QEX 51

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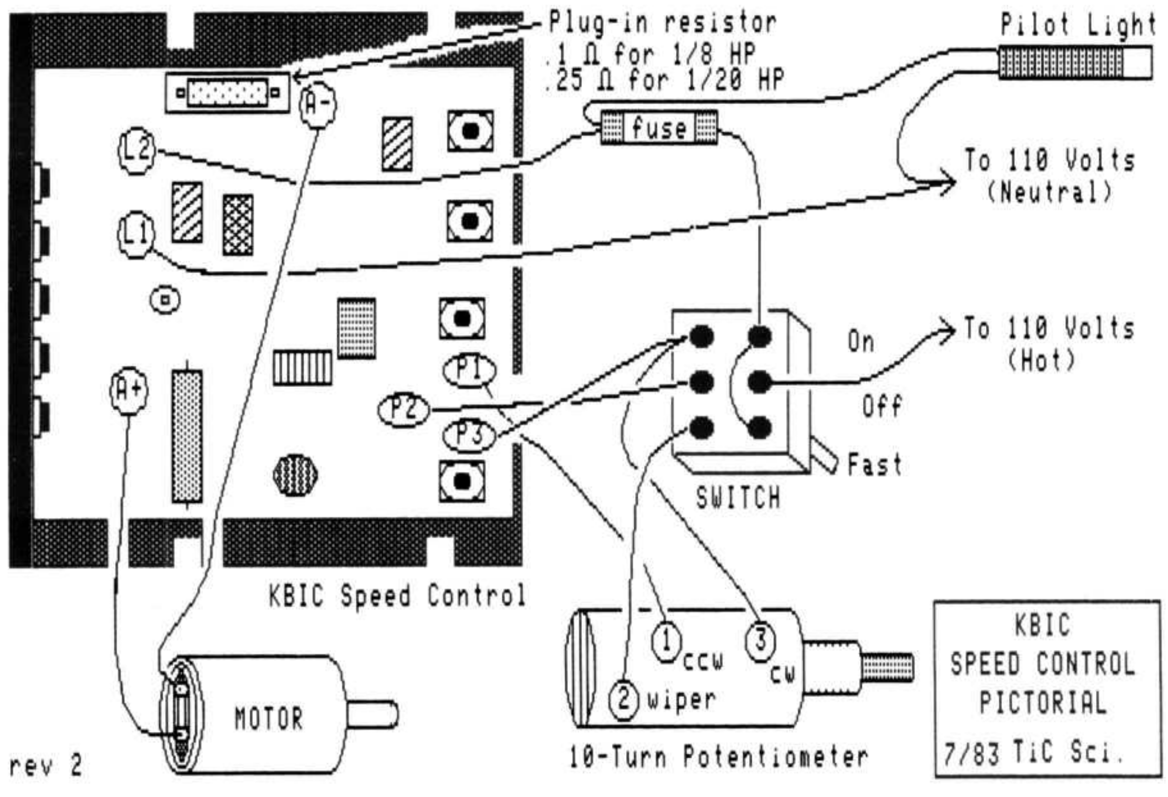
MAY 1986

The ARRL Experimenter's Exchange



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COLUMNS

ABOUT THE COVER

Stephen J. Noll, WA6EJO, wrote his own computer-aided drafting software to perform tasks associated with his job. A North Star Advantage computer and an NEC PC-8023 printer are used. More on WA6EJO's CAD system can be found on page 8.

THE AMERICAN RADIO RELAY LEAGUE, INC

The American Radio Relay League, Inc, is a noncommercial association of radio amateurs, organized for the promotion of interest in Amateur Radio communication and experimentation, for the establishment of networks to provide communications in the event of disasters or other emergencies, for the advancement of the radio art and of the public welfare, for the representation of the radio amateur in legislative matters, and for the maintenance of fraternalism and a high standard of conduct.

ARRL is an incorporated association without capital stock chartered under the laws of the State of Connecticut, and is an exempt organization under Section 501(c)(3) of the Internal Revenue Code of 1954. Its affairs are governed by a Board of Directors, whose voting members are elected every two years by the general membership. The officers are elected or appointed by the Directors. The League is noncommercial, and no one who could gain financially from the shaping of its affairs is eligible for membership on its Board.

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Purposes of *QEX*:

1) provide a medium for the exchange of ideas and information between Amateur Radio experimenters
2) document advanced technical work in the Amateur Radio Field
3) support efforts to advance the state of the Amateur Radio art.

All correspondence concerning *QEX* should be addressed to the American Radio Relay League, 225 Main Street, Newington, CT USA 06111. Envelopes containing manuscripts and correspondence for publication in *QEX* should be marked: Editor, *QEX*.

Both theoretical and practical technical articles are welcomed. Manuscripts should be typed and double spaced. Please use the standard ARRL abbreviations found in the 1985 and 1986 ARRL Handbooks and in the January 1984 issue of *QST*. Photos should be glossy, black-and-white positive prints of good definition and contrast, and should be the same size or larger than the size that is to appear in *QEX*.

Empirically Speaking. . .

Packet Conclave in Orlando

On March 8, the ARRL Ad Hoc Committee on Amateur Radio Digital Communication met in Orlando, Florida to discuss current packet-radio issues. Besides FCC PR Docket No. 85-105, reduction of congestion on 2-meter packet frequencies and networking developments were hot topics. The needs for higher-speed modems and user education were stressed. The following day, at the ARRL's 5th Computer Networking Conference, working prototypes of both virtual-circuit and datagram networking protocols were presented and demonstrated. The next phase is to make the next versions available for field testing in selected areas. This was an important milestone in amateur packet-radio technical development. Hats off to these key players: J. Gordon Beattie, N2DSY, Thomas Moulton, W2VY, Howard Goldstein, N2WX, Terry Fox, WB4JFI and Philip Karn, KA9Q. Nevertheless, years of complex work lie ahead in packet-radio protocol and network development.

FCC Eases VHF Packet-Radio Control Rules

Just after this column was wrapped up for the April issue, the FCC issued an Order that waived the rules to permit the transmission of third-party traffic via packet radio under certain conditions in response to a Petition for Extraordinary Relief filed by the ARRL.

The following is the text of the waiver:

"(a) The provisions of Sections 97.80(b) and 97.114(b)(4) are waived to permit amateur stations, retransmitting digital packet radio communications (see Section 97.69) on frequencies 50 MHz and above, using the AX.25 (or compatible) protocol, to be operated under automatic control while retransmitting third-party traffic. See Section 97.3(v).

"(b) This waiver applies only to the retransmission of third-party traffic originated at another amateur station which is under local control or remote control. See Section 97.3(m).

"(c) When an amateur station is operated under automatic control, devices must be installed and procedures must be implemented which will ensure compliance with the rules when the control operator is not present at the control point of the amateur station. See Section 97.80(a).

"(d) This waiver will remain in effect until the Commission takes final action on the petitions for reconsideration filed in PR Docket No. 85-105."

The Waiver goes on to say:

"Control operators of amateur stations capable of monitoring AX.25 packet transmissions must be alert to the increased dependency upon them for monitoring during the period of this waiver. We call upon them to immediately make known to the responsible control operator of a station retransmitting communications under automatic control any misuse of the station so that the control operator can take prompt corrective action."

According to FCC officials, formal Commission action on the pending Petitions for Reconsideration is not scheduled until late summer.—W4RI

Correspondence

Information Wanted on the 1N34 Diode

In the early 1950s, I read a description of a relaxation oscillator using the reverse-breakdown characteristic of a 1N34 diode. The circuit was identical to the neon-lamp oscillator except for the reverse-biased diode replacing the neon lamp. I built such an oscillator and it worked. Evidently, the 1N34 exhibited a negative-resistance region in its reverse-breakdown characteristic.

I recently tried to duplicate this circuit using the currently available 1N34A, but without success. The diodes show no sign of a negative resistance. Does anyone recall the original description of this oscillator, or know why today's diodes do not work in this circuit?—*Albert E. Weller, WD8KBW, 1325 Cambridge Blvd, Columbus, OH 43212.*

Help Needed for ACSSB Newcomer

I was fortunate to obtain recently a cassette tape recording of TELECON in which Paul Rinaldo, W4RI, gave an excellent status report on ACSSB. This immediately sparked my interest in the project.

It appears not to be difficult to obtain the boards because some people have a set, but never put them together. Reasons range from difficulty in finding parts or that there was no one nearby to participate in tests.

I came across a set of boards; the manual and notes on the TXCO and X-1 boards were included. After looking over the project, the following questions came to mind:

- Is it true that the power amplifier module and interface boards must be purchased locally?
- The nearest substitute for the 26-pin connector is the Radio Shack 34-pin connector. A section would have to be cut off each end, but I have found that these are only available for the ribbon cable and not for chassis mounting.
- Three pages are missing from my manual: 5-75, 5-76 and 5-77.
- Besides the two Reticon R-5609 chips, U7 (MC3303L) and U9 (NE572N) are missing. Where can I locate a source and obtain prices?

I have found that Robert McGwier, N4HY, in Auburn, AL owns a set of boards. We plan to run tests when the units are completed.—*Roy Brougher, W4IK, 2628 Highland Ave, Montgomery, AL 36107.*

Bits

Casio Does It All—Almost

Casio's new fx-700G Scientific Calculator performs 82 scientific functions that include paired variable statistics, and binary, octal and hexadecimal calculations. Graphics can also be written into the program.

Graphic features include composing, tracing, plotting, line drawing, detailing (magnification or reduction), multi-form statistical graphs and overwriting. The display area is large and easy to read.

What makes the fx-700G different from other scientific calculators? It will perform a formula-to-graph conversion at the touch of a key, has instant recall of formulas for repeat or revision and 26 memories that can be expanded to 78 and fits into many applications required by different technological areas.

The price for the fx-7000G Graphics Scientific Calculator is $99.95. For futher performance and specification information, contact Casio, Inc, 15 Gardner Rd, PO Box 1386, Fairfield, NJ 07007; tel 201-575-7400.—*KA1DYZ*

■ Graph sample 2

Waveform analysis through graph composition

Formulas: $x_1 = \sin(a_1 t + c_1)$

$x_2 = \sin(a_2 t + c_2)$ $\quad * c_1 = 0,\ c_2 = \frac{\pi}{2}$

Composite wave: $x = x_1 + x_2$

•Program

```
Rad : Range 0, 35, 5, −3, 3, 1 ↵
"A1 = " ? → A ↵
"A2 = " ? → B ↵
Graph sin AX : Graph sin (BX + π ÷ 2) ◢
Cls : Graph sin AX + sin (BX + π ÷ 2)
```

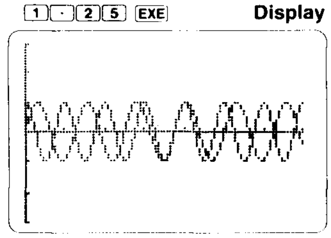
*↵ indicates EXE key operation

•Example execution ($a_1 = 1$, $a_2 = 1.25$)

Operation

Prog 0 EXE
1 EXE
1 . 2 5 EXE

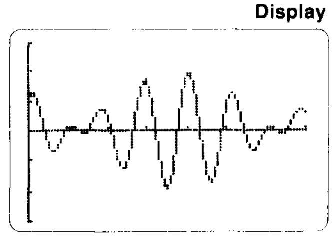
Display



Operation

EXE

Display



Using the fx-700G, graphs for waveform analysis can be programmed to appear in the calculator's display window. The routine for applying this data is shown in written form to the left. The example execution via the keys is displayed to the right.

A Bridge Method of Sweep-Frequency Impedance Measurement

By Ken Simons, W3UB
2035 Willowbrook Dr
Huntingdon Valley, PA 19006

Fundamentals

Since high-frequency measurements frequently require unavoidable lengths of transmission line, HF measuring techniques usually involve an application of transmission-line principles. The bridge circuit to be described is no exception. Understanding its operation requires a clear picture of the concepts of reflection coefficient and return loss.

Consider an ac generator with an internal impedance R_o and a voltage E as illustrated in Fig 1A. When the output of this generator is connected to a load having an impedance equal to R_o, the output voltage is E ÷ 2. In the case where this load is the input impedance of a section of transmission line having a characteristic impedance R_o, it is convenient to consider the input voltage as consisting of two components—a main voltage wave, e_m, (travels down the line away from the generator), and a reflected wave, e_r, (travels back from the far end towards the generator). When the transmission-line section is terminated in R_o, the reflected wave is zero and the input voltage is simply e_m (Fig 1B).

This terminology can be applied even when there is no transmission line in the circuit. It may correctly be said in reference to Fig 1A that the voltage across the load, R_o, is e_m.

In the case where the generator feeds a section of transmission line terminated in some impedance other than R_o, the input voltage can be considered to be the sum of e_m and e_r (Fig 1C). Similarly, the voltage across any load connected to a generator can be considered to be the sum of a main wave and a reflected wave (Fig 1D).

A convenient way of describing the relation between the main and reflected waves is to use the reflection coefficient. Fig 2 illustrates a generator feeding a load having any impedance Z. The voltage and current across this load are expressed in terms of their main and reflected components. The quantity k is defined as the ratio of the reflected voltage e_r to the main voltage e_m. The current reflection coefficient is numerically equal to the voltage reflection coefficient and has the opposite sign, so that the relationships indicated in Fig 2 hold true. A significant point is that the impedance of the load can be fully described by the internal impedance of the generator and the voltage reflection coefficient. The relation is

$$Z = R_o \frac{1 + K}{1 - K} \qquad \text{Eq 1}$$

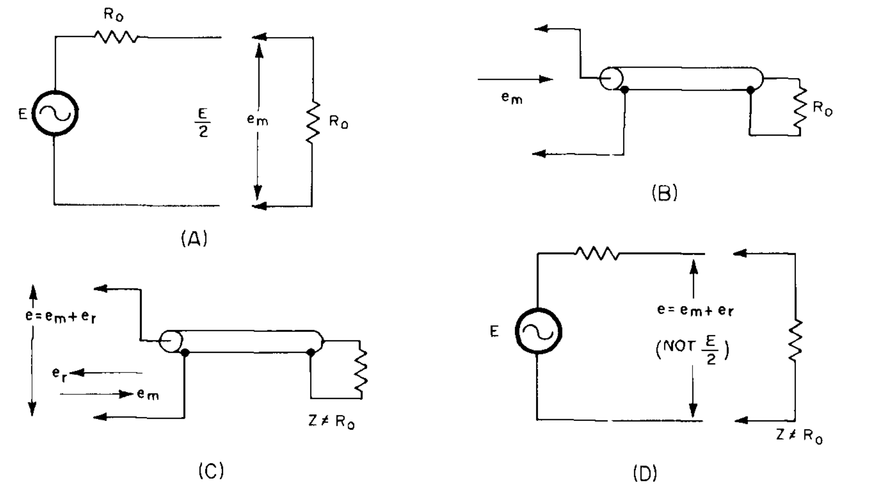
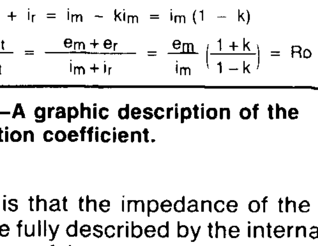


Fig 1—An ac generator with an internal impedance R_o and a voltage E is shown at A; B shows that when a transmission-line section is terminated in R_o, the reflected wave is zero and the input voltage is e_m. C illustrates that where the generator feeds a section of transmission line terminated in an impedance other than R_o, $V_{in} = e_m + e_r$. D shows that the voltage across any load connected to a generator can be considered the sum of the main wave and the reflected wave.

LET K = VOLTAGE REFLECTION COEFFICIENT
THEN $e_r = ke_m$
AND CURRENT REFLECTION COEFF = $-k$
SO $i_r = -ki_m$



$$e_t = e_m + e_r = e_m + ke_m = e_m(1 + k)$$

$$i_t = i_m + i_r = i_m - ki_m = i_m(1 - k)$$

$$Z = \frac{e_t}{i_t} = \frac{e_m + e_r}{i_m + i_r} = \frac{e_m}{i_m}\left(\frac{1+k}{1-k}\right) = R_o\left(\frac{1+k}{1-k}\right)$$

Fig 2—A graphic description of the reflection coefficient.

A further convenience is achieved by expressing the reflection coefficient logarithmically. The return loss is defined as $20 \log_{10} k$. Thus, it is the ratio of e_r to e_m expressed in decibels. The interrelation between return loss, reflection coefficient and SWR is indicated on the nomograph of Fig 3.

The Bridge Principle

A convenient way of measuring an unknown impedance is to separate the reflected wave from the main wave and to measure its relative magnitude and phase angle. This is commonly done in HF and microwave testing by the use of a directional coupler. Another approach is the use of a bridge.

Fig 4 shows how a bridge can provide a voltage equal to the reflected wave. A generator having zero internal impedance feeds a load, Z, through a resistor R_o. The voltage e_r across Z is equal by definition to e_m plus e_r. If a second divider consisting of two equal resistances R_1 and R_2 is connected across the voltage source, the voltage e_2 across the lower resistor will be equal to E ÷ 2 which is

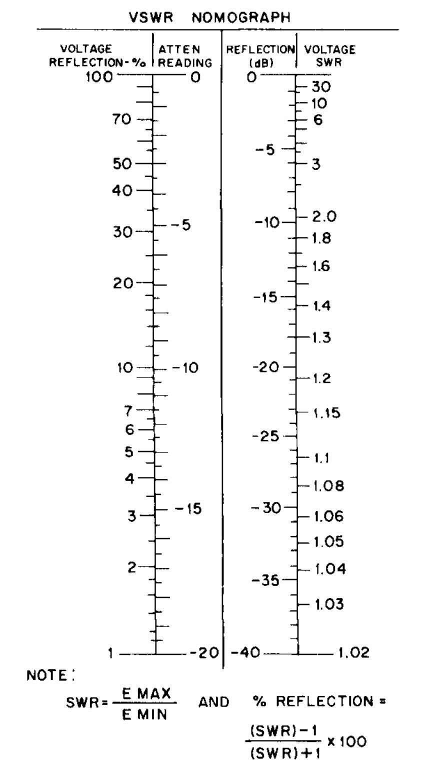


Fig 3—The nomograph illustrates the interrelationship between the return loss, reflection coefficient and SWR.

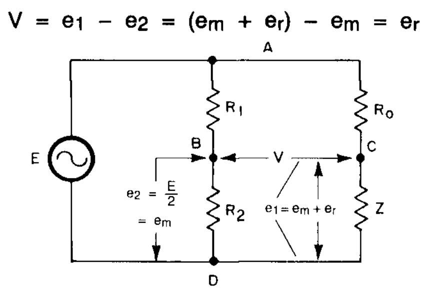


Fig 4—This graphic shows how a bridge can provide a voltage equal to the reflected wave.

the same as e_m. If the voltage between the center points of the two dividers is measured, it is found to be the difference between e_m plus e_r and e_m, which is e_r. Thus, the output voltage V of this network is identical to the reflected voltage component from the impedance Z.

The Terminated Bridge

Unfortunately, this simple circuit uses a voltage source having an internal impedance of zero and a voltage-measuring device with an infinite impedance that measures the difference of voltage between two points, neither of them grounded. As a practical matter, these conditions are difficult to approach.

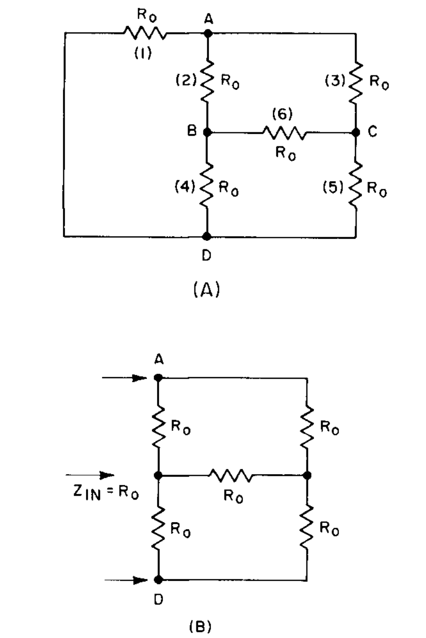


Fig 5—The terminated bridge is shown at A. At B, if all six resistors are equal in value, $Z_{in} = R_o$ when a resistor is removed from the circuit.

Fortunately, an alternative configuration is available. The terminated bridge illustrated in Fig 5A has several characteristics that make it especially suitable for this application. When all six resistances are equal, the impedance seen when you look into the network at the remaining terminals (after disconnecting any one of the resistances) is always equal to R_0. Thus, for example, in Fig 5B the impedance seen between A and D with no. 1 resistor removed is equal to R_0. When the resistors are equal to the characteristic impedance of a particular coaxial cable, the bridge has matched input and output impedances.

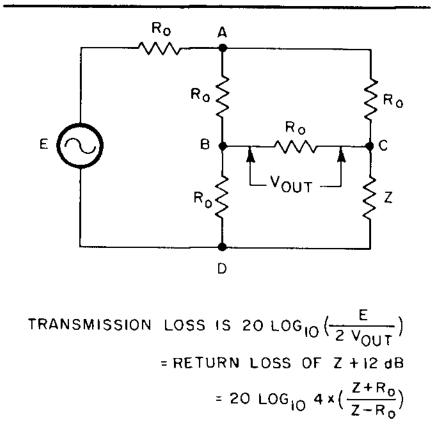


Fig 6—This illustration shows that the transmission loss from the input terminals of the bridge to V_{out} is equal to the return loss of Z (R_o) plus 12 dB.

The terminated bridge has a further advantage; it provides an output voltage precisely equal in magnitude and phase to a constant times the reflection coefficient of the unknown. This is illustrated in Fig 6, which states that the transmission loss from the input terminals of the bridge to V_{out} is equal to the return loss of Z (referred to as R_o) plus 12 dB. This relation is fully derived in Appendix 1. It may be understood better by referring to Figs 7 and 8. Fig 7 shows that the input voltage to a matched load connected between C and D (e_m) is equal to the bridge input (V_{in}) reduced by 6 dB.

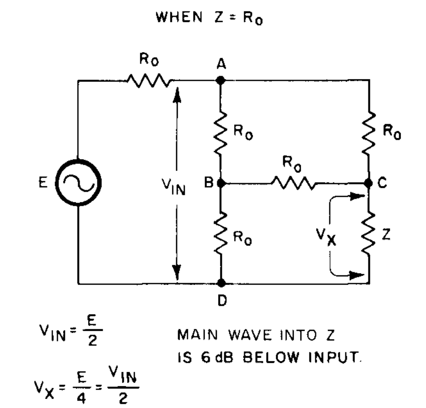


Fig 7—The input voltage to a matched load connected between C and D (e_m) is equal to the bridge input (V_{in}) reduced by 6 dB.

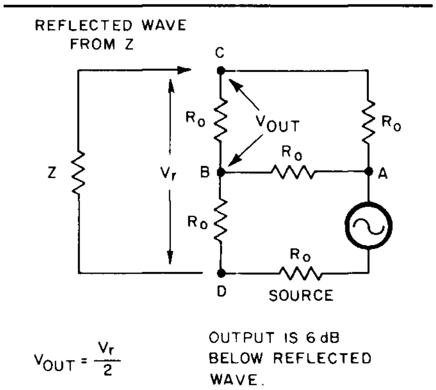


Fig 8—Fig 7 is redrawn to show the voltage division experienced by the return wave from Z.

In Fig 8, the bridge is redrawn to show the voltage division experienced by the return wave from Z. It comes back into terminals C and D and is attenuated 6 dB before coming out of terminals B and C.

As compared with the simple bridge circuit illustrated in Fig 4, the matched bridge has this advantage: The input and output impedances match connecting coaxial cables so that wideband fre-

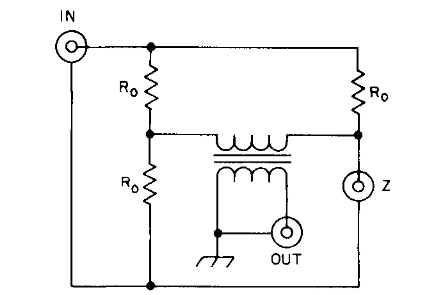


Fig 9—To build a practical matched bridge, it is necessary to provide a transformer having balanced-input terminals.

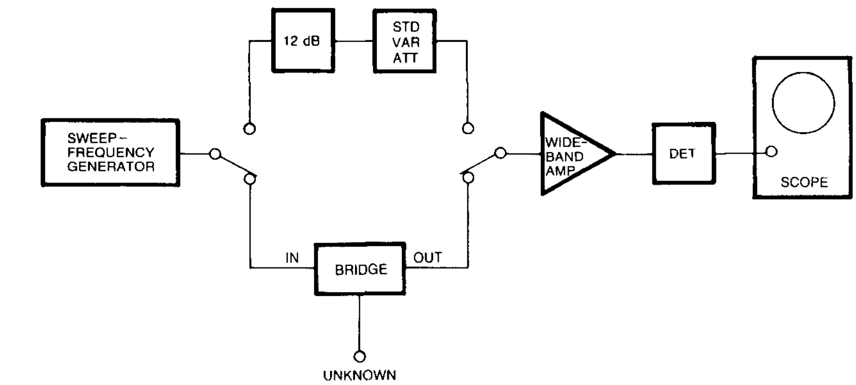


Fig 10—Bridge sweep frequency test set-up.

quency performance can be obtained. The problem of providing a differential voltage measurement between two ungrounded terminals is still present. To build a practical matched bridge, it is necessary to provide a transformer having balanced-input terminals (Fig 9). It is possible to build such a transformer with a very wide range of frequency response. The resulting bridge is conveniently connected to provide a calibrated sweep display as illustrated in Fig 10. A high-speed coaxial switch (Jerrold Model FD-30) is connected so that in the *up* position it connects the output of the sweep through a 12-dB pad and a standard variable attenuator to the input of a wideband amplifier. The amplifier is followed by a detector and scope and displays a curve representing loss v frequency. In the *down* position, the switches insert the bridge in place of the attenuators. Since the loss of the bridge is equal to the return loss of the unknown plus 12 dB, the scope shows a plot of return loss v frequency with a reference line corresponding to the setting of the standard variable attenuator.

Examples of Use

The performance of a particular bridge is illustrated in Figs 11 to 16. This bridge was designed for a characteristic impedance of 75 ohms and the test circuit covered a frequency range from 4 to 100 MHz. Fig 11 illustrates the relation between the reference line and the bridge response with the unknown terminal of the bridge open circuited. The bridge indicates 0-dB return loss within about 1/2 dB from 4 to 100 MHz.

Fig 12 shows the same situation with the unknown terminal short circuited, again indicating 0-dB return loss with approximately 1/2 dB error.

In Fig 13, the X terminal of the bridge was terminated as accurately as possible. Here, the reference line represents a return loss of 50 dB and it is shown that the loss through the bridge indicates a return loss substantially better than 50 dB across this entire frequency range. A

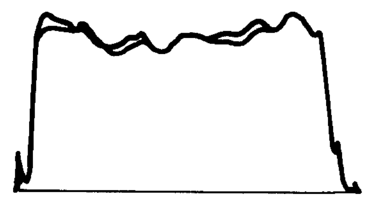


Fig 11—Bridge response at 4 to 100 MHz; open circuit.

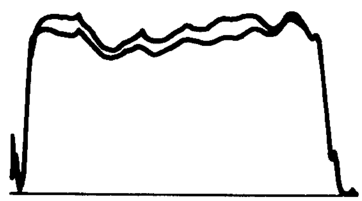


Fig 12—Bridge response at 4 to 100 MHz; short circuit.

Fig 13—Bridge response at 4 to 100 MHz; optimum termination, 50-dB reference.

50-dB return loss corresponds to an SWR of 1.06. It is apparent that this technique is capable of precision comparable with the best that can be obtained with other HF measuring techniques.

Although this method is extremely precise, (ie, it can compare an unknown with a standard and show deviations of considerably less than 1%), its accuracy is entirely dependent on the accuracy of the standard impedance against which the bridge is tested. Where suitable standards are available, its accuracy can be nearly as good as its precision.

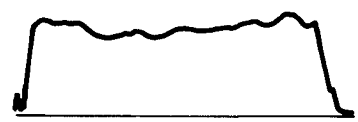


Fig 14—Bridge response at 4 to 100 MHz; 70-ohm termination, 30-dB reference.

Fig 14 shows the agreement between the reference line and the bridge loss when the bridge was first adjusted for balance with a 75-ohm resistor. A resistor was then substituted and its dc resistance was accurately adjusted to 70 ohms. A 70-ohm resistor in a 75-ohm system gives an SWR of 1.07 or a return loss of 29.2 dB. The reference line on this trace was 30 dB.

The delay-line method of sweep-frequency impedance measurement provides a convenient method of measuring HF impedances with a minimum of equipment. Practical characteristics of delay lines limit the usefulness of this method to relatively wide-frequency bands. The bridge technique has no such limitation. It is equally useful for extremely narrowband measurements or extremely wideband measurements.

Fig 15 shows the return loss measurement of a triple-tuned filter having a bandwidth of 1.5 MHz and a maximum

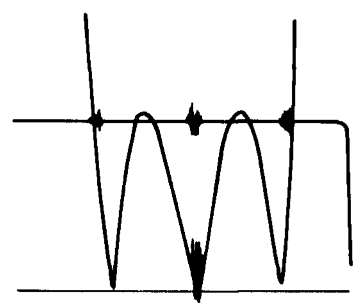


Fig 15—Bridge response; markers 100 MHz ± 1.5 MHz, 10 dB-reference.

return loss in the pass band of approximately 10 dB. Notice the simplicity of this presentation and the ease with which an operator could adjust such a filter to meet given frequency and return loss specifications.

Fig 16 shows an extremely wideband measurement—the return loss of a piece of high-grade coaxial cable over a frequency range of 4 to 100 MHz with a 40-dB reference. The bridge provides a way of testing this complicated function with a high degree of speed and accuracy.

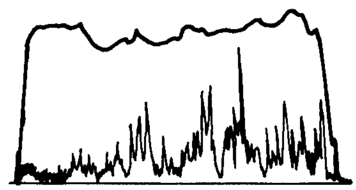
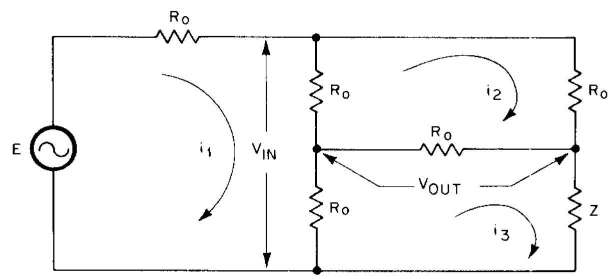


Fig 16—Bridge response at 4 to 100 MHz; input of a 1000-foot piece of high-grade coaxial cable, 40-dB reference.

The sweep frequency technique provides a convenient way of observing the frequency variation of gain or loss. It is also possible to measure these quantities simultaneously with the sweep presentation. The wideband return-loss bridge provides the same degree of convenience in viewing and measuring the frequency variation of return loss and offers both speed and convenience in laboratory and production testing of HF networks.

Appendix



① ---------------------- $E = 3R_0i_1 - R_0i_2 - R_0i_3$

② ---------------------- $0 = -R_0i_1 + 3R_0i_2 - R_0i_3$

③ ---------------------- $0 = -R_0i_1 - R_0i_2 + (Z + 2R_0)i_3$

④ ② - ③ ---------------- $0 = 4R_0i_2 - (Z + 3R_0)i_3$

⑤ ① + (3 × ②) ------------ $E = 8R_0i_2 - 4R_0i_3$

⑥ SOLVING ④ for i_2 ---------- $i_2 = \frac{Z + 3R_0}{4R_0} i_3$

⑦ SUBSTITUTING ⑥ IN ⑤ ------- $E = 8R_0\left(\frac{Z + R_0}{4R_0}\right)i_3 - 4R_0i_3 = 2(Z + R_0)i_3$

HENCE $i_3 = \frac{E}{2(Z + R_0)}$

⑧ SUBSTITUTING ⑦ in ⑥ ------- $i_2 = \frac{Z + 3R_0}{4R_0} \times \frac{E}{2(Z + R_0)} = \frac{E}{8R_0} \times \frac{Z + 3R_0}{Z + R_0}$

⑨ ---------------------- $V_{OUT} = R_0(i_2 - i_3) = R_0\left(\frac{E}{8R_0} \times \frac{Z + 3R_0}{Z + R_0} - \frac{E}{2(Z + R_0)}\right)$;

HENCE $V_{OUT} = \frac{E}{8}\left(\frac{Z + 3R_0 - 4R_0}{Z + R_0}\right)$

AND $\boxed{V_{OUT} = \frac{E}{8} \times \frac{Z - R_0}{Z + R_0}}$

TRANSMISSION LOSS $= 20\ LOG_{10}\left(\frac{E}{2V_{OUT}}\right) = 20\ LOG_{10}\ \frac{E \times 8(Z + R_0)}{2 \times E(Z - R_0)}$

$= 20\ LOG_{10}\ 4\frac{Z + R_0}{Z - R_0} = 12$ dB + RETURN LOSS OF Z.

The CAD Experience Part II

By Stephen J. Noll, WA6EJO
TiC Scientific
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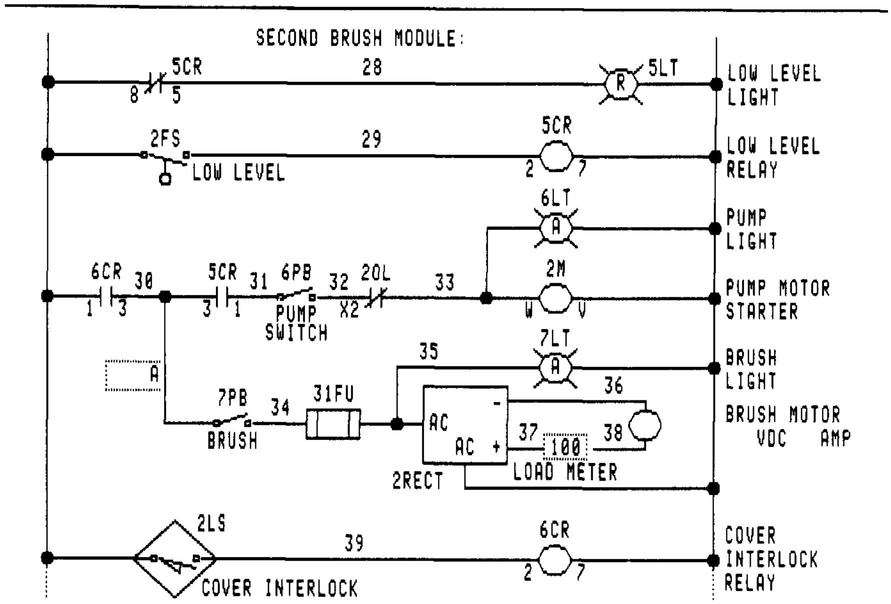
Ventura, CA 93004-2504



Interested in employing a computer-aided drafting (CAD) system for personal or business use? That was my consideration several years ago when I wanted something for my business. I combed the advertisements for price and performance information on various CAD systems, but to no avail. Thus, I sat down and wrote my own program to serve my needs. The result was a successful program that I have been using during the past two years.

System Requirements

A North Star Advantage computer and an NEC PC-8023 printer comprise my hardware needs. The Advantage is an all-in-one Z80™ machine that combines a high resolution (640 × 240) green monitor, two double sided 360-kbyte floppy disks, a five-megabyte hard disk, and a high-quality 87-key keyboard, all in one package. The machine runs CP/M® and North Star Graphics DOS and BASIC. The NEC printer is a dot matrix type that can print as fast as 100 cps and as dense as 144 × 160 dots per square inch.

I wrote my own drafting software in North Star Graphics BASIC. This variant of BASIC is exceptionally easy to use and has a good complement of graphics functions. I chose the version of North Star BASIC that runs under North Star DOS as I find that disk operating system easier to work with than CP/M.

Program Facilities

The CAD program I wrote does its own simple file management. It maintains a directory of drawing files, creates new files and destroys old ones by name. I use the program to draw electrical control (ladder) diagrams. I also use it for electronic pictorials. The program is limited to single screen-sized drawings that are stored on disk as screen images of about 20-kbytes. The printer output is a screen dump. Large drawings are made with multiple printouts that are taped together and photocopied to B-, C- or D-sized blueprints as needed.

The program currently has 26 built-in schematic elements that are drawn on the screen immediately with the press of a function key. This part of the progarm is extremely fast as the elements are part of the program and not separate disk files. The elements range from a simple dot for connecting wires, to LEDs and resistors, and elements as complex as multi-winding transformers and three-phase magnetic motor starters. Any assortment of solid or dashed lines can be drawn in addition to circles, ellipses, and rectangles, with or without fill patterns.

Conclusion

The program is crude by any commercial standard, but serves my purposes. I have not had any reason to modify it during the last two years. There is great satisfaction in writing a program that can be applied to a business practice!

I have just started using AutoCAD™ by Autodesk™ on a Compaq® Deskpro™. This is a truly professional CAD system, but the software cost is beyond most amateur's budgets—$2500. This software allows "dragging" an object around the screen before "laying it down;" a function my program cannot do. AutoCAD seems to have the lion's share of the market in that price range, and for good reasons, but there are other programs more within the realm of the Amateur Radio operator. One is called Generic CADD™ by Generic Software, Inc. It lists for $100, but I have had no experience with it.

If I should want to upgrade my CAD program, I will start from square one and write a version for my MS-DOS® Compaq Deskspro. It is a more "state-of-the-art" machine by today's standards!

Whatever computer-aided drafting system you should choose, first analyze your personal or business needs, and what is already available on the market. If it does not suffice and you have computer skills, sit down and write your own. You'll see results.

Bits

New US Distributor

A new US distributor for Microwave Modules transverters is: Ivars Lauzums, KC2PX, PX Shack, 52 Stonewyck Dr, Belle Mead, NJ 08502, tel 201-874-6013. Contact him for further information on availability of products.

A Print Routine for the Computerized Smith Chart

By Fred A. Sontag, PE, NØCAO
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Tebbetts, MO 65080

I was happy to see Gary White's, KOØP, "Computerized Smith Chart Program," in a previous issue of *QEX*.[1] At last, a program for noise-bridge applications that eliminates the tedious calculations always associated with the use of the device.

Though the author stated that he developed this C64 program because he wanted the option of having a hard copy of the entry data and results, he provided no print feature. I believe many amateurs like to file a hardcopy of their experiments for future reference. Therefore, to provide for permanent records, I have written a printer routine for the computerized Smith Chart (Table 1).

Instructions

Type in the KOØP program and load it from disk or cassette, but *do not* run it. After loading, type in the printer routine. When finished, save the newly created program under a name of your choice. Now, when you run the expanded program, you will be given the option of viewing the results on screen or getting a printout.

Two items have been added to the printer program: Date of Reading and Antenna Description. This provides a complete record of your experiment.

Program Operation

Table 2 shows a typical printout of KOØP's example of the 80-meter antenna. For illustrative purposes, the date 09/04/85 and the Antenna Description as a dipole are listed. You can use the Antenna Description space for any notes you may want to make.

The program is fairly straightforward. The special characters listed in lines 5, 400, 405, 410, 440, 450, 460, 470, 480, 505, 610, 620 and 630 prevent the computerized Smith Chart and print routine from running on other computers, however, they can easily be removed and the program should run with almost any version of BASIC. The first character in lines 5, 400 and 630 provide a "clear screen." The other character in the remaining lines provides "reversed characters" for all the input data.

[1]White, Gary A., KOØP, "Computerized Smith Chart for Noise Bridge Applications," *QEX*, Sep 1985, no. 43, p 7.

Table 1

```
1 REM *** PRINTER ROUTINE ADDED - BY FRED A.SONTAG ***
2 REM ********************** TO **********************
3 REM ******** SMITH CHART - BY GARY A. WHITE *********
5 PRINT"ɔ":PRINT" * OPTION: SCREEN OR HARDCOPY ? S/H *"
10 INPUTO$
15 IF O$="S"THEN 30
20 IF O$="H"THEN 400
25 IF O$<>"S" AND O$<>"H" THEN 5
395 END
400 PRINT"ɔ"
405 INPUT"■ENTER LOSS(DB/100 FEET)";DB
410 INPUT"■ENTER LINE LENGTH(FT)";L
415 AA=10↑-(L*DB/1000)
420 OPEN4,4:PRINT#4
425 PRINT#4,"LOSS (DB/100 FEET)=";DB:PRINT#4
430 PRINT#4,"LINE LENGTH(FT)=";L:PRINT#4
435 PRINT#4,"ATTENUATION FACTOR=";AA
440 INPUT"■ENTER VELOCITY FACTOR";VF:IF VF=0 THEN GOTO440
445 PRINT#4:PRINT#4,"VELOCITY FACTOR=";VF
450 INPUT"■ENTER LINE IMPEDANCE";ZO:IF ZO=0 THEN GOTO450
455 PRINT#4:PRINT#4,"LINE IMPEDANCE=";ZO
460 INPUT"■ENTER FREQ(MHZ)";F:IF F=0 THEN GOTO460
465 PRINT#4:PRINT#4,"FREQ(MHZ)=";F
470 INPUT "■ENTER BRIDGE RESISTANCE";RL
475 PRINT#4:PRINT#4,"BRIDGE RESISTANCE=";RL;"OHMS"
480 INPUT "■ENTER BRIDGE CAPACITANCE";XJ
485 PRINT#4:PRINT#4,"BRIDGE CAPACITANCE=";XJ:IF XJ=0 THEN XJ=1E-10
490 XJ=(-159000)/(F*XJ)
495 R=RL:RL=RL*(XJ↑2)/(RL↑2+XJ↑2)
500 XJ=XJ*(R↑2)/(R↑2+XJ↑2)
505 INPUT"■RANGE EXTENDER USED (Y/N)";RE$:IF RE$="Y" THEN RL=RL-100
510 PRINT#4:PRINT#4,"RANGE EXTENDER USED=";RE$
515 PRINT#4:PRINT#4,"SERIES RESISTANCE/REACTANCE AT SHACK",RL;XJ
520 LDEG=0.3659*L*(F/VF)
525 PRINT#4:PRINT#4,"LINE LENGTH (DEGREES) =";LDEG
530 RL=RL/ZO:XJ=XJ/ZO:D=((RL+1)↑2)+(XJ↑2):RP=(RL-1)*(RL+1)+XJ↑2
535 RP=RP/D:IP=(RL+1)*XJ-(RL-1)*XJ:IP=IP/D
540 P=SQR((RP↑2)+(IP↑2))
545 PRINT#4:PRINT#4,"COEFFIECIENT OF REFLECTION=";P
550 VSWR=(1+P)/(1-P)
555 PRINT#4:PRINT#4,"VSWR AT SHACK =";VSWR
560 AA=10↑(DB*L/1000)
565 KK=(2*π)/360
570 LDEG=LDEG*KK*2
575 RE=COS(LDEG)*AA:IE=SIN(LDEG)*AA:RN=1+RP*RE-IP*IE
580 IN=RP*IE+IP*RE:RD=1-RP*RE+IP*IE:ID=(-IP*RE)-(IE*RP)
585 DD=RD↑2+ID↑2:RO=ZO*((RN*RD+IN*ID)/DD):IO=ZO*((IN*RD-ID*RN)/DD)
590 P=P/AA
595 VSWR=(1+P)/(1-P):
600 PRINT#4:PRINT#4,"VSWR AT ANTENNA =";VSWR
605 PRINT#4:PRINT#4,"ANTENNA RESISTANCE/REACTANCE",,RO;"/";IO
610 INPUT"■DATE OF READING";Y$
615 PRINT#4:PRINT#4,"DATE OF READING =";Y$
620 INPUT"■ANTENNA DESCRIPTION";T$
625 PRINT#4:PRINT#4,"ANTENNA DESCRIPTION =";T$
630 CLOSE4:PRINT"ɔ":END

READY.
```

Table 2

```
LOSS (DB/100 FEET)- 0

LINE LENGTH(FT)- 60

ATTENUATION FACTOR- 1

VELOCITY FACTOR- .66

LINE IMPEDANCE- 50

FREQ(MHZ)- 3.65

BRIDGE RESISTANCE- 240 OHMS

BRIDGE CAPACITANCE--98

RANGE EXTENDER USED-Y

SERIES RESISTANCE/REACTANCE AT SHACK                            85.8277685  100.33297

LINE LENGTH (DEGREES) - 121.412273

COEFFIECIENT OF REFLECTION- .6309005

VSWR AT SHACK - 4.41859309

VSWR AT ANTENNA - 4.41859309

ANTENNA RESISTANCE/REACTANCE                                       24.0716376 /-50.1107286

DATE OF READING -09/04/85

ANTENNA DESCRIPTION -DIPOLE
```

Bits

Packet Radio Magazine

Lo and behold, packet radio enthusiasts! At last, a monthly magazine that deals exclusively with your favorite mode of communication.

The Florida Amateur Digital Communications Association (FADCA) is the group responsible. Two years prior, the group, like many other Amateur Radio clubs across the country, issued a monthly newsletter. With the growth of packet radio and interest in this area, FADCA realized a change was inevitable for their newsletter as well. Thus, the January 1986 issue of *Packet Radio Magazine* is the first of a new format. Advertisers specializing in equipment for this mode are encouraged to participate. Special columns and feature articles comprise the 20-page magazine.

Our inset is the cover shot of the first issue. It features "A Briefcase Station."

How can you subscribe to *PRM*, as it is affectionately called by FADCA members? Subscriptions are handled two ways. A participating club newsletter section is listed in each issue from which you would choose the name of the closest. The second way would be to contact the FADCA, 812 Childers Loop, Brandon, FL 33511, for individual membership information. Happy packeting!—*KA1DYZ*

PRM is a new approach by FADCA to keep its' members up to date on the latest in packet radio communications.

Optoelectronics Data Book

The TRW Electronic Components Group offers a new data book. Device information on infrared emitting diodes, slotted optical switches, high reliability and military devices and photosensors are just a few of the areas covered. A device index, application bulletins, and an optoelectronics interchangeability guide are also included.

Many of the component pictures are dark, and detail in certain instances is hard to see. However, if you work with optoelectronics and want the latest device information, this book is a must. A telephone call to your area sales office will secure you a copy.—*KA1DYZ*

An Inexpensive Repeater Offset Modification—From CB to 10

By Andrew Pickens WB5QWF
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San Antonio, TX 78213

When I first considered a CB-to-10-meter FM conversion for my repeater, I referenced a number of designs already available for obtaining the +100-kHz offset. After searching through many articles, I concluded that the easiest and most inexpensive method would be the use of a binary-adder chip to automatically command the offset frequency. I used a Motorola MC14008 chip in my Hy-Gain CB board conversion, so why not use the same in the repeater? The MC14008 sells for under $2 and the circuit modification should be applicable to other radios with binary programmed frequency synthesizer circuits.

Insert the adder chip between the programming device and the phase-locked loop (PLL) chip with connections to add 100 kHz on receive. Fig 1 shows this is simply a matter of applying a high to adder pins 4 and 15 when the transceiver is switched to receive. I used an inverter in the key-line connection to get negative and positive offset. So far, I have not used that feature. Be sure to use pull-down resistors in the adder chip inputs (pull-down resistors were unnecessary in the PLL chip inputs on my Hy-Gain board). A 4.7 kilohm,¼ watt resistor is sufficient.

I am happy with the operation of the repeater. If you have an opportunity to perform this circuit update, I would recommend using this method.

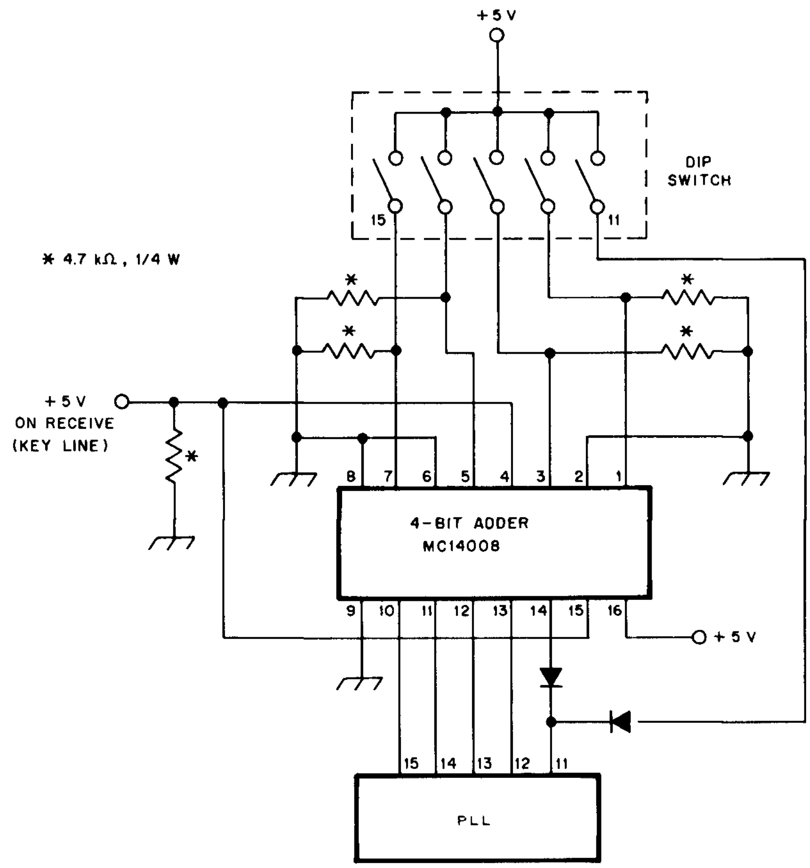

Fig 1—The repeater offset circuit that undergoes modification in a CB-to-10-meter FM project. The key line, pin 11, on a Hy-Gain CB board goes high on receive and low on transmit.

Table 1
4008 4-Bit Full Adder

1	A4
2	B3
3	A3
4	B2
5	A2
6	B1
7	A1
8	VSS
9	Carry in
10	S1
11	S2
12	S3
13	S4
14	Carry out
15	B4
16	VDD

Table 2
+5-V Adds

PLL	Pin	kHz
S1	15	10
S2	14	20
S3	13	40
S4	12	80
	11	160

Table 3
Truth Table

Ai	*Bi*	*Ci*	*Co*	*Sum*
0	0	0	0	0
1	0	0	0	1
0	1	0	0	1
1	1	0	1	0
0	0	1	0	1
1	0	1	1	0
0	1	1	1	0
1	1	1	1	1

By Bill Olson, W3HQT
Box 1655A, RFD 1
Burnham, ME 04922

RF Transistor Chips

Last month we discussed the transistor package, describing the package as the means of connecting a *chip* to the outside world. This month we will take a closer look at the chips themselves. This is not a discussion on semiconductor physics, but is meant to impart a general understanding of what's inside the package and how it got there.

Chip Overview

Before getting into how chips are made, let's take a quick look at their physical appearance. The modern transistor chip (also called a *die* or *pellet*) is a flat, rectangular chunk of semiconductor material. The most common materials are germanium, silicon or gallium arsenide (GaAs). Chips are tiny. Physical dimensions vary from around 0.010 inch square for low-noise receiving types to nearly 0.25 inch square for some very-high-power HF or VHF types. Chips are usually between 0.003 to 0.010 inch thick. Rather than try to deal with one chip at a time, manufacturers process hundreds or thousands of chips simultaneously on *wafers* of semiconductor material. The wafers are then cut into individual chips. A wafer looks a little like a thin, round piece of glass and may contain as many as 50,000 transistors.

For most applications, a chip must be mounted in a package to connect it to the outside world. We discussed packages in detail last month. Remember that for bipolar chips, the collector connection is made to the bottom of the chip, while emitter and base connections are made to the top. On most FET structures, the connections are all made to the top, and the chip's backside is electrically insulated from the active part of the transistor. New silicon power FETs appear much like silicon bipolars—the drain is connected to the back. The source and gate connections are on top.

Connections to the top of a chip are made with gold or aluminum *bond wires* that range from less than 0.001 inch to about 0.004 inch in diameter. Wire size depends on the size of the chip and the power level for which the chip is designed. Connected to the top of each chip can be anywhere from two wires (one for the base, one for the emitter for a low-power bipolar device) to 30 or 40 wires for some high-power, high-frequency types. The bond wires attach to the chip on areas known as *bond pads*. Bond pads are part of the top-side metallization (either gold or aluminum) and are usually just large enough to accommodate the specified wire diameter. The back of the chip is usually covered with a thin layer of gold to facilitate the attachment of the chip to the package.

The power capability of a single chip can vary from a few hundred milliwatts to 150 watts or more, depending on chip size and the thermal resistance of the package to which the chip is attached. Often, a transistor manufacturer will mount two, three or even more chips in a single transistor package to increase the power capability. The upper-frequency capability for silicon bipolars is around 10 GHz these days, while GaAsFET devices are useful well above 50 GHz. The silicon power FET, while normally used only up to the UHF range, is now being developed for use in the low-gigahertz range.

Making Silicon Bipolars: Wafer Processing

A transistor chip starts out life in some far away and secret factory where gremlins take sand and turn it into long cylinders of pure crystalline silicon called *ingots*. These ingots are cut with a diamond saw into slices that are about 0.030 inch thick. Each slice is then polished to perfect flatness. The final product, a silicon wafer, can vary in diameter from 1.5 to 4 inches for RF transistors. Some IC manufacturers use wafers that are 6 and 7 inches in diameter. Wafers are supplied to transistor manufacturers as either N type for NPNs or P type for PNPs.

Most manufacturers also buy wafers with an *epitaxial layer* on the top side. This layer is very thin compared to the thickness of the wafer, and it eventually becomes the transistor collector. The characteristics of the epitaxial layer can be specified for thickness and resistivity depending on the ultimate chip design frequency, operating voltage, class of operation and other factors. We don't need to know much about the epitaxial layer except that it is one of the factors that determines the voltage ratings and ruggedness (resistance to blowing up) of a transistor.

Once the correct material for an application is selected, the wafers are put in batches or *lots*. Each lot goes through a series of steps that, if everything goes right, will end with a whole batch of identical, electrically perfect wafers that each contain hundreds or thousands of good chips. The "recipe" that specifies how a wafer is processed may have 50 or more steps. A very simple, low-frequency device might require only 10 steps. I will mention just a few of the steps here to show the basic idea. This is not a "how to make your own transistor" article, but the following should give you an appreciation for the complexity of the manufacturing process.

Individual transistors are created on a wafer by means of a photolithography process similar to that used to make PC boards, but many times more complex. Each element of each device (base, emitter, top metal, and so forth) has a different pattern that must be defined on the wafer in a separate step. For each step, the wafer is coated with photosensitive material, and then the wafer is exposed to the pattern for an element. It's sort of like exposing photoresist on a PC board with positive or negative artwork.

Photographic plates, called *photomasks*, contain the patterns for the various elements. Since each wafer contains hundreds or thousands of chips, a photomask has the basic pattern for a single chip repeated on it over and over in a grid fashion. For example, if the chip size is 0.010 × 0.010 inch, the basic pattern is repeated in 0.010 inch intervals up and down and across the wafer. See Fig 1.

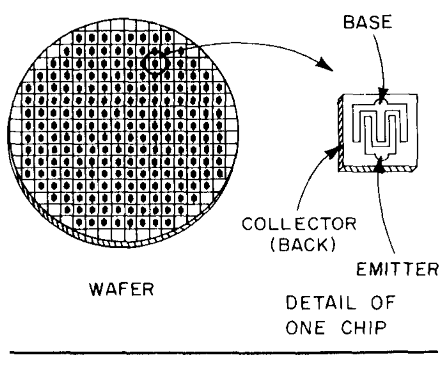

Fig 1—A chip is a piece of a wafer. After processing, a wafer is covered with identical transistor chips. Chips are separated by scribing and breaking or by sawing.

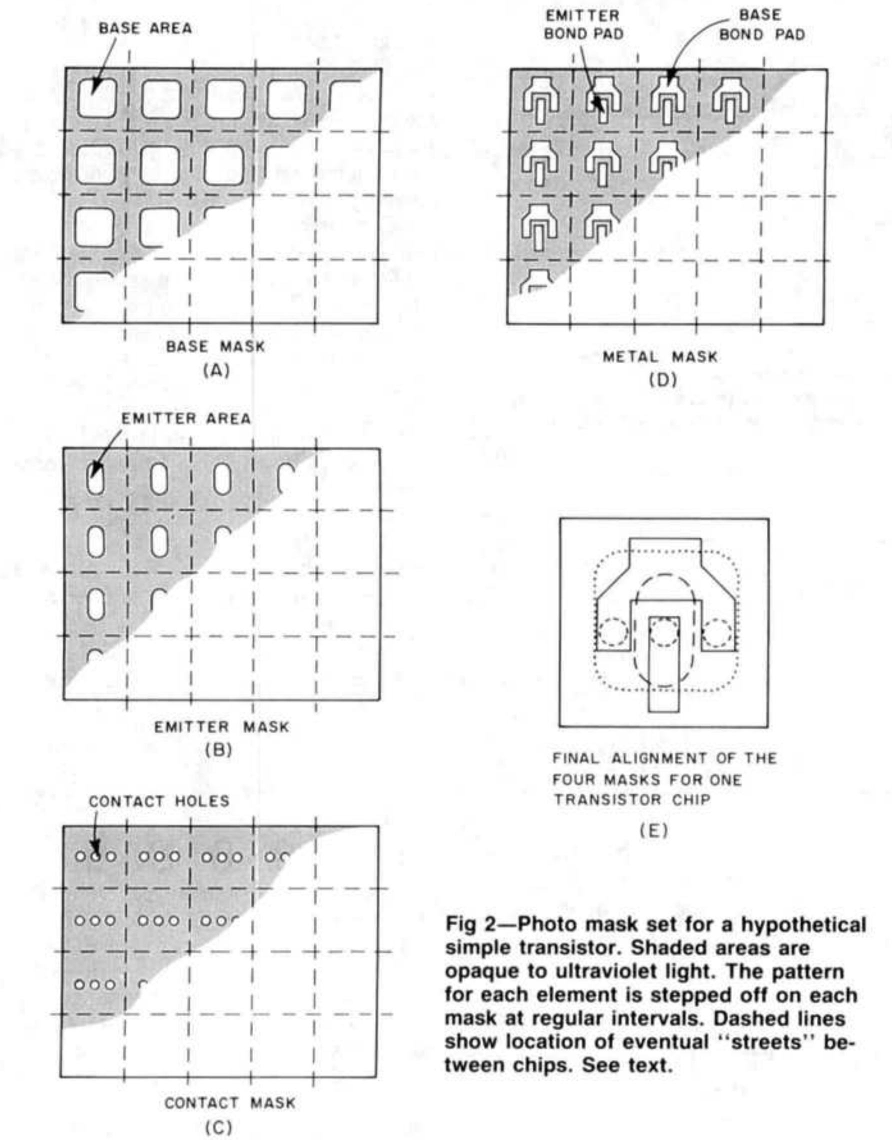

Fig 2—Photo mask set for a hypothetical simple transistor. Shaded areas are opaque to ultraviolet light. The pattern for each element is stepped off on each mask at regular intervals. Dashed lines show location of eventual "streets" between chips. See text.

Since each photo step requires a separate mask, tolerances are very carefully controlled so that alignment of all the elements will be correct across the entire wafer at the end of the process. This is often done by computer-controlled optics.

A hypothetical transistor is shown in Fig 2. This is a very simple device that requires only base, emitter, contact and top-metal masks. This example is meant to show, in general, how the process works. If transistors were really this simple, I could probably make one in my barn.

Here we are starting with a wafer that has an epitaxial layer, so the collector has been taken care of for us. The base goes in first. This is done by coating the wafer with a thin layer of photoresist and exposing it to ultraviolet light through the base mask. The wafer then goes into a developing solution, and the resist is removed from the area where the base is to go. For now, the rest of the wafer remains covered with impenetrable photoresist.

The wafer is then placed in a carefully controlled environment containing the right chemical gases at the correct temperature to cause the base to *diffuse* down into the wafer to the proper depth. For an NPN transistor, the chemical is usually boron, and the process occurs in a long quartz tube that is part of a *diffusion furnace*. Temperatures in the furnace can vary from 700-1100 °C, depending on what's going on in there. Hot! Sounds like black magic? Actually the base formation is one of the simpler processes!

Now, the remaining photoresist is removed and the wafer moves on to the next step in the recipe. Again, the wafer is coated with photoresist. This time, it is exposed to the emitter photomask and is subjected to a heat and chemical process similar to that which formed the base.

When the base and emitter are formed, an insulating layer of silicon oxide is grown on top of the wafer. Holes are etched through this layer for the emitter and base connections. The top of the wafer is then plated with a thin layer of *top-side metal* (usually gold or aluminum). The top-side metal contacts the base and emitter diffusion areas through the contact holes in the insulating layer (sort of like plated-through holes in a PC board). Using another photo step and a *top-metal mask*, excess material is removed. The metal that remains connects the base and emitter diffusion areas to pads that the bonding wires will be connected to. We now have a wafer full of transistors!

The main point here is that building a transistor is a serial process where the wafer keeps going back and forth through photo operations and processing operations until it is finished. The device is actually built up in layer fashion—hence the name *planar transistor* is given to this type of device.

Final Steps

After the top-metal pattern is defined, the transistors on the wafer can be tested for electrical characteristics. This is done on a machine called an auto-prober where each transistor on the wafer is tested in turn for parameters such as hfe, breakdown voltages, leakage currents and so on. Each device that does not pass all the predetermined tests is marked with an ink dot so it can be removed later when the wafer is cut up.

Since silicon is not a very good thermal conductor, and since an RF power device generates lots of heat, the finished chip must be as thin as possible. The wafer starts out around 0.020 or 0.030 inch thick because it needs to be strong enough for repeated handling. The finished wafer is thinned or *lapped* on a machine that basically wet sands the back of the wafer until it reaches the proper thickness, (0.003 to 0.005 inch). The back of the thinned wafer is usually gold plated so that the chips can be eutectically attached to the package.

The final step before the chips are placed in packages is cutting up the wafer and removing the bad chips. The wafer is either scribed with a diamond tool and broken into separate chips (just like cutting glass) or sawed with a diamond-bladed saw. The scribe or saw lines are centered in the *streets* between the rows of chips on the wafer. Chips that failed electrical tests (marked with ink dots) and chips that do not pass certain visual criteria are removed under a high-power microscope and discarded.

Depending upon the chip type and the wafer size, there can be anywhere from

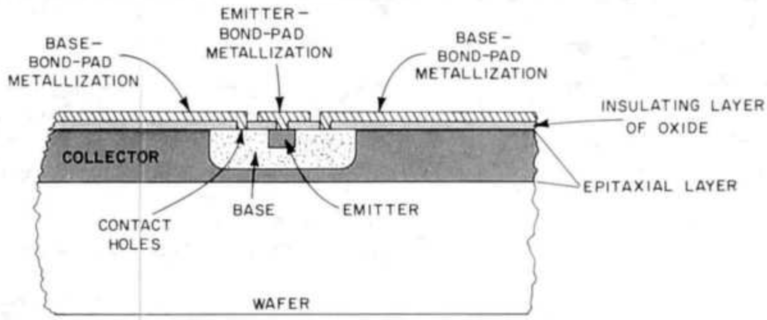

Fig 3—Cross-sectional view of a simple planar bipolar transistor. The base goes down into the collector, and the emitter goes down into the base area. Oxide covers the entire transistor, and holes are etched through the oxide for top-metal contact. (The oxide layer keeps the metal from shorting the various elements together.)

100 to 50,000 good chip *candidates* on a wafer. The number of good chips can vary from none to one or two to 95% of the maximum available. Obviously a chip from a wafer with 50,000 possibilities and a 95% yield is very inexpensive to manufacture, while a chip that was the only one to survive a 16-week process should not be dropped on the floor! While it is very discouraging, it is not all that unusual to have zero yield on a batch of wafers—especially the more state-of-the-art types. Ever wonder why the delivery time quoted on that special microwave device you ordered is 16 weeks?

As you might have guessed there are plenty of places where Murphy's Law applies to semiconductor manufacturing. One is the "Lot 1A Syndrome." This states that the first wafer from the first lot of a new device will surpass all expectations in performance, and all subsequent wafers will show mediocre performance at best. (Usually the data sheet for this device is written around the best and only surviving transistor from lot 1A!)

Next month, we'll take a quick look at special cases, such as multi-cell chips and emitter ballasting, and see how the chips are connected to the package.

Bits

Telecommunication Program Offers Packet Radio Enhancements

A new telecommunications program for IBM® PC compatible computers with major enhancements for packet radio users has been developed by Kalt and Associates of Anchorage, Alaska. The program is used with a packet controller, and is designed to help the operator enjoy packet radio.

The program has full cursor control, split screen, transmit line buffering, transparent binary or X-modm file transfers. Pop-up help windows and macro-command keys allow the operator to connect via multiple repeaters and sign on to a BBS with one keystroke. Function key labels, user-defined initialization files, five separate types of time and date stamps with a "brag" line enables the operator to use packet radio with ease. The split-screen mode buffers the transmit text so that incoming packets are always displayed for the operator.

A built-in QBF (Quick Brown Fox) message, received-text highlighting and additional features are included. The program runs on an IBM PC, XT, AT and PC jr with 256-k byte memory or other compatible models. Interface speeds run from 300 to 9600 bps, operator selected. The price is $49.95 with a $3 shipping and handling fee. The price also includes telephone software support and special prices on major upgrades. The program is not copy protected.

For further information, write to Kalt and Associates, 2440 E Tudor Rd, Suite 138, Anchorage, AK 99507; tel 907-248-0133. Checks and money orders only are accepted.—*KA1DYZ*

The 1986 IEEE MTT-S International Microwave Symposium

The Baltimore Convention Center will host this year's Symposium on June 2, 3 and 4. The theme of the program is "Microwaves Linking Nations." A special transmission sent over a live microwave satellite link to West Germany will highlight the opening ceremony. The best technical papers in this field were chosen from approximately 350 submissions. A special presentation of "Microwave Research in China" will be featured, as will six workshops and six panel sessions added to the regular schedule of events.

Session topics include guided-wave structures, passive components, low-noise techniques, GaAsFET amplifiers, microwave acoustics and magnetostatics, microwave measurements and much more. Open forums and a microwave exhibition area will be set up. Programs for spouses and children are also available. Preregistration is encouraged. For complete information contact IEEE, 6411 Chillum Pl, NW, Washington, DC 20012.—KA1DYZ

VHF+ Update

If your interest lies in the VHF and microwave area, how have you been getting along without referencing KCØW's *VHF+ Update?* Jack's editorial presents information on EME, meteor scatter and microwave activity. References to individuals and manufacturers who specialize in selling VHF equipment are found throughout the pages of each issue. Articles detailing specialized projects that are of particular interest to experimenters will be found there, too.

At the end of 1985, Jack relocated to Tucson, AZ, an area he describes as the "hotbed of astronomical research." A tour of Kitt Peak National Observatory and a private showing of a radio telescope at the site highlighted his arrival.

KCØW would like to hear from any amateur who might be interested in helping set up a SETI (Search for Extraterrestrial Intelligence) program. Questions yet to be answered involve the selection of probable targets for a search, frequencies to be investigated, necessary minimum system requirements that could produce results, and so on.

If you are interested in contacting Jack for both information on his monthly newsletter, *VHF+ Update,* and the SETI program, write to: Jack Parker, KCØW, VHF+ Update, 2018 West La Osa, Tucson, AZ 85705-2233. A 1-year subscription is $5 in the US, Canada and Mexico, $9 per year in Europe and $11 elsewhere.—*KA1DYZ*

VHF+ Technology

By Geoff Krauss, WA2GFP
16 Riviera Drive
Latham, NY 12110

Measured Noise Figure Trends

The use of new noise figure (NF) test gear (ie, HP-8970A with a properly corrected HP-346A noise head) is providing more meaningful data in the NF "contests" at various conferences. While VHF+ers may disagree on the desirability of the lowest NF for certain bands and modes, there is evidence that the use of GaAsFETs in a receiver's front end is highly beneficial in at least two other respects.

- The level of RF input necessary to destroy the device is generally greater than with a bipolar transistor.
- The third-order intermodulation point is generally better (higher) for the same degree of circuit complexity.

This year's crop of NF results indicates that consistent measurements occur almost without regard to the device used, up to 450 MHz, as long as a single-gate GaAsFET is employed. This indicates that the overall NF is basically set by the insertion loss of the input/noise-matching network of the first stage and that the NF of the device may be of minimal effect. Therefore, the least-expensive device will generally be sufficient; the cost of most 1-micron gate devices is now in the $10-15 range.

(As an aside, I am told that an NE72089 is equivalent to a MGF1402, both in the price category mentioned. The NE71084-06, at about $17, has caught my attention, but I have not seen any circuitry or data. Anyone in a position to comment or provide real-world, not data-sheet, results?)

It is now commonplace to expect a NF of less than 0.6 dB at 50 MHz, 0.5 dB at 144 or 220 MHz, and 0.6 dB at 432 MHz. I deliberately say nothing about the gain to be expected; more than enough gain, for any reasonable use, is available. It is often a problem of how to "kill" enough gain to make a hot circuit stable to be used at all, especially if the preamp will be located in an inaccessible place. Don't agree? Here's the test: Place a quarter-wave cavity in front of your 50/144/220/432 LNA and see if it takes off! Then, add a good filter at the LNA output (a band-pass filter using four or more helical resonators is typical). If a reproducible preamp design (with unconditional stability, a NF not greater than that listed above, and a gain in the 13- to 17-dB range) results, publish as soon as possible! No one, to my knowledge, has yet discovered how to accomplish these goals simultaneously. The problem? A device with low noise in the VHF range (50 to 500 MHz) generally is only marginally stable below some microwave frequency (would you believe 5 to 8 GHz, typical?) and, with 20+ dB gains in abundance, many combinations of source and load impedance (often including 50 ohms) will make the circuit oscillate. Tuning the amplifier for best NF often provides the needed input impedance for the circuit to take off; it becomes easier if the highly-reflective, off-frequency impedance of a filter is present.

Switching Bias Voltages

A question asked of me recently concerns fast switching of power-tube negative bias voltage—the kind usually found at −50 to −200-V dc. The voltage is not low enough to switch with the average transistor, but it can be switched by relays. Most relays, however, cannot move fast enough for many uses, even if they could be driven by +5 V at a few milliamperes. I can't remember where I originally found this idea, but I have used it and it works (the bottom-line criterion!). Fig 1 illustrates this concept.

The solid-state relay is a model DC200P from Opto-22, 15461 Springdale St, Huntington Beach, CA 92649. To activate the relay, apply 3 to 32-V dc control (into a 1-k resistance). It has 4-kV isolation and a controlled circuit capable of handling 200-V dc at 1 Amp.

Read Any Good Books Lately?

In addition to *QST*, *QEX* and the other ham magazines, I also reference foreign reading sources (English-translations of periodicals). *VHF Communications;* the well-known German journal *UKW Berichte* (now available from a new source, UV COMMS, PO Box 432, Lanham, MD 20706); or collected works, such as *The UHF Compendium* (Vol I; again available from Gerd Schrick, WB8IFM, 4741 Harlow Dr, Dayton, OH 45432). I repeat my often-given word of warning: Be aware that these sources, like many others from off the North American continent, use tubes and semiconductor devices that are more often than not unavailable here in the US. I reference these sources mainly for ideas, rather than construction projects.

What reference books are worthwhile? At the amateur level, any book available from the ARRL or independent publishers has something to offer. Some of the tomes lining my working-bookshelf include:

Computer-Aided Design of Microwave Circuits, by K. G. Gupta et al, 1981. I believe I have mentioned this thick, not inexpensive work before. It remains the best single over-all microwave reference I have encountered!

Design of Amplifiers and Oscillators by the S-Parameter Method, by G. Vendelin, 1981. Not as all encompassing as the Gupta work, but more useful if straight paper-and-pencil design is to be done.

Stripline Circuit Design, by H. Howe, Jr, 1973. Covers most practical aspects of microwave "printed-circuit" design; an excellent starting point.

Modern Transmission Line Theory and Applications, by L. Dworsky, 1979. More theoretical treatment, but complements Howe's work.

Microwave Circuit Design Papers, an IEEE-MTT reprint collection. The book is somewhat old and outdated, but it is great for understanding background theory in the active-circuit areas. It is best to borrow and read the book from a library before you enter into a big microwave project.

Have you a favorite reference book to bring to the attention of other VHF+ers? A letter or postcard will put it on the next list in this column.

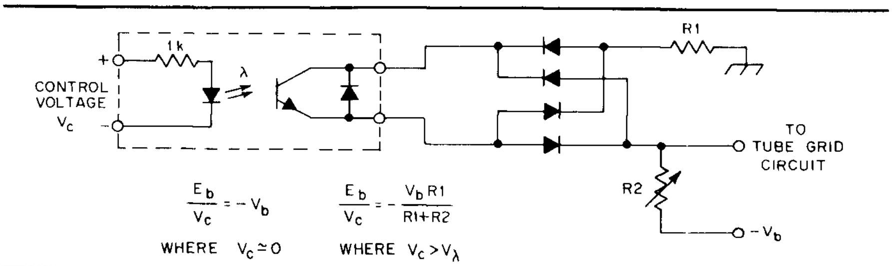

Fig 1—Fast switching a power-tube negative bias voltage. To activate the relay, 3- to 32-V dc control is applied through a 1-k resistance. A 4-kV isolation is present and the circuit is capable of handling 200-V dc at 1 A.

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