Ring Modulation[1]

Introduction

A ring modulator is a simple device that can be used to create unusual sounds from an instruments output. It effectively takes two signals (each with some frequency), and produces a signal containing the sum and differences of those frequencies. These frequencies will typically be non-harmonic, so the ring modulator can create some very dissonant sounds. For this reason, ring modulation is not a widely used effect.

How it Works

Modulation means that we are changing some aspect of a tone, such as it's amplitude, frequency, or phase. In the ring modulator, we are using amplitude modulation (more specifically, suppressed-carrier modulation) which is implemented simply by multiplying two signals. This scheme is illustrated in Figure 1.

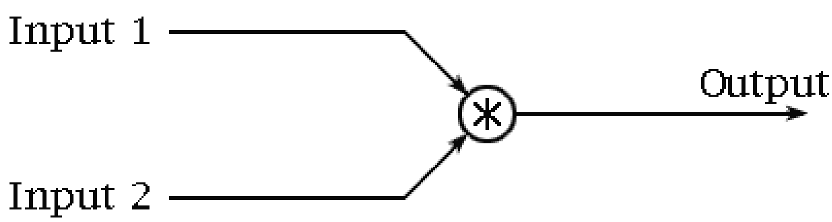

Figure 1: A ring modulator multiplies two input signals.

This multiplication results in a new signal that contains frequencies different than those of either of the original signals. More specifically, the multiplication results in an output that contains notes at the sum and difference of the two input signal's frequencies. (For the technical types, these new frequencies are the sidebands - the sums are the upper sideband, and the differences are the lower sideband) This is not a harmonizer - in general, the notes produced by the ring modulator are not related to the inputs by some musical interval or harmonic relationship. Thus, the sound produced is very dissonant and harsh. This sound is often described as being 'gong-like' (bells often contain strong non-harmonic components when ringing). Figure 2 shows a segment of a 400 Hz, a 600 Hz sine wave, and the product of the two. Looking at the multiplied signals, we can see the higher frequency component (at 1000 Hz) added on top of the lower frequency component (at 200 Hz). This 200 Hz component gives the waveform the gentle dip and rise in the figure.

1 Scott Lehman, URL: http://www.harmony-central.com/Effects/Articles/Ring_Modulation 1996 [26.11.2012]

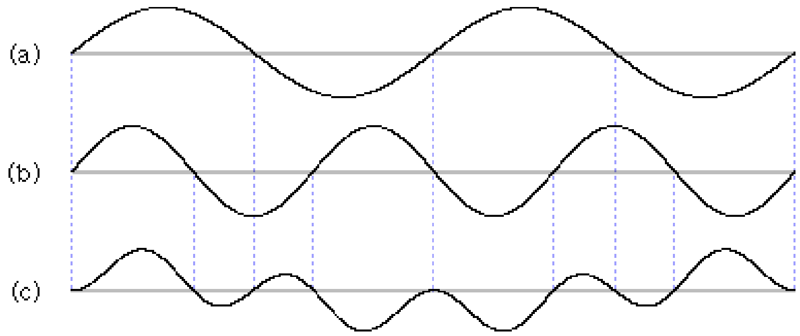

Figure 2: (a) 400 Hz sine wave, (b) 600 Hz sine wave, and (c) the product of the two (a 200 Hz and 1000 Hz sine wave added together). The product is zero when either wave is zero.

Many of the ring modulators you encounter will only have one input for connecting an instrument. The other signal is usually created with some internal oscillator (which is generally considered to be the carrier signal. This signal doesn't appear in the output, hence the name 'suppressed carrier'). In some cases, you may be able to select the frequency of that oscillator, and in others, the frequency may be fixed at some value, or limited to a set of different values. But there's no reason why both signals couldn't be instruments, or why they both couldn't be oscillators for that matter.

Of course, and instrument's sound is usually considered as being a sum of many different sine waves, not a pure tone. And the oscillator used could also generate a complex waveform as well. The number of tones grows quickly as each component produces the sum and difference with all the partials in the other signal, creating a very complex sound.

The ring modulator's output alone may be totally unsuitable depending on one's tastes, but the sound can be smoothed a bit by simply mixing in the original instrument sound. This will give an instrument a strange timbre.

Implementation

Analog

Implementing amplitude modulation in the analog world is not always an easy thing to do. One implementation consists of a ring of four diodes (hence the name 'ring modulator') and a pair of transformers. This is also referred to as a lattice-type modulator, and it can actually be constructed as a passive circuit. Alternatively, a four-quadrant multiplier can be used, which is commonly available as an integrated circuit package.

Digital

Creating a digitally based ring modulator comes down to simply multiplying two numbers each sampling interval which is very easy to accomplish. However, there needs to be some consideration about the signals used as aliasing can create a noisy output. The highest frequency component in the output is the sum of the highest components in each of the signals being used.

References

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Dodge, Charles and Thomas A. Jerse. Computer Music: Synthesis, Composition, and Performance. New York: Schirmer Books, 1984. (ISBN 0028646827)