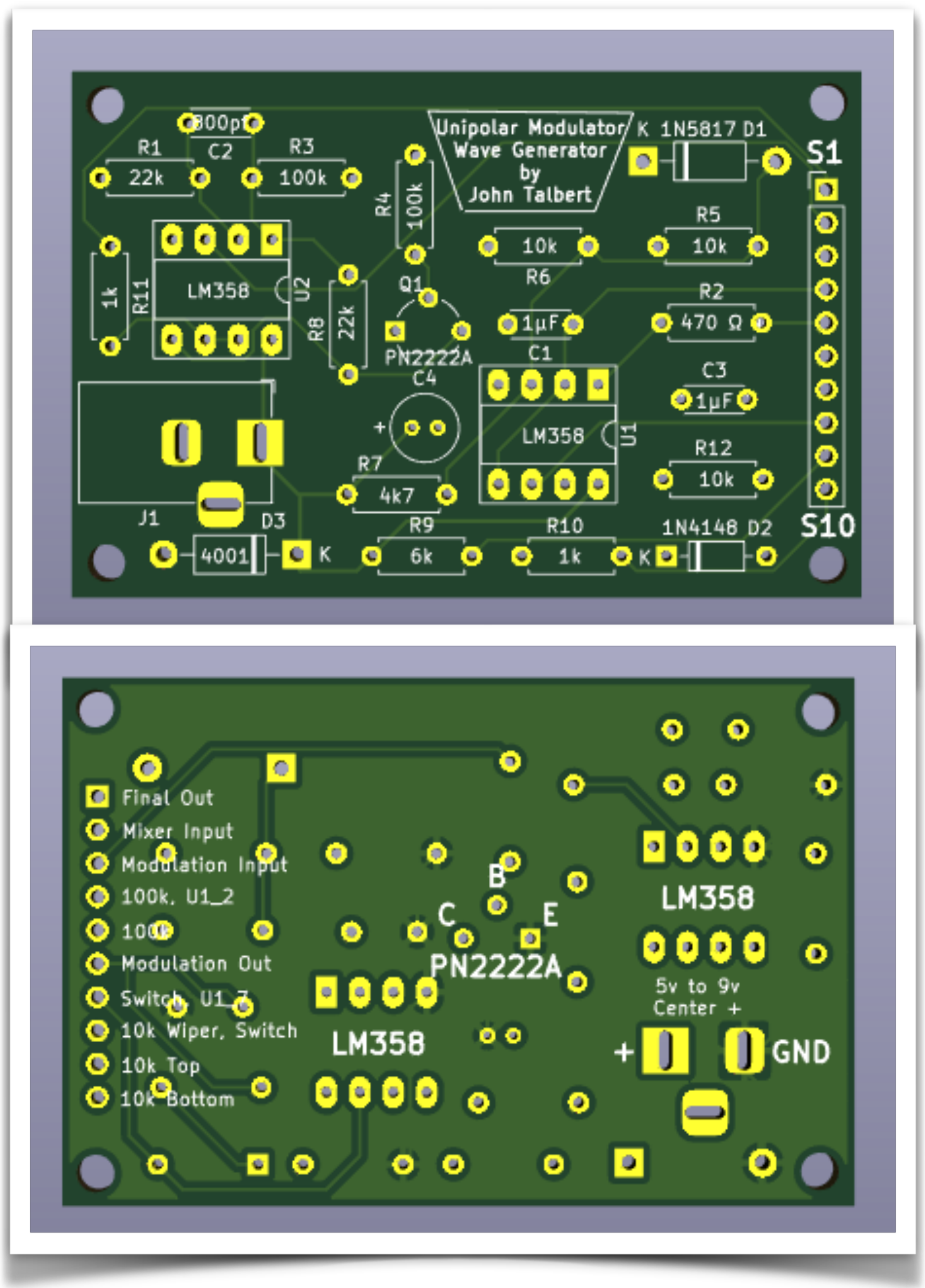
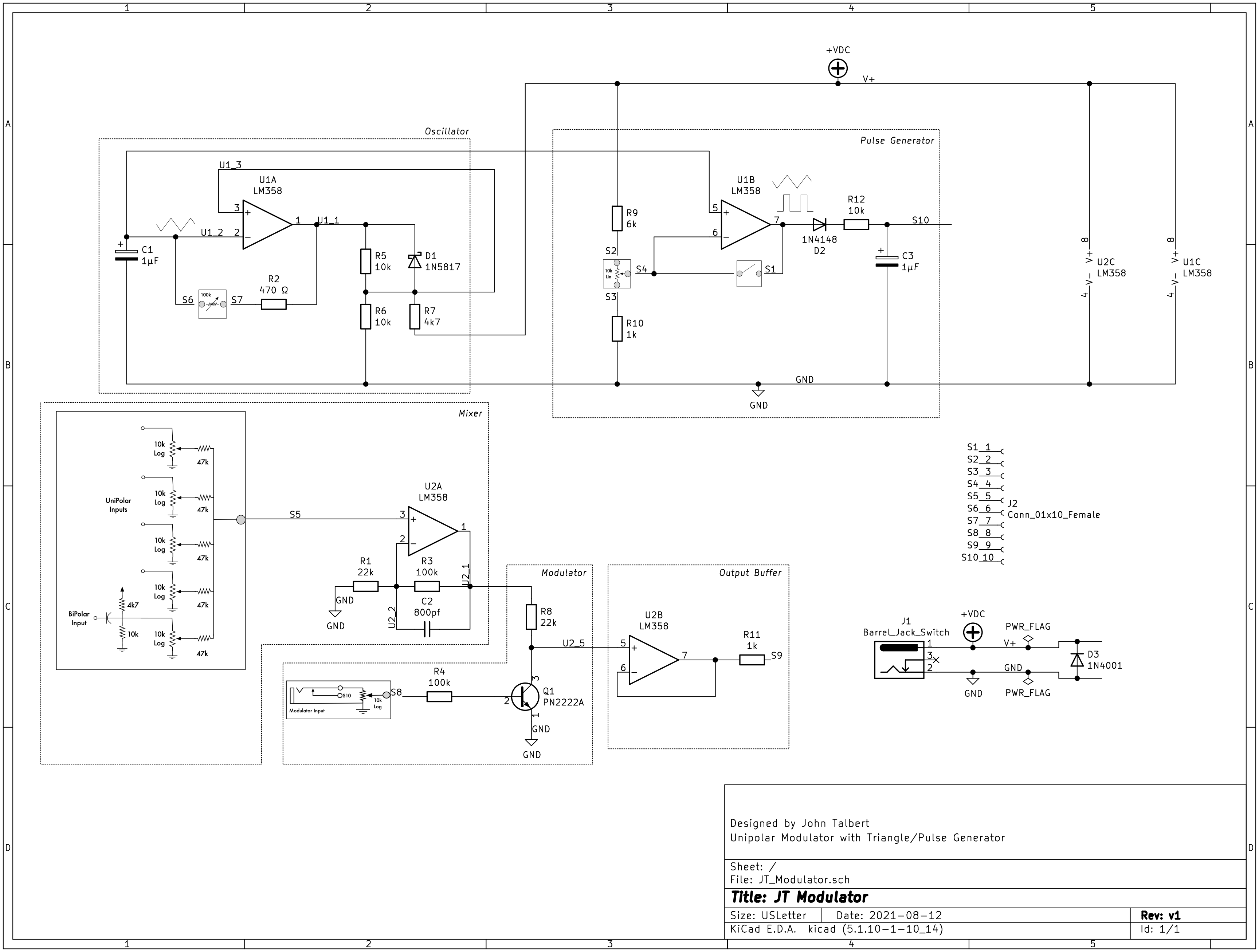
JT Modulator PCB

John Talbert - March 2022




Oscillator
U1A
LM358
U1_3
U1_2
U1_1
C1
1µF
S6
S7
R2
470 Ω
R5
10k
R6
10k
D1
1N5817
R7
4k7
Pulse Generator
+VDC
V+
R9
6k
S2
S3
S4
R10
1k
U1B
LM358
S1
1N4148
D2
R12
10k
S10
C3
1µF
GND
U2C
LM358
U1C
LM358
Mixer
UniPolar
Inputs
BiPolar
Input
10k
Log
47k
4k7
10k
S5
U2A
LM358
R1
22k
R3
100k
C2
800pf
U2_1
U2_2
Modulator
R8
22k
U2_5
R4
100k
S8
Modulator Input
Q1
PN2222A
Output Buffer
U2B
LM358
R11
1k
S9
J2
Conn_01x10_Female
J1
Barrel_Jack_Switch
PWR_FLAG
D3
1N4001
Designed by John Talbert
Unipolar Modulator with Triangle/Pulse Generator
Sheet: /
File: JT_Modulator.sch
Title: JT Modulator
Size: USLetter
Date: 2021-08-12
Rev: v1
KiCad E.D.A. kicad (5.1.10-1-10_14)
Id: 1/1

Circuit Description

The circuit shown above is a combination unipolar Waveform Generator and Modulator. The generated waveform is used to distort a mix of unipolar audio inputs with a unique kind of modulation.

Unipolar Power Supply

The circuit operates from a single sided power supply of any voltage between 3 and 12 volts. It makes use of two special purpose dual op amp chips, the LM358. These chips were designed specifically to operate from a single power supply over a wide range of voltages, as low as 3.0 V or as high as 32 V, with low operating currents, about one−fifth of those associated with the MC1741. The output voltage can swing all the way to ground (zero volts), even though operated from only a single power supply voltage.

The unipolar operation is especially useful in applications involving microprocessors whose Digital and DAC output pins only operate in a positive voltage range. Because of the low operating current of the LM358, the board can be powered from the same supply as the microprocessor, usually from a USB connection.

Waveform Generator

Opamps U1A and U1B, at the top of the schematic, make up the Wave Generator.

Op-amp U1A forms an oscillator while acting as a comparator. It compares the charging and discharging C1 capacitor voltage with an attenuated version of the digital op-amp output voltage. Op-amp U1B manipulates the oscillator waveform creating either a triangle wave or a variable pulse wave.

What follows is a sequence of events for the U1A oscillator circuit.

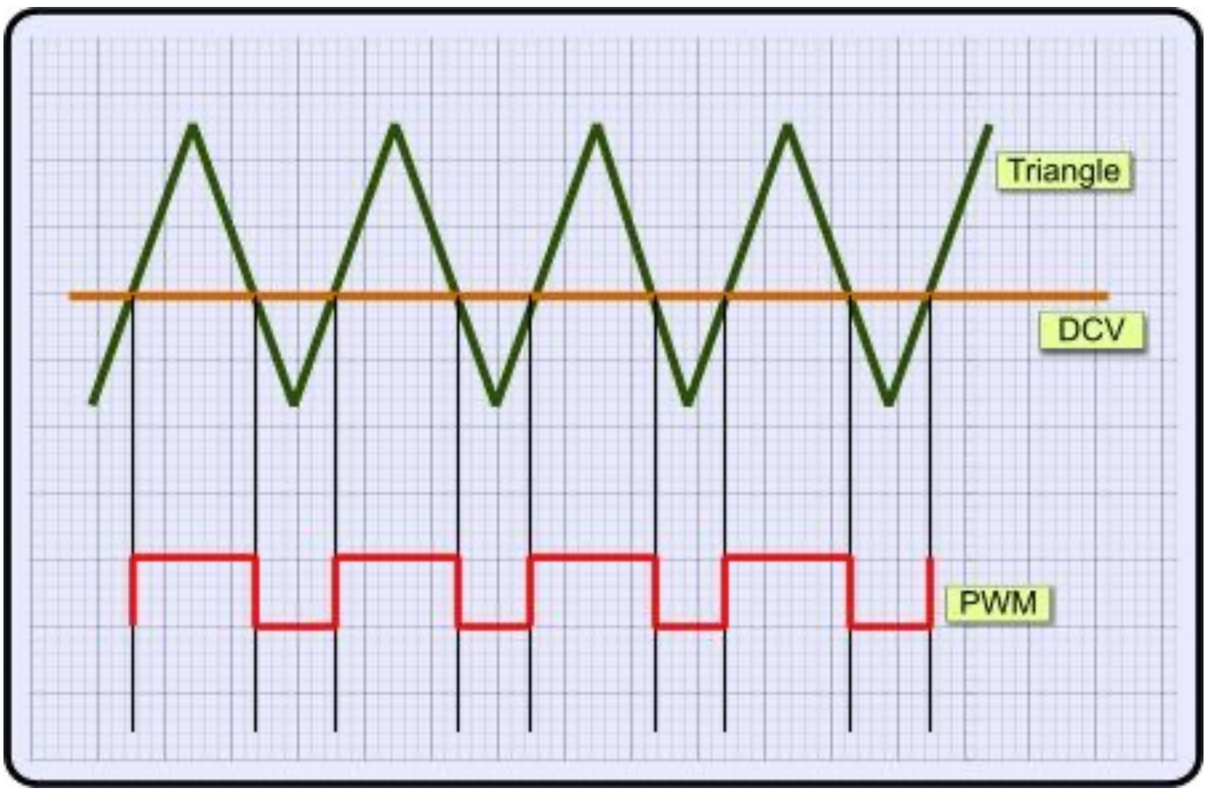
1. When the opamp output is high at Vs (Supply Voltage) the non-inverting (+) input is sitting at Vs/2, from the R5/R6 resistor divider. Diode D1 is reverse biased and thus out of the picture. The capacitor C1 charges towards Vs through R2 and an external 100k potentiometer.
2. When the voltage on C1 rises just above Vs/2 the opamp comparator output switches low to zero volts.
3. The non-inverting (+) input is now sitting at 0.2 volts, from the forward biased 1N5817 diode. Capacitor C1 now discharges towards zero volts through the same R2 and 100k pot.
4. When the voltage on C1 drop just below 0.2 volts the opamp comparator output switches back high to Vs, starting the whole cycle again.

The result is a square wave oscillation at the opamp output that switches between zero and Vs at a rate of about 1/2RC Hz where C is the 1μF capacitance and R is R2 plus the Pot value. This results in the following user variable frequency range:

1/(2 x 1μF x 470Ω) = **1063 Hz** to 1/(2 x 1μF x 100,470Ω) = **5 Hz**

However, the waveform chosen for the next U1B opamp stage is not the square wave but the somewhat triangle-looking, same frequency, waveform at the capacitor. This is connected to the non-inverting (+) input of the U1B opamp. Opamp inputs have very high input impedances giving this second stage an ideal buffer feature guaranteeing that connecting the capacitor to this second stage will not interfere with the capacitor's charging and discharging work.

When Switch S1 is open, the U1B acts as a comparator comparing the triangle wave voltage with a user variable DC voltage selected on an external 10k linear potentiometer. The comparator output then becomes a variable pulse width waveform as illustrated in the diagram below.



When the Switch S1 is closed the opamp becomes a Voltage Follower with the output simply following the input triangle wave. In this case the variable DC voltage at the pot is overridden by the direct opamp output connection.

The Triangle wave output oscillates between peak values of 0.2 volts and Vs/2. The pulse waveform oscillates between zero and Vs. The final diode and low pass RC filter were used to soften the distortion effect in the next stage and prevent harsh clicking when using the pulse wave.

Mixer Stage

The next opamp stage with U2A is an audio mixer. The actual mixer circuit is external to the board. It is a passive resistor mixer with volume controls on each input. All the inputs are expected to be unipolar signals except for one. This one input allows for a bipolar signal by rebiasing the signal to 2/3 Vs with a blocking capacitor and a resistor divider. All of this, again, is external to the PCB board. Most of the components can easily be mounted from the volume pot wipers.

Passive resistor mixers have the unfortunate property of attenuation. This 5 input resistor mixer will attenuate the inputs by 1/5. The U2A non-inverting opamp configuration will make up for this attenuation by amplifying the mixed signal with a gain of (1 + 100k/22k), or about 6.

Modulator

The next stage is a PN2222A NPN transistor which acts as a type of digital AM (Amplitude Modulation) modulator. The output of the opamp mixer stage is a positive voltage signal. This unipolar property enables the use of this unique type of distortion circuit.

Those familiar with transistor configurations may recognize this circuit as a common emitter transistor configuration with one strange difference, an audio signal is connected to the collector through 22k instead of the usual DC power supply voltage.

The base input signal, connected through a 100k resistor to the transistor base, drives the distortion of the mixer signal. This modulator base signal comes from either the Pulse/Triangle Waveform Generator, or an External Modulation signal, as selected by a prepatch switch in a miniphone jack. The amount of distortion is controlled by a volume control on the base input signal.

This simple transistor circuit has three states of operation.

1. When the base input voltage is at zero volts, the transistor is said to be in **CUTOFF** which is an inactive state. Nothing happens to the mixed signal on the collector lead and it is allowed to advance unaffected to the output opamp U2B.

2. When the base input voltage is high enough, the transistor goes into **SATURATION**. This is an extremely active state which clamps the collector voltage to zero volts effectively shutting off the mixer signal.

3. A small range of base input voltages between zero volts and the higher voltages causing saturation, will put the transistor into its **ACTIVE** state. In this state the mixer signal is allowed to pass on, but with attenuation. Rising base input voltages cause more and more attenuation until the mixer signal disappears when saturation voltages are finally reached.

It must be noted that both the base input voltage and the collector mixer signal voltage affect the saturation and active states. It takes more base input voltage to drive a higher mixer collector voltage into saturation than it would for a smaller collector voltage.

To put this picture together, imagine a slow square wave base input signal switching the transistor state between cutoff and saturation. The mixed signal output will alternate between full signal and silence at the rate of the base square wave.

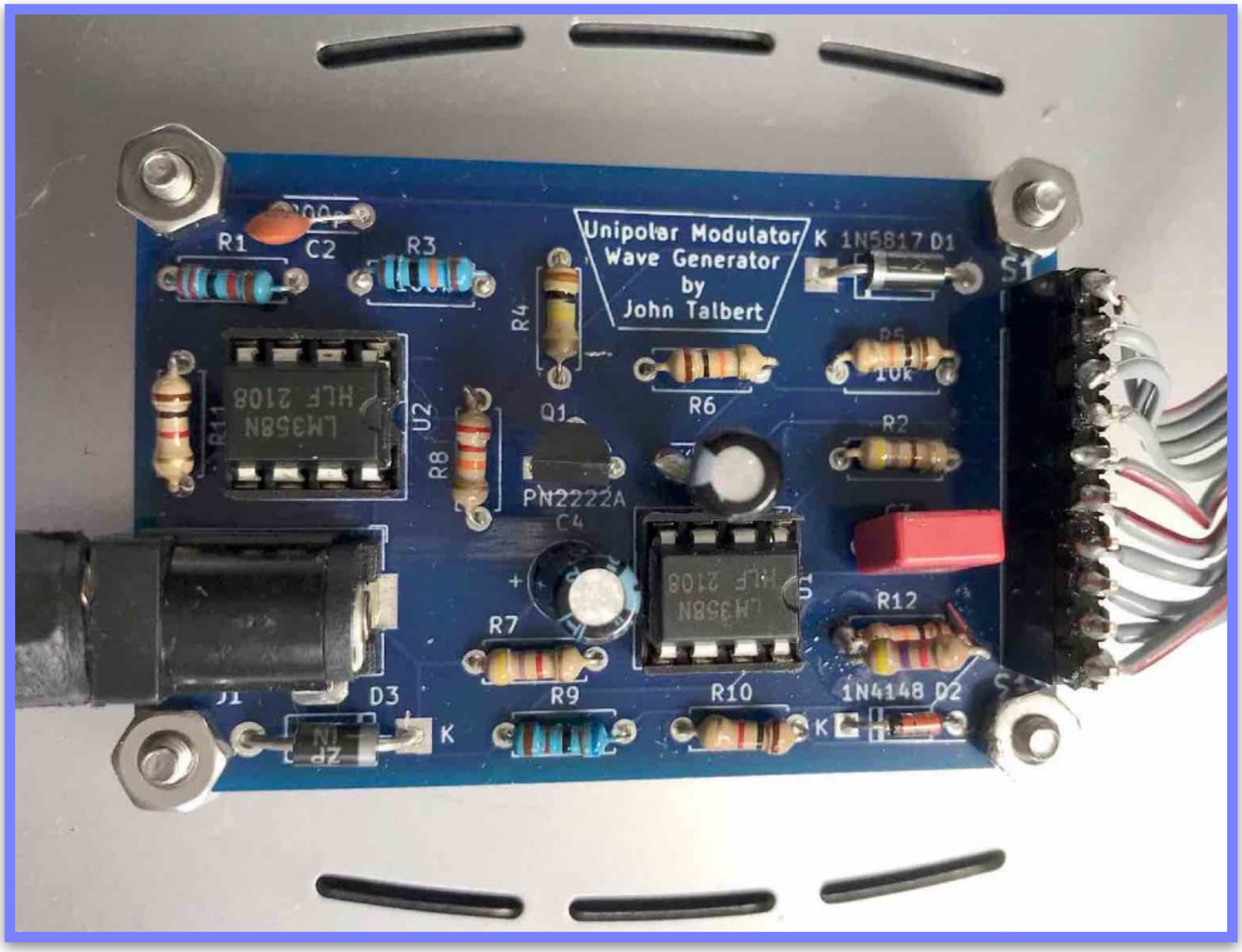
Turning down the volume control on the square wave will move the saturated state into the active region. Those periods of silence will turn into low volume signal. The output will alternate between full signal and attenuated signal, a type of amplitude modulation (AM). Turning the volume control all the way to zero will effectively turn off the modulation effect and allow the full mixed signal through.

Now imagine the effect of changing the modulation signal. Its frequency can go from low sub-audio frequencies where you can hear the alternating changes, to audio frequencies where you get a complex AM type of modulation. Changing the waveform of the modulation signal will move from abrupt alterations with a pulse wave to smoother AM alterations with the triangle wave.

This distortion circuit has another fortunate property. When the mixed signal goes to zero, or silence, the transistor is put into its cutoff or inactive state resulting in zero output. The distortion driving signal at the transistor base will not feed through to the mixer output when the mixed signal is silent.

Final Stage

The final op amp U2B stage is a Voltage Follower with that useful buffering feature that prevents any output connection from interfering with the Transistor's modulation operation.


Unipolar Modulator
Wave Generator
by
John Talbert
R1
C2
R3
R4
K 1N5817 D1
S1
R6
R2
Q1
PN2222A
C4
U2
R8
R11
LM358N
R12
R7
R9
R10
1N4148 D2
J1
D3
K