MUSC 4081/5081

Analog Synthesis Terms and Concepts

FREQUENCY – The repetition of rate of cyclic energy such as sound or alternating current, expressed as cycles or kilocycles per second (cps, kcps are expressed as Hertz [1 Hz = 1 cps] or kilohertz [1 kHz = 1,000 cps]). In music, frequency is perceived as pitch.

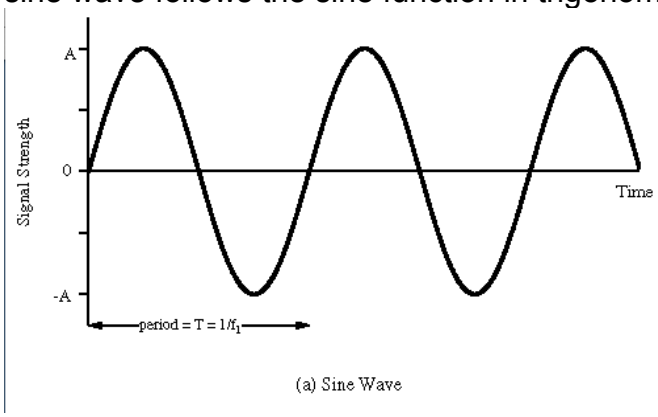
AMPLITUDE – The amount of signal, measured by determining the amount of fluctuation of air pressure, voltage, or numerical data (in a digital system). When the signal is in the audio range, amplitude is perceived as loudness.

AMPLITUDE ENVELOPE – A shape that changes non-periodically as a function of time. This shape, the envelope, is what gives a sound its most recognizable characteristics.

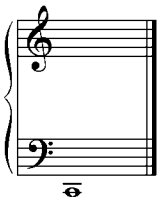
ENVELOPE GENERATOR – A module that creates a contour of voltage that is applied to the control input of a **VOLTAGE CONTROLLED AMPLIFIER** (VCA) to shape the amplitude envelope of a sound. In an analog synthesizer the most common type of envelope generator has the following parameters: **A**ttack, **D**ecay (initial decay), **S**ustain, and **R**elease (ADSR).

OSCILLATOR – A device that creates a repeating electrical waveshape. (If we think of the waveshape a the graphic representation of the rise and fall of voltage from zero to a maximum positive or negative and back again, it is possible to identify basic electronically generated sounds by their shape.) A **VOLTAGE CONTROLLED OSCILLATOR** (VCO) will usually have a potentiometer for coarse adjustments to the frequency of the signal as well as voltage control inputs. In most synthesizers the frequency can be controlled by various control sources such as keyboards, ribbon controllers, sequencers and **LOW FREQUENCY OSCILLATORS** (LFO). An LFO generates a sub-audio frequency that is generally used a as control source for producing vibrato, tremolo, trills, and automatically repeating triggers.

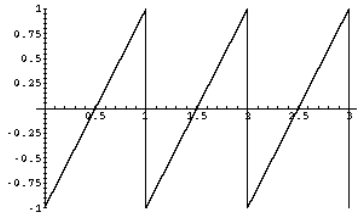
SINE WAVE – The sine wave is the most non-complex type of sound consisting of a fundamental and no overtones. The change in voltage, starting at zero, is gradual increase to a maximum positive, then a decay through zero to a maximum negative, then returning to the starting point. The basic shape of the sine wave follows the sine function in trigonometry.

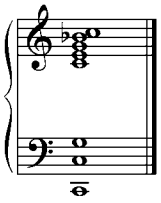


(a) Sine Wave

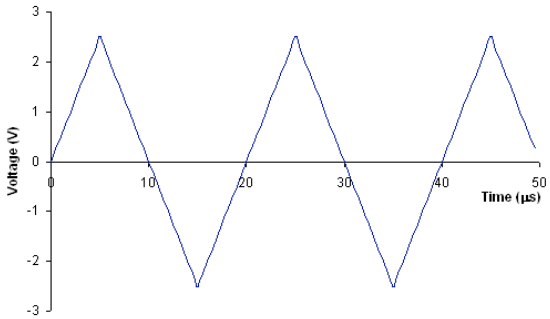


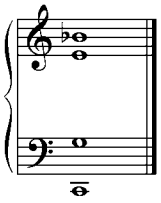
SAWTOOTH WAVE – (Ramp Wave) The sawtooth wave contains all the overtones of the fundamental frequency. These overtones have relative amplitudes that decrease exponentially as they exist higher up in the harmonic series. The change in voltage, starting at a maximum positive, is a smooth decline to the maximum negative then a sudden jump up to the starting point (negative-going ramp). This wave may also begin with the maximum negative rising to a maximum positive with a sudden jump down to the starting point (positive-going ramp). Positive and negative ramps will both sound the same.



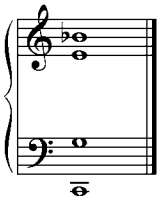


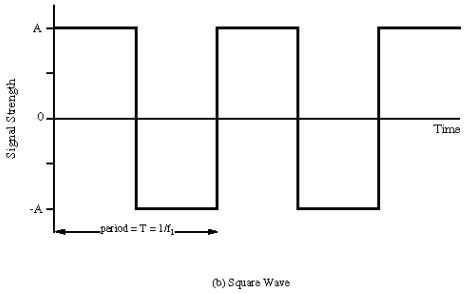
TRIANGLE WAVE – (Delta Wave) The triangle wave consists of the fundamental and all the odd numbered harmonics with amplitudes falling off in ratios of 1/9, 1/25, 1/49, etc. ($1/n^2$, where *n* is the partial number.) The change in voltage, starting from zero, is a smooth and linear rise to a maximum positive with a sharp corner between the positive-going and negative-going directions of the voltage. The voltage then decays smoothly back to through the starting point to the maximum negative.





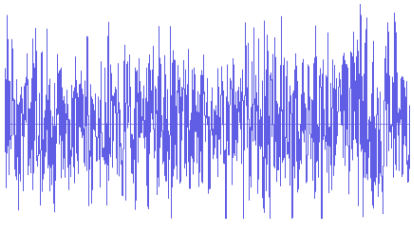
PULSE WAVE – In a pulse wave, the positive and negative voltages are never in a transient state. The voltage is either at the positive maximum r the negative maximum. The proportion of the positive portion of the total cycle to the total length of the cycle is called the **duty cycle**. Variance in the duty cycle will vary the timbre of the wave. For example, a pulse wave with a duty cycle of 1:3 will have every third partial missing, and duty cycle of 1:4 will have every fourth partial missing. A **SQUARE WAVE** has a duty cycle of 1:2 (the positive cycle is one half the frequency). The square wave contains the fundamental and all the odd numbered harmonics falling off in ratios of 1/2, 1/5, 1/7, 1/9, etc. (1/n, where *n* is the partial number.)



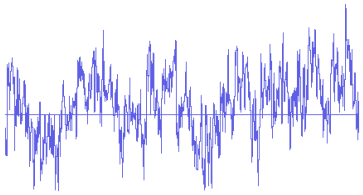


(b) Square Wave

WHITE SOUND – (Gaussian Noise, Thermal Noise) A mixture of all the audible frequencies at random instantaneous amplitudes. White sound has *equal energy per unit frequency*. (There is the same amount of energy 500Hz and 501 Hz as there is between 1500Hz and 1501Hz, i.e., it is spectrally flat.)

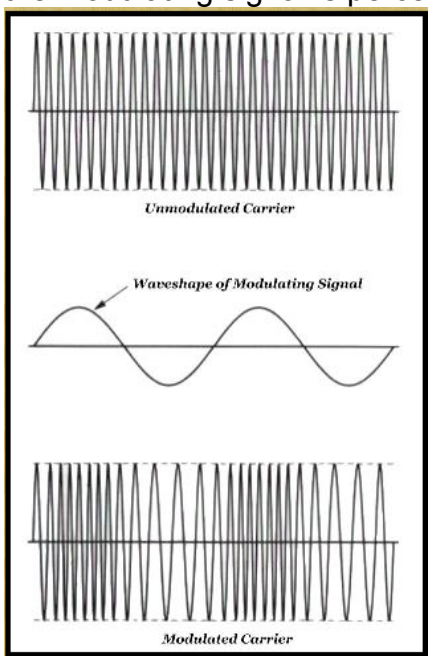


PINK SOUND – Like white sound, pink sound contains all the frequencies in the audio spectrum but the energy distribution (amplitude curve) is different. Because pink sound contains *equal energy per octave*, the sound will seem to have more bass rumble.

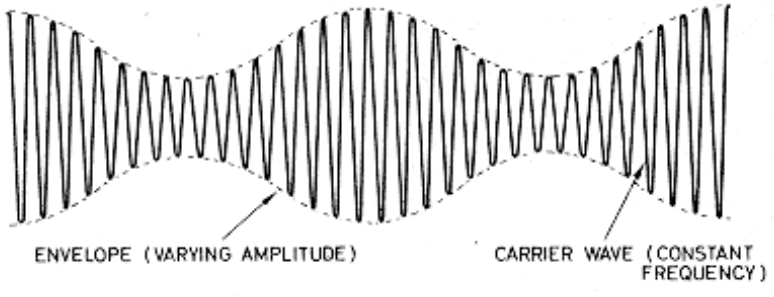


WAVE SHAPE DISTORTION – (Wave Form Modulation) A voltage-controlled change in the shape of the wave an oscillator is putting out, independent of any change of frequency.
CARRIER SIGNAL – The parameter, for example, a wave from an oscillator, that is being affected.
MODULATOR SIGNAL – The signal, and LFO, for example, that causes the carrier to be effected.
INDEX – The intervallic displacement of the pitch will be in direct proportion to the amount of **attenuation** (the reduction of a signal; a signal at full value has zero attenuation and signal with zero value has full attenuation). This is referred to as the *modulation index*, or depth of modulation. (The more the modulator is attenuated, the less the carrier is distorted, thus the smaller the index.)

FREQUENCY MODULATION – A change in the frequency of a signal. When the modulator is a sub-audio frequency, FM is perceived as vibrato. More tha16Hz in the modulating signal is perceived as a change in color.



AMPLITUDE MODULATION – A change in the amplitude of a signal. The carrier is always present in AM.



ADDITIVE SYNTHESIS – (Fourier Synthesis) Any sonic object can be re-created by subdividing its instantaneous spectrum into individual sine wave frequency components, then combining the correct number of sine waves with the proper amplitude relationships to recreate the original sound. The **SPECTRUM** of a sound is the collection of many individual frequencies that combine to make a single event. Additive synthesis at a complex level is not practical in an analog system.

SUBTRACTIVE SYNTHESIS – Using filters to alter the timbre of a sound by removing or attenuating one or more bands of partial frequencies.
FILTER – A device for removing selected frequencies fro the sound spectrum of an incoming signal.
HIGH PASS FILTER – Attenuates frequencies below the filters cutoff frequency, letting the high frequencies through.
LOW PASS FILTER – Attenuates frequencies above the filters cutoff frequency, letting the low frequencies through.
BAND REJECT FILTER – (Notch Filter) Eliminates frequencies within a specified range.
BAND PASS FILTER – Eliminates frequencies outside of a specified range.

VOLTAGE CONTROLLED AMPLIFIER – (VCA) A device that responds to a change in voltage at its control input by altering the amount of gain of a signal being passed through it.

CONTROL VOLTAGE – An Electrical signal that tells a voltage controlled device (VCA, VCO, VCF) what levels to go to or changes to make in the setting of any voltage controlled parameter.

PATCH – To connect together the inputs and outputs of various modules, generally with patch chords. The configuration of hookups and settings that result from the process of patching, and by extension, the tone color that results is also called a patch.