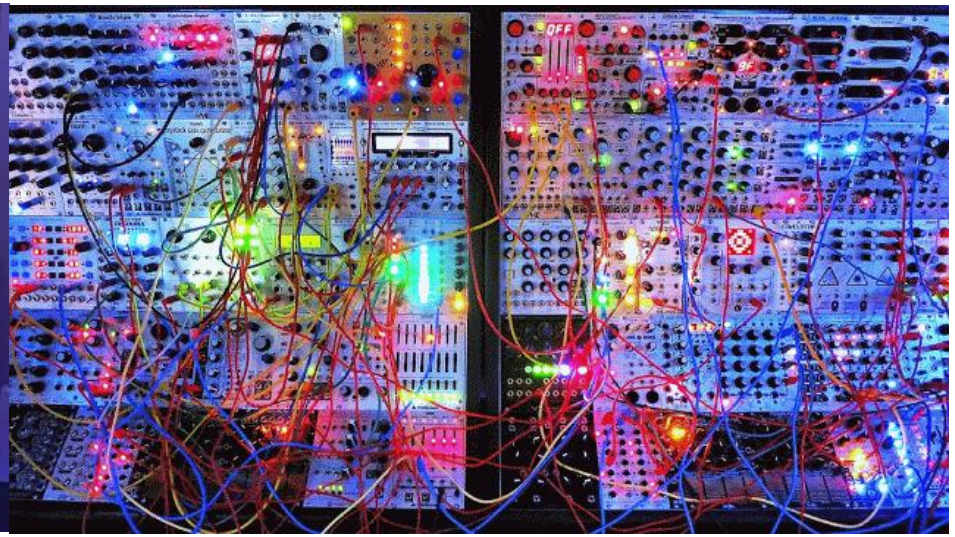
MUSC 4820/5820 Digital Music Techniques 001

Week 4: Digital Interfaces and Prototcols



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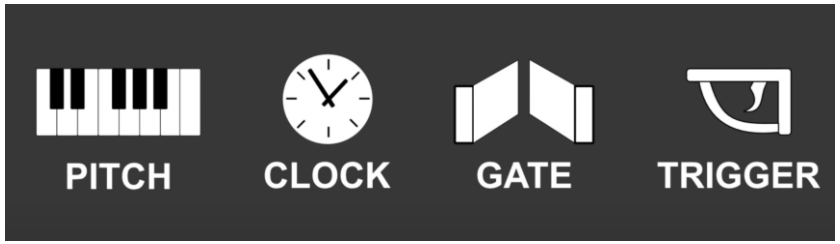
Fundamental Concept: Voltage Control

How do you tell a synthesizer module what you want it to do? How do modules know what others are doing?



Control Voltage – Similarly, sending a particular voltage to the frequency or "cutoff" input on a voltage-controlled filter (VCF) will tell it at what "corner" frequency it should start altering the sounds going through it. For another example, the same voltage tell a voltage-controlled amplifier (VCA) how much to boost or attenuate the sound. Raising the voltage will change which frequencies get through the VCF and makes the sound going through the VCA louder; reducing the voltage to zero tells a VCA to mute the sound.

Generating Voltage – a keyboard, sequencer, knob, gate, trigger, modulators that raise and lower voltages in realtime (input and control)

CV Modifiers – CVAs, Attenuators, Attenuverters, Inverters, Offsets, Adders, Multiples, Minimum/Maximum, Rectifiers, Utility mixers and CVP (Control Voltage Processors), switches, triggers, clock dividers, quantizers, lag generator (smoothing rapid changing in control voltages), comparators (watch the output voltage and change behaviors of the patch after a certain threshold has been crossed), slope detectors

Audio Connections between Analog and Digital World

Typical audio Voltage Ranges:

Format	Voltage References	Wires (Cables)
Eurorack	+-5 V or higher	3.5mm
Pro Level	+-1.78 V (+4 dBu)	Balanced XLR or TRS ¼"
Buchla 200	+-1.75 V (~ pro level)	Tini-Jax
Buchla 100, 200e	+-1.41 V	Tini-Jax
Moog 921	+-0.75 V	¼"
Moog 901	+-0.5 V (~line level)	¼"
Line Level	+-0.45 V (-10 dBV)	Unbalanced phono, 3.5mm or ¼"

- There are two types of line level: +4dBu "Pro" Line Level (balanced) or -10 dBV "Consumer" line level.
- The Pro level (balanced) of the audio signal in a professional studio is +4 dBu or about 1.23 volts (0 dBu=.775 volts).
- When the console output meters read "0" on a VU meter, the level of the signal is +4 dBu (Pro level).
- Inexpensive "semi-pro" gear uses unbalanced Line level, which is -10 dBV or 0.316 volts (0dBV=1 volt).
- This lower "line level" is about 12 dB lower than professional line level.
- Line level's inter-connecting wiring is four times more likely to have unacceptable hum or noise.
- The professional level is higher and therefore less-sensitive to the introduction of noise.
- dBv is the same as dBu, with 0 dBv = 0.775 volts. For 4 dBv = 20 log (E1 / 0.775) => E1 = 1.23 volts.
- dBV has a voltage reference of 0 dBV = 1 volt. For 4 dBV = 20 log (E1 / 1) => E1 = 1.6 volts. Calculation method

- In real world, we need to take these level differences into account to avoid distorted or sounds "compressed" audio output when fed through our external mixer or DAW.
- For the **input level knob (top of the signal flow**) of your mixer, look for its maximum level specification, and if it's over +22 dBu (good headroom), you should be ok. If there's a "Pad", use it o reduced the input level.
- Then, adjust the channel volume (**mixer's slider – bottom of the signal flow**) as needed to avoid unwanted clipping
- If the signal is still too hot, use an attenuator module before sending signals to your mixer.
- Also watch out for your effect send levels on the mixer as they likely need to be set lower than usual.

Musical Instrument Digital Interface (MIDI)

- MIDI is a communication protocol for remote/synchronized control mechanism and for storing information
- It's a standard established in 1983
- It's extensible, many uses beside MIDI notes
- Max 1.5 kHz bandwidth
- Uni-directional serial interface and asynchronous communication
- These often used one port for timing and another for note triggering a
- Max cable length 15 m, USB and wireless MIDI connections also work
- Long cables and slow wifi connection cause unwanted signal distortion
- MIDI/computer Interface: External MIDI/USB devices such as are widely used for multi-port interfaces, which are able to handle a number of MIDI streams (each controlling up to 16 channels) and distribute separately. They also allow the synchronized handling of several devices (video recorder, automated mixer, effects, samplers, etc)
- Message scheme based on keyboard's model

Serial:

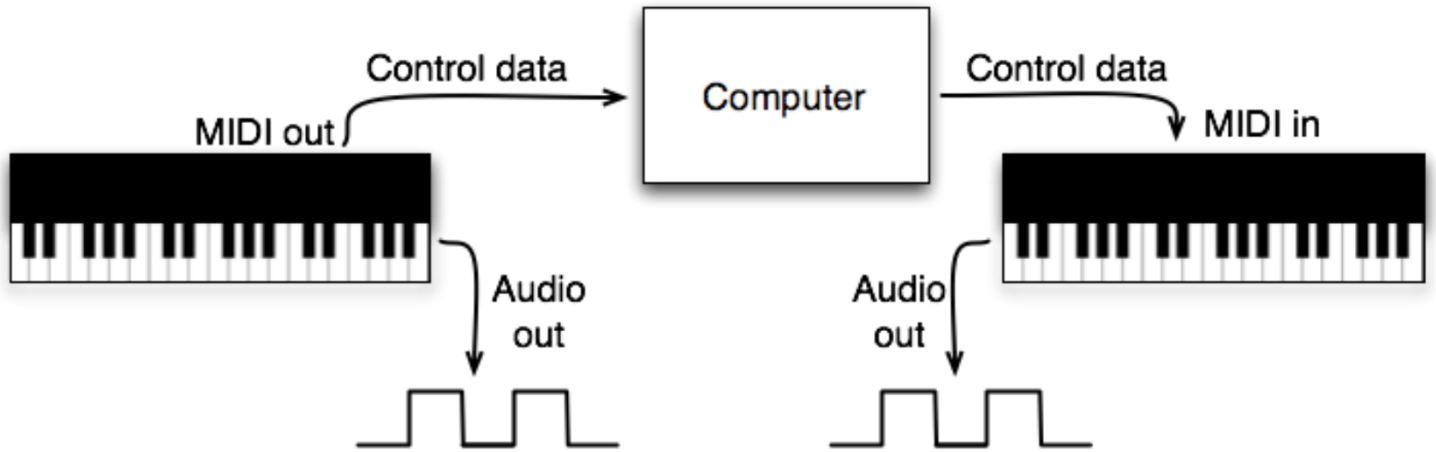
Transmitter → Receiver
101001 → 11

Parallel:

Transmitter	→	Receiver
1	→	1
1	→	1
1	→	1
0	→	0
0	→	0
1	→	1
0	→	0
1	→	1

Musical Instrument Digital Interface (MIDI)

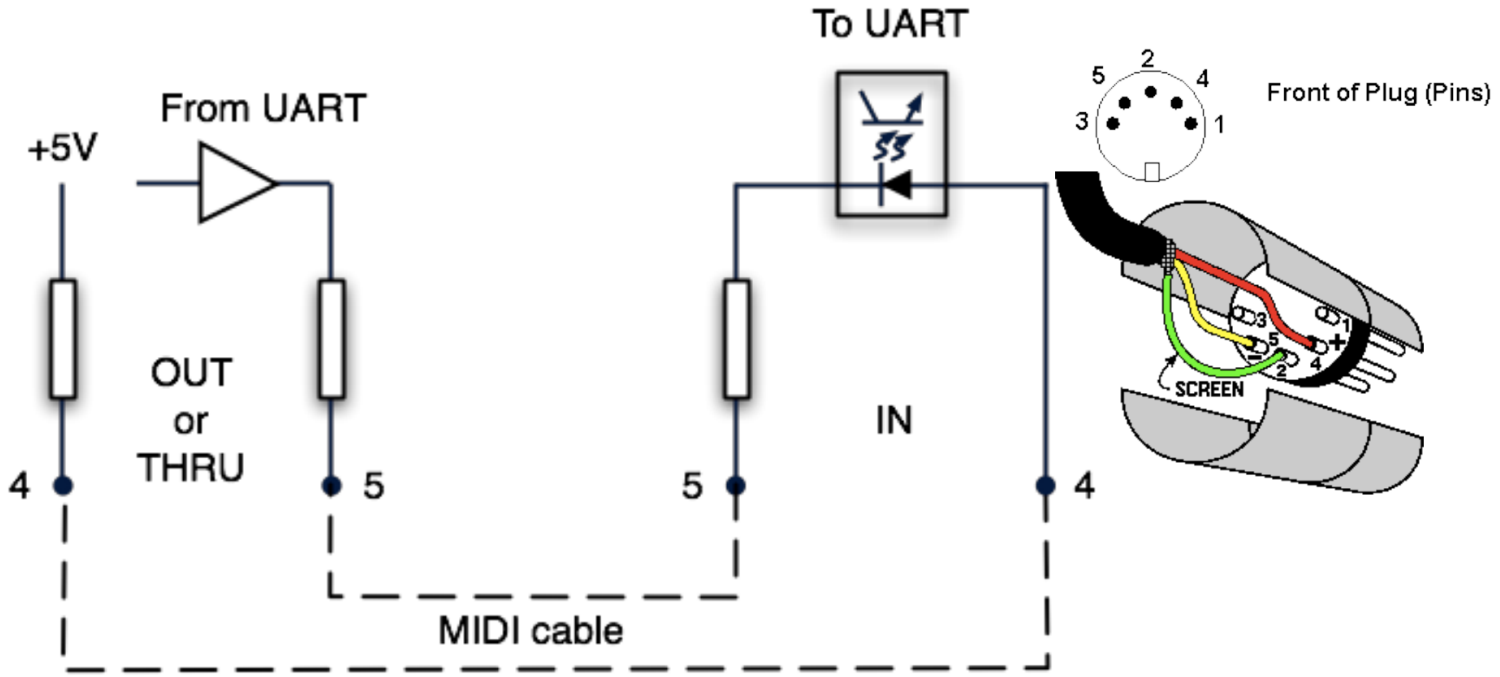
- In MIDI, processing and storage also occurs in the digital domain, but the information being processed is not the audio signal but the control data used to generate it.
- An electronic instrument is needed to reproduce the sound, which means that unless we use the exact same synthesis engine, MIDI-generated sounds are never the same.



- Because it comprises control data only, MIDI uses significantly less memory space than digital audio

Musical Instrument Digital Interface (MIDI)

- There are 3 kinds of MIDI ports: IN, THRU, and OUT. The IN port accepts input to a device, the THRU port passes an amplified copy of the input signal along, and the OUT port is used to transmit the device's output.
- The hardware uses cables terminated in 180-degree 5-pin DIN connectors, of which only three pins are used (5, 4 and 2). (Pin 2 is connected to earth in OUT and THRU only)

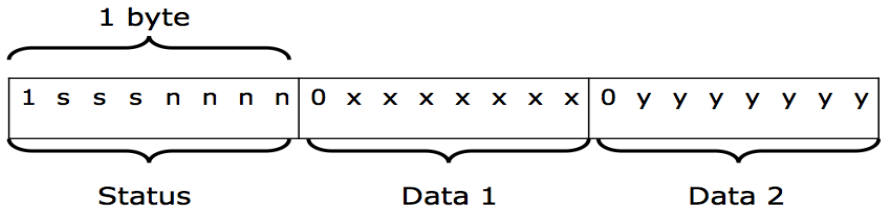


*** UART** stands for "Universal Asynchronous Receiver/Transmitter". It is a piece of digital hardware that transports bytes between digital devices, commonly found as a peripheral on computer and microcontroller systems. It is the device that underlies a serial port, and it is also used by **MIDI**.

Musical Instrument Digital Interface (MIDI)
MIDI Transmission Standard

- A maximum transmission rate of 31250 bits per second/3125 bytes per second (One start bit, eight data bits, and one stop bit result in a maximum transmission rate of 3125 bytes per second), no more than 651 (usually 500-651) notes can be transmitted /second.
- 16 channels limits due to bandwidth
- If first bit =1, the following byte is a “status” byte

  If first bit = 0, the following byte is a “data” byte



- The status byte determines the length of most messages, which are usually 1,2,or 3 bytes in length
- System exclusive messages are of variable length and have a start and ending status byte.
- MIDI uses hexadecimal system: Hexadecimal numbers are a base-16 representation of numbers and are useful for humans when dealing with binary numbers.

  Every 4 binary digits are represented by 1 hexadecimal digit

number base equivalences

dec	hex	bin	dec	hex	bin
0	0	0	8	8	1000
1	1	1	9	9	1001
2	2	10	10	A	1010
3	3	11	11	B	1011
4	4	100	12	C	1100
5	5	101	13	D	1101
6	6	110	14	E	1110
7	7	111	15	F	1111

MIDI Transmission Standard

T23 – MIDI-Code

Status Bytes	Data Bytes	Command type
1000nnnnb (=8mh)	pitch number [0–127], force of attack* [0–127]	Note Off
1001nnnnb (=9mh)	pitch number [0–127], force of attack* [0=off, else 1–127]	Note On
1010nnnnb (=Amh)	pitch number [0–127], force of attack* [0–127]	After-touch
1011nnnnb (=Bmh)	control nummer [0–121: e.g. 7=Volume,....], control value [0–127]	Control Change
1100nnnnb (=Cmh)	program number [0–127] (only 1 data byte!)	Program Change
1101nnnnb (=Dmh)	pressure value [0–127] (only 1 data byte!)	Channel Pressure
1110nnnnb (=Emh)	lower byte [0–127], upper byte [0–127]	Pitch Wheel
11110nnnb (=Fmh)	brand dependent	System Exclusive

* 'velocity' for technocrats

MIDI commands

0x**8**0	Note Off
0x**9**0	Note On
0x**A**0	Aftertouch
0x**B**0	Continuous controller
0x**C**0	Patch change
0x**D**0	Channel Pressure
0x**E**0	Pitch bend
0x**F**0	(non-musical commands)

MIDI 1.0 and MIDI 2.0

Feature	MIDI (1.0)	MIDI 2.0
Resolution	7-bit (128 levels)	Up to 32-bit (massive precision)
Communication	One-way	Bidirectional
Per-Note Control	Global	Independent per note
Profiles and Configurations	No	Supported
Extended Messages	Fixed set	Customizable
Channel Count	16 channels	Still 16 (scalable for future)
Timing	Standard (lower precision)	Enhanced timing accuracy
Backward Compatibility	N/A	Fully backward-compatible

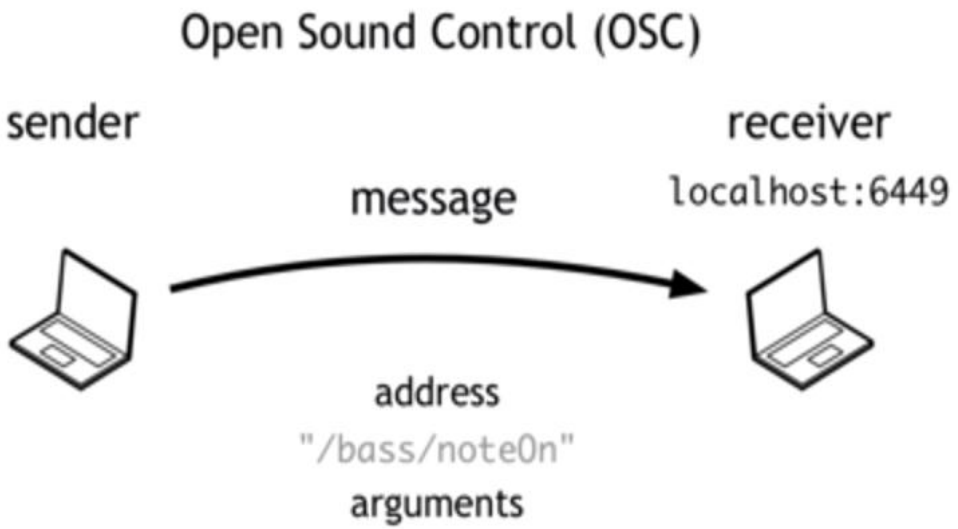
Open Sound Control (OSC)

- Communication protocol
- Flexible (wireless)
- Big community not only in music but also in visual arts
- Same network! IP
- Different address

Different OSC objects,

Different control

- Synchronous events!!



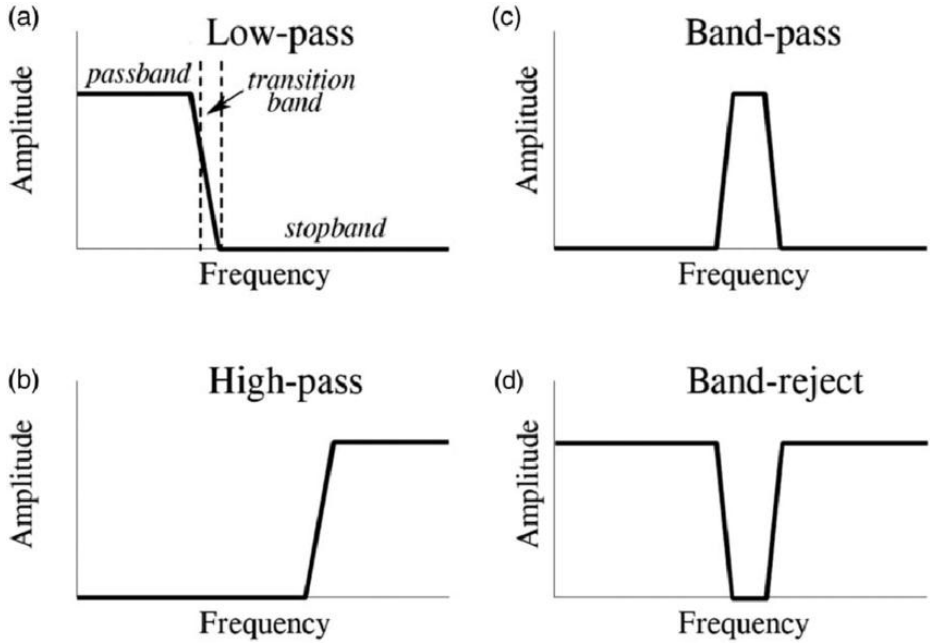
The Building Blocks of Modular Synth

Modulation Sources: Sculpturing sound

- **Filters**: These modlues weakens or removes some of the sonic harmonics. In modular synth, they are called Voltage Controlled filter, aka. “VCF”.

Note:

1. Different filters may use different circuit designs which resulting in different tonal shifts every though they have the same specifications.
2. Many filters create internal feedback loop, often referred to as ”resonance” of “Q.” This feedback reinforces or strengthened harmonics around the cutoff frequency. This is also known as “self-oscillation.”

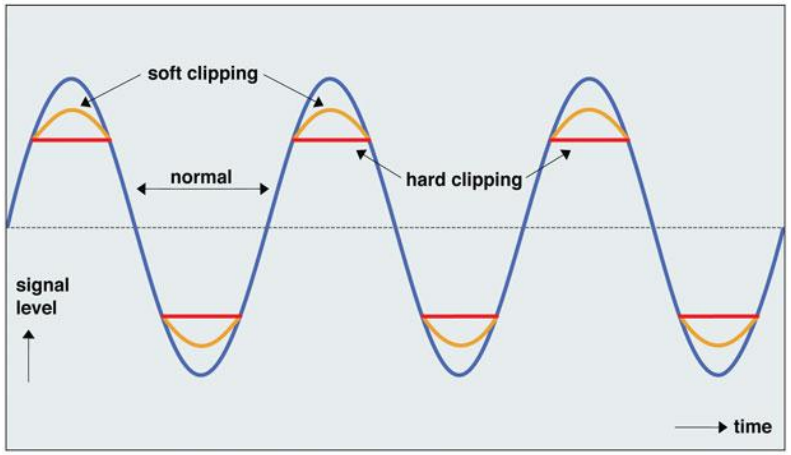


The Building Blocks of Modular Synth

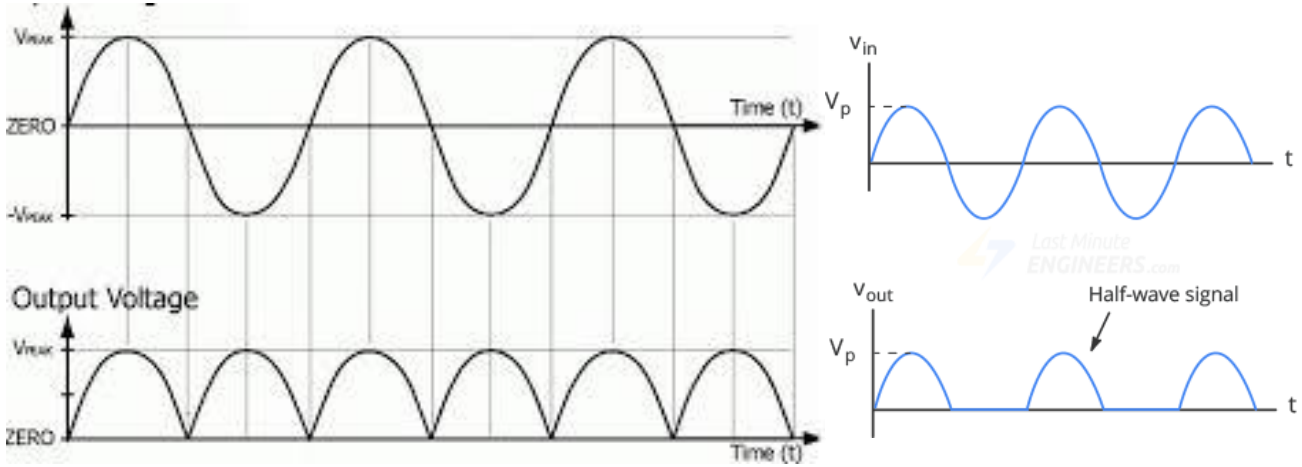
Modulation Sources: Sculpturing sound

- **Wave shapers**: Directly change the waveforms and then you can fine-tune the sound to make it musical.

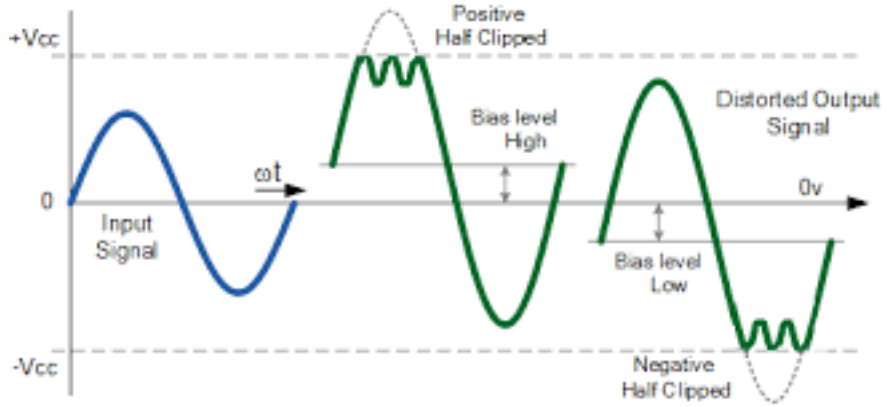
1. **Clipping, distortions, or saturation circuits.**



2. **Full-wave and half-wave rectifiers**



3. **Wavefolders**



4. **Waveshapers**