

## Tutorial: The audio input in FM7

By Paul Sellars



If you had to sum up exactly what an FM synth does, you could say it makes complex sounds out of simple sounds. More accurately, it makes complex waveforms out of simple waveforms.

Yamaha's famous DX7, for example, made all its characteristic sounds with nothing more than sine waves. If you don't believe me, open the "DX7 Factory Presets.f7a" bank from FM7's "Presets" folder and see for yourself!

Of course, FM synthesis is such a powerful technique that an enormous variety of sounds can be created in this way – but wouldn't it be interesting to try FM synthesis with some other, more complex waveforms?

If you've spent any time exploring FM7, you'll already know that you can. Each of the instrument's six "operators" can be set to use one of thirty two different built-in waveforms, which can be combined to create a staggering variety of timbres, tones and textures.

However that's only the beginning. FM7 is so flexible that it can take you beyond the limits of conventional operator-based FM synthesis altogether, and into whole new areas of sound generation and processing.

The key to this flexibility is its audio input.

### The Audio Input



FM7's audio input allows you to route any audio signal – any sound you can hear – directly into its Frequency Modulation (FM) Matrix, and use it as if it were an operator waveform. Furthermore, the external signal can be used either as a carrier, or a modulator – or even both at the same time!

What does this mean?

- If the audio input is used as a carrier, this means that the frequency of the audio signal can be modulated by the output of one or more of the other operators.
- If the audio input is used as a modulator, this means that the frequency of one or more of the other operators can be modulated by the audio signal.
- Like every other operator in the FM7 Matrix, the audio input can also be set to feed back into itself – in which case the audio signal effectively acts as both a carrier and its own modulator!

Let's experiment.

Note: while external signals can be routed into the audio input of the standalone version of FM7, the "FM7 FX" plugin is a much simpler, more elegant solution. In the examples that follow I'm using "FM7 FX" in Cubase VST, but the same basic procedures should apply to any VST compatible host sequencer.

The first thing we need is an audio signal. Download the File Package (same as above in the left column) and unzip it. The file "USM Piano.AIF" contains a descending sequence of three chords, played with a piano sound from a basic GM sound module.

USM Piano MP3.

As you can hear in the MP3, it's not very exciting on its own.

In your sequencer, import "USM Piano.AIF" to an audio track, check that the tempo is set to 120 BPM, then set up a sixteen bar cycle. (In Cubase set the Left Locator to 1.1.0 and the Right Locator to 5.1.0, then click on the Cycle button.) The chord sequence should now loop in sync with your sequencer's tempo.



Next, insert the FM7 FX plugin into the relevant mixer channel. In Cubase, the easiest way to do this is from the Arrange window, by clicking on the "INS" button in the Inspector:



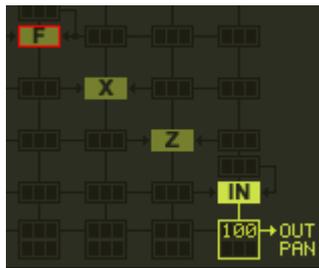
This opens the Channel Settings window, where you can select FM7 FX as an insert effect.

Switch the plugin on and... everything goes quiet! Don't worry; this is only because we haven't told FM7 what we want it to do with the incoming audio signal yet. Open FM7's editor window, and we can get started.

- You might find it helpful to start with an empty bank before you begin experimenting. Opening the file "Empty 128.f7a" or "Empty 32.f7b" in FM7's "Presets" folder is the easiest way to get one.

The first thing to do is activate the audio input "operator". Click on one of the operator buttons (for example "F"), and then click the "ON/OFF" button for the "IN" operator.

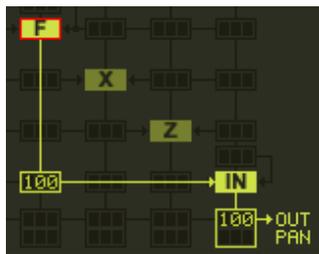
## Making connections



Just passing through FM7

Click on the “MATRIX” button in the top right hand corner of the Envelope window, to display the FM matrix. You can see that the “IN” operator is active (highlighted). Click immediately below the “IN” operator, and drag upwards, until the number “100” is displayed.

You should now be able to hear the piano sound passing directly through FM7.



*“F” is the Modular, “In” the carrier*

Now lets try some modulation. First activate operator “F” by clicking on its “ON/OFF” button, then click in the Matrix three slots below the operator, and drag upwards until the number “100” is displayed. This connects the audio output of operator “F” (by default a sine wave) to the modulation input of the “IN” operator.

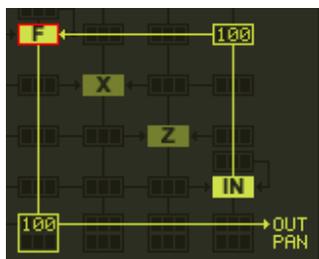
In other words, “F” is the **modulator**, while “IN” is the **carrier**.

To hear the result, it is necessary to trigger the F envelope: press a key on the FM7 keyboard while the sequencer is running. Alternatively you can send a MIDI note to the plugin while the audio is processed. To do this select an unused MIDI track in your sequencer, and choose “FM7 FX” as its output (In Cubase, choose “FM7 FX” from the “Output” pop-up menu in the Inspector). Draw in a MIDI note which is as long as the loop.

Sound example: IN as a Carrier (MP3)

You’ll notice that sound quickly becomes somewhat “metallic” and discordant.

Interesting... but what about the other way around?



*“In” is the Modulator, “F” the carrier*

Disconnect the “F” operator from the IN operator by clicking on the number “100”, and dragging downwards until you reach zero. The connection will disappear, Next click in the Matrix three slots to the right of operator “F”, and drag upwards until the number “100” is displayed. This connects the audio output of the “IN” operator to the modulation input of the “F” operator.

In other words, “F” is now the **carrier**, while “IN” is the **modulator**.

In order to hear what effect this has, you must connect the “F” operator to the main audio output, by clicking immediately below the “IN” operator and dragging upwards.

Sound Example: IN as a modulator (MP3)

The result is something like a cross-between a piano and a thunderstorm! A pretty alarming noise, and maybe a useful special effect, but perhaps not very “musical”.

### What's going on?



Ratio setting  
of an operator

The kinds of sounds that an FM synth produces depend on the relationships between the different operators in a patch. Generally, the “best” results come about when there is a more or less straightforward mathematical relationship between the operators, e.g. when the frequency (pitch) of the modulator is twice the frequency of the carrier, or when the frequency of the carrier is one quarter of the frequency of the modulator.

Simple operator “ratios” like these are the most likely to produce tones with a clearly discernible pitch, where the fundamental frequency is augmented by frequencies that are harmonically related to it.

When operator frequencies have no clear relationship to one another, the results tend to be rather different; often “clanging” or “metallic” sounds. With higher operator frequencies, the results can even be reminiscent of “white noise” or static.

These general “rules” are worth bearing in mind when you want you want to start processing sounds with FM7. Let’s look at a couple of examples.

### Playing the keyboard

To begin with, we’ll return to our GM piano phrase. Our first experiment didn’t produce fantastic results...in fact it was pretty much just noise! However if we try again, and this time make sure that FM7’s operators are producing something harmonically related to the audio signal, we should be able to get some more “tuneful” results.

The easiest way to control this is simply to send a few carefully chosen MIDI notes to the plugin while the audio is processed. To do this select an unused MIDI track in your sequencer, and choose “FM7 FX” as its output. (In Cubase, choose “FM7 FX” from the “Output” pop-up menu in the Inspector.) Now you can “play” the FM7 FX plugin just as you would the regular FM7 instrument.

You’ll notice that what you play has a direct effect on the kinds of sounds FM7 produces; when you play “in tune” with the incoming audio the results tend to be more harmonious and melodic, when you play “out of tune”, the results tend to be more discordant and harsh.

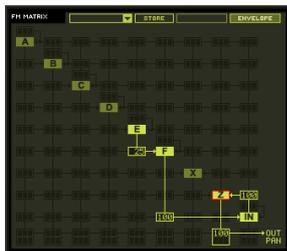
## Arpeggio Pattern

In this example I'm playing a simple arpeggio pattern, based on the chords in the piano phrase.

This is how it sounds: Piano Example MP3

You can see how this works for yourself by using the FM7 preset "110 BPM Example.f7p" and the standard MIDI file of the arpeggio pattern, "Piano Example.MID". Both are included in the download package (navigation above left).

Load the FM7 preset "110 BPM Example.f7p", import the MIDI file "Piano Example.MID" onto a sequencer track (with "FM7 FX" selected as its output) and hit play.



This is a very simple patch, using a combination of two operators to modulate the audio input, and a Z operator filter controlled by an envelope to help "shape" the sound. I've also added a short delay, for a little extra "polish". What about unpitched sounds?

## What about drums and percussion, for example?

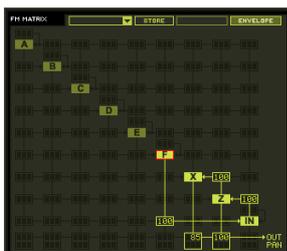
These kinds of sounds can contain a wide range of frequencies, none of which will necessarily be related to what the operators are doing. In other words, things are likely to get a bit noisy! This needn't be a problem though: in fact it can open the door to some excellent hard-edged electronic beats.

The file OB Loop 110.AIF is an original drum loop, specially provided for this tutorial by Oli Bell.

Set your sequencer's tempo to 110 BPM, import OB Loop 110.AIF (included in the download package), and set up a sixteen bar cycle as before. Then choose FM7 FX as an insert effect and load the preset "110 BPM example.f7p".

This is the original drum loop sound: OB Loop 110. (MP3)

After routing it through FM7 you should hear this: 110 BPM Example (MP3)



This is another fairly simple patch; operator F modulates the audio input, which is then passed to the filter in the Z operator, and the saturator in the X operator. A very short delay adds a mild "comb filter" effect.

What really makes this patch work is FM7's "IN ENV" option, available on the "MOD" page.

The IN ENV function tells FM7 to create a kind of “virtual envelope” based on the changing amplitude of the incoming signal. In other words, it works as an “envelope follower”. Patching IN ENV to the cutoff frequency of the Z operator filter can make for some nice, dynamic sounds – ideal for drum or percussion tracks.

As ever, this tutorial can only scratch the surface of what’s possible, but hopefully it will have given you a few ideas for some experiments of your own. Frequency Modulation of audio signals is still a very under-used technique, so there’s plenty of scope for coming up with sounds that haven’t been heard before!

Have fun.

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