FEEDBACK

The OFFICIAL Newsletter of the
Georgian Bay Amateur Radio Club Inc.

December 1994

Sponsoring

VE3OSR FM REPEATER 146.940- Mhz BARROW BAY
VE3OST FM REPEATER 145.290- Mhz OWEN SOUND
VE3GBT FM REPEATER 146.895- Mhz MARKDALE
VE3IJD PACKET BBS 145.630 Mhz KEADY

REGULAR EVENTS	
GBARC MEETINGS:	Fourth Tuesday of each month except July and August
BREAKFAST MEETINGS:	Second and Last Saturday of each month at Rockford Esso
GBARC INFORMATION:	For information regarding membership please contact Tom Merner VE3NEM 519-371-9499

Minutes of the meeting of November 22 1994...

The meeting was opened by president Ken with 15 members present. The minutes of the last meeting were adopted as printed. Tom VE3NEM reported that we had $189.78 in the account at the beginning of the month.

Gene VE3IJD reported that 9 guys went on the Hammond museum tour and saw many wonderful things.

Ken VA3KMS suggested we skip the next meeting on December 27 and make it up later, there were no objections.

There will soon be a phone patch on the club repeaters, it will be in Owen Sound, access codes will probably be * for on and # for off.

Bob VE3LKD has been asked whether we would like to participate with Guides On The Air on February 18 and 19 1995. On December 22 Santa will be on the air. On the last weekend of January the Scouts plan to camp out at Harrison Park, Gene plans to set up a station in a building.

Club Crests were discussed , new crests are not cheap, it may be time to change the crest also while we are at it.

Five guys showed up to work the Santa Clause parade, we could have used a couple more.

We voted on the ham of the year and Gene VE3IJD was selected.

John VE3TXB moved we close the meeting and Tom VE3TSA seconded.

The 50/50 draw was won by Nick VE3MWU......

THE **DECEMBER MEETING** HAS BEEN **CANCELLED**

CLUB DUES

JUST A REMINDER THAT ITS DUES TIME AGAIN...THE FEE SCHEDULE IS LISTED BELOW

ON JAN 1st OR LATER PLEASE REMIT THE AMOUNT AS INDICATED........

BEFORE OR ON DEC 31ST SUBTRACT $5

.PLEASE SEND YOUR DUES TO:

TOM MERNER RR#4 OWEN SOUND,ON N4K5N6

A) REGULAR MEMBERSHIP $25.00 (for anyone with an amateur radio licence)

B) ASSOCIATE MEMBERSHIP $15.00 (for those who do not hold an amateur radio licence)

C) FAMILY MEMBERSHIP 1ST MEMBER $25 PLUS $15 EACH FOR OTHERS IN SAME HOUSEHOLD

SHORT BITS

MIKE HESLIN, VE3FOY HAS AN FT101 FOR PARTS IF ANYONE NEEDS THEM. HIS PHONE# IS 376-9415

MARION CHAPPLE, VE3DDC, HAS REQUESTED ASSISTANCE IN HELPING HER GET ON THE AIR. HER STATION IS ALL SET UP BUT SHE NEEDS SOME HELP WITH OPERATING PROCEDURES ETC. SHE LIVES IN MEAFORD SO COULD SOMEONE OUT THAT WAY GIVE HER A HAND. HER PHONE# IS 538-4591

GUIDES ON THE AIR..... GOTA WILL BE HELD ON FEB 18TH AND 19TH....FOR MORE INFO CONTACT VE3LKD BOB AT 371-2257

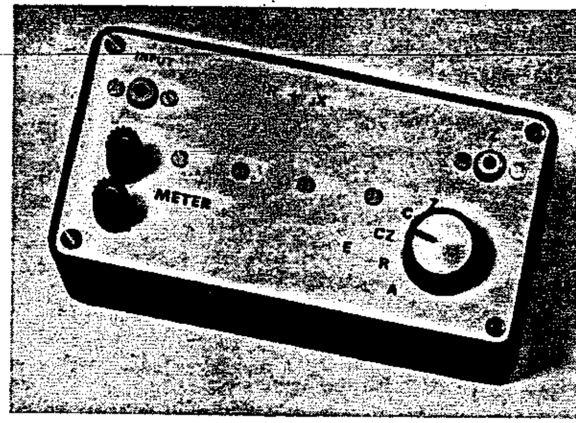
FOR SALE

VE3TFQ, JIM, 519-369-6596.....HF-5B BUTTERNUT BUTTERFLY ANTENNA $200......35' OF TV TOWER $50

VE3BZC, ROSS, 371-4326....PRINTER, STANDARD WIDTH, 24 PIN OKIDATA MICROLINE 380 $125

FROM THE EDITOR

WELL, ANOTHER YEAR HAS NEARLY EXPIRED, AND IT IS TIME TO REFLECT ON OUR PAST YEARS ACCOMPLISHMENTS. WE HAD ANOTHER SUCCESSFUL FIELD DAY, JOTA, SANTA CLAUS PARADE, CHRISTMAS DINNER AND OUR INCORPORATION BECAME FINAL. TWO NEW REPEATERS WERE PUT INTO SERVICE WITH LINKING BETWEEN ALL THREE AND I UNDERSTAND, A PHONE PATCH IN THE NEAR FUTURE. MANY THANKS TO THOSE WHO MAKE THESE EVENTS HAPPEN. I WON'T GO INTO NAMES AS I'M SURE I WOULD FORGET SOMEONE, LET'S JUST SAY THANKS TO ALL OF YOU WHO HELPED OUT IN 94. BRAD, VE3RHJ IS OUR NEW DELEGATED EXAMINER AND THIS WILL BE OFFICIAL ON THE 1ST OF JANUARY 1995. MANY THANKS TO BRAD FOR TAKING OVER THESE DUTIES. I WAS LOOKING OVER ALL THE EXAM RESULT SHEETS I HAD SENT TO ISC(DOC). I WAS SURPRISED TO LEARN THAT I HAD LICENCED 71 AMATEURS. OUR CURRENT RADIO COURSE IS PROGRESSING ALONG VERY WELL. WE HAVE 15 STUDENTS IN THE CLASS THIS YEAR, TWO OF WHICH ARE FEMALE. IN 1995 I INTEND TO GIVE UP THE JOB OF EITHER, THE BULLETIN EDITOR OR THE RADIO COURSE CO-ORDINATOR. I FIND THIS A DRAIN ON MY SPARE TIME. I DO NOT MIND DOING ONE JOB FOR THE CLUB, BUT I CANNOT DO TWO. SOMEONE ELSE WILL HAVE TO TAKE THIS OVER ONE OF THESE JOBS, WHETHER IT IS THE EDITOR OR THE CO-ORDINATOR DOESN'T MUCH MATTER TO ME. YOU DECIDE OR I WILL. FINALLY, I WOULD LIKE TO WISH EVERYONE A MERRY CHRISTMAS AND A HAPPY NEW YEAR...73...MR EDITOR



Panel view of the impedance-measuring network unit, showing the input and output jacks in the upper corners, the v.t.v.m. terminals at the left, and the volt-meter switch at the right. The aluminum panel measures 3 by 5 inches. The enclosure may be of metal or plastic.

Amateur Measurement of R + jX

Inexpensive Method of Determining Complex Impedances

BY DOYLE STRANDLUND,* W8CGD

SINCE someone once said, "It's easier to get a bigger signal with a better antenna than with more power," the topic has been a favorite in amateur thoughts and conversations in every variation imaginable. However, nearly every type of antenna, except a dipole (used at its resonant frequency, and high off the ground) presents a problem in matching and feeding. There is no shortage of material to read on how authors have matched and fed everything from needles and noodles to wet string, using absolutely foolproof systems that worked every time — for them. With the advent of TVI, the popularity of coaxial transmission lines rose rapidly and, along with it, came the problem of matching impedances.

Most amateurs associate a high s.w.r. with loss in the coaxial line. This concern may or may not be justified, depending on the frequency of operation, and the length of the line. However, there is another consideration which may be of equal or even greater importance in practice. When a transmission line is terminated in an impedance other than its characteristic impedance, the impedance offered to the transmitter at the input end of the line may be quite different from either the line characteristic impedance, or the impedance in which the line is terminated. In such a case, the line acts like an impedance transformer, and the impedance presented to the transmitter may be a value with which the output circuit of the transmitter is unable to cope. In other words, "The rig won't load."

Impedance mismatches can be handled more intelligently if the values of the impedances to be matched are known. The purpose of this article is to show the amateur how he, with available materials and a straightforward technique, can make impedance measurements previously impossible without expensive equipment.

* Design Engineer, Heath Company, St. Joseph, Michigan.

The Smith Chart

The Smith Chart is a marvellously handy device for simplifying transmission-line calculations to a minimum of math. These charts are available in most college book stores for a few cents. The material in this article will be based on 50-ohm cable, so Smith Charts with "50" at the center will be most easily used. If unobtainable, or if 75-ohm cable is to be used, get the charts that are normalized — with 1.0 at the center. Admittance charts, with 20 mmho at the center, are designed to be used with admittance bridges. They are similar, but would require conversion to ohmic values to fit the thinking in this article.

A very good presentation of the use of the Smith Chart is an article by K6CRT [1] which appeared in an earlier issue of *QST*. The reader is urged to refer to this article if he is not familiar with the Chart manipulation. The subject has also been treated more recently by W7RGL.[2]

To make use of the Smith Chart and make complete measurements of the r.f. impedance at any point on a transmission line, either a slotted line or an impedance bridge must be used. With the slotted line, the voltage inside a portion of the transmission line is actually measured. The points of maximum and minimum voltage are carefully determined, and the ratio of these two voltages determines the s.w.r. This s.w.r. circle is drawn on the Smith Chart. Since the maximum and minimum voltage points are at the places where the line impedance appears purely resistive, these two values then appear where the s.w.r. circle crosses the vertical resistance axis of the chart. By measuring the line length, converting to wavelengths, and rotating around the s.w.r. circle on the chart, the impedance at any point on the line can be found. However, below

[1] Cholewski, "Some Amateur Applications of the Smith Chart," *QST*, January, 1960.
[2] Amis, "Antenna Impedance Matching," *CQ*, December, 1963.

50 Mc., the length of the slotted line becomes unwieldy, and it is difficult to construct such a line to the precision necessary for accurate work.

Impedance Bridges

Impedance bridges, as the alternative, present problems that appear to be equally formidable; available commercial laboratory units are expensive and seldom appear on the used or surplus market. They require auxiliary equipment, such as generators, standards, and null detectors, which are also expensive. The wide variety of s.w.r. bridges and directional couplers on the market would indicate with varying accuracy the s.w.r. circles to be drawn on the Smith Chart, but they lack one thing: They will not indicate where around the circle one would be at any time. The simple resistive antenna "impedance" bridges appear to have utility, but they will not null to zero unless they are measuring pure resistances. At any point along a line, except at a voltage maximum or minimum, no null can be obtained that means anything.

Amateur antenna measurements usually fall into an s.w.r. range of less than 5 to 1, low-impedance cable is used, and extreme accuracy is not required. Most amateurs would substitute a little time for lots of money, and following is a system that uses the ubiquitous junk box to obtain satisfying results.

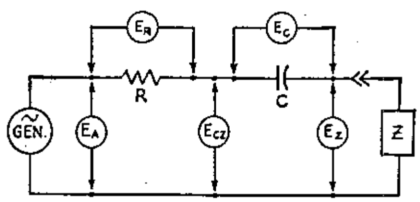


Fig. 1—Block diagram of impedance-measuring system, showing the various voltages of interest.

System of Measurement

The block diagram, Fig. 1, illustrates the way the measurements are made. A signal source, at the operating frequency, supplies a small voltage to the unknown impedance, Z, through a resistor, R, and a capacitor, C. The voltage across each element is measured. The applied voltage from the generator is E_A, the drop across the resistor is E_R, across the capacitor is E_C, and the voltage across the unknown is E_Z. Also measured is the voltage across the series capacitor and the unknown. This is E_{CZ}.

To make sense out of this group of voltages, they are shown as vectors in the diagram of Fig. 2. This diagram can be easily constructed with only a ruler and compass. It eliminates the trigonometry needed for a mathematical solution, and offers accuracy well within the needs of this work.

Starting at the origin in Fig. 2, the line E_R is drawn to the right for a length proportional to the voltage E_R. This line is the "standard," or reference, setting the scale for the remaining lines. It is convenient to make this voltage, and the

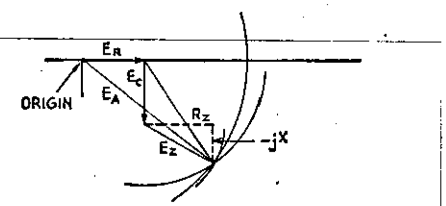


Fig. 2—Vector diagram illustrating the method of determining the resistive and reactive components of a complex load from the voltage readings of Fig. 1.

units of measurement, scaled to 50 units. Then all the remaining lines can be read off as ohms directly on completion. At the end of E_R, the line E_C is drawn straight down, using the scale established when drawing E_R. Next, a circle is drawn with the center at the origin, and with a radius corresponding to the applied voltage, E_A. Another circle is drawn with the center at the junction of E_R and E_C, with a radius corresponding to the voltage across the capacitor and unknown, E_{CZ}. Then, the last voltage, that across the unknown, E_Z, is used to draw a circle with the center at the bottom end of E_C. These three circles intersect at a common point, with the co-ordinates of the impedance connected to the generator. However, the impedance connected to the generator includes the series resistor and capacitor, so their contribution must be removed to find the impedance of the unknown. A look at the diagram will show that the unknown impedance can be described by the x and y components of E_Z. These values can be found by constructing a line horizontally to the right from the bottom end of E_C, and another vertically through the E_Z-circle-intersection point to meet the first. Measuring these lines will give the values of resistance and reactance of the unknown mpedance.

Does this sound a bit familiar? It should to many, for this same technique is used at power-line frequencies in a.c.-circuit classes.

To answer a couple of questions now: "Why use a fixed resistor and capacitor as standards, instead of a variable bridge?" That is just what makes an impedance bridge cost so much — it is difficult to calibrate inductors or capacitors to represent reactance without frequency sensitivity. Next, "What is the reason for the capacitor in series with the resistor?" It is to resolve the ambiguity which would exist without it. Without the fixed vertical offset of the capacitive voltage E_C, the circles of the applied voltage, E_A, and the unknown, E_Z, would intersect at two points. While the resistive component of E_Z would appear correctly, the reactive portion would be without direction, since it could go to either intersection, and there would be no way to determine whether the unknown was capacitive or inductive.

Voltage Measurement

To use this system in practice, a means of measuring the various voltages is needed. Since

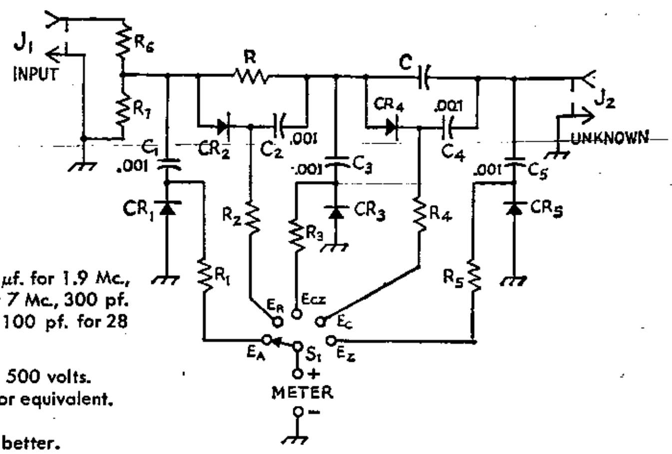


Fig. 3—Circuit of the impedance-measuring network.

C—Silver mica: Suitable values are 0.002 μf. for 1.9 Mc., 0.001 μf. for 3.9 Mc., 500 pf. for 7 Mc., 300 pf. for 14 Mc., 200 pf. for 21 Mc., 100 pf. for 28 Mc. through 50 Mc. See text.

C_1–C_5, inc.—0.001-μf. disk ceramic, 20%, 500 volts.

CR_1–CR_5 inc.—Germanium diode, 1N191 or equivalent.

J_1, J_2—Phono jack.

R—51 ohms, ½ or 1 watt, carbon, 5% or better.

R_1—R_5 inc.—Resistances should be as nearly equal as possible, but the common value may be anything from 1 megohm to 5 megohms.

R_6—Five 220-ohm 2-watt carbon resistors in parallel.

R_7—10 ohms, 2 watts, carbon.

S_1—Single section, single-pole, 5-position rotary switch, phenolic or ceramic.

the voltages across the capacitor and resistor are floating above ground, an ordinary r.f. probe and v.t.v.m. having a grounded chassis return will not work. Therefore, five probe circuits are built into the measuring unit of Fig. 3, and a switch selects them as desired.

In Fig. 3, the series resistor and capacitor are R and C. The five voltmeter probes are C_1, CR_1, and R_1, through C_5, CR_5, and R_5. Each of these is connected across the points needed to obtain the voltage desired. The probes measure the peak values of voltage, and require a high-resistance meter. Use a d.c. v.t.v.m. with an input resistance in the megohms and ranges of one to five volts, full-scale. Resistors R_6 and R_7 are used to provide a load and voltage divider when using a transmitter as the signal source. The transmitter should be adjusted for an output of about 10 watts. These resistors can be eliminated if a signal generator is available with about three volts output at low impedance. If a signal generator is used, a d.c. return must be made at the input end of R so the probes will work. Use a resistor or r.f. choke across the input if the generator has an output blocking capacitor.

Construction

Constructional details are not especially critical. Mount the components on terminal strips to obtain a short, direct line from the INPUT to UNKNOWN jacks, and be sure to connect the probe circuits so that the diodes and capacitors have short leads. The resistors in the probe circuits are for isolation, and the connection between the diode and resistor should be short to avoid capacitive pickup. The lead at the switch end may be long without harm. If possible, match these resistors as closely as possible; any value between one megohm and five megohms will do, so long as they are alike. The grounded end of R_7 should go directly to the ground terminal of the INPUT jack to avoid heavy ground currents that would disturb the other circuits. Capacitor C should be a high-quality mica unit. Its value is not critical, but it should have 25 to 50 ohms of reactance at the frequency in use. Suitable values for the amateur bands are listed under Fig. 3. To minimize lead length, it is better to solder the capacitor leads rather than to use terminals.

Measurement Procedure

The following procedure should be observed, at least until familiarity is attained, to assure reliable results. A few trial runs using known resistors connected with short leads to the UNKNOWN jack will help to get the procedure down pat, and to check the results.

1. Check that the right value of C is used for the frequency. Connect the transmitter to the INPUT jack, the antenna or unknown to the UNKNOWN jack, and the v.t.v.m. to the METER terminals.
2. Adjust the signal level to give two or three volts for E_A, and watch a bit to see that it stays constant.
3. Check E_R, and adjust the signal level for either:
   a. 0.5 volts. Read this as "50", thus converting all readings to ohms to agree with the 50-ohm center of the Smith Chart. (If desired, set to a "5" or "50" reading on *any* voltage scale. For instance, with the v.t.v.m. on the 5-volt range, set to "50" on the 150-volt scale.)
   b. When using a Smith Chart with 1.0 at the center, set E_R to 1.0 volt, and read all the voltages directly in normalized values.
4. Quickly record the readings for all five probes, so the input voltage will be constant for all five readings.
5. Mark an origin point on a sheet of paper. Draw a horizontal line to the right from the

origin, of a length corresponding to E_R (for the normalized charts, make this line 1.0 inches long: for the 50-ohm charts, 50 millimeters works fine). Label this line E_R. (See Fig. 4.)

6. At the right-hand end of E_R, draw a vertical line down from E_R of a length corresponding to E_C. Use the same units of length as for E_R. Label this line E_C.
7. With the origin as the center, draw a circle with a radius corresponding to E_A. Label it E_A.
8. With the junction of E_R and E_C as the center, and with a radius corresponding to E_{CZ}, draw a circle. Label it E_{CZ}.
9. With the bottom end of E_C as the center, and a radius corresponding to E_Z, draw a circle and label it E_Z.
10. The three circles should intersect in a common point. If they do not, there is an error in measurement of either voltage or length.
11. Draw a horizontal line through the bottom end of E_C to the right past the circle intersection point. Label this line R_Z.
12. Draw a line vertically through the circle intersection point to intersect the R_Z line. The circle intersection will be either above or below the R_Z-line intersection point. If it is above, label the line $+jX$; if below, label the line $-jX$.
13. Measure the lengths of R_Z and jX, and these will be the values of the components of the unknown impedance. Positive jX will indicate inductive reactance, and negative jX will indicate capacitive reactance. These values will be in the terms of the Smith Chart, and this completes the measurement.

This may seem lengthy, but it actually takes only a few minutes to go through the whole process and is much less painful than paying for an impedance bridge!

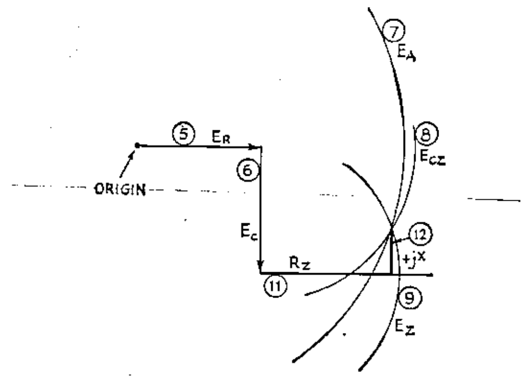
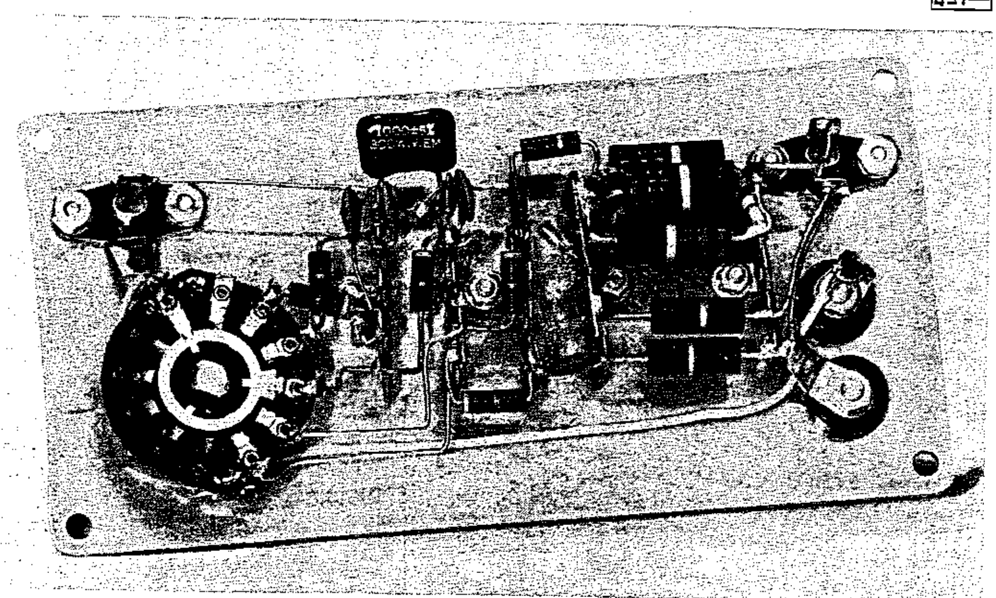


Fig. 4—Voltage-diagram construction. Circled numbers refer to numbered steps in the procedure outlined in the text.

This system has some limitations regarding frequency. It will do pretty well at 50 Mc., but lead inductances and stray capacitances introduce error. At s.w.r.s above 3:1, the angles of the diagram may get rather narrow, introducing error in measurement. At voltage readings below about a quarter of a volt, the diodes in the probes will tend to give a square-law reading not consistent with higher readings. Assuming that E_C is at right angles to E_R ignores the resistance in the series capacitor, which should be small. (This could be corrected by adding another probe to read the voltage across R and C, and plotting all three sides of this triangle.) These limitations may concern the purist, but for the ham who takes the trouble to learn the Smith Chart, this technique presents a quick and cheap way to measure $R + jX$, otherwise impossible. QST



Internal view of the impedance-measuring unit. Resistors and capacitors are supported on tie-point strips.

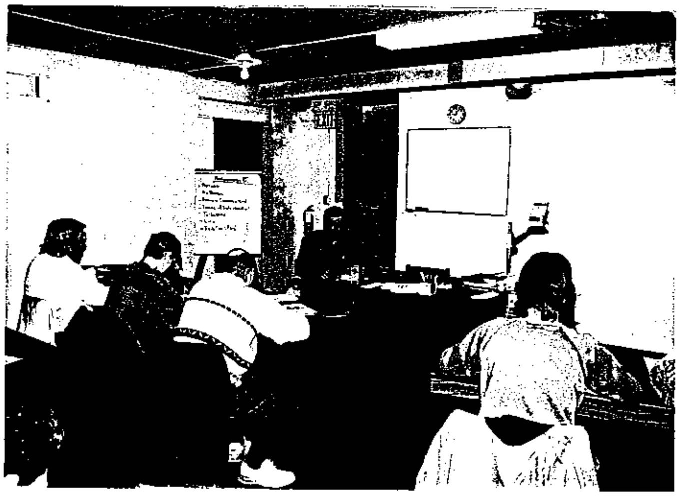
1994 SPLIT RAIL FESTIVAL

SHOWN HERE IS BRAD RHJ, JOHN TXB, WALT FFN AND STAN GUZONAS

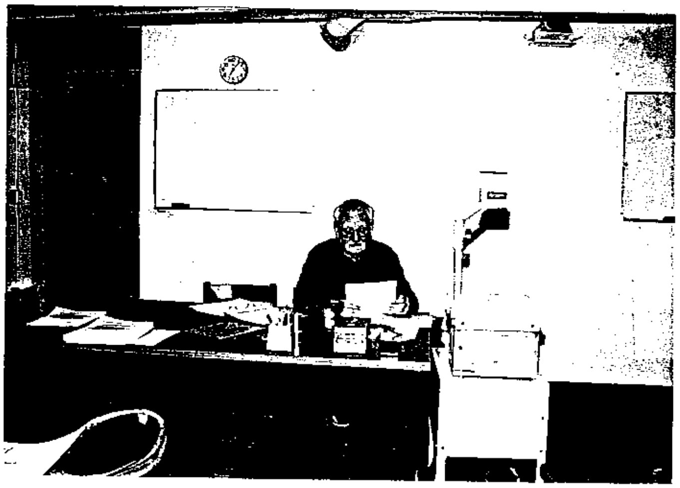
1994 CHRISTMAS DINNER

AT THE TIEN-BO RESTAURANT

PHOTOS BY JOHN TXB



1994 AMATEUR RADIO CLASSES



PHOTOS BY JOHN TXB