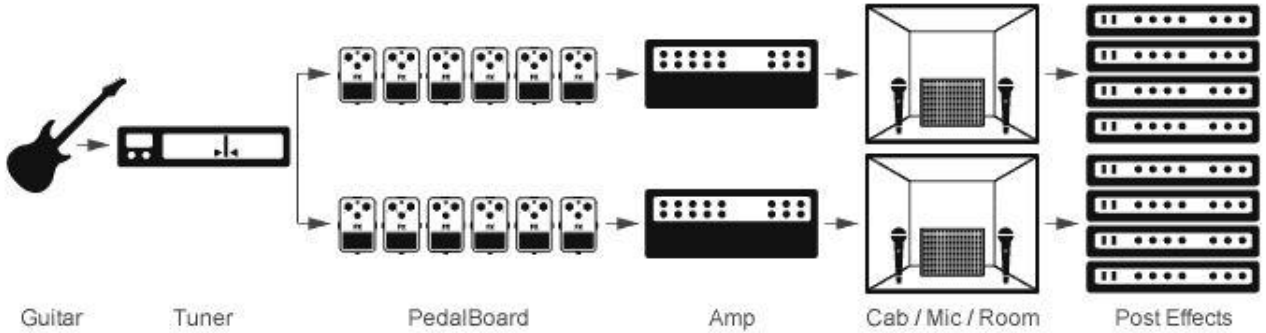
Corbin Dale

Ibanez TS808 Tube Screamer

Intro

- Will explore the theory and circuitry behind the ‘legendary’ Ibanez TS808 Tube Screamer Effect Pedal
- Pedals are used to ‘flavor’ guitar tone, allowing players to achieve unique, personalized guitar tones
- Pedals are part of what is called the pre-amp or ‘color’ stage



Motivation

- Ibanez Tube Screamer is one of the most successful and widely emulated guitar pedals ever created
- Wanted a better understanding of the theory and topology of the circuit used for the pedal

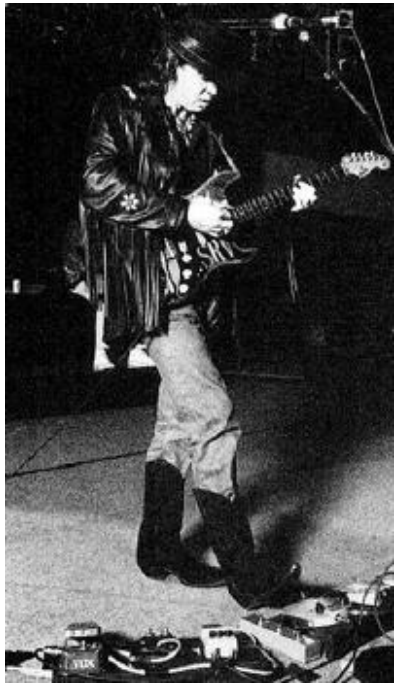
History

- Since the advent of electric guitar and amplified instruments, artists have sought out new and unique tones
- Earliest effects were added by recording engineers in post recording sessions (would manipulate the actual reel-tape to create effects)
- Artists wanted to be able to replicate these sounds during their live performances
- The electronic transistor allowed for effect pedals to be cheap, portable, and sturdy

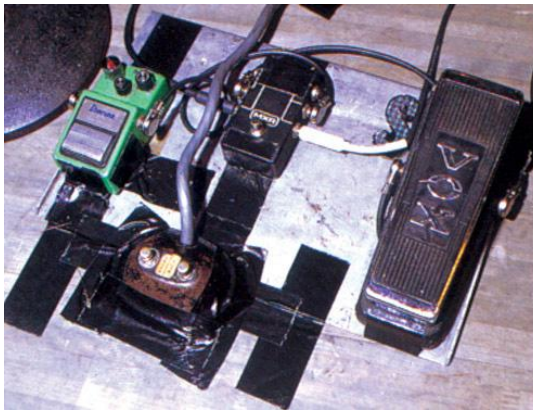
History Cont.

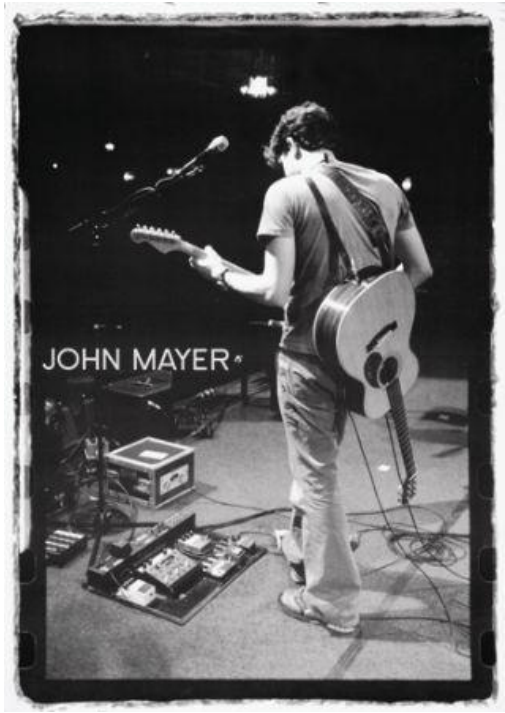
- TubeScreamer (TS 808) designed by Susumu Tamura and produced by Ibanez in the late ‘70s
- Offered an organic sounding distortion, allowing the instrument to sound ‘warmer’ by boosting the mid range frequencies and adding harmonics (overtones)
- Became extremely popular among artists
- Huge demand among collectors for authentic pedals with original parts

Notable Artists



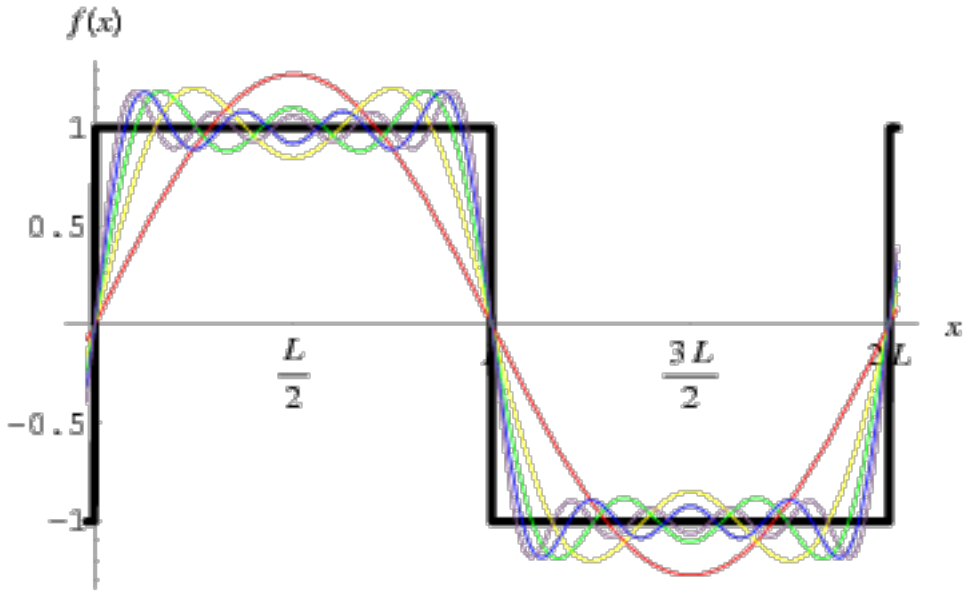
Stevie Ray Vaughan





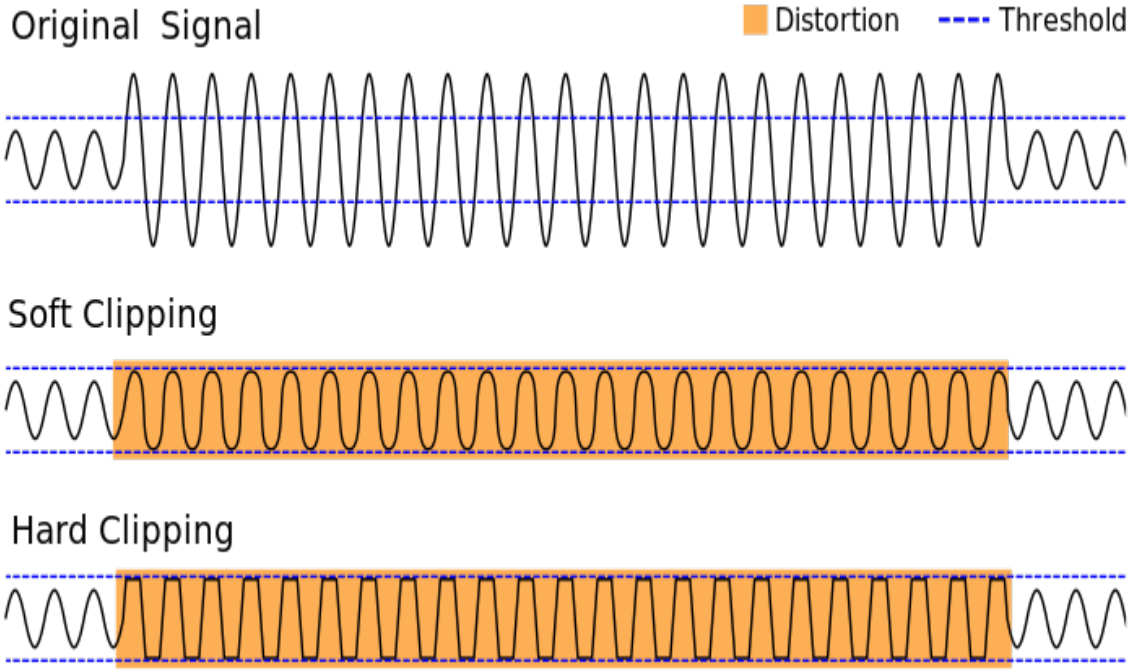
John Mayer

Signal Theory



- Square wave produced by infinite sum of frequencies
- By clipping the input signal, harmonics (overtones) are added to the signal which produces ‘warmer’, richer sound

Signal Theory Cont.



- Different degrees of clipping allow for different tones
- Soft clipping sounds warm and bright
- Hard clipping sounds ‘fuzzy’

Circuit Topology Overview

There are 4 distinct stages within the pedal:

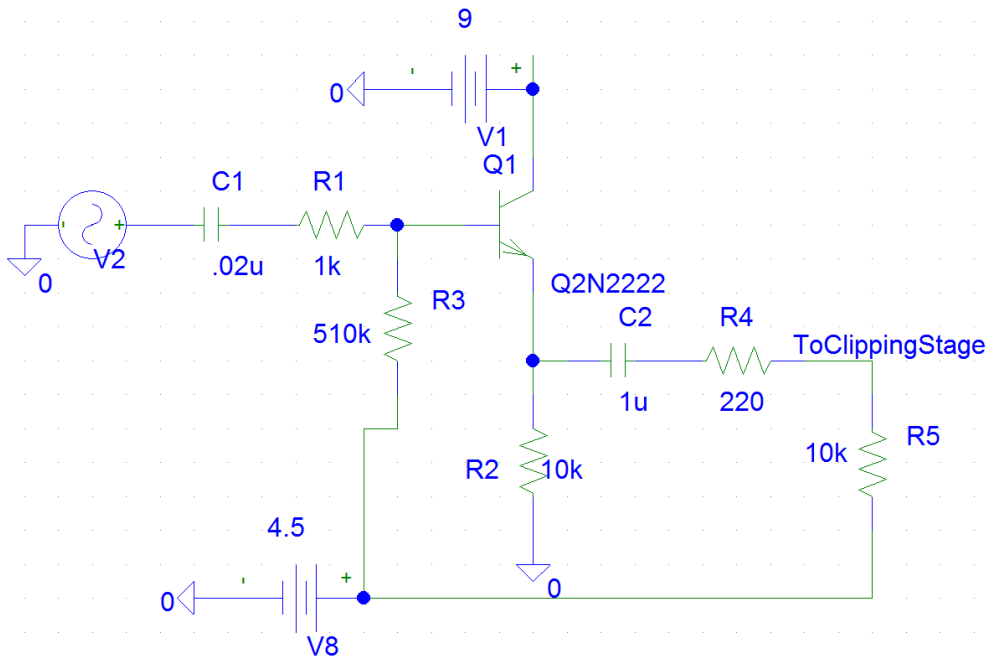
Input Buffer - matches the high output impedance of the guitar pickup

Clipping Stage - creates the distortion or ‘flavoring’ of the sound

Tone and Volume- allows the high and mid range frequencies to be controlled

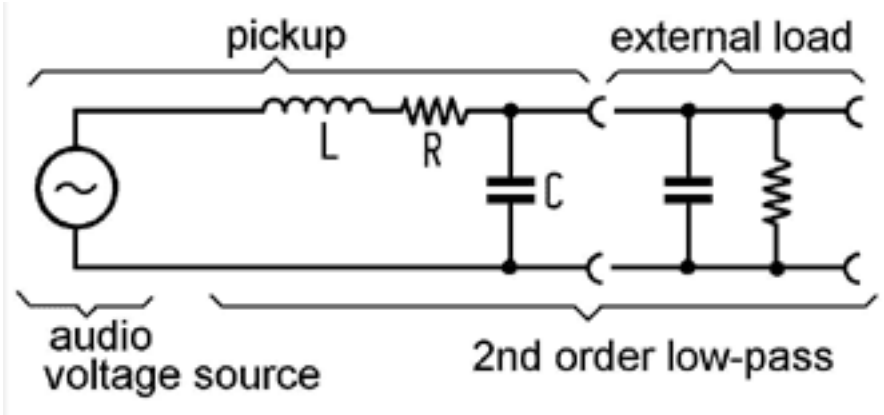
Output Buffer - allows unity gain of previous stages while significantly lowering output impedance

Input Buffer Stage



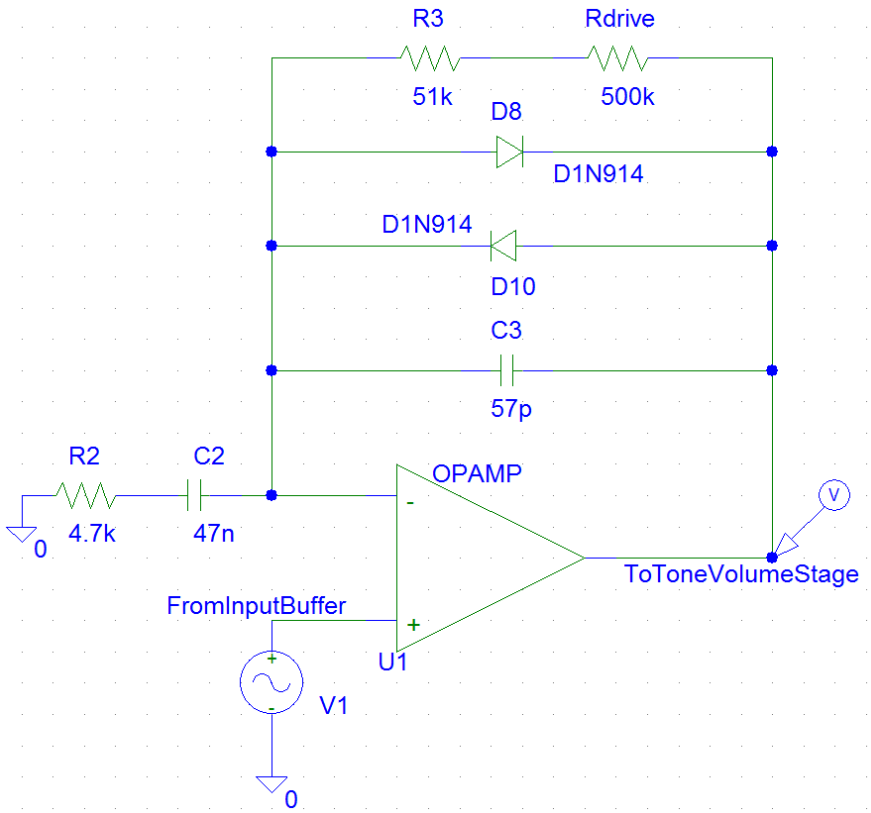
- This stage is a basic emitter follower circuit, allowing for a very high input impedance and a gain of 1
- The output impedance of a guitar has a very large inductance value, which causes the impedance to increase as frequency increases
- If the input stage is not equally large, ‘tone sucking’ can occur in which high frequencies are lost

Input Buffer Stage Cont.



- Equivalent circuit model of guitar pickup
- As frequency increases, the impedance of the guitar pickup itself does as well
- external loading will add to loss of higher frequency components

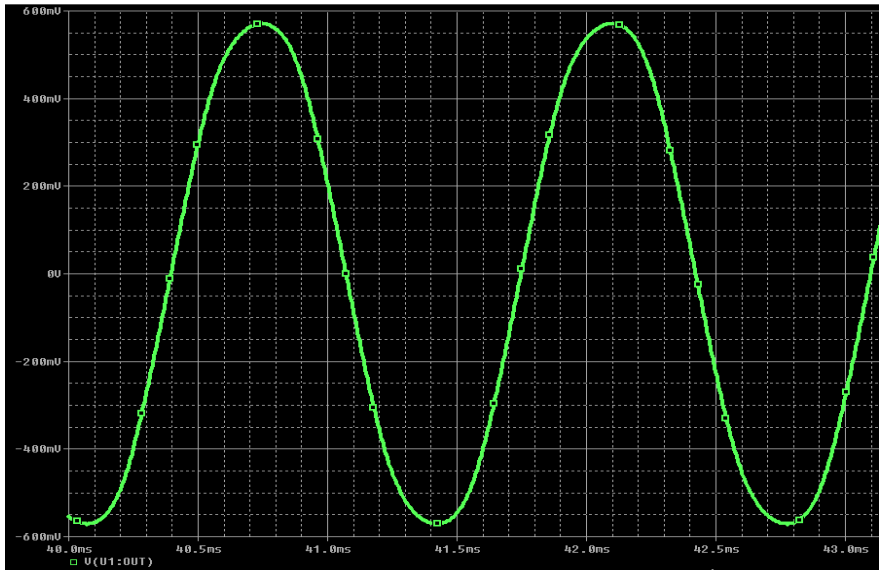
Clipping Stage



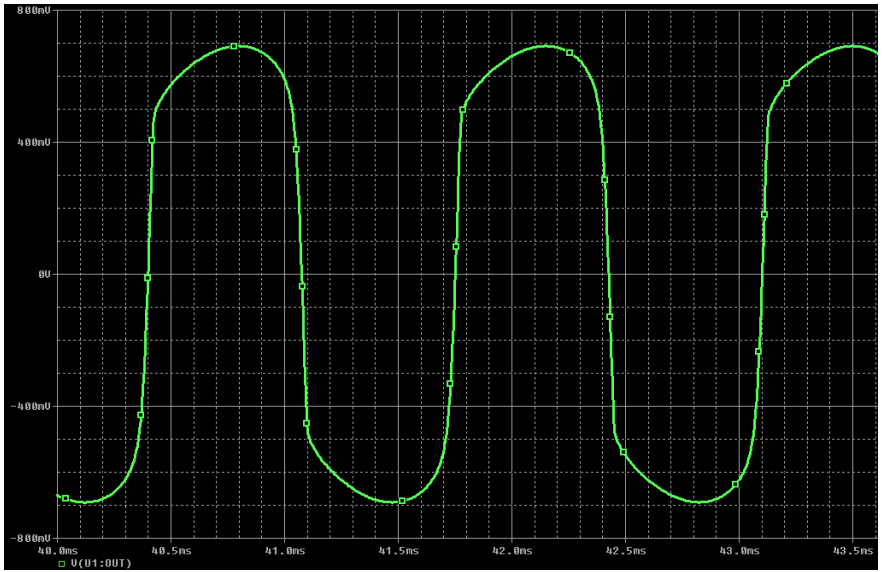
- The topology of this stage is a simple non-inverting amplifier
- when the output voltage is below the ‘turn on’ voltage of the diode clamps, the gain is given by 1+Zf/Zi, where Zf = R3 + Rdrive and Zi = R2 + C2
- when the output voltage is high enough to turn on the diodes, Zf goes to 0 and a constant voltage drop appears between input and output stage, effectively clipping the signal
- As the clipping gets sharper, higher frequencies are injected into the signal. These are ‘bled’ off however by the 57 pF capacitor in parallel with the diodes
- Rdrive is a variable resistor, allowing for differing amounts of gain

Clipping Stage Cont.

- Varying values of Rdrive

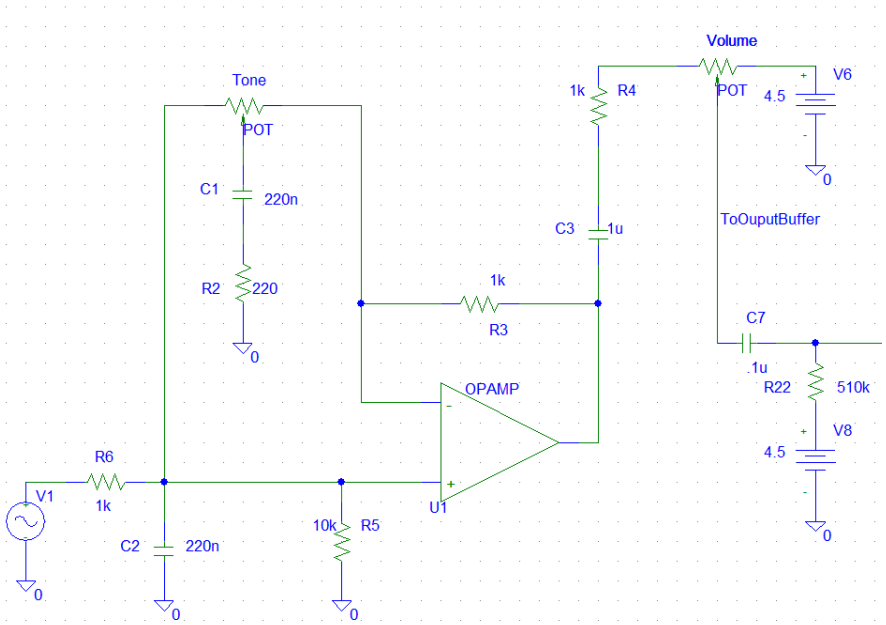


Vin=75mV Freq=740Hz Rdrive=1 Ohm



Vin=75mV Freq=740Hz Rdrive=500k Ohm

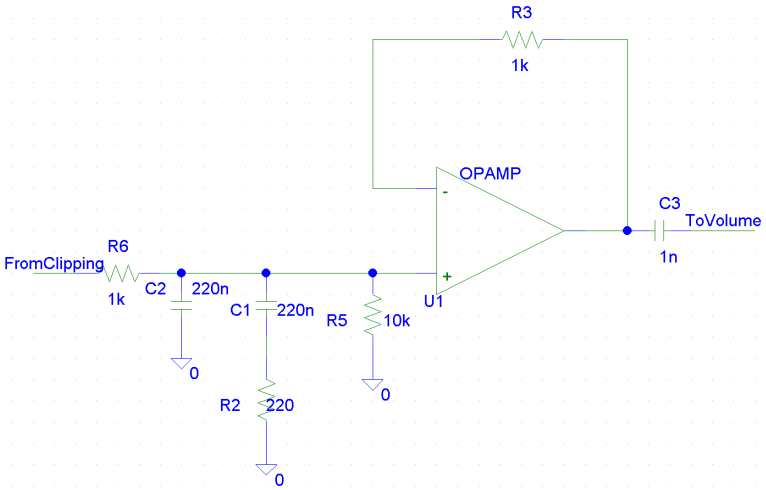
Tone



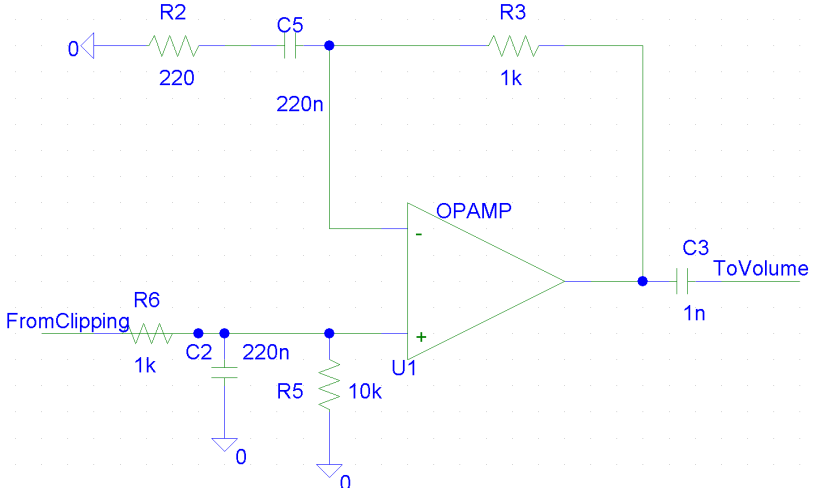
- Immediately following the Clipping stage is a low pass filter with a roll off frequency of about 723 Hz
- With the tone control turned to the positive side, the C1R2 network acts in parallel with the noninverting input circuit. This creates a 2nd order low pass filter
- With tone control turned to the negative side, the C1R2 network acts as a High-pass filter. This results in a Band-pass C2R6 (low)+C1R2(high)

Tone Stage Cont.

Equivalent Circuits at Tone Extremes

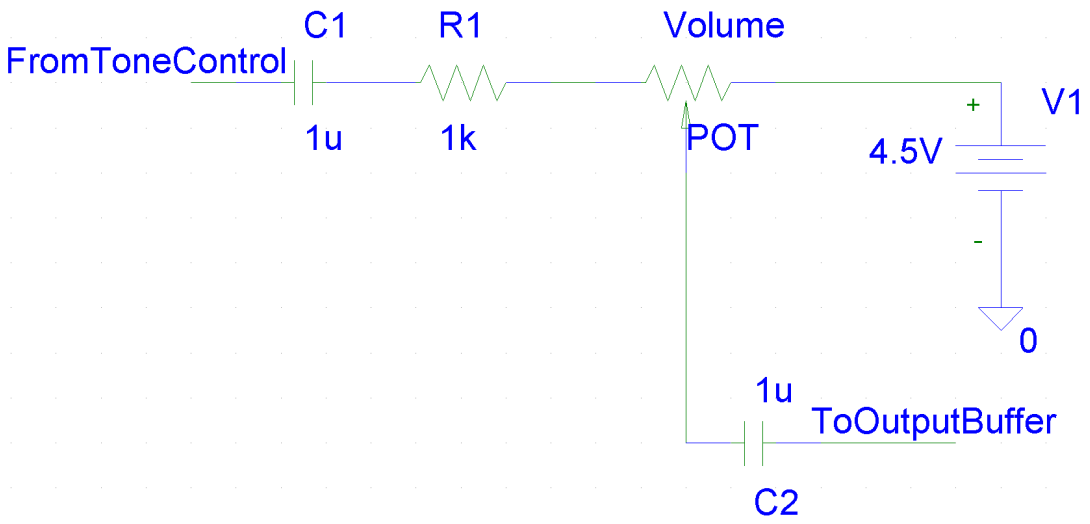


Tone towards Bass Side(Low-Pass)



Tone toward the Treble Side(Band-Pass)

Volume



-Volume is controlled by a 100k Pot with the hot side coming from the tone and cold side to AC ground.

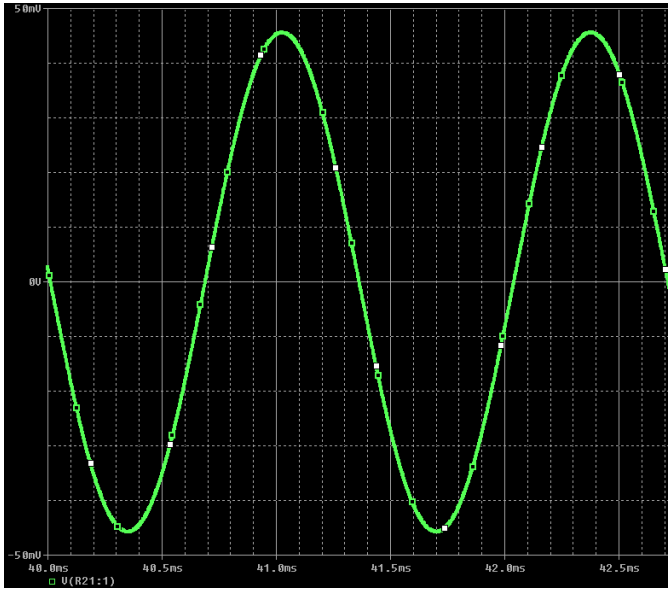
-The wiper controls the amount of voltage that is bled to ground

Volume Stage Cont.

Snack Break Mode

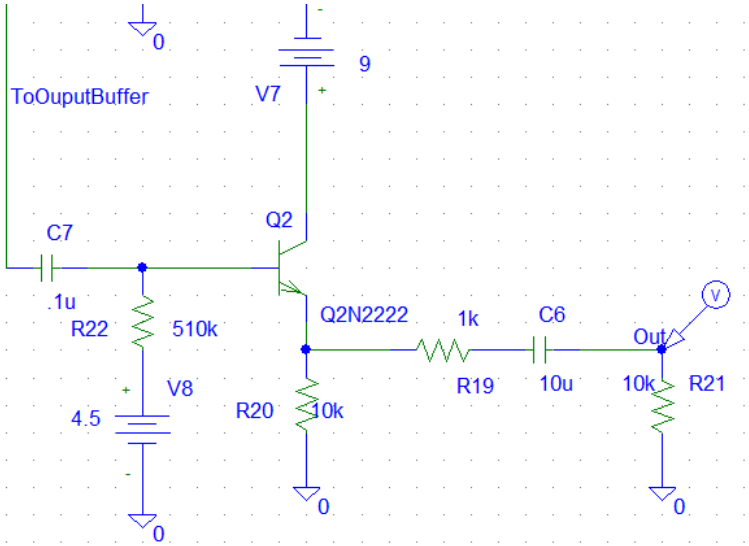
Volume=0% Peak at 480pV

Rock Out Mode!!



Volume=100% Peak @ 45mV

Output Buffer

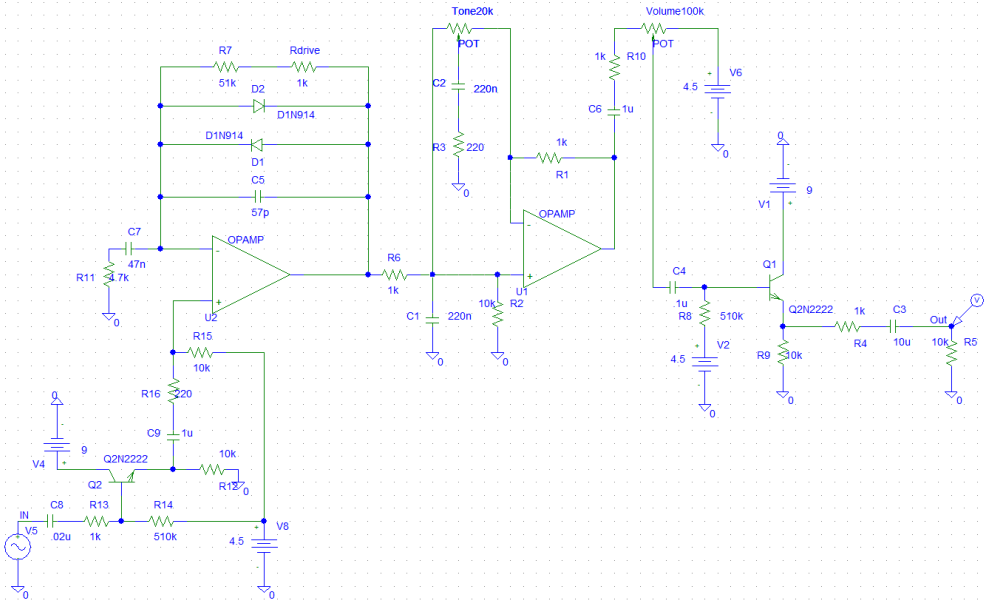


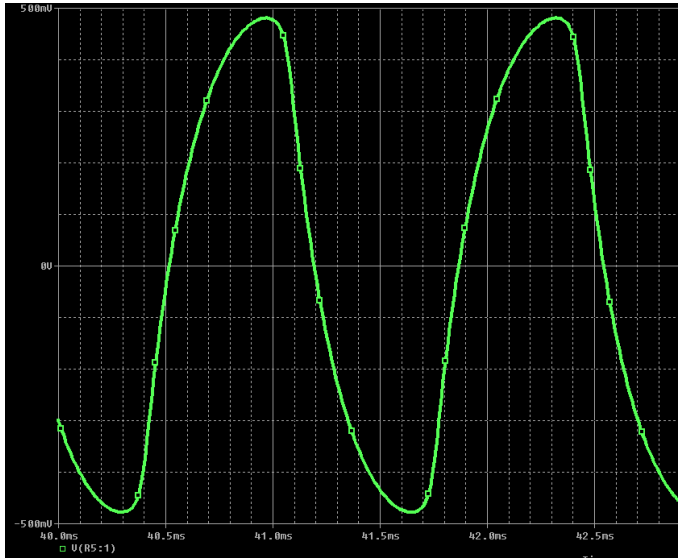
- The output buffer is again an emitter follower circuit, with the intent of unity gain and a low output impedance
- The output impedance can be found by taking the hybrid pi model of the transistor and is equivalent to:

$$Zout = R21 // [R19 + (R20 // (rpi + R22)/(\beta+1))]$$

- In this case Zout = 3k Ω (the typical input impedance of a tube amp is around 3M Ω)

Total Circuit Response





Vin=75mV Drive=100% Tone=50%
Volume=100% Freq=740Hz

Listen to the difference for yourself!

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Dale