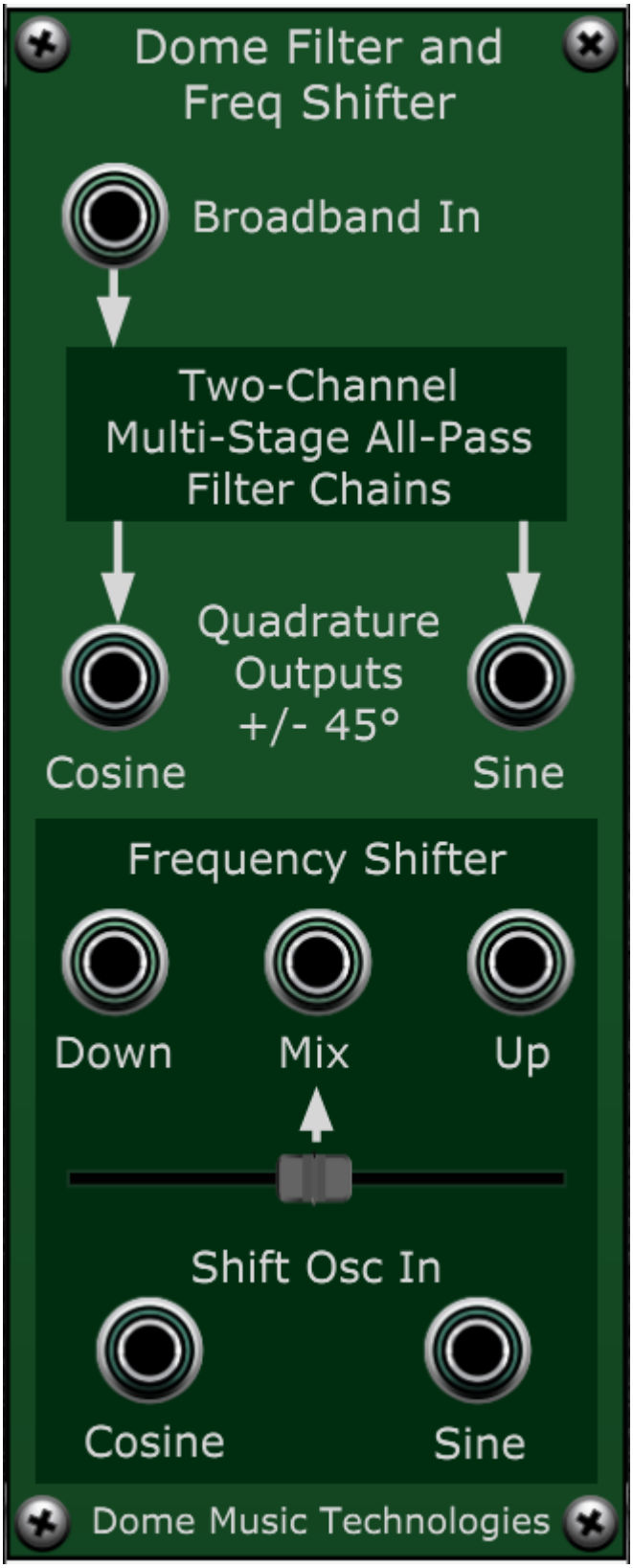
Dome Filter and Frequency Shifter from Dome Music Technologies



Introduction

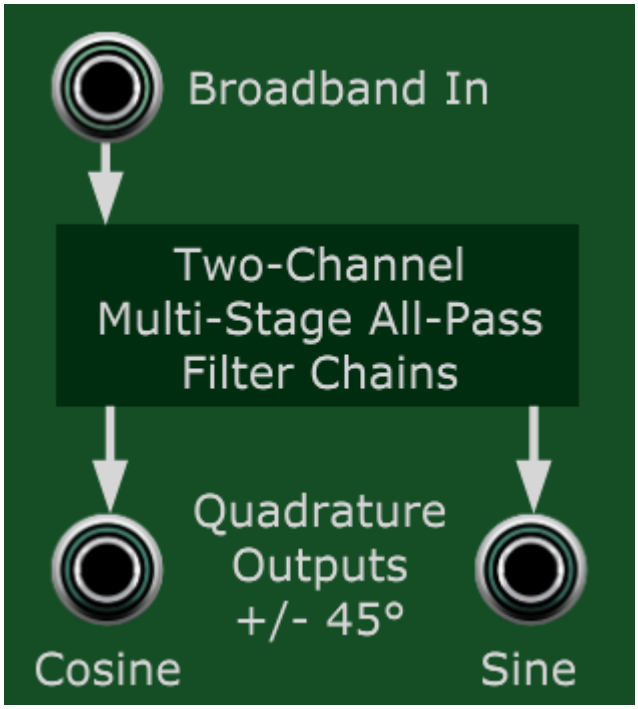
The **Dome Filter and Freq Shifter** module from Dome Music Technologies uses the Bode Frequency Shifter design to perform linear frequency shifting on an audio input signal.

Frequency Shifting is a related effect to ring modulation. However, whereas a ring modulator produces a mixture of both sum and difference frequencies at its single output, a frequency shifter separates the sum frequencies (shift up) and difference frequencies (shift down) into two separate output signals. An in-depth explanation of how frequency shifters work is presented at the end of this user guide for those who are interested.

To operate as a frequency shifter, this module requires an external sinusoidal “Shift Oscillator”, which provides phase-quadrature outputs (i.e. simultaneous Sine and Cosine outputs). Fortunately, the Dome Music Technologies Test Rack Oscillator is the perfect companion, and the two modules share the same fetching shades of green:

Rest assured that you can also create a shift oscillator by combining only free-of-charge modules. See later.

The Dome Filter Section



The Dome Filter section has a broadband signal input and two phase-quadrature outputs.

When using the module as a frequency shifter, the complex audio signal which you want to shift should be plugged into the “Broadband In” socket.

The Cosine output will always lead the Sine output by 90 degrees for input frequencies between 20 Hz and 5,000 Hz. Above 5,000 Hz, the phase difference between the two outputs starts dropping below 90 degrees. While this can lead to some leakage between the sum and difference frequencies, it still produces a satisfying and useful frequency shifting effect, with good audio separation between the up-shifted and down-shifted outputs.

The Sine and Cosine outputs of the Dome Filter are internally hard-wired to the Frequency Shifter section, but the outputs can also be used for any other application where phase-quadrature signals are required.

The Frequency Shifter Section

The Frequency Shifter section uses the Sine and Cosine outputs of the Dome Filter section and combines it with an external phase-quadrature oscillator to create up-shifted and down-shifted versions of the Broadband In signal.

"Shift Osc In" Sockets

The Cosine and Sine inputs at the bottom of the module should be connected to the Cosine and Sine outputs of a sinusoidal phase-quadrature oscillator. The amount of frequency shift (up or down) is determined by the frequency of the external shift oscillator. As mentioned previously, the Test Rack Oscillator from Dome Music Technologies is the perfect companion for this duty. For low-frequency shifts (up to 20Hz), the Quad Sine LFO is a good free-of-charge alternative. In fact, you can even use the Dome Filter section to create phase-quadrature outputs from a simple sine-wave VCO (such as the stock Cherry Audio Oscillator module), allowing you to use it to generate Shift Osc In signals (audio rate, over 20Hz) in Voltage Modular Nucleus.

Frequency Shifter Output Sockets and Mix Slider

There are three outputs from the Frequency Shifter section of the module. The "Down" socket will output only the down-shifted frequencies. The "Up" socket will output only the up-shifted frequencies. The "Mix" socket allows you to mix the down-shifted signal, the dry input signal and the up-shifted signal according to the setting of the Mix Slider:

At the full-left position (-1.0), the mix is 100% down-shifted output.
At the half-left position (-0.5), the mix is 50% down-shifted output, 50% dry input.
At the centre position (0.0), the mix is 100% dry input.
At the half-right position (+0.5), the mix is 50% up-shifted output, 50% dry input.
At the full-right position (+1.0), the mix is 100% up-shifted output.

The 50% mixes have a nice 'phaser-like' quality to them, particularly when used with a low-frequency Shift Osc input.

Principles of Operation

Bode Frequency Shifter

The Bode Frequency Shifter was named after its inventor, Harald Bode. Here is a block diagram of how it operates:

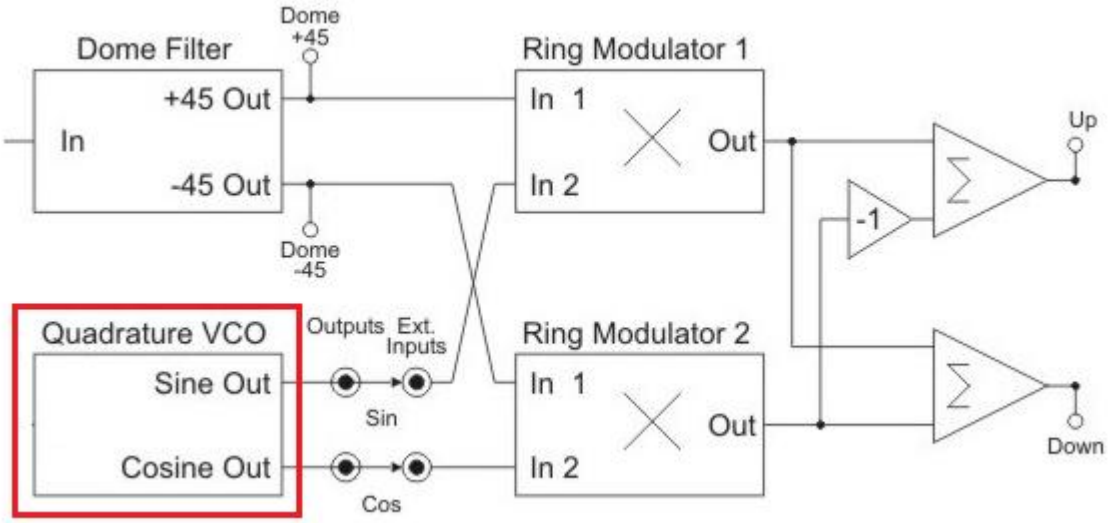


Figure 1- Bode Frequency Shifter (External Shift Oscillator outlined in red)

Ring Modulators 1 and 2 operate exactly like a standard ring modulator. That is, they will produce a mixture of sum and difference frequencies based on the two inputs. However, the 'magic' of a frequency shifter is that the difference frequencies (lower sideband) of both ring modulators are in phase with each other, while the sum frequencies (upper sideband) are 180 degrees out-of-phase with each other.

This means that adding the outputs of the two ring modulators will reinforce the amplitude of the difference frequencies and cancel out the sum frequencies. This leaves only the down-shifted signals, which are sent to the "Down" output.

By contrast, subtracting the output of Ring Modulator 2 from the output of Ring Modulator 1 has the opposite effect. In this case, the sum frequencies are reinforced while the difference frequencies are cancelled out. This leaves only the up-shifted signals, which are sent to the "Up" output.

Dome Filter

You might be tempted to imagine that a Dome Filter refers to the shape of its frequency response, or its phase response. However, like the Bode Frequency Shifter, the Dome Filter is named after its inventor, Robert B. Dome.

The ‘design brief’ for a Dome filter is to ensure that for a wide range of frequencies at the input, you can provide two outputs which have a phase difference of 90 degrees between them. It’s important to note that the phase relationship between the input signal and either output is irrelevant, so long as the two outputs are 90 degrees apart for all in-range input frequencies.

For analogue designs, a Dome Filter is usually made up of two chains of all-pass filters, precisely tuned so that the phase difference between each chain remains as close to 90 degrees as possible for all frequencies within the critical bandwidth.

In the case of this module, the all-pass filters are of a single-pole design. There are six in series in each channel with corner frequencies as shown below:

Position in Chain	Channel A (Sine) Corner Freq	Channel B (Cosine) Corner Freq
1	5.413 Hz	18.790 Hz
2	41.124 Hz	83.327 Hz
3	167.35 Hz	335.06 Hz
4	671.54 Hz	1348.8 Hz
5	2692.9 Hz	5469.2 Hz
6	7285.0 Hz	31371.0 Hz

Table 1 - Dome Filter all-pass filter corner frequencies

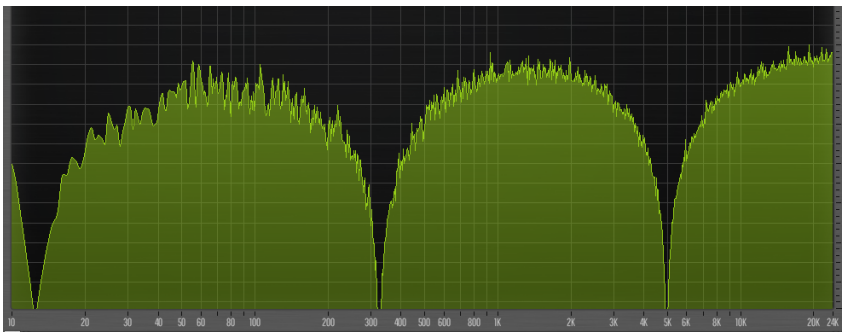


Figure 2 - Notches in the Sine channel (when mixed 50:50 with dry signal)

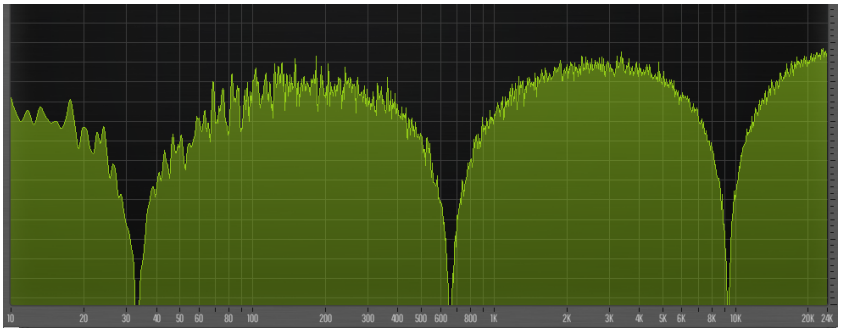


Figure 3- Notches in the Cosine Channel (when mixed 50:50 with dry signal)