A COMPUTER PROGRAM FOR SIMULATION
OF TAPERED DISPERSIONLESS LOSSY
TRANSMISSION LINES

by
S. R. P. Teixeira and R. A. Rohrer

Memorandum No. ERL-M265
10 October 1969

ELECTRONICS RESEARCH LABORATORY
College of Engineering
University of California, Berkeley
94720
The FORTRAN IV subroutine LINE listed in the last section of this report computes the approximate response of a doubly loaded loss transmission line. The approximations employed are those which arise from representing the tapered line as a finite cascade of uniform lines and representing time only at equally spaced discrete points. Neither of these approximations need incur serious error since the user may trade granularity for computation time by increasing appropriate dimensions in the subroutine.

where:

$x_1$ is an integer constant or variable specifying the number of sections (it cannot be greater than 20 in value unless the subroutine is modified).

$x_2$ is a real constant or variable specifying the time step size for calculation. (As indicated above, this quantity must be smaller than the propagation time in any section ($x_9$), otherwise an error message, 'TIME STEP TOO LARGE', will be printed and execution stopped. For good precision $x_2$ should be as small as possible.)

$x_3$ is an integer constant or variable specifying the number of time steps ($x_2$) necessary to cover the total time interval of the solution (it cannot be greater than 30 unless the subroutine is modified; an $x_3$ greater than 30 causes the printing of an error message, 'TIME INTERVAL TOO LARGE' and stops execution).

$x_4$ is a real vector such that its $i$th element gives the value of the

Research sponsored by the Air Force Office of Scientific Research under Grant AF-AFOSR-1219-67 and the National Science Foundation under Grant GK-716.
voltage \( e_0(t) \) for \( t = (i - 1)x_2 \).

\( x_5 \) is identical to \( x_4 \), but for \( e_\lambda(t) \).

\( x_6 \) is a real constant or variable specifying the load resistance at the beginning of the line.

\( x_7 \) is a real constant or variable specifying the load resistance at the end of the line.

\( x_8 \) is a real vector such that its \( i \)th element is equal to \( \sqrt{R_1 G_1} \cdot \xi_i \), where \( R_1 \) is the series resistance and \( G_1 \) is the shunt conductance per unit length, respectively, and \( \xi_i \) is the length of the \( i \)th line section.

\( x_9 \) is a real vector such that its \( i \)th element is equal to \( \sqrt{L_1 C_1} \cdot \xi_i \), where \( L_1 \) is the series inductance and \( C_1 \) is the shunt capacitance per unit length, respectively, and \( \xi_i \) is the length of the \( i \)th line section.

\( x_{10} \) is a real vector such that its \( i \)th element is \( \sqrt{L_1/C_1} \), the characteristic impedance of the \( i \)th section.

For consistency with the subroutine LINE as it stands, in the calling program, \( x_4 \) and \( x_5 \) must have dimensions 31 and \( x_8 \), \( x_9 \), and \( x_{10} \) must have dimensions 20.

The output of the subroutine LINE is the matrix \( x \), where \( x \) is any real identifier, and the calling program must have the statement

\[ \text{COMMON/SLINE/x(2, 21, 31)}. \]

\( x(i, j, k) \) indicates a voltage if \( i = 1 \) or a current if \( i = 2 \) at the boundary point \( j \) (there are \( x_1 + 1 \) of these points) at time \( t = (k - 1) \cdot x_2 \).

If a number of sections \( x_1 \) or a number of time steps \( x_3 \) greater than the limits already stated are to be used, the 4th, 5th, and 6th cards
and the statement number 1 of the subroutine LINE must be modified by changing all 20's to the dimension of \( x_1 \), all 21's to the dimension of \( x_1 + 1 \), all 30's to the dimension of \( x_3 \), and all 31's to the dimension of \( x_3 + 1 \). The same rules must, of course, be applied to the COMMON/SLINE/ statement and to the DIMENSIONS of the appropriate vectors in the calling program.
SUBROUTINE LINE LISTING

SUBROUTINE LINE(NSC, DEL, NI, VO, VL, RO, RL, A, V, Z)

C SUBROUTINE FOR ANALYSIS OF TRANSMISSION LINES MADE UP OF A
C FINITE NUMBER OF CONSTANT, DISPERSIONLESS LINE SECTIONS

DIMENSION VO(31), VL(31), A(20), V(20), Z(20), R(2, 20, 31), IT(20)

COMMON/SLINE/RF(2, 21, 31)

IF(NSC.LE.20)GO TO 1

PRINT 2
2 FORMAT(• NUMBER OF SECTIONS TOO LARGE•)
STOP

1 IF(NI.LE.30)GO TO 3
PRINT 4
4 FORMAT(• TIME INTERVAL TOO LARGE•)
STOP

3 DO 5 I=1, NSC
IF(DEL.GE.V(I))GO TO 6
5 CONTINUE
GO TO 7

6 PRINT 8
8 FORMAT(• TIME STEP TOO LARGE•)
STOP

7 NI1=NI+1
NSCM1=NSC-1
DO 9 I=1, NSC
9 IT(I)=V(I)/DEL

10 DO 11 I=1, NI1
11 X=0.
GO TO 15

12 X=0.
GO TO 14

13 X=R(2, I, I)

14 X=(R(2, I, I+1)-X)*(DEL*IT(I)+1)-V(I))/DEL+X

15 YR=(VO(I)+(RO/Z(I)-1.)*X)/(RO/Z(I)+1.)

16 RF(1, I, I)=YR+X
17 RF(2, I, I)=(YR-X)/Z(I)
18 R(I, I, I)=YR
19 IF(NSC.EQ.1)GO TO 16
20 DO 17 J=1, NSCM1
21 X=I-IT(J+1)-1
22 IF(I)18, 19, 20

18 X=0.
GO TO 22

19 X=0.
GO TO 21

20 X=R(2, J+1, I)

21 X=(R(2, J+1, I+1)-X)*(DEL*(IT(J)+1)-V(J+1))/DEL+X
22 II=I-IT(J)-1
23 IF(I)23, 24, 25
0048 23 Y=0.
0049 24 Y=0.
0050 25 Y=R(1,J,II+1)-Y*((IT(J)+I)*DEL-V(J))/DEL+Y
0051 26 E=EXP(-A(J))
0052 27 R(2,J,II)=(2.*Z(J)*X-MZ(J)+Z(J))*Y*E/E(Z(J+1)+Z(J))
0053 28 Y=0.
0054 29 Y=0.
0055 30 Y=R(1,NSC,II)
0056 31 Y=(R(1,NSC,II+1)-Y)*((IT(NSC)+1)*DEL-V(NSC))/DEL+Y
0057 32 E=EXP(-A(NSC))
0058 33 XR=(V(L(I)+(RL/Z(NSC)-1.)*E*Y)*E/(1.+RL/Z(NSC))
0059 34 R(2,NSC,II)=XR
0060 35 Y=Y*E
0061 36 XR=XR/E
0062 37 RF(1,NSC+1,II)=XR+Y
0063 38 RF(2,NSC+1,II)=(Y-XR)/Z(NSC)
0064 39 RETURN
0065 40 END