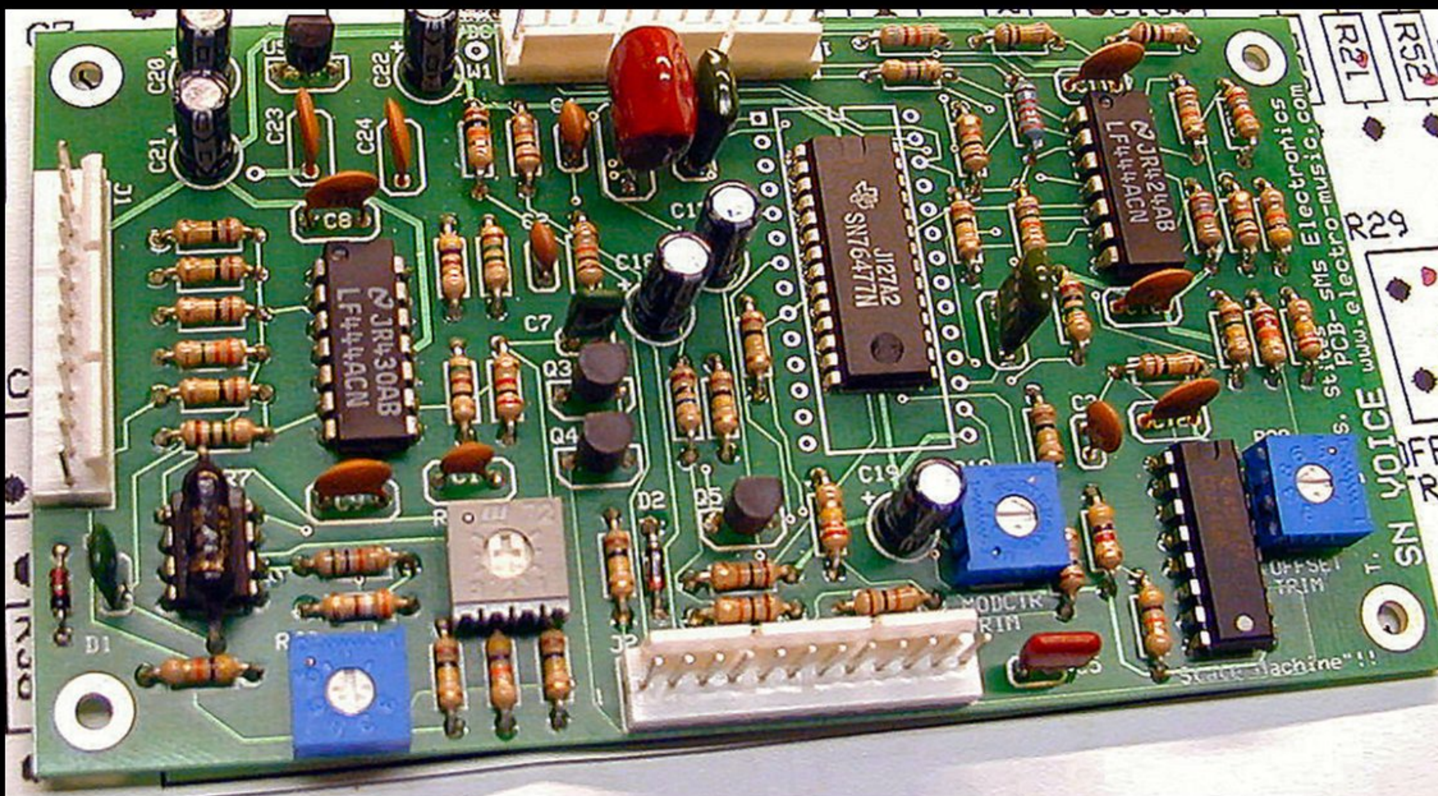


sMs Audio Electronics

DIGITAL & ANALOG

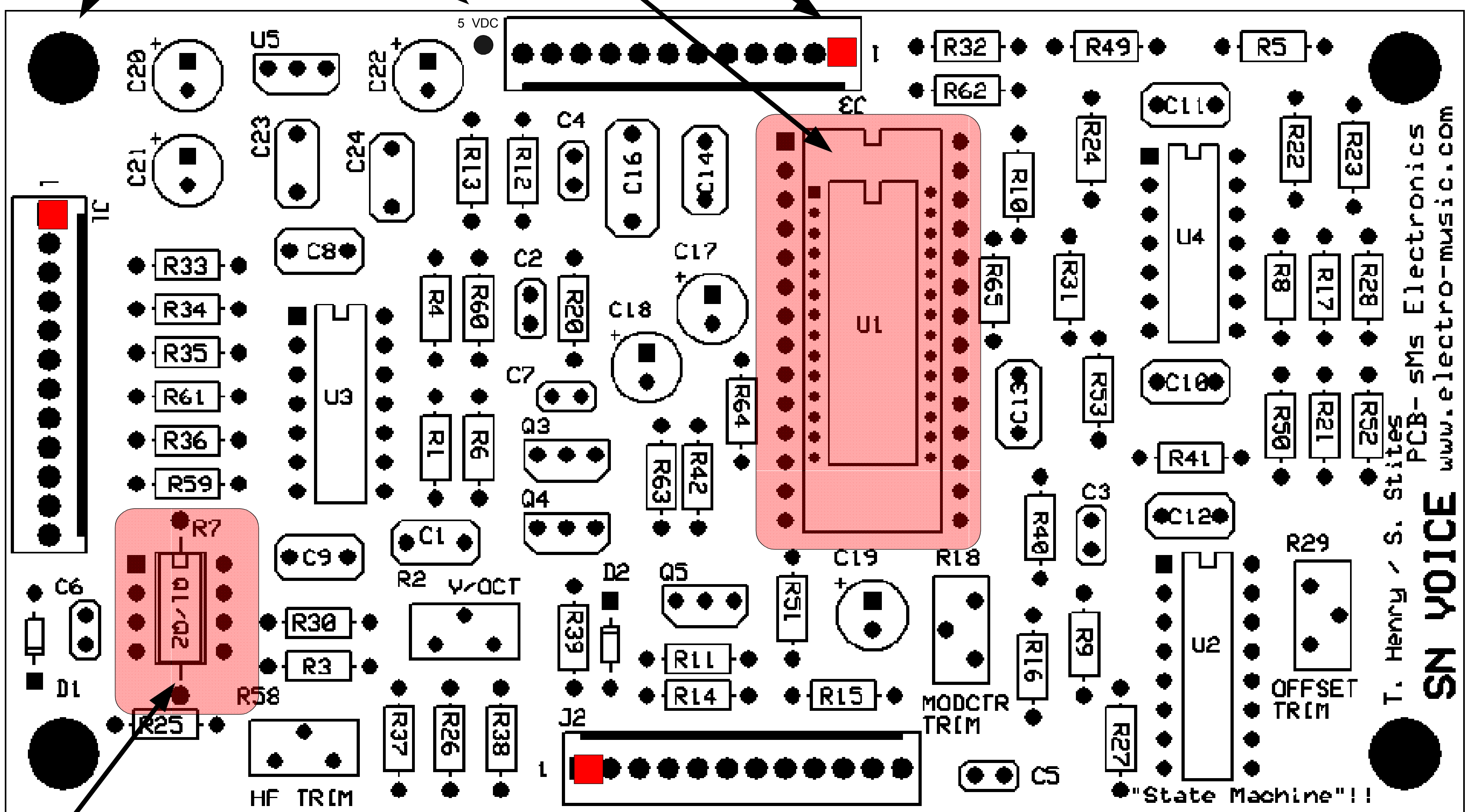
MUSIC PRODUCTS

Use either 0.6" or 0.4" DIP Soldertail DIP Socket

0.25" PAD, 0.125" MTG. HOLE X4

TO S5

Please observe polarity of all connector headers when constructing mating connectors



After soldering Q1/Q2 package, solder R7 TEMPCO resistor in place such that it comes in contact with the package. Use thermal compound to create a fillet between R7 and Q1/Q2 to aid in matching the temperature of both devices.

sMs Electronics

SN VOICE

PCB PARTS LAYOUT

PARTS LIST

Fixed resistors are 1/4-watt, 5% values.

R1	51Ω
R2	100Ω trimmer
R3	390Ω
R4	470Ω
R5	1k
R6	2k
R7	2k, +3500ppm/°C thermistor
R8	2.7k
R9	4.7k
R10 - R17	10k
R18	10k trimmer
R19	10k linear potentiometer
R20	11k
R21	12k
R22	18k
R23	27k
R24	33k
R25 - R28	47k
R29	50k trimmer
R30	56k
R31	75k
R32	82k
R33 - R42	100k
R43 - R48	100k linear potentiometer
R49	110k
R50	150k
R51, R52	220k
R53	1M
R54 - R57	1M linear potentiometer
R58	1M trimmer
R59, R60	1.5M
R61	3.3M
R62	4.7M
R63	10M

NOTE: For 1Hz to 16KHz operation without pulse width modulation, replace R21 with 8.2k and R50 with 270k. Then dial trimmer R18 to its lowest position (ground).

All capacitors are 16V or better.

C1, C2	100pF disc
C3, C4	470pF disc
C5	470pF poly
C6, C7	0.001μF mylar
C8 - C12	0.01μF disc
C13	0.022μF mylar
C14	0.047μF mylar
C15	0.22μF mylar
C16	0.47μF mylar
C17 - C19	4.7μF electrolytic
C20 - C22	10μF electrolytic

Semiconductors

D1, D2	1N4148 diode
Q1/Q2	LM394 matched transistor pair
Q3 - Q5	2N3904
IC1	SN76477
IC2	4046 phase locked loop
IC3, IC4	LF444 quad op-amp

Other components

J1 - J10	1/4" phone jack, n.o.
S1, S2	SPST toggle switch
S3	SPDT toggle switch
S4, S5	SP3T rotary switch

Miscellaneous: printed circuit board, IC sockets, front panel, knobs, wire, solder, heat sink grease, etc.

Additional Components and Notes for sMs PCB:

Resistors

R64, R65	100K

Capacitors

C23,C24	0.01 uF disc

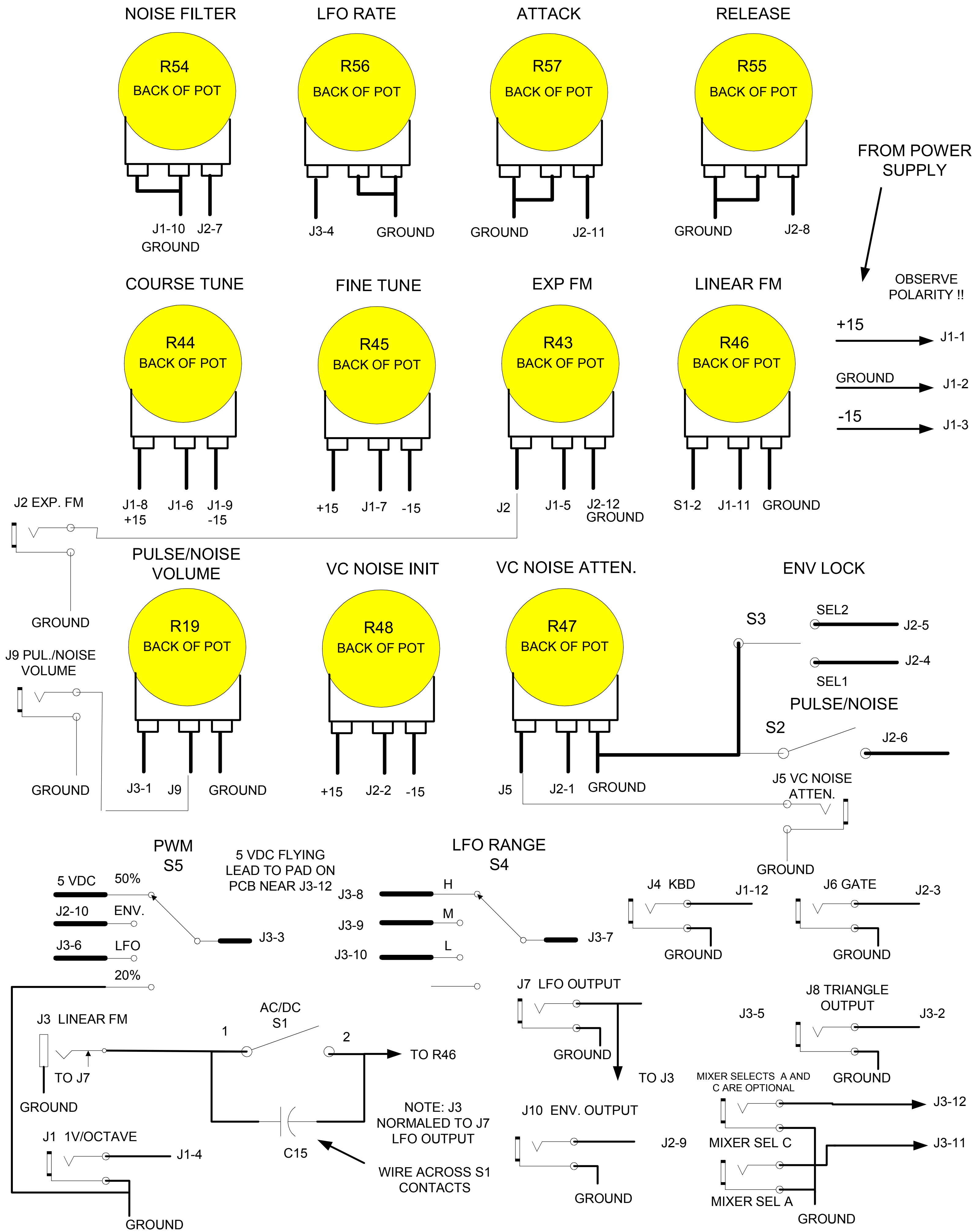
Semiconductors

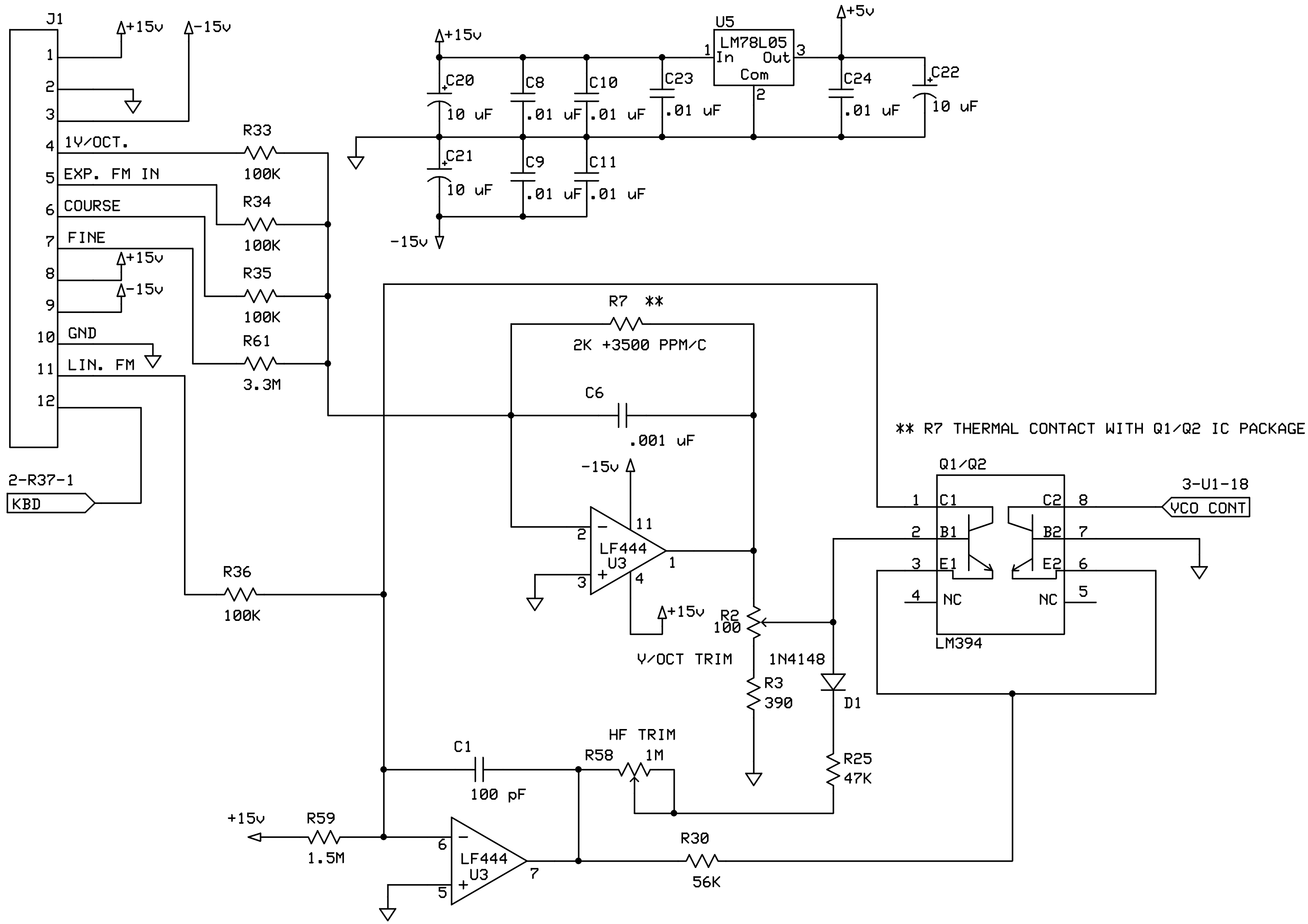
IC5	78L05 5V Linear Regulator

NOTES:

C15 Mounted at S1 on control panel

LM394 should be ordered in the DIP package

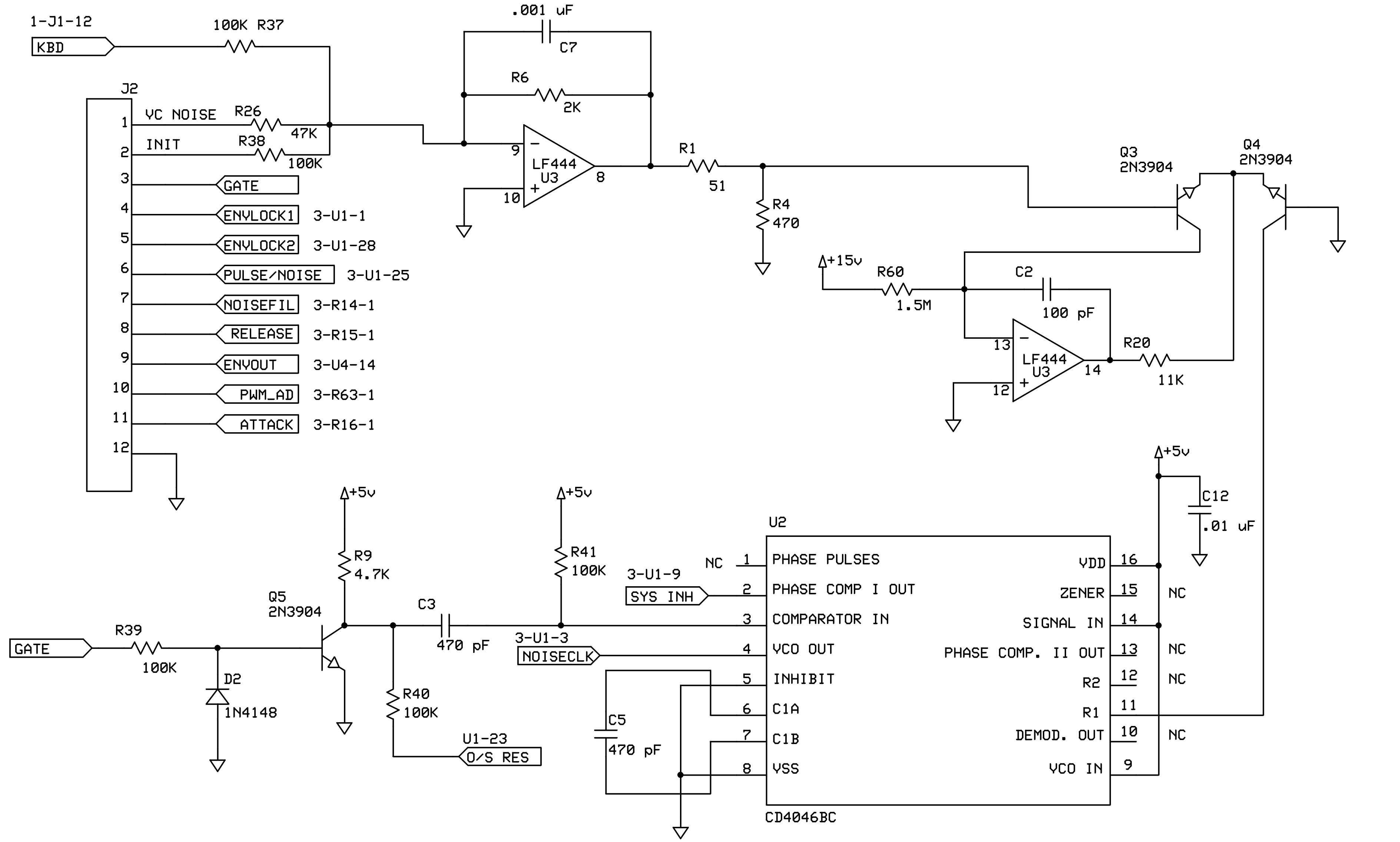

NOISE FILTER
R54
BACK OF POT
J1-10
J2-7
GROUND
LFO RATE
R56
BACK OF POT
J3-4
GROUND
ATTACK
R57
BACK OF POT
GROUND
J2-11
RELEASE
R55
BACK OF POT
GROUND
J2-8
FROM POWER SUPPLY
OBSERVE POLARITY !!
+15
J1-1
GROUND
J1-2
-15
J1-3
COURSE TUNE
R44
BACK OF POT
J1-8
+15
J1-6
J1-9
-15
FINE TUNE
R45
BACK OF POT
+15
J1-7
-15
EXP FM
R43
BACK OF POT
J2
J1-5
J2-12
GROUND
LINEAR FM
R46
BACK OF POT
S1-2
J1-11
GROUND
J2 EXP. FM
GROUND
PULSE/NOISE VOLUME
R19
BACK OF POT
J3-1
J9
GROUND
J9 PUL./NOISE VOLUME
GROUND
VC NOISE INIT
R48
BACK OF POT
+15
J2-2
-15
VC NOISE ATTEN.
R47
BACK OF POT
J5
J2-1
GROUND
ENV LOCK
S3
SEL2
J2-5
J2-4
SEL1
PULSE/NOISE
S2
J2-6
J5 VC NOISE ATTEN.
GROUND
PWM
S5
5 VDC
50%
J2-10
ENV.
J3-6
LFO
20%
J3-3
5 VDC FLYING LEAD TO PAD ON PCB NEAR J3-12
LFO RANGE
S4
J3-8
H
J3-9
M
J3-10
L
J3-7
J4 KBD
J1-12
GROUND
J6 GATE
J2-3
GROUND
J3 LINEAR FM
TO J7
GROUND
AC/DC
S1
1
2
TO R46
C15
NOTE: J3 NORMALED TO J7 LFO OUTPUT
WIRE ACROSS S1 CONTACTS
J1 1V/OCTAVE
J1-4
GROUND
J7 LFO OUTPUT
GROUND
TO J3
J10 ENV. OUTPUT
J2-9
GROUND
J3-5
J8 TRIANGLE OUTPUT
J3-2
GROUND
MIXER SELECTS A AND C ARE OPTIONAL
J3-12
MIXER SEL C
J3-11
MIXER SEL A
GROUND



Drawn by sMs Electronics

SN Voice

Thomas Henry	Rev 1.0 10/18/2006	Page 1 of 3



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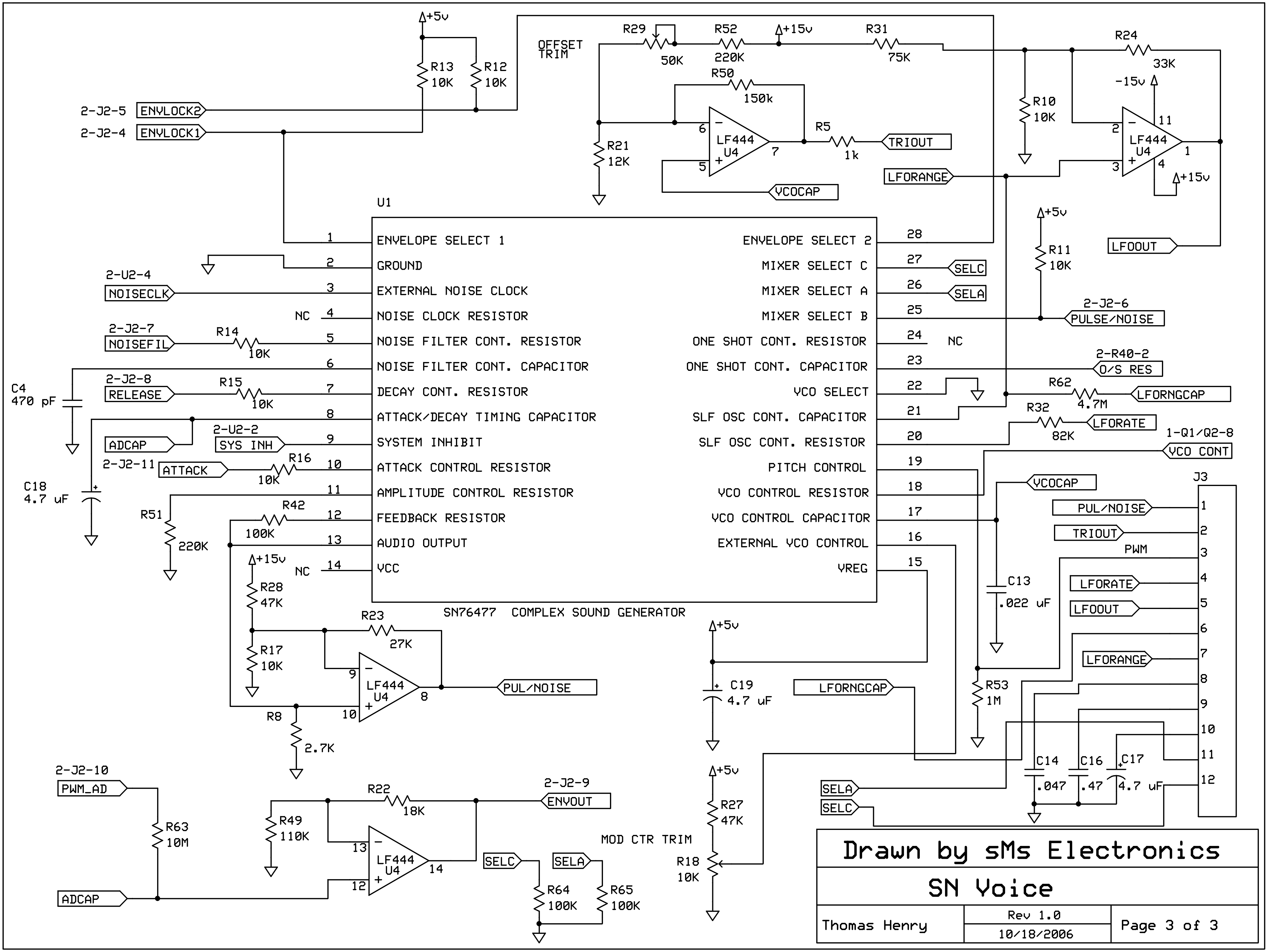
SN Voice

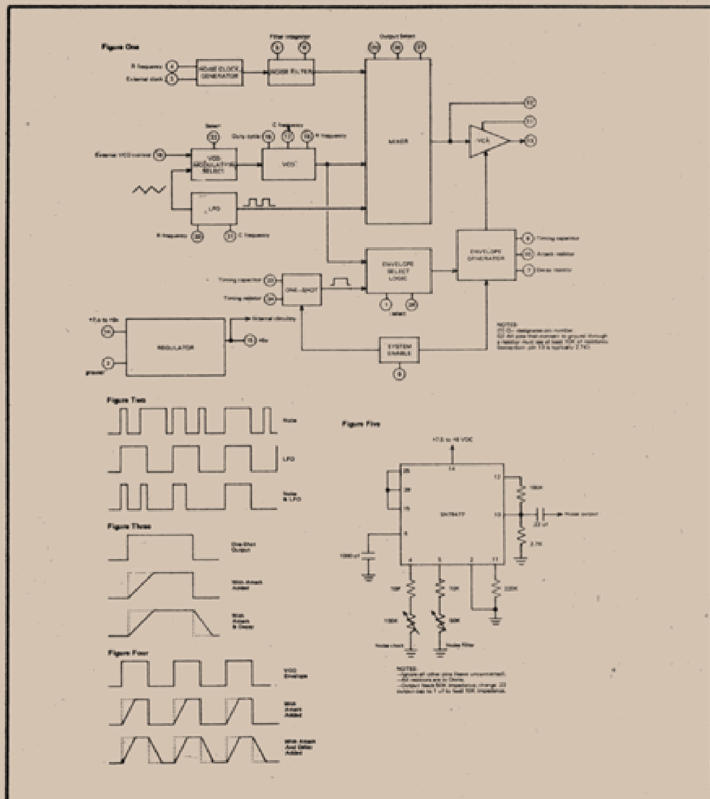
Thomas Henry	Rev 1.0 10/18/2006	Page 2 of 3



Drawn by sMs Electronics
SN Voice
Thomas Henry
Rev 1.0
10/18/2006
Page 3 of 3
SN76477 COMPLEX SOUND GENERATOR
U1
ENVELOPE SELECT 1
GROUND
EXTERNAL NOISE CLOCK
NOISE CLOCK RESISTOR
NOISE FILTER CONT. RESISTOR
NOISE FILTER CONT. CAPACITOR
DECAY CONT. RESISTOR
ATTACK/DECAY TIMING CAPACITOR
SYSTEM INHIBIT
ATTACK CONTROL RESISTOR
AMPLITUDE CONTROL RESISTOR
FEEDBACK RESISTOR
AUDIO OUTPUT
VCC
ENVELOPE SELECT 2
MIXER SELECT C
MIXER SELECT A
MIXER SELECT B
ONE SHOT CONT. RESISTOR
ONE SHOT CONT. CAPACITOR
VCO SELECT
SLF OSC CONT. CAPACITOR
SLF OSC CONT. RESISTOR
PITCH CONTROL
VCO CONTROL RESISTOR
VCO CONTROL CAPACITOR
EXTERNAL VCO CONTROL
VREG
NC
2-J2-5 ENVLOCK2
2-J2-4 ENVLOCK1
2-U2-4 NOISECLK
2-J2-7 NOISEFIL
2-J2-8 RELEASE
ADCAP
2-U2-2 SYS INH
2-J2-11 ATTACK
2-J2-6 PULSE/NOISE
2-R40-2 O/S RES
LFORNGCAP
LFORATE
1-Q1/Q2-8 VCO CONT
VCOCAP
SELC
SELA
TRIOUT
LFORANGE
LFOOUT
PUL/NOISE
PWM
2-J2-10 PWM_AD
2-J2-9 ENVOUT
OFFSET TRIM
MOD CTR TRIM
R29 50K
R52 220K
R31 75K
R50 150k
R5 1k
R21 12K
R24 33K
R10 10K
R11 10K
R13 10K
R12 10K
R14 10K
R15 10K
R16 10K
R42 100K
R51 220K
R28 47K
R17 10K
R23 27K
R8 2.7K
R62 4.7M
R32 82K
R53 1M
R27 47K
R18 10K
R63 10M
R49 110K
R22 18K
R64 100K
R65 100K
C4 470 pF
C18 4.7 uF
C13 .022 uF
C19 4.7 uF
C14 .047
C16 .47
C17 4.7 uF
LF444 U4
J3
+5v
+15v
-15v

TECH NOTES

Texas Instruments SN 76477



ILLUSTRATIONS: COLIN GARDNER

Electronic music functions are generally not difficult to integrate on a single chip; witness parts like the 3080, basically a VCA on a chip, and the 566 and 8038ICs, which are multi-waveform oscillators on a chip. However, electronic music does not represent a very significant slice of the total semiconductor market, so manufacturers have been hesitant to invest in ICs specifically designed for electronic music. An exception is the Solid State Music series of electronic music ICs, but since these are not produced in the vast quantities characteristic of semiconductor houses, they are essentially custom chips and carry a custom price tag.

While the SN76477 is not exactly an electronic music IC (it was designed to produce sound effects in video games and other mass market items), there are several features of great interest to electronic music experimenters. The SN76477 is a 28 pin IC, and may be thought of as a bunch of sound generating blocks integrated into a single package. These blocks are: Square wave VCO with voltage control input and variable duty cycle output; Square (and triangle wave) LFO, may also be used for audio frequencies; Shift register type white noise generator; Envelope generator with attack/sustain/decay/ functions; VCA and output stage; On-chip voltage regulator; Switched mixer.

Before going any further, I'd like to emphasize that this is a digital, on/off type of part. The oscillators basically produce square wave outputs; the white noise output is a bunch of pulses with randomly varying width and frequency; and the mixer is not an analog mixer, but rather a mixer that can switch in various combinations of outputs. Nonetheless, there are ways to get around these limitations... and even if there weren't, the chip still presents a variety of useful functions.

Economically speaking, the SN7-6477 is not all that costly- around $2 to $4, depending on where and how you buy it. This means that even if you don't need all the functions available on the chip, you can afford to use just one function- say, the white noise generator- and just ignore the chip's other capabilities.

Figure 1 shows an overall diagram of the IC's innards. There are three audio signal sources capable of being passed through the mixer to the output: noise(s) appears at the mixer output. These pins respond to logic levels; ground them for 0 or low level logic, tie to pin 15 (the regulated +5V output that powers the system) for a 1 or high logic level. The chart below specifies which signals appear at the mixer output...

Pin 25	26	27	
0	0	0	VCO
0	1	0	LFO
1	0	0	Noise
1	1	0	VCO + noise
0	0	1	LFO + noise
0	1	1	VCO + LFO + noise
1	0	1	LFO + VCO
1	1	1	Inhibit (no output)

However, since this is a digital mixer remember that adding two signals together is equivalent to ANDing them logically. For example, if the LFO and noise are selected together, the noise will be turned on and off according to the frequency of the LFO (see Figure 2).

Ignoring the envelope generating circuitry for the time being, the mixer passes signals to an output amp (VCA). The output of this amp is an emitter follower stage, so pin 13 must connect to ground through a resistor (I generally use 2.7K). The feedback resistor sets gain; 100K in conjunction with the 2.7K resistor at pin 13 gives an output of about 2.8V peak-to-peak (i.e., 0 VU). A resistor from pin 11 to ground sets the overall amplitude capability of the output; I use about 220K. Too low a resistance can saturate the amp, but too high a value leads to a reduction in output. You might want to experiment with different values to obtain different types of effects.

Now let's consider the various signal generators. The noise clock needs a timing resistor from pin 4 to ground to set the frequency of the clock; a minimum value of 10K gives a high clock speed, while raising this resistance lowers the clock speed. Because the on-chip clock is limited in its range, you may disable it by connecting pin 4 to pin 15 (a high logic level) and feeding an external +5V clock to pin 3. By clocking at a very slow speed, for example, you may obtain very slow noise patterns which are similar to a random control voltage.

The noise filter requires a capacitor from pin 6 to ground, and a resistor from pin 5 to ground. These two components act as an integrator to alter the high frequency content of the noise generator, or "smooth out" the output waveform if you're using a low frequency clock. Tapping off the filter capacitor with a buffer stage gives yet another type of white noise/control voltage.

The VCO's basic frequency is set with a capacitor from pin 17 to ground and a resistor from pin 18 to ground. The duty cycle control pin, when connected to 2.5V or greater, gives a 50% square wave; when connected to 1V or less, the duty cycle drops to about 18%. Voltages in between 1V and 2.5V vary the duty cycle between 18% and 50%.

The frequency of the VCO is further controlled by the VCO modulation select, which may be thought of as a logic-controlled switch. With pin 22 at a low logic level, the frequency of the VCO depends on an external voltage present at pin 16. With pin 22 high, the VCO frequency is modulated by a triangle wave generated by the LFO (good for sirens, bird chirps, and the like).

The LFO is a similarly designed oscillator, with a resistor from pin 20 to ground and a capacitor from pin 21 to ground setting the output frequency. While designed as an LFO, it will go up to 20 KHz without any problems.

The envelope generator section is somewhat more difficult to understand, since there are several options not normally associated with standard envelope generators. There are also some limitations.

First of all, let's look at the **envelope select** logic block. This block has two pins which are logically controlled. With pin 1 low and pin 28 high, there is no envelope shaping at all and the output of the mixer passes directly to the output VCA. Under these conditions, with system enable pin 9 **high**, sound from the IC is disabled. With the system enable **low**, the IC is enabled.

With pin 1 low and pin 28 low, the VCO gates the signal on and off. When the square wave output of the VCO is high, the mixer output passes through the amp; when the VCO output is low, the amp is off. With sub-audio VCO frequencies, this produces a "square wave tremolo" type of effect. With pin 1 high and pin 28 high, the same basic effect occurs except that the amp is on during alternating cycles of the VCO. The system enable performs the same function as before: high for disabled, low for enabled.

Pin 1 high and pin 28 low gives our fourth option, one shot control; this is most like the traditional envelope generator. In this mode, the system enable pin performs two functions. First, when it is high, the IC is disabled; however, bringing pin 9 low and keeping it low not only enables the IC, but triggers the one-shot. The one-shot generates an output (i.e. turns on the amp) for a period of time dependent on the time constant set by a resistor to ground at pin 24 and a capacitor to ground at pin 23. When the one-shot timing cycle has ended, or when pin 9 goes high, the amp once more shuts off. To re-trigger the one-shot, pin 9 must be brought high and then low again.

However, you'll note that all the envelopes generated so far are simply on/off types, albeit of different lengths. To add attack/decay functions, we need to look at the envelope generator section.

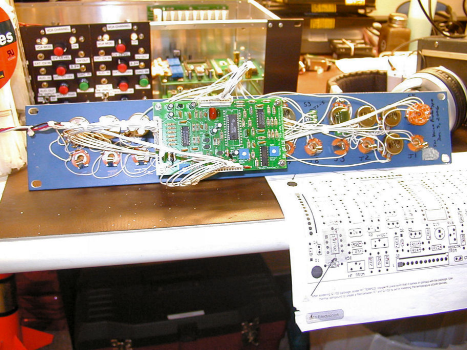
The capacitor connected from pin 8 to ground charges through the resistor connected from pin 10 to ground, setting the attack time; it discharges through the resistor connected from pin 7 to ground to give the decay time (actually, it is charged and discharged by current sources inside the chip... the attack time is part of the one-shot envelope, whereas the decay is added at the end of the envelope (see Figure 3). Therefore, you must make sure that if you have, say, 250 milliseconds of attack time, the one-shot generates an output for at least 250 milliseconds. A shorter one-shot period will either clip the attack time, or eliminate it altogether. The same constraint occurs with the VCO envelope (see Figure 4); the attack time must be less than or equal to the period of time that the VCO is high.

Finally, let's examine the power supply requirements. The chip is designed to take the 7.5 to 9V filtered but unregulated DC present in most computer/game systems at


SN-VOICE
VCO
Lin FM
DC
FM
LFO
Mid
High
Rate
LFO Out
CV1
CV2
CV2
Course
Fine
Tri Out
Pulse Sel.
Noise Sel.
MIX
Mix
Noise
PWM
Env.
20%
50/20 Sel.
NOISE
CV1
CV2
CV2
Init.
Filt.
Mix Out
Gate In
ENV
Gated
Resp.
Att.
Dec.
Env. Out

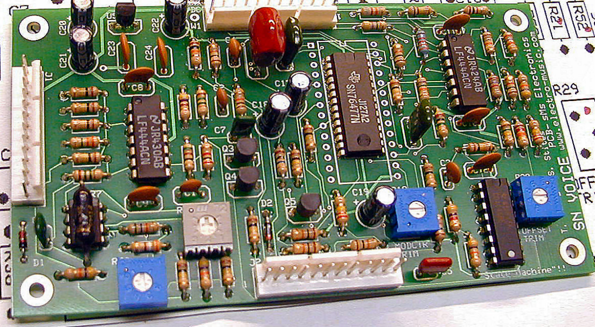

VOLTAGE CONTROLLED OSCILLATOR
ENVELOPE
L F O
NOISE MIXER


VCO
NOISE
LFO
Fixed
Envelope
Pulse+Noise
20%
50%
AR
PWM
Coarse Tune
AC
DC
A Mix
Noise
1V/Octave
Fine Tune
Exp FM
Linear FM
Triangle Out
Main Out
VCO
Fixed
Pulse+Noise
20%
PWM
Tune
AC
A Mix
1V/Octave
Fine
Exp FM
Linear FM
Triangle Out
Main Out
NOISE
LFO
ENVELOPE
GM
MIDI In



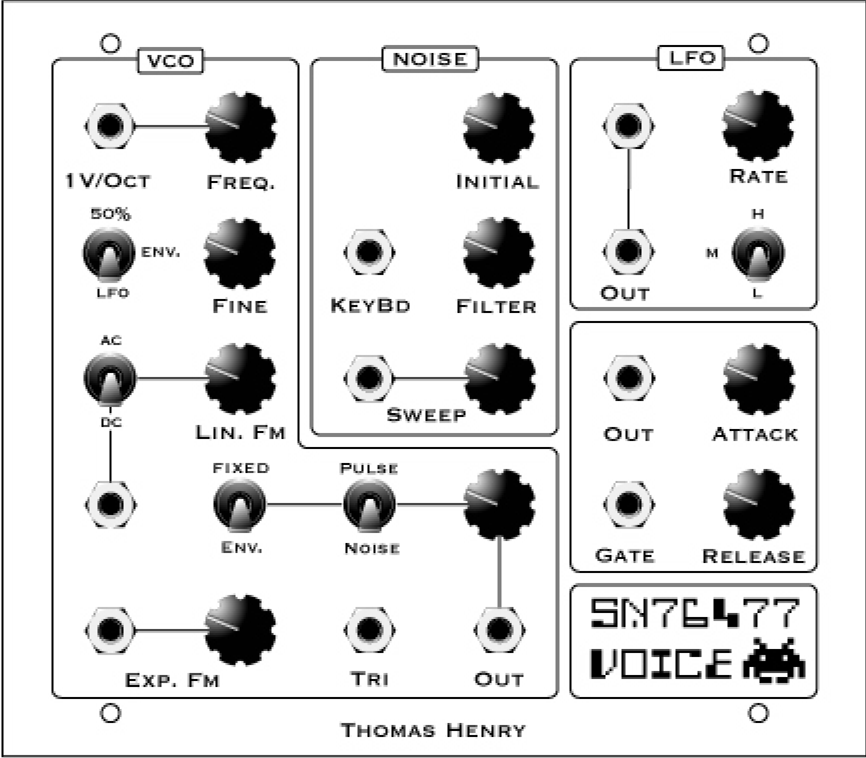

VCA CHANNEL
VCA MOD
CV
CV LEVEL
SN
voice
VCO
Envelope
PWM
COURSE
FINE
1V/OCT
EXP FM
LINEAR FM
FIXED
ENVELOPE
DC
TRIANGLE
NOISE
OUTPUT
NOISE / MIXER
INITIAL
FILTER
KEYBOARD
MIXER SELECTS
ENVELOPE
ATTACK
RELEASE
RATE
OUTPUT
GATE


VOLTAGE CONTROLLED OSCILLATOR
ENVELOPE
L F O
SN



SN VOICE
LF444ACN
SN76477N
LF444ACN
LF444ACN
OFFSET TRIM


VCO
LFO
Lin FM
AC
DC
Low
Mid
High
LFO Out
CV1
CV2
Fine
Tri Out
MIX
PWM
Pwm Sel.
Noise Sel.
Pwm
Mix
Noise
LFO
Env.
50%
20%
50/20 Sel.
NOISE
CV1
CV2
CV2
Init.
Filt.
Mix Out
ENV
Gate In
Locked
Gated
Resp.
Att.
Dec.
Env.Out
THOMAS HENRY


VCO
NOISE
LFO
1V/OCT
FREQ.
INITIAL
RATE
50%
ENV.
LFO
FINE
KEYBD
FILTER
H
M
L
OUT
AC
DC
LIN. FM
SWEEP
OUT
ATTACK
FIXED
ENV.
PULSE
NOISE
GATE
RELEASE
EXP. FM
TRI
OUT
SN76477
VOICE
THOMAS HENRY


SN76477 voice
fine
pwm
ac
dc
50%
env
lfo
lin FM
exp FM
fixed
env
noise
filter
pulse
noise
tri
pls/nse
range
high
mid
low
out
LFO rate
gate
attack
env
Thomas Henry