FM Audio/Squelch Board

by Steve Dold, W6KCS

stevedold1960 (at) gmail (dot) com

Board hardware version 7-18
Firmware version 7.x
Manual revision 29

This board connects to an FM receiver's discriminator/detector and provides squelched, de-emphasized, CTCSS-filtered audio and an active-high or low carrier operated switch (COS) output for driving repeater controllers or other devices. A speaker amplifier with volume control is also provided.

This board requires only a single connection to the receiver's discriminator, and provides:

- COS output (active high or low, jumper-selectable)
- CTCSS-filtered, de-emphasized audio to drive a repeater controller or other device
- Speaker amplifier with on-board volume control, and provision for external volume control
- On-board squelch control
- Space on the board to install an optional CTCSS (PL) decoder
- Separate CTCSS logic output available for repeater controllers that use separate COS and CTCSS logic inputs (if optional CTCSS board is installed)
- When a CTCSS board is installed, optional temporary carrier-squelch operation when CTCSS is decoded and/or a transmitter is keyed (useful for a link or remote base)

The squelch tail (noise burst) length varies depending on the amount of receiver noise quieting. The length is about 15 milliseconds with a signal that is nearly full quieting and about 150 milliseconds with a noisy signal. The squelch has hysteresis; a signal that is just strong enough to open the squelch must drop by about 1-2 dB in strength for the squelch to close. These features allow the squelch to stay open on signals that are "picket fencing" rapidly. The method used for gating the audio ensures that no "pops" due to DC voltage changes, capacitor charging/discharging etc. occur when squelching or unsquelching, so the squelch tail is fairly quiet, being purely receiver noise.

Space is provided on the board to mount a CTCSS decoder such as a Comm-Spec TS-32 or TS-64. All of the necessary connections to the CTCSS board are provided as solder pads so that all of the interfacing to the outside (repeater controller, etc.) can be done using the 12-position terminal strip on the squelch board. If the CTCSS board is installed, several options are available for its operation:

- Carrier-squelch mode for one minute after decoding a valid CTCSS tone. This is useful if it is not necessary to have full-time CTCSS protection, for example:
  - A link receiver switching to carrier-squelch mode during a conversation to minimize the decode-time of the system so that the first words of transmissions are not "cut off."
  - A repeater protected with CTCSS when sitting idle, but going into temporary carrier squelch mode when it's being used so that users without CTCSS can join in.
- Carrier-squelch mode for one minute after a transmitter has been keyed, useful for:
  - The above-mentioned case of a link receiver, to put it into carrier-squelch temporarily when its associated transmitter has been keyed.
  - A remote base receiver where you'd like to have CTCSS protection most of the time, but want it to go into carrier-squelch mode temporarily when the transmitter is keyed.

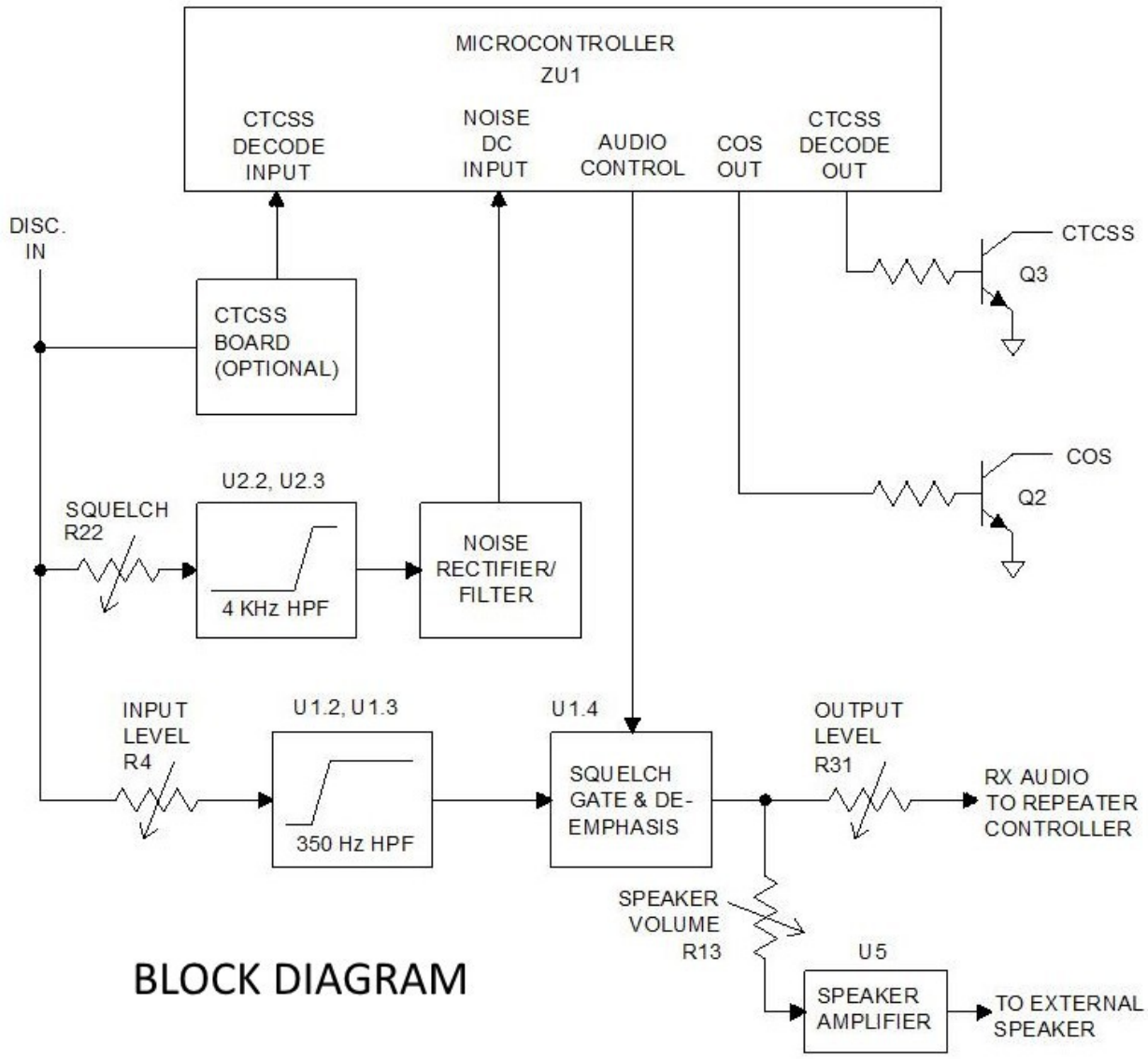
Installation

A plastic mounting plate with standoffs has been provided. The plate may be attached to any surface by drilling holes where needed, using double-sided tape, etc. Be sure to leave room for trimmer adjustments and terminal block screwdriver access.

Connections

All external connections are made to the 12-position terminal strip:

PIN	FUNCTION	
1	+12V	+11V to +18V DC in
2	GND	Ground
3	DISC IN	Input to the board from the receiver's discriminator; connect to the receiver's audio before any squelch or de-emphasis circuitry. The high side of the radio's squelch pot is often a good place to connect.
4	AUD OUT	Audio out to a repeater controller or other external device requiring low-level audio.
5	COS OUT	Carrier Operated Switch, an active-low or active-high output (set by JU1) when carrier squelch is open (signal present).
6	PTT/AUX	Auxiliary input to the microcontroller logic input. In this firmware version, connected to a transmitter's PTT line if using Options C or D.
7	HANG UP	Internally connects to the microphone hang-up line on the CTCSS decoder board, if installed. Ground this line to enable CTCSS decoder (CTCSS squelch), un-ground to disable (carrier squelch). Typically controlled by repeater controller open-collector on/off logic output or tie to ground for full-time CTCSS squelch. Note that there is a jumper on the board (JU-4) that also does this if you want the CTCSS decoder to be permanently "on hook." Be sure to remove JU-4 if you plan to externally control CTCSS/Carrier squelch mode using this connection.
8	ENC OUT	CTCSS Encoder output. This can be used to route the CTCSS board's encode tone output (if used) to a transmitter.
9	DEC OUT	CTCSS Decode. An active-low or active-high output (set by JU3) when CTCSS decoder (if installed) is decoding the proper tone.
10	VOL HIGH	To the high side of an external speaker volume pot (if used), JU2 must also be set to "EXT" and the internal volume control set to max level desired.
11	VOL LOW	From wiper of external speaker volume pot. Also connect the low side of the pot to ground.
12	SPKR	To high side of external 8 ohm speaker. Connect other side of speaker to ground.



Circuit Description

Discriminator audio is applied to J2, terminal 3. This audio goes to three circuits: a 4000 Hz high pass filter, a 350 Hz high pass filter, and the CTCSS board (if installed).

The 4000 Hz high-pass filter (U2) removes the voice audio, leaving the high-frequency noise component that is present on weak signals (or no signal). The noise is detected by D1 and D4, and filtered by C28 and R10. The detected noise level is monitored by the microcontroller (ZU1) which controls audio squelch gate U1.4 via Q1. The detected level can be monitored on TP1 with a voltmeter or an oscilloscope. It should be about 4.5V with no signal (full noise) and 0V with a full-quieting signal.

When the microcontroller senses a reduction in detected noise level, it opens the audio squelch gate (U1.4) and sends an active-high COS signal to J2 terminal 5, either directly or through inverter Q2 which changes the COS output to an active-low open collector. When the signal becomes weak or disappears, the microcontroller squelches the audio and de-activates the COS after about 150 milliseconds if the signal was noisy, or about 15 milliseconds if the signal was close to full quieting.

The discriminator audio also passes through input buffer amp U1.1, then through 350 Hz high-pass filter U1.2 and U1.3 that (mostly) removes any CTCSS component. The audio then passes through the squelch gate/de-emphasis circuit U1.4 and on to J2-4 to feed an external repeater controller or other device. Part of this audio also feeds speaker amplifier U5.

Special-case modifications:

- If you do not want the board to de-emphasize the audio, remove capacitor C6. The speaker audio will sound very "tinny" if you do this, and you may want to add an external resistor between the J2 VOL-HIGH and VOL-LOW terminals and set JU2 to "EXT" to reduce the audio amplifier gain.
- If you do not want the board to squelch the audio, you may remove Q1.

Internal vs. External volume control

The speaker amplifier can drive an 8-ohm speaker with up to about 300 milliwatts of audio. The volume is controlled by either the on-board volume potentiometer R13 or an external volume control, possibly mounted to a panel. If the on-board volume control is used, JU2 is set to position "INT" (internal). If an external volume control is needed, JU2 is set to position "EXT" and an external 10K to 20K pot is used.

Connect the high-side of the external pot to J2-10 (VOL HIGH), the wiper to J2-11 (VOL LOW), and the low-side to ground. R13 must still be set to some non-zero point, which determines the maximum volume level obtainable with the external control.

JU1-JU4 jumper settings (not the four Option A through D jumpers)

JU1 sets the polarity of the COS output. The "L" (active low) position provides an open collector output on squelch-open. Maximum current should be kept below 500 mA, and if used to drive an external relay coil, a suppression diode should be installed across the coil to prevent damage to the transistor. The "H" (active high) position gives +5V at a maximum of 40 mA (20 mA recommended) on squelch-open.

JU2 is set to "INT" if the internal volume control (R13) is used, and to "EXT" if an external volume control is used or an external resistor is installed to limit the maximum level using the on-board pot.

JU3 sets the polarity of the CTCSS decode output logic signal. "L" is active low, "H" is active high. The same current limitations as JU1 apply.

JU4 connects the CTCSS board hang-up line to ground to enable CTCSS protection. If left open, and with nothing grounding the hang-up terminal on J2, the CTCSS board will be in monitor (carrier squelch) mode. Leave JU4 off if a repeater controller will ground or un-ground the hang-up line to select CTCSS or carrier squelch.

Adjustments

If a CTCSS board is installed, leave the Options A-D jumpers out for now.

With power applied and the receiver's discriminator feeding the input (J2-3), make sure there is no signal present in the receiver (noise only). Rotate R22 fully counter-clockwise; the CSQ (carrier-squelch) LED should turn on indicating unsquelch. Noise should be heard if a speaker is installed and the speaker

volume pot (R13) is adjusted above minimum, around ¼ turn or so. Rotate squelch control (R22) clockwise until the LED just turns off and the audio mutes (squelches), plus another half turn or so. Generate a signal into the receiver to confirm that the squelch opens and closes when carrier is on and off. After testing, R22 can be adjusted a little either way to make the squelch open and close at the desired quieting levels.

Generate a full-quieting signal into the receiver with a 1000 Hz tone at full system deviation (typically +/- 5 KHz or +/- 2.5 KHz). Measure TP2 with an AC voltmeter and adjust R4 (Input Gain) for 250 mV RMS.

If a test signal with tone is not available, a reasonably good setting can be made by adjusting R4 for about 280 mV RMS on an AC voltmeter using discriminator noise with no signal.

Adjust R31 (output level) for the desired audio level into your repeater controller, transmitter, or other device.

Finally, set JU1-4 and option jumpers A-D for the operation desired (see table below).

Option jumpers A through D

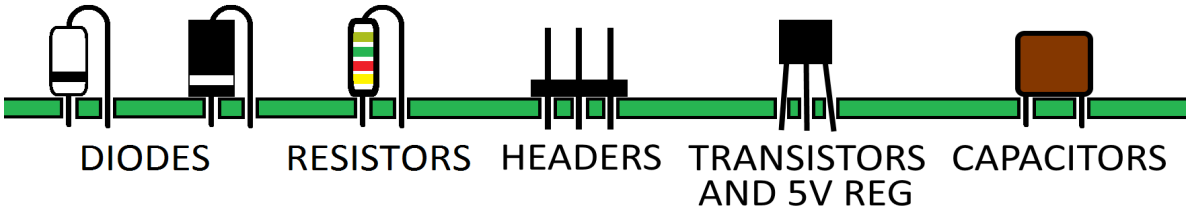
Firmware version 7	JUMPER IN	JUMPER OUT
Option A	"And" squelch. Install this jumper only if a CTCSS board is installed. Audio output (J2-4) and COS (J2-5) are active only if a valid CTCSS tone is being received. Removing this jumper is useful to temporarily put the CTCSS squelch into "monitor" mode.	Separate COS and CTCSS outputs. Audio and COS are available even if no valid CTCSS is present. A separate CTCSS decode output is available. This option is useful with repeater controllers that have a separate COS and CTCSS input. Leave this jumper out if no CTCSS board is installed.
Option B	If a CTCSS board is installed, decode is simulated for one minute (effectively, carrier squelch) after decoding valid CTCSS. Useful when talking to someone without a CTCSS encoder.	CTCSS works normally (must be continuous). Leave out if no CTCSS board is installed.
Option C	If a CTCSS board is installed, decoding is simulated for one minute after AUX input goes from low to high. Useful for putting a remote base receiver into carrier squelch for one minute after its transmitter is unkeyed.	Aux input has no effect on CTCSS operation. Leave out if no CTCSS board is installed.
Option D	Useful for links or remote bases. If AUX input is low, board will not provide COS output even if discriminator noise is muted (for example, by keying the remote base or link transmitter.)	Board will give COS output indication when discriminator noise is muted, either by receiving a carrier or by keying the transmitter (on transceivers).

Assembly

A board layout is included at the end of this manual, and it may help to keep it handy during assembly. Several photos of the completed board are available at stevedold.com that may be useful as well.

Parts are supplied in several bags to make sorting easier. Parts may be installed in any order desired, but the easiest and least error-prone way is to install one parts bag at a time as described below, starting with Bag #1.

Check off each part as it is installed to keep track of your progress. Most of the parts are installed as shown below. Resistors and diodes are installed vertically to save board space. Diodes are installed with the band (cathode) end down, against the board, over the larger circle on the PCB silkscreen.

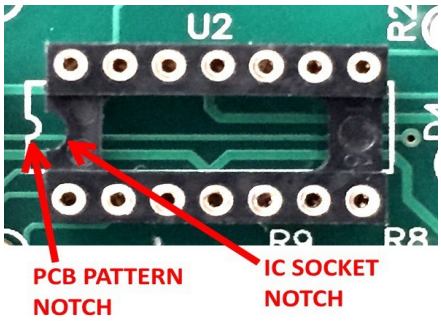


Before starting assembly, remove the PC board from the plastic mounting plate by unscrewing the four screws holding the board to the standoffs.

Bag #1

Leave the ICs on the foam pad for now, they will be inserted into the sockets after the board is completed and some voltage tests have been made.

Install the four IC sockets. Be certain these are oriented correctly! The notch in one end of the socket corresponds to a similar notch on the PC board pattern:

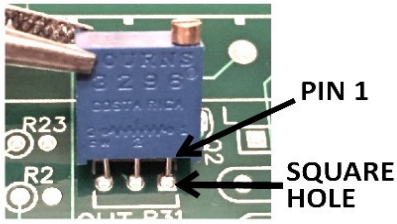


It's easiest to solder two pins on opposite corners first, and then inspect the socket to make sure that pin 1 is oriented correctly, all pins are visible on the back side, and the socket is completely flat against the board before soldering the remaining pins.

( ) SO1 14 pin socket for U1
( ) SO2 14 pin socket for U2
( ) SO3 28 pin socket for ZU1
( ) SO4 8 pin socket for U5

Pin 1 of the multi-turn potentiometers is directly below the trimmer, and should be installed in the square hole in the board, as shown below:

( ) R4 Potentiometer 100K multi-turn, may be marked “104”
( ) R13 Potentiometer 20K 1-turn, may be marked “203”
( ) R22 Potentiometer 20K multi-turn, may be marked “203”
( ) R31 Potentiometer 20k multi-turn, may be marked “203”



Bag #2

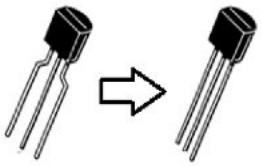
Install the ¼ watt 5% resistors. Be careful; some colors look similar. Again, please measure with an ohmmeter before installing. Install with the body of the part over the large circle on the PCB silkscreen.

( )	R33	10	brown, black, black, gold
( )	R32	470	yellow, violet, brown, gold
( )	R35	470	yellow, violet, brown, gold
( )	R25	1.3k	brown, orange, red, gold
( )	R18	2.7K	red, violet, red, gold
( )	R16	82K	gray, red, orange, gold
( )	R10	100k	brown, black, yellow, gold
( )	R3	10k	brown, black, orange, gold
( )	R7	10k	brown, black, orange, gold
( )	R8	10k	brown, black, orange, gold
( )	R12	10k	brown, black, orange, gold
( )	R17	1M	brown, black, green, gold
( )	R20	1M	brown, black, green, gold
( )	R24	270k	red, violet, yellow, gold
( )	R26	270k	red, violet, yellow, gold
( )	R5	470k	yellow, violet, yellow, gold
( )	R1	47k	yellow, violet, orange, gold
( )	R2	47k	yellow, violet, orange, gold
( )	R14	47k	yellow, violet, orange, gold
( )	R23	47k	yellow, violet, orange, gold
( )	R9	8.2k	gray, red, red, gold

Bag #3

Install the 5V regulator. It's included in this bag to distinguish it from similar-looking transistors in another bag. Make sure its orientation matches the pattern on the PC board. Instead of installing it flush with the board surface, install it slightly above the board with about 1/8” to 1/4” between the part and the board as shown below:

If the 5V regulator is supplied on tape with the legs bent and spread apart as shown at right, please straighten the leads with a needle-nose pliers before installing. This also applies to the three 2N4401 transistors installed later.

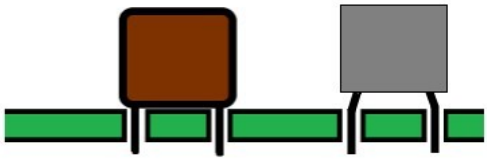


( ) U3 5V regulator, 78L05, small TO-92 case

Install the ¼ watt 1% tolerance resistors. They may have five color bands or be a single color with the value printed on them.

( )	R19	13k	brown, orange, black, red, brown or “1302”
( )	R28	22.1k	red, red, brown, red, brown or “2212”
( )	R15	2k	red, black, black, brown, brown or “2001”
( )	R27	2k,	red, black, black, brown, brown or “2001”
( )	R21	5.49k	green, yellow, white, brown, brown or “5491”

Install the non-polarized capacitors. They may be one of the two general types shown below. For example, the two caps in the picture appear different, but are the same value (0.047 uF), and are interchangeable. Install flush with the board as shown (if the hole spacing is more than the cap's lead spacing, they can be installed just slightly off the board):



There is something else to be careful of with the capacitors. Some have a lowercase “n” in the value, like “100n” or “3n3.” The lowercase “n” means “nano” as in “nanofarad.” If it's an uppercase “N”, it is not part of the part value. Look at the two examples below. The Panasonic cap on the left is **NOT** a 100 nF, because the N is uppercase, not lowercase. It's a 3.3 uF (335). The cap on the right **IS** a 100 nanofarad, because the “n” is lowercase. So when the parts list calls for a “100n”, look for a lowercase “n.”

PANASONIC 3.3 uF, 100V

KEMET 100 nF (0.1 uF), 100V

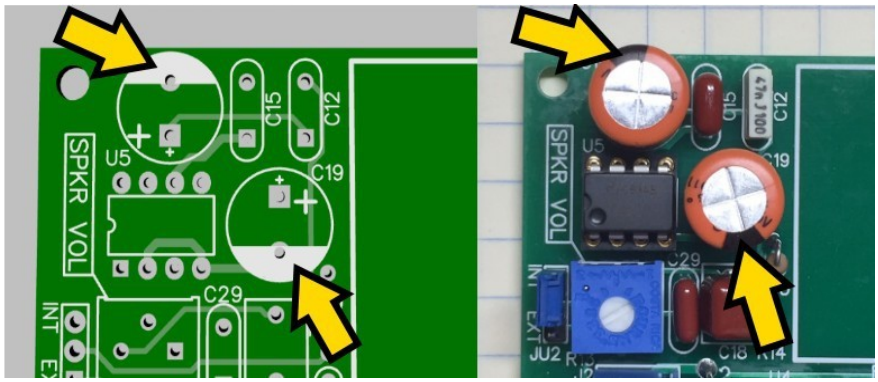
( ) C1 0.1uF may be marked “104”, “1j100” or “100n”
( ) C4 0.1uF may be marked “104”, “1j100” or “100n”
( ) C7 0.1uF may be marked “104”, “1j100” or “100n”
( ) C10 0.1uF may be marked “104”, “1j100” or “100n”
( ) C13 0.1uF may be marked “104”, “1j100” or “100n”
( ) C15 0.1uF may be marked “104”, “1j100” or “100n”
( ) C21 0.1uF may be marked “104”, “1j100” or “100n”
( ) C6 0.001uF may be marked “1.0”, “1n0” or “102”
( ) C29 0.001uF may be marked “1.0”, “1n0” or “102”
( ) C24 0.0015uF may be marked “1.5”, “1n5” or “152”
( ) C12 0.047uF may be marked “473” or “47n”
( ) C2 0.33uF may be marked “334”
( ) C11 0.33uF may be marked “334”
( ) C8 1uF may be marked “105” or “1J63”
( ) C14 1uF may be marked “105” or “1J63”
( ) C18 1uF may be marked “105” or “1J63”
( ) C28 1uF may be marked “105” or “1J63”
( ) C30 1uF may be marked “105” or “1J63”
( ) C22 0.0033uF may be marked “332” or “3n3”
( ) C23 0.0033uF may be marked “332” or “3n3”
( ) C25 0.0033uF may be marked “332” or “3n3”
( ) C26 0.0033uF may be marked “332” or “3n3”
( ) C27 0.0033uF may be marked “332” or “3n3”
( ) C3 0.033uF may be marked “333” or “33n”
( ) C5 0.033uF may be marked “333” or “33n”
( ) C9 0.033uF may be marked “333” or “33n”
( ) C17 0.033uF may be marked “333” or “33n”
( ) C20 0.033uF may be marked “333” or “33n”

Bag #4

Install the polarized electrolytic capacitors. The negative (minus) side is marked with a band containing a minus symbol and goes toward the silkscreen-filled white part of the circle as shown below. The positive side, which may be unmarked, goes toward the “+” symbol on the board,

( ) C16 220uF electrolytic
( ) C19 220uF electrolytic

YELLOW ARROWS AT RIGHT DENOTE NEGATIVE TERMINAL OF CAPACITOR ("−" BANDED SIDE)

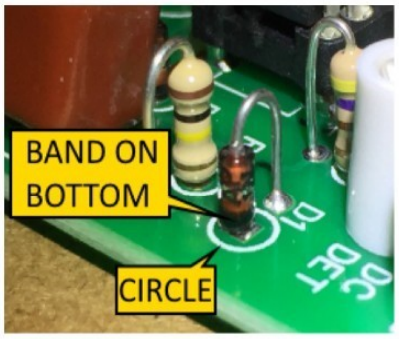


Install three NPN transistors. If necessary, straighten the leads as shown above for the 5V regulator, and leave about 1/8” to 1/4” between the part and the board.

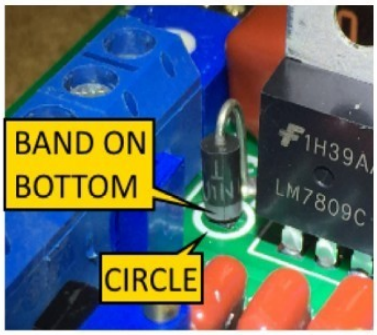
( ) Q1 NPN Transistor 2N4401
( ) Q2 NPN Transistor 2N4401
( ) Q3 NPN Transistor 2N4401

When installing diodes, make sure the **banded end** (or the end with the widest band if it has multiple bands) is **on the bottom, against the board**, in the hole with the silk screened circle. Please be careful here; installing diodes backwards is a very common mistake made during assembly.

( ) D1 Small glass diode 1N4148
( ) D4 Small glass diode 1N4148
( ) D5 Small glass diode 1N4148
( ) D7 Small glass diode 1N4148
( ) D3 1N4001 or 1N4005



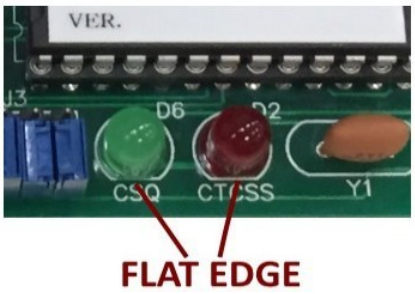
1N4148



1N4001 OR 1N4005

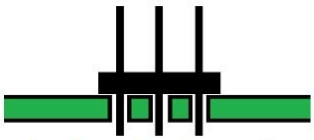
Install the two LEDs. Make sure the flat edge matches the flat edge on the PC board pattern.

( ) D6 LED, green, "CSQ"
( ) D2 LED, red, "CTCSS"



Install the 6-pin ICSP (programming) header J1, 8-pin option jumper header J3, and the JU1 through JU4 jumper headers. The short ends of the pins are soldered to the board, the long ends are for the push-on jumpers that will be added later.

( ) J1 2x3 header (6-pin)
( ) J3 2x4 header (8-pin)
( ) JU1 3-pin header
( ) JU2 3-pin header
( ) JU3 3-pin header
( ) JU4 2-pin header


Place headers firmly against the board as shown before soldering

Install four push-on jumpers onto jumper headers JU1-JU4 according to the "Jumper Settings" instructions above. If you're not sure of your requirements yet, jumper JU1 and JU3 in the "L" position (active low COS and CTCSS outputs), JU2 in the "INT" (internal volume control) position, and JU4 OUT.

Also install four jumpers on Option A through D, but leave out at this time (install on one pin only).

( ) JU-PIN 1 2-pin jumper (JU1)

( ) JU-PIN 2 2-pin jumper (JU2)
( ) JU-PIN 3 2-pin jumper (JU3)
( ) JU-PIN 4 2-pin jumper (JU4)
( ) JU-PIN 5 2-pin jumper (Option A)
( ) JU-PIN 6 2-pin jumper (Option B)
( ) JU-PIN 7 2-pin jumper (Option C)
( ) JU-PIN 8 2-pin jumper (Option D)

Install the two test jacks:

( ) TP1 Test jack
( ) TP2 Test jack

Install the 9V regulator U4. The heat sink tab faces the CTCSS board area. It doesn't pass much current, so it doesn't need a heat sink. You can put a piece of heat shrink tubing over it if you want to be sure that it doesn't short to something else.

( ) U4 LM7809 Voltage Reg (9V) TO-220 case

Install the 16 MHz resonator. This part looks like a brown disk ceramic capacitor with three leads and can be installed in either direction.

( ) Y1 Resonator 16 MHz

Install the 12-pin terminal strip. Be sure it is flat against the board before soldering, and that the wire installation openings are toward the edge of the board, not toward the middle. The terminal strip supplied with this kit will be either a full-length 12-position strip, or smaller (three or six position) strips that are first assembled into a 12-position strip and then soldered to the board. For the second type, assemble them by sliding the tab(s) of one into the slot(s) of the other.

( ) J2 12-position terminal strip

Voltage testing prior to IC installation

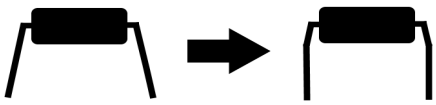
Before installing the ICs, it's a good idea to apply power to the +12V input and ground terminals and measure the voltages at the IC sockets to make sure the regulators are functioning correctly. You should measure +9V on the following pins:

( ) U1 pin 4 ( ) U2 pin 4 ( ) U5 pin 6

You should measure +5V on the following pins:

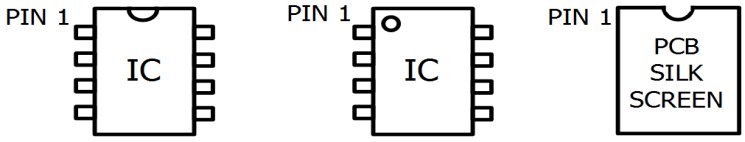
( ) ZU1 pins 7 and 20

If the above voltage tests pass, remove power and insert the four ICs. It might be necessary to press each IC sideways against a flat surface to bend each row of pins inward as necessary to allow insertion into the sockets. Use caution to prevent static discharge, especially with the microcontroller.



IC PINS (END VIEW)
BEND PINS INWARD TO ALLOW INSERTION INTO SOCKET

When inserting each IC into its socket, be certain that pin 1 faces the correct way. On the ICs, the pin 1 end is denoted by a notch or a dimple as shown below:



( ) U1 Quad op-amp TL084CN 14-pin DIP

( ) U2 Quad op-amp TL084CN 14-pin DIP

( ) U5 Audio amplifier IC LM386N 8-pin DIP

( ) ZU1 Microcontroller 28-pin DIP

This completes the board assembly. If you want to do a quick test, connect +12V and Ground, and if the "CSQ" LED flashes a few times, at least some of the board is working.

Installing the optional CTCSS board

Solder pads and board space are provided to install a CTCSS decoder board such as a Communications Specialists (Comm Spec) TS-32 or TS-64, Selectone ST-101, or any similar unit that samples discriminator audio and provides a ground closure when decoding.

The CTCSS board may be installed with double-sided tape or by using mounting hardware. Holes may be drilled in the PC board as long as they do not penetrate any traces. Be sure that the mounting hardware does not touch any traces. Set the CTCSS board's options to give an open-collector ground closure when decoding.

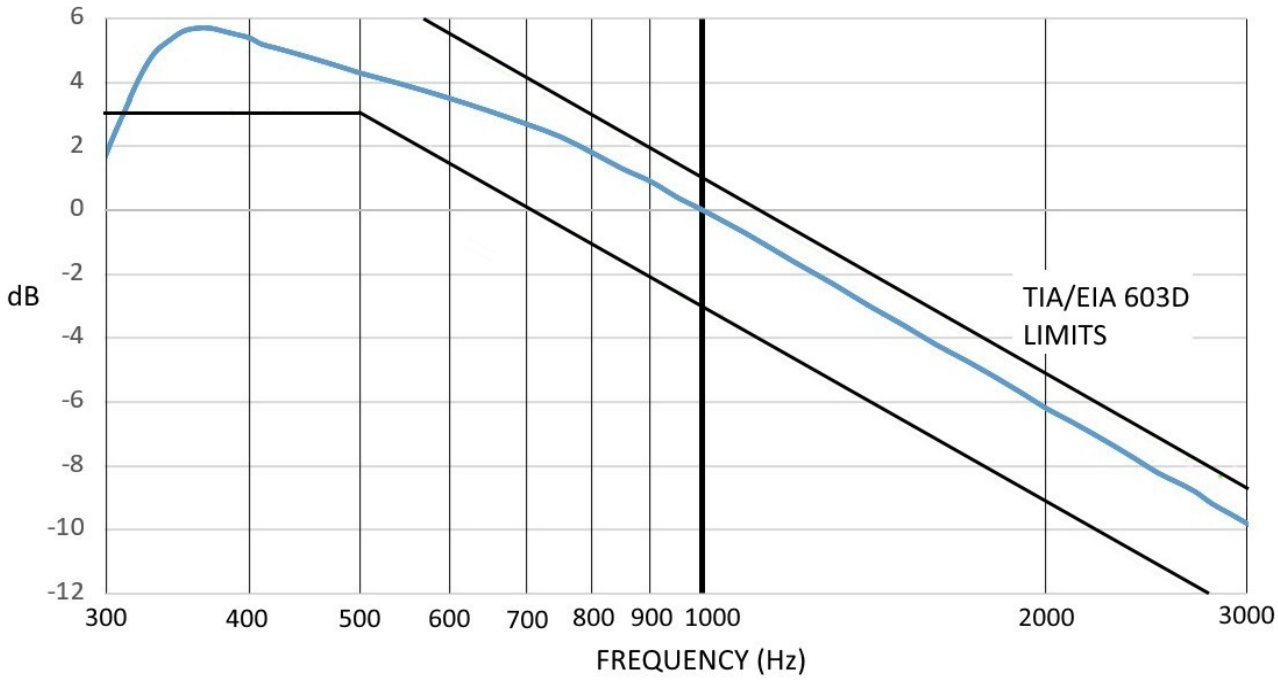
Instructions below cover the Comm Spec TS-32 since it was a very popular board and many are still floating around in drawers and junk boxes waiting to be used.

SQUELCH BOARD PAD	TS-32 CTCSS BOARD CONNECTION
DISC	"DECODER INPUT" The input from receiver discriminator
DEC	"OUT-1" Active-low during CTCSS tone decode, remove JU-1 on TS-32
HUP	"HANG UP" Normally connects to a microphone hang up button in a mobile installation to allow monitoring the channel before transmitting
ENC	"ENCODE OUT" The TS-32's CTCSS encode tone out
GND	"GROUND"
12V	"+V POWER" +12V to power the TS-32

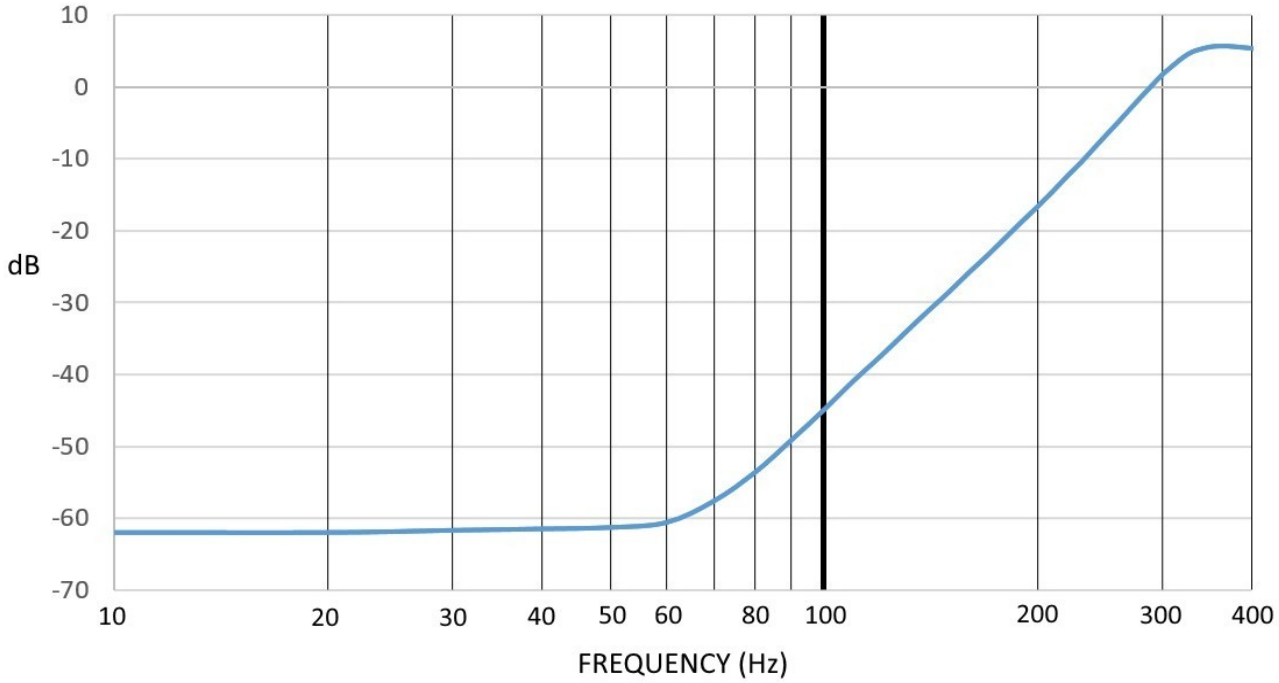
Specifications

- Board size: 3.875” x 3.875” (99 mm x 99 mm)
- Voltage requirements: +11V to +18V (down to +10.5V if D3 is bypassed)
- Current draw: 50 mA at idle (squelched), 320 mA at maximum speaker volume
- Minimum discriminator input level required: 300 mV P-P (1000 Hz test tone)
- Discriminator input impedance: >10k ohms
- Maximum speaker audio output level: 300 mW at 8 ohms
- Maximum audio level at “AUD OUT” terminal (J2-4): 2.2V P-P at 1000 Hz
- Squelch hysteresis: 1-2 dB
- Squelch audio muting: >50 dB
- Squelch tail length: <20 milliseconds or about 150 milliseconds, depending on signal quieting level
- COS and CTCSS logic output output maximum current: 500 mA sink, 20 mA source

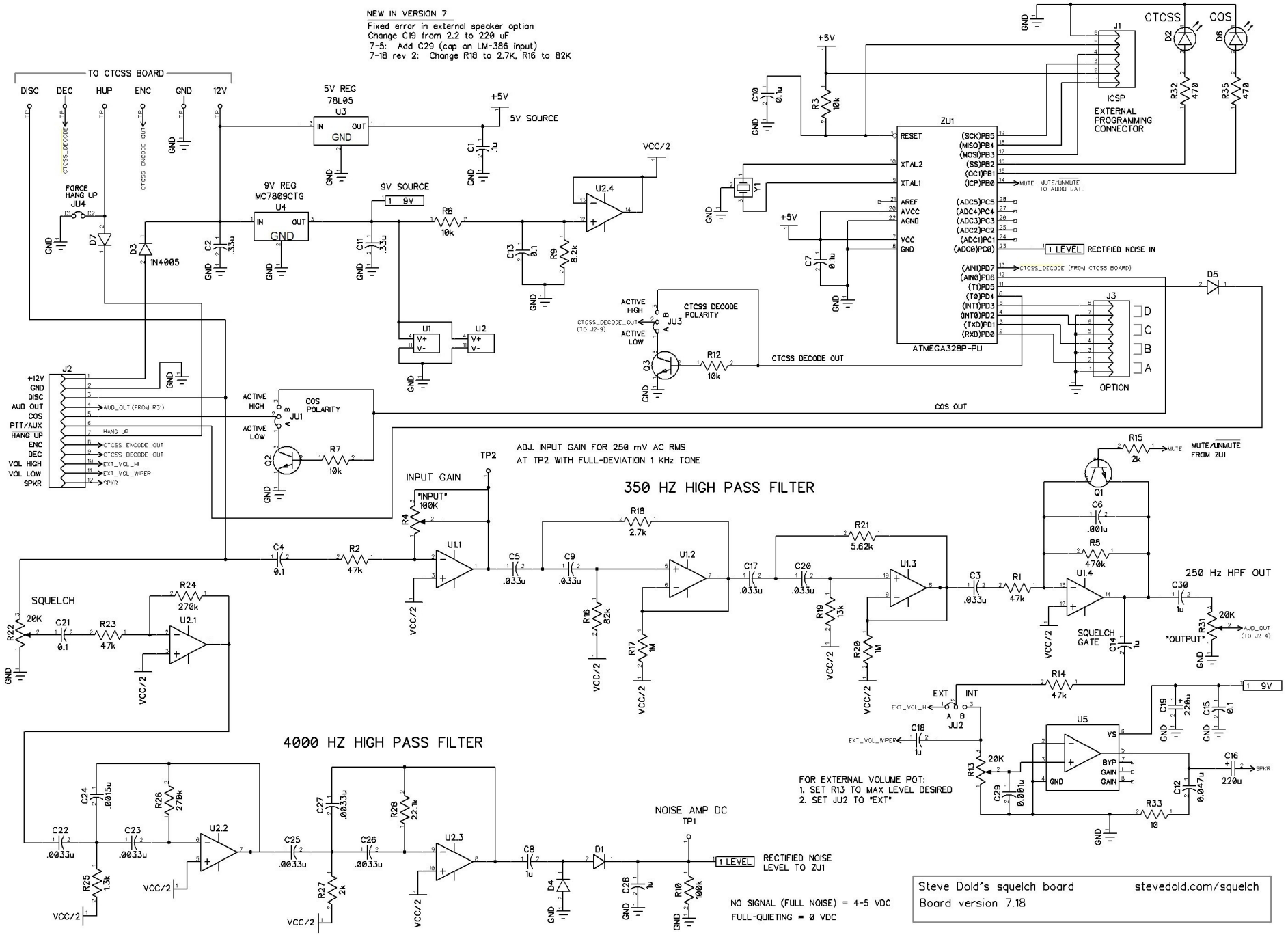
The following plots show the frequency response through the board's audio path, from discriminator input (J2-3) to audio output (J2-4). The response is shown in two plots to better show the CTCSS removal filter at the low end, and the receiver de-emphasis response in the voice audio range.



DE-EMPHASIS FILTER RESPONSE

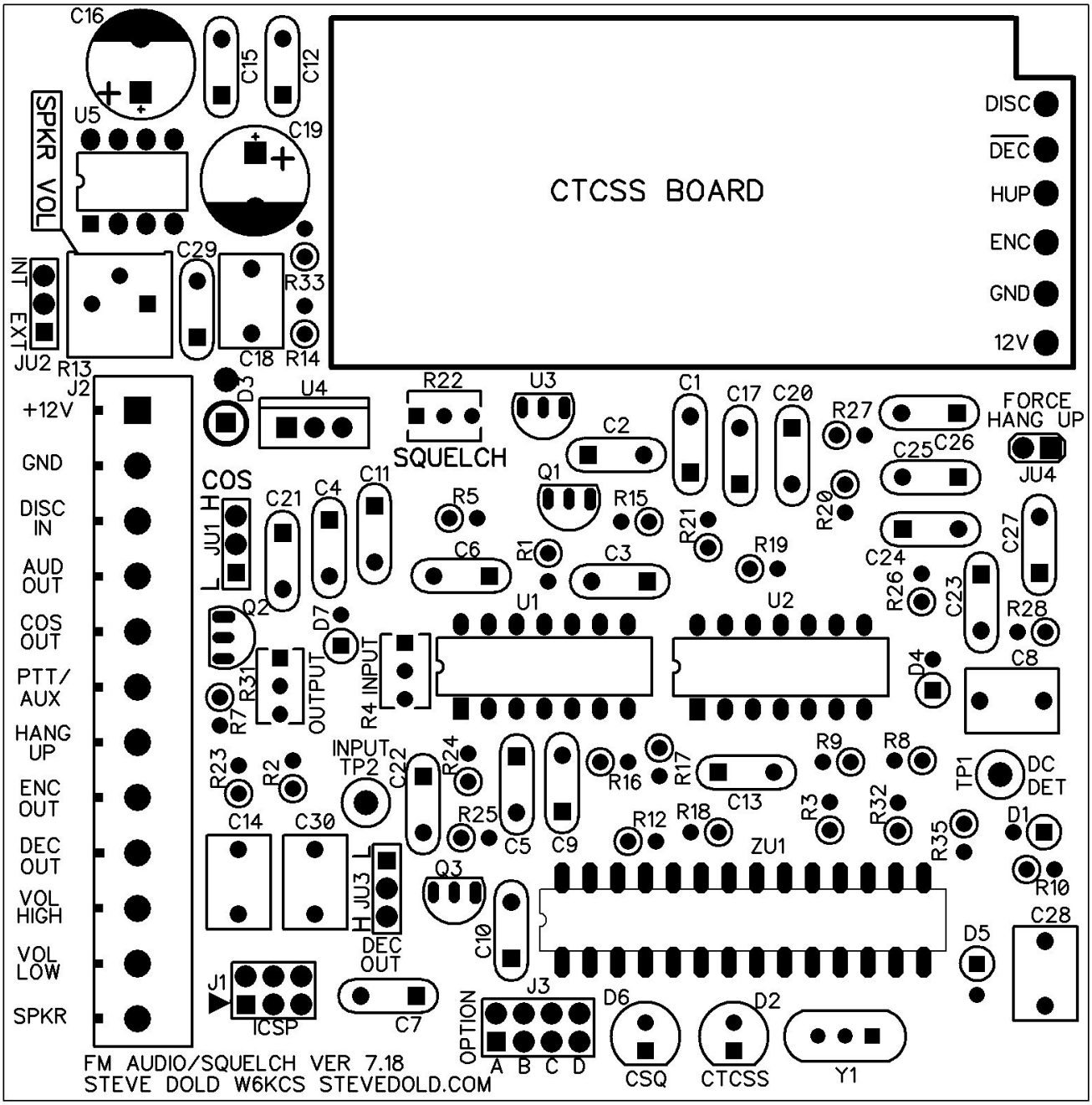


CTCSS FILTER RESPONSE


NEW IN VERSION 7
Fixed error in external speaker option
Change C19 from 2.2 to 220 uF
7-5: Add C29 (cap on LM-386 input)
7-18 rev 2: Change R18 to 2.7K, R16 to 82K
TO CTCSS BOARD
DISC
DEC
HUP
ENC
GND
12V
5V REG
78L05
U3
5V SOURCE
9V REG
MC7809CTG
U4
9V SOURCE
FORCE HANG UP
JU4
D7
D3
1N4005
ATMEGA328P-PU
ZU1
ICSP
EXTERNAL PROGRAMMING CONNECTOR
CTCSS
COS
D2
D6
J1
MUTE
MUTE/UNMUTE TO AUDIO GATE
1 LEVEL
RECTIFIED NOISE IN
CTCSS_DECODE (FROM CTCSS BOARD)
D5
J3
OPTION
CTCSS DECODE POLARITY
ACTIVE HIGH
ACTIVE LOW
JU3
CTCSS_DECODE_OUT
(TO J2-9)
CTCSS DECODE OUT
COS POLARITY
JU1
COS OUT
J2
+12V
GND
DISC
AUD OUT
COS
PTT/AUX
HANG UP
ENC
DEC
VOL HIGH
VOL LOW
SPKR
AUD_OUT (FROM R31)
HANG_UP
CTCSS_ENCODE_OUT
CTCSS_DECODE_OUT
EXT_VOL_HI
EXT_VOL_WIPER
ADJ. INPUT GAIN FOR 250 mV AC RMS
AT TP2 WITH FULL-DEVIATION 1 KHz TONE
INPUT GAIN
350 HZ HIGH PASS FILTER
250 Hz HPF OUT
SQUELCH
SQUELCH GATE
MUTE/UNMUTE FROM ZU1
4000 HZ HIGH PASS FILTER
NOISE AMP DC
RECTIFIED NOISE LEVEL TO ZU1
NO SIGNAL (FULL NOISE) = 4-5 VDC
FULL-QUIETING = 0 VDC
FOR EXTERNAL VOLUME POT:
1. SET R13 TO MAX LEVEL DESIRED
2. SET JU2 TO "EXT"
EXT
INT
JU2
Steve Dold's squelch board
stevedold.com/squelch
Board version 7.18

Item	Qty.	Ref.	Description	Value	Notes
1	7	C1	Film cap	0.1u	may be marked “104”, “1j100” or “100n”
		C4	Film cap	0.1u	may be marked “104”, “1j100” or “100n”
		C7	Film cap	0.1u	may be marked “104”, “1j100” or “100n”
		C10	Film cap	0.1u	may be marked “104”, “1j100” or “100n”
		C13	Film cap	0.1u	may be marked “104”, “1j100” or “100n”
		C15	Film cap	0.1u	may be marked “104”, “1j100” or “100n”
		C21	Film cap	0.1u	may be marked “104”, “1j100” or “100n”
2	2	C2	Film cap	0.33u	may be marked “334”
		C11	Film cap	0.33u	may be marked “334”
3	5	C3	Film cap 5%	0.033u	may be marked “333” or “33n”
		C5	Film cap 5%	0.033u	may be marked “333” or “33n”
		C9	Film cap 5%	0.033u	may be marked “333” or “33n”
		C17	Film cap 5%	0.033u	may be marked “333” or “33n”
		C20	Film cap 5%	0.033u	may be marked “333” or “33n”
4	2	C6	Film cap 5%	0.001u	may be marked “1.0”, “1n0” or “102”
		C29	Film cap 5%	0.001u	may be marked “1.0”, “1n0” or “102”
55	1	C24	Film cap 5%	0.0015u	may be marked “1.5”, “1n5” or “152”
5	5	C8	Film cap	1u	may be marked “105”
		C14	Film cap	1u	may be marked “105”
		C18	Film cap	1u	may be marked “105”
		C28	Film cap	1u	may be marked “105”
		C30	Film cap	1u	may be marked “105”
6	1	C12	Film cap	0.047u	may be marked “473” or “47n”
7	2	C16	Electrolytic	220uF	
		C19	Electrolytic	220uF	
8	5	C22	Film cap 5%	0.0033u	may be marked “332” or “3n3”
		C23	Film cap 5%	0.0033u	may be marked “332” or “3n3”
		C25	Film cap 5%	0.0033u	may be marked “332” or “3n3”
		C26	Film cap 5%	0.0033u	may be marked “332” or “3n3”
		C27	Film cap 5%	0.0033u	may be marked “332” or “3n3”
10	4	D1	Small glass diode	1N4148	
		D4	Small glass diode	1N4148	
		D5	Small glass diode	1N4148	
		D7	Small glass diode	1N4148	
11	1	D2	LED, red		
12	1	D3	Diode	1N4001	may be 1N4005
14	1	D6	LED, green		
15	1	J1	2x3 header	6-pin	
16	1	J2	0.198 term	12 pin	Wire openings face board edge
51	1	J3	2x4 header	8-pin	
17	3	JU1	3-pin header	3-pin	
		JU2	3-pin header	3-pin	
		JU3	3-pin header	3-pin	
54	1	JU4	2-pin header	2-pin	
19	8	JU-PIN 1-8	2-pin jumper		Push-on shorting jumper
20	3	Q1	NPN Transistor	2N4401	
		Q2	NPN Transistor	2N4401	
		Q3	NPN Transistor	2N4401	

21	4	R1	Res 5%	47k	yellow, violet, orange, gold
		R2	Res 5%	47k	yellow, violet, orange, gold
		R14	Res 5%	47k	yellow, violet, orange, gold
		R23	Res 5%	47k	yellow, violet, orange, gold
22	4	R3	Res 5%	10k	brown, black, orange, gold
		R7	Res 5%	10k	brown, black, orange, gold
		R8	Res 5%	10k	brown, black, orange, gold
		R12	Res 5%	10k	brown, black, orange, gold
23	1	R9	Res 5%	8.2k	gray, red, red, gold
24	1	R10	Res 5%	100k	brown, black, yellow, gold
53	2	R22	Potentiometer	20K	multi-turn, may be marked “203”
		R31	Potentiometer	20K	multi-turn, may be marked “203”
26	1	R13	Potentiometer	20K	1-turn, may be marked “203”
38	1	R4	Potentiometer	100K	Multi-turn, may be marked “104”
57	1	R18	Res 5%	2.7k	red, violet, red, gold
58	1	R16	Res 5%	82k	Gray, red, orange, gold
29	2	R17	Res 5%	1M	brown, black, green, gold
		R20	Res 5%	1M	brown, black, green, gold
30	1	R19	Res 1%	13k	brown, orange, black, red, brown or “1302”
31	1	R21	Res 1%	5.49k	green, yellow, white, brown, brown or “5491”
32	2	R24	Res 5%	270k	red, violet, yellow, gold
		R26	Res 5%	270k	red, violet, yellow, gold
33	1	R25	Res 5%	1.3k	brown, orange, red, gold
34	2	R15	Res 1%	2k	red, black, black, brown, brown or “2001”
		R27	Res 1%	2k	red, black, black, brown, brown or “2001”
35	1	R28	Res 1%	22.1k	red, red, brown, red, brown or “2212”
36	2	R32	Res 5%	470	yellow, violet, brown, gold
		R35	Res 5%	470	yellow, violet, brown, gold
37	1	R33	Res 5%	10	brown, black, black, gold
39	1	R5	Res 5%	470k	yellow, violet, yellow, gold
40	2	SO1	14-pin IC socket	14 pin	
		SO2	14-pin IC socket	14 pin	
41	1	SO3	28-pin IC socket	28 pin	
42	1	SO4	8-pin IC socket	8 pin	
43	2	U1	Quad op-amp	TL084CN	14-pin DIP
		U2	Quad op-amp	TL084CN	14-pin DIP
44	1	U3	Voltage Reg (5V)	5V	Small TO-92 case
45	1	U4	Voltage Reg (9V)	9V	TO-220 case
46	1	U5	Audio amplifier IC	LM386N	8-pin DIP
47	1	Y1	Resonator	16 MHz	Looks like a fat 3-lead disc cap
48	1	ZU1	Microcontroller		28-pin DIP
49	2	TP1	Test jack		Metering test lead jack
		TP2	Test jack		Metering test lead jack
56	1		Squelch PCB V7.18		


CTCSS BOARD
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C12
C19
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SPKR VOL
C29
R33
C18
R14
INT
EXT
JU2
R13
J2
+12V
GND
DISC IN
AUD OUT
COS OUT
PTT/ AUX
HANG UP
ENC OUT
DEC OUT
VOL HIGH
VOL LOW
SPKR
D3
U4
R22
SQUELCH
U3
C1
C17
C20
R27
FORCE HANG UP
JU4
C25
C26
C2
Q1
R15
R20
COS
JU1
C21
C4
C11
R5
C6
R1
C3
R21
R19
C24
C27
R26
C23
R28
C8
U1
U2
Q2
D7
R31
OUTPUT
R4 INPUT
D4
R7
INPUT
TP2
C22
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R16
R17
C13
R9
R8
TP1
DC DET
R23
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R25
C5
C9
R12
R18
R3
R32
R35
D1
R10
JU3
Q3
ZU1
C10
C28
D5
DEC OUT
J1
ICSP
C7
J3
OPTION
A B C D
D6
CSQ
D2
CTCSS
Y1
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