the actual time.

The **Stage loop point** can be defined on the GUI, also in the POP UP menu.

Each stage **shape can be adjusted** by the user by just left clicking on it.

The **Release stage** will include all stages after the **sustain point**.

## VELOCITY CONTROL

The **VL slider** on the **TL CTRL panel** will adjust the amount of velocity that will be applied to the operators' **volume**. The velocity max is the TL of the current operator.

A **VL enable square button** is available on the TL screen for **each operator**.

Velocity can add expressivity to the sound when used on Modulators.

# RATE RATIO CONTROL

## RATE RATIO CONTROL

Allows to change the global EG RATE/SPEED from \*0.1 to \*4 for rapid tweaking and adjustment of the envelopes.

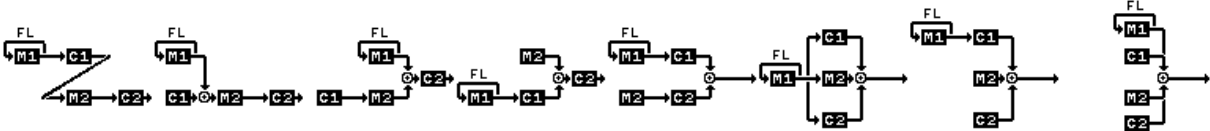
IT IS INVERTED when in PARAMETRIC MODE (\*0.1 = \*4 and \*4=\*0.1)

# ALGORITHMS

There is 8 operator's combination (connection status) available in the YM2612

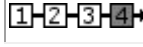
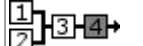

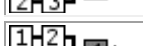

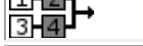




Each slot works by the algorithm as a modulator or a carrier. However, the fourth slot (C2) is always set to the carrier regardless of the algorithm. (Graphic representation is also available on TL panel)



The choice of algorithm is essential in the process of sound design; the following type of sounds can be achieved depending on the choice.

Some examples of sound types:

0		Distortion guitar, "high hat chopper" Bass...
1		Harp, PSG type sound...
2		Bass, electric guitar, brass, piano, woods ...
3		String, folk guitar, chimes...
4		Flute, bells, chorus, bass drum, snare drum, tom-tom...
5		Brass, organ ...
6		Xylophone, tom-tom, organ, vibraphone, snare drum, kick drum
7		Pipe organ, CSM speech...

The First SLOT, Operator M1 is capable of self-modulation called **feedback**. (FB)

Regarding this formula:

$$y = x + \beta \sin y$$

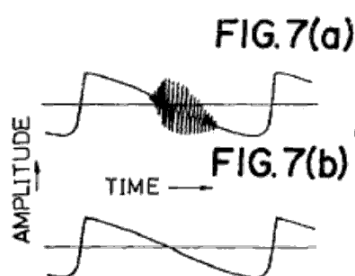
$$x^n = \sin(\pi(\theta + \beta x^{n-1}))$$

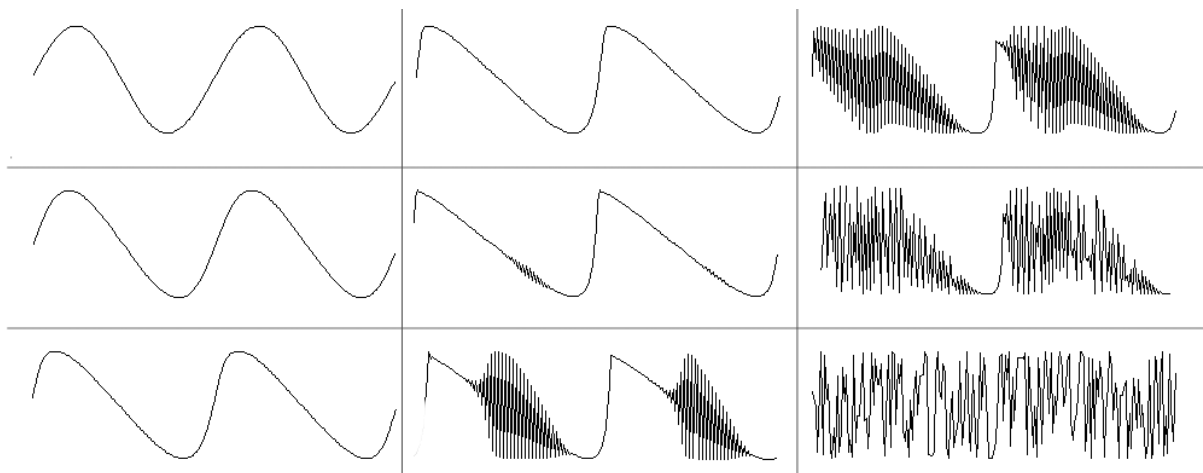
It is assumed that  $x^n$  is the output of the oscillator,  $\theta$  is the phase accumulator ranging from -1 to 1, and  $\beta$  is the scaling function

**The effect is slowly changing the sine wave into a saw tooth waveform then into noise. Depending on the TL volume of M1 operator and the setting of FB the effect will be more or less pronounced.**

*The feedback system is based on Tomisawa 1981 US patent "Tone production method for an electronic musical instrument"*

**U.S. Patent** Feb. 10, 1981





*Note on filtering: Filtering the output is done internally.*

# LFO

LFO can be used for tremolo type effect (AMS) or vibrato (PMS) both can be used for FX.

The LFO is a basic sine wave in the YM2612. Others types of wave could only be achieved by software programming. FMDRIVE adds 5 classic waveforms.



## List of parameters

---

**FRQ:** the frequency of the LFO/ ranges from **3.98Hz to 72.2Hz** on the YM2612

**CUSTOM FRQ MODE:** Will set FRQ to an even more usable range kind of like YM2151 from **0,013Hz to 53.49Hz**.

The SONIC sprite will run according to the frequency.

**AR:** Attack rate, slowly increase AMS/PMS to the setting point. 127 = no attack

**RR:** Release rate starting on KEY OFF / Similar to AR

**WF:** 6 Waveforms/ SIN/SAW/RAMP/TRIANGLE/SQUARE/NOISE

**AMS:** Amplitude Amount of Modulation



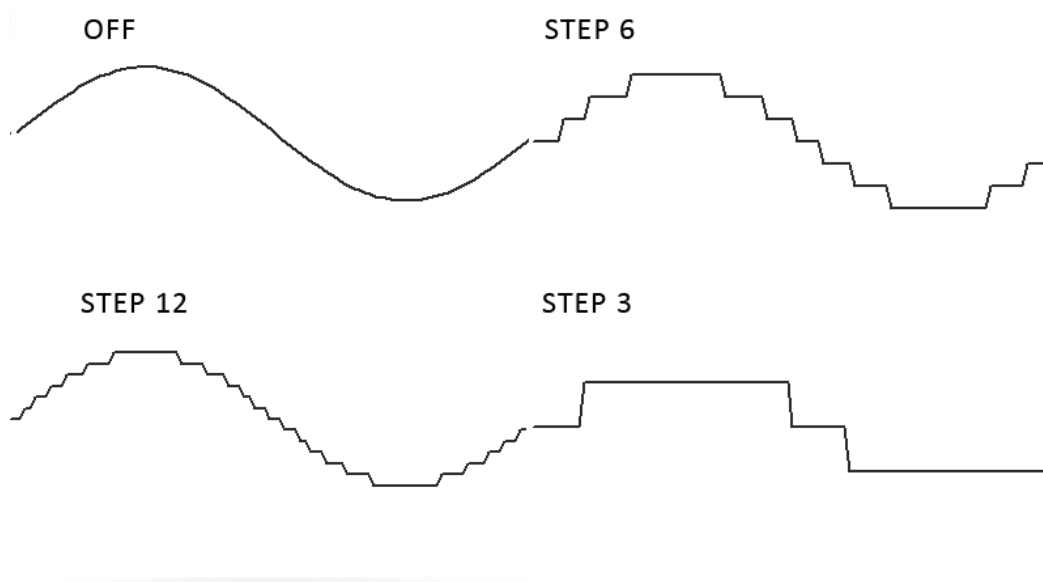
AMS	EFFECT ON VOLUME	PMS	EFFECT ON PITCH
0	No effect	0	No effect
1	Displacement of 1.4 dB	1	Displacement of $\pm 3.4\%$ +PMD
2	Displacement of 5.9 dB	2	Displacement of $\pm 6.7\%$ +PMD
3	Displacement of 11.8 dB	3	Displacement of $\pm 10\%$ +PMD
		4	Displacement of $\pm 14\%$ +PMD
		5	Displacement of $\pm 20\%$ +PMD
		6	Displacement of $\pm 40\%$ +PMD
		7	Displacement of $\pm 80\%$ +PMD

**UNSYNC PMS:** Disable the global PMS control and add a PMS parameter per Operator

**PMD:** Pitch Frequency Amount of modulation can increase the initial YM2612 limit of PMS

**STEP:** LFO waveform stepping.

Ex:



# SOUND MODELS

## MD1 SEGA MEGADRIVE MODEL 1

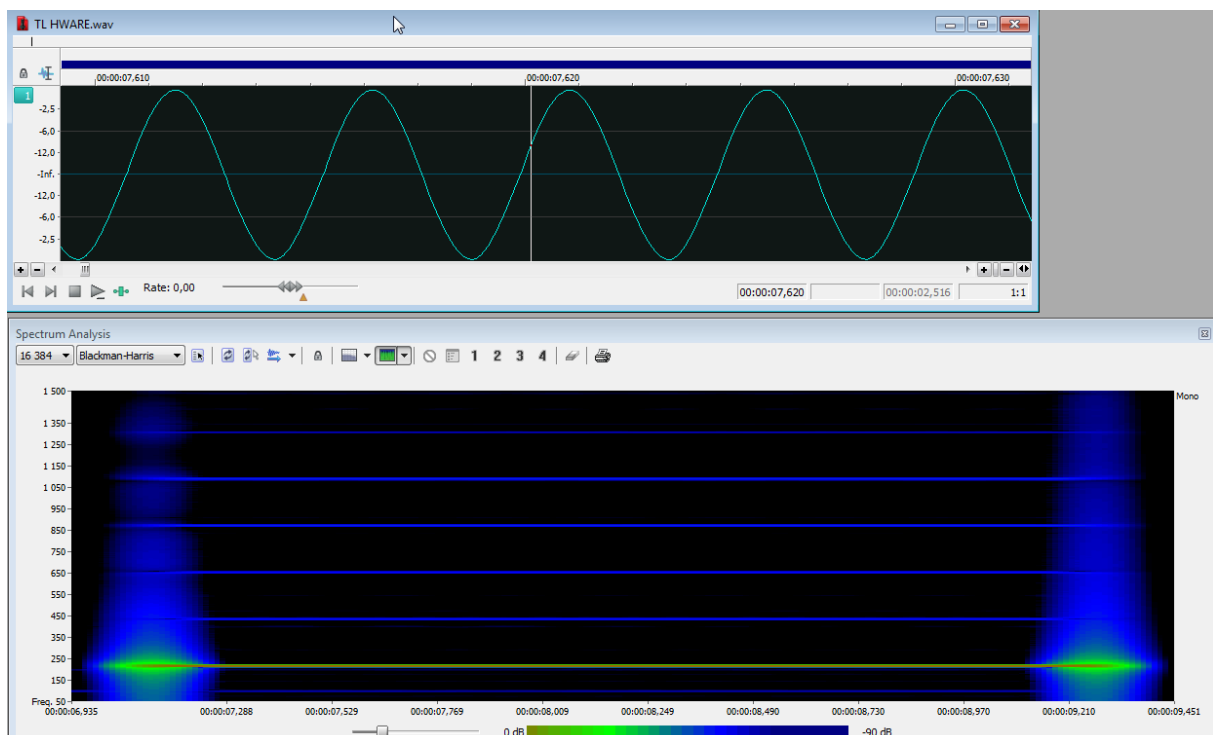


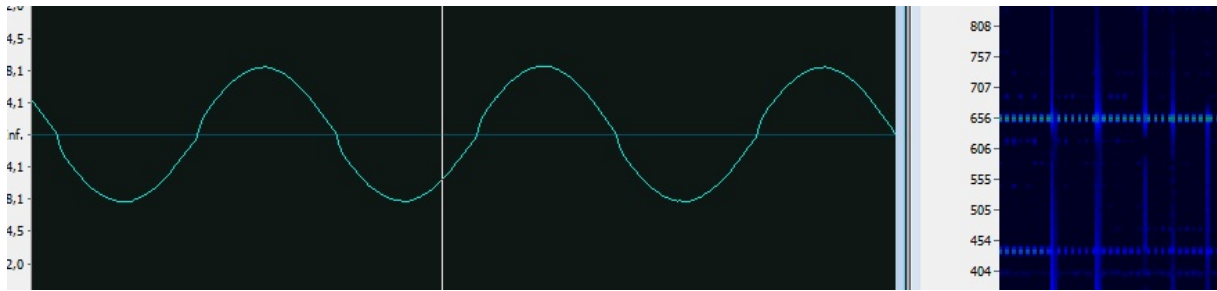
FMDRIVE try to approximate the real hardware distortion

### HARMONIC DISTORTION – LADDER

As previously stated, the first generation of SEGA MEGADRIVE consoles produced harmonic distortion. It gives the sound a special character that actually no software has emulated before.

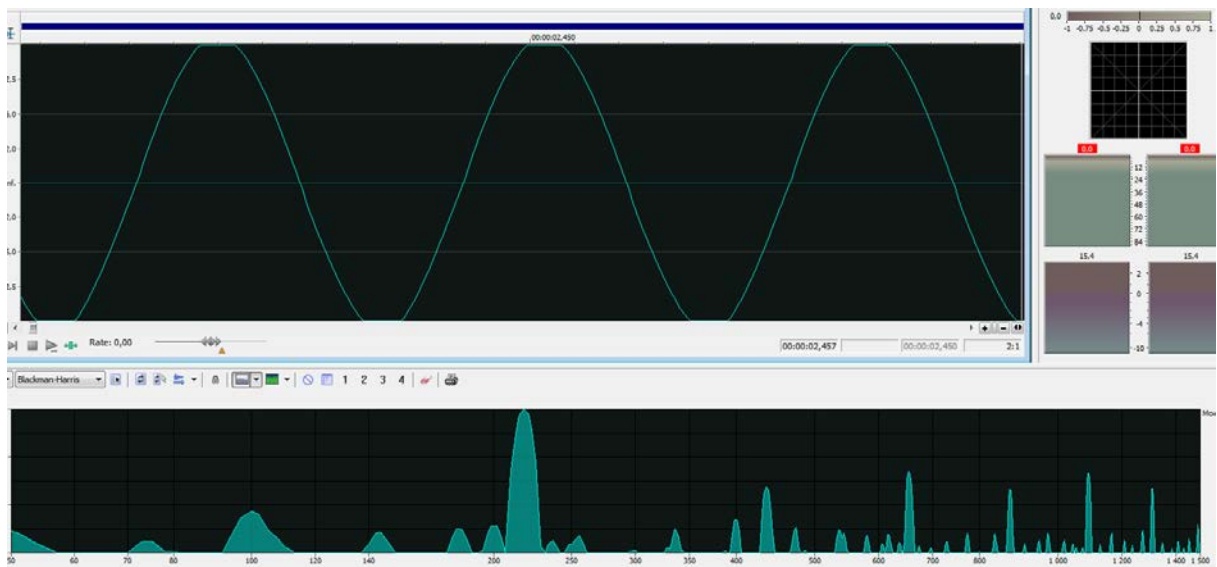
Consider a pure sine wave signal at 440 Hz; it will ideally produce only one strong frequency at 440 Hz. However observing the Megadrive sine on a Spectral analyzer and on oscilloscope, shows a lots of harmonics components are added to the original frequency and also a change on the sine shape, resulting in a richer distorted sound. The effect is even more pronounced the lower TLis. This unique sound problem to the YM2612 DAC is called “The Ladder effect”. And can be used creatively.





When using MD1 Model the **Overdrive parameter** allows to fine tune the effect to taste, *most notably when ALGO 7 is in use, the output might distort too much.* (Different Sega models and revision will produce different result in real world.)

The Sine wave also can clip when TL is set to 0 (max volume).



## ENVELOPE CYCLES

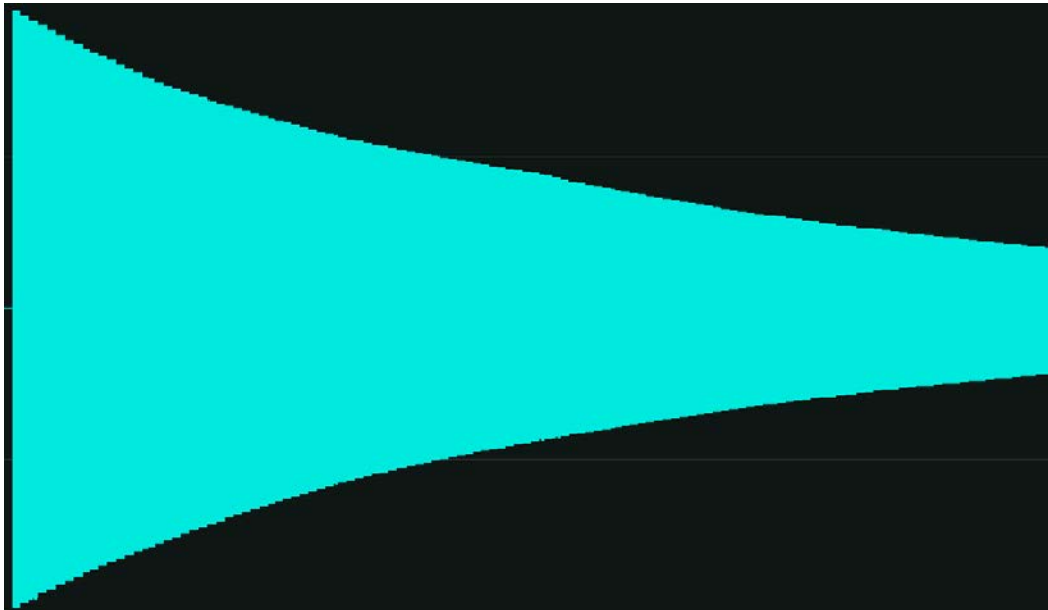
YM2612 Attenuation Values:

The envelope generator maintains a 10-bit attenuation value for each operator following different update cycles. Depending on the Rate setting at the moment of the update, the attenuation will occur more often for high rates than for low rates. This particular implementation is very practical to obtain very long envelope time and still maintain accuracy at short settings.

However this actually means that you can hear stepping when a rate is low.

Ex: try this setting on MD1 sound model,

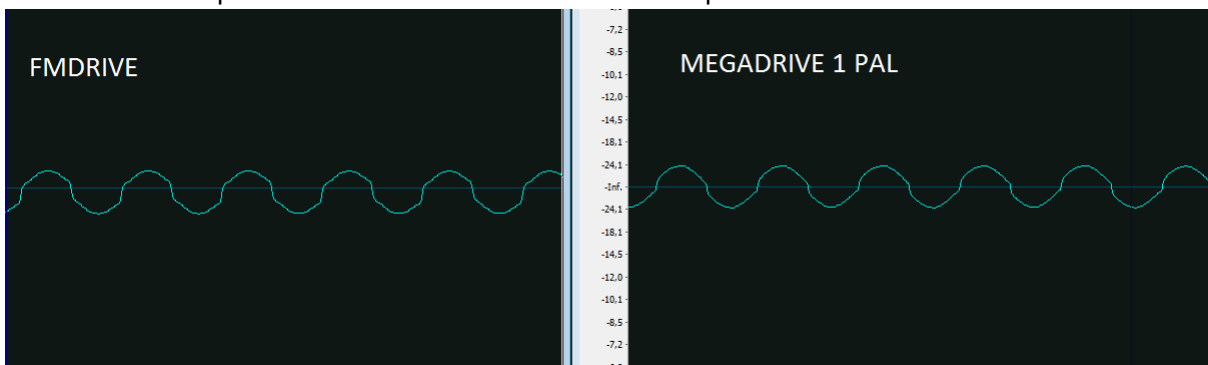
**ALGO 0 , C2 TL = 0 AR=31 (DR,SL,D2R)=0,RR=15 // M2 TL=0 AR=31 (DR,SL)=0, D2R=2, RR=15**



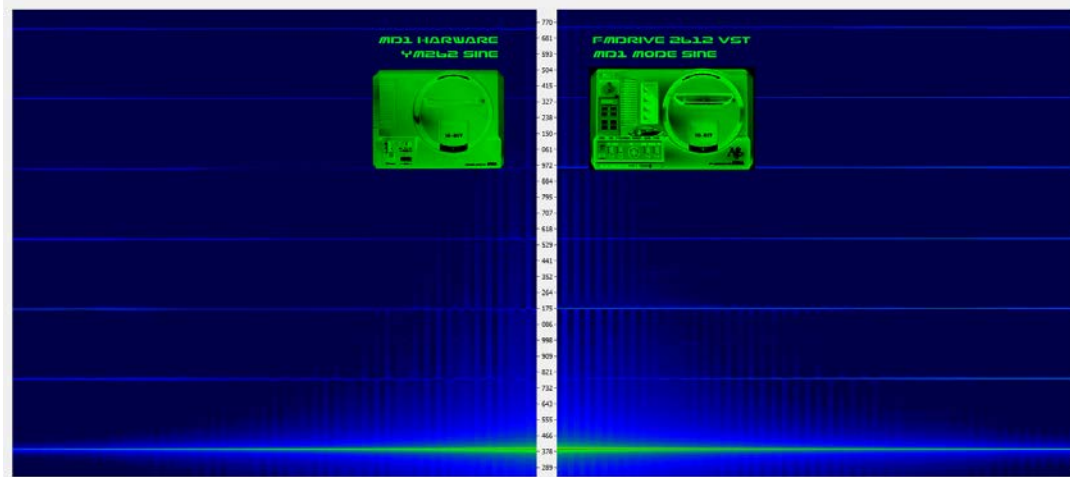
**NOISE FLOOR**

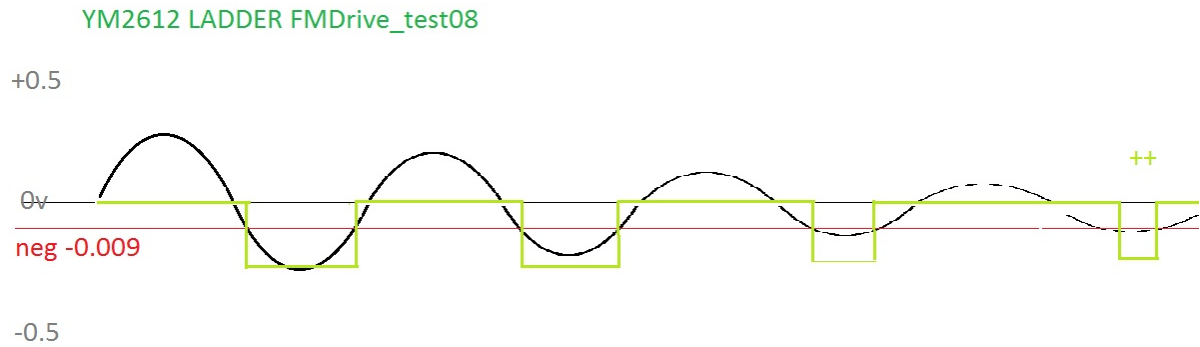
The Output resolution is also limited and no sound will be produced if TL is lower than 104. Quantification noise could also be noticeable at very low volume settings or when the envelope ends toward max attenuation value.

Here is a comparison between the FMDRIVE output and the Real SEGA hardware :

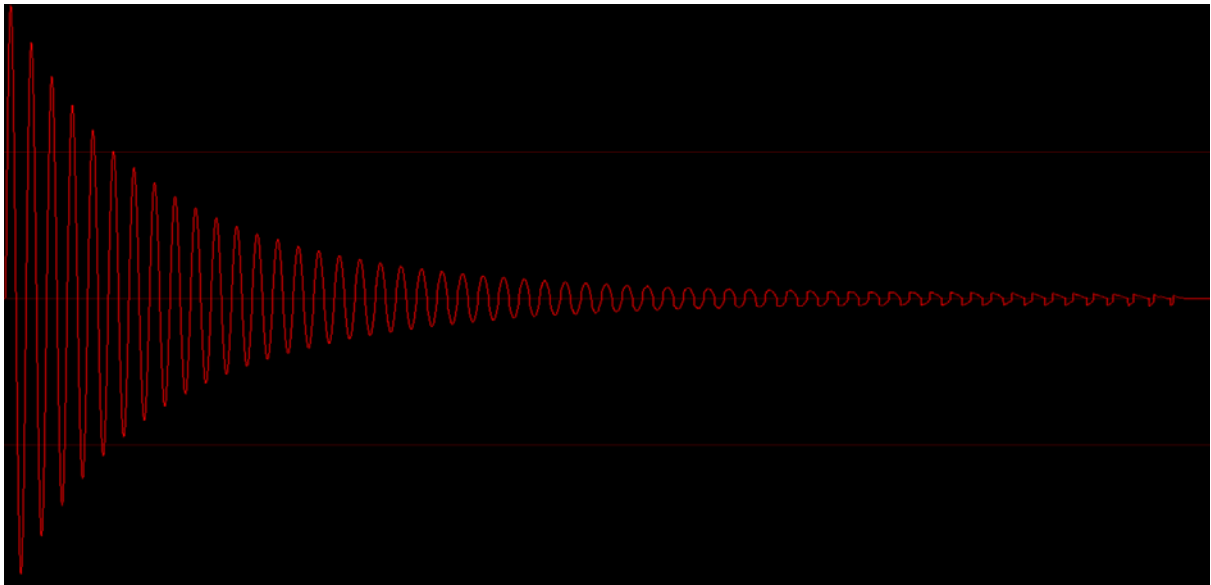


Very close spectrum between MD1 and FMDrive.





What I have found during close experimentation on the real chip is that the distorted part is actually here even when the output register for a channel are zeroed out. This leads me to search for an analog problem then trying to do basic reverse engineering; I have implemented a “negative value bug” that reproduces the effect closely, especially at the very end of an envelope where the signal period also change...



## HQ MODEL



Designing a new core adds the ability to completely remove the hardware limitation.

No harmonic distortion is produced in this mode, just perfect sine.

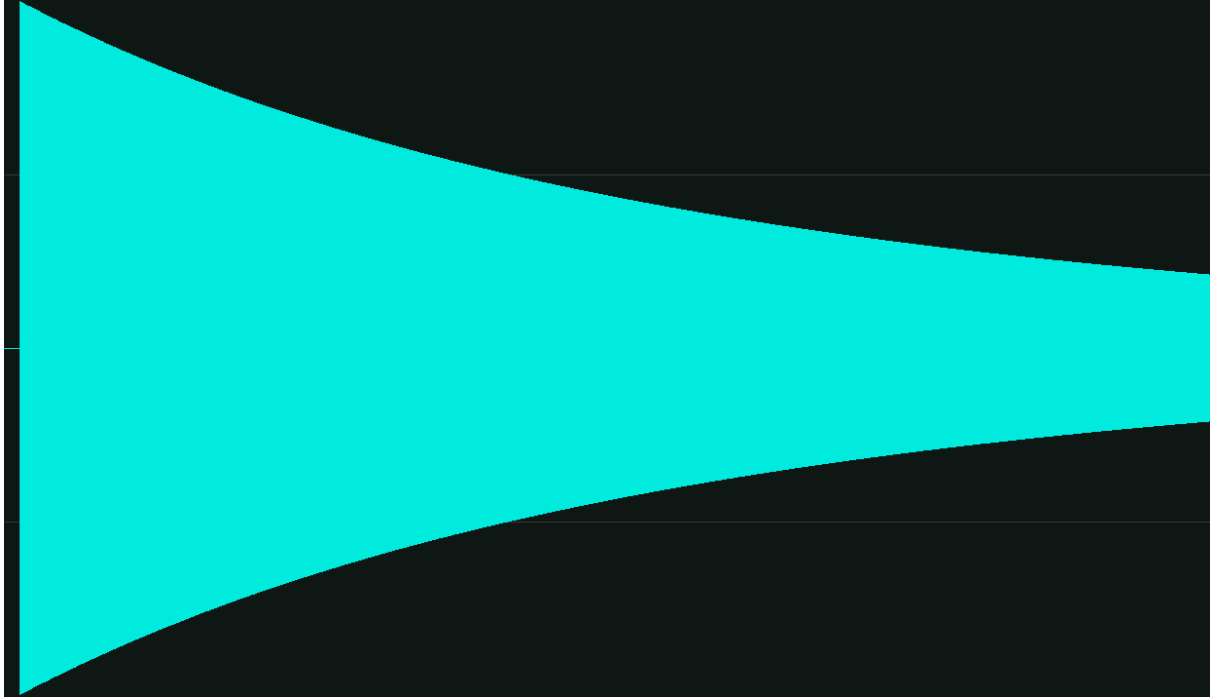
Output resolution is far more capable using 24 Bit resolution as are the envelope update cycles that

are maintaining high precision even at low rate value (high envelope times).

**HQ Model will produce YM2612 sound at ideal capabilities, removing hardware limitation.**

Ex: try the same setting as before with HQ sound model,

**ALGO 0 , C2 TL = 0 AR=31 (DR,SL,D2R)=0,RR=15 // M2 TL=0 AR=31 (DR,SL)=0, D2R=2, RR=15**



**DEPENDING ON WHAT YOU NEED, these two sound models can provide a variety of nuance, thus enhancing the sound capabilities of FMdrive. Note that the stepping on some others parameters like TL is also greatly improved in HQ mode...**

FMdrive sound models can be changed into the CIRCUIT BENDING PANELS.

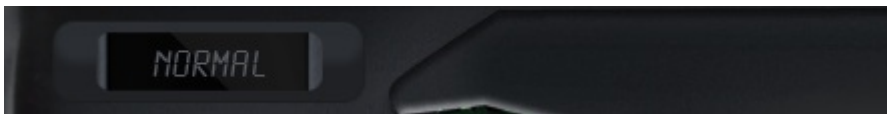
It can be done simply by clicking on the model in order to switch to the other.

# NORMAL/SPECIAL MODE

YAMAHA added to the YM2612 three different settings that produce a change in the global function.

## NORMAL MODE

---



Under normal mode each operator will received the **same root note (frequency)** on each key on. The frequency relation can be changed harmonically with the MUL parameter or detuned by DT (also DT2 on FMDRIVE).

## SPECIAL MODE

---



Under special mode **each operator on channel 3 can have a different root frequency setting**, allowing special effects and more inharmonic sounds. *(The frequency can also be entered with the PC keyboard on FMDRIVE GUI for precise setting and more decimal points, ex: 221.25Hz).*

**At initialization, every operator frequencies are tied to MIDI CH1. Setting a different frequency will change the root note, so if you play an A 440Hz on the keyboard, having 540Hz on Operator M2 will play 540Hz instead of 440Hz. This means that operator M2 is detuned by 100Hz from the note played.**

However you can optionally “**Freeze**” the frequency of all the operators (M1, C1 or M2) to have a fixed frequency setting. This means that if you play an A 440Hz on the keyboard, having 540Hz on Operator M2 will play 540Hz instead of 440Hz but playing a C note will still play 540Hz on M2.

This can be done by activating the **FREEZE button** on the TL panel.

*(When freeze there will be a “freeze indicator” next to the frequency on each operator panel, it is not working when external MIDI switch is set even if Freeze is activated)*



Activating the **MIDI switch** next to an OPERATOR allows **frequency and key on / off** happening independently. Controls are made by a different MIDI channel for M2, C1 and M1.



#### MIDI MAPPING for SPECIAL MODE MIDI ON

- M2 is controlled by MIDI CH11
- C1 is controlled by MIDI CH12
- M1 is controlled by MIDI CH13



# CSM MODE

## CSM (illegal Mode)

---



This mode will also switch the YM2612 in special mode

It was officially called "Illegal Mode" because it seems SEGA did not find any use of this or developers found it too hard to program...

**CSM** stands for **COMPOSITE SINE WAVE MODELING** aka early **speech synthesis** system

What this does is automatically Key on /off operators very fast, precisely at the speed of **TIMER A**\*

Each time the Operator is key on, the phase is restarted, this happens so fast that we actually hear a tone instead of a looping envelope. This method of synthesis tends to produce what is called vocal formants.

As there are 4 Operators, different settings on TL volume and frequencies at precise timing plus different **TIMER** values can mimic a talking voice and produce vocal sound and even words.

However there are no easy implementation or values tables internally in the YM2612 chip. All of this should be programmed by software. Implemented a complete speech synthesis system could have been great but nothing was done in this way for YM2612 by YAMAHA.

FMDRIVE does not include a speech driver, but adds interesting new control over the CSM

\***TIMER A** is one of the two onboard timers of the YM2612 chip.

The lowest period is 18.4ms (19.4 PAL) and the shortest is 18μs. Very fast period produce very high frequencies, higher than 40 000 Hz! this is why **FMDRIVE limit the highest period to 1.13636ms = A5**, it saves CPU and still maintains the useful musical range.

**In conjunction with the SPECIAL MODE external MIDI control, we can produce interesting talking vocal effects.**

Activating the **MIDI switch next to the TIMER A** allows the frequency of **the period to be controlled by MIDI notes** (in the limit of **TIMER A** speed), turning the CSM mode into another useful filtered **vocal singing waveform** and enhancing the FMDRIVE variety of sound.



## MIDI MAPPING for CSM TIMER A MIDI ON

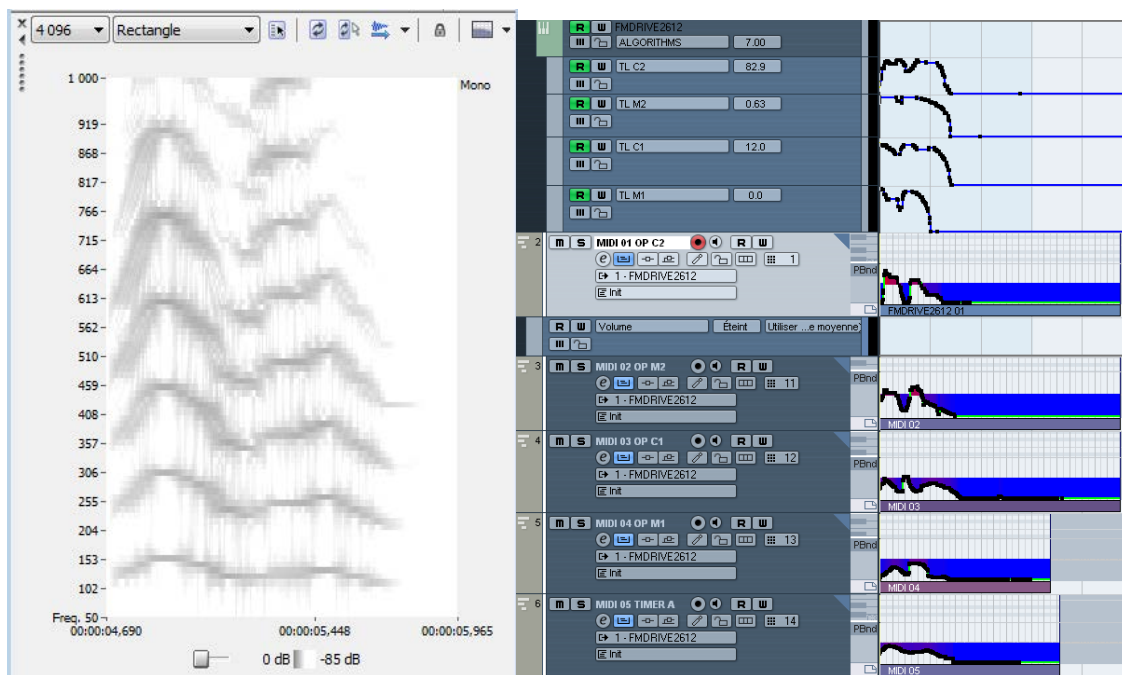
- Timer A Frequency/Period is controlled by MIDI CH14

**In CSM mode only the Release Rate RR will have a noticeable effect on the sound.**

*NOTE: On the YM2612, Performing a manual key on will overwrite CSM key on/off and deactivate the effect until manual key off. Also the EG has little to no effect on the fast key on, key off events happening in CSM mode. However if an attack phase is set (AR>30) no sound will be produced.*

*FOR MORE PRACTICAL USE, FMDRIVE ACTIVATE THE CSM MODE on each CHANNEL 1 MIDI KEY ON and DEACTIVATE on each CHANNEL 1 MIDI KEY off and EG is bypassed.*

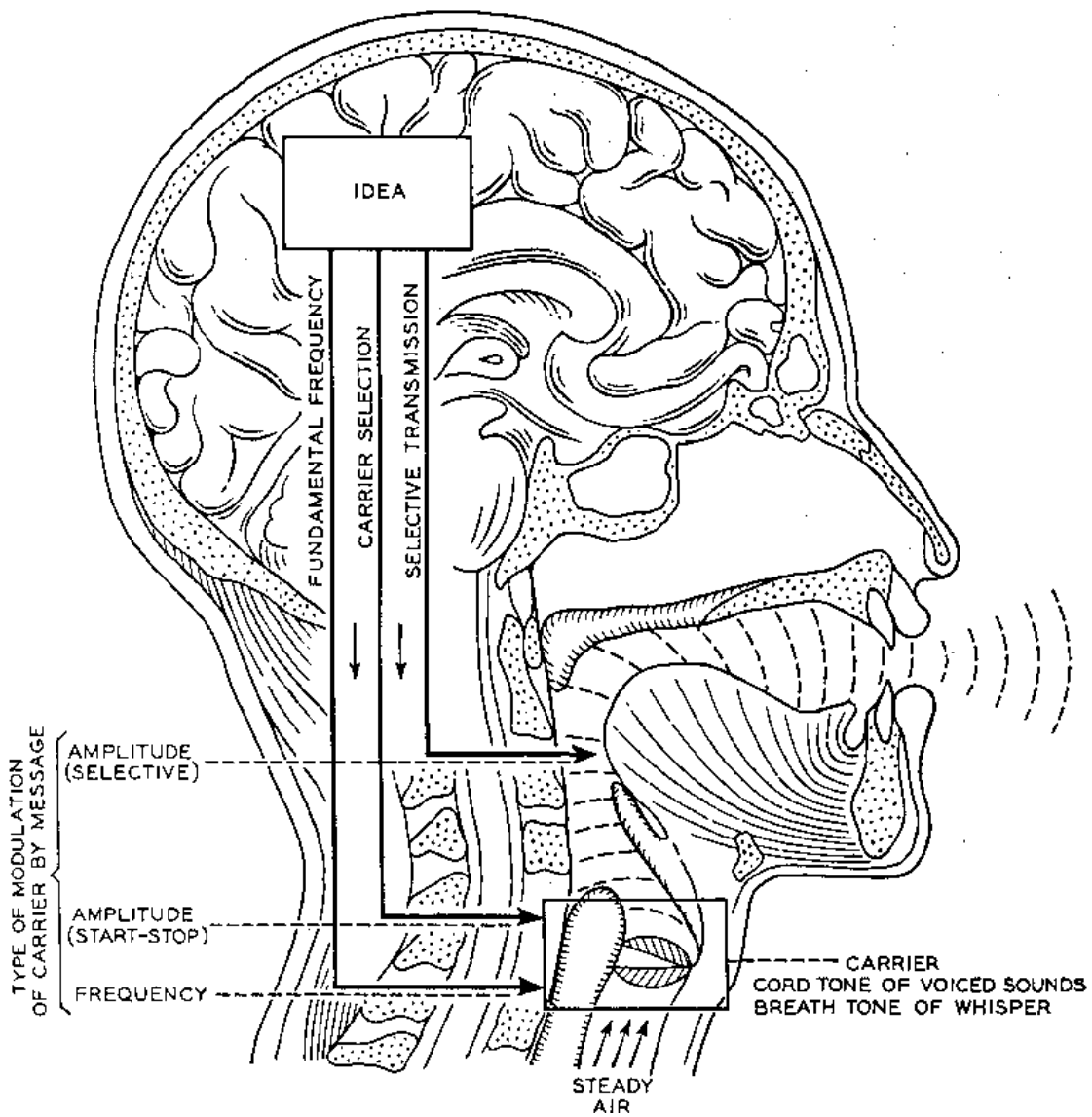
*IMPLEMENTING THIS CSM FEATURE ON THE REAL SEGA GENESIS HARDWARE could be done in future GENMDM Updates.*



**A practical way for using the CSM mode is MIDI automation. Use Midi Channels 11, 12, 13 and 14 in your DAW to control Operators frequencies and Timer A by Midi notes. Pitch bend values can add to the natural vocal tone of the sound.**

**Here you can see the word Hello programmed in Cubase, with automation similar to the vocal spectrum at the left.**

**Try to produce a formant by playing notes on the keyboard and setting different frequencies for each operator. CSM Speech is most effective in Algorithm 7 when all operators are non-modulated, in order to produce a sum of sinusoids similar to the FFT approach.**



# D.A.C



## LOADING SAMPLES

---

The YM2612 has the ability to play 8bit PCM sound data instead of FM sound on the Channel 6.

It is useful to play complex sounds; effects, vocals and percussions that FM alone could not reproduce. **Activating the DAC disable the FM part.**

FMDRIVE has **4 SLOTS to load sample data** from wave files. (.WAV) and will play them like on the Megadrive with a crunchy sound.

Click on the OPEN button to browse your hard drives and load WAV files. (Avoid using very long paths for folders as they might not be scanned) or click on the folder to use windows explorer with no limitation of location.

A global **SAMPLE RATE CONTROL** allows outputting 22 KHz, 11 KHz or 8 KHz.

A global **BIT RATE CONTROL** allows switching between 8bit and 4bit.

The **start and end sliders** controls the starting point and ending point of the loaded sample data.

The **pitch slider** controls the playback rate and the **LOOP switch** toggles the data loop mode on or off.

SLOTS are MAPPED to standard midi GM drums. **MIDI CH1 Notes** like so:

#### MIDI MAPPING for DAC SAMPLE SLOTS

- Slot 1 MIDI notes 35, 36 (KICK)
- Slot 2 MIDI notes 38, 40 (SNARE)
- Slot 3 MIDI notes 41, 43, 45 (TOM1)
- Slot 4 MIDI notes 42, 44,46 (HIHAT)

## CUSTOM WAVEFORM

---



14 bytes of data can also be directly written to the DAC allowing the use of raw custom waveforms.

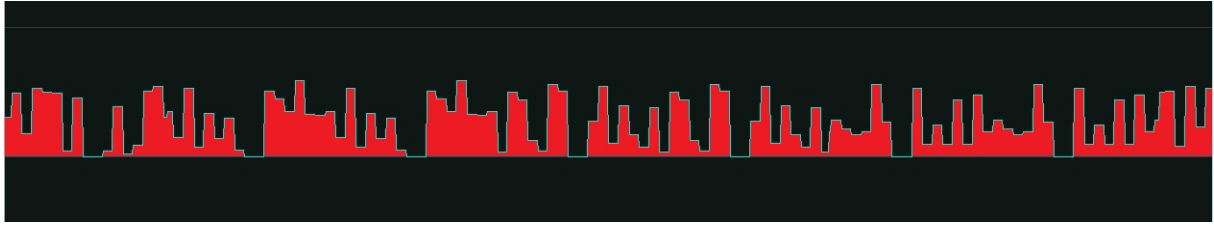
**(this feature is also possible on a real YM2612).**

**DRAW MODE** allow direct draw of the shape on the GUI.

**LFSR MODE** randomly generates data bytes on each key on. This produces a constantly changing waveform. The rate of the random change is governing by the clock speed.

**LFSR CLOCK** is sync to the HOST tempo. That means that it will be in sync with the song. A divider will change the clock speed regarding the master tempo.

Example of the LFSR output waveforms



## TFI IMPORT / EXPORT



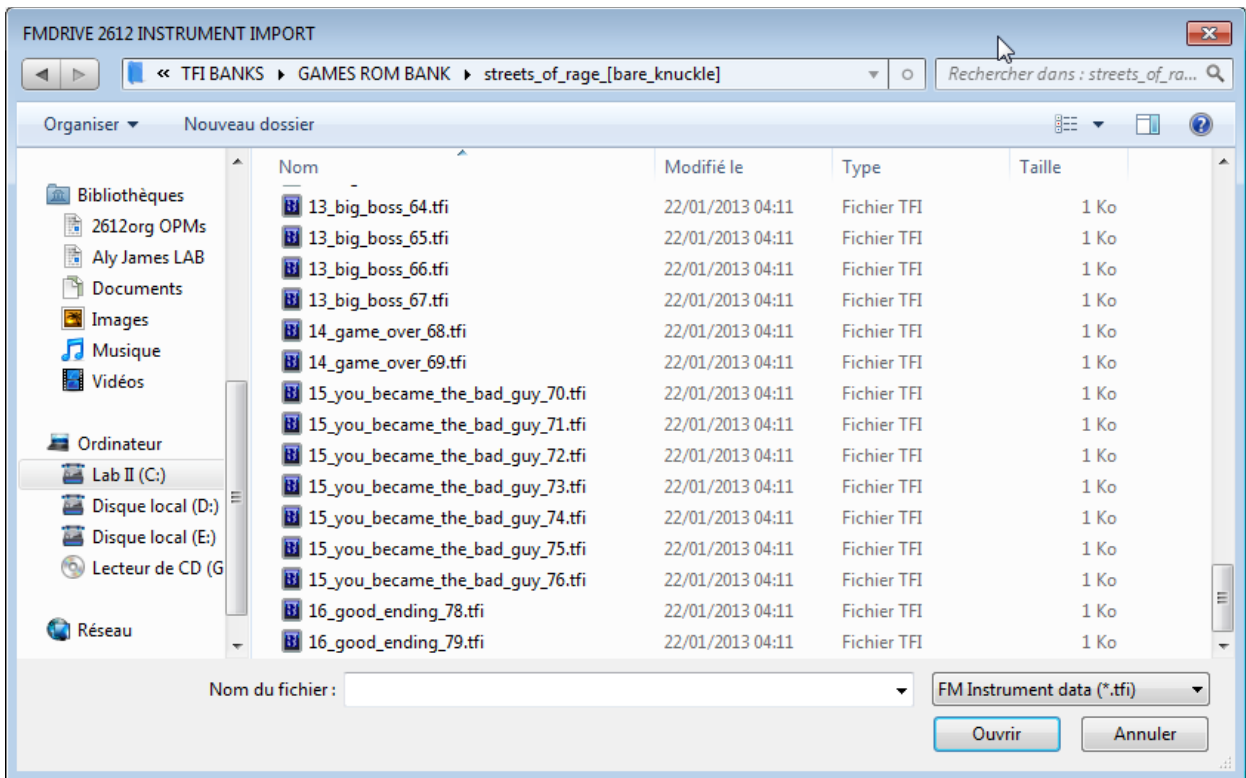
## TFI FORMAT

The TFI format is a 42 Bytes binary file, it contains register values for the main parameters of the YM2612 chip.

FMDRIVE has the ability to load and save TFI file format that is compatible with most of the YM2612 software. Tools allow extracting instruments for original SEGA MEGADRIVE Games VGM music on a per song basis.

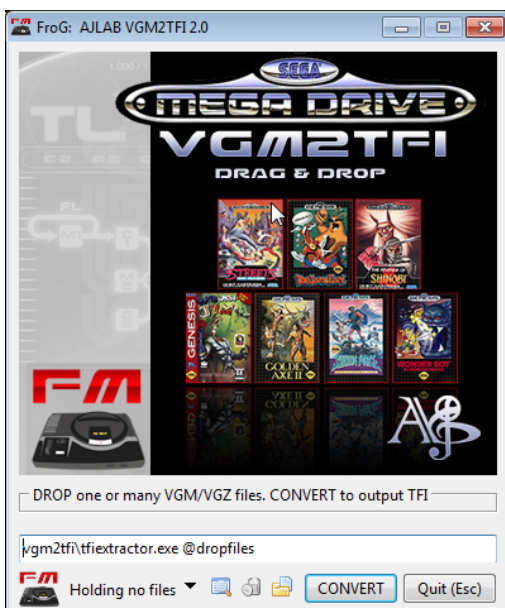
The VGM format is a standard for YM2612 register writes, it contains all of the data that the chip or game emulators will need to play a song.

The internal browser is limited to a certain number of characters so you will have to put your TFI preset folder into the **root location C:** if there is any problem. However there is no problem with that if you use the OPEN button on the JOYPAD to load from any location using the windows explorer.



The tool **VGM2TFI 2.0** allows extracting TFI instruments from a loaded YM2612 VGM music file.

This means that you can load thousands of instruments from your favorite VGM songs. It could be a *start for designing* your own instrument or simply a large database of presets. Also, certain game emulators (*Regen, GenKmod...*) have the ability to save TFI presets from the game being emulated.



# LIMITATION

---

TFI format contains all of the main parameters that define an YM2612 sound.

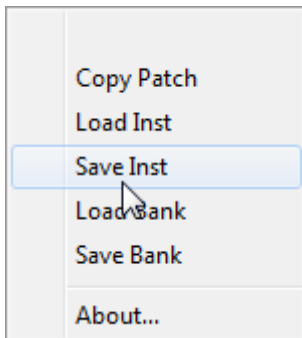
However the TFI format **does not contains data** for:

- LFO
- DAC
- EXTENDED FEATURES

That means that:

- You will need to use ONLY **PARAMETRIC EG** and **activate all Operators** when loading TFI
- LFO parameters will not be loaded or saved with the TFI patch
- DAC will not be loaded or saved
- SPECIAL MODE frequencies, CSM and DT2 will not be saved

**You can of course save all these information in the native FMDRIVE PATCH format from the main panel**



# LIST OF PARAMETERS

---

**AUTO & MANUAL MODE** when switched to **AUTO**, TFI preset is loaded immediately after clicking in the GUI browser. In **MANUAL** you need to select it first then click on the GAME PAD LOAD button.

**BE SURE TO BE IN MANUAL MODE IF YOU SEND A MIDI PROGRAM CHANGE WHEN TFI PANEL IS ACTIVE TO PREVENT AUTOMATIC DATA LOADING ATTEMPT**

**SAVE & SAVE AS** will save the actual FMDRIVE data to a TFI file. **Save** will save the preset at the current location and **save as** allows specifying the location.

**OPEN** will use the standard WINDOWS browser to search for files that may not be accessed by the GUI browser (*if folders names or path are too long*)

The actual registers data and the last changing parameter are displayed on the TFI GUI Panel and can also be saved as a simple text file for further conversion.



# CIRCUIT BENDING



The FMDRIVE add the unique ability to tweak the system in many ways. Opening the tweaking panel lead you to these following controls over the FM engine:

**GLOBAL VOLUME:** useful to adjust the level when clipping occurs or boosting some TFI patches that may be too quiet

**POLY & MONO:** switches between 3 Voice polyphony and mono voice. Keep in mind that on the real console each channel is always mono and polyphony were only achieved by using multiple channels.

**GLIDE:** two parameters to controls the amount of time the pitch will reach the note played.

**DR or HP** = Direct Output or Headphone out filtering (*can add analog feeling to the sound*)

**OP FILTER:** a GLOBAL parameter that will filter out high frequencies **during phase modulation**. *Leave to max for MD1 realistic emulation*. Can be used to reduce the harshness of the sound at high frequencies, reduce aliasing and also be used as an automatable low pass filter

**SAMPLE RATE DEGRADATION:** can degrade the audio output signal by skipping samples. When set to max it switches to POLYRATE.

**POLYRATE:** degrade the output according to the number of voice being played.

“Polyrate” is a kind of dynamic sample rate reducer.

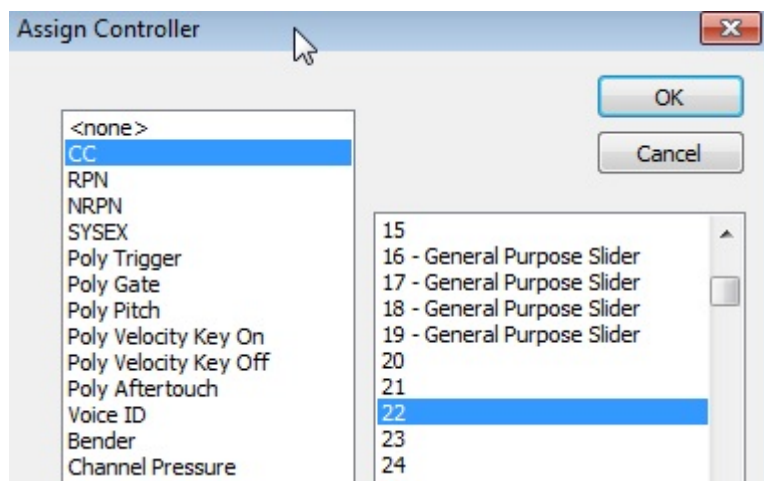
# MIDI AUTOMATION

## MIDI LEARN

---

Almost all of the FMDRIVE parameters can be automated via midi learn or DAW automation allowing great control over the sound. (Excepted graphic envelope parameters)

Simply right click on a button, knob or slider to assign external MIDI Control or use DAW automation.



Almost all type of MIDI message can be assigned or MIDI learned.

*NOTE: If a TFI preset is loaded during an automation recording, every registers change will be recorded. It can be a fast way to write automation different than global MIDI program change.*

## MIDI OUT

---



All **assigned midi parameters** will also send MIDI OUT message. The MIDI OUT Channel is chosen via the tweak panel.

All assigned MIDI parameters will send MIDI OUT data on **global patch change**.

You can also sync parameters between different FMDRIVE instances, using one instance to control the others via MIDI.

*Ex: Assign LFO ON/OFF to CC 25 on each instance of the plugin. Then allow other instance to receive MIDI in from the FMDRIVE chosen master Instance. Now each time you activate or deactivate the LFO from the master instance of the plugin, all others will follow.*

## **GENMDM**

The GENMDM is a midi hardware interface created and designed by Sebastian Tomczak that allows the real SEGA MEGADRIVE/GENESIS to understand MIDI data. It means you can control the YM2612 sound chip in real time via MIDI. *(The PSG SN76489 sound chip is also supported and will also be controllable via a separate VST plugin in the future)*

FMDRIVE can act as a visual controller for the interface allowing more user friendly control over the huge list of parameters and visual feedback. **(See the GENMDM Control MANUAL)**

The VST plugin can control the GENMDM by setting the appropriate MIDI CC on each parameter.

**However a special VST version "GENMDM CONTROLLER ONLY" is provided with all the MIDI CC pre assigned and no sound emulation. This is more practical than loading the emulation engine and saves CPU resources. (Controller version still in development for 1.2)**

*Some of the extended features are not available yet on GENMDM such as GRAPHIC ENVELOPES, CSM and custom parameters. Some are still in development and could be implemented in future FMDRIVE and GENMDM updates.*



# PARAMETERS LIST

## GLOBAL PANEL

---

L M R = output the FM sound hard left, center or hard right

ALGO REGISTER= Switch between different Operator configuration

DAC = Disable FM, Activate the DAC an open the DAC control panel

TFI = Open the TFI control panel

TL CTRL = Open the TL control panel

LFO = Open the LFO control panel

CARRIER2, 1, MODULATOR 2, 1 = Open the chosen Operator panel (*you can do the same by clicking on the op name on EG Display*)

NORMAL/SPECIAL= switches between normal and special mode

# TL PANEL

---

POWER = reset OPERATORS, FEEDBACK and VELOCITY

TL = Total attenuation level of the selected Operator

FB = Feedback level of Operator M1

VL = Global velocity sensitivity for all Operators (per operator enabled)

VOICES = Controls the amount of voice in polyphonic mode (3 or 6)

FREEZE = Assign a fixed frequency behavior in SPECIAL MODE

OVERDRIVE = Controls the amount of ladder effect in MD1 mode (max is like the real chip)

# OPERATOR PANEL

---

POWER = Disable or enable the operator to receive key on/off commands

KS = Key Scaling level. Reduce the envelope time according to the note pitch

MUL = Root frequency multiplier

DT1 = Small detune

DT2 = Large detune

AM= Enable or disable amplitude modulation by LFO

PMS = Level of pitch modulation by LFO (Global or Unsync)

SSG = Disable or set the specified SSG envelope sequence

AR = Attack rate

DR = First decay rate

SL = Secondary amplitude level (sustain point)

D2R = Secondary decay rate

RR = Release rate

## SPECIAL MODE & CSM PANEL

---

F-NUMBER = the root frequency of the current operator

RESET = Reset the root frequency to 440 Hz (ratio 1:1)

MIDI = activate external midi control for that operator and / or for Timer A

TIMER A = Speed of the Timer Period

## LFO PANEL

---

POWER = Enable or disable LFO

FRQ = Frequency of the LFO

AR = LFO PMS AMS attack rate

RR = LFO PMS AMS release rate

WF = Waveform shape of the LFO

AMS = Amplitude modulation sensitivity

PMS = Pitch modulation sensitivity

PMS REG = choose between normal or un-sync PMS

LFO FRQ = choose between normal or custom LFO frequency

STEP = LFO waveform stepping

# FM SYNTHESIS

## WHAT IS FM?

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**Frequency Modulation** (yes, the same as that thing you listen to on the radio) synthesis was made popular by **Yamaha in the early 1980s** with their line of **DX synthesizers**, which were instrumental in both the downfall of classic analogue synths, and giving keyboard players worldwide a polyphonic-palette of groundbreaking new sounds to use.

Dedicated FM synthesizers are digital in nature due to the instability of analogue VCOs, and the nature of FM synthesis techniques makes it very easy to create un-pitched and metallic tones, rather than standard subtractive sounds.

FM synthesis is based on two key things – a **‘modulator’ oscillator, and a ‘carrier’ oscillator**. These oscillators usually both use a sine waveform, and from this the modulator oscillator works just like an LFO – because it modulates the frequency/pitch of the carrier oscillator. You can try this yourself on a normal subtractive synthesizer, by setting up a sine wave oscillator and an LFO, and using the LFO to modulate the pitch of the oscillator – as you increase the rate of the LFO, the sound becomes non-harmonic. Note that in FM synthesis, the word ‘oscillator’ is often replaced with the term **‘operator’**.

As you change the modulation of the carrier operator, the frequency of the carrier will constantly move up and down depending on how the modulator is set up and in doing this different harmonics are created (called **‘sidebands’**), because these harmonics surround the carrier frequency depending on how it is modulated.

Because of the somewhat lifeless sound of the operators, FM synthesizers tend to include somewhere around 4-8 operators on a synth to spice things up.

These extra operators can be routed in all sorts of different and interesting ways, called **‘algorithms’**. For example, with the addition of an extra modulator operator, we can arrange the operators so that they go “modulator 1’ & ‘modulator 2’ go into the carrier’, or ‘modulator 1 goes into modulator 2, which goes into the carrier’ – this being more complicated and creating a new waveform.

**Therefore, using many operators can produce unique and lifelike sounds unachievable with other types of sound synthesis.**

# APPENDIX

## Early Interface design sketch & design

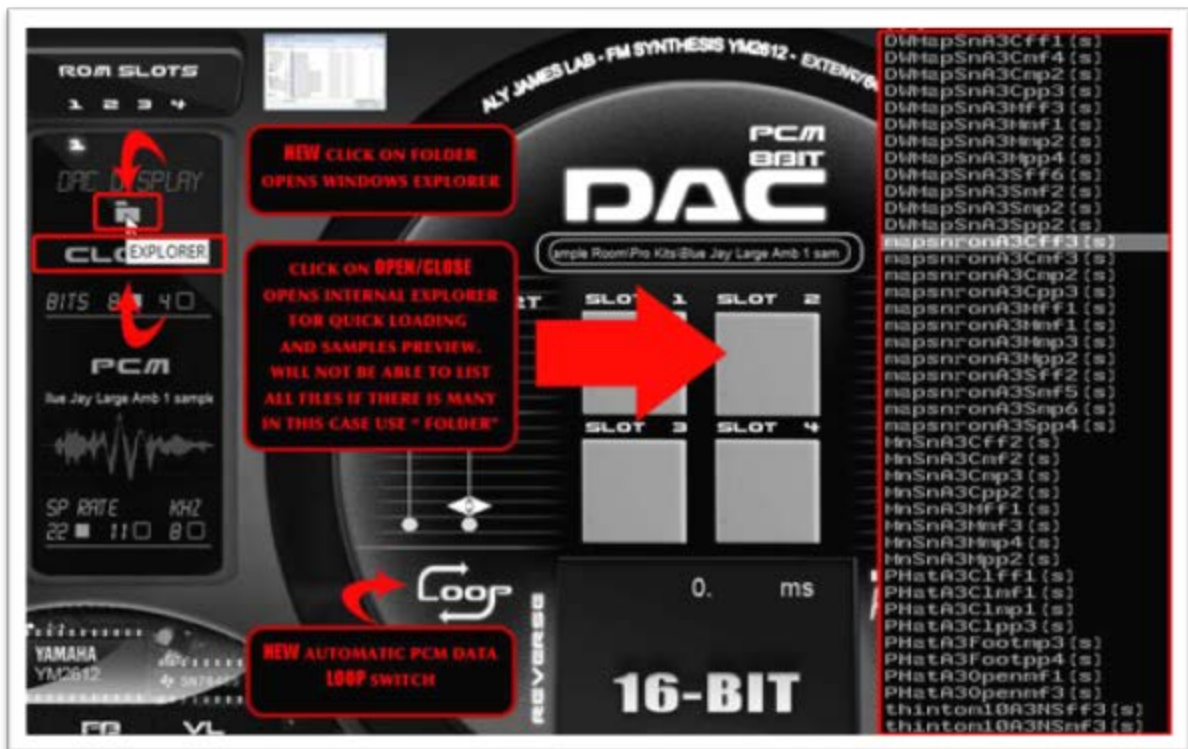




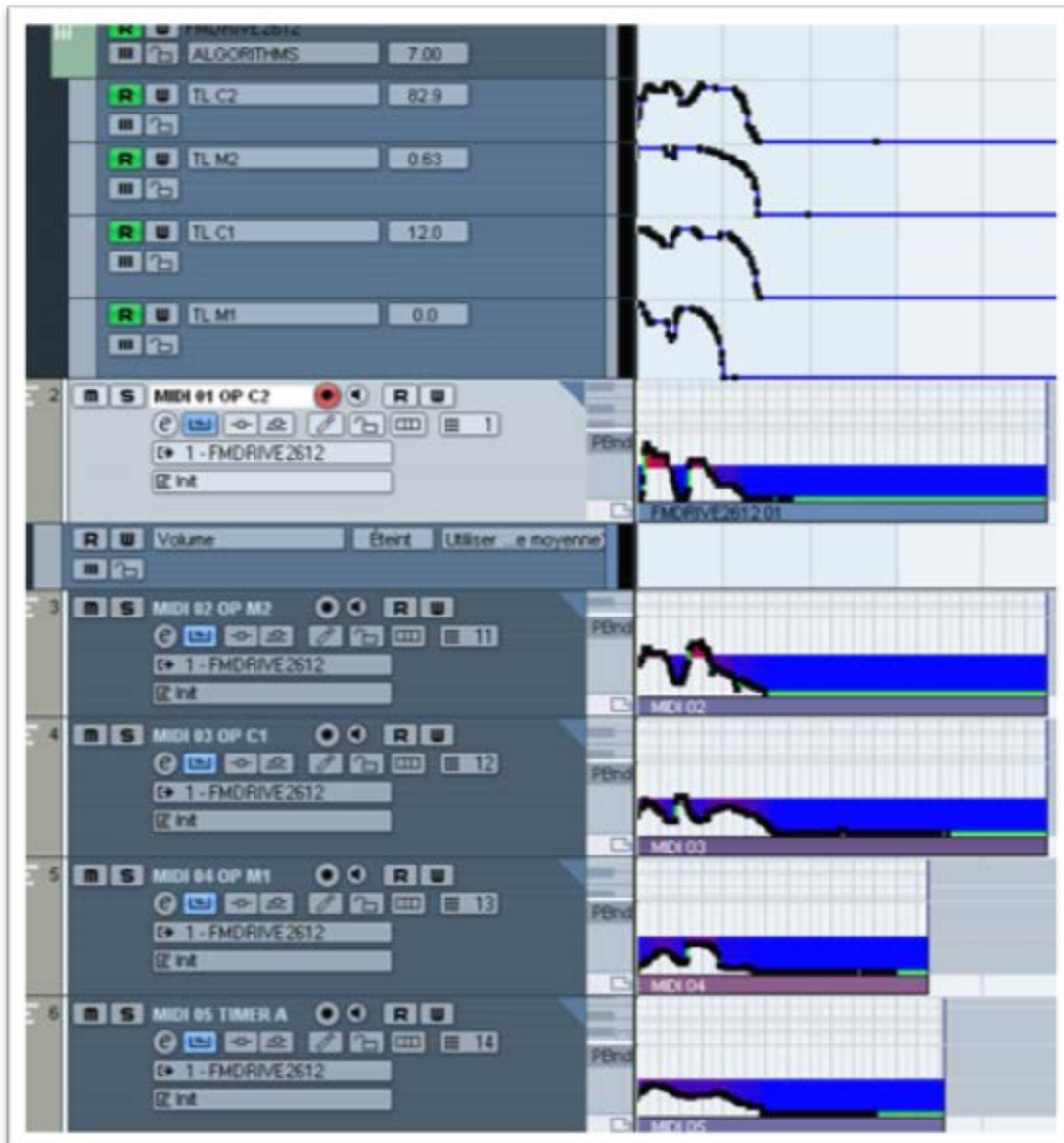


Some hints...











## Aly James centric links

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Official Website [www.alyjameslab.com](http://www.alyjameslab.com)

Dev Blog [www.alyjameslab.blogspot.com](http://www.alyjameslab.blogspot.com)

Facebook News [www.facebook.com/alyjamesound](http://www.facebook.com/alyjamesound)

Youtube Channel [www.youtube.com/alijamesproduction](http://www.youtube.com/alijamesproduction)

Soundcloud demos <http://www.soundcloud.com/alyjameslab>

Twitter @alyjamestwitt

CONTACT [alyjames.info@gmail.com](mailto:alyjames.info@gmail.com)

## External links

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GENMDM <http://little-scale.com/>

An Introduction to FM

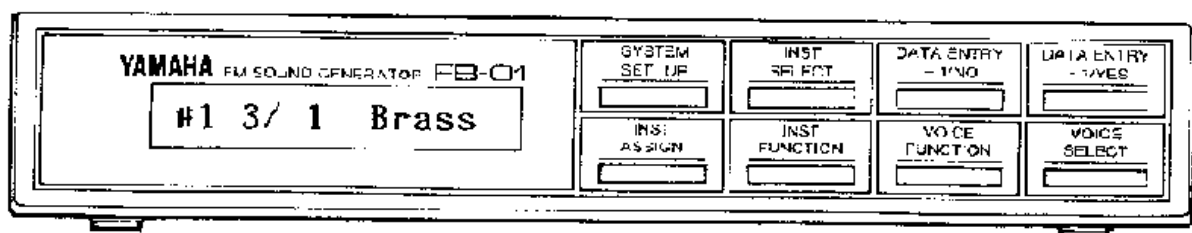
<https://ccrma.stanford.edu/software/snd/snd/fm.html>

<http://www.soundonsound.com/sos/apr00/articles/synthsecrets.htm>

YAMAHA YM chips numerical classification <http://www.vorc.org/text/column/hally/ymxxx.html>

YAMAHA FB01

This box is basically an YM2151 in the box with MIDI IN & OUT same as YAMAHA CX5M computer.  
Get one!



Maxim's YM2612 INFOS <http://www.smspower.org/maxim/Documents/YM2612>

**HOPE YOU HAVE FUN WITH FMDrive!**



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Secondly the use of Sega name and logo is use strictly here for the legitimate purpose of comparison and tribute to this great console, and it does not in any way imply SEGA®'s or YAMAHA®'s permission or endorsement of the FMDRIVE product.