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Commodore 64® & 128® Programs for Amateur Radio & Electronics

Joseph J. Carr

Commodore 64 & 128 Programs for Amateur Radio & Electronics

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Contents

Introduction

This book provides amateur radio operators and general electronics hobbyists with a collection of practical, workbench programs that will run on most standard computers—in most cases with no modifications to the programs. It is based on earlier books on the Apple® II series and IBM® PC which I wrote for engineers.

The book has two major sections: amateur radio and general electronics. The first deals with radio programs, and covers such matters as

- Antenna impedance matching networks
- Standing wave ratio
- Satellite antenna dimensions

The second section treats general electronics topics, and includes programs for

- Operational amplifier designs
- Waveform generators
- RLC network solutions

A third section contains a program unrelated to radio or general electronics but which has been popular with readers of my earlier books. It is a BASIC import program that imports a BASIC program from any computer with a 300 baud RS-232C serial port to either a Commodore 64® or a Commodore 128® computer.

Since the Commodore 64 has become the *de facto* standard computer in amateur radio and certain other hobbyist electronics fields, the programs are designed for the Commodore 64

PROGRAM 1

Coil Loaded Shortened Dipole Antenna

The half-wave dipole antenna is a popular and efficient antenna that is capable of considerable performance considering the low cost of the antenna. But half wavelength for some frequencies is simply too long for all applications. For some of these situations we can use a shortened dipole such as Fig. 1.1. In this type of antenna, loading coils are placed in each half of the radiator to take up the missing length. Although the design of these antennas can permit placing the coil anywhere along the length of the radiators, simplicity in this program forces us to place the coil at either the halfway point or at the feed point (i.e., when dimension "B" is zero). Discrete shortening factors from 5 to 98 percent are allowed.

$$L_1 = L_2 = L$$

$$C = 2A$$

$$A = \frac{1}{2}C$$

$$C = \frac{468M}{F_{MHz}}$$

$$0 < M \leq 1$$

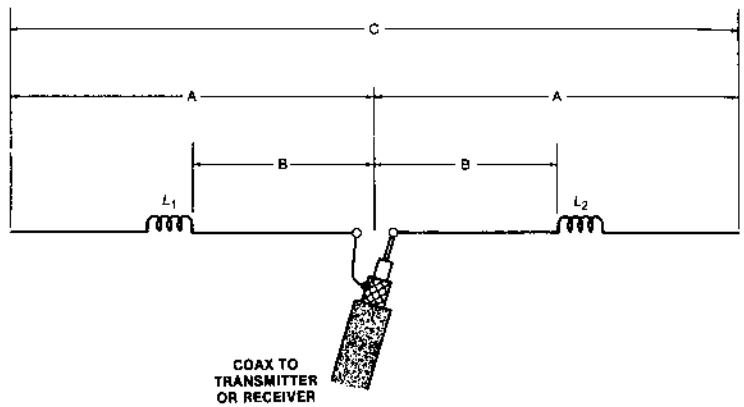


FIG. 1.1. A SHORTENED DIPOLE ANTENNA.

Coil Loaded Shortened Dipole Antenna

```
10 E = 5
20 G1 = 5
30 G2 = 25
100 REM  CLEAR SCREEN
110 GOSUB 20000
150 REM  GET OPENING SUBROUTINE
160 GOSUB 23000
200 REM  CLEAR SCREEN
210 GOSUB 20000
240 REM  PROGRAM OPTIONS SELECTION
250 GOSUB 25000
290 REM  CLEAR SCREEN
292 REM  MAKE CALCULATIONS
293 GOSUB 24000
300 GOSUB 20000
330 REM  DISPLAY RESULTS
340 GOSUB 28000
400 GOSUB 29000
20000 REM  CLEAR SCREEN SUBROUTINE
20020 FOR N = 1 TO 25
20040 PRINT
20060 NEXT N
20080 RETURN
21000 REM  CLEAR SMALL SPACE SUBROUTINE
21020 FOR N = 1 TO 3
21040 PRINT
```



```
21060 NEXT N
21080 RETURN
22000 REM  PRESS AND NUMBER KEY SUBROUTINE
22030 GOSUB 21000
22050 GOSUB 21000
22060 PRINT "PRESS CR TO CONTINUE..."
22080 INPUT S
22100 RETURN
23000 REM  OPENING SUBROUTINE
23010 GOSUB 20000
23020 PRINT  TAB( E);"* * * * * * * * * * * * * * * *"
23030 PRINT  TAB( E);"*                              *"
23040 PRINT  TAB( E);"*  COPYRIGHT 1986 J.J. CARR *"
23050 PRINT  TAB( E);"*                              *"
23060 PRINT  TAB( E);"* * * * * * * * * * * * * * * *"
23070 GOSUB 21000
23080 GOSUB 21000
23090 GOSUB 22000
23100 GOSUB 20000
23120 PRINT "THIS PROGRAM HELPS YOU DESIGN"
23125 PRINT "A SHORTENED LOADED DIPOLE"
23130 PRINT "AT A SPECIFIED FREQUENCY. YOU"
23135 PRINT "WILL BE ABLE TO SELECT THE"
23140 PRINT "LENGTH IN FEET, AND AN OPERATING"
23142 PRINT "FREQUENCY BETWEEN 0.1 AND 40 MHZ"
23150 PRINT
23160 PRINT "IF YOU ARE READY TO START..."
23170 GOSUB 22000
23200 GOSUB 20000
23220 PRINT "ENTER OPERATING FREQUENCY"
23222 PRINT "IN MEGAHERTZ (MHZ)"
23225 PRINT "(0.1 TO 40 MHZ):"
23230 PRINT
23250 INPUT F
23290 PRINT "THANK YOU..."
23300 GOSUB 20000
23500 RETURN
24000 REM  ARITHMETIC SUBROUTINE
24010 L1 = LX
24020 L3 = L1 / 2
24030 P = (L1 * 100) / L2
24050 P = P * 100
24060 P =  INT (P)
24070 P = P / 100
24080 X = L3 / 2
24090 LA = BA / (6.28 * F)
24100 LB = CA / (6.28 * F)
24110 LA = LA * 100
```

```
24120 LB = LB * 100
24130 LA =  INT (LA)
24150 LB =  INT (LB)
24160 LA = LA / 100
24170 LB = LB / 100
24900 RETURN
25000 REM  SELECTION SUBROUTINE
25020 L2 = 468 / F
25025 LC = 0.05 * L2
25030 LD = 0.1 * L2
25035 LE = 0.2 * L2
25040 LF = 0.3 * L2
25050 LG = 0.4 * L2
25055 LH = 0.5 * L2
25060 LI = 0.6 * L2
25065 LJ = 0.7 * L2
25070 LK = 0.8 * L2
25075 LM = 0.9 * L2
25080 LN = 0.95 * L2
25085 LO = 0.98 * L2
25110 PRINT "PERCENT OF FULL-SIZE     LENGTH (F)"
25120 PRINT "================================"
25180 PRINT  TAB( G1);"1.   5"; TAB( G2);LC
25190 PRINT  TAB( G1);"2.  10"; TAB( G2);LD
25200 PRINT  TAB( G1);"3.  20"; TAB( G2);LE
25210 PRINT  TAB( G1);"4.  30"; TAB( G2);LF
25220 PRINT  TAB( G1);"5.  40"; TAB( G2);LG
25230 PRINT  TAB( G1);"6.  50"; TAB( G2);LH
25240 PRINT  TAB( G1);"7.  60"; TAB( G2);LI
25250 PRINT  TAB( G1);"8.  70"; TAB( G2);LJ
25260 PRINT  TAB( G1);"9.  80"; TAB( G2);LK
25270 PRINT  TAB( G1);"10. 90"; TAB( G2);LM
25280 PRINT  TAB( G1);"11. 95"; TAB( G2);LN
25290 PRINT  TAB( G1);"12. 98"; TAB( G2);LO
25300 PRINT  TAB( G1);"13. 100"; TAB( G2);L2
25330 PRINT
25340 PRINT
25350 PRINT "SELECT 1 - 13 FROM ABOVE..."
25360 PRINT
25370 INPUT W
25380 IF W < 1 THEN  GOTO 25000
25390 IF W > 13 THEN  GOTO 25000
25400 IF W = 13 THEN  GOTO 25800
25410 ON W GOTO 25430,25440,25450,25460,25470,25480,
      25490,25500,25510,25520,255
25430 LX = LC
25431 BA = 5000
25432 CA = 8500
```



```
25435 GOTO 25900
25440 LX = LD
25441 BA = 2700
25442 CA = 4800
25445 GOTO 25900
25450 LX = LE
25451 BA = 1450
25452 CA = 2500
25455 GOTO 25900
25460 LX = LF
25461 BA = 950
25462 CA = 1750
25465 GOTO 25900
25470 LX = LG
25471 BA = 700
25472 CA = 1250
25475 GOTO 25900
25480 LX = LH
25481 BA = 500
25482 CA = 900
25485 GOTO 25900
25490 LX = LI
25491 BA = 375
25492 CA = 700
25495 GOTO 25900
25500 LX = LJ
25501 BA = 260
25502 CA = 500
25505 GOTO 25900
25510 LX = LK
25511 BA = 160
25512 CA = 310
25515 GOTO 25900
25520 LX = LM
25521 BA = 80
25522 CA = 155
25525 GOTO 25900
25530 LX = LN
25531 BA = 45
25532 CA = 70
25535 GOTO 25900
25540 LX = LO
25541 BA = 10
25542 CA = 32
25545 GOTO 25900
25550 GOT025900
25800 REM  FULL-SIZE MESSAGE
25810 GOSUB 21000
```

```
25820 PRINT "YOU HAVE SELECTED 100-PERCENT"
25825 PRINT "...WHY DO YOU NEED THIS PROGRAM?"
25830 PRINT "MAKE ANTENNA ";L2;" FT. LONG."
25840 GOSUB 21000
25850 GOSUB 22000
25860 GOTO 29000
25900 RETURN
28000 REM  DISPLAY SUBROUTINE
28050 PRINT "OPERATING FREQUENCY: ";F;" MHZ"
28070 PRINT "LENGTH OF FULL-SIZE DIPOLE AT"
28075 PRINT "THIS FREQ.: ";L2;" FT."
28076 -30000
28090 PRINT
28100 PRINT "SPECIFICATIONS FOR"
28105 PRINT "SHORTENED LOADED DIOPLE..."
28110 PRINT
28120 PRINT "OVERALL LENGTH: ";L1;" FT."
28130 PRINT "EACH ELEMENT LENGTH: ";L3;" FT."
28140 PRINT "LENGTHS ARE ";P;" PERCENT"
28142 PRINT "OF FULL-SIZED DIPOLE."
28180 PRINT "LOADING COIL DATA:"
28200 PRINT
28210 PRINT "INDUCTANCE: ";LA;" UH AT FEEDPOINT"
28220 PRINT "INDUCTANCE: ";LB;" UH AT "
28222 PRINT  X;" FT. FROM FEEDPOINT."
28250 GOSUB 22000
28400 RETURN
29000 REM  ENDING SUBROUTINE
29040 GOSUB 20000
29060 PRINT "ARE YOU FINISHED ?????"
29080 PRINT
29090 PRINT "1.  YES"
29100 PRINT "2.  NO"
29110 PRINT
29120 PRINT "ENTER ONE SELECTION FROM"
29122 PRINT "ABOVE AND PRESS CR..."
29130 INPUT SS
29150 IF SS > 2 THEN  GOTO 29000
29160 IF SS < 1 THEN  GOTO 29000
29200 ON SS GOTO 29500,100
29500 GOSUB 20000
29520 PRINT "PROGRAM ENDED"
29530 END
```


PROGRAM 2

Antenna Calculations I—Half-Wave Dipole and Quarter-Wave Vertical

This program calculates the length in either English (feet/inches) or Metric (meters) units; either form of units may be selected by the user. When you run the program, you will be asked to enter the operating frequency and select the type of units. The program will then return the length in the units selected for the type of antenna selected.

The program will ask you whether the antenna is in free space or close to the earth's surface. While all antennas use one rendering or the other of the speed of light for the velocity constant, this constant is distorted a little if the antenna is closer than several (usually taken to be three) wavelengths from the earth. Thus, most amateur antennas in the HF bands will be considered close to the earth's surface, and the velocity constant is approximately 5 percent smaller than free space. A VHF antenna, however, is a lot shorter than HF antennas of the same type. Those antennas can easily be more than three wavelengths above the earth's surface without the need for sky-scraper towers.

Antenna Calculations I—Half-Wave Dipole and Quarter-Wave Vertical

```
100 REM THIS IS PROGRAM NO. 2 PROG2
110 REM ANTENNA CALCULATIONS PROGRAM
180 GOSUB 400
190 GOSUB 570
200 GOSUB 400
210 GOSUB 450
220 GOSUB 400
230 GOSUB 510
240 GOSUB 400
250 GOSUB 630
260 IF X = 1 THEN C = 492
262 IF X > 1 THEN C = 150
270 LET L = C / F
280 IF V = 1 THEN L = L
282 IF V > 1 THEN L = 0.9512 * L
290 IF Y = 2 THEN L = L
292 IF Y = 1 THEN L = L / 2
300 IF X = 1 THEN  GOTO 730
310 IF X = 2 THEN  GOTO 800
320 GOSUB 400
330 PRINT "YOU MUST HAVE GOOFED SOMEWHERE!"
350 PRINT
360 PRINT
370 PRINT "ANSWER ALL QUESTIONS WITH THE"
375 PRINT "PROPER KEYSTROKE...."
380 PRINT "I.E. 1 OR 2, BUT NOT 3 OR K"
390 GOTO 730
400 REM  SUBROUTINE TO CLEAR THE SCREEN
410 FOR N = 1 TO 30
420 PRINT
430 NEXT N
440 RETURN
450 REM FREESPACE SUBROUTINE
470 PRINT "SELECT ONE FROM BELOW..."
471 PRINT
472 PRINT "1. ANTENNA IN FREESPACE"
475 PRINT "2. ANTENNA CLOSE TO EARTH"
478 PRINT
480 PRINT "IF YOU DON'T KNOW WHAT I'M"
485 PRINT "TALKING ABOUT, SEE TEXT OF BOOK."
490 INPUT V
500 RETURN
510 REM METRIC/ENGLISH UNITS
520 PRINT "SELECT ONE FORM OF UNITS..."
525 PRINT
530 PRINT "1. FEET/INCHS (ENGLISH UNITS)"
535 PRINT "2. METERS (METRIC UNITS)"
```



```
540 PRINT
545 PRINT "ENTER SELECTION:"
550 INPUT X
560 RETURN
570 REM SELECT VERTICAL/HORIZONTAL
580 PRINT "WHICH TYPE OF ANTENNA DO YOU WANT?"
585 PRINT
590 PRINT "   1. QUARTER WAVELENGTH VERTICAL"
600 PRINT "   2. HALF WAVELENGTH DIPOLE"
605 PRINT
606 PRINT "ENTER SELECTION..."
610 INPUT Y
620 RETURN
630 REM SUPPLY OPERATING FREQUENCY
640 PRINT "ENTER OPERATING FREQUENCY IN MEGAHERTZ (MHZ)"
650 PRINT "FOR EXAMPLE, 21.380"
660 INPUT F
670 GOSUB 400
680 FOR Z = 1 TO 35
690 PRINT "OH TH[$1]ANK YOU!!!!!"
700 NEXT Z
710 GOSUB 400
720 RETURN
730 REM  USER WANTS ANSWER IN FEET/INCHS
740 LET M = L -  INT (L)
750 LET M = M * 12
760 LET M =  INT (M)
770 LET K =  INT (L)
780 PRINT K;"FT.";M;"IN."
790 GOTO 860
800 REM  THIS SUBROUTINE PRINTS ANSWER IN METERS
810 LET L = L * 100
820 LET L =  INT (L)
830 LET L = L / 100
840 PRINT L;" METERS"
850 GOTO 860
860 PRINT
862 PRINT
865 PRINT "WANT TO DO ANOTHER ???"
866 PRINT
870 PRINT "  1. YES"
880 PRINT "  2. NO"
890 INPUT R
900 IF R = 1 THEN  GOTO 910
905 IF R = 2 THEN  GOTO 980
908 IF R > 2 THEN  GOTO 860
910 GOSUB 400
920 FOR K = 1 TO 30
```

```
930 PRINT "HEEERRRRRRRRR WE GO AGAIN!!!!!"
940 NEXT K
950 FOR K = 1 TO 30
960 NEXT K
970 GOTO 110
980 GOSUB 400
990 PRINT "THANX, SEE YOU NEXT TIME"
1000 FOR K = 1 TO 30
1010 PRINT "GOING NOW"
1020 NEXT K
1030 GOSUB 400
1040 PRINT "GONE"
1050 END
```

Example

```
WHICH TYPE OF ANTENNA DO YOU WANT?

   1. QUARTER WAVELENGTH VERTICAL
   2. HALF WAVELENGTH DIPOLE

ENTER SELECTION...
 2


SELECT ONE FROM BELOW...

1. ANTENNA IN FREESPACE
2. ANTENNA CLOSE TO EARTH

IF YOU DON'T KNOW WHAT I'M
TALKING ABOUT, SEE TEXT OF BOOK.
 2


SELECT ONE FORM OF UNITS...

1. FEET/INCHS (ENGLISH UNITS)
2. METERS (METRIC UNITS)

ENTER SELECTION:
 1
```



```
ENTER OPERATING FREQUENCY IN MEGAHERTZ (MHZ)
FOR EXAMPLE, 21.380
 14.1


OH THANK YOU!!!!!
OH THANK YOU!!!!!
OH THANK YOU!!!!!


 33 FT. 2 IN.

WANT TO DO ANOTHER ???

  1. YES
  2. NO
 2


THANX, SEE YOU NEXT TIME
GOING NOW
GOING NOW
GOING NOW
```

Program 3

Antenna Calculations II

Program 3 will calculate and print out a table of lengths (in feet) for the following six different types of radio antenna:

1. 1/2-wavelength in free space
2. 1/4-wavelength in free space
3. 1/2-wavelength dipole
4. 1/4-wavelength vertical
5. 5/8-wavelength vertical
6. 1/2-wavelength inverted-vee

You will be asked to input the lower edge of the band of interest (in kilohertz—any other units of frequency will result in wrong answers), the upper edge of the band (in kilohertz), and the frequency increment (again, in kilohertz) between successive measurement points. In the example that follows the program listing, the frequency band was 4000 to 4500 kilohertz, with a length calculation made every 25 kilohertz. Theoretically, you could set the lower edge of the band near DC (0.0001 Hz) and the upper edge of the band at daylight (10^{10} hertz) with increments every 100 cycles (0.1 kHz). Of course, the printer would run out of paper.


```
100 REM THIS IS PROGRAM NO. 3 PROG3
140 LET S = 8
150 LET Q = 5
160 GOSUB 790
170 PRINT  TAB( S);"* * * * * * * * * * * * * * *"
180 PRINT  TAB( S);"*  ANTENNA CALCULATIONS   *"
190 PRINT  TAB( S);"*          PROGRAM        *"
200 PRINT  TAB( S);"*     COPYRIGHT 1986 BY   *"
210 PRINT  TAB( S);"*         J.J. CARR       *"
220 PRINT  TAB( S);"* * * * * * * * * * * * * * *"
250 PRINT
260 PRINT
270 PRINT
280 GOSUB 830
290 GOSUB 790
300 PRINT "SELECT TYPE OF CALCULATION FROM MENU BELOW:"
310 PRINT
320 PRINT "1.  1/2-WAVELENGTH (FREE SPACE)"
330 PRINT "2.  1/4-WAVELENGTH (FREE SPACE)"
340 PRINT "3.  1/2-WAVELENGTH DIPOLE"
350 PRINT "4.  1/4-WAVELENGTH VERTICAL"
360 PRINT "5.  5/8-WAVELENGTH VERTICAL"
370 PRINT "6.  1/2-WAVELENGTH INVERTED-VEE"
380 PRINT
390 PRINT "SELECTION?"
392 INPUT A
394 PRINT A
400 GOSUB 750
410 IF A = 1 THEN C = 492000
420 IF A = 2 THEN C = 246000
430 IF A = 3 THEN C = 468000
440 IF A = 4 THEN C = 234000
450 IF A = 5 THEN C = 585000
460 IF A = 6 THEN C = 496000
470 IF A > 6 THEN  GOTO 300
480 GOSUB 750
490 PRINT "ENTER LOWER BANDEDGE IN KILOHERTZ:"
492 INPUT F1
494 PRINT F1
500 GOSUB 750
510 PRINT "ENTER UPPER BANDEDGE IN KILOHERTZ:"
515 INPUT F2
516 PRINT F2
520 GOSUB 750
530 PRINT "ENTER FREQUENCY INCREMENT IN KILOHERTZ:"
532 INPUT F3
534 PRINT F3
540 GOSUB 790
550 L = C / F1
```

```
560 L = L * 100
570 L =  INT (L)
580 L = L / 100
590 PRINT F1;" KHZ";"    L = ";L;" FT."
600 LET F1 = F1 + F3
610 IF F1 >  = (F2 + F3) THEN  GOTO 620
620 IF F1 < (F2 + F3) THEN  GOTO 550
630 PRINT
635 PRINT
640 GOSUB 830
650 GOSUB 790
660 GOSUB 750
670 PRINT "1. FINISHED"
680 PRINT "2. DO ANOTHER OF THE SAME TYPE"
690 PRINT "3. SELECT ANOTHER TYPE OF ANTENNA"
700 PRINT
710 PRINT "WHICH IS YOUR PLEASURE?"
715 INPUT H
716 PRINT H
720 IF H > 3 THEN  GOTO 660
730 ON H GOTO 860,480,290
740 END
750 FOR I = 1 TO 5
760 PRINT
770 NEXT I
780 RETURN
790 FOR I = 1 TO 30
800 PRINT
810 NEXT I
820 RETURN
830 PRINT "PRESS CR TO CONTINUE..."
840 INPUT KK
850 RETURN
860 GOSUB 790
870 PRINT "GONE BYE-BYE"
```

Example

```
* * * * * * * * * * * * * * *
*  ANTENNA CALCULATIONS     *
*        PROGRAM            *
*    COPYRIGHT 1986 BY      *
*        J.J. CARR          *
* * * * * * * * * * * * * * *
```



```
PRESS CR TO CONTINUE...


SELECT TYPE OF CALCULATION FROM MENU BELOW:

1.  1/2-WAVELENGTH (FREE SPACE)
2.  1/4-WAVELENGTH (FREE SPACE)
3.  1/2-WAVELENGTH DIPOLE
4.  1/4-WAVELENGTH VERTICAL
5.  5/8-WAVELENGTH VERTICAL
6.  1/2-WAVELENGTH INVERTED-VEE

SELECTION?
 5


ENTER LOWER BANDEDGE IN KILOHERTZ:
 7000

ENTER UPPER BANDEDGE IN KILOHERTZ:
 7300

ENTER FREQUENCY INCREMENT IN KILOHERTZ:
 20


 7000  KHZ    L =  83.57  FT.
 7020  KHZ    L =  83.33  FT.
 7040  KHZ    L =  83.09  FT.
 7060  KHZ    L =  82.86  FT.
 7080  KHZ    L =  82.62  FT.
 7100  KHZ    L =  82.39  FT.
 7120  KHZ    L =  82.16  FT.
 7140  KHZ    L =  81.93  FT.
 7160  KHZ    L =  81.7   FT.
 7180  KHZ    L =  81.47  FT.
 7200  KHZ    L =  81.25  FT.
 7220  KHZ    L =  81.02  FT.
 7240  KHZ    L =  80.8   FT.
 7260  KHZ    L =  80.57  FT.
 7280  KHZ    L =  80.35  FT.
 7300  KHZ    L =  80.13  FT.
```

```
PRESS CR TO CONTINUE...


1. FINISHED
2. DO ANOTHER OF THE SAME TYPE
3. SELECT ANOTHER TYPE OF ANTENNA

WHICH IS YOUR PLEASURE?
 1


GONE BYE-BYE
```


PROGRAM 4

Antenna Calculations III—5/8 Wavelength Vertical

This program is designed to create a series of tables of antenna lengths as a function of frequency. Although this program is designed for a 5/8-wavelength vertical, it can easily be modified for 1/4-wavelength vertical or 1/2-wavelength dipole antennas. Two lines of programming are affected if you want to change this program. Line 160 contains the velocity constant 585,000 for a 5/8-wavelength vertical. Change this line as follows:

1. For 1/4-wavelength vertical, change line 160 to K1 = 234000.
2. For 1/2-wavelength dipole, change line 160 to K1 = 468000.

The other line to change is 940. This line must be changed to either 1/4-wavelength vertical or 1/2-wavelength dipole.

The program cycles through all of the common amateur radio and international shortwave broadcast bands, including the new WARC bands. The program will calculate lengths as a function of frequency for the entire band (see example for 3500 to 4000 kHz that follows program listing). Each chart is headed with the frequency range in kilohertz, and the normal use of that band. Following each printout, the program will offer you two choices: whether to continue or end the exercise.

Antenna Calculations III—5/8 Wavelength Vertical

```
100 REM THIS IS PROGRAM NO. 4 PROG4
130 LET R = 0
140 LET Z = 5
150 LET Y = 1
160 LET K1 = 585000
170 F1 = 3500
180 F2 = 4000
190 LET X = 1
200 GOTO 930
210 F1 = 5500
220 F2 = 6000
230 LET X = 2
240 GOTO 930
250 F1 = 6000
260 F2 = 6500
270 LET X = 2
280 GOTO 930
290 F1 = 7000
300 F2 = 7300
310 LET X = 1
320 GOTO 930
330 F1 = 9500
340 F2 = 10000
350 LET X = 2
360 GOTO 930
370 F1 = 11500
380 F2 = 12000
390 LET X = 2
400 GOTO 930
410 F1 = 14000
420 F2 = 12450
430 LET X = 1
440 GOTO 930
450 F1 = 15500
460 F2 = 16000
470 LET X = 2
480 GOTO 930
490 F1 = 16500
500 F2 = 17000
510 LET X = 2
520 GOTO 930
530 F1 = 18500
540 F2 = 19000
550 LET X = 2
560 GOTO 930
570 F1 = 21000
580 F2 = 21450
590 LET X = 1
```



```
600 GOTO 930
610 F1 = 25500
620 F2 = 26000
630 LET X = 2
640 GOTO 930
650 F1 = 26500
660 F2 = 27000
670 LET X = 2
680 GOTO 930
690 F1 = 28500
700 F2 = 29000
710 LET X = 1
720 GOTO 930
730 F1 = 29000
740 F2 = 29500
750 LET X = 1
760 GOTO 930
770 F1 = 29500
780 F2 = 30000
790 LET X = 1
800 GOTO 930
810 F1 = 10100
820 F2 = 10150
830 LET X = 1
840 GOTO 930
850 ,890
860 F2 = 18500
870 LET X = 1
880 GOTO 930
890 F1 = 24500
900 F2 = 25000
910 LET X = 1
920 GOTO 930
930 PRINT "TABLE ";Z;"-";Y
940 PRINT "5/8-WAVELENGTH VERTICAL"
950 PRINT F1;" - ";F2;" KILOHERTZ"
960 IF X = 1 THEN  GOTO 980
970 IF X = 2 THEN  GOTO 1000
980 PRINT "USE: AMATEUR RADIO"
990 GOTO 1010
1000 PRINT "USE: INTERNATIONAL BROADCASTING"
1010 PRINT
1020 PRINT
1030 PRINT
1040 FOR Q = 1 TO 3
1050 F(Q) = F1
1060 L(Q) = K1 / F(Q)
1070 L(Q) = L(Q) * 100
```

```
1080 L(Q) =  INT (L(Q))
1090 L(Q) = L(Q) / 100
1100 A = L(1)
1110 B = L(2)
1120 C = L(3)
1200 F1 = F1 + 2
1210 NEXT Q
1220 PRINT F(1);" ";A;" ";B;" ";C
1230 IF F1 > F2 THEN  GOTO 1260
1240 IF F1 = F2 THEN  GOTO 1040
1250 IF F1 < F2 THEN  GOTO 1040
1260 R = R + 1
1270 Y = Y + 1
1280 PRINT
1290 PRINT
1300 PRINT
1310 PRINT
1320 PRINT "TYPE 1 TO END, 2 TO CONTINUE"
1322 INPUT A
1330 IF A > 2 THEN  GOTO 1300
1340 IF A = 1 THEN  GOTO 1360
1350 ON R GOTO 210,250,290,330,370,410,450,490,530,570,
     610,650,690,730,770,810,
1360 END
```

Example

TABLE
5/8-WAVELENGTH VERTICAL
3500 - 4000 KILOHERTZ
USE: AMATEUR RADIO

Freq	Length of Increments		
3500	167.14	167.04	166.95
3506	166.85	166.76	166.66
3512	166.57	166.47	166.38
3518	166.28	166.19	166.09
3524	166	165.91	165.81
3530	165.72	165.62	165.53
3536	165.44	165.34	165.25
3542	165.16	165.06	164.97
3548	164.88	164.78	164.69
3554	164.6	164.51	164.41
3560	164.32	164.23	164.14
3566	164.04	163.95	163.86

3572	163.77	163.68	163.59
3578	163.49	163.4	163.31
3584	163.22	163.13	163.04
3590	162.95	162.86	162.77
3596	162.68	162.59	162.5
3602	162.4	162.31	162.22
3608	162.13	162.04	161.96
3614	161.87	161.78	161.69
3620	161.6	161.51	161.42
3626	161.33	161.24	161.15
3632	161.06	160.97	160.89
3638	160.8	160.71	160.62
3644	160.53	160.44	160.36
3650	160.27	160.18	160.09
3656	160.01	159.92	159.83
3662	159.74	159.66	159.57
3668	159.48	159.4	159.31
3674	159.22	159.14	159.05
3680	158.96	158.88	158.79
3686	158.7	158.62	158.53
3692	158.45	158.36	158.27
3698	158.19	158.1	158.02
3704	157.93	157.85	157.76
3710	157.68	157.59	157.51
3716	157.42	157.34	157.25
3722	157.17	157.08	157
3728	156.92	156.83	156.75
3734	156.66	156.58	156.5
3740	156.41	156.33	156.25
3746	156.16	156.08	156
3752	155.91	155.83	155.75
3758	155.66	155.58	155.5
3764	155.41	155.33	155.25
3770	155.17	155.09	155
3776	154.92	154.84	154.76
3782	154.68	154.59	154.51
3788	154.43	154.35	154.27
3794	154.19	154.1	154.02
3800	153.94	153.86	153.78
3806	153.7	153.62	153.54
3812	153.46	153.38	153.3
3818	153.22	153.14	153.06
3824	152.98	152.9	152.82
3830	152.74	152.66	152.58
3836	152.5	152.42	152.34
3842	152.26	152.18	152.1
3848	152.02	151.94	151.86
3854	151.79	151.71	151.63

3860	151.55	151.47	151.39
3866	151.31	151.24	151.16
3872	151.08	151	150.92
3878	150.85	150.77	150.69
3884	150.61	150.54	150.46
3890	150.38	150.3	150.23
3896	150.15	150.07	150
3902	149.92	149.84	149.76
3908	149.69	149.61	149.53
3914	149.46	149.38	149.31
3920	149.23	149.15	149.08
3926	149	148.93	148.85
3932	148.77	148.7	148.62
3938	148.55	148.47	148.4
3944	148.32	148.25	148.17
3950	148.1	148.02	147.95
3956	147.87	147.8	147.72
3962	147.65	147.57	147.5
3968	147.42	147.35	147.28
3974	147.2	147.13	147.05
3980	146.98	146.91	146.83
3986	146.76	146.69	146.61
3992	146.54	146.46	146.39
3998	146.32	146.25	146.17

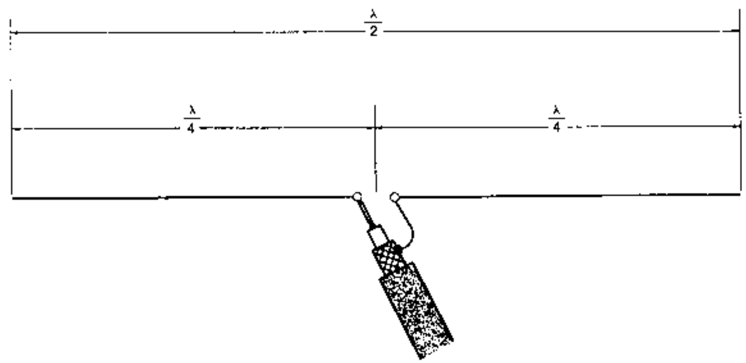
```
TYPE 1 TO END, 2 TO CONTINUE
```


PROGRAM 5

More Antenna Calculations

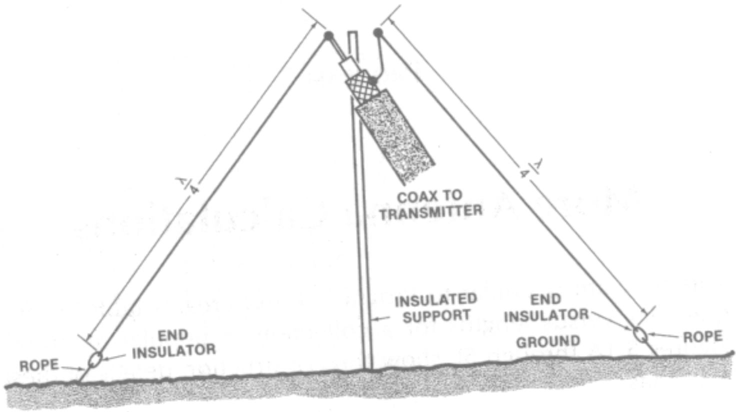
This program is similar to Program 4 and creates tables of frequencies versus lengths for a collection of popular antennas. Figures 5.1A through 5E show the construction details of these antennas.

$$\frac{5}{8}\lambda \leq L \leq \frac{3}{4}\lambda$$

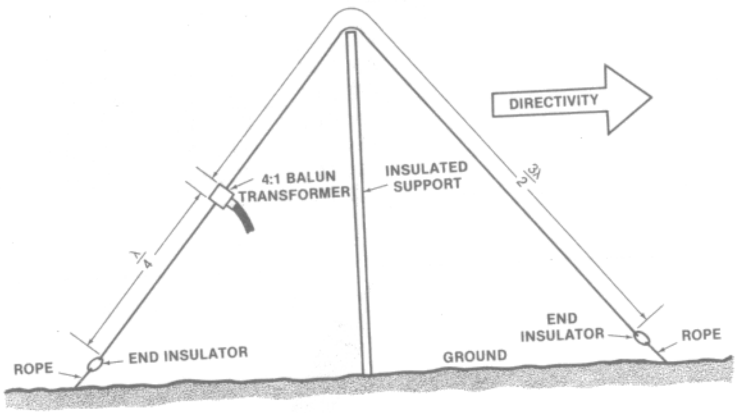


(A) 1/2-wavelength dipole.

FIG. 5.1. SHOWS THE CONSTRUCTION DETAILS OF THESE ANTENNAS.

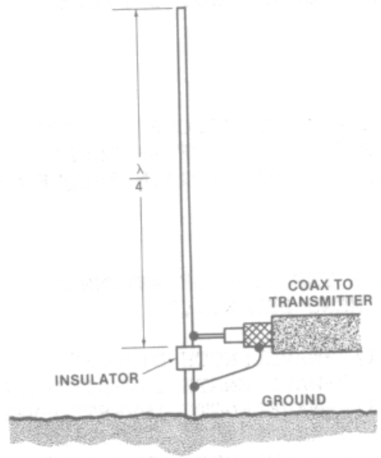


(B) 1/2-wavelength inverted-vee.

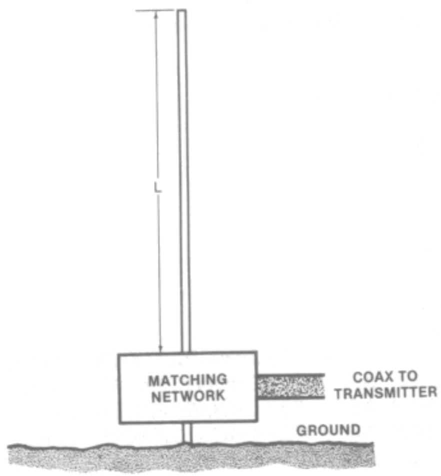


(C) 3/4-wavelength inverted-vee.

FIG. 5.1. SHOWS THE CONSTRUCTION DETAILS OF THESE ANTENNAS—CONT.



(D) 1/4-wavelength vertical.



(E) 5/8-wavelength vertical.

FIG. 5.1. SHOWS THE CONSTRUCTION DETAILS OF THESE ANTENNAS—CONT.

```
100 REM THIS IS PROGRAM NO. 5 PROG5
140 R = 0
150 Z = 5
160 Y = 1
170 GOSUB 1770
180 PRINT  "THIS PROGRAM ALLOWS YOU TO"
185 PRINT "GENERATE CHARTS OF ANTENNA"
190 PRINT "LENGTHS GIVEN CERTAIN FREQUENCIES."
200 PRINT
210 GOSUB 1810
220 GOSUB 1730
230 PRINT "SELECT THE TYPE OF ANTENNA"
235 PRINT "FROM MENU BELOW..."
240 PRINT
250 PRINT "1.  1/2-WAVELENGTH DIPOLE"
260 PRINT "2.  1/2-WAVELENGTH INVERTED-VEE"
270 PRINT "3.  3/4-WAVELENGTH INVERTED-VEE"
280 PRINT "4.  1/4-WAVELENGTH VERTICAL"
290 PRINT "5.  5/8-WAVELENGTH VERTICAL"
300 PRINT "6.  3/4-WAVELENGTH VERTICAL"
310 PRINT
320 PRINT "SELECTION?"
322 INPUT P
330 IF P > 6 THEN  GOTO 220
340 ON P GOTO 350,370,390,410,430,450
350 K1 = 468000
360 GOTO 460
370 K1 = 468000 * 1.06
380 GOTO 460
390 K1 = 702000
400 GOTO 460
410 K1 = 234000
420 GOTO 460
430 K1 = 585000
440 GOTO 460
450 K1 = 702000
460 GOSUB 1730
470 IF P = 1 THEN A$ = "1/2-WAVELENGTH DIPOLE"
480 IF P = 2 THEN A$ = "1/2-WAVELENGTH INVERTED-VEE"
490 IF P = 3 THEN A$ = "3/4-WAVELENGTH INVERTED-VEE"
500 IF P = 4 THEN A$ = "1/4-WAVELENGTH VERTICAL"
510 IF P = 5 THEN A$ = "5/8-WAVELENGTH VERTICAL"
520 IF P = 6 THEN A$ = "3/4-WAVELENGTH VERTICAL"
530 F1 = 3500
540 F2 = 4000
550 X = 1
560 GOTO 1290
570 F1 = 5500
580 F2 = 6000
```



```
590 X = 2
600 GOTO 1290
610 F1 = 6000
620 F2 = 6500
630 X = 2
640 GOTO 1290
650 F1 = 7000
660 F2 = 7300
670 X = 1
680 GOTO 1290
690 F1 = 9500
700 F2 = 10000
710 X = 2
720 GOTO 1290
730 F1 = 11500
740 F2 = 12000
750 X = 2
760 GOTO 1290
770 F1 = 14000
780 F2 = 14450
790 X = 1
800 GOTO 1290
810 F1 = 15500
820 F2 = 16000
830 X = 2
840 GOTO 1290
850 F1 = 16500
860 F2 = 17000
870 X = 2
880 GOTO 1290
890 F1 = 18500
900 F2 = 19000
910 X = 2
920 GOTO 1290
930 F1 = 21000
940 F2 = 21450
950 X = 1
960 GOTO 1290
970 F1 = 25500
980 F2 = 26000
990 X = 2
1000 GOTO 1290
1010 F1 = 26500
1020 F2 = 27000
1030 X = 2
1040 GOTO 1290
1050 F1 = 28500
1060 F2 = 29000
1070 X = 1
```

```
1080 GOTO 1290
1090 F1 = 29000
1100 F2 = 29500
1110 X = 1
1120 GOTO 1290
1130 F1 = 29500
1140 F2 = 30000
1150 X = 1
1160 GOTO 1290
1170 ,1210,1250
1180 F2 = 10150
1190 X = 1
1200 GOTO 1290
1210 F1 = 18000
1220 F2 = 18500
1230 X = 1
1240 GOTO 1290
1250 F1 = 24500
1260 F2 = 25000
1270 X = 1
1280 GOTO 1290
1290 PRINT "TABLE ";Z;"-";Y
1300 PRINT A$
1310 PRINT F1;" - ";F2;" KILOHERTZ"
1320 IF X = 1 THEN  GOTO 1340
1330 IF X = 2 THEN  GOTO 1360
1340 PRINT "USE: AMATEUR RADIO"
1350 GOTO 1370
1360 PRINT "USE: INTERNATIONAL BROADCASTING"
1370 PRINT
1380 PRINT
1390 PRINT
1400 FOR Q = 1 TO 3
1410 F(Q) = F1
1420 L(Q) = K1 / F(Q)
1430 L(Q) = L(Q) * 100
1440 L(Q) =  INT (L(Q))
1450 L(Q) = L(Q) / 100
1460 A = L(1)
1470 B = L(2)
1480 C = L(3)
1560 F1 = F1 + 2
1570 NEXT Q
1580 PRINT F(1);" ";A;" ";B;" ";C
1590 IF F1 > F2 THEN  GOTO 1620
1600 IF F1 = F2 THEN  GOTO 1400
1610 IF F1 < F2 THEN  GOTO 1400
1620 R = R + 1
```



```
1630 Y = Y + 1
1640 PRINT
1650 PRINT
1660 PRINT
1670 PRINT
1680 PRINT "TYPE 1 TO END, 2 TO CONTINUE:"
1682 INPUT A
1690 IF A > 2 THEN  GOTO 1660
1700 IF A = 1 THEN  GOTO 1720
1710 ON R GOTO 570,610,650,690,730,770,810,850,890,930,
     970,1010,1050,1090,1130,
1720 END
1730 FOR I = 1 TO 1
1740 PRINT
1750 NEXT I
1760 RETURN
1770 FOR I = 1 TO 2
1780 PRINT
1790 NEXT I
1800 RETURN
1810 PRINT "PRESS CR TO CONTINUE..."
1820 INPUT AA
1830 RETURN
```

PROGRAM 6

Antenna Calculations IV—HF Beam Antennas such as Quads, Yagis, or Delta Loops

This program is functionally similar to programs 4 and 5, with the exception that these antennas are nominally designed three element HF beam antennas (yagis, quads, or delta loops).

The three elements are the driven, reflector, and director. The driven element is a 1/2-wavelength dipole. The reflector element is located behind (with respect to direction of transmission) the driven element and is approximately 4 percent longer. The director element is located in front of the driven element, and is approximately 4 percent shorter. Spacing between the antennas can be between 0.1 and 0.25 wavelength. The charts in the examples following the program listing are in feet.


```
100 REM THIS IS PROGRAM NO. 6 PROG6
130 P = 0
140 Z = 8
150 Y = 1
160 K1 = 1030000
170 K2 = 984000
180 K3 = 935000
190 F1 = 3500
200 F2 = 4000
210 X = 1
220 GOTO 950
230 F1 = 5500
240 F2 = 6000
250 X = 2
260 GOTO 950
270 F1 = 6000
280 F2 = 6500
290 X = 2
300 GOTO 950
310 F1 = 7000
320 F2 = 7300
330 X = 1
340 GOTO 950
350 F1 = 9500
360 F2 = 10000
370 X = 2
380 GOTO 950
390 F1 = 11500
400 F2 = 12000
410 X = 2
420 GOTO 950
430 F1 = 14000
440 F2 = 14450
450 X = 1
460 GOTO 950
470 F1 = 15500
480 F2 = 16000
490 X = 2
500 GOTO 950
510 F1 = 16500
520 F2 = 17000
530 X = 2
540 GOTO 950
550 F1 = 18500
560 F2 = 19000
570 X = 2
580 GOTO 950
```

```
590 F1 = 21000
600 F2 = 21450
610 X = 1
620 GOTO 950
630 F1 = 25500
640 F2 = 26000
650 X = 2
660 GOTO 950
670 F1 = 26500
680 F2 = 27000
690 X = 2
700 GOTO 950
710 F1 = 28500
720 F2 = 29000
730 X = 1
740 GOTO 950
750 F1 = 29000
760 F2 = 29500
770 X = 1
780 GOTO 950
790 F1 = 29500
800 F2 = 30000
810 X = 1
820 GOTO 950
830 F1 = 10100
840 F2 = 10150
850 X = 1
860 GOTO 950
870 ,910
880 F2 = 18500
890 X = 1
900 GOTO 950
910 F1 = 24500
920 F2 = 25000
930 X = 1
940 GOTO 950
950 PRINT "TABLE ";Z;"-";Y
960 PRINT "THREE-ELEMENT QUAD & DELTA LOOP ANTENNAS"
970 PRINT F1;" - ";F2;" KILOHERTZ"
980 IF X = 1 THEN  GOTO 1000
990 IF X = 2 THEN  GOTO 1020
1000 PRINT "USE: AMATEUR RADIO"
1010 GOTO 1030
1020 PRINT "USE: INTERNATIONAL BROADCASTING"
1030 PRINT
1040 PRINT
1050 PRINT
1070 PRINT
```



```
1080 PRINT
1090 D = K3 / F1
1100 L = K2 / F1
1110 R = K1 / F1
1120 D = D * 100
1130 L = L * 100
1140 R = R * 100
1150 D =  INT (D)
1160 L =  INT (L)
1170 R =  INT (R)
1180 D = D / 100
1190 L = L / 100
1200 R = R / 100
1210 A = L*0.1
1220 B = L*0.125
1230 C = L*0.15
1240 E = L * .22
1245 PRINT
1250 PRINT "FREQ: ";F1
1254 PRINT "DIRECTOR:";D
1256 PRINT "DRIVEN ELEMENT: ";L
1258 PRINT "REFLECTOR: ";R
1260 PRINT "0.1-L SPACING:";A
1261 PRINT "0.125-L SPACING: ";B
1263 PRINT "0.15-L SPACING: ";C
1264 PRINT "0.22-L SPACING: ";E
1268 F1 = F1+20
1270 IF F1 > F2 THEN  GOTO 1300
1280 IF F1 = F2 THEN  GOTO 1090
1290 IF F1 < F2 THEN  GOTO 1090
1300 P = P + 1
1310 Y = Y + 1
1320 PRINT
1330 PRINT
1340 PRINT
1350 PRINT "TYPE 1 TO END, 2 TO CONTINUE"
1360 INPUT A
1370 IF A = 2 THEN  GOTO 1380
1375 IF A = 1 THEN  GOTO 1390
1378 IF A = 0 THEN  GOTO 1320
1379 IF A > 2 THEN  GOTO 1320
1380 ON P GOTO 230,270,310,350,390,430,470,510,550,590,
     630,670,710,750,790,830,
1390 END
```

PROGRAM 7

VSWR Calibration from Forward and Reflected RF Power

The purpose of this program is to create a custom calibration chart for an antenna system given the maximum power output from the transmitter and the minimum value of reflected power (which is not usually zero, but could be).

VSWR Calibration from Forward and Reflected RF Power

```
100 REM THIS IS PROGRAM NO. 7 PROG7
140 GOSUB 510
150 PRINT
160 PRINT
170 PRINT
230 PRINT "LOWEST POSSIBLE REFLECTED POWER IS: ???"
235 INPUT P2
240 PRINT
250 PRINT "MAXIMUM POSSIBLE FORWARD POWER IS: ???"
255 INPUT P1
260 PRINT
270 PRINT "POWER INCREMENT PER CALCULATION: ???"
275 INPUT P3
280 GOSUB 510
290 IF D = 2 THEN  GOTO 330
300 PRINT "REFL.PWR","   VSWR"
310 PRINT
350 R =  SQR (P2 / P1)
360 S1 = 1 + R
370 S2 = 1 - R
380 S = S1 / S2
390 S = S * 1000
400 S =  INT (S)
410 S = S / 1000
440 PRINT P2,S;":1"
470 P2 = P2 + P3
480 IF P1 = P2 THEN  GOTO 550
490 IF P2 < P1 THEN  GOTO 350
500 IF P2 > P1 THEN  GOTO 550
510 FOR I = 1 TO 30
520 PRINT
530 NEXT I
540 RETURN
550 PRINT
560 PRINT
570 PRINT "PROGRAM ENDED"
580 END
```

Example

```
LOWEST POSSIBLE REFLECTED POWER IS: ???
 50

MAXIMUM POSSIBLE FORWARD POWER IS: ???
 1000
```

```
POWER INCREMENT PER CALCULATION: ???
 50


REFL.PWR              VSWR

 50               1.576 :1
 100              1.924 :1
 150              2.264 :1
 200              2.618 :1
 250              3     :1
 300              3.422 :1
 350              3.897 :1
 400              4.441 :1
 450              5.075 :1
 500              5.828 :1
 550              6.74  :1
 600              7.872 :1
 650              9.321 :1
 700             11.244 :1
 750             13.928 :1
 800             17.944 :1
 850             24.626 :1
 900             37.973 :1
 950             77.987 :1

PROGRAM ENDED
```


PROGRAM 8

Standing-Wave Ratio (SWR)

This program permits calculation of standing-wave ratio from any of the following measurements:

1. Voltage maxima and minima along transmission line
2. Current maxima and minima along transmission line
3. Forward and reflected RF power
4. Load impedance and transmission line surge impedance

Standing-Wave Ratio (SWR)

```
100 REM THIS IS PROGRAM NO. 8 PROG8
140 GOSUB 690
330 GOSUB 730
340 PRINT  TAB( 20);"* * * * * * * * *"
350 PRINT  TAB( 20);"*               *"
360 PRINT  TAB( 20);"*  SWR PROGRAM  *"
370 PRINT  TAB( 20);"*               *"
380 PRINT  TAB( 20);"* * * * * * * * *"
390 GOSUB 690
400 GOSUB 770
410 PRINT "CALCULATE SWR FROM..."
420 PRINT
430 PRINT
440 PRINT "1.  VOLTAGES ON TRANSMISSION LINE"
450 PRINT "2.  CURRENTS ON TRANSMISSION LINE"
460 PRINT "3.  FORWARD & REVERSE POWER"
470 PRINT "4.  LINE/ANTENNA (LOAD) IMPEDANCE"
480 PRINT
490 PRINT
500 PRINT
510 PRINT "ENTER ONE OF ABOVE AND PRESS CR: "
520 INPUT M
530 IF M = 1 THEN  GOTO 820
540 IF M = 2 THEN  GOTO 910
550 IF M = 3 THEN  GOTO 1000
560 GOSUB 730
570 PRINT "ENTER THE LOAD IMPEDANCE IN OHMS"
580 INPUT Z1
590 GOSUB 690
600 PRINT "ENTER THE TRANSMISSION LINE"
605 PRINT "IMPEDANCE IN OHMS"
610 INPUT Z2
620 IF Z1 > Z2 THEN  GOTO 650
630 S = Z2 / Z1
640 GOTO 1130
650 S = Z1 / Z2
660 GOTO 1130
670 Z = Z2 / Z1
680 END
690 FOR X = 1 TO 15
700 PRINT
710 NEXT X
720 RETURN
730 FOR X = 1 TO 30
740 PRINT
750 NEXT X
760 RETURN
770 PRINT "PRESS CR TO CONTINUE..."
```



```
780 INPUT B
800 GOSUB 730
810 RETURN
820 GOSUB 730
830 PRINT "ENTER MAXIMUM LINE VOLTAGE (VMAX):"
840 INPUT V1
850 GOSUB 690
860 PRINT "ENTER MINIMUM LINE VOLTAGE (VMIN):"
870 INPUT V2
880 GOSUB 730
890 S = V1 / V2
900 GOTO 1130
910 GOSUB 730
920 PRINT "ENTER MAXIMUM FORWARD LINE CURRENT (IMAX):"
930 INPUT I1
940 GOSUB 690
950 PRINT "ENTER MINIMUM LINE CURRENT (IMIN):"
960 INPUT I2
970 GOSUB 730
980 S = I1 / I2
990 GOTO 1130
1000 GOSUB 690
1010 PRINT "ENTER FORWARD POWER..."
1020 INPUT P1
1030 GOSUB 690
1040 PRINT "ENTER REVERSE POWER..."
1050 PRINT "USE SAME UNITS AS USED FOR"
1052 PRINT "FORWARD POWER!"
1060 INPUT P2
1070 FOR X = 1 TO 45
1080 PRINT "THINKING"
1090 NEXT X
1100 LET H = P2 / P1
1110 LET H2 =  SQR (H)
1120 S = (1 + H2) / (1 - H2)
1130 GOSUB 730
1140 S = S * 100
1150 S =  INT (S)
1160 S = S / 100
1170 PRINT "SWR IS ";S;":1"
1180 PRINT
1190 PRINT
1200 PRINT
1210 PRINT "DO ANOTHER?? YES = 1, NO = 2"
1220 PRINT
1230 PRINT
1240 PRINT
1250 INPUT C
```

```
1260 IF C = 1 THEN  GOTO 330
1270 IF C = 2 THEN  GOTO 1290
1272 IF C < 1 THEN  GOTO 1200
1274 IF C > 2 THEN  GOTO 1200
1280 GOTO 1180
1290 FOR X = 1 TO 30
1300 PRINT "BYE-BYE!!!"
1310 NEXT X
1320 END
```

Example

```
                    * * * * * * * * *
                    *               *
                    *  SWR PROGRAM  *
                    *               *
                    * * * * * * * * *


 PRESS CR TO CONTINUE...
  0


 CALCULATE SWR FROM...


 1.  VOLTAGES ON TRANSMISSION LINE
 2.  CURRENTS ON TRANSMISSION LINE
 3.  FORWARD & REVERSE POWER
 4.  LINE/ANTENNA (LOAD) IMPEDANCE


 ENTER ONE OF ABOVE AND PRESS CR:
  4


 ENTER THE LOAD IMPEDANCE IN OHMS
  37


 ENTER THE TRANSMISSION LINE
 IMPEDANCE IN OHMS
  73
```



```
SWR IS  1.97 :1


DO ANOTHER?? YES = 1, NO = 2


 2
BYE-BYE!!!
BYE-BYE!!!
BYE-BYE!!!
```

Program 9

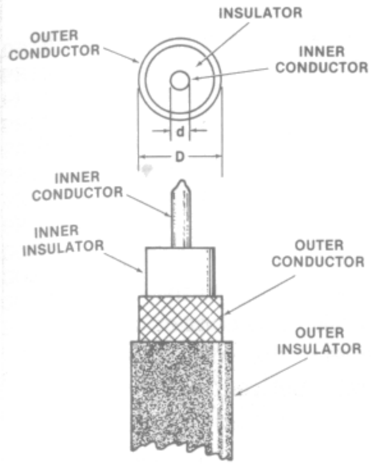
Transmission Line—Characteristic Impedance

The transmission line is the conduit between a source of RF energy, such as a radio transmitter, and the load, such as an antenna. There are several different types of transmission lines—four are considered here:

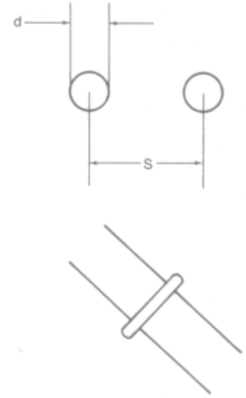
1. Two-conductor coaxial cable
2. Parallel two-conductor line
3. Shielded parallel two-conductor line
4. Microstrip line

Coaxial cable (Fig. 9.1A) is, perhaps, the most commonly found form of transmission line, consisting of a round inner conductor surrounded by a round outer conductor (which is usually either a braided conductor or aluminum foil); the name coaxial is derived from the fact that the longitudinal axis of the two conductors is the same. The surge impedance of the line is determined by the ratio of the outer conductor diameter to the inner conductor diameter, according to the equation given in Fig. 9.1B.

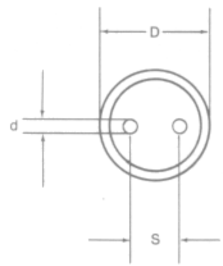
Parallel open-wire feeders were probably the first transmission line that was not simply a piece of wire extending from one end of the antenna. This type of transmission line (Fig. 9.1B) consists of two conductors, parallel to each other (spacing constant). The surge impedance is determined by the conductor diameter and the spacing between the conductors (center-to center). The dielectric constant (ϵ), is defined as 1 for air, so drops out of the equation for open-wire feeders. If some other



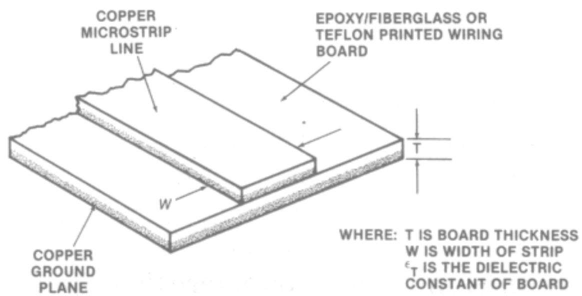
(A) Coaxial cable.



(B) Two conductors, parallel to each other (spacing constant).



(C) Shielded twin-lead.



(D) Microstrip line is part of the printed circuit.

Fig. 9.1. Different types of transmission line.

type of dielectric is used, then the dielectric constant must be used (refer to a dielectric constants table).

Since it is often less difficult to find the velocity factor, keep in mind that

$$\epsilon = 1/V^2 \qquad [9.1]$$

Shielded twin lead (Fig. 9.1C) adds something to the complexity of our calculations. We have to take into consideration the dielectric constant, the ratio between the inner conductor spacing and the diameter, and the ratio between the inner conductor spacing and the diameter of the outer conductor.

Microstrip transmission line is a special type used in VHF, UHF and microwave amplifiers (and other devices). The microstrip line is part of the printed circuit (see Fig. 9.1D). You can find a clear and nearly comprehensive explanation of microstrip basics in James Hardy, *High Frequency Circuit Design* (Reston: Reston Publishing Co., Inc., 1982).

$$Z_0 = \frac{276}{\sqrt{\epsilon}} \log \frac{2S}{d} \qquad [9.2]$$

$$Z_0 = \frac{377}{\sqrt{\epsilon_T}} \frac{T}{W} \qquad [9.3]$$

where

- T is board thickness,
- W is width of strip,
- ϵ_T is the dielectric constant of board,
- $\epsilon = 1$ for air.

Transmission Line—Characteristic Impedance

```
100 REM THIS IS PROGRAM NO. 9 PROG9
140 S = 0
150 Q = 5
160 GOSUB 1970
```



```
170 PRINT  TAB( S);"* * * * * * * * * * * * * * * * * * * * *"
180 PRINT  TAB( S);"*                                       *"
190 PRINT  TAB( S);"* PROGRAM TO CALCULATE CHARACTERISTIC *"
200 PRINT  TAB( S);"*    IMPEDANCE OF TRANSMISSION LINES  *"
210 PRINT  TAB( S);"*                                       *"
220 PRINT  TAB( S);"*     COPYRIGHT 1986 BY J.J. CARR     *"
230 PRINT  TAB( S);"*                                       *"
240 PRINT  TAB( S);"* * * * * * * * * * * * * * * * * * * * *"
250 GOSUB 1930
260 GOSUB 2010
270 GOSUB 1970
280 PRINT "THIS PROGRAM COMPUTES THE"
290 PRINT "CHARACTERISTIC IMPEDANCE OF"
295 PRINT "SEVERAL FORMS OF RADIO"
300 PRINT "TRANSMISSION LINE."
310 GOSUB 1930
320 GOSUB 2010
330 GOSUB 1930
340 PRINT  TAB( Q);"SELECT ONE FROM MENU BELOW:"
350 PRINT
355 PRINT  TAB( Q);"1.  TWO-CONDUCTOR COAXIAL CABLE"
360 PRINT  TAB( Q);"2.  PARALLEL FEEDERS (OPEN-WIRE)"
370 PRINT  TAB( Q);"3.  SHIELDED PARALLEL CONDUCTOR"
380 PRINT  TAB( Q);"4.  MICROSTRIP (PC) PARALLEL LINE"
400 PRINT
410 PRINT "SELECTION: ???"
412 INPUT M
420 ON M GOTO 430,850,1140,1470
430 GOSUB 1930
440 PRINT "COAXIAL CABLE SELECTED"
450 PRINT
470 PRINT
480 PRINT "ENTER DIAMETER OF INNER CONDUCTOR:"
482 INPUT D1
490 PRINT
500 PRINT "ENTER OVERALL OUTSIDE DIAMETER:"
502 INPUT D2
510 GOSUB 1930
520 PRINT "SELECT DIELECTRIC MATERIAL"
530 PRINT
540 PRINT "1.  FOAMED POLYETHYLENE"
550 PRINT "2.  REGULAR POLYETHYLENE"
560 PRINT "3.  TEFLON"
570 PRINT "4.  AIR-SPACE POLYETHYLENE"
580 PRINT "5.  AIR INSULATED"
590 PRINT
600 PRINT "SELECTION: ???"
602 INPUT S
```

```
610 IF S = 1 THEN V = 0.8
620 IF S = 2 THEN V = 0.66
630 IF S = 3 THEN V = 0.70
640 IF S = 4 THEN V = 0.86
650 IF S = 5 THEN V = 1.00
660 IF S > 5 THEN  GOTO 530
670 E = 1 / (V ^ 2)
680 ZA =  LOG (D2 / D1)
690 ZA = ZA * 0.4343
700 ZB = 138 / ( SQR (E))
710 ZO = ZA * ZB
720 ZO =  INT (ZO)
730 PRINT "ZO = ";ZO
740 PRINT "E = ";E
750 PRINT "V = ";V
760 GOSUB 2010
770 PRINT
780 PRINT "1.  DO ANOTHER COAXIAL CABLE?"
790 PRINT "2.  SELECT ANOTHER TYPE OF LINE?"
800 PRINT "3.  FINISHED?"
810 PRINT
820 PRINT "SELECTION:  ???"
825 INPUT P
830 IF P > 3 THEN  GOTO 770
840 ON P GOTO 430,330,2040
850 GOSUB 1930
860 PRINT "PARALLEL OPEN-WIRE FEEDERS SELECTED"
870 GOSUB 1930
880 PRINT "ALL DIMENSIONS IN SAME UNITS!"
890 GOSUB 1930
900 GOSUB 2010
910 GOSUB 1930
920 PRINT "ENTER CONDUCTOR DIAMETER (D):"
925 INPUT D
928 PRINT
930 PRINT "ENTER CONDUCTOR SPACING (S):"
935 INPUT S
950 PRINT
960 ZA = (2 * S) / D
970 ZA =  LOG (ZA)
980 ZA = 0.4343 * ZA
990 ZO = 276 * ZA
1000 PRINT
1010 PRINT "ZO = ";ZO
1020 PRINT
1030 PRINT "VELOCITY FACTOR (V) AND DIELECTRIC CONSTANT (E)"
1040 PRINT "DEFINED AS 1"
1050 GOSUB 1930
```



```
1060 GOSUB 2010
1070 GOSUB 1930
1080 PRINT "1. DO ANOTHER PARALLEL OPEN"
1085 PRINT "   WIRE LINE?"
1088 PRINT
1090 PRINT "2. SELECT ANOTHER TYPE"
1095 PRINT "   TRANSMISSION LINE?"
1098 PRINT
1100 PRINT "3. FINISHED?"
1110 PRINT
1120 PRINT "SELECTION: ???"
1124 INPUT P
1130 IF P > 3 THEN  GOTO 1110
1132 ON P GOTO 850,330,2040
1140 GOSUB 1930
1150 PRINT "SHIELDED PARALLEL CONDUCTOR"
1155 PRINT "LINE SELECTED"
1160 PRINT
1170 PRINT "ALL DIMENSIONS IN SAME UNITS!"
1180 PRINT
1190 PRINT "ENTER CONDUCTOR-TO-CONDUCTOR SPACING"
1192 INPUT H
1200 PRINT
1210 PRINT "ENTER INNER CONDUCTOR DIAMETER"
1212 INPUT D1
1220 PRINT
1230 PRINT "ENTER OUTER-SHIELD DIAMETER:"
1232 INPUT D2
1240 PRINT
1250 B = H / D2
1260 A = H / D1
1270 C = 2 * A * ((1 - B ^ 2) / (1 + B ^ 2))
1280 F =  LOG (C)
1290 F = 0.4343 * F
1300 V = 0.80
1310 E = 1 /  SQR (V)
1320 ZO = (276 * F) /  SQR (E)
1330 PRINT
1340 PRINT "ZO = ";ZO
1350 PRINT "V = ";V
1360 PRINT "E = ";E
1370 PRINT
1380 GOSUB 2010
1390 GOSUB 1930
1400 PRINT "1. DO ANOTHER SHIELDED"
1404 PRINT "   PARALLEL CONDUCTOR LINE?"
1406 PRINT
1410 PRINT "2. SELECT ANOTHER TYPE OF LINE?"
```

```
1415 PRINT
1420 PRINT "3. FINISHED?"
1430 PRINT
1440 PRINT "SELECTION: ???"
1442 INPUT M
1450 IF M > 3 THEN  GOTO 1390
1460 ON M GOTO 1140,330,2040
1470 GOSUB 1930
1480 PRINT "MICROSTRIP (PRINTED-CIRCUIT)"
1485 PRINT "LINE SELECTED"
1490 GOSUB 1930
1500 PRINT "ALL DIMENSIONS MUST BE IN SAME UNITS!!"
1510 GOSUB 1930
1520 GOSUB 2010
1530 GOSUB 1930
1540 PRINT "ENTER PRINTED CIRCUIT BOARD THICKNESS:"
1542 INPUT T
1550 GOSUB 1930
1560 PRINT "ENTER CONDUCTOR WIDTH:"
1562 INPUT W
1570 GOSUB 1930
1580 PRINT "SELECT BOARD TYPE:"
1590 PRINT
1600 PRINT "1.  GLASS-EPOXY"
1610 PRINT "2.  TEFLON-LOADED GLASS"
1620 PRINT
1630 PRINT
1640 PRINT "SELECTION:"
1643 INPUT G
1650 IF G > 2 THEN  GOTO 1570
1660 IF G = 1 THEN E = 4.8
1662 IF G = 2 THEN E = 2.5
1664 IF G < 1 THEN  GOTO 1570
1670 ZA = W * ( SQR (E))
1680 ZB = T / ZA
1690 ZO = 377 * ZB
1700 K = (W / T) ^  - 0.836
1710 L = 1.735 * (E ^  - 0.724)
1720 J = K * L
1730 Y = 1 + J
1740 ZO = ZO / Y
1750 ZO =  INT (ZO)
1760 GOSUB 1930
1770 PRINT "ZO = ";ZO
1780 PRINT "WIDTH (W): ";W
1790 PRINT "BOARD THIKNESS (T): ";T
1800 IF G = 2 THEN  GOTO 1830
1810 PRINT "E = ";E;" FOR GLASS-EPOXY BOARDS"
```



```
1820 GOTO 1840
1830 PRINT "E = ";E;" FOR TEFLON-LOADED GLASS BOARDS"
1840 GOSUB 2010
1850 GOSUB 1930
1860 PRINT "1.  DO ANOTHER MICROSTRIP LINE?"
1870 PRINT "2.  SELECT ANOTHER TYPE OF LINE?"
1880 PRINT "3.  FINISHED?"
1890 PRINT
1900 PRINT "SELECTION: ???"
1905 INPUT P
1910 IF P > 3 THEN  GOTO 1850
1920 ON P GOTO 1470,330,2040
1930 FOR I = 1 TO 5
1940 PRINT
1950 NEXT I
1960 RETURN
1970 FOR I = 1 TO 30
1980 PRINT
1990 NEXT I
2000 RETURN
2010 PRINT "PRESS CR TO CONTINUE..."
2020 INPUT GG
2030 RETURN
2040 PRINT "END"
2050 END
```

PROGRAM 10

Coaxial Cable—Characteristic Impedance and Other Parameters

Coaxial cable is one of the most popular radio transmission lines. A typical coaxial cable (refer to Fig. 9.1A) consists of a cylindrical inner conductor surrounded coaxially by a cylindrical outer conductor. The two conductors are separated by a dielectic insulator of polyethylene, foamed poly, Teflon, air, dry inert gas, or some other insulating material. This program will calculate the most important parameters of coaxial cable transmission lines:

1. Surge ("characteristic") Impedance
2. Capacitance in pF/ft
3. Inductance in μH/ft
4. Time delay factor (TDF) in nanoseconds/ft
5. Cut-off frequency in gigahertz (GHz)

These parameters are defined according to the following rules:

Surge Impedance, Z_o. There are two ways to determine surge impedance:

$$Z = 1000\sqrt{L/C} \qquad [10.1]$$

where
L is the inductance in μH/ft,
C is the capacitance in pF/ft.
and

$$Z = (138/\epsilon)(\log(D/d)) \qquad [10.2]$$

where
Z is the impedance in ohms,
ϵ is the dielectric constant. ϵ is $1/V^2$, where V is the velocity factor,
D is the outer diameter,
d is the diameter of the inner conductor.

Capacitance, C. The capacitance in picofarads per foot is defined as

$$C = (7.36\varsigma) / \log(D/d) \qquad [10.3]$$

where
ϵ is the dielectric constant (which is $1/V^2$),
D is the diameter of the outer conductor,
d is the diameter of the inner conductor.

Inductance, L. The inductance in microhenries per foot is defined as

$$L = 0.14 \log(D/d) \qquad [10.4]$$

Time Delay Factor (TDF). This parameter tells us how much delay to expect of an RF signal passing down the coaxial cable. Radio technicians often use the *TDF* to incorporate delays needed to test devices such as transponders, depth finders and other instruments in which a delay is expected. The *TDF* is as follows:

$$TDF = 1.016\sqrt{\epsilon} \qquad [10.5]$$

Coaxial Cable—Characteristic Impedance and Other Parameters

```
100 REM THIS IS PROGRAM NO. 10 PROG10
110 GOSUB 700
120 PRINT "SELECT DIELECTRIC TYPE FROM"
125 PRINT "MENU BELOW:"
```

```
130 PRINT
140 PRINT "1.  REGULAR POLYETHYLENE"
150 PRINT "2.  FOAM POLYETHYLENE"
160 PRINT "3.  TEFLON"
170 PRINT "4.  AIR"
180 PRINT
190 PRINT "SELECTION? "
192 INPUT P
200 IF P > 4 THEN  GOTO 120
210 IF P = 1 THEN V = 0.66
220 IF P = 2 THEN V = 0.80
230 IF P = 3 THEN V = 0.70
240 IF P = 4 THEN V = 1.00
250 GOSUB 660
260 PRINT "ENTER DI{$1}AMETER OF INNER CONDUCTOR"
262 INPUT DI
270 PRINT
280 PRINT "ENTER DIAMETER OF OUTER CONDUCTOR:"
282 INPUT DO
290 PRINT
300 D = DO / DI
303 J = 0.4348 *  LOG (D)
310 E = 1 / (V ^ 2)
320 C = (7.36 * E) / (J)
330 L = (0.14 * (J))
340 Z =  SQR (L / C) * 1000
350 TD = 1.016 *  SQR (E) * (DI + DO)
360 FC = 7.5 / ( SQR (E) * (DI + DO))
370 C = C * 100
380 C =  INT (C)
390 C = C / 100
400 L = L * 100
410 L =  INT (L)
420 L = L / 100
430 FC = FC * 100
440 FC =  INT (FC)
450 FC = FC / 100
460 TD = TD * 1000
470 TD =  INT (TD)
480 TD = TD / 1000
490 Z = Z * 100
500 Z =  INT (Z)
510 Z = Z / 100
520 GOSUB 700
530 PRINT "PARAMETERS:"
540 PRINT
550 PRINT "SURGE IMPEDANCE (ZO): ";Z;" OHMS"
```



```
560 PRINT "VELOCITY FACTOR (V): ";V
570 PRINT
580 PRINT "CAPACITANCE (C): ";C;" PF/FT"
590 PRINT "INDUCTANCE (L): ";L;" UH/FT"
600 PRINT
610 PRINT "TIME-DELAY FACTOR: ";TD;" NS/FT"
620 PRINT "CUT-OFF FREQUENCY: ";FC;" GHZ"
630 GOSUB 660
640 GOSUB 740
650 GOSUB 770
660 FOR I = 1 TO 5
670 PRINT
680 NEXT I
690 RETURN
700 FOR I = 1 TO 30
710 PRINT
720 NEXT I
730 RETURN
740 PRINT "PRESS CR TO CONTINUE..."
742 INPUT SS
760 RETURN
770 GOSUB 700
780 PRINT "WHAT'S YOUR PLEASURE?"
790 PRINT
800 PRINT "1. DO ANOTHER"
810 PRINT "2. FINISHED"
820 PRINT
830 PRINT "SELECTION:  ????"
840 INPUT L
850 IF L > 2 THEN  GOTO 790
855 ON L GOTO 110,860
860 PRINT
870 PRINT "PROGRAM ENDED"
880 END
```

Example

```
SELECT DIELECTRIC TYPE FROM
MENU BELOW:

1.  REGULAR POLYETHYLENE
2.  FOAM POLYETHYLENE
3.  TEFLON
4.  AIR
```

Coaxial Cable—Characteristic Impedance and Other Parameters—cont.

```
SELECTION?
 2


ENTER DIAMETER OF INNER CONDUCTOR
 .108

ENTER DIAMETER OF OUTER CONDUCTOR:
 .406



PARAMETERS:

SURGE IMPEDANCE (ZO):  63.52  OHMS
VELOCITY FACTOR (V):  .8

CAPACITANCE (C):  19.97  PF/FT
INDUCTANCE (L):  .08  UH/FT

TIME-DELAY FACTOR:  .652  NS/FT
CUT-OFF FREQUENCY:  11.67  GHZ


PRESS CR TO CONTINUE...


WHAT'S YOUR PLEASURE?

1. DO ANOTHER
2. FINISHED

SELECTION:  ????

PROGRAM ENDED
```

ARTICLE 1

Impedance Matching Networks for Radio Antennas

In this subsection we are going to digress a moment to present some information about antenna impedance matching. Following this discussion we present several programs for computing the values of components used in antenna matching networks. But before we digress into the various programs, let's present for the noninitiator some information on just what we are doing.

Figure 10.1 shows a model for a radio transmitter/antenna system. There is a radio frequency energy source—the transmitter—that has a certain output impedance. Maximum power transfer in such a system (or any other electrical system, incidentally) occurs when the load impedance is identical to the output impedance of the transmitter (which is often called the source impedance). In real world situations, however, we find at least two problems. One, which is inside of the transmitter, is that the natural output impedance of signal source devices such as transistors and vacuum tubes rarely matches the antenna impedance. The output impedance of transistor circuits tends to be lower than the typical load impedance, while the output impedance of tubes tends to be much higher than typical load impedances. The other problem is that commercial radio transmitters tend to offer a limited range of output impedances. It is not unlikely, for example, that the nominal output impedance of a typical transmitter will be 40 to 90 ohms. The antenna, on the other hand, can have a resistive feed-point impedance of 5 to 600 ohms, depending upon design and location.

Regardless of the problem, however, the solution is an inductor capacitor matching network of some sort—the block diagram of Fig. 10.1.

The circuits shown in this subsection are widely used. There are other possible matching schemes, but these are the most popular and most common.

Impedance is a complex parameter that contains both a real (resistive) and imaginary (reactive) component. The reactive component consists of inductive reactance (X_L) and capacitive reactance (X_C). At resonance, these two reactances are equal, but opposite, so will cancel each other leaving only the resistive component. For our purposes, therefore, it is assumed that the antenna is resistive at the feed point. Thus, the impedances shown in Fig. 10.1 are labelled R1 and R2 for input and output impedance, respectively.

Matching nonresistive impedances requires the matching network to offer the complex conjugate of the feed-point impedance. For example, if the antenna feed-point impedance is

$$Z = R + jX_L \qquad [10.6]$$

Then the matching network must provide an output impedance of

$$Z = R - jX_C \qquad [10.7]$$

While the input impedance remained resistive.

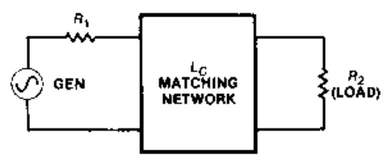


FIG. 10.1. BLOCK DIAGRAM OF AN INDUCTOR / CAPACITOR MATCHING NETWORK.

PROGRAM 11

Inverted-L Network

Figure 11.1 shows the inverted-L impedance matching network. This network is just the opposite of the normal L-section network, as demonstrated by the fact that the capacitor is across the input impedance rather than the output impedance. The main constraint of this network is that the input impedance, R1, must be greater than the output impedance, R2:

$$R_1 > R_2$$

This program will calculate the inductive reactance and capacitive reactance required to match R_1 and R_2, using the equations shown in Fig. 11.1. The program will ask you whether or not you want to interpret these reactances as capacitances and inductances for operation at a specific frequency.

$$R_1 > R_2$$

$$X_L = 2\pi F_L = \sqrt{R_1 R_2 - R_2^2} \qquad [11.1]$$

$$X_C = \frac{1}{2\pi F_C} = R_1 \ (R_2/X_L) \qquad [11.2]$$

$$C = \frac{1}{2\pi F_{XC}} \qquad [11.3]$$

$$L = \frac{X_L}{2\pi F} \qquad [11.4]$$

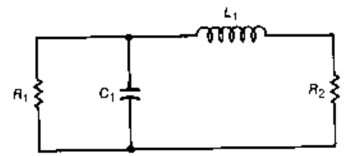


FIG. 11.1. AN INVERTED-L IMPEDANCE MATCHING NETWORK.

Inverted-L Network

```
100 REM THIS IS PROGRAM NO. 11 PROG11
130 GOSUB 680
140 PRINT "THIS PROGRAM CALCULATES THE"
145 PRINT "REACTANCES, CAPACITANCES, AND"
150 PRINT "INDUCTANCE NEEDED TO MATCH THE"
155 PRINT "INPUT IMPEDANCE (R1) TO THE"
160 PRINT "OUTPUT IMPEDANCE (R2)."
170 PRINT
180 PRINT "CONSTRAINT: R1 > R2"
190 PRINT
200 GOSUB 720
210 GOSUB 680
220 PRINT "ENTER R1 (INPUT IMPEDANCE):"
230 INPUT R1
240 PRINT
250 PRINT "ENTER R2 (OUTPUT IMPEDANCE - LOAD):"
260 INPUT R2
270 IF R1 > R2 THEN  GOTO 300
280 GOSUB 750
290 GOTO 210
300 XL = (R1 * R2) - (R2 ^ 2)
310 XL =  SQR (XL)
320 XC = (R1 * R2) / XL
330 XC =  INT (XC)
340 XL = XL * 100
350 XL =  INT (XL)
360 XL = XL / 100
370 PRINT
380 PRINT
390 PRINT
400 PRINT "DESIGN FOR A SPECIFIC FREQUENCY?"
410 PRINT
420 PRINT "1. YES"
430 PRINT "2. NO"
440 PRINT
450 PRINT "ENTER ONE (1) AND PRESS CR:"
```



```
460 INPUT G
470 IF G > 2 THEN  GOTO 390
475 IF G < 1 THEN  GOTO 440
480 ON G GOTO 490,810
490 PRINT
500 PRINT
510 PRINT
520 PRINT "ENTER FREQUENCY (F) IN"
525 PRINT "KILOHERTZ (KHZ) AND PRESS CR:"
530 INPUT F
540 F = F * 1000
550 W = 2 * 3.1415 * F
560 L = XL / W
570 L = L * (10 ^ 6)
580 L = L * 100
590 L =  INT (L)
600 L = L / 100
610 C = 1 / (W * XC)
620 C = C * (10 ^ 12)
630 C = C * 100
640 C =  INT (C)
650 C = C / 100
660 F = F / 1000
670 GOTO 810
680 FOR I = 1 TO 2
690 PRINT
700 NEXT I
710 RETURN
720 PRINT "PRESS CR TO CONTINUE..."
730 INPUT DD
740 RETURN
750 PRINT
760 PRINT
770 PRINT "ERROR!  R1 MUST BE GREATER THAN R2"
780 PRINT
790 GOSUB 720
800 RETURN
810 GOSUB 680
820 PRINT "INPUT IMPEDANCE (R1): ";R1;" OHMS"
830 PRINT "OUTPUT IMPEDANCE (R2): ";R2;" OHMS"
840 PRINT
850 PRINT "INDUCTIVE REACTANCE (XL): ";XL;" OHMS"
860 PRINT "CAPACITIVE REACTANCE (XC): ";XC;" OHMS"
870 PRINT
880 IF G = 1 THEN  GOTO 900
890 GOTO 940
900 PRINT "FOR A FREQUENCY OF ";F;" KILOHERTZ USE:"
910 PRINT "C = ";C;" PF"
```

```
920 PRINT "L = ";L;" UH"
930 PRINT
940 GOSUB 720
950 GOSUB 680
960 PRINT "FINISHED?"
970 PRINT "1.  YES"
980 PRINT "2.  NO"
990 PRINT
1000 PRINT "ENTER ONE (1) AND PRESS CR:"
1010 INPUT M
1015 IF M > 2 THEN  GOTO 960
1016 IF M < 1 THEN  GOTO 960
1020 ON M GOTO 1030,100
1030 GOSUB 680
1040 FOR I = 1 TO 2
1050 PRINT "************ BYE-BYE***********"
1060 NEXT I
1070 PRINT
1080 PRINT
1090 PRINT "PROGRAM ENDED"
1100 END
```

Example

```
THIS PROGRAM CALCULATES THE
REACTANCES, CAPACITANCES, AND
INDUCTANCE NEEDED TO MATCH THE
INPUT IMPEDANCE (R1) TO THE
OUTPUT IMPEDANCE (R2).

CONSTRAINT: R1 > R2

PRESS CR TO CONTINUE...


ENTER R1 (INPUT IMPEDANCE):
 20

ENTER R2 (OUTPUT IMPEDANCE - LOAD):
 50


ERROR!  R1 MUST BE GREATER THAN R2

PRESS CR TO CONTINUE...
```



```
ENTER R1 (INPUT IMPEDANCE):
 200

ENTER R2 (OUTPUT IMPEDANCE - LOAD):
 50


DESIGN FOR A SPECIFIC FREQUENCY?

1. YES
2. NO

ENTER ONE (1) AND PRESS CR:
 1


ENTER FREQUENCY (F) IN
KILOHERTZ (KHZ) AND PRESS CR:
 21390


INPUT IMPEDANCE (R1):  200  OHMS
OUTPUT IMPEDANCE (R2):  50  OHMS

INDUCTIVE REACTANCE (XL):  86.6  OHMS
CAPACITIVE REACTANCE (XC):  115  OHMS

FOR A FREQUENCY OF  21390  KILOHERTZ USE:
C =  64.7  PF
L =  .64  UH

PRESS CR TO CONTINUE...


FINISHED?
1.  YES

ENTER ONE (1) AND PRESS CR:
 2


THIS PROGRAM CALCULATES THE
REACTANCES, CAPACITANCES, AND
INDUCTANCE NEEDED TO MATCH THE
INPUT IMPEDANCE (R1) TO THE
OUTPUT IMPEDANCE (R2).
```

```
CONSTRAINT: R1 > R2

PRESS CR TO CONTINUE...


ENTER R1 (INPUT IMPEDANCE):
 50

ENTER R2 (OUTPUT IMPEDANCE - LOAD):
 15


DESIGN FOR A SPECIFIC FREQUENCY?

1. YES
2. NO

ENTER ONE (1) AND PRESS CR:
 2


INPUT IMPEDANCE (R1):  50  OHMS
OUTPUT IMPEDANCE (R2):  15  OHMS

INDUCTIVE REACTANCE (XL):  22.91  OHMS
CAPACITIVE REACTANCE (XC):  32  OHMS

PRESS CR TO CONTINUE...


FINISHED?
1.  YES
2.  NO

ENTER ONE (1) AND PRESS CR:
 1


************ BYE-BYE**********
************ BYE-BYE**********


PROGRAM ENDED
```


PROGRAM 12

L-Section Network

This program is similar to Program 11, with the exception that it requires the load impedance to be greater than the source impedance.

$$R_1 < R_2$$

The L-section network is shown in Fig. 12.1, along with the design equations that are used in the program. Q is the quality factor of the LC network and is constrained to values between 1 and 5 for the practical circuits covered by this program.

An example follows the program listing.

$$R_1 < R_2$$

$$X_L = 2\pi F_L = QR_1 \quad [12.1]$$

$$X_C = \frac{1}{2\pi F_L} = \frac{R_2}{Q} \quad [12.2]$$

$$Q = \sqrt{\frac{R_2}{R_1} - 1} = \frac{X_L}{R_1} = \frac{R_2}{X_C} \quad [12.3]$$

$$(1 \le Q \le 5)$$

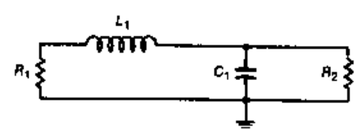


FIG. 12.1. L-SECTION NETWORK ALONG WITH THE DESIGN EQUATIONS THAT ARE USED IN THE PROGRAM.

L-Section Network

```
100 REM THIS IS PROGRAM NO. 12 PROG12
130 GOSUB 670
140 PRINT "THIS PROGRAM CALCULATES THE"
150 PRINT "REACTANCES, CAPACITANCES, AND"
160 PRINT "INDUCTANCES NEEDED TO MATCH"
170 PRINT "THE INPUT IMPEDANCE (R1) TO THE"
180 PRINT "OUTPUT IMPEDANCE (R2)."
190 PRINT "THE SIMPLE L-SECTION NETWORK"
200 PRINT "MATCHES A LONG WIRE ANTENNA TO"
205 PRINT "A LOW-Z TRANSMITTER OUTPUT."
210 PRINT
220 PRINT "CONSTRAINT: R2 > R1"
230 PRINT
240 GOSUB 710
250 GOSUB 670
260 PRINT "ENTER R1 (INPUT-Z):"
270 INPUT R1
280 PRINT
290 PRINT "ENTER R2 (OUTPUT-Z):"
300 INPUT R2
310 IF R2 > R1 THEN  GOTO 340
320 GOSUB 740
330 GOTO 250
340 GOSUB 670
350 Q = (R2 / R1) - 1
360 Q =  SQR (Q)
370 XL = Q * R11
380 XC = R2 / Q
390 PRINT "DESIGN FOR A SPECIFIC FREQUENCY?"
400 PRINT
410 PRINT "1. YES"
420 PRINT "2. NO"
430 PRINT
440 PRINT "ENTER ONE (1) AND PRESS CR:"
450 INPUT G
460 IF G > 2 THEN  GOTO 390
465 IF G < 1 THEN  GOTO 390
470 ON G GOTO 480,800
480 PRINT
490 PRINT
500 PRINT
510 PRINT "ENTER FREQUENCY (F) IN"
515 PRINT "KILOHERTZ AND PRESS CR..."
520 INPUT F
530 F = F * 1000
540 W = 2 * 3.1415 * F
550 L = XL / W
560 L = L * (10 ^ 6)
```



```
570 L = L * 100
580 L =  INT (L)
590 L = L / 100
600 C = 1 / (W * XC)
610 C = C * (10 ^ 12)
620 C = C * 100
630 C =  INT (C)
640 C = C / 100
650 F = F / 1000
660 GOTO 800
670 FOR I = 1 TO 30
680 PRINT
690 NEXT I
700 RETURN
710 PRINT "PRESS CR TO CONTINUE..."
720 INPUT EE
730 RETURN
740 PRINT
750 PRINT
760 PRINT "ERROR!!!  R2 MUST BE GREATER THAN R1"
770 PRINT
780 GOSUB 710
790 RETURN
800 GOSUB 670
810 PRINT "INPUT IMPEDANCE (R1): ";R1;" OHMS"
820 PRINT "OUTPUT IMPEDANCE (R2): ";R2;" OHMS"
830 PRINT
840 PRINT "INDUCTIVE REACTANCE (XL): ";XL;" OHMS"
850 PRINT "CAPACITIVE REACTANCE (XC): ";XC;" OHMS"
860 PRINT
870 IF G = 1 THEN  GOTO 890
880 GOTO 930
890 PRINT "FOR A FREQUENCY OF ";F;" KHZ USE:"
900 PRINT "C = ";C;" PF"
910 PRINT "L = ";L;" UH"
920 PRINT
930 GOSUB 710
940 GOSUB 670
950 PRINT "FINISHED?"
960 PRINT "1.  YES"
970 PRINT "2.  NO"
980 PRINT
990 PRINT "ENTER ONE (1) AND PRESS CR:"
1000 INPUT M
1005 IF M > 2 THEN  GOTO 940
1006 IF M < 1 THEN  GOTO 940
1010 ON M GOTO 1020,100
1020 GOSUB 670
```

```
1030 FOR I = 1 TO 30
1040 PRINT "********** BYE-BYE **********"
1050 NEXT I
1060 PRINT
1070 PRINT
1080 PRINT "PROGRAM ENDED"
1090 END
```

Example

```
THIS PROGRAM CALCULATES THE
REACTANCES, CAPACITANCES, AND
INDUCTANCES NEEDED TO MATCH
THE INPUT IMPEDANCE (R1) TO THE
OUTPUT IMPEDANCE (R2).
THE SIMPLE L-SECTION NETWORK
MATCHES A LONG WIRE ANTENNA TO
A LOW-Z TRANSMITTER OUTPUT.

CONSTRAINT: R2 > R1

PRESS CR TO CONTINUE...
 0



ENTER R1 (INPUT-Z):
 50

ENTER R2 (OUTPUT-Z):
 150


DESIGN FOR A SPECIFIC FREQUENCY?

1. YES
2. NO

ENTER ONE (1) AND PRESS CR:
 1


ENTER FREQUENCY (F) IN
KILOHERTZ AND PRESS CR...
 14300
```



```
INPUT IMPEDANCE (R1):  50  OHMS
OUTPUT IMPEDANCE (R2):  150  OHMS

INDUCTIVE REACTANCE (XL):  70.7106781  OHMS
CAPACITIVE REACTANCE (XC):  106.066017  OHMS

FOR A FREQUENCY OF  14300  KHZ USE:
C =  104.93  PF
L =  .78  UH

PRESS CR TO CONTINUE...
 0


FINISHED?
1.  YES
2.  NO

ENTER ONE (1) AND PRESS CR:
 1


********** BYE-BYE **********
********** BYE-BYE **********
********** BYE-BYE **********


PROGRAM ENDED
```

PROGRAM 13

Reverse L-Section Network

The reverse L-section network shown in Fig. 13.1 is used when the output impedance (R_2) is greater than the source impedance (R_1).

$$R_2 > R_1$$

$$X_L = R_2 \sqrt{R_1/(R_2 - R_1)} \qquad [13.1]$$

$$X_C = R_1 \, (R_2/X_L) \qquad [13.2]$$

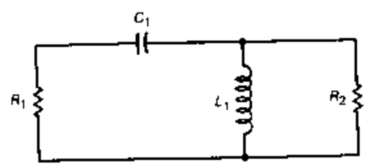


FIG. 13.1. REVERSE L-SECTION NETWORK.


```
100 REM THIS IS PROGRAM NO. 13 PROG13
130 GOSUB 670
140 PRINT "THIS PROGRAM COMPUTES THE"
145 PRINT "REACTANCES, CAPACITANCES AND"
150 PRINT "INDUCTANCES NEEDED TO MATCH"
160 PRINT "THE INPUT RESISTANCE (R1) TO"
170 PRINT "OUTPUT RESISTANCE (R2):"
180 PRINT
185 PRINT "THE CAPACITOR-INPUT L-SECTION"
190 PRINT "NETWORK IS USED TO MATCH AN"
195 PRINT "ANTENNA TO A LOW-Z TRANSMITTER OUTPUT."
200 PRINT
210 PRINT
220 PRINT "CONSTRAINT: R2 > R1"
230 PRINT
240 GOSUB 710
250 GOSUB 670
260 PRINT "ENTER R1 (INPUT-Z):"
270 INPUT R1
280 PRINT
290 PRINT "ENTER R2 (OUTPUT-Z):"
300 INPUT R2
310 IF R2 > R1 THEN  GOTO 340
320 GOSUB 740
330 GOTO 250
340 GOSUB 670
350 XL = R2 * ( SQR (R1 / (R2 - R1)))
360 XC = (R1 * R2) / XL
390 PRINT "DESIGN FOR A SPECIFIC FREQUENCY?"
400 PRINT
410 PRINT "1. YES"
420 PRINT "2. NO"
430 PRINT
440 PRINT "ENTER ONE (1) AND PRESS CR:"
450 INPUT G
460 IF G > 2 THEN  GOTO 390
465 IF G < 1 THEN  GOTO 390
470 ON G GOTO 480,800
480 PRINT
490 PRINT
500 PRINT
510 PRINT "ENTER FREQUENCY (F) IN"
515 PRINT "KILOHERTZ AND PRESS CR..."
520 INPUT F
530 F = F * 1000
540 W = 2 * 3.1415 * F
550 L = XL / W
560 L = L * (10 ^ 6)
```

```
570 L = L * 100
580 L =  INT (L)
590 L = L / 100
600 C = 1 / (W * XC)
610 C = C * (10 ^ 12)
620 C = C * 100
630 C =  INT (C)
640 C = C / 100
650 F = F / 1000
660 GOTO 800
670 FOR I = 1 TO 30
680 PRINT
690 NEXT I
700 RETURN
710 PRINT "PRESS CR TO CONTINUE..."
720 INPUT EE
730 RETURN
740 PRINT
750 PRINT
760 PRINT "ERROR!!!  R2 MUST BE GREATER THAN R1"
770 PRINT
780 GOSUB 710
790 RETURN
800 GOSUB 670
810 PRINT "INPUT IMPEDANCE (R1): ";R1;" OHMS"
820 PRINT "OUTPUT IMPEDANCE (R2): ";R2;" OHMS"
830 PRINT
835 GOSUB 1200
840 PRINT "INDUCTIVE REACTANCE (XL): ";XL;" OHMS"
850 PRINT "CAPACITIVE REACTANCE (XC): ";XC;" OHMS"
860 PRINT
870 IF G = 1 THEN  GOTO 890
880 GOTO 930
890 PRINT "FOR A FREQUENCY OF ";F;" KHZ USE:"
900 PRINT "C = ";C;" PF"
910 PRINT "L = ";L;" UH"
920 PRINT
930 GOSUB 710
940 GOSUB 670
950 PRINT "FINISHED?"
960 PRINT "1.  YES"
970 PRINT "2.  NO"
980 PRINT
990 PRINT "ENTER ONE (1) AND PRESS CR:"
1000 INPUT M
1005 IF M > 2 THEN  GOTO 940
1006 IF M < 1 THEN  GOTO 940
1010 ON M GOTO 1020,100
```



```
1020 GOSUB 670
1030 FOR I = 1 TO 2
1040 PRINT "********** BYE-BYE **********"
1050 NEXT I
1060 PRINT
1070 PRINT
1080 PRINT "PROGRAM ENDED"
1090 END
1200 XL = XL*1000
1210 XL = INT(XL)
1220 XL = XL/1000
1230 XC = XC*1000
1240 XC = INT(XC)
1250 XC = XC/1000
1260 C = C*1000
1270 C = INT(C)
1280 C = C/1000
1290 L = L*1000
1300 L = INT(L)
1310 L = L/1000
1350 RETURN
```

Example

```
THIS PROGRAM COMPUTES THE
REACTANCES, CAPACITANCES AND
INDUCTANCES NEEDED TO MATCH
THE INPUT RESISTANCE (R1) TO
OUTPUT RESISTANCE (R2):

THE CAPACITOR-INPUT L-SECTION
NETWORK IS USED TO MATCH AN
ANTENNA TO A LOW-Z TRANSMITTER OUTPUT.


CONSTRAINT: R2 > R1

PRESS CR TO CONTINUE...
 0


ENTER R1 (INPUT-Z):
 50

ENTER R2 (OUTPUT-Z):
 300
```

```
DESIGN FOR A SPECIFIC FREQUENCY?

1. YES
2. NO

ENTER ONE (1) AND PRESS CR:
 1


ENTER FREQUENCY (F) IN
KILOHERTZ AND PRESS CR...
 10100


INPUT IMPEDANCE (R1):  50  OHMS
OUTPUT IMPEDANCE (R2):  300  OHMS

INDUCTIVE REACTANCE (XL):  134.164  OHMS
CAPACITIVE REACTANCE (XC):  111.803  OHMS

FOR A FREQUENCY OF  10100  KHZ USE:
C =  140.94  PF
L =  2.11  UH

PRESS CR TO CONTINUE...
 0


FINISHED?
1.  YES
2.  NO
```


PROGRAM 14

Split-Capacitor Network

The split-capacitor network shown in Fig. 14.1 is used to transform a source impedance that is less than the load impedance. In addition to matching antennas, there is also an application for this network in matching receiver antennas to the inputs of RF amplifiers. For example, a transistor FM receiver may use a 75 ohm antenna and have an input impedance of 470 ohms (as determined by an emitter resistor of the grounded base stage).

The constraint on this circuit is that the input resistance (R_1) must be less than the load resistance (R_2).

$$R_1 < R_2$$

$$Q > \sqrt{\frac{R_2}{R_1} - 1} \quad [14.1]$$

$$X_L = \frac{R_2}{Q} \quad [14.2]$$

$$X_{C2} = \sqrt{\frac{R_1\ (Q^2 + 1)}{R_2} - 1} \quad [14.3]$$

$$X_{C1} = \frac{R_2 Q}{Q^2 + 1}\left(1 - \frac{R_1}{Q X_{C2}}\right) \quad [14.4]$$

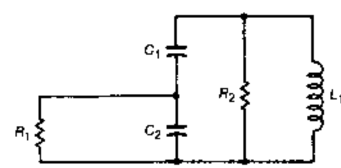


FIG. 14.1. SPLIT-CAPACITOR NETWORK.

Split-Capacitor Network

```
100 REM THIS IS PROGRAM NO. 14 PROG14
130 GOSUB 790
140 PRINT "THIS PROGRAM COMPUTES THE"
145 PRINT "REACTANCES, CAPACITANCES AND"
150 PRINT "INDUCTANCES NEEDED TO MATCH"
155 PRINT "INPUT IMPEDANCE (R1) TO OUTPUT"
160 PRINT  "IMPEDANCE (R2)."
170 PRINT
180 PRINT "THE SPLIT-CAPACITOR NETWORK"
185 PRINT "IS USED TO MATCH ANTENNA TO A"
190 PRINT "LOWER IMPEDANCE TRANSMITTER OUTPUT"
200 PRINT
210 PRINT
220 PRINT "CONSTRAINT: R2 > R1"
230 PRINT
240 GOSUB 830
250 GOSUB 790
260 PRINT "ENTER R1 (INPUT-Z):"
270 INPUT R1
280 PRINT
290 PRINT "ENTER R2 (OUTPUT-Z):"
300 INPUT R2
310 IF R2 > R1 THEN  GOTO 340
320 GOSUB 860
330 GOTO 250
340 GOSUB 790
350 PRINT "VALUE OF Q: ???"
355 INPUT Q
360 PRINT
370 IF Q > ( SQR ((R2 / R1) - 1)) THEN  GOTO 420
380 PRINT "VALUE OF Q TOO LOW, SELECT"
385 PRINT "HIGHER VALUE..."
390 PRINT
400 GOSUB 830
410 GOTO 350
420 XL = R2 / Q
430 A = 1 + (Q ^ 2)
440 BB = (R1 * A) / R2
450 BB = BB - 1
460 BB =  SQR (BB)
470 BB = R1 / BB
480 AA = (R2 * Q) / A
490 B = R1 / (Q * BB)
500 B = 1 - B
510 AA = AA * B
520 PRINT "DESIGN FOR A SPECIFIC FREQUENCY?"
530 PRINT
540 PRINT "1. YES"
```



```
550 PRINT "2. NO"
560 PRINT
570 PRINT "ENTER ONE FROM ABOVE AND"
575 PRINT "PRESS CR:"
580 INPUT G
590 IF G > 2 THEN  GOTO 520
600 ON G GOTO 610,920
610 PRINT
620 PRINT
630 PRINT
640 PRINT "ENTER FREQUENCY (F) IN KILOHERTZ (KHZ) AND
    PRESS CR:"
650 INPUT F
660 F = F * 1000
670 W = 2 * 3.1415 * F
680 L = XL / W
690 L = L * (10 ^ 6)
700 L = L * 100
710 L =  INT (L)
720 L = L / 100
730 C1 = 1 / (W * AA)
740 C1 = C1 * (10 ^ 12)
750 C2 = 1 / (W * BB)
760 C2 = C2 * (10 ^ 12)
770 F = F / 1000
780 GOTO 920
790 FOR I = 1 TO 30
800 PRINT
810 NEXT I
820 RETURN
830 PRINT "PRESS CR TO CONTINUE..."
840 INPUT GGG
850 RETURN
860 PRINT
870 PRINT
880 PRINT "ERROR!!! R2 MUST BE GREATER THAN R1"
890 PRINT
900 GOSUB 830
910 RETURN
920 GOSUB 790
930 PRINT "INPUT IMPEDANCE (R1): ";R1;" OHMS"
940 PRINT "OUTPUT IMPEDANCE (R2): ";R2;" OHMS"
945 GOSUB 1300
950 PRINT
960 PRINT "INDUCTIVE REACTANCE (XL): ";XL;" OHMS"
970 PRINT "CAPACITIVE REACTANCE (XC1): ";AA;" OHMS
980 PRINT "CAPACITIVE REACTANCE (XC2): ";BB;" OHMS"
990 PRINT
```

```
1000 IF G = 1 THEN  GOTO 1020
1010 GOTO 1070
1020 PRINT "FOR A FREQUENCY OF ";F;" KHZ USE:"
1030 PRINT "C1 = ";C1;" PF"
1040 PRINT "C2 = ";C2;" PF"
1050 PRINT "L  = ";L;" UH"
1060 PRINT
1070 GOSUB 830
1080 GOSUB 790
1090 PRINT "FINISHED?"
1100 PRINT "1. YES"
1110 PRINT "2. NO"
1120 PRINT
1130 PRINT "ENTER ONE FROM ABOVE AND"
1135 PRINT "PRESS CR..."
1140 INPUT M
1150 IF M > 2 THEN  GOTO 1090
1152 IF M < 1 THEN  GOTO 1090
1155 ON M GOTO 1160,100
1160 GOSUB 790
1170 FOR I = 1 TO 30
1180 PRINT "XXXXXX -- BYE-BYE -- XXXXXX"
1190 NEXT I
1200 PRINT
1210 PRINT
1220 PRINT "PROGRAM ENDED"
1230 END
1300 XL = XL*1000
1310 XL = INT(XL)
1320 XL = XL/1000
1330 AA = AA*1000
1340 AA = INT(AA)
1350 AA = AA/1000
1360 BB = BB*1000
1370 BB = INT(BB)
1380 BB = BB/1000
1390 C1 = C1*1000
1400 C1 = INT(C1)
1410 C1 = C1/1000
1420 C2 = C2*1000
1430 C2 = INT(C2)
1440 C2 = C2/1000
1450 L = L*1000
1460 L = INT(L)
1470 L = L/1000
1500 RETURN
```


Example

```
THIS PROGRAM COMPUTES THE
REACTANCES, CAPACITANCES AND
INDUCTANCES NEEDED TO MATCH
INPUT IMPEDANCE (R1) TO OUTPUT
IMPEDANCE (R2).

THE SPLIT-CAPACITOR NETWORK
IS USED TO MATCH ANTENNA TO A
LOWER IMPEDANCE TRANSMITTER OUTPUT


CONSTRAINT: R2 > R1

PRESS CR TO CONTINUE...
 0


ENTER R1 (INPUT-Z):
 50

ENTER R2 (OUTPUT-Z):
 300


VALUE OF Q: ???
 3

DESIGN FOR A SPECIFIC FREQUENCY?

1. YES
2. NO

ENTER ONE FROM ABOVE AND
PRESS CR:
 1



ENTER FREQUENCY (F) IN KILOHERTZ (KHZ) AND PRESS CR:


INPUT IMPEDANCE (R1):  50  OHMS
OUTPUT IMPEDANCE (R2):  300  OHMS
```

```
INDUCTIVE REACTANCE (XL):  100  OHMS
CAPACITIVE REACTANCE (XC1):  65.505  OHMS
CAPACITIVE REACTANCE (XC2):  61.237  OHMS

FOR A FREQUENCY OF  14000  KHZ USE:
C1 =  173.552  PF
C2 =  185.647  PF
L  =  1.13  UH

PRESS CR TO CONTINUE...
 0


FINISHED?
1. YES
2. NO

ENTER ONE FROM ABOVE AND
PRESS CR...
 1


XXXXXX -- BYE-BYE -- XXXXXX
XXXXXX -- BYE-BYE -- XXXXXX


PROGRAM ENDED
```


PROGRAM 15

Pi Network

The pi network (Fig. 15.1) is probably one of the most commonly found impedance matching networks. In vacuum tube transmitters, where the plate resistance is much higher than the load impedance, the pi network is the matching circuit of choice for most designers. The constraint is that the source resistance (R_1) must be greater than the load resistance (R_2).

$$R_1 > R_2$$

$$Q > \sqrt{\frac{R_1}{R_2} - 1}$$

$$(9 \le Q \le 15)$$

$$X_{C2} = \frac{R_2}{\sqrt{R_2/R_1\ (1 + Q^2) - 1}} \qquad [15.1]$$

$$X_{C1} = \frac{R_1}{Q} \qquad [15.2]$$

$$X_L = \frac{(R_1\ (Q + (R_2/X_{C2})))}{Q^2 + 1} \qquad [15.3]$$

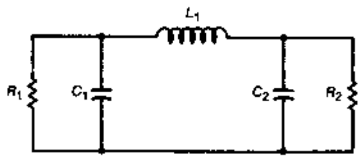


FIG. 15.1. PI NETWORK.

Pi Network

```
100 REM THIS IS PROGRAM NO. 15 PROG15
120 GOSUB 790
130 PRINT "THIS PROGRAM COMPUTES THE VALUES"
140 PRINT "OF REACTANCES, CAPACITANCES AND"
150 PRINT "INDUCTANCES NEEDED TO MATCH INPUT"
160 PRINT "IMPEDANCE (R1) TO OUTPUT"
170 PRINT  "IMPEDANCE (R2)."
180 PRINT
185 PRINT "THE PI-NETWORK IS USED TO MATCH"
190 PRINT "AN ANTENNA TO A TRANSMITTER OUTPUT"
200 PRINT
210 PRINT
220 PRINT "CONSTRAINT: R1 > R2"
230 PRINT
240 GOSUB 830
250 GOSUB 790
260 PRINT "ENTER R1 (INPUT-Z):"
270 INPUT R1
280 PRINT
290 PRINT "ENTER R2 (OUTPUT-Z):"
300 INPUT R2
310 IF R1 > R2 THEN  GOTO 340
320 GOSUB 860
330 GOTO 250
340 GOSUB 790
350 PRINT "VALUE OF Q: ???"
355 INPUT Q
360 PRINT
370 IF Q > ( SQR ((R1 / R2) - 1)) THEN  GOTO 420
380 PRINT "VALUE OF Q TOO LOW, SELECT"
385 PRINT "HIGHER VALUE..."
390 PRINT
400 GOSUB 830
410 GOTO 350
420 AA = R1 / Q
430 A = 1 + (Q ^ 2)
440 BB = (R2 / R1) * A
450 BB = BB - 1
460 BB =  SQR (BB)
470 BB = R2 / BB
480 XL = (R1 * (Q + (R2 / BB))) / A
520 PRINT "DESIGN FOR A SPECIFIC FREQUENCY?"
530 PRINT
540 PRINT "1. YES"
550 PRINT "2. NO"
560 PRINT
570 PRINT "ENTER ONE FROM ABOVE AND"
575 PRINT "PRESS CR..."
```



```
580 INPUT G
590 IF G > 2 THEN  GOTO 520
600 ON G GOTO 610,920
610 PRINT
620 PRINT
630 PRINT
640 PRINT "ENTER FREQUENCY (F) IN"
645 PRINT "KILOHERTZ AND PRESS CR..."
650 INPUT F
660 F = F * 1000
670 W = 2 * 3.1415 * F
680 L = XL / W
690 L = L * (10 ^ 6)
700 L = L * 100
710 L =  INT (L)
720 L = L / 100
730 C1 = 1 / (W * AA)
740 C1 = C1 * (10 ^ 12)
750 C2 = 1 / (W * BB)
760 C2 = C2 * (10 ^ 12)
770 F = F / 1000
780 GOTO 920
790 FOR I = 1 TO 30
800 PRINT
810 NEXT I
820 RETURN
830 PRINT "PRESS CR TO CONTINUE..."
840 INPUT GGG
850 RETURN
860 PRINT
870 PRINT
880 PRINT "ERROR!!! R2 MUST BE GREATER THAN R1"
890 PRINT
900 GOSUB 830
910 RETURN
920 GOSUB 790
930 PRINT "INPUT IMPEDANCE (R1): ";R1;" OHMS"
940 PRINT "OUTPUT IMPEDANCE (R2): ";R2;" OHMS"
950 PRINT
955 GOSUB 1300
960 PRINT "INDUCTIVE REACTANCE (XL): ";XL;" OHMS"
970 PRINT "CAPACITIVE REACTANCE (XC1): ";AA;" OHMS
980 PRINT "CAPACITIVE REACTANCE (XC2): ";BB;" OHMS"
990 PRINT
1000 IF G = 1 THEN  GOTO 1020
1010 GOTO 1070
1020 PRINT "FOR A FREQUENCY OF ";F;" KHZ USE:"
1030 PRINT "C1 = ";C1;" PF"
```

```
1040 PRINT "C2 = ";C2;" PF"
1050 PRINT "L  = ";L;" UH"
1060 PRINT
1070 GOSUB 830
1080 GOSUB 790
1090 PRINT "FINISHED?"
1100 PRINT "1. YES"
1110 PRINT "2. NO"
1120 PRINT
1130 PRINT "ENTER ONE FROM ABOVE AND"
1135 PRINT "PRESS CR..."
1140 INPUT M
1150 IF M > 2 THEN  GOTO 1090
1152 IF M < 1 THEN  GOTO 1090
1155 ON M GOTO 1160,100
1160 GOSUB 790
1170 FOR I = 1 TO 30
1180 PRINT "****** --BYE-BYE-- ******"
1190 NEXT I
1200 PRINT
1210 PRINT
1220 PRINT "PROGRAM ENDED"
1230 END
1300 XL = XL*1000
1310 AA = AA*1000
1320 BB = BB*1000
1330 C1 = C1*1000
1340 C2 = C2*1000
1350 L = L*1000
1360 XL = INT(XL)
1370 AA = INT(AA)
1380 BB = INT(BB)
1390 C1 = INT(C1)
1400 C2 = INT(C2)
1410 L  = INT(L)
1420 XL = XL/1000
1430 AA = AA/1000
1440 BB = BB/1000
1450 C1 = C1/1000
1460 C2 = C2/1000
1470 L  = L/1000
1500 RETURN
```


Example

```
THIS PROGRAM COMPUTES THE VALUES
OF REACTANCES, CAPACITANCES AND
INDUCTANCES NEEDED TO MATCH INPUT
IMPEDANCE (R1) TO OUTPUT
IMPEDANCE (R2).

THE PI-NETWORK IS USED TO MATCH
AN ANTENNA TO A TRANSMITTER OUTPUT


CONSTRAINT: R1 > R2

PRESS CR TO CONTINUE...
 0


ENTER R1 (INPUT-Z):
 3500

ENTER R2 (OUTPUT-Z):
 75


VALUE OF Q: ???
 12

DESIGN FOR A SPECIFIC FREQUENCY?

1. YES
2. NO

ENTER ONE FROM ABOVE AND
PRESS CR...
 1



ENTER FREQUENCY (F) IN
KILOHERTZ AND PRESS CR...
 14250


INPUT IMPEDANCE (R1):  3500  OHMS
OUTPUT IMPEDANCE (R2):  75  OHMS

INDUCTIVE REACTANCE (XL):  324.693  OHMS
```

```
CAPACITIVE REACTANCE (XC1):  291.666  OHMS
CAPACITIVE REACTANCE (XC2):  51.667  OHMS

FOR A FREQUENCY OF  14250  KHZ USE:
C1 =  38.294  PF
C2 =  216.174  PF
L  =  3.62  UH

PRESS CR TO CONTINUE...
 0


 FINISHED?
 1. YES
 2. NO

 ENTER ONE FROM ABOVE AND
 PRESS CR...
  1


 ****** --BYE-BYE-- ******
 ****** --BYE-BYE-- ******


 PROGRAM ENDED
```


PROGRAM 16

Three-Element L-Section Network

The three-element L-section network shown in Fig. 16.1 is used when the input impedance (R_1) is less than the load impedance (R_2). This particular network is used in some transistorized RF power amplifiers. It is also used in cases such as a grounded grid power amplifier in which the input resistance is higher than the typically 50-ohms driving impedance. The constraint is

$$R_1 < R_2$$

$$X_{C2} = R_2 \sqrt{\frac{R_1}{R_2 - R_1}} \quad [16.1]$$

$$X_L = \frac{R_1 R_2}{X_{C2}} + X_{C1} \quad [16.2]$$

$$X_{C1} = Q\,R_1 \quad [16.3]$$

$$(1 \leq Q \leq 12)$$

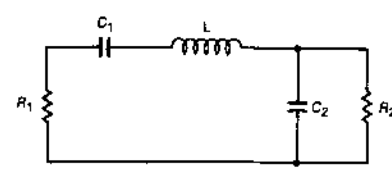


FIG. 16.1. THREE-ELEMENT L-SECTION NETWORK.

Three-Element L-Section Network

```
100 REM
130 GOSUB 830
140 PRINT "THIS PROGRAM COMPUTES THE"
145 PRINT "REACTANCES, CAPACITANCES AND"
150 PRINT "INDUCTANCES NEEDED TO MATCH"
160 PRINT "INPUT IMPEDANCE (R1) TO OUTPUT"
165 PRINT "IMPEDANCE (R2)."
170 PRINT
175 PRINT "THE L-NETWORK IS USED TO MATCH"
180 PRINT "LONG-WIRE ANTENNAS TO A LOW-Z"
190 PRINT "TRANSMITTER OUTPUT."
200 PRINT
210 PRINT
220 PRINT "CONSTRAINT: R1 < R2"
230 PRINT
240 GOSUB 870
250 GOSUB 830
260 PRINT "ENTER R1 (INPUT-Z):"
270 INPUT R1
280 PRINT
290 PRINT "ENTER R2 (OUTPUT IMPEDANCE):"
300 INPUT R2
310 IF R1 < R2 THEN  GOTO 340
320 GOSUB 900
330 GOTO 250
340 GOSUB 830
350 PRINT "Q = ???"
355 INPUT Q
360 AA = Q * R1
370 A = (R1 / (R2 - R1))
380 BB = R2 * ( SQR (A))
390 AA = AA * 100
400 AA =  INT (AA)
410 AA = AA / 100
420 B = (R1 * R2) / BB
430 BB = BB * 100
440 BB =  INT (BB)
450 BB = BB / 100
460 XL = (AA + ((R1 * R2) / BB))
470 XL = XL * 100
480 XL =  INT (XL)
490 XL = XL / 100
500 PRINT "DESIGN FOR A SPECIFIC FREQUENCY?"
510 PRINT
520 PRINT "1. YES"
530 PRINT "2. NO"
540 PRINT
550 PRINT "ENTER ONE OF ABOVE AND PRESS CR:"
```



```
560 INPUT G
570 IF G > 2 THEN  GOTO 500
572 IF G < 1 THEN  GOTO 500
580 ON G GOTO 590,960
590 PRINT
600 PRINT
610 PRINT
620 PRINT "ENTER FREQUENCY (F) IN"
625 PRINT "KILOHERTZ AND PRESS CR..."
630 INPUT F
640 F = F * 1000
650 W = 2 * 3.1415 * F
660 L = XL / W
670 L = L * (10 ^ 6)
680 L = L * 100
690 L = INT(L)
700 L = L / 100
710 C1 = 1 / (W * AA)
720 C1 = C1 * (10 ^ 12)
730 C1 = C1 * 100
740 C1 =  INT (C1)
750 C1 = C1 / 100
760 C2 = 1 / (W * BB)
765 C2 = C2 * (10 ^ 12)
770 C2 = C2 * 100
780 C2 =  INT (C2)
790 C2 = C2 / 100
810 F = F / 1000
820 GOTO 960
830 FOR I = 1 TO 30
840 PRINT
850 NEXT I
860 RETURN
870 PRINT "PRESS CR TO CONTINUE..."
880 INPUT GGG
890 RETURN
900 PRINT
910 PRINT
920 PRINT "ERROR!!! R2 MUST BE GREATER THAN R1"
930 PRINT
940 GOSUB 870
950 RETURN
960 GOSUB 830
970 PRINT "INPUT IMPEDANCE (R1): ";R1;" OHMS"
980 PRINT "OUTPUT IMPEDANCE (R2): ";R2;" OHMS"
990 PRINT
995 GOSUB 1300
1000 PRINT "INDUCTIVE REACTANCE (XL): ";XL;" OHMS"
```

```
1010 PRINT "CAPACITIVE REACTANCE (XC1): ";AA;" OHMS"
1020 PRINT "CAPACITIVE REACTANCE (XC2): ";BB;" OHMS"
1030 PRINT
1040 IF G = 1 THEN  GOTO 1060
1050 GOTO 1110
1060 PRINT "FOR A FREQUENCY OF ";F;" KILOHERTZ USE:"
1070 PRINT "C1 = ";C1;" PF"
1080 PRINT "C2 = ";C2;" PF"
1090 PRINT "L  = ";L;" UH"
1100 PRINT
1110 GOSUB 870
1120 GOSUB 830
1130 PRINT "FINISHED?"
1140 PRINT "1. YES"
1150 PRINT "2. NO"
1160 PRINT
1170 PRINT "ENTER ONE FROM ABOVE AND"
1175 PRINT "PRESS CR..."
1180 INPUT M
1183 IF M < 1 THEN  GOTO 1130
1184 IF M > 2 THEN  GOTO 1130
1190 ON M GOTO 1200,100
1200 GOSUB 830
1210 FOR I = 1 TO 20
1220 PRINT "****** BYE-BYE *******"
1230 NEXT I
1240 PRINT
1250 PRINT
1260 PRINT "PROGRAM ENDED"
1270 END
1300 XL = XL*100
1310 AA = AA*100
1320 BB = BB*100
1330 XL = INT(XL)
1340 AA = INT(AA)
1350 BB = INT(BB)
1360 XL = XL/100
1370 AA = AA/100
1380 BB = BB/100
1400 RETURN
```


Example

```
THIS PROGRAM COMPUTES THE
REACTANCES, CAPACITANCES AND
INDUCTANCES NEEDED TO MATCH
INPUT IMPEDANCE (R1) TO OUTPUT
IMPEDANCE (R2).

THE L-NETWORK IS USED TO MATCH
LONG-WIRE ANTENNAS TO A LOW-Z
TRANSMITTER OUTPUT.


CONSTRAINT: R1 < R2

PRESS CR TO CONTINUE...
 0



ENTER R1 (INPUT-Z):
 50

ENTER R2 (OUTPUT IMPEDANCE):
 75



Q = ???
 5
DESIGN FOR A SPECIFIC FREQUENCY?

1. YES
2. NO

ENTER ONE OF ABOVE AND PRESS CR:
 1



ENTER FREQUENCY (F) IN
KILOHERTZ AND PRESS CR...
 7000



INPUT IMPEDANCE (R1):  50  OHMS
OUTPUT IMPEDANCE (R2):  75  OHMS
```

```
INDUCTIVE REACTANCE (XL):  285.35  OHMS
CAPACITIVE REACTANCE (XC1):  250  OHMS
CAPACITIVE REACTANCE (XC2):  106.06  OHMS

FOR A FREQUENCY OF  7000  KILOHERTZ USE:
C1 =  90.94  PF
C2 =  214.37  PF
L  =  6.48  UH

PRESS CR TO CONTINUE...
 0


FINISHED?
1. YES
2. NO

ENTER ONE FROM ABOVE AND
PRESS CR...
 1


****** BYE-BYE *******
****** BYE-BYE *******


PROGRAM ENDED
```


PROGRAM 17

Quarter-Wave Matching Section

Figure 17.1 shows two versions of the quarter-wave matching section, which is a type of transmission line transformer used to match an antenna feed-point impedance (resistive) to the characteristic impedance of a transmission line. There are two versions shown here. In Fig. 17.1A we see a coaxial cable type and in Fig. 17.1B an open-wire parallel feeder version.

In both cases, the impedance transformation follows the expression

$$Z_s = Z_o^2/Z_r \qquad [17.1]$$

where

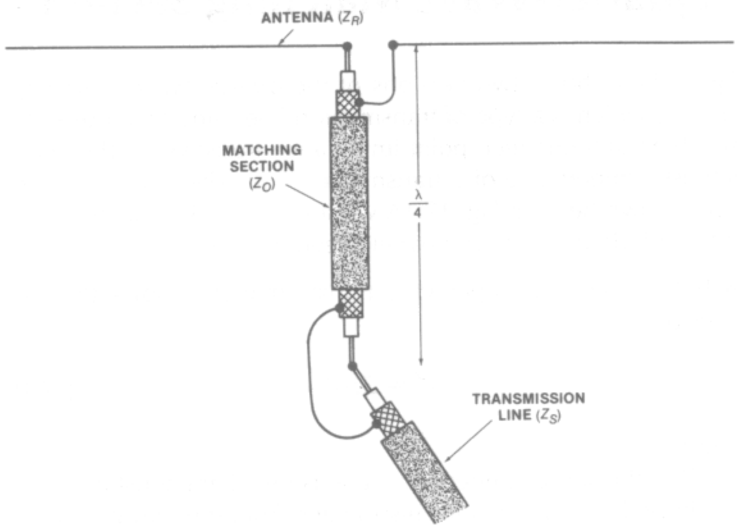
- Z_s is the source impedance, that is the characteristic impedance of the transmission line from the transmitter,
- Z_o is the characteristic impedance of the line used to make the quarter-wave section,
- Z_r is the load impedance.

For the coaxial version, we are a little more restricted because it is impossible to find some values of impedance that might be calculated by the program. For this case, you might want to calculate several versions by varying the surge impedance of the transmission line to the transmitter (using standard values) until a combination of Z_o and Z_s is found that will provide a close match. The physical length of the coaxial cable will be

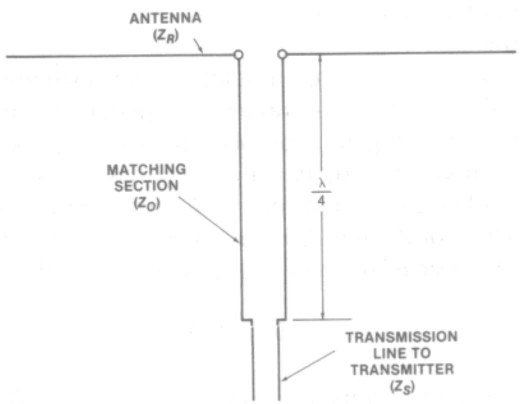
$$L\text{ (ft)} = 492\ V/F\text{ (MHz)} \qquad [17.2]$$

The parallel feeders version is shown in Fig. 17.1B, and this method is a little more versatile than the coaxial type. The program will calculate the characteristic impedance of the line used to make the matching section, and then you can use another calculation (see Program 18) to design the transmission line that will produce the desired impedance. The formula for that transmission line is

$$s = (d/2)\,(10^{Zo/276}) \qquad [17.3]$$



(A) A coaxial cable type.



(B) An open-wire parallel feeder version.

Fig. 17.1 Shows two versions of the quarter-wave matching section.

Quarter-Wave Matching Section

```
100 REM THIS IS PROGRAM NO. 17 PROG17
110 GOSUB 230
120 PRINT "LOAD IMPEDANCE (ZR): ???"
122 INPUT ZR
130 GOSUB 190
140 PRINT "SOURCE IMPEDANCE (ZS): ???"
144 INPUT ZS
150 ZO =  SQR (ZR * ZS)
160 GOSUB 190
170 PRINT "TRANSMISSION LINE IMPEDANCE ZO: "
175 PRINT ZO;" OHMS"
180 GOTO 270
190 FOR I = 1 TO 5
200 PRINT
210 NEXT I
220 RETURN
230 FOR I = 1 TO 30
240 PRINT
250 NEXT I
260 RETURN
270 GOSUB 190
280 PRINT "TRY ANOTHER?"
290 PRINT "1. YES"
300 PRINT "2. NO"
310 INPUT P
311 IF P < 1 THEN  GOTO 280
312 IF P > 2 THEN  GOTO 280
320 ON P GOTO 120,330
330 GOSUB 190
340 PRINT "PROGRAM ENDED"
350 GOSUB 190
360 END
```

Example

```
LOAD IMPEDANCE (ZR): ???
 120


SOURCE IMPEDANCE (ZS): ???
 50


TRANSMISSION LINE IMPEDANCE ZO:
 77.459667  OHMS
```

```
TRY ANOTHER?
1. YES
2. NO
 2


PROGRAM ENDED
```


PROGRAM 18

Custom Parallel Line

This program will help you design a custom parallel transmission line—you will need to know the impedance. In some cases, you will calculate the impedance from some other consideration—such as the impedance required for a quarter-wave matching section (see Program 17). In other cases, the impedance is dictated by the nature of the load being matched. Obviously, if you are trying to match a 300-ohm folded dipole or 150-ohm J pole antenna, then that impedance is used for Z_o.

You will also be required to tell the program the diameter of the conductors. This will be determined from the type of construction material being used.

1. 1/4-inch aluminum or copper tubing
2. 1/2-inch aluminum or copper tubing
3. 3/4-inch aluminum or copper tubing
4. No. 10 copper wire
5. No. 12 copper wire
6. No. 14 copper wire

For those who desire to build with other than the materials listed here, the program has an "OTHER" selection on its menu. If this number is selected, then the program branches to a subroutine that asks you to input the conductor diameter in inches.

The standard equation for the impedance of a parallel transmission line is shown as follows:

$$Z_o = 276 \log (2s/d) \qquad [18.1]$$

This equation is solved to find spacings.

$$s = (d/2)\,(10^{Zo/276}) \quad [18.2]$$

An example follows the program listing.

Custom Parallel Line

```
110 REM THIS IS PROGRAM NO. 18 PROG18
140 GOSUB 530
150 ZO = 0
160 S = 0
170 D = 0
180 PRINT "ENTER REQUIRED CHARACTERISTIC"
185 PRINT "IMPEDANCE (ZO):"
190 INPUT ZO
200 GOSUB 530
210 PRINT "SELECT TYPE OF CONDUCTOR:"
220 PRINT
230 PRINT "1.  1/4-INCH ALUMINUM TUBING"
240 PRINT "2.  1/2-INCH ALUMINUM TUBING"
250 PRINT "3.  3/4-INCH ALUMINUM TUBING"
260 PRINT "4.  NO. 10 WIRE"
270 PRINT "5.  NO. 12 WIRE"
280 PRINT "6.  NO. 14 WIRE"
290 PRINT "7.  OTHER"
300 PRINT
310 PRINT "ENTER ONE FROM MENU ABOVE:"
320 INPUT K
330 IF K > 7 THEN GOI TO 200
340 IF K = 1 THEN D = 0.25
350 IF K = 2 THEN D = 0.50
360 IF K = 3 THEN D = 0.75
370 IF K = 4 THEN D = 0.102
380 IF K = 5 THEN D = 0.0808
390 IF K = 6 THEN D = 0.0641
400 IF K = 7 THEN  GOSUB 570
410 S = (D * (10 ^ (ZO / 276))) / 2
420 S = S * 100
430 S =  INT (S)
440 S = S / 100
450 GOSUB 530
460 PRINT "FOR A CHARACTERISTIC IMPEDANCE OF ";ZO;" OHMS:"
```



```
470 PRINT
480 PRINT "CONDUCTOR DIAMETER: ";D;" INCHS"
490 PRINT "CONDUCTOR SPACING: ";S;" INCHS"
500 GOSUB 530
510 GOSUB 610
520 GOTO 640
530 FOR I = 1 TO 5
540 PRINT
550 NEXT I
560 RETURN
570 GOSUB 530
580 PRINT "ENTER CONDUCTOR DIAMETER IN"
585 PRINT "INCHS (IN.):"
590 INPUT D
600 RETURN
610 PRINT "PRESS CR TO CONTINUE..."
620 INPUT UUU
630 RETURN
640 GOSUB 530
645 PRINT "FINISHED???"
650 PRINT
660 PRINT "1. YES"
670 PRINT "2. NO"
680 PRINT
690 INPUT A
700 IF A > 2 THEN  GOTO 640
702 IF A < 1 THEN  GOTO 640
710 ON A GOTO 720,110
720 GOSUB 530
730 PRINT "PROGRAM ENDED"
```

Example

```
ENTER REQUIRED CHARACTERISTIC
IMPEDANCE (ZO):
 250

SELECT TYPE OF CONDUCTOR:

1.  1/4-INCH ALUMINUM TUBING
2.  1/2-INCH ALUMINUM TUBING
3.  3/4-INCH ALUMINUM TUBING
4.  NO. 10 WIRE
5.  NO. 12 WIRE
6.  NO. 14 WIRE
```

```
7.  OTHER

ENTER ONE FROM MENU ABOVE:
 6


FOR A CHARACTERISTIC IMPEDANCE OF  250  OHMS:

CONDUCTOR DIAMETER:  .0641  INCHS
CONDUCTOR SPACING:  .25  INCHS


PRESS CR TO CONTINUE...
 0


FINISHED???

1. YES
2. NO

 2


ENTER REQUIRED CHARACTERISTIC
IMPEDANCE (ZO):
 250


SELECT TYPE OF CONDUCTOR:

1.  1/4-INCH ALUMINUM TUBING
2.  1/2-INCH ALUMINUM TUBING
3.  3/4-INCH ALUMINUM TUBING
4.  NO. 10 WIRE
5.  NO. 12 WIRE
6.  NO. 14 WIRE
7.  OTHER

ENTER ONE FROM MENU ABOVE:
 7


ENTER CONDUCTOR DIAMETER IN
INCHS (IN.):
 1


FOR A CHARACTERISTIC IMPEDANCE OF  250  OHMS:
```



```
CONDUCTOR DIAMETER:  1  INCHS
CONDUCTOR SPACING:  4.02  INCHS


PRESS CR TO CONTINUE...
 0


FINISHED???

1. YES
2. NO

 1


PROGRAM ENDED
```

PROGRAM 19

Transmission Line Matching "Q" Section

A "Q-section" is a transmission line impedance transformer comprised of three different lengths of line. Figure 19.1A shows a model of the Q-section, while Fig. 19.1B shows the physical arrangement when coaxial cable is used.

The transformer consists of two sections of transmission line designated as L1 and L2. Section L1 is connected to the antenna and is of the same kind of transmission line as the third length—which goes to the transmitter (in other words, Z_o for L_1 is the same as Z_o for the line to the transmitter). The second part of the transformer, L_2, consists of a transmission line with a characteristic impedance that is different from the other two sections.

The program calculates the line length in electrical degrees, and from that data we can also calculate the physical length given the operating frequency and the velocity factor of the transmission lines. It is important that both types of transmission line (Z_1 and Z_o) have the same dielectric material.

The physical lengths, which are generated when you indicate that you want to design to a specific frequency, are given in feet.

The example following the program listings asks to calculate L_1 and L_2, plus the physical lengths, for an antenna impedance of $Z_L = 30 + j\,5$ ohms, a frequency of 14 MHz, a source impedance (Z_o) of 50 ohms, and a matching section impedance (Z_1) of 75 ohms. A second example follows.

If $Z_L = R_L \pm j\,X_L$

$$\text{Tan } L_2 = B = \frac{(r-1)^2 + X^2}{r(N - \frac{1}{N})^2 - (r-1)^2 - X^2} \qquad [19.1]$$

$$\text{Tan } L_1 = A = \frac{(N - \frac{r}{N})B + X}{r + (X\,N\,B) - 1} \qquad [19.2]$$

where

$N = Z_1/Z_0$
$r = R_L/Z_0$
$X = X_L/Z_0$
X_L = reactive component of ZL
R_L = resistive component of ZL

CONSTRAINTS

$$Z_1 > Z_0\sqrt{SWR}$$

or

$$Z_1 < Z_0/\sqrt{SWR}$$

If $L_1 < 0$, add 180°

If $B < 0$, Z_1 is too close to Z_0

$$Z_1 \neq Z_0$$

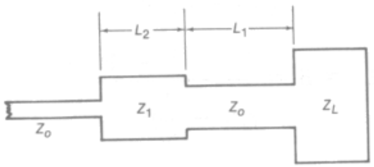
$$(Z_0\sqrt{SWR}) < Z_1 < (Z_0/\sqrt{SWR})$$

PHYSICAL LENGTH IN FEET

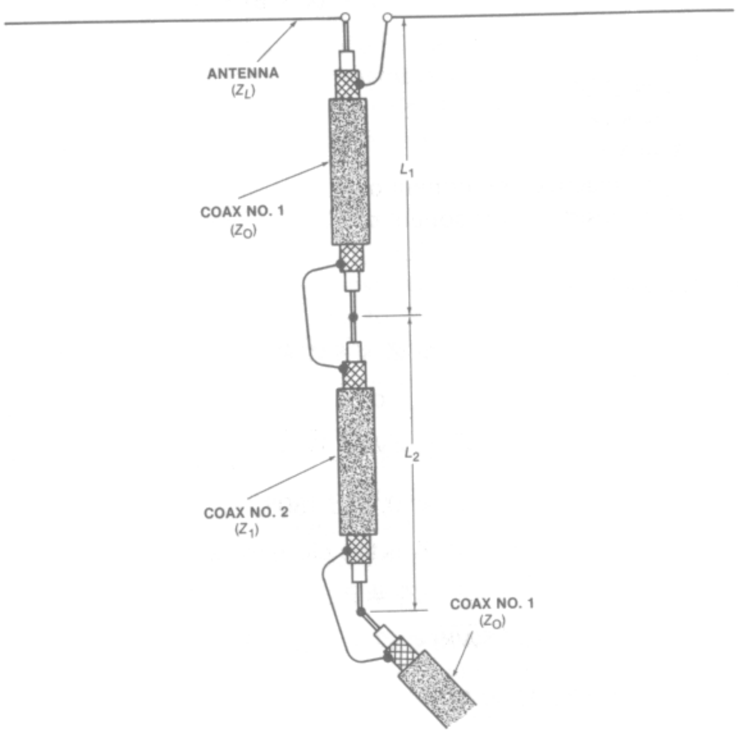
$$L_1' = L_1\,\lambda/360$$
$$L_2' = L_2\,\lambda/360$$

where

$$\lambda = \frac{984 \text{ velocity factor}}{F\text{ (MHz)}}$$



(A) A model of the Q-section.



(B) Physical arrangement when coaxial cable is used.

FIG. 19.1. TRANSMISSION LINE MATCHING "Q" SECTION.

Transmission Line Matching "Q" Section

```
160 LET PI = 3.141593
170 GOSUB 840
180 PRINT "LOAD IMPEDANCE RESISTIVE"
185 PRINT "COMPONENT (RL)?"
187 INPUT RL
190 GOSUB 800
200 PRINT "LOAD IMPEDANCE REACTIVE"
201 PRINT "COMPONENT (XL):???"
202 INPUT XL
210 GOSUB 800
220 PRINT "SOURCE IMPEDANCE (ZO): ????"
222 INPUT ZO
230 GOSUB 800
240 PRINT "MATCHING SECTION SURGE IMPEDANCE (Z1): ???"
242 PRINT "(TRIAL VALUE)"
244 INPUT Z1
250 GOSUB 800
260 IF (RL / ZO) > 1 THEN SWR = RL / ZO
270 IF (RL / ZO) < 1 THEN SWR = ZO / RL
272 IF RL = ZO THEN SWR = 1
280 IF Z1 < (ZO *  SQR (SWR)) THEN  GOTO 1170
290 N = Z1 / ZO
300 R = RL / ZO
310 X = XL / ZO
320 M = (R - 1) ^ 2
330 J = (N - (1 / N)) ^ 2
340 K = M + (X ^ 2)
350 Y = (R * J) - M - (X ^ 2)
360 Z = K / Y
370 B =  Z
380 D = (N - (R / N))
390 E = X * N * B
400 H = (B * D) + X
410 C = R + E - 1
420 A = H / C
430 L2 =  ATN (B)
440 L1 =  ATN (A)
450 L1 = L1 * (180 / PI)
460 L2 = L2 * (180 / PI)
470 IF L1 < 0 THEN L1 = L1 + 180
480 GOSUB 800
490 L1 = L1 * 100
500 L1 =  INT (L1)
510 L1 = L1 / 100
520 L2 = L2 * 100
530 L2 =  INT (L2)
540 L2 = L2 / 100
550 PRINT "DESIGN FOR A PARTICULAR FREQUENCY?"
```

```
555 PRINT
560 PRINT "1. NO"
570 PRINT "2. YES"
580 PRINT
590 PRINT "SELECT ONE OF ABOVE AND PRESS CR:"
595 INPUT Q
600 GOSUB 910
605 IF Q < 1 THEN  GOTO 580
606 IF Q > 2 THEN  GOTO 580
610 IF Q = 2 THEN  GOSUB 970
620 IF Q = 1 THEN  GOSUB 640
630 IF Q = 1 THEN GOTO 1260
640 GOSUB 800
650 WL = (984 * V) / F
660 LP = (L1 * WL) / 360
670 LR = (L2 * WL) / 360
740 PRINT "LENGTH L1: ";LP;" FEET"
750 PRINT "LENGTH L2: ";LR;" FEET"
760 GOSUB 800
770 GOSUB 880
780 GOSUB 840
790 GOTO 1240
800 FOR I = 1 TO 5
810 PRINT
820 NEXT I
830 RETURN
840 FOR I = 1 TO 30
850 PRINT
860 NEXT I
870 RETURN
880 PRINT "PRESS CR TO CONTINUE..."
890 INPUT XXX
900 RETURN
910 GOSUB 800
920 PRINT "LENGTH OF THE MATCHING SECTION"
925 PRINT "(L2): ";L2; " DEGREES"
930 PRINT "DISTANCE FROM THE LOAD (L1) "
935 PRINT L1;" DEGREES"
940 GOSUB 800
950 GOSUB 880
960 RETURN
970 GOSUB 800
980 PRINT "OPERATING FREQUENCY IN"
985 PRINT "MEGAHERTZ (MHZ):"
987 INPUT F
990 GOSUB 800
1000 PRINT "SELECT TRANSMISSION LINE TYPE:"
```



```
1010 PRINT
1020 PRINT "1. FOAM-FILLED COAXIAL CABLE"
1030 PRINT "2. REGULAR POLYETHYLENE COAXIAL CABLE"
1040 PRINT "3. TEFLON-FILLED COAXIAL CABLE"
1050 PRINT "4. 300-OHM TWIN-LEAD"
1060 PRINT "5. OTHER"
1070 PRINT
1080 PRINT "SELECTION: ????"
1082 INPUT T
1090 IF T > 5 THEN  GOTO 990
1100 IF T = 1 THEN V = 0.8
1110 IF T = 2 THEN V = 0.66
1120 IF T = 3 THEN V = 0.70
1130 IF T = 4 THEN V = 0.82
1140 IF T < 5 THEN  GOTO 1160
1150 PRINT "ENTER VELOCITY FACTOR (V): "
1152 INPUT V
1160 RETURN
1170 GOSUB 800
1180 IF Z1 < (ZO / ( SQR (SWR))) THEN  GOTO 290
1190 PRINT "SELECT ANOTHER VALUE OF SURGE IMPEDANCE FOR
     THE "
1200 PRINT "MATCHING SECTION TRANSMISSION LINE"
1210 PRINT
1220 GOSUB 880
1230 GOTO 230
1240 GOSUB 800
1250 PRINT
1260 PRINT "FINISHED???"
1270 PRINT
1280 PRINT "1. YES"
1290 PRINT "2. NO"
1300 PRINT
1310 PRINT "ENTER SELECTION THEN PRESS CR:"
1312 INPUT E
1314 IF E < 1 THEN  GOTO 1270
1315 IF E > 2 THEN  GOTO 1270
1320 ON E GOTO 1330,170
1330 GOSUB 840
1340 PRINT "PROGRAM ENDED"
```

Example

```
LOAD IMPEDANCE RESISTIVE
COMPONENT (RL)?
 30
```

```
LOAD IMPEDANCE REACTIVE
COMPONENT (XL):???
 5

SOURCE IMPEDANCE (ZO): ????
 50

MATCHING SECTION SURGE IMPEDANCE (Z1): ???
(TRIAL VALUE)
 75

DESIGN FOR A PARTICULAR FREQUENCY?

1. NO
2. YES

SELECT ONE OF ABOVE AND PRESS CR:
 2

LENGTH OF THE MATCHING SECTION
(L2):  39.69  DEGREES
DISTANCE FROM THE LOAD (L1)
 105.21  DEGREES

PRESS CR TO CONTINUE...
 0

OPERATING FREQUENCY IN
MEGAHERTZ (MHZ):
 14

SELECT TRANSMISSION LINE TYPE:

1. FOAM-FILLED COAXIAL CABLE
2. REGULAR POLYETHYLENE COAXIAL CABLE
3. TEFLON-FILLED COAXIAL CABLE
4. 300-OHM TWIN-LEAD
5. OTHER
```



```
SELECTION: ????
 1

LENGTH L1:  16.4328  FEET
LENGTH L2:  6.1992  FEET

LOAD IMPEDANCE RESISTIVE
COMPONENT (RL)?
 29

LOAD IMPEDANCE REACTIVE
COMPONENT (XL):???
 0

SOURCE IMPEDANCE (ZO): ????
 50

MATCHING SECTION SURGE IMPEDANCE (Z1): ???
(TRIAL VALUE)
 75

DESIGN FOR A PARTICULAR FREQUENCY?

1. NO
2. YES

SELECT ONE OF ABOVE AND PRESS CR:
 2

LENGTH OF THE MATCHING SECTION
(L2):  41.43  DEGREES
DISTANCE FROM THE LOAD (L1)
 113.13  DEGREES

PRESS CR TO CONTINUE...
 0
```

```
OPERATING FREQUENCY IN
MEGAHERTZ (MHZ):
 21.39


SELECT TRANSMISSION LINE TYPE:

1. FOAM-FILLED COAXIAL CABLE
2. REGULAR POLYETHYLENE COAXIAL CABLE
3. TEFLON-FILLED COAXIAL CABLE
4. 300-OHM TWIN-LEAD
5. OTHER

SELECTION: ????
 5
ENTER VELOCITY FACTOR (V):
 .95


LENGTH L1:  13.7335624  FEET
LENGTH L2:  5.02944834  FEET


PRESS CR TO CONTINUE...
 0




FINISHED???

1. YES
2. NO

ENTER SELECTION THEN PRESS CR:
 1


PROGRAM ENDED
```


PROGRAM 20

Mobile and Other Short HF Antenna Design

A vertical antenna with a radiator less than a quarter wavelength is usually used for mobile and portable communications. An example of such an antenna is shown in Fig. 20.1. The lack of length in this antenna is made up by inductance (L) placed in series with the radiator. This inductor is used to cancel the capacitive reactance caused by using a radiator that is too short for the resonant frequency. The transmission line center conductor is connected to one end of the inductor, while the transmission line shield is connected either to ground (which could be earth ground or the body of a vehicle depending upon whether operation is mobile or portable) or to a quarter-wave radial. The radial consists of one or more parallel wires connected to the shield. The wires have a length of L (ft) = 246/F (MHz).

$$C = \frac{17l}{\left[L_N\left(\frac{24l}{d}\right) - 1\right]\left[1 - \left(\frac{Fl}{234}\right)^2\right]} \qquad [20.1]$$

where

l is antenna length in feet,
d is average antenna diameter in inches,
c is antenna capacitance.

$$X_C = \frac{1}{2\pi FC} \quad [20.2]$$

where

X_C is capacitive reactance in ohms,
F is operating frequency in hertz,
C is capacitance in farads.
$X_L = X_C$

$$N = \sqrt{\frac{L_{\mu H}\,(9a + 10b)}{a^2}} \quad [20.3]$$

where

$L_{\mu H}$ is inductance in microhenrys,
a is coil radius in inches,
N is number of turns,
b is coil length in inches.

$$L_{\mu H} = \frac{a^2N^2}{9a + 10b} \quad [20.4]$$

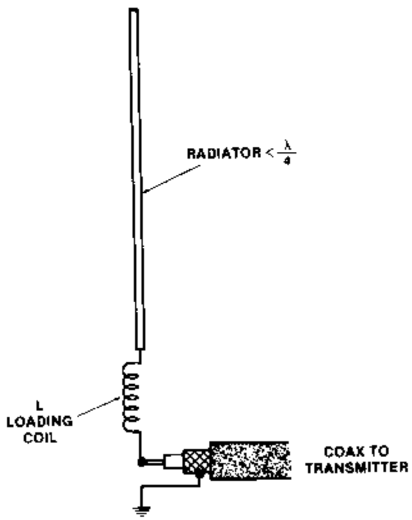


FIG. 20.1. A VERTICAL ANTENNA WITH A RADIATOR LESS THAN A QUARTER WAVELENGTH.


```
100 REM THIS IS PROGRAM NO. 20 PROG20
110 REM
120 REM THIS PROGRAM WILL CALCULATE THE
125 REM CAPACITANCE AND THE INDUCTOR
130 REM NEEDED FOR A MOBILE HF ANTENNA
140 REM LESS THAN QUARTER WAVELENGTH
150 GOSUB 780
160 PRINT "OPERATING FREQUENCY (CENTER-"
162 PRINT "BAND) IN MEGAHERTZ:"
165 INPUT F
170 PRINT
180 PRINT "ANTENNA HEIGHT IN FEET?"
182 INPUT M
190 N = 234 / F
200 GOSUB 740
210 IF N < M THEN  GOSUB 1200
260 GOSUB 740
270 PRINT "AVERAGE RADIATOR DIAMETER IN"
272 PRINT "INCHS (IN.): ???"
275 INPUT D
280 PRINT
290 P =  LOG ((24 * M) / D)
300 Q = (((F * M) / 234) ^ 2)
310 C = (17 * M) / ((P - 1) * (1 - Q))
320 C = C * 100
330 C =  INT (C)
340 C = C / 100
350 RR = 273 * 10 ^  - 8 * ((M * 12 * F) ^ 2)
360 RR = RR * 100
370 RR =  INT (RR)
380 RR = RR / 100
390 XC = 1 / (2 * 3.14159 * F * C)
400 XL = XC
410 L = XL / (2 * 3.14159 * F)
420 L = L * 10 ^ 6
430 GOSUB 740
440 PRINT "SELECT COIL DIAMETER (NOTE: "
445 PRINT "USE 3 OR 4 INCHS FOR > 500-W"
450 PRINT "OPERATION, AND NOT LESS THAN"
455 PRINT "1 INCH FOR 100-WATT OPERATION)"
460 PRINT
470 PRINT "COIL DIAMETER IN INCHS (IN.): ???"
474 INPUT D
480 A = D / 2
490 PRINT
500 PRINT "FIRST TRIAL - COIL LENGTH IN"
502 PRINT "INCHS (IN.): ???"
505 INPUT B
```

```
510 PRINT
520 IF B < D THEN  PRINT "LENGTH MUST BE > DIAMETER"
530 IF B < D THEN  GOSUB 820
540 IF B < D THEN  GOTO 430
550 N = ( SQR (L * ((9 * A) + (10 * B)))) / A
560 N = N * 100
570 N =  INT (N)
580 N = N / 100
590 PRINT "CAPACITANCE: ";C;" PF"
600 PRINT "CAPACITIVE REACTANCE: ";XC;" OHMS"
610 PRINT "FOR RESONANCE, XL = XC = ";XC;" OHMS"
620 PRINT
630 PRINT "INDUCTANCE OF LOADING COIL: ";L;" UH"
640 PRINT
650 PRINT "LOADING COIL DIMENSIONS"
660 PRINT "LENGTH: ";B;" INCHS"
670 PRINT "DIAMETER: ";D;" INCHS"
680 PRINT "NO. OF TURNS: ";N
690 PRINT "RADIATION RESISTANCE: ";RR;" OHMS"
700 PRINT
710 GOSUB 820
720 GOTO 850
730 GOTO 1000
740 FOR I = 1 TO 5
750 PRINT
760 NEXT I
770 RETURN
780 FOR I = 1 TO 30
790 PRINT
800 NEXT I
810 RETURN
820 PRINT "PRESS CR TO CONTINUE..."
830 INPUT HHH
840 RETURN
850 GOSUB 780
860 PRINT "WHAT'S YOUR PLEASURE?"
870 PRINT
880 PRINT "1. DO ANOTHER"
890 PRINT "2. FINISHED"
900 PRINT
910 PRINT "SELECTION: ???"
912 INPUT V
920 IF V > 3 THEN  GOTO 860
922 IF V < 1 THEN  GOTO 860
930 ON V GOTO 150,940
940 GOSUB 780
950 FOR I = 1 TO 20
960 PRINT "****** --GOOD DX-- ******"
```



```
970 NEXT I
980 GOSUB 740
990 PRINT "PROGRAM OVER"
1000 END
1200 PRINT "LENGTH > 0.25 WAVELENGTH,"
1205 PRINT "SO USE A 0.25 WAVELENGTH"
1210 PRINT "ANTENNA, WHICH IS ";N
1212 GOSUB 820
1214 GOTO 150
1215 PRINT "FEET IN LENGTH"
1220 RETURN
```

Example

```
OPERATING FREQUENCY (CENTER-
BAND) IN MEGAHERTZ:
 21

ANTENNA HEIGHT IN FEET?
 8



AVERAGE RADIATOR DIAMETER IN
INCHS (IN.): ???
 .33



SELECT COIL DIAMETER (NOTE:
USE 3 OR 4 INCHS FOR > 500-W
OPERATION, AND NOT LESS THAN
1 INCH FOR 100-WATT OPERATION)

COIL DIAMETER IN INCHS (IN.): ???
 1

FIRST TRIAL - COIL LENGTH IN
INCHS (IN.): ???
 2.5

CAPACITANCE:  52.3  PF
CAPACITIVE REACTANCE:  1.44910386E-04  OHMS
FOR RESONANCE, XL = XC =  1.44910386E-04  OHMS
```

```
INDUCTANCE OF LOADING COIL:  1.09824875  UH

LOADING COIL DIMENSIONS
LENGTH:  2.5  INCHS
DIAMETER:  1  INCHS
NO. OF TURNS:  11.38
RADIATION RESISTANCE:  11.09  OHMS

PRESS CR TO CONTINUE...
 0


WHAT'S YOUR PLEASURE?

1. DO ANOTHER
2. FINISHED

SELECTION: ???
 2


 ****** --GOOD DX-- ******
 ****** --GOOD DX-- ******


 PROGRAM OVER
```


PROGRAM 21

Distance to VHF/UHF/Microwave Radio Horizon

VHF, UHF, and microwave radio signals are said to be "line of sight" signals because they travel only by ground wave to a point somewhere just beyond the optical horizon. The distance to the radio horizon is dependent upon the height of the transmitting antenna above ground, assuming that the receiving antenna is at the earth's surface (see Fig. 21.1). This program will permit you to work in either metric or English units for antenna height and either kilometers (metric), English miles, or nautical miles for the distance.

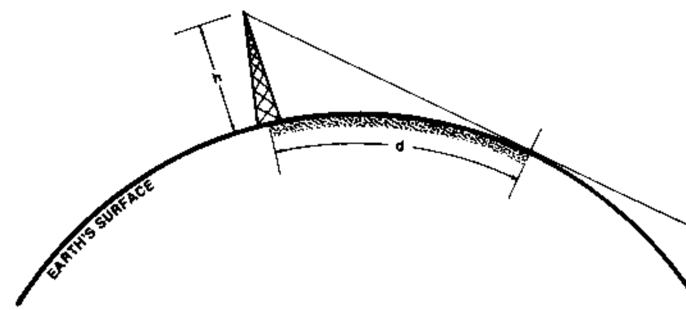


FIG. 21.1. DISTANCE TO THE RADIO HORIZON IS DEPENDENT UPON THE HEIGHT OF THE TRANSMIT ANTENNA ABOVE GROUND.

Distance to VHF/UHF/Microwave Radio Horizon

```
100 REM THIS IS PROGRAM NO. 21 PROG21
140 REM  GROUND
170 H = 0
180 D = 0
190 GOSUB 900
200 PRINT "* * * * * * * * * * * * * * *"
210 PRINT "*  DISTANCE TO THE RADIO     *"
220 PRINT "*     HORIZON GIVEN THE      *"
230 PRINT "*   ANTENNA HEIGHT ABOVE     *"
240 PRINT "*           GROUND           *"
250 PRINT "*                            *"
260 PRINT "*   COPYRIGHT 1984 BY        *"
270 PRINT "*         J.J. CARR          *"
280 PRINT "* * * * * * * * * * * * * * *"
290 PRINT
300 PRINT
310 PRINT
320 PRINT "USE STATUTORY MILES, NAUTICAL"
325 PRINT "MILES OR KILOMETERS"
330 PRINT
340 PRINT
350 GOSUB 940
360 GOSUB 900
370 PRINT "SELECT ONE FROM MENU ABOVE:"
380 PRINT "  1. STATUTORY MILES (5280 FT/MI)"
390 PRINT "  2. NAUTICAL MILES (6000 FT/MI)"
400 PRINT "  3. KILOMETERS"
410 PRINT
420 PRINT "SELECT ONE AND PRESS CR:"
430 INPUT K
440 ON K GOSUB 490,570,640
450 IF K > 3 THEN  GOTO 370
455 IF K < 1 THEN  GOTO 370
460 IF K = 3 THEN  GOSUB 970
470 IF K = 3 THEN  GOTO 1180
480 GOTO 1120
490 GOSUB 900
500 PRINT "DISTANCE WILL BE GIVEN IN"
505 PRINT "STATUTORY MILES"
510 PRINT "ENTER HEIGHT (H) IN FEET:"
520 INPUT H
530 D =  SQR (2 * H)
540 GOSUB 900
550 RETURN
560 GOTO 1120
570 GOSUB 900
580 PRINT "DISTANCE WILL BE GIVEN IN NAUTICAL MILES"
590 PRINT "ENTER HEIGHT (H) IN FEET:"
```



```
600 INPUT H
610 D = 1.23 * ( SQR (H))
620 GOSUB 900
630 RETURN
640 GOSUB 900
650 PRINT
660 PRINT
670 PRINT "DISTANCE WILL BE GIVEN IN KILOMETERS"
680 PRINT "WILL YOU ENTER ANTENNA HEIGHT"
685 PRINT "IN FEET OR METERS?"
690 PRINT "  1. FEET"
700 PRINT "  2. METERS"
710 PRINT
720 PRINT "SELECT ONE AND PRESS CR:"
740 INPUT Q
750 IF Q > 2 THEN  GOTO 670
755 IF Q < 1 THEN  GOTO 670
760 ON Q GOTO 770,830
770 PRINT
780 PRINT
790 PRINT "ENTER ANTENNA HEIGHT (H) IN FEET:"
800 INPUT H
810 H = H / 3.28
820 GOTO 870
830 PRINT
840 PRINT
850 PRINT "ENTER HEIGHT (H) IN METERS:"
860 INPUT H
870 H = H / 1000
880 D = 130 * ( SQR (H))
890 RETURN
900 FOR I = 1 TO 30
910 PRINT
920 NEXT I
930 RETURN
940 PRINT "PRESS CR TO CONTINUE..."
950 INPUT JJJ
960 RETURN
970 D =  INT (D)
980 PRINT
990 PRINT
1000 PRINT "DISTANCE TO RADIO HORIZON IS"
1005 PRINT D;" KILOMETERS"
1010 IF Q = 2 THEN  GOTO 1060
1020 H = H * 1000
1030 H = H * 3.28
1040 PRINT "WHEN THE ANTENNA IS ";H
1045 PRINT "FEET ABOVE GROUND"
```

```
1050 GOTO 1100
1060 H = H * 1000
1070 PRINT "WHEN THE ANTENNA IS ";H
1075 PRINT "METERS ABOVE GROUND"
1080 PRINT
1090 PRINT
1100 GOSUB 940
1110 RETURN
1120 D =  INT (D)
1130 PRINT "DISTANCE TO RADIO HORIZON IS ";D;" MILES"
1140 PRINT "WHEN ANTENNA IS ";H;" FEET ABOVE GROUND"
1150 PRINT
1160 PRINT
1170 GOSUB 940
1180 GOSUB 900
1190 PRINT "FINISHED?"
1200 PRINT "1. YES"
1210 PRINT "2. NO"
1220 PRINT
1230 PRINT "SELECT ONE AND PRESS CR:"
1240 INPUT L
1242 IF L < 1 THEN  GOTO 1180
1244 IF L > 2 THEN  GOTO 1180
1250 ON L GOTO 1260,100
1260 GOSUB 900
1270 PRINT "PROGRAM ENDED"
1280 PRINT
1290 PRINT
1300 PRINT "GONE!!!"
1310 END
```

Example

```
* * * * * * * * * * * * * *
*  DISTANCE TO THE RADIO   *
*    HORIZON GIVEN THE     *
*   ANTENNA HEIGHT ABOVE   *
*          GROUND          *
*                          *
*   COPYRIGHT 1984 BY      *
*        J.J. CARR         *
* * * * * * * * * * * * * *


USE STATUTORY MILES, NAUTICAL
MILES OR KILOMETERS
```



```
PRESS CR TO CONTINUE...
 0


SELECT ONE FROM MENU ABOVE:
  1. STATUTORY MILES (5280 FT/MI)
  2. NAUTICAL MILES (6000 FT/MI)
  3. KILOMETERS

SELECT ONE AND PRESS CR:
 1


DISTANCE WILL BE GIVEN IN
STATUTORY MILES
ENTER HEIGHT (H) IN FEET:
 200


DISTANCE TO RADIO HORIZON IS  20  MILES
WHEN ANTENNA IS  200  FEET ABOVE GROUND


PRESS CR TO CONTINUE...
 0


FINISHED?
1. YES
2. NO

SELECT ONE AND PRESS CR:
 2


* * * * * * * * * * * * * *
*  DISTANCE TO THE RADIO   *
*    HORIZON GIVEN THE     *
*   ANTENNA HEIGHT ABOVE   *
*          GROUND          *
*                          *
*   COPYRIGHT 1984 BY      *
*        J.J. CARR         *
* * * * * * * * * * * * * *
```

```
USE STATUTORY MILES, NAUTICAL
MILES OR KILOMETERS


PRESS CR TO CONTINUE...
 0



SELECT ONE FROM MENU ABOVE:
  1. STATUTORY MILES (5280 FT/MI)
  2. NAUTICAL MILES (6000 FT/MI)
  3. KILOMETERS

SELECT ONE AND PRESS CR:
 3


DISTANCE WILL BE GIVEN IN KILOMETERS
WILL YOU ENTER ANTENNA HEIGHT
IN FEET OR METERS?
  1. FEET
  2. METERS

SELECT ONE AND PRESS CR:
 2


ENTER HEIGHT (H) IN METERS:
 22


DISTANCE TO RADIO HORIZON IS
 19  KILOMETERS
WHEN THE ANTENNA IS  22
METERS ABOVE GROUND


PRESS CR TO CONTINUE...
 0


FINISHED?
1. YES
2. NO
```



```
SELECT ONE AND PRESS CR:
 1


PROGRAM ENDED


GONE!!!


READY.
```

PROGRAM 22

Satellite Dish Antenna

Satellite television signals are transmitted on microwave frequencies (that is those above 1000 MHz, or 1 GHz). These signals are weak when they arrive on earth, so they must be amplified by a high gain antenna feeding a low noise amplifier. The antenna usually selected is the parabolic dish (see Fig. 22.1).

This program allows you to calculate the gain, beam width, and focal length of a parabolic dish antenna, assuming that you know or can specify the dish diameter, depth, and the operating frequency. This program will permit you to determine how much gain is available, thus how much gain the LNA and rest of the system must provide in order to receive a specified microwave signal from outer space.

F = focal point

$$G = \frac{0.55\pi D^2}{\lambda} \qquad [22.1]$$

$$S = \frac{D^2}{16DE} \qquad [22.2]$$

$$\phi = \frac{70°}{D}\lambda$$

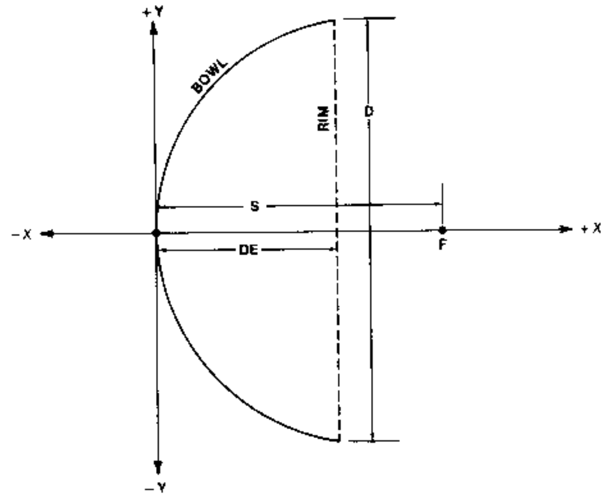


FIG. 22.1. A PARABOLIC DISH.

Satellite Dish Antenna

```
100 REM THIS IS PROGRAM NO. 22 PROG22
110 REM THIS PROGRAM CALCULATES THE GAIN
120 REM BEAMWIDTH AND FOCAL LENGTH OF A
125 REM PARABOLIC DISH ANTENNA
130 GOSUB 630
140 PRINT "SATELLITE ANTENNA COMPUTATIONS"
150 PRINT
160 GOSUB 670
170 GOSUB 590
180 PRINT "FREQUENCY OF OPERATION IN MEGAHERTZ:"
185 INPUT F
190 WL = 300 / F
200 WL = WL * 3.28
210 GOSUB 590
220 PRINT "ANTENNA DIAMETER IN FEET.(FT.):"
222 INPUT D
230 GOSUB 590
240 PRINT "DEPTH OF ANTENNA IN FEET (FT.):"
245 INPUT DE
250 GOSUB 590
260 G1 = (3.1415 * D) ^ 2
270 G2 = 0.55 * G1
```

```
280 G = G2 / WL
290 G =  LOG (G)
300 G = 0.4343 * G
310 G = 10 * G
320 G =  INT (G)
330 FL = FL * 100
340 FL =  INT (FL)
350 FL = FL / 100
360 PHI = (70 * WL) / D
370 PHI = PHI * 100
380 PHI =  INT (PHI)
390 PHI = PHI / 100
400 FL = (D ^ 2) / (16 * DE)
410 PRINT "GAIN: ";G;" DB OVER ISOTROPIC SOURCE"
420 PRINT "GAIN: ";G - 2.1;" DB OVER SIMPLE DIPOLE"
430 PRINT "BEAMWIDTH: ";PHI;" DEGREES"
440 PRINT "FOCAL LENGTH: ";FL;" FEET"
450 PRINT
460 PRINT "DISH DIAMETER: ";D;" FEET"
470 PRINT "DEPTH OF DISH: ";DE;" FEET"
480 PRINT "FREQUENCY: ";F;" MHZ"
490 PRINT
500 PRINT
510 GOSUB 670
520 GOSUB 630
530 PRINT "1. DO ANOTHER?"
540 PRINT "2. FINISHED?"
550 PRINT
560 PRINT "SELECTION???"
565 INPUT H
570 IF H > 2 THEN  GOTO 530
580 ON H GOTO 100,700
590 FOR I = 1 TO 5
600 PRINT
610 NEXT I
620 RETURN
630 FOR I = 1 TO 30
640 PRINT
650 NEXT I
660 RETURN
670 PRINT "PRESS CR TO CONTINUE..."
680 INPUT KK
690 RETURN
700 GOSUB 630
710 PRINT "PROGRAM ENDED"
720 END
```


Example

```
SATELLITE ANTENNA COMPUTATIONS

PRESS CR TO CONTINUE...
 0


FREQUENCY OF OPERATION IN MEGAHERTZ:
 3515


ANTENNA DIAMETER IN FEET (FT.):
 12


DEPTH OF ANTENNA IN FEET (FT.):
 1.5


GAIN:  34  DB OVER ISOTROPIC SOURCE
GAIN:  31.9  DB OVER SIMPLE DIPOLE
BEAMWIDTH:  1.63  DEGREES
FOCAL LENGTH:  6  FEET

DISH DIAMETER:  12  FEET
DEPTH OF DISH:  1.5  FEET
FREQUENCY:  3515  MHZ


PRESS CR TO CONTINUE...
 0



1. DO ANOTHER?
2. FINISHED?

SELECTION???
 2


PROGRAM ENDED
```

Program 23

Antenna Bearings Given Latitude/Longitude

This program calculates the great circle bearing between any two points on the earth's surface. You will be asked to enter the latitude and longitude of your location, and the latitude and longitude of the other location. The program will then calculate the bearing in degrees relative to true north and the distance between the two points. This program is used mostly for positioning directional radio antennas.

Use decimal degrees, that is 27.33 instead of 27 degrees 20 minutes.


```
100 REM THIS IS PROGRAM NO. 23 PROG23
140 REM
150 REM  SET CONSTANTS
160 PI = 3.1415926
170 R = 57.295779
180 Q = 2
190 REM
200 REM  OPENING DISPLAY
210 REM
220 DIM B$(30)
230 GOSUB 1350
240 PRINT  TAB( Q);"* * * * * * * * * * * * * * * * * * * * *"
245 PRINT  TAB( Q);"*                                       *"
250 PRINT  TAB( Q);"*   ANTENNA BEARINGS CALCULATION        *"
260 PRINT  TAB( Q);"*       COPYRIGHT  1983   BY            *"
270 PRINT  TAB( Q);"*                J.J. CARR              *"
280 PRINT  TAB( Q);"*                                       *"
300 PRINT  TAB( Q);"* * * * * * * * * * * * * * * * * * * * *"
310 PRINT
320 PRINT
330 PRINT
340 GOSUB 1390
350 GOSUB 1350
360 REM
370 REM  GET INFORMATION FOR CALCULATIONS
380 REM
390 PRINT "YOUR LATITUDE IN DECIMAL DEGREES:"
392 INPUT A
400 GOSUB 1310
410 PRINT "YOUR LONGITUDE IN DECIMAL DEGREES:"
412 INPUT L1
420 GOSUB 1310
430 PRINT "NOW ENTER THE LATITUDE AND LONGITUDE"
440 PRINT "OF THE OTHER CITY OR COUNTRY:"
450 PRINT "IF YOU DO NOT KNOW THE LAT/LONG THEN"
460 PRINT "CONSULT AN ATLAS"
470 PRINT
480 GOSUB 1310
490 PRINT "ENTER THE NAME OF THE CITY OR COUNTRY:"
500 INPUT B$
510 GOSUB 1310
520 PRINT "ENTER LATITUDE OF ";B$
530 INPUT B
540 GOSUB 1310
550 PRINT "ENTER LONGITUDE OF ";B$
560 INPUT L2
570 REM  CALCULATE THE DIFFERENCE IN LONGITUDE
580 L3 = L1 - L2
```

```
590 IF  ABS (L3) = 180 THEN  GOTO 650
600 IF  ABS (L3) < 180 THEN  GOTO 650
610 IF L3 > 180 THEN L3 = L3 - 360
620 IF L3 <  - 180 THEN L3 = L3 + 360
630 REM
640 REM  CONVERT FROM DEGREES TO RADIANS
650 L = L3 / R
660 A = A / R
670 B = B / R
680 REM
690 REM  CALCULATE ANGULAR DISTANCE
700 D1 =  SIN (A) *  SIN (B)
710 D2 =  COS (A) *  COS (B) *  COS (L)
720 REM
730 REM
740 REM  D3 IS COSINE D
750 REM
760 D3 = D1 + D2
770 D =  -  ATN (D3 /  SQR ( - D3 * D3 + 1)) + 1.5708
780 REM  CALCULATE BEARING
790 C1 =  SIN (B)
800 C2 =  SIN (A) * D3
810 C3 =  COS (A) *  SIN (D)
820 C4 = ((C1 - C2) / C3)
830 REM
840 REM
850 C =  -  ATN (C4 /  SQR ( - C4 * C4 + 1)) + 1.5708
860 I = L3
870 IF I > 0 THEN C = C
880 IF I < 0 THEN C = (2 * PI) - C
890 REM  RECONVERT ANGLES FROM RADIANS TO DEGREES
900 C = C * R
910 A = A * R
920 B = B * R
930 D = D * R
940 REM  ROUND-OFF BEARINGS
950 M = C -  INT (C)
960 IF M > 0.5 THEN C =  INT (C) + 1
970 IF M = 0 THEN C = C
980 IF M < 0.5 THEN C =  INT (C)
990 REM  CALCULATE LINEAR DISTANCE
1000 REM  S1 IS MILES, S2 IS KILOMETERS
1010 S1 = D * 60 * 1.15078
1020 S2 = D * 60 * 1.852
1030 REM
1040 REM  ROUND-OFF ALL DISTANCES
1050 REM
1060 G = S1 -  INT (S1)
1070 IF G = 0 THEN S1 = S1
```



```
1080 IF G > 0.5 THEN S1 =  INT (S1) + 1
1090 IF G < 0.5 THEN S1 =  INT (S1)
1100 H = S2 -  INT (S2)
1110 IF H = 0 THEN S2 = S2
1120 IF H > 0.5 THEN S2 =  INT (S2) + 1
1130 IF H < 0.5 THEN S2 =  INT (S2)
1140 REM
1150 REM  OUTPUT DATA
1160 GOSUB 1310
1170 PRINT B$
1180 PRINT "LAT. ";B;"  ";"LONG. ";L2
1190 PRINT S1;" MILES";S2;" KILOMETERS"
1200 PRINT
1210 PRINT "BEARINGS: ";C;" DEGREES"
1220 GOSUB 1310
1230 GOSUB 1390
1240 GOSUB 1350
1250 PRINT "1. FINISHED?"
1260 PRINT "2. DO ANOTHER?"
1270 PRINT
1280 PRINT "SELECTION????"
1282 INPUT J
1290 IF J > 2 THEN  GOTO 1250
1300 ON J GOTO 1420,350
1310 FOR I = 1 TO 5
1320 PRINT
1330 NEXT I
1340 RETURN
1350 FOR I = 1 TO 30
1360 PRINT
1370 NEXT I
1380 RETURN
1390 PRINT "PRESS CR TO CONTINUE"
1400 INPUT KK
1410 RETURN
1420 GOSUB 1350
1430 PRINT "PROGRAM ENDED"
1440 END
```

SECTION II

BASIC PROGRAMS FOR GENERAL ELECTRONICS

PROGRAM 24

Resistors in Series or Parallel

Resistors can be combined in either series or parallel or in a combination of these two circuits (Fig. 24.1). This program asks for the number of resistors and whether they are in series or parallel circuit configuration. The following equations apply:

SERIES RESISTORS

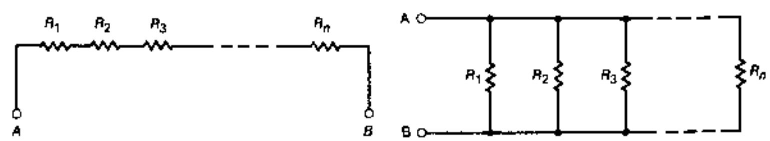
$$R = R_1 + R_2 + R_3 + \ldots + R_n \qquad [24.1]$$

TWO RESISTORS IN PARALLEL

$$R = \frac{R_1 R_2}{R_1 + R_2} \qquad [24.2]$$

"N" RESISTORS IN PARALLEL

$$R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots + \frac{1}{R_n}} \qquad [24.3]$$



(A) Series. (B) Parallel.

FIG. 24.1. RESISTORS CAN BE COMBINED IN EITHER SERIES OR PARALLEL.

Resistors in Series or Parallel

```
100 REM THIS IS PROGRAM NO. 24 PROG24
110 REM RUNS ON C-64 OR C-128
120 REM
125 REM THIS PROGRAM CALCULATES THE
126 REM VALUE OF N RESISTORS IN PARALLEL130 DIM R(1000)
140 DIM G(1000)
150 GSUM = 0
160 RSUM = 0
170 GOSUB 520
180 PRINT "HOW MANY RESISTORS ARE THERE?"
190 INPUT N
192 IF N = 1 THEN GOTO 800
193 IF N < 1 THEN GOTO 900
200 GOSUB 520
210 FOR I = 1 TO N
220 PRINT "ENTER R(";I;") IN OHMS:"
230 INPUT R(I)
240 G(I) = 1/R(I)
250 GSUM = GSUM + G(I)
260 RSUM = RSUM + R(I)
270 NEXT I
280 GOSUB 520
290 RTP = 1/GSUM
291 RTP = RTP*100
292 RTP = INT(RTP)
293 RTP = RTP/100
294 RSUM = RSUM*100
295 RSUM = INT(RSUM)
296 RSUM = RSUM/100
300 PRINT "PARALLEL OR SERIES?"
310 PRINT TAB(5);"1. PARALLEL"
320 PRINT TAB(5);"2. SERIES"
330 PRINT TAB(5);"3. BOTH PARALLEL & SERIES"
340 PRINT
350 PRINT "SELECT ONE FROM ABOVE "
355 PRINT "AND PRESS CR"
360 INPUT D
370 IF D > 3 THEN GOTO 300
380 IF D = 2 THEN GOTO 410
390 IF D = 1 THEN GOTO 440
400 IF D = 3 THEN GOTO 470
405 IF D < 1 THEN GOTO 300
410 GOSUB 420
420 PRINT "SERIES OF TOTAL OF ";N;" RESISTORS IS ";RSUM;"
    OHMS"
430 GOTO 560
440 GOSUB 520
450 PRINT "PARALLEL TOTAL OF ";N;" RESISTORS IS ";RTP;" OHMS"
460 GOTO 560
```



```
470 GOSUB 520
480 PRINT "TOTAL PARALLEL RESISTANCE ";RTP;" OHMS"
490 PRINT
500 PRINT "TOTAL SERIES RESISTANCE ";RSUM;" OHMS"
510 GOTO 560
520 FOR I = 1 TO 30
530 PRINT
540 NEXT I
550 RETURN
560 PRINT
570 PRINT "PRESS CR TO CONTINUE..."
580 INPUT KK
590 GOSUB 520
600 PRINT "FINISHED"
610 PRINT TAB(5);"1. YES"
620 PRINT TAB(5);"2. NO"
630 PRINT
640 PRINT "SELECT ONE FROM ABOVE AND
645 PRINT "PRESS CR..."
650 INPUT F
660 IF F > 2 THEN GOTO 600
670 IF F = 2 THEN GOTO 150
675 IF F < 1 THEN GOTO 600
680 GOSUB 520
690 PRINT "PROGRAM ENDED..."
700 PRINT
710 PRINT
720 GOTO 1000
800 REM ONE RESISTOR ERROR MSG.
810 PRINT "ONE RESISTOR IS A TRIVIAL"
820 PRINT "CASE ...TRY AGAIN"
830 PRINT
840 PRINT
850 PRINT "PRESS CR TO CONTINUE..."
860 PRINT
870 PRINT
880 GOTO 180
900 PRINT "LESS THAN 1 RESISTOR?"
920 PRINT "TRY AGAIN..."
940 PRINT
950 PRINT "PRESS CR TO CONTINUE..."
960 INPUT EE
970 PRINT
980 PRINT
990 GOTO 180
1000 END
```

Example

```
HOW MANY RESISTORS ARE THERE?
 3


ENTER R( 1 ) IN OHMS:
 3000
ENTER R( 2 ) IN OHMS:
 2000
ENTER R( 3 ) IN OHMS:
 1000


PARALLEL OR SERIES?
     1. PARALLEL
     2. SERIES
     3. BOTH PARALLEL & SERIES

SELECT ONE FROM ABOVE
AND PRESS CR
 3


TOTAL PARALLEL RESISTANCE  545.45  OHMS

TOTAL SERIES RESISTANCE  6000  OHMS

PRESS CR TO CONTINUE...


FINISHED
     1. YES
     2. NO

SELECT ONE FROM ABOVE AND
PRESS CR...


 1
PROGRAM ENDED...
```


PROGRAM 25

Capacitors in Series or Parallel

Capacitors can be combined in either series or parallel or in a combination of these two circuits (Fig. 25.1). This program asks for the number of capacitors and whether they are in series or parallel circuit configuration. The following equations apply:

CAPACITORS IN PARALLEL

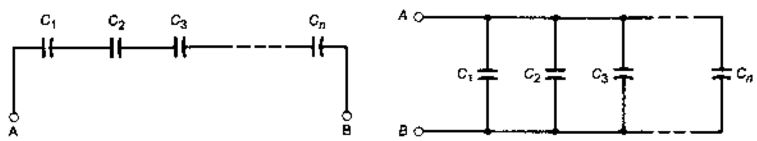
$$C = C_1 + C_2 + C_3 + ... + C_n \quad [25.1]$$

TWO CAPACITORS IN SERIES

$$C = \frac{C_1 C_2}{C_1 + C_2} \quad [25.2]$$

"N" CAPACITORS IN SERIES

$$C = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + ... + \frac{1}{C_n}} \quad [25.3]$$



(A) Series. (B) Parallel.

FIG. 25.1. CAPACITORS CAN BE COMBINED IN EITHER SERIES OR PARALLEL.

Capacitors in Series or Parallel

```
100 REM THIS IS PROGRAM NO. 25 PROG25
110 REM IT WILL CALCULATE THE VALUES OF
120 REM N CAPACITORS IN SERIES OR
125 REM PARALLEL.
130 DIM C(1000)
150 GSUM = 0
160 CSUM = 0
170 GOSUB 550
180 PRINT "HOW MANY CAPACITORS ARE THERE???"
190 INPUT N
205 GOSUB 550
210 FOR I = 1 TO N
220 C(I) = 0
230 NEXT I
240 FOR I = 1 TO N
250 PRINT "ENTER C(";I;"): "
260 INPUT C(I)
270 G(I) = 1/C(I)
280 GSUM = GSUM + G(I)
290 CSUM = CSUM + C(I)
300 NEXT I
310 GOSUB 550
320 CTP = 1/GSUM
330 PRINT "PARALELL OR SERIES???"
340 PRINT TAB(5);"1. PARALLEL"
350 PRINT TAB(5);"2. SERIES"
360 PRINT TAB(5);"3. BOTH SERIES & PARALLEL"
370 PRINT
380 PRINT "SELECT ONE FROM ABOVE..."
390 INPUT D
400 IF D > 3 THEN GOTO 330
410 ON D GOTO 470,440,500
440 GOSUB 550
450 PRINT "SERIES TOTAL OF ";N;" CAPACITORS: ";RTP;" UF"
460 GOTO 590
470 GOSUB 550
480 PRINT "PARALLEL TOTAL OF ";N;" CAPACITORS: ";RSUM;" UF"
490 GOTO 590
500 GOSUB 550
510 PRINT "TOTAL PARALLEL CAPACITANCE: ";CSUM;" UF"
520 PRINT
530 PRINT "TOTAL SERIES CAPACITANCE: ";CTP;" UF"
540 GOTO 590
550 FOR I = 1 TO 30
560 PRINT
570 NEXT I
580 RETURN
590 PRINT
```



```
600 PRINT "PRESS CR TO CONTINUE..."
610 INPUT KK
620 GOSUB 550
630 PRINT "FINISHED (Y/N)????"
640 PRINT TAB(5);"1. YES"
650 PRINT TAB(5);"2. NO"
660 PRINT
670 PRINT "SELECT ONE FROM ABOVE AND"
675 PRINT "PRESS CR....."
680 INPUT F
690 IF F > 2 THEN GOTO 630
700 IF F = 2 THEN GOTO 150
710 GOSUB 550
720 PRINT "PROGRAM ENDED....."
730 PRINT
740 PRINT
750 END
```

Example

```
HOW MANY CAPACITORS ARE THERE???
 3



ENTER C( 1 ):
 300
ENTER C( 2 ):
 200
ENTER C( 3 ):
 300



PARALELL OR SERIES???
     1. PARALLEL
     2. SERIES
     3. BOTH SERIES & PARALLEL

SELECT ONE FROM ABOVE...
 3



TOTAL PARALLEL CAPACITANCE:  85.7142858  UF
```

```
TOTAL SERIES CAPACITANCE:  800  UF

PRESS CR TO CONTINUE...
 0


FINISHED (Y/N)????
     1. YES
     2. NO

SELECT ONE FROM ABOVE AND
PRESS CR.....
 1


PROGRAM ENDED.....
```


PROGRAM 26

Inductors in Series or Parallel

Inductors can be combined in either series or parallel (Fig. 26.1) or in a combination of these two circuits. This program asks for the number of inductors and whether they are in series or parallel circuit configuration; zero mutual inductance is assumed. The following equations apply:

INDUCTORS IN SERIES

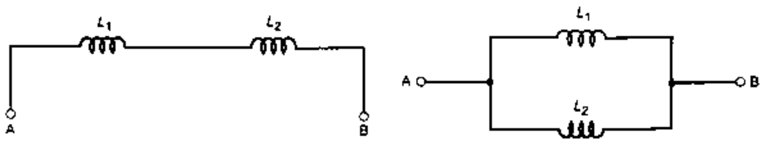
$$L = L_1 + L_2 + L_3 + ... + L_n \qquad [26.1]$$

TWO INDUCTORS IN PARALLEL

$$L = \frac{L_1 L_2}{L_1 + L_2} \qquad [26.2]$$

"N" INDUCTORS IN PARALLEL

$$L = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + ... + \frac{1}{L_n}} \qquad [26.3]$$



(A) Series. *(B) Parallel.*

FIG. 26.1. INDUCTORS CAN BE COMBINED IN EITHER SERIES OR PARALLEL.

Inductors in Series or Parallel

```
100 REM THIS IS PROGRAM NO. 26 PROG26
110 REM THIS PROGRAM WILL CALCULATE
115 REM THE VALUE OF N INDUCTORS IN
120 REM EITHER SERIES OR PARALLEL
125 REM ASSUMING NO MUTUAL INDUCTANCE
130 DIM L(1000)
140 DIM G(1000)
150 GSUM = 0
160 RSUM = 0
170 GOSUB 610
180 PRINT "THIS PROGRAM WILL CALCULATE THE SERIES"
190 PRINT "OR PARALLEL INDUCTANCE OF A"
195 PRINT "NETWORK, PROVIDED THAT"
200 PRINT "THERE IS ZERO MUTUAL INDUCTANCE"
210 PRINT
220 PRINT "ALL INDUCTANCE VALUES SHOULD BE ENTERED IN SAME
    UNITS, E.G."
225 PRINT "MICROHENRYS (UH)"
230 PRINT
240 PRINT "HOW MANY INDUCTORS ARE THERE?"
250 INPUT N
260 GOSUB 610
270 FOR I = 1 TO N
280 L(I) = 0
290 NEXT I
300 FOR I = 1 TO N
310 PRINT "ENTER L(";I;"):"
320 INPUT L(I)
330 G(I) = 1/L(I)
340 GSUM = GSUM + G(I)
350 RSUM = RSUM + L(I)
360 NEXT I
370 GOSUB 610
380 RTP = 1/GSUM
390 PRINT "PARALLEL OR SERIES?"
400 PRINT TAB(5);"1. PARALEL"
410 PRINT TAB(5);"2. SERIES"
420 PRINT TAB(5);"3. BOTH PARALEL AND SERIES"
430 PRINT
440 PRINT "SELECT ONE FROM ABOVE AND PRESS CR..."
450 INPUT D
460 IF D > 3 THEN GOTO 390
465 IF D < 1 THEN GOTO 390
470 ON D GOTO 530,500,560
500 GOSUB 610
510 PRINT "SERIES TOTAL OF ";N;" INDUCTORS IS: ";RSUM;" UH"
520 GOTO 650
530 GOSUB 610
540 PRINT "PARALLEL TOTAL OF ";N;" INDUCTORS IS: ";RTP;" UH"
```



```
550 GOTO 650
560 GOSUB 610
570 PRINT "TOTAL PARALLEL INDUCTANCE: ";RTP;" UH"
580 PRINT
590 PRINT "TOTAL SERIES INDUCTANCE: ";RSUM;" UH"
600 GOTO 650
610 FOR I = 1 TO 30
620 PRINT
630 NEXT I
640 RETURN
650 PRINT
660 PRINT "PRESS CR TO CONTINUE..."
670 INPUT KK
680 GOSUB 610
690 PRINT "FINISHED?"
700 PRINT TAB(5);"1. YES"
710 PRINT TAB(5);"2. NO"
720 PRINT
730 PRINT "SELECT ONE FROM ABOVE AND PRESS CR..."
740 INPUT F
750 IF F > 2 THEN GOTO 690
755 IF F < 1 THEN GOTO 690
760 IF F = 2 THEN GOTO 150
770 GOSUB 610
780 PRINT "PROGRAM ENDED"
790 PRINT
800 PRINT
810 END
```

Example

```
THIS PROGRAM WILL CALCULATE THE SERIES
OR PARALLEL INDUCTANCE OF A
NETWORK, PROVIDED THAT
THERE IS ZERO MUTUAL INDUCTANCE

ALL INDUCTANCE VALUES SHOULD BE ENTERED IN SAME UNITS, E.G.
MICROHENRYS (UH)

HOW MANY INDUCTORS ARE THERE?
 3



ENTER L( 1 ):
 20
```

```
ENTER L( 2 ):
 25
ENTER L( 3 ):
 10


PARALLEL OR SERIES?
     1. PARALEL
     2. SERIES
     3. BOTH PARALEL AND SERIES

SELECT ONE FROM ABOVE AND PRESS CR...
 3


TOTAL PARALLEL INDUCTANCE:  5.2631579  UH

TOTAL SERIES INDUCTANCE:  55  UH

PRESS CR TO CONTINUE...
 1


FINISHED?
     1. YES
     2. NO

SELECT ONE FROM ABOVE AND PRESS CR...
 1


PROGRAM ENDED
```


PROGRAM 27

Zener Diode Voltage Regulator Design

Figure 27.1 shows the basic circuit of a simple voltage regulator based on the properties of the zener diode (D_1). The series resistor (R_1) is used to limit the current to a safe value. Otherwise, when the zener operated, it would draw excessive current. This program calculates the value of this resistor as well as the power dissipation of the resistor and the zener diode. When specifying the power rating of these components, use the next higher standard value.

Three conditions are taken into account by this program:

1. Variable input voltage, constant load current
2. Constant input voltage, variable load current
3. Variable input voltage, variable load current

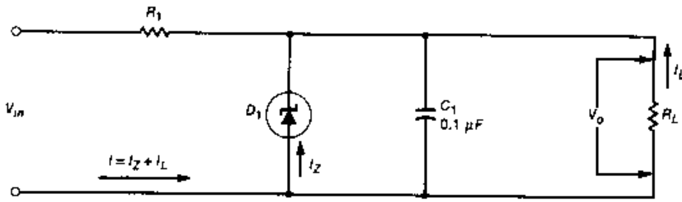


FIG. 27.1. CIRCUIT OF A SIMPLE VOLTAGE REGULATOR BASED ON THE PROPERTIES OF THE ZENER DIODE.

```
10 REM THIS IS PROGRAM NO. 27 PROG27
12 REM THIS PROGRAM ALLOWS YOU TO
13 REM DESIGN SIMPLE ZENER DIODE
14 REM VOLTAGE REGULATOR CIRCUITS
20 VZ = 0
30 MIN = 0
40 MAX =0
50 I = 0
55 V = 0
60 PD = 0
65 R = 0
70 PRMIN = 0
75 IMAX = 0
80 H = 0
130 GOSUB 770
140 PRINT "THIS PROGRAM IS A DESIGN AID"
145 PRINT "FOR ZENER DIODE VOLTAGE"
150 PRINT "REGULATOR CIRCUITS."
160 PRINT
170 PRINT "THERE ARE THREE CONDITIONS:"
180 PRINT
190 PRINT
200 PRINT TAB(5);"1. VARIABLE V,CONSTANT I"
210 PRINT
220 PRINT TAB(5);"2. CONSTANT V, VARIABLE I"
230 PRINT
240 PRINT TAB(5);"3. VARIABLE V, VARIABLE I"
250 PRINT
260 PRINT "SELECT ONE FROM ABOVE AND PRESS CR...."
270 INPUT N
271 IF N > 3 THEN GOTO 160
272 IF N < 1 THEN GOTO 160
280 GOSUB 770
290 PRINT "ENTER REGULATED OUTPUT VOLTAGE: ???"
300 INPUT VZ
310 GOSUB 770
320 ON N GOTO 350,490,600
350 PRINT "ENTER MINIMUM VALUE OF INPUT VOLTAGE: ???"
360 INPUT MIN
361 IF MIN = VZ THEN GOSUB 3000
362 IF MIN = VZ THEN GOTO 280
365 IF MIN < VZ THEN GOSUB 2000
366 IF MIN < VZ THEN GOTO 280
370 PRINT
380 PRINT "ENTER MAXIMUM VALUE OF INPUT VOLTAGE: ???"
390 INPUT MAX
395 IF MAX < VZ THEN GOSUB 2000
396 IF MAX < VZ THEN GOTO 370
```



```
397 IF MAX = VZ THEN GOSUB 3000
398 IF MAX = VZ THEN GOTO 370
400 PRINT
410 PRINT "ENTER LOAD CURRENT"
420 INPUT I
430 R = (MIN - VZ)/(1.1*I)
440 PD = ((MAX - VZ)^2)/R
450 PRMIN = PD
460 PD = PD - (I*VZ)
470 GOSUB 840
480 GOTO 950
490 PRINT "ENTER VALUE OF CONSTANT INPUT VOLTAGE: ???"
500 INPUT V
510 PRINT
520 PRINT "ENTER MAXIMUM VALUE OF LOAD CURRENT: ???"
530 INPUT I
540 R = (V - VZ)/(1.1*I)
550 PD = ((V - VZ)^2)/R
560 PRMIN = PD
570 PRMIN = PD + (I*VZ)
580 GOSUB 840
590 GOTO 950
600 PRINT "ENTER MINIMUM VALUE OF INPUT VOLTAGE: ???"
610 INPUT MIN
614 IF MIN = VZ THEN GOSUB 2000
615 IF MIN = VZ THEN GOTO 600
616 IF MIN < VZ THEN GOSUB 3000
617 IF MIN < VZ THEN GOTO 600
620 PRINT
630 PRINT "ENTER MAXIMUM VALUE OF INPUT VOLTAGE: ???"
640 INPUT MAX
644 IF MAX < VZ THEN GOSUB 3000
645 IF MAX < VZ THEN GOTO 620
646 IF MAX = VZ THEN GOSUB 2000
647 IF MAX = VZ THENE GOTO 620
650 PRINT
660 PRINT  "ENTER MAXIMUM VALUE OF LOAD CURRENT: ???"
670 INPUT IMAX
680 PRINT
690 PRINT
700 R = (MIN - VZ)/(1.1*IMAX)
710 PD = ((MAX - VZ)^2)/R
720 PRMIN = PD
730 PD = PD - (IMAX*VZ)
740 GOSUB 840
750 GOTO 950
760 GOTO 1050
770 FOR I = 1 TO 30
```

```
780 PRINT
800 RETURN
810 PRINT "PRESS CR TO CONTINUE..."
820 INPUT KK
830 RETURN
840 PRINT
850 R = R*100
860 R = INT(R)
870 R = R/100
880 PRINT
890 PRINT "RESISTOR R1: ";R;" OHMS"
900 PRINT
910 PRINT "RESISTOR R1 POWER DISSAPATION IS:"
915 PRINT PRMIN;" WATTS"
920 PRINT
930 PRINT "ZENER DIODE DISSAPATION: ";PD;" WATTS"
940 RETURN
950 PRINT "FINISHED?"
960 PRINT TAB(5);"1. YES"
970 PRINT TAB(5);"2. NO"
980 PRINT
990 INPUT H
1000 IF H > 2 THEN GOTO 950
1005 IF H < 1 THEN GOTO 950
1010 IF H = 2 THEN GOTO 10
1020 PRINT
1040 PRINT "PROGRAM ENDED"
1050 END
2000 REM INPUT LESS THAN OUTPUT???
2020 PRINT
2030 PRINT
2040 PRINT
2050 PRINT "OUTPUT VOLTAGE CANNOT BE"
2060 PRINT "LESS THAN INPUT VOLTAGE!"
2070 PRINT "TRY AGAIN"
2080 PRINT "PRESS CR TO CONTINUE..."
2090 INPUT ZZ
2100 RETURN
3000 REM TRIVIAL CASE MESSAGE
3010 PRINT
3020 PRINT
3030 PRINT "WHEN INPUT = OUTPUT NO"
3040 PRINT "REGULATOR IS POSSIBLE!"
3050 PRINT
3060 PRINT "TRY AGAIN"
3070 PRINT
3080 PRINT "PRESS CR TO CONTINUE..."
3090 INPUT ZZ
3100 RETURN
```


Example

```
THIS PROGRAM IS A DESIGN AID
FOR ZENER DIODE VOLTAGE
REGULATOR CIRCUITS.

THERE ARE THREE CONDITIONS:


     1. VARIABLE V,CONSTANT I

     2. CONSTANT V, VARIABLE I

     3. VARIABLE V, VARIABLE I

SELECT ONE FROM ABOVE AND PRESS CR....
 1

ENTER REGULATED OUTPUT VOLTAGE: ???
 6.8

ENTER MINIMUM VALUE OF INPUT VOLTAGE: ???
 11

ENTER MAXIMUM VALUE OF INPUT VOLTAGE: ???
 15.8

ENTER LOAD CURRENT
 .07


RESISTOR R1:  54.54  OHMS

RESISTOR R1 POWER DISSAPATION IS:
 1.485  WATTS

ZENER DIODE DISSAPATION:  1.009  WATTS
FINISHED?
     1. YES
     2. NO

 1

PROGRAM ENDED
```

Program 28

RLC Networks

This program evaluates an RLC network (see Fig. 28.1) and will provide the following:

1. Total reactance
2. Total impedance
3. Phase angle between I and V
4. Parallel-to-Series Conversion (Equivalent Circuit)
5. Series-to-Parallel Conversion (Equivalent Circuit)
6. Quality Factor (Q)

SERIES RLC

$$Z = \sqrt{R^2 + (X_L - X_C)^2} \quad [28.1]$$

$$X_T = X_L - X_C \quad [28.1]$$

PARALLEL RLC

$$Z = \frac{R_X}{R^2 + (X_L - X_C)^2} \quad [28.2]$$

$$X_T = \frac{-X_L X_C}{X_L - X_C} \quad [28.3]$$

POWER FACTOR

$$\mathrm{PF} = \frac{R}{Z} \quad [28.4]$$

PHASE ANGLE

$$\theta = \tan^{-1}(X/R)$$

$$\theta = \sin^{-1}(X/Z) \quad [28.5]$$

$$\theta = \cos^{-1}(R/Z)$$

SERIES-TO-PARALLEL CONVERSION

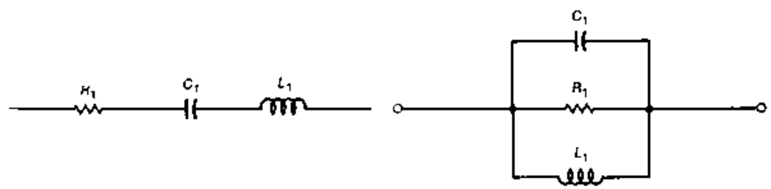
$$R_P = \frac{R_S^2 + X_S^2}{R_S} \quad [28.6]$$

$$X_P = \frac{R_S^2 + X_S^2}{X_S} \quad [28.7]$$

PARALLEL-TO-SERIES CONVERSION

$$R_S = \frac{R_P}{1 + \left(\frac{R_P}{X_P}\right)^2} \quad [28.8]$$

$$X_S = \frac{R_S R_P}{X_P} \quad [28.9]$$



(A) Series. (B) Parallel.

Fig. 28.1 Program evaluates an RLC network.

RLC Networks

```
10 REM THIS IS PROGRAM NO. 28 PROG28
12 REM THIS PROGRAM WILL CALCULATE THE
13 REM TOTAL REACTANCE, IMPEDANCE AND
15 REM PHASE SHIFT ANGLE OF RLC NETWORKS
18 REM IT WILL ALSO FIND RESONANT FREQ.
20 REM AND PERFORM PARALLEL-SERIES CON-
22 REM VERSIONS.
140 W = 0
150 Y = 0
160 K = 0
170 GOSUB 1420
230 GOSUB 1420
240 GOSUB 1500
250 GOSUB 1460
260 PRINT "THIS PROGRAM CALCULATES CERTAIN "
265 PRINT "PARAMETERS OF NETWORKS CONTAINING "
270 PRINT "RESISTOR, CAPACITOR AND INDUCOR "
275 PRINT "ELEMENTS.  NO SINGLE NETWORK NEED"
280 PRINT "CONTAIN ALL THREE ELEMENTS."
290 PRINT
300 PRINT "FOLLOW DIRECTIONS GIVEN ON THE SCREEN..."
310 GOSUB 1420
320 GOSUB 1500
330 GOSUB 1460
340 PRINT TAB(K);"TYPE OF RLC NETWORK:???"
350 PRINT
355 PRINT TAB(K);"  1. SERIES RLC"
360 PRINT TAB(K);"  2. PARALLEL RLC"
370 PRINT
380 PRINT "SELECT ONE FROM ABOVE"
385 PRINT "AND PRESS CR..."
390 INPUT T
395 PRINT T
400 IF T > 2 THEN GOTO 340
410 GOSUB 1460
420 PRINT TAB(Y);"ENTER THE VALUES OF RLC "
422 PRINT TAB(Y);"NETWORK COMPONENTS (IN OHMS..."
430 PRINT
440 PRINT TAB(Y);"RESISTANCE R IS: ???"
450 INPUT R
455 PRINT R
460 PRINT
470 PRINT TAB(Y);"CAPACITIVE REACTANCE IS: ???"
480 INPUT XC
490 PRINT XC
495 PRINT
500 PRINT TAB(Y);"INDUCTIVE REACTANCE IS: ???"
510 INPUT XL
```



```
515 PRINT XL
520 GOSUB 1460
530 PRINT TAB(Y);"PERFORM THE FOLLOWING
535 PRINT TAB(Y);"CALCULATION..."
540 PRINT
550 PRINT TAB(Y);"1. TOTAL REACTANCE XT"
560 PRINT TAB(Y);"2. TOTAL IMPEDANCE ZT"
570 PRINT TAB(Y);"3. PHASE ANGLE"
580 PRINT TAB(Y);"4. SERIES-PARALLEL CONVERSION"
590 PRINT TAB(Y);"5. PARALLEL-SERIES CONVERSION"
600 PRINT TAB(Y);"6. QUALITY FACTOR (Q)"
610 PRINT
620 PRINT TAB(Y);"SELCT ONE FROM ABOVE AND PRESS CR..."
630 INPUT S
635 PRINT S
640 IF S = 1 THEN GOTO 650
641 IF S = 2 THEN GOTO 760
642 IF S = 3 THEN GOTO 860
643 IF S = 4 THEN GOTO 950
644 IF S = 5 THEN GOTO 1060
645 IF S = 6 THEN GOTO 1190
650 GOSUB 1420
660 IF T = 1 THEN GOTO 710
670 XT = (-XL*XC)/(XL-XC)
672 IF XL = XC THEN XT = 0
673 IF XL = XC THEN GOTO 680
680 GOSUB 1460
690 GOTO 720
700 GOTO 750
710 IF XL = XC THEN XT = 0
711 IF XL = XC THEN GOTO 720
712 XT = XL-XC
720 PRINT "TOTAL REACTANCE IS: ";XT;" OHMS"
730 PRINT
740 GOSUB 1500
750 GOTO 1530
760 GOSUB 1420
770 Z = (R^2) + (XL - XC)^2
780 Z = SQR(Z)
790 IF T = 1 THEN GOTO 820
800 X = XL - XC
810 Z = (R*X)/Z
820 PRINT "IMPEDANCE IS: ";Z;" OHMS"
830 PRINT
840 GOSUB 1500
850 GOTO 1530
860 GOSUB 1460
870 THETA = ATN((XL - XC)/R)
```

```
880 PRINT TAB(Y);"PHASE ANGLE IS: ";THETA;" RADIANS"
890 PRINT
900 THETA = THETA*(180/3.141593)
910 PRINT TAB(Y);"PHASE ANGLE IS: ";THETA;" RADIANS"
920 PRINT
930 GOSUB 1500
940 GOTO 1530
950 GOSUB 1460
960 IF T = 2 THEN GOTO 1040
970 X = XL - XC
980 RP = ((R^2) +  (X^2))/R
985 IF X = 0 THEN GOTO 1000
990 XP = (RP*R)/X
1000 PRINT TAB(Y);"PARALLEL EQUIVALENT RESISTANCE: "
1005 PRINT TAB(Y);RP;" OHMS"
1010 PRINT TAB(Y);"PARALLEL EQUIVALENT REACTANCE: "
1015 PRINT TAB(Y);XP;" OHMS"
1020 GOSUB 1500
1030 GOTO 1530
1040 GOSUB 1280
1050 GOTO 520
1060 GOSUB 1460
1070 IF T = 1 THEN GOTO 1170
1080 X = XL - XC
1090 XP = X^2
1100 RS = R/(1 + XP)
1110 XS = (R*RS)/X
1115 GOSUB 5000
1120 PRINT TAB(Y);"SERIES EQUIVALENT RESISTANCE: "
1125 PRINT TAB(Y);RS;" OHMS"
1130 PRINT TAB(Y);"SERIES EQUIVALENT REACTANCE: "
1135 PRINT TAB(Y);XS;" OHMS"
1140 PRINT
1150 GOSUB 1500
1160 GOTO 1530
1170 GOSUB 1350
1180 GOTO 520
1190 GOSUB 1460
1200 IF T = 2 THEN GOTO 1230
1210 Q = (XL - XC)/R
1220 GOTO 1240
1230 Q = R/(XL - XC)
1240 PRINT TAB(Y);"Q = ";Q
1250 PRINT
1260 GOSUB 1500
1270 GOTO 1530
1280 PRINT
1290 PRINT "ERROR: SERIES-PARALLEL CONVERSION"
```



```
1292 PRINT "SELECTED FOR A PARALLEL CIRCUIT."
1300 PRINT "RETURN TO MENU AND SELECT NO. 5 FOR"
1310 PRINT "PARALLEL-SERIES CONVERSION."
1320 PRINT
1330 GOSUB 1500
1340 RETURN
1350 PRINT
1360 PRINT "ERROR: PARALLEL-SERIES CONVERSION"
1362 PRINT "SELECTED FOR A SERIES CIRCUIT"
1370 PRINT "RETURN TO MENU AND SELECT NO. 4 FOR"
1380 PRINT "SERIES-PARALLEL CONVERSION."
1390 PRINT
1400 GOSUB 1500
1410 RETURN
1420 FOR I = 1 TO 5
1430 PRINT
1440 NEXT I
1450 RETURN
1460 FOR I = 1 TO 30
1470 PRINT
1480 NEXT I
1490 RETURN
1500 PRINT "PRESS CR TO CONTINUE..."
1510 INPUT KK
1515 PRINT KK
1520 RETURN
1530 GOSUB 1460
1540 PRINT TAB(Y);"1. MORE CALCULATIONS ON SAME NETWORK"
1550 PRINT TAB(Y);"2. DO ANOTHER PROBLEM"
1560 PRINT TAB(Y);"3. FINISHED - EXIT PROGRAM"
1570 PRINT
1590 PRINT
1600 PRINT TAB(Y);"ENTER ONE FROM ABOVE AND PRESS CR..."
1605 PRINT U
1610 INPUT U
1611 PRINT U
1612 IF U >3 THEN GOTO 1540
1620 ON U GOTO 520,330,1630
1630 FOR I = 1 TO 20
1640 PRINT "**********BYE-BYE**********"
1650 NEXT I
1660 GOSUB 1420
1670 PRINT "PROGRAM ENDED..."
1680 END
5000 PRINT "X =  ";X
5010 PRINT "XP = ";XP
5040 PRINT "R = ";R
5050 PRINT "XL = ";XL
```

```
5060 PRINT "XC = ";XC
6000 RETURN
```

Example

```
PRESS CR TO CONTINUE...
 0



THIS PROGRAM CALCULATES CERTAIN
PARAMETERS OF NETWORKS CONTAINING
RESISTOR, CAPACITOR AND INDUCOR
ELEMENTS.  NO SINGLE NETWORK NEED
CONTAIN ALL THREE ELEMENTS.

FOLLOW DIRECTIONS GIVEN ON THE SCREEN...


PRESS CR TO CONTINUE...
 0



TYPE OF RLC NETWORK:???

  1. SERIES RLC
  2. PARALLEL RLC

SELECT ONE FROM ABOVE
AND PRESS CR...
 1



ENTER THE VALUES OF RLC
NETWORK COMPONENTS (IN OHMS...

RESISTANCE R IS: ???
 22000

CAPACITIVE REACTANCE IS: ???
 4000

INDUCTIVE REACTANCE IS: ???
 2300
```



```
PERFORM THE FOLLOWING
CALCULATION...

1. TOTAL REACTANCE XT
2. TOTAL IMPEDANCE ZT
3. PHASE ANGLE
4. SERIES-PARALLEL CONVERSION
5. PARALLEL-SERIES CONVERSION
6. QUALITY FACTOR (Q)

SELCT ONE FROM ABOVE AND PRESS CR...
 2


IMPEDANCE IS:  22065.5841  OHMS

PRESS CR TO CONTINUE...
 0



1. MORE CALCULATIONS ON SAME NETWORK
2. DO ANOTHER PROBLEM
3. FINISHED - EXIT PROGRAM


ENTER ONE FROM ABOVE AND PRESS CR...
 0
 3
**********BYE-BYE**********
**********BYE-BYE**********
**********BYE-BYE**********
**********BYE-BYE**********
**********BYE-BYE**********


PROGRAM ENDED...
```

Program 29

Decibel Calculations

This program is designed to do either of two calculations:

1. The number of decibels represented by some specified voltage, current, or power ratio.
2. The voltage, current, or power required to produce a specified number of decibels.

The following equations are used:

$$dB = 20 \log(V_1/V_2) \quad [29.1]$$

$$dB = 20 \log(I_1/I_2) \quad [29.2]$$

$$dB = 10 \log(P_1/P_2) \quad [29.3]$$

. . . Plus these same equations solved for V_1/V_2, I_1/I_2, or P_1/P_2 when given the dB.


```
100 REM THIS IS PROGRAM NO. 29 PROG29
105 V1 = 0
106 V2 = 0
107 I1 = 0
108 I2 = 0
109 P1 = 0
110 P2 = 0
120 PRINT "WHICH OF THE FOLLOWING IS REQUIRED?"
130 PRINT
140 PRINT "1. DECIBEL CONVERSION GIVEN
145 PRINT "   VOLTAGE, CURRENT OR POWER"
146 PRINT "   RATIOS."
147 PRINT
150 PRINT "2. VOLTAGE. CURRENT OR POWER"
155 PRINT "   RATIOS NEEDED FOR GIVEN
158 PRINT "   DECIBEL LEVEL."
160 PRINT
170 PRINT "SELECT ONE FROM ABOVE AND PRESS CR..."
180 INPUT S
185 PRINT S
190 IF S >2 THEN GOTO 120
200 ON S GOTO 210,600
210 GOSUB 1000
220 PRINT "WHICH CALCULATION IS DESIRED?"
230 PRINT
240 PRINT "1. VOLTAGE RATIO"
250 PRINT "2. CURRENT RATIO"
260 PRINT "3. POWER RATIO"
270 PRINT
280 PRINT "SELECT ONE FROM ABOVE AND PRESS CR..."
290 INPUT Q
295 PRINT Q
300 IF Q >3 THEN GOTO 220
310 ON Q GOTO 320,390,460
320 GOSUB 960
330 PRINT "ENTER V1:"
340 INPUT V1
345 PRINT V1
347 PRINT
350 PRINT "ENTER V2:"
360 INPUT V2
365 PRINT V2
367 PRINT
370 DB = 20*(LOG(V1/V2)/LOG(10))
380 GOTO 520
390 GOSUB 960
400 PRINT "ENTER I1:"
410 INPUT I1
```

```
415 PRINT I1
418 PRINT
420 PRINT "ENTER I2:"
430 INPUT I2
435 PRINT I2
438 PRINT
440 DB = 20*(LOG(I1/I2)/LOG(10))
450 GOTO 520
460 GOSUB 960
470 PRINT "ENTER P1:"
480 INPUT P1
485 PRINT P1
488 PRINT
490 PRINT "ENTER P2:"
500 INPUT P2
505 PRINT P2
508 PRINT
510 DB = 10*(LOG(P1/P2)/LOG(10))
520 PRINT
530 DB = DB*100
540 DB = INT(DB)
550 DB = DB/100
560 PRINT "RATIO REPRESENTS: ";DB;" DB"
570 PRINT
580 GOSUB 1040
590 GOTO 1070
600 GOSUB 1000
610 PRINT "SELECT ONE FROM MENU BELOW:"
620 PRINT
630 PRINT "1. VOLTAGE RATIO"
640 PRINT "2. CURRENT RATIO"
650 PRINT "3. POWER RATIO"
660 PRINT
670 PRINT "ENTER ONE FROM ABOE AND PRESS CR..."
680 INPUT L
685 PRINT L
688 PRINT
690 IF L >3 THEN GOTO 610
700 GOSUB 960
710 PRINT "ENTER NUMBER OF DECIBELS:"
720 INPUT DB
725 PRINT DB
738 PRINT
740 ON L GOTO 750,770,790
750 RA = (10^(DB/20))
760 GOTO 800
770 RA = (10^(DB/20))
780 GOTO 800
```



```
790 RA = (10^(DB/10))
800 PRINT
810 RA = RA*100
820 RA = INT(RA)
830 RA = RA/100
840 PRINT
850 PRINT DB;" DB REPRESENTS A"
860 ON L GOTO 870,890,910
870 PRINT "VOLTAGE RATIO OF ";RA;":1"
880 GOTO 930
890 PRINT "CURRENT RATIO OF ";RA;":1"
900 GOTO 930
910 PRINT "POWER RATIO OF ";RA;":1"
920 GOTO 930
930 PRINT
940 GOSUB 1040
950 GOTO 1070
960 FOR I = 1 TO 5
970 PRINT
980 NEXT I
990 RETURN
1000 FOR I = 1 TO 30
1010 PRINT
1020 NEXT I
1030 RETURN
1040 PRINT "PRESS CR TO CONTINUE..."
1050 INPUT KK
1055 PRINT KK
1058 PRINT
1060 RETURN
1070 GOSUB 1000
1080 PRINT "FINISHED?"
1090 PRINT
1100 PRINT "1. YES"
1110 PRINT "2. NO"
1120 PRINT
1130 PRINT "SELECT ONE FROM ABOVE AND PRESS CR..."
1140 INPUT Z
1145 PRINT Z
1150 IF Z > 2 THEN GOTO 1080
1160 ON Z GOTO 1170,110
1170 GOSUB 1000
1180 FOR I = 1 TO 20
1190 PRINT "********** BYE-BYE ********"
1200 NEXT I
1210 GOSUB 960
1220 PRINT "PROGRAM ENDED"
1290 END
```

Example

```
WHICH OF THE FOLLOWING IS REQUIRED?

1. DECIBEL CONVERSION GIVEN
   VOLTAGE, CURRENT OR POWER
   RATIOS.

2. VOLTAGE. CURRENT OR POWER
   RATIOS NEEDED FOR GIVEN
   DECIBEL LEVEL.

SELECT ONE FROM ABOVE AND PRESS CR...
 1


WHICH CALCULATION IS DESIRED?

1. VOLTAGE RATIO
2. CURRENT RATIO
3. POWER RATIO

SELECT ONE FROM ABOVE AND PRESS CR...
 3


ENTER P1:
 1000

ENTER P2:
 500


RATIO REPRESENTS:  3.01  DB

PRESS CR TO CONTINUE...
 0



FINISHED?

1. YES
2. NO
```



```
SELECT ONE FROM ABOVE AND PRESS CR...
 1



********** BYE-BYE ********
********** BYE-BYE ********
********** BYE-BYE ********
********** BYE-BYE ********
```

PROGRAM 30

Evaluation of an LC Tuned Tank Circuit

An LC tuned tank circuit consists of a coil (inductor) and capacitor connected in either series or parallel. Each component exhibits *reactance* (opposition to alternating current), and when the reactance of the coil is equal to the reactance of the capacitor, the condition of *resonance* exists. Figure 30.1 shows the two principal configurations with the equations that are used to find frequency, inductive reactance, and capacitive reactance. In Fig. 30.1C we see the vector relationship between the resistance, inductive reactance (X_L) and capacitive reactance(X_C). When the circuit is at resonance with the applied AC signal, reactance components X_L and X_C are equal and opposite and therefore cancel out to zero. Figure 30.1D shows the relationship between frequency and impedance for the series and parallel RLC circuits.

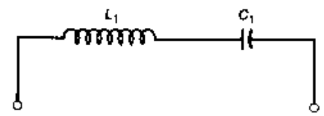
This program offers the following options:

1. Resonant frequency when *L* and C are known.
2. Inductance needed for specified frequency when C is known.
3. Capacitance needed for specified frequency when *L* is known.
4. Inductive reactance when *F* and *L* are known.
5. Capacitive reactance when F and C are known.

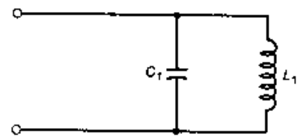
$$F = \frac{1}{2\pi\sqrt{LC}} \qquad [30.1]$$

$$X_L = 2\pi FL \qquad [30.2]$$

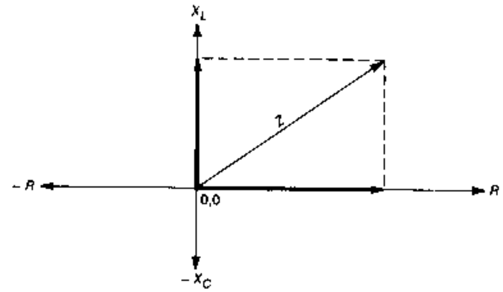
$$X_C = \frac{1}{2\pi FC} \qquad [30.3]$$



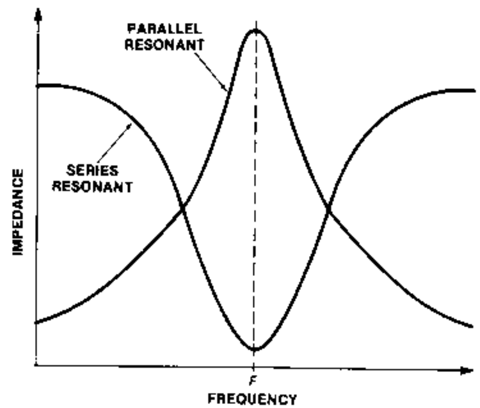
(A) Series circuit.



(B) Parallel circuit.



(C) Vector relationship between the resistance, inductive reactance, and capacitive reactance.



(D) Relationship between frequency and impedance for the series and parallel RLC circuits.

Fig. 30.1. EVALUATION OF AN LC TUNED TANK CIRCUIT.

Evaluation of an LC Tuned Tank Circuit

```
100 REM THIS IS PROGRAM NO. 30 PROG30
110 REM PROG7 WORKS RESOANCE PROBLEMS
120 REM IN LC TANK CIRCUITS.
140 A$ = "YOU HAVE SELECTED TO CALCULATE"
150 B$  = "FOLLOW INSTRUCTIONS AT LOWER LEFT"
160 C$ = "ENTER CAPACITANCE IN PICOFARADS"
170 F$ = "ENTER FREQUENCY IN KILOHERTZ (KHZ)"
180 L$ = "ENTER INDUCTANCE IN MICROHENRYS"
190 GOSUB 1440
300 GOSUB 1440
310 PRINT "AVAILABLE PROGRAM FUNCTIONS ARE:"
320 PRINT
330 PRINT "1. RESONANT FREQ. WHEN LC KNOWN"
340 PRINT "2. INDUCTANCE NEEDED FOR F WHEN C KNOWN"
350 PRINT "3. CAPACITANCE NEEDED FOR F WHEN L KNOWN"
360 PRINT "4. INDUCTIVE REACTANCE"
370 PRINT "5. CAPACITIVE REACTANCE"
380 GOSUB 1400
400 PRINT "SELECT ONE FROM ABOVE"
401 PRINT "AND PRESS CR..."
410 INPUT A
415 PRINT A
417 PRINT
420 GOSUB 1440
430 IF A < 1 THEN GOTO 310
440 IF A > 5 THEN GOTO 310
450 ON A GOTO 490,760,960,1200,1520
480 END
490 PRINT A$
491 PRINT "RESONANT FREQUENCY WHEN L&C"
492 PRINT "ARE KNOWN."
500 PRINT
510 PRINT B$
520 GOSUB 1400
540 PRINT C$
550 INPUT C
555 PRINT C
557 PRINT
560 C1 = 1E+12
570 C = C/C1
580 GOSUB 1400
590 PRINT L$
600 INPUT L
605 PRINT L
607 PRINT
610 L1 = 1000000
620 L = L/L1
630 GOSUB 1400
```



```
640 F = L*C
650 F = SQR(F)
660 F = 2*3.1415*F
670 F = 1/F
680 F = F/1000
690 F = INT(F)
700 PRINT "F = ";F;" KHZ"
710 GOSUB 1740
720 ON K GOTO 490,300,1810
750 RETURN
760 PRINT A$
762 PRINT "INDUCTANCE WHEN F AND C ARE KNOWN"
770 PRINT
780 PRINT
790 GOSUB 1400
810 PRINT C$
820 INPUT C
825 PRINT C
827 PRINT
830 GOSUB 1400
840 PRINT F$
850 INPUT F
855 PRINT F
857 PRINT
860 C1 = 1E+12
870 C = C/C1
880 F = F*1000
890 L = 4*(3.1415^2)*(F^2)*C
900 L = 1/L
910 L = L*1000000
920 GOSUB 1400
930 PRINT "L = ";L;" UH"
940 GOSUB 1740
950 ON K GOTO 760,300,1810
960 PRINT A$
962 PRINT "CAPACITANCE WHEN F AND L ARE KNOWN"
970 PRINT
980 PRINT B$
990 GOSUB 1400
1010 PRINT L$
1020 GOSUB 1400
1030 INPUT L
1035 PRINT L
1037 PRINT
1040 L1 = 1000000
1050 L = L/L1
1060 PRINT F$
1070 GOSUB 1400
```

```
1080 INPUT F
1085 PRINT F
1087 PRINT
1090 F = F*1000
1100 C  = 4*(3.1415^2)*(F^2)*L
1110 C = 1/C
1120 C = C*(1E+12)
1130 C = INT(C)
1140 PRINT "C = ";C;" PF"
1150 GOSUB 1740
1160 ON K GOTO 960,300,1810
1190 RETURN
1200 PRINT A$
1202 PRINT "INDUCTIVE REACTANCE"
1210 PRINT
1220 GOSUB 1400
1240 PRINT L$
1250 INPUT L
1255 PRINT L
1257 PRINT
1260 L = L/1000000
1270 GOSUB 1400
1280 PRINT F$
1290 INPUT F
1300 F = F*1000
1310 GOSUB 1400
1320 XL = 2*3.1415*F*L
1330 XL = INT(XL)
1340 PRINT "XL = ";XL;" OHMS"
1350 GOSUB 1740
1360 ON K GOTO 1200,300,1810
1390 RETURN
1400 FOR B = 1 TO 5
1410 PRINT
1420 NEXT B
1430 RETURN
1440 FOR B = 1 TO 30
1450 PRINT
1460 NEXT B
1470 RETURN
1480 PRINT "ENTER ONE FROM ABOVE AND PRESS CR..."
1490 INPUT B
1500 IF B = 1 THEN GOTO 1510 ELSE 1480
1510 RETURN
1520 PRINT A$
1522 PRINT "CAPACITIVE REACTANCE"
1530 PRINT
1540 PRINT B$
```



```
1550 GOSUB 1400
1570 PRINT C$
1580 INPUT C
1585 PRINT C
1587 PRINT
1590 C = C/(1E+12)
1600 GOSUB 1400
1610 PRINT F$
1620 INPUT F
1625 PRINT F
1627 PRINT
1630 F = F*1000
1640 GOSUB 1400
1650 XC = 2*3.1415*F*C
1660 XC = 1/XC
1670 XC = INT(XC)
1680 PRINT "XC = ";XC;"OHMS"
1690 GOSUB 1740
1700 ON K GOTO 1520,300,1810
1730 RETURN
1740 GOSUB 1400
1750 PRINT "1. DO ANOTHER OF THE SAME"
1760 PRINT "2. RETURN TO MAIN MENU"
1770 PRINT "3. FINISHED"
1780 PRINT
1785 PRINT
1790 INPUT K
1795 PRINT K
1797 PRINT
1800 RETURN
1810 GOSUB 1440
1820 PRINT "PROGRAM ENDED"
```

Example

```
AVAILABLE PROGRAM FUNCTIONS ARE:

1. RESONANT FREQ. WHEN LC KNOWN
2. INDUCTANCE NEEDED FOR F WHEN C KNOWN
3. CAPACITANCE NEEDED FOR F WHEN L KNOWN
4. INDUCTIVE REACTANCE
5. CAPACITIVE REACTANCE
```

```
SELECT ONE FROM ABOVE
AND PRESS CR...
 1



YOU HAVE SELECTED TO CALCULATE
RESONANT FREQUENCY WHEN L&C
ARE KNOWN.

FOLLOW INSTRUCTIONS AT LOWER LEFT


ENTER CAPACITANCE IN PICOFARADS
 100


ENTER INDUCTANCE IN MICROHENRYS
 1590


F =  399  KHZ


1. DO ANOTHER OF THE SAME
2. RETURN TO MAIN MENU
3. FINISHED


 3



PROGRAM ENDED
```


PROGRAM 31

Design of an Instrumentation Amplifier with a Gain of 2 to 1000

The instrumentation amplifier solves many routine signal amplification and/or acquisition problems. The classical instrumentation amplifier circuit shown in Fig. 31.1A uses three operational amplifiers. For best results, these amplifiers (or especially A_1 and A_2) should be in the same package. The advantage of this circuit is that it provides high gain coupled with extremely high input impedances. If BIMOS or BIFET operational amplifiers are used for A_1 and A_2, then input impedances on the order of 10^{12} ohms are realizable.

This program will calculate the value of resistor R needed to provide the voltage gain that you selected. Also calculated, if the AC-coupled option is selected, is the value of capacitance C_1 and C_2 needed for the specified value of low frequency (−3 dB) response.

The following constraints are to be observed in this circuit for balance:

$$R_1 = R_2$$
$$R_3 = R_4$$
$$R_5 = R_6$$
$$R_7 = R_8$$
$$C_1 = C_2$$

In the context of these constraints, "=" means within 1 or 2 percent, depending upon the required common mode rejection ratio.

In the AC-coupled input circuitry in Fig. 31.1B, each of the instrumentation amplifier inputs has a series capacitor in order to prevent DC signal components from affecting the input. The 10 megohm resistors are used to keep input bias currents of the operational amplifiers from charging the capacitors and thereby latching up the amplifier.

$$A_V = \frac{2R_1}{R} + 1 \qquad [31.1]$$

$$A_V = \frac{40\ K}{R} + 1$$

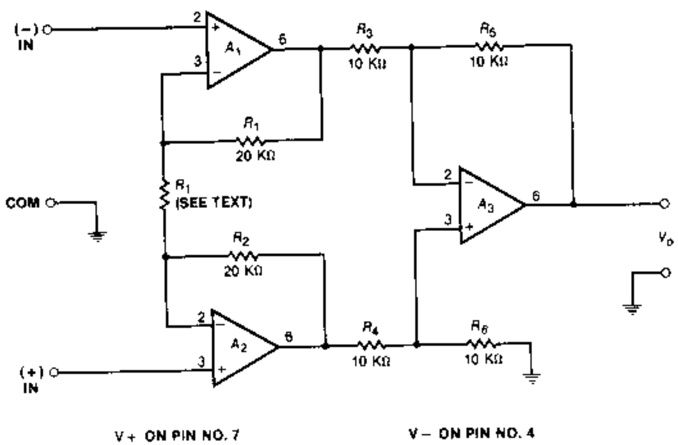
$$F_L = \frac{10^6}{2\pi 10^7 C} \qquad [31.2]$$

where

F_L is low frequency,

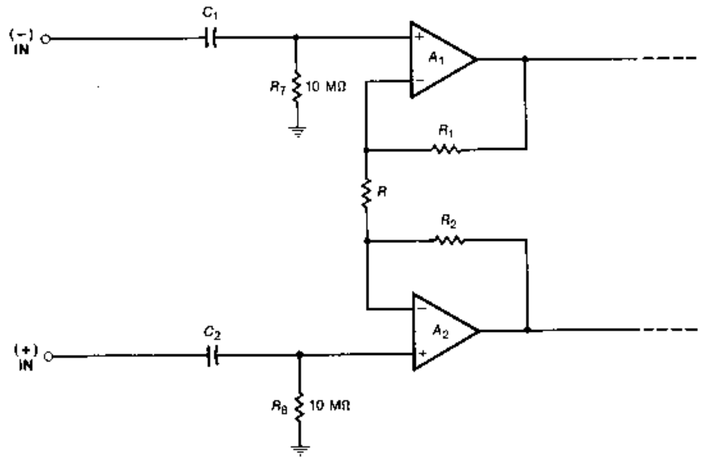
10^7 is in ohms,

C is in microfarads.



(A) Classical instrumentation amplifier circuit using three operational amplifiers.

FIG. 31.1. INSTRUMENTATION AMPLIFIER.



(B) AC-coupled input circuitry.

FIG. 31.1. INSTRUMENTATION AMPLIFIER—CONT.

Design of an Instrumentation Amplifier with a Gain of 2 to 1000

```
110 REM THIS PROGRAM WILL COMPUTE
112 REM 1. THE VALUE OF RESISTOR R THAT
113 REM WILL PRODUCE GIVEN VOLTAGE GAIN
115 REM 2. THE VALUE OF INPUT CAPACITOR
118 REM REQUIRED FOR A GIVEN LOWER -3 DB
120 REM FREQUENCY RESPONSE
140 U = 5
150 S = 5
160 DIM B$(50)
170 GOSUB 1010
180 PRINT  TAB( S);"* * * * * * * * * * * * * * *"
190 PRINT  TAB( S);"*                            *"
200 PRINT  TAB( S);"* PROGRAM FOR DESIGNING AN   *"
210 PRINT  TAB( S);"* INSTRUMENTATION AMPLIFIER *"
220 PRINT  TAB( S);"* WITH A VOLTAGE GAIN FROM   *"
230 PRINT  TAB( S);"*        2 TO 1000           *"
240 PRINT  TAB( S);"*                            *"
245 PRINT  TAB( S);"* * * * * * * * * * * * * * *"
250 PRINT
260 PRINT  TAB( U);"COPYRIGHT 1983 BY J.J. CARR"
```

```
280 GOSUB 970
290 GOSUB 1050
300 GOSUB 1080
310 GOSUB 1010
320 PRINT "HELLO ";B$
325 PRINT "IT'S GOOD TO MEET YOU."
330 PRINT
340 PRINT "THIS PROGRAM CALCULATES:"
345 PRINT "1. RESISTOR NEEDED FOR GAIN"
348 PRINT "2. CAPACITOR NEEDED FOR LOW"
350 PRINT "END -3 DB FREQUENCY RESPONSE"
370 PRINT
380 PRINT "YOU WILL BE ASKED TO SELECT"
385 PRINT "EITHER AC OR DC COUPLED VERSION."
390 PRINT "AND TO ENTER THE DESIRED VOLTAGE GAIN."
395 PRINT "IF THE AC-COUPLED VERSION"
400 PRINT "IS SELECTED, THEN YOU WILL"
405 PRINT "ALSO BE ASKED"
407 PRINT "TO  SELECT THE"
410 PRINT "FREQUENCY FOR THE LOW-END OF"
412 PRINT "THE RESPONSE CURVE (-3 DB)"
420 PRINT
430 PRINT
440 GOSUB 1050
450 GOSUB 1010
460 PRINT "SELECT CONFIGURATION"
465 PRINT "FROM MENU BELOW:"
470 PRINT  TAB( 5);"1. AC-COUPLED"
480 PRINT  TAB( 5);"2. DC-COUPLED"
490 PRINT
500 GOSUB 970
510 PRINT
520 PRINT "ENTER SELECTION AND PRESS CR:"
530 INPUT B
540 IF B > 2 THEN  GOTO 510
550 GOSUB 1010
560 Q = 0
570 PRINT "SELECT VOLTAGE GAIN REQUIRED:"
580 PRINT "(VALUE MUST BE BETWEEN 2 AND 1000)"
590 PRINT "ENTER SELECTION:"
600 INPUT AV
610 GOSUB 1010
620 PRINT B$;", YOU HAVE SELECTED A"
625 PRINT "VOLTAGE GAIN OF: ";AV
630 PRINT
640 IF AV < 2 THEN  GOSUB 900
650 IF AV > 1000 THEN  GOSUB 900
```



```
660 GOSUB 1050
670 GOSUB 1010
680 IF Q = 1 THEN  GOTO 560
690 R = 40 / (AV - 1)
700 R = R * 1000
710 R =  INT (R)
720 R = R / 1000
730 IF B = 1 THEN  GOSUB 1120
740 PRINT
750 PRINT
760 PRINT "RESISTOR OF ";R;" KOHMS YIELDS"
765 PRINT "GAIN OF ";AV
770 PRINT
780 GOSUB 1050
790 GOSUB 1010
800 PRINT "FINISHED?"
810 PRINT "1. YES"
820 PRINT "2. NO"
830 PRINT
840 PRINT
850 PRINT "ENTER SELECTION FROM ABOVE"
855 PRINT "AND PRESS CR..."
860 INPUT P
870 IF P > 2 THEN  GOTO 800
875 IF P < 1 THEN  GOTO 800
880 IF P = 1 THEN  GOTO 1360
890 GOTO 450
900 PRINT
910 PRINT
920 PRINT "VALUE SELECTED IS OUT OF"
925 PRINT "ALLOWED RANGE -- TRY AGAIN"
930 PRINT
940 GOSUB 1040
950 Q = 1
960 RETURN
970 FOR I = 1 TO 5
980 PRINT
990 NEXT I
1000 RETURN
1010 FOR I = 1 TO 30
1020 PRINT
1030 NEXT I
1040 RETURN
1050 PRINT "PRESS CR TO CONTINUE..."
1060 INPUT KK
1070 RETURN
1080 GOSUB 1010
```

```
1090 PRINT "ENTER YOUR NAME:"
1100 INPUT B$
1110 RETURN
1120 PRINT "ENTER LOW-END -3 DB FREQUENCY"
1125 PRINT "RESPONSE POINT IN HERTZ (HZ):"
1130 PRINT
1140 PRINT
1150 INPUT F
1160 C = 1 / (6.2832 * 10 ^ 7 * F)
1170 C = C * 10 ^ 12
1180 GOSUB 1010
1190 IF C < 1000 THEN  GOTO 1210
1200 IF C >  = 1000 THEN  GOTO 1250
1210 C =  INT (C)
1220 PRINT "-3 DB FREQUENCY RESPONSE OF "
1225 PRINT F;" HZ REQUIRES C OF: ";C;" UF"
1226 PRINT
1230 PRINT "FOR C1 AND C2 (USE NEXT HIGHER"
1235 PRINT "STANDARD VALUE"
1240 GOTO 1350
1250 C = C / 10 ^ 6
1260 C = C * 100
1270 X =  INT (C)
1280 IF X <  = 0 THEN  GOTO 1310
1290 IF X > 0 THEN  GOTO 1300
1300 C =  INT (C)
1310 C = C / 100
1320 PRINT "-3 DB FREQUENCY RESPONSE OF "
1325 PRINT F;" HZ REQUIRES A C OF: ";C;" UF."
1327 PRINT
1330 PRINT "USE NEXT HIGHER STANDARD VALUE."
1340 GOTO 1350
1350 RETURN
1360 GOSUB 1010
1370 PRINT "PROGRAM ENDED"
1380 GOSUB 970
1390 END
```


Example

```
 * * * * * * * * * * * * * * *
 *                           *
 * PROGRAM FOR DESIGNING AN  *
 * INSTRUMENTATION AMPLIFIER *
 * WITH A VOLTAGE GAIN FROM  *
 *        2 TO 1000          *
 *                           *
 * * * * * * * * * * * * * * *

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PRESS CR TO CONTINUE...



ENTER YOUR NAME:



HELLO
IT'S GOOD TO MEET YOU.

THIS PROGRAM CALCULATES:
1. RESISTOR NEEDED FOR GAIN
2. CAPACITOR NEEDED FOR LOW
END -3 DB FREQUENCY RESPONSE

YOU WILL BE ASKED TO SELECT
EITHER AC OR DC COUPLED VERSION.
AND TO ENTER THE DESIRED VOLTAGE GAIN.
IF THE AC-COUPLED VERSION
IS SELECTED, THEN YOU WILL
ALSO BE ASKED
TO  SELECT THE
FREQUENCY FOR THE LOW-END OF
THE RESPONSE CURVE (-3 DB)


PRESS CR TO CONTINUE...
```

```
SELECT CONFIGURATION
FROM MENU BELOW:
     1. AC-COUPLED
     2. DC-COUPLED



ENTER SELECTION AND PRESS CR:



SELECT VOLTAGE GAIN REQUIRED:
(VALUE MUST BE BETWEEN 2 AND 1000)
ENTER SELECTION:


 , YOU HAVE SELECTED A
 VOLTAGE GAIN OF:  100

 PRESS CR TO CONTINUE...


 ENTER LOW-END -3 DB FREQUENCY
 RESPONSE POINT IN HERTZ (HZ):




 -3 DB FREQUENCY RESPONSE OF
  .05  HZ REQUIRES A C OF:  .31  UF.

 USE NEXT HIGHER STANDARD VALUE.


 RESISTOR OF  .404  KOHMS YIELDS
 GAIN OF  100

 PRESS CR TO CONTINUE...


 FINISHED?
 1. YES
 2. NO
```



```
ENTER SELECTION FROM ABOVE
AND PRESS CR...


PROGRAM ENDED
```

Timer and Oscillator Circuits Based on the LM-555

The LM-555, or simply 555, is a resistor-capacitor timed integrated circuit that will function as either a monostable multivibrator (one-shot) or as an astable multivibrator. In the former mode, the 555 produces one output pulse of constant amplitude and duration for each input pulse applied to the "trigger" line. In the latter case, the astable multivibrator, the LM-555 device will produce a chain of square waves at the output (pin 3). In both cases, the output waveform is timed by an RC network.

Figure 32.1 shows both the monostable and astable configurations for the LM-555 device. The program allows you to review the definitions of the pinouts.

$$T_{HIGH} = 0.693\,(R_1 + R_2)\,C_1$$

$$T_{LOW} = 0.693 R_2 C_1$$

$$F = \frac{1.44}{(R_1 + R_2)\,C_1} \qquad [32.1]$$

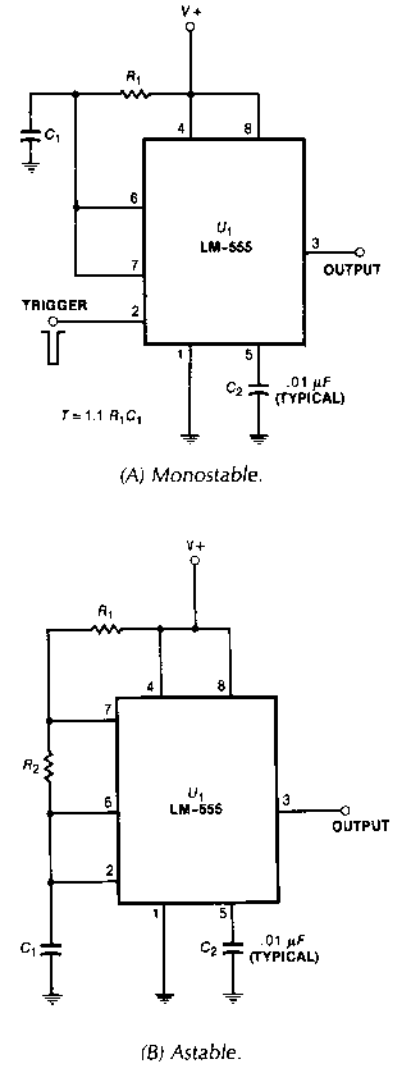


FIG. 32.1. MONOSTABLE AND ASTABLE CONFIGURATIONS FOR THE LM-555 DEVICE.

```
100 REM THIS IS PROGRAM NO. 32 PROG32
110 REM THIS PROGRAM CALCULATES THE
115 REM THE VALUE OF RC COMPONENTS
120 REM NEEDED TO FORM IC TIMER CIRCUITS
125 REM BASED ON THE LM-555 DEVICE.
127 PRINT
128 PRINT
130 GOSUB 1050
140 PRINT "THE 555 IS A MULTIPURPOSE IC TIMER"
145 PRINT "THAT USES BIPOLAR TECHNOLOGY."
148 PRINT "THE 7555 IS A CMOS VERSION THAT"
150 PRINT "IS PIN-FOR-PIN COMPATIBLE."
155 PRINT
160 PRINT "THE 555 IS TTL, CMOS AND"
165 PRINT "TRANSISTOR COMPATIBLE."
170 PRINT "THE 555 USES VOLTAGES OF"
180 PRINT "+4.5 TO +18 VDC"
190 PRINT
200 PRINT "WOULD YOU LIKE TO REVIEW LM-555 PIN-OUTS?"
210 PRINT "1. YES"
212 PRINT "2. NO"
213 PRINT
214 PRINT "SELECTION IS: ???"
215 INPUT S
220 PRINT
230 IF S > 2 THEN  GOTO 190
240 ON S GOSUB 1120,250
250 GOSUB 1050
260 PRINT "SELECT LM-555 MODE:"
270 PRINT
280 PRINT "1. MONOSTABLE MULTIVIBRATOR"
290 PRINT "2. ASTABLE MULTIVIBRATOR"
300 PRINT
310 PRINT "SELECTION: ???"
312 INPUT X
320 IF X > 2 THEN  GOTO 260
330 ON X GOTO 340,620
340 GOSUB 1050
350 PRINT "MONOSTABLE (ONE-SHOT) MULTIVIBRATOR MODE SELECTED
360 PRINT
370 PRINT "ENTER ONE-SHOT DURATION IN MILLISECONDS:"
375 INPUT T
380 Y = 0
390 PRINT
400 PRINT "ENTER FIRST TRIAL VALUE OF CAPACITOR (UF): "
405 INPUT C
410 IF C < 0.0005 THEN  GOTO 380
420 IF Y = 1 THEN  GOTO 380
```



```
430 PRINT
440 T1 = T / 1000
450 C1 = C / (10 ^ 6)
460 R = T1 / (1.1 * C1)
470 R =  INT (R)
480 IF R < 1000 THEN  GOTO 580
490 IF Y = 1 THEN  GOTO 580
500 PRINT "FOR A DURATION OF ";T;" MILLISECONDS,"
510 PRINT "YOU NEED A RESISTANCE OF ";R;" OHMS"
520 PRINT
530 GOSUB 1090
560 IF Q = 2 THEN  GOTO 250
570 IF Q = 3 THEN  GOTO 1540
580 PRINT "RESISTANCE LESS THAN 1000 OHMS NOT PERMITTED"
590 PRINT
600 GOSUB 1090
610 GOTO 340
620 GOSUB 1050
630 PRINT "ASTABLE MODE SELECTED"
640 PRINT
650 PRINT "OPERATING FREQUENCY IN HERTZ (HZ): ???"
655 INPUT F
660 PRINT
670 Y = 0
680 PRINT "FIRST TRIAL VALUE OF CAPACITOR (UF):"
685 INPUT C
690 IF C < 0.0005 THEN  GOSUB 1470
700 C1 = C / (10 ^ 6)
710 IF Y = 1 THEN  GOTO 660
720 PRINT
730 Y = 0
740 PRINT "FIRST TRIAL VALUE OF RESISTOR R1 (OHMS):"
745 INPUT R1
750 PRINT
760 IF R1 < 1000 THEN  GOSUB 1470
770 IF Y = 1 THEN  GOTO 720
780 Y = 0
790 R2 = ((1.44 / (F * C1)) - R1) / 2
800 R2 =  INT (R2)
810 IF R2 < 1000 THEN  GOSUB 1470
820 IF Y = 1 THEN  GOTO 950
830 GOSUB 1050
840 PRINT "FOR A FREQUENCT OF ";F;" HERTZ:"
850 PRINT
860 PRINT "C = ";C;" UF"
870 PRINT "R1 = ";R1;" OHMS"
880 PRINT "R2 = ";R2;" OHMS"
890 PRINT
```

```
900 GOSUB 1090
910 GOSUB 1370
920 IF Q = 1 THEN  GOTO 620
930 IF Q = 2 THEN  GOTO 250
940 IF Q = 3 THEN  GOTO 1540
950 GOSUB 1010
960 PRINT "VALUE OF R2 LESS THAN 1000 OHMS."
970 PRINT "TRY ANOTHER COMBINATION OF R1 AND C, OR CHANGE
    FREQUENCY"
980 PRINT
990 GOSUB 1090
1000 GOTO 670
1010 FOR I = 1 TO 5
1020 PRINT
1030 NEXT I
1040 RETURN
1050 FOR I = 1 TO 30
1060 PRINT
1070 NEXT I
1080 RETURN
1090 PRINT "PRESS CR TO CONTINUE..."
1100 INPUT KK
1110 RETURN
1120 GOSUB 1050
1130 PRINT "LM-555 PIN-OUT DEFINITIONS"
1140 PRINT
1150 PRINT "THE LM-555 COMES IN AN 8-PIN MINIDIP IC
     PACKAGE"
1160 PRINT
1170 PRINT "PIN NO.    FUNCTION"
1180 PRINT "-------    ---------"
1182 PRINT
1185 PRINT "  1        GROUND OR COMMON"
1200 PRINT "  2        TRIGGER"
1210 PRINT "  3        OUTPUT"
1220 PRINT "  4        RESET"
1230 PRINT "  5        CONTROL VOLTAGE"
1240 PRINT "  6        THRESHOLD VOLTAGE"
1250 PRINT "  7        DISCHARGE"
1260 PRINT "  8        V+ (POSITIVE POWER SUPPLY)
1270 PRINT
1350 GOSUB 1090
1360 RETURN
1370 GOSUB 1050
1380 PRINT "WHAT'S YOUR PLEASURE?"
1390 PRINT
1400 PRINT "1. ANOTHER TRIAL SAME CIRCUIT"
1410 PRINT "2. RETURN TO MODE SELECT MENU"
1420 PRINT "3. FINISHED"
```



```
1430 PRINT
1440 PRINT "SELECTION: ???"
1445 INPUT Q
1450 IF Q > 3 THEN  GOTO 1380
1460 RETURN
1470 PRINT
1480 PRINT
1490 PRINT "ERROR: COMPONENT VALUE OUT OF TOLERANCE RANGE"
1500 PRINT
1510 GOSUB 1090
1520 Y = 1
1530 RETURN
1540 GOSUB 1050
1550 PRINT "PROGRAM ENDED"
1560 GOSUB 1010
1570 END
```

PROGRAM 33

Operational Amplifier Circuits

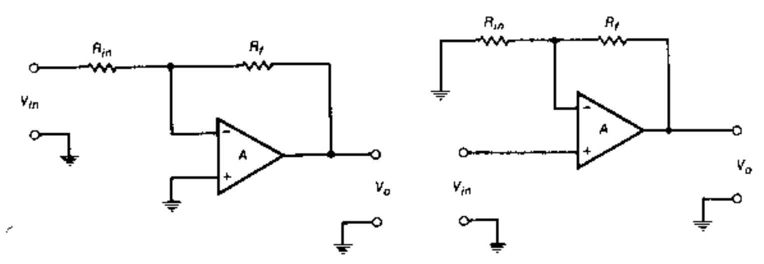
Figure 33.1 shows the two main configurations for operational amplifiers used as voltage amplifiers: inverting follower (Fig. 33.1A) and noninverting follower with gain (Fig. 33.1B). The transfer equation for each circuit is shown with the respective diagram. An in-depth study of operational and other amplifiers can be found in Joseph J. Carr, *Elements of Microcomputer Interfacing* (Reston: Reston Publishing Co., Inc., 1983) and Howard M. Berlin, *Design of Op-AMP Circuits with Experiments* (Indianapolis: Howard W. Sams & Co., 1977, 1985). This program will permit you to calculate values for the resistors needed to set a specified gain. In addition, for the inverting follower configuration, you will be able to specify the minimum input impedance.

$$V_O = -A\,V_{IN}$$

$$V_O = -\frac{R_F}{R_{IN}}V_{IN} \qquad [33.1]$$

$$V_O = A\,V_{IN}$$

$$V_O = \left(\frac{R_F}{R_{IN}} + 1\right) V_{IN} \qquad [33.2]$$



(A) Inverter follower. (B) Noninverter follower with gain.

FIG. 33.1. TWO MAIN CONFIGURATIONS FOR OPERATIONAL AMPLIFIERS USED AS VOLTAGE AMPLIFIERS.

Operational Amplifier Circuits

```
100 REM THIS PROGRAM WILL CALCULATE THE
110 REM VALUES OF FEEDBACK AND INPUT RE-
120 REM RESISTANCES NEEDED FOR A GIVEN
125 REM VOLTAGE GAIN IN AN OP-AMP.
130 GOSUB 910
140 PRINT "ENTER GAIN REQUIRED"
145 PRINT
150 PRINT "USE MINUS SIGN TO INDICATE THE"
155 PRINT "INVERTING CONFIGURATION.  E.G."
160 PRINT " -10 FOR A GAIN OF 10 WITH 180"
165 PRINT "DEGREE PHASE-SHIFT, OR 10 FOR"
170 PRINT "A GAIN OF 10 AND NO PHASE SHIFT"
180 PRINT "AND OUTPUT."
190 PRINT
200 PRINT "ENTER GAIN:"
205 INPUT A
210 IF A = 0 THEN  GOTO 250
220 IF A = 1 THEN  GOTO 330
230 IF A < 0 THEN  GOTO 410
240 IF A > 0 THEN  GOTO 720
250 GOSUB 870
260 PRINT "GAIN OF ZERO ENTERED"
270 PRINT "THIS GAIN IS IMPRACTICAL"
280 PRINT
290 PRINT "PLEASE ENTER ANOTHER SELECTION..."
300 PRINT
310 GOSUB 950
320 GOTO 130
```

```
330 GOSUB 870
340 PRINT "GAIN OF ONE (1) ENTERED"
350 PRINT "A GAIN OF +1 CAN BE OBTAINED FROM THE"
360 PRINT "NONINVERTING FOLLOWER CIRCUIT, AND NO"
370 PRINT "CALCULATIONS ARE NEEDED"
380 PRINT
390 GOSUB 950
400 GOTO 980
410 GOSUB 910
420 PRINT "INVERTING FOLLOWER SELECTED"
430 PRINT
440 PRINT "THIS CONFIGURATION PRODUCES A"
445 PRINT "PHASE REVERSAL OF 180 DEGREES"
450 PRINT "BETWEEN INPUT AND OUTPUT."
460 PRINT
470 Y = 0
480 PRINT "MINIMUM ALLOWABLE INPUT"
485 PRINT "IMPEDANCE (IN OHMS)...???"
488 INPUT RI
490 IF RI < 500 THEN  GOTO 620
500 A =  ABS (A)
510 RF = A * RI
520 GOSUB 870
530 A =  - A
540 PRINT "FOR A VOLTAGE GAIN OF ";A;" USE: "
550 PRINT "FEEDBACK RESISTOR OF ";RF;" OHMS"
560 PRINT "INPUT RESISTOR OF ";RI;" OHMS"
570 PRINT
580 PRINT "INPUT IMPEDANCE IS ";RI;" OHMS"
590 PRINT
600 GOSUB 950
610 GOSUB 980
620 GOSUB 870
630 PRINT "INPUT IMPEDANCE OF LESS THAN"
635 PRINT "500 OHMS ARE INADVISABLE."
640 PRINT "DO YOU WANT TO RECONSIDER?"
650 PRINT
660 PRINT "1. YES"
670 PRINT "2. NO"
680 PRINT
690 PRINT "SELECTION: ???"
695 INPUT X
700 IF X > 2 THEN  GOTO 620
710 ON X GOTO 460,500
720 GOSUB 910
730 PRINT "NONINVERTING FOLLOWER SELECTED"
740 PRINT
750 PRINT "SELECT TRIAL VALUE FOR INPUT"
```



```
755 PRINT "RESISTOR (IN OHMS)..."
758 INPUT RI
760 PRINT
770 RF = (A - 1) * RI
780 RF =  INT (RF)
790 GOSUB 870
800 PRINT "FOR A GAIN OF ";A;" USE:"
810 PRINT
820 PRINT "RIN = ";RI;" OHMS"
830 PRINT "RF = ";RF;" OHMS"
840 PRINT
850 GOSUB 950
860 GOSUB 980
870 FOR I = 1 TO 5
880 PRINT
890 NEXT I
900 RETURN
910 FOR I = 1 TO 30
920 PRINT
930 NEXT I
940 RETURN
950 PRINT "PRESS CR TO CONTINUE..."
960 INPUT KK
970 RETURN
980 GOSUB 910
990 PRINT "WHAT'S YOUR PLEASURE???"
995 PRINT
1000 PRINT "1. TRY ANOTHER VALUE FOR SAME CIRCUIT"
1010 PRINT "2. DO ANOTHER PROBLEM ENTIRELY"
1020 PRINT "3. FINISHED"
1030 PRINT
1040 PRINT "SELECTION: ???"
1045 INPUT J
1050 IF J > 3 THEN  GOTO 990
1060 ON J GOTO 1070,130,1100
1070 IF A > 0 THEN  GOTO 720
1080 IF A < 0 THEN  GOTO 460
1090 RETURN
1100 GOSUB 910
1110 FOR I = 1 TO 30
1120 PRINT "************* BYE-BYE ***************"
1130 NEXT I
1140 GOSUB 870
1150 PRINT "PROGRAM ENDED"
1160 END
```

Program 34

Brute Force DC Power Supply Filter

The Brute Force filter circuit shown in Fig. 34.1 consists of a single, large-value electrolytic capacitor in parallel with the load resistor (R_L) and the output of the rectifier. This program calculates the capacitance needed to achieve a specified ripple factor in the DC output, the ripple factor to expect from a given filter capacitor, or the input voltage required of a specified filter to achieve a given output voltage. Both full-wave rectifier and half-wave rectifier cases are considered.

FULL WAVE

$$R_F = \frac{1}{416\, R_L\, C_1} \qquad [34.1]$$

HALF WAVE

$$R_F = \frac{1}{208\, R_L\, C_1} \qquad [34.2]$$

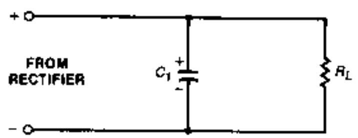


Fig. 34.1. Brute force filter circuit.


```
100 REM THIS IS PROGRAM NO. 34 PROG34
101 GOSUB 1240
102 PRINT "A 'BRUTE-FORCE' FILTER IS DESIGNED"
105 PRINT "IN WHICH A SINGLE LARGE-VALUE"
110 PRINT "CAPACITOR IS CONNECTED"
120 PRINT "IN PARALLEL WITH THE LOAD."
130 PRINT
140 PRINT
150 GOSUB 1280
160 GOSUB 1240
170 PRINT "SELECT TYPE OF CALCULATION TO BE PERFORMED:"
180 PRINT
190 PRINT "1. RIPPLE FACTOR OF A GIVEN"
192 PRINT "   POWER SUPPLY."
195 PRINT
200 PRINT "2. CAPACITANCE NEEDED FOR A"
205 PRINT "   SPECIFIED RIPPLE FACTOR(R)."
220 PRINT
240 PRINT "3. INPUT VOLTAGE TO PRODUCE A"
245 PRINT "   REQUIRED OUTPUT VOLTAGE"
250 PRINT
260 PRINT "CHOICE: ???"
265 INPUT A
270 IF A > 3 THEN  GOTO 170
280 ON A GOTO 290,580,860
290 GOSUB 1240
300 PRINT "NOW, LET'S COLLECT SOME INFORMATION --- OK?"
310 PRINT
320 PRINT "OUTPUT VOLTAGE AT FULL LOAD:"
325 INPUT VO
330 PRINT
340 PRINT "MAXIMUM LOAD CURRENT (IN AMPERES):"
345 INPUT I
350 PRINT
360 PRINT "VALUE OF FILTER CAPACITOR IN UF: "
365 INPUT C1
370 PRINT
380 C = C1 / (10 ^ 6)
390 RL = VO / I
400 RH = 1 / (208 * RL * C)
410 RH = RH * 100
420 RH =  INT (RH)
430 RH = RH / 100
440 RF = 1 / (416 * RL * C)
450 RF = RF * 100
460 RF =  INT (RF)
470 RF = RF / 100
480 GOSUB 1200
```

```
490 PRINT "FULLWAVE RIPPLE FACTOR: ";RF
500 PRINT
510 PRINT "HALFWAVE RIPPLE FACTOR: ";RH
520 PRINT
530 GOSUB 1280
540 GOSUB 1310
550 IF S = 1 THEN  GOTO 290
560 IF S = 2 THEN  GOTO 160
570 IF S = 3 THEN  GOTO 1410
580 GOSUB 1240
590 PRINT "LET'S COLLECT SOME INFORMATION -- OK?"
600 PRINT
610 PRINT "OUTPUT VOLTAGE AT FULL LOAD:"
615 INPUT VO
620 PRINT
630 PRINT "MAXIMUM LOAD CURRENT (IN AMPERES):"
635 INPUT I
640 PRINT
650 RL = VO / I
660 PRINT "DESIRED RIPPLE FACTOR (R):"
665 INPUT RF
670 PRINT
680 CH = 1 / (208 * RL * RF)
690 CF = 1 / (416 * RL * RF)
700 GOSUB 1200
710 CH = CH * 10 ^ 6
720 CH =  INT (CH)
730 CF = CF * 10 ^ 6
740 CF =  INT (CF)
750 PRINT "TO ACHIEVE A RIPPLE FACTOR OF ";RF
760 PRINT "USE A CAPACITOR AS FOLLOWS:"
770 PRINT
780 PRINT "FULLWAVE CIRCUIT: ";CF;" UF"
790 PRINT "HALFWAVE CIRCUIT: ";CH;" UF"
800 PRINT
810 GOSUB 1280
820 GOSUB 1310
830 IF S = 1 THEN  GOTO 580
840 IF S = 2 THEN  GOTO 160
850 IF S = 3 THEN  GOTO 1410
860 GOSUB 1240
870 PRINT "NOW LET'S COLLECT SOME INFORMATION -- OK?"
880 PRINT
890 PRINT "REQUIRED OUTPUT VOLTAGE UNDER FULL LOAD:"
895 INPUT VO
900 PRINT
910 PRINT "MAXIMUM LOAD CURRENT (IN AMPERES):"
915 INPUT I
```



```
920 PRINT
930 PRINT "FILTER CAPACITANCE BEING USED: ???"
935 INPUT C
940 PRINT
950 C1 = C / 10 ^ 6
960 VH = VO + (1 / (240 * C1))
980 VF = VO + (1 / (120 * C1))
1000 PF = ((VF - VO) * 100) / VF
1020 PH = ((VH - VO) * 100) / VH
1040 GOSUB 1200
1050 PRINT "REQUIRED PEAK PULSATING DC VOLTAGE:"
1060 PRINT
1070 PRINT "HALWAVE CASE: ";VH
1080 PRINT "FULLWAVE CASE: ";VF
1090 PRINT
1100 PRINT "VOLTAGE REGULATION:"
1110 PRINT
1120 PRINT "HALFWAVE CASE: ";PH;" %"
1130 PRINT "FULLWAVE CASE: ";PF;" %"
1140 PRINT
1150 GOSUB 1280
1160 GOSUB 1310
1170 IF S = 1 THEN  GOTO 860
1180 IF S = 2 THEN  GOTO 160
1190 IF S = 3 THEN  GOTO 1410
1200 FOR I = 1 TO 5
1210 PRINT
1220 NEXT I
1230 RETURN
1240 FOR I = 1 TO 30
1250 PRINT
1260 NEXT I
1270 RETURN
1280 PRINT "PRESS CR TO CONTINUE..."
1290 INPUT KK
1300 RETURN
1310 GOSUB 1200
1320 PRINT "WHAT'S YOUR PLEASURE?"
1330 PRINT
1340 PRINT "1. DO ANOTHER OF THE SAME SORT"
1345 PRINT
1350 PRINT "2. RETURN TO MAIN MENU TO"
1355 PRINT "   MAKE ANOTHER SELECTION"
1358 PRINT
1360 PRINT "3. FINISHED"
1370 PRINT
1380 PRINT "SELECTION: ???"
1385 INPUT S
```

```
1390 IF S > 3 THEN  GOTO 1310
1391 ON S GOTO 270,140,1410
1400 RETURN
1410 GOSUB 1200
1420 PRINT "PROGRAM ENDED"
1430 END
```


PROGRAM 35

RC Pi Network DC Power Supply Filter

Figure 35.1 shows a dual power supply filter section. Output voltage V_1 is higher than V_2 and is derived directly from the rectifier output as filtered by capacitor C_1. This output uses the same sort of "brute force" filter as in the previous circuit. Output V_2 produces a lower voltage, but at substantially better ripple factor. This program calculates the capacitances of C_1 and C_2 and the resistance of R_1 required to produce the voltages and ripple factors that you specify.

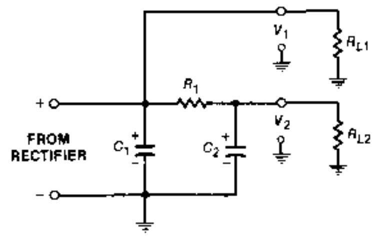


FIG. 35.1. A DUAL POWER SUPPLY FILTER SECTION.

RC Pi Network DC Power Supply Filter

```
100 REM THIS IS PROGRAM NO. 35 PROG35
140 GOSUB 830
150 PRINT "THIS PROGRAM IS USED TO SELECT"
155 PRINT "VALUES FOR AN RC POWER SUPPLY"
160 PRINT "FILTER CIRCUIT.  YOU WILL NEED"
170 PRINT "TO SELECT THE OUTPUT VOLTAGES"
175 PRINT "(V1 & V2) AND CURRENTS (I1 &I2)",
180 PRINT "IN ADDITION TO THE DESIRED RIPPLE"
185 PRINT "FACTORS FOR THE TWO VOLTAGE"
190 PRINT "OUTPUTS.  IN GENERAL,THE "
200 PRINT "RIPPLE FACTOR FOR THE LOWER"
205 PRINT "VOLTAGE OUTPUT (V2) IS"
210 PRINT "CONSIDERABLY LOWER THAN FOR V1"
220 GOSUB 790
230 GOSUB 870
240 GOSUB 830
250 PRINT "HIGHER VOLTAGE OUTPUT (V1): ???"
255 INPUT V1
260 PRINT
270 PRINT "OUTPUT CURRENT FROM V1 IN AMPERES: ???"
275 INPUT I1
280 PRINT
290 PRINT "RIPPLE FACTOR AT V1: ???"
295 INPUT F1
300 PRINT
310 PRINT "LOWER VOLTAGE OUTPUT (V2): ???"
315 INPUT V2
320 PRINT
330 PRINT "OUTPUT CURRENT FOR V2 IN AMPERES: ???"
335 INPUT I2
340 PRINT
350 PRINT "RIPPLE FACTOR AT V2: ???"
355 INPUT F2
360 GOSUB 830
370 L1 = V1 / I1
380 L2 = V2 / I2
390 C1 = 1 / (416 * L1 * F1)
400 R1 = ((V2 - V1) / I2) + (1 / (120 * C1))
410 R1 =  - R1
420 C2 = (2 * 10 ^  - 6) / (C1 * R1 * L2 * F2)
430 C1 = C1 * 10 ^ 6
440 C2 = C2 * 10 ^ 6
450 C1 =  INT (C1)
460 C2 =  INT (C2)
470 R1 =  INT (R1)
471 C1 =  ABS (C1)
472 C2 =  ABS (C2)
473 R1 =  ABS (R1)
480 PRINT "CAPACITANCES GIVEN BELOW ARE"
```



```
485 PRINT "MINIMUM VALUES -- USE HIGHER"
488 PRINT "VALUES IF DESIRED."
489 PRINT
490 PRINT "SELECT A WORKING DC VOLTAGE (WVDC)"
495 PRINT "RATING THAT IS 150-PERCENT OFTHE"
500 PRINT "OUTPUT VOLTAGE, OR MORE"
510 PRINT
512 PRINT
515 GOSUB 870
520 PRINT "**********************************"
530 PRINT "MAIN OUTPUT VOLTAGE (V1): ";V1;" VOLTS"
540 PRINT "MAIN OUTPUT CURRENT (I1): ";I1;" AMPERES"
550 PRINT
560 PRINT "FILTER CAPACITOR C1: ";C1;" UF"
570 PRINT "RIPPLE FACTOR AT V1: ";F1
580 PRINT "**********************************"
590 PRINT "LOWER OUTPUT VOLTAGE (V2): ";V2;" VOLTS"
600 PRINT "LOWER OUTPUT CURRENT (I2): ";I2;" AMPERES"
610 PRINT
620 PRINT "FILTER CAPACITOR C2: ";C2;" UF"
630 PRINT "SERIES RESISTOR R1: ";R1;" OHMS"
640 PRINT "RIPPLE FACTOR: ";F2
650 PRINT "**********************************"
660 PRINT
670 PRINT
680 GOSUB 870
690 GOSUB 830
700 PRINT "SELECT ONE FROM MENU BELOW"
705 PRINT "AND PRESS CR..."
710 PRINT
720 PRINT "1. DO ANOTHER"
730 PRINT "2. FINISHED"
740 PRINT
750 PRINT "SELECTION: ???"
755 INPUT K
760 IF K > 2 THEN  GOTO 710
770 ON K GOTO 100,900
780 END
790 FOR I = 1 TO 5
800 PRINT
810 NEXT I
820 RETURN
830 FOR I = 1 TO 30
840 PRINT
850 NEXT I
860 RETURN
870 PRINT "PRESS CR TO CONTINUE..."
880 INPUT LK
```

```
890 RETURN
900 GOSUB 830
910 PRINT "PROGRAM ENDED"
920 END
```

Example

```
THIS PROGRAM IS USED TO SELECT
VALUES FOR AN RC POWER SUPPLY
FILTER CIRCUIT.  YOU WILL NEED
TO SELECT THE OUTPUT VOLTAGES
(V1 & V2) AND CUURENTS (I1 & I2)
IN ADDITION TO THE DESIRED RIPPLE
FACTORS FOR THE TWO VOLTAGE
OUTPUTS.  IN GENERAL,THE
RIPPLE FACTOR FOR THE LOWER
VOLTAGE OUTPUT (V2) IS
CONSIDERABLY LOWER THAN FOR V1


PRESS CR TO CONTINUE...


HIGHER VOLTAGE OUTPUT (V1): ???
 18

OUTPUT CURRENT FROM V1 IN AMPERES: ???
 1.2

RIPPLE FACTOR AT V1: ???
 .6

LOWER VOLTAGE OUTPUT (V2): ???
 12

OUTPUT CURRENT FOR V2 IN AMPERES: ???
 .25

RIPPLE FACTOR AT V2: ???
 2E-03


CAPACITANCES GIVEN BELOW ARE
MINIMUM VALUES -- USE HIGHER
VALUES IF DESIRED.
```

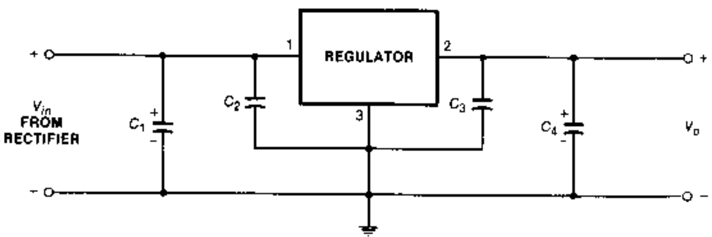


```
SELECT A WORKING DC VOLTAGE (WVDC)
RATING THAT IS 150-PERCENT OFTHE
OUTPUT VOLTAGE, OR MORE


PRESS CR TO CONTINUE...
*********************************
MAIN OUTPUT VOLTAGE (V1):  18  VOLTS
MAIN OUTPUT CURRENT (I1):  1.2  AMPERES

FILTER CAPACITOR C1:  267  UF
RIPPLE FACTOR AT V1:  .6
*********************************
LOWER OUTPUT VOLTAGE (V2):  12  VOLTS
LOWER OUTPUT CURRENT (I2):  .25  AMPERES

FILTER CAPACITOR C2:  10834  UF
SERIES RESISTOR R1:  8  OHMS
RIPPLE FACTOR:  2E-03
*********************************


PRESS CR TO CONTINUE...


SELECT ONE FROM MENU BELOW
AND PRESS CR...

1. DO ANOTHER
2. FINISHED

SELECTION: ???


PROGRAM ENDED
```

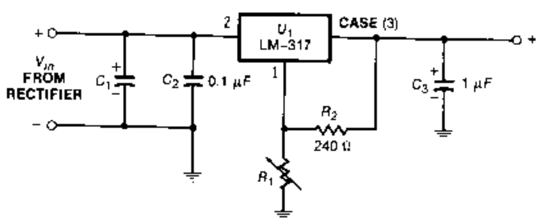
Program 36

Design of Simple Regulated DC Power Supplies

Two simple voltage regulator circuits are shown in Fig. 36.1; both are three terminal integrated circuit regulators. The fixed voltage version is shown in Fig. 36.1A. In this circuit, the output voltage is fixed by the type of regulator inserted into the regulator slot. There are several families of devices, and which is selected by the program depends upon the maximum output current requirements. The adjustable voltage version is shown in Fig. 36.1B. This circuit is based on the LM 317 device. Potentiometer R1 can be adjusted to determine the output voltage.



(A) Fixed voltage version.



(B) Adjustable voltage version.

Fig. 36.1. Two simple voltage regulator circuits.


```
100 REM THIS IS PROGRAM NO. 36 PROG36
110 REM
120 REM THIS PROGRAM WILL SELECT
125 REM COMPONENTS FOR A STANDARD POWER
130 REM SUPPLY, GIVEN YOUR REQUIREMENTS
140 DIM B$(15)
150 DIM C$(15)
160 DIM D$(15)
170 C$ = "K-"
180 B$ = "LM-340"
190 GOSUB 1480
200 PRINT "SELECT VALUE OF REGULATED DC"
205 PRINT "OUTPUT VOLTAGE:"
210 PRINT
220 PRINT "1. 5-VOLTS"
230 PRINT "2. 6-VOLTS"
240 PRINT "3. 12-VOLTS"
250 PRINT "4. 15-VOLTS"
260 PRINT "5. 18-VOLTS"
270 PRINT "6. 24-VOLTS"
280 PRINT "7. ADJUST[$1]ABLE (1.2 TO 35 VOLTS)"
290 PRINT
300 PRINT "SELECTION: ???"
305 INPUT VO
310 IF VO > 7 THEN  GOTO 200
320 GOSUB 1480
330 PRINT "SELECT MAXIMUM OUTPUT CURRENT LEVEL:"
340 PRINT
350 PRINT "1. 100 MA"
360 PRINT "2. 500 MA"
370 PRINT "3. 750-MA"
380 PRINT "4. 1-AMPERE"
390 PRINT "5. 1.5-AMPERES
400 PRINT "6. 3-AMPERES"
410 PRINT "7. 5-AMPERES"
420 PRINT
430 PRINT "SELECTION: ???"
435 INPUT I
440 IF I > 7 THEN  GOTO 330
450 GOSUB 1480
460 PRINT "PERMISSABLE REGULATOR TYPES:"
470 IF VO = 1 THEN  GOSUB 980
480 IF VO = 2 THEN  GOSUB 1060
490 IF VO = 3 THEN  GOSUB 1160
500 IF VO = 4 THEN  GOSUB 1230
510 IF VO = 5 THEN  GOSUB 1300
520 IF VO = 6 THEN  GOSUB 1350
530 IF I = 1 THEN C1 = 500
```

```
540 IF I = 2 THEN C1 = 1000
550 IF I = 3 THEN C1 = 1000
560 IF I = 4 THEN C1 = 2000
570 IF I = 5 THEN C1 = 3000
580 IF I = 6 THEN C1 = 5000
590 IF I = 7 THEN C1 = 10000
600 IF I = 1 THEN C4 = 10
610 IF I = 2 THEN C4 = 50
620 IF I = 3 THEN C4 = 100
630 IF I = 4 THEN C4 = 100
640 IF I = 5 THEN C4 = 150
650 IF I = 6 THEN C4 = 300
660 IF I = 7 THEN C4 = 500
670 IF I < 5 THEN C2 = 0.1
680 IF I > 4 THEN C2 = 0.47
690 IF VO = 1 THEN V = 5
700 IF VO = 2 THEN V = 6
710 IF VO = 3 THEN V = 12
720 IF VO = 4 THEN V = 15
730 IF VO = 5 THEN V = 18
740 IF VO = 6 THEN V = 24
750 IF I = 1 THEN IO = .1
760 IF I = 2 THEN IO = .5
770 IF I = 3 THEN IO = 0.75
780 IF I = 4 THEN IO = 1
790 IF I = 5 THEN IO = 1.5
800 IF I = 6 THEN IO = 3
810 IF I = 7 THEN IO = 5
820 IF VO = 7 THEN  GOTO 1550
830 PRINT "C1: ";C1;" UF"
840 PRINT "C2: ";C2;" UF"
850 PRINT "C4: ";C4;" UF"
860 PRINT
870 PRINT "MINIMUM INPUT VOLTAGE TO REGULATOR: ";V
    + 2.5;" VOLTS"
880 PRINT
890 PRINT "MINIMUM WVDC RATING OF C1: ";(V + 2.5) * 1.5;
    " VOLTS"
900 PRINT "MINIMUM WVDC RATING OF C2: ";(V * 1.5);
    " VOLTS"
910 PRINT "C2 WVDC RATING SAME AS C1, C3 SAME AS C4"
920 PRINT
930 PRINT "RATINGS: ";V;" VOLTS, @";IO;"AMPS"
940 PRINT
950 PRINT
960 GOSUB 1520
970 GOTO 1790
980 IF I = 1 THEN  GOSUB 1980
```



```
990 IF I = 2 THEN  GOSUB 1990
1000 IF I = 3 THEN  GOSUB 2000
1010 IF I = 4 THEN  GOSUB 2010
1020 IF I = 5 THEN  GOSUB 2020
1030 IF I = 6 THEN  GOSUB 2030
1040 IF I = 7 THEN  GOSUB 2040
1050 RETURN
1060 PRINT
1070 IF I = 1 THEN  GOSUB 2070
1080 IF I = 2 THEN  GOSUB 2080
1090 PRINT
1100 IF I = 3 THEN  GOSUB 2100
1110 IF I = 4 THEN  GOSUB 2110
1120 IF I > 4 THEN  GOSUB 2220
1130 IF I > 4 THEN  GOSUB 2230
1140 IF I > 4 THEN  GOSUB 2240
1150 RETURN
1160 PRINT
1170 IF I = 1 THEN  GOSUB 2170
1180 IF I = 2 THEN  GOSUB 2180
1190 IF I = 3 THEN  GOSUB 2190
1200 IF I = 4 THEN  GOSUB 2200
1210 IF I > 4 THEN  GOSUB 2210
1220 RETURN
1230 PRINT
1240 IF I = 1 THEN  GOSUB 2240
1250 IF I = 2 THEN  GOSUB 2250
1260 IF I = 3 THEN  GOSUB 2260
1270 IF I = 4 THEN  GOSUB 2270
1280 IF I > 4 THEN  GOSUB 2280
1290 RETURN
1300 PRINT
1310 IF I < 4 THEN  GOSUB 2310
1320 IF I = 4 THEN  GOSUB 2320
1330 IF I > 4 THEN  GOSUB 2330
1340 RETURN
1350 PRINT
1360 IF I = 1 THEN  GOSUB 2360
1370 IF I = 2 THEN  GOSUB 2370
1380 IF I = 3 THEN  GOSUB 2380
1390 IF I = 4 THEN  GOSUB 2390
1400 IF I > 4 THEN  GOSUB 2400
1410 RETURN
1420 PRINT "ENDED"
1430 END
1440 FOR Q = 1 TO 5
1450 PRINT
1460 NEXT Q
```

```
1470 RETURN
1480 FOR Q = 1 TO 30
1490 PRINT
1500 NEXT Q
1510 RETURN
1520 PRINT "PRESS CR TO CONTINUE..."
1530 INPUT KK
1540 RETURN
1550 PRINT
1560 IF I < 5 THEN  GOSUB 2560
1570 IF I > 4 THEN  GOSUB 2570
1580 PRINT
1590 IF I < 5 THEN R2 = 240
1600 IF I > 4 THEN R2 = 120
1610 PRINT "MAXIMUM OUTPUT VOLTAGE ( <= 35 VDC): "
1615 INPUT MAX
1620 IF MAX > 35 THEN  GOSUB 2620
1630 PRINT
1640 IF MAX > 35 THEN  GOTO 1610
1650 GOSUB 1440
1660 R1 = R2 * ((MAX / 1.25) - 1)
1670 VINMIN = MAX + 3
1680 PRINT
1690 PRINT "FOR ADJUSTABLE POWER SUPPLY"
1695 PRINT "OVER THE RANGE 1.2 VDC TO"
1700 PRINT MAX;"VDC USE THE FOLLOWING:"
1710 PRINT
1720 PRINT "R1: ";R1;" OHMS"
1730 PRINT "C1: ";C1;" UF"
1740 PRINT
1750 PRINT "MINIMUM INPUT VOLTAGE: ";VINMIN;" VOLTS"
1760 PRINT
1770 GOSUB 1520
1780 GOTO 1790
1790 PRINT
1800 PRINT "WHAT'S YOUR PLEASURE?"
1810 PRINT "1. DO ANOTHER"
1820 PRINT "2. FINISHED"
1830 PRINT
1840 PRINT "SELECTION: ????"
1845 INPUT D
1850 IF D > 2 THEN  GOTO 1790
1860 ON D GOTO 190,1870
1870 GOSUB 1440
1880 PRINT "PROGRAM ENDED"
1890 END
1980 PRINT "LM-309H, LM-340LAH-05, LM-340T-05 OR 7805"
1985 RETURN
```



```
1990 PRINT "LM-340T-05, 7805"
1995 RETURN
2000 PRINT "LM-340T-05, LM-340K-05 OR 7805"
2005 RETURN
2010 PRINT "LM-340K-05 OR 7805 (K-PACKAGE ONLY)"
2015 RETURN
2020 PRINT "LM-340K-05, LAS-1505 OR 7805 (K-PACKAGE ONLY)"
2025 RETURN
2030 PRINT "LM-323K"
2040 PRINT "LAS-1905"
2045 RETURN
2070 PRINT "LM-340H-06 OR LM-340T-06"
2075 RETURN
2080 PRINT "LM-340T-06 OR LM-340K-06"
2085 RETURN
2100 PRINT "LM-340T-06 OR LM-340K-06"
2105 RETURN
2110 PRINT "LM-340K-06"
2115 RETURN
2120 PRINT "CURRENT REQUIREMENT TOO HIGH FOR THIS SERIES
     OF"
2130 PRINT "VOLTAGE REGULATOR (SELECT A LOWER CURRENT OR
     USE"
2140 PRINT "AN APPROPRIATE ADJUSTABLE REGULATOR)"
2170 PRINT LM - 340H - 12 OR 7812"
2175 RETURN
2180 PRINT "LM-340T-12 OR 7812"
2185 RETURN
2190 PRINT "LM-340T-12 OR 7812"
2200 PRINT "LM-340K-12 OR 7812 (K-PACKAGE ONLY)"
2205 RETURN
2210 PRINT "USE LM-317 OR LM-338 ADJUSTABLE VOLTAGE
     REGULATOR"
2215 RETURN
2240 PRINT "LM-340H-15, LM-340T-15, LM-340K-15 OR 7815"
2245 RETURN
2250 PRINT "LM-340T-15, LM-340K-15, OR 7815"
2255 RETURN
2260 PRINT "LM-340T-15, LM-340K-15 OR 7815"
2265 RETURN
2270 PRINT "LM-340K-15 OR 7815 (K-PACKAGE ONLY)"
2275 RETURN
2280 PRINT "USE LM-317 OR LM-338 ADJUSTABLE VOLTAGE
     REGULATOR"
2285 RETURN
2310 PRINT "LM-340T-18, LM-340K-18 OR 7818"
2315 RETURN
2320 PRINT "LM-340K-18 OR 7818 (K-PACKAGE ONLY)"
```

```
2325 RETURN
2330 PRINT "USE LM-317 OR LM-338 ADJUSTABLE VOLTAGE
     REGULATOR"
2360 PRINT "LM-340H-24, LM-340T-24, LM-340K-24 OR 7824"
2365 RETURN
2370 PRINT "LM-340T-24, LM-340K-24 OR 7824 (K-PACKAGE
     ONLY)"
2375 RETURN
2380 PRINT "LM-340T-24, LM-340K-24 O4 7824 (K-PACKAGE
     ONLY)"
2385 RETURN
2390 PRINT "LM-340K-24 OR 7824 (K-PACKAGE ONLY)"
2395 RETURN
2400 PRINT "USE LM-317 OR LM-338 ADJUSTABLE VOLTAGE
     REGULATOR"
2405 RETURN
2560 PRINT "LM-317K"
2565 RETURN
2570 PRINT "LM-338K"
2575 RETURN
2620 PRINT "VOLTAGE OUT OF RANGE"
2625 RETURN
```

Example

```
SELECT VALUE OF REGULATED DC
OUTPUT VOLTAGE:

1. 5-VOLTS
2. 6-VOLTS
3. 12-VOLTS
4. 15-VOLTS
5. 18-VOLTS
6. 24-VOLTS
7. ADJUSTABLE (1.2 TO 35 VOLTS)

SELECTION: ???


SELECT MAXIMUM OUTPUT CURRENT LEVEL:

1. 100 MA
2. 500 MA
3. 750-MA
4. 1-AMPERE
```



```
5. 1.5-AMPERES
6. 3-AMPERES
7. 5-AMPERES

SELECTION: ???


PERMISSABLE REGULATOR TYPES:

LM-340T-12 OR 7812
C1:  1000  UF
C2:  .1  UF
C4:  50  UF

MINIMUM INPUT VOLTAGE TO REGULATOR:  14.5  VOLTS

MINIMUM WVDC RATING OF C1:  21.75  VOLTS
MINIMUM WVDC RATING OF C2:  18  VOLTS
C2 WVDC RATING SAME AS C1, C3 SAME AS C4

RATINGS:  12  VOLTS, @ .5 AMPS


PRESS CR TO CONTINUE...

WHAT'S YOUR PLEASURE?
1. DO ANOTHER
2. FINISHED

SELECTION: ????


PROGRAM ENDED


SELECT VALUE OF REGULATED DC
OUTPUT VOLTAGE:

1. 5-VOLTS
2. 6-VOLTS
3. 12-VOLTS
4. 15-VOLTS
5. 18-VOLTS
6. 24-VOLTS
7. ADJUSTABLE (1.2 TO 35 VOLTS)

SELECTION: ???
```

```
SELECT MAXIMUM OUTPUT CURRENT LEVEL:

1. 100 MA
2. 500 MA
3. 750-MA
4. 1-AMPERE
5. 1.5-AMPERES
6. 3-AMPERES
7. 5-AMPERES

SELECTION: ???


PERMISSABLE REGULATOR TYPES:

LM-338K

MAXIMUM OUTPUT VOLTAGE ( <= 35 VDC):



FOR ADJUSTABLE POWER SUPPLY
OVER THE RANGE 1.2 VDC TO
 20 VDC USE THE FOLLOWING:

R1:  1800  OHMS
C1:  5000  UF

MINIMUM INPUT VOLTAGE:  23  VOLTS

PRESS CR TO CONTINUE...

WHAT'S YOUR PLEASURE?
1. DO ANOTHER
2. FINISHED

SELECTION: ????


PROGRAM ENDED
```


PROGRAM 37

Design of RC Phase-Shift Oscillator

The RC Phase-Shift Oscillator (Fig. 37.1) is a simple circuit that will produce a sine-wave output at a frequency determined by the components in the RC feedback network (R_1, R_2, R_3, and C_1, C_2, C_3). This network consists of three RC elements (R_1/C_1, R_2/C_2, and R_3/C_3) each of which produces a 60 degree phase shift at some specific frequency. The other 180 degrees required for oscillation occurs because the operational amplifier is used in the inverting configuration.

This program will allow you to select values for the capacitors and resistors of the RC phase shift network and for the feedback resistor as well. In addition, if the variable frequency option is selected, it will calculate the minimum and maximum values of R that will yield the desired frequency range.

$$R_1 = R_2 = R_3 = R$$

$$R_4 = 30\,R$$

$$C_1 = C_2 = C_3 = C$$

$$F = \frac{1}{2\pi\sqrt{6}RC} \qquad [37.1]$$

$$R = \frac{1}{15.391CF} \qquad [37.2]$$

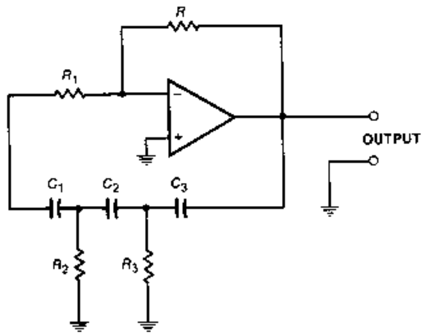


FIG. 37.1. RC PHASE-SHIFT OSCILLATOR.

Design of RC Phase-Shift Oscillator

```
100 REM THIS IS PROGRAM NO. 37 PROG37
130 S = 5
140 GOSUB 940
150 PRINT  TAB( S);"* * * * * * * * * * * * * * * *"
160 PRINT  TAB( S);"* PROGRAM TO DESIGN AN RC *"
170 PRINT  TAB( S);"* PHASE-SHIFT OSCILLATOR  *"
180 PRINT  TAB( S);"*    COPYRIGHT 1986       *"
190 PRINT  TAB( S);"*        JJ CARR          *"
200 PRINT  TAB( S);"* * * * * * * * * * * * * * * *"
210 GOSUB 900
220 GOSUB 980
230 GOSUB 940
240 PRINT "SELECT ONE FROM MENU BELOW:"
250 PRINT
260 PRINT "1. FIXED-FREQUENCY OSCILLATOR"
270 PRINT "2. VARIABLE-FREQUENCY OSCILLATOR"
280 PRINT
290 PRINT "SELECTION: ???"
295 INPUT A
300 IF A > 2 THEN  GOTO 240
310 ON A GOTO 320,570
320 GOSUB 900
330 PRINT "FIXED-FREQUENCY OPTION SELECTED"
340 PRINT
350 PRINT "OPERATING FREQUENCY IN HERTZ (HZ):"
355 INPUT F
360 PRINT
```



```
370 PRINT
380 PRINT "FIRST TRIAL CAPACITANCE IN MICROFARADS (UF):"
385 INPUT C
390 C = C / (10 ^ 6)
400 R = 1 / (15.391 * C * F)
410 R =  INT (R)
420 R4 = 30 * R
430 C = C * 10 ^ 6
440 GOSUB 900
450 R4 =  INT (R4)
460 PRINT "RC PHASE-SHIFT OSCILLATOR"
465 PRINT "COMPONENT VALUES FOR FIXED"
470 PRINT "FREQUENCY OPERATION."
480 PRINT
490 PRINT "OPERATING FREQUENCY: ";F;" HZ"
500 PRINT "CAPACITORS C1 = C2 = C3 = ";C;" UF"
510 PRINT "RESISTORS R1 = R2 = R3 = ";R;" OHMS"
520 PRINT "FEEDBACK RESISTOR R4 = ";R4;" OHMS"
530 PRINT
540 PRINT
550 GOSUB 980
560 GOTO 1180
570 GOSUB 940
580 PRINT "VARIABLE FREQUENCY OPTION SELECTED"
590 PRINT
600 PRINT "SET UPPER AND LOWER OPERATING"
605 PRINT "FREQUENCY LIMITS:"
610 PRINT
620 PRINT "LOWER FREQUENCY LIMIT IN HERTZ (HZ):"
625 INPUT FL
628 PRINT
630 PRINT "UPPER FREQUENCY LIMIT IN HERTZ (HZ):"
635 INPUT FH
640 PRINT
660 IF FH > 11 * FL THEN  GOSUB 1010
670 GOSUB 900
680 PRINT "FIRST TRIAL VALUE OF CAPACITANCE?"
690 PRINT
700 PRINT "CAPACITANCE IN MICROFARADS: ???"
705 INPUT C
710 C = C / 10 ^ 6
720 RL = 1 / (15.391 * C * FL)
730 RL =  INT (RL)
740 RH = 1 / (15.391 * C * FH)
750 RH =  INT (RH)
760 R4 = 30 * RH
770 R4 =  INT (R4)
780 C = C * 10 ^ 6
790 GOSUB 900
```

```
800 PRINT "RC PHASE-SHIFT OSCILLATOR"
805 PRINT "COMPONENT VALUES FOR VARIABLE"
810 PRINT "FREQUENCY OPERATION."
820 PRINT
830 PRINT "OPERATING FREQUENCY RANGE: ";FL;" TO ";FH;" HZ"
840 PRINT "CAPACITORS C1 = C2 = C3 = ";C;" UF"
850 PRINT "RESISTOR RANGE: ";RH;" TO ";RL;" OHMS"
860 PRINT "FEEDBACK RESISTOR R4: ";R4;" OHMS"
870 GOSUB 900
880 GOSUB 980
890 GOTO 1180
900 FOR I = 1 TO 5
910 PRINT
920 NEXT I
930 RETURN
940 FOR I = 1 TO 30
950 PRINT
960 NEXT I
970 RETURN
980 PRINT "PRESS CR TO CONTINUE..."
990 INPUT LL
1000 RETURN
1010 GOSUB 900
1020 PRINT "FREQUENCY RANGE SELECTED IS"
1025 PRINT "GREATER THAN ONE DECADE"
1030 PRINT "(I.E. 10:1).  IT WOULD BE"
1035 PRINT "BETTER IN MOST CASES TO BREAK"
1040 PRINT "THE RANGE INTO TWO BANDS --"
1045 PRINT "SELECT ONE FROM BELOW:"
1050 PRINT
1060 PRINT "1. LEAVE IT AS IS"
1080 PRINT
1090 PRINT "2. LET'S BREAK IT INTO TWO"
1130 PRINT
1140 PRINT "SELECTION: ????"
1145 INPUT W
1150 IF W > 2 THEN  GOTO 1010
1160 ON W GOTO 1170,230
1170 RETURN
1180 PRINT
1190 PRINT "WHAT'S YOUR PLEASURE?"
1200 PRINT
1210 PRINT "1.  DO ANOTHER OF THE SAME TYPE"
1220 PRINT "2.  RETURN TO OPTIONS MENU"
1230 PRINT "3.  FINISHED"
1240 PRINT
1250 INPUT L
1260 IF L > 3 THEN  GOTO 1180
```



```
1270 ON L GOTO 320,240,1280
1280 GOSUB 940
1290 PRINT "PROGRAM ENDED"
1300 END
```

PROGRAM 38

Design of RC Triangle-Function Oscillator

Figure 38.1 shows the circuit of a triangle waveform oscillator that is based on two operational amplifiers. The output operational amplifier (A_2) works as a Miller integrator, while the other device operates as a comparator. When the output of A_1 is high(+), the output of A_2 charges toward V− at a constant rate. When a certain voltage is reached, which is determined by R_1 and R_2, the comparator (A_1) output snaps to high(−), and this forces the output of A_2 to discharge toward V+ (again, at a constant rate). The result of these two slopes at V_o is a triangle waveform with a period that is determined by R, C_1, R_1, and R_2.

The program allows you to select either fixed frequency or variable frequency options. The latter results in a resistance range that will produce the required frequency range

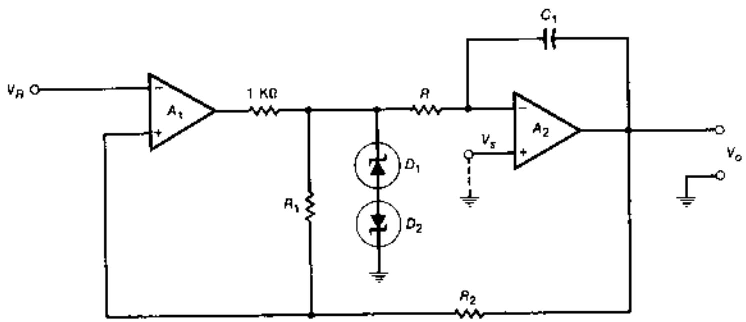


FIG. 38.1. CIRCUIT OF A TRIANGLE WAVEFORM OSCILLATOR THAT IS BASED ON TWO OPERATIONAL AMPLIFIERS.


```
100 REM THIS IS PROGRAM NO. 38 PROG38
130 S = 5
140 GOSUB 940
150 PRINT  TAB( S);"* * * * * * * * * * * * * * *"
160 PRINT  TAB( S);"* PROGRAM TO DESIGN AN RC *"
170 PRINT  TAB( S);"*    TRIANGLE WAVEFORM    *"
180 PRINT  TAB( S);"*        GENERATOR        *"
190 PRINT  TAB( S);"*      COPYRIGHT 1986     *"
200 PRINT  TAB( S);"*         JJ CARR         *"
210 PRINT  TAB( S);"* * * * * * * * * * * * * * *"
220 GOSUB 900
230 GOSUB 980
240 GOSUB 940
250 PRINT "SELECT ONE FROM THE MENU BELOW:"
260 PRINT
270 PRINT "1. FIXED-FREQUENCY OSCILLATOR"
280 PRINT "2. VARIABLE-FREQUENCY OSCILLATOR"
290 PRINT
300 PRINT "SELECTION: ???"
305 INPUT A
310 IF A > 2 THEN  GOTO 250
320 GOSUB 1340
330 ON A GOTO 340,580
340 GOSUB 900
350 PRINT "FIXED-FREQUENCY OPTION SELECTED"
360 PRINT
370 PRINT "OPERATING FREQUENCY IN HERTZ (HZ):"
375 INPUT F
380 PRINT
390 PRINT
400 PRINT "FIRST TRIAL CAPACITANCE IN"
405 PRINT "MICROFARADS (UF): ???"
408 INPUT C
410 C = C / (10 ^ 6)
420 IF K = 1 THEN R = 0.25 / (F * C)
430 IF K = 2 THEN  GOSUB 1180
440 R =  INT (R)
450 C = C * 10 ^ 6
460 GOSUB 900
470 PRINT "RC TRIANGLE WAVEFORM GENERATOR"
480 PRINT "FOR FIXED-FREQUENCY OPTION:"
485 PRINT "FREQUENCY OPERATION."
490 PRINT
500 PRINT "OPERATING FREQUENCY: ";F;" HZ"
510 PRINT "CAPACITOR C1 = ";C;" UF"
520 PRINT "RESISTOR = ";R;" OHMS"
530 IF K = 2 THEN  GOSUB 2000
540 PRINT
```

```
550 PRINT
560 GOSUB 980
570 GOTO 1050
580 GOSUB 940
590 PRINT "VARIABLE-FREQUENCY OPTION SELECTED"
600 PRINT
610 PRINT "SET UPPER AND LOWER FREQUENCY LIMITS"
620 PRINT
630 PRINT "LOWER FREQUENCY LIMIT IN HERTZ (HZ): ???"
635 INPUT FL
640 PRINT
650 PRINT "UPPER FREQUENCY LIMIT IN HERTZ (HZ): ???"
655 INPUT FH
660 PRINT
670 GOSUB 900
680 PRINT "FIRST TRIAL VALUE OF CAPACITANCE: "
690 PRINT
700 PRINT "CAPACITANCE IN MICROFARADS (UF): ???"
705 INPUT C
710 C = C / 10 ^ 6
720 IF K = 2 THEN  GOSUB 1260
730 IF K = 1 THEN RL = 0.25 / (FL * C)
740 IF K = 1 THEN RH = 0.25 / (FH * C)
750 C = C * 10 ^ 6
760 GOSUB 900
770 RL =  INT (RL)
780 RH =  INT (RH)
790 PRINT "RC TRIANGLE WAVEFORM GENERATOR"
795 PRINT "COMPONENT VALUES FOR VARIABLE"
800 PRINT "FOR VARIABLE-FREQUENCY OPERATION:"
810 PRINT
820 PRINT "OPERATING FREQUENCY RANGE: ";FL;" TO ";FH;" HZ"
830 PRINT "CAPACITOR C1 = ";C;" UF"
840 PRINT "RESISTOR RANGE: ";RH;" TO ";RL;" OHMS"
850 PRINT
860 IF K = 2 THEN  GOSUB 3000
870 GOSUB 900
880 GOSUB 980
890 GOTO 1050
900 FOR I = 1 TO 5
910 PRINT
920 NEXT I
930 RETURN
940 FOR I = 1 TO 30
950 PRINT
960 NEXT I
970 RETURN
980 PRINT "PRESS CR TO CONTINUE..."
```



```
990 INPUT KK
1000 RETURN
1010 PRINT "SELECTION: ???"
1015 INPUT W
1020 IF W > 2 THEN  GOTO 1010
1030 ON W GOTO 1040,240
1040 RETURN
1050 PRINT
1060 PRINT "WHAT'S YOUR PLEASURE?"
1070 PRINT
1080 PRINT "1. DO ANOTHER OF THE SAME TYPE"
1090 PRINT "2. RETURN TO THE OPTIONS MENU"
1100 PRINT "3. FINISHED"
1110 PRINT
1120 INPUT L
1130 IF L > 3 THEN  GOTO 1050
1140 ON L GOTO 340,250,1150
1150 GOSUB 940
1160 PRINT "PROGRAM ENDED"
1170 GOTO 1430
1180 GOSUB 900
1190 PRINT "VALUE OF R1: ???"
1195 INPUT R1
1200 PRINT
1210 PRINT "VALUE OF R2: ???"
1215 INPUT R2
1220 PRINT
1230 R = R1 / (4 * R2 * C * F)
1240 R =  INT (R)
1250 RETURN
1260 PRINT
1270 PRINT "VALUE OF R1 IN OHMS: ???"
1275 INPUT R1
1280 PRINT
1290 PRINT "VALUE OF R2 IN OHMS: ???"
1295 INPUT R2
1300 PRINT
1310 RH = R1 / (4 * R2 * C * FH)
1320 RL = R1 / (4 * R2 * C * FL)
1330 RETURN
1340 GOSUB 900
1350 PRINT "SELECT ONE FROM MENU BELOW:"
1360 PRINT
1370 PRINT "1. STANDARDIZED VERSION (R1 = R2)"
1380 PRINT "2. SELECT CUSTOM VALUES FOR R1 AND R2"
1390 PRINT
1400 PRINT "SELECTION: ???"
1405 INPUT K
```

```
1410 IF K > 2 THEN  GOTO 1340
1420 RETURN
1430 END
2000 PRINT "R1 = ";R1;" OHMS, R2 = ";R2;" OHMS"
2005 RETURN
3000 PRINT "R1 = ";R1;" OHMS, R2 = ";R2;" OHMS"
3005 RETURN
```


PROGRAM 39

Design of Monostable Multivibrator ("One-Shot")

The circuit in Fig. 39.1 is a one-shot, or monostable multivibrator. The name one-shot derives from the fact that this circuit produces one and only one output pulse for every applied input trigger pulse. The name monostable multivibrator derives from the fact that this circuit has only one stable output state. When a negative-going trigger pulse is applied to the trigger input, the output snaps to the unstable state for a period of time, *T*, and then reverts automatically back to the stable state. The duration of the output pulse thereby obtained is a function of the RC time constant.

This program will ask you to enter a trial capacitance value (select a value from the standard values), and it will then calculate the required resistance. If this value is absurd (or too hard to obtain), try again with another trial capacitance value.

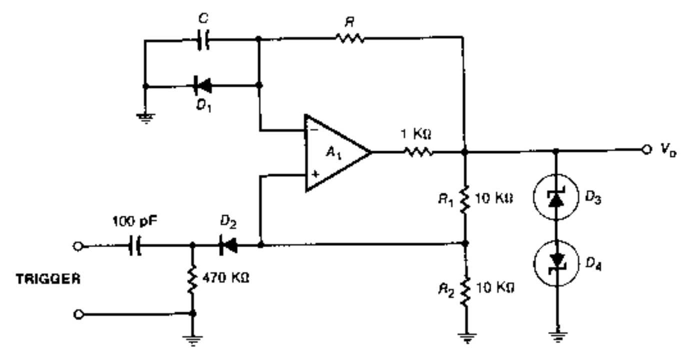


FIG. 39.1. CIRCUIT OF A ONE-SHOT, OR MONOSTABLE MULTIVIBRATOR.

```
100 REM THIS IS PROGRAM NO. 39 PROG39
150 GOSUB 610
160 PRINT "* * * * * * * * * * * * * * *"
170 PRINT "*  MONOSTABLE MULTIVIBRATOR *"
180 PRINT "*          DESIGN           *"
190 PRINT "*       COPYRIGHT 1986      *"
200 PRINT "*          JJ CARR          *"
210 PRINT "* * * * * * * * * * * * * * *"
220 GOSUB 570
230 GOSUB 650
240 GOSUB 610
250 PRINT "THIS PROGRAM CALCULATES THE"
255 PRINT"RESISTOR AND CAPACITOR VALUES"
260 PRINT "FOR A MONOSTABLE MULTIVIBRATOR"
270 PRINT "(ONE-SHOT) BASED ON AN OPERATIONAL"
275 PRINT "AMPLIFIER ACTIVE ELEMENT."
280 GOSUB 570
290 GOSUB 650
300 GOSUB 610
310 PRINT "DURATION OF OUTPUT PULSE IN"
312 PRINT "MILLISECONDS (MS): ???"
315 INPUT T
320 T = T / 1000
330 GOSUB 570
340 PRINT "FIRST TRIAL VALUE OF CAPACITANCE"
343 PRINT "IN MICROFARADS (UF): ???"
345 INPUT C
350 C = C / 10 ^ 6
360 R = T / (0.693 * C)
370 R =  INT (R)
380 C = C * 10 ^ 6
390 GOSUB 570
400 T = T * 1000
410 PRINT "FOR A DURATION OF ";T;" MS USE"
420 PRINT "A RESISTANCE OF ";R;" OHMS"
425 PRINT "AND A CAPACITANCE OF ";C;" UF"
430 PRINT
440 GOSUB 650
450 GOSUB 610
460 PRINT "WHAT NOW?"
470 PRINT
480 PRINT "1. DO ANOTHER?"
490 PRINT "2. FINISHED?"
500 PRINT
510 PRINT "SELECTION: ???"
515 INPUT D
520 IF D > 2 THEN  GOTO 460
530 ON D GOTO 300,540
```



```
540 GOSUB 610
550 PRINT "PROGRAM ENDED"
560 GOTO 680
570 FOR I = 1 TO 5
580 PRINT
590 NEXT I
600 RETURN
610 FOR I = 1 TO 30
620 PRINT
630 NEXT I
640 RETURN
650 PRINT "PRESS CR TO CONTINUE..."
660 INPUT KK
670 RETURN
680 END
```

Example

```
* * * * * * * * * * * * * * *
*  MONOSTABLE MULTIVIBRATOR *
*          DESIGN           *
*       COPYRIGHT 1986      *
*          JJ CARR          *
* * * * * * * * * * * * * * *


PRESS CR TO CONTINUE...


THIS PROGRAM CALCULATES THE
RESISTOR AND CAPACITOR VALUES
FOR A MONOSTABLE MULTIVIBRATOR
(ONE-SHOT) BASED ON AN OPERATIONAL
AMPLIFIER ACTIVE ELEMENT.


PRESS CR TO CONTINUE...


DURATION OF OUTPUT PULSE IN
MILLISECONDS (MS): ???
 10
```

```
FIRST TRIAL VALUE OF CAPACITANCE
IN MICROFARADS (UF): ???
 .22


FOR A DURATION OF  10  MS USE
A RESISTANCE OF  65590  OHMS
AND A CAPACITANCE OF  .22  UF

PRESS CR TO CONTINUE...



WHAT NOW?

1. DO ANOTHER?
2. FINISHED?

SELECTION: ???
 2


PROGRAM ENDED
```


PROGRAM 40

Design of a Square-Wave Oscillator

The circuit of Fig. 40.1 will produce a square-wave output of a frequency that is determined by R_A, C, R_1 and R_2. This circuit is called an astable multivibrator. This program will permit you to calculate the values of C and R_A for a specified frequency. You may also select either the standard configuration in which $R_1 = R_2$ or the custom configuration in which you set the values of R_1 and R_2. The program allows you to select duty factors of 25 to 75 percent.

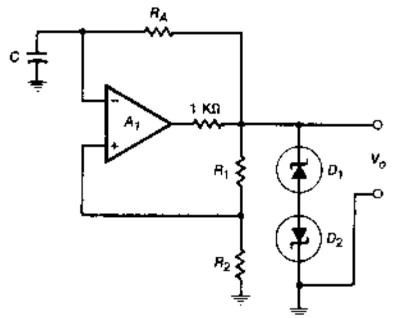


FIG. 40.1. CIRCUIT WILL PRODUCE A SQUARE-WAVE OUTPUT.

Design of a Square-Wave Oscillator

```
100 REM THIS IS PROGRAM NO. 40 PROG40
150 GOSUB 880
160 PRINT "* * * * * * * * * * * * * * * * * *"
170 PRINT "*  PROGRAM TO DESIGN A SIMPLE    *"
180 PRINT "*     SQUAREWAVE GENERATOR       *"
190 PRINT "*        COPYRIGHT  1986         *"
200 PRINT "*           BY JJ CARR           *"
210 PRINT "* * * * * * * * * * * * * * * * * *"
220 GOSUB 840
230 GOSUB 920
240 GOSUB 880
250 PRINT "THIS PROGRAM CALCULATES THE"
255 PRINT "COMPONENT VALUES USED TO SET"
260 PRINT "OPERATING FREQUENCY IN AN"
265 PRINT "OPERATIONAL AMPLIFIER SQUAREWAVE"
270 PRINT "GENERATOR CIRCUIT."
272 PRINT
275 PRINT "SELECT A TRIAL VALUE OF"
280 PRINT "CAPACITANCE (IN UF), AND THEN"
285 PRINT "THE PROGRAM WILL CALCULATE THE"
295 PRINT "THE REQUIRED RESISTANCE."
330 PRINT
340 GOSUB 920
350 GOSUB 880
360 REM  SELECT VARIABLE OR FIXED FREQUENCY OPERATION
370 GOSUB 480
380 REM  SELECT STANDARD OR CUSTOM CONFIGURATION
390 GOSUB 620
400 REM  SET DUTY FACTOR 25 TO 75 PERCENT (NORMAL = 50%)
410 GOSUB 710
420 REM  CALCULATE THE VALUE OF RESISTANCES
430 IF M = 1 THEN  GOSUB 950
440 IF M = 2 THEN  GOSUB 1290
450 PRINT
460 GOSUB 920
470 GOTO 1720
480 GOSUB 840
490 PRINT "SELECT ONE FROM MENU BELOW:"
500 PRINT
510 PRINT "1. FIXED-FREQUENCY OPERATION"
520 PRINT "2. VARIABLE-FREQUENCY OPERATION"
530 PRINT
540 PRINT "SELECTION: ???"
545 INPUT M
550 IF M > 2 THEN  GOTO 500
560 RETURN
570 GOSUB 840
580 PRINT "FIRST TRIAL CAPACITANCE IN MICROFARADS (UF):
    ???"
```



```
585 INPUT C
590 C = C / 10 ^ 6
600 GOSUB 840
610 RETURN
620 GOSUB 840
630 PRINT
640 PRINT "SELECT ONE FROM MENU BELOW:"
650 PRINT
660 PRINT "1. STANDARD CONFIGURATION (R1 = R2)"
670 PRINT "2. CUSTOM CONFIGURATION"
680 PRINT
690 PRINT "SELECTION: ???"
695 INPUT K
700 RETURN
710 GOSUB 840
720 PRINT "SET DUTY FACTOR 25 TO 75 PERCENT):"
730 PRINT "USE DECIMAL FORM, E.G. '0.25' FOR 25 PERCENT"
740 PRINT
750 PRINT "DUTY FACTOR: ???"
755 INPUT D1
760 D2 = 1 - D1
770 IF D1 > 0.75 THEN  GOSUB 2000
780 IF D1 > 0.75 THEN  GOSUB 920
790 IF D1 > 0.75 THEN  GOTO 710
800 IF D1 < 0.25 THEN  GOSUB 2000
810 IF D1 < 0.25 THEN  GOSUB 920
820 IF D1 < 0.25 THEN  GOTO 710
830 RETURN
840 FOR I = 1 TO 5
850 PRINT
860 NEXT I
870 RETURN
880 FOR I = 1 TO 30
890 PRINT
900 NEXT I
910 RETURN
920 PRINT "PRESS CR TO CONTINUE..."
930 INPUT KK
940 RETURN
950 REM
960 GOSUB 840
970 PRINT "FIXED-FREQUENCY OPTION SELECTED"
980 GOSUB 840
990 PRINT "OPERATING FREQUENCY IN HERTZ"
993 PRINT "(HZ): ???"
995 INPUT F
1000 PRINT
1010 REM  SELECT TRIAL CAPACITANCE
```

```
1020 GOSUB 570
1030 T = 1 / F
1040 IF K = 1 THEN RA = T / (2.1972 * C)
1050 IF K = 2 THEN  GOSUB 1080
1060 IF D1 = 0.5 THEN  GOTO 1180
1070 IF D1 <  > 0.5 THEN  GOTO 1160
1080 GOSUB 840
1090 PRINT "VALUE OF R1 IN OHMS: ???"
1095 INPUT R1
1100 PRINT
1110 PRINT "VALUE OF R2 IN OHMS: ???"
1115 INPUT R2
1120 PRINT
1130 A =  LOG (1 + ((2 * R1) / (R2)))
1140 RA = T / (2 * C * A)
1150 RETURN
1160 RB = RA * D2
1170 RA = RA * D1
1180 GOSUB 840
1190 C = C * 10 ^ 6
1200 PRINT "FOR A FREQUENCY OF ";F;" HZ, USE:"
1210 RA =  INT (RA)
1220 RB =  INT (RB)
1230 PRINT "C = ";C;" UF"
1240 PRINT "RA = ";RA;" OHMS"
1250 IF D1 <  > 0.5 THEN  GOSUB 2100
1260 PRINT "DUTY FACTOR: ";D1 * 100;" PERCENT"
1270 IF K = 2 THEN  GOSUB 2200
1280 RETURN
1290 REM
1300 GOSUB 840
1310 PRINT "VARIABLE-FREQUENCY OPERATION SELECTED"
1320 GOSUB 840
1330 PRINT "LOWEST FREQUENCY OF OPERATION"
1333 PRINT "IN HERTZ (HZ): ???"
1335 INPUT FL
1340 PRINT
1350 PRINT "HIGHEST FREQUENCY OF OPERATION"
1353 PRINT "IN HERTZ (HZ): ???"
1355 INPUT FH
1360 PRINT
1370 REM  SELECT TRIAL CAPACITANCE
1380 GOSUB 570
1390 TL = 1 / FL
1400 TH = 1 / FH
1410 IF K = 1 THEN RL = TL / (2.1972 * C)
1420 IF K = 1 THEN RH = TH / (2.1972 * C)
1430 IF K = 2 THEN  GOSUB 1460
```



```
1440 IF D1 = 0.5 THEN  GOTO 1580
1450 IF D2 <  > 0.5 THEN  GOTO 1540
1460 PRINT "VALUE OF R1 IN OHMS: ???"
1465 INPUT R1
1470 PRINT
1480 PRINT "VALUE OF R2 IN OHMS: ???"
1485 INPUT R2
1490 PRINT
1500 A =  LOG (1 + ((2 * R1) / (R2)))
1510 RL = TL / (2 * C * A)
1520 RH = TH / (2 * C * A)
1530 RETURN
1540 RZ = RL * D2
1550 RX = RH * D2
1560 RL = RL * D1
1570 RH = RH * D1
1580 GOSUB 840
1590 C = C * 10 ^ 6
1600 PRINT "FOR A FREQUENCY OF ";FL
1605 PRINT "TO ";FH;" HZ, USE:"
1610 RL =  INT (RL)
1620 RH =  INT (RH)
1630 RZ =  INT (RZ)
1640 RX =  INT (RX)
1650 PRINT
1660 PRINT "CAPACITANCE C = ";C;" UF"
1670 PRINT "RESISTANCE RA: ";RL;" TO ";RH;" OHMS"
1680 IF D1 <  > 0.5 THEN  GOSUB 2400
1690 PRINT "DUTY FACTOR: ";D1 * 100;" PERCENT"
1700 IF K = 2 THEN  GOSUB 2500
1710 RETURN
1720 GOSUB 880
1730 PRINT "WHAT'S YOUR PLEASURE?"
1740 PRINT
1750 PRINT "1. DO ANOTHER OF THE SAME SORT"
1760 PRINT "2. RETURN TO MAIN MENU"
1770 PRINT "3. FINISHED"
1780 PRINT
1790 PRINT "SELECTION: ???"
1795 INPUT L
1800 IF L > 3 THEN  GOTO 1730
1810 ON L GOTO 430,350,1820
1820 GOSUB 880
1830 PRINT "PROGRAM ENDED"
1840 END
2000 PRINT "ERROR! DUTY FACTOR OUT OF"
2002 PRINT "LIMITS --- TRY AGAIN!"
2005 RETURN
```

```
2100 PRINT "RB = ";RB;" OHMS"
2105 RETURN
2200 PRINT "R1 = ";R1;" OHMS, R2 = ";R2;"OHMS"
2205 RETURN
2400 PRINT "RESISTANCE RB: ";RZ;" TO ";RX;" OHMS"
2405 RETURN
2500 PRINT "R1 = ";R1;" OHMS, R2 = ";R2;" OHMS"
2505 RETURN
```


PROGRAM 41

Design of RC Low-Pass, High-Pass, and Bandpass Filter Networks

Figure 41.1 shows three simple RC networks: high-pass filter, low-pass filter, and bandpass filter. These networks are used to waveshape complex signals or to set the frequency response limits for circuits such as audio and instrumentation amplifiers. The high-pass and low-pass filters require you to select either the high or low (−3 dB) frequency (respectively), while the bandpass filter requires you to select both the upper and lower (−3 dB) frequencies. You will also supply the input and output resistances, which generally must be matched to source and load resistances, respectively. These circuits yield a rolloff of approximately −6 dB/octave from the appropriate −3 dB point. Greater slopes can be achieved by cascading sections, but this requires care in that the output resistance (R_B) of a driving stage must match the input resistance (R_L) of a receiving stage.

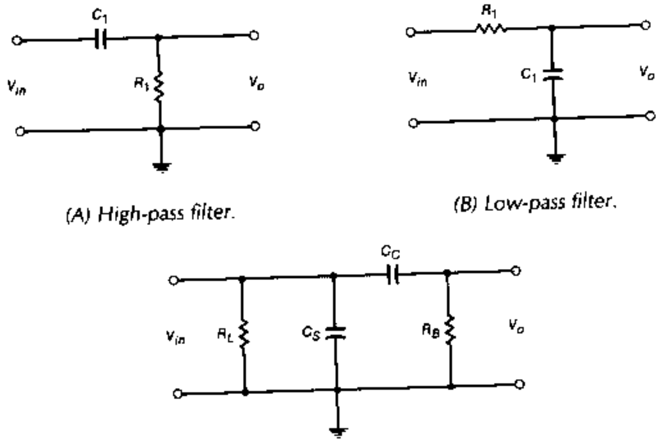
$$F = \frac{1}{2\,\pi\,R\,C} \qquad [41.1]$$

$$C_S = \frac{R_L + R_B}{2\,\pi\,F_H\,R_L\,R_B} \qquad [41.2]$$

$$C_C = \frac{1}{2\,\pi\,F_L\,(R_L + R_B)} \qquad [41.3]$$

$$F_L = \frac{1}{2\,\pi\,C_C\,(R_L + R_B)} \qquad [41.4]$$

$$F_H = \frac{1}{2\,\pi\,C_S\,R_L\,R_B} \qquad [41.5]$$



(A) High-pass filter. (B) Low-pass filter.

(C) Bandpass filter.

FIG. 41.1. THREE SIMPLE RC NETWORKS.

Design of RC Low-Pass, High-Pass, and Bandpass Filter Networks

```
100 REM THIS IS PROGRAM NO. 41 PROG41
130 PI = 3.1415926
140 GOSUB 1320
150 PRINT "SELECT ONE FROM MENU BELOW:"
160 PRINT
170 PRINT "1. HIGH-PASS FILTER"
180 PRINT "2. LOW-PASS FILTER"
190 PRINT "3. BANDPASS FILTER"
200 PRINT
210 PRINT "SELECTION: ???"
215 INPUT M
220 IF M > 3 THEN  GOTO 150
230 ON M GOTO 240,240,660
240 GOSUB 1280
250 GOSUB 1280
260 PRINT "DESIGN OR EVALUATE?"
270 PRINT
280 PRINT "1. DESIGN"
290 PRINT "2. EVALUATE"
300 PRINT
```



```
310 PRINT "SELECTION: ???"
315 INPUT N
320 IF N > 2 THEN  GOTO 250
330 ON N GOTO 340,510
340 GOSUB 1280
350 PRINT "ENTER BREAKPOINT (-3 DB)"
353 PRINT "FREQUENCY IN HERTZ (HZ):"
355 INPUT F
360 PRINT
370 PRINT "SELECT TRIAL VALUE OF CAPACITANCE"
373 PRINT "IN MICROFARADS (UF):"
375 INPUT C
380 C = C / 10 ^ 6
390 R = 1 / (2 * PI * F * C)
400 R =  INT (R)
410 C = C * 10 ^ 6
420 GOSUB 1280
430 PRINT "FREQUENCY: ";F;" HZ"
440 PRINT "C = ";C;" UF"
450 PRINT "R = ";R;" OHMS"
460 IF M = 1 THEN  GOSUB 1600
470 IF M = 2 THEN  GOSUB 1610
480 PRINT
490 GOSUB 1360
500 GOSUB 1390
510 GOSUB 1280
520 PRINT "ENTER RESISTANCE IN OHMS: "
525 INPUT R
530 PRINT
540 PRINT "ENTER CAPACITANCE IN"
543 PRINT "MICROFARADS (UF):"
545 INPUT C
550 C = C / 10 ^ 6
560 PRINT
570 F = 1 / (2 * PI * R * C)
580 C = C * 10 ^ 6
590 F =  INT (F)
600 GOSUB 1280
610 PRINT "FREQUENCY: ";F;" HZ"
620 PRINT "C = ";C;" UF"
630 PRINT "R = ";R;" OHMS"
640 GOSUB 1360
650 GOSUB 1390
660 GOSUB 1320
670 PRINT "DESIGN OR EVALUATE?"
680 PRINT
690 PRINT "1. DESIGN"
```

```
700 PRINT "2. EVALUATE"
710 PRINT
720 PRINT "SELECTION: ???"
725 INPUT N
730 IF N > 2 THEN  GOTO 670
740 ON N GOTO 750,990
750 GOSUB 1320
760 PRINT "ENTER LOWER CUT-OFF (-3 DB) FREQUENCY:"
765 INPUT FL
770 PRINT
780 PRINT "ENTER UPPER CUT-OFF (-3 DB) FREQUENCY:"
785 INPUT FH
790 PRINT
800 PRINT "ENTER INPUT RESISTANCE (RL):"
805 INPUT RL
810 PRINT
820 PRINT "ENTER OUTPUT RESISTANCE (RB):"
825 INPUT RB
830 PRINT
840 CS = (RL + RB) / (2 * PI * FH * RL * RB)
850 CS = CS * 10 ^ 6
860 CC = 1 / (2 * PI * FL * (RL + RB))
870 CC = CC * 10 ^ 6
880 GOSUB 1280
890 PRINT "LOWER -3 DB FREQUENCY: ";FL;" HZ"
900 PRINT "UPPER -3 DB FREQUENCY: ";FH;" HZ"
910 PRINT
920 PRINT "INPUT RESISTANCE: ";RL;" OHMS"
930 PRINT "OUTPUT RESISTANCE: ";RB;" OHMS"
940 PRINT
950 PRINT "CAPACITANCE CC: ";CC;" UF"
960 PRINT "CAPACITANCE CS: ";CS;" UF"
970 GOSUB 1360
980 GOSUB 1390
990 GOSUB 1320
1000 PRINT "ENTER INPUT RESISTANCE (RL) IN OHMS:"
1005 INPUT RL
1010 PRINT
1020 PRINT "ENTER OUTPUT RESISTANCE (RB) IN OHMS:"
1025 INPUT RB
1030 PRINT
1040 PRINT "ENTER CAPACITANCE (CC) IN"
1043 PRINT "MICROFARADS (UF):"
1045 INPUT CC
1050 PRINT
1060 PRINT "ENTER CAPACITANCE (CS) IN"
1063 PRINT "MICROFARADS (UF):"
```



```
1065 INPUT CS
1070 PRINT
1080 CC = CC / 10 ^ 6
1090 CS = CS / 10 ^ 6
1100 FL = 1 / (2 * PI * CC * (RL + RB))
1110 FH = (RL + RL) / (2 * PI * CS * RL * RB)
1120 FL =  INT (FL)
1130 FH =  INT (FH)
1140 CC = CC * 10 ^ 6
1150 CS = CS * 10 ^ 6
1160 GOSUB 1320
1170 PRINT "INPUT IMPEDANCE (RL): ";RL;" OHMS"
1180 PRINT "OUTPUT IMPEDANCE (RB): ";RB;" OHMS"
1190 PRINT
1200 PRINT "CAPACITANCE CS: ";CS;" UF"
1210 PRINT "CAPACITANCE CC: ";CC;" UF"
1220 PRINT
1230 PRINT "LOWER -3 DB FREQUENCY: ";FL;" HZ"
1240 PRINT "UPPER -3 DB FREQUENCY: ";FH;" HZ"
1250 PRINT
1260 GOSUB 1360
1270 GOSUB 1390
1280 FOR I = 1 TO 5
1290 PRINT
1300 NEXT I
1310 RETURN
1320 FOR I = 1 TO 30
1330 PRINT
1340 NEXT I
1350 RETURN
1360 PRINT "PRESS CR TO CONTINUE..."
1370 INPUT KK
1380 RETURN
1390 GOSUB 1320
1400 PRINT "WHAT'S YOUR PLEASURE?"
1410 PRINT
1420 PRINT "1. DO ANOTHER?"
1430 PRINT "2. FINISHED?"
1440 PRINT
1450 PRINT "SELECTION: ???"
1455 INPUT V
1460 IF V > 2 THEN  GOTO 1400
1470 ON V GOTO 140,1480
1480 GOSUB 1320
1490 PRINT "PROGRAM ENDED"
1500 END
1600 PRINT "HIGH-PASS FILTER"
```

```
1605 RETURN
1610 PRINT "LOW-PASS FILTER"
1615 RETURN
7400 NN GOTO 750,990
```


PROGRAM 42

Design of Active Bandpass Filter Using Operational Amplifier

The circuit for an operational amplifier active bandpass filter and the equations governing this circuit are shown in Fig. 42.1. The program will permit you to input and add low end (−3 dB) frequencies and then center-band frequency. It will then calculate the values of the resistances from the trial values of capacitance that you selected. If the resistance values are too difficult to obtain, try another trial value of C. If there is a combination that results in a nearly perfect match to available "standard" resistor values, evaluate your actual need for precision in the upper and lower (−3 dB) frequencies. The slight degradation may well be worth the ability to use easily available resistor values.

Select:

$$C_1, C_2, Q, A_V, \text{ and } F_O$$

$$Q = \frac{F_O}{F_H - F_L} \qquad [42.1]$$

$$R_1 = \frac{Q}{A_V \omega C_1} \qquad [42.2]$$

$$R_2 = \frac{Q}{(2Q^2 - A_V)\omega C_1} \qquad [42.3]$$

$$R_3 = \frac{2Q}{\omega C_1} \qquad [42.4]$$

$$R_4 = R_5 = 0.02R_3$$

$$\omega = 2\pi F$$

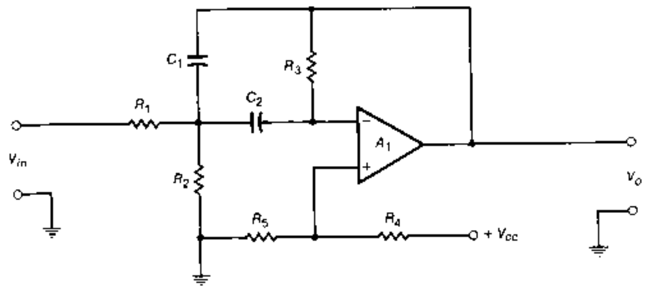


FIG. 42.1. CIRCUIT FOR AN OPERATIONAL AMPLIFIER ACTIVE BANDPASS FILTER.

Design of Active Bandpass Filter Using Operational Amplifier

```
100 REM THIS IS PROGRAM NO. 42 PROG42
130 GOSUB 620
140 PRINT "ENTER CENTER FREQUENCY IN HERTZ:"
145 INPUT FO
150 PRINT
160 PRINT "ENTER LOWER -3 DB FREQUENCY IN HERTZ:"
165 INPUT FL
170 PRINT
180 PRINT "ENTER UPPER -3 DB FREQUENCY IN HERTZ:"
185 INPUT FH
190 PRINT
200 Q = FO / (FH - FL)
210 PRINT "SELECT VOLTAGE GAIN (AV):"
215 INPUT AV
220 PRINT
230 PRINT "SELECT TRIAL VALUE FOR C1 ANDC2"
232 PRINT "IN MICROFARADS (UF0:"
235 INPUT C
240 PRINT
250 C = C / 10 ^ 6
260 W = 2 * 3.14159 * FO
270 R1 = Q / (AV * W * C)
280 R2 = Q / (((2 * Q ^ 2) - AV) * W * C)
```



```
290 R2 =  ABS (R2)
300 R3 = (2 * Q) / (W * C)
310 R4 = 0.02 * R3
320 R5 = R4
330 C = C * 10 ^ 6
340 C4 = C
350 C5 = C
360 R1 =  INT (R1)
370 R2 =  INT (R2)
380 R3 =  INT (R3)
390 R4 =  INT (R4)
400 R5 =  INT (R5)
410 GOSUB 620
420 PRINT "CENTER FREQUENCY: ";FO;" HZ"
430 PRINT "LOWER -3 DB FREQUENCY: ";FL;" HZ"
440 PRINT "UPPER -3 DB FREQUENCY: ";FH;" HZ"
450 PRINT "R1 = ";R1;" OHMS"
460 PRINT "R2 = ";R2;" OHMS"
470 PRINT "R3 = ";R3;" OHMS"
480 PRINT "R4 = ";R4;" OHMS"
490 PRINT "R5 = ";R5;" OHMS"
500 PRINT "C1 = ";C;" UF"
510 PRINT "C2 = ";C;" UF"
520 PRINT "VOLTAGE GAIN: ";AV
530 PRINT "Q = ";Q
540 PRINT
550 PRINT
560 GOSUB 660
570 GOTO 690
580 FOR I = 1 TO 5
590 PRINT
600 NEXT I
610 RETURN
620 FOR I = 1 TO 30
630 PRINT
640 NEXT I
650 RETURN
660 PRINT "PRESS CR TO CONTINUE..."
670 INPUT KK
680 RETURN
690 GOSUB 620
700 PRINT "WHAT'S YOUR PLEASURE?"
710 PRINT
720 PRINT "1. DO ANOTHER?"
730 PRINT "2. FINISHED?"
740 PRINT
750 PRINT "SELECTION: ???"
```

Design of Active Bandpass Filter Using Operational Amplifier—cont.

```
755 INPUT K
760 IF K > 2 THEN  GOTO 700
770 ON K GOTO 130,780
780 GOSUB 620
790 PRINT "PROGRAM ENDED"
800 END
```


Section III

MISCELLANEOUS

The program in this section is included as a bonus. The program allows you to "import" BASIC programs from other computers that do not speak the BASIC dialect used by the Commodore 64 and Commodore 128 computers.

PROGRAM 43

BASIC Import

In the equipment connection in Fig. 43.1, the receiving computer that imports the BASIC programs is the Commodore 64 or Commodore 128 equipped with an Omnitronix Deluxe RS-232 Interface Unit. The exporting computer can be almost any computer with a 300 baud RS-232C serial port available.

The program makes the Commodore computer think that computer "A" is a 300 baud keyboard. The BASIC programs are tacked onto the end of Program 43, so it will only correctly import programs with starting line numbers of 7 or higher. Once the programs are imported into the Commodore computer, they can be saved in the ordinary manner (be sure to delete line numbers 0–6 before saving, however).

The exporting computer must be capable of converting the BASIC program on the screen into ASCII text. Most computers store BASIC programs in the form of tokens or keyword fragments, which are not exportable to other computers. Some computers allow the disk drive to be designated as a de facto printer; thus when you "print to disk," the new file on the disk will be in ASCII, not in token format. Alternatively, you can often buy software that will convert BASIC programs into an ASCII file. For example, the program called *ASCII Express* for Apple II is basically a telecommunications program, but it contains a utility program ("MPF.A" on reverse side of disk) that is designed to convert BASIC files into ASCII files.

Operation of Program 43 is as follows:

1. Convert BASIC program on Computer "A" to an ASCII file.
2. Set up computer "A" telecommunications program to

send file to Commodore computer, but don't transmit just yet.

3. Load Program 1 into the Commodore computer.
4. Type RUN on Commodore computer and press return.
5. Transmit program from Computer "A" to the Commodore computer.
6. After transfer ends, type LIST on computer "A" keyboard and press Computer "A" return.
7. On Commodore computer delete lines 0 through 6.
8. Save program on Commodore computer.

Note: The RS-232 Interface Unit is available from Omnitronix, Inc., 6014 E. Mercer Way, POB 43, Mercer Island, WA, 98040, or its authorized dealers.

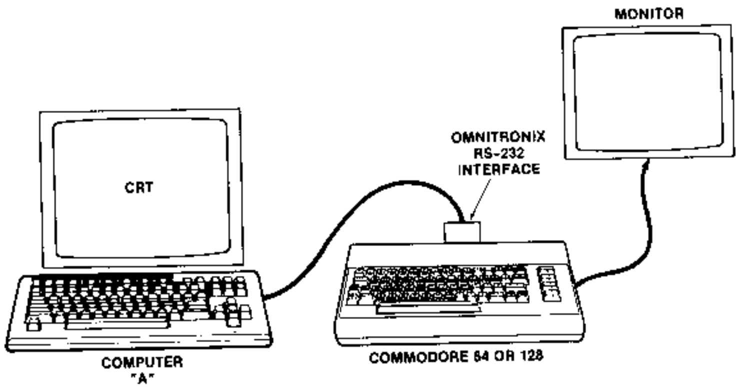


FIG. 43.1. EQUIPMENT CONNECTION.

BASIC Import

```
0 OPEN2,2,0,CHR$(6):PRINTCHR$(147)
1 GET#2,A$:IFVAL(A$)=0THEN1
2 PRINTA$;
3 GET#2,A$:PRINTA$;:IFA$<>CHR$(13)THEN3
4 PRINT:PRINT"POKE152,1:GOTO6"
5 POKE631,19:POKE632,13:POKE633,13:POKE634,13:POKE635,
  13:POKE198,5:END
6 PRINTCHR$(147);:GOTO3
```

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Joseph J. Carr, an electrical engineer, has authored over 43 books and written more than 200 magazine articles for *Electronic Digest*, *Electronic Servicing*, *Ham Radio*, *Popular Electronics*, and others.

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