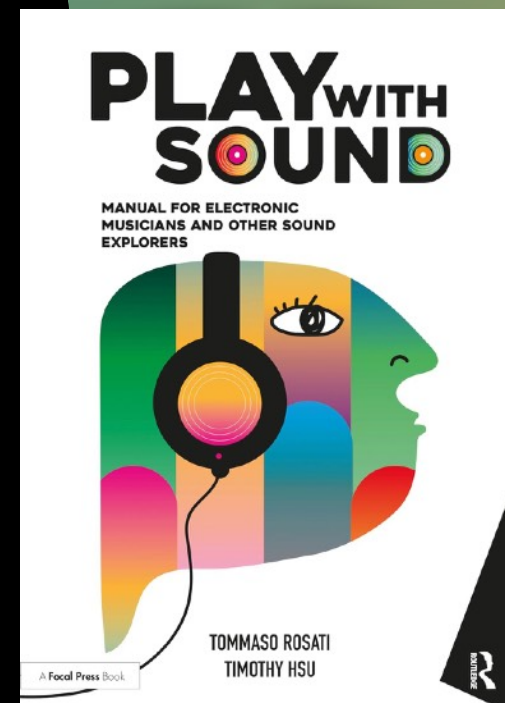


# DISTORTION

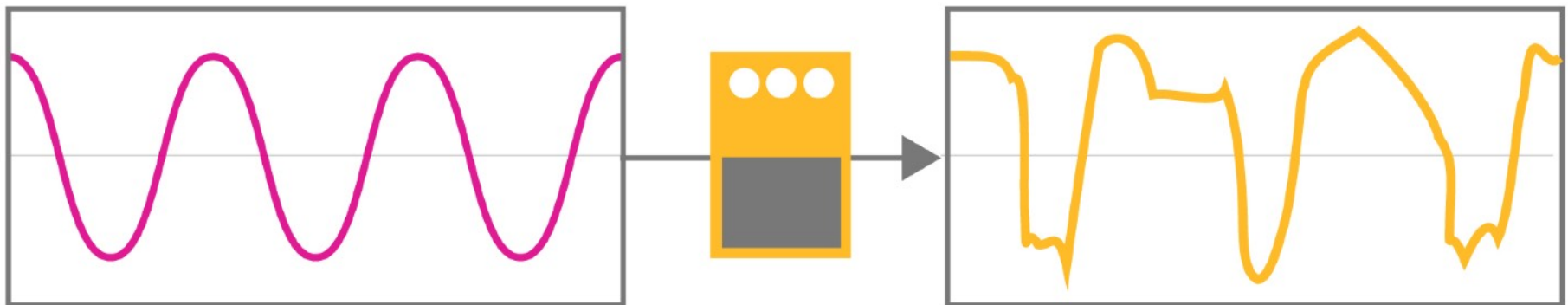
OVERDRIVE  
FUZZ  
BIT CRUSHING AND RESAMPLER  
WAVESHAPING

TOMMASO ROSATI  
SOUND ART

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AVAILABLE!

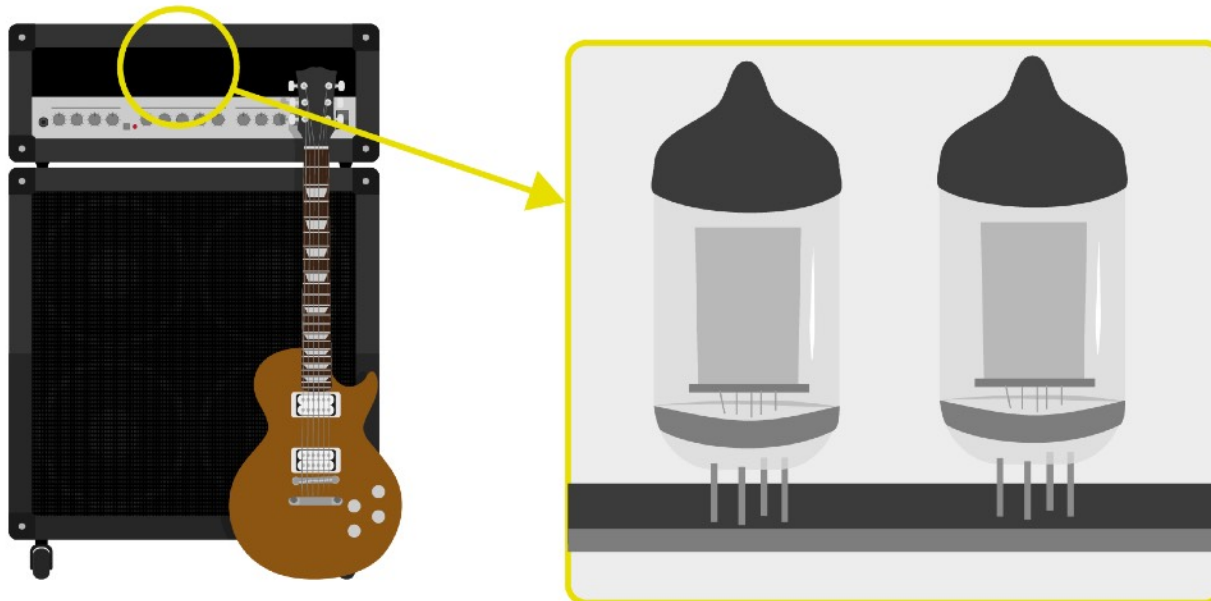


**Distortion** is the result of intentional or unintentional waveform modification. In particular, audio distortion is generated from an alteration in waveform that can come from analog circuit effects or special digital audio algorithmic treatments. This ultimately creates a “dirtier” and muddier sound that is more harmonically complex and scratchy in tone.

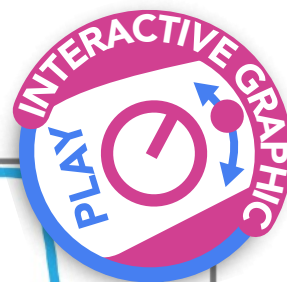
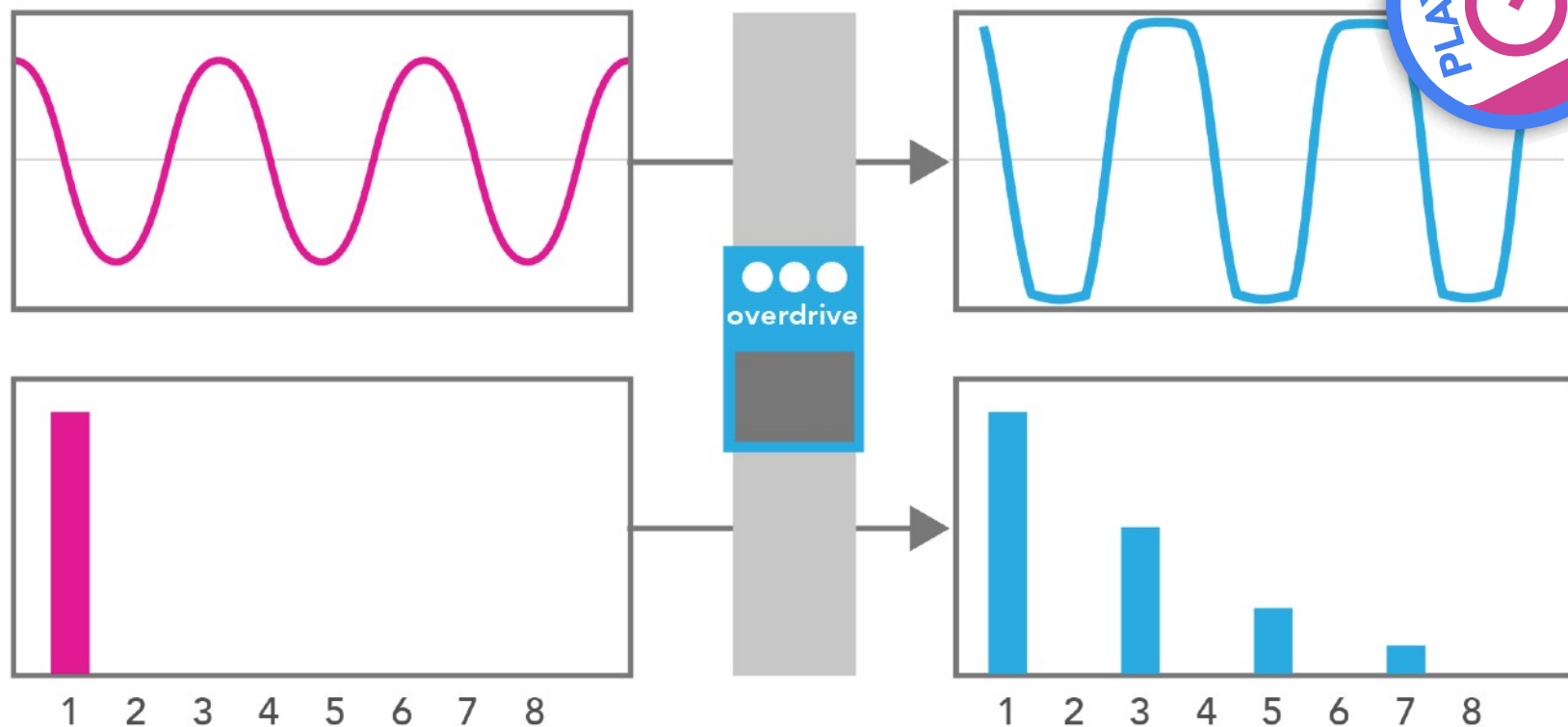


# OVERDRIVE

In tube-based amplification systems, people realized that if they turned up the amplifier a lot, the sound would have a “color” to it, stemming from a type of distortion called **overdrive**. This happens when the tube transistor gets an input beyond the normal limits of operation. The result is a distorted output waveform.



In an overdrive circuit, the sine wave is amplified and experiences **clipping**, causing a flattened waveform at the peaks. The outputted wave, instead of matching the sine wave shape of the input, begins to look closer to the shape of a square wave. This results in a timbre that possesses many new harmonics placed at odd harmonics frequencies.



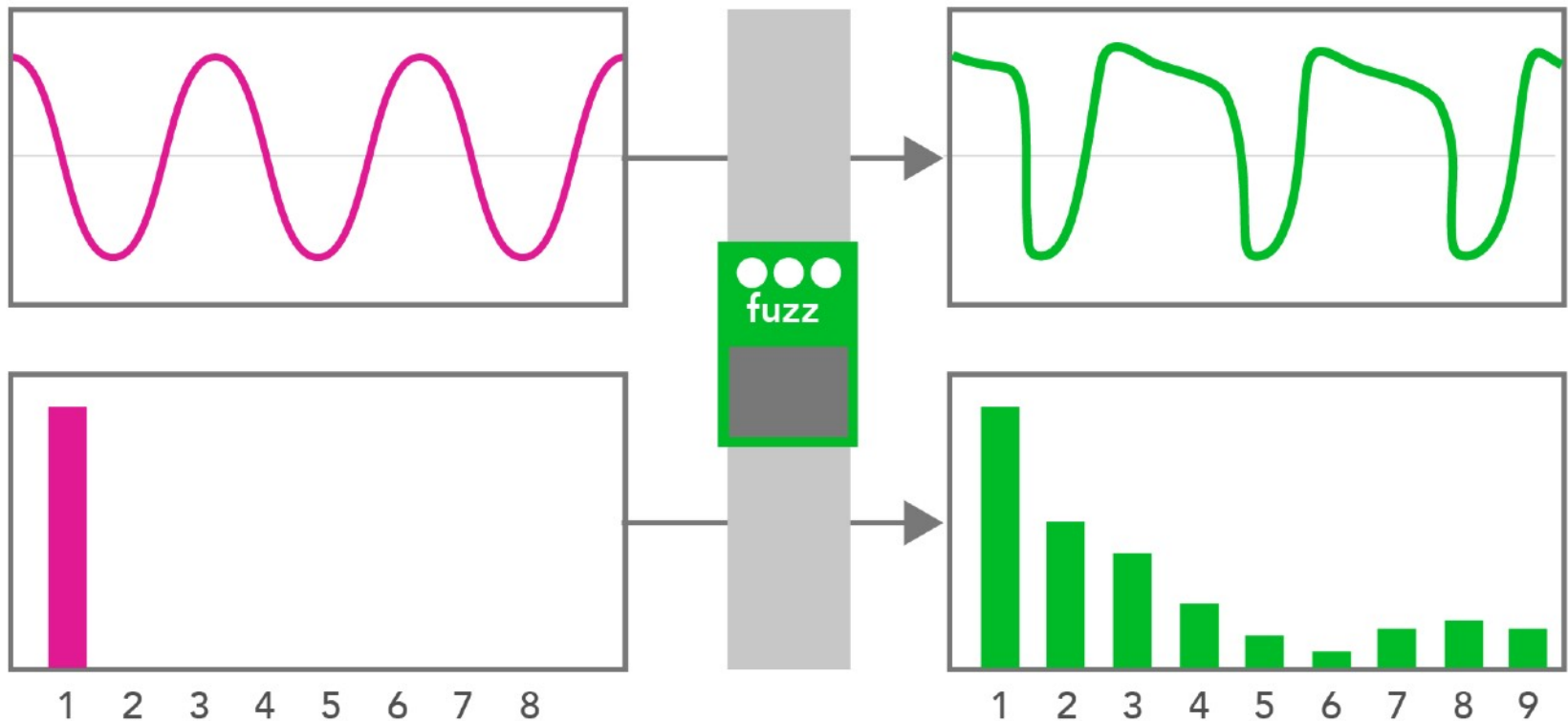
# FUZZ

**Fuzz** originated from a chance mistake in 1960 in a Nashville recording studio where *Marty Robbins* was recording the song “*Don’t Worry.*” At one point in the recording session, the transformer on the guitar amplifier broke, and the amplifier began to produce a distorted sound. Despite the artist and the sound engineer immediately noticing the sonic surprise, everyone enjoyed it so much that they decided to leave it in. The track was released with this effect, and it was a great success.

The engineer *Glenn Snoddy* wanted to recreate this distorted sound; he reverse engineered it with the world’s first fuzz pedal circuit. This was the birth of the **Maestro Fuzz Tone** in 1962.



When compared to overdrive, the fuzz distortion exhibits peaks that are not only a bit squashed in amplitude, but also **asymmetrical**, with seemingly skewed triangles on top of a square wave. When analyzing the spectrum of this waveform, we will find the addition of even harmonics, even beyond the ninth harmonic. This is the primary reason why we hear fuzz sounds to be a bit invasive, scratchy, and sour.



# BIT CRUSHING and RESAMPLER

There are distortions that are possible through **digital signal** or digital sound processing.

It is helpful to visit the process of analog to digital conversion. As we go from analog to digital, we start from a continuous signal (without individual steps or samples) and convert the signal to a digital one (with steps at discrete time intervals). When we digitize an analog sound, the ADC (analog-digital converter) creates an approximation of the input wave through sampling (via sample rate) and quantization (with bit depth). The resultant signal is encoded then as 1s and 0s.

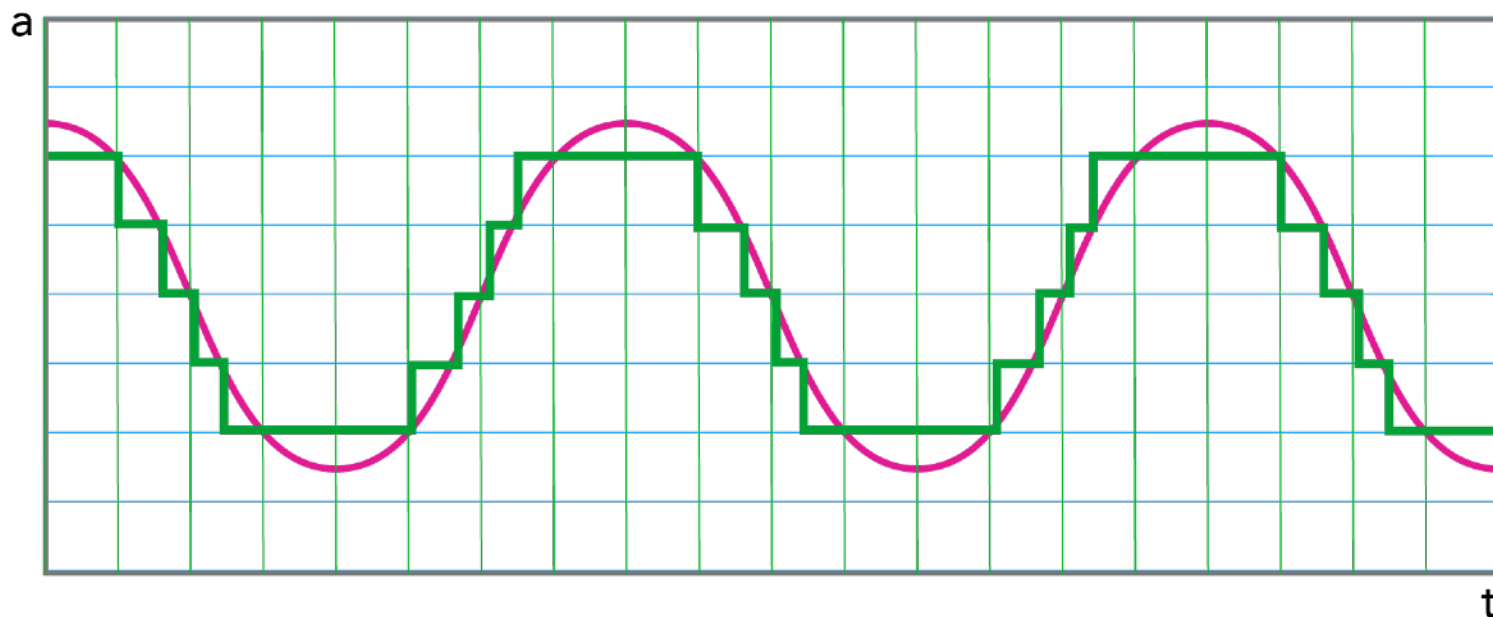


# SAMPLE RATE and BIT DEPTH

The first major step is ADC, where we convert a signal from analog to digital by taking the continuous original signal (without any gaps) and turn it into a discrete one (with specific time steps). The rate at which these time steps occur is the **sample rate**. By only having a certain number of samples per second, we are, in effect, approximating the original analog signal. As for the amplitude, we convert, or quantize, the continuous amplitudes of the discretized signal into specific amplitude bins. The **bit depth** determines how many possible values of amplitude are possible.

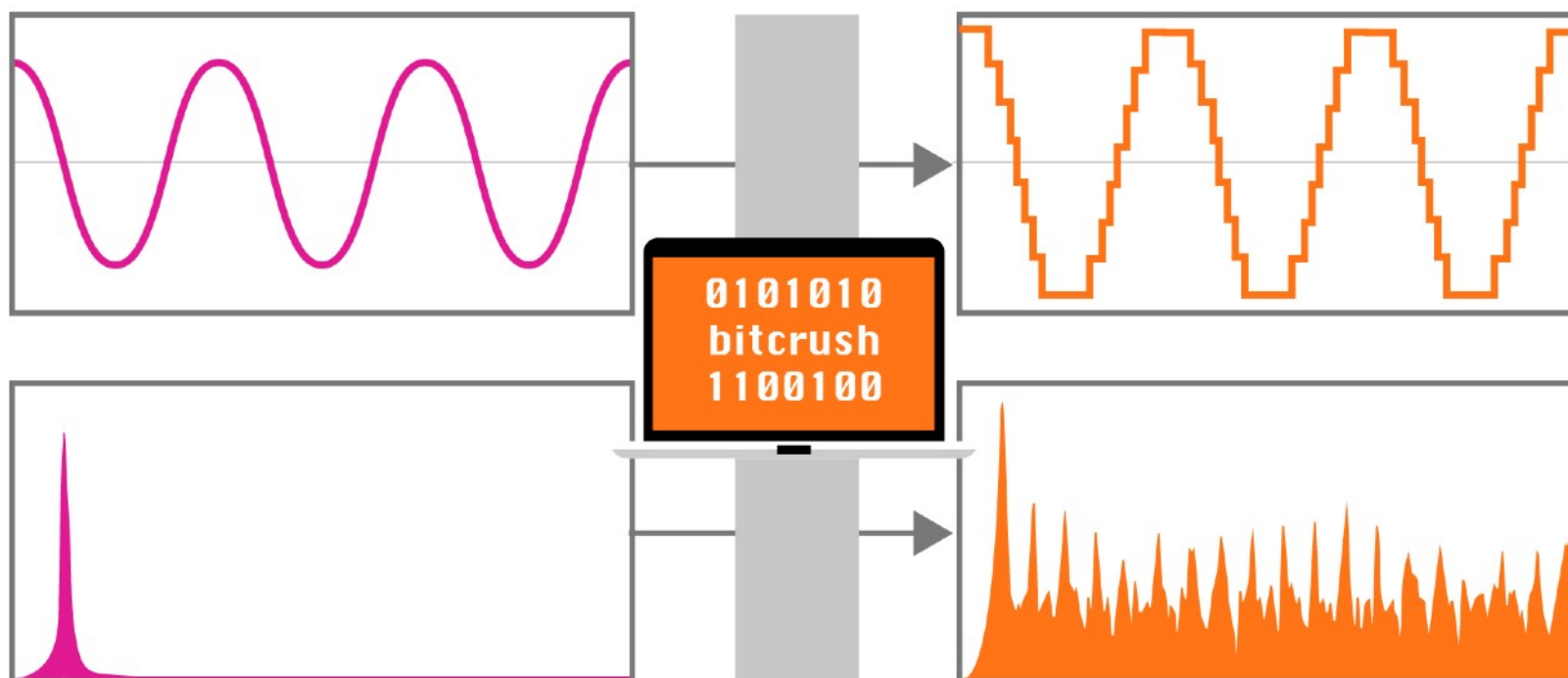
The sampling rate is generally at least 44,100 samples per second and the bit depth is at least 16 bits.

3 bit =  $2^3 = 8$  possible amplitude values



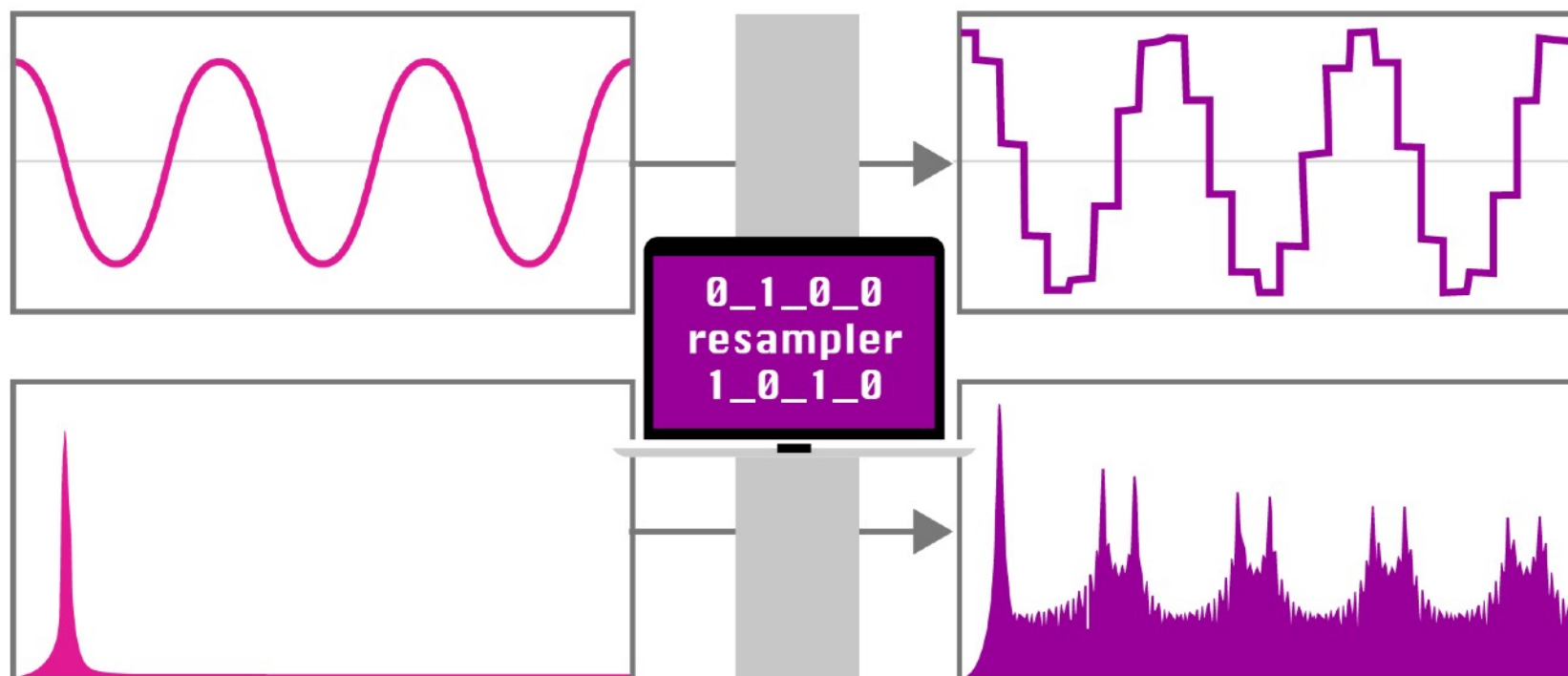
# BIT CRUSHING

**Bit crushing** decreases the bit depth of the original sound, thereby reducing the number of amplitude steps that are possible to describe the wave. This leads to sound waves that are more angular and, therefore, richer in high frequencies, creating a sharp, acidic sound. At its limit, if the bit crusher is set to only 1 bit, we reduce the original input to only two possible states, a maximum value or a minimum value.



# RESAMPLING

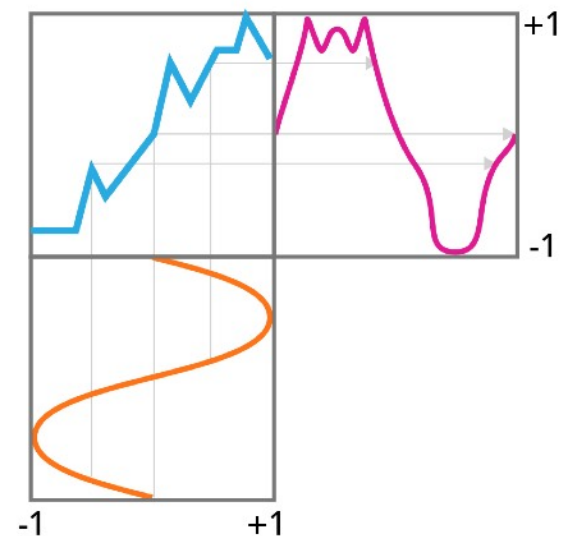
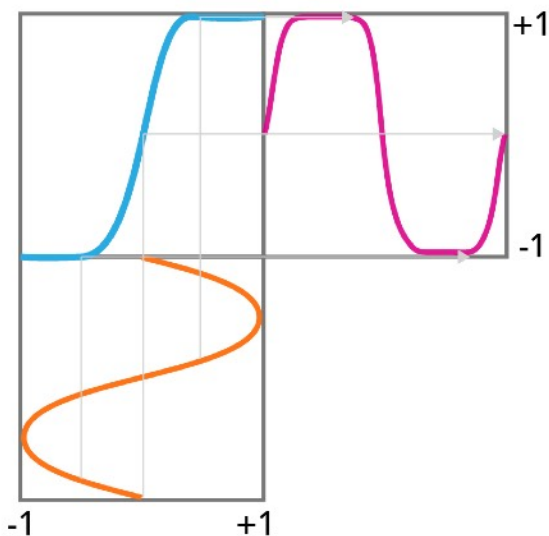
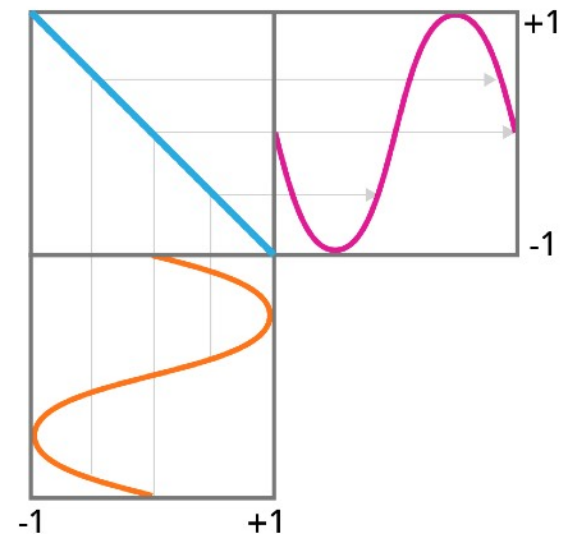
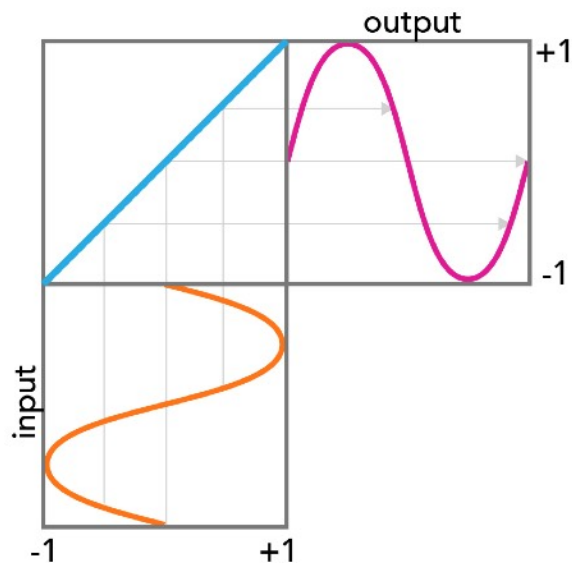
In the case of **Resampling**, we reduce the sample rate and therefore lower the number of samples we take per second. This action distorts and degrades the waveform through **aliasing**. When we look at the frequency domain when sampling, spectral copies of the sound (aliases) are created at integer multiples of the sample rate. When the sampling rate drops below the Nyquist Frequency (half of the sample rate), the aliases begin to overlap in a substantial and audible way, creating a distorted waveform. With resampling, we can creatively choose lower sample rates to create aliasing purposefully.



# WAVESHAPING

**Waveshaping** is primarily considered a sound synthesis technique, we can exploit this technique as as an efficient distortion tool.

This algorithm is based on inputting the audio signal into a transfer function that distorts its shape. While we usually think of wave shaping in terms of wine waves, we can use any sound as an input.



# Resources



**VIDEO:** A Brief History of Electric Guitar Distortion - Polyphonic [LINK](#)



**WEB:** IT Breve storia della chitarra distorta - Noisey by Vice - [LINK](#)



**WEB:** IT Come funzionano gli effetti: la distorsione - SM Strumenti Musicali - [LINK](#)



**BOOK:** Curtis Roads - The Computer Music Tutorial - ed. Mit Press, 1995



**BOOK:** IT Leonello Tarabella – Musica Informatica – ed. Maggioli, 2014

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