CONTIGUOUS BAND MULTIPLEXER

SIMULATION AND OPTIMIZATION

OSA-84-MX-7-L

February 29, 1984

SUMMARY

This document contains a diagram (Fig. 1) of the structure of the subprograms called by the MXSOS2 package. Subprograms FILTER, FILABCD, MATMUL, SEQUENC, RESPONS, WGUIDE, CSOLLU, DABCDF2, DRLOSS2, DVOLTA2, SIMGRD2, INSERT, SIMUL, BETAVAL, INSOUT, CONST1, DISPAT, DISPER, TOTAL2 and PHASE are presented consecutively, organized for an 8 x 8 coupling matrix, 16 channels and an arbitrary number of frequencies. These subprograms form the heart of the simulation and required sensitivity analysis for multiplexer optimization. The essential programming differences with the original MXSOS package are clearly identified by the character "2". This package supercedes and replaces the packages presented earlier [1,2].

The package permits synchronously and asynchronously tuned coupled-cavity filters distributed along a waveguide manifold to be considered. All design parameters, e.g., filter spacings or section lengths between channels, filter input transformer ratios and output transformer ratios, all filter couplings and resonant frequencies can be directly optimized.

The package can exploit three commonly used practical models of the multiplexer, depending on whether the filters are lossless or lossy (dissipation is included), whether the junctions are ideal or nonideal (junction susceptance is included) and whether the filters are modelled as dispersive or non-dispersive. The waveguide manifold is always assumed dispersive. Exact response sensitivities with respect to all permitted variables are calculated for common port return loss and channel insertion loss.

REFERENCES

[1] Document OSA-84-MX-1-L, "Contiguous band multiplexer simulation and optimization," Optimization Systems Associates, Dundas, Ontario, Canada, January 30, 1984.

[2] Document OSA-84-MX-5-L, "Contiguous band multiplexer simulation and optimization," Optimization Systems Associates, Dundas, Ontario, Canada, January 31, 1984.

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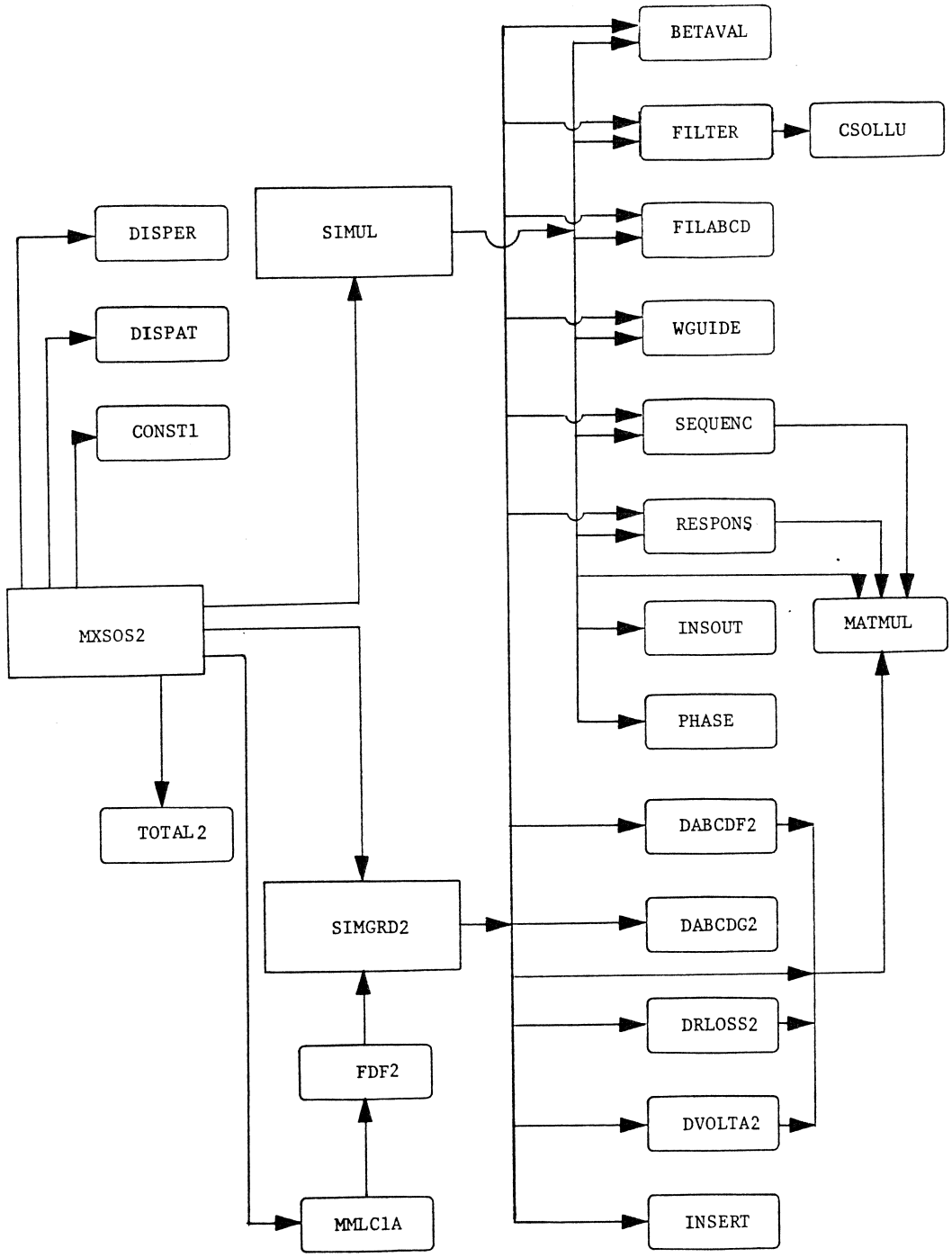

Fig. 1 The structure of the MXSOS2 package identifying the calling and called subprograms.

```
      SUBROUTINE FILTER(N,M,Z,P,Q)                                      000001
C                                                                       000002
C     PERFORM ANALYSES FOR ALL CHANNELS                                 000003
C                                                                       000004
C     N  NUMBER OF CHANNELS                                             000005
C     M  ORDER OF MATRIX                                                000006
C     Z  IMPEDANCE MATRIX                                               000007
C                                                                       000008
      COMPLEX Z(16,8,8),ZT(8,8),P(16,8),Q(16,8),PT(8),QT(8)             000009
C                                                                       000010
      DO 10 I=1,N                                                       000011
C                                                                       000012
      DO 11 J=1,M                                                       000013
C                                                                       000014
      PT(J)=(0.0,0.0)                                                   000015
      QT(J)=(0.0,0.0)                                                   000016
      PT(1)=(1.0,0.0)                                                   000017
      QT(M)=(1.0,0.0)                                                   000018
C                                                                       000019
C     SET TWO-DIMENSIONAL Z MATRIX                                      000020
C                                                                       000021
      DO 11 K=1,M                                                       000022
      ZT(J,K)=Z(I,J,K)                                                  000023
   11 CONTINUE                                                          000024
C                                                                       000025
C     SET PARAMETER TO PERFORM LU FACTORIZATION AND FORWARD-            000026
C     BACKWARD SUBSTITUTION FOR UNIT VOLTAGE AT INPUT                   000027
C                                                                       000028
      IPAR=0                                                            000029
C                                                                       000030
      CALL CSOLLU(M,ZT,PT,IFALL,IPAR)                                   000031
C                                                                       000032
C     SET PARAMETER TO PERFORM ONLY FORWARD-BACKWARD SUBSTITUTION       000033
C     FOR UNIT VOLTAGE AT OUTPUT                                        000034
C                                                                       000035
      IPAR=1                                                            000036
C                                                                       000037
      CALL CSOLLU(M,ZT,QT,IFALL,IPAR)                                   000038
C                                                                       000039
C     SET TWO DIMENSIONAL SOLUTION VECTORS,EACH COLUMN                  000040
C     CORRESPONDING TO ONE CHANNEL                                      000041
C                                                                       000042
      DO 12 J=1,M                                                       000043
      P(I,J)=PT(J)                                                      000044
      Q(I,J)=QT(J)                                                      000045
   12 CONTINUE                                                          000046
C                                                                       000047
   10 CONTINUE                                                          000048
      RETURN                                                            000049
      END                                                               000050
C                                                                       000051
```

```
C                                                                       000052
      SUBROUTINE FILABCD(N,M,P,Q,PN1,PN2,Y1,GL,YC,Y,YP,YIN,Y3,          000053
     +                        Y3SQ,TF,H7,H8,H13,H14,PN11,PN12,PN22)     000054
C                                                                       000055
C     CALCULATION OF EQUIVALENT ABCD MATRICES OF FILTER-                000056
C     JUNCTION COMBINATIONS AS SEEN IN THE WAVEGUIDE MANIFOLD           000057
C                                                                       000058
      COMPLEX Y(16,4),YP(16,4),YIN(16),Y3(16),Y3SQ(16),TF(16,4)         000059
      COMPLEX P(16,8),Q(16,8),Y1(16),YC(16)                             000060
      COMPLEX H7(16),H8(16),H13(16),H14(16)                             000061
      REAL PN1(16),PN2(16),GL(16)                                       000062
      REAL PN11(16),PN12(16),PN22(16)                                   000063
C                                                                       000064
C     CALCULATION OF SHORT-CIRCUIT ADMITTANCE MATRIX "Y" OF             000065
C     EACH FILTER                                                       000066
C                                                                       000067
      DO 13 I=1,N                                                       000068
C                                                                       000069
      Y(I,1)=P(I,1)                                                     000070
      Y(I,2)=Q(I,1)                                                     000071
      Y(I,3)=Y(I,2)                                                     000072
      Y(I,4)=Q(I,M)                                                     000073
C                                                                       000074
C     PREPARATION FOR INCLUSION OF IDEAL TRANSFORMERS                   000075
C                                                                       000076
      PN11(I)=PN1(I)*PN1(I)                                             000077
      PN12(I)=PN1(I)*PN2(I)                                             000078
      PN22(I)=PN2(I)*PN2(I)                                             000079
C                                                                       000080
C     INCLUSION INTO Y MATRIX OF THE INPUT-OUTPUT TRANSFORMERS          000081
C                                                                       000082
      YP(I,1)=PN11(I)*Y(I,1)                                            000083
      YP(I,2)=PN12(I)*Y(I,2)                                            000084
      YP(I,3)=YP(I,2)                                                   000085
      YP(I,4)=PN22(I)*Y(I,4)                                            000086
C                                                                       000087
C     SAVE COMMON FACTORS FOR USE WITH SENSITIVITY FORMULAS             000088
C                                                                       000089
      H7(I)=YP(I,4)+GL(I)                                               000090
      H8(I)=YP(I,2)*YP(I,2)                                             000091
      H13(I)=H8(I)/(H7(I)*H7(I))                                        000092
      H14(I)=Y1(I)*Y1(I)                                                000093
C                                                                       000094
      YIN(I)=YP(I,1)-H8(I)/H7(I)                                        000095
C                                                                       000096
C     USE AN IMPEDANCE INVERTER                                         000097
C                                                                       000098
      YIN(I)=1.0/YIN(I)                                                 000099
C                                                                       000100
C     CONNECT THE FILTER TO THE MANIFOLD JUNCTION                       000101
C                                                                       000102
      Y3(I)=YC(I)+YIN(I)                                                000103
      Y3SQ(I)=Y3(I)*Y3(I)                                               000104
C                                                                       000105
      TF(I,1)=1.0+Y1(I)/Y3(I)                                           000106
      TF(I,2)=1.0/Y3(I)                                                 000107
      TF(I,3)=Y1(I)*TF(I,1)+Y1(I)                                       000108
      TF(I,4)=1.0+Y1(I)/Y3(I)                                           000109
C                                                                       000110
   13 CONTINUE                                                          000111
      RETURN                                                            000112
      END                                                               000113
C                                                                       000114
```

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C                                                                       000115
      SUBROUTINE MATMUL(V1,V2,V3,V4,V5,V6,V7,V8,V9,V10,V11,V12)         000116
C                                                                       000117
C     COMPLEX 2X2 MATRIX MULTIPLICATION                                 000118
C                                                                       000119
      COMPLEX V1,V2,V3,V4,V5,V6,V7,V8,V9,V10,V11,V12                    000120
      V9=V1*V5+V2*V7                                                    000121
      V10=V1*V6+V2*V8                                                   000122
      V11=V3*V5+V4*V7                                                   000123
      V12=V3*V6+V4*V8                                                   000124
      RETURN                                                            000125
      END                                                               000126
C                                                                       000127
```

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C                                                                       000128
      SUBROUTINE SEQUENC(N,NP1,T,A)                                     000129
C                                                                       000130
C     CALCULATE THE EQUIVALENT ABCD MATRICES OF ALL POSSIBLE            000131
C     ADJACENT CASCADED SECTIONS AND STORE THEM IN THE A MATRICES.      000132
C     MATRIX A(I,J,.) INDICATES CALCULATIONS FROM REFERENCE             000133
C     PLANE I TO REFERENCE PLANE J ,WHERE J>I.                          000134
C     T IS THE  ABCD MATRIX OF A SECTION(FILTER-JUNCTION COMBINATION    000135
C     AND WAVEGUIDE SPACING)                                            000136
C                                                                       000137
      COMPLEX T(16,4),A(17,17,4)                                        000138
C                                                                       000139
C     INITIALIZE UNIT MATRICES                                          000140
C                                                                       000141
      DO 16 I=1,NP1                                                     000142
C                                                                       000143
      A(I,I,1)=CMPLX(1.0,0.0)                                           000144
      A(I,I,2)=CMPLX(0.0,0.0)                                           000145
      A(I,I,3)=A(I,I,2)                                                 000146
      A(I,I,4)=A(I,I,1)                                                 000147
C                                                                       000148
   16 CONTINUE                                                          000149
C                                                                       000150
      DO 17 I=1,N                                                       000151
      IP1=I+1                                                           000152
C                                                                       000153
      DO 18 J=IP1,NP1                                                   000154
      JM1=J-1                                                           000155
C                                                                       000156
      CALL MATMUL(T(JM1,1),T(JM1,2),T(JM1,3),T(JM1,4),A(I,JM1,1),       000157
     +            A(I,JM1,2),A(I,JM1,3),A(I,JM1,4),A(I,J,1),           000158
     +            A(I,J,2),A(I,J,3),A(I,J,4))                          000159
C                                                                       000160
   18 CONTINUE                                                          000161
   17 CONTINUE                                                          000162
      RETURN                                                            000163
      END                                                               000164
C                                                                       000165
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C                                                                       000166
      SUBROUTINE RESPONS(N,NP1,RS,ZIN,RLOSS,VL,A,H23,H1,RO,RCOEFF,      000167
     +                   YC,YP,TG,Y1,VS,H2,H3,H4,H5,H6,H7,H9,H10)       000168
C                                                                       000169
C     CALCULATE COMMON PORT RETURN LOSS AND OUTPUT VOLTAGE              000170
C     OF EACH CHANNEL                                                   000171
C                                                                       000172
      COMPLEX VL(16),A(17,17,4),HMX(4)                                  000173
      COMPLEX H2(16),H3(16),H4(16),H5(16),H6(16),H7(16),H9(16),H10(16)  000174
      COMPLEX YC(16),YP(16,4),TG(16,4),Y1(16)                           000175
      COMPLEX RCOEFF,ZIN,H22,H23,H1,JPLX                                000176
      JPLX=CMPLX(0.0,1.0)                                               000177
C                                                                       000178
C     CALCULATION OF INPUT IMPEDANCE USING ABCD MATRIX FROM             000179
C     REFERENCE PLANE 1 (SHORT CIRCUIT) TO REFERENCE PLANE N+1          000180
C                                                                       000181
      ZIN=A(1,NP1,2)/A(1,NP1,4)                                         000182
      H22=(ZIN+RS)*(ZIN+RS)                                             000183
      H23=2.0*RS/H22                                                    000184
      RCOEFF=(ZIN-RS)/(ZIN+RS)                                          000185
      RO=CABS(RCOEFF)                                                   000186
      RLOSS=-20.0*ALOG10(RO)                                            000187
C                                                                       000188
      H1=A(1,NP1,2)+RS*A(1,NP1,4)                                       000189
C                                                                       000190
      DO 19 I=1,N                                                       000191
C                                                                       000192
      H9(I)=1.0+YC(I)*YP(I,1)                                           000193
      H10(I)=H7(I)*H9(I)                                                000194
      H2(I)=H10(I)/YP(I,2)-YC(I)*YP(I,2)                                000195
C                                                                       000196
C     CALCULATE ABCD MATRICES FROM THE SHORT CIRCUIT REFERENCE          000197
C     PLANE TO THE REFERENCE PLANE I                                    000198
C                                                                       000199
      CALL MATMUL(TG(I,1),TG(I,2),TG(I,3),TG(I,4),A(1,I,1),A(1,I,2),    000200
     +            A(1,I,3),A(1,I,4),HMX(1),HMX(2),HMX(3),HMX(4))        000201
C                                                                       000202
      H3(I)=VS*(HMX(4)+Y1(I)*HMX(2))                                    000203
      H4(I)=H2(I)*H1                                                    000204
      H5(I)=H4(I)*H4(I)                                                 000205
      H6(I)=H3(I)*H2(I)                                                 000206
C                                                                       000207
C     CALCULATE OUTPUT VOLTAGES OF CHANNELS                             000208
C                                                                       000209
      VL(I)=JPLX*H3(I)/H4(I)                                            000210
   19 CONTINUE                                                          000211
      RETURN                                                            000212
      END                                                               000213
C                                                                       000214
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C                                                                       000215
      SUBROUTINE WGUIDE(N,BETA,WGL,TG,DTG)                              000216
C                                                                       000217
C     CALCULATE ABCD MATRICES OF THE WAVEGUIDE SPACINGS AND             000218
C     THEIR DERIVATIVES W.R.T. SPACINGS(SECTION LENGTHS)                000219
C                                                                       000220
      COMPLEX TG(16,4),DTG(16,4)                                        000221
      REAL WGL(16)                                                      000222
C                                                                       000223
      CZ=1.0                                                            000224
      CZ2=CZ*CZ                                                         000225
C                                                                       000226
      DO 77 I=1,N                                                       000227
      TETA=BETA*WGL(I)                                                  000228
C                                                                       000229
      TG(I,1)=CMPLX(COS(TETA),0.0)                                      000230
      TG(I,2)=CMPLX(0.0,SIN(TETA)*CZ)                                   000231
      TG(I,3)=TG(I,2)/CZ2                                               000232
      TG(I,4)=TG(I,1)                                                   000233
C                                                                       000234
      DTG(I,1)=CMPLX(-BETA*SIN(TETA),0.0)                               000235
      DTG(I,2)=CMPLX(0.0,COS(TETA)*CZ*BETA)                             000236
      DTG(I,3)=DTG(I,2)/CZ2                                             000237
      DTG(I,4)=DTG(I,1)                                                 000238
   77 CONTINUE                                                          000239
C                                                                       000240
      RETURN                                                            000241
      END                                                               000242
C                                                                       000243
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C                                                                       000244
      SUBROUTINE CSOLLU(M,A,B,IFALL,IPAR)                               000245
C                                                                       000246
C     PERFORM LU FACTORIZATION, FORWARD AND BACKWARD SUBSTITUTION       000247
C     IN THE COMPLEX MODE                                               000248
C                                                                       000249
      COMPLEX A(8,8),B(8),ZZ                                            000250
C                                                                       000251
C     CROUT'S ALGORITHM FOR LU FACTORIZATION                            000252
C                                                                       000253
      IFALL=0                                                           000254
      M2=M-1                                                            000255
      M1=M+1                                                            000256
      IF(IPAR.EQ.1)GO TO 290                                            000257
C                                                                       000258
C     BEGIN FACTORIZATION                                               000259
C                                                                       000260
      DO 82 II=1,M2                                                     000261
      ZZ=A(II,II)                                                       000262
      IF(ZZ.EQ.(0.0,0.0))GO TO 100                                      000263
      MM=II+1                                                           000264
      DO 82 J=MM,M                                                      000265
      A(II,J)=A(II,J)/ZZ                                                000266
      DO 80 K=MM,M                                                      000267
   80 A(K,J)=A(K,J)-A(K,II)*A(II,J)                                     000268
   82 CONTINUE                                                          000269
C                                                                       000270
C     FORWARD SUBSTITUTION                                              000271
C                                                                       000272
  290 CONTINUE                                                          000273
      IF(A(1,1).EQ.(0.0,0.0))GO TO 100                                  000274
      B(1)=B(1)/A(1,1)                                                  000275
      DO 88 II=2,M                                                      000276
      ZZ=A(II,II)                                                       000277
      IF(ZZ.EQ.(0.0,0.0))GO TO 100                                      000278
      IM=II-1                                                           000279
      DO 86 K=1,IM                                                      000280
   86 B(II)=B(II)-A(II,K)*B(K)                                          000281
      B(II)=B(II)/ZZ                                                    000282
   88 CONTINUE                                                          000283
C                                                                       000284
C     BACKWARD SUBSTITUTION                                             000285
C                                                                       000286
      DO 92 L=2,M                                                       000287
      II=M1-L                                                           000288
      IP=II+1                                                           000289
      DO 90 K=IP,M                                                      000290
   90 B(II)=B(II)-A(II,K)*B(K)                                          000291
   92 CONTINUE                                                          000292
      GO TO 120                                                         000293
  100 IFALL=-1                                                          000294
      WRITE 200                                                         000295
  200 FORMAT(/"INDEFINITE VALUE IN CSOLLU DUE TO ZERO ON THE DIAGONAL") 000296
  120 CONTINUE                                                          000297
      RETURN                                                            000298
      END                                                               000299
C                                                                       000300
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C                                                                       000301
      SUBROUTINE DABCDF2(N,M,IR,IRT,IPN1,IPN2,LC,KC,DYP11,              000302
     +                   DYP21,DYP22,YIN,P,Q,PN1,PN2,                   000303
     +                   PN11,PN12,PN22,H7,H13,H14,Y1,TG,D,Y3SQ,YP,     000304
     +                   LAMR,IDISPER)                                  000305
C                                                                       000306
C     CALCULATE DERIVATIVES OF THE FILTER-JUNCTION ABCD MATRICES        000307
C     W.R.T. VARIABLE COUPLING ELEMENTS, AS WELL AS INPUT/OUTPUT        000308
C     TRANSFORMER RATIOS, AND STORE THEM IN A DESIGNATED  ARRAY         000309
C     FOR THE DERIVATIVES OF THE ABCD MATRICES  OF  THE SECTIONS        000310
C     W.R.T. ALL VARIABLES CONTAINED IN THEM                            000311
C                                                                       000312
      INTEGER IR(16),IRT(16),IPN1(16),IPN2(16),LC(16,36),KC(16,36)      000313
      REAL PN1(16),PN2(16),PN11(16),PN12(16),PN22(16),LAMR(16)          000314
      INTEGER CEL(16,8,8)                                               000315
      COMPLEX DY11,DY21,DY22,DYP11(100),DYP21(100),DYP22(100)           000316
      COMPLEX DYIN,DAF,DBF,DCF,DDF                                      000317
      COMPLEX P(16,8),Q(16,8),Y1(16),H15,H7(16),H13(16),H14(16)         000318
      COMPLEX TG(16,4),D(100,4),YIN(16),YINSQ,JPLX,Y3SQ(16),YP(16,4)    000319
      COMPLEX H72                                                       000320
      COMMON/BLK7/CEL                                                   000321
      JPLX=CMPLX(0.0,1.0)                                               000322
C                                                                       000323
      DO 21 I=1,N                                                       000324
      YINSQ=YIN(I)*YIN(I)                                               000325
      H72=2.0*YP(I,2)/H7(I)                                             000326
      IM1=I-1                                                           000327
      IF(IR(I).EQ.0)GO TO 10                                            000328
C                                                                       000329
      KP=IR(I)                                                          000330
      DO 22 J=1,KP                                                      000331
C                                                                       000332
      IX3=LC(I,J)                                                       000333
      IX4=KC(I,J)                                                       000334
C                                                                       000335
      IF(I.EQ.1)GO TO 23                                                000336
      IV=IRT(IM1)+J                                                     000337
      GO TO 24                                                          000338
   23 IV=J                                                              000339
   24 CONTINUE                                                          000340
C                                                                       000341
      IF(IX3.EQ.IX4)GO TO 35                                            000342
C                                                                       000343
      DY11=-2.0*JPLX*P(I,IX3)*P(I,IX4)                                  000344
      DY21=-JPLX*(P(I,IX3)*Q(I,IX4)+P(I,IX4)*Q(I,IX3))                  000345
      DY22=-2.0*JPLX*Q(I,IX3)*Q(I,IX4)                                  000346
C                                                                       000347
      IF(IDISPER.NE.1)GO TO 36                                          000348
      CF=LAMR(I)**CEL(I,IX3,IX4)                                        000349
      DY11=DY11*CF                                                      000350
      DY21=DY21*CF                                                      000351
      DY22=DY22*CF                                                      000352
      GO TO 36                                                          000353
C                                                                       000354
   35 DY11=-JPLX*P(I,IX3)*P(I,IX3)                                      000355
      DY21=-JPLX*P(I,IX3)*Q(I,IX3)                                      000356
      DY22=-JPLX*Q(I,IX3)*Q(I,IX3)                                      000357
C                                                                       000358
   36 CONTINUE                                                          000359
C                                                                       000360
      DYP11(IV)=PN11(I)*DY11                                            000361
      DYP21(IV)=PN12(I)*DY21                                            000362
      DYP22(IV)=PN22(I)*DY22                                            000363
C                                                                       000364
      DYIN=DYP11(IV)-DYP21(IV)*H72+DYP22(IV)*H13(I)                     000365
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C                                                                       000366
C     USE AN IMPEDANCE INVERTER                                         000367
C                                                                       000368
      DYIN=-YINSQ*DYIN                                                  000369
C                                                                       000370
      H15=-DYIN/Y3SQ(I)                                                 000371
C                                                                       000372
      DAF=Y1(I)*H15                                                     000373
      DBF=H15                                                           000374
      DCF=H15*H14(I)                                                    000375
      DDF=DAF                                                           000376
C                                                                       000377
      CALL MATMUL(DAF,DBF,DCF,DDF,TG(I,1),TG(I,2),                     000378
     +            TG(I,3),TG(I,4),D(IV,1),D(IV,2),D(IV,3),D(IV,4))     000379
C                                                                       000380
   22 CONTINUE                                                          000381
C                                                                       000382
   10 CONTINUE                                                          000383
      IF((IPN1(I)+IPN2(I)).EQ.0)GO TO 21                                000384
      IF(IPN1(I).EQ.0)GO TO 11                                          000385
C                                                                       000386
      J=IR(I)+1                                                         000387
      IF(I.EQ.1)GO TO 12                                                000388
      IV=IRT(IM1)+J                                                     000389
      GO TO 13                                                          000390
   12 IV=J                                                              000391
   13 CONTINUE                                                          000392
C                                                                       000393
      DYP11(IV)=2.0*PN1(I)*P(I,1)                                       000394
      DYP21(IV)=PN2(I)*Q(I,1)                                           000395
      DYP22(IV)=(0.0,0.0)                                               000396
      DYIN=DYP11(IV)-DYP21(IV)*H72                                      000397
      DYIN=-YINSQ*DYIN                                                  000398
C                                                                       000399
      H15=-DYIN/Y3SQ(I)                                                 000400
      DAF=Y1(I)*H15                                                     000401
      DBF=H15                                                           000402
      DCF=H15*H14(I)                                                    000403
      DDF=DAF                                                           000404
C                                                                       000405
      CALL MATMUL(DAF,DBF,DCF,DDF,TG(I,1),TG(I,2),TG(I,3),TG(I,4),      000406
     +            D(IV,1),D(IV,2),D(IV,3),D(IV,4))                      000407
C                                                                       000408
   11 CONTINUE                                                          000409
      IF(IPN2(I).EQ.0)GO TO 21                                          000410
      J=IR(I)+IPN1(I)+1                                                 000411
      IF(I.EQ.1)GO TO 15                                                000412
      IV=IRT(IM1)+J                                                     000413
      GO TO 16                                                          000414
   15 IV=J                                                              000415
   16 CONTINUE                                                          000416
C                                                                       000417
      DYP11(IV)=(0.0,0.0)                                               000418
      DYP21(IV)=PN1(I)*Q(I,1)                                           000419
      DYP22(IV)=2.0*PN2(I)*Q(I,M)                                       000420
      DYIN=-DYP21(IV)*H72+DYP22(IV)*H13(I)                              000421
      DYIN=-YINSQ*DYIN                                                  000422
C                                                                       000423
      H15=-DYIN/Y3SQ(I)                                                 000424
      DAF=Y1(I)*H15                                                     000425
      DBF=H15                                                           000426
      DCF=H15*H14(I)                                                    000427
      DDF=DAF                                                           000428
C                                                                       000429
      CALL MATMUL(DAF,DBF,DCF,DDF,TG(I,1),TG(I,2),TG(I,3),TG(I,4),      000430
```

```
     +              D(IV,1),D(IV,2),D(IV,3),D(IV,4))                    000431
C                                                                       000432
   21 CONTINUE                                                          000433
      RETURN                                                            000434
      END                                                               000435
C                                                                       000436
```

```
C                                                                       000437
      SUBROUTINE DABCDG2(N,IRT,IWG,D,DG)                                000438
C                                                                       000439
C     STORE THE CALCULATED DERIVATIVES OF THE ABCD MATRICES OF THE      000440
C     WAVEGUIDE SPACINGS W.R.T. SPACINGS (FROM SUBROUTINE WGUIDE)       000441
C     IN THE DESIGNATED DERIVATIVE ARRAY OF THE ABCD MATRICES OF        000442
C     THE SECTIONS (ONLY FOR THOSE SPACINGS WHICH ARE VARIABLES)        000443
C                                                                       000444
      INTEGER IRT(16),H20,IWG(16)                                       000445
      COMPLEX D(100,4),DG(16,4)                                         000446
C                                                                       000447
      DO 40 I=1,N                                                       000448
C                                                                       000449
      IF(IWG(I).EQ.0)GO TO 40                                           000450
      H20=IRT(I)                                                        000451
C                                                                       000452
      DO 42 J=1,4                                                       000453
      D(H20,J)=DG(I,J)                                                  000454
   42 CONTINUE                                                          000455
   40 CONTINUE                                                          000456
      RETURN                                                            000457
      END                                                               000458
C                                                                       000459
```

```
C                                                                       000460
      SUBROUTINE DRLOSS2(N,NP1,IRT,E,F,A,D,H23,RCOEFF,RO,DRTLOSS)       000461
C                                                                       000462
C     CALCULATE SENSITIVITIES OF COMMON PORT RETURN LOSS W.R.T.         000463
C     ALL VARIABLES                                                     000464
C                                                                       000465
      INTEGER IRT(16)                                                   000466
      COMPLEX E(100,4),F(100,4),A(17,17,4),D(100,4),H23,RCOEFF          000467
      COMPLEX DZIN,H21,DRCFF,H212                                       000468
      REAL DRTLOSS(100)                                                 000469
C                                                                       000470
      KP=IRT(1)                                                         000471
C                                                                       000472
      IF(KP.EQ.0)GO TO 10                                               000473
      DO 50 J=1,KP                                                      000474
      DO 53 K=1,4                                                       000475
C                                                                       000476
      E(J,K)=D(J,K)                                                     000477
   53 CONTINUE                                                          000478
C                                                                       000479
      CALL MATMUL(A(2,NP1,1),A(2,NP1,2),A(2,NP1,3),A(2,NP1,4),D(J,1),   000480
     +            D(J,2),D(J,3),D(J,4),F(J,1),F(J,2),F(J,3),F(J,4))     000481
C                                                                       000482
   50 CONTINUE                                                          000483
   10 CONTINUE                                                          000484
C                                                                       000485
      IF(N.EQ.1)GO TO 54                                                000486
      DO 51 I=2,N                                                       000487
      IM1=I-1                                                           000488
      IF(IRT(I).EQ.IRT(IM1))GO TO 51                                    000489
      JB=IRT(IM1)+1                                                     000490
      JE=IRT(I)                                                         000491
      IP1=I+1                                                           000492
C                                                                       000493
      DO 52 J=JB,JE                                                     000494
C                                                                       000495
      CALL MATMUL(D(J,1),D(J,2),D(J,3),D(J,4),A(1,I,1),A(1,I,2),        000496
     +            A(1,I,3),A(1,I,4),E(J,1),E(J,2),E(J,3),E(J,4))        000497
C                                                                       000498
      CALL MATMUL(A(IP1,NP1,1),A(IP1,NP1,2),A(IP1,NP1,3),A(IP1,NP1,4),  000499
     +            E(J,1),E(J,2),E(J,3),E(J,4),F(J,1),F(J,2),F(J,3),     000500
     +            F(J,4))                                               000501
C                                                                       000502
   52 CONTINUE                                                          000503
   51 CONTINUE                                                          000504
   54 CONTINUE                                                          000505
C                                                                       000506
      H21=1.0/(A(1,NP1,4)*A(1,NP1,4))                                   000507
      H211=-20.0/(ALOG(10.0)*RO*RO)                                     000508
      H212=CONJG(RCOEFF)                                                000509
C                                                                       000510
      KP=IRT(N)                                                         000511
      DO 55 J=1,KP                                                      000512
C                                                                       000513
      DZIN=H21*(A(1,NP1,4)*F(J,2)-A(1,NP1,2)*F(J,4))                    000514
      DRCFF=H23*DZIN                                                    000515
      DRTLOSS(J)=H211*REAL(H212*DRCFF)                                  000516
   55 CONTINUE                                                          000517
      RETURN                                                            000518
      END                                                               000519
C                                                                       000520
```

```
C                                                                       000521
      SUBROUTINE DVOLTA2(N,IRT,IR,IPN1,IPN2,IWG,VS,H4,TG,H6,RS,         000522
     + DVL,F,H5,H3,H1,YC,Y1,H10,H8,H9,YP,H7,DYP21,DYP22,DYP11,          000523
     +              DTG,A,E)                                           000524
C                                                                       000525
C     CALCULATE SENSITIVITIES OF ALL OUTPUT VOLTAGES W.R.T. ALL         000526
C     VARIABLES                                                         000527
C                                                                       000528
      INTEGER IRT(16),IR(16),IPN1(16),IPN2(16),IWG(16),UPB,UPBP1        000529
      COMPLEX A(17,17,4),E(100,4),DAI(100,4),Y1(16),TG(16,4)            000530
      COMPLEX DVL(16,100),F(100,4),YC(16),YP(16,4)                      000531
      COMPLEX DH2,DYP21(100),DYP22(100),DYP11(100),DTG(16,4)            000532
      COMPLEX H3(16),H4(16),H5(16),H6(16),H7(16),H8(16),H9(16),H10(16)  000533
      COMPLEX JPLX,H1                                                   000534
      COMPLEX H29,H30,H31,H32,H35,H36,H37,H50,H51,H52,H40,H41,H42,H43   000535
      JPLX=CMPLX(0.0,1.0)                                               000536
C                                                                       000537
      DO 60 I=1,N                                                       000538
C                                                                       000539
      H29=-VS*H4(I)                                                     000540
      H30=(Y1(I)*TG(I,1)+TG(I,3))*H29                                   000541
      H31=(Y1(I)*TG(I,2)+TG(I,4))*H29                                   000542
      H32=H6(I)*RS                                                      000543
C                                                                       000544
      H35=H3(I)*H1/H5(I)                                                000545
      H36=H6(I)/H5(I)                                                   000546
      H37=H36*RS                                                        000547
C                                                                       000548
      H40=(Y1(I)*DTG(I,1)+DTG(I,3))*A(1,I,2)                            000549
      H41=(Y1(I)*DTG(I,2)+DTG(I,4))*A(1,I,4)                            000550
      H42=VS*(H40+H41)                                                  000551
      H43=-H42/H4(I)                                                    000552
C                                                                       000553
      H50=-YC(I)-H10(I)/H8(I)                                           000554
      H51=H9(I)/YP(I,2)                                                 000555
      H52=H7(I)*YC(I)/YP(I,2)                                           000556
C                                                                       000557
      UPB=IRT(I)                                                        000558
      IF(UPB.EQ.0)GO TO 10                                              000559
      IM1=I-1                                                           000560
      IF(I.EQ.1)GO TO 70                                                000561
C                                                                       000562
      LOB=IRT(IM1)                                                      000563
      IF(LOB.EQ.0)GO TO 70                                              000564
C                                                                       000565
      DO 62 JJ=1,IM1                                                    000566
      ISECT=IR(JJ)+IPN1(JJ)+IPN2(JJ)+IWG(JJ)                            000567
      IF(ISECT.EQ.0)GO TO 62                                            000568
      LL=IRT(JJ)                                                        000569
      KK=LL-ISECT+1                                                     000570
C                                                                       000571
      JJP1=JJ+1                                                         000572
      DO 63 J=KK,LL                                                     000573
C                                                                       000574
      CALL MATMUL(A(JJP1,I,1),A(JJP1,I,2),A(JJP1,I,3),A(JJP1,I,4),      000575
     +            E(J,1),E(J,2),E(J,3),E(J,4),DAI(J,1),DAI(J,2),        000576
     +            DAI(J,3),DAI(J,4))                                    000577
C                                                                       000578
   63 CONTINUE                                                          000579
   62 CONTINUE                                                          000580
C                                                                       000581
      DO 65 J=1,LOB                                                     000582
      DVL(I,J)=(H30*DAI(J,2)+H31*DAI(J,4)+H6(I)*F(J,2)+H32*F(J,4))/H5(I)000583
      DVL(I,J)=-JPLX*DVL(I,J)                                           000584
   65 CONTINUE                                                          000585
```

```
C                                                                       000586
      IF(IRT(I).EQ.IRT(IM1))GO TO 10                                    000587
      GO TO 72                                                          000588
C                                                                       000589
   70 LOB=0                                                             000590
C                                                                       000591
   72 LOB1=LOB+1                                                        000592
      DO 66 J=LOB1,UPB                                                  000593
      IF(J.NE.UPB)GO TO 30                                              000594
      IF(IWG(I).NE.1)GO TO 30                                           000595
C                                                                       000596
      DVL(I,J)=H43+H36*F(J,2)+H37*F(J,4)                                000597
      DVL(I,J)=-JPLX*DVL(I,J)                                           000598
C                                                                       000599
      GO TO 66                                                          000600
C                                                                       000601
   30 CONTINUE                                                          000602
      DH2=H50*DYP21(J)+H51*DYP22(J)+H52*DYP11(J)                        000603
C                                                                       000604
      DVL(I,J)=H35*DH2+H36*F(J,2)+H37*F(J,4)                            000605
      DVL(I,J)=-JPLX*DVL(I,J)                                           000606
   66 CONTINUE                                                          000607
C                                                                       000608
   10 KP=IRT(N)                                                         000609
      IF(UPB.EQ.KP)GO TO 60                                             000610
      UPBP1=UPB+1                                                       000611
      DO 67 J=UPBP1,KP                                                  000612
      DVL(I,J)=H36*F(J,2)+H37*F(J,4)                                    000613
      DVL(I,J)=-JPLX*DVL(I,J)                                           000614
C                                                                       000615
   67 CONTINUE                                                          000616
   60 CONTINUE                                                          000617
      RETURN                                                            000618
      END                                                               000619
C                                                                       000620
```

```
C                                                                       000621
      SUBROUTINE SIMGRD2(OMEG,RLOSS,DRTLOSS,INLOSS,DINLOSS,N,M,         000622
     +                   ICOUNT,IFLAGJS,IFLAGDP,IDISPER)                000623
C                                                                       000624
C     THIS SUBROUTINE CALLS ALL OTHER SUBROUTINES NECESSARY TO          000625
C     CALCULATE THE RESPONSE AND EXACT SENSITIVITIES                    000626
C                                                                       000627
      COMPLEX Z(16,8,8),P(16,8),Q(16,8)                                 000628
      COMPLEX Y(16,4),YP(16,4),YIN(16),Y1(16),Y3(16),YC(16)             000629
      COMPLEX TF(16,4),TG(16,4),T(16,4),A(17,17,4),Y3SQ(16)             000630
      COMPLEX H2(16),H3(16),H4(16),H5(16),H6(16),H7(16),H8(16)          000631
      COMPLEX H9(16),H10(16),H13(16),H14(16)                            000632
      COMPLEX VL(16)                                                    000633
      COMPLEX H1,H23,ZIN,RCOEFF                                         000634
      COMPLEX S,SD                                                      000635
      REAL WO(16),BW(16)                                                000636
      REAL CM(16,8,8),PN1(16),PN2(16),PN11(16),PN12(16)                 000637
      REAL PN22(16),GL(16),WGL(16)                                      000638
      REAL INLOSS(16),DINLOSS(16,100)                                   000639
      REAL DISP(16),LAMR(16)                                            000640
      REAL FCNST(16),LAMRES(16),LAMDEL(16),LAMFIL,LREAC                 000641
      INTEGER IR(16),IRT(16),LC(16,36),KC(16,36),CEL(16,8,8)            000642
      INTEGER IPN1(16),IPN2(16),IWG(16)                                 000643
      COMPLEX DYP11(100),DYP21(100),DYP22(100)                          000644
      COMPLEX D(100,4)                                                  000645
      COMPLEX DTG(16,4),DG(16,4)                                        000646
      COMPLEX E(100,4),F(100,4)                                         000647
      REAL DRTLOSS(100)                                                 000648
      COMPLEX DVL(16,100)                                               000649
C                                                                       000650
      COMMON/BLK1/WO,BW,PN1,PN2,GL,VS,RS,PI2,WIDTH,NP1                  000651
      COMMON/BLK2/CM,WGL                                                000652
      COMMON/BLK4/CBR,FCUT                                              000653
      COMMON/BLK5/DISP                                                  000654
      COMMON/BLK6/FCNST,LAMRES,LAMDEL                                   000655
      COMMON/BLK7/CEL                                                   000656
      COMMON/BLK8/IR,IRT,IPN1,IPN2,IWG,LC,KC                            000657
C                                                                       000658
      IF(ICOUNT.NE.1)GO TO 5                                            000659
C                                                                       000660
      DO 100 I=1,N                                                      000661
      DO 100 J=1,M                                                      000662
      DO 100 KK=1,J                                                     000663
      CM(I,J,KK)=CM(I,KK,J)                                             000664
  100 CONTINUE                                                          000665
C                                                                       000666
      DO 99 I=1,N                                                       000667
      DO 99 J=1,M                                                       000668
      DO 99 K=1,M                                                       000669
      Z(I,J,K)=CMPLX(0.0,CM(I,J,K))                                     000670
   99 CONTINUE                                                          000671
C                                                                       000672
      C1=11802.85                                                       000673
      C2=4.0*WIDTH*WIDTH                                                000674
C                                                                       000675
    5 CONTINUE                                                          000676
C                                                                       000677
      IF(IDISPER.NE.1)GO TO 500                                         000678
C                                                                       000679
      DO 51 I=1,N                                                       000680
      LAMFIL=C1/SQRT(OMEG*OMEG-FCNST(I))                                000681
      LAMR(I)=LAMFIL/LAMRES(I)                                          000682
      LREAC=2.0*(LAMRES(I)-LAMFIL)/LAMDEL(I)                            000683
C                                                                       000684
C     SET UP THE COMPLEX IMPEDANCE MATRIX OF THE FILTERS                000685
```

```
C                                                                       000686
      DO 52 J=1,M                                                       000687
      DO 52 K=1,M                                                       000688
      Z(I,J,K)=CMPLX(0.0,CM(I,J,K))*LAMR(I)**CEL(I,J,K)                 000689
   52 CONTINUE                                                          000690
C                                                                       000691
C     SET UP DIAGONAL ELEMENTS INCLUDING FILTER DISPERSION              000692
C                                                                       000693
      DO 53 J=1,M                                                       000694
      Z(I,J,J)=CMPLX(0.0,CM(I,J,J)+LREAC)                               000695
C                                                                       000696
C     INCLUDE FILTER DISSIPATION                                        000697
C                                                                       000698
      IF(IFLAGDP.EQ.1)Z(I,J,J)=Z(I,J,J)+DISP(I)                         000699
   53 CONTINUE                                                          000700
   51 CONTINUE                                                          000701
      GO TO 75                                                          000702
C                                                                       000703
  500 CONTINUE                                                          000704
      DO 106 I=1,N                                                      000705
      XR=WO(I)/BW(I)                                                    000706
      C3=(OMEG/WO(I))-(WO(I)/OMEG)                                      000707
      S=CMPLX(0.0,C3)                                                   000708
      SD=S*XR                                                           000709
C                                                                       000710
C     SET UP DIAGONAL ELEMENTS FOR ZERO FILTER DISPERSION               000711
C                                                                       000712
      DO 106 J=1,M                                                      000713
      Z(I,J,J)=CMPLX(0.0,CM(I,J,J))+SD                                  000714
C                                                                       000715
C     INCLUDE FILTER DISSIPATION                                        000716
C                                                                       000717
      IF(IFLAGDP.EQ.1)Z(I,J,J)=Z(I,J,J)+DISP(I)                         000718
  106 CONTINUE                                                          000719
C                                                                       000720
   75 CONTINUE                                                          000721
      IF(IFLAGJS.EQ.1)GO TO 68                                          000722
      DO 66 I=1,N                                                       000723
      YC(I)=CMPLX(0.0,0.0)                                              000724
      Y1(I)=CMPLX(0.0,0.0)                                              000725
   66 CONTINUE                                                          000726
      GO TO 70                                                          000727
C                                                                       000728
   68 CONTINUE                                                          000729
C                                                                       000730
C     THE JUNCTION SUSCEPTANCE IS CALCULATED                            000731
C                                                                       000732
      BETAJS=FCUT/(((20.0*(CBR/OMEG)**2)-1.0)*SQRT(OMEG*OMEG-FCUT*FCUT)) 000733
      DO 69 I=1,N                                                       000734
      YC(I)=(0.0,0.0)                                                   000735
      Y1(I)=CMPLX(0.0,-BETAJS)                                          000736
   69 CONTINUE                                                          000737
C                                                                       000738
   70 CONTINUE                                                          000739
C                                                                       000740
      CALL BETAVAL(C1,C2,OMEG,PI2,BETA)                                 000741
C                                                                       000742
      CALL FILTER(N,M,Z,P,Q)                                            000743
C                                                                       000744
      CALL FILABCD(N,M,P,Q,PN1,PN2,Y1,GL,YC,Y,YP,YIN,Y3,                000745
     +             Y3SQ,TF,H7,H8,H13,H14,PN11,PN12,PN22)                000746
C                                                                       000747
      CALL WGUIDE(N,BETA,WGL,TG,DTG)                                    000748
C                                                                       000749
      DO 121 I=1,N                                                      000750
```

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C                                                                       000751
      CALL MATMUL(TF(I,1),TF(I,2),TF(I,3),TF(I,4),TG(I,1),TG(I,2),      000752
     +            TG(I,3),TG(I,4),T(I,1),T(I,2),T(I,3),T(I,4))          000753
C                                                                       000754
  121 CONTINUE                                                          000755
C                                                                       000756
      CALL SEQUENC(N,NP1,T,A)                                           000757
C                                                                       000758
      CALL RESPONS(N,NP1,RS,ZIN,RLOSS,VL,A,H23,H1,RO,RCOEFF,            000759
     +             YC,YP,TG,Y1,VS,H2,H3,H4,H5,H6,H7,H9,H10)             000760
C                                                                       000761
      CALL DABCDF2(N,M,IR,IRT,IPN1,IPN2,LC,KC,DYP11,                    000762
     +                 DYP21,DYP22,YIN,P,Q,PN1,PN2,                     000763
     +                 PN11,PN12,PN22,H7,H13,H14,Y1,TG,D,Y3SQ,YP,       000764
     +                 LAMR,IDISPER)                                    000765
C                                                                       000766
      DO 125 I=1,N                                                      000767
C                                                                       000768
      CALL MATMUL(TF(I,1),TF(I,2),TF(I,3),TF(I,4),DTG(I,1),DTG(I,2),    000769
     +            DTG(I,3),DTG(I,4),DG(I,1),DG(I,2),DG(I,3),DG(I,4))    000770
C                                                                       000771
  125 CONTINUE                                                          000772
C                                                                       000773
      CALL DABCDG2(N,IRT,IWG,D,DG)                                      000774
C                                                                       000775
      CALL DRLOSS2(N,NP1,IRT,E,F,A,D,H23,RCOEFF,RO,DRTLOSS)             000776
C                                                                       000777
      CALL DVOLTA2(N,IRT,IR,IPN1,IPN2,IWG,VS,H4,TG,H6,RS,DVL,F,H5,      000778
     + H3,H1,YC,Y1,H10,H8,H9,YP,H7,DYP21,DYP22,DYP11,DTG,A,E)           000779
C                                                                       000780
      CALL INSERT(N,VL,DVL,INLOSS,DINLOSS,IRT)                          000781
C                                                                       000782
      RETURN                                                            000783
      END                                                               000784
C                                                                       000785
```

```
C                                                                       000786
      SUBROUTINE INSERT(N,VL,DVL,INLOSS,DINLOSS,IRT)                    000787
C                                                                       000788
C     CHANNEL INSERTION LOSS AND ITS SENSITIVITIES ARE CALCULATED       000789
C                                                                       000790
      COMPLEX VL(16),DVL(16,100),HH2                                    000791
      REAL INLOSS(16),DINLOSS(16,100)                                   000792
      INTEGER IRT(16)                                                   000793
C                                                                       000794
C     THIS SUBROUTINE IS WRITTEN FOR VS=1.0, RS=1.0, GL(I)=1.0          000795
C                                                                       000796
      HH0=-20.0/ALOG(10.0)                                              000797
      KP=IRT(N)                                                         000798
      DO 10 I=1,N                                                       000799
      VABS=CABS(VL(I))                                                  000800
      INLOSS(I)=-20.0*ALOG10(2.0*VABS)                                  000801
      HH1=HH0/(VABS*VABS)                                               000802
      HH2=CONJG(VL(I))                                                  000803
C                                                                       000804
      DO 20 J=1,KP                                                      000805
      DINLOSS(I,J)=HH1*REAL(HH2*DVL(I,J))                               000806
   20 CONTINUE                                                          000807
   10 CONTINUE                                                          000808
      RETURN                                                            000809
      END                                                               000810
C                                                                       000811
```

```
C                                                                       000812
      SUBROUTINE SIMUL(OMEG,N,M,ICOUNT,IFLAGJS,IFLAGDP,IDISPER,         000813
     +                 RLOSS,INLOSS,ANGLE)                            000814
C                                                                       000815
C     THIS SUBROUTINE CALLS ALL SUBROUTINES NECESSARY FOR RESPONSE      000816
C     CALCULATIONS ONLY                                                 000817
C                                                                       000818
      COMPLEX Z(16,8,8),P(16,8),Q(16,8)                                 000819
      COMPLEX Y(16,4),YP(16,4),YIN(16),Y1(16),Y3(16),YC(16)             000820
      COMPLEX TF(16,4),TG(16,4),T(16,4),A(17,17,4),Y3SQ(16)             000821
      COMPLEX DTG(16,4)                                                 000822
      COMPLEX H2(16),H3(16),H4(16),H5(16),H6(16),H7(16),H8(16)          000823
      COMPLEX H9(16),H10(16),H13(16),H14(16)                            000824
      COMPLEX VL(16)                                                    000825
      COMPLEX H1,H23,ZIN,RCOEFF                                         000826
      COMPLEX S,SD                                                      000827
      REAL WO(16),BW(16)                                                000828
      REAL CM(16,8,8),PN1(16),PN2(16),PN11(16),PN12(16)                 000829
      REAL PN22(16),GL(16),WGL(16),INLOSS(16),ANGLE(16)                 000830
      REAL DISP(16),LAMR(16)                                            000831
      REAL FCNST(16),LAMRES(16),LAMDEL(16),LAMFIL,LREAC                 000832
      INTEGER CEL(16,8,8)                                               000833
C                                                                       000834
      COMMON/BLK1/WO,BW,PN1,PN2,GL,VS,RS,PI2,WIDTH,NP1                  000835
      COMMON/BLK2/CM,WGL                                                000836
      COMMON/BLK4/CBR,FCUT                                              000837
      COMMON/BLK5/DISP                                                  000838
      COMMON/BLK6/FCNST,LAMRES,LAMDEL                                   000839
      COMMON/BLK7/CEL                                                   000840
C                                                                       000841
      IF(ICOUNT.NE.1)GO TO 5                                            000842
C                                                                       000843
      DO 100 I=1,N                                                      000844
      DO 100 J=1,M                                                      000845
      DO 100 KK=1,J                                                     000846
      CM(I,J,KK)=CM(I,KK,J)                                             000847
  100 CONTINUE                                                          000848
C                                                                       000849
      DO 99 I=1,N                                                       000850
      DO 99 J=1,M                                                       000851
      DO 99 K=1,M                                                       000852
      Z(I,J,K)=CMPLX(0.0,CM(I,J,K))                                     000853
   99 CONTINUE                                                          000854
C                                                                       000855
      C1=11802.85                                                       000856
      C2=4.0*WIDTH*WIDTH                                                000857
C                                                                       000858
    5 CONTINUE                                                          000859
C                                                                       000860
      IF(IDISPER.NE.1)GO TO 500                                         000861
C                                                                       000862
      DO 51 I=1,N                                                       000863
      LAMFIL=C1/SQRT(OMEG*OMEG-FCNST(I))                                000864
      LAMR(I)=LAMFIL/LAMRES(I)                                          000865
      LREAC=2.0*(LAMRES(I)-LAMFIL)/LAMDEL(I)                            000866
C                                                                       000867
C     SET UP THE COMPLEX IMPEDANCE MATRIX OF THE FILTERS                000868
C                                                                       000869
      DO 52 J=1,M                                                       000870
      DO 52 K=1,M                                                       000871
      Z(I,J,K)=CMPLX(0.0,CM(I,J,K))*LAMR(I)**CEL(I,J,K)                 000872
   52 CONTINUE                                                          000873
C                                                                       000874
C     SET UP DIAGONAL ELEMENTS INCLUDING FILTER DISPERSION              000875
C                                                                       000876
```

```
      DO 53 J=1,M                                                       000877
      Z(I,J,J)=CMPLX(0.0,CM(I,J,J)+LREAC)                               000878
C                                                                       000879
C     INCLUDE FILTER DISSIPATION                                        000880
C                                                                       000881
      IF(IFLAGDP.EQ.1)Z(I,J,J)=Z(I,J,J)+DISP(I)                         000882
   53 CONTINUE                                                          000883
   51 CONTINUE                                                          000884
      GO TO 75                                                          000885
C                                                                       000886
  500 CONTINUE                                                          000887
      DO 106 I=1,N                                                      000888
      XR=WO(I)/BW(I)                                                    000889
      C3=(OMEG/WO(I))-(WO(I)/OMEG)                                      000890
      S=CMPLX(0.0,C3)                                                   000891
      SD=S*XR                                                           000892
C                                                                       000893
C     SET UP DIAGONAL ELEMENTS FOR ZERO FILTER DISPERSION               000894
C                                                                       000895
      DO 106 J=1,M                                                      000896
      Z(I,J,J)=CMPLX(0.0,CM(I,J,J))+SD                                  000897
C                                                                       000898
C     INCLUDE FILTER DISSIPATION                                        000899
C                                                                       000900
      IF(IFLAGDP.EQ.1)Z(I,J,J)=Z(I,J,J)+DISP(I)                         000901
  106 CONTINUE                                                          000902
C                                                                       000903
   75 CONTINUE                                                          000904
      IF(IFLAGJS.EQ.1)GO TO 68                                          000905
      DO 66 I=1,N                                                       000906
      YC(I)=CMPLX(0.0,0.0)                                              000907
      Y1(I)=CMPLX(0.0,0.0)                                              000908
   66 CONTINUE                                                          000909
      GO TO 70                                                          000910
C                                                                       000911
   68 CONTINUE                                                          000912
C                                                                       000913
C     THE JUNCTION SUSCEPTANCE IS CALCULATED                            000914
C                                                                       000915
      BETAJS=FCUT/(((20.0*(CBR/OMEG)**2)-1.0)*SQRT(OMEG*OMEG-FCUT*FCUT))000916
      DO 69 I=1,N                                                       000917
      YC(I)=(0.0,0.0)                                                   000918
      Y1(I)=CMPLX(0.0,-BETAJS)                                          000919
   69 CONTINUE                                                          000920
C                                                                       000921
   70 CONTINUE                                                          000922
C                                                                       000923
      CALL BETAVAL(C1,C2,OMEG,PI2,BETA)                                 000924
C                                                                       000925
      CALL FILTER(N,M,Z,P,Q)                                            000926
C                                                                       000927
      CALL FILABCD(N,M,P,Q,PN1,PN2,Y1,GL,YC,Y,YP,YIN,Y3,                000928
     +             Y3SQ,TF,H7,H8,H13,H14,PN11,PN12,PN22)                000929
C                                                                       000930
      CALL WGUIDE(N,BETA,WGL,TG,DTG)                                    000931
C                                                                       000932
      DO 121 I=1,N                                                      000933
C                                                                       000934
      CALL MATMUL(TF(I,1),TF(I,2),TF(I,3),TF(I,4),TG(I,1),TG(I,2),      000935
     +          TG(I,3),TG(I,4),T(I,1),T(I,2),T(I,3),T(I,4))            000936
C                                                                       000937
  121 CONTINUE                                                          000938
C                                                                       000939
      CALL SEQUENC(N,NP1,T,A)                                           000940
C                                                                       000941
```

```
      CALL RESPONS(N,NP1,RS,ZIN,RLOSS,VL,A,H23,H1,RO,RCOEFF,          000942
     +             YC,YP,TG,Y1,VS,H2,H3,H4,H5,H6,H7,H9,H10)           000943
C                                                                     000944
      CALL INSOUT(N,VL,INLOSS)                                        000945
C                                                                     000946
      CALL PHASE(N,VL,ANGLE)                                          000947
C                                                                     000948
      RETURN                                                          000949
      END                                                             000950
C                                                                     000951
```

```
C                                                                       000952
      SUBROUTINE BETAVAL(C1,C2,OMEG,PI2,BETA)                           000953
C                                                                       000954
C     WAVEGUIDE MANIFOLD PROPAGATION PHASE CONSTANT IS CALCULATED       000955
C                                                                       000956
      REAL LAM,LAMG                                                     000957
      LAM=C1/OMEG                                                       000958
      LAMG=LAM/SQRT(1.0-LAM*LAM/C2)                                     000959
      BETA=PI2/LAMG                                                     000960
      RETURN                                                            000961
      END                                                               000962
C                                                                       000963
```

```
C                                                                       000964
      SUBROUTINE INSOUT(N,VL,INLOSS)                                    000965
C                                                                       000966
C     CHANNEL INSERTION LOSS IS CALCULATED                              000967
C                                                                       000968
      COMPLEX VL(16)                                                    000969
      REAL INLOSS(16)                                                   000970
C                                                                       000971
C     THIS SUBROUTINE IS WRITTEN FOR VS=1.0, RS=1.0, GL(I)=1.0          000972
C                                                                       000973
      DO 10 I=1,N                                                       000974
      VABS=CABS(VL(I))                                                  000975
      INLOSS(I)=-20.0*ALOG10(2.0*VABS)                                  000976
   10 CONTINUE                                                          000977
      RETURN                                                            000978
      END                                                               000979
C                                                                       000980
```

```
C                                                                       000981
      SUBROUTINE CONST1(WIDTH)                                          000982
C                                                                       000983
C     WAVEGUIDE MANIFOLD CUTOFF FREQUENCY IS CALCULATED                 000984
C                                                                       000985
      COMMON/BLK4/CBR,FCUT                                              000986
      CBR=11802.85                                                      000987
      FCUT=CBR/(2.0*WIDTH)                                              000988
      RETURN                                                            000989
      END                                                               000990
C                                                                       000991
```

```
C                                                                       000992
      SUBROUTINE DISPAT(N,WO,BW,QO)                                     000993
C                                                                       000994
C     FILTER DISSIPATION IS CALCULATED USING UNLOADED Q, BANDWIDTHS     000995
C     AND CENTER FREQUENCIES                                            000996
C                                                                       000997
      REAL WO(16),BW(16),DISP(16),QO(16)                                000998
      COMMON/BLK3/DISP                                                  000999
C                                                                       001000
      DO 10 I=1,N                                                       001001
      DISP(I)=WO(I)/(BW(I)*QO(I))                                       001002
   10 CONTINUE                                                          001003
      RETURN                                                            001004
      END                                                               001005
C                                                                       001006
```

```
C                                                                       001007
      SUBROUTINE DISPER(N,WO,BW,DIA)                                    001008
C                                                                       001009
C     CALCULATES THE DISPERSIVE EFFECTS IN EACH FILTER                  001010
C     THE OUTPUT FROM THIS SUBROUTINE  INCLUDES  FILTER  GUIDE          001011
C     WAVELENGTH CORRESPONDING TO THE FILTER RESONANT FREQUENCY         001012
C     AND THE DIFFERENCE IN FILTER GUIDE WAVELENGTHS CORRESPONDING      001013
C     TO THE BAND EDGES.                                                001014
C                                                                       001015
      REAL WO(16),BW(16),DIA(16),FCNST(16),LAMRES(16),LAMDEL(16)        001016
      REAL LAMLOG,LAMHIG                                                001017
      COMMON/BLK6/FCNST,LAMRES,LAMDEL                                   001018
      CB=11802.83                                                       001019
      CDIA=CB/1.7063                                                    001020
C                                                                       001021
      DO 10 I=1,N                                                       001022
      FCNST(I)=CDIA/(DIA(I)*DIA(I))                                     001023
C                                                                       001024
      FLO=WO(I)-BW(I)/2.0                                               001025
      FHI=FLO+BW(I)                                                     001026
C                                                                       001027
      LAMLOG=CB/(SQRT(FLO*FLO-FCNST(I)))                                001028
      LAMHIG=CB/(SQRT(FHI*FHI-FCNST(I)))                                001029
C                                                                       001030
      LAMRES(I)=(LAMLOG+LAMHIG)/2.0                                     001031
      LAMDEL(I)=LAMLOG-LAMHIG                                           001032
C                                                                       001033
   10 CONTINUE                                                          001034
      RETURN                                                            001035
      END                                                               001036
C                                                                       001037
```

```
C                                                                       001038
      SUBROUTINE TOTAL2(N,IR,IRT,IPN1,IPN2,IWG)                         001039
C                                                                       001040
C     CALCULATE THE TOTAL NUMBER OF VARIABLES ACCUMULATED AFTER         001041
C     EACH SECTION                                                      001042
C                                                                       001043
      INTEGER IR(16),IRT(16),IPN1(16),IPN2(16),IWG(16)                  001044
      IRT(1)=IR(1)+IPN1(1)+IPN2(1)+IWG(1)                               001045
      IF(N.EQ.1)GO TO 5                                                 001046
      DO 15 I=2,N                                                       001047
      IM1=I-1                                                           001048
      IRT(I)=IRT(IM1)+IR(I)+IPN1(I)+IPN2(I)+IWG(I)                      001049
   15 CONTINUE                                                          001050
    5 CONTINUE                                                          001051
      RETURN                                                            001052
      END                                                               001053
C                                                                       001054
```

```
C                                                                       001055
      SUBROUTINE PHASE(N,VL,ANGLE)                                      001056
C                                                                       001057
C     GIVEN THE COMPLEX CHANNEL OUTPUT VOLTAGE CALCULATE THE            001058
C     CORRESPONDING PHASE                                               001059
C                                                                       001060
      COMPLEX VL(16)                                                    001061
      REAL ANGLE(16)                                                    001062
C                                                                       001063
      DO 10 I=1,N                                                       001064
      HRE=REAL(VL(I))                                                   001065
      HIM=AIMAG(VL(I))                                                  001066
      ANGLE(I)=ATAN2(HIM,HRE)                                           001067
   10 CONTINUE                                                          001068
      RETURN                                                            001069
      END                                                               001070
```