**6. Modulation Synthesis**

* *Modulation*, in electronic and computer music implies one aspect of the *carrier signal* being modified by a *modulator signal*.
* *Modulation products*, or *sidebands*, begin to get noticeable whenever the frequency of modulation rises above the audible bandwidth.
* Modulation synthesis is more efficient in achieving complex spectrums.

**Bipolar and Unipolar Signals**

* Bipolar signals have a positive and negative excursion around zero.
* Unipolar signals only have either a positive or negative excursion.
* Unipolar signals can be conceptualized as a bipolar signal to which a constant has been added.
* The difference between ring modulation and amplitude modulation, is that the former modulates two bipolar signals, while the later modulates a bipolar signal with a unipolar.

**Ring Modulation**

* Ring modulation is a form of amplitude modulation.
* Formula for determining the value of a simple ring-modulated signal at time:
* If frequency of modulator is below , the amplitude of varies at the frequency of .
* If the frequency of is in the audible range, the timbre of changes.
* For each sinusoidal component of , adds a pair of *sidebands*.
* If and are in an integer ratio, the sidebands are harmonic, otherwise they’re inharmonic.
* Sidebands in signal multiplication derive from a trigonometric identity:
* Ring Modulation can also be understood as a case of *convolution*.
* As an example, let assume is a sine and is a sine. We’ll have bands at and .

**Negative Frequencies**

* Negative frequencies are a biproduct of a modulation where has a frequency higher than . As an example, given and , , while .

**Application of RM**

* Modification of sampled carrier by sinewave modulator.
* Creation of pure synthetic sounds.

**Analog Ring Modulation and Frequency Shifting**

* Digital RM, in general tends to always sound the same, whereas analog RM, due to its circuits and components, tend to sound different, or to present a “character” of their own.
* Silicon or germanium diodes within the system, would introduce extraneous frequencies.

**Amplitude Modulation**

* As in ring modulation, the amplitude of the carrier varies with the modulator signal. The difference between RM and AM, is that in AM the modulator is a unipolar signal.
* A common example of AM happens when an envelope is applied to a sinewave. The envelope, being unipolar (with values ranging from 0 to 1) acts as the modulator, and the sine, being bipolar, as the carrier.
* We can apply an envelope to a signal by multiplying the two waveforms:
* Just like in RM, a pair of sidebands is generated for every sinusoidal component of the carrier and modulator.
* The difference in spectrum, from RM, is that AM contains the carrier frequency as well.

AM Instruments

* To implement AM, we simply restrict the modulator to a unipolar signal (between 0 and 1).