

# Deluxe Communications Audio Board

*Enhance your audio with this practical add-on.*

by David Curry WD4PLI

Have you ever wanted to improve the audio quality of your old receiver? Would you like to add technical improvements to a modern receiver? Though state-of-the-art ham transceivers and communication receivers have improved audio design, there are many benefits to building your own auxiliary audio section and implementing it to your receiver. Or, for the truly ambitious, use it as part of your own home-brew communications receiver.

The strategy here is to simply add several audio processes in series to achieve an improved audio output signal. My desire to design something like this was purely selfish. I wanted my long-wave receiver (a Watkins Johnson R-1401) to have some bells and whistles like my Kenwood TS-430S. I'm also in the process of building my own receiver for LF, and I wanted a good audio section to follow the RF section. This audio board will do both nicely.

The first section of the audio stages is an adjustable bandpass filter, providing control of either the frequency or the bandwidth without changing the volume or other parameters. The original bandpass filter circuit appeared in the December 1992 issue of *RF Design*, in an article written by Jefferson Hall and Alvin Connelly. It was an excellent article and I quickly built the circuit, much to my satisfaction. After a short time, however, it was apparent that more circuitry was needed to eliminate a carrier that was within the passband, so I added a simple notch filter. This very effective design was by Randy Seden WD6ELU. The combination of a notch filter and variable bandpass filter can improve receiving conditions, but for weaker signals more circuitry is required.

An additional circuit that adds this improvement, especially for CW, is a regenerative audio stage with adjustable frequency and "Q." This type of circuit has been virtually left behind in modern radio equipment,

yet it offers many advantages, considering its simplicity. One of the greatest things about a regenerative or Q-multiplier is the ability it has to reject noise and to peak the desired signal. As the regeneration is increased, the sideband noise drops, which improves your signal-to-noise ratio. The final addition to the audio board is what I call a "digitizer" circuit, which eliminates background noise for CW signals. This is nothing more than a comparator used as a variable threshold detector. The digitizer compares the audio signal to a voltage reference, and provides a square-wave or digital output. The comparator will sometimes trigger on noise that just crosses over the threshold point, so a second comparator is used as a "window," allowing the digitized CW signal

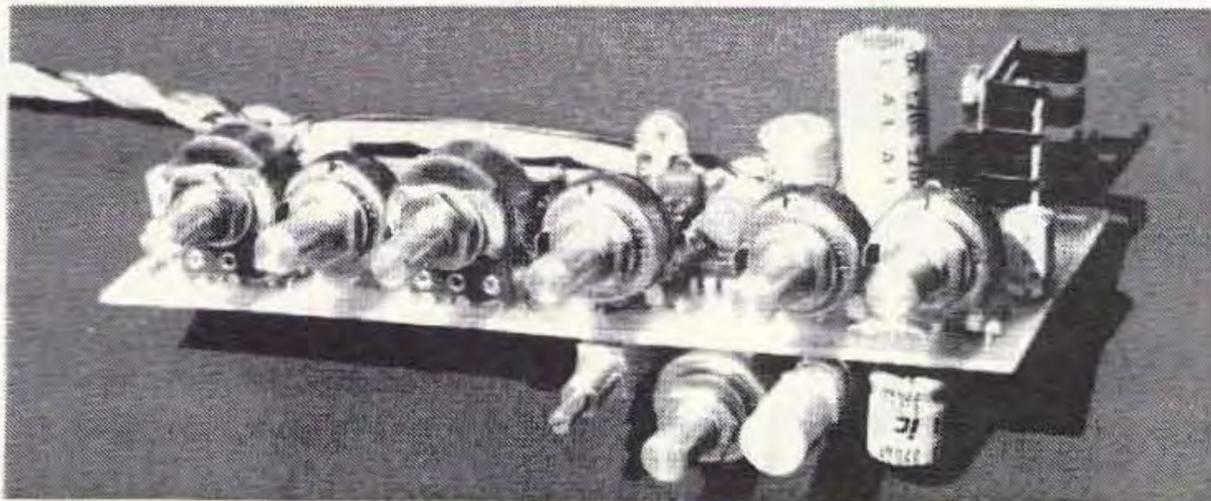


Photo A. The Deluxe Communications Audio Board.

(which is stronger) to pass, but not the weaker noise pulse. Low-pass filtering is used to clean up the square-wave signal to a more natural tone. Finally, an audio output circuit that has appeared in virtually every radio handbook was chosen for the speaker section.

I originally discovered the circuit in a SAMS book written by Walter Jung, *Audio IC Op-Amp Applications*. Low noise and low standby current are the hallmarks of this legendary circuit, using very common components. So let's review: A variable bandpass filter, followed by a variable notch filter, followed by a Q-multiplier, then a digitizer, then a 5 watt audio output section. WOW! With these devices in this particular order, it is very possible to do wonders with your receiver.

## Circuit Description

The schematic shows a lot of ICs and parts, but don't let that fool you! The circuit is rather simple and can be followed easily at the top left corner, labeled "Audio Input." C1 is simply a DC blocking capacitor, while R1 sets the overall gain of the first section. If a very low audio signal is connected, R1 can be decreased in value to increase the gain. U1a, b, c, and d are all low-noise quad op amps, which keeps the size down. The filter frequency is adjusted with dual-gang potentiometer R7. The bandwidth is adjusted with R6, which controls the amount of feedback to U1a. The entire top portion of the schematic is the variable audio filter section.

The next stage is the notch filter located directly below U1. U2a and c sections provided a 180-degree phase shift of the frequency controlled by R13a and b. Using two sections of notch filtering provides a very deep null with steep skirts. Summing amplifiers U2b and d provide the nodal point where the phase-shifted frequency meets the original signal and is subtracted to almost zero. U2 is also a low-noise quad op amp. Output of the notch

section is applied to R24, which is the regeneration control for the regenerative preamp. The regenerative preamp is located by itself on the right side of the schematic. U3a and b make up a dual low-noise op amp and, as you can see, feedback is applied in desired amounts from the output of U3a to U3b and out to the U3a input again. C10, R27, C9, and R25 and 26 provide the adjustable frequency response for the filter. The potentiometer marked "Q" is adjusted once to allow smooth control of regeneration with R24. If oscillation develops, rotate R28 to the point where oscillation just ceases. The frequency control has a fairly wide frequency range to facilitate most CW signals. The audio signal is sampled at the output of U3a, and directed to switch S1. Normally, S1 is out or OFF, which applies the signal directly

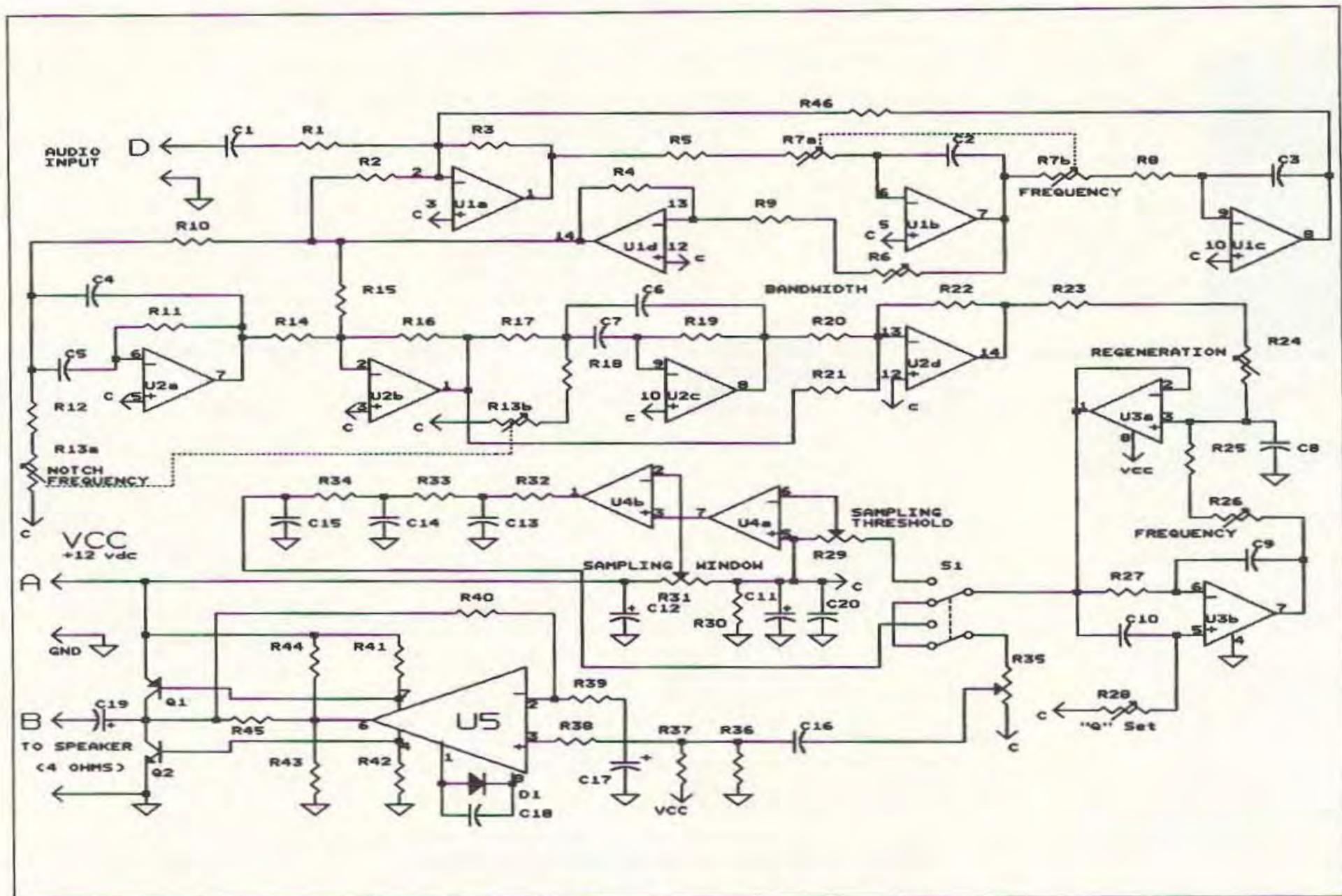


Figure 1. Schematic for the Deluxe Communications Audio Board.

to the audio amplifier stage U5. However, if the digitizer is desired, the signal is routed to comparators U4a and b. The same low-noise dual op amps are used here as with U3. Though not really intended to be used as comparators, the TI072 or LF353n op amps provide a softer comparator, making the threshold point easier to adjust. Potentiometer R29 is the input threshold control to the first comparator U4a. The signal that triggers the comparator will provide a square-wave output at U4a that is the same frequency as the input signal.

During weak signal conditions some residual noise may slightly trigger the first comparator, creating a small noise spike that is usually lower in amplitude at the output of U4a. To help eliminate this, a second comparator is used, sampling the signal that has the largest square-wave output from U4a by adjustment of R31. R31 is set to not trigger on other noise that has a lower amplitude. U4b provides us a square-wave representation of the signal to the low-pass filter. R23, R33, R34, C13, C14, and C15 comprise a low-pass filter arrangement that attenuates the high frequency components of the square wave, providing a cleaner, more listenable tone. It also lowers the square-wave amplitude to a level that can be used by the audio power amp stage. The audio power amp uses a class AB op amp to drive power transistors Q1, and Q2.

The biasing for these transistors is done

within the chip itself. This provides good audio quality at low and high volume levels since the bias is internally etched in U5. Volume is adjusted by R35. Power amp gain is set by R40. Usually there is plenty of gain to drive a common 4 or 8 ohm speaker. Diode D1 is a clamping diode to eliminate any latch-up that might occur if the speaker became shorted. C18 rolls the high frequency off just above 2.5 kHz. Resistors R43, R44, and R45 are used to set the gain and bias for Q1, and Q2. R41 and R42 are part of the biasing and power to U5.

#### Building Notes

The double-sided circuit board makes building this project very easy. Remember to solder both sides of this double-sided PC board because the holes are not plated-through. Note that potentiometers R26 and R29 are located next to switch S1 on the solder side of the board. This helps to fit more controls in a smaller space. R24 must be installed before R26. Similarly, R31 must be installed before S1, and R30 before R35. A small 5 watt heat sink is sandwiched between Q1 and Q2, and screwed securely.

Many resistors are mounted vertically on the circuit board. A small square on the layout sheet indicates this configuration. A longer rectangle denotes a horizontally-mounted resistor. Be sure to solder all pads on the component side of the circuit board that have connections to any components.

The connection points to the speaker, power supply, and audio input are marked on the layout sheet. All points marked "C" on the schematic are connected together as a common bias-point reference. There are no "C" connections to be concerned about during assembly.

#### Operation

Connect the speaker and the audio input cable to the appropriate points on the circuit board, then apply power. The advised minimum voltage for this circuit is 12 VDC, with up to 18 volts recommended. The higher voltage will help avoid any distortion at high volume. Turn all component-side controls counterclockwise.

Push S1 in to bypass the digitizer section.

Turn the far right hand control clockwise to a comfortable level.

The controls are in this order (from left to right on the component side): Bandpass Filter Frequency, Bandpass Filter Bandwidth, Notch Filter, Q Multiplier, Digitizer Sampling Window, Volume. Under the circuit board are: Q Multiplier Frequency, Digitizer Sampling Threshold, Digitizer Bypass Switch. Take time to experiment with these controls. The Q multiplier and digitizer controls take getting used to. Remember that with a Q multiplier you must have the frequency control at *exactly* the same frequency of the desired signal. The more regeneration you apply to the Q multiplier, the more

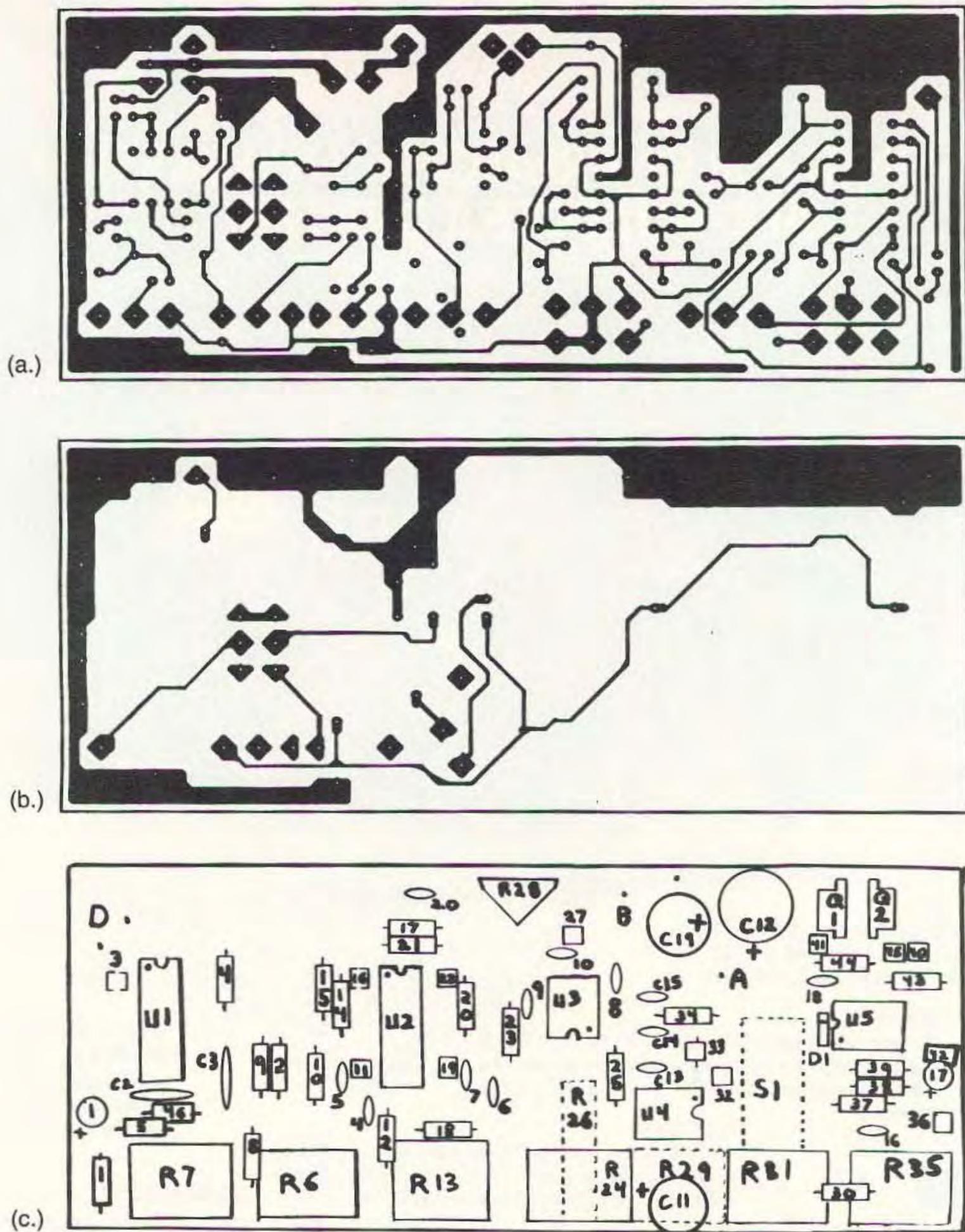


Figure 2. Double-sided PC board layout: a. Solder side; b. Component side; c. Parts placement diagram.

this requirement must be met. Another consequence of using large amounts of regeneration with the Q multiplier is that the CW signal becomes elongated, like a bubble. You can hear this effect distinctly. The digitizer can minimize this effect by triggering on the top portion of the elongated waveform, and then using the window comparator control to shore up the pulse width. Simply put, both controls can adjust the duty cycle when heavy regeneration from the Q

multiplier is needed. During regular operation, I recommend notching any undesired signal first, then apply the bandpass filter. Sometimes the Q multiplier works very well to improve SSB or voice communication, but over-driving with too much output volume from the receiver will degrade its ability to peak the desired signal.

#### Conclusion

This audio output section will provide

improved reception. It is perfect for an easy weekend project, or for someone who wants to "go all the way" and build a complete receiver from scratch. This design matches perfectly to an NE602 mixer or product detector. I would like to thank the authors for engineering these fine circuits, and Randy Seden for his computer design of the notch filter section.

## Parts List

Part #	Description	Purchase
C1,C17	4.7 $\mu$ F electrolytic	Digi-Key
C11,C19	100 $\mu$ F/16 VDC electrolytic	Mouser: 140-XRL25V100
C12	2200 $\mu$ F/16 VDC	
C13,C14,C15,C16,C20	0.1 $\mu$ F/50 VDC disc	
C18	27 pF/50 VDC disc	Digi-Key: P4449
C2,C3	0.01 $\mu$ F/50 VDC poly.	Digi-Key: P3103
C4,C5,C6,C7,C9,C10	0.0047 $\mu$ F/50 VDC poly.	Digi-Key: P3472
C8	0.047 $\mu$ F/50 VDC poly.	Digi-Key: P3473
D1	1N914 diode	
Q1	TIP32B PNP power transistor	
Q1,Q2 H/S	5 watt heat sink	
Q2	TIP31B NPN power transistor	
R1	33k ohm resistor 1/4 watt	
R10,R17	316k ohm resistor 1/4 watt, 1%	Digi-Key: 316KX
R11,R19	634k resistor 1/4 watt, 1%	Digi-Key: 634KX
R12,R18	274 ohm 1/4 watt, metal film, 1%	Digi-Key: 274X
R2,R3,R46,R14,R15,R16,R20,R21,R22	100k ohm resistor 1/4 watt, 1%	Digi-Key: 100KX
R24	50k ohm potentiometer	Mouser: 31CW405
R26	100k ohm 25-turn potentiometer	Mouser: 594-43P104
R28	10k PC mount trim pot.	Mouser: 32RM401
R29,R31,R35	10k ohm potentiometer linear	Mouser: 31CW401
R36,R37,R40	22k ohm resistor 1/4 watt	
R38,R39,R43,R44,R45	1k ohm resistor 1/4 watt	
R4,R30	10k ohm resistor 1/4 watt	
R41,R42	470 ohm resistors 1/4 watt	
R5,R8,R25,R27,R32,R33,R34	6.8k resistors 1/4 watt, 1%	
R6	500k ohm potentiometer, linear taper	Mouser: 31CW505
R7,R13	50k ohm dual potentiometer, audio taper	Calrad: 25-397
R9,R23	4.3k ohm resistor 1/4 watt	
S1	DPDT switch PC mount	Digi-Key: EG1003-ND
S1B	Knob for S1	Digi-Key: EG1092-ND
U1,U2	TL074 low noise quad op amps	
U3,U4	TL072/LF353N op amp	
U5	LM301AN op amp	

A complete kit is available for \$76.23 ppd.; a PC board with complete instructions is available for \$22 ppd. (CA residents add sales tax) from Curry Communications, 737 North Fairview Street, Burbank, California 91505.