# MODULATORS

Modulation is a process whereby the modulator or program signal, controls a parameter of the other signal, called the carrier. The result is a modulated carrier. All forms of modulation at audio rates (i.e. greater than 20 Hz) produce added spectral components in the output signal called sidebands.

Amplitude Modulation (AM): modulator controls the amplitude of the carrier

Frequency Modulation (FM): modulator controls the frequency of the carrier

Ring modulation (RM) is a special case of amplitude modulation where each signal modulates the other simultaneously. It is sometimes called product modulation because essentially the two signals are multiplied together.

```
    CARRIER              PROGRAM SIGNAL
                            (MODULATOR)

       ↓                        ↓
          RING MODULATOR
                ↓
          OUTPUT SIGNAL
```
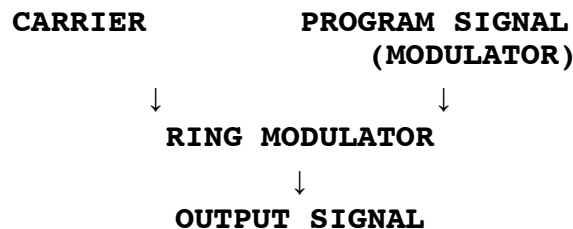
The output of the ring modulated signal is the sum and difference of the two frequencies at the input. If two sine waves, frequency f_1 and f_2 are input, the output is: **$f_1 + f_2$ and $f_1 - f_2$ (sum and difference frequencies)**

Note that, except in special cases ($f_2 = 2.f_1$), <u>neither</u> input frequency is present in the output spectrum.

Another special case is where the two inputs are the same. The difference frequency is 0, and the sum frequency is twice the frequency of the input -- hence an octave higher, a result called pitch shifting.

Modulator Range	Effect
subaudio range	AM style beating (or chopping if a square wave is used)
same range as input	added spectral components
equal to carrier	octave pitch shift
much higher than input	entire signal shifted to high frequency