

Includes easy-entry keystroke listings.

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# PROGRAM DESCRIPTION

## TRANSISTOR AMP EVALUATION

Given supply voltage (Vcc), the five resistor values R(1)-R(5), and transistor Beta, operating parameters are computed from the formulas:

(See schematic for resistor labels)

Temporary values

$$R = R(1) * R(2) / (R(1) + R(2))$$

$$V\phi = V * (R(1) / (R(1) + R(2)))$$

$$K = V\phi - * .7$$

$$D = .026 / A(3) + 2$$

$$T = B * (R(4) + D)$$

$$V = V_{cc} \quad B = \text{Beta}$$

R(1) thru R(5) input as values from schematic

Displayed values

$$I_B = A(1) = K / (B * (R(4) + R(5)) + R)$$

$$V_B = A(2) = V\phi - A(1) * R$$

$$I_C = A(3) = B * A(1)$$

$$V_C = A(4) = V - A(3) * R(3)$$

$$V_E = A(5) = A(1) + A(3) * (R(4) + R(5))$$

$$\text{Gain} = A(6) = R(3) / (R(4) + D)$$

$$R_{in} = A(7) = R * T / (R + T)$$

Answers are rounded to two digits and displayed with proper units and unit multiplier.

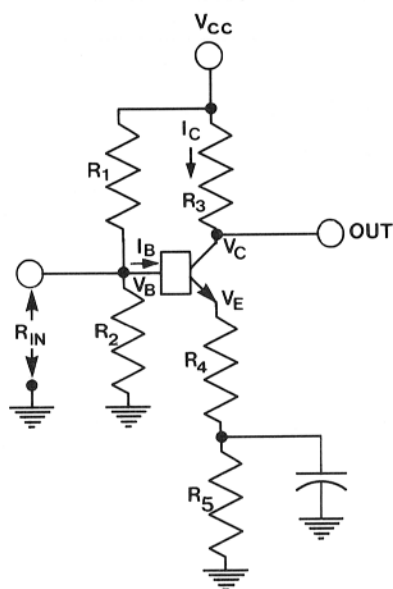
# SAMPLE PROBLEM

Using the schematic and sample problem values, find  $I_B$ ,  $V_B$ ,  $I_C$ ,  $V_C$ ,  $V_E$ , Gain and input resistance for a Beta of 30, then for a Beta of 300.

Answers: Gain varies 18.96 - 19.2

Rin varies 946 - 2050

Collector current varies by 1.5 m Amps



## Sample Problem Values

$R1 = 8200$

$R2 = 3300$

$R3 = 1000$

$R4 = 47$

$R5 = 270$

$V_{cc} = 12$

First  $\beta_{a1} = 30$

Second  $\beta_{a2} = 300$

# SOLUTION

| STEP | INSTRUCTIONS       | DISPLAY                         | INPUT      |
|------|--------------------|---------------------------------|------------|
|      | Run program        | * TRANSISTOR AMP EVALUATION *   |            |
| 1    | Enter supply volts | $V_{cc} =$                      | 12 [RTN]   |
| 2    | Enter supply R1    | $R1 =$                          | 8200 [RTN] |
| 3    | Enter supply R2    | $R2 =$                          | 3300 [RTN] |
| 4    | Enter supply R3    | $R3 =$                          | 1000 [RTN] |
| 5    | Enter supply R4    | $R4 =$                          | 47 [RTN]   |
| 6    | Enter supply R5    | $R5 =$                          | 270 [RTN]  |
| 7    | Enter supply Beta  | Beta =                          | 30 [RTN]   |
| 8    | Answers            | $I_b = 231.26 \mu \text{ AMPS}$ | [RTN]      |
| 9    |                    | $V_b = 2.9 \text{ VOLTS}$       | [RTN]      |
| 10   |                    | $I_c = 6.94 \text{ m AMPS}$     | [RTN]      |



# SOLUTION

| STEP | INSTRUCTIONS                  | DISPLAY                                                | INPUT     |
|------|-------------------------------|--------------------------------------------------------|-----------|
| 11   |                               | $V = 5.06$ VOLTS                                       | [RTN]     |
| 12   |                               | $V = 2.2$ VOLTS                                        | [RTN]     |
| 13   |                               | Gain = 18.96                                           | [RTN]     |
| 14   |                               | $R_{in} = 946.14$ OHMS                                 | [RTN]     |
| 15   | Press [RTN] to default to 'B' | New <u>B</u> eta, <u>R</u> un again, or <u>E</u> nd? B | [RTN]     |
| 16   | Enter new Beta                | Beta =                                                 | 300 [RTN] |
|      |                               | $I_b = 28.15$ AMPS                                     | [RTN]     |
|      |                               | $V_b = 3.38$ VOLTS                                     | [RTN]     |
|      |                               | $I_c = 8.45$ m AMPS                                    | [RTN]     |
|      |                               | $V_c = 3.55$ VOLTS                                     | [RTN]     |
|      |                               | $V_e = 2.68$ VOLTS                                     | [RTN]     |
|      |                               | Gain = 19.2                                            | [RTN]     |
|      |                               | $R_{in} = 2.05K$ OHMS                                  | [RTN]     |
| 17   | End program                   | New <u>B</u> eta, <u>R</u> un again, or <u>E</u> nd? B | E [RTN]   |

# USER INSTRUCTIONS

| STEP | INSTRUCTIONS            | DISPLAY                                              | INPUT               |
|------|-------------------------|------------------------------------------------------|---------------------|
| 1    | Run program             | * TRANSISTOR AMP EVALUATION *                        |                     |
| 2    | Enter values:           |                                                      |                     |
| 2a   | Enter Vcc in volts      | Vcc =                                                | Vcc [RTN]           |
| 2b   | Enter R1 in ohms        | R1 =                                                 | R1 [RTN]            |
| 2c   | Enter R2 in ohms        | R2 =                                                 | R2 [RTN]            |
| 2d   | Enter R3 in ohms        | R3 =                                                 | R3 [RTN]            |
| 2e   | Enter R4 in ohms        | R4 =                                                 | R4 [RTN]            |
| 2f   | Enter R5 in ohms        | R5 =                                                 | R5 [RTN]            |
| 2g   | Enter Beta              | Beta =                                               | Beta [RTN]          |
| 3    | Display answers:        | I = value AMPS                                       | [RTN]               |
|      |                         | V = value VOLTS                                      | [RTN]/[BACK]        |
|      |                         | I = value AMPS                                       | [RTN]/[BACK]        |
|      |                         | V = value VOLTS                                      | [RTN]/[BACK]        |
|      |                         | V = value VOLTS                                      | [RTN]/[BACK]        |
|      |                         | GAIN = value                                         | [RTN]/[BACK]        |
|      |                         | Rin = value OHMS                                     | [RTN]/[BACK]        |
| 4    | Program options:        | New <u>B</u> eta, <u>R</u> un again, or <u>E</u> nd? | B, R, or E<br>[RTN] |
|      | If 'B' then goto 2g     |                                                      |                     |
|      | If 'R' then goto 1      |                                                      |                     |
|      | If 'E' then end program |                                                      |                     |

## VARIABLE NAMES

| NAME | DESCRIPTION                                                                                                                                                   | NAME          | DESCRIPTION                                                                |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|----------------------------------------------------------------------------|
| A(x) | Computed answers A(1)=I <sub>B</sub> , A(2)=V <sub>B</sub> , A(3)=I <sub>C</sub> , A(4)=V <sub>C</sub> , A(5)=V <sub>e</sub> , A(6)=Gain A(7)=R <sub>in</sub> | V             | Supply voltage V                                                           |
|      |                                                                                                                                                               | V $\emptyset$ | Intermediate value                                                         |
| B(x) | Same as A(x) but adjusted for unit multiplier F\$                                                                                                             | X             | For loop counter                                                           |
| R(x) | Input resistance values R1-R5                                                                                                                                 | A\$           | Labels for prompts                                                         |
| A    | Always A=VAL(X\$) in non-error input subroutine                                                                                                               | B\$           | Units for answers                                                          |
| B    | Beta                                                                                                                                                          | F\$           | Unit multiplier from FNF(F)                                                |
| D    | Intermediate value saved for further computation                                                                                                              | K\$           | Single key input                                                           |
| F    | Value passed to function FNF(F) and FNR(F,J)                                                                                                                  | Q\$           | Query option input                                                         |
| J    | Value passed to function FNR(F,J)                                                                                                                             | X\$           | String input always changed to A=VAL(X\$) and negative values not allowed. |
| K,T  | Intermediate values                                                                                                                                           |               |                                                                            |

## NOTES AND REFERENCES

1. When viewing answers [RTN] key steps forward to next answer and [BACK] key steps to previous answer.
2. Resistance values of zero ohms are allowed for R4 and R5 only. All inputs in common units and must be positive.
3. Program designed to be most useful as computing parameters based on fixed resistor values and changing Beta.
4. Invalid inputs are ignored and user is re-prompted until valid input is received.
5. Refer to schematic for transistor configuration and resistor labels.
6. From HP Users' Library #3970D.

# PROGRAM LISTING

```

10 ! TRANSISTOR AMP EVALUATION
20 ! Computes transistor amp
30 ! operating parameters as a
40 ! function of transistor
50 ! Beta.
60 ! Revision 11/01/82
70 !
80 DELAY 2
90 DIM A$(28),B$(36)
100 DIM R(5),A(7),B(7)
110 ! DEFINE FUNCTIONS
120 ! Fix answer to common unit
130 DEF FNF(F)
140 F$="MK m"&CHR$(12)&"np"
150 J=3
160 IF F<1000 AND F>=1 THEN 240
170 IF F<1 THEN 210
180 IF F=1 THEN 240
190 F=F/1000 @ J=J-1
200 GOTO 160
210 IF J=7 THEN 240
220 F=F*1000 @ J=J+1
230 GOTO 160
240 F$=F$(J,J)
250 FNF=F
260 END DEF
270 !
280 ! Single, upper case key in
290 DEF FNK$

300 K$=KEY$ @ IF K$="" THEN 300
310 FNK$=UPRC$(K$)
320 END DEF
330 !
340 ! Round 'F' to 'J' digits
350 DEF FNR(F,J)
360 F=INT(F*10^J+.5)/10^J
370 FNR=F

380 END DEF
390 !
400 ! Labels
410 A$=" Ib Vb Ic Vc VeGAIN Rin"
420 ! Units
430 B$=" AMPSVOLTS AMPSVOLTSVOLTS 0
HMS "
440 DISP " * TRANSISTOR AMP EVALUATION
*"
450 P$="Vcc = " @ GOSUB 820 @ V=A
460 FOR X=1 TO 5
470 P$="R"&STR$(X)&" = "
480 GOSUB 830
490 R(X)=A

```

-FNK\$ returns single uppercase input

-FNR(F,J) rounds F to J digits

-FNF(F) returns F between 1 and 100 with unit F\$

-Prompts and labels

-Units for answers

-Sign on message

-Get supply voltage Vcc

-Get five resistor values R(1) through R(5)

# PROGRAM LISTING

```

500 IF R(X) THEN 520
510 IF X=4 OR X=5 THEN 520 ELSE 480
520 NEXT X
530 ! Loop here for new Beta
540 P$="Beta = " @ GOSUB 820 @ B=A
550 ! Compute results
560 R=R(1)*R(2)/(R(1)+R(2))
570 V0=V*(R(2)/(R(1)+R(2)))
580 K=V0-.7
590 A(1)=K/(B*(R(4)+R(5))+R)
600 A(3)=B*A(1)
610 A(5)=A(1)+A(3)*(R(4)+R(5))
620 A(2)=V0-A(1)*R
630 A(4)=V-A(3)*R(3)
640 D=.026/A(3)+2
650 A(6)=R(3)/(R(4)+D)
660 T=B*(R(4)+D)
670 A(7)=R*T/(R+T)
680 ! Show results
690 FOR X=1 TO 7
700 B(X)=FNF(A(X))
710 DISP A$[4*X-3,4*X]A$&"=" ;FNR(B(X),2)
    ;F$&" "&B$[X*5-4,X*5]
720 K$=FNK$
730 IF NUM(K$)#13 AND NUM(K$)#8 THEN 72
    0
740 IF NUM(K$)=13 THEN 760
750 X=X-2 @ IF X<0 THEN X=0

760 NEXT X
770 DISP "New ";CHR$(194);"eta, ";CHR$(
    210);"un again, or ";CHR$(197);
780 INPUT "nd? ";B$; Q$ @ Q$=UPRC$(Q$)
790 IF Q$="R" OR Q$="B" OR Q$="E" THEN
    800 ELSE GOTO 770
800 IF Q$="R" THEN 450
810 IF Q$="B" THEN 540 ELSE 890
820 ! Non-error input

830 DISP P$;
840 INPUT " ";X$
850 ON ERROR GOTO 830
860 A=VAL(X$) @ OFF ERROR
870 IF A<0 THEN 830
880 RETURN
890 DISP @ DELAY 1 @ STOP

```

-Only R4 and R5 can be zero

-Get transistor beta  
-Compute all parameters

-B(X) = fixed value of A(X)

-Wait for RTN or BACK keys

-Step forward on RTN  
-Step back on BACK but no  
further than 0

-Continuation prompt and input  
-Wait for valid input

-Non-error input prompt from P\$  
returning A

-Require positive input

-Program stops to preserve  
variables for inspection

# PROGRAM DESCRIPTION

## COMMON COMPONENTS FOR 555 & 567 IC'S

Trial and error is usually used to find values for common components for use with a 555 oscillator and 567 tone decoder which yield an acceptable tolerance about a given frequency.

This program completes the trial-and-error method by stepping through all common values of components and testing each combination to see if it is within specified tolerance.

Every value in array A(I) is tested by one of the two formulas:

$$555 = C = 1.433 / (R(A) + R(B) + R(B)) * F$$

$$567 = C = 1/(R(A) * F)$$

Component values are displayed along with the computed operating frequency.

Upper tolerance is held in variable 'U'.

Lower tolerance is held in variable 'L'.

i.e.: L = .95 = -5%  
 U = 1.05 = +5% ± 5% tolerance



# SAMPLE PROBLEM

A) What values of R and C should be used to decode 1200 Hz  $\pm 5\%$  in a 567 tone decoder?

## SOLUTION

| STEP           | INSTRUCTIONS                | DISPLAY                                           | INPUT      |
|----------------|-----------------------------|---------------------------------------------------|------------|
| A <sub>1</sub> | Run program, select 567     | Select: 555 or 567? 555                           | 567 [RTN]  |
| 2              | Sign-on message             | *** 567 TONE DECODER ***                          |            |
| 3              | Enter frequency             | Frequency in Hz =                                 | 1200 [RTN] |
| 4              | Step and test               | Searching for first combination                   |            |
| 5              | Show components             | R(A)=180 $\Omega$ C=4.7 $\mu$ fd                  | [RTN]      |
| 6              | Now show computed frequency | Frequency is 1.82KHz                              | [RTN]      |
| 7              | End program                 | <u>V</u> iew again, <u>M</u> ore, or <u>E</u> nd? | E [RTN]    |

# SAMPLE PROBLEM

B) What values of  $R(A)$ ,  $R(B)$  and  $C$  are suitable for the operation of a 3.3 KHz oscillator?

## SOLUTION

| STEP           | INSTRUCTIONS            | DISPLAY                                   | INPUT      |
|----------------|-------------------------|-------------------------------------------|------------|
| B <sub>1</sub> | Run program select 555  | Select: 555 or 567? 555                   | [RTN]      |
| 2              | Sign-on message         | *** 555 OSCILLATOR ***                    |            |
| 3              | Enter frequency         | Frequency in Hz =                         | 3300 [RTN] |
| 4              | Step and test           | Searching for first combination           |            |
| 5              | Show component values   | $R(A)=100\Omega$ $R(B)=180\Omega$         | [RTN]      |
| 6              | Show capacitor          | $C=1\mu\text{fd}$                         | [RTN]      |
| 7              | Show computed frequency | Frequency is 3.137 KHz                    | [RTN]      |
| 8              | End program             | View again, <u>M</u> ore, or <u>E</u> nd? | E [RTN]    |

# USER INSTRUCTIONS

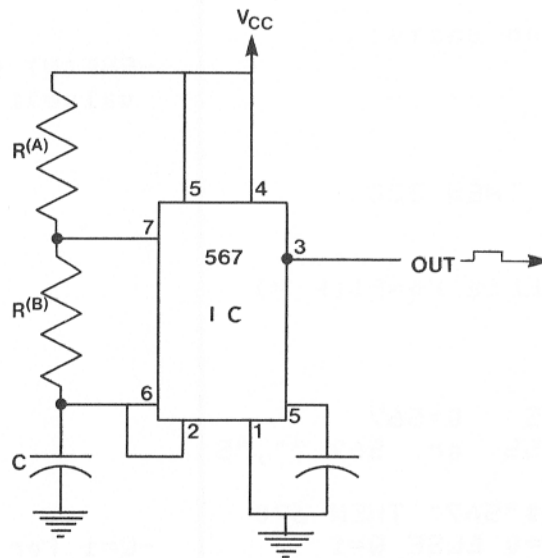
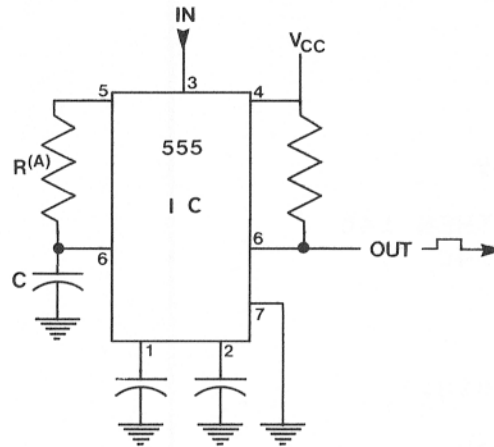
| STEP | INSTRUCTIONS                   | DISPLAY                                           | INPUT               |
|------|--------------------------------|---------------------------------------------------|---------------------|
| 1    | Run program, select operation  | Select: 555 or 567? 555                           | 555 or 567<br>[RTN] |
| 2    | If 567 then goto 14            |                                                   |                     |
| 3    | 555 selected                   | **555 OSCILLATOR**                                |                     |
| 4    | Input frequency                | Frequency in Hz =                                 | Freq.<br>[RTN]      |
| 5    | Searching array                | Searching for first combination                   |                     |
| 6    | Display resistor values        | R(A)=100 $\Omega$ R(B)=220 $\Omega$               | [RTN]               |
| 7    | Display capacitor value        | C=2.2                                             | [RTN]               |
| 8    | Show actual frequency          | Frequency is 1.215 KHz                            | [RTN]               |
| 9    | Continuation options           | <u>V</u> iew again, <u>M</u> ore, or <u>E</u> nd? | V, M, E<br>[RTN]    |
| 10   | If <u>V</u> iew then 6         |                                                   |                     |
| 11   | If <u>E</u> nd then 24         |                                                   |                     |
| 12   | <u>M</u> ore - continue search |                                                   |                     |
| 13   | Goto 6                         | Searching for more combinations                   |                     |
|      |                                |                                                   |                     |
| 14   | 567 selected                   | **567 TONE DECODER**                              |                     |
| 15   | Input frequency                | Frequency in Hz =                                 | Freq.<br>[RTN]      |
| 16   | Search for combination         | Searching for first combination                   |                     |
| 17   | Display results                | R(A)=100 C=5                                      | [RTN]               |
| 18   | Display frequency              | Frequency is 2KHz                                 | [RTN]               |
| 19   | Continuation options           | <u>V</u> iew again, <u>M</u> ore, or <u>E</u> nd? | V, M, E<br>[RTN]    |
| 20   | If <u>V</u> then 17            |                                                   |                     |
| 21   | If <u>E</u> then 24            |                                                   |                     |
| 22   | <u>M</u> ore - continue search | Searching for more combinations                   |                     |
| 23   | Goto 16                        |                                                   |                     |
| 24   | Stop                           |                                                   |                     |

VARIABLE NAMES

| NAME | DESCRIPTION                    | NAME | DESCRIPTION                      |
|------|--------------------------------|------|----------------------------------|
| A    | Array pointer and loop counter | N    | Value passed to function         |
| B    | Loop counter                   | P    | Function pointer                 |
| C    | Capacitor value                | Q    | Operation flag<br>1=555    0=567 |
| D    | Temporary capacitor value      | U    | Upper tolerance                  |
| F    | Frequency selected             | Z    | Computed frequency               |
| H    | Range exponent for C           | R1   | R(A) from formula                |
| I    | Loop counter                   | R2   | R(B) from formula                |
| J    | Loop counter                   | F\$  | Temporary string                 |
| L    | Lower tolerance                | K\$  | Single key input                 |
|      |                                | Q\$  | Option string input              |

# NOTES AND REFERENCES

Schematic for component values:



# PROGRAM LISTING

```

10 ! 567 TONE DECODER
20 ! and 555 OSCILATOR
30 ! Find the common resistor
40 ! and capacitor combinations
50 ! for either of the
60 ! two circuits.
70 ! Revision 11/01/82
80 DELAY 2
90 DIM A(25),R(77)
100 ! Define Functions
110 !
120 ! Wait for 'RTN' key
130 DEF FNK$
140 K$=KEY$ @ IF K$="" THEN 140
150 IF NUM(K$)#13 THEN 140
160 FNK$=K$
170 END DEF
180 !
190 ! Round 'N' to 'P' digits
200 DEF FNR(N,P)
210 N=INT(N*10^P+.5)/10^P
220 FNR=N
230 END DEF
240 !
250 ! Fix ohms to common units.
260 DEF FNF(N)

270 F$="MK "
280 P=3
290 IF N<1000 AND N>=1 THEN 320
300 N=N/1000 @ P=P-1
310 IF P#1 THEN 290
320 IF P=3 THEN F$="" ELSE F$=F$[P,P]
330 FNF=N
340 END DEF
350 !
360 ! Which chip? 1=555 0=567
370 INPUT "Select: 555 or 567 ?","5
55";Q$
380 IF Q$#"555" AND Q$#"567" THEN 370
390 IF Q$="567" THEN Q=0 ELSE Q=1
400 ! Main program loop
410 IF Q THEN DISP " * * * 555 OSCILLA
TOR * * *" ELSE DISP " * * * 567
TONE DECODER * * *"
420 R1,C=0 @ IF Q THEN R2=0
430 ! Set upper & lower tolerance
440 U=1.05 @ L=.95
450 ! Non-error input
460 INPUT "Frequency in Hz = "; F$ @ IF
F$="" THEN 460
470 ON ERROR GOTO 460
480 F=ABS(VAL(F$)) @ OFF ERROR
490 DELAY 0

```

-FNF(N) sets N = smallest  
value>1, sets Multiplier

-Q=1 for 555 and Q=0 for 567

-Tolerance set to 5%

-Wait for valid frequency

# PROGRAM LISTING

```

500 DISP "Searching for first combinati
    on."
510 ! Search for values
520 FOR I=1 TO 13
530 READ A(I)
540 NEXT I
550 ! Common values
560 DATA 5,10,1,2.2,3.3,4.7,1.2,1.5,1.8
    ,3.9,5.6,6.2,8.2
570 ! Load resistor array
580 A=1
590 FOR J=2 TO 7
600 FOR I=3 TO 13
610 R(A)=A(I)*10^J

620 A=A+1
630 NEXT I
640 NEXT J
650 ! Possible combinations
660 FOR A=1 TO 66
670 IF NOT Q THEN 690

680 FOR B=1 TO 66
690 IF Q THEN C=1.443/((R(A)+R(B)+R(B))
    *F) ELSE C=1/(R(A)*F)
700 IF C<10^(-9) THEN 840
710 ! Range C
720 FOR H=1 TO 9
730 D=C/10^(-H)
740 IF 1>D THEN 760
750 IF D<10 THEN 780
760 NEXT H
770 ! Check tolerance
780 FOR I=1 TO 6
790 IF L*A(I)>D THEN 810
800 IF D<U*A(I) THEN 870

810 NEXT I
820 IF NOT Q THEN 840
830 NEXT B
840 NEXT A
850 GOTO 1050
860 ! Display results
870 DISP "R(A)=",FNF(R(A));F$&CHR$(17);
    " ";
880 IF Q THEN DISP "R(B)=",FNF(R(B));F$
    &CHR$(17)
890 IF Q THEN K$=FNK$
900 DISP "  C=",A(I)*10^(6-H);CHR$(12)&
    "fd  "
910 K$=FNK$
920 DISP "Frequency is ";

930 IF NOT Q THEN Z=1/(R(A)*A(I)*10^(-H
    ))

```

-Load data values into array A

-Load values with exponent  
multiplier into array R

-Skip search for R(B) if in 567  
mode

-Display values if they fall  
within tolerance

-Compute frequency as a  
function of component value



# PROGRAM LISTING

```
940 IF Q THEN Z=1.443/((R(A)+R(B)+R(B))
    *A(I)*10^(-H))
950 Z=FNR(FNF(Z),3) @ DISP Z;F$&"Hz"
960 K$=FNK$
970 ! Continuation options
980 DISP CHR$(214);"iew again, ";CHR$(2
    05);"ore, or ";CHR$(197);
990 INPUT "nd? ",M"; Q$ @ Q$=UPRC$(Q$)
1000 IF Q$="M" THEN 1030
1010 IF Q$="V" THEN 870
1020 IF Q$#"E" THEN 980 ELSE 1050
1030 DISP "Searching for more combinatio
    ns"
1040 GOTO 840
1050 DELAY 1 @ DISP @ STOP
```

# PROGRAM DESCRIPTION

## OHMS LAW WITH dBm CONVERSION

dBm Section:      Given watts computes dBm by the formula  $\text{dBm} = 30 + 10 \cdot \log_{10}(\text{watts})$ .  
                              Given dBm computes watts by the formula  $\text{watts} = 10^{((\text{dBm} - 30)/10)}$ .

OHMS Law Section:      Given any two of four inputs, computes volts, Ohms, amps and watts.

Variables Are:      Volts = E    Current = I      = R    Watts = P

Formulas Are:

|             |                        |                   |
|-------------|------------------------|-------------------|
| Given E & R | $I = E/R$              | $P = E^2/R$       |
| Given E & I | $R = E/I$              | $P = E \cdot I$   |
| Given R & I | $E = I \cdot R$        | $P = I^2 \cdot R$ |
| Given P & E | $R = E^2/P$            | $I = P/E$         |
| Given P & R | $E = \sqrt{P \cdot R}$ | $I = \sqrt{P/R}$  |
| Given P & I | $E = P/I$              | $R = P/I^2$       |

Answers are displayed one at a time and scanned forward by pressing the [RTN] key or backward by pressing the [BACK] key.

## SAMPLE PROBLEM

A) How many watts are represented by -13.5 dBm?

Answer: -13.5 dBm is 44.67  $\mu$ watts.

## SOLUTION

| STEP | INSTRUCTIONS        | DISPLAY                          | INPUT       |
|------|---------------------|----------------------------------|-------------|
| A    | Run program         |                                  |             |
| 1    | Select dBm function | Select: 0=Ohms law or D=dBm ?    | D [RTN]     |
| 2    | Sign-on message     | dBm TO WATT(s) to dBm CONVERSION |             |
| 3    | Watts prompt (skip) | Watt(s) =                        | [RTN]       |
| 4    | dBm prompt          | dBm =                            | -13.5 [RTN] |
| 5    | Answer displayed    | -13.5 dBm IS 44.67 $\mu$ WATTS   | [RTN]       |
| 6    | End program         | Run again, View again, or End?   | E [RTN]     |

# SAMPLE PROBLEM

- B) What power rating is required for a resistor of 220 Ohms across a 12 volt power supply?

Answer: 654.55 m watt - use a 1 watt resistor

# SOLUTION

| STEP | INSTRUCTIONS                        | DISPLAY                                                | INPUT     |
|------|-------------------------------------|--------------------------------------------------------|-----------|
| B    | Run program                         |                                                        |           |
| 1    | Select Ohms function                | Select: 0=Ohms law or D=dBm                            | 0 [RTN]   |
| 2    | Sign on message                     | ** OHMS LAW CALCULATOR **                              |           |
| 3    | Input volts                         | VOLTS =                                                | 12 [RTN]  |
| 4    | Input Ohms                          | OHMS =                                                 | 220 [RTN] |
| 5    | Answer:                      volts: | 12 VOLTS                                               | [RTN]     |
|      | Ohms:                               | 220 OHMS                                               | [RTN]     |
|      | amps:                               | 54.55 m AMPS                                           | [RTN]     |
|      | (Use 1 watt resistor) watts:        | 654.55 m WATTS                                         | [RTN]     |
| 6    | End program                         | <u>R</u> un again, <u>V</u> iew again, or <u>E</u> nd? | E [RTN]   |

# USER INSTRUCTIONS

| STEP | INSTRUCTIONS                   | DISPLAY                        | INPUT                   |
|------|--------------------------------|--------------------------------|-------------------------|
| 1    | Run program                    |                                |                         |
| 2    | Select Ohms or dBm function    | Select: 0=Ohms law or D=dBm ?  | 0 or D [RTN]            |
|      | D=dBm selected                 | dBm to WATTS to dBm CONVERSION |                         |
| 2    | Enter value of [RTN]           | WATT(s) =                      | W or [RTN]              |
| 3    | If value for watts then goto 5 |                                |                         |
| 4    | Enter dBm value if known       | dBm =                          | D [RTN]<br>or [RTN]     |
| 5    | Answer stays until [RTN]       | D dBm is W WATTS               | [RTN]                   |
| 6    | Programs options:              | Run again, View again, or End? | R, V, or E<br>[RTN]     |
| 7    | If 'V' then goto 5             |                                |                         |
| 8    | If 'R' then goto 2 else 14     |                                |                         |
|      | (0=Ohms selected)              | ** OHMS LAW CALCULATOR **      |                         |
| 9    | These four prompts will loop   | VOLTS =                        | value [RTN]<br>or [RTN] |
|      | through until two are answered | OHMS =                         | value [RTN]<br>or [RTN] |
|      | with values. ([RTN] skips to   | AMPS =                         | value [RTN]<br>or [RTN] |
|      | next prompt)                   | WATTS =                        | value [RTN]<br>or [RTN] |
| 10   | After two entries the answers  | VOLTS = answer                 | [RTN]/[BACK]            |
|      | are displayed: [RTN] steps     | OHMS = answer                  | [RTN]/[BACK]            |
|      | to next answer, [BACK] steps   | AMPS = answer                  | [RTN]/[BACK]            |
|      | back to previous answer        | WATTS = answer                 | [RTN]/[BACK]            |
| 11   | Program options:               | Run again, View again, or End? | R, V, or E<br>[RTN]     |
| 12   | If 'V' then goto 10            |                                |                         |
| 13   | If 'R' then goto 9             |                                |                         |
| 14   | If 'E' then end program        |                                |                         |

## VARIABLE NAMES

| NAME | DESCRIPTION                          | NAME | DESCRIPTION                             |
|------|--------------------------------------|------|-----------------------------------------|
| C    | Input counter (Z-0)                  | V(4) | Watts (for OHMS law)                    |
| D    | dBm                                  | W    | Watts (for dBm conversion)              |
| F    | Variable passed to function FNF(F)   | X    | For loop counter                        |
| J    | Variable passed to function FNR(F,J) | A\$  | Labels and units                        |
| N    | Binary computed pointer              | F\$  | Units prefix "MK mnp"                   |
| V(1) | Volts                                | K\$  | Single key input                        |
| V(2) | OHMS                                 | X\$  | Value input always converted to numeric |
| V(3) | Amps                                 | Q\$  | Input needs to be followed by [RTN]     |

## NOTES AND REFERENCES

When viewing OHMS law answers [RTN] steps to next answer, [BACK] steps to previous answer. [RTN] after last (WATTS =) answer will fall into continuation prompt for program options.

# PROGRAM LISTING

```

10 ! OHMS LAW & dBm CONVERSION
20 ! Computes VOLTS, AMPS, OHMS &
30 ! WATTS using Ohms Law and
40 ! given any two known inputs
50 ! dBm converts WATTS to dBm &
60 ! dBm to WATTS.
70 ! Revision 11/01/82
80 !
90 DELAY 2
100 DIM A$(24)
110 ! Define Functions
120 ! Fix answer to common unit

130 DEF FNF(F)

140 F$="MK m"&CHR$(12)&"np"
150 J=3
160 IF F<1000 AND F>=1 THEN 240
170 IF F<1 THEN 210
180 IF F=1 THEN 240
190 F=F/1000 @ J=J-1
200 GOTO 160
210 IF J=7 THEN 240
220 F=F*1000 @ J=J+1
230 GOTO 160
240 F$=F$(J,J)
250 FNF=F
260 END DEF
270 !
280 ! Single, upper case key in

290 DEF FNK$
300 K$=KEY$ @ IF K$="" THEN 300
310 FNK$=UPRC$(K$)
320 END DEF
330 !
340 ! Round 'F' to 'J' digits

350 DEF FNR(F,J)
360 F=INT(F*10^J+.5)/10^J
370 FNR=F
380 END DEF
390 !
400 ! Prompt and label strings
410 A$=" VOLTS OHMS AMPS WATTS"
420 ! Selection Ohms or dBm
430 DISP "Select: ";CHR$(207);"=Ohms la
w or ";CHR$(196);"=dBm ";
440 INPUT "?"; K$ @ K$=UPRC$(K$(1,1))
450 IF K$="O" THEN 670
460 IF K$="D" THEN 430
470 ! Fall into dBm routine.
480 DISP "dBm TO WATT(s) TO dBm CONVERS
ION"

```

-FNF(F) CHANGES F TO SMALLEST  
VALUE>1 AND  
-ASSIGNS A UNIT PREFIX F\$ OF  
M,K,' ',m,u,n, or p

-FNK\$ RETURNS SINGLE UPPERCASE  
KEYBOARD INPUT

-FNR(F,J) Round of F to J  
digits

-Expected entries are  
underlined when prompted

-Goto Ohms law routine  
-Try again if not 'dBm'



# PROGRAM LISTING

```

490 INPUT "WATT(s) = "; X$ @ IF X$="" THEN 540 -Skip to dBm entry if no watts
500 ON ERROR GOTO 490
510 W=VAL(X$) @ OFF ERROR @ IF W<=0 THEN 540 -Wait for positive non-zero
N 490 value for watts
520 D=30+10*LOG10(W) -Compute dBm given watts
530 GOTO 580 -Goto answer display
540 INPUT "dBm = "; X$ @ X$=UPRC$(X$) @
IF X$="" THEN 1260
550 ON ERROR GOTO 540
560 D=VAL(X$) @ OFF ERROR -Wait for any numeric value for
dBm
570 W=10^((D-30)/10) -Compute watts given dBm
580 D=FNR(D,2) @ W=FNR(W,2) -Round of dBm and watts to two
places
590 DISP D;"dBm IS ";W;F$&"WATT"; -Display single line answer
600 IF W=1 THEN DISP ELSE DISP "S"
610 K$=FNK$
620 GOSUB 1230
630 IF Q$="V" THEN 590
640 IF Q$="R" THEN 490 ELSE 1260
650 !
660 ! Begin OHMS LAW routine.
670 DISP " * * OHMS LAW CALCULATOR * *
"
680 ! Data entry loop
690 ! Set C and clear variables
700 C=2 @ FOR X=1 TO 4 @ V(X)=0 @ NEXT
X
710 FOR X=1 TO 4 -Prompt for 4 entries and loop
until 2 are entered
720 DISP A$(X*6-5,X*6+1)&" = ";
730 IF V(X) THEN DISP V(X);
740 B=SGN(V(X))
750 INPUT " "; X$ @ IF X$="" THEN 820
760 IF X$="Q" THEN 1260
770 ON ERROR GOTO 790
780 V(X)=VAL(X$) @ OFF ERROR @ GOTO 800
790 DISP "OOPS.. "; @ GOTO 720
800 C=C+(B-SGN(V(X)))
810 IF NOT C THEN X=4
820 NEXT X
830 IF C THEN 710
840 ! Compute answers
850 GOSUB 940
860 ! Display the results
870 GOSUB 1110
880 ! Loop back for more inputs
890 GOTO 680
900 !

```

-Loop back for more variables

# PROGRAM LISTING

```

910 ! Subroutines Follow
920 !
930 ! Find proper formulas
940 N=0 @ FOR X=1 TO 4
950 Z=2^(X-1) @ IF V(X) THEN N=N+Z

960 NEXT X @ N=IP(N/2)
970 ON N GOSUB 1000,1020,1040,1060,1080
,1100
980 RETURN

990 ! Given E & R

1000 V(3)=V(1)/V(2) @ V(4)=V(1)^2/V(2) @
RETURN
1010 ! Given E & I
1020 V(2)=V(1)/V(3) @ V(4)=V(1)*V(3) @ R
RETURN
1030 ! Given R & I
1040 V(1)=V(2)*V(3) @ V(4)=V(3)^2*V(2) @
RETURN
1050 ! Given P & E
1060 V(2)=V(1)^2/V(4) @ V(3)=V(4)/V(1) @
RETURN
1070 ! Given P & R
1080 V(1)=SQR(V(4)*V(2)) @ V(3)=SQR(V(4)
/V(2)) @ RETURN
1090 ! Given P & I
1100 V(1)=V(4)/V(3) @ V(2)=V(4)/V(3)^2 @
RETURN
1110 ! Display results
1120 FOR X=1 TO 4
1130 V=FNR(FNF(V(X)),2)
1140 DISP V;F$&A$[X*6-5,X*6]

1150 Q$=FNK$
1160 IF NUM(Q$)#8 AND NUM(Q$)#13 THEN 11
50
1170 IF NUM(Q$)#8 THEN 1190
1180 X=X-2 @ IF X<0 THEN X=0
1190 NEXT X
1200 GOSUB 1230

1210 IF Q$="V" THEN 1120
1220 IF Q$="R" THEN 700 ELSE 1260
1230 DISP CHR$(210);"un again, ";CHR$(21
4);"iew again, or ";CHR$(197);
1240 INPUT "nd?","R"; Q$ @ Q$=UPRC$(Q$)
1250 IF Q$="V" OR Q$="R" OR Q$="E" THEN
RETURN
1260 DELAY 1 @ DISP @ STOP

```

-Use array V() to create table  
to point to formula

-Return from computation  
subroutine  
-Six possible formula pairs  
follow

-Round off and fix each answer  
-Show value V and unit prefix  
and unit A\$

-Wait for RTN or BACK key

-If BACK key adjust counter

-Prompt continuation options  
and return Q\$

-View answer again

-Run again else stop program

-Wait for R, V, or E before  
returning

-Program always stops here.

# PROGRAM DESCRIPTION

## IMPEDANCE CONVERSION

Given impedance Z and Phase Angle Theta, the Resistance and Reactance, (R & X), Normalized Resistance and Reactance, R(N) & X(N), Reflection Coefficient and Associated Angle, VSWR and Return Loss can all be computed from the following formulas:

$$R = Z * \cos (\theta)$$

$$X = Z * \sin (\theta)$$

$$R(n) = R/\text{characteristic } Z$$

$$X(n) = X/\text{characteristic } Z$$

$$\text{Reflected Angle} = \frac{\sqrt{(R(n)-1)^2 + X(n)^2}}{\sqrt{(R(n)+1)^2 + X(n)^2}}$$

$$\text{Reflection Coefficient} = (57.2958 * \text{ATN } (X(n)/R(n)) - 1) - (57.2958 * \text{ATN } (X(n)/R(n)) + 1)$$

$$\text{VSWR} = (\text{Reflected Angle} + 1) / (1 - \text{Reflected Angle})$$

$$\text{Return Loss} = -20 * .434294 * \text{LOG } (\text{Reflected Angle})$$

## SAMPLE PROBLEM

What is the VSWR and return loss on a  $50\Omega$  line with a characteristic impedance of  $50\Omega$  and a phase angle of  $+36.9$  degrees?

## SOLUTION

| STEP | INSTRUCTIONS                  | DISPLAY                                                  | INPUT      |
|------|-------------------------------|----------------------------------------------------------|------------|
| 1    | Run program                   | ***IMPEDANCE CONVERSION***                               |            |
| 2    | Enter impedance               | Enter Impedance Z =                                      | 50 [RTN]   |
| 3    | Enter phase angle             | Enter angle =                                            | 36.9 [RTN] |
| 4    | Display R & X                 | R=39.985    X=30.021                                     | [RTN]      |
| 5    | Enter characteristic Z        | Characteristic impedance =                               | 50 [RTN]   |
| 6    | Display R(n) & X(n)           | R(n)=.8    X(n)=.6                                       | [RTN]      |
| 7    | Reflected Coefficient & theta | Ref Cof=.334 angle=89.999                                | [RTN]      |
| 8    | Display VSWR & R.L.           | VSWR=2.001    R.L.=9.535                                 | [RTN]      |
| 9    | End program                   | <u>R</u> un again, <u>V</u> iew again, or <u>E</u> nd? R | E [RTN]    |

# USER INSTRUCTIONS

| STEP | INSTRUCTIONS                  | DISPLAY                          | INPUT            |
|------|-------------------------------|----------------------------------|------------------|
| 1    | Run program                   | *** IMPEDANCE CONVERSION ***     |                  |
| 2    | Enter impedance               | Enter Impedance Z =              | Z [RTN]          |
| 3    | Enter phase angle             | Enter angle =                    | Angle [RTN]      |
| 4    | Display R & X                 | R=value          X=value         | [RTN]            |
| 5    | Enter characteristic Z        | Characteristic Impedance =       | Impedance [RTN]  |
| 6    | Display R(n) & X(n)           | R(n)=value      X(n)=value       | [RTN]            |
| 7    | Reflected coefficient & angle | Ref Coef=value   Angle = value   | [RTN]            |
| 8    | Display VSWR & R.L.           | VSWR=value      R.L.=value       | [RTN]            |
| 9    | Program options               | Run again, View again, or End? R | R, V, or E [RTN] |
|      | If 'R' then goto 2            |                                  |                  |
|      | If 'V' then goto 6            |                                  |                  |
|      | If 'E' then end program       |                                  |                  |

|  |                |  |
|--|----------------|--|
|  | VARIABLE NAMES |  |
|--|----------------|--|

| NAME | DESCRIPTION       | NAME  | DESCRIPTION            |
|------|-------------------|-------|------------------------|
| I    | Function variable | P3-P6 | Intermediate values    |
| J    | Function variable | V4    | Reflection coefficient |
| K    | Formula constants | V5    | Angle                  |
| L    | Formula constants | Y3    | VSWR                   |
| M    | Formula constants | Y4    | Return Loss            |
| P1   | R(n)              | K\$   | Single key input       |
| P2   | X(n)              | Q\$   | Continuation input     |

# PROGRAM LISTING

```

10 ! IMPEDANCE CONVERSIONS
20 !
30 ! Convert Z and Theta to
40 ! R & X,      R(n) & X(n),
50 ! and Rho & VSWR.
60 ! Revision 11/01/82
70 !
80 OPTION ANGLE RADIANS
90 ! Define Functions
100 !
110 ! Single, upper case key in
120 DEF FNK$
130 K$=KEY$ @ IF K$="" THEN 130
140 FNK$=UPRC$(K$)
150 END DEF
160 !
170 ! Round 'I' to 'J' digits
180 DEF FNR(I,J)
190 I=INT(I*10^J+.5)/10^J
200 FNR=I
210 END DEF
220 !
230 ! Formula constants
240 K=.434294 @ L=57.2958 @ M=.017453
250 ! Sign on message
260 DISP " * * * IMPEDANCE CONVERSION *
    * *"
270 INPUT "Enter Impedance Z= ";V1
280 INPUT "Enter angle = ";V2
290 V2=V2*M
300 Y1=FNR(V1*COS(V2),3) @ Y2=FNR(V1*SIN(V2),3)
310 DISP "R=";Y1;" X=";Y2
320 K$=FNK$
330 INPUT "Characteristic Impedance = "
    ;V3
340 P1=Y1/V3 @ P2=Y2/V3
350 DISP "R(n)=";FNR(P1,3);" X(n)=";
    FNR(P2,3)
360 P3=SQR((P1+1)^2+P2^2)
370 IF P1+1>0 THEN P4=ATN(P2/(P1+1)) EL
    SE P4=ATN(P2/(P1+1))-PI
380 P4=P4*L
390 P5=SQR((P1-1)^2+P2^2)
400 IF P1-1>0 THEN P6=ATN(P2/(P1-1)) EL
    SE P6=ATN(P2/(P1-1))-PI
410 P6=P6*L
420 V4=P5/P3 @ V5=P6-P4
430 IF V5<=180 AND V5>=-180 THEN 450
440 IF V5>180 THEN V5=V5-360 ELSE V5=V5
    +360
450 Y1=FNR(V4,3) @ Y2=FNR(V5,3)

```

-Adjust phase angle

-Compute R and X

-Compute R(N) and X(N)

-Compute intermediate values

-Compute reflection coefficient  
and angle

-Adjust angle if not in first  
or fourth quadrant

-Adjust angle

# PROGRAM LISTING

```

460 Y3=FNR((V4+1)/(1-V4),3)
470 Y4=FNR(-20*K*LOG(V4),3)
480 K#=FNK#
490 DISP "Ref Cof=";Y1;" angle=";Y2
500 K#=FNK#
510 DISP "VSWR=";Y3;" R.L.=";Y4
520 K#=FNK#
530 !
540 ! Continuation options
550 DISP CHR$(210);"un again, ";CHR$(21
4);"iew again, or ";CHR$(197);
560 INPUT "nd?";"R"; Q# @ Q#=UPRC$(Q#)
570 IF Q##"V" AND Q##"R" AND Q##"E" THE
N 550
580 IF Q#="V" THEN 350
590 IF Q#="R" THEN 270
600 STOP

```

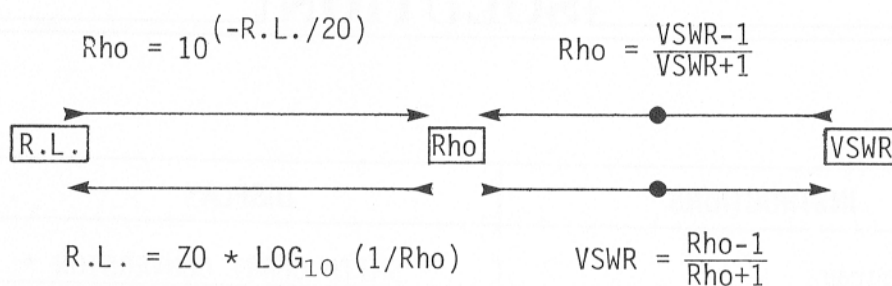
-Compute return loss



# PROGRAM DESCRIPTION

## SMITH CHART CONVERSION

Rho, VSWR, and Return Loss are related by the following diagram.



Given any value the other two are computed.

Practical operating range:

$$0 < \text{Rho} < 1$$

$$0 < \text{VSWR} < Z_0$$

$$1 < \text{R L} < Z_0$$

All three are displayed on a single display line.

**SAMPLE PROBLEM**

If the measured VSWR is 1.6, what are Rho and the return loss?

**SOLUTION**

| STEP | INSTRUCTIONS    | DISPLAY                             | INPUT     |
|------|-----------------|-------------------------------------|-----------|
| 1    | Run program     | * SMITH CHART CONVERSION *          |           |
| 2    | Skip Rho        | Rho =                               | [RTN]     |
| 3    | Skip R L        | Return Loss =                       | [RTN]     |
| 4    | Enter VSWR      | VSWR =                              | 1.6 [RTN] |
| 5    | Display results | Rho=.23 R L=12.74 VSWR=1.6          | [RTN]     |
| 6    | End program     | <u>R</u> un again or <u>E</u> nd? R | E [RTN]   |

# USER INSTRUCTIONS

| STEP | INSTRUCTIONS               | DISPLAY                             | INPUT                   |
|------|----------------------------|-------------------------------------|-------------------------|
| 1    | Run program                | * SMITH CHART CONVERSION *          |                         |
| 2    |                            | Rho =                               | Value [RTN]<br>or [RTN] |
| 3    | If Rho was entered then 9  |                                     |                         |
| 4    | Else                       | Return loss =                       | Value [RTN]<br>or [RTN] |
| 5    | If R L was entered then 9  |                                     |                         |
| 6    | Else                       | VSWR =                              | Value [RTN]<br>or [RTN] |
| 7    | If VSWR was entered then 9 |                                     |                         |
| 8    | Else goto 12               |                                     |                         |
| 9    | Compute results            |                                     |                         |
| 10   | Display results            | Rho=R R L =L VSWR=V                 | [RTN]                   |
| 11   | Program options            | <u>R</u> un again or <u>E</u> nd? R | E [RTN]<br>or [RTN]     |
|      | If [RTN] then 2            |                                     |                         |
|      | If 'E' end program         |                                     |                         |

## VARIABLE NAMES

| NAME | DESCRIPTION                 | NAME | DESCRIPTION                                          |
|------|-----------------------------|------|------------------------------------------------------|
| A    | Temporary value             | V    | VWSR                                                 |
| B    | Temporary value             | K\$  | Single key input                                     |
| F    | Variable passed to function | Q\$  | Response to program options                          |
| J    | Variable passed to function | X\$  | String input always converted to A by<br>A=VAL(=O\$) |
| L    | Return loss (R.L.)          |      |                                                      |
| R    | Rho                         | P\$  | Prompt string passed to non-error input subroutine   |

## NOTES AND REFERENCES

Practical limits:    0   Rho   1  
                              0   VSWR   Z0  
                              1   R.L.   Z0

Reference: From Hewlett-Packard Users' Library program number 00031D

# PROGRAM LISTING

```

10 ! SMITH CHART CONVERSION
20 ! VSWR, Rho and Return Loss
30 ! are each related and given
40 ! any one the other two will
50 ! be computed.
60 ! Revision 11/01/82
70 !
80 DELAY 2
90 DIM P$(20)
100 ! Define Functions
110 !
120 ! Single, upper case key in
130 DEF FNK$
140 K$=KEY$ @ IF K$="" THEN 140
150 FNK$=UPRC$(K$)
160 END DEF
170 !
180 ! Round 'F' to 'J' digits
190 DEF FNR(F,J)
200 F=INT(F*10^J+.5)/10^J
210 FNR=F
220 END DEF
230 !
240 ! Main program loop
245 DISP " * SMITH CHART CONVERSION *
"
250 R,V,L=0
260 P$="Rho = " @ GOSUB 550
270 IF A THEN 330

280 P$="Return Loss = " @ GOSUB 550
290 IF A THEN 380

300 P$="VSWR = " @ GOSUB 550
310 IF A THEN 430 ELSE 500

320 ! Compute VSWR & R.L.
330 R=A
340 A=R+1 @ B=R-1 @ V=-A/B
350 L=20*LOG10(1/R)
360 GOTO 470
370 ! Compute Rho & VSWR
380 L=A
390 R=10^(-L/20)
400 A=R+1 @ B=R-1 @ V=-A/B
410 GOTO 470
420 ! Compute Rho
430 V=A
440 A=V-1 @ B=V+1 @ R=A/B
450 GOTO 350
460 ! Display results
470 DISP "Rho=";FNR(R,2);" RL=";FNR(L,2)
;" VSWR=";FNR(V,1)
480 K$=FNK$

```

-If Rho input#0 then compute RL  
and VSWR

-If RL#0 then compute Rho and  
VSWR

-If A then compute else goto  
continue options

-Goto display

-Goto display

-Go compute RL

# PROGRAM LISTING

```
490 ! Continuation options
500 DISP CHR$(210); "un again or "; CHR$(
    197);
510 INPUT "nd ", "R"; Q$ @ Q$=UPRC$(Q$)
520 IF Q$#"R" AND Q$#"E" THEN 500
530 IF Q$="R" THEN 250 ELSE 600
540 ! Non-error input
550 DISP P$;
560 INPUT " "; X$ @ IF X$="" THEN X$="0"
570 ON ERROR GOTO 550
580 A=VAL(X$) @ OFF ERROR
590 RETURN
600 DELAY 1 @ DISP @ STOP
```

-Return A=0 for null input

# PROGRAM DESCRIPTION

## MISMATCH

Mismatch uncertainty in dB can be computed given two VSWR's and the constant  $K=.434294$  using the following formulas:

$$\text{Rho1} = \text{P1} = (\text{VSWR1}-1) / (\text{VSWR1}+1)$$

$$\text{Rho2} = \text{P2} = (\text{VSWR2}-1) / (\text{VSWR2}+1)$$

$$\text{Positive error} = 20 * K * \text{LOG}(1 + \text{P1} * \text{P2})$$

$$\text{Negative error} = 20 * K * \text{LOG}(1 - \text{P1} * \text{P2})$$

## SAMPLE PROBLEM

What is the mismatch uncertainty in dB of two VSWR's  $V_1=2.43$  and  $V_2=4.56$ ?

Answer: +2.055 dB  
-2.697 dB

## SOLUTION

| STEP | INSTRUCTIONS           | DISPLAY                                                         | INPUT      |
|------|------------------------|-----------------------------------------------------------------|------------|
| 1    | Run program            | ***MISMATCH***                                                  |            |
| 2    | Enter first VSWR       | Enter first VSWR?                                               | 2.43 [RTN] |
| 3    | Enter second VSWR      | Enter second VSWR?                                              | 4.56 [RTN] |
| 4    | Display positive error | Plus 2.055 dB                                                   | [RTN]      |
| 5    | Display negative error | Minus 2.697 dB                                                  | [RTN]      |
| 6    | End program            | <u>R</u> un again, <u>V</u> iew again or <u>E</u> nd? R E [RTN] |            |



# USER INSTRUCTIONS

| STEP | INSTRUCTIONS            | DISPLAY                                                  | INPUT                |
|------|-------------------------|----------------------------------------------------------|----------------------|
| 1    | Run program             | *** MISMATCH ***                                         |                      |
| 2    | Enter first VSWR        | Enter first VSWR                                         | First VSWR<br>[RTN]  |
| 3    | Enter second VSWR       | Enter second VSWR                                        | Second VSWR<br>[RTN] |
| 4    | Display positive error  | Plus -value- dB                                          | [RTN]                |
| 5    | Display negative error  | Minus -value- dB                                         | [RTN]                |
| 6    | Program options         | <u>R</u> un again, <u>V</u> iew again, or <u>E</u> nd? R | R, V, or E<br>[RTN]  |
|      | If 'R' then step 2      |                                                          |                      |
|      | If 'V' then step 4      |                                                          |                      |
|      | If 'E' then end program |                                                          |                      |

## VARIABLE NAMES

| NAME | DESCRIPTION                | NAME | DESCRIPTION               |
|------|----------------------------|------|---------------------------|
| I    | Function variable          | V1   | VSWR 1                    |
| J    | Function variable          | V2   | VSWR 2                    |
| K    | Formula constant (.434294) | Y1   | Positive error            |
| P1   | Rho of VSWR 1              | Y2   | Negative error            |
| P2   | Rho of VSWR 2              | K\$  | Single key input          |
|      |                            | Q\$  | Continuation option input |

## NOTES AND REFERENCES

Accuracy for VSWR >15 uncertain. From Series 80 Electrical Engineering Solution Book.

# PROGRAM LISTING

```

10 ! MISMATCH
20 !
30 ! Compute the mismatch
40 ! uncertainty in dB based
50 ! on two VSWR's.
60 ! Revision 11/01/82
70 !
80 DELAY 2
90 ! Define Functions
100 !
110 ! Single, upper case key in
120 DEF FNK$
130 K$=KEY$ @ IF K$="" THEN 130
140 FNK$=UPRC$(K$)
150 END DEF
160 !
170 ! Round 'I' to 'J' digits
180 DEF FNR(I,J)
190 I=INT(I*10^J+.5)/10^J
200 FNR=I
210 END DEF
220 !
230 ! Formula constant
240 K=.434294
250 ! Sign on message
260 DISP " *** M I S M A T C H ***
      *"
270 INPUT "Enter first VSWR ? ";V1
280 P1=(V1-1)/(V1+1)
290 INPUT "Enter second VSWR ? ";V2
300 P2=(V2-1)/(V2+1)
310 Y1=ABS(FNR(20*K*LOG(1+P1*P2),3))
320 Y2=ABS(FNR(20*K*LOG(1-P1*P2),3))
330 DISP "Plus ";Y1;"dB"
340 K$=FNK$
350 DISP "Minus ";Y2;"dB"
360 K$=FNK$
370 ! Re-run option select
380 DISP CHR$(210);"un again, ";CHR$(21
4);"iew again, or ";CHR$(197);
390 INPUT "nd?";"R"; Q$ @ Q$=UPRC$(Q$)
400 IF Q$#"V" AND Q$#"R" AND Q$#"E" THE
      N 380
410 IF Q$="V" THEN 330
420 IF Q$="R" THEN 270
430 DELAY 1 @ DISP @ STOP

```

-Drop sign as answer is the proper sign  
 -Drop sign as answer label is the proper sign

# PROGRAM DESCRIPTION

## dB TO % TO dB CONVERSION

It is sometimes necessary to convert a voltage or power change expressed as a percentage to a change expressed as a dB ratio.

1. To convert dB to % use the following formulas:

$$\begin{aligned}
 P2 &= 10^{(D/10)} & P1 &= \sqrt{P2} & D &= \text{dB} \\
 \text{Voltage \% increase} &= 100*(P1-1) \\
 \text{Voltage \% decrease} &= 100*(P1-1)/P1 \\
 \text{Power \% increase} &= 100*(P2-1) \\
 \text{Power \% decrease} &= (P2-1)/P2
 \end{aligned}$$

2. To convert % to a dB ratio use the following P=% change

$$\begin{aligned}
 \text{Voltage dB increase} &= V1 = |(20*\text{LOG}_{10} (1/(1+P/100)))| \\
 \text{Voltage dB decrease} &= V2 = |(20*\text{LOG}_{10} (1/(1-P/100)))| \\
 \text{Power dB increase} &= P1 = V1/2 \\
 \text{Power dB decrease} &= P2 = V2/2
 \end{aligned}$$

Limited range is:  $0 < \text{dB} < 30$

For % a value  $\geq 100$  will not compute a decrease as decreases can not exceed 100%.

# SAMPLE PROBLEM

A) What is the % of power increase for a dB increase of 4.8?

## SOLUTION

| STEP           | INSTRUCTIONS       | DISPLAY                          | INPUT     |
|----------------|--------------------|----------------------------------|-----------|
| A <sub>1</sub> | Run program        | ** dB to % to dB Conversion **   |           |
| 2              | Select operation D | Select: % >dB or dB >%? %        | D [RTN]   |
| 3              | Enter dB ratio     | Enter: dB =                      | 4.8 [RTN] |
| 4              | Display voltage %  | Voltage = +73.78% -42.46%        | [RTN]     |
| 5              | Display power %    | Power = +202% -66.89%            | [RTN]     |
| 6              | End program        | Run again, View again, or End? R | E [RTN]   |

# SAMPLE PROBLEM

B) What is the dB change for a 45% change in voltage?

## SOLUTION

| STEP           | INSTRUCTIONS        | DISPLAY                                                          | INPUT    |
|----------------|---------------------|------------------------------------------------------------------|----------|
| B <sub>1</sub> | Run program         | ** dB to % to dB Conversion **                                   |          |
| 2              | Select default %    | Select % >dB or dB >%? %                                         | [RTN]    |
| 3              | Enter % of change   | Enter: Percent =                                                 | 45 [RTN] |
| 4              | Display voltage, dB | Voltage = +3.23dB -5.19dB                                        | [RTN]    |
| 5              | Display power, dB   | Power = +1.61dB -2.59dB                                          | [RTN]    |
| 6              | End program         | <u>R</u> un again, <u>V</u> iew again, or <u>E</u> nd? R E [RTN] |          |

# USER INSTRUCTIONS

| STEP | INSTRUCTIONS            | DISPLAY                          | INPUT               |
|------|-------------------------|----------------------------------|---------------------|
| 1    | Run program             | ** dB to % to dB Conversion **   |                     |
| 2    | Select operation        | Select: % >dB or dB >%? %        | [RTN] or<br>D [RTN] |
| 3    | If D then goto 8        |                                  |                     |
| 4    | Enter % of change       | Enter: Percent =                 | %value [RTN]        |
| 5    | Display voltage dB      | Voltage = +Val dB -Val dB        | [RTN]               |
| 6    | Display power in dB     | Power = +Val dB -Val dB          | [RTN]               |
| 7    | Program options:        | Run again, View again, or End? R | R, V, or E<br>[RTN] |
|      | If 'R' then 4           |                                  |                     |
|      | If 'V' then 5           |                                  |                     |
|      | If 'E' then end program |                                  |                     |
|      |                         |                                  |                     |
| 8    | Enter dB ratio          | Enter: dB =                      | dB value<br>[RTN]   |
| 9    | Display voltage %       | Voltage = +Val % -Val %          | [RTN]               |
| 10   | Display power %         | Power = +Val % -Val %            | [RTN]               |
| 11   | Program options         | Run again, View again, or End? R | R, V, or E<br>[RTN] |
|      | If 'R' then 4           |                                  |                     |
|      | If 'V' then 5           |                                  |                     |
|      | If 'E' then end program |                                  |                     |

# VARIABLE NAMES

| NAME | DESCRIPTION          | NAME | DESCRIPTION                   |
|------|----------------------|------|-------------------------------|
| D    | dB input             | V3   | Power dB increase             |
| I    | Function variable    | V4   | Power dB decrease             |
| J    | Function variable    | V7   | Voltage intermediate variable |
| P1   | Intermediate voltage | Y1   | Voltage % increase            |
| P2   | Intermediate power   | Y2   | Voltage % decrease            |
| Q    | Flag 1=%>dB 0=dB>%   | Y3   | Power % increase              |
| V1   | Voltage dB increase  | Y4   | Power % decrease              |
| V2   | Voltage dB decrease  | K\$  | Single key input              |
|      |                      | Q\$  | Continuation options input    |



# PROGRAM LISTING

```

10 ! dB to % to dB CONVERSION
20 ! Convert a dB ratio to a
30 ! % of voltage and current
40 ! increase and decrease and
50 ! visa-versa.
60 ! Revision 11/01/82
70 !
80 DELAY 2
90 ! Define Functions
100 !
110 ! Single, upper case key in
120 DEF FNK$
130 K$=KEY$ @ IF K$="" THEN 130
140 FNK$=UPRC$(K$)
150 END DEF
160 !
170 ! Round 'I' to 'J' digits
180 DEF FNR(I,J)
190 I=INT(I*10^J+.5)/10^J
200 FNR=I
210 END DEF
220 !
230 ! Sign on message
240 DISP " * * dB to % to dB Conversion
    * *"
250 DISP "Select:  ";CHR$(165);" > dB
    or  ";CHR$(228);"B > % ";
260 INPUT "?","%"; Q$ @ Q$=UPRC$(Q$)
270 IF Q$#%" AND Q$#D" THEN 250

280 IF Q$="%" THEN 450
290 ! Convert dB to percent
300 Q=0 @ INPUT "Enter:  dB = ";D
310 D=ABS(D) @ IF D>30 THEN 300

320 P2=10^(D/10)
330 P1=SQR(P2)
340 ! Convert + & - Voltages
350 V7=P1 @ GOSUB 430
360 Y1=FNR(V3,2) @ Y2=FNR(V4,2)
370 ! Convert + & - Powers
380 V7=P2 @ GOSUB 430
390 Y3=FNR(V3,2) @ Y4=FNR(V4,2)
400 DISP "Voltage =  +";Y1;"%  ";Y2;"%
    " @ K$=FNK$
410 DISP "Power =  +";Y3;"%  ";Y4;"%" @
    K$=FNK$
420 GOTO 530
430 V3=100*(V7-1) @ V4=-100*(V7-1)/V7 @
    RETURN
440 ! Convert percent to dB
450 Q=1 @ INPUT "Enter:  Percent = ";P
460 V1=ABS(20*LOG10(1/(1+P/100)))
470 IF P>=100 THEN P=0

```

-Wait for proper selection,  
either '%' or 'D'

-Keep dB positive and <=30 else  
answer too long

-Display voltage as % and wait  
for key

-Display power as % and wait  
for key

-Goto continuation options  
-Subroutine for dB to %

# PROGRAM LISTING

```

480 V2=ABS(20*LOG10(1/(1-P/100)))
490 V3=FNR(V1/2,2) @ V4=FNR(V2/2,3) @ V
    1=FNR(V1,2) @ V2=FNR(V2,2)
500 DISP "Voltage =  +";V1;"dB    -";V2;
    "dB" @ K$=FNK$
510 DISP "Power =    +";V3;"dB    -";V4;"
    dB" @ K$=FNK$
520 ! Continuation options
530 DISP CHR$(210);"un again, ";CHR$(21
    4);"iew again, or ";CHR$(197);
540 INPUT "nd?";"R"; Q$ @ Q$=UPRC$(Q$)
550 IF Q##"V" AND Q##"R" AND Q##"E" THE
    N 530
560 IF Q##"V" THEN 580
570 IF Q THEN 500 ELSE 400

580 IF Q##"R" THEN 600
590 IF Q THEN 450 ELSE 300

600 DELAY 1 @ DISP @ STOP

```

-Display voltage in dB and wait  
for key

-Display power in dB and wait  
for key

-Goto proper view routine based  
on Q

-Goto proper run routine based  
on Q

# PROGRAM DESCRIPTION

## BUTTERWORTH FILTER DESIGN

The common Butterworth Filter (BF) is made up of an odd number of components with each section of a low pass filter looking like this:



And each section of a High Pass filter like this:



Where 'T' is the final terminating element.

$L_K$  &  $C_K$  coefficients are determined by:

$Q_K = Z * \sin(2 * K - 1) * \pi / 2 * N$  where  $K$  is each element number 1 thru  $N$  and  $N$  is total or last element number.

Actual component values are determined by:

$$C_K = Q_K / (R * W) \quad L_K = Q_K * R / W \text{ for low pass.}$$

$$C_K = 1 / (Q_K * R * W) \quad L_K = R * (1 / Q_K / W)$$

In this program  $3 \leq N \leq 19$  and is always ODD.

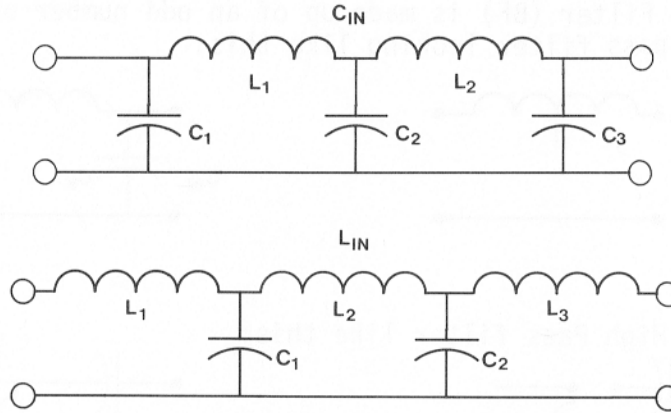
To use the program provide the number of elements, cut-off frequency, and terminating impedance. Choose between a low pass or high pass filter. The program will display values for all the  $C_{in}$  sections followed by the single termination value. The program will then display the corresponding values for  $L_{in}$ , and the termination value.

The display can be stepped forward with the [RTN] key or backward with the [BACK] key.

Negative values on any component means the filter cannot be designed properly around the given parameters.

## SAMPLE PROBLEM

Design a Low Pass filter with a cut-off frequency of 10 MHz and five elements as shown in the schematic. Assume a  $50\Omega$  terminating impedance.



## SOLUTION

| STEP | INSTRUCTIONS              | DISPLAY                           | INPUT          |
|------|---------------------------|-----------------------------------|----------------|
| 1    | Run program               | *BUTTERWORTH FILTER DESIGN*       |                |
| 2    | Set number of element     | Number of elements ( $\leq 19$ )? | 5 [RTN]        |
| 3    | Select Low Pass           | Low Pass or High Pass?            | L [RTN]        |
| 4    | Set cut-off frequency     | Cut-off frequency?                | 10000000 [RTN] |
| 5    | Set terminating impedance | Terminating impedance?            | 50 [RTN]       |
| 6    |                           | Low pass filter [RTN] to VIEW     | [RTN]          |
| 7    | Display values:           | C(in) 1 196.73pfd 1.29 $\mu$ H    | [RTN]          |
| 8    |                           | C(in) 2 636.62pfd 1.29 $\mu$ H    | [RTN]          |
| 9    |                           | C(in) 3 196.726pfd                | [RTN]          |
| 10   |                           | L(in) 1 491.82nH 515.04pfd        | [RTN]          |
| 11   |                           | L(in) 2 1.59 $\mu$ H 515.04pfd    | [RTN]          |
| 12   |                           | L(in) 3 491.816nH                 | [RTN]          |
| 13   | End program               | Run again, View again, or End? R  | E [RTN]        |

# USER INSTRUCTIONS

| STEP | INSTRUCTIONS                | DISPLAY                                                  | INPUT               |
|------|-----------------------------|----------------------------------------------------------|---------------------|
| 1    | Run program                 | *BUTTERWORTH FILTER DESIGN*                              |                     |
| 2    | Enter number of elements    | Number of elements (<=19)?                               | N [RTN]             |
| 3    | Enter Low or High Pass      | <u>L</u> ow Pass or <u>H</u> igh Pass?                   | L or H [RTN]        |
| 4    | Enter cut-off frequency     | Cut-off frequency?                                       | W [RTN]             |
| 5    | Enter terminating impedance | Terminating impedance?                                   | R [RTN]             |
| 6    | Display output section      | High pass filter..[RTN] to view                          | [RTN]               |
| 7    | or                          | Low pass filter..[RTN] to view                           | [RTN]               |
| 8    | First C input element       | C(in)1   C1   L1                                         | [RTN]/[BACK]        |
| 9    | Continue display on         |                                                          | [RTN]               |
| 10   | Termination element         | C(in)n   C <sub>n</sub>                                  |                     |
| 11   | First L input element       | L(in)1   L1   C1                                         | [RTN]/[BACK]        |
| 12   | Continue display on         |                                                          | [RTN]               |
| 13   | Terminating L element       | L(in)n   L <sub>n</sub>                                  | [RTN]               |
| 14   | Program options             | <u>R</u> un again, <u>V</u> iew again, or <u>E</u> nd? R | R, V, or E<br>[RTN] |
| 15   | If 'V' goto 6               |                                                          |                     |
| 16   | If 'R' goto 2               |                                                          |                     |
| 17   | If 'E' then end program     |                                                          |                     |

## VARIABLE NAMES

| NAME | DESCRIPTION               | NAME | DESCRIPTION            |
|------|---------------------------|------|------------------------|
| C(n) | Capacitor array           | W    | Cut-off frequency      |
| F    | Value passed to functions | Z    | ON Z GOTO pointer      |
| G(n) | Coefficient array         | Q    | Section counter        |
| I    | Loop counter              | F\$  | Returned from function |
| J    | Value passed to function  | K\$  | Single key input       |
| L(n) | Inductance array          | O\$  | String inputs          |
| R    | Termination impedance     | M\$  | Display header string  |
| N    | Number of elements        |      |                        |

## NOTES AND REFERENCES

NOTE: Any negative computed value indicates the filter can not be designed properly with the parameters given.

From Series 80 Electrical Engineering Solution Book.

# PROGRAM LISTING

```

10 ! PASSIVE BUTTERWORTH
20 ! FILTER DESIGN
30 ! Compute the inductor and
40 ! capacitor combinations,
50 ! required to construct a
60 ! passive butterworth filter.
70 ! Revision 11/01/82
80 DELAY 2
90 ! Define Functions
100 !
110 ! Wait for a 'RTN'
120 DEF FNK$
130 K$=KEY$ @ IF K$="" THEN 130
140 IF NUM(K$)#13 THEN 130
150 FNK$=K$
160 END DEF
170 !
180 ! Round 'F' to 'J' digits
190 DEF FNR(F,J)
200 F=INT(F*10^J+.5)/10^J
210 FNR=F
220 END DEF
230 !
240 ! Fix values to common units.
250 DEF FNF(F)
260 J=3 @ F$="MK m"&CHR$(12)&"np"
270 IF F<1000 AND F>=1 THEN 320
280 IF F>1000 THEN 300
290 F=F*1000 @ J=J+1 @ GOTO 310
300 F=F/1000 @ J=J-1
310 IF J#1 AND J#7 THEN 270
320 IF J=3 THEN F$="" ELSE F$=F$(J,J)
330 FNF=F
340 END DEF
350 !
360 DIM C(20),G(20),L(20)
370 ! Main program loop
380 DISP " * BUTTERWORTH FILTER DESIGN
    *"
390 DELAY 0
400 INPUT "Number of elements ( <=19 )?
    "; N @ N=ABS(N)
410 IF N/2=INT(N/2) OR N>19 OR N<3 THEN
    400
420 FOR I=1 TO N
430 G(1)=2*SIN((2*I-1)*PI/(2*N))
440 NEXT I
450 DISP CHR$(204);"ow pass or ";CHR$(2
    00);"igh pass ";
460 INPUT "?"; Q$ @ Q$=UPRC$(Q$)
470 IF Q$#"H" AND Q$#"L" THEN 450
480 IF Q$="L" THEN Z=1

```

-CHR\$(12) is micro symbol

-G is coefficient of Ck and Lk

-Be sure that N is positive

-N must be odd

-Set coefficient for each  
element

-Wait for 'H' or 'L'

-Z is flag for High Pass or Low  
Pass

# PROGRAM LISTING

```

490 IF Q$="H" THEN Z=2
500 INPUT "Cut-off frequency?";W
510 W=2*PI*W
520 INPUT "Terminating impedance?";R
530 ON Z GOTO 550,610
540 ! Low pass
550 FOR I=1 TO N
560 C(I)=G(I)/(R*W) @ L(I)=G(I)*R/W
570 NEXT I
580 M$="Low pass filter..."
590 GOTO 660
600 ! High pass
610 FOR I=1 TO N
620 C(I)=1/(G(I)*R*W) @ L(I)=R*(1/G(I)/
W)
630 NEXT I
640 M$="High pass filter.."
650 ! Display results
660 DISP M$;
670 INPUT "[RTN] to view";Q$
680 FOR I=1 TO N-2 STEP 2

690 Q=IP(I/2)+1
700 DISP "C(in)";Q;
710 DISP FNR(FNF(C(I)),2);F$&"fd ";
720 DISP FNR(FNF(L(I+1)),2);F$&"H"
730 K$=KEY$ @ IF K$="" THEN 730
740 IF NUM(K$)#8 AND NUM(K$)#13 THEN 73
0
750 IF NUM(K$)=13 THEN 770
760 I=I-4 @ IF I<0 THEN I=-1
770 NEXT I
780 DISP "C(in)";Q+1;" ";FNR(FNF(C(N)
),3);F$&"fd"
790 K$=FNK$
800 FOR I=1 TO N-2 STEP 2

810 Q=IP(I/2)+1
820 DISP "L(in)";Q;
830 DISP FNR(FNF(L(I)),2);F$&"H ";
840 DISP FNR(FNF(C(I+1)),2);F$&"fd"
850 K$=KEY$ @ IF K$="" THEN 850
860 IF NUM(K$)#13 AND NUM(K$)#8 THEN 85
0
870 IF NUM(K$)=13 THEN 890
880 I=I-4 @ IF I<0 THEN I=-1
890 NEXT I
900 DISP "L(in)";Q+1;" ";FNR(FNF(L(N)
),3);F$&"H"
910 K$=FNK$
920 ! Continuation options
930 DISP CHR$(210);"un again, ";CHR$(21
4);"iew again, or ";CHR$(197);
940 INPUT "nd?";"R"; Q$ @ Q$=UPRC$(Q$)
950 ON POS('RVE',Q$)+1 GOTO 930,400,650
,960
960 DELAY 1 @ DISP @ STOP

```

-Select filter type

-Display header message

-Display header message

-Loop to display C(input)  
values

-Q is the section counter

-Step back to previous values

-Loop to display L(input)  
values

-Step back to previous answer



# PROGRAM DESCRIPTION

## ACTIVE FILTER DESIGN

Using constants from a published data table, resistors for high pass filters or capacitors for low pass filters can be computed using the formulas:

$$\begin{aligned} \text{High Pass} \quad & RA = K / (12.56 * F * C) * 2 \quad \& \quad RB = 1 / (RA * C^2 * (2PI * F)^2) \\ \text{Low Pass} \quad & CA = 1 / (R * (2PI * F) * K) \quad \& \quad CB = K / (2PI * F * R) \\ & K = \text{constant} \end{aligned}$$

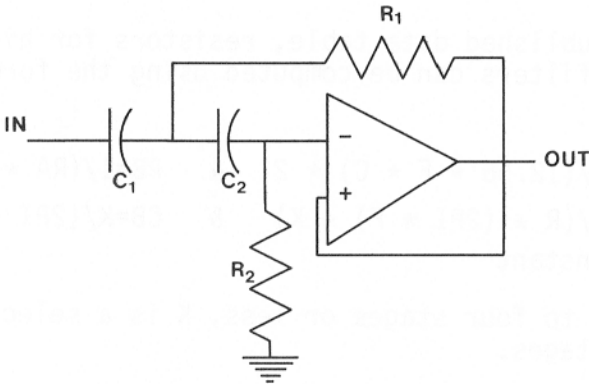
In this program, limited to four stages or less, K is a selected set of values based on the number of stages.

|              |              |                                                                                    |
|--------------|--------------|------------------------------------------------------------------------------------|
| Single stage | K=K(1)       | Array K is loaded with the proper values one time early in program initialization. |
| Two stages   | K=K(2)-K(3)  |                                                                                    |
| Three stages | K=K(4)-K(6)  |                                                                                    |
| Four stages  | K=K(7)-K(10) |                                                                                    |

Results are computed into array A(x) and displayed two at a time for each stage.

SAMPLE PROBLEM

Using the schematic, design a high pass filter with a cut-off frequency of 1KHz, attenuation of 48 db per octave and a capacitor value of .001 mfd.



To cascade stages, change the component labels to their label plus the stage number. i.e.: for three stages:

|         |    |    |
|---------|----|----|
| Stage 1 | R1 | R2 |
|         | C1 | C2 |
| Stage 2 | R3 | R4 |
|         | C3 | C4 |
| Stage 3 | R5 | R6 |
|         | C5 | C6 |

SOLUTION

| STEP | INSTRUCTIONS               | DISPLAY                                   | INPUT      |
|------|----------------------------|-------------------------------------------|------------|
| 1    | Run program                | ** ACTIVE FILTER DESIGN **                |            |
| 2    | Enter cut-off frequency    | Cut-off frequency in Hz?                  | 1000 [RTN] |
| 3    | Select filter mode         | High pass or Low pass? L                  | H [RTN]    |
| 4    | Select att. per octave     | Attneuation (12,24,36,48)? 12             | 48 [RTN]   |
| 5    | Enter value for C          | C in microfarads =                        | .001 [RTN] |
| 6    | Display section values for | S1: R1=31.1K $\Omega$ R2=816.2K $\Omega$  | [RTN]      |
|      | each section S             | S2: R3=88.5K $\Omega$ R4=286.6K $\Omega$  | [RTN]      |
|      |                            | S3: R5=132.4K $\Omega$ R6=191.5K $\Omega$ | [RTN]      |
|      |                            | S4: R7=156.2K $\Omega$ R8=162.4K $\Omega$ | [RTN]      |
| 7    | End program                | Run again, View again, or End? R          | E [RTN]    |

# USER INSTRUCTIONS

| STEP | INSTRUCTIONS                  | DISPLAY                          | INPUT               |
|------|-------------------------------|----------------------------------|---------------------|
| 1    | Run program                   | ** ACTIVE FILTER DESIGN**        |                     |
| 2    | Enter cut-off frequency       | Cut-off frequency in Hz?         | F [RTN]             |
| 3    | Enter High or Low Pass        | High Pass or Low Pass? L         | H [RTN]<br>or [RTN] |
| 4    | Enter attenuation per octave  | Attenuation (12,24,36,48)? 12    | Select [RTN]        |
| 5    | If Low Pass                   | R in Ohms =                      | R [RTN]             |
| 6    | If High Pass                  | C in microfarads =               | C [RTN]             |
| 7    | Display results:              |                                  |                     |
| 8    | If Low Pass                   | S#: C#=value      C#+1=value     | [RTN]               |
| 9    | If High Pass                  | S#: R#=value      R#+1=value     | [RTN]               |
| 10   | Repeat for number of sections |                                  |                     |
|      | based on attenuation per      |                                  |                     |
|      | octave                        |                                  |                     |
| 11   | Program options               | Run again, View again, or End? R | R, V, or E<br>[RTN] |
|      | If 'R' goto 2                 |                                  |                     |
|      | If 'V' goto 7                 |                                  |                     |
|      | If 'E' end program            |                                  |                     |

## VARIABLE NAMES

| NAME | DESCRIPTION                                                    | NAME | DESCRIPTION           |
|------|----------------------------------------------------------------|------|-----------------------|
| A    | Attenuation token                                              | Z    | Constant K(z) pointer |
| F    | Cut-off frequency                                              | A( ) | Answer array          |
| I    | Function variable                                              | K( ) | Constant array        |
| J    | Function variable                                              | F\$  | Function string       |
| P    | High Pass=1<br>Low Pass=0 Flag                                 | K\$  | Single key input      |
| S    | Section number for display                                     | L\$  | Label string          |
| V    | Capacitor Value on High<br>Pass, Resistor Value on<br>Low Pass | P\$  | Prompt string         |
|      |                                                                | U\$  | Units string          |
| X    | Loop counter                                                   | Q\$  | Options input         |

## NOTES AND REFERENCES

When viewing results, step forward with the [RTN] key and backward with the [BACK] key.

Answers greater than 999M will "spill" off the display.

# PROGRAM LISTING

```

10 ! ACTIVE FILTER DESIGN
20 ! Computes resistor and
30 ! capacitor combinations
40 ! needed to design an
50 ! active, OP AMP filter.
60 ! Revision 11/01/82
70 !
80 DELAY 2
90 DIM A(8),K(10),P$(20),L$(5),U$(2),Q
  $(11)
100 FOR X=1 TO 10 @ READ K(X) @ NEXT X
110 DATA .707,.3827,.9239,.2588,.7071,.
  9659,.1951,.5556,.8315,.9808
120 ! Define Functions
130 ! Fix answer to common unit
140 DEF FNF(I)
150 F$="MK m"&CHR$(12)&"np"
160 J=3
170 IF I<1000 AND I>=1 THEN 250
180 IF I<1 THEN 220
190 IF I=1 THEN 250
200 I=I/1000 @ J=J-1
210 GOTO 170
220 IF J=7 THEN 250
230 I=I*1000 @ J=J+1
240 GOTO 170
250 F$=F$(J,J)
260 FNF=I
270 END DEF
280 !
290 ! Single, upper case key in
300 DEF FNK$
310 K$=KEY$ @ IF K$="" THEN 310
320 FNK$=UPRC$(K$)
330 END DEF
340 !
350 ! Round 'F' to 'J' digits
360 DEF FNR(I,J)
370 I=INT(I*10^J+.5)/10^J
380 FNR=I
390 END DEF
400 !
410 ! Sign on message
420 DISP "  * * ACTIVE FILTER DESIGN *
  *"
430 INPUT "Cut-off frequency in Hz? ";F
440 DISP CHR$(200);"igh pass or ";CHR$(
  204);
450 INPUT "ow pass?","L"; Q$ @ Q$=UPRC
  $(Q$)
460 IF Q$#"H" AND Q$#"L" THEN 440
470 ! Set Hi / Lo flag P
480 IF Q$="L" THEN P=0 ELSE P=1

```

-Load constant array K(X) with  
vales from DATA stmt

-CHR\$(12) is symbol for micro

-Select High-Pass or Low-Pass

# PROGRAM LISTING

```

490 ! Set prompt label P$
500 IF P THEN P$="C in microfarads = "
    ELSE P$="R in ohms = "
510 ! Set answer label L$
520 IF P THEN L$="R" ELSE L$="C"
530 ! Set answer units U$
540 IF P THEN U$=CHR$(17) ELSE U$="fd"
550 INPUT "Attenuation (12, 24, 36, 48)
    ?","12";A
560 IF A/12#IP(A/12) THEN 550 ELSE A=A/
    12
570 IF A<1 OR A>4 THEN 550
580 DISP P$; @ INPUT "";V
590 IF P THEN V=V*.000001
600 Z=0 @ FOR X=1 TO A @ Z=X+Z-1 @ NEXT
    X @ Z=Z+1
610 FOR X=1 TO A*2 STEP 2
620 IF P THEN 650
630 A(X)=1/(V*(6.28*F)*K(Z))
640 A(X+1)=K(Z)/(6.28*F*V) @ GOTO 670
650 A(X)=K(Z)/(12.56*F*V)*2
660 A(X+1)=1/(A(X)*V^2*(6.28*F)^2)
670 Z=Z+1
680 NEXT X
690 ! Display the answers
700 S=1
710 FOR X=1 TO A*2 STEP 2
720 DISP "S"&STR$(S)&": ";
730 DISP L$&STR$(X)&="";FNR(FNF(A(X)),1
    );F$&U$&" ";
740 DISP L$&STR$(X+1)&="";FNR(FNF(A(X+1
    )),1);F$&U$
750 K$=FNK$
760 IF NUM(K$)#13 AND NUM(K$)#8 THEN 75
    0
770 IF NUM(K$)=13 THEN 810
780 ! Step backwards
790 X=X-4 @ IF X<0 THEN X=-1
800 S=S-2 @ IF S<1 THEN S=0
810 S=S+1 @ NEXT X
820 ! Re-run option select
830 DISP CHR$(210);"un again, ";CHR$(21
    4);"iew again, or ";CHR$(197);
840 INPUT "nd?";R"; Q$ @ Q$=UPRC$(Q$)
850 IF Q$#"V" AND Q$#"R" AND Q$#"E" THE
    N 830
860 IF Q$="V" THEN 700
870 IF Q$="R" THEN 430
880 DELAY 1 @ DISP @ STOP

```

-Set units string to ohms if  
high pass else 'fd'

-Set attenuation level

-If High-Pass adjust to farads

-Select formula

-Increment constant pointer

-S = section pointer

-Wait for keyboard entry

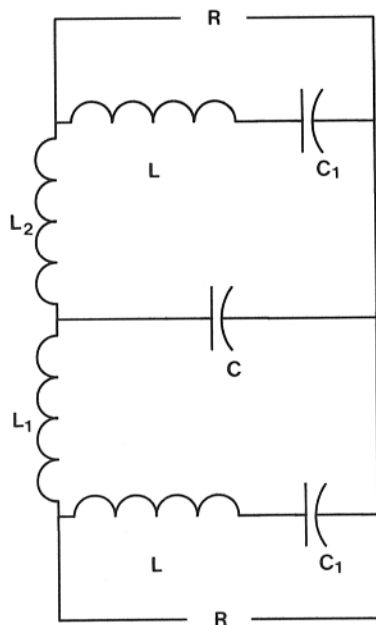
-Decrement loop and section  
number

-Increment section number and  
loop counter

# PROGRAM DESCRIPTION

## LOW PASS FILTER

Component values in a single section Low Pass Filter without attenuators are related by the following formulas and schematic. Given cut-off frequency and impedance, the program calculates the component value.



$F$  = Cut-off Frequency

$R$  = Characteristic Impedance

$L_0 = R/\pi * F$

$L = .64 * L_0/1.2$

$L1 = L_0/2 + L2$

$L2 = .6 * L_0/2$

$C = 1/(\pi * F * R)$

$C1 = .6 * C/2$

## SAMPLE PROBLEM

What components are required to construct a low pass filter with a 1MHz cut-off frequency and a characteristic impedance of 50 ohms? (see schematic)

## SOLUTION

| STEP | INSTRUCTIONS                   | DISPLAY                                                | INPUT        |
|------|--------------------------------|--------------------------------------------------------|--------------|
| 1    | Run program                    | * LOW PASS FILTER DESIGN *                             |              |
| 2    | Enter cut-off frequency        | Cut-off Frequency in Hz?                               | 1000000[RTN] |
| 3    | Enter characteristic impedance | Impedance in Ohms?                                     | 50 [RTN]     |
| 4    | Display L and C1               | L=8.49 $\mu$ H      C1=1.91nfd                         | [RTN]        |
| 5    | Display L1 and L2              | L1=12.73 $\mu$ H      L2=4.77 $\mu$ H                  | [RTN]        |
| 6    | Display C                      | C=6.73nfd                                              | [RTN]        |
| 7    | End program                    | <u>R</u> un again, <u>V</u> iew again, or <u>E</u> nd? | E [RTN]      |



## USER INSTRUCTIONS

| STEP | INSTRUCTIONS                   | DISPLAY                                                  | INPUT               |
|------|--------------------------------|----------------------------------------------------------|---------------------|
| 1    | Run program                    | * LOW PASS FILTER DESIGN *                               |                     |
| 2    | Enter cut-off frequency        | Cut-off Frequency in Hz?                                 | Freq [RTN]          |
| 3    | Enter characteristic impedance | Impedance in Ohms?                                       | Zc [RTN]            |
| 4    | Display L and C1               | L=value      C1=value                                    | [RTN]               |
| 5    | Display L1 and L2              | L1=value      L2=value                                   | [RTN]               |
| 6    | Display C                      | C=value                                                  | [RTN]               |
| 7    | Continuation options           | <u>R</u> un again, <u>V</u> iew again, or <u>E</u> nd? R | R, V, or E<br>[RTN] |
|      | If 'R' goto 2                  |                                                          |                     |
|      | If 'V' goto 4                  |                                                          |                     |
|      | If 'E' end program             |                                                          |                     |

## VARIABLE NAMES

| NAME | DESCRIPTION                         | NAME | DESCRIPTION                         |
|------|-------------------------------------|------|-------------------------------------|
| F    | Function variable                   | C1   | Circuit components<br>See schematic |
| J    | Function variable                   | R    | Circuit components<br>See schematic |
| L    | Circuit components<br>See schematic | F    | Cut-off frequency                   |
| L1   | Circuit components<br>See schematic | K\$  | Single key input                    |
| L2   | Circuit components<br>See schematic | Q\$  | Option string inputs                |
| C    | Circuit components<br>See schematic | F\$  | Function string                     |

# PROGRAM LISTING

```

10 ! LOW PASS FILTER DESIGN
20 ! Compute the inductor and
30 ! capacitor combinations,
40 ! required to construct a
50 ! a low pass filter.
60 ! Revision 11/01/82
70 DELAY 2
80 ! Define Functions
90 !
100 ! Wait for a 'RTN'
110 DEF FNK$
120 K$=KEY$ @ IF K$="" THEN 120
130 IF NUM(K$)#13 THEN 120
140 FNK$=K$
150 END DEF
160 !
170 ! Round 'F' to 'J' digits
180 DEF FNR(F,J)
190 F=INT(F*10^J+.5)/10^J
200 FNR=F
210 END DEF
220 !
230 ! Fix values to common units.
240 DEF FNF(F)
250 J=3 @ F$="MK m"&CHR$(12)&"np"
260 IF F<1000 AND F>=1 THEN 310
270 IF F>1000 THEN 290
280 F=F*1000 @ J=J+1 @ GOTO 300
290 F=F/1000 @ J=J-1
300 IF J#1 AND J#7 THEN 260
310 IF J=3 THEN F$="" ELSE F$=F$(J,J)
320 FNF=F
330 END DEF
340 !
350 ! Main program loop
360 DISP " * LOW PASS FILTER DESIGN
    *"
370 L,L1,L2,C,C1,R=0
380 DELAY 0
390 INPUT "Cut-off Frequency in Hz ? ";
    F
400 INPUT "Impedance in Ohms? ";R
410 ! Compute values
420 L0=R/(PI*F)
430 C=1/(PI*F*R)
440 L2=.6*L0/2
450 L=.64*L0/1.2
460 C1=.6*C/2
470 L1=L0/2+L2
480 ! Display values
490 DISP "L=";FNR(FNF(L),2);F$&"H"    C1
    =";FNR(FNF(C1),3);F$&"fd"
500 K$=FNK$
510 DISP "L1=";FNR(FNF(L1),2);F$&"H"    L
    2=";FNR(FNF(L2),2);F$&"H"

```

-Clear variables

-Wait for 'RTN' to continue

# PROGRAM LISTING

520 K\$=FNK\$

-Wait for 'RTN' to continue  
display

530 DISP "C=";FNR(FNF(C),2);F\$&"fd"

540 ! Continuation options

550 K\$=FNK\$

-Wait for 'RTN' to continue  
display

560 DISP CHR\$(210);"un again, ";CHR\$(214);  
"iew again, or ";CHR\$(197);

570 INPUT "nd?","R"; Q\$ @ Q\$=UPRC\$(Q\$)

580 IF Q\$="R" THEN 390

590 IF Q\$="E" THEN 610

600 IF Q\$="V" THEN 490 ELSE 560

610 DELAY 1 @ DISP @ STOP

# PROGRAM DESCRIPTION

## COIL DESIGN

The approximate inductance of a single-layer, air-core coil can be calculated from the simplified formula:

$$L (\mu\text{H}) = A^2 * N^2 / (9*A + 10*B)$$

Where:

L = Inductance in microhenrys

A = Coil radius in inches

B = Coil length in inches

N = Number of turns

Likewise, to approximate the number of turns of a single-layer, air-core coil for a specified inductance use the formula:

$$N = \sqrt{L * (9*A + 10*B) / A^2}$$

Given A, B, and N the program calculates inductance (L).

Given A, B, and L the program calculates the number of turns (N).

## SAMPLE PROBLEM

What is the approximate inductance of a single-layer, air-core coil with a diameter  $\frac{3}{4}$ ", a length of  $1\frac{1}{2}$ " and 48 turns?

## SOLUTION

| STEP | INSTRUCTIONS          | DISPLAY                                      | INPUT     |
|------|-----------------------|----------------------------------------------|-----------|
| 1    | Run program           | ** COIL DESIGN **                            |           |
| 2    | Select inductance     | Find: <u>T</u> urns or <u>I</u> nductance? I | [RTN]     |
| 3    | Enter diameter        | Coil diameter in inches =                    | .75 [RTN] |
| 4    | Enter length          | Coil length in inches =                      | 1.5 [RTN] |
| 5    | Enter number of turns | Total turns =                                | 48 [RTN]  |
| 6    | Display results       | Inductance is 17.6 $\mu$ H                   | [RTN]     |
| 7    | End program           | <u>R</u> un again or <u>E</u> nd? R          | E [RTN]   |

# USER INSTRUCTIONS

| STEP | INSTRUCTIONS            | DISPLAY                       | INPUT               |
|------|-------------------------|-------------------------------|---------------------|
| 1    | Run program             | ** COIL DESIGN **             |                     |
| 2    | Select option           | Find: Turns or Inductance? I  | T [RTN]<br>or [RTN] |
| 3    | If 'I' then goto 8 else |                               |                     |
|      | enter inductance        | Inductance in $\mu\text{H}$ = | Inductance<br>[RTN] |
| 4    | Enter coil diameter     | Coil diameter =               | Diameter<br>[RTN]   |
| 5    | Enter coil length       | Coil length =                 | Length [RTN]        |
| 6    | Display results         | N turns                       | [RTN]               |
| 7    | Goto 12                 |                               |                     |
| 8    | Enter coil diameter     | Coil diameter in inches =     | Diameter<br>[RTN]   |
| 9    | Enter coil length       | Coil length in inches =       | Length [RTN]        |
| 10   | Enter turns             | Total turns =                 | Turns [RTN]         |
| 11   | Display results         | Inductance is L $\mu\text{H}$ | [RTN]               |
| 12   | Program options         | Run again or End? R           | E [RTN]<br>or [RTN] |
|      | If [RTN] goto 3 or 8    |                               |                     |
|      | If 'E' then end program |                               |                     |

## VARIABLE NAMES

| NAME | DESCRIPTION                      | NAME | DESCRIPTION               |
|------|----------------------------------|------|---------------------------|
| A    | Coil diameter                    | I    | Function variable         |
| B    | Coil length                      | J    | Function variable         |
| L    | Inductance in $\mu\text{H}$      | K\$  | Single key input          |
| N    | Number of turns in coil          | Q\$  | Continuation option input |
| Q    | Flag Q=1=Turns<br>Q=0=Inductance |      |                           |

## NOTES AND REFERENCES

This is a simple approximation program for common values of inductance found in Amateur Radio Projects. Practical limit is less than 100  $\mu\text{H}$ .

Formulas are from: Robert Myers (editor)  
The RADIO AMATEUR'S HANDBOOK  
American Radio Relay League, 1975, Page 26

# PROGRAM LISTING

```

10 ! COIL DESIGN
20 ! Compute the inductance of
30 ! a coil given diameter,
40 ! number of turns,
50 ! and length OR compute the
60 ! number of turns given the
70 ! inductance, diameter and
80 ! length of a coil.
90 ! Revision 11/01/82
100 !
110 DELAY 2
120 ! Define Functions
130 !
140 ! Single, upper case key in
150 DEF FNK$
160 K$=KEY$ @ IF K$="" THEN 160
170 FNK$=UPRC$(K$)
180 END DEF
190 !
200 ! Round 'I' to 'J' digits
210 DEF FNR(I,J)
220 I=INT(I*10^J+.5)/10^J
230 FNR=I
240 END DEF
250 !
260 ! Sign on message
270 DISP " * * C O I L   D E S I G N *
    *"
280 DISP "Find: ";CHR$(212);"urns or
    ";CHR$(201);"nductance ";
290 INPUT "?","I"; Q$ @ Q$=UPRC$(Q$)
300 IF Q$="I" THEN 410
310 IF Q$="T" THEN 280
320 ! Compute number of turns
330 Q=1 @ DISP "Inductance in ";CHR$(12)
    );"H = ";
340 INPUT " ";L
350 INPUT "Coil diameter in inches = ";
    A @ A=A/2
360 INPUT "Coil length in inches = ";B
370 N=FNR(SQR(L*(9*A+10*B)/A^2),1)

380 DISP N;"turns" @ K$=FNK$
390 GOTO 480

400 ! Compute inductance
410 Q=0 @ INPUT "Coil diameter in inches = ";
    A @ A=A/2
420 INPUT "Coil length in inches = ";B
430 INPUT "Total turns = ";N
440 L=A^2*N^2/(9*A+10*B)
450 DISP "Inductance is ";FNR(L,1);" "&
    CHR$(12);"H"
460 K$=FNK$

```

-Select operation  
-If Q\$='I' compute inductance

-Formula to compute number of  
turns

-Goto continuation options  
after viewing answer

-Formula to compute inductance



# PROGRAM LISTING

```
470 ! Continue option select
480 DISP CHR$(210);"un again or ";CHR$(
197);
490 INPUT "nd?";"R"; Q$ @ Q$=UPRC$(Q$)
500 IF Q##"R" AND Q##"E" THEN 480
510 IF Q##"R" THEN 530
520 IF Q THEN 330 ELSE 410
530 DELAY 1 @ DISP @ STOP
```

-Select continuation option

-If Q=1 then compute turns else  
compute inductance

NOTES

PROGRAM LISTING

```
430 1 CONTINUE OPTION SELECT
440 HIGH CHARGE(1); ON ERROR GO TO CHARGE
450
460 INPUT "CHARGE", CHARGE
470 IF CHARGE AND CHARGE THEN GOTO
480 IF CHARGE THEN GOTO
490 IF CHARGE THEN GOTO
500 GOTO 1
510 GOTO 1
520 GOTO 1
530 GOTO 1
540 GOTO 1
550 GOTO 1
560 GOTO 1
570 GOTO 1
580 GOTO 1
590 GOTO 1
600 GOTO 1
610 GOTO 1
620 GOTO 1
630 GOTO 1
640 GOTO 1
650 GOTO 1
660 GOTO 1
670 GOTO 1
680 GOTO 1
690 GOTO 1
700 GOTO 1
710 GOTO 1
720 GOTO 1
730 GOTO 1
740 GOTO 1
750 GOTO 1
760 GOTO 1
770 GOTO 1
780 GOTO 1
790 GOTO 1
800 GOTO 1
810 GOTO 1
820 GOTO 1
830 GOTO 1
840 GOTO 1
850 GOTO 1
860 GOTO 1
870 GOTO 1
880 GOTO 1
890 GOTO 1
900 GOTO 1
910 GOTO 1
920 GOTO 1
930 GOTO 1
940 GOTO 1
950 GOTO 1
960 GOTO 1
970 GOTO 1
980 GOTO 1
990 GOTO 1
1000 GOTO 1
```

## NOTES

## NOTES

## NOTES

## NOTES



## **ELECTRONICS**

TRANSISTOR AMP EVALUATION  
COMMON COMPONENTS FOR 555 & 567 IC'S  
OHMS LAW WITH dBm CONVERSION  
IMPEDANCE CONVERSION  
SMITH CHART CONVERSION  
MISMATCH  
BUTTERWORTH FILTER DESIGN  
ACTIVE FILTER DESIGN  
LOW PASS FILTER DESIGN  
COIL DESIGN

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