Build an Audio Filter With Pizzazz!

Ssb and cw enthusiasts. . . STOP!. . .LOOK!. . . and LISTEN (finally) to what you want to hear.

By Robert E. Lee,* K2TWK

Here's an ssb/cw audio filter with a lot to offer. It provides variable degrees of cw and ssb audio selectivity and a means of limiting the audio level at your ears without the need for constantly adjusting the receiver audio gain control. The annoying effects of cw key clicks and static crashes are reduced or eliminated by a limiter circuit. When operating cw, a panel-mounted LED blinks in unison with the received signal when it is centered in the filter passband. An external sidetone may be mixed with the incoming receiver audio, and level adjustments are provided.

Description

Fig. 1 is a block diagram of the unit. Audio is taken from the speaker output jack and may be passed around or fed through a limiter circuit. The signal is then delivered to a cw bandpass-filter section or to a high-pass/low-pass filter section for ssb operation. During cw operation the signal is also passed to another filter that feeds the signal-indicating LED driver. A tone/summing amplifier follows the filter circuits. Here, sidetone from an external source can be added to permit monitoring cw transmissions. An audio amplifier provides for speaker or headphone operation and a tape recorder take-off point. Power for the unit is taken from a well filtered and regulated 12-volt supply.

The cw filter is designed for a center frequency of 750 Hz. If your equipment has a different frequency offset, the filter center frequency will have to be changed. Information for such changes is given in the Appendix.

Operational Theory

U1 of Fig. 2 is an inverting unity-gain amplifer. Diodes can be switched across the feedback resistor between pins 2 and 6 to provide limiting action. Limiting occurs at 0.4 V peak-to-peak (p-p) with the LIMITER switch in the CW position and 1.2 V p-p in the SSB position.

The cw filter employs U2 as a 4-section, 8-pole, multiple-feedback, active bandpass filter with unity gain. It has a center frequency of 750 Hz. The bandwidths at the −6 and −60 dB points of the filter are 120 and 1125 Hz, respectively.

For ssb, U3 is used as a 4-section series of 3-pole unity gain, multiple-feedback Butterworth-response filters. U3A acts as a high-pass filter with a 300-Hz −6 dB point. U3B, C and D are low-pass filter sections with −6 dB points at 2.2-, 2.0- and 1.5-kHz, respectively. Each filter section exhibits a roll-off of 18 dB per octave.

U4 and Q1 are part of the signal-indicator circuit. The IC operates as a 2-pole multiple feedback active filter with a gain of 10 and a center frequency of 750 Hz. The U4 output drives Q1, which has the SIGNAL LED in the collector circuit. The resulting bandwidth of this filter when cascaded with the cw filter (U2), is approximately 40 Hz.

An external sidetone signal may be fed to U5A. This permits the amplitude of the sidetone signal to be adjusted to a comfortable level for speaker or headphone operation. U5B performs as a unity gain summing amplifier. It is used to mix the sidetone signal and incoming receiver audio.

U6 provides over 1 watt of audio power output. The frequency response of the amplifier has been limited to a range of 340 to 3900 Hz at the −3 dB points. The basic design of this amplifier was done by Robert Sherwood.[1] C1 and R3 were added to provide feedback and ensure stability.

*69 Kinderkamack Rd., Park Ridge, NJ 07656

[1]R. Sherwood, "New Audio Amplifier for the Drake R-4C," *Ham Radio*, April 1979, p. 48.

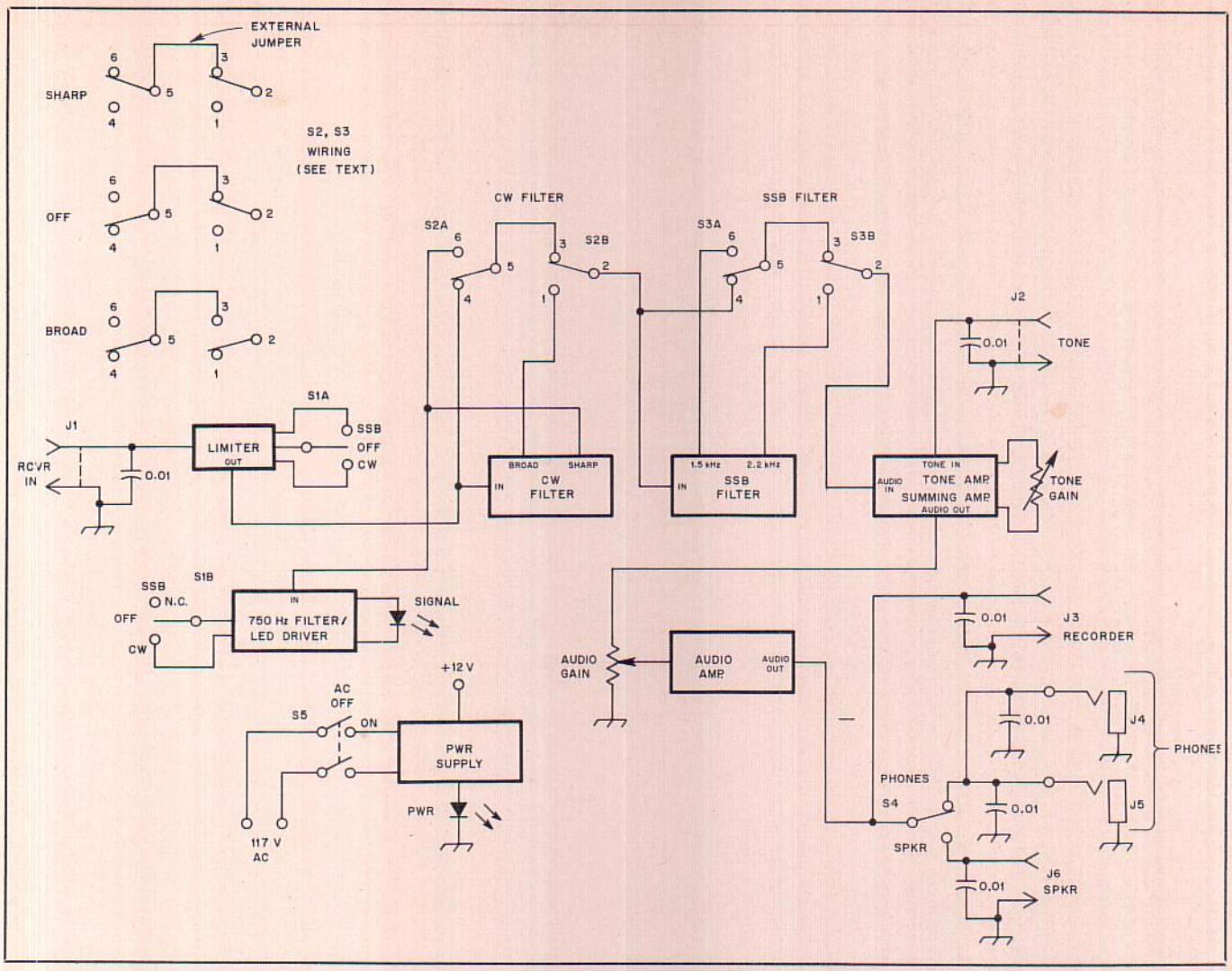


Fig. 1 — Block diagram of the audio filter. S2 and S3 are shown in the OFF position. These switches are special types that are not operated as ordinary dpdt toggle switches.

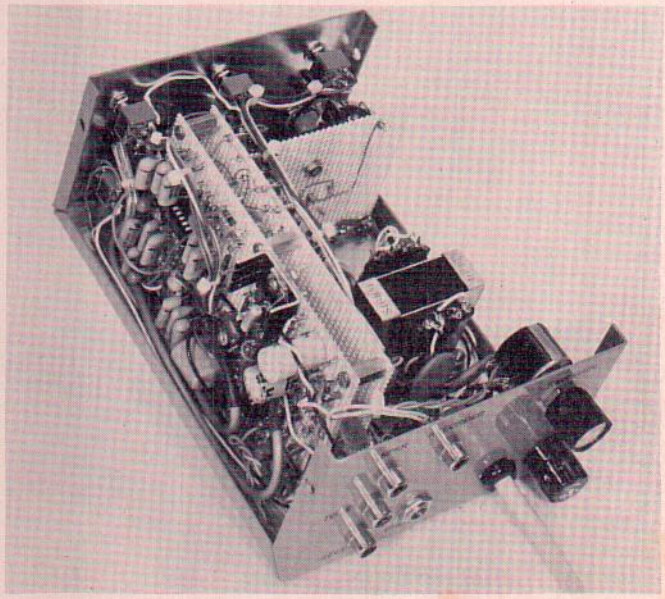
Power for the unit is supplied by a full-wave bridge rectifier. An LM-340T-12 provides voltage regulation.

Construction

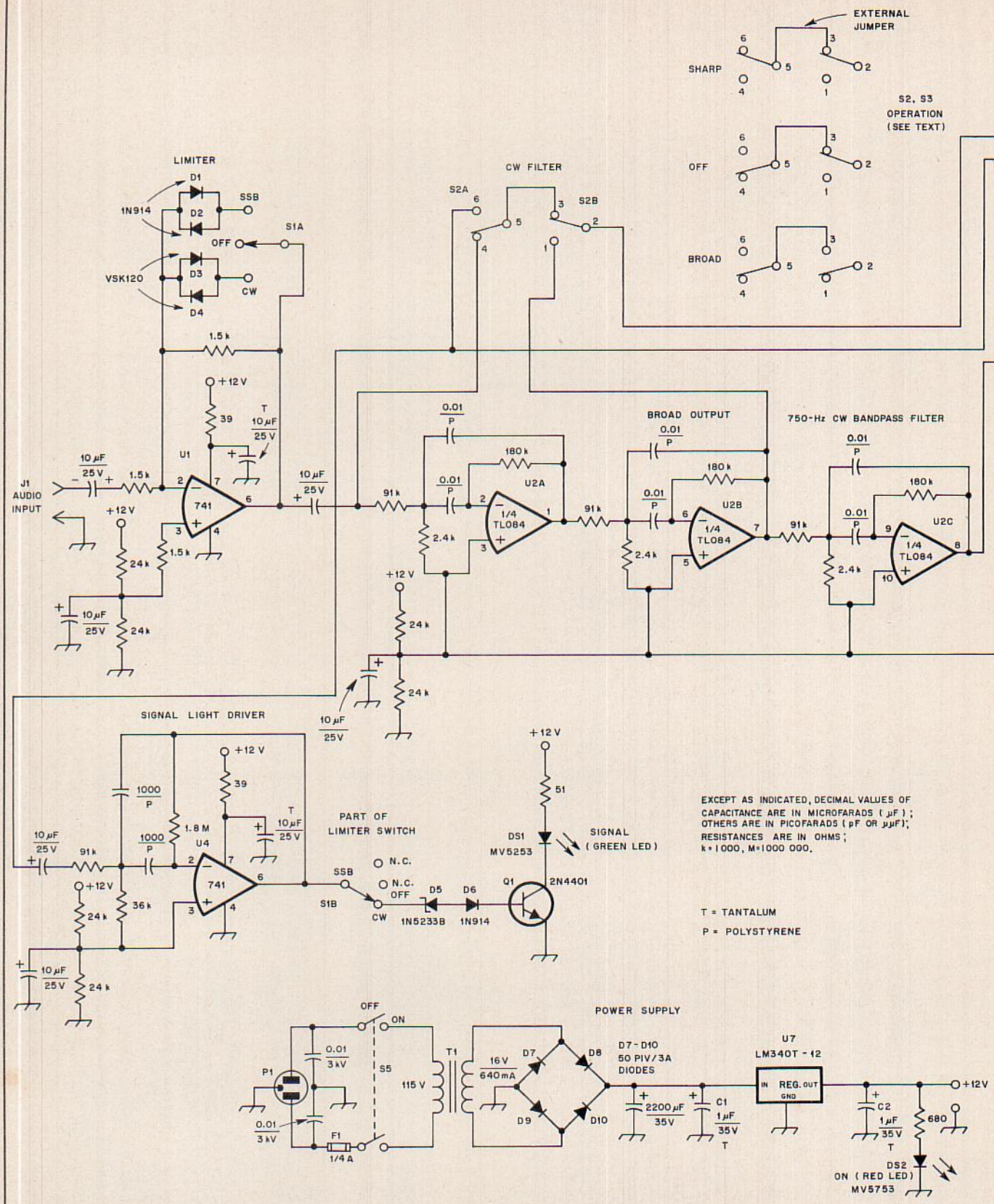
The filter unit must be constructed in a shielded enclosure. I used a 7 × 5 × 3-inch (mm = inches × 25.4) Bud box (CU-2108-B), but would recommend use of a larger enclosure. Three perf boards hold the circuit components. The power transformer is mounted on the box bottom. All transformer and ac wiring should be kept as far away as possible from the filter/amplifier boards. This will prevent 60-Hz hum pick-up. Small heat sinks should be used on U6 and U7.

When wiring the unit, follow good construction practices and keep leads between the switches and boards short. The audio-amplifier layout should follow that described in the original article. AUDIO GAIN control wiring should be done using small-diameter shielded audio cable with the low side of the AUDIO GAIN control connected to the cable shield and the shield connected *only* to pin 3 of U6. C3 should be connected between pins 3 and 4 of U6 using 3/4-inch lead lengths.

The switches used for S2 and S3 are not ordinary dpdt toggle switches. These switches have a special toggling arrangement. This permits them to be used as 3-way toggle switches when an external jumper wire is added between terminals 3 and 5. Use of these switches instead of rotary types enhances compact construction.



An inside view of the filter. The two large boards to the left of the unit contain all of the filter components. Power supply components are mounted on the small perf board toward the front of the enclosure.


EXTERNAL JUMPER
SHARP
S2, S3 OPERATION (SEE TEXT)
OFF
BROAD
LIMITER
1N914
VSK120
SSB
CW
S1A
CW FILTER
S2A
S2B
BROAD OUTPUT
750-Hz CW BANDPASS FILTER
J1 AUDIO INPUT
U1
741
1/4 TL084
U2A
U2B
U2C
SIGNAL LIGHT DRIVER
U4
PART OF LIMITER SWITCH
N.C.
S1B
DS1 MV5253
SIGNAL (GREEN LED)
Q1 2N4401
D5
D6
1N5233B
1N914
EXCEPT AS INDICATED, DECIMAL VALUES OF CAPACITANCE ARE IN MICROFARADS (μF); OTHERS ARE IN PICOFARADS (pF OR μμF); RESISTANCES ARE IN OHMS; k=1000, M=1000 000.
T = TANTALUM
P = POLYSTYRENE
POWER SUPPLY
S5
P1
F1
1/4 A
T1
115 V
16 V 640 mA
D7
D8
D9
D10
D7-D10 50 PIV/3A DIODES
U7 LM340T-12
IN REG. OUT GND
DS2 ON (RED LED) MV5753

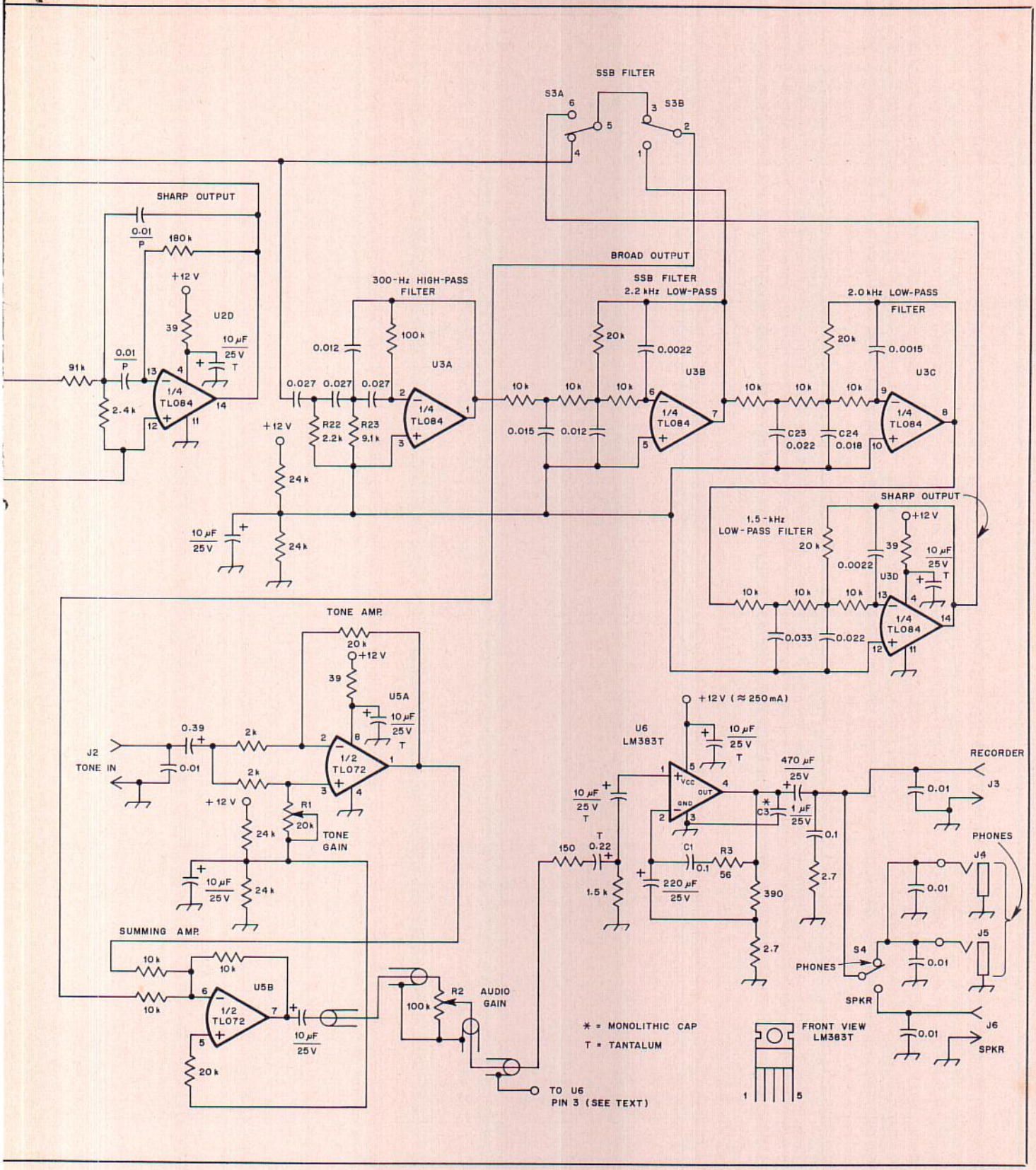


Fig. 2 — Schematic diagram of the unit. Information is given in the text that will allow the builder to alter the cw filter center frequency. All resistors are 1/4-watt carbon composition or film types. Note: Part numbers in parentheses are Radio Shack.

C3 — 1 μF Monolithic ceramic. Sprague 5CZ5U10SX-0050C5 or equiv.

D3, D4 — 1-A/20-V Shottky diodes, Vero VSK120, 1N5817 or equiv. (Available from Fuji-Svea, Inc., P. O. Box 40325, Cincinnati, OH 45240.)

J1-J3, J6 — Phono jack.

J4, J5 — Open-circuit phone jack.

R1 — 20-kΩ linear-taper potentiometer.

R2 — 100-kΩ audio-taper potentiometer.

S2, S3 — C & K 7211SYZQ 3-way toggle switch. (Available from Gerber Electronics, 128 Carnegie Row, Norwood, MA 02062.)

T1 — 16-V/640 mA secondary, 115-V primary, Signal DPC 16-640 with 10BR mounting bracket or equiv. (Available from Signal Transformer Co., Inc., 500 Bayview Ave., Inwood, NY 11696. Single-lot purchases require payment in advance.)

U1, U4 — 741 op amp (267-007).

U2, U3 — Quad bi-FET op amp, TL084CN or equiv. (276-1714).

U5 — Dual bi-FET op amp, TL072CP, LF353N (276-1715) or equiv.

U6 — LM383T audio amplifier (276-703).

Mallory SXK (or equivalent) polystyrene capacitors are recommended for use in the cw and signal-light driver filter sections. The other capacitors in the low-pass/high-pass filter sections can be Sprague type 225P or equivalent. Polarized capacitors can be electrolytic or tantalum types. Be sure to use tantalum capacitors at C1 and C2, and use a monolithic ceramic capacitor at C3. The remainder of the capacitors can be disc-ceramic types. Resistors used in the filter sections should have a 5% tolerance and be matched, using an ohmmeter. Other resistors can have a 10% tolerance.

Operation

This is the procedure I follow to set up my Drake C line for cw transceive operation. Turn on the CALIBRATOR and peak the PRESELECTOR on the calibrator signal. Connect the filter to the speaker jack on the rear of the receiver and connect the speaker to the jack on the rear of the filter unit. Place the receiver MODE switch in the maximum cw selectivity position and adjust the PASSBAND tuning control for lsb operation with a beat note of 750 Hz (the frequency offset used with the C line). Place the LIMITER switch in the CW position. The receiver RF GAIN should be set at maximum and the AUDIO GAIN at the 11 o'clock position. Adjust the filter unit AUDIO GAIN for the desired audio level. If the unit is operating properly, the SIGNAL LED should illuminate as you tune the receiver across the calibrator signal. Slow tuning is required because the bandpass of the SIGNAL LED filter circuit is narrow — approximately 40 Hz. The PASSBAND control is then adjusted for a maximum S-meter reading while the LED is lit. Do not readjust the PASSBAND control after it has been set up as described. The C line is now ready for proper cw transceive operation.

For separate receiver/transmitter cw operation, use the following procedure. Place the transmitter in the SPOT mode and adjust the tuning until the LED lights. Both the receiver and transmitter will then be on the same frequency.

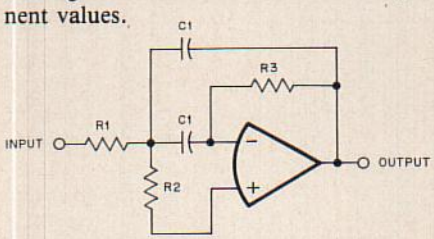
When sharp audio selectivity during cw operation is not required, I place the filter switch in the SSB NARROW position. Otherwise, the cw signal will sound distorted because of limiter action with no filter section in operation. When more audio selectivity is desired, the cw filter can be placed in the BROAD or SHARP position to give the required amount of selectivity. With the limiter circuit in operation, you can tune across the cw portion of the band and not have to adjust the AUDIO GAIN control to protect your ears from the effects of strong signals.

In the SSB mode, the LIMITER can be switched on to help reduce the effect of static crashes or other such annoyances. The required amount of audio selectivity is then chosen. Do not leave the LIMITER in the CW position when operating ssb: Severe distortion of the audio signal will result.

With the audio-filter unit, both cw and ssb operation become more relaxing. Hum, high-frequency noise, static crashes and key clicks are reduced or eliminated. I know you'll find the use of this filter a boon to cw and ssb operation. Should you desire more information, I'll be glad to answer questions, provided an s.a.s.e. is enclosed.

APPENDIX

Use these formulas to determine the cw and signal indicator filter circuit component values.



1) Select A_o — gain at filter center frequency.
   Select f_o — filter center frequency.
   Select Q.
2) Select R1 for desired input resistance.
3) Calculate R1:

$$R1 = \frac{Q}{(2Q^2 - A_o)\,2\pi f_o C1} \qquad \text{(Eq. 1)}$$

4) Calculate R3:

$$R3 = 2A_oR1 \qquad \text{(Eq. 2)}$$

5) Calculate C1:

$$C1 = \frac{Q}{2\pi f_o A_o R1} \qquad \text{(Eq. 3)}$$

6) Calculate R2:

$$R2 = \frac{A_oR1}{2Q^2 - A_o} \qquad \text{(Eq. 4)}$$

The following example will demonstrate how to determine the filter component values for a filter center frequency of 800 Hz. This particular frequency is used in many popular transceivers, such as the Kenwood TS-830S.

1) $A_o = 1$ (sets the gain at unity)
   $f_o = 800$ Hz
   $Q = 4$

2) Because it is easier to select resistor rather than capacitor values, C1 is chosen, and R1, R2 and R3 are then calculated. Thus, with a value of 0.01 μF for C1

$$C1 = \frac{Q}{2\pi\, f_o A_o R1} \qquad \text{(Eq. 5)}$$

becomes

$$R1 = \frac{Q}{2\pi\, f_o A_o C1} \qquad \text{(Eq. 6)}$$

and

$$R1 = \frac{4}{(2\pi)(800)(1)(1 \times 10^{-8})} = 79.6\ \text{k}\Omega \qquad \text{(Eq. 7)}$$

The nearest standard value of 82 kΩ is used.

3) $R3 = 2A_oR1$ (Eq. 8)

$R3 = (2)\,(1)\,(79.6\ \text{k}\Omega) = 159.2\ \text{k}\Omega$ (Eq. 9)

A 160-kΩ resistor is used for R3.

4) $$R2 = \frac{A_oR1}{2Q^2 - A_o}$$

$$= \frac{(1)\,(79.6\ \text{k}\Omega)}{(2)\,(4)^2 - 1} = 2.56\ \text{k}\Omega \qquad \text{(Eq. 10)}$$

Use a 2.4-kΩ resistor for R2.

Determination of the signal indicator filter circuit values uses the same procedure. A value of 1000 pF is used for C1 and an A_o of 10. This nets values of 82 kΩ for R1, 1.6 MΩ for R3 and 33 kΩ for R2.