

**PMRESO – PM RESONATOR™**

**3 CHANNEL FORMANT FILTER**

**PRELIMINARY OPERATION MANUAL**

**April 11, 2016**

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## INTRODUCTION

The PM Resonator – 3 Channel Formant filter is a recreation of the formant filter in the Polymoog™ polyphonic keyboard instrument. The module consists of three resonant filters with adjustable filter modes and Emphasis (resonance) followed by a 3 channel mixer. The filter modes are Low Pass, Band Pass, Band Notch, and High Pass. All three filters will have the same mode as set by the Mode switch.

A toggle switch on the panel labelled Range allows the ranges of the two lower channels, LOW and MEDIUM, to be extended to cover a better range of values for vocal formant use. A second toggle allows the filters and mixer to be bypassed so that the input signal can be heard directly. This assists in

adjusting the signal characteristics so that the desired result can be achieved.

## BASIC OPERATION

- Simulate natural body resonances of musical instruments
- Create human vocal formants corresponding to vowels
- Serve as a simple parametric equalizer

The Frequency control (and the associated Range switch) are adjusted to the frequencies of the three major partials of the resonance structure that is being simulated. Typically three frequencies are all that is needed to give a good approximation of the body resonances of a typical instrument. For example, the violin has a narrow peak at 300 Hz., another narrow peak at 700 Hz. and a broader peak at 3 KHz. The relative amplitudes are 3.5, 3.5 and 10 respectively. This information can be obtained by searching for the particular instrument to be simulated and “body resonance” or “formant”. The peak width is set on the Emphasis controls and the relative amplitudes are set on the Gain controls. Typically, when using the filter for formant simulation, the bandpass Mode setting should be used.

To get an accurate frequency setting, set the filter for bandpass, connect the input to an oscillator sine wave output, set the oscillator to the desired frequency and then move the corresponding frequency control on the filter back and forth until a peak in the filter output is detected. It may be necessary to increase the emphasis control to help make the peak more prominent.

## FORMANT SYNTHESIS BASICS

Musical instruments and human voices are identified by the effect that the resonant cavity associated with the body of an instrument or the vocal tract of a human has on the amplitude distribution of the harmonics produced by the driving frequency source. The auditory perception of a human ear and brain is acute enough to be able to make an identification of the type of instrument or the vowel produced in vocalizations with only the first three formants being present.

Formants are fixed structures for any particular resonant system.

Discussion of difference between formants and harmonics.

This effect can be produced electronically by using three bandpass filters working in parallel with variable frequency, gain and Q. Q is a dimensionless factor representing the ratio of the filter bandwidth measured at -3dB power level (.7071 for voltage) to the center frequency. Formant Q's are generally in the range of 5 – 50.

As an example, here are the first three formants for a violin. The fundamental frequency is 220 Hz.

F1 (Hz)	F1 (dB)	F1 (Q)	F2 (Hz)	F2 (dB)	F2 (Q)	F3 (Hz)	F3 (dB)	F3 (Q)
518			1613			2685		

And here are the first three formants for a tenor voice (pitch range C3-C5) singing “a” as in “bob”. The fundamental frequency is 120Hz.

F1 (Hz)	F1 (dB)	F1 (Q)	F2 (Hz)	F2 (dB)	F2 (Q)	F3 (Hz)	F3 (dB)	F3 (Q)
673			1097			2457		

### USE A HARMONIC RICH WAVEFORM

In order for formant synthesis to work effectively waveforms with sufficient harmonic content should be used. Sine waves would not work well as the energy content of the wave is all concentrated at one frequency. The best driving waveform for formant synthesis purposes is a sawtooth wave as this waveform produces energy in all odd and even harmonics providing a source of energy to the resonators.

### KEEP THE PITCH WELL BELOW THE FIRST FORMANT

If the driving waveform frequency is too high, there will not be enough harmonics that fall within the range of the resonator filters to provide a realistic simulation of the formant. This effect becomes apparent when simulating higher pitched vocal formants. The vowel being produced will be harder to identify if the driving frequency approaches or exceeds the frequencies of the first or second formants.

## TECHNICAL SPECIFICATIONS – PM Resonator™

Low Frequency Range	Normal 60Hz - 300Hz: Extended 180Hz - 900Hz
Medium Frequency Range	Normal 300Hz - 1.5KHz; Extended 600Hz - 3KHz
High Frequency Range	1.5KHz - 7.5KHz
Input Range	+/-10 Volts max.
Input Impedance	100K Ohms
Module Power	+15 Volts 25 mA., -15 Volts 25 mA., +5 Volts 0 mA.
Module Size	Panel height - 8.75 inches (222 mm); Panel width - 4.250 inches (108 mm); Depth (behind panel) 2.5 inches (96 mm)

### PM RESONATOR “VINTAGE” MOD

If you ordered the vintage mod kit for your PM Resonator you will find a set of three op amps that can be substituted for the TL074 op amps that are supplied installed. The LM348s are similar to the units installed in the original Polymoog. You can remove the socketed op amps and substitute these to experiment with different sound textures. Be sure to observe the correct orientation of the op amps carefully matching the notch in the socket with the notch in the plastic body of the part. This diagram illustrates the correct orientation.

