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
- 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
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
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 $1 + \frac{Z_f}{Z_i}$, where $Z_f = R_3 + R_{drive}$ and $Z_i = R_2 + C_2$.

- When the output voltage is high enough to turn on the diodes, $Z_f$ 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.

- $R_{drive}$ 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
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:

\[
Z_{\text{out}} = \frac{R_{21}}{R_{19} + \frac{(R_{20}/(r_{pi} + R_{22})/\beta + 1))}}
\]

- In this case, \(Z_{\text{out}} = 3k \, \Omega\) (the typical input impedance of a tube amp is around \(3M \, \Omega\))
Total Circuit Response

Vin=75mV Drive=100% Tone=50%
Volume=100% Freq=740Hz
Listen to the difference for yourself!

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