Link Controller for the S-COM 5K Repeater Controller

Repeater linking—cheaply!

by Allan Overcast KF7FW

Would you like to have a repeater of your own, but you can't afford the luxuries of remote programming, selected access, and linking? A new repeater controller has hit the market that skillfully fulfills two of the three requirements: remote programming and selected access. The third luxury, repeater linking, only comes with high-priced repeater controllers, right? Wrong! The S-COM 5K repeater controller, priced at $189, is the perfect piece of equipment to upgrade your repeater's controller. With this low-cost link controller project, you can expand your system into a two-link prioritized controller.

The Heart of the System

The inexpensive S-COM 5K repeater controller is the heart of the system. With it, you can program all functions of the repeater remotely, using either the control receiver or the main repeater receiver as the communications medium. Included in its operations are three logical inputs, three logical outputs, priority control receiver ports, and a PL tone input. You can create macros, which are "small programs." Macros allow you to simplify operation; a couple of keystrokes will execute a sequence of commands. Once you have programmed these simple keystrokes to execute the sequence, you no longer have to remember the longer sequence. This feature also allows you, the control operator, to keep secret sensitive commands. Only you know the macros you've created and what they will do. With all of these features available for such a small price, any repeater organization can afford to upgrade their repeater to a fully automatic microprocessor-based system.

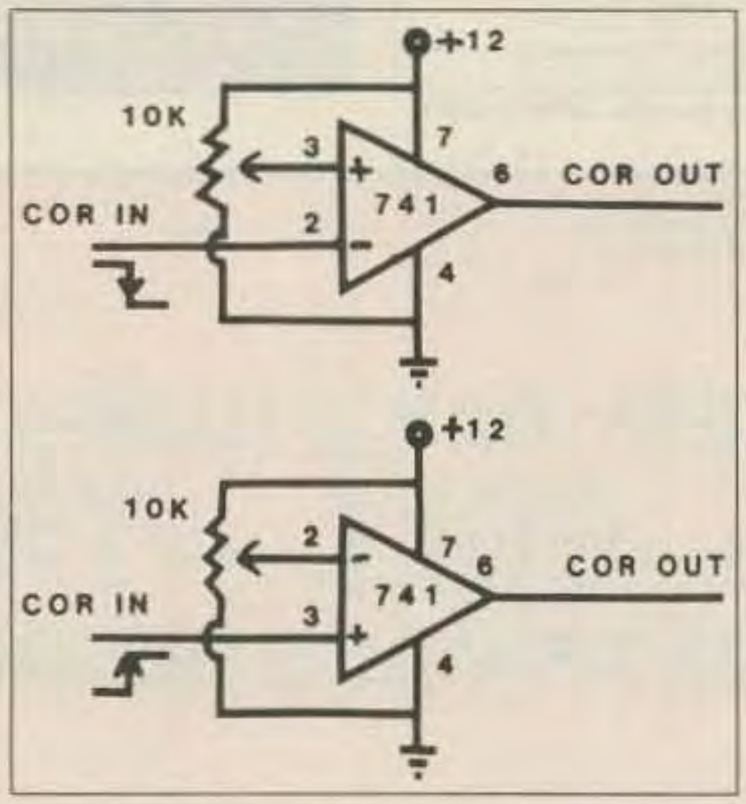


Figure 2. Receiver COR circuit.

Construction of the Link Controller

Keeping to the low current needs of most repeater systems, the link controller is designed completely around CMOS devices. Along with the need for low current was the need for user-friendliness. You can observe all functions of the link controller by adding an optional plug-in LED display board which communicates all major functions.

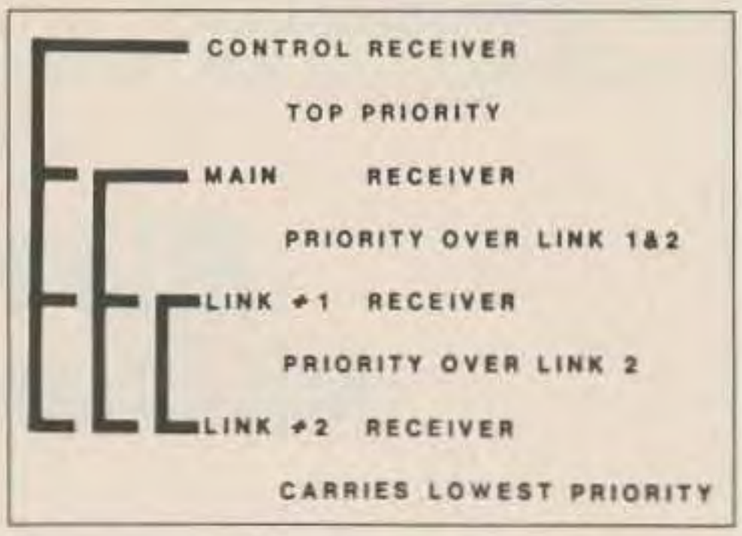


Figure 1. Receiver voting scheme.

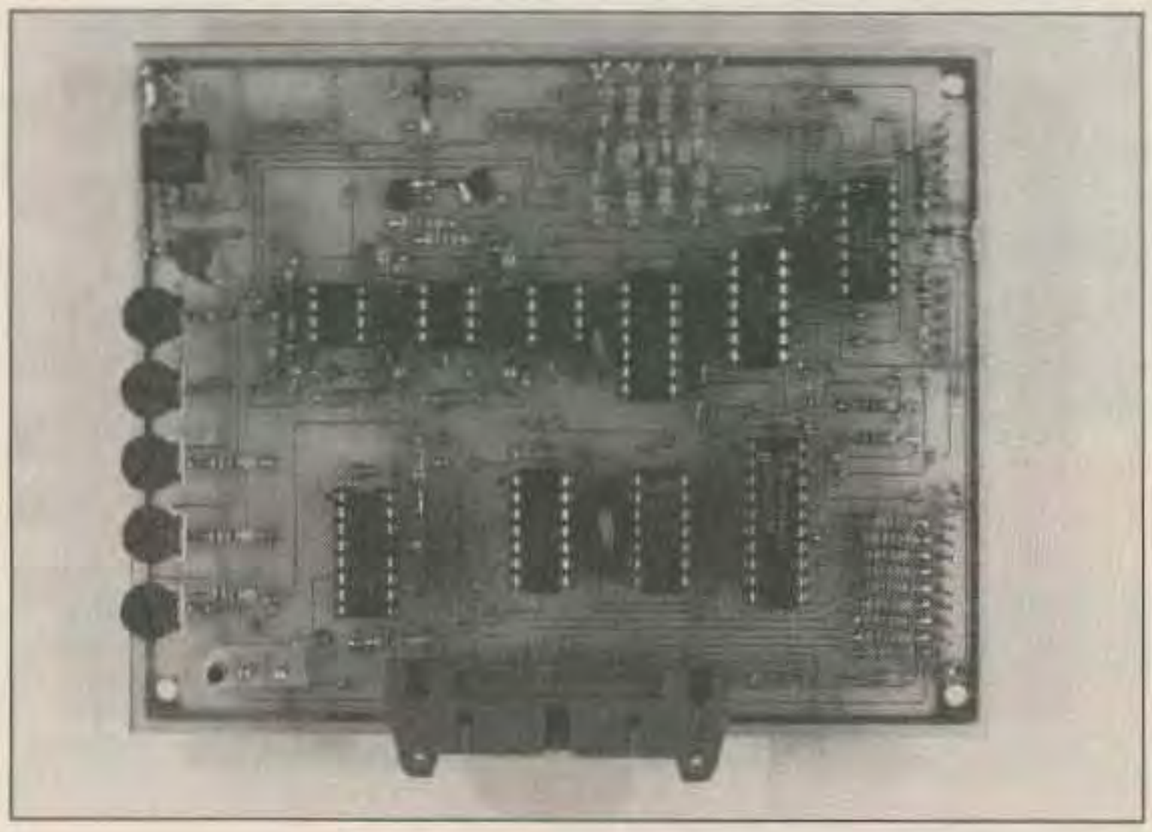


Photo A. The '5K Link Controller.

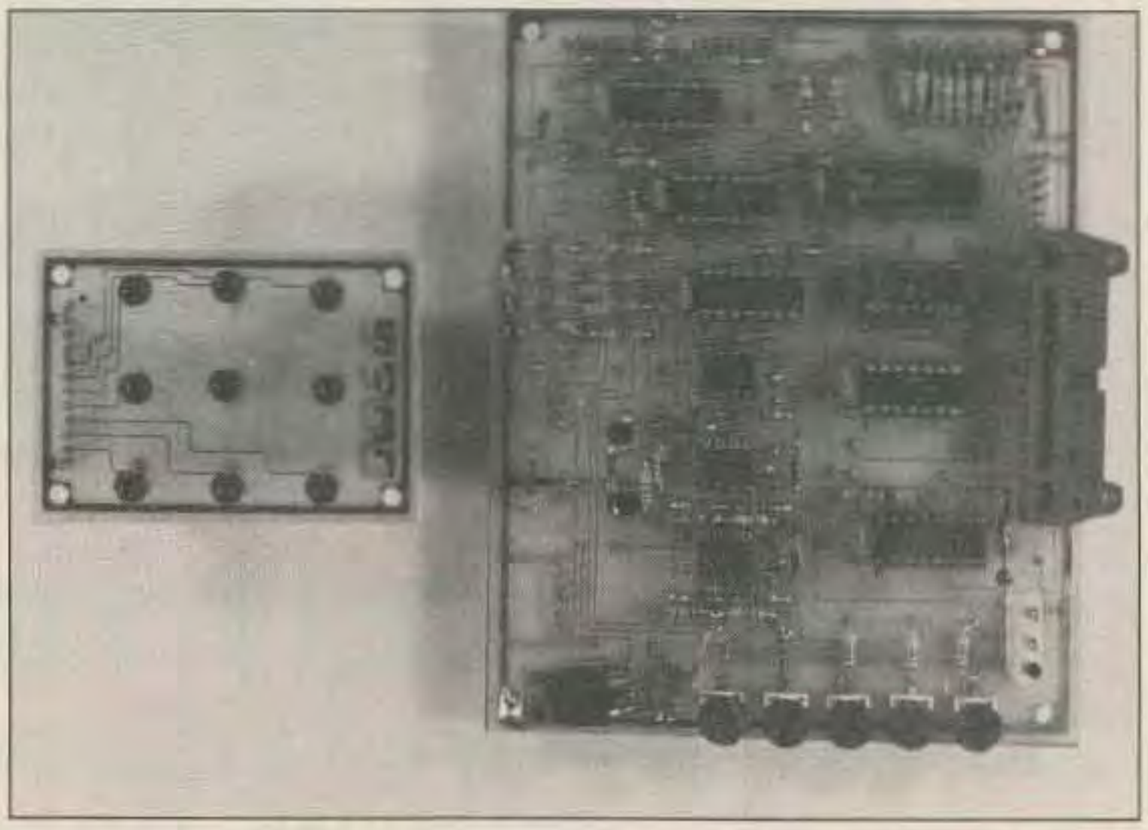


Photo B. The Main Controller Board and the optional LED display panel.

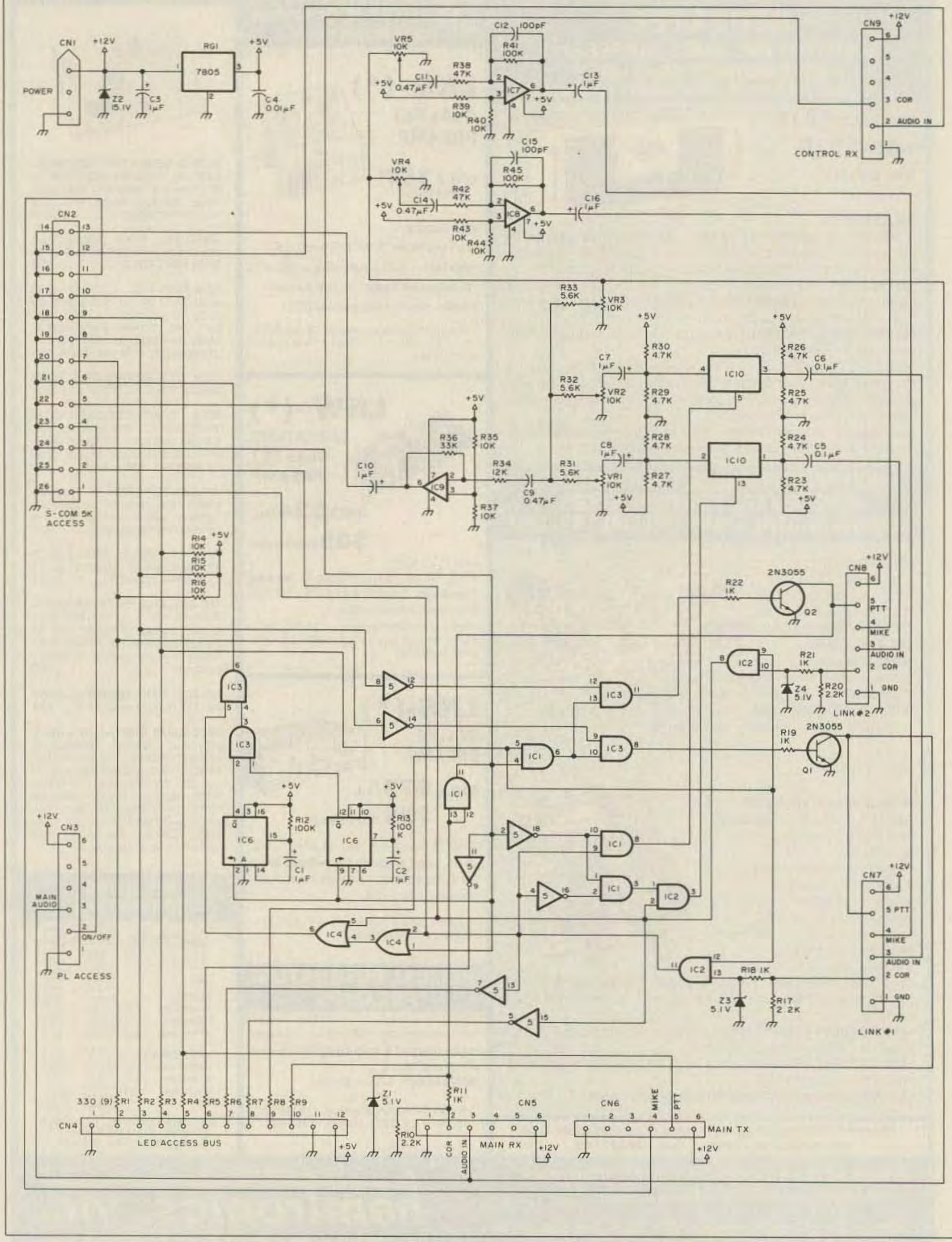
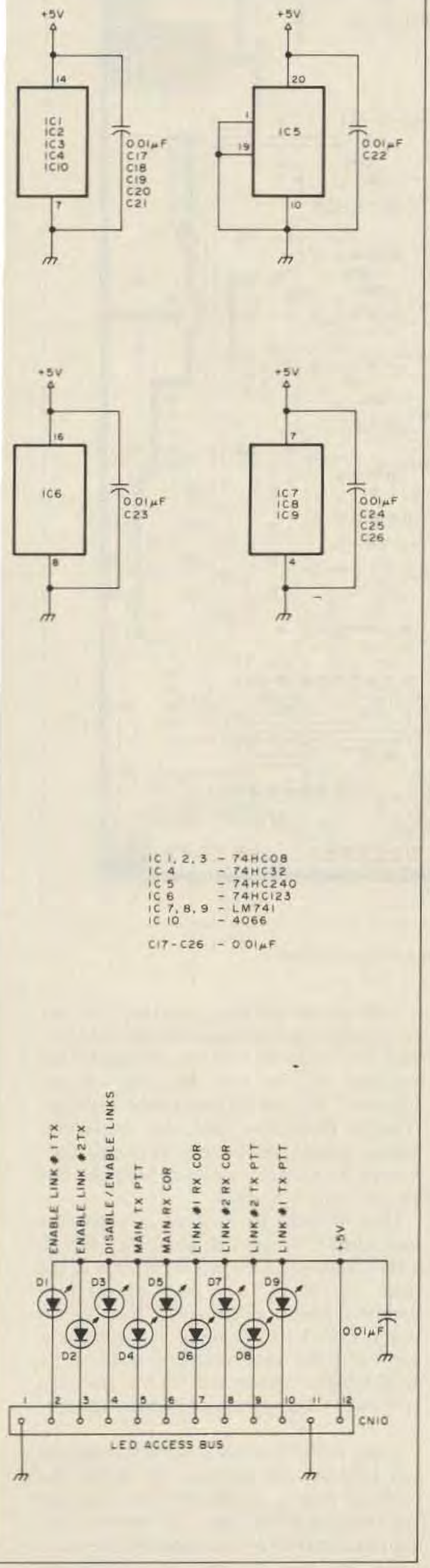


Figure 3. Schematic for the complete board of the 5K link controller.



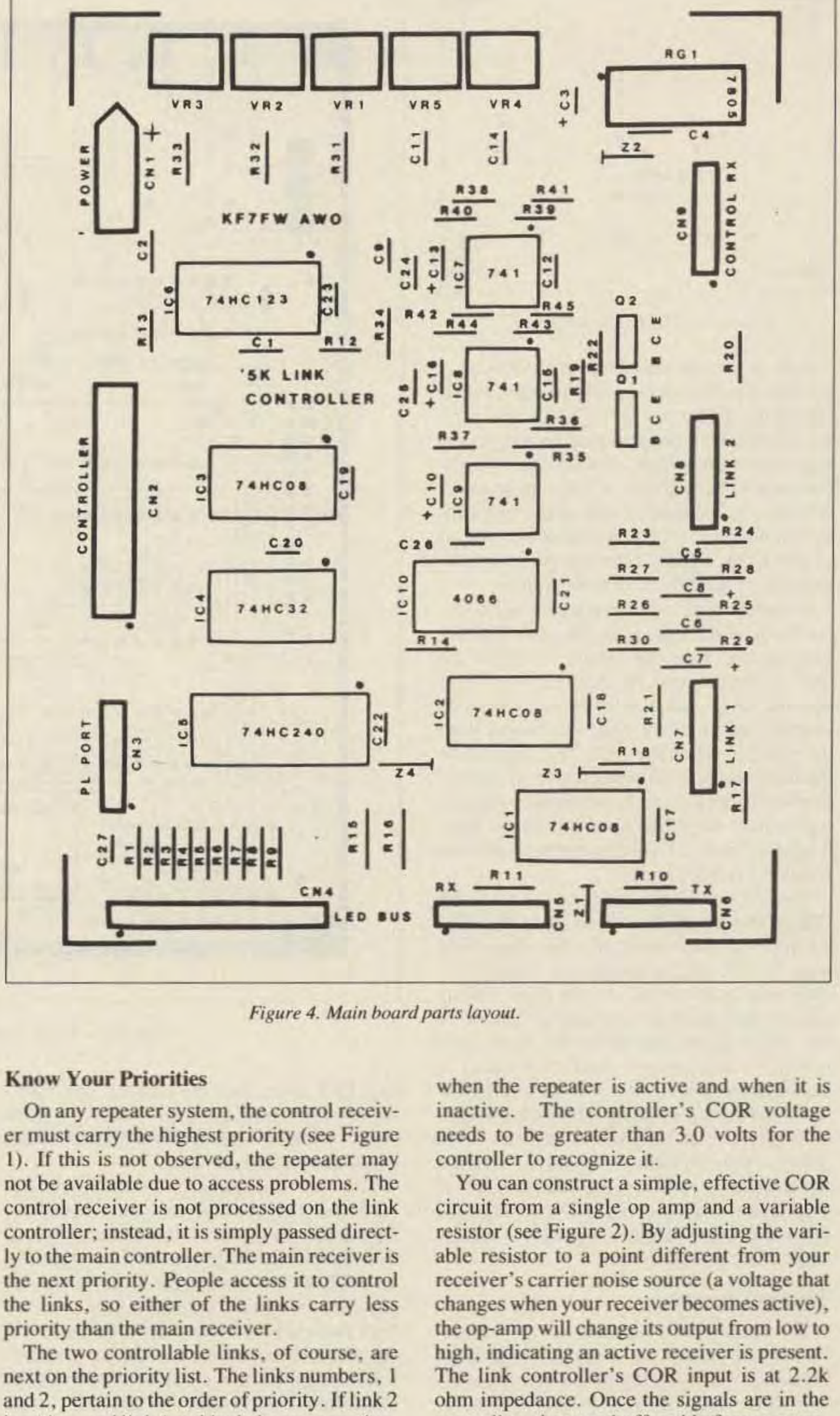


Figure 4. Main board parts layout.

Know Your Priorities

On any repeater system, the control receiver must carry the highest priority (see Figure 1). If this is not observed, the repeater may not be available due to access problems. The control receiver is not processed on the link controller; instead, it is simply passed directly to the main controller. The main receiver is the next priority. People access it to control the links, so either of the links carry less priority than the main receiver.

The two controllable links, of course, are next on the priority list. The links numbers, 1 and 2, pertain to the order of priority. If link 2 is active, and link 1 suddenly becomes active, then link 2's audio is cut off until link 1 becomes inactive. The same activity pertains to link 1 and the main receiver. The priority feature allows the repeater owner to assign the order of important to each item.

Constructing the COR Circuit

On any receiver, there is a voltage that changes when the receiver's squelch opens. This voltage, referred to as the COR (carrier operated relay) signal, tells the link controller when the repeater is active and when it is inactive. The controller's COR voltage needs to be greater than 3.0 volts for the controller to recognize it.

You can construct a simple, effective COR circuit from a single op amp and a variable resistor (see Figure 2). By adjusting the variable resistor to a point different from your receiver's carrier noise source (a voltage that changes when your receiver becomes active), the op-amp will change its output from low to high, indicating an active receiver is present. The link controller's COR input is at 2.2k ohm impedance. Once the signals are in the controller, they are buffered before any processing occurs. The main receiver's COR signal is passed directly to the links ORing section. At this point, all COR signals are passed to the main controller.

The greatest section that the main receiver's COR signal passes through is the time-out reset section. This section will reset the main controller's time-out timer every time the main receiver becomes active and every time it becomes inactive. IC 6, the 74HC123, is used for this purpose.

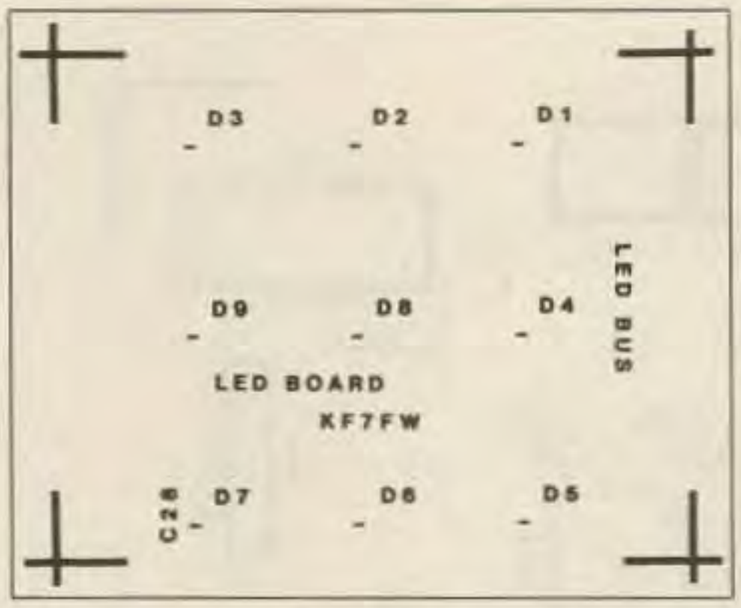


Figure 5. LED board parts layout.

Half of the one-shot multivibrator is programmed to trigger on a low-to-high transition of the main receiver's COR signal, and the other half is programmed to trigger the high-to-low transition. When either of the one shots is triggered, a 100 ms pulse is delivered to the reset circuit of the link controller. This reset circuit is needed because all of the COR signals entering the link controller are ORed together through IC 4.

In correct operation the repeater will time-out if one of the links is on for more than the programmed time-out period. Without the time-out reset circuit, the main receiver could not use the repeater until the links became inactive and reset the time-out timer. With the reset circuit on the controller, every time the main receiver becomes active, it sets the time-out timer to zero. If the repeater is timed out because one of the links was on too long, it is back, ready for use, the moment the main receiver becomes active.

The two link COR signals do not reach the ORing section of the controller before they are processed for their priority. Once they pass the link enable section, IC 2 and IC 3, they now head for IC 4, the COR ORing section. Now their priority is to switch one of the link's audio source to the main controller's audio section. Audio switching is accomplished by IC 10, a 4066 which contains four analog switches. This switch makes or breaks the audio from both links. Link priority only applies to audio; it decides which audio is routed to the main controller. Once audio switching occurs, you can adjust the audio level before it enters the mixing stage of the link controller.

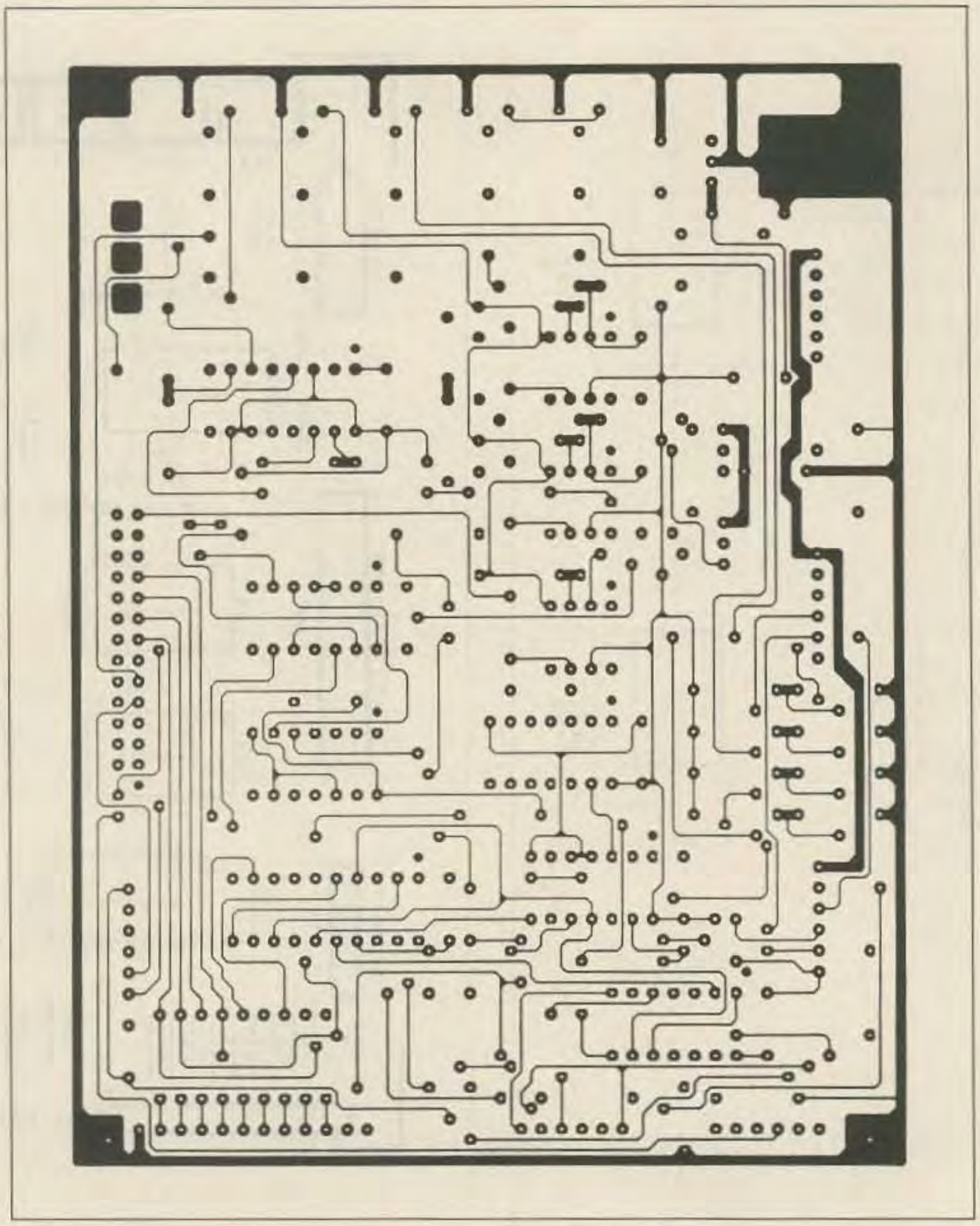


Figure 6a. Top foil layout for the main board..

Time to Transmit

The purpose of a repeater link is to transmit. If your links were always enabled, your repeater would be tying up another repeater, as well as your repeater, on every transmission. The main controller controls the section of the link controller that enables the links to transmit. Three MOSFET switchable lines come from the S-COM 5K controller and are processed by the link controller before they can PTT either of the link transmitters.

The first two lines, Out 1 and Out 2, are inverted by IC 5 and then gated through IC 3. The third line, Out 3, determines if the main receiver's COR signal will reach the link transmit enable section. If Out 3 is enabling the links, and the user has enabled one of the link PTT lines, then the enabled link transmitter will follow the main receiver's COR signal. (Refer to your S-COM manual for the output enable commands.)

The link transmitter's 2N3055, a hefty NPN current driver transistor, drives the PTT circuit of the link's radio. The link controller will supply a ground to your transmitter PTT. It was not designed to handle the current of the link transmitter. If you need a high current PTT driver, use an external relay that will handle the current. A +12 volt line is supplied on the link controller's edge connector. Use this line for any low current +12 needs, i.e., a +12 volt PTT relay. If problems occur on either of the incoming links, you can simply use the Out 3 line to disable the links, shutting down the link section of the controller completely. If you do this, only the main receiver's COR signal is active on the link controller.

Controlling the Links

The link-enable line controls the two links. Using this line, you can shut off the links if, for example, the repeater that you are linked to malfunctions and stays keyed up. First, the controller would time-out after extended use, then you would enter the correct code to shut the links off. This way, the faulty repeater link won't time-out the main repeater system. After the problem is fixed, you can then re-enable the links and continue operations. This feature is especially useful at locations that are not easily accessible.

Once the links are working, how does the user identify which link is which? The S-COM 5K controller has 3 input lines to the main controller. These lines can be programmed to react to changes in their logical states. Link 1's COR signal is connected to Input 1 on the main controller, and link 2's COR signal is connected to Input 2. The main receiver's COR signal is connected to Input 3.

Using the S-COM 5K's macro feature, you can program the controller to change the courtesy tone to a different tone when the links become active. This is the easiest way to signal the user of an incoming link message. There are many possible ways to program these lines.

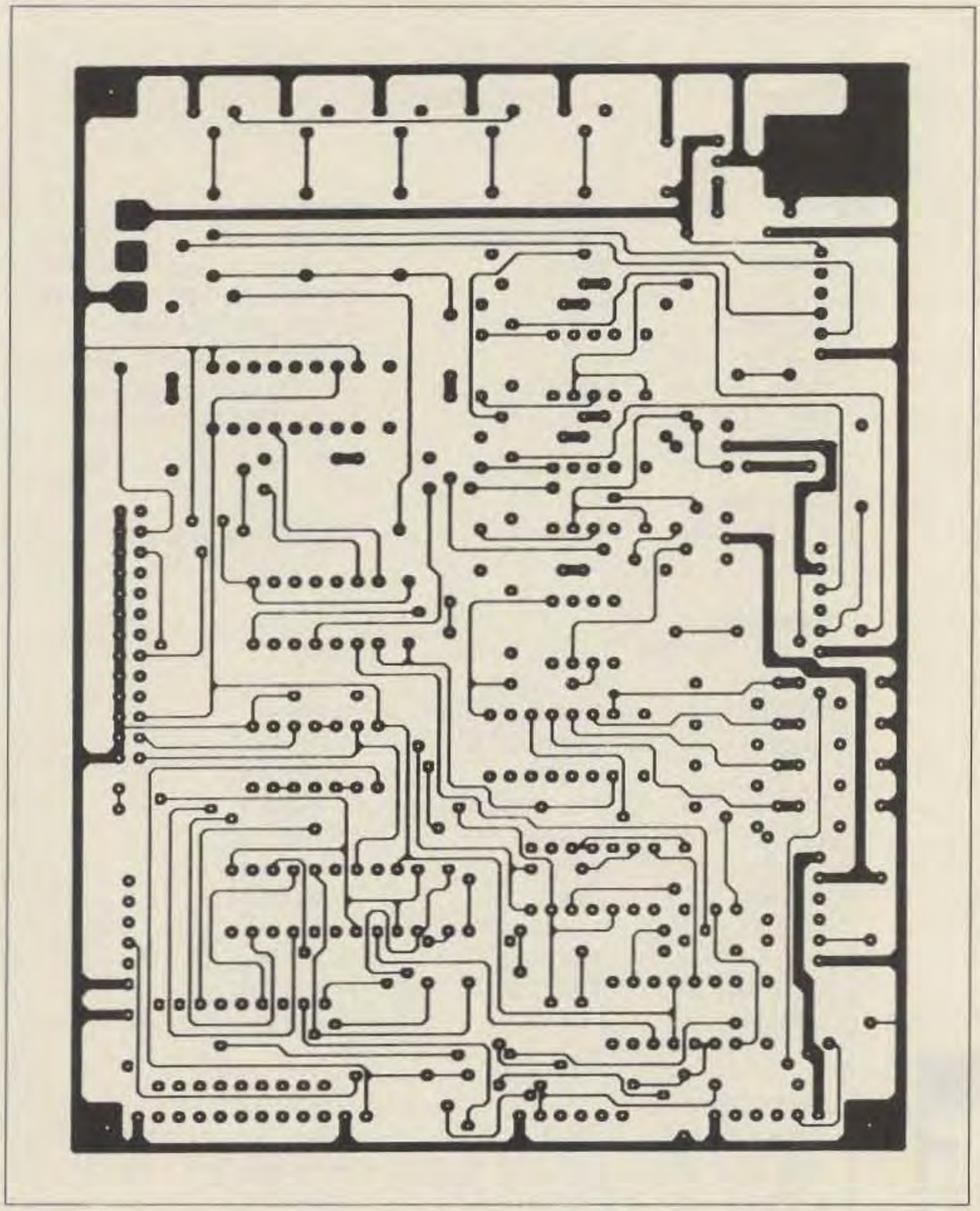


Figure 6b. Bottom foil layout for the main board.

Link Controller's Appearance

The cosmetics of the link controller are not complete without the lights. A 12-pin connector on the link controller's board lets you have external LEDs so that you can see what is happening on the link board.

Part of IC 5, the 74HC240 driver chip, sinks (supplies a low level) to the LEDs when the display is active. All of the current-limiting resistors for the LEDs are mounted on the link controller's board. Just add the LEDs.

If low power applications are required, special 1 mA LEDs are available with only minor changes to the link controller board. By changing the current-limiting resistors from 330 ohm to 4.7k ohm, and using special low power LEDs, you save 126 mA from the LED display board. The display section will show the main receiver's COR, both links' CORs, the main controller's PTT along with the two links' PTT, the two links' PTT enable, and the link enable's signal. This display feature will come in handy when programming the main controller or tracking problems in the repeater system. Just look at the display and presto, your questions are answered.

A Little Caution, Please

When constructing and handling the link controller board and components, remember that static electricity kills components. Use CMOS handling precautions. Always make sure that any static electricity is discharged from your body before touching any component or the main controller board.

Adjusting the Link Controller

Adjustment is simple and fast. To start out, adjust the three receiver level pots, VR 1, 2, and 3 to a 12 o'clock position. For proper adjustments, you'll need an auxiliary receiver that monitors the repeater's transmitter. Once the monitoring receiver is adjusted to an acceptable level, transmit a known level, such as a touch-tone from your hand-held, for a known level reference. Now open the squelch on the main repeater receiver, and transmit on the main repeater transmitter. Adjust VR 3, the level pot, of the main receiver on the link controller board, for a good level.

Once you have your main receiver adjusted *near* the correct point, transmit a touch-tone through the main receiver, and monitor it on the reference receiver. Now adjust the main receiver's audio level to match your reference level. If the level is too low, go to the main controller and locate the pot labeled RX and increase its level. Once the main receiver sounds good, move on to link 1 and adjust only its input level pot, VR 2. Continue with the same procedure as link 1 for link 2 adjusting only VR 1's level. You may need to play with the receiver levels and the RX level on the main controller to obtain a suitable audio balance.

Once the three receiver levels are adjusted, move on to the three transmitter levels. The main transmitter level, marked TX, is on the main controller board. This is the only adjustment used to control the main transmitter audio level. When you obtain a suitable mike level for the main transmitter, you need to adjust the two link transmitters. On both the links, audio levels are located on the link controller board. Link 1's output level pot is marked VR 5, and link 2's level pot is marked VR 4. To adjust their levels, input the appropriate code to enable the link portion of the controller, Out 3. Now input the code to enable the link transmitters, Out 1 and Out 2.

". . . remember that static electricity kills components."

To keep from overdriving your link transmitters' mike input, bypass the first mike amplifier section, and apply the links' audio at this point; you'll get cleaner audio on your link transmitter. If access to your mike amplifier is difficult, adding in a series resistor with the value between 50k and 100k ohms will keep the link controller from overdriving your link transmitter. Use your reference receiver to calibrate both of your link transmitters' levels, and use the same procedure when you adjust your link transmitter levels that you did when you adjusted your main receiver level.

Now input the same touch-tone on the main receiver's frequency. You enable the links so the main receiver will control the link's transmitters. Now adjust VR 4 and VR 5, the output level control on the link controller, so it matches the earlier observed level on the link monitoring receiver. Once link 1 is adjusted, proceed to link 2. Do the same adjustments for link 2 as you did for link 1. Once you have adjusted the levels, you should no longer need to do any adjusting on the link controller board.

Conclusion

The complete link controller and S-COM

5K system are currently in use on my 444.500 MHz and 147.380 MHz repeaters. With difficult access to the 147.380 MHz repeater site, I put plenty of care into the design and building of this link controller. I haven't had any problems with either the S-COM 5K or the link controller since transplanting them on the mountain. This controller was designed around the S-COM 5K repeater controller, but you can adapt it to any controller that has 3 logical outputs and 3 logical inputs. The combined link system and main controller, once built, totaled about $240. For a 2-link prioritized microprocessor-based repeater system, the price cannot be beat.

Both of the circuit boards are available from me. My address is 306 S. 20th St., Bozeman, MT 59715. The '5K Link Controller Main Board is $28.50 plus $2.50 S/H. The '5K Link Controller LED board is $7.50 plus $1.50 S/H. Both boards are $34.50 plus $2.50 S/H. The main board includes plate through-holes, solder mask, and parts ID mask. The LED Board is a non-plated through-board, but it comes with the appropriate ID mask.

The S-COM 5K Repeater Controller is available from S-COM Industries, PO Box 8921, Ft. Collins CO 80525-0700 (303-493-8316) for $189.

Happy home-brewing! 73

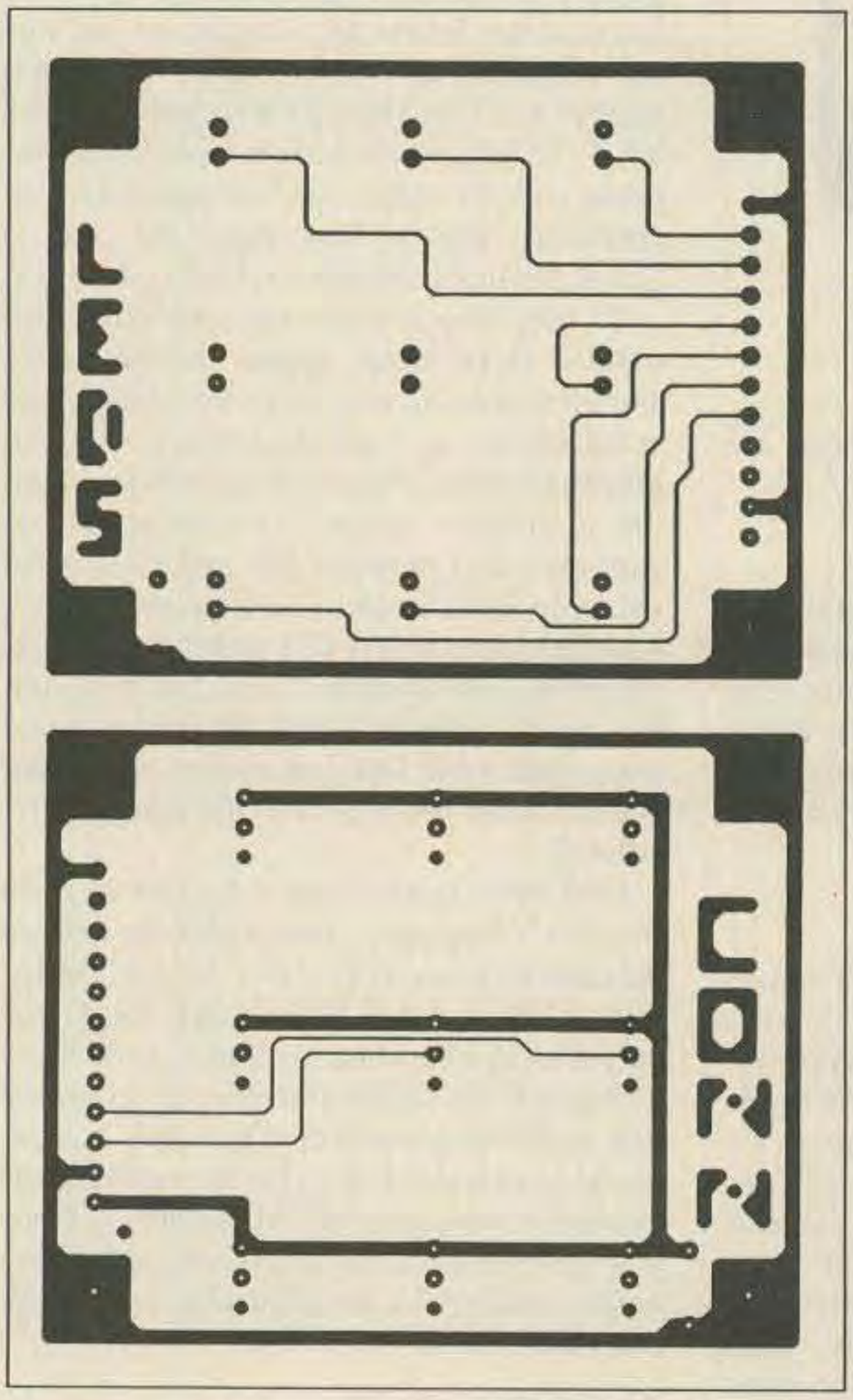


Figure 7. a) Top foil layout for the LED board. b) Bottom foil layout for the LED board.

The '5K Link Controller Parts List

ICs

	Quantity	Chip #	Description
7805	1	RG1	5 volt regulator
74HC08	3	IC 1, 2, 3	Quad 2 input CMOS logical AND
74HC32	1	IC 4	Quad 2 input CMOS logical OR
74HC240	1	IC 5	Inverting CMOS line driver
74HC123	1	IC 6	Dual CMOS multi-vibrators
LM741	3	IC 7, 8, 9	8-pin dip-packaged op amp
4066	1	IC 10	Quad CMOS analog switch

Transistors

2N3055	2	Q1, Q2	TO-220 NPN transistor

Resistors

Value	Quantity	Res. #	Style
10k ohm	5	VR 1,2,3,4,5	Variable res.
330 ohm	9	R 1,2,3,4,5,6,7,8,9	¼ Watt res.
10k ohm	9	R 14,15,16,35,37,39, 40,43,44	¼ Watt res.
100k ohm	4	R 12,13,41,45	¼ Watt res.
4.7k ohm	8	R 23,24,25,26	¼ Watt res.
47k ohm	2	R 38,39	¼ Watt res.
12k ohm	1	R 34	¼ Watt res.
1k ohm	5	R 11,18,19,21,22	¼ Watt res.
5.6k ohm	3	R 31,32,33	¼ Watt res.
2.2k ohm	3	R 10,17,20	¼ Watt res.
33k ohm	1	R 36	¼ Watt res.

Capacitors

Value	Quantity	Cap. #	Style
1 mF	8	C 1,2,3,7,8,10,13,16	electrolytic. cap.
0.1 mF	2	C 5, 6	disk cap.
0.47 mF	3	C 9, 11, 14	disk cap.
100 pF	2	C 12, 15	disk cap.
0.01 mF	11	C 4, 17–28	disk cap.

LEDs

Type	Quantity	Diode #	Style
Red	3	D 4, 8, 9	Red - transmit
Yellow	3	D 5, 6, 7	Yellow - COR
Green	3	D 1, 2, 3	Green - Enable/Disable
5.1 V	3	Z 1, 3, 4	1N4733 5.1 V Zener Diode
15 V	1	Z 2	MPTE15 15 volt Zener Diode

Connectors

Type	Quantity	Conn. #	Style
wafer	6	CN 3,5,6,7,8,9	6-pin Modular connector
mate	6	CN 3,5,6,7,8,9	6-pin Modular connector
wafer	1	CN 4	12-pin Modular connector
mate	1	CN 4	12-pin Modular connector
male	1	CN 2	26-pin Ansley right angle
female	1	CN 2	26-pin Ansley cable crimp
male	1	5K connect	DB-25 male cable crimp
male	1	CN 1	3-pin Molex PC mount
female	1	CN 1	3-pin Molex crimp mount
cable	1 ft.	26-pin ribbon cable	