QEX July 41 1985 $1

The ARRL Experimenters' Exchange

New Tools for the ARRL Technical Department

How do you layout and etch a circuit board for a dedicated microprocessor? That is a question that we had to answer recently in the Technical Department. The old procedures and processes were no longer good enough for the new projects with many narrow traces that we are doing these days.

We had been using clear mylar to create a double-size pattern using art supplies. That procedure is tedious and difficult, nearly impossible for highly complicated boards. Our former process used Xylene (a suspected carcinogen) in the developing step. A glass cake pan held the developer; the pan was hand agitated by the person doing the board. For etching, we used an arrangement similar to the one shown in recent editions of **The ARRL 1985 Handbook.** Our etching stand had an air bubbler agitator and heat lamp. Metallic fixtures in the etching room were showing signs of corrosion.

It was time for a change! Health and technical concerns had to be addressed.

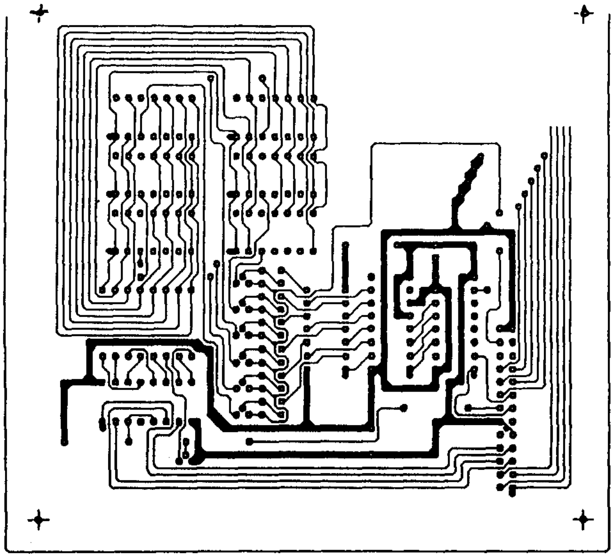
New equipment and chemicals are now used to process boards. The new process uses sodium carbonate instead of Xylene as the developer. For an etchant, we now use sodium persulphate in place of ferric chloride. No longer are the developer and etchant used in open containers. We have purchased closed developer and etcher tanks (Kepro BTD-201B and BTE-202). These tanks heat the chemicals and spray them on the board. The results are great! Faster, finer, more even action. Best of all, employee exposure to hazardous substances is greatly reduced.

But what about board layouts? The obvious solution was a CAD package. We have an IBM PC and an Epson FX-100 printer. To work with these, we chose the Wintek smARTWORK CAD package. A mouse from Microsoft and a Houston Instruments DMP-40 complete the package. Single or double sized test patterns can be printed on the FX-100. Final layouts are drawn with the plotter and then photographically reduced. You can see the results on this page.

To debug complicated digital projects, like our microprocessor board, requires sophisticated test equipment. A Hewlett Packard HP-1630 logic analyzer is the new tool that we have to meet that need.

All this equipment will do more than help us develop the Z-80 dedicated microprocessor board. It will be used for many new projects for the **ARRL Handbook** and **QST**. Watch **QST** for the microprocessor board and the first application board.

Two other items have improved our capabilities in the RF realm. A Superior Electric Co. BCR3205U line conditioning and voltage stabilizing transformer allows us to check 234-V ac powered equipment -- such as legal-limit RF amplifiers. In the future we will not use photographs for spectral displays. Those displays will be drawn by a new Hewlett Packard HP-7090 plotter. We are pleased with our new tools and hope that you notice a difference in our publications. — Chuck Hutchinson, K8CH



Correspondence

Current Equalizing in Paralleled Transformers

The correspondence query in January 1985 **QEX** (no. 37) and response in March (no. 37) should be followed with at least a note on the classical current equalizer.

The current-equalizing inductor may be the secondary (center-tapped) of a low-voltage filament transformer, as this winding will only see the difference between voltages E_1 and E_2. For the ideal case, $E_1 = E_2$, the currents are equal but opposite in the center-tapped winding. There is no net flux, and therefore no inductive voltage drop. Ideally there is no loss.

When E_1 is not equal to E_2, the open-circuit voltage at the center-tap is $E_2 + 1/2(E_1 - E_2)$. If the difference between E_1 and E_2 is very small, the currents will be approximately equal and there will be essentially only the normal transformer losses.

This scheme has been used for at least 50 years (and more) for paralleling nominally-equal transformers. Hope this fills a need. -- Dave Geiser, ARRL Technical Advisor, RR 2, Box 787, Snowden Hill Road, New Hartford, NY 13413.

ACSSB Replacement Parts Available Soon

Amateur experimenters who purchased ACSSB boards now have a new link to the manufacturer! Ronald J. Bartholomew, WA8SVO, of American Telecommunications is an Aerotron dealer who hopes to have replacement parts for the boards available soon. He may even be able to supply complete modules, such as the interface board and the power amplifier stage. He can be reached at (216) 455-9350.

Timex-1000 Program For Series Line Matching Sections For Impedance Matching

While recently reviewing Russell Prack's, K5RP, notes on "Series Line Matching Sections for Impedance Matching," January 1984 **QEX** (no. 23), it seemed that an appropriate computer program could be written for quick computation of the many variables.

Herewith is a listing of my program, for the Timex-1000. It is designed to accommodate any impedance feed line, and section matching line to any load impedance and load reactance. In addition, I have added computation of L1 and L2 lengths in decimal feet, for which frequency of interest is specified as well as velocity of propagation for both the feed line and matching section.

Note that whenever L1 computation results in a negative value, L1 (+180) will give the proper positive value to use. -- R. H. Knaack, Jr., W7FGQ, 11415 28th Ave. SW, Seattle, WA 98146.

```
100 REM      "SERIES SECT"
110 REM   SERIES SECTION LINE MATCHING - REF: QEX
          JAN 1984, AND ARRL ANTENNA HANDBOOK
          14TH EDITION
130 REM
140 REM   ARR: BY W7FGQ APR 85
150 REM
160 REM   L1 DESIGNATES LENGTH OF LINE FROM THE
          LOAD
170 REM
180 REM   L2 DESIGNATES LENGTH OF SERIES SECTION
190 REM
200 REM   RL IS LOAD IMPEDANCE
210 REM
220 REM   XL IS LOAD REACTANCE
230 REM
240 REM   ZØ IS LINE IMPEDANCE
250 REM
260 REM   Z1 SECTION IMPEDANCE
270 CLS
280 PRINT  "ENTER LINE IMPEDANCE ZØ"
290 INPUT ZØ
300 PRINT AT 9, 2; "ZØ = "; ZØ
310 PRINT AT 2, Ø; "ENTER SECTION IMPEDANCE Z1"
320 INPUT Z1
330 PRINT AT 11,2; "Z1 = "; Z1
340 PRINT AT 4, Ø; "ENTER LOAD IMPEDANCE RL"
350 INPUT RL
360 PRINT AT 9,16; "RL= "; RL
370 PRINT AT 6, Ø; "ENTER REACTANCE XL (JXL)"
380 INPUT XL
390 PRINT AT 11,15; "XL = ";XL
400 LET N = Z1/ZØ
410 LET R = RL/ZØ
420 LET X = XL/ZØ
430 LET B = R * (N-1/N) * (N-1/N) - (R-1)
    * (R-1) - (X*X)
440 LET B = ((R-1) * (R-1) + (X*X)) /B
450 LET B = SQR ABS B
460 LET A = R + (X*N*B) - 1
470 LET A = ((N-R/N) *B+X) /A
480 PRINT AT 14,2; "L1 (DEGREES) = ", INT ((ATN
    A*57.3) *1ØØØ) /1ØØØ
490 PRINT AT 16,2; "L1(+18Ø) = ",INT (((ATN A*
    57.3) +18Ø) *1ØØØ)/1ØØØ
500 PRINT AT 18,2; "L2 (DEGREES) = ", INT ((ATN
    B*57.3) *1ØØØ)/1ØØØ
510 PRINT ,,,, "TO COMPUTE LENGTHS, PRESS <ENTER>"
520 IF INKEY$="" THEN GOTO 52Ø
530 IF INKEY$<>"" THEN GOTO 53Ø
540 CLS
550 PRINT ,,,, "ENTER FREQUENCY F,MHZ";
560 INPUT F
570 PRINT TAB 27;F
580 PRINT ,, "ENTER L1 VELOCITY FACTOR";
590 INPUT VFA
600 PRINT TAB 27;VFA
```

(Continued on page 8.)

Improvements to the TI PHP-2500, Epson RX-80 or Other Similar Printers

By John S. Davis,* WB4KOH

Would you like to improve your printer for quiet operation or remote switching to the RS-232-C board? These modifications can be performed on the Texas Instruments model PHP-2500, Epson model RX-80, or other similar printers. The last change enables you to switch between bit rates, parity and word length (text or graphic mode) without removing the cover. Total cost for this project is $6.87. This includes the electronic parts, which were obtained from Radio Shack™. See the Materials List. The placement of the new remote switch assembly is shown in photo 1.

The material used for sound absorption is shown in Fig. 1. I used the packing material that comes with TI's writer/word processor (PHM-3111). Actually any styrofoam-type padding 5/8-inch thick will do.

Cut the foam as shown in Fig. 1; photos 1 and 2 show its placement. Follow the instructions given in your User's Manual, and remove the paper, paper lid, paper separater, ribbon and top cover. With the printer facing you, the left portion is inserted with the notch for the paper thickness adjustment lever, as seen in photos 3 and 4. The top back portion is held in place with double-stick tape, with the 1/4-inch cut against the bend of the cover. Make sure that you do not block any vent holes in the cover when installing the foam. The right portion is shown in photos 3, 4 and 5. The manual paper feed shaft fits into the notch cut into this portion. The front portion is mounted last, in the front of the top cover. This is shown in photo 3. It stays in place by itself (friction fit).

This modification provides noise reduction while printing. With the paper cover raised and lowered before the foam padding was inserted, little sound difference in output was noted. However, after the installation, a noticeable difference is heard.

To add the RS-232-C switches, follow the instructions given in your User's Manual. Remove the RS-232-C board. The added wiring is shown in Fig. 2 and photo 7. The remote switch(es) is shown in Fig. 3 and photo 8. The wiring location is shown in photo 5. Begin by soldering the IC socket and an end of the cable back to back. Align the tracer and pin no. 1 of the IC socket (flat side). Allow these pins to cross each other their full length. Use a large clip or small vise-grips to hold these in place while soldering. Be careful as shorts are easy to create! The DIN switches are plugged into this socket with pin number 1 lined up. A small piece of double-stick tape holds this remote assembly to the top of the ribbon as shown in photo 1.

The RS-232-C board wiring is as follows. Bind out pins 5, 6, 11 and 12 of the other end of the cable assembly. Solder a short length of wire to pins 5 and 12. Pins 6 and 11 are not used (switch number 6). Solder this in place to SW-1 (foil side) of the RS-232-C board as seen in Fig. 2 and photo 7. Watch for solder bridges. Pin no. 1 connects to pin no. 1, 2 to 2, and so on. Solder the wire from pin 5 of SW-1 to pin 1 of SW-2 and pin 12 of SW-1 to pin 8 of SW-2. SW-1 has 8 switches and SW-2 has 4 switches. Consult your User's Manual. Install the RS-232-C board and follow the wiring placement as in photo 5. Turn OFF switches 1, 2, 3, 4, 7 and 8 of SW-1 and switch 1 of SW-2. The new remote switches now control their functions.

Cut out a copy of Tables D1, D2 and D2 (on pages 51 and 52 of the Texas Instruments User's Manual) and tape this to the foam underside of the paper cover as seen in photo 1. Use this as a reference to set these switches. Switches 1 through 4 control the bit rate (.BA, see Table D3); number 5 sets 7 or 8 word length (.DA, ON for 7 word length or text mode, Table D2); number 6 is unused (spare); and numbers 7 and 8 are for parity check (.PA, Table D1). Reassemble your printer, sit back and relax -- you do not have to check your software to work your printer. Your printer can now be set to work your software, and with less noise!

Materials List

No.	Model Number*	Description	Price**
1	276-1998	15 DIN socket	.89
1	276-1676A	18-in ribbon jumper cable	3.99
1	275-1301	8 position switches for 16 pin DIN	1.99
		TOTAL	6.87

* From Radio Shack
** Price as of July 1984

(Figs. and photos for this article appear on pages 4 through 7.)

*3929 #4 Winterfield Place, Charlotte, NC 28205

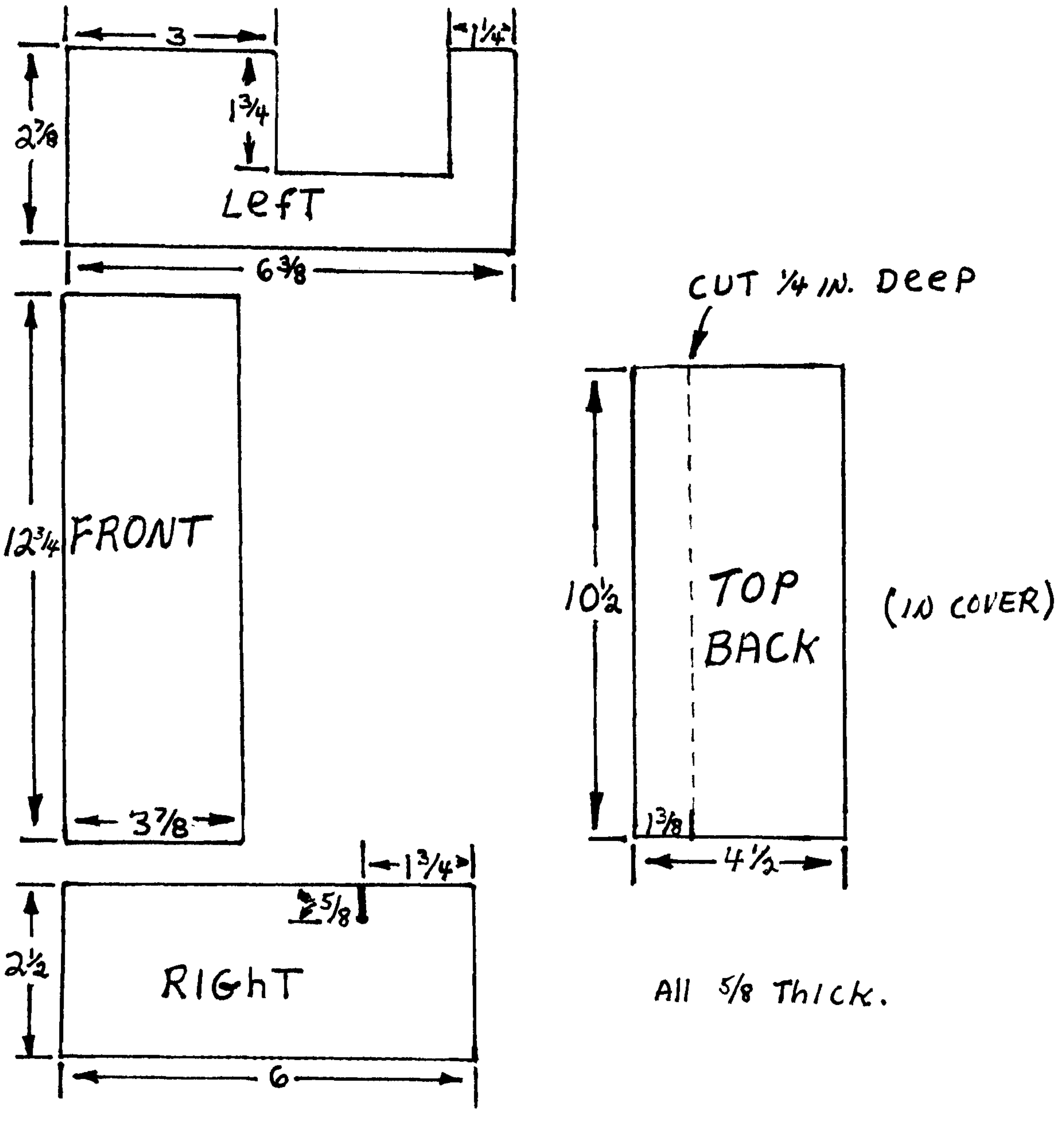


Fig. 1 — Dimensions for cutting the foam padding to be inserted in sections of the printer cover. All dimensions are in inches and the diagrams are not drawn to scale.

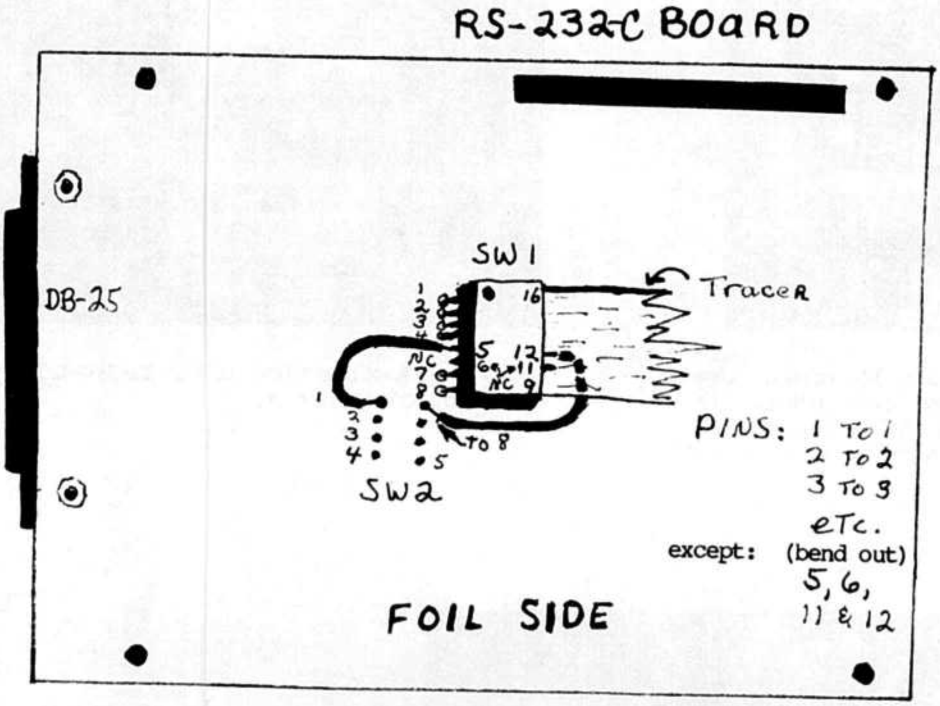


Fig. 2 -- The RS-232-C board showing pin connections.

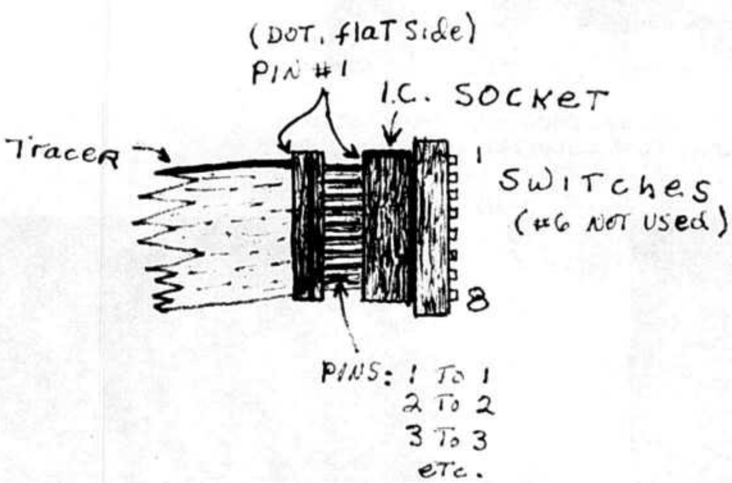


Fig. 3 -- A close up view showing the cable wiring.

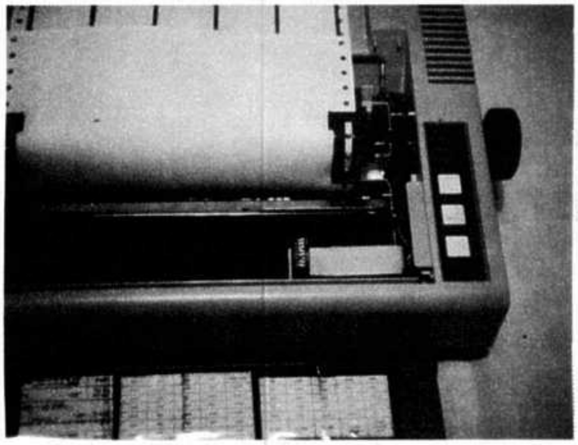


Photo 1 -- The remote switching location. Use double-stick tape to hold the foam padding in place. A copy of Table D3, D2 and D1 (pp. 52, 52 of the TI User's Manual) are taped to the underside of the lid for reference.

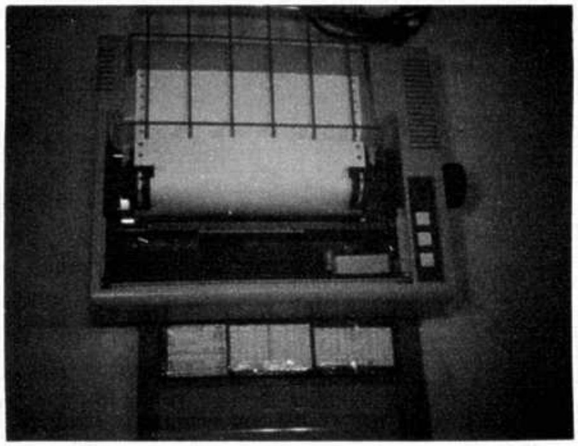
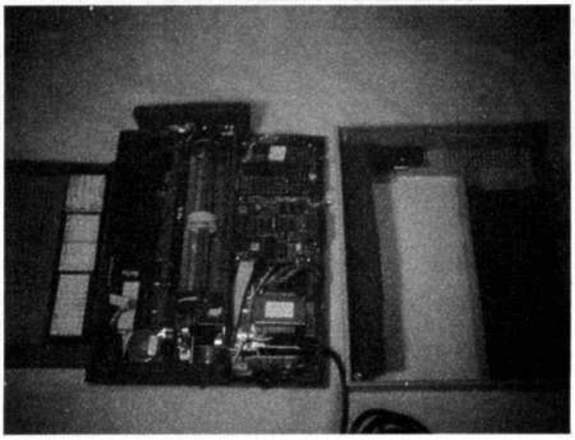


Photo 2 — Another view of the TI PHP-2500 printer and front cover layout.

Left



Top Back (in cover — use double-stick tape to hold padding in place)

Right

Photo 3 -- With the case removed, the locations for adding sound-proof material is shown. See Fig. 1.

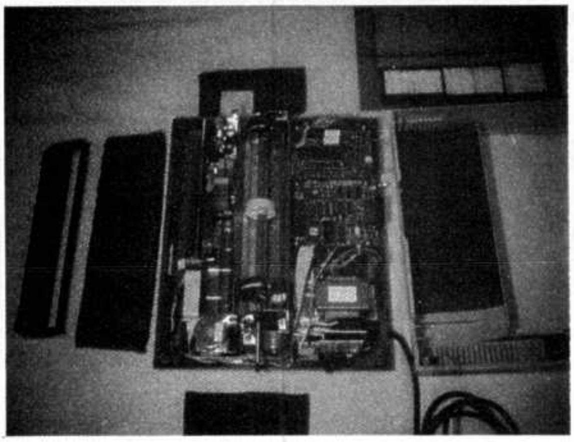


Photo 4 -- This view shows the sound-proofing material locations removed.

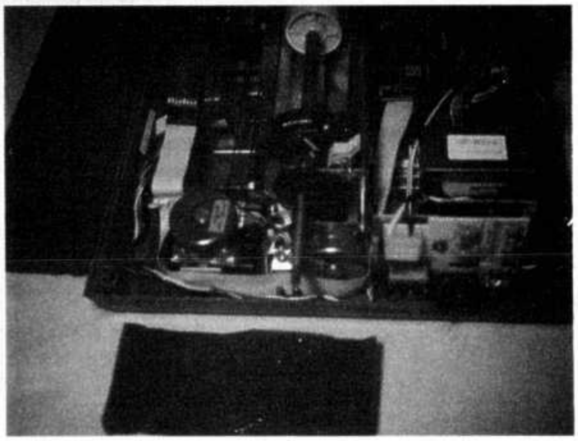


Photo 5 -- Added wiring location to remote switches.

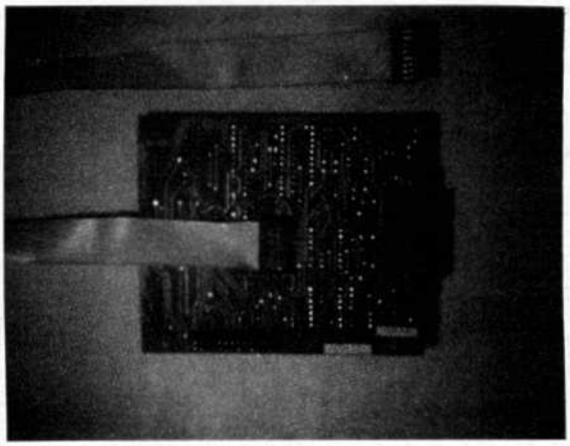


Photo 6 -- RS-232-C board is removed, showing added wiring to and from remote switches.

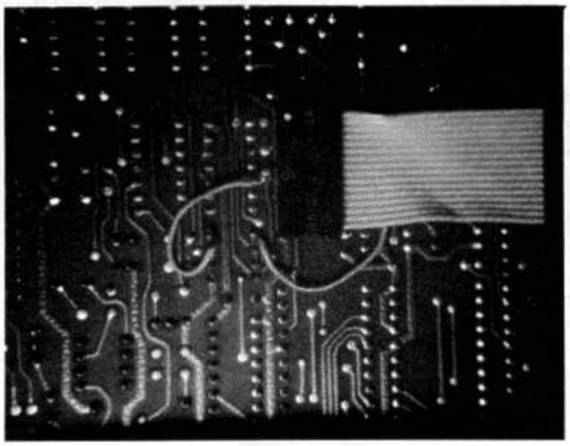


Photo 7 -- A close up of the added wiring to the RS-232-C board. See Fig. 2 also.

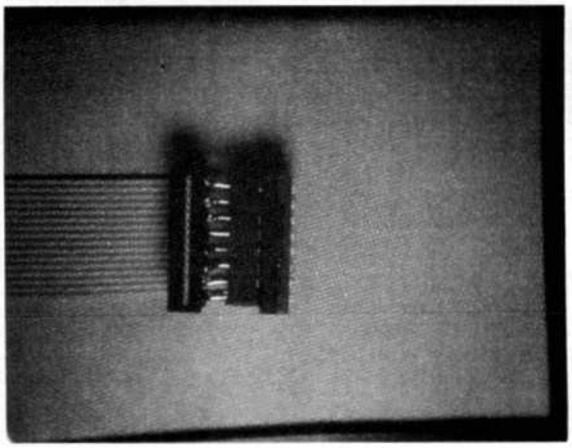


Photo 8 -- A close up view of the remote switch. Refer to Fig. 3.

A Method for Achieving High Isolation Between Antenna Arrays

By Bill Conwell,* K2PO

A "Method for Achieving High Isolation Between Antenna Arrays" is the subject of U. S. Patent No. 4,480,255 recently issued to Alan L. Davidson and assigned to Motorola. The method permits a transmitting antenna to operate in the same band as a nearby receiving antenna without overloading the receiver front end.

The invention uses two co-linear arrays and requires each array be divided into two sections: top and bottom. The top section of each array is operated in phase quadrature with its bottom section. The horizontal spacing between the two arrays is small enough so that substantially no radiation from the top of one array is received by the bottom on the other array, and vice versa. (This is preferably achieved by selecting the spacing between the arrays to be less than the height of the arrays. The arrays, however, should not be so close that the mutual impedance between antennas degrades their performance.)

Referring to the illustration, it can be seen that the feed lines feeding the bottom sections of each antenna are 90 degrees longer than the feed lines feeding the top sections. Transmitted signals arriving at the receiver via the bottom sections are thus delayed 180 degrees relative to transmitted signals arriving via the top sections. These out-of-phase signals cancel at the receiver input, preventing front end overload.

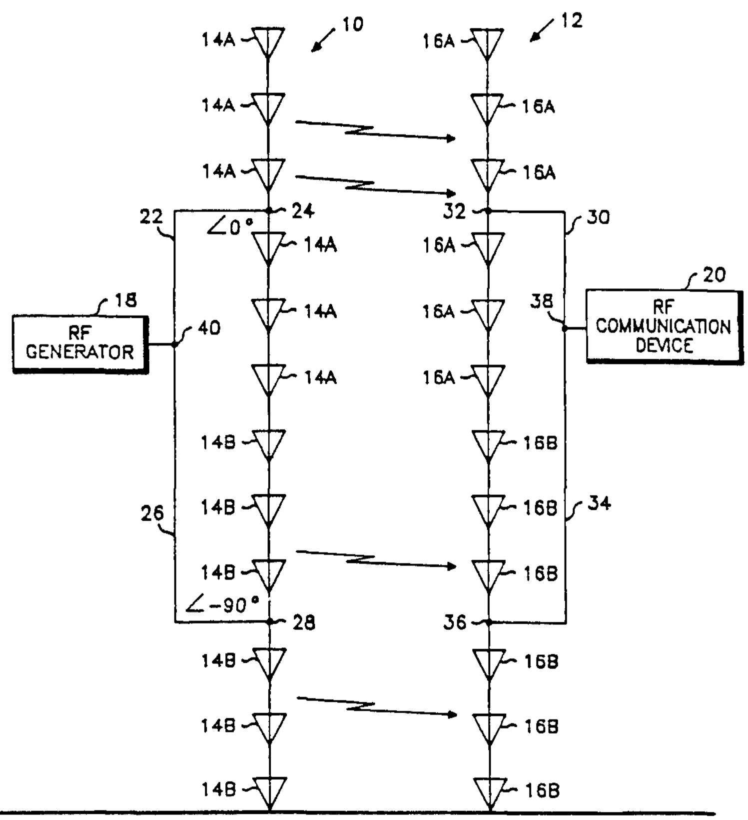
The tradeoff in this scheme, not mentioned in the patent, is that feeding two halves of a co-linear array in quadrature lowers its gain at the horizon by 3 dB. This may or may not be important, depending on the application.

Copies of this patent are available from the Commissioner of Patents, U. S. Patent and Trademark Office, Washington, D.C. 20231 for $1.00 (approximately four week delivery).

Caveat: "Whoever without authority makes, uses or sells any patented invention, within the United States during the term of the patent therefor, infringes the patent." 35 U.S.C. 271.

*16th Willamette Center, 121 SW Salmon St., Portland, OR 97204

Information on this patented invention is printed here in accord with **QEX**'s stated purposes of (1) providing a medium for the exchange of ideas and information; (2) documenting advanced technical work in the Amateur Radio field; and (3) supporting efforts to advance the state of the Amateur Radio art. This particular invention may not be practiced, without a license from Motorola, until October 30, 2001. Nonetheless, it is believed that publicity of such advances in the state of the art will broaden the perspective of amateur experimenters and promote future technical advances within the amateur community.



(Correspondence continued from page 2.)

```
610 PRINT ,,"ENTER L2 VELOCITY FACTOR";
620 INPUT VFB
630 PRINT TAB 27;VFB
640 PRINT ,,,, TAB 4; "L1(FT) = ",INT
    ((((ATN A*57.3) * (984/F) *VFA/36Ø
    *1ØØØ)/1ØØØ
650 PRINT ,, TAB 4; "L1(+180)FT=", INT
    (((((ATN A*57.3) +18Ø) * (984/F)
    *VFA)/36Ø) *1ØØØ)/
    1ØØØ
660 PRINT ,, TAB 4; "L1(FT) = ", INT ((((ATN
    B*57.3) * (984/F) *VFB)/36Ø) *1ØØØ)/1ØØØ
670 PRINT AT 2Ø,2; "TO RUN AGAIN, PRESS <ENTER>
680 IF INKEY$="" THEN GOTO 68Ø
690 IF INKEY$<>"" THEN GOTO 69Ø
700 GOTO 27Ø
```

Composition Resistors — Trimmed and Otherwise

By Albert E. Weller,* WD8KBW

A recurring problem when building instruments on Amateur Radio budgets is obtaining "precision" resistors usable at RF. Composition resistors of moderate resistance values, say 10 to 1000 ohms, appear to have reasonably good RF behavior.[1,2] However, the most commonly available type of composition resistor can be obtained only in specific standard resistances and with tolerances of 20, 10 and 5 percent.

Most published amateur construction projects requiring a tighter tolerance and/or a nonstandard resistance suggest selecting a resistor from among standard units or using standard values in series parallel combinations to obtain the desired value — as measured with a **good** ohmmeter. An alternative method is to **trim** a standard value, of lower resistance than the target value, by filing a notch through the insulating shell and into the resistance composition. As the notch is cut deeper into the resistance composition, the cross section is reduced and the resistance increased.

Two obvious questions concerning the behavior of resistors trimmed by notching can be asked. What is the effect of trimming on the power handling capability and the possible increase in sensitivity to environmental factors, particularly moisture, caused by the direct exposure of the resistance composition?

Tests and Results

To investigate these questions, I purchased ten 47 ohm, 1 watt, 5 percent resistors from a local electronics parts supplier. Also on hand for comparison purposes were a 500 ohm, 0.1 percent precision resistor and a 500 ohm, 5 percent wire wound resistor.

All resistors were measured using a four-dial Wheatstone bridge. Surprisingly, none of the composition resistors fell within the specified tolerance. The measured range was 51.11 to 53.61 ohms, or +8.7 to +14.1 percent. The 500-ohm precision resistor measured 499.9 ohms (-0.02 percent) and the 500 ohm, 5 percent resistor mesured 500.9 ohms (+0.18 percent).

Several of the composition resistors were trimmed by filing: some using a V-notch formed with a 6-inch triangular file and some using a square note formed with a 1/4-inch flat file. The resistances wre increased approximately 2.5, 5 and 15 percent. (These rather normal resistance increases required surprisingly deep notches — approaching half way through the resistance composition.) The resistances of the trimmed resistors and of an unmodified (standard) resistor were measured at two power levels: approximately 0.25 watt and 0.9 watt. It was expected that:

o The trimmed resistors would show a larger change in resistance at the high power level than would the unmodified resistor as a result of the hot spot formed at the reduced cross section of the resistance composition, and

o The V-notched resistors would show a larger change in resistance at the high power level than would the square notched resistors as a result of the smaller minimum cross section of the V-notched resistors.

The results of this test are shown in the table below.

Behavior of Notch-Trimmed Resistors

Notch	Trimmed R/Original R	R at High Power/ R at Low Power
Vee	1.0254	1.00697
Square	1.0315	1.01032
Vee	1.0503	1.00995
Square	1.0500	1.00897
Vee	1.1507	1.00925
Square	1.1514	1.01055
None	—	1.00894

I see no consistent difference between the two types of notches or between the notched and unmodified resistors.

Two resistors, one square notched to increase its resistance 5 percent and one unmodified, were measured over a period of two months while exposed to ordinary room conditions during the fall season. (Space heating was begun on the sixth day of the monitoring period.) Fig. 1 shows the observed changes of resistance. The two resistors appear to respond similarly to changes in ambient conditions.

As a final test, the notches in two of the square notched resistors were sealed with epoxy cement. Each of these was paired with an unsealed square notched resistor and mounted in a 4-ounce plastic jar. An unmodified resistor was also mounted in one of the jars. One jar contained a layer of anhydrous calcium sulfate, which results in near zero relative humidity. The other jar contained about one ounce of a saturated sodium carbonate solution, which results in a relative humidity of approximately 90 percent.[3]

After an eight day conditioning period, the two groups of resistors were interchanged. Fig. 2 shows the observed changes in resistance for the two resistors having the greatest and least change in resistance and for the unmodified resistor, and

*1325 Cambridge Blvd., Columbus, OH 43212

the final resistances for the remaining resistors.

During the entire 68 days of the test period, the 500 ohm, 5 percent and 500 ohm, 0.1 percent resistors showed no change of resistance.

Conclusion

The results of these tests are rather surprising in several ways. First, of course, is the fact that composition resistors purchased through a reputable source may grossly fail to meet specifications. I certainly hope my experience is not common. I must say that the average composition in my junk box is much closer to the marked resistance than were these ten.

The second surprise is the large variability in the response of the tested resistors to humidity changes. The final surprise is that trimming the resistors by notching appears to have little effect on the behavior of the resistors. Power handling capability and response to humidity changes seems unaffected, or at least, any effects are submerged by the unit-to-unit variations.

Would I recommend notch trimming composition resistors of 5 percent or greater tolerance to produce a **precision** resistor? Only as a last resort. If the trimmed resistor can be maintained in a reasonably constant environment, you can probably expect the resistor to remain within 0.5 percent of the trimmed value (Fig. 1). At least there is no indication that the trimmed resistor will perform more poorly than a series/parallel combination adjusted to the same specification. For either method of trimming, if the resistors are exposed to large changes in humidity, your careful trimming is probably wasted effort.

If a composition resistor is required for its RF properties, purchase of 1 percent tolerance resistors (whose specifications on temperature and humidity coefficients are better than those for the common 5 to 20 percent tolerance resistors) seems well justified. Where only dc properties are involved, the stability of even low cost wirewound resistors is strongly in their favor.

References

[1] **The ARRL 1985 Handbook**, p. 25-28, The American Radio Relay League, 1985 edition.

[2] **The Electronic Components,** Publication RO 1980/1982, pp. 15-16, Allen-Bradley Co.

[3] **Handbook of Chemistry and Physics,** pp. 2499-2500, Chemical Rubber Publishing Co., 42nd Ed., 1960-1961

[4] Demaw, D., W1FB, "Beating the High Cost of Parts," **QST**, Feb. 1985, p. 24.

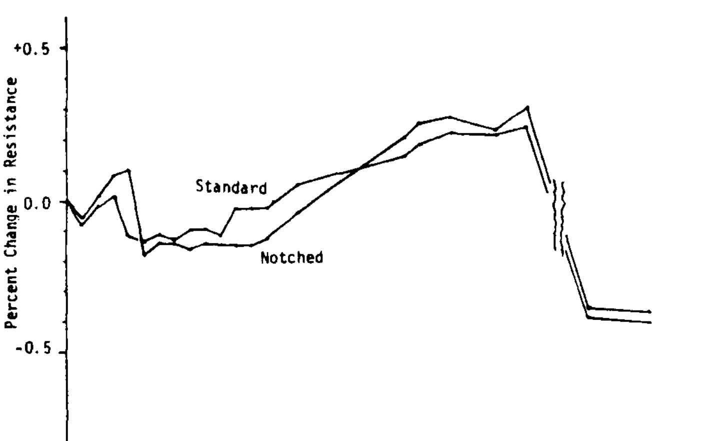


Fig. 1 -- Notched and standard resistors exposed to room air.

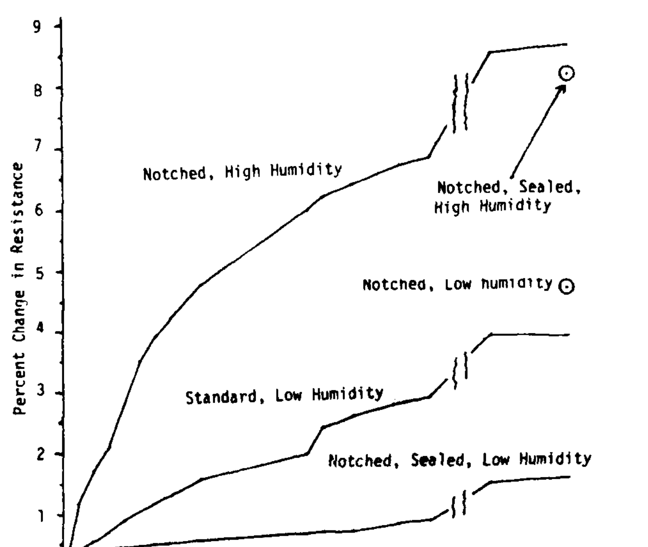


Fig. 2 -- Behavior of resistors exposed to high and low humidities.

Bits

The Liquid Crystal Shutter

Want to turn your very high resolution monochrome CRT display into an equally high resolution color display? Tektronix is creating Color Magic with a technological break through -- the new Liquid Crystal Shutter. It provides all the benefits of color, without sacrificing resolution! Some of the features include higher resolution, higher contrast, no color misconvergence, larger usable viewing area, smaller package, and it is more rugged.

The LCS color display system consists of two basic elements: the Liquid Crystal Shutter and a high resolution monochrome CRT. The LCS itself consists of a fast liquid crystal optical switch (pi-cell) sandwiched between two color polarizers and a neutral polarizer.

In a red/green LCS color display system, the monochrome CRT uses a phosphor, which emits both red and green light. The polarizers are arranged to transmit only red polarized light along one axis and green polarized light along the other.

The LCS pi-cell, developed by Tektronix, either passes the light with polarization direction unaltered, or rotates the polarization direction by 90 degrees, depending on the voltage state (on/off) of the pi-cell.

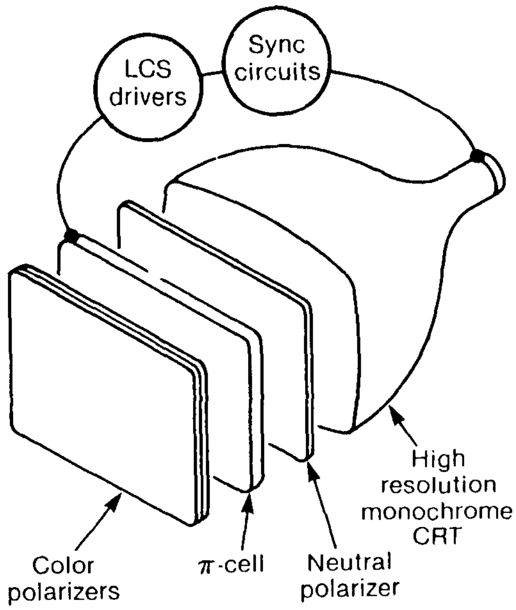
Colored images are generated by first switching the cell so that only one color field, for instance green, is transmitted by the LCS. All information to be green is then written on the CRT screen. Next, the cell is switched to transmit only the red field, and all information to be red is written.

The switching is so rapid and repetitive that the eye integrates the two fields into one color image. Any information written in only one field appears green and that written in the other appears red. Information written in both fields appears yellow, or an intermediate color, depending on the relative intensities of the combined red and green light. Any combination of the two primary colors is accomplished by varying the CRT beam current.

The LCS color display system can be widely applied. It works well with either raster or vector displays, and accommodates either magnetic or electrostatic deflection systems. Additional color palettes will be available.

For additional information on the LCS, call or write Liquid Crystal Shutter, Tektronix, Inc., P. O. Box 500 M. S. 02-100, Beaverton, OR 97077, tel. (503) 627-5000.

[A complete article about the design and operation of the LCS appeared in the March 7, 1985 issue of **Electronic Design**, p. 177, written by John McCormick. — Asst. Ed.]



LCS switched on: Green field is transmitted
LCS switched off: Red field is transmitted

(Drawing by Tektronix)

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