00297D

~~02259D~~

Program Description I

Program Title: LC-LNAP, LC LADDER NETWORK ANALYSIS PROGRAM.

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00297

Program Description, Equations, Variables

This program will provide the transfer function (20 log magnitude and phase) of a ladder network consisting of up to seven LC branches. Each branch may contain an inductor, a capacitor, a series LC network, or a parallel LC network. In addition, the network may have load resistors at each end. These features allow the analysis of singly or doubly loaded lossless LC filter networks.

The program will provide analysis over a sweep of frequencies. The sweep may be linear (additive delta) or logarithmic (multiplicative delta).

The input data may be reviewed for correctness, and changes made before the analysis and frequency sweep are done.

Operating Limits and Warnings

The number of branches cannot exceed seven because of register storage limitations. Shunt inductors, or series capacitors cannot equal zero.

If networks contain L-R-C networks , use the program "LNAP", (01585D) to do the analysis.

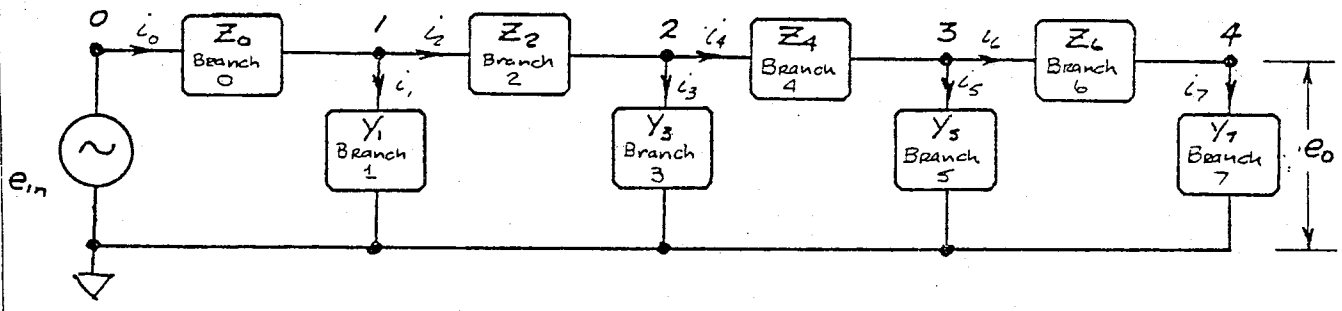
Program Description

The algorithm used by this program assumes 1 volt at the output of the ladder. Knowing the last branch admittance, the branch complex current may be determined. Since no current flows out of the last node, this shunt branch current must also flow through the preceeding series branch. Knowing the series branch impedance allows the complex branch voltage drop to be calculated using a complex multiplication (subroutine under label 1). A complex addition (label 2) of this series voltage drop to the last node voltage determines the next node voltage. The node voltage times the shunt admittance yields the shunt node current. Adding this shunt node current to the previously determined series node current provides the next series node current.

This loop is repeated until the input voltage source is reached (node 0). The complex voltage at node 0 represents the reciprical of the transfer function, i.e.,

$$e_o/e_{in} = 1/e_{in} = H(jw)$$

The algorithm may be expressed in mathematical shorthand using indicies.



1) $$i_{2k-2} = \{e_k\}\{Y_{2k-1}\} + i_{2k} \quad (i_{2n} \equiv 0)$$

2) $$e_{k-1} = \{i_{2k-2}\} \cdot \{Z_{2k-2}\} + e_k \quad (e_n \equiv 1)$$

where k n, n-1, ... , 1, 0
and n equals the highest node number.

Equation 1 is solved and substituted into equation 2 to obtain the next lower numbered node voltage, k is decremented by one, and equations 1, and 2 are again solved. This process is continued until the voltage at node 0 is obtained.

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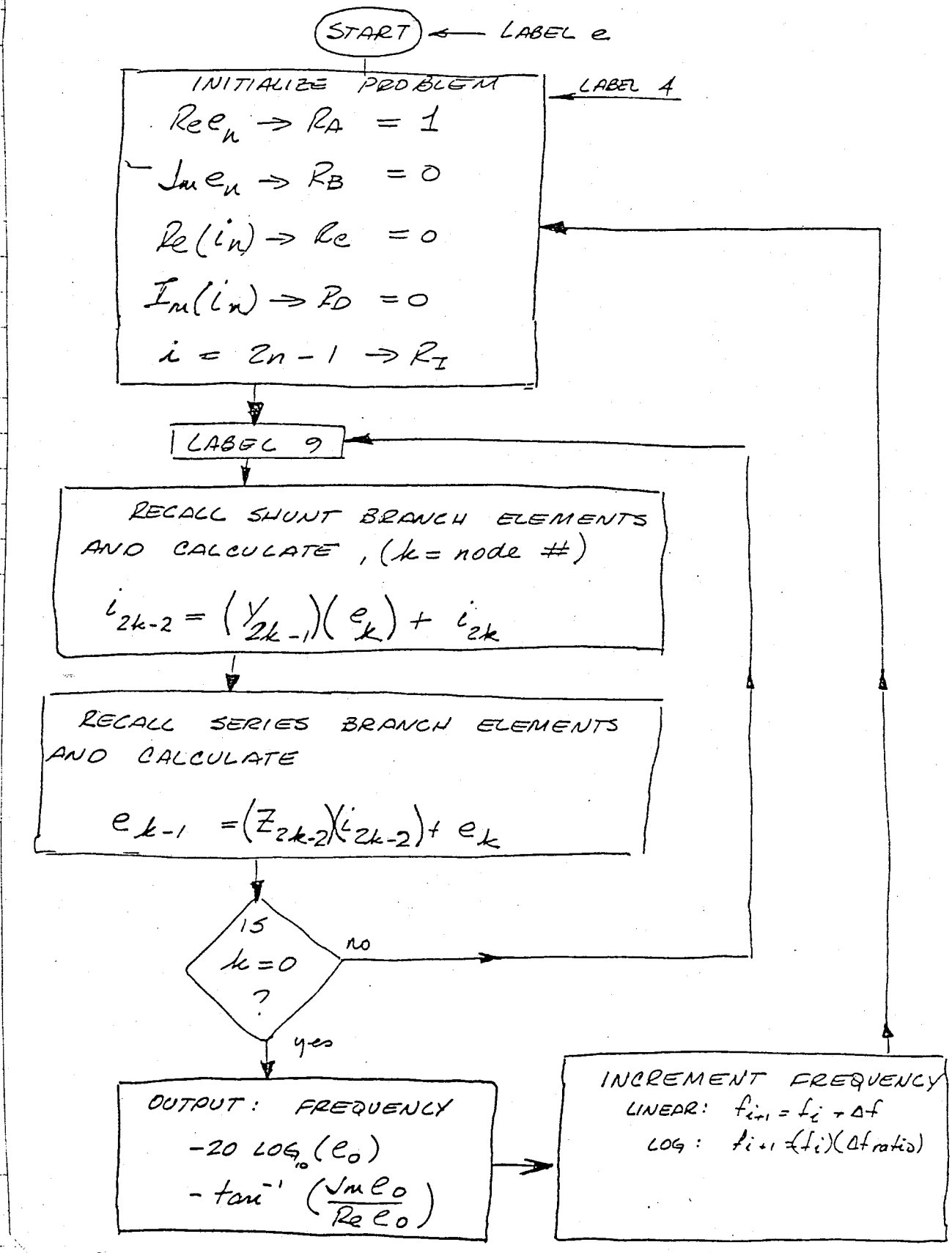
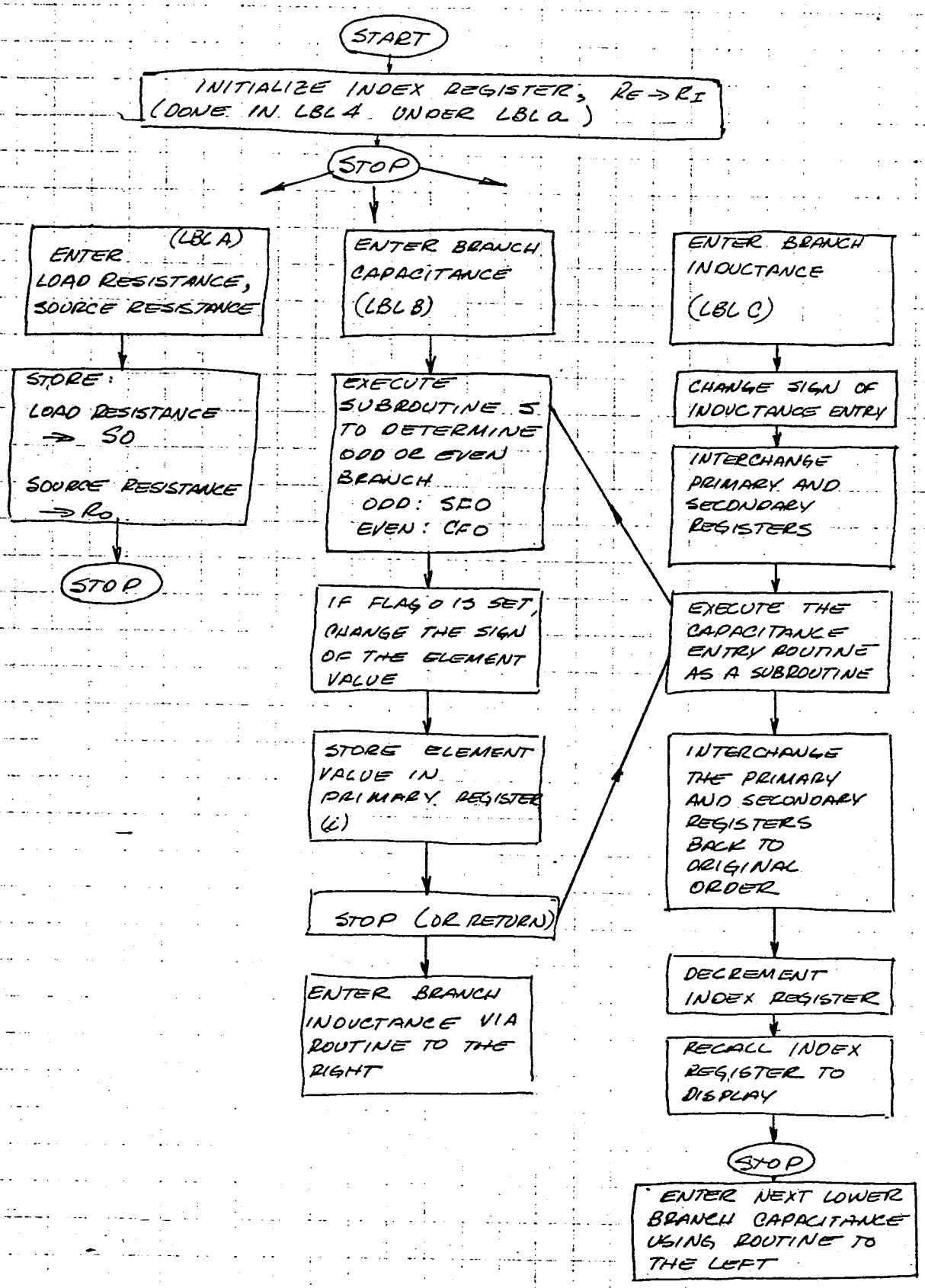
A flow chart of the program operation becomes:



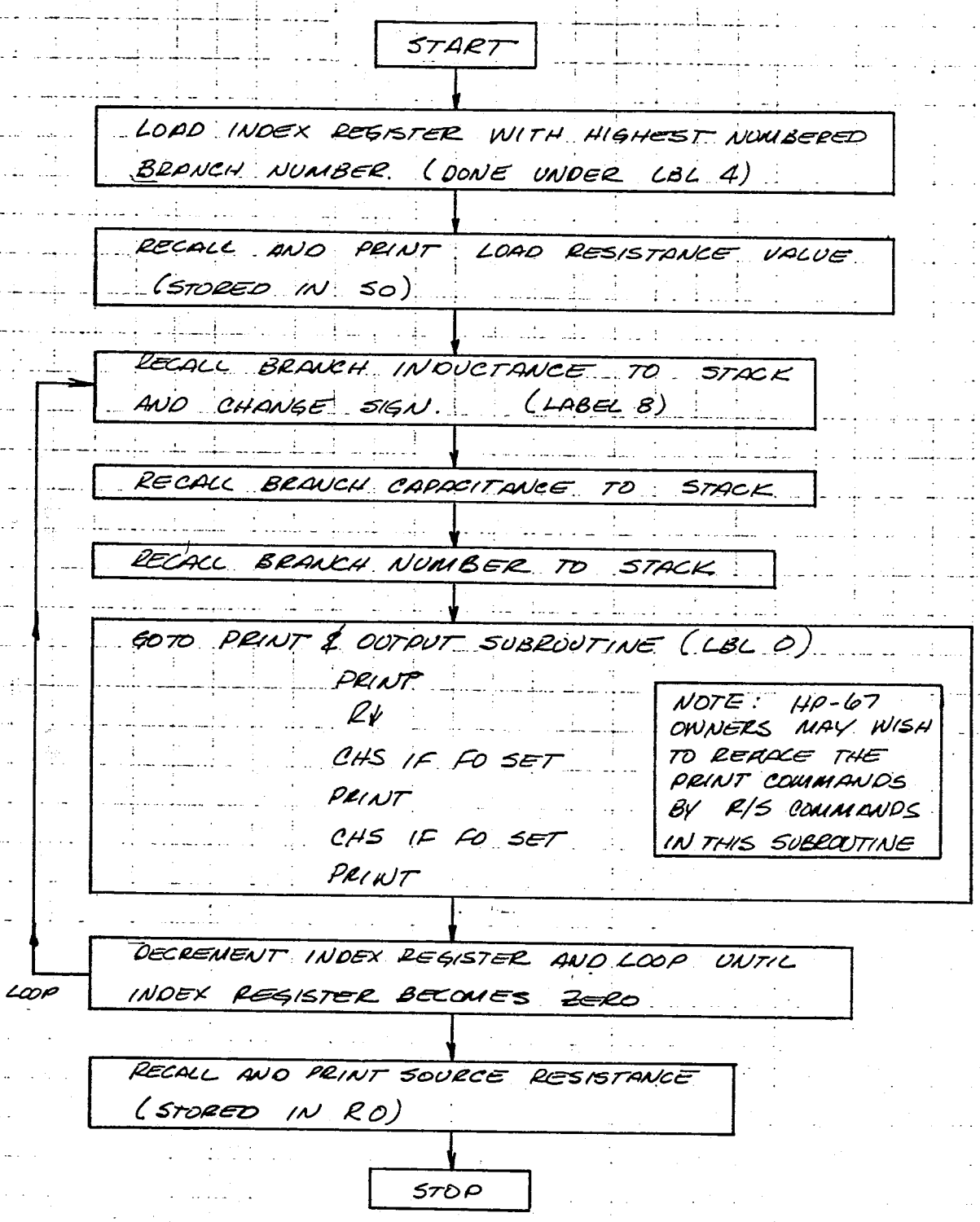
THE ANCILLARY PROGRAM ROUTINES ARE ALSO FLOWCHARTED:

DATA ENTRY



02259D Program Description

DATA REVIEW ROUTINE (LBL d)



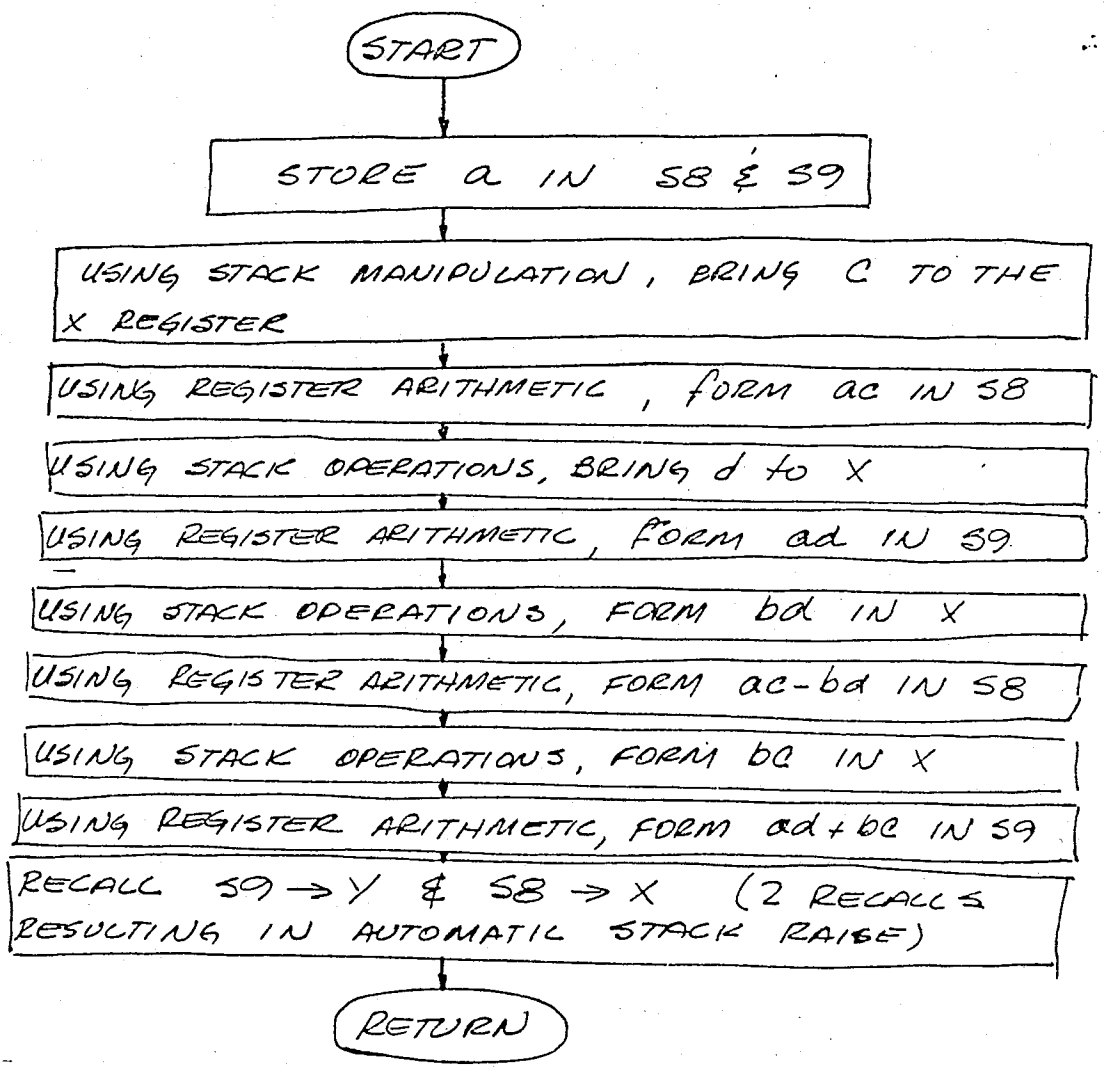
LABEL 1

COMPLEX MULTIPLY SUBROUTINE ; $(a+jb)(c+jd) = e+jf$

THE STACK IS INITIALLY LOADED AS FOLLOWS

$d \rightarrow t$
$c \rightarrow z$
$b \rightarrow y$
$a \rightarrow x$

AFTER THE MULTIPLICATION e AND f ARE RETURNED IN REGISTERS X AND Y RESPECTIVELY



COMPLEX ADD SUBROUTINE (LBL 2)

$$(a+jb)+(c+jd)=e+jf$$

THESE OPERATIONS ARE ALL DONE USING STACK MANIPULATIONS. THE STACK IS INITIALLY LOADED AS FOLLOWS:

t : d
z : c
y : b
x : a

DIAGRAMATICALLY, THE ALGORITHM PROCEEDS:

t	d	d	b	b	a+c	a+c	
z	c	c	d	b	b	a+c	
y	b	a	c	d	b	b	b+d = f
x	a	b	a	a+c	d	b+d	a+c = e
operation		x≷y	R↓	+	R↓	+	R↑

UPON COMPLETION, THE ROUTINE RETURNS THE RESULT e+jf IN THE X AND Y REGISTERS RESPECTIVELY

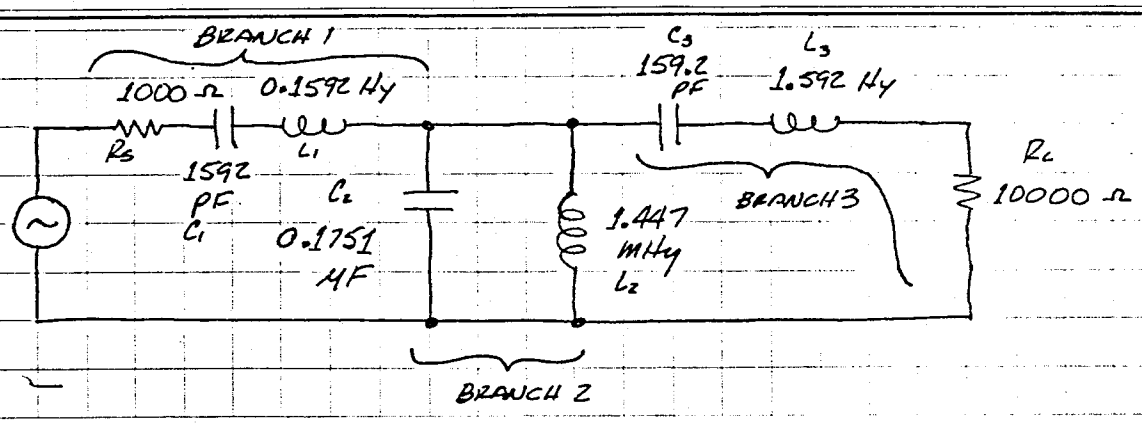
BRANCH ELEMENT RECALL (SUBROUTINE 3)

1. LBL 3, START
2. RECALL PRESENT FREQUENCY AND CALCULATE: $W = 2\pi f$
3. RECALL REACTIVE ELEMENT STORED IN R(I) AND CALCULATE W·R(I)
4. IF SIGN OF W·R(I) IS NEGATIVE, REPLACE W·R(I) BY $1/\{W \cdot R(I)\}$
5. RECALL REACTIVE ELEMENT STORED IN R(I+10) AND FORM W·R(I+10)
6. IF SIGN OF W·R(I+10) IS NEGATIVE, REPLACE W·R(I+10) BY $1/\{W \cdot R(I+10)\}$
7. ADD TERMS CALCULATED IN STEPS 4 AND 6
8. RECALL REACTIVE ELEMENT STORED IN R(I)
9. IF SIGN OF R(I) IS NEGATIVE, REPLACE THE RESULT CALCULATED IN STEP 7 BY IT'S NEGATIVE RECIPRICAL
10. RAISE THE STACK AND LEAVE ZERO IN X REGISTER (REAL PART OF BRANCH IMMITANCE)
11. IF FLAG 2 IS SET (FIRST TIME THROUGH LOOP): REPLACE CONTENTS OF X REGISTER BY LOAD CONDUCTANCE, AND, IF BRANCH NUMBER IS ODD, REPLACE CONTENTS OF Y REGISTER WITH ZERO AND INCREMENT INDEX REGISTER BY ONE

RETURN

02259D Program Description II

Sketch(es)



Sample Problem(s) DETERMINE THE VOLTAGE TRANSFER FUNCTION OF THE ABOVE DOUBLY LOADED L-C NETWORK

DATA INPUT

3.00	GSBa	NUMBER OF BRANCHES
10000.	ENTt	R_L
1000.	GSBA	R_s
159.2-12	GSBB	C_3
1.592	GSBC	L_3
.1751-06	GSBB	C_2
1.447-03	GSBC	L_2
1592.-12	GSBB	C_1
.1592	GSBC	L_1
	GSBb	SET LINEAR SWEEP
7000.	GSBD	START FREQUENCY
100.	GSBE	FREQUENCY INCREMENT

DATA REVIEW

	GSBd	
10.00+03	***	LOAD RESISTANCE
3.000+00	***	BRANCH NUMBER
159.2-12	***	BRANCH CAPACITANCE
1.592+00	***	BRANCH INDUCTANCE
2.000+00	***	#
175.1-09	***	C
1.447-03	***	L
1.000+00	***	#
1.592-09	***	C
159.2-03	***	L
1.000+03	***	SOURCE RESISTANCE

THE ANALYSIS OUTPUT IS SHOWN ON NEXT PAGE

Reference(s)

02259D Program Description

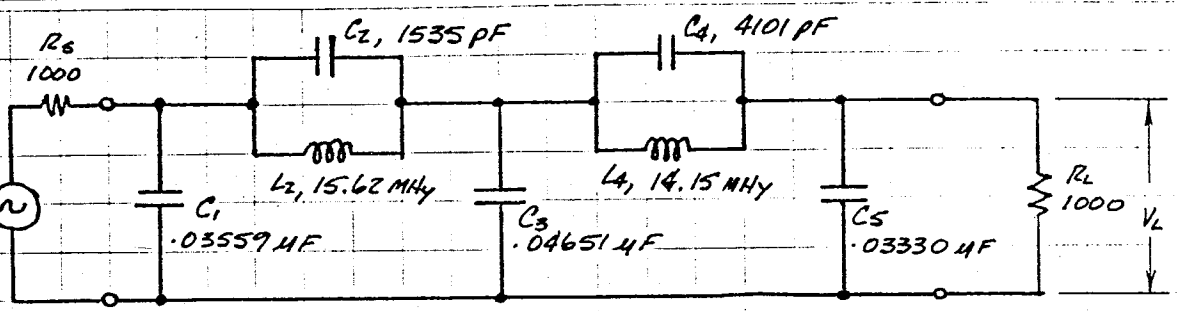
PROGRAM OUTPUT

GSBe START ANALYSIS

7000.00	8000.00	9000.00	10000.00	11000.00	12000.00	FREQUENCY
-52.56	-39.99	-20.29	-0.83	-17.83	-34.72	GAIN, dB
-105.79	-115.72	-146.92	-0.48	153.27	121.62	PHASE, DEGREES
7100.00	8100.00	9100.00	10100.00	11100.00	12100.00	
-51.46	-38.48	-17.44	-0.83	-20.16	-35.89	
-106.48	-117.29	-154.43	-23.45	147.20	120.20	
7200.00	8200.00	9200.00	10200.00	11200.00	12200.00	
-50.33	-36.89	-14.32	-0.84	-22.29	-37.00	
-107.21	-119.05	-164.23	-47.28	142.27	118.90	
7300.00	8300.00	9300.00	10300.00	11300.00	12300.00	
-49.17	-35.23	-10.93	-1.01	-24.25	-38.07	
-108.00	-121.01	-177.51	-73.45	138.17	117.72	
7400.00	8400.00	9400.00	10400.00	11400.00	12400.00	
-47.99	-33.48	-7.40	-1.76	-26.06	-39.06	
-108.85	-123.24	163.89	-102.68	134.72	116.64	
7500.00	8500.00	9500.00	10500.00	11500.00	12500.00	
-46.76	-31.63	-4.14	-3.58	-27.75	-40.05	
-109.76	-125.77	138.09	-132.20	131.76	115.65	
7600.00	8600.00	9600.00	10600.00	11600.00	12600.00	
-45.50	-29.66	-1.93	-6.35	-29.32	-40.98	
-110.76	-128.69	106.39	-157.06	129.20	114.74	
7700.00	8700.00	9700.00	10700.00	11700.00	12700.00	
-44.20	-27.57	-1.04	-9.45	-30.79	-41.87	
-111.83	-132.09	74.86	-175.59	126.95	113.89	
7800.00	8800.00	9800.00	10800.00	11800.00	12800.00	
-42.85	-25.33	-0.85	-12.47	-32.16	-42.73	
-113.01	-136.12	47.27	170.95	124.97	113.11	
7900.00	8900.00	9900.00	10900.00	11900.00	12900.00	
-41.45	-22.91	-0.83	-15.27	-33.48	-43.55	
-114.30	-140.96	22.71	160.35	123.20	112.36	

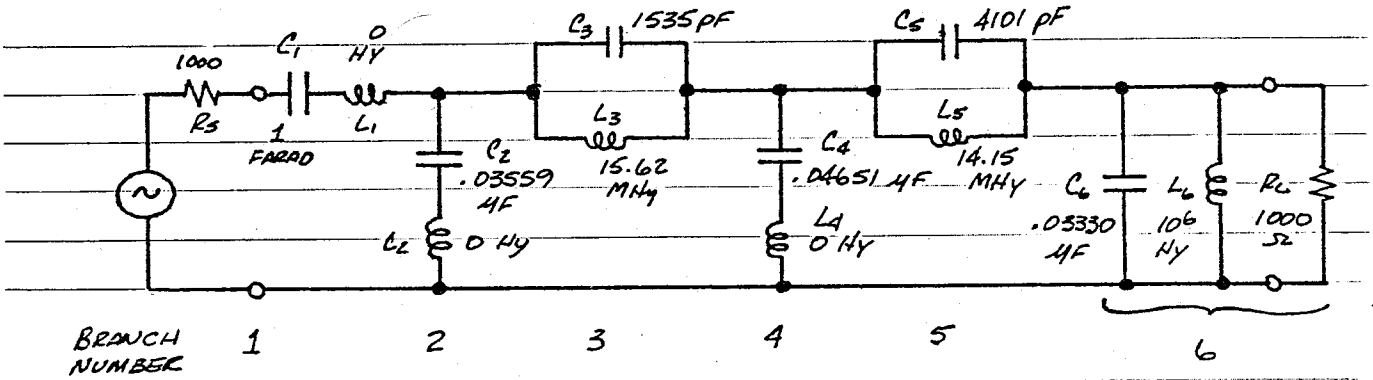
Program Description II

Sketch(es)



Sample Problem(s) THE ABOVE FILTER IS A 5th ORDER, 30°, 50% ELLIPTIC LOW PASS FILTER WITH 10 KHz CUTOFF FREQUENCY. FIND THE FILTER GAIN AND PHASE CHARACTERISTIC BETWEEN 1 KHz AND 1 MHz. USE LOGRITHMIC SWEEP WITH 20 POINTS PER DECADE.

THE SCHEMATIC IS AUGMENTED TO SHOW DUMMY ELEMENTS NECESSARY TO PLACE THE FILTER TOPOLOGY IN PROPER LADDER CONFIGURATION.



THE NETWORK VALUES ARE LOADED FROM BRANCH 6 TO BRANCH 1. BRANCHES 2, 3, 4, AND 5 CONTAIN SERIES NETWORKS IN SHUNT PATHS AND VICE VERSA. THE SIGN OF THE ELEMENT VALUE SHOULD BE NEGATIVE TO INDICATE THIS SITUATION TO THE PROGRAM.

SEE THE HP-97 PRINTOUT ON THE FOLLOWING PAGES FOR THE DETAILS OF THE DATA INPUT AND OUTPUT

HP-97 PRINTOUT

INPUT DATA

```
      6.00 GSBa   NUMBER OF BRANCHES

      1000. ENT↑  LOAD RESISTANCE
            GSBA  SOURCE RESISTANCE

 .03330-06 GSBB   C6
    1.+06 GSBC    L6 (DUMMY)

 -4101.-12 GSBB   C5   } NOTE MINUS VALUE
 -14.15-03 GSBC   L5   }

-.04651-06 GSBB   C4
        0. GSBC   L4 (DUMMY)

 -1535.-12 GSBB   C3
 -15.62-03 GSBC   L3

-.03559-06 GSBB   C2
        0. GSBC   L2 (DUMMY)

        1. GSBB   C1 (DUMMY)
        0. GSBC   L1 (DUMMY)
```

DATA REVIEW

```
                GSBd
1.000+03        ***   LOAD RESISTANCE

6.000+00        ***   BRANCH NUMBER
33.30-09        ***   C6
1.000+06        ***   L6

5.000+00        ***   #
-4.101-09       ***   C5
-14.15-03       ***   L5

4.000+00        ***   #
-46.51-09       ***   C4
0.000+00        ***   L4

3.000+00        ***   #
-1.535-09       ***   C3
-15.62-03       ***   L3

2.000+00        ***   #
-35.59-09       ***   C2
0.000+00        ***   L2

1.000+00        ***   #
1.000+00        ***   C1
0.000+00        ***   L1

1.000+03        ***   SOURCE RESISTANCE
```

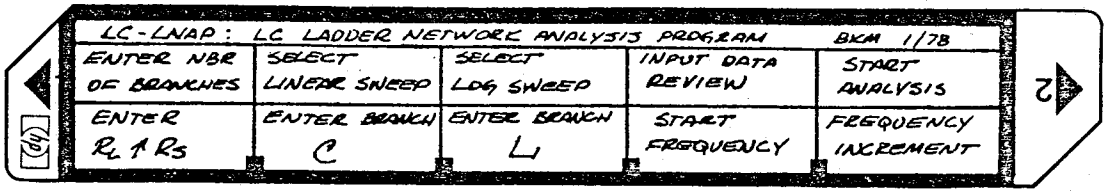
OUTPUT PRINTOUT CONTINUED ON NEXT PAGE

02259D Program Description

1000. GSBD	START FREQUENCY
.05 10^x GSBE	SELECT FREQUENCY INCREMENT FOR 20 POINTS PER DECADE ($10^{1/20}$)
GSBc	SELECT LOG SWEEP
GSBe	START ANALYSIS

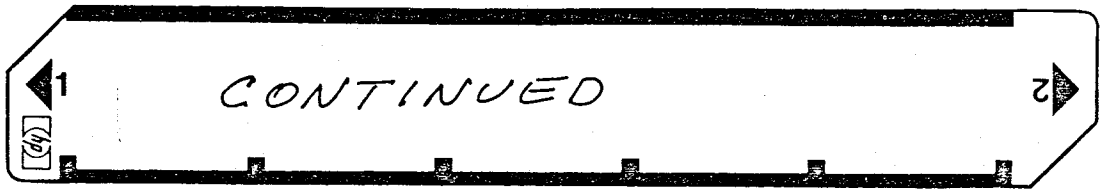
1000.00	3162.28	10000.00	31622.78	100000.00	316227.76	FREQUENCY
-6.30	-7.27	-7.27	-95.67	-78.34	-87.21	GAIN, dB
-25.49	-71.41	46.46	106.14	-85.06	-88.44	PHASE, deg
1122.02	3548.13	11220.18	35481.34	112201.84	354813.39	
-6.37	-7.25	-16.71	-86.74	-79.07	-88.19	
-28.43	-76.99	-14.74	-75.73	-85.60	-88.61	
1258.93	3981.07	12589.25	39810.72	125892.54	398107.17	
-6.45	-7.14	-29.30	-80.70	-79.86	-89.17	
-31.68	-87.81	-35.00	-77.36	-86.08	-88.76	
1412.54	4466.84	14125.38	44668.36	141253.75	446683.59	
-6.53	-6.90	-38.78	-78.21	-80.70	-90.15	
-35.24	-98.46	-45.77	-78.79	-86.51	-88.90	
1584.89	5011.87	15848.93	50118.72	158489.32	501187.23	
-6.64	-6.54	-48.26	-77.04	-81.57	-91.14	
-39.15	-111.90	-53.03	-80.05	-86.89	-89.02	
1778.28	5623.41	17782.79	56234.13	177827.94	562341.32	
-6.75	-6.16	-59.02	-76.55	-82.47	-92.13	
-43.41	-129.43	-58.45	-81.15	-87.23	-89.13	
1995.26	6309.57	19952.62	63095.73	199526.23	630957.34	
-6.87	-6.03	-75.90	-76.50	-83.39	-93.12	
-48.06	-151.93	-62.74	-82.13	-87.53	-89.22	
2238.72	7079.46	22387.21	70794.58	223872.11	707945.78	
-7.00	-6.47	-78.55	-76.71	-84.33	-94.12	
-53.12	-178.07	113.74	-83.00	-87.80	-89.31	
2511.89	7943.28	25118.86	79432.82	251188.64	794328.23	
-7.11	-7.18	-76.84	-77.13	-85.28	-95.11	
-58.64	154.81	110.80	-83.77	-88.04	-89.36	
2818.38	8912.51	28183.83	89125.09	281838.29	891250.93	
-7.21	-6.87	-81.16	-77.68	-86.24	-96.11	
-64.70	121.95	108.29	-84.46	-88.25	-89.45	
					999995.59	
					-97.11	
					-89.51	

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	LOAD BOTH SIDES OF PROGRAM CARD			
2	ENTER NUMBER OF BRANCHES IN NETWORK	# BRANCHES	f A	# BRANCHES
3	ENTER LOAD AND SOURCE RESISTANCES	R_L R_S	1 A	
4	ENTER BRANCH CAPACITANCE IF PARALLEL TANK IN SERIES BRANCH, OR SERIES IN SHUNT BRANCH, ENTER CAPACITANCE AS NEGATIVE VALUE START FROM HIGHEST NUMBERED BRANCH (LOAD RESISTOR END) WORKING TOWARD BRANCH 1. THE BRANCH INDEX COUNTER IS DECREMENTED, AND THE CURRENT BRANCH DISPLAYED EACH TIME STEP 5 IS EXECUTED (THE NEXT STEP). ENTER BRANCH ELEMENTS USING STEPS 4 AND 5 ALTERNATELY.	$\pm C_{BRANCH}$	B	C_{BRANCH}
5	ENTER BRANCH INDUCTANCE IF PARALLEL TANK IN SERIES BRANCH (OOO NUMBERED BRANCH), OR SERIES TANK IN SHUNT BRANCH, ENTER NEGATIVE INDUCTANCE VALUE. START FROM HIGHEST NUMBERED BRANCH AND WORK TOWARDS BRANCH 1 USING STEPS 4 AND 5 ALTERNATIVELY.	$\pm L_{BRANCH}$	C	NEXT LOWER BRANCH NUMBER
6	OPTIONAL: TO REVIEW INPUT DATA FORMAT: BRANCH NUMBER BRANCH CAPACITOR BRANCH INDUCTOR		f D	R_{LOAD} HIGHEST BRANCH # $\pm C$ $\pm L$ • • R_{SOURCE}

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
7	SELECT FREQUENCY SWEEP MODE DESIRED			
	LINEAR SWEEP OR		A B	
	LOG SWEEP		f C	
8	ENTER START FREQUENCY FOR SWEEP	f_{START}	D	
9	ENTER FREQUENCY INCREMENT	$f_{increment}$	E	
	IF LINEAR SWEEP, THE INCREMENT IS THE Δ FREQUENCY BETWEEN POINTS, I.E. FOR OUTPUT DATA EACH 100 Hz, THE INCREMENT IS 100			
	IF LOG SWEEP, THE INCREMENT IS THE RATIO BETWEEN ADJACENT ANALYSIS FREQUENCIES, I.E. FOR 10 POINTS PER DECADE, THE FREQUENCY INCREMENT IS $10^{1/10} = 1.259$			
10	START ANALYSIS		f G	FREQUENCY GAIN (dB) PHASE (deg) spare FREQ dB ϕ ⋮
	TO STOP ANALYSIS, PRESS R/S WHEN PRINTER STARTS TO PRINT.			
	PRESSING R/S AT OTHER TIMES MAY LEAVE REGISTERS INTERCHANGED.			
	TO DETERMINE IF AN INTERCHANGE HAS OCCURRED, GTO STEP 6 AND REVIEW DATA INPUT. IF L'S AND C'S VALUES ARE REVERSED, EXECUTE A PZS INSTRUCTION.			

00259D

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	ENTER R_L ↑ R_S
002	STO0	35 00	STORE R_S
003	R↓	-31	
004	F⇄S	16-51	
005	STO0	35 00	STORE R_L
006	F⇄S	16-51	
007	GTO7	22 07	
008	*LBLC	21 13	ENTER BRANCH INDUCTANCE
009	CHS	-22	
010	F⇄S	16-51	
011	GSBB	23 12	
012	F⇄S	16-51	
013	DSZI	16 25 46	
014	RCLI	36 46	
015	GTO7	22 07	
016	*LBLB	21 12	ENTER BRANCH CAPACITANCE
017	GSB5	23 05	
018	F0?	16 23 00	
019	CHS	-22	
020	STOi	35 45	
021	RTN	24	
022	*LBLD	21 14	ENTER START FREQUENCY
023	STO8	35 08	
024	GTO7	22 07	
025	*LBLE	21 15	ENTER FREQ INCREMENT
026	STO9	35 09	
027	*LBL7	21 07	
028	SPC	16-11	SPACE & RTN SUBROUTINE
029	RTN	24	
030	*LBLa	21 16 11	ENTER NUMBER OF BRANCHES
031	ENG	-13	
032	DSP3	-63 03	
033	SPC	16-11	
034	STOE	35 15	
035	*LBL4	21 04	LOOP INITIALIZATION SUBROUTINE
036	1	01	LOAD VOLTAGE = 1+j0
037	STOA	35 11	
038	0	00	
039	STOB	35 12	
040	STOC	35 13	CURRENT ENTERING, LOAD = 0+j0
041	STOD	35 14	
042	RCLE	36 15	INITIALIZE BRANCH INDEX
043	STOI	35 46	
044	SF2	16 21 02	INITIALIZE FLAG 2
045	RTN	24	
046	*LBLb	21 16 12	SELECT LINEAR SWEEP
047	CF1	16 22 01	
048	GTO7	22 07	
049	*LBLc	21 16 13	SELECT LOG SWEEP
050	SF1	16 21 01	
051	GTO7	22 07	
052	*LBLe	21 16 15	START ANALYSIS
053	FIX	-11	SET FIX 2 DISPLAY
054	DSP2	-63 02	
055	GSB4	23 04	INITIALIZE REG'S & FLAGS
056	*LBL9	21 09	ANALYSIS LOOP START
057	GSB3	23 03	RECALL SHUNT BRANCH Y
058	RCLB	36 12	RECALL COMPLEX SHUNT BRANCH VOLTAGE
059	RCLA	36 11	
060	GSB1	23 01	CALCULATE BRANCH CURRENT
061	RCLD	36 14	RECALL NEXT HIGHER BRANCH CURRENT
062	RCLC	36 13	
063	GSB2	23 02	ADD BRANCH CURRENTS
064	STOC	35 13	STORE COMPLEX BRANCH CURRENT
065	X⇄Y	-41	
066	STOD	35 14	
067	DSZI	16 25 46	DECREMENT BRANCH NUMBER
068	GSB3	23 03	RECALL SERIES BRANCH Z
069	CLX	-51	IF BRANCH 1, ADD IN SOURCE RESISTANCE
070	RCL0	36 00	
071	CF0	16 22 00	
072	DSZI	16 25 46	
073	SF0	16 21 00	
074	F0?	16 23 00	
075	CLX	-51	
076	ENT↑	-21	
077	RCLD	36 14	RECALL COMPLEX BRANCH CURRENT
078	RCLC	36 13	
079	GSB1	23 01	CALCULATE BRANCH VOLTAGE
080	RCLB	36 12	RECALL NEXT HIGHER BRANCH VOLTAGE
081	RCLA	36 11	
082	GSB2	23 02	ADD BRANCH VOLTAGES
083	STOA	35 11	STORE PRESENT COMPLEX BRANCH VOLTAGE
084	X⇄Y	-41	
085	STOB	35 12	
086	X⇄Y	-41	
087	F0?	16 23 00	TEST FOR LOOP / EXIT
088	GTO9	22 09	
089	→P	34	CONVERT TO POLAR COORDS
090	LOG	16 32	CALCULATE MAGNITUDE IN dB
091	2	02	
092	0	00	
093	x	-35	
094	RCL8	36 08	RECALL PRESENT FREQUENCY
095	SF0	16 21 00	SET FLAG 0 FOR PRINTOUT
096	GSB0	23 00	GSB OUTPUT SUBROUTINE
097	RCL9	36 09	RECALL FREQ. INCREMENT
098	F1?	16 23 01	LOG SWEEP ?
099	STx8	35-35 08	IF SO R9·R8 → R8
100	F1?	16 23 01	& GTO LOOP START
101	GTOe	22 16 15	LINEAR SWEEP
102	ST+8	35-55 08	R9+R8 → R8
103	GTOe	22 16 15	GTO LOOP START
104	*LBLd	21 16 14	INPUT DATA REVIEW
105	GSB4	23 04	INITIALIZE REGS & FLAGS
106	P⇄S	16-51	RECALL & PRINT
107	RCL0	36 00	LOAD RESISTANCE
108	P⇄S	16-51	
109	PRTX	-14	
110	*LBL8	21 08	LOOP START
111	GSB5	23 05	CALC ODD/EVEN BRANCH

REGISTERS

0 R_S	1 C_1	2 C_2	3 C_3	4 C_4	5 C_5	6 C_6	7 C_7	8 present frequency	9 frequency increment
S0 R_L	S1 L_1	S2 L_2	S3 L_3	S4 L_4	S5 L_5	S6 L_6	S7 L_7	S8 used by complex multiply	S9 used by complex multiply

A $Re\{V_i\}$	B $Imag\{V_i\}$	C $Re\{I_i\}$	D $Imag\{I_i\}$	E # of branches	I index

STEP	KEY ENTRY	KEY CODE	COMMENTS
112	P↕S	16-51	RECALL BRANCH INDUCTANCE
113	RCLi	36 45	
114	P↕S	16-51	
115	CHS	-22	
116	RCLi	36 45	RECALL BRANCH CAPACITANCE
117	RCLI	36 46	RECALL BRANCH NUMBER
118	GSB0	23 00	GTO OUTPUT SUBROUTINE
119	DSZI	16 25 46	DECREMENT BRANCH NUMBER
120	GTO8	22 08	TEST FOR LOOP / EXIT
121	RCL0	36 00	RECALL AND PRINT SOURCE RESISTANCE
122	SPC	16-11	
123	PRTX	-14	
124	GTO7	22 07	GTO SPACE & RTN
125	*LBL0	21 00	OUTPUT SUBROUTINE
126	SPC	16-11	
127	PRTX	-14	PRINT FIRST ITEM
128	GSB0	23 00	PRINT SECOND ITEM
129	*LBL0	21 00	PRINT THIRD ITEM
130	R↓	-31	
131	F0?	16 23 00	IF ODD BRANCH (OR FLAG 0 IS SET)
132	CHS	-22	CHANGE SIGN OF ITEM
133	RND	16 24	ROUND & PRINT ITEM
134	PRTX	-14	
135	RTN	24	
136	*LBL1	21 01	COMPLEX MULTIPLY (a+jb)(c+jd) = e+jf
137	P↕S	16-51	a
138	STO8	35 08	a
139	STO9	35 09	b
140	R↓	-31	b
141	ENT↑	-21	b
142	R↓	-31	c
143	R↓	-31	ac
144	ST×8	35-35 08	d
145	R↓	-31	ad
146	ST×9	35-35 09	bd
147	×	-35	ac - bd = e
148	ST-8	35-45 08	b
149	R↓	-31	bc
150	×	-35	ad+bc = f
151	ST+9	35-55 09	rcl f
152	RCL9	36 09	rcl e
153	RCL8	36 08	
154	P↕S	16-51	
155	RTN	24	
156	*LBL2	21 02	COMPLEX ADD (a+jb)+(c+jd) = e+jf
157	X↕Y	-41	
158	R↓	-31	ac = e
159	+	-55	
160	R↓	-31	
161	+	-55	bd = f
162	R↑	16-31	restore proper stack order
163	RTN	24	
164	*LBL3	21 03	BRANCH IMMITANCE RECALL
165	GSB5	23 05	ODD/EVEN BRANCH
166	RCL8	36 08	
167	Fi	16-24	
168	×	-35	FORM ω = 2πf
169	2	02	
170	×	-35	
171	ENT↑	-21	
172	ENT↑	-21	
173	RCLi	36 45	RECALL BRANCH CAPACITANCE
174	×	-35	FORM ωC
175	X<0?	16-45	IF C IS NEGATIVE,
176	1/X	52	TAKE RECIPROCAL
177	X↕Y	-41	RESTORE ω
178	P↕S	16-51	
179	RCLi	36 45	RECALL BRANCH INDUCTANCE
180	P↕S	16-51	
181	×	-35	FORM ωL
182	X<0?	16-45	IF L IS NEGATIVE,
183	1/X	52	TAKE RECIPROCAL
184	+	-55	FORM IMMITTANCE
185	RCLi	36 45	RECALL BRANCH CAPACITANCE
186	F0?	16 23 00	IF BRANCH ODD,
187	CHS	-22	CHANGE SIGN
188	X<0?	16-45	IF SIGN NEGATIVE,
189	GSB3	23 03	FORM RECIPROCAL
190	R↓	-31	
191	F2?	16 23 02	FIRST TIME THROUGH ?,
192	GTO0	22 00	ADD LOAD RESISTANCE
193	0	00	OTHERWISE LOAD = 0
194	RTN	24	
195	*LBL3	21 03	SUBROUTINE TO FORM RECIPROCAL OF IMAGINARY PART OF IMMITTANCE.
196	R↓	-31	
197	1/X	52	
198	CHS	-22	
199	ENT↑	-21	
200	RTN	24	
201	*LBL5	21 05	ODD/EVEN BRANCH CALCULATION SUBROUTIN
202	RCLI	36 46	
203	2	02	
204	÷	-24	
205	ENT↑	-21	
206	INT	16 34	
207	CF0	16 22 00	TO CLEAR IF I IS EVEN
208	X≠Y?	16-32	
209	SF0	16 21 00	TO SET IF I IS ODD
210	R↓	-31	
211	R↓	-31	
212	RTN	24	
213	*LBL0	21 00	LOAD RESISTANCE ADDITION SUBROUTINE (EXECUTED THE FIRST TIME THROUGH LOOP 3)
214	F0?	16 23 00	
215	0	00	
216	P↕S	16-51	RECALL LOAD RESISTANCE AND FORM LOAD CONDUCTANCE
217	RCL0	36 00	
218	P↕S	16-51	
219	1/X	52	
220	F0?	16 23 00	IF ODD BRANCH INCREMENT I
221	ISZI	16 26 46	
222	RTN	24	

LABELS

A Enter R_L ↑ R_S	B Enter C	C Enter L	D Enter f start	E enter freq increment
a enter abr A branches	b select linear sweep	c select log sweep	d input data review	e start analysis
0 multiple uses	1 Complex multiply	2 complex add	3 Complex recall	4 initialize
5 odd / even branch	6	7 space & rtn	8 input data loop label	9 analysis loop start

FLAGS

0 multiple uses	
1 Clear : linear set : log	
2 first time thru analysis loop	
3 unused	

SET STATUS

FLAGS		TRIG	DISP
ON	OFF		
0 ■		DEG ■	FIX ■
1 ■		GRAD	SCI
2 ■		RAD	ENG
3 ■			n 2

02259D Program Description

PROGRAM CHANGES. HP-67 OWNERS MAY WISH TO MAKE.

1) PROGRAM SPACE DOES NOT ALLOW A PRINT / R/S TOGGLE AND ACCOMPIANING OUTPUT ROUTINE. TO CAUSE HP-67 PROGRAM EXECUTION TO HALT SO DATA OUTPUT MAY BE RECORDED, REPLACE THE PRINT COMMANDS BY R/S COMMANDS AT THE FOLLOWING PROGRAM LINE NUMBERS:

109
123
127
134

2) ADDITIONAL ROOM MAY BE CREATED FOR PROGRAM MODIFICATION IF THE SPACE COMMANDS ARE REMOVED. (A NOP ON THE 67) THESE SPACE COMMANDS ARE LOCATED AT THE FOLLOWING LINE NUMBERS:

028
033
126

3) LABEL 7 IS A SPACE AND RETURN SUBROUTINE, AND MAY BE ELIMINATED.

DELETE THE *LBL 7 COMMAND AT LINE 027

REPLACE GTO 7 COMMANDS BY RETURN COMMANDS AT THESE LINE NUMBERS:

007 124
015
024
048
051