GROUP 6

INSTRUMENT SYNTHESIZER

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SPRING 2013

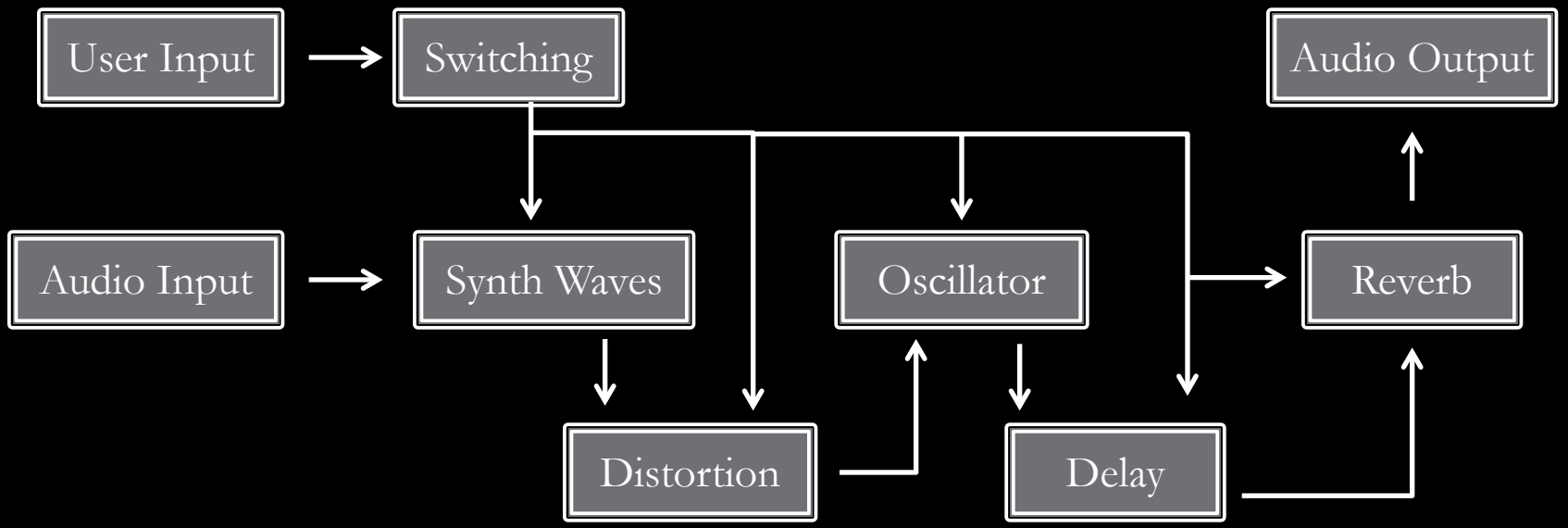
BUSINESS VALUE

Motivation

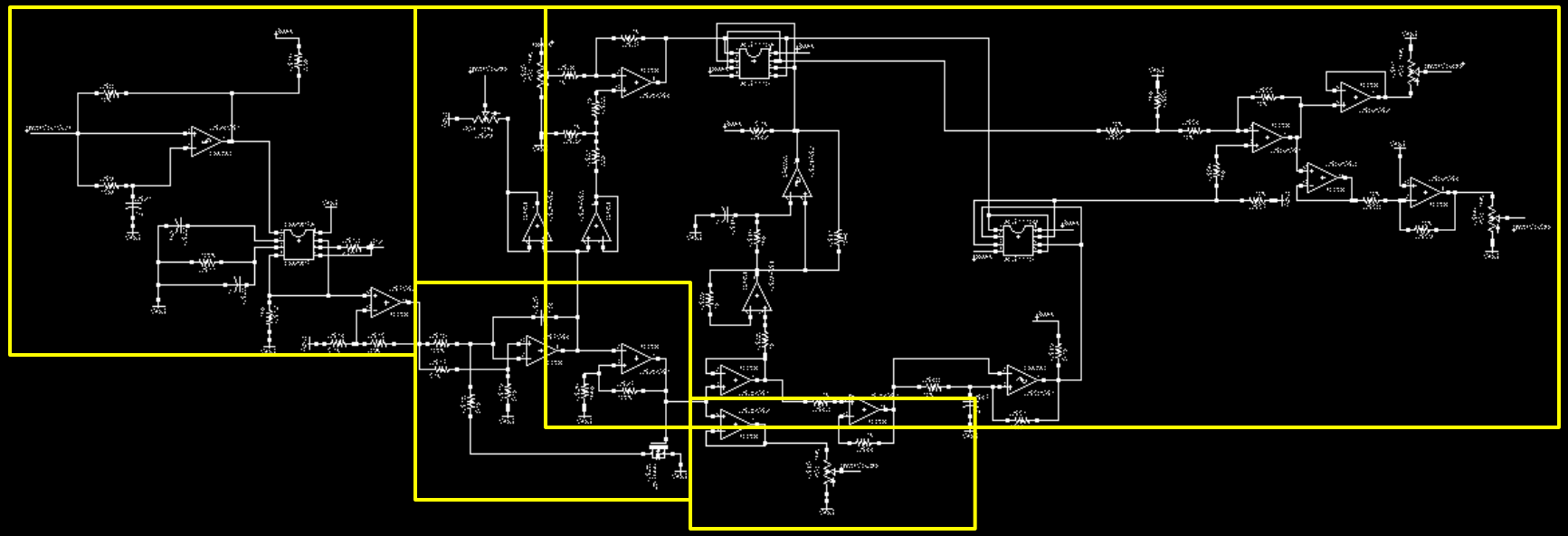
The motivation for this device is to allow the user to combine the versatility of a multi-effects pedal with the quality of typical single effect pedals. In addition to this, we wanted to combine synthetic waveforms with the device to further broaden the potential applications for the device's use. The device needed to be user friendly and compliant with typical effect pedal standards. This will allow it to be used virtually anywhere, recreationally in a bedroom, casually in a live setting, or professionally in a recording studio.

Target Audience

BLOCK DIAGRAM



SYNTHESIZED WAVEFORMS



AC to DC conversion

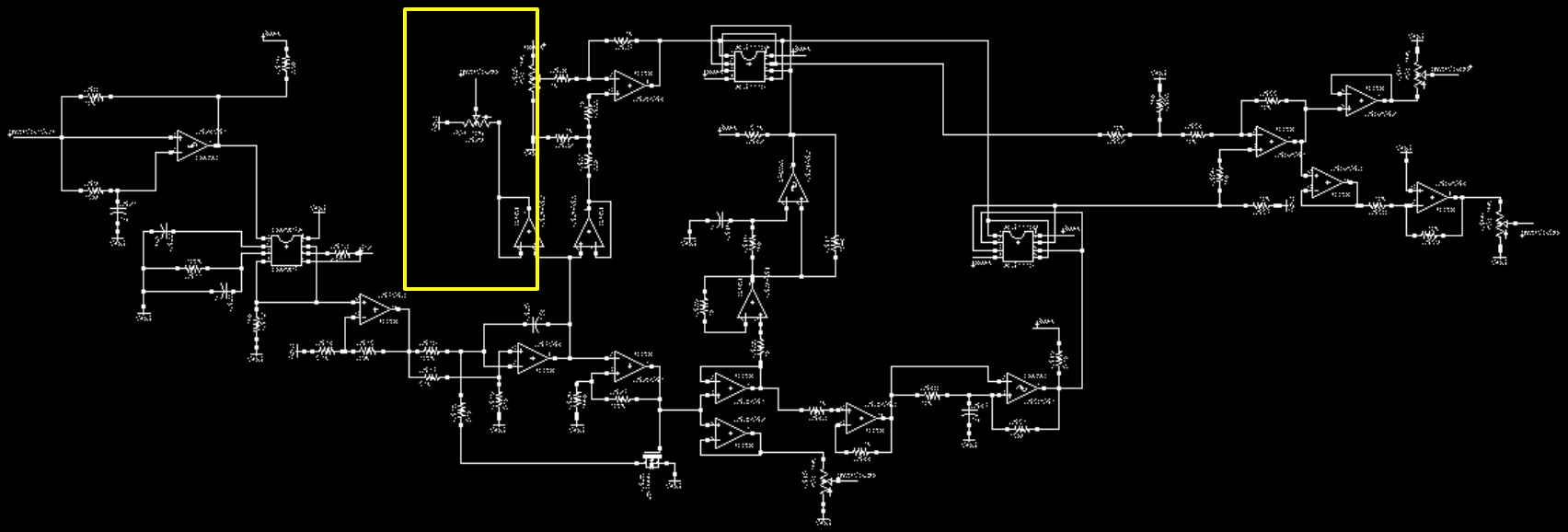
Voltage controlled oscillator

Triangle wave output

Square wave output

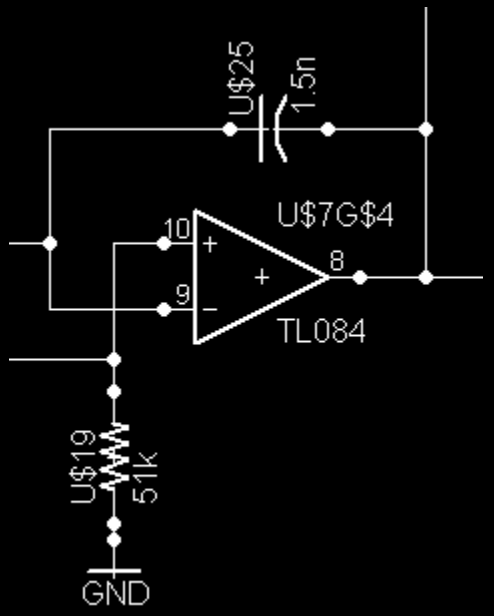
Saw-tooth and inverted saw-tooth outputs

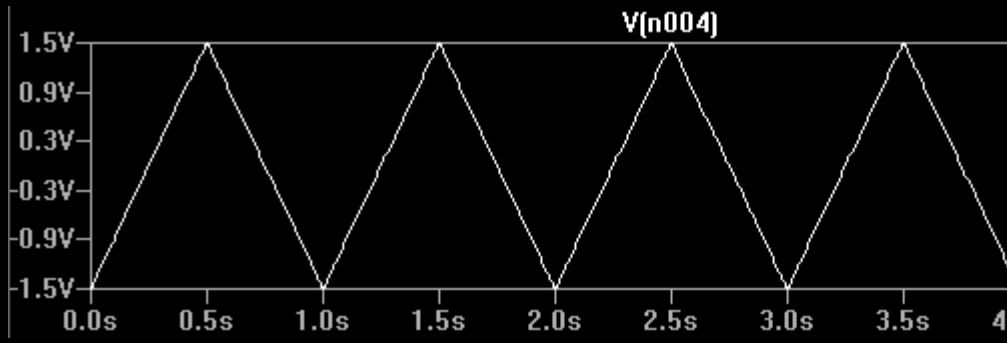
TRIANGLE WAVE



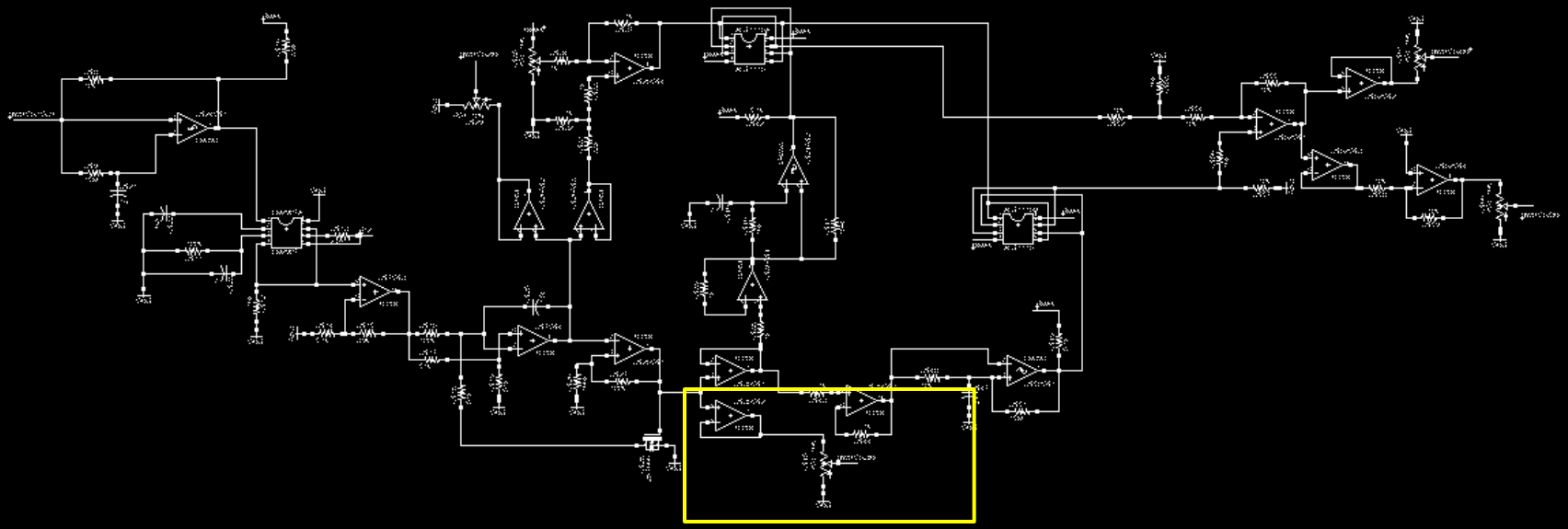
TRIANGLE WAVE

- Natural part of the voltage controlled oscillator
- Triangle formed by use of derivative amplifier circuit
- Sounds similar to old gaming consoles, used to replicate sine waves due to limited technology



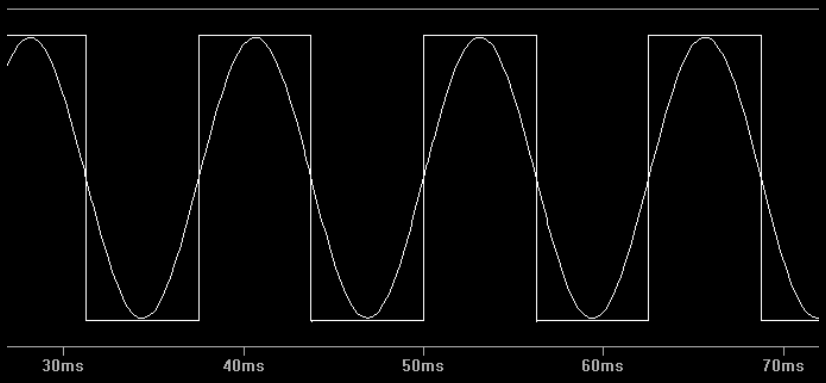


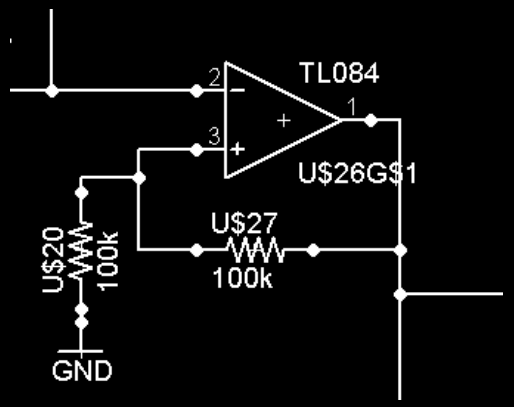
SQUARE WAVE



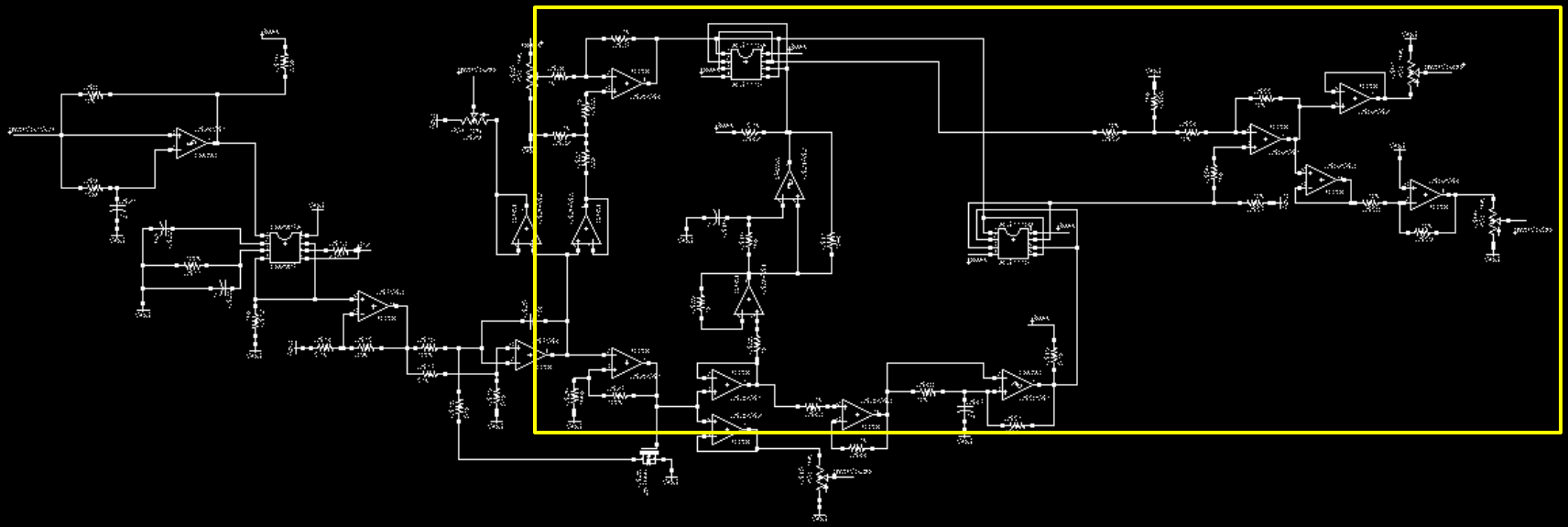
SQUARE WAVE

- Natural waveform of the voltage controlled oscillator
- Uses a Schmitt trigger circuit to produce waveform
- Produces a clear, harsh tone



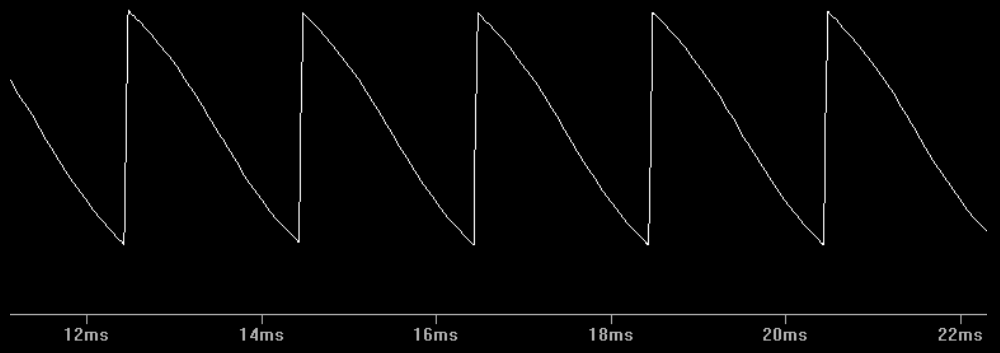


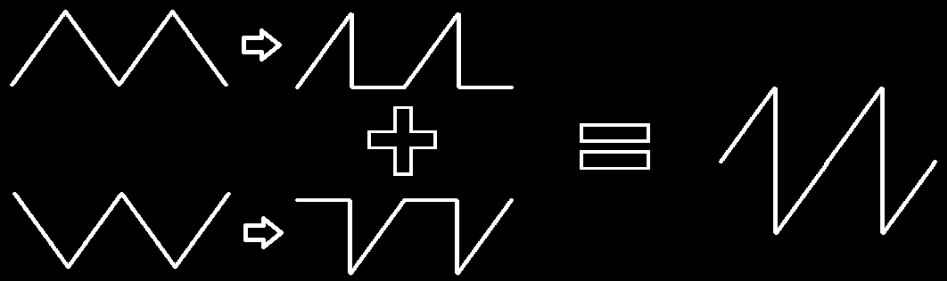
SAW-TOOTH WAVE



SAW-TOOTH WAVE

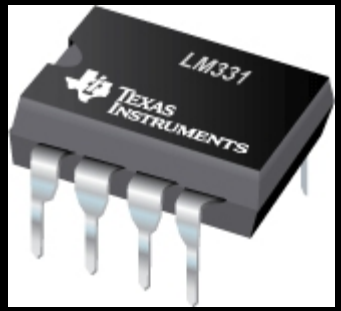
- Staple synthesized sound
- Both rising slope and falling slope available to user
- Produced from 3 operations:
  - Square wave used as control lines for MOSFET switches
  - Switches allow triangle wave to partially pass through
  - Waveforms from both switches are added together



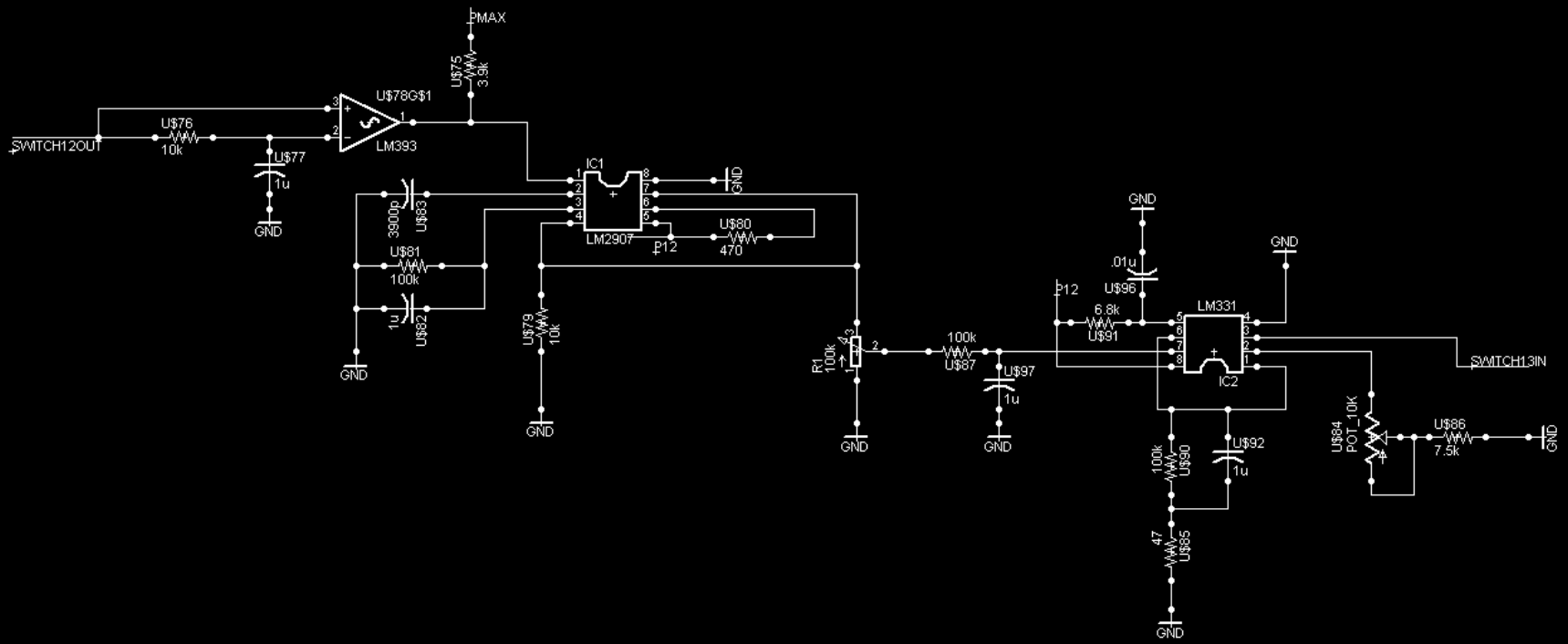


PEASE

- Allow the user to shift the frequency simply by using a knob
- Utilizes the LM2907 as well as the LM331
- Knob will offset the voltage from the LM2907 which then is converted back into a frequency using the LM331



PEASE


PMAX
U$75
3.3k
U$78G$1
LM393
SWITCH12OUT
U$76
10k
U$77
1u
GND
IC1
LM2907
P12
U$80
470
3900p
U$83
U$81
100k
1u
U$82
U$79
10k
R1
100k
43
U$87
100k
U$97
1u
P12
U$96
.01u
6.8k
U$91
LM331
IC2
SWITCH13IN
U$84
POT_10K
U$86
7.5k
U$90
100k
U$92
1u
U$85
47

BYPASS

- Clean direct output of audio signal
- Individualizes each effect
- Gives options to skip distortions and effects
- Economical alternative to other bypass
- Pedals with true bypass are $80+

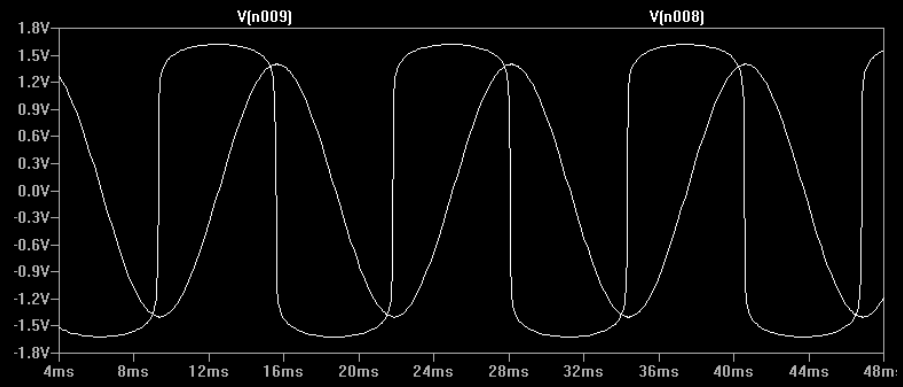
DISTORTION SHAPING

Used to make relatively subtle changes to the waveforms. Will typically still retain its general shape, but will usually involve some form of controlled clipping or frequency modulation.

- Sweet Distortion
- Savory Distortion
- Sharp-tooth Distortion
- Shark-fin Distortion
- Koviak Distortion
- Bypass

SWEET DISTORTION

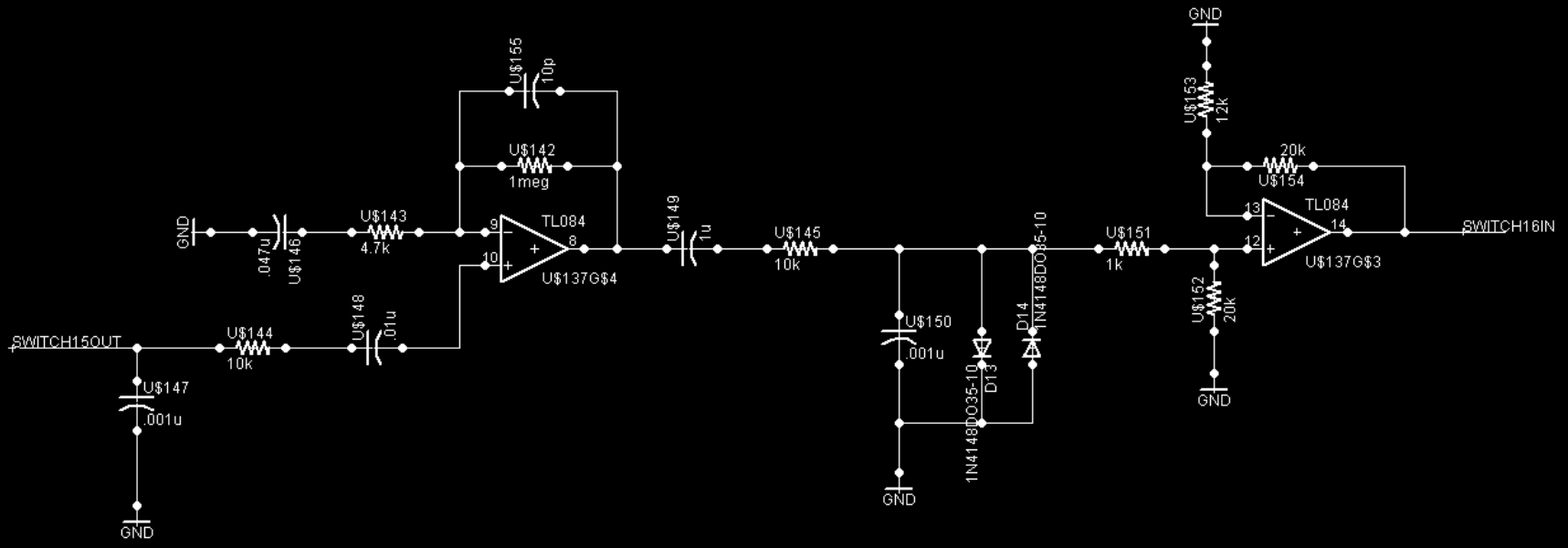
- Staple guitar sound
- Operational Amplifier implementation
- A combination of harsh fuzz and softer clipping
- Symmetrical Clipping
- Great sustain
- We refer to this one as “sweet”



1N4148 DIODE

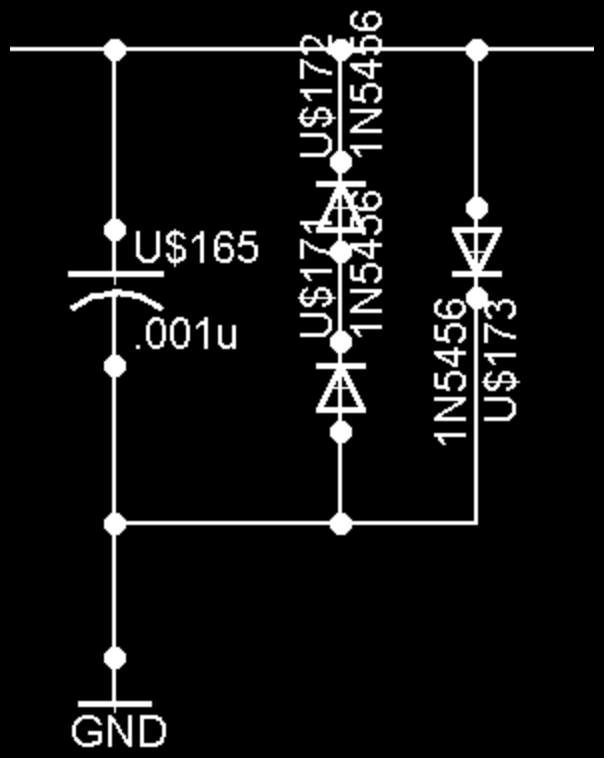
- V_{RRM} = 100 V (maximum repetitive reverse voltage)
- I_O = 200 mA (average rectified forward current)
- I_F = 300 mA (maximum direct forward current)
- V_F = 1.0 V at 10 mA.[6]
- I_{FSM} = 1.0 A (pulse width = 1 sec), 4.0 A (pulse width = 1 μsec) (non-repetitive peak forward surge current)
- P_D = 500 mW (power dissipation)
- T_{RR} < 4 ns (reverse-recovery time)

SWEET DISTORTION



SAVORY DISTORTION

- Another staple guitar sound
- Operational Amplifier implementation
- Uses harsher clipping for thicker rhythm tones
- Asymmetrical Clipping
- We refer to this one as “savory”



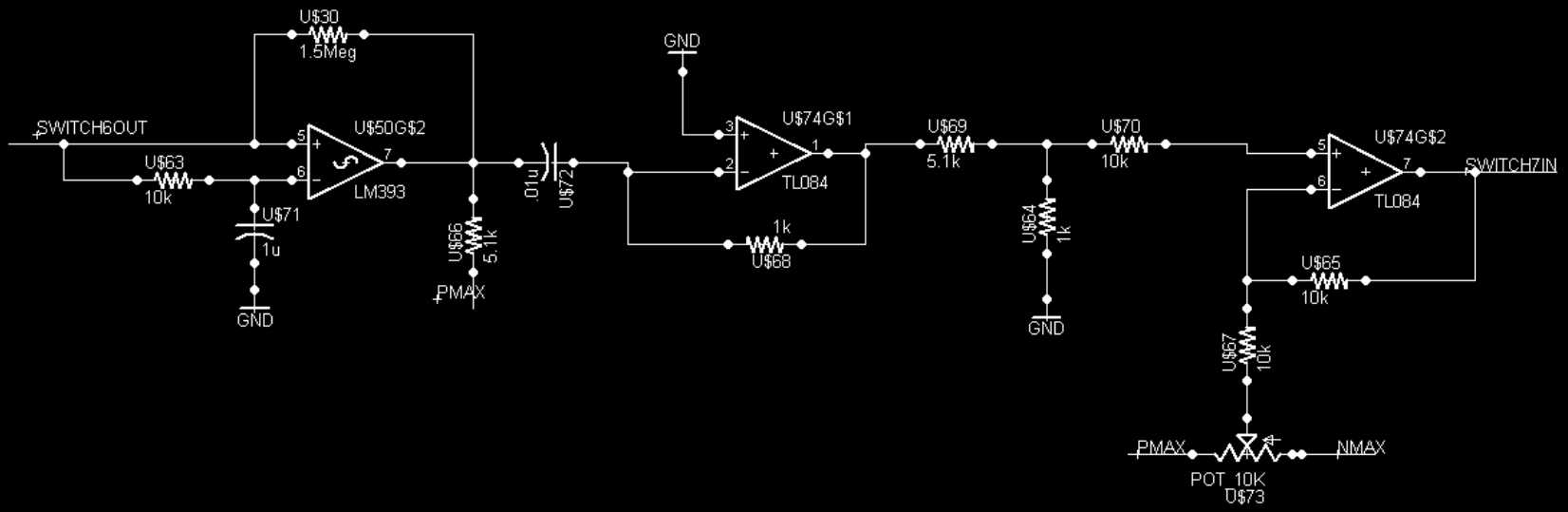
1N5456 DIODE

Package style		DO-7
DC Power Dissipation	@ Ta = 25°C	400 mW
Min Reverse Breakdown Voltage	@ I_R = 10 µA	30 V
Max Reverse Current (I_R)	@ 25 Vdc	0.02 µA
Max Reverse Current (I_{R2})	@ 25 Vdc 150°C	20 µA
Temp. Coefficient of Capacitance	@ V_R=4 Vdc; Ta -65° to + 85°c	.04% /°C
Operating Temperature (Topr)		-65 to +175°C
Storage Temperature (Tstg)		-65 to +200°C
Capacitance Tolerance	Standard Device	±20%

SHARP TOOTH WAVE

- Harsh and dry tone
- Utilizes the LM393
- Voltage impulses sent through the comparator

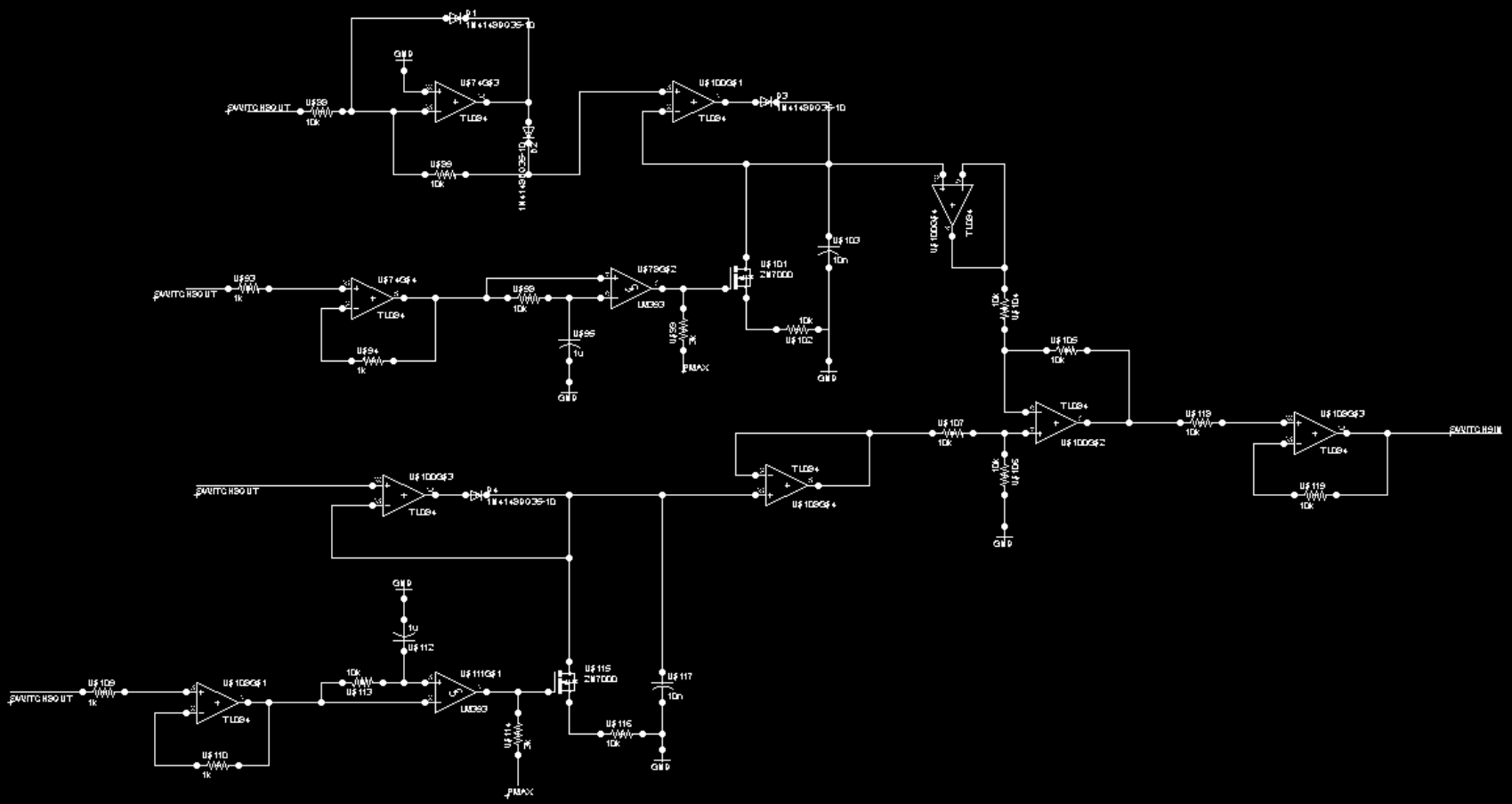
•Newly formed square wave is then sent through a derivative Op Amp circuit to form "tooth" shape



SHARK FIN

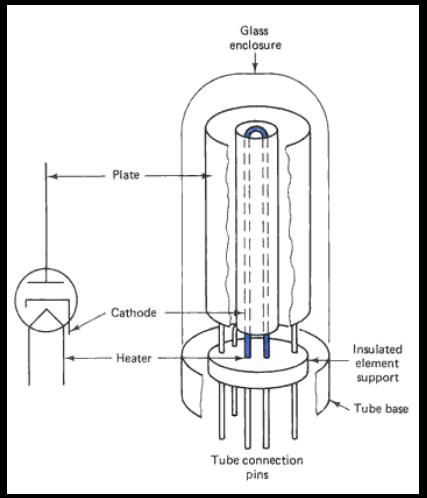
- Unique sound characteristics that sound similar to the sound from the Super Nintendo 16-bit games
- Minimal Interference from Harmonics
- Peak-Detector Implementation
- Low Noise from the Peak-Detector
- LM393 as Clock
- MOSFET as switch

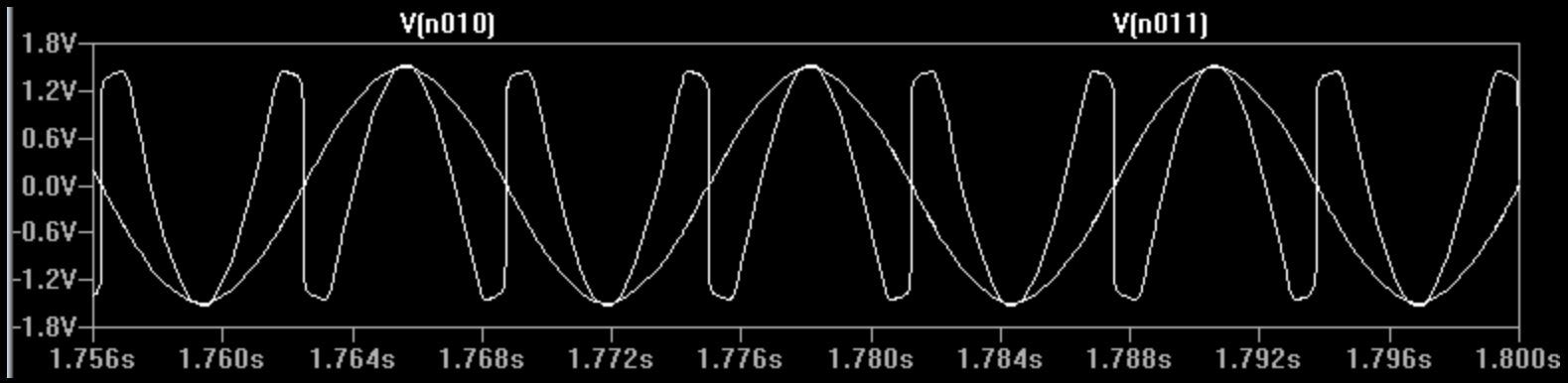
SHARK FIN



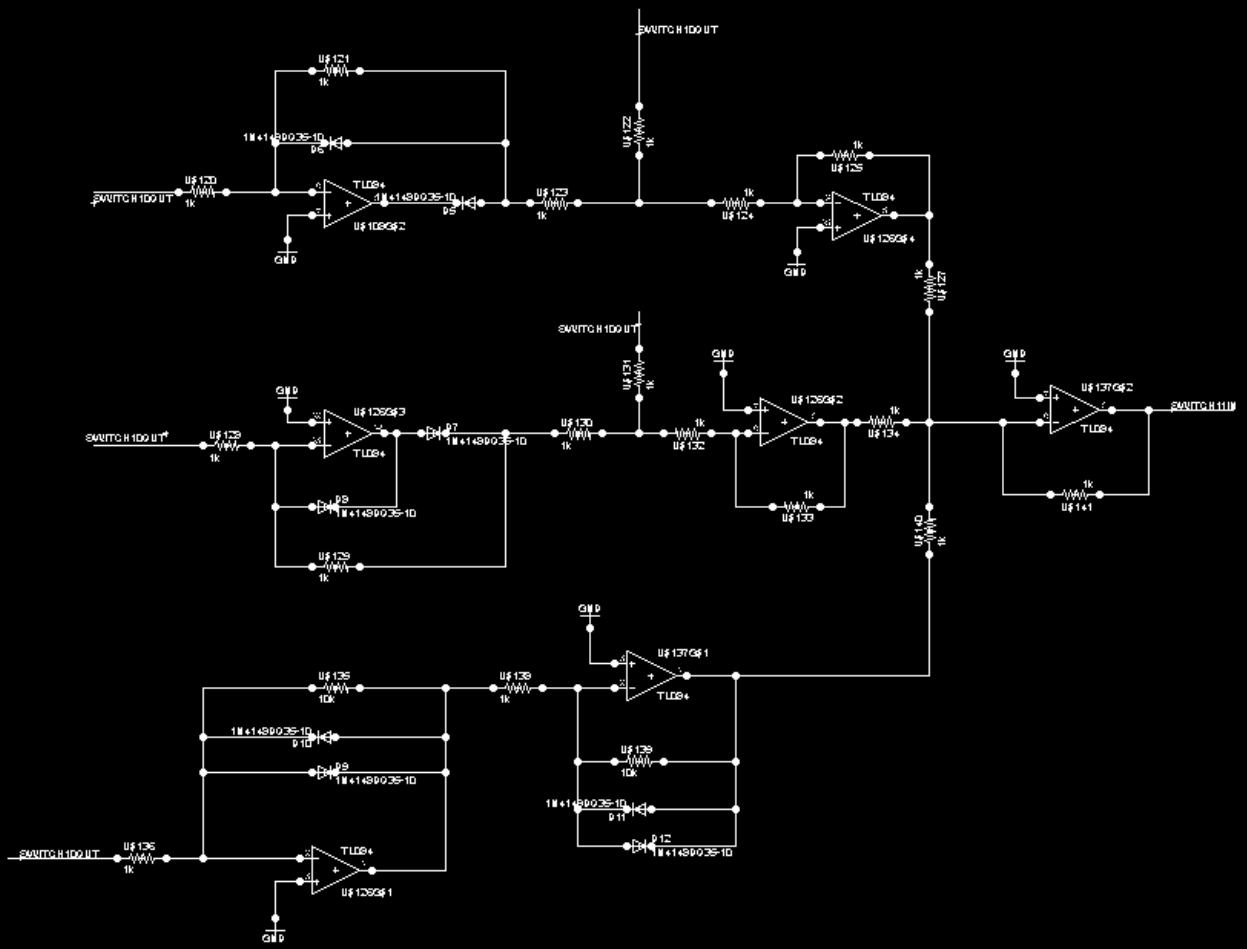
KOVIAK WAVE

- Unique Distortion
- Overdriven Sound Characteristics
- Minimal Harmonic Interference





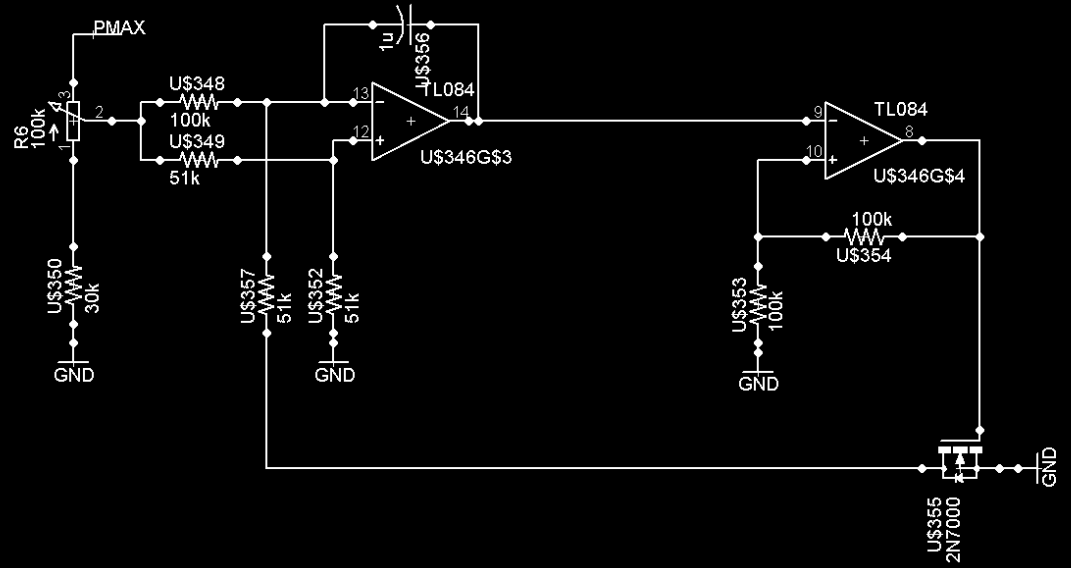
KOVIAK WAVE


SWITCH 1D0 UT
SWITCH 1D0 UT*
SWITCH 11W
GND
TL084
1N4148/DO35-10
U$120
U$121
U$122
U$123
U$124
U$125
U$126
U$127
U$128
U$129
U$130
U$131
U$132
U$133
U$134
U$135
U$136
U$137
U$138
U$139
U$140
U$141
1k
10k
D6
D7
D8
D9
D10
D11
D12
U$128@1
U$128@2
U$128@3
U$128@4
U$137@1
U$137@2

OSCILLATORY SHAPING

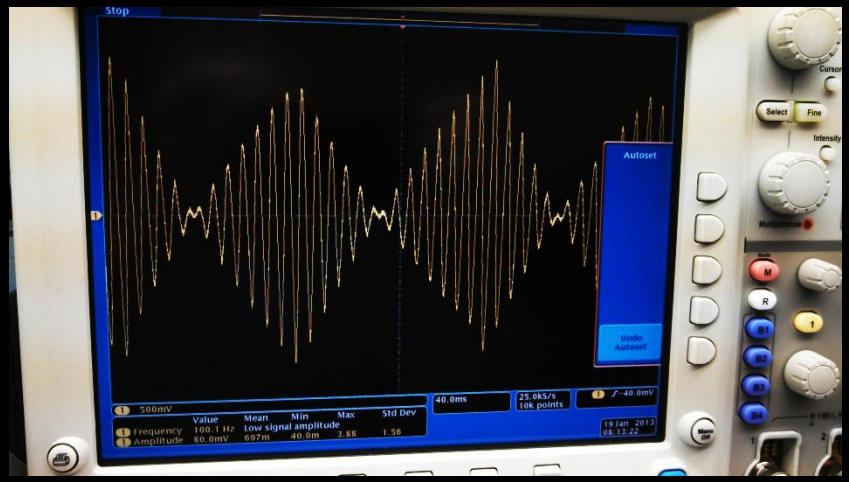
Used a custom two Op Amp VCO in order to maintain a 50% duty cycle. 30 KΩ resistor is used to mark a base voltage. Without this resistor the oscillator will not function properly.

- Tremolo
- Phaser
- Bypass

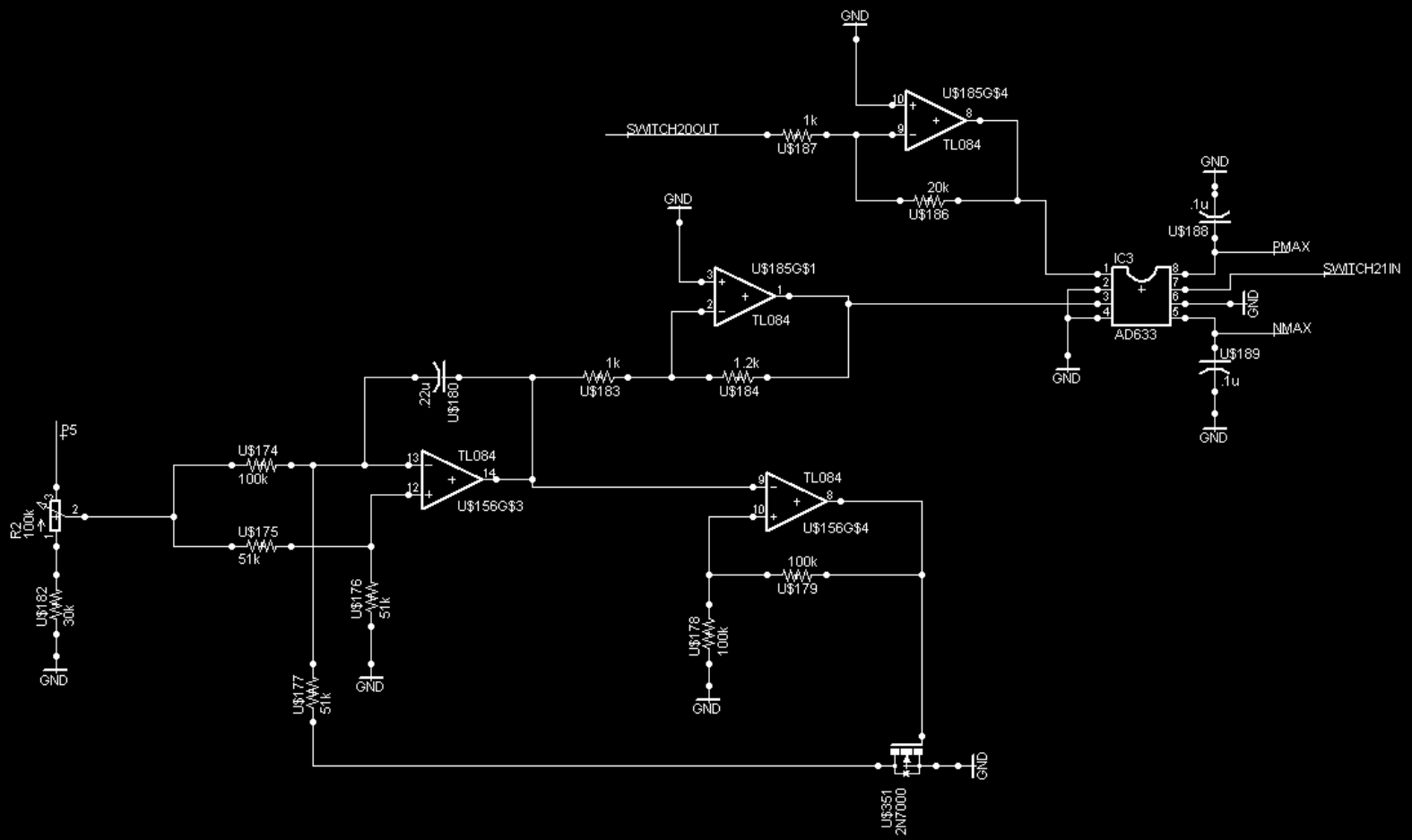


TREMOLO

- Comprised of a gradual rise and fall of original signal amplitude
- Desired effect is to simulate a common wobbling effect often used in electronic music
- Implemented using AD633 Analog Multiplier

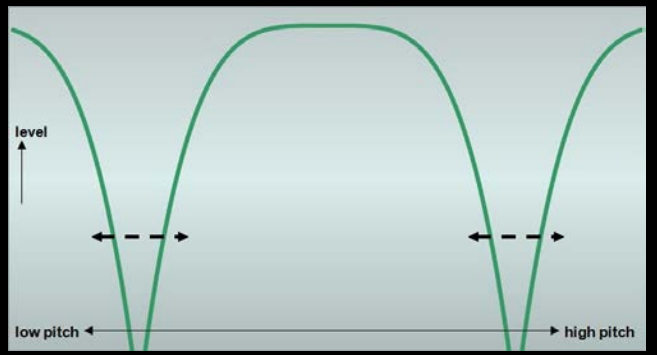


TREMOLO

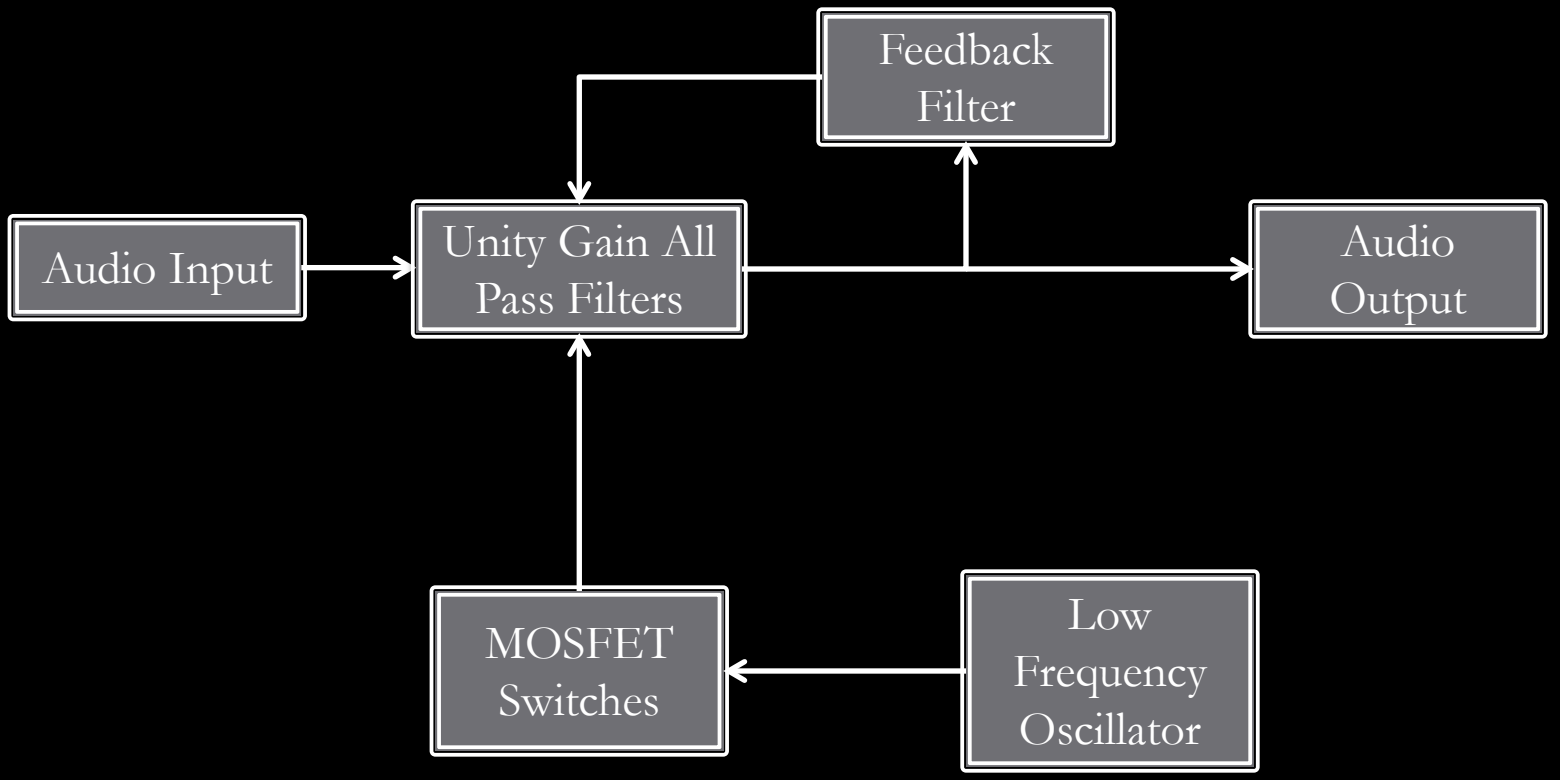

GND
U$185G$4
SWITCH20OUT
1k
U$187
TL084
20k
U$186
GND
.1u
U$188
PMAX
SWITCH21IN
IC3
AD633
GND
NMAX
U$189
.1u
GND
U$185G$1
TL084
22u
U$180
1k
U$183
1.2k
U$184
GND
P5
R2
100k
U$174
100k
U$175
51k
TL084
U$156G$3
TL084
U$156G$4
100k
U$179
U$182
30k
GND
U$176
51k
GND
U$177
51k
U$178
100k
GND
U$351
2N7000
GND

PHASER

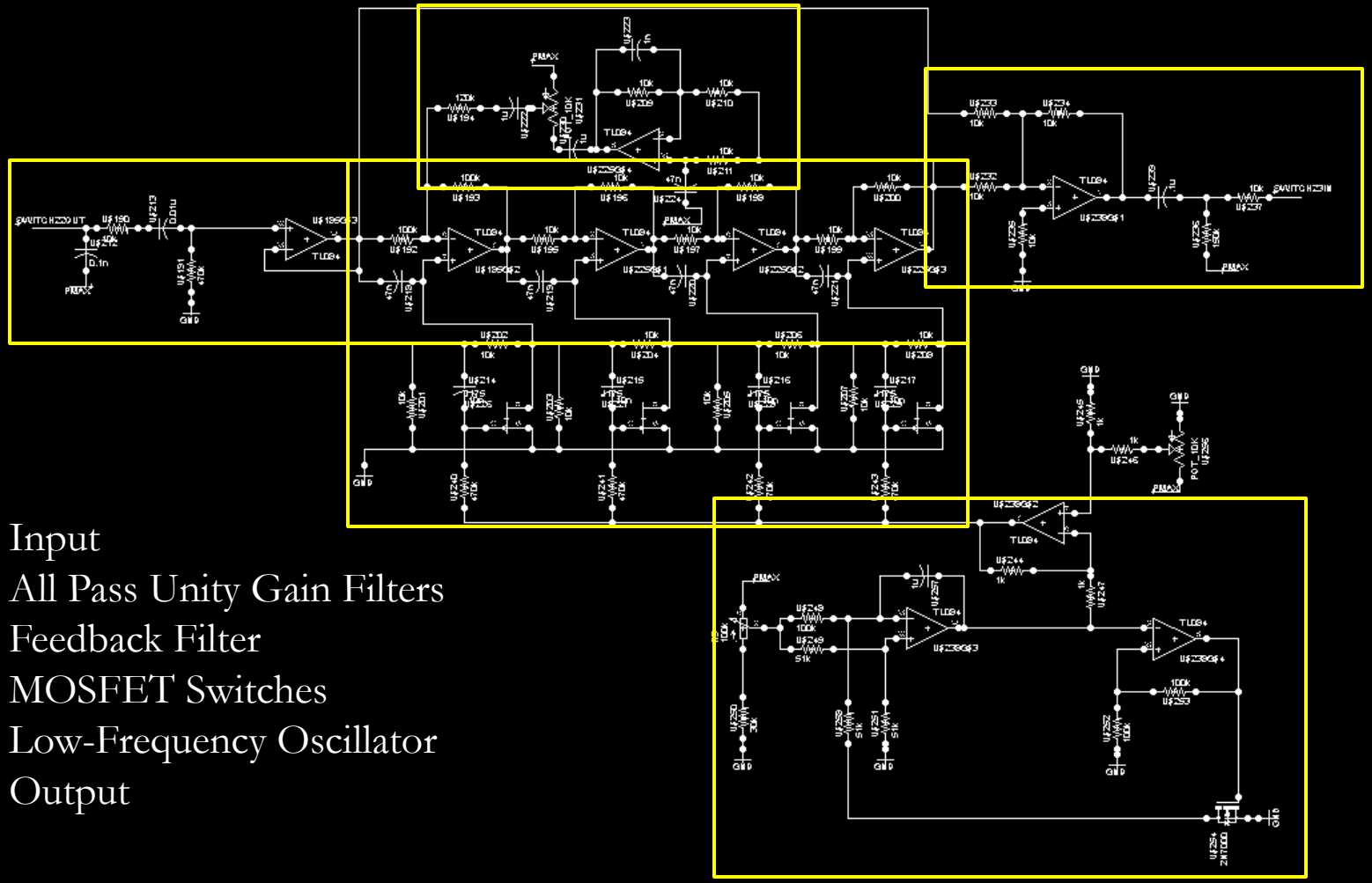
- Utilizes TL084 for all pass filters or “stages”
- Changes the phase of input for every stage it enters then combines with original input for desired effect at output
- Four stages and a feedback loop will create a greater sound effect
- Creates a viscous, whooshing effect



PHASER


Feedback Filter
Audio Input
Unity Gain All Pass Filters
Audio Output
MOSFET Switches
Low Frequency Oscillator

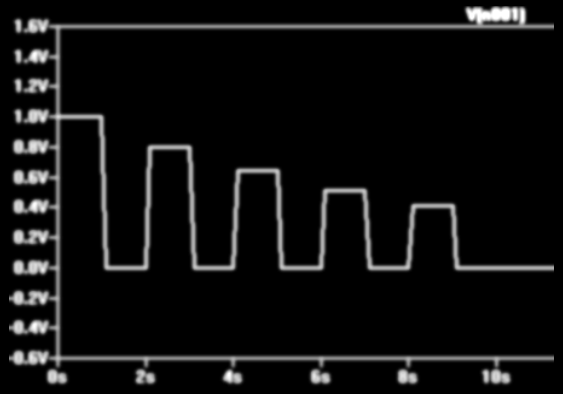
PHASER



- Input
- All Pass Unity Gain Filters
- Feedback Filter
- MOSFET Switches
- Low-Frequency Oscillator
- Output

DELAY SHAPING

- Final effect stages. Stage input is the signal after it has been reshaped, distorted, and run through an oscillator effect
- All effects are driven by PT2399 Delay IC
- Effects are varied by changing echo time, echo amplitude, and decay time

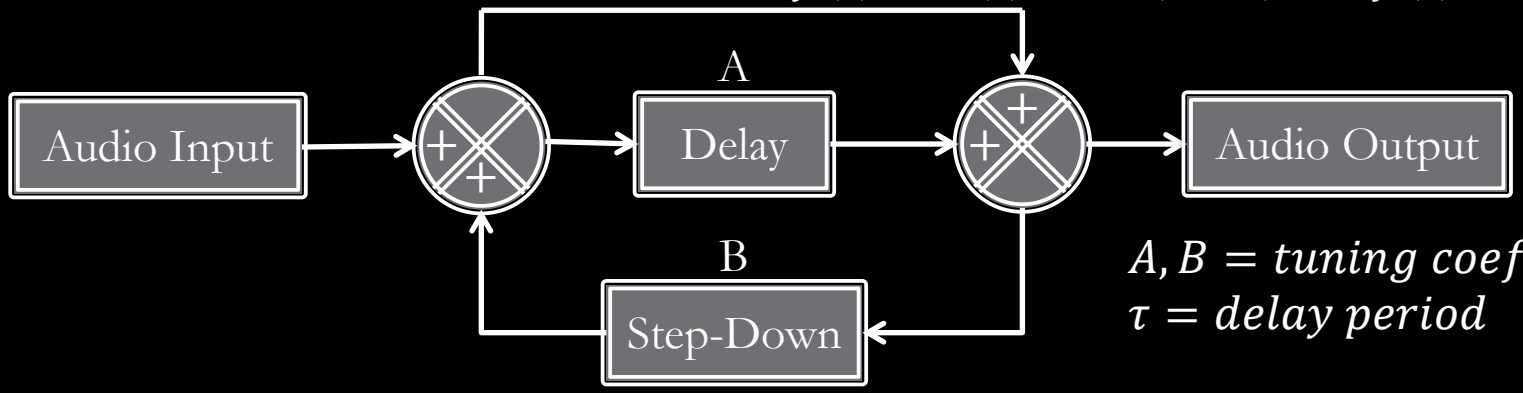


- Delay
- Chorus
- Isolated Reverb
- Bypass

DELAY

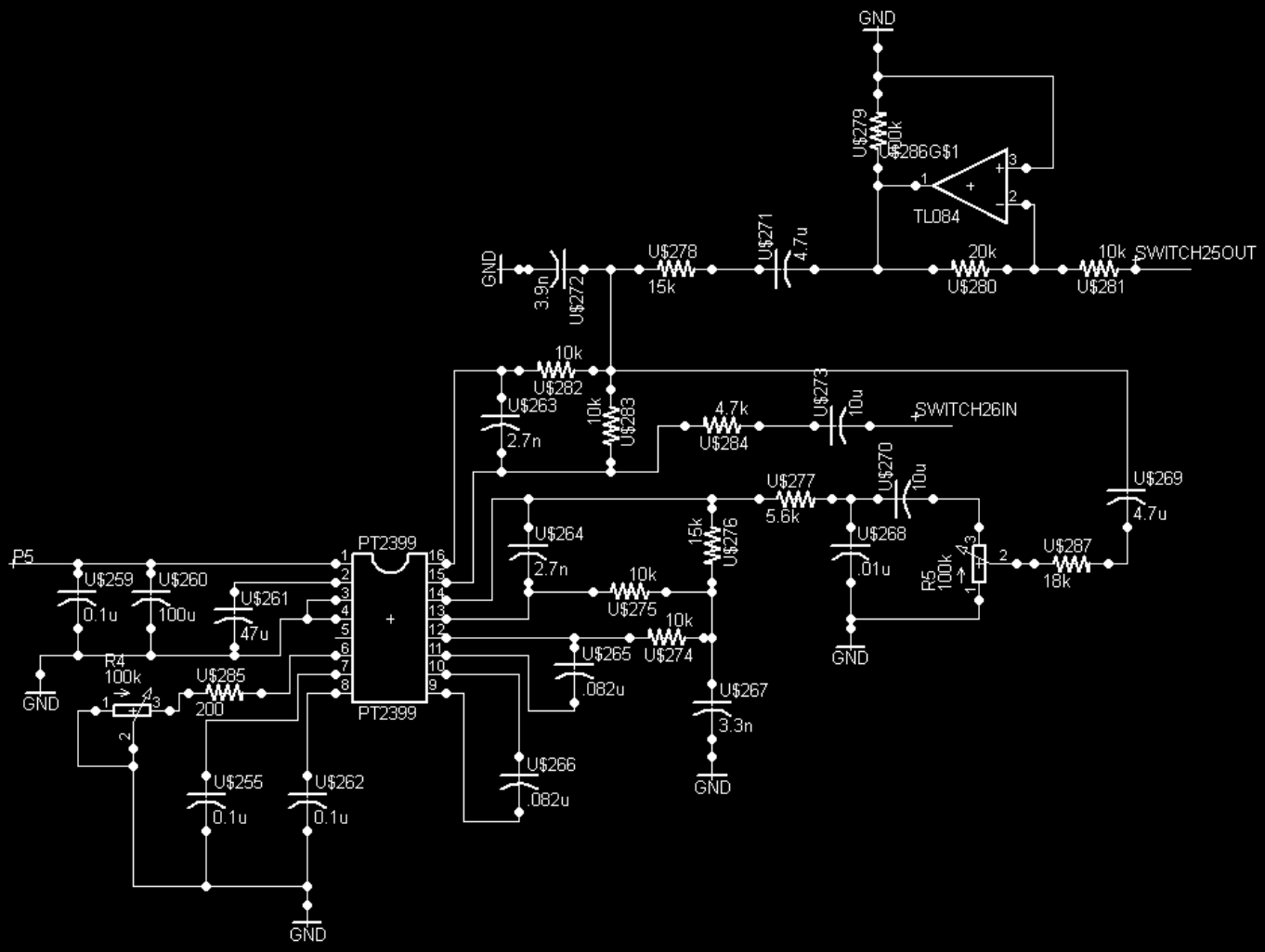
- Delay using PT2399 Echo Processor
- Gives a Spacy Sound
- The coefficients τ, A, & B are tuned
  - τ = period of delay
  - A, B are tuned to effect the envelope of the delay
  - Both τ and B are available to user

$$y(t) = x(t) + Ax(t-\tau) + By(t) + ABy(t-\tau)$$



$A, B = tuning\ coefficients$
$\tau = delay\ period$

DELAY

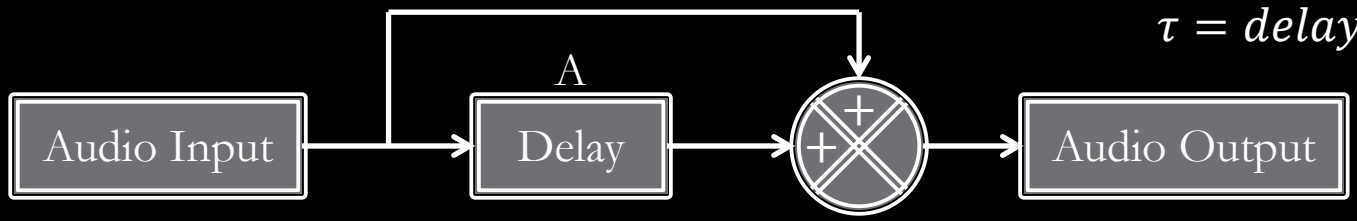

GND
U$279
50k
U$286G$1
TL084
U$271
4.7u
U$278
15k
U$272
3.9n
20k
U$280
10k
U$281
SWITCH25OUT
10k
U$282
U$263
2.7n
10k
U$283
4.7k
U$284
U$273
10u
SWITCH26IN
U$277
5.6k
U$270
10u
U$269
4.7u
P5
PT2399
U$259
0.1u
U$260
100u
U$261
47u
R4
100k
U$285
200
U$264
2.7n
10k
U$275
15k
U$276
10k
U$274
U$265
.082u
U$267
3.3n
U$266
.082u
U$255
0.1u
U$262
0.1u
U$268
.01u
R5
100k
U$287
18k

CHORUS

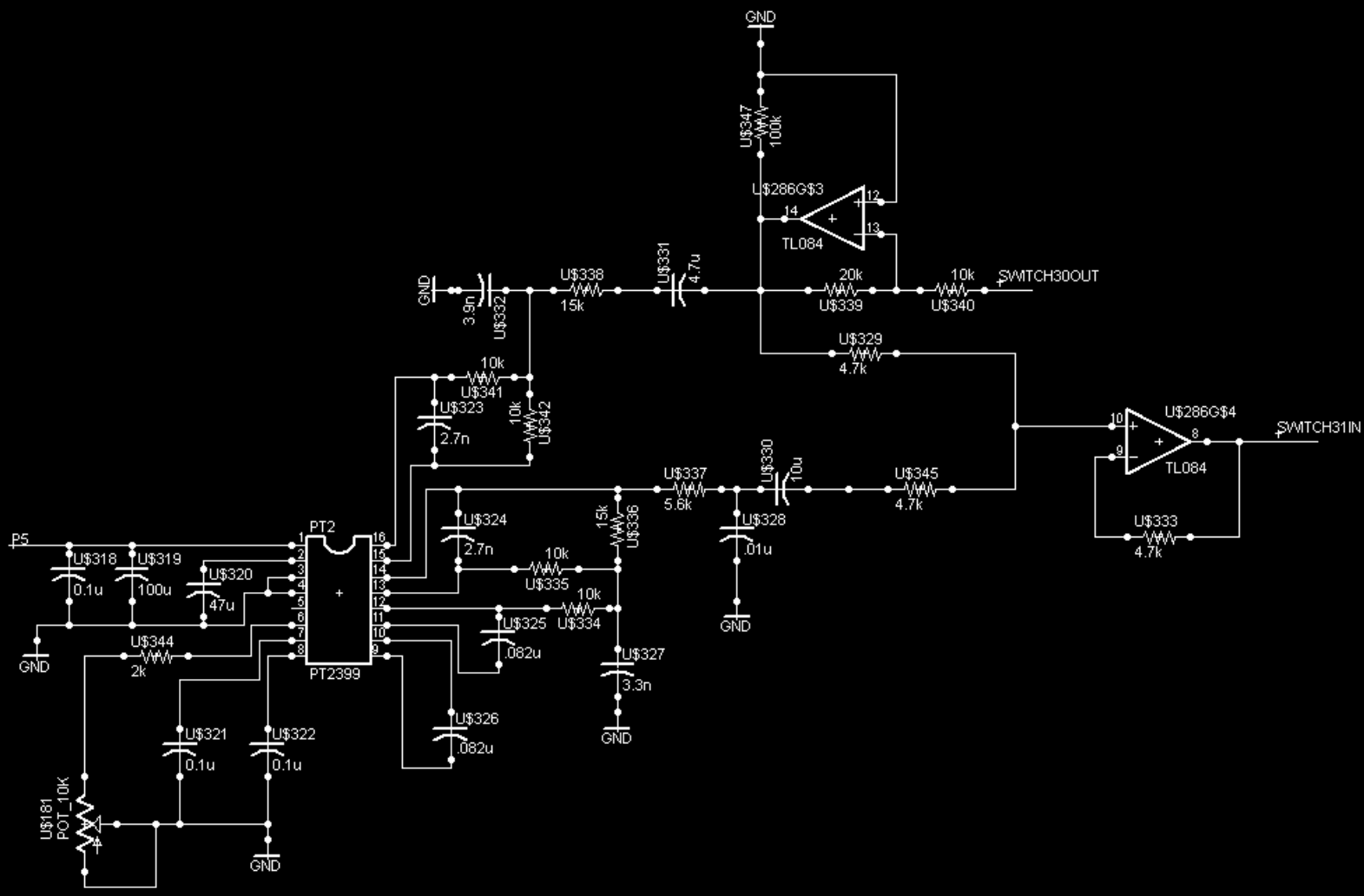
- Designed to emulate the effect of multiple instruments playing simultaneously
- τ is very small and fixed
- No feedback loop, resulting in immediate decay

$$y(t) = f(t) + Af(t - \tau)$$

$A = tuning\ coefficient$
$\tau = delay\ period$



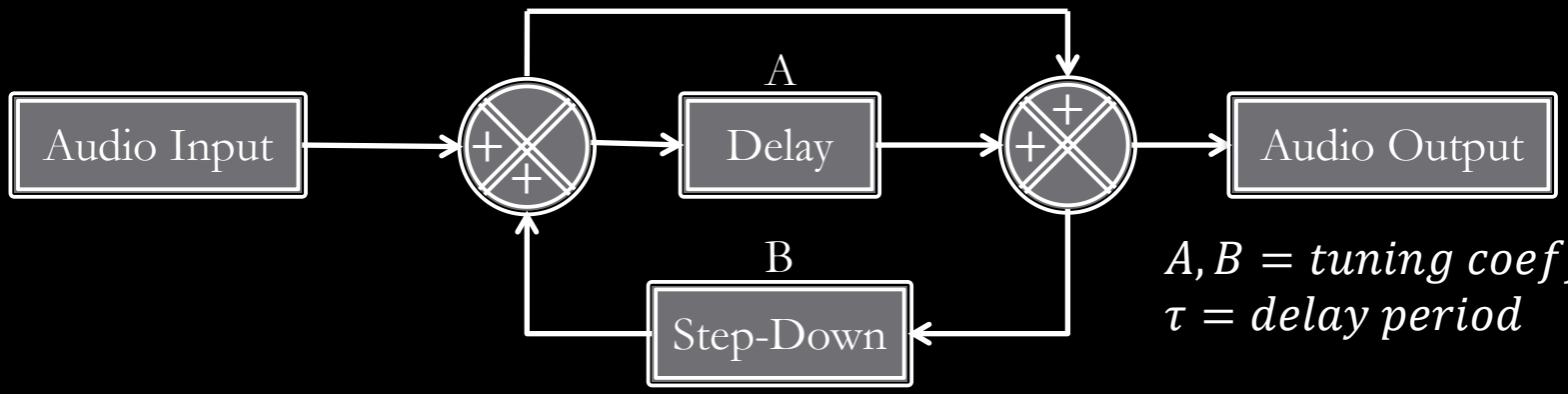
CHORUS


GND
U$347
100k
U$286G$3
TL084
U$331
4.7u
U$338
15k
20k
U$339
10k
U$340
SWITCH30OUT
3.9n
U$332
U$329
4.7k
10k
U$341
U$323
2.7n
10k
U$342
U$286G$4
TL084
SWITCH31IN
U$337
5.6k
U$330
10u
U$345
4.7k
U$333
4.7k
P5
PT2
PT2399
U$318
0.1u
U$319
100u
U$320
47u
U$344
2k
U$324
2.7n
15k
U$336
10k
U$335
10k
U$334
U$325
.082u
U$328
.01u
U$327
3.3n
U$326
.082u
U$321
0.1u
U$322
0.1u
U$181
POT_10K

REVERB

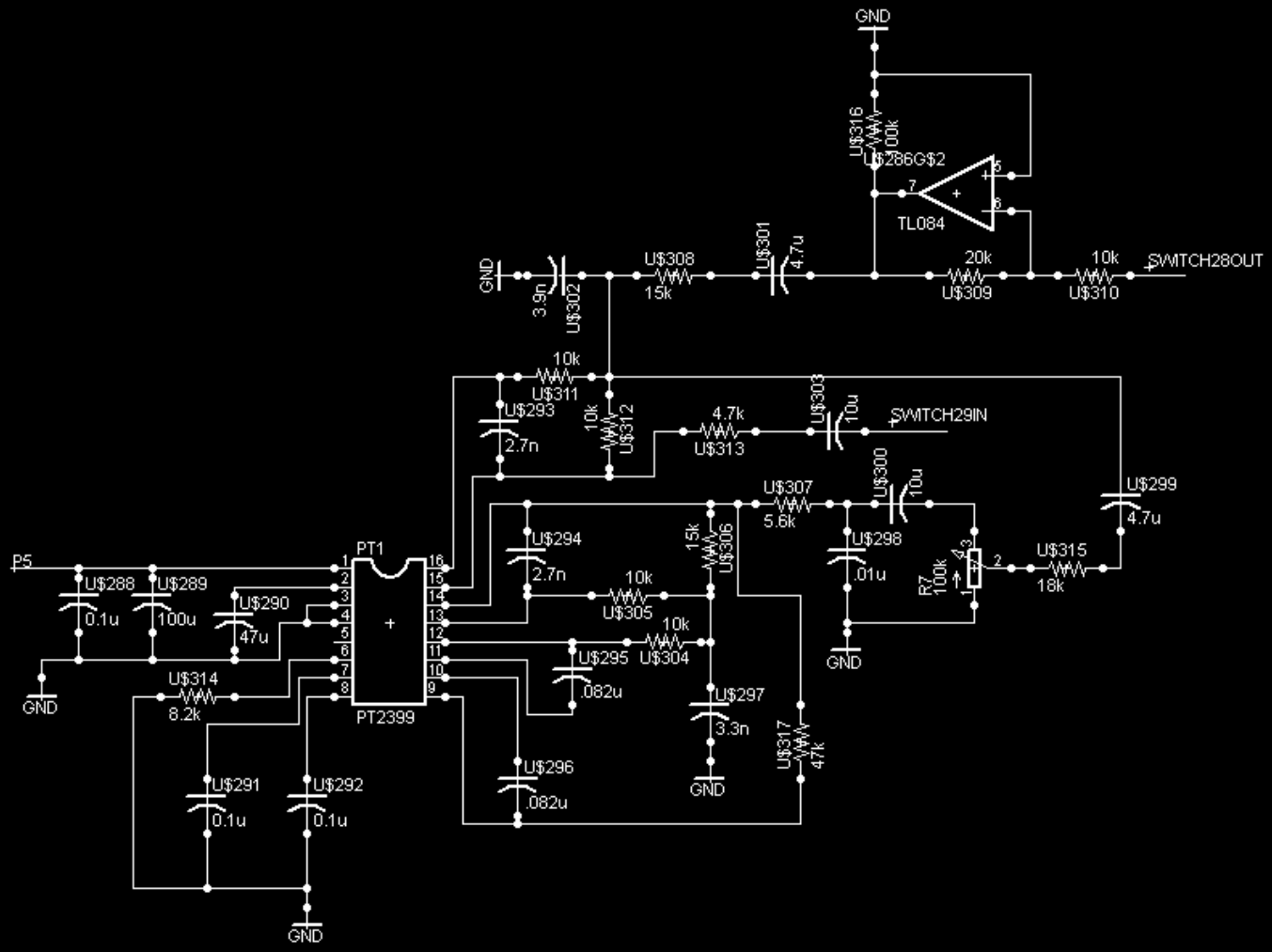
- Designed to emulate the effect of echo in a closed building i.e. an auditorium
- τ value is fixed, at a very small value
- Decay adjustment available to user, variable B

$$y(t) = x(t) + Ax(t - \tau) + By(t) + ABy(t - \tau)$$



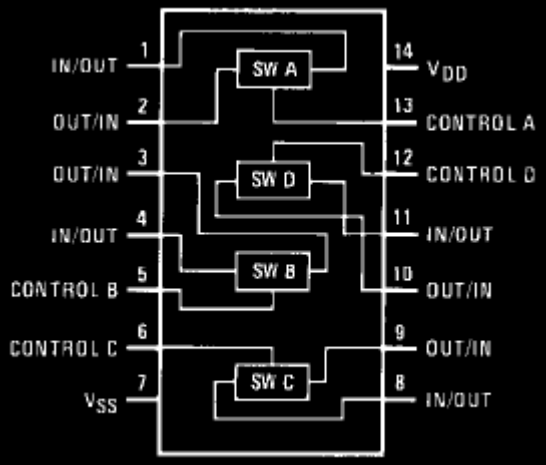
$A, B = tuning\ coefficients$
$\tau = delay\ period$

REVERB


GND
U$316
100k
U$286G$2
TL084
U$301
4.7u
U$308
15k
20k
U$309
10k
U$310
SWITCH28OUT
GND
3.9n
U$302
10k
U$311
U$293
2.7n
10k
U$312
4.7k
U$313
U$303
10u
SWITCH29IN
U$307
5.6k
U$300
10u
U$299
4.7u
U$294
2.7n
15k
U$306
U$298
.01u
R7
100k
.43
U$315
18k
P5
PT1
PT2399
U$288
0.1u
U$289
100u
U$290
47u
10k
U$305
10k
U$304
U$295
.082u
U$297
3.3n
U$314
8.2k
U$317
47k
U$291
0.1u
U$292
0.1u
U$296
.082u
GND
GND
GND
GND

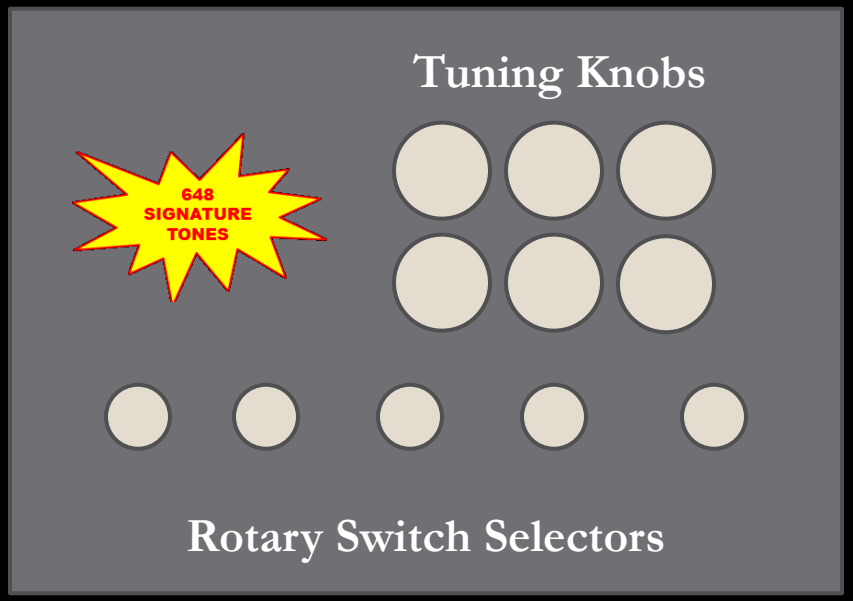
SELECTION SYSTEM

- Rotary switches used to select effect from each group
- Every group includes one bypass
- Rotary switch turns on and off control lines for CD4066 switches
- Switches open and close both input and output lines for each effect



HOUSING

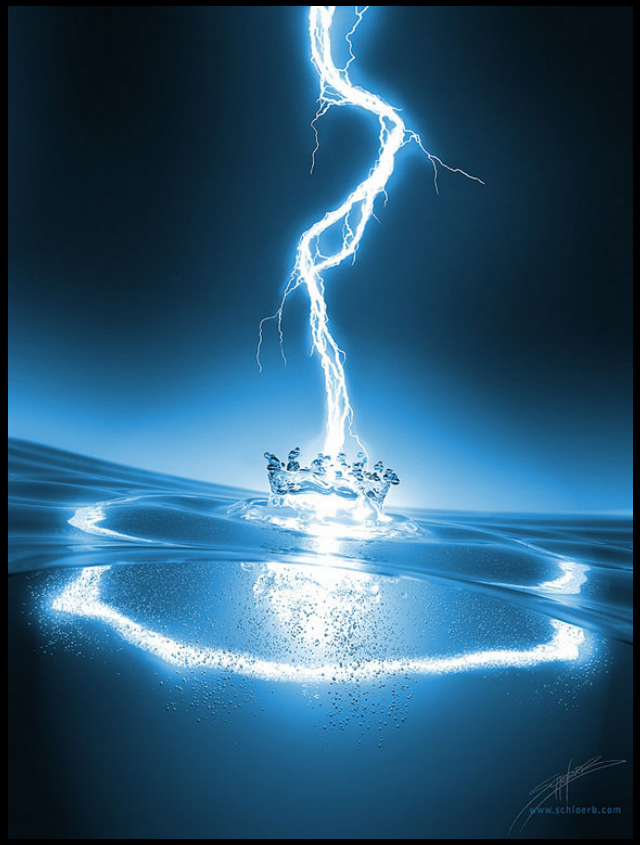
- Rotary switches cycle through distortions and effects
- Tuning knobs fine tune pease, tremolo, phasor, delay, and reverb effects



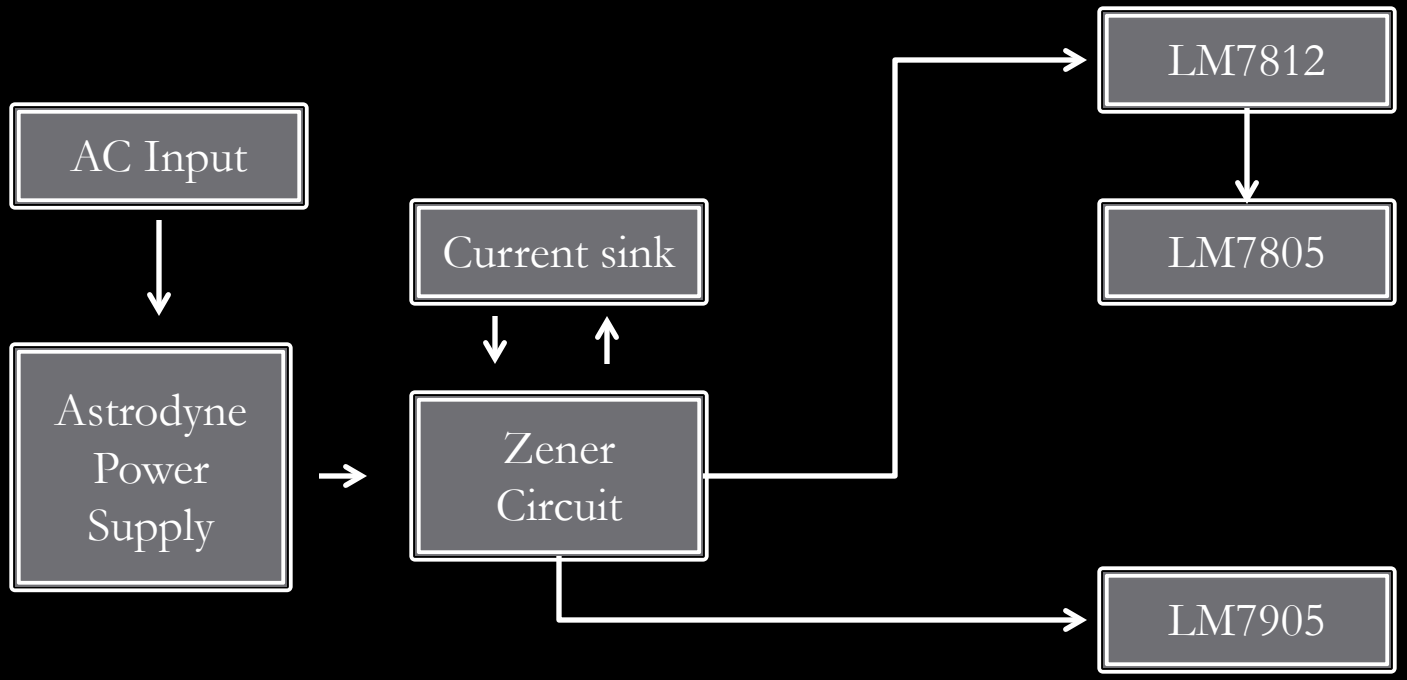
POWER

Design Requirements

- Astrodyne EFM1506 power supply used to convert AC to DC. Input range at 100 to 230VAC. Output at ±12V @ 630mA.
- Output +12 V and -9 V to power most of the ICs and OpAmps
- Output +5 V for PT2399 with separate ±5 V regulators for CD4066



POWER


AC Input
Astrodyne Power Supply
Current sink
Zener Circuit
LM7812
LM7805
LM7905