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APPENDICES

APPENDIX A

FREQUENCY RESPONSE OF RF NOISE FILTER

```
// FOR
*LIST SOURCE PROGRAM
*ONE WORD INTEGERS
*EXTENDED PRECISION
*IOCS(CARD,TYPEWRITER,KEYBOARD,1132PRINTER,DISK)
      WRITE(3,90)
   90 FORMAT(/////10X,6HRADIAN,17X,'FREQUENCY',13X,'DECIBEL',//)
      R   =  30.
      AL  =  6.0E-4
      C   =  1.0E-6
      W   =  0.125
    1 G1  =  1.
      G2  =  W*W*(AL*AL/4./(R*R)+C*C*R*R-AL*C)
      G3  =  W**4*(AL*AL*C*C/2.-AL*R*R*C*C*C)
      G4  =  (W**6)*R*R*AL*AL*(C**4)
      G0  =  G1+G2+G3+G4
      G00  =  1/SQRT(G0)
      G  =  ALOG(G00)*20.
      F  =  W/2./3.14159
      WRITE(3,100) W,F,G
  100 FORMAT(5X,F18.3,5X,F18.3,5X,F18.3)
      W   =  2.0*W
      IF(W-100000000.)1,1,2
    2 D   =  0.1
      RA  =50./10000.
      D1  =  D**0.33333
      D2  =  D**0.66666
      D0  =  1./D1-D2
      DL  =  1.+(RA**2)*(D0**2)-2.*(RA**4)*D0+RA**6
      DLOSS =  10.*ALOG(DL)
      WRITE(3,101) DLOSS
  101 FORMAT(////5X,'INSERTION LOSS  = ',F10.3,'  DECIBEL')
      CALL EXIT
      END

FEATURES SUPPORTED
 ONE WORD INTEGERS
 EXTENDED PRECISION
 IOCS

CORE REQUIREMENTS FOR
 COMMON       0  VARIABLES     72  PROGRAM     404

END OF COMPILATION

// XEQ
```

RADIAN	FREQUENCY	DECIBEL
0.125	0.019	0.000
0.250	0.039	0.000
0.500	0.079	0.000
1.000	0.159	0.000
2.000	0.318	0.000
4.000	0.636	-0.000
8.000	1.273	-0.000
16.000	2.546	-0.000
32.000	5.092	-0.000
64.000	10.185	-0.000
128.000	20.371	-0.000
256.000	40.743	-0.000
512.000	81.487	-0.001
1024.000	162.974	-0.004
2048.000	325.949	-0.016
4096.000	651.899	-0.065
8192.000	1303.798	-0.250
16384.000	2607.596	-0.840
32768.000	5215.193	-3.475
65536.000	10430.387	-30.794
131072.000	20860.774	-73.424
262144.000	41721.548	-115.470
524288.000	83443.097	-157.179
1048576.000	166886.194	-179.233
2097152.001	333772.389	-178.098
4194304.003	667544.779	-177.306
8388608.007	1335089.558	-212.663
16777216.015	2670179.116	-240.717
33554432.031	5340358.232	-268.463
67108864.062	10680716.464	-296.191

INSERTION LOSS = 0.000 DECIBEL

GEOMETRIC PROGRAMMING FOR TRANSFORMER DESIGNED

```
C       SOLUTION TO A GENERALIZED GEOMETRIC PROGRAMMING PROBLEM
C
        COMMON N,M,SIG,M1,KTT,KTO,MR,N1,IT,MR1,V,SUM,NR
        COMMON C(16)
        COMMON X(9),KT(7),W(16),A(16,9),R(16,16),PIVOT(16),AMD(6),E(16)
        COMMON MM
        DIMENSION IPVCT(16),INDEX(16,2)
C
        NI = 5
        NO = 6
        WRITE(NO,399)
C
C       ************** INPUT TO THE PROBLEM ************************
C
        WRITE(NO,315)
        READ(NI,100) N,M,SIG
        KTT=0
        M1=M+1
C
C       NUMBER OF TERMS IN EACH POLYNOMIAL
C
        DO 200 L=1,M1
        READ(NI,101) KT(L)
  200   KTT = KTT + KT(L)
        KSIG=SIG
        IF(M-1)263,263,264
  263   WRITE(NO,197) N,M,KTT,KSIG
        GO TO 500
  264   WRITE(NO,109) N,M,KTT,KSIG
  500   CONTINUE
        WRITE(NO,301)
        WRITE(NO,305)
C
C       COEFFICIENTS AND EXPONENTS
C
        I2=0
        DO202L=1,M1
        I1=I2+1
        I2=I1+KT(L)-1
        DO202I=I1,I2
        READ(NI,199) C(I)
        READ(NI,102) A(I,1),A(I,2),A(I,3),A(I,4),A(I,5),A(I,6)
        READ(NI,102) A(I,7),A(I,8),A(I,9)
  202   WRITE(NO,107) L,I,C(I),A(I,1),A(I,2),A(I,3),A(I,4),A(I,5),A(I,6),
       1A(I,7),A(I,8),A(I,9)
C
C       INITIAL SOLUTION
C
        DO 203 J=1,N
  203   READ(NI,103) X(J)
C
C       ************************************************************
C
```

```
C     ************************************************************
      MR = M + N + 1
      N1=N + 1
      NR = N + 2
      MR1= MR+1
      KTO = KT(1)
      IT = 1
      MRX=16
      DO 213 IR=1,MRX
      DO 213 JR=1,MRX
  213 R(IR,JR) = 0.
C     ************************************************************
C
C     ****** EVALUATION OF THE INITIAL WEIGHTS ****************
C
C     THESE WEIGHTS WILL CHANGE AT EACH ITERATION
C
      CALL GP3
C
C     EVALUATION OF THE OBJECTIVE FUNCTION
C
      SUM =0.
      DO 206 I=1,KTO
  206 SUM=SUM+W(I)*(C(I)/ABS(C(I)))
C
C     INITIAL VALUE OF V
C
      V = ABS (SUM)
C
      DO 207 I = 1,KTO
  207 W(I)= W(I)/V
C
C     ************************************************************
  100 FORMAT(I4,I4,F5.1)
  109 FORMAT(1HO,9X,I3,10H VARIABLES,7X,I3,14H RESTRICTIONS ,7X,I3,
     19H TERMS    ,7X,14HOBJECTIVE SIGN,I3)
  197 FORMAT(1HO,9X,I3,10H VARIABLES,7X,I3,14H RESTRICTION  ,7X,I3,
     19H TERMS    ,7X,14HOBJECTIVE SIGN,I3)
  301 FORMAT(1HO,37X,26HCOEFFICIENTS AND EXPONENTS)
  305 FORMAT(1HO,1X,4HTERM,2X,11HCOEFFICIENT,3X,4HX(1),5X,4HX(2),5X,
     14HX(3),5X,4HX(4),5X,4HX(5),5X,4HX(6),5X,4HX(7),5X,4HX(8),5X,
     24HX(9))
  102 FORMAT(7F10.3)
  107 FORMAT(1HO,I2,1H-,I3,E13.6,9F9.4)
  199 FORMAT(E15.8)
  101 FORMAT(I4)
  103 FORMAT(6X,F10.5)
  315 FORMAT(10X,'**  GEOMETRIC PROGRAMMING PROBLEM  **')
  399 FORMAT(1H1)
C     ************************************************************
      CALL GP22
C
C     PRODUCT OF THE TRANSPOSE MATRIX OF ORTHOGONAL CONDITIONS FOR THE
C     CONSTRAINTS BY THE SAME MATRIX WITHOUT TRANSPOSING
C
      DO 215 JR=NR,MR
      DO 215 IR=NR,MR
      DO 215 KR= 1,N
```

```
  215 R(IR,JR) = R(IR,JR) + R(KR,IR) * R(KR,JR)
      MM=NR
C
C     INVERSION OF THE MATRIX FOUND ABOVE
C
      CALL GP10
C
C     PRODUCT OF THE TRANSPOSE MATRIX OF ORTHOGONAL CONDITIONS FOR
C     THE CONSTRAINTS BY THE VECTOR OF THE SAME CONDITIONS FOR THE
C     OBJECTIVE FUNCTION
C
      DO 224 JR=NR,MR
      DO 224 IR= 1,N
  224 R(N1,JR) = R(N1,JR) + R(IR,JR) * R(IR,N1)
C
C     INITIAL MULTIPLIERS
C
      DO 225 IR=NR,MR
      L = IR - N1
      AMD(L) = 0.
      DO 225 JR=NR,MR
  225 AMD(L) = AMD(L) + R(N1,JR) * R(IR,JR)
C
      DO 273 KKK=1,20
      IF(IT - 1)232,226,232
C
C     THE FIRST ITERATION IS NOT OVER
C
  226 CONTINUE
C
C     MATRIX T
C
      DO 231 J=1,N
      DO 231 JJ=1,N
      SU=0.
      DO 228 I=1,KTO
  228 SU = SU + C(I) / ABS(C(I)) * A(I,J) * A(I,JJ) * W(I)
      I2 = KTO
      SUD=0.
      DO 230 L=2,M1
      I1 = I2 + 1
      I2 = I1 + KT(L) - 1
      SUS = 0.
      DO 229 I=I1,I2
  229 SUS = SUS + C(I) / ABS(C(I)) * A(I,J) * A(I,JJ) * W(I)
      SUL = SUS * AMD(L - 1)
  230 SUD = SUD + SUL
  231 R(J,JJ) = SUD - SU
      GO TO 236
C
C     THE FIRST ITERATION IS OVER
C
  232 CONTINUE
C
C     NEW WEIGHTS GENERATED BY THE ALGORITHM
C
      CALL GP3
C
```

```
      SUM=0.
      DO243I=1,KTO
  243 SUM=SUM+W(I)*(C(I)/ABS(C(I)))
      DO 233 I=1,KTO
  233 W(I)=W(I)/V
C
C     NEW VECTOR AND MATRIX OF ORTHOGONAL CONDITIONS
C
      CALL GP22
C
      DO 235 L=1,M
      IR = L + N1
  235 AMD(L) = AMD(L) + PIVOT(IR)
      GO TO 226
  236 CONTINUE
C     ***************************************************************
C
C     EVALUATION OF THE ERROR
C
      SUMV=0.
      DO 286 I=1,KTO
  286 SUMV=SUMV+W(I)*(C(I)/ABS(C(I)))
      DO 254 IR=1,N
      E(IR)= 0.
      DO 253 JR=NR,MR
      J = JR - N1
  253 E(IR)=E(IR)+R(IR,JR)*AMD(J)
  254 E(IR)=R(IR,N1)-E(IR)
      E(N1)=SIG-SUMV
      I2 = KTO
      DO 256 L=2,M1
      I1 = I2 + 1
      I2 = I1 + KT(L) - 1
      SG = 0.
      DO 255 I=I1,I2
  255 SG=SG+W(I)*(C(I)/ABS(C(I)))
      IR=L+N1-1
  256 E(IR)= 1. - SG
C
C     ***************************************************************
C
      WRITE(NO,314) IT
      DO 396 J=1,N
  396 WRITE(NO,108) J,X(J)
      WRITE(NO,308)
      VV=V*SIG
      WRITE(NO,104) SUM
      WRITE(NO,105) VV
C
C     ***************************************************************
  104 FORMAT(34X,18HOBJECTIVE FUNCTION,1H=,F15.8)
  105 FORMAT(34X,18HDUAL FUNCTION      ,1H=,F15.8)
  108 FORMAT(1HO,42X,2HX(,I2,5H ) = ,F15.8)
  314 FORMAT(1H1,//,1X,42H*****************************************
     11X,9HITERATION,I3,1X,41H*****************************************
  308 FORMAT(1X)
C     ***************************************************************
C
```

```
C     FINAL EXPRESSION OF THE NEWTON-RAPHSON MATRIX
C
      DO 250 IR=N1,MR
      DO 250 JR=1,N
  250 R(IR,JR) = R(JR,IR)
      DO 251 IR= N1,MR
      DO 251 JR= N1,MR
  251 R(IR,JR)= 0.
      R(N1,N1) =-SIG
C     ************************************************************
C
C     INVERSION OF THE MATRIX R
C
      MM = 1
C
      CALL GP10
C
C     THE INVERSE OF THE MATRIX R IS MULTIPLIED BY THE VECTOR E IN ORDER
C     TO FIND THE VECTOR OF ADJUSTMENTS
C
      DO 257 IR=1,MR
      PIVOT(IR)=0.
      DO 257 JR=1,MR
  257 PIVOT(IR) = PIVOT(IR) + R(IR,JR) * E(JR)
C
C     THE NEW ITERATION STARTS HERE
C
      IT = IT +1
C
C     THE PRIMITIVE SOLUTION IS MODIFIED AND A NEW VALUE OF V IS FOUND
C
      DO 258 J=1,N
  258 X(J) = X(J) * EXP(PIVOT(J))
      V = V * EXP(PIVOT(N1))
      DO 298 IR=1,N
      DO 298 JR=N1,MR
  298 R(IR,JR)=0.
C
C     TEST OF THE SOLUTION
C
      IF(ABS(V-SIG*SUM)/V-0.000003)274,274,273
C
C     THE SOLUTION IS SATISFACTORY*******************************
C
  274 GO TO 299
C
C     THE SOLUTION IS NOT SATISFACTORY***************************
C
  273 CONTINUE
      WRITE(NO,778)
      GO TO 897
  299 WRITE(NO,388)
  897 CONTINUE
      DO 395 J=1,N
  395 WRITE(NO,108) J,X(J)
      WRITE(NO,308)
      WRITE(NO,104) SUM
      VV=V*SIG
```

```
      WRITE(ND,105) VV
C
C     ****************************************************************
  388 FORMAT(1HO,45X,15HOPTIMAL RESULTS)
  778 FORMAT(30X,39HNOT ENOUGH CONVERGENCE IN 20 ITERATIONS)
C     ****************************************************************
C
      STOP
      END



      SUBROUTINE GP10
C
C     THE SUBROUTINE GP10 IS USED TO INVERT THE NEWTON AND RAPHSON
C     MATRIX,OR ONE SUBMATRIX OF IT
C
      COMMON N,M,SIG,M1,KTT,KTO,MR,N1,IT,MR1,V,SUM,NR
      COMMON C(16)
      COMMON X(9),KT(7),W(16),A(16,9),R(16,16),PIVOT(16),AMD(6),E(16)
      COMMON MM
      DIMENSION IPVOT(16),INDEX(16,2)
C
      DET = 1.
      DO 216 JR=MM,MR
  216 IPVOT(JR) = 0
      DO 241 IR=MM,MR
C
C     INVESTIGATION OF THE PIVOT
C
      T = 0.
      DO 220 JR=MM,MR
      IF(IPVOT(JR)-1)217,220,217
  217 DO 219 K=MM,MR
      IF(IPVOT(K)-1)218,219,239
  218 IF(ABS(T) - ABS(R(JR,K)))242,219,219
  242 IROW = JR
      ICOL = K
      T = R(JR,K)
  219 CONTINUE
  220 CONTINUE
      IPVOT(ICOL) = IPVOT(ICOL) + 1
C
C     THE PIVOT IS LOCATED ON THE DIAGONAL
C
      IF(IROW - ICOL)221,223,221
  221 DET = -DET
      DO 222 LL=MM,MR
      T = R(IROW,LL)
      R(IROW,LL) = R(ICOL,LL)
  222 R(ICOL,LL) = T
  223 INDEX(IR,1) = IROW
      INDEX(IR,2)=ICOL
      PIVOT(IR)=R(ICOL,ICOL)
      DET = DET * PIVOT(IR)
C
```

```
C
      R(ICOL,ICOL)=1.
      DO 284 LL=MM,MR
  284 R(ICOL,LL)=R(ICOL,LL)/PIVOT(IR)
C
C     ROWS WITHOUT PIVOT ARE REDUCED
C
      DO 241 KL=MM,MR
      IF(KL-ICOL) 245,241,245
  245 T=R(KL,ICOL)
      R(KL,ICOL)=0.
      DO 240 LL=MM,MR
  240 R(KL,LL)=R(KL,LL)-R(ICOL,LL)*T
  241 CONTINUE
C
C     COLUMNS ARE EXCHANGED
C
      DO 238 IR=MM,MR
      LL=MR-IR+MM
      IF (INDEX(LL,1)-INDEX(LL,2)) 227,238,227
  227 JROW=INDEX(LL,1)
      JCOL=INDEX(LL,2)
      DO 237 K=MM,MR
      T=R(K,JROW)
      R(K,JROW)=R(K,JCOL)
      R(K,JCOL)=T
  237 CONTINUE
  238 CONTINUE
  239 RETURN
      END

FEATURES SUPPORTED
 ONE WORD INTEGERS

CORE REQUIREMENTS FOR GP10
 COMMON   1638  VARIABLES     76  PROGRAM     474

RELATIVE ENTRY POINT ADDRESS IS 0052 (HEX)

END OF COMPILATION

// DUP

*STORE       WS  UA  GP10
D 06 ENTRY POINT NAME ALREADY IN LET/FLET


// EJECT
```

```
      SUBROUTINE GP3
C
C     THE SUBROUTINE GP3 CALCULATES THE ABSOLUTE VALUE OF ALL THE TERMS
C     OF THE MODEL
C
      COMMON N,M,SIG,M1,KTT,KTO,MR,N1,IT,MR1,V,SUM,NR
      COMMON C(20)
      COMMON X(15),KT(10),W(20),A(20,15),R(20,20),PIVOT(20),AMD(9),E(20)
      COMMON MM
C
      I2=0
      DO 205 L=1,M1
      I1=I2+1
      I2=I1+KT(L)-1
      DO 205 I=I1,I2
      W(I)=1.
      DO 204 J=1,N
  204 W(I)=W(I)*X(J)**A(I,J)
  205 W(I)=W(I)*ABS(C(I))
      RETURN
      END

FEATURES SUPPORTED
 ONE WORD INTEGERS

CORE REQUIREMENTS FOR GP3
 COMMON   1638  VARIABLES      8  PROGRAM    134

RELATIVE ENTRY POINT ADDRESS IS 000C (HEX)

END OF COMPILATION

// DUP

*STORE      WS  UA  GP3
D 06 ENTRY POINT NAME ALREADY IN LET/FLET


// EJECT
```

```
*LIST SOURCE PROGRAM
*ONE WORD INTEGERS
      SUBROUTINE GP22
C
C  THE SUBROUTINE GP22 IS USED TO FIND THE VECTOR OF ORTHOGONAL
C      CONDITIONS FOR THE OBJECTIVE, AND THE MATRIX OF THESE CONDITIONS
C      FOR THE CONSTRAINTS
C
      COMMON N,M,SIG,M1,KTT,KTO,MR,N1,IT,MR1,V,SUM,NR
      COMMON C(20)
      COMMON X(15),KT(10),W(20),A(20,15),R(20,20),PIVOT(20),AMD(9),E(20)
      COMMON MM
C
      DO 212 IR=1,N
      I2=0
      DO 212 JR=N1,MR
      L=JR-N1+1
      I1=I2+1
      I2=I1+KT(L)-1
      J=IR
      DO 212 I=I1,I2
  212 R(IR,JR)=R(IR,JR)+C(I)/ABS(C(I))*A(I,J)*W(I)
      RETURN
      END

FEATURES SUPPORTED
 ONE WORD INTEGERS

CORE REQUIREMENTS FOR GP22
 COMMON    1638  VARIABLES      12  PROGRAM     128

RELATIVE ENTRY POINT ADDRESS IS 000E (HEX)

END OF COMPILATION

// DUP

*STORE       WS  UA  GP22
D 06 ENTRY POINT NAME ALREADY IN LET/FLET


// EJECT
```

ITERATION 1

X(1) = 0.10000002E 01

X(2) = 0.20000004E 01

X(3) = 0.10000002E 01

X(4) = 0.10000002E 01

X(5) = 0.10000001E-02

X(6) = 0.10000001E-02

X(7) = 0.10000001E-02

X(8) = 0.10000002E 01

X(9) = 0.10000002E 01

REMARK :

THE VARIABLE X_1 REPRESENTS c

THE VARIABLE X_2 REPRESENTS d

THE VARIABLE X_3 REPRESENTS a

THE VARIABLE X_4 REPRESENTS b

THE VARIABLE X_5-X_9 ARE SLACK VARIABLES

OPTIMAL RESULTS

X(1) = 0.70000069E 00

X(2) = 0.16996578E 01

X(3) = 0.88487433E 00

X(4) = 0.98010504E 00

X(5) = 0.18180036E 00

X(6) = 0.30432180E 00

X(7) = 0.14584275E 00

X(8) = 0.10000000E 01

X(9) = 0.10000000E 01

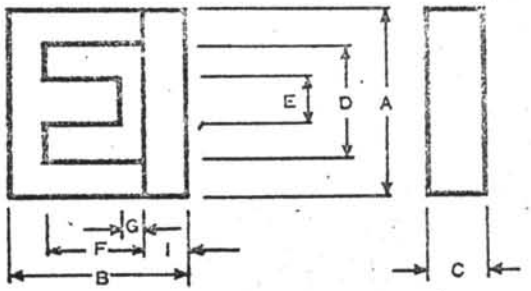
APPENDIX C

CHARACTERISTICS OF FERRITE

○ STANDARD CHARACTERISTICS

MATERIAL		2C3
μ_{iac}		2000 ±20%
$\tan\delta/\mu_{iac}$ 0.01MHz	10^{-6}	6
$\Delta\mu_{iac}/\mu_{iac}^2/℃$ (−30℃～−20～+60℃)	10^{-6}	1 ～5
Tc	℃	110
FREQUENCY	MHz	<0.2
D. F. (1 ～10min.)	10^{-6}	< 4
d	g/cm³	4.9
B 15	G	3,700
Hcms	Oe	0.2
ρ	Ωcm	130

EXAMPLE OF DEMENTIONS

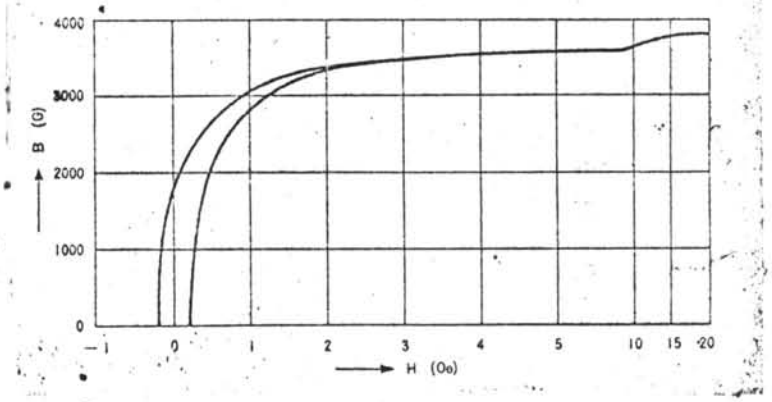


UNIT mm

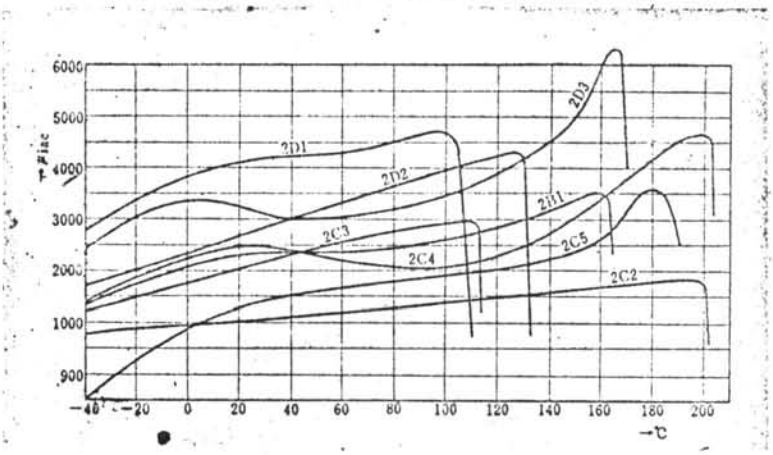
Name	A		B		C、E		D		F		I	
	Size	Tolerance	Size	Tolerance	Size	Tolerance	Size	Tolerance	Size	Tolerance	Size	Tolerance
E I 1-60	60.0	±0.6	44.0	±0.6	16.0	0 −0.6	44.5	±0.5	28.0	±0.5	8.0	±0.1
E I 2-60		±0.9		±0.6		0 −0.8		±0.7		±0.5		±0.3
E I 1-50	50.0	±0.5	42.0	±0.4	14.0	0 −0.6	35.0	±0.4	25.0	±0.4	8.5	±0.1
E I 2-50		±0.8		±0.6		0 −0.6		±0.6		±0.4		±0.3
E I 1-40	40.0	±0.4	34.0	±0.4	11.0	0 −0.4	28.0	±0.3	21.0	±0.4	6.5	±0.1
E I 2-40		±0.6		±0.6		0 −0.6		±0.5		±0.4		±0.3
E I 1-30	30.0	±0.3	26.0	±0.4	10.0	0 −0.4	20.0	±0.3	16.0	±0.3	5.5	±0.1
E I 2-30		±0.5		±0.4		0 −0.6		±0.4		±0.3		±0.2
E I 1-22	22.0	±0.3	18.6	±0.3	6.0	0 −0.4	14.0	±0.2	10.6	±0.2	4.0	±0.1
E I 2-22		±0.4		±0.4		0 −0.5		±0.3		±0.3		±0.2
E I 1-19	19.0	±0.2	15.8	±0.3	4.7	0 −0.4	14.5	±0.2	11.0	±0.2	2.4	±0.1
E I 2-19		±0.3		±0.4		0 −0.5		±0.3		±0.3		±0.2
E I 1-16	16.0	±0.2	14.0	±0.3	4.0	0 −0.3	12.0	±0.2	10.0	±0.2	2.0	±0.1
E I 2-16		±0.3		±0.4		0 −0.4		±0.3		±0.3		±0.2
E I 1-12	12.0	±0.2	9.6	±0.2	3.0	0 −0.2	8.0	±0.2	5.6	±0.2	2.0	±0.1
E I 2-12		±0.3		±0.3		0 −0.4		±0.3		±0.3		±0.1

STATIC MAGNETISATION CURVES

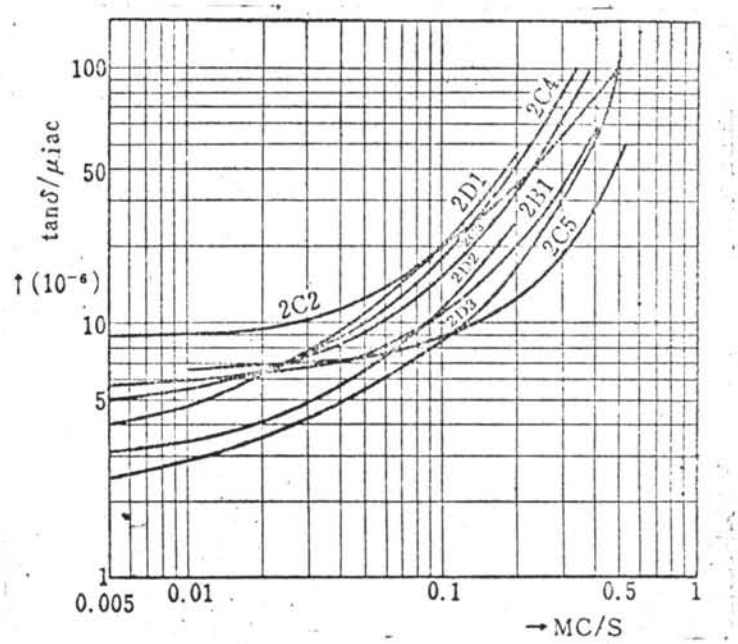
2C3



② TEMPERATURE CHARACTERISTIC



③ tan δ/μ iac CHARACTERISTICS



APPENDIX D

TRANSISTORS AND DIODES DATA

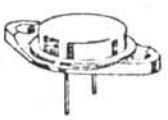
2N3902 NPN (SILICON)
2N5157

HIGH VOLTAGE NPN SILICON TRANSISTORS

. . . designed for use in high-voltage inverters, converters, switching regulators and line operated amplifiers.

- High Collector-Emitter Voltage – V_{CEX} = 700 Vdc
- Excellent DC Current Gain – h_{FE} = 10 (Min) @ I_C = 2.5 Adc
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 0.8 Vdc (Max) @ I_C = 1.0 Adc

3.5 AMPERE
POWER TRANSISTORS
NPN SILICON
400 and 500 VOLTS
100 WATTS



*MAXIMUM RATINGS

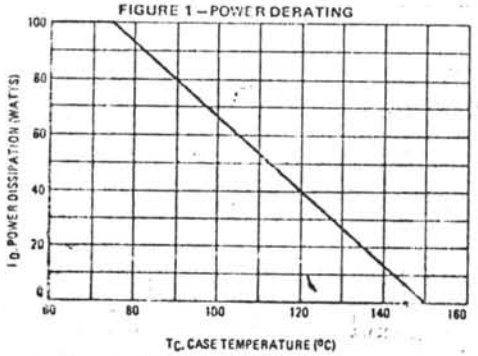
Rating	Symbol	2N3902	2N5157	Unit
Collector-Emitter Voltage	V_{CEO}	400	500	Vdc
Collector-Emitter Voltage	V_{CEX}	700		Vdc
Emitter-Base Voltage	* V_{EB}	5.0	6.0	Vdc
Collector Current – Continuous	I_C	3.5		Adc
Base Current	I_B	2.0		Adc
Total Device Dissipation @ T_C = 75°C Derate above 75°C	P_D	100 1.33		Watts W/°C
Operating Junction Temperature Range	T_J	-65 to +150		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

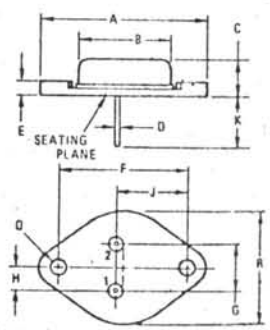
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.75	°C/W

*Indicates JEDEC Registered Data

FIGURE 1 – POWER DERATING



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.17	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

Collector connected to case.
CASE 11

2N3902, 2N5157 (continued)

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc, I_B = 0) (See Figure 12)	2N3902 2N5157	$V_{CEO(sus)}$	 325 400	 – –	Vdc
Collector-Emitter Breakdown Voltage (I_C = 3.5 Adc, R_{BE} = 10 Ohms) (See Figure 12)	2N5157	BV_{CER}	500	–	Vdc
Collector Cutoff Current (V_{CE} = 400 Vdc, I_B = 0) (V_{CE} = 500 Vdc, I_B = 0)	 2N3902 2N5157	I_{CEO}	 0.25 0.25	 – –	mAdc
Collector Cutoff Current (V_{CE} = 700 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 400 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)	 2N3902 2N5157 Both Types	I_{CEX}	 – – –	 2.5 0.5 0.5	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0) (V_{BE} = 6.0 Vdc, I_C = 0)	 2N3902 2N5157	I_{EBO}	 – –	 5.0 5.0	mAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc) (I_C = 2.5 Adc, V_{CE} = 5.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc, T_C = -55°C)	 2N3902,2N5157 2N3902,2N5157 2N5157	h_{FE}	 30 10 10	 90 – –	–
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc) (I_C = 2.5 Adc, I_B = 0.5 Adc) (I_C = 3.5 Adc, I_B = 0.7 Adc)	 2N3902,2N5157 2N3902 2N5157	$V_{CE(sat)}$	 – – –	 0.8 2.5 2.5	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc) (I_C = 2.5 Adc, I_B = 0.5 Adc) (I_C = 3.5 Adc, I_B = 0.7 Adc)	 2N3902,2N5157 2N3902 2N5157	$V_{BE(sat)}$	 – – –	 1.5 2.0 2.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 0.2 Adc, V_{CE} = 10 Vdc) (I_C = 0.2 Adc, V_{CE} = 12 Vdc)	 2N3902 2N5157	f_T	 2.8 2.8	 – –	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	2N5157	C_{ob}	–	150	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 125 Vdc, I_C = 1.0 Adc, I_{B1} = 0.1 Adc)	2N5157	t_{on}	–	0.8	μs
Turn-Off Time (V_{CC} = 125 Vdc, I_C = 1.0 Adc, I_{B1} = 0.1 Adc, I_{B2} = 0.5 Adc)	2N5157	t_{off}	–	1.7	μs

*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – SWITCHING TIMES TEST CIRCU.

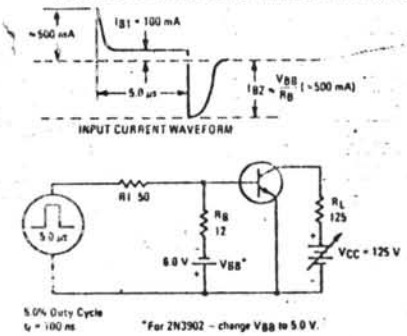


FIGURE 3 – TURN-ON TIME

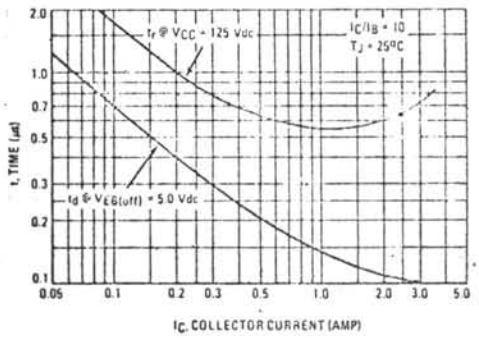


FIGURE 4 – THERMAL RESPONSE

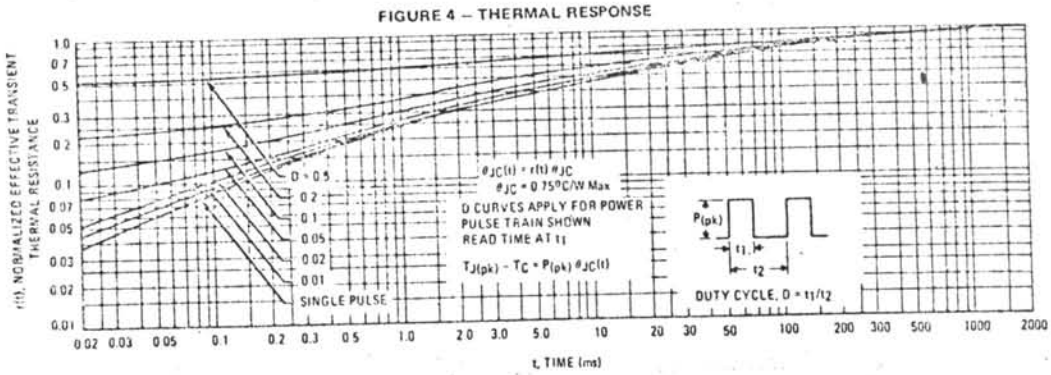
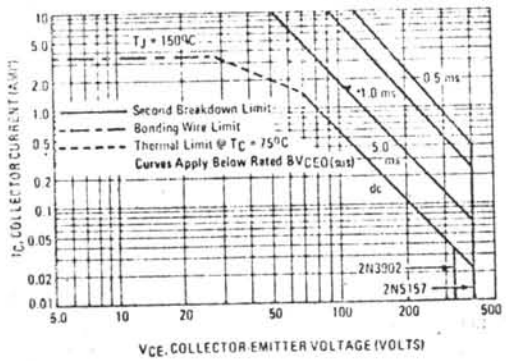


FIGURE 5 – ACTIVE-REGION SAFE-OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

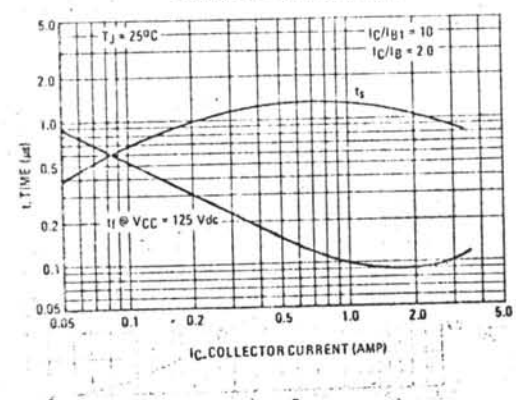
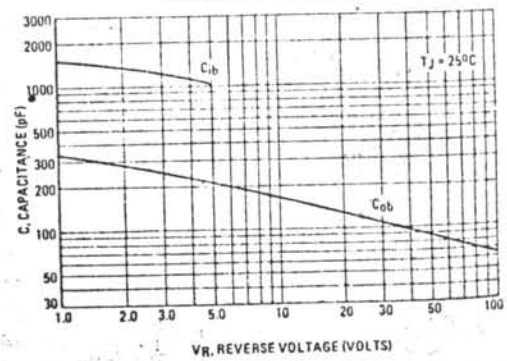


FIGURE 7 – CAPACITANCE



2N3902, 2N5157 (continued)

FIGURE 8 – DC CURRENT GAIN

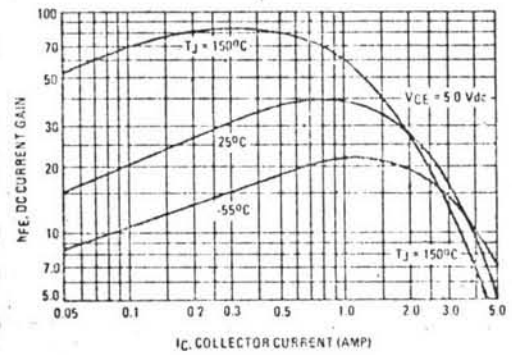


FIGURE 9 – "ON" VOLTAGES

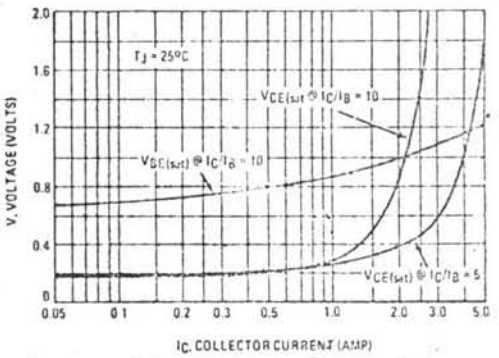


FIGURE 10 – COLLECTOR CUT-OFF REGION

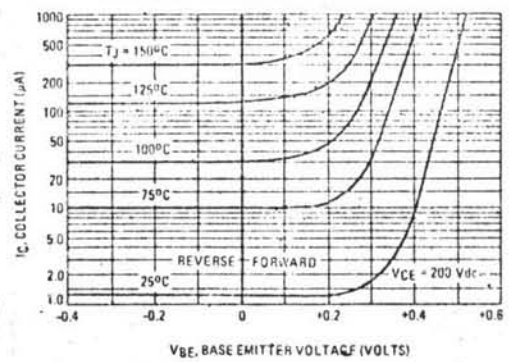


FIGURE 11 – TEMPERATURE COEFFICIENTS

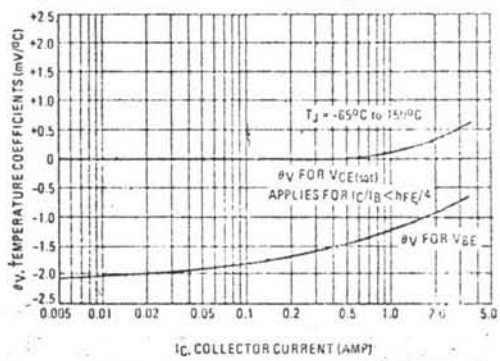
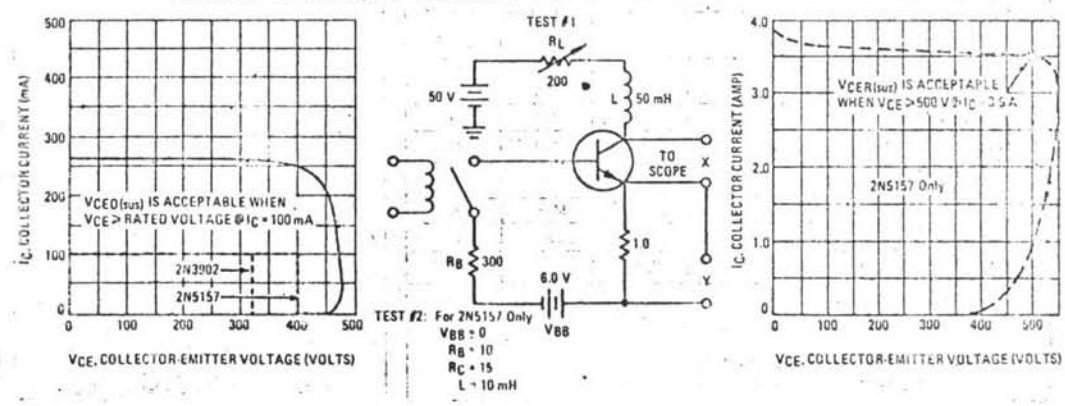


FIGURE 12 – COLLECTOR-EMITTER SUSTAINING VOLTAGE TEST CIRCUITS AND LOAD LINES



SPECIFICATION FOR FAST RECOVERY DIODE

"RAB 040"

peak inverse voltage 400 Volt DC.

reverse recovery time T_{rr} = 150 ns (at I_f 500 mA,)

minimum forward current at 25C

I_f = 3A

V_f = 0.6 Volt.

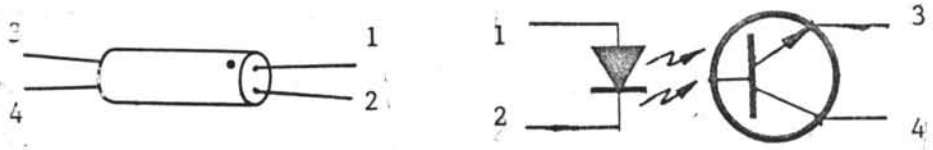
Maximum reverse current

I_r = 15 µA, T = 25C, V_r = 400 V

I_r = 300 µA, T = 100C, V_r = 400 Volt

SPECIFICATION FOR OPTICAL COUPLE

"OPI 110"



Current transfer ratio V_{CE} = 5V I_F = 10 mA

CRT = 20%

Collector current off state I_{Coff} 100 nA

at V_{CE} = 10 Volts

Input forward voltage V_{Fmax} 1.5 Volts

at I_F = 50 mA.

Isolation voltage 10 KV.

Rise time 6µsec at I_F = 10 mA

V_{CC} = 5 V

R_L = 100 Ω

APPENDIX E

WIRE GAGE

Gauge				Diameter		Sectional area			Copper wire weight	
B.W.G.	A.W.G.	S.W.G.	mm.G.	mil	mm	cir. mil	in²	mm²	lb/1,000ft	kg/km
5/0	-	7/0	-	500	12.700	250,000	.1964	126.7	756.9	1,126
-	-	-	12	472.4	12.000	223,162	.1753	113.1	675.6	1,005
-	-	6/0	-	464	11.786	215,296	.1691	109.1	651.7	969.9
-	4/0	-	-	460	11.684	211,600	.1662	107.2	640.5	953
4/0	-	-	-	454	11.532	206,100	.1619	104.4	624	928.1
-	-	5/0	-	432	10.973	186,624	.1466	94.56	565	840.6
3/0	-	-	-	425	10.795	180,600	.1419	91.52	546.9	813.6
-	3/0	-	-	409.6	10.404	167,772	.1318	85.03	508	755.9
-	-	4/0	-	400	10.160	160,000	.1257	81.07	484.5	720.7
-	-	-	10	393.7	10.000	155,000	.1217	78.54	468	698.2
2/0	-	-	-	380	9.652	144,400	.1134	73.17	437.1	650.5
-	-	3/0	-	372	9.440	138,384	.1087	70.12	418.9	623.4
-	2/0	-	-	364.8	9.266	133,079	.1045	67.42	402.7	599.4
-	-	-	9	354.3	9.000	125,528	.09859	63.62	380	565.6
-	-	2/0	-	348	8.839	121,104	.09512	61.36	366.6	545.5
0	-	-	-	340	8.636	115,600	.09079	58.58	349.9	520.8
-	0	-	-	324.9	8.250	105,560	.08291	53.49	319.5	475.5
-	-	0	-	324	8.230	104,976	.08245	53.19	317.8	472.8
-	-	-	8	315	8.000	99,225	.07793	50.27	300.3	446.9
1	-	1	-	300	7.629	90,000	.07069	45.60	272.4	405.4
-	1	-	-	289.3	7.348	83,694	.06573	42.41	253.3	377
2	-	-	-	284	7.214	80,660	.06335	40.87	244.2	363.3
-	-	2	-	276	7.010	76,176	.05983	39.60	230.6	343.2
-	-	-	7	275.6	7.000	75,955	.05966	38.48	229.9	342.1
3	-	-	-	259	6.579	67,080	.05269	33.99	203.1	302.2
-	-	-	6.5	255.9	6.500	65,485	.05143	33.08	189.2	295
-	-	3	-	252	6.401	63,504	.04988	32.18	192.2	286.1
4	-	-	-	238	6.045	56,640	.04449	28.70	171.5	255.1
-	-	-	6.0	236.2	6.000	55,790	.04382	28.27	168.9	251.1
-	-	4	-	232	5.893	53,824	.04227	27.27	162.9	242.4
-	3	-	-	229.4	5.827	52,624	.04133	26.66	159.3	237
5	-	-	-	220	5.588	48,400	.03801	24.52	146.5	218
-	-	-	5.5	216.5	5.500	46,872	.03681	23.72	141.9	210.9
-	-	5	-	212	5.385	44,944	.03530	22.77	136	202.4
-	4	-	-	204.3	5.189	41,738	.03278	21.15	126.3	188
6	-	-	-	203	5.156	41,210	.03237	20.88	124.8	185.6
-	-	-	50	196.9	5.000	38,770	.03045	19.63	117.4	174.5
-	-	6	-	192	4.877	36,864	.02895	18.68	111.6	166.3
-	5	-	-	181.9	4.621	33,088	.02599	16.77	100.2	149.1
7	-	-	-	180	4.572	32,400	.02545	16.42	98.08	146
-	-	-	4.5	177.2	4.500	31,400	.02466	15.90	95.04	141.4
-	-	7	-	176	4.470	30,976	.02433	15.70	93.77	139.6
8	-	-	-	165	4.191	27,220	.02138	13.80	82.40	122.7
-	6	-	-	162	4.115	26,244	.02061	13.30	79.43	118.2
-	-	8	-	160	4.064	25,600	.02011	12.97	77.50	115.3
-	-	-	4.0	157.5	4.000	24,806	.01948	12.57	75.08	111.8
9	-	-	-	148	3.759	21,900	.01720	11.10	66.29	98.68
-	7	-	-	144.3	3.665	20,822	.01635	10.55	63.01	93.79
-	-	9	-	144	3.658	20,736	.01629	10.52	62.78	93.52
-	-	-	3.5	137.8	3.500	18,989	.01491	9.621	57.46	85.53
10	-	-	-	134	3.404	17,960	.01410	9.098	54.34	80.88
-	8	-	-	128.5	3.264	16,512	.01297	8.368	49.99	74.39
-	-	10	-	128	3.251	16,384	.01287	8.302	49.60	73.81
-	-	-	3.2	126	3.200	15,876	.01247	8.042	48.06	71.49

Gauge				Diameter		Sectional area			Copper wire weight	
B.W.G.	A.W.G.	S.W.G.	mm.G.	mil	mm	cir. mil	in²	mm²	lb/1,000ft	kg/km
25	-	25	-	20	050.80	400	.0003142	0.2027	1.211	1.802
-	-	-	.50	19.69	0.5000	387.7	.0003045	0.1963	1.174	1.745
26	-	26	-	18	0.4572	324	.0002545	0.1642	0.9809	1.460
-	25	-	-	17.90	0.4547	320.4	.0002516	0.1623	0.9697	1.443
-	-	-	.45	17.72	0.4500	314	.0002466	0.1590	0.9504	1.414
-	-	27	-	16.4	0.4166	269	.0002113	0.1363	0.1844	1.212
27	-	-	-	16	0.4064	256	.0002011	0.1297	0.7750	1.153
-	26	-	-	15.94	0.4049	254.1	.0001996	0.1288	0.7693	1.145
-	-	-	.40	15.75	0.4000	248.1	.0001949	0.1257	0.7512	1.118
-	-	28	-	14.8	0.3759	219	.0001720	0.1110	0.6629	0.9868
-	27	-	-	14.20	0.3606	201.6	.0001583	0.1021	0.6101	0.9077
28	-	-	-	14	0.3556	196	.0001539	0.09932	0.5931	0.8330
-	-	-	.35	13.78	0.3500	189.9	.0001491	0.09621	0.5746	0.8553
-	-	29	-	13.6	0.3454	185	.0001453	0.09372	0.5600	0.8332
29	-	-	-	13	0.3302	169	.0001327	0.08563	0.5114	0.7613
-	28	-	-	12.64	0.3211	159.8	.0001255	0.08097	0.4837	0.7198
-	-	-	.30	12.60	0.3200	158.8	.0001246	0.08042	0.7806	0.7149
-	-	30	-	12.4	0.3150	153.8	.0001208	0.07791	0.4656	0.6926
30	-	-	-	12	0.3048	144	.0001131	0.07297	0.4359	0.6487
-	-	31	-	11.6	0.2946	134.6	.0001057	0.06818	0.4074	0.6061
-	-	-	.29	11.42	0.2900	130.4	.0001024	0.06605	0.3947	0.5872
-	29	-	-	11.26	0.2859	126.8	.00009959	0.06425	0.3838	0.5712
-	-	32	-	10.8	0.2743	116.6	.00009158	0.05913	0.3530	0.5257
-	-	-	.26	10.24	0.2600	104.9	.00008239	0.05309	0.3175	0.4720
-	30	-	-	10.03	0.2546	100.6	.00007901	0.05097	0.3045	0.4531
31	-	33	-	10	0.2540	100	.00007954	0.05067	0.3027	0.4505
-	-	34	-	9.2	0.2337	84.64	.00006648	0.04289	0.2562	0.3813
-	-	-	.23	6.055	0.2300	81.99	.00006440	0.04155	0.2482	0.3694
32	-	-	-	9.	0.2286	81.102	.00006362	0.04104	0.2452	0.3649
-	31	-	-	8.928	0.2238	79.71	.00006260	0.04039	0.2413	0.3591
-	-	35	-	8.4	0.2134	70.56	.00005542	0.03575	0.2136	0.3178
33	-	-	-	8	0.2032	64	.00005027	0.03243	0.1937	0.2883
-	32	-	-	7.950	0.2019	63.20	.00004964	0.03203	0.1913	0.2847
-	-	-	.20	7.874	0.2000	62	.00004869	0.03142	0.1877	0.2793
-	-	36	-	7.6	0.1930	57.76	.00004536	0.02927	0.1748	0.2602
-	-	-	.18	7.087	0.1800	50.23	.00003945	0.02545	0.1520	0.2263
-	33	-	-	7.080	0.1798	50.13	.00003937	0.02540	0.1517	0.2258
34	-	-	-	7	0.1778	49	.00003848	0.02483	0.1483	0.2207
-	-	37	-	6.8	0.1727	46.24	.00003632	0.02343	0.1400	0.2083
-	34	-	-	6.305	0.1601	39.75	.00003122	0.02014	0.1203	0.1790
-	-	-	.16	6.295	0.1600	39.68	.00003116	0.02011	0.1201	0.1788
-	-	38	-	6	0.1524	36	.00002827	0.01824	0.1090	0.1622
-	35	-	-	5.615	0.1426	3.53	.00002476	0.01597	0.09543	0.1420
-	-	-	.14	5.512	0.1400	310.38	.00002386	0.01539	0.09196	0.1368
-	-	39	-	5.2	0.1321	27.04	.00002124	0.01370	0.08186	0.1218
35	36	-	-	5.000	0.1270	25	.00001963	0.01267	0.07565	0.1126
-	-	40	-	4.8	0.1219	23.04	.00001810	0.01167	0.06976	0.1037
-	-	-	.12	4.724	0.1200	22.32	.00001753	0.01131	0.06756	0.1006
-	37	-	-	4.453	0.1131	19.83	.00001557	0.01005	0.06001	0.08934
-	-	41	-	4.4	0.1118	19.36	.00001521	0.009814	0.05812	0.08721
36	-	42	-	4	0.1016	16.00	.00001257	0.008107	0.04845	0.07207
-	38	-	-	3.965	0.1007	15.72	.00001235	0.007968	0.04760	0.07084
-	-	-	.10	3.937	0.1000	15.50	.00001217	0.007854	0.04690	0.06982
-	-	43	-	3.6	0.09114	12.96	.00001018	0.006567	0.03923	0.05838
-	39	-	-	3.531	0.08969	12.47	.000009794	0.006319	0.03775	0.05618

Gauge				Diameter		Sectional area			Copper wire weight	
B.W.G.	A.W.G.	S.W.G.	mm.G.	mil	mm	cir. mil	in²	mm²	lb/1,000ft	kg/km
11	-	-	-	120	3.048	14,400	.01131	7.297	43.59	64.87
-	-	11	-	116	2.946	13,456	.01057	6.818	40.74	60.61
-	9	-	-	114.4	2.906	13,087	.01028	6.632	39.62	58.96
-	-	-	2.9	114.2	2.900	13,042	.01024	6.605	39.47	58.72
12	-	-	-	109	2.769	11,880	.009331	6.020	35.96	53.52
-	-	12	-	104	2.642	10,816	.008495	5.481	32.74	48.73
-	-	-	2.6	102.4	2.600	10,486	.008246	5.309	31.78	47.29
-	10	-	-	101.9	2.588	10,384	.008156	5.262	31.43	46.78
13	-	-	-	95	2.413	9,025	.007088	4.573	27.32	40.65
-	-	13	-	92	2.337	8,464	.006648	4.289	25.62	38.13
-	11	-	-	90.75	2.305	8,234	.006467	4.172	24.92	37.09
-	-	-	2.3	90.54	2.300	8,199	.006439	4.155	24.82	36.94
14	-	-	-	83	2.108	6,889	.005411	3.491	20.85	31.04
-	12	-	-	80.81	2.053	6,530	.005129	3.309	19.77	29.42
-	-	14	-	80	2.032	6,400	.005027	3.243	19.37	28.83
-	-	-	2.0	78.74	2.000	6,200	.004869	3.142	18.77	27.93
15	-	15	-	72	1.829	5,184	.004072	2.627	18.77	27.93
-	13	-	-	71.96	1.828	5,178	.004067	2.624	15.67	23.33
-	-	-	1.8	70.87	1.800	5,023	.003945	2.545	15.20	22.63
16	-	-	-	65	1.651	4,225	.003318	2.141	12.79	19.03
-	14	-	-	64.08	1.628	4,106	.003225	2.081	12.43	18.50
-	-	16	-	64	1.626	4,096	.003217	2.075	12.40	18.45
-	-	-	1.6	62.99	1.600	3,968	.003116	2.011	12.01	17.88
17	-	-	-	58	1.473	3,364	.002642	1.705	10.18	15.16
-	15	-	-	57.07	1.450	3,257	.002558	1.650	9.859	14.67
-	-	17	-	56	1.422	3,136	.002463	1.589	9.493	14.13
-	-	-	1.4	55.12	1.400	3,038	.002386	1.539	9.196	13.68
-	16	-	-	50.82	1.291	2,583	.002029	1.309	7.820	11.64
18	-	-	-	49	1.245	2,401	.001886	1.217	7.269	10.82
-	-	18	-	48	1.219	2,304	.001810	1.167	6.976	10.38
-	-	-	1.2	47.24	1.200	2,232	.001753	1.131	6.756	10.06
-	17	-	-	45.26	1.150	2,048	.001608	1.037	6.197	9.219
19	-	-	-	42	1.067	1,764	.001385	0.8938	5.388	7.946
-	18	-	-	40.30	1.024	1,624	.075	0.8226	4.914	7.313
-	-	19	-	40	1.016	1,600	.001257	0.8107	4.845	7.207
-	-	-	1.0	39.37	1.000	1,550	.001217	0.7854	4,690	6.982
-	-	20	-	36	0.9144	1,296	.001018	0.6576	3.923	5.838
-	19	-	-	35.89	0.9116	1,288	.001012	0.6529	3.900	5.804
-	-	-	9.0	35.43	0.9000	1,255	.0009857	0.6362	3.799	5.656
20	-	-	-	35	0.8890	1,225	.0009621	0.6207	3.708	5.518
21	-	21	-	32	0.8128	1,024	.0008042	0.5189	3.099	4.613
-	20	-	-	31.96	0.8118	1,021	.0008019	0.5174	3.091	4.600
-	-	-	8.0	31.50	0.8000	992.3	.0007794	0.5027	3.004	4.469
-	21	-	-	28.46	0.7229	810	.0006362	0.4105	2.452	3.649
22	-	22	-	28	0.7112	784	.0006158	0.3973	2.373	3.532
-	-	-	7.0	27.56	0.7000	759.6	.0005966	0.3848	2.299	3.421
-	-	-	6.5	25.59	0.6500	654.8	.0005143	0.3318	1.982	2.950
-	22	-	-	25.35	0.6438	642.6	.0005047	0.3256	1.945	2.895
23	-	-	-	25	0.6350	625	.0004909	0.3167	1.892	2.816
-	-	23	-	24	0.6096	576	.0004524	0.2919	1.744	2.595
-	-	-	6.0	23.62	0.6000	557.9	.0004382	0.2827	1.689	2.513
-	23	-	-	22.57	0.5733	509.4	.0004001	0.2581	1.542	2.295
24	-	24	-	22	0.5583	484	.0003801	0.2452	1.465	2.180
-	-	-	5.5	21.65	0.5500	468.7	.0003681	0.2376	1.419	2.112
-	24	-	-	20.10	0.5106	404	.0003173	0.2047	1.223	1.820

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