A TEST METHOD FOR MEASURING
CORONA INCEPTION VOLTAGE
FOR TRANSDUCER AUTOTRANSFORMERS

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An autotransformer corona inception test circuit has been developed and a prototype has been constructed and demonstrated. Circuit diagrams and component values are presented. Ancillary equipment for the test is identified and recommended, test procedures and precautions are presented, and measured corona inception voltage data as well as pictorial data are presented for autotransformers of different manufacture and type. Included is a computer program which is used to model and calculate values of test circuit filter components.

Corona Transformers
Autotransformer Transducer reliability (electroacoustic)

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A TEST METHOD FOR MEASURING CORONA INCEPTION VOLTAGE FOR TRANSDUCER AUTOTRANSFORMERS

INTRODUCTION

A small but significant percentage of failures in high-power fleet sonar transducers are due to breakdown of electrical insulating or dielectric materials. A physical phenomenon that contributes to these failures is corona which is a discharge of electricity caused by ionization of the surrounding medium when the voltage gradient exceeds a certain critical value. The frequency of discharge is above 75 kHz. At high operating voltages corona occurs before dielectric breakdown, but will, in time, deteriorate insulating materials and cause dielectric failure.

One of the components in a typical high-power transducer that is susceptible to corona is the autotransformer (tapped power inductor) which is used to augment tuning, transmit voltage response, and transmit impedance. These transformers usually operate at secondary voltages in the range of 1500 V, but may be as high as 5000 to 6000 V in some instances. A suitable corona test is valuable in determining if a particular transformer design or production transformer has corona at relatively low voltages. Such a situation may be indicative of poor terminal design, voids or air pockets in the coil coatings or potting compounds, and an indication of premature failure in the normal operating environment.

This report covers the development of a corona inception voltage (CIV) test that can be applied as a qualification, quality control, or quality assurance provision in a transducer autotransformer specification.

BACKGROUND

In 1987, General Electric (GE) and Raytheon were awarded production contracts to fabricate TR-317( ) sonar transducers according to a government developed Fabrication Specification Package (FSP). The FSP contains requirements that are deemed necessary for the composite transducer to achieve a 15-year service life. One such requirement was a corona specification for the autotransformer. As a part of the FSP development, certain critical assemblies of the transducer, which included the transformer, were procured by sample buys (in small quantities) to proof the FSP drawings. Because of limited financial resources in the years prior to the TR-317( ) production contract award, some of the sample buys were still in progress at the time of contract award.
During the transformer sample buy, a transformer contractor (Harder, Inc.) expressed concern about the validity of the corona requirements and the test method specified in the transformer drawings [1]. The concerns were: (1) the validity of a quantitative limit and measure of corona; and (2) the effectiveness of the specified filter circuit in attenuating the fundamental frequencies and passing the frequencies associated with corona. After consultation with the Naval Sea Systems Command (NAVSEA) it was determined that Harder's concerns were valid. These concerns led the TR-317( ) production contractors, with NAVSEA concurrence, to submit a Deviation/Waiver requesting modifications to the transformer drawing with respect to corona measurement, corona suppression, and abatement. In order to prevent delays in receiving First-Article transducers, the waiver (applicable to these transducers only) was allowed.

Since the waiver was allowed for First-Article transducers only, and at the beginning of production NAVSEA would again have to address the problem, NRL-USRD accepted the task of developing a technically defensible corona test for the TR-317 transformer that could be applied to the production transformers.

Several references are made in this report, to the TR-330A transducer (NAVSEA Drawing 53711-5517085), and TR-330A transformer corona data are presented. Corona requirements were not included in the original TR-330A FSP because the corona specifications for the TR-317( ) transformer were indefensible, and there were problems associated with corona testing the TR-317( ) transformer. The TR-317( ) FSP was used as a template for the TR-330A, thus the solution for the problem in the TR-317( ) also becomes the basis for a validated corona test for the TR-330A transformer.

APPROACH AND OBJECTIVES

The approach to the problem was to use the corona test circuit and specification in the TR-317( ) transformer drawing and make the necessary changes to provide a technically defensible test. That is, "defensible" in the sense that if a transformer failed to pass the test, the transformer would be questionable -- not the measurement, methodology, or test circuit.

The first step in the approach was to eliminate the quantitative test procedure and replace it with a qualitative test procedure. Therefore, instead of specifying a quantitative measure of corona current at some test voltage, the approach would be based on the qualitative detection of corona inception. That is, the goal was simply to be able to detect when corona first occurs, and measure the voltage at which it occurs.

The hardware for the test must be specified and tested to determine if corona can be detected reliably, repeatedly, and economically at the transformer assembly level.
The items needed to accomplish a CIV test, not including ancillary equipment, are:

- A circuit to resonate with the autotransformer at the approximate center of the operating frequency range.
- A high pass filter to attenuate the lower fundamental frequencies, yet allow the higher corona frequencies to be passed for detection.
- A properly constructed Faraday shield to provide protection from outside electromagnetic interference which can mask the corona signal.

**CIV Test Circuit Description**

The corona test circuit and test procedure originally developed by the TR-317R transducer design team was inadequate for its intended purpose. Figure 1 depicts an improved CIV test circuit, including the ancillary test equipment, that has been developed from the original test circuit and validated. In Fig. 1, capacitor $C_A$, inductor $L$, and capacitor $C_B$ are the essential parts of the autotransformer resonant circuit: $C_A$ resonates with the transformer under test, $C_B$ isolates the EMI filter from the rest of the circuit to prevent loading, and $L$ enhances the corona detection by preventing the source from shunting the corona signal. $C_A$ is calculated from the formula for the resonance frequency of an ideal parallel LC circuit which is,

$$f_r = \frac{1}{2\pi \sqrt{L C_A}}$$ \hspace{1cm} (1)

If, in Eq. (1), we define $L_T$ as the inductance of the transformer under test, and $f_r$ as the approximate center of the transformers operating frequency band, then

$$C_A = \frac{1}{4\pi^2 f_r^2 L_T}$$ \hspace{1cm} (2)
Figure 2 is a schematic diagram of the EMI filter section of the circuit shown in Fig. 1 and depicts the three stage ladder, R-C, R-L, high-pass filter which passes the corona signal to an appropriate detector. The circuit component values shown in Fig. 2 were determined by using equations derived from the model of a three-stage, high pass, L section filter. The circuit values were verified on a computer program, developed by the Naval Ocean Systems Center (NOSC) for an L section filter. The computer program for the circuit is contained in the appendix.
Several different circuits were evaluated to determine the five most optimum values shown in Fig. 3, although all the circuits evaluated were, to some degree, acceptable in that the fundamental frequency would be attenuated while allowing the corona frequency to be passed through for detection. Circuit value set #1 was chosen because at no time did $E_{\text{out}}/E_{\text{in}}$ exceed 0 dB, and set #1 exhibited a steep cutoff slope. Set #2 also exhibited a steep cutoff slope, but exceeded 0 dB $E_{\text{out}}/E_{\text{in}}$. The other circuit values would allow attenuation of the fundamental frequency, but not to the same degree as set #1. The calculated values (along with actual tests) verified that the circuit would be acceptable for testing both TR-317( ) and TR-330 transformers with only a change in the value of capacitor $C_A$ shown in Fig. 1.

Fig. 2 - EMI filter for CIV test circuit.

R1, R2, R3 = 4000 OHMS, 5W
R4 = 400 OHMS 5W
R5 = 300 OHMS 5W
R6 = 200 OHMS 5W
C1 = 0.5uF 3KVDC
C2 = 0.2uF 3KVDC
C3 = 0.1uF 3KVDC

L1, L2, L3 = 0.02H 0.1AMP

COMPONENTS TOLERANCE = ±5%
The quality of the components used in the circuit is very important to eliminate the possibility of corona in any other part of the circuit except the transformer under test. All capacitors are oil-filled polypropylene capacitors and have a dielectric dissipation factor of 0.001 (0.1%) or less.

The inductors for the CIV test circuit were designed and fabricated at NRL-USRD. Inductor L, in Fig. 1, consists of 18 turns of #25 polythermaleze insulated copper wire, pi wound on a three section bobbin. The bobbin assembly is placed into a Ferroxcube #2616 P 3C8 ferrite cup core, and the Q, measured on a RLC bridge, is 68. Inductors L1, L2, and L3 in Fig. 2 consist of 223 turns of #25 polythermaleze insulated copper wire in a Ferroxcube #3622 PA400 3B7 ferrite cup core; and the measured Q is approximately 270.

Figures 4a through 4f are photographs of the test circuit chassis and enclosure. Excluding the ancillary equipment, only the transformer under test is not within the shielded enclosure.

The Faraday shield for the circuit consists of the aluminum chassis bottom, the chassis faceplate, and the copper wire mesh attached by screws to the chassis as shown in Fig. 4c. Shielding the circuit could also be accomplished by enclosure in a metal box or cabinet instead of using a copper mesh. The mesh was used during the development phase to visually determine the existence of any arcing. The circuit components and wiring should be isolated from the enclosure to minimize any interaction between the return current path of the circuit and the grounded case shield which should not have any current flow. This condition is implied by the single point ground connection shown in Fig. 1.
The electrical connections between circuit components on the chassis are made with 15 kV dc rated, silicone insulated, 20 AWG stranded copper wire.

Fig. 4a - Front view of faceplate.

Fig. 4b - Rear view shield mesh installed.
Fig. 4c - Side view Faraday shield/chassis.

Fig. 4d - Top view mesh installed.
Fig. 4e - Top view internal components/mesh shield.

Fig. 4f - Rear view component mounting.
CIV TEST PROCEDURES

An oscilloscope with a measurement capability of dc to at least 20 MHz should be used. The output connector V1 is connected to the vertical input of the oscilloscope. The oscilloscope should be preset to a vertical input sensitivity of 2 V/division and a horizontal sweep time of 20 μs/division. The rest of the setup is done as shown in Fig. 1.

The hookup wire from the power amplifier output should be a single twisted pair. All other circuit connections are made with RG-58/U coaxial cable (which will withstand 2 kV) to further shield the circuit from EMI.

In evaluating test procedures, measurements were made with and without transformer shielding and the results indicated that a shield was not necessary for the transformers tested (TR-317 and TR-330A autotransformers). In extremely noisy environments, transformer shielding can easily be accomplished, if necessary, but all shielded ground connections to the circuit should be made at a single point on the chassis.

To make the CIV test:

1. Adjust the input voltage as read on the VM to the transformer to approximately 5 to 10V at the approximate resonant frequency \( f_r \) of the autotransformer under test. Then carefully adjust the frequency generator to the frequency that produces the maximum voltage on the voltmeter, or the maximum amplitude waveform on the oscilloscope.

2. After the frequency is adjusted to resonance, carefully increase the applied voltage as read on the VM until the corona inception "hash" is sporadically observed on the oscilloscope. Corona inception is evidenced by the sporadic high-frequency "hash" type oscillations on the oscilloscope waveform and by an increase in the voltmeter reading. Record the frequency and the voltage at which corona inception is observed.

3. Repeat the first two steps two more times to insure repeatability.

Figures 5 and 6 serve to illustrate how the corona "hash" appears on the oscilloscope waveform. Figure 5a shows the scope waveform for a TR-330A transformer under normal drive conditions and Fig. 5b under higher drive conditions that has produced corona. Note that a small amount of the drive frequency is evident in the oscilloscope display; but, as seen in the high-drive condition, Fig. 5b, is not detrimental to the observance of the corona "hash" in Fig. 5b. Figures 6a and 6b show the same drive conditions just described, respectively, for a TR-317 transformer; Fig. 6a shows a clean waveform; and Fig. 6b shows a waveform with high-frequency corona "hash." If desired, corona detection can be augmented if an AM radio receiver is available, placed near the transformer under test, and tuned to 550-560 kHz; sporadic noise (loud static) will be heard from the receiver at the same time that corona "hash" (as illustrated in Figs. 5b and 6b) appears on the oscilloscope waveform.
Fig. 5a - Output of the CIV test circuit for a TR-330A autotransformer under normal drive conditions.

Fig. 5b - Output of the CIV test circuit for a TR-330A autotransformer under high-drive conditions with corona "hash."
Fig. 6a - Output of the output of the CIV test circuit for a TR-317 autotransformer under normal drive conditions.

Fig. 6b - Output of the CIV test circuit for a TR-317 autotransformer under high-drive conditions with corona "hash."
CIV TEST PRECAUTIONS

The amplifier chosen for the CIV test must be adequate for the intended purpose. For the TR-317 transformer test circuit, shown in Fig. 1, the power amplifier should be an Instruments Inc. Model LDV 2-6, 10 kVA or an equivalent that will supply the current and voltages necessary for the test. For the TR-330A transformer, a McIntosh Model MG-2500, 1 kVA amplifier or equivalent is adequate. Since a high impedance output may make the test circuit susceptible to high-frequency noise pickup, one should use the minimum impedance setting on the amplifier compatible with providing the required test voltage across the transformer.

For the TR-317 corona test circuit, capacitor $C_A$ should be the value shown in Fig. 1. For the TR-330A transformer corona test, the value of $C_A$ should be 3000 pF.

It should be emphasized that corona occurs in the presence of high voltages; therefore, high voltage is required to make the test. The measurements should be made with care and respect for the operating conditions to prevent serious electrical shock to the operator.

CIV TEST DATA

The CIV test circuit and procedures previously described have been used to determine the CIV for several TR-317 and TR-330A production transformers and for experimental TR-330A toroidal autotransformers. The TR-317 group contains transformers salvaged from TR-317 autopsies, transformers from the TR-317R sample buy, and GE TR-317( ) production transformers -- the latter two made by Harder, Inc. and Chloride, respectively. The transformers are fabricated in a variety of ways; i.e., varnish coated but not potted, potted, etc., these conditions are noted with the measured data in Tables 1 and 2.

The TR-330A group contains transformers which are potted except for two experimental toroidal transformers which are unpotted. The unpotted transformers were included in the test to demonstrate the difference in CIV between unpotted and potted transformers.

Table 1 provides data from the CIV tests on the TR-317 transformers. The serial numbers shown in the table are the actual serial numbers shown on the transformers, except for those that have an A prefix (the A prefix indicates the serial number of the transducer from which the transformer was removed). The table indicates, in the column headed "Type," certain conditions and materials used in the fabrications of the transformer. Table 1a is corona test data for TR-317 transformers, some of which were salvaged from autopsies. Table 1b is test data for 6 GE TR-317( ) production transformers (Chloride). Table 1c shows the test data from 6 TR-317R Sample Buy (Harder) transformers. The frequency data shown in Table 1 is relative to the electrical resonance of the transducer in-water (peak of free-field voltage sensitivity). The table indicates three independent measurements on each transformer. Measurements were taken at approximately 1 minute intervals.
### Table 1a - Corona Test Data for TR-317 Autotransformers.

<table>
<thead>
<tr>
<th>Ser #</th>
<th>CIV (Hz)</th>
<th>Relative Freq</th>
<th>CIV (Hz)</th>
<th>Type</th>
<th>CIV (Hz)</th>
<th>Type</th>
<th>Std Mean</th>
<th>Std Dev</th>
</tr>
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<td>013</td>
<td>2731</td>
<td>790</td>
<td>2522</td>
<td>858</td>
<td>2561</td>
<td>852</td>
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<tr>
<td>405</td>
<td>2915</td>
<td>586</td>
<td>2865</td>
<td>583</td>
<td>2596</td>
<td>597</td>
<td>Coated</td>
<td>2725</td>
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<tr>
<td>H-1</td>
<td>3115</td>
<td>462</td>
<td>2557</td>
<td>499</td>
<td>2550</td>
<td>473</td>
<td>Potted</td>
<td>2741</td>
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<tr>
<td>H-2</td>
<td>3007</td>
<td>518</td>
<td>2825</td>
<td>532</td>
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<td>2981</td>
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<tr>
<td>H-3</td>
<td>2731</td>
<td>578</td>
<td>2899</td>
<td>613</td>
<td>2758</td>
<td>570</td>
<td>Coated</td>
<td>2795</td>
</tr>
<tr>
<td>A31108</td>
<td>3372</td>
<td>587</td>
<td>3169</td>
<td>634</td>
<td>3125</td>
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<td>586</td>
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<td>605</td>
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<td>3020</td>
<td>572</td>
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<td>A24394</td>
<td>2998</td>
<td>593</td>
<td>3142</td>
<td>579</td>
<td>3057</td>
<td>772</td>
<td>Autopsies</td>
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### Table 1b - TR-317( ) Autotransformers from GE (made by Chloride).

<table>
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<tr>
<th>Ser #</th>
<th>CIV (Hz)</th>
<th>Relative Freq</th>
<th>CIV (Hz)</th>
<th>Type</th>
<th>CIV (Hz)</th>
<th>Type</th>
<th>Std Mean</th>
<th>Std Dev</th>
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<td>3152</td>
<td>509</td>
<td>3199</td>
<td>596</td>
<td>3267</td>
<td>597</td>
<td>Coated</td>
<td>3206</td>
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<tr>
<td>2</td>
<td>3428</td>
<td>501</td>
<td>3137</td>
<td>617</td>
<td>3203</td>
<td>616</td>
<td>with corona</td>
<td>3256</td>
</tr>
<tr>
<td>3</td>
<td>3055</td>
<td>515</td>
<td>3200</td>
<td>609</td>
<td>3175</td>
<td>608</td>
<td>suppressant</td>
<td>3144</td>
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<tr>
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<td>3108</td>
<td>620</td>
<td>3013</td>
<td>621</td>
<td>3135</td>
<td>618</td>
<td>*</td>
<td>3085</td>
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* Hi Temp 221, Hi Temp Resins Inc.

### Table 1c - TR-317R Sample Buy Autotransformers from Harder Inc.

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<th>Ser #</th>
<th>CIV (Hz)</th>
<th>Relative Freq</th>
<th>CIV (Hz)</th>
<th>Type</th>
<th>CIV (Hz)</th>
<th>Type</th>
<th>Std Mean</th>
<th>Std Dev</th>
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<td>589</td>
<td>with</td>
<td>2509</td>
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<td>054</td>
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<td>571</td>
<td>3100</td>
<td>588</td>
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<td>599</td>
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<td>3049</td>
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<td>2703</td>
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<td>dwg pkg</td>
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Table 2 provides corona inception data for several TR-330A transformers. The test circuit shown in Fig. 1 was used to take the data with the following modifications: Capacitor CA was changed to 3000 pF and the power amplifier was a McIntosh Model 2500. The frequencies shown in Table 2 are, in this case, the actual resonance frequencies.

Table 2 - TR-330A Autotransformer Corona Test Data.

<table>
<thead>
<tr>
<th>Ser #</th>
<th>CIV (Hz)</th>
<th>CIV (Hz)</th>
<th>CIV (Hz)</th>
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<th>Mean</th>
<th>Std Dev</th>
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- MPP 1 = Unpotted toroid 55251-W4 core.
- MPP 2 = Potted toroid 55251-W4 core.
- MPP 3 = Unpotted toroid 55248-A2 core.
- MPP 4 = Potted toroid 55248-A2 core.

Potting compound = Eccobond 45 black with 19M catalyst. Autotransformer was vacuum potted.

CONCLUSIONS

The data from both the TR-330A, TR-317( ), TR-317R, and the TR-317 autotransformer samples indicate that the TR-330A representatives have a smaller standard deviation than representatives from the TR-317 group. In particular, serial #H-1 of the TR-317 group, with a standard deviation of 324 V, presents an interesting problem. Operator error is the most probable cause of the first excessively high CIV reading for serial #H-1, as the last two readings are much closer to each other (within 7 V). Standard deviations were below 6% of the mean CIV recorded. For this type of measurement, the standard deviations are acceptable. An AM receiver was added to the rest of the ancillary equipment to gather the TR-330A data where the standard deviations were less than 2% of the mean CIV. The AM receiver has the advantage of providing the operator with an audio reference which compliments the visual reference.
SUMMARY

An autotransformer corona test circuit has been developed and tested, ancillary equipment for the test has been identified and recommended, test procedures and precautions have been presented, and measured corona data are presented for autotransformers of different manufacture and type. As a result, recommendations have been made to NAVSEA to incorporate the test into appropriate drawing packages.

ACKNOWLEDGMENTS

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REFERENCES


Appendix

LADDER COMPUTER PROGRAM FOR EMI FILTER

Figure A1 contains the circuit identifiers used to operate the computer program which follows. This program was used successfully on a Hewlett Packard 9000, model 200 computer using HP BASIC 5.0. Lines 80-120 in the program describe the initial procedure of loading the program.

Fig. A1 - Circuit identifiers.
10 ! LADDER PROGRAM VERSION 1.0, OCTOBER 1988
20 ! AUTHOR: HOMER DING
30 ! NAVAL OCEAN SYSTEMS CENTER
40 ! CODE 711, BLDG 132
50 ! SAN DIEGO, CA. 92152
60 ! (619) 553-1443
70
80 ! THIS PROGRAM WAS WRITTEN IN HP BASIC 4.0.
90 ! A COMPLEX EXTENSION FROM STRUCTURED SOFTWARE SYSTEMS
100 ! WAS ALSO USED.
110 ! THIS PROGRAM SHOULD WORK WITH HP BASIC 5.0 IF THE GET STATEMENT
120 ! IS USED TO PLACE THE ASCII FILE IN THE COMPUTER.
130 !
140 ! THIS PROGRAM WILL COMPUTE THE OUTPUT/INPUT VOLTAGE TRANSFER FUNCTION
150 ! OF A LADDER NETWORK.
160 ! Nb - TOTAL NUMBER OF BRANCHES
170 ! THE FIRST LETTER OF A BRANCH TYPE IS S, P, OR T
180 ! S - SERIES BRANCH
190 ! P - PARALLEL BRANCH
200 ! T - IDEAL TRANSFORMER
210 ! IF T THEN THERE ARE NO OTHER LETTERS WHICH DESCRIBES THE BRANCH TYPE
220 ! Z - SERIES COMBINATION OF BRANCH COMPONENTS
230 ! Y - PARALLEL COMBINATION OF BRANCH COMPONENTS
240 ! C, L, AND R - TYPE OF BRANCH COMPONENTS
250 !
260 COM /Menu/ Menu$(20)[80],Ch$(20)[6],Mark0$(1),Mark1$(1),INTEGER N
270 ent,Nchr,Xtab,Ytab,Ch(20)
280 COM /N/ @Path1,Netfile$(20),Cmnt$(2)[80],Br$(20)[6],INTEGER Nb,REAL
290 AL R(20),L(20),C(20),Clks$(80)
300 COM /C/ REAL F,W,F1,F2,Fs,Swpsegs(6,4),INTEGER Nseg,Ns,Tns,Logflg
310 ,Logflags(6),COMPLEX Eb(20),Ib(20),Imb(20),Yb(20),Anet(2,2)
320 COM /LJ/ Lf$(1),Cr$(1),Fs$(3),Esc$(1),Portraits$(6),Landscapes$(6)
330 ,Font$(4)[80],INTEGER Ps,C,Page,Pages,Fontnum
340 INTEGER Chose,M,K1,K2,I
350 REAL X,Y,G,B,Z,Mag,Ang
360 DIM S$(80),K$(2)
370 LOCAL 7
380 LFS=CHR$(10)
390 CR$=CHR$(13)
400 Esc$=CHR$(27)
410 FFS=Esc$&CHR$(7)&CHR$(12)
420 Portraits=Esc$"$100"
430 Portraits=Esc$&"110"
440 Font$(1)=Portraits&Esc$"(10U"&Esc$&"(s0p10.00h12.00v0s08"&Esc$&
450 &16D"
460 Font$(2)=Landscape$&Esc$"(10U"&Esc$"(s0p10.00h12.00v0s08"&Esc$&
470 "&16D"
480 Font$(3)=Portraits&Esc$"(10U"&Esc$"(s0p16.66h8.50v0s-3B"&Esc$&
490 &15.6667C"
500 Font$(4)=Landscape$&Esc$"(10U"&Esc$"(s0p16.66h8.50v0s-3B"&Esc$&
510 &15.6667C"
520 REPEAT
CALL Menu(1)
CALL Cls
SELECT Ch$(1)
CASE "G"
    CALL Getnfile
CASE "E"
    CALL Entnet
CASE "S"
    CALL Recnfile
CASE "P"
    CALL Entint("PRINTER SELECT CODE(1=CRT, 2=THINKJET, 9=LASER JET)",Psc)
    Clk$(1,80]=FNClock$
CALL Prtnet
CASE "F"
    CALL Entswpseg
CASE "R"
    CALL Entint("PRINTER SELECT CODE(1=CRT, 2=THINKJET, 9=LASER JET)",Psc)
    Clk$(1,80]=FNClock$
CALL Prtrat
CASE "I"
    CALL Entint("PRINTER SELECT CODE(1=CRT, 2=THINKJET, 9=LASER JET)",Psc)
    Clk$(1,80]=FNClock$
CASE "A"
    CALL Entlev
CASE "P"
    CALL Entint("PRINTER SELECT CODE(1=CRT, 2=THINKJET, 9=LASER JET)",Psc)
    Clk$(1,80]=FNClock$
CALL Prtnet
END SELECT
UNTIL Ch(1)=Nent
CALL Cls
STOP
END

SUB Beep(OPTIONAL INTEGER Nbeep,Freq,REAL Secon,Secof)
    INTEGER I,F,N
    REAL S1,S0
    N=1
    F=2700
    S1=.03
    S0=.04
    IF NPAR>0 THEN N=Nbeep
    IF NPAR>1 THEN F=Freq
    IF NPAR>2 THEN S1=Secon
    IF NPAR>3 THEN S0=Secof
    FOR I=1 TO N
        BEEP F,S1
        WAIT S0
    NEXT I
SUBEND | Beep
SUB Fkeys(OPTIONAL INTEGER Keyon) !0=OFF, 1=ON
   INTEGER K
   K=1
   IF NPAR=1 THEN K=Keyon
   CONTROL CRT,12;K
SUBEND Fkeys

SUB Curs(OPTIONAL INTEGER Col,Row,Poscur)
   INTEGER C,R,S
   C=1
   R=19
   S=1 ! CURS ON
   IF NPAR>0 THEN C=Col
   IF NPAR>1 THEN R=Row
   IF NPAR>2 THEN S=Poscur
   CONTROL CRT,0;C
   CONTROL CRT,1;R
   CONTROL CRT,10;S
SUBEND Curs

SUB CIs(OPTIONAL INTEGER Col,Row,Keyof)
   INTEGER C,R,K
   C=1
   R=19
   K=0
   IF NPAR>0 THEN C=Col
   IF NPAR>1 THEN R=Row
   IF NPAR>2 THEN K=Keyof
   OUTPUT CRT;CHR$(128);
   OUTPUT Keyboard;CHR$(255)&"K";
   CALL Fkeys(K)
   CALL Curs(C,R)
SUBEND CIs

DEF FNClock$ !
   RETURN UPC$(DATE$(TIMEDATE)&".
   FNEND FNClock$

SUB Continue
   INTEGER K1,K2
   DISP "TO CONTINUE HIT ANY KEY"
   CALL Kbscan(K1,K2)
   DISP
SUBEND Continue

DEF FNAtn2(X,Y,OPTIONAL INTEGER Posang) ! 4 QUADRANT ARC TANGENT
   INTEGER P
   DEG
   P=0
   IF NPAR=3 THEN P=Posang
   RETURN ARG(CMPLX(X,Y))+(P<>0)*360
FNEND FNAtn2

SUB Rec2pol(Xr,Xi,Mag,Ang,OPTIONAL INTEGER Posang)
INTEGER P
REAL M
DEG
P=0
IF NPAR=5 THEN P=Posang
M=ABS(CMPLX(Xr,Xi))
Ang=FNAsn2(Xr,Xi,P)
Mag=M
SUBEND ! Rec2pl!

SUB Pol2rec(Mag,Ang,Xr,Xi) !POLAR TO RECTANGULAR
REAL Txr
Txr=Mag*COS(Ang)
XI=Mag*SIN(Ang)
Xr=Txr
SUBEND ! Pol2rec

DEF FNdb(X)
RETURN 20*LGT(X)
FNEND ! FNdb

DEF FNAdb(X)
RETURN 10**(.05*X)
FNEND ! FNAdb

SUB Entstr(Prompt$,Str$)
DIM Temp$(80)
DISP Prompt$&" = ";
OUTPUT 2;Str$;
OUTPUT KBD;CHR$(255);"H";
LINPUT Temp$
IF Temp$<>"" THEN Str$=Temp$
PRINT Prompt$&" = ";Str$
SUBEND ! EntSTR

SUB Entint(Prompt$,INTEGER I,OPTIONAL INTEGER Noprt)
DIM Temp$(80)
INTEGER Prtflg
Prtflg=1
IF NPAR=3 THEN Prtflg=NOT Noprt
DISP Prompt$&" = ";
OUTPUT 2;VAL$(I);
OUTPUT KBD;CHR$(255);"H";
LINPUT Temp$
IF Temp$<>"" THEN I=VAL(Temp$)
IF Prtflg THEN PRINT Prompt$&" = ";I
SUBEND ! Entint

SUB Entreal(Prompt$,REAL U,OPTIONAL REAL Unitmult)
REAL U
DIM Temp$(80)
U=1
IF NPAR=3 THEN U=Unitmult
DISP Prompt$&" = ";
DIEBEL and TIMS

2030   OUTPUT 2:VAL$(V/U);
2040   OUTPUT KBD:CHR$(255);"H";
2050   LINPUT Temp$
2060   IF Temp$<"" THEN V=VAL(Temp$)*U
2070   PRINT Prompt$&" = \";U/U
2080   SUBEND ! Entreal
2090   !
2100   SUB PrtMenu(INTEGER Nmenu)
2110   COM /Menu/ Menu$(20),Ch$(20),Mark0$(1),Mark1$(1),INTEGER
R Nent,Nchr,Xtab,Ytab,Ch(20)
2120   PRINTER IS CRT
2130   SELECT Nmenu
2140   CASE 1
2150       RESTORE Menu1
2160   CASE 2
2170       RESTORE Menu2
2180   CASE 3
2190       RESTORE Menu3
2200   END SELECT ! Nmenu
2210   CALL Cis
2220   ALPHA OFF
2230   READ MenuS(0)
2240   READ Nent
2250   READ Nchr
2260   Mxlen=0
2270   FOR I=1 TO Nent
2280       READ Menu$(I)
2290       Mxlen=MAX(Mxlen,LEN(Menu$(I)))
2300   NEXT I
2310   Xtab=INT(.5*(80-Mxlen))+1
2320   Ytab=18-Nent
2330   PRINT TABXY(Xtab+Nchr+2,Ytab-1);Mark0$&Menu$(0)
2340   FOR I=1 TO Nent
2350       PRINT TABXY(Xtab,Ytab+I);Mark0$&Menu$(I)
2360   NEXT I
2370   SUBEXIT
2380   !
2390   Menu1: DATA "LADDER NETWORK PROGRAM",9,1
2400   DATA G GET DATA FROM DISK
2410   DATA E ENTER NETWORK
2420   DATA S SAVE DATA TO DISK
2430   DATA P PRINT NETWORK
2440   DATA F ENTER FREQUENCY SWEEP
2450   DATA A PRINT A MATRIX
2460   DATA R PRINT I/O RATIOS
2470   DATA I PRINT INTERNAL LEVELS
2480   DATA Q QUIT
2490   !
2500   Menu2: DATA MAIN PLOT MENU,9,1
2510   DATA I INITIALIZE FOR PLOTTING
2520   DATA T ENTER TYPE OF PLOT
2530   DATA N ENTER NAMES FOR PLOT AND AXES
2540   DATA S ENTER SCALES
2550   DATA L ENTER LEGEND

22
DATA A PLOT AXES
DATA 0 PLOT DATA
DATA + ADD TO FILE NUMBERS
DATA Q QUIT

SUBEND ! PrtMenU

! SUB Kbscan(INTEGER K1,K2,OPTIONAL K$)
DIM Ch$[2]  
K1=0
ON KBD GOSUB Kbintr
REPEAT
UNTIL K1<>0
OFF KBD
SUBEXIT

SUBEND ! Kbscan

SUB Menu(INTEGER Nmenu)
COM /Menu/ Menu$(20)[80],Ch$(20)[6],Mark0$[1],Mark1$[1],INTEGER Nent,Nchr,Xtab,Ytab,Ch(20)
INTEG
R K$I[2]
DIM K$[2]
Mark0$=CHR$(128)
Mark1$=CHR$(129)
CALL Prtmenu(Nmenu)
Chose=Ch(Nmenu)
Xtml=Xtab(Nmenu)
DISP "SELECT WITH ALPHA-NUMERIC OR UP-DOWN KEYS, THEN HIT RETU RN"
REPEAT
Scan: IF Chose<l THEN Chose=Nent
IF Chose>Nent THEN Chose=1
PRINT TABXY(Xtml,Ytab+Chose);Mark1$&" "&Menu$(Chose)&" ";
CALL Kbscan(K1,K2,K$)
PRINT TABXY(Xtml,Ytab+Chose);Mark0$&" "&Menu$(Chose)&" ";
IF K1<>255 THEN
GOSUB Search
ELSE
IF K2<>69 THEN Chose=Chose+(K2=86)-(K2=94)
END IF
UNTIL K1=255 AND K2=69
Ch(Nmenu)=Chose
Ch$(Nmenu)=Menu$(Chose)[1,Nchr]

23
3080 DISP
3090 SUBEXIT
3100 !
3110 Search: FOR I=1 TO Nent
3120 IF K$=Menu$(I)[1,1] THEN
3130 Chose=I
3140 I=Nent
3150 END IF
3160 NEXT I
3170 RETURN
3180 !
3190 SUSENO !
3200 !
3210 SUB Tboxon
3220 LJ$=*CALL 25CE,I*CHR$(13)
3230 OUTPUT 9;"QUIET ON"*CHR$(13);
3240 OUTPUT 9;LJ$;
3250 SUBEND ! Tboxon
3260 !
3270 SUB Tboxoff
3280 Quit$=CHR$(27)&CHR$(127)&"DONE"&CHR$(13)&CHR$(13)
3290 OUTPUT 9;Quit$;
3300 WAIT !
3310 OUTPUT 9;"QUIET OFF"*CHR$(13);
3320 SUBEND ! Tboxoff
3330 !
3340 SUB Preprint
3350 COM /Lj/ Lf$[1],Cr$[1],Ff$[3],Esc$[1],Portrait$[6],Landscape$[6],Font$(4)[80],INTEGER Psc,Page,Npages,Fontnum
3360 PRINTER IS Psc
3370 IF Psc=CRT THEN
3380 OUTPUT Psc;Esc$&CHR$(7)&"Q0;"; ! GO TO LASERJET SERIES II EMULATION
3390 WAIT 1.5
3400 OUTPUT Psc;Font$(Fontnum);
3410 OUTPUT Psc;Esc$&"&a10L"; ! SET LEFT MARGIN 10 SPAACES
3420 OUTPUT Psc;Esc$&"&s0C"; ! SET LINE WRAP
3430 END IF
3440 SUBEND ! Preprint
3450 !
3460 SUB Postprint
3470 COM /Lj/ Lf$[1],Cr$[1],Ff$[3],Esc$[1],Portrait$[6],Landscape$[6],Font$(4)[80],INTEGER Psc,Page,Npages,Fontnum
3480 IF Psc=CRT THEN
3490 CALL Continue
3500 ELSE
3510 OUTPUT Psc;Ff$;
3520 END IF
3530 CALL Beep(S)
3540 SUBEND ! Postprint
3550 !
3560 SUB Llist
3570 COM /Lj/ Lf$[1],Cr$[1],Ff$[3],Esc$[1],Portrait$[6],Landscape$[6],Font$(4)[80],INTEGER Psc,Page,Npages,Fontnum
CALL Entint("PRINTER SELECT CODE(1=CRT, 2=THINKJET, 9=LASERJET)", Psc)

3590 File$="LADDER"
3600 Page=0
3610 Npages=0
3620 Fontnum=3
3630 CALL Preprint
3640 CAT File$
3650 CALL Postprint
3660 CALL Continue
3670 CALL Preprint
3680 LIST #Psc
3690 CALL Postprint
3700 CALL Beep(5)
3710 SUBEND ! List
3720 !
3730 SUB Record(OPTIONAL INTEGER A)
3740 File$="LADDER"
3750 IF NPAR>0 THEN
3760 RE-SAVE File$&"",702,0"
3770 DISP """"&File$&"" PROGRAM RE-SAVED IN ASCII FORMAT";TAB(80)
3780 ELSE
3790 RE-STORE File$&"",1400"
3800 DISP """"&File$&"" PROGRAM RE-STORED IN INTERNAL FORMAT";TAB(80)
3810 END IF
3820 CALL Beep(5)
3830 SUBEND ! Record
3840 !
3850 DEF FNExist(Name$)
3860 INTEGER Existflg
3870 Existflg=1
3880 ON ERROR RECOVER Er
3890 ASSIGN @P TO Name$
3900 R: IF Existflg THEN ASSIGN @P TO *
3910 OFF ERROR
3920 RETURN Existflg
3930 !
3940 Er: Existflg=0
3950 GOTO R
3960 !
3970 FNEND ! FNExist
3980 !
3990 SUB Mknet
4000 COM /N/ @Path!,Netfile$[20],Cmnt$(2)[80],Br$(20)[6],INTEGER Nb,
4010 REAL R(20),L(20),C(20),Clk$(80)
4020 CREATE BOAT Netfile$$4
4030 SUBEND ! Mknet
4040 !
4050 SUB Getnfile
4060 COM /N/ @Path!,Netfile$[20],Cmnt$(2)[80],Br$(20)[6],INTEGER Nb,
4070 REAL R(20),L(20),C(20),Clk$(80)
4080 INTEGER F1g
4070  \textbf{REPEAT}
4080          \textbf{CALL } \texttt{Entstr("NETWORK FILE NAME",Netfile$)}
4090          \texttt{Flg=FNExist(Netfile$)}
4100          \textbf{IF Flg=0 THEN}
4110          \texttt{BEEP}
4120          \texttt{PRINT \"\"Netfile$\:" DOESN'T EXIST, TRY AGAIN\"\"
4130          \textbf{END IF}
4140          \texttt{UNTIL Flg}
4150          \texttt{ASSIGN @Path1 TO Netfile$}
4160          \texttt{ENTER @Path1;Cmnt$(*)NbBr(*)R(*)C(*)L(*)}
4170          \texttt{ASSIGN @Path1 TO *}
4180          \texttt{SUBEND ! Getnfile}
4190 |
4200          \texttt{SUB Recnfile}
4210          \texttt{COM /N/ @Path1,Netfile$[20],Cmnt$(2)[80],Br$(20)[6],INTEGER Nb}
4220          \texttt{,REAL R(20),L(20),C(20),Clk$(80]}
4230          \texttt{CALL Entstr("NETWORK FILE NAME",Netfile$)}
4240          \texttt{IF FNExist(Netfile$)<>0 THEN CALL Mknet}
4250          \texttt{ASSIGN @Path1 TO Netfile$}
4260          \texttt{OUTPUT @Path1;Cmnt$(*)NbBr$(*)R$(*)C$(*)L$(*)}
4270          \texttt{ASSIGN @Path1 TO *}
4280          \texttt{SUBEND ! Recnfile}
4290          |
4300          \texttt{SUB Entnet}
4310          \texttt{COM /N/ @Path1,Netfile$[20],Cmnt$(2)[80],Br$(20)[6],INTEGER Nb}
4320          \texttt{,REAL R(20),L(20),C(20),Clk$(80]}
4330          \texttt{INTEGER I}
4340          \texttt{DIM S$(40),T$(12]}
4350  \texttt{Format1: IMAGE \"BRANCH \",K,#}
4360          \texttt{CALL CIs}
4370          \texttt{CALL Entstr("REM 1",Cmnt$(1))}
4380          \texttt{CALL Entstr("REM 2",Cmnt$(2))}
4390          \texttt{CALL Entint("NUMBER OF BRANCHES",Nb)}
4400          \texttt{FOR I=1 TO Nb}
4410          \texttt{OUTPUT S$ USING Format1;I}
4420          \texttt{T$=Br$(I)}
4430          \texttt{CALL Entstr(S$&" TYPE",T$)}
4440          \texttt{Br$(I)=T$}
4450          \texttt{IF T$(I,1)="X" OR T$(I,1)="T" THEN CALL Entreal("TRANSFORMER TURNS RATIO (NS/NP)\",R(I))}
4460          \texttt{IF POS(T$,"R")<>0 THEN CALL Entreal(S$&" R (KOHM)\",R(I),1.E +3)}
4470          \texttt{IF POS(T$,"C")<>0 THEN CALL Entreal(S$&" C (nF)\",C(I),1.E-9)}
4480          \texttt{IF POS(T$,"L")<>0 THEN CALL Entreal(S$&" L (mH)\",L(I),1.E-3)}
4490          \texttt{NEXT I}
4500          \texttt{SUBEND ! Entnet}
4510          |
4520          \texttt{SUB Seg2f(INTEGER S)}
4530          \texttt{COM /C/ REAL F,W,F1,F2,Fs,Swpsegs(6,4),INTEGER Nseg,Ns,Tns,Log}
4540          \texttt{fig,Logflags(6),COMPLEX Eb(20),Ib(20),Imb(20),Yb(20),Anet(2,2)}
4550          \texttt{F1=Swpsegs(S,1)}
4560          \texttt{F2=Swpsegs(S,2)}

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4540   Fs=SWPseg5(S,3)
4550   Ns=SWpseg5(S,4)
4560   Logflg=Logflags(S)
4570   SUBEND  ! Seg2f
4580   !
4590   SUB F2seg(INTEGER S)
4600   COM /C/ REAL F,W,F1,F2,Fs,SWPseg5(6,4),INTEGER Nseg,Ns,Tns,Log
flg,Logflags(6),COMPLEX Eb(20),Ib(20),Imb(20),Yb(20),A net(2,2)
4610   SWPseg5(S,1)=F1
4620   SWPseg5(S,2)=F2
4630   SWPseg5(S,3)=Fs
4640   SWPseg5(S,4)=Ns
4650   Logflg(S)=Logflg
4660   SUBEND  ! F2seg
4670   !
4680   SUB Entswp($$)
4690   COM /C/ REAL F,W,F1,F2,Fs,SWPseg5(6,4),INTEGER Nseg,Ns,Tns,Log
flg,Logflags(6),COMPLEX Eb(20),Ib(20),Imb(20),Yb(20),A net(2,2)
4700   CALL Entint($$&"SWEEP TYPE (0-LINEAR, 1=LOG)"",Logflg)
4710   CALL Entreal($$&"FIRST FREQUENCY (Hz)"",F1)
4720   CALL Entreal($$&"LAST FREQUENCY (Hz)"",F2)
4730   SELECT Logflg
4740   CASE 0 ! LINEAR SWEEP
4750      CALL Entreal($$&"STEP FREQUENCY (Hz)"",Fs)
4760      IF Fs=0 THEN
4770         CALL Entint($$&"NUMBER OF STEPS"",Ns)
4780         Fs=(F2-F1)/(N-1)
4790      ELSE
4800         Ns=((F2-F1)/Fs)+1
4810      END IF
4820   CASE 1 ! LOG SWEEP
4830      CALL Entreal($$&"NUMBER OF STEPS"",Ns)
4840      Fs=(F2/F1)^(1/(N-1))
4850      END SELECT
4860   SUBEND  ! Entswp
4870   !
4880   SUB Compimb(INTEGER Bi)
4890   COM /N/ @Pathi,Netfile$(20),Cmnt$(2)(80),Br$(20)(6),INTEGER Nb
 ,REAL R(20),L(20),C(20),Cks$(80)
4900   COM /C/ REAL F,W,F1,F2,Fs,SWPseg5(6,4),INTEGER Nseg,Ns,Tns,Log
flg,Logflags(6),COMPLEX Eb(20),Ib(20),Imb(20),Yb(20),A net(2,2)
4910   INTEGER Ps,Pp,Py,Pz,P1,Pc
4920   REAL Xr,Xi
4930   Ps=POS(Br$(Bi),"S")
4940   Pp=POS(Br$(Bi),"P")
4950   Pz=POS(Br$(Bi),"Z")
4960   Py=POS(Br$(Bi),"Y")
4970   Pr=POS(Br$(Bi),"R")
4980   P1=POS(Br$(Bi),"L")
4990   Pc=POS(Br$(Bi),"C")
5000   Xr=0
5010   Xi=0
5020   W=(PI+PI)*F
5030   IF Pz<>0 THEN
5040 IF \( P < 0 \) THEN \( X_r = R(B_i) \)
5050 IF \( P > 0 \) THEN \( X_i = X_i + W \cdot L(B_i) \)
5060 IF \( P < 0 \) THEN \( X_i = X_i - 1/(W \cdot C(B_i)) \)
5070 END IF
5080 IF \( Y > 0 \) THEN
5090 IF \( P > 0 \) THEN \( X_r = X_r - R(B_i) \)
5100 IF \( P < 0 \) THEN \( X_i = X_i - 1/(W \cdot L(B_i)) \)
5110 IF \( P < 0 \) THEN \( X_i = X_i + W \cdot C(B_i) \)
5120 END IF
5130 \( \text{Im}(B_i) = \text{CMPLX}(X_r, X_i) \)
5140 IF \( (P > 0 \text{ AND } Y > 0) \) OR \( (P < 0 \text{ AND } Z > 0) \) THEN \( \text{Im}(B_i) = 1/\text{Im}(B_i) \)
5150 SUBEND \( ! \text{CompimbEDIT4530} \)
5160 !
5170 SUB Cascade
5180 COM /N/ @Path1, Netfile$[20], Cmmt$[20], Br$,\{20\}[6], INTEGER Nb, REAL R[20], L[20], C[20], Clk$[80]
5190 COM /C/ REAL F, W, F1, F2, SwpsegS(6, 4), INTEGER Nseg, Ns, Trns, Log, Logflags(6), COMPLEX Eb[20], Ib[20], Imb[20], Yb[20], Anet[2, 2]
5200 INTEGER I
5210 Anet(1, 1) = CMPLX(1, 0)
5220 Anet(1, 2) = CMPLX(0, 0)
5230 Anet(2, 1) = Anet(1, 2)
5240 Anet(2, 2) = Anet(1, 1)
5250 FOR I = Nb TO 1 STEP -1
5260 CALL Compimb(I)
5270 SELECT Br$(I)[1]
5280 CASE "V"
5290 Anet(1, 1) = Anet(1, 1)/R(I)
5300 Anet(1, 2) = Anet(1, 2)/R(I)
5310 Anet(2, 1) = Anet(2, 1)*R(I)
5320 Anet(2, 2) = Anet(2, 2)*R(I)
5330 CASE "S"
5340 Anet(1, 1) = Anet(1, 1) + Imb(I)*Anet(2, 1)
5350 Anet(1, 2) = Anet(1, 2) + Imb(I)*Anet(2, 2)
5360 CASE "P"
5370 Anet(2, 1) = Anet(2, 1) + Imb(I)*Anet(1, 1)
5380 Anet(2, 2) = Anet(2, 2) + Imb(I)*Anet(1, 2)
5390 END SELECT
5400 NEXT I
5410 SUBEND \( ! \text{Cascade} \)
5420 !
5430 SUB Compeiy
5440 COM /N/ @Path1, Netfile$[20], Cmmt$[20], Br$,\{20\}[6], INTEGER Nb, REAL R[20], L[20], C[20], Clk$[80]
5450 COM /C/ REAL F, W, F1, F2, SwpsegS(6, 4), INTEGER Nseg, Ns, Trns, Log, Logflags(6), COMPLEX Eb[20], Ib[20], Imb[20], Yb[20], Anet[2, 2]
5460 INTEGER I, Im1
5470 Yb(Nb) = CMPLX(0, 0)
5480 Ib(Nb) = Yb(Nb)
5490 Eb(Nb) = CMPLX(1, 0)
5500 FOR I = Nb TO 1 STEP -1
5510 Im1 = I - 1
5520 CALL Compimb(I)
5530 SELECT Br$(I)(1,1)
5540 CASE "T","X"
5550   Eb(Im1)=Eb(I)/R(I)
5560   Ib(Im1)=Ib(I)*R(I)
5570 CASE "S"
5580   Eb(Im1)=Eb(I)+Ib(I)*Imb(I)
5590   Ib(Im1)=Ib(I)
5600 CASE "P"
5610   Eb(Im1)=Eb(I)
5620   Ib(Im1)=Eb(I)*Imb(I)+Ib(I)
5630 END SELECT
5640 NEXT I
5650 SUBEND ! Compeiy
5660 !
5670 SUB Pnth
5680   COM /N/ @Pathi,Netfile$(20),Cmnt$(2)[80],Br$(20)[6],INTEGER Nb
5690 ,REAL R(20),L(20),C(20),Clk$(80)
5690 COM /Lj/ Lf$(1),Cr$(1),Ff$(3),Esc$(1),Portrait$(6),Landscape$(6),Font$(4)[80],INTEGER Psc,Page,Npages,Fontnum
5700 IF Page>0 THEN
5710   IF Npages=0 THEN
5720     PRINT Clk$(1,51+10*(F>2))&"PAGE "&VAL$(Page)
5730   ELSE
5740     PRINT Clk$(1,55+10*(F>2))&"PAGE "&VAL$(Page)& OF "&VAL$(Npages)
5750   END IF
5760 END IF
5770 IF NOT (Cmnt$(1)[1,1]=" " OR LEN(Cmnt$(1))=0) THEN PRINT Cmnt$(1)
5780 IF NOT (Cmnt$(2)[1,1]=" " OR LEN(Cmnt$(2))=0) THEN PRINT Cmnt$(2)
5790 PRINT
5800 SUBEND ! Pnth
5810 !
5820 SUB Prtnet
5830   COM /N/ @Pathi,Netfile$(20),Cmnt$(2)[80],Br$(20)[6],INTEGER Nb
5840 ,REAL R(20),L(20),C(20),Clk$(80)
5840 COM /Lj/ Lf$(1),Cr$(1),Ff$(3),Esc$(1),Portrait$(6),Landscape$(6),Font$(4)[80],INTEGER Psc,Page,Npages,Fontnum
5850 INTEGER I
5860 Fmt1: IMAGE "BR TYPE R (KOHM) L (mH) C"
5870  (nF) TURNS RATIO(S/P)"
5870 Fmt2: IMAGE DD,3X,AAAAAA,#
5880 Fmt3: IMAGE 6X,DDDDDD.DDDDD,#
5890 Fmt4: IMAGE " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " 
CALL Prth
IF Psc<>CRT THEN OUTPUT CRT USING Fmt7;Page,Npages
PRINT USING Fmt1
FOR I=1 TO Nb
PRINT USING Fmt2;I,Br$(I)
IF POS(Br$(I),"R")<>0 THEN
PRINT USING Fmt3;R(I)*1.E-3
ELSE
PRINT USING Fmt4
END IF
IF POS(Br$(I),"L")<>0 THEN
PRINT USING Fmt3;L(I)*1.E+3
ELSE
PRINT USING Fmt4
END IF
IF POS(Br$(I),"C")<>0 THEN
PRINT USING Fmt3;C(I)*1.E+9
ELSE
PRINT USING Fmt4
END IF
IF POS(Br$(I),"T")>0 OR POS(Br$(I),"X")>0 THEN
PRINT USING Fmt5;R(I)
ELSE
PRINT USING Fmt6
END IF
PRINT
NEXT I
CALL Postprint
SUBEND Prtnet
SUB Prtnet
CON /N/ @Pathl,Netfile$(20),Cmnt$(2)(80),Br$(20)E61.INTEGER Nb
,REAL R(20),L(20),C(20),Clk$[80]
CON /C/ REAL F,W,F1,F2,Fs,Swpsegs(6,4),INTEGER Nseg,Ns,Tns,Log
flag,Logflags(6),COMPLEX Eb(20),Ib(20),Imb(20),Yb(20),Anet(2,2)
CON /Lj/ Ff$(11),Cr$[11],Ff$[3],Esc$[1],Portraits[61],Landscape$s
(61),Font$(4)[80],INTEGER Psc,Page,Npages,Fontnum
INTEGER I,K,S,Md,Im1
REAL Zm, Za, Rm, Ra, Np
COMPLEX T
!! Addition by Mitch Boiling to store data for plotting by PLOTTER
!! program - Dec 1988.
INTEGER Nbyte5,Numrec
REAL Npts
Fmt1: IMAGE " # FREQ(Hz) EOUT/EIN(dB) EOUT/EIN(DEG) ZINMAG(K
OM) ZINANG(DEG)"
Fmt2: IMAGE DDD.S(2X,DDDDDDDD.DDD)
Fmt3: IMAGE "PRINTING PAGE ",K," OF ",K
!! *** plot patch ***
Askplot: INPUT "Do you wish to create a PLOTTER file? (Y/N) ",Plots$
IF (Plot$="Y" OR Plot$="y") THEN
  Pflag=1
ELSE
  IF Plot$<"N" AND Plot$<"n" THEN Askplot
END IF

IF Psc=9 THEN
  Fontnum=3
ELSE
  Fontnum=0
END IF
CALL Preprint
Page=1
Np=Tns/(10+35*(Psc=2)+55*(Psc=9))
IF Np<1 THEN Np=1
Npages=INT(Np)
IF Np MOD Npages<>0 THEN Npages=Npages+1
K=1
*** plot patch ***

IF Pflag THEN
  Npts=0
  FOR I=1 TO Nseg
    CALL Seg2f(I)
    Npts=Npts+Ns
  NEXT I
  Nbytes=INT((Npts*2+8)/256)+1)*256
  ASSIGN @Buffer TO BUFFER[Nbytes];FORMAT OFF
  Num_rec=INT(((2*Npts+1)*8)/820)
  INPUT "Enter the file name for the Plot: ",Pfile$
  CREATE BOAT Pfile$,Num_rec,8200
  ASSIGN @Path_1 TO Pfile$
  OUTPUT @Path_1;INpts
  TRANSFER @Buffer TO @Path_1;COUNT (Npts*2*8),CONT
END IF

FOR S=1 TO Nseg
  CALL Seg2f(S)
  F=F1
  FOR I=1 TO Ns
    Im1=I-1
    Md=K MOD (10+40*(Psc=2)+55*(Psc=9))
    IF Md=1 THEN
      CALL Prth
      IF Psc<>CRT THEN OUTPUT CRT USING Fmt3;Page,Npages
      PRINT USING Fmt1
      Page=Page+1
    END IF
    CALL Compa
  NEXT I
END IF

T=Eb(0)/Ib(0)
Rec2pol(REAL(T),IMAG(T),Zm,Za)
T=Eb(Nb)/Eb(0)
Rec2pol(REAL(T), IMAG(T), Rm, Ra)
PRINT USING Fmt2;K,F,FN~b(Rm),Ra,.E3Zm,Za

*** plotter patch ***
IF Pflag THEN
    OUTPUT @BufferiF,FN~b(Rm)
END IF

***************

IF Logflg THEN
    F=F*Fs
ELSE
    F=F+Fs
END IF

IF K MOD 5=0 THEN
    PRINT
    WAIT .5
END IF

IF Md=0 THEN
    IF Psc=CRT THEN
        CALL Continue
    ELSE
        OUTPUT Psc;Fs;
        WAIT 1
    END IF
    END IF

K=K+1
NEXT I
NEXT S

*** plotter patch ***
CONTROL @Buffer, 9; 0
WAIT FOR EOT @Path_!
ASSIGN @Path_ I TO *
ASSIGN @Buffer TO *

***************

CALL Postprint
SUBEND ! Prtmat

SUB Prtmat
COM /N/ @Pathi,Netfile$[20],Cmnt$(2)[80],Br$(20)[6],INTEGER Nb,
REAL R(20),L(20),C(20),Clk$[80]
COM /C/ REAL F,W,F1,F2,Fs,Supsegs(6,4),INTEGER Nseg,Ns,Trns,Log
flg,Logflags(6),COMPLEX Eb(20),Ib(20),Imp(20),Yb(20),Anet(2,2)
COM /L/ Lf$[1],Cr$[1],Fs$[3],Esc$[1],Portrait$[6],Landscape$s
[6],Font$[4][80],INTEGER Psc,Page,Npages,Fontnum
DIM S$[80]
INTEGER I,Indx,S,Md,Iml,J,K
REAL Xm,Xa,Xr,Xi,Np
COMPLEX T
Fnt1: IMAGE "F(Hz) = " ,2X,DDDDDD.DD," MAG ANG(DEG)
REAL IMAGE MAG"
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7040  Fmt3:  IMAGE "PRINTING PAGE ",K," OF ",K
7050  IF  Psc=9 THEN
7060      Fontnum=3
7070  ELSE
7080      Fontnum=0
7090  END IF
7100  CALL Preprint
7110  Page=1
7120  Np=Ns/((3+8*(Psc=2)+12*(Psc=9))
7130  Npages=INT(Np)
7140  IF  Np MOD Npages<>0 THEN Npages=Npages+1
7150  Indx=1
7160  FOR  S=1 TO Nseg
7170      Seg2f(S)
7180      F=F1
7190      FOR  I=1 TO Ns
7200          Md=Indx MOD (3+8*(Psc=2)+12*(Psc=9))
7210          IF  Md=1 THEN
7220              CALL Prth
7230              IF  Psc<>CRT THEN OUTPUT CRT USING Fmt3;Page,Npages
7240              Page=Page+1
7250          END IF
7260          CALL Cascade
7270          PRINT USING Fmt1;F
7280      FOR  J=1 TO 2
7290          FOR  K=1 TO 2
7300              Xr=REAL(Anet(J,K))
7310              Xi=IMAG(Anet(J,K))
7320              Rec2pol(Xr,Xi,Xm,Xa)
7330              PRINT USING Fmt2;J,K,Xm,Xa,Xr,Xi
7340          NEXT K
7350      NEXT J
7360      IF  Logflg THEN
7370          F=F*F5
7380  ELSE
7390      END IF
7400  END IF
7410  IF  Md=0 THEN
7420      IF  Psc=CRT THEN
7430          CALL Continue
7440      PRINT
7450      ELSE
7460          OUTPUT Psc:FF$;
7470      END IF
7480  END IF
7490  Indx=Indx+1
7500  NEXT I
7510  NEXT S
7520  CALL Postprint
7530  SUBEND ! Prtanel
7540  !
7550  SUB Ptrlve
7555  CON /N/ @Path1.Netfile$[20],Cmnt$(2)(80),Br$(20)(5),INTEGER Nb
    ,REAL R(20),L(20),C(20),Clk$(80)
DIEBEL and TIMS

7570 COM /C/ REAL F,W,F1,F2,Fs,Swpsegs(6,4).INTEGER Nseg,Ns,Tns,Log
flg,Logflags(6),COMPLEX Eb(20),Ib(20),Imb(20),Yb(20),Anet(2,2)
7580 COM /Lj/ Lfs$[1],Cr$[1],Fs$[3],Esc$[1],Portrait$[6],Landscape$[6],Font$[4][80],INTEGER Psc,Page,Npages,Fontnum
7590 INTEGER Indx,I,J,S,Md,Iml,Lpi,ipp
7600 REAL Em,Ea,Im,Ia,Zm,Za,Np
7610 COMPLEX T

7620 Fmt1: IMAGE "FREQ (Hz) = ",K
7630 Fmt2: IMAGE ": BRANCH EMAG(V) EANG(0EG) IMAG(mA) IANG(DEG)
\( ) IMAG(KOHM) ZANG(DEG)
7640 Fmt3: IMAGE DD,2X,AAAAAAAA,2X,DDDDDDDDD,2X,DDDDDDDDD,2X,DDDDDDDDD,2X
7650 Fmt4: IMAGE DD,2X,AAAAAAAA,2X,DDDDDDDDD,2X,DDDDDDDDD,2X
7660 Fmt5: IMAGE "PRINTING PAGE ",K," OF ",K
7670 IF Psc=9 THEN
7680 Fontnum=3
7690 ELSE
7700 Fontnum=0
7710 END IF
7720 CALL Preprint
7730 PAGE=1
7740 Lpi=Nb+4
7750 Ipp=INT((14+42*(Psc=2)+64*(Psc=9))/Lpi)
7760 Np=Nns/Ipp
7770 Npages=INT(Np)
7780 IF Np MOD Npages<>0 THEN Npages=Npages+1
7790 Indx=1
7800 FOR S=1 TO Nseg
7810 CALL Seg2f(S)
7820 F=F1
7860 FOR I=1 TO Ns
7860 Md=(Indx MOD Ipp)+(Ipp-1)
7870 IF Md=1 THEN
7880 CALL Prth
7890 IF Psc<>CRT THEN OUTPUT CRT USING Fmt5;Page,Npages
7890 Page=Page+1
7900 END IF
7910 CALL Compeiy
7920 PRINT USING Fmt1;F
7920 PRINT USING Fmt2
7930 FOR J=0 TO Nb
7940 Rec2pol(REAL(Eb(J)),IMAG(Eb(J)),Em,Ea)
7950 Rec2pol(REAL(Ib(J)),IMAG(Ib(J)),Im,Ia)
7960 IF Ib(J)<CMPLX(0,0) THEN
7970 T=Eb(J)/Ib(J)
7980 Rec2pol(REAL(T),IMAG(T),Zm,Za)
7990 PRINT USING Fmt3;J,Br$(J),Em,Ea,1.E+3*Im,Ia,1.E-3*
8000 ELSE
8010 PRINT USING Fmt4;J,Br$(J),Em,Ea,1.E+3*Im,Ia
8020 END IF
8030 NEXT J
8040 IF Logflg THEN
F=F*Fs
ELSE
F=F+Fs
END IF
IF Ipp=1 THEN Md=0
IF Md=0 THEN
IF Psc=CRT THEN
CALL Continue
ELSE
OUTPUT Psc;Ff$;
END IF
ELSE
PRINT
END IF
Indx=Indx+1
NEXT I
NEXT S
SUBEND ! Prtlerv
SUB Entswpsegs
COM /C/ REAL F,W,F1,F2,Fs,Swpsegs(6,4),INTEGER Nseg,Ns,Tns,Log
flg,Logflags(6),COMPLEX Eb(20),Ib(20),Imb(20),Yb(20),Anet(2,2)
INTEGER S
DIM S$(80)
Fmt1: IMAGE "SEGMENT",D,X,#
Tns=0
CALL Entint("NUMBER OF SWEEP SEGMENTS",Nseg)
FOR S=1 TO Nseg
CALL Seg2f(S)
OUTPUT S$ USING Fmt1;$
CALL Entswp(S$)
Tns=Tns+Ns
CALL F2seg(S)
NEXT S
SUBEND ! Entswpsegs