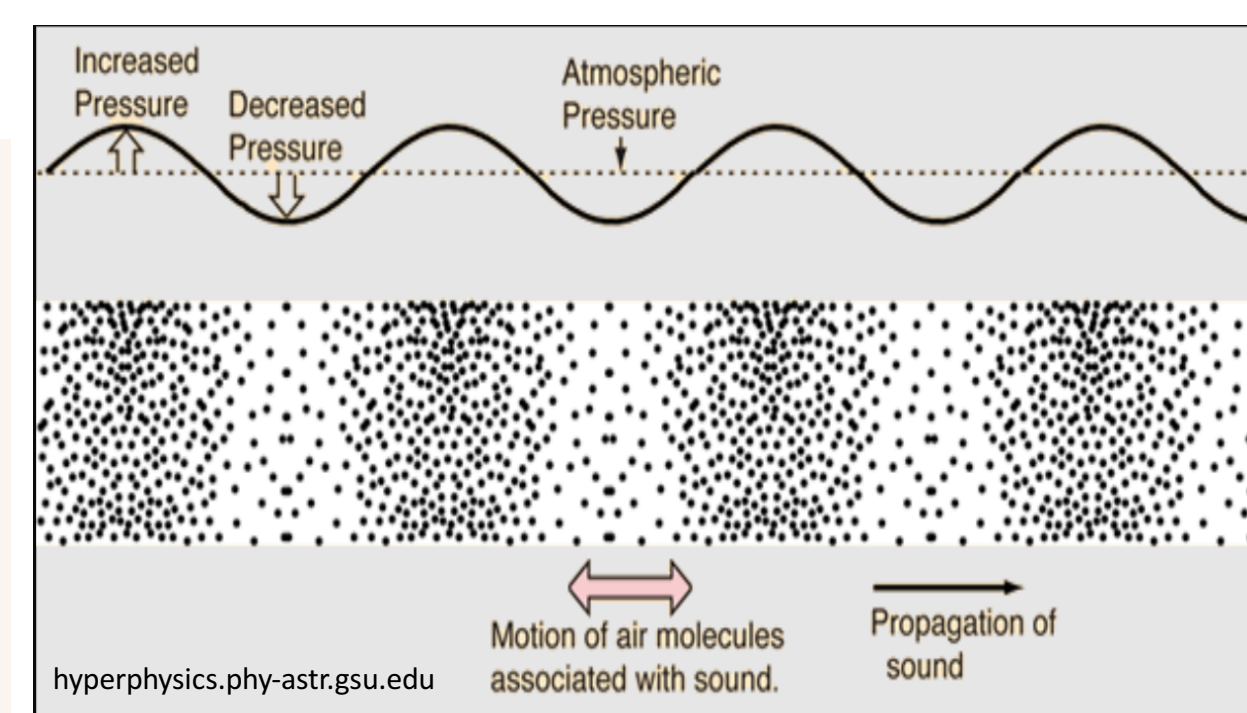
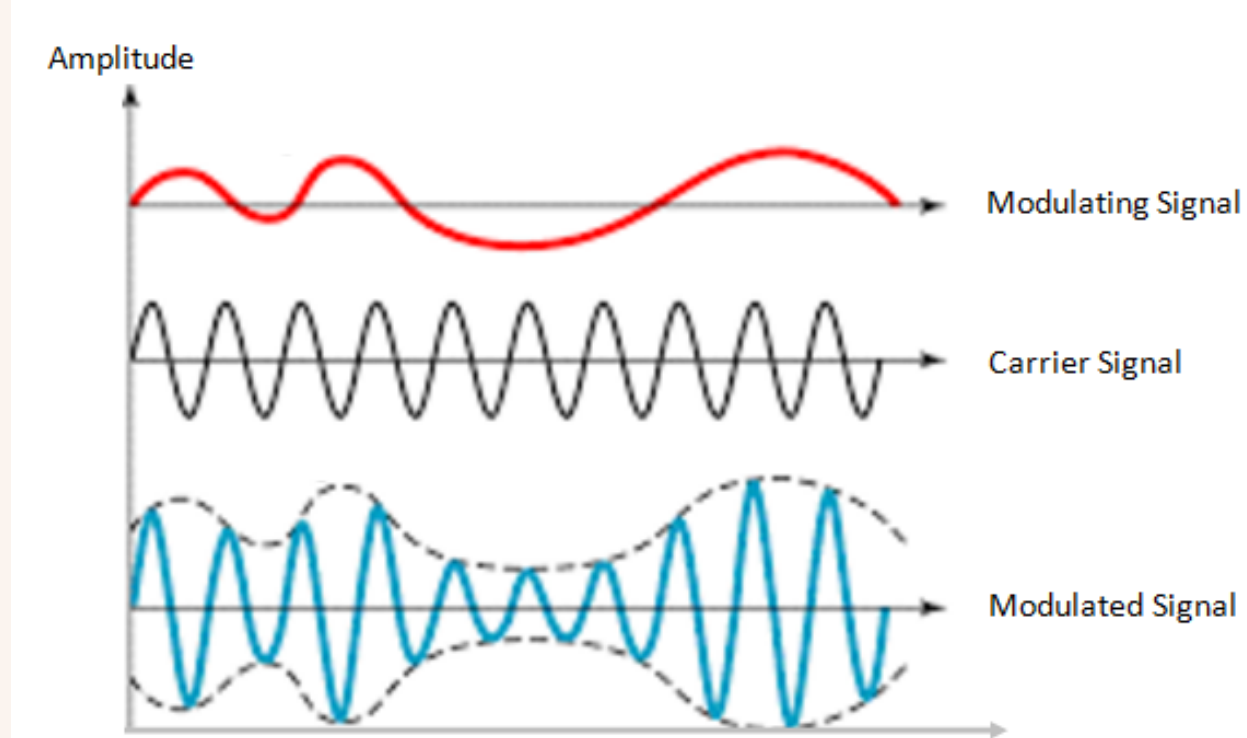


# Sound Waves

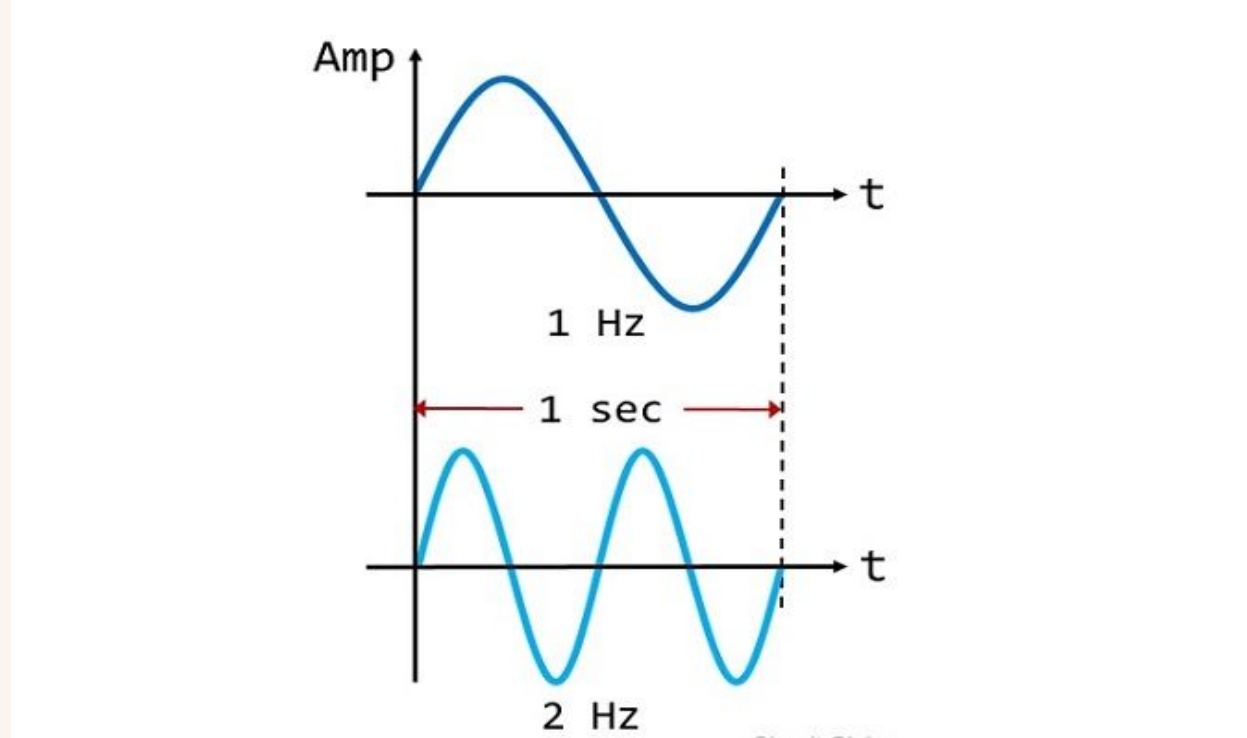
Sound is a pressure wave which is created by a vibrating object. This vibrations set particles in the surrounding medium (typical air) in vibrational motion, thus transporting energy through the medium. Our ears detect the vibrations as sound.



**Amplitude** is the volume or scale of a wave, the amount of work done to generate the energy that sets the particles in motion is reflected in the degree of displacement.



**Frequency** of a wave is the number of complete back-and-forth vibrations per unit of time.



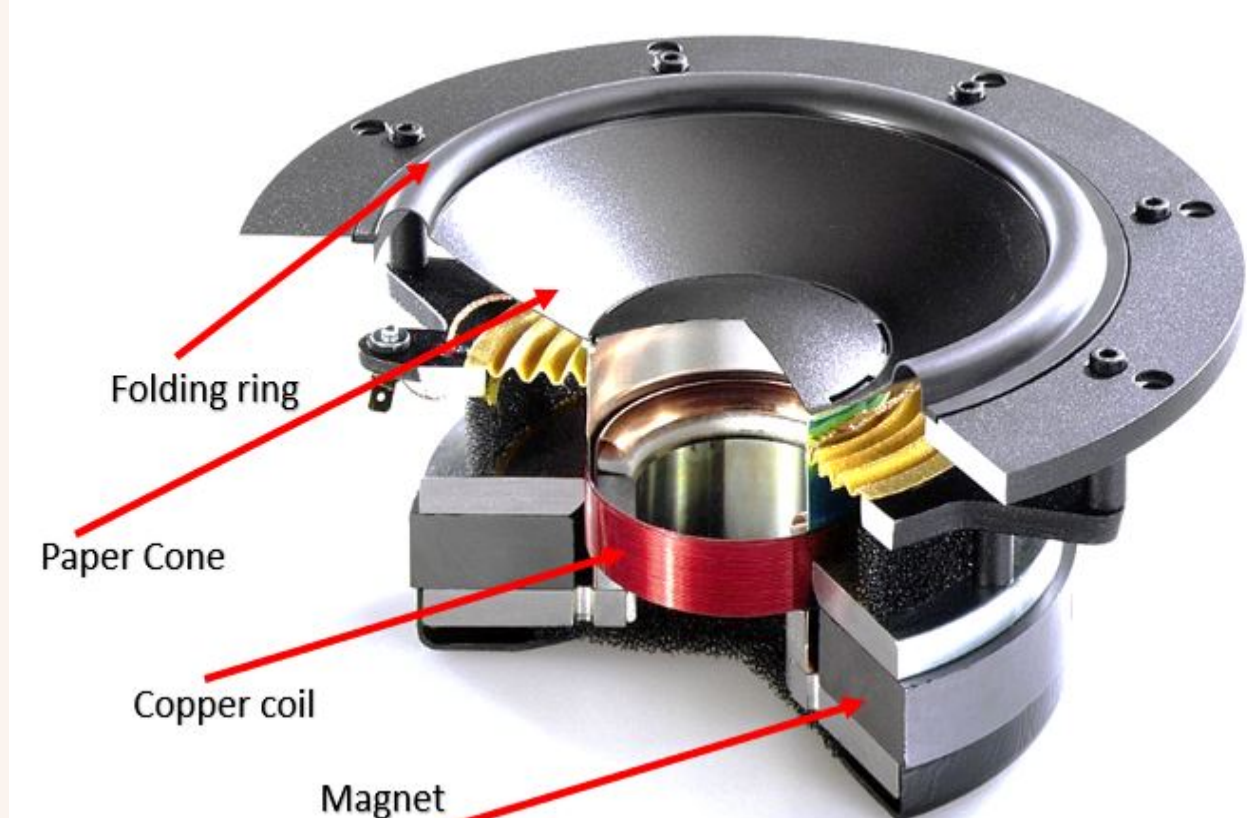
1 Hertz = 1 vibration/second

We perceive frequency as the pitch of a sound; with 'middle C' at 256 waves per second, or Hertz. Octaves are doubling the frequency, so one octave above middle C is 512 Hz. The range of human hearing is about 20 Hz through 20,000 Hz.

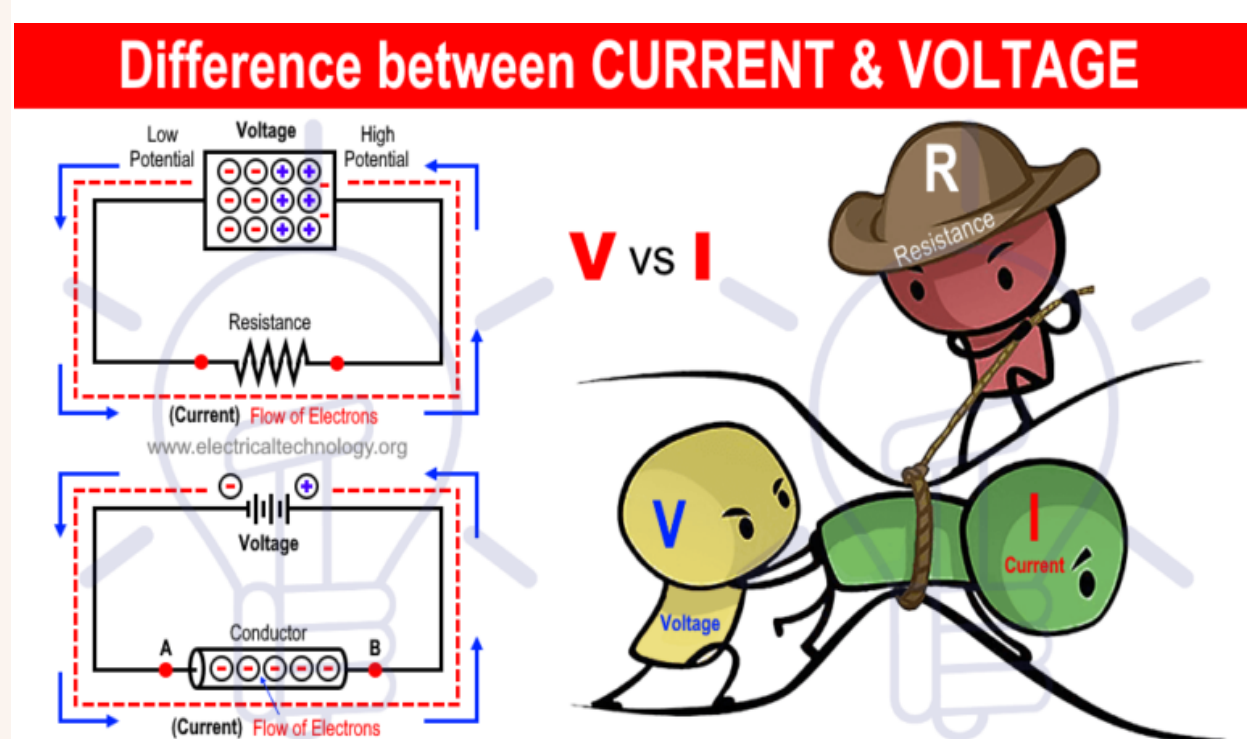
While a pure tone has one frequency, complex sound will have various amplitudes at every frequency. At the extreme, white noise is defined as a sound with equal power at every frequency.



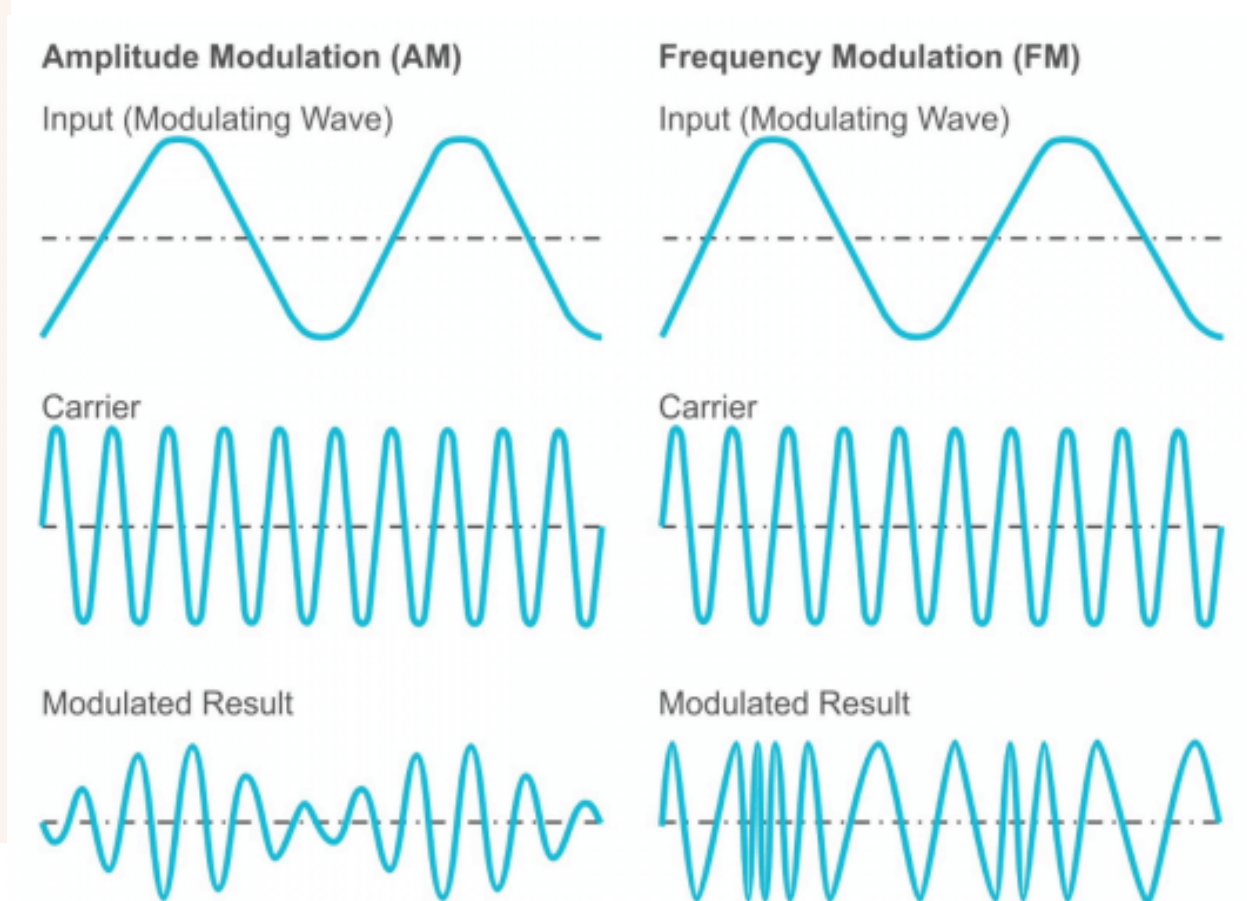
**Speaker** is a device that converts an electrical audio signal into a corresponding sound. The speaker driver can be viewed as a linear motor attached to a diaphragm which couples that motor's movement to motion of air, that is, sound. An audio signal must be amplified electronically to a power level capable of driving that motor.



When the electrical current from an audio signal passes through its voice coil—a coil of wire capable of moving axially in a cylindrical gap containing a concentrated magnetic field produced by a permanent magnet—the coil is forced to move rapidly back and forth due to induction; this attaches to a diaphragm or speaker cone in contact with air, thus creating sound waves.



**Voltage** is the measure of electrical potential, and because it drives a speaker so directly, voltage becomes equivalent to sound. Using electrical control we can manipulate signals and produce any sound.



**Modulation** is the process of changing something, amplitude modulation changes the amplitude, and frequency modulation changes the frequency. Multiplying one signal by another can create new interesting tones.

# Eurorack DIY

## hand-crafted electronic music

Presented by Karl D. Stamm, Ph.D.

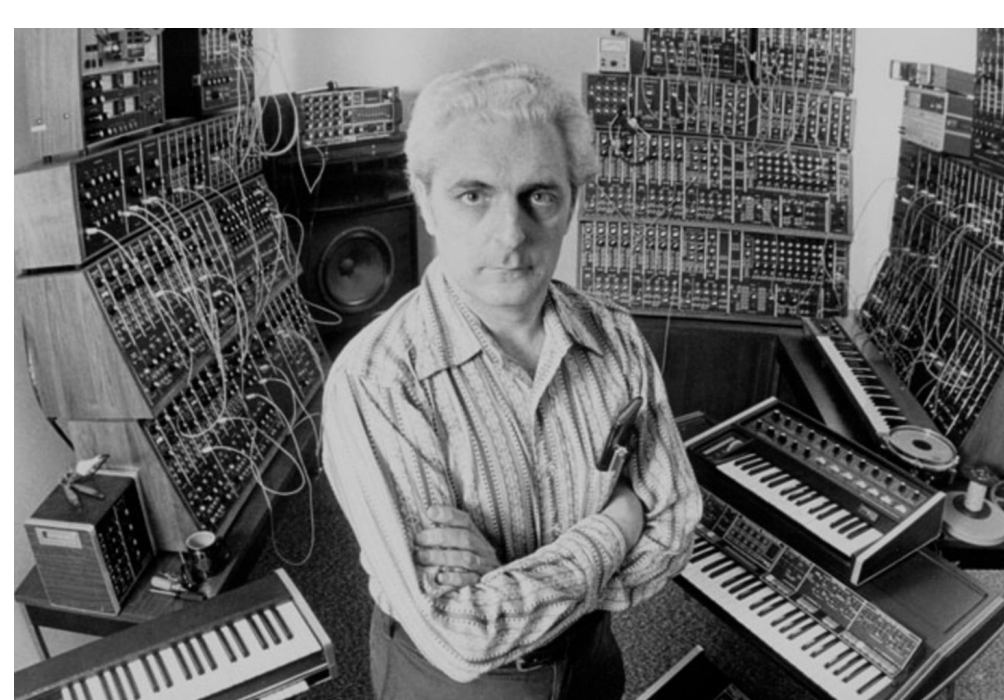
www.karltron.com

# Technology

## Modular Equipment

### Moog

Robert Moog was an American engineering physicist and pioneer of electronic music. He was the founder of Moog Music and the inventor of the first commercial synthesizer in 1964. This was followed in 1970 by a more portable model, the Minimoog, described as the most famous and influential synthesizer in history.



Moog created fundamental synthesizer concepts such as the pitch wheel, modularity, envelope generation, and voltage control. He is credited for helping bring synthesizers to a wider audience and influencing the development of popular music.



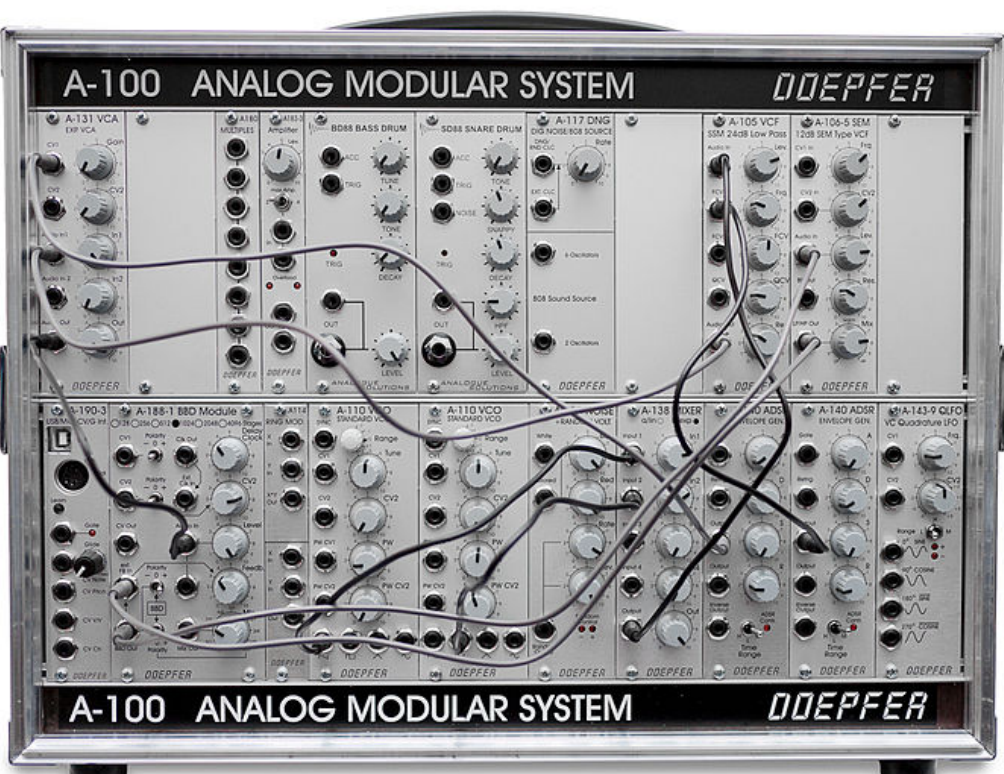
### Doepfer

If any one individual can be said to be responsible for the resurgence of modular synthesis over the past decade, it would have to be Dieter Doepfer. With the invention of the Eurorack standard for his own company's A-100 modular system in 1995, Doepfer opened the way for other manufacturers to start producing an ever-increasing array of mutually compatible modules.



### Eurorack

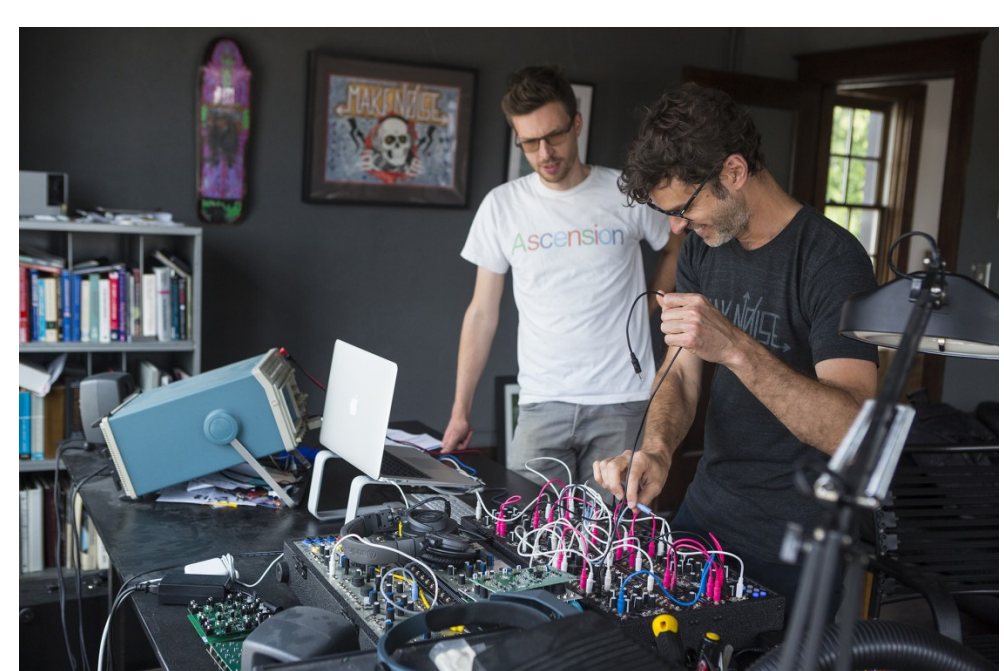
is a modular synthesizer format originally specified in 1996 by Doepfer Musikelektronik. It has since grown in popularity, and as of 2018 has become a dominant hardware modular synthesizer format, with over 5000 modules available from more than 270 different manufacturers ranging from DIY kits and boutique, cottage-industry designers to well-known, established synth mass-manufacturers like Moog and Roland.



Compact size, 3.5mm mono jacks and cables for patching all signals, and lack of a visual or sonic aesthetic defined by one manufacturer sets Eurorack apart from other modular synthesizer formats, and these factors have contributed to the popularity of Eurorack among both manufacturers and musicians.

### Make Noise

was founded in 2008 by Tony Rolando, a self-taught electronic musical instrument designer who got started by obsessively reading amateur radio books at the public library, building electronics for artists, working for Moog Music, and playing in bands for many years.



What started as a re-visioning of jettisoned music technology has grown into a crew of folks working together in Asheville, NC, to design and build some pretty strange, but thoughtful modular synthesizers. They see their instruments as a collaboration with musicians who create once in a lifetime performances that push boundaries and play the notes between the notes to discover the unfound sounds. "Also, we think what we do is fun and we hope you like it, too."



## Artists

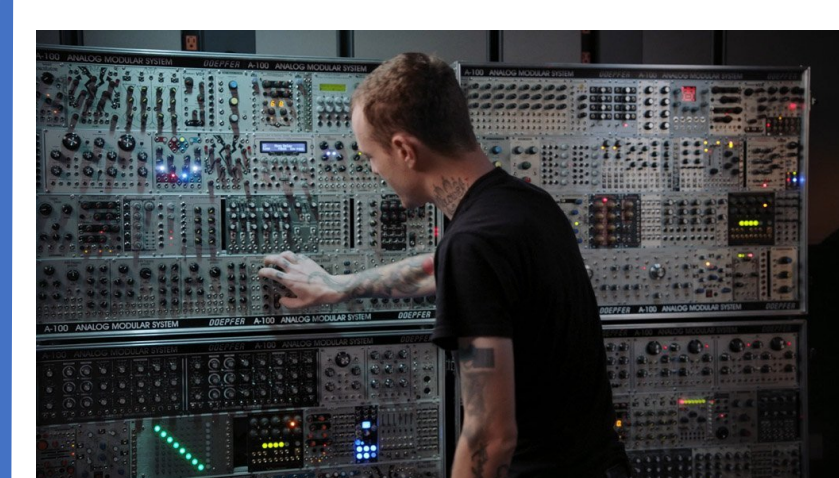
### Hans Zimmer

is a film score composer and record producer. His works are notable for integrating electronic music sounds with traditional orchestral arrangements. Since the 1980s, he has composed music for over 150 films, include The Lion King, The Dark Knight Trilogy, Inception, and Interstellar. He has received four Grammy Awards, two Golden Globes, and an Academy Award.



### Deadmau5

is a Canadian electronic music producer, DJ, and musician. He mainly produces progressive house music, though he also produces and DJs other genres of electronic music, including techno under the alias Testpilot. He has six Grammy Award nominations for his work.



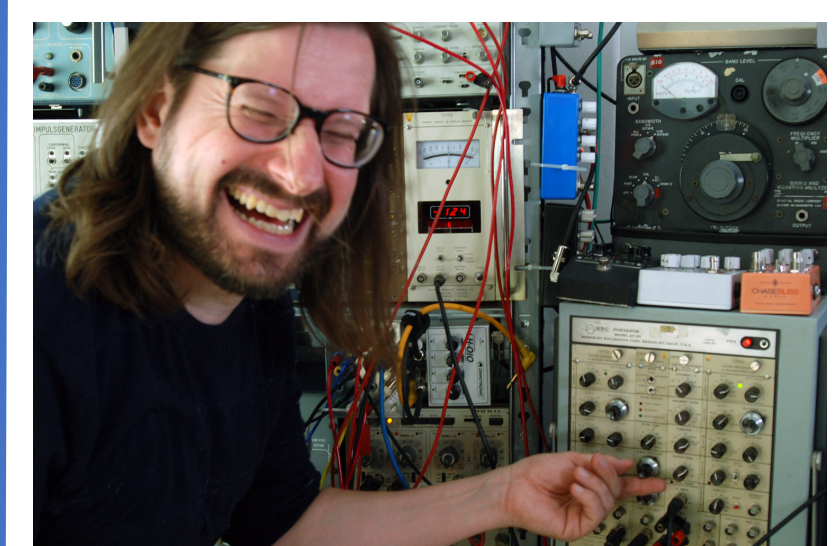
### Radiohead

are an English rock band formed in 1985. Their experimental approach is credited with advancing the sound of alternative rock. Rolling Stone named Radiohead one of the 100 greatest artists of all time. They were inducted into the Rock and Roll Hall of Fame in 2019.



### Hainbach

is an electronic music composer and performer based out of Berlin, creating shifting audio landscapes. He searches for the sounds in between on modular synths, tape and test equipment, making even the unmusical "music". Through his YouTube channel Hainbach brings experimental music techniques to a wider audience. Using antique electronics not intended for musical use gives him a unique sound.

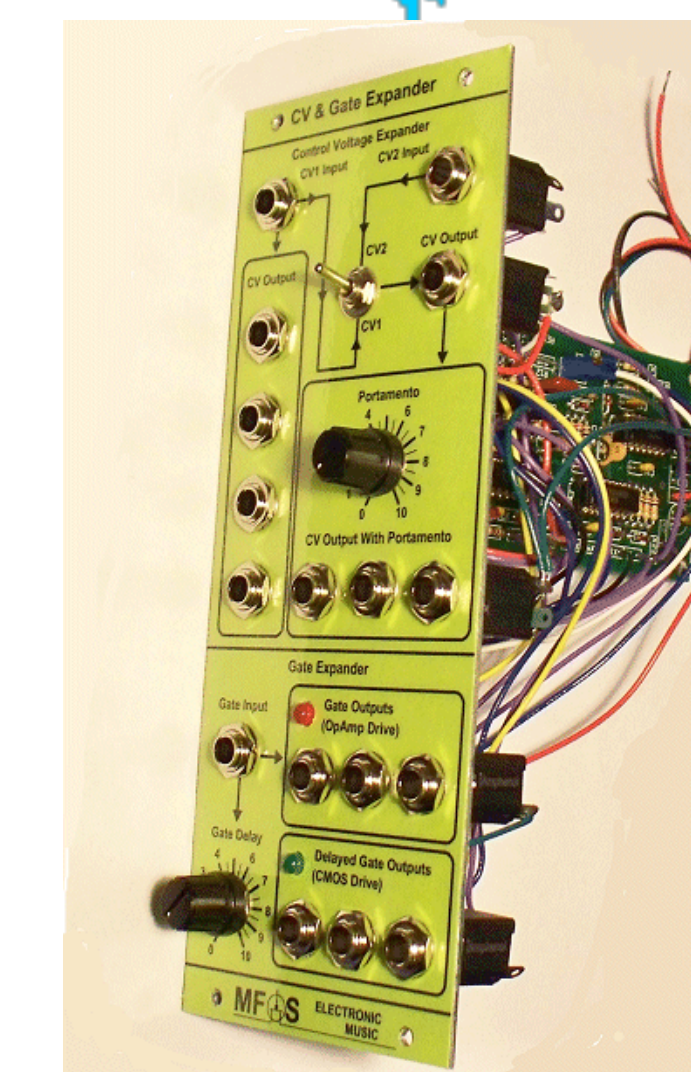


### Sam Battle

is a musician and hardware hacker, operating a Youtube channel as Look Mum No Computer, where he demonstrates circuit bending, musical hacking, electronics experimentation, and music production with otherwise obsolete equipment. His philosophy of "Don't be scared to try it" was the inspiration for much of my work here.



His most famous works are the Gameboy Megamachine and the Furby Organ, where dozens of simple, familiar robots sing in horror or harmony.



### Modular Synthesizers

are like normal synthesizers but inside out, so the components are interchangeable and audio path reconfigurable. A basic synth has several vital modules inside, on a format like Eurorack you can have a different brand for each component, and create a truly unique instrument.

### Oscillator

is the core noise maker, a Voltage Controlled Oscillator makes a tone based on the voltage it is given.

### Amplifier

controls the volume, so a Voltage Controlled Amplifier lets you automatically vary the volume, creating separate notes.

### Envelope

generator makes shapes that specify the shape of a sound, like a slowly rising swell, or a sharp snappy drum.

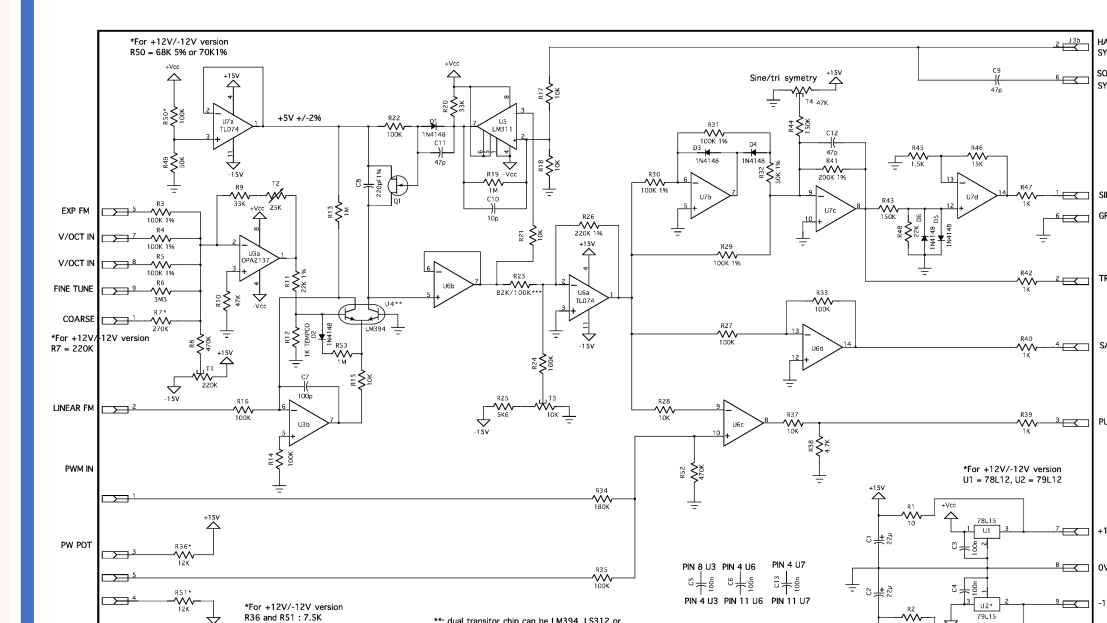
### Trigger

generators or rhythm generators can drive the synth to play sequences. More than 11 thousand unique modules are described on the wiki [modulargrid.com](http://modulargrid.com)



### Circuitry

Open source designs and shared schematics are available so you can find and learn about voltage controlled modular synthesis. [musicfromouterspace.com](http://musicfromouterspace.com), [Yusynth.net](http://Yusynth.net), and [sdiy.info/wiki](http://sdiy.info/wiki) have tutorials and explanations of hundreds of circuits for sound making or manipulation.

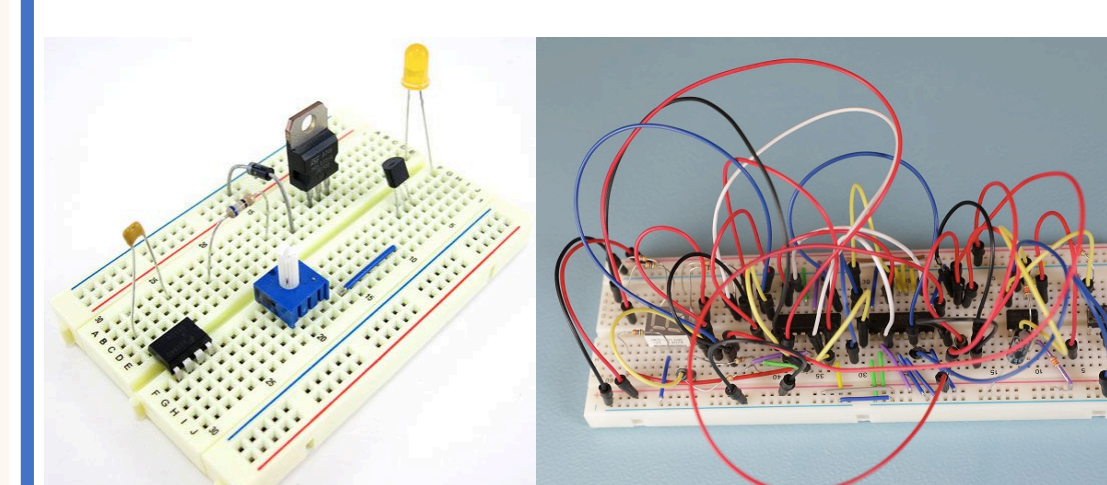


### Schematics

are not copyrighted, because arrangements of parts are more like math. A particular image or printing is, and the image at left belongs to Yves Usson of Yusynth but the same arrangement of parts is free for us to learn and build upon.

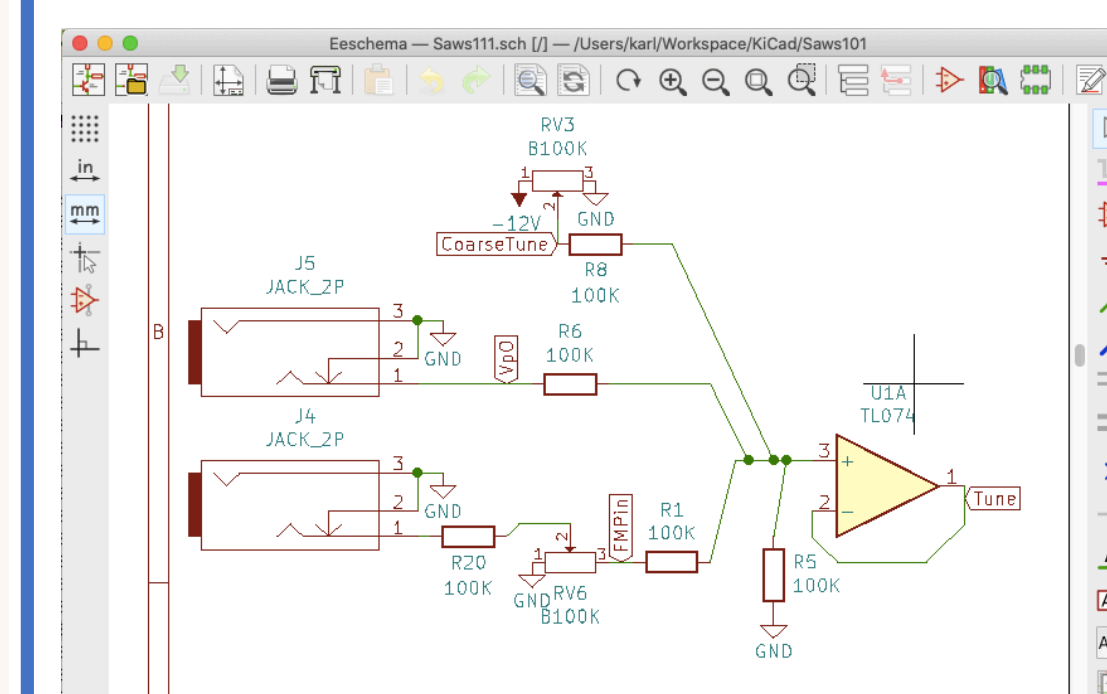
### Breadboards

are arrangements of holes to easily and quickly demonstrate or prototype circuits while learning electronics. They start like the left picture and quickly become the right. After this you'll need to move to something more substantial.



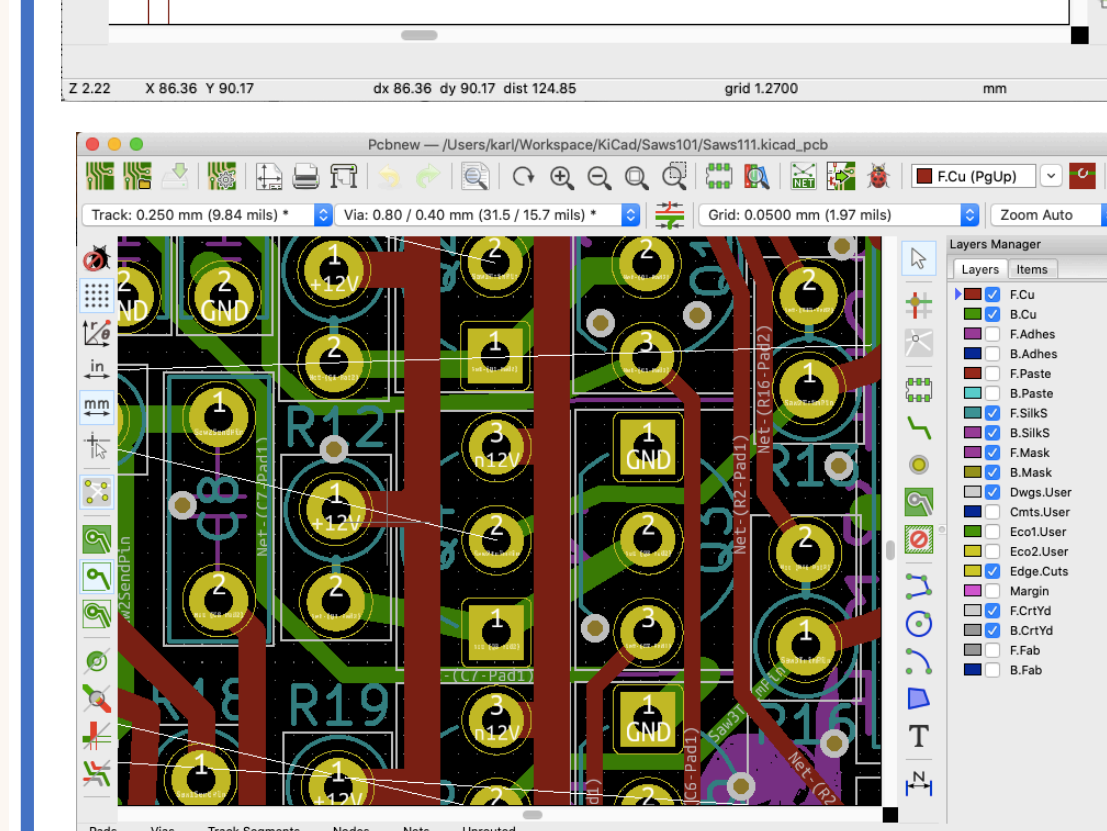
### PCB

is the printed circuit board. All modern circuits are made on printed boards, allowing for electrical paths that are intricately detailed and layered. PCB can be made of metal, paper or fiberglass substrate, coated in copper. Computer aided drafting is required for very small components in high density arrangements.



### KiCad

is a free software for drawing your own schematics and PCBs. CAD software takes a little while to learn, because there are many buttons and tools required. If you're interested, it's painless and rewarding to make your own professional looking circuits come to life.



### Manufacturing

PCBs can be done at home with a mill or etching acid, but is now available from international factories for only a few dollars, plus shipping. American factories like OshPark cost more and have customer service.

### Parts

kits you can buy parts online at various electronics retailers. Passives like resistors, capacitors and connectors cost only pennies, but there may be hours of work to find the right parts at an industrial supplier like Mouser or DigiKey. You could buy a kit including just what you need from synth DIY vendors like Think or ModularAddict. Add a soldering iron and you can put together a module in an evening, or a synthesizer in a week.

