

## APPENDIX B. FORTRAN LISTINGS

This appendix contains listings of (1) the synthesizer control program, HANDSY.FOR, (2) the subroutine for converting user-oriented control parameter data into difference equation coefficients, PARCOE.FOR, and (3) the subroutine for converting these coefficients into a synthetic waveform, COEWAV.FOR. Also included are two small subroutines for converting from decibels to linear amplitudes, GETAMP.FOR, and for converting from formant frequency and bandwidth to difference-equation coefficients, SETABC.FOR.

As listed below, the programs should compile and run

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C      HANDSY.FOR          D. KLATT          6/1/79
C
C      SPECIFY AN ARRAY OF CONTROL PARAMETER DATA
C      AND SYNTHESIZE A SPEECH WAVEFORM
C
C      LOAD WITH PARCOE.FOR, COEWAV.FOR, SETABC.FOR, GETAMP.FOR
C
C      IF THIS PROGRAM DOES NOT FIT INTO CORE, DECREASE D(10050),
C      IWAVE(10050), AND WSIZE ALL BY THE SAME FRACTION
C
C      IMPLICIT INTEGER (A-Z)
C      REAL DB,DBLPNT,EPSLON,XMAXWA
C      EACH OF THE FOLLOWING VARIABLES HOLDS UP TO 5 ASCII CHARACTERS
C      REAL QUIT,NAMEV,NAMES(39),NAMEX(39)
C      DIMENSION MAXVAL(39),MINVAL(39),VALUES(39),IPAR(39)
C      DIMENSION VARPAR(39),LOC(39),LOCSAV(39),D(10050),IWAVE(10050)
C      DIMENSION COEFIC(50)
C      COMMON /PARS/IPAR
C      COMMON /COEFS/ COEFIC
C      EQUIVALENCE (D(1),IWAVE(1))
C
C      3-CHARACTER SYMBOL FOR EACH OF 39 CONTROL PARAMETER VALUES
C      DATA NAMES /'AV','AF','AH','AVS','FO','F1','F2','F3','F4','FNZ'
C      1,'AM','A1','A2','A3','A4','A5','A6','AB','B1','B2'
C      1,'B3','SW','FGP','BGP','FGZ','BGZ','B4','F5','B5','F6'
C      1,'B6','FNP','BNP','BNZ','BGS','SR','NWS','GO','NFC' /
C
C      MAXIMUM POSSIBLE VALUE FOR EACH OF 39 CONTROL PARAMETERS
C      DATA MAXVAL/80,80,80,80,500,900,2500,3500,4500,700
C      1,80,80,80,80,80,80,80,1000,1500
C      1,2000,1,600,2000,5000,10000,3000,4900,4000,4999
C      1,2000,500,500,500,1000,20000,200,80,6 /
C
C      MINIMUM POSSIBLE VALUE FOR EACH OF 39 CONTROL PARAMETERS
C      DATA MINVAL/0,0,0,0,0,150,500,1300,2500,200
C      1,0,0,0,0,0,0,0,40,40
C      1,40,0,0,100,0,100,100,3500,150,4000
C      1,200,200,50,50,100,5000,1,0,4 /
C
C      DETERMINATION OF VARIABLE (=1 OR =2) OR CONSTANT (=0) PARAMETERS
C      (PROGRAM SETS =2 IF ACTUALLY VARIED)
C      DATA VARPAR/1,1,1,1,1,1,1,1,1,1
C      1,0,0,1,1,1,1,1,1,1
C      1,1,0,0,0,0,0,0,1,0,0
C      1,0,0,0,0,0,0,0,0,0 /
C
C      DEFAULT VALUES FOR EACH OF 39 CONTROL PARAMETERS
C      DATA VALUES/0,0,0,0,0,450,1450,2450,3300,250
C      1,0,0,0,0,0,0,0,50,70
C      1,110,0,0,100,1500,6000,250,3750,200,4900
C      1,1000,250,100,100,200,10000,50,47,5 /
C
C      SIZE OF PARAMETER AND WAVEFORM ARRAYS THAT RESIDE IN CORE
C
C      DATA WSIZE/10050 /
C
C      NAMES OF SOME RESPONSE CHARACTERS
C      DATA QUIT,QUIT1,YES,NO,VAR,CON/'Q','Q','Y','N','V','C' /
C
C      1000 WRITE (5,1010)
C      1010 FORMAT (/ 'KLATT CASCADE/PARALLEL FORMANT SYNTHESIZER 6/1/79'
C      1 //)
C
C      SEE IF FILE PARAM.DOC EXISTS; IF SO, READ CONFIGURATION
C      OPEN(UNIT=1,NAME='PARAM.DOC',ACCESS='SEQUENTIAL',ERR=1140)
C      OPENPA=1
C      WRITE (5,1020)
C      1020 FORMAT (' READING INITIAL SYNTHESIZER CONFIGURATION FROM FILE
C      1 "PARAM.DOC" /')
C      DO 1060 M=1,13
C      N=M+13
C      N1=M+26
C      READ (1,2617) DUMMY,NAMES(M),VARPAR(M),VALUES(M),DUMMY,NAMES(N)
C      1,VARPAR(N),VALUES(N),DUMMY,NAMES(N1),VARPAR(N1),VALUES(N1)
C      1060 CONTINUE
C
C      CHANGE CONFIGURATION, CHANGE WHICH PARS ARE VARIABLE
C      1140 WRITE (5,1160)
C      1160 FORMAT (' PRINT AND/OR CHANGE CONFIGURATION (Y,Q):')
C      1170 READ (5,1180,ERR=1140) ANSWER
C      1180 FORMAT (A1)
C      1185 IF (ANSWER.EQ.QUIT1) GO TO 1740
C      GO TO 1685
C      1190 WRITE (5,1220)
C      1220 FORMAT (/ ' NAME OF PARAMETER TO BECOME VAR OR CON (QUIT="Q"):'$)
C      1240 READ (5,1260,ERR=1190) NAMEV
C      1260 FORMAT (A3)
C      1270 IF (NAMEV.EQ.QUIT) GO TO 1500
C      DO 1280 N=1,39
C      IF (NAMEV.EQ.NAMES(N)) GO TO 1320
C      1280 CONTINUE
C      WRITE (5,1300) NAMEV
C      1300 FORMAT (' 'A5,' TYPING ERROR, TRY AGAIN')
C      WRITE (5,1555) (NAMES(M),M=1,39)
C      GO TO 1190
C      1320 MODPAR=YES
C      IF (N.LE.35) GO TO 1330
C      WRITE (5,1325) NAMES(N)
C      1325 FORMAT (' PARAMETER 'A3,' CANNOT BE MADE VARIABLE')
C      GO TO 1190
C      1330 IF (VARPAR(N).NE.0) GO TO 1380
C      1340 VARPAR(N)=1
C      WRITE (5,1360)NAMEV

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on, e.g., any Digital Equipment Corporation PDP-11 having sufficient core. Some of the Fortran input-output instructions may have to be changed for other computer environments. For a machine with insufficient core, it may be possible to rewrite the routine HANDSY.FOR so as to use the disk for storage of parameter/waveform data instead of the 10050-word core array IWAVE. The arrays MAXVAL and MINVAL in HANDSY.FOR are included primarily to detect accidental typing errors and conceptual errors on the part of naive users; these values may have to be changed in order to synthesize unusual stimuli.

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1360 FORMAT (' 'A3,' IS NOW A VARIABLE')
GO TO 1190
1380 IF (VARPAR(N).NE.2) GO TO 1390
C      IF VARIED IN PREVIOUS SYNTH ATTEMPT, CAN'T MAKE INTO A CONSTANT
C
C      WRITE (5,1385) NAMEV
C      1385 FORMAT (' 'A3,' CAN NO LONGER BE MADE A CONSTANT')
C      GO TO 1190
C      1390 VARPAR(N)=0
C      1400 WRITE (5,1420) NAMEV
C      1420 FORMAT (' 'A3,' IS NOW A CONSTANT')
C      1440 FORMAT (' DONE')
C      GO TO 1190
C
C      CHANGE DEFAULT VALUE FOR A PARAMETER
C      1500 WRITE (5,1520)
C      1520 FORMAT (' NAME OF PARAMETER WHOSE
C      1 DEFAULT VALUE TO BE CHANGED (QUIT="Q"):'$)
C      READ (5,1260,ERR=1550) NAMEV
C      IF (NAMEV.EQ.QUIT) GO TO 1140
C      DO 1530 N=1,39
C      IF (NAMEV.EQ.NAMES(N)) GO TO 1560
C      1540 CONTINUE
C      1550 WRITE (5,1300) NAMEV
C      WRITE (5,1555) (NAMES(M), M=1,39)
C      1555 FORMAT (' PARS= ',13A4)
C      GO TO 1500
C      1560 IF ((N.NE.36).AND.(N.NE.37)) GO TO 1570
C      DON'T CHANGE NWS OR SR IF READING FROM PARAMETER FILE
C      IF (OPENPA.EQ.0) GO TO 1570
C      WRITE (5,1565) NAMEV
C      1565 FORMAT (' CANNOT CHANGE THE VALUE OF 'A3,' ANYMORE')
C      GO TO 1500
C      1570 WRITE (5,1580) NAMEV
C      1580 FORMAT (' NEW DEFAULT VALUE FOR 'A3,'='$)
C      READ (5,1900,ERR=1560) VALUE
C      IF (VALUE.LE.MAXVAL(N)) GO TO 1620
C      1590 WRITE (5,1600)VALUE,MAXVAL(N)
C      1600 FORMAT (' 'I6,' EXCEEDS MAXIMUM OF 'I5,' TRY AGAIN')
C      GO TO 1560
C      1620 IF (VALUE.GE.MINVAL(N)) GO TO 1660
C      1620 WRITE (5,1640)VALUE,MINVAL(N)
C      1640 FORMAT (' 'I5,' IS LESS THAN MINIMUM='I5,' TRY AGAIN')
C      GO TO 1560
C      1660 MODPAR=YES
C      VALUES(N)=VALUE
C      WRITE (5,1440)
C      GO TO 1500
C
C      PRINT CONFIGURATION
C      1680 IF (MODPAR.EQ.NO) GO TO 1740
C      1685 WRITE (5,1690)
C      1690 FORMAT (' CURRENT CONFIGURATION (NAME,VAR/CON,DEFAULT-VALUE):')
C      DO 1720 M=1,13
C      N=M+13
C      N1=M+26
C      WRITE (5,1700) M,NAMES(M),VARPAR(M),VALUES(M),N,NAMES(N)
C      1,VARPAR(N),VALUES(N),N1,NAMES(N1),VARPAR(N1),VALUES(N1)
C
C      1700 FORMAT(' 'I2,' 'A4,I2,I6,2(' 'I2,' 'A4,I2,I6))
C      1720 CONTINUE
C      GO TO 1190
C
C      COUNT NUMBER OF VARIABLE PARAMETERS, NVAR,
C      AND PLACE NAMES IN NAMEX(NVAR)
C      1740 NSAMP=VALUES(37)
C      DENOM=VALUES(36)/10
C      DELTAT=(NSAMP*100)/DENOM
C      NVAR=0
C      DO 1760 N=1,39
C      IF (VARPAR(N).EQ.0) GO TO 1760
C      NVAR=NVAR+1
C      LOC(NVAR)=N
C      NAMEX(NVAR)=NAMES(N)
C      1760 CONTINUE
C      IF (NVAR.GT.0) GO TO 1800
C      WRITE(5,1780)
C      1780 FORMAT (' ILLEGAL CONFIG, NO VARIABLE PARAMS, TRY AGAIN')
C      GO TO 1680
C      1800 MAXDUR=((WSIZE/NSAMP)*DELTAT)-20
C      WRITE (5,1820) NVAR
C      1820 FORMAT (/ ' THERE ARE 'I2,' VARIABLE PARAMETERS')
C      1840 WRITE (5,1840) DELTAT
C      1860 FORMAT (' PARAMETERS ARE TO BE SPECIFIED EVERY 'I2,' MSEC')
C      IF (OPENPA.EQ.0) GO TO 1870
C      READ (1,2625) VALUE
C      WRITE (5,1867) VALUE
C      1867 FORMAT (' LENGTH OF UTTERANCE IN MSEC = 'I5)
C      GO TO 1910
C      1870 WRITE (5,1880) MAXDUR
C      1880 FORMAT (' DESIRED LENGTH OF UTTERANCE IN MSEC (MAX='I4,'):'$)
C      1885 READ (5,1900,ERR=1860) VALUE
C      1900 FORMAT (I5)
C      1910 IF (VALUE.GE.DELTAT) GO TO 1920
C      WRITE (5,1300) NAMEV
C      GO TO 1860
C      1920 IF (VALUE.LE.MAXDUR) GO TO 1960
C      WRITE (5,1940) VALUE,MAXDUR
C      1940 FORMAT (' 'I4,' ILLEGAL, MAXIMUM DURATION='I4,' TRY AGAIN')
C      GO TO 1860
C      1960 UTTDUR=VALUE
C

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C      INSERT DEFAULT VALUES INTO PARAMETER TRACKS
      NSAMT1=((UTTDUR+20)/DELTAT)-1
      DO 2000 M=0,NSAMT1
      M1=M*NSAMP
      M2=0
      DO 1980 N=1,39
      IF (VARPAR(N).EQ.0) GO TO 1980
      M2=M2+1
      D(M1+M2)=VALUES(N)
      CONTINUE
1980
2000  CONTINUE
      WRITE (5,2020)
      FORMAT ('// DEFAULT VALUES INSERTED IN PARAMETER TRACKS')
2020  C
      PUT VARIABLE DATA FROM FILE PARAM.DOC INTO PARAMETER TRACKS
      IF (OPENPA.EQ.0) GO TO 2050
      WRITE (5,2041)
      FORMAT (' READING VARIABLE PARAMETRIC DATA FROM FILE
2041  1 "PARAM.DOC"')
      READ (1,2043) DUMMY,(DUMMY,M=1,NVAR1)
      FORMAT (27A5)
2043  NVAR1=0
      DO 2045 N=1,NVAR
      IF (VARPAR(LOC(N)).NE.2) GO TO 2045
      NVAR1=NVAR1+1
      LOCSAV(NVAR1)=N
      CONTINUE
2045  IF (NVAR1.GT.0) GO TO 2047
      WRITE (5,1780)
      STOP
2047  IF (NVAR1.GT.26) NVAR1=26
      NSAMT1=(UTTDUR/DELTAT)-1
      DO 2048 M=0,NSAMT1
      M1=M*NSAMP
      READ (1,2660) TIME,(D(LOCSAV(N)+M1),N=1,NVAR1)
      CONTINUE
      CLOSE(UNIT=1)
2048  C
      ACCEPT MODIFICATIONS TO PARAMETER TRACKS
      C
      OLDTIM=0
      SETPNT=NO
      MAXD1=UTTDUR-DELTAT
      WRITE (5,2060)
2060  FORMAT ('// NAME OF PARAMETER TRACK TO BE MODIFIED (QUIT="Q"):$')
2065  READ (5,1260,ERR=2090) NAMEV
2075  IF (NAMEV.EQ.QUIT) GO TO 2600
      DO 2080 N=1,NVAR
      IF (NAMEV.EQ.NAMEX(N)) GO TO 2120
      CONTINUE
2080  WRITE (5,1300) NAMEV
2090  WRITE (5,2100) NAMEX(M), M=1,NVAR
2100  FORMAT (' VARIABLE PARS= ',10A4)
      GO TO 2050
2120  CONTINUE
      VARPAR(LOC(N))=2
      MAXV=MAXVAL(LOC(N))
      MINV=MINVAL(LOC(N))
      WRITE (5,2200)
2180  FORMAT (' T=$')
2200  READ (5,2240,ERR=2550) TIME
2220  FORMAT (I3)
2240  C
      QUIT DRAWING CURRENT PARAMETER CONTOUR?
      IF ((TIME.EQ.0).AND.(SETPNT.EQ.YES)) GO TO 2050
      IF (TIME.LT.0) GO TO 2050
      C
      MAKE SURE LEGAL TIME
      IF (TIME.GE.OLDTIM) GO TO 2280
      WRITE (5,2260) TIME,OLDTIM
      FORMAT (' ILLEGAL TIME=',I3,', LESS THAN OLDTIM=',I3)
      GO TO 2180
2255  IF (TIME.LE.MAXD1) GO TO 2320
2260  WRITE (5,2300) TIME,MAXD1
      FORMAT (' ILLEGAL TIME=',I3,', GREATER THAN MAX=',I3)
      GO TO 2180
2280  NPTS=TIME/DELTAT
      TIME=NPTS*DELTAT
      POINTR=((NPTS)*NSAMP)+N
      WRITE (5,2340)
2300  FORMAT (' V=$')
2320  READ (5,1900,ERR=2550) VALUE
      C
      SEE IF LEGAL VALUE
      IF (VALUE.LE.MAXV) GO TO 2400
      WRITE (5,2371) MINV,MAXV
      FORMAT (' VMIN=',I5,', VMAX=',I5)
      GO TO 2330
2330  IF (VALUE.GE.MINV) GO TO 2420
2340  GO TO 2370
2370  IF ((SETPNT.EQ.YES).AND.(TIME.GE.(OLDTIM+DELTAT))) GO TO 2480
      C
      SET A POINT
      D(POINTR)=VALUE
      OLDVAL=VALUE
      SETPNT=YES
      GO TO 2180
2400  C
      DRAW A LINE
      NPTS=(TIME-OLDTIM)/DELTAT
      DVALUE=VALUE-OLDVAL
      EPSLON=0.1
      IF (DVALUE.LT.0) EPSLON=-EPSLON
      TIME1=OLDTIM/DELTAT
      DO 2500 M=1,NPTS
      DBLPNT=FLOAT(M)*FLOAT(DVALUE)
      DBLPNT=DBLPNT/DELTAT(NPTS)
      VALUE2=OLDVAL+IFIX(DBLPNT+EPSLON)
      POINTR=((TIME1+M)*NSAMP)+N
      D(POINTR)=VALUE2
      GO TO 2460
2460  C
      UNRECOVERABLE I/O ERROR, SAVE PARAMETERS AND QUIT
      WRITE (5,2560)
      FORMAT (' UNRECOVERABLE TYPING ERROR, SAVE PARAMETERS')
2500  C
      MAKE FILE OF PARAMETER VALUES VS TIME THAT CAN BE LISTED
      C
      ON LINE PRINTER
      CONTINUE
      OPEN(UNIT=1,NAME='PARAM.DOC',ACCESS='SEQUENTIAL',ERR=2600)
      DO 2620 M=1,13
      N=M+13
      N1=M+26
      DUMMY=' '
      WRITE (1,2617) DUMMY,NAMES(M),VARPAR(M),VALUES(M)
      1,DUMMY,NAMES(N),VARPAR(N),VALUES(N)
      1,DUMMY,NAMES(N1),VARPAR(N1),VALUES(N1)
      FORMAT (' ',3(A5,A3,I2,I5))
2617  CONTINUE
      WRITE (1,2625) UTTDUR
      FORMAT (' ',I5)
2620
2625

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C COMPUTE SAMPLING PERIOD T (ALL CONSTANT CONTROL PARAMETERS
C MUST BE SET BEFORE CALLING INIT)
SAMRAT=NNSR
T=1./SAMRAT
PIT=PI*T
TWOPI=2.*PIT
NTIMED=(NNNWS*1000)/NNSR
C CONVERT INHERENTLY INTEGER PARAMS TO REAL COEFFICIENTS
C(48)=NNNWS
C(49)=NNWS
C(50)=NNNFC
110 CONTINUE
C
C
C
C UPDATE ALL COEFFICIENTS OF HARDWARE SYNTHESIZER
C
C COMPUTE PARALLEL BRANCH AMPLITUDE CORRECTION TO F2 DUE TO F1
130 DELF1=FLOAT(NNF1)/500.
A2COR=DELF1*DELF1
C COMPUTE AMPLITUDE CORRECTION TO F3-5 DUE TO F1 AND F2
DELF2=FLOAT(NNF2)/1500.
A2SKRT=DELF2*DELF2
A3COR=A2COR*A2SKRT
C TAKE INTO ACCOUNT FIRST DIFF OF GLOTTAL WAVE FOR F2
A2COR=A2COR/DELF2
C COMPUTE AMPLITUDE CORRECTIONS DUE TO PROXIMITY OF 2 FORMANTS
N12COR=0
N23COR=0
N34COR=0
NF21=NNF2-NNF1
IF (NF21.LT.50) GO TO 135
IF (NF21.LT.550) N12COR=NDBCOR(NF21/50)
NF32=NNF3-NNF2-50
IF (NF32.LT.50) GO TO 135
IF (NF32.LT.550) N23COR=NDBCOR(NF32/50)
NF43=NNF4-NNF3-150
IF (NF43.LT.50) GO TO 135
IF (NF43.LT.550) N34COR=NDBCOR(NF43/50)
C PRINT INPUT PARAMETERS IF NTIMPR SET TO ZERO OR TO A SPECIFIC TIME
IF (NTIMPR.EQ.0) GO TO 135
IF (NTIMPR.NE.NTIMEP) GO TO 146
135 WRITE (5,140) NTIMEP
140 FORMAT (' INPUT PARS AT T = ',I4,' MS')
WRITE (5,141) (I(NPP),NPP=NPPBEG,NPPEND)
141 FORMAT (' ',13I5)
WRITE (5,142)
142 FORMAT (' ')
143 NPAR=1
144 NTIMEP=NTIMEP+NTIMED
C SET AMPLITUDE OF VOICING
NDBAV=NNGO+NNAV+NDBSCA(9)
IMPULS=GETAMP(NDBAV)
C AMPLITUDE OF ASPIRATION
NDBAH=NNGO+NNAH+NDBSCA(10)
150 AHH=GETAMP(NDBAH)
C AMPLITUDE OF FRICTION
C (IN AN ALL-PARALLEL CONFIGURATION, AF=MAX(AF,AH))
IF ((NNAH.GT.NNAF).AND.(NNSW.EQ.1)) NNAF=NNAH
NDBAF=NNGO+NNAF+NDBSCA(11)
AFF=GETAMP(NDBAF)
C ADD A STEP TO WAVEFORM AT A PLOSIVE RELEASE
PLSTEP=0.
IF (NNAF-NAFLAS.LT.49) GO TO 151
PLSTEP=GETAMP(NNGO+NDBSCA(11)+44)
151 NAFLAS=NNAF
C AMPLITUDE OF QUASI-SINUSOIDAL VOICING SOURCE
NDBAVS=NNGO+NNAVS+NDBSCA(12)
SINAMP=10.*GETAMP(NDBAVS)
C SET AMPLITUDES OF PARALLEL FORMANTS A1 THRU A6
NDB=NNA1+N12COR+NDBSCA(1)
A1P=GETAMP(NDB)
NDB=NNA2+N12COR+N23COR+NDBSCA(2)
A2P=A2COR*GETAMP(NDB)
NDB=NNA3+N23COR+N23COR+N34COR+NDBSCA(3)
A3P=A3COR*GETAMP(NDB)
NDB=NNA4+N34COR+N34COR+NDBSCA(4)
A4P=A3COR*GETAMP(NDB)
NDB=NNA5+NDBSCA(5)
A5P=A3COR*GETAMP(NDB)
NDB=NNA6+NDBSCA(6)
A6P=A3COR*GETAMP(NDB)
C SET AMPLITUDE OF PARALLEL NASAL FORMANT
NDB=NNA6+NDBSCA(7)
ANPP=GETAMP(NDB)
C SET AMPLITUDE OF BYPASS PATH OF FRICTION TRACT
NDB=NNA6+NDBSCA(8)
ABP=GETAMP(NDB)
C RESET DIFFERENCE EQUATION CONSTANTS FOR RESONATORS
230 CALL SETABC(NNF1,NNB1,A1,B1,C1)
CALL SETABC(NNF2,NNB2,A2,B2,C2)
CALL SETABC(NNF3,NNB3,A3,B3,C3)
CALL SETABC(NNF4,NNB4,A4,B4,C4)
CALL SETABC(NNF5,NNB5,A5,B5,C5)
CALL SETABC(NNF6,NNB6,A6,B6,C6)
C CALL SETABC(NNFP,NNBNP,ANP,BNP,CNP)
C AND FOR NASAL ANTIRESONATOR
MNFNZ=-MNFNZ
IF (MNFNZ.GE.0) MNFNZ=-1
CALL SETABC(MNFNZ,NNBNZ,ANZ,BNZ,CNZ)
C AND FOR GLOTTAL RESONATORS AND ANTIRESONATOR
NPULSN=1
IF (NNFO.LE.0) GO TO 245
C ISSUE NO PULSE IF NNAV AND NNAVS BOTH .LE.0
IF ((NNAV.LE.0).AND.(NNAVS.LE.0)) GO TO 245
C WAVEFORM MORE SINUSOIDAL AT HIGH FUNDAMENTAL FREQUENCY
NXBGP=(NNBGP-100)/NNFO
CALL SETABC(NNFGP,NXBGP,AGP,BGP,CGP)
CALL SETABC(0,NNBGS,AGS,BGS,CGS)
MNFZ=-MNFZ
IF (MNFZ.GE.0) MNFZ=-1
CALL SETABC(MNFZ,NNBGZ,AGZ,BGZ,CGZ)
C SET GAIN TO CONSTANT IN MID-FREQUENCY REGION FOR RGP
AGP=.007
C DO NOT LET FO DROP BELOW 40 HZ
IF (NNFO.LT.40) NNFO=40
C MAKE AMPLITUDE OF IMPULSE INCREASE WITH INCREASING FO
IMPULS=IMPULS*NNFO
C NUMBER OF SAMPLES BEFORE A NEW GLOTTAL PULSE MAY BE GENERATED
NPULSN=NNSR/NNFO
245 CONTINUE
C CONVERT INHERENTLY INTEGER PARAMS TO REAL COEFFICIENTS
C(47)=NPULSN
RETURN
END
C
C COEWAV.FOR D.H. KLATT 8/1/78
C
C "COEF-TO-WAVE" TRANSFORMATION SUBROUTINE
C (FOR A 16-BIT PDP-11 COMPUTER)
C
C SIMULATION OF THE HARDWARE KLATT SYNTHESIZER
C TAKE 50 COEFFICIENTS FROM COMMON ARRAY C, AND

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C SYNTHESIZE NEXT NNXWS SAMPLES OF THE OUTPUT WAVEFORM
C
C SUBROUTINE COEWAV(IWAVE,OUTMA)
C IWAVE IS AN ARRAY IN WHICH WAVEFORM SAMPLES ARE PLACED
C LEFT-JUSTIFIED IN A 36-BIT WORD
C OUTMA IS RETURN ARG INDICATING MAX ABSOL. VALUE OF WAVE
C IF CALLING PROGRAM SETS TO -1., COEWAV IS INITIALIZED
C
C REAL NOISE, INPUTS, INPUT, IMPULS
C DIMENSION IWAVE(1),C(50)
C COMMON /COEFS/ C
C COEFFICIENT VALUES IN C(50) ARE REAL
C EQUIVALENCE (C(1),IMPULS),(C(2),SINAMP),(C(3),AFRICI)
C EQUIVALENCE (C(4),AASPI),(C(5),A1PAR),(C(6),A2PAR)
C EQUIVALENCE (C(7),A3PAR),(C(8),A4PAR),(C(9),A5PAR)
C EQUIVALENCE (C(10),A6PAR),(C(11),ABPAR),(C(12),ANPAR)
C EQUIVALENCE (C(13),AGP),(C(14),BGP),(C(15),CGP)
C EQUIVALENCE (C(16),AGZ),(C(17),BGZ),(C(18),CGZ)
C EQUIVALENCE (C(19),AGS),(C(20),BGS),(C(21),CGS)
C EQUIVALENCE (C(22),A1),(C(23),B1),(C(24),C1)
C EQUIVALENCE (C(25),A2),(C(26),B2),(C(27),C2)
C EQUIVALENCE (C(28),A3),(C(29),B3),(C(30),C3)
C EQUIVALENCE (C(31),A4),(C(32),B4),(C(33),C4)
C EQUIVALENCE (C(34),A5),(C(35),B5),(C(36),C5)
C EQUIVALENCE (C(37),A6),(C(38),B6),(C(39),C6)
C EQUIVALENCE (C(40),ANP),(C(41),BNP),(C(42),CNP)
C EQUIVALENCE (C(43),ANZ),(C(44),BNZ),(C(45),CNZ)
C EQUIVALENCE (C(46),PLSTEP)
C MAXIMUM VALUE FOR A WAVEFORM SAMPLE (LEFT-JUSTIFY IN 36-BIT WORD)
DATA WAVMA,WAVMAX/32767,-32767/
C
C INITIALIZE COEWAV IF OUTMA=-1.
C ZERO MEMORY REGISTERS IN ALL RESONATORS
IF (OUTMA.GE.0.) GO TO 250
249 YL1P=0.
YL2P=0.
YL21P=0.
YL22P=0.
YL3P=0.
YL32P=0.
YL41P=0.
YL42P=0.
YL51P=0.
YL52P=0.
YL61P=0.
YL62P=0.
YLN1P=0.
YLN2P=0.
YL11C=0.
YL12C=0.
YL21C=0.
YL22C=0.
YL31C=0.
YL32C=0.
YL41C=0.
YL42C=0.
YL51C=0.
YL52C=0.
YL61C=0.
YL62C=0.
YLN1C=0.
YLN2C=0.
YLN21C=0.
YLN22C=0.
YLG1P=0.
YLG2P=0.
YLG1S=0.
YLG2S=0.
YLG3S=0.
YLG4S=0.
YLGZ1=0.
YLGZ2=0.
C ZERO ALL OTHER MEMORY REGISTERS
NPULSE=1
MPULSE=0
UGLOTX=0.
UGLOTL=0.
OUTMA=0.
AFRIC=0.
STEP=0.
AASPIR=0.
C
C GENERATE NNXWS SAMPLES OF OUTPUT WAVEFORM
250 CONTINUE
C TRANSLATE SOME COEFFICIENTS TO INTEGER
NPULSN=C(47)
NNXWS=C(48)
NXSW=C(49)
NXNFC=C(50)
XNSAMI=1.0/FLOAT(NNXWS)
C DELTA AMPLITUDE OF ASPIRATION
DAHH=(AASPI-AASPIR)*XNSAMI
C DELTA AMPLITUDE OF FRICTION
DAFF=(AFRICI-AFRIC)*XNSAMI
C
C MAIN LOOP
DO 530 NTIME=1,NNXWS
C GENERATE NEW GLOTTAL PULSE IF PERIOD COUNTER EXCEEDED
NPULSE=NPULSE-1
IF (NPULSE.GT.0) GO TO 260
C AND IF NPULSN.GT.1 (I.E. IF FO>0 AND AV+AVS>0)
IF (NPULSN.LE.1) GO TO 260
C RESET PULSE COUNTER
NPULSE=NPULSN
C PULSE COUNTER FOR MODULATED NOISE
MPULSE=NPULSE/2
C SET AMPLITUDE OF NORMAL VOICING IMPULSE
INPUT=IMPULS
C AMPLITUDE OF QUASI-SINUSOIDAL VOICING
INPUTS=SINAMP
GO TO 275
C SET INPUT TO ZERO BETWEEN GLOTTAL IMPULSES
260 INPUT=0.
INPUTS=0.
C RESONATOR RGP:
275 YGP=AGP*INPUT + BGP*YLGP1 + CGP*YLG2
YLGP2=YLGP1
YLGP1=YGP
C GLOTTAL ZERO PAIR RGZ:
290 YGZ=AGZ*YGP + BGZ*YLGZ1 + CGZ*YLGZ2
YLGZ2=YLGZ1
YLGZ1=YGP
C QUASI-SINUSOIDAL VOICING PRODUCED BY IMPULSE INTO RGP AND RGS:
YGS=INPUTS*AGS + BGS*YLG1 + CGS*YLG2
YLG2=YLG1
YLG1=YGS
YGS=AGP*YGS + BGP*YLG3 + CGP*YLG4
YLG4=YLG3
YLG3=YGS
C GLOTTAL VOLUME VELOCITY IS THE SUM OF NORMAL AND
QUASI-SINUSOIDAL VOICING
UGLOT2=YGZ + YGS

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C RADIATION CHARACTERISTIC IS A ZERO AT THE ORIGIN
  UGLOT=UGLOT2-UGLOTX
  UGLOTX=UGLOT2
C
C TURBULENCE NOISE OF ASPIRATION AND FRICATION
C GENERATE RANDOM NOISE, RANDOM PRODUCES UNIFORM DIST. (0. TO 1.)
C NOISE=0.
370 C MAKE PSEUDO-GAUSSIAN
  DO 371 NRANDX=1,16
  NOISE=NOISE+RAN(IRAN1,IRAN2)
371 C SUBTRACT OFF DC
  NOISE=NOISE-8.
C MODULATE NOISE DURING SECOND HALF OF A GLOTTAL PERIOD
375 C IF (MPULSE.LE.0) NOISE=NOISE/2.
  MPULSE=MPULSE-1
C LOW-PASS NOISE AT -6 DB/OCTAVE TO SIMULATE SOURCE IMPEDANCE
C HIGH-PASS NOISE AT +6 DB/OCTAVE FOR RADIATION CHARACTERISTIC
  (TWO EFFECTS CANCEL ONE ANOTHER)
C GLOTTAL SOURCE VOLUME VELOCITY = VOICING+ASPIRATION
  AASPIR=AASPIR+DAHH
  UASP=AASPIR*NOISE
  UGLOT=UGLOT+UASP
C SET FRICATION SOURCE VOLUME VELOCITY
390 C AFRIC=AFRIC+DAFF
C PREPARE TO ADD IN A STEP EXCITATION OF VOCAL TRACT
C IF PLOSIVE RELEASE (I.E. IF PLSTEP.GT.0.)
  IF (PLSTEP.LE.0.) GO TO 391
  STEP=PLSTEP
  PLSTEP=0.
391 C UFRIC=AFRIC*NOISE
C
C SEND GLOTTAL SOURCE THRU CASCADE VOCAL TRACT RESONATORS
C DO FORMANT EQUATIONS FOR NNXFRC FORMANTS IN DESCENDING ORDER
C TO MINIMIZE TRANSIENTS
  IF (NXSW.EQ.1) GO TO 430
C BYPASS R6 IF NNXFRC LESS THAN 6
  Y6C=UGLOT
  IF (NNXFRC.LT.6) GO TO 415
  Y6C=A6*UGLOT + B6*YL61C + C6*YL62C
  YL62C=YL61C
  YL61C=Y6C
C BYPASS R5 IF NNXFRC LESS THAN 5
415 C Y5C=Y6C
  IF (NNXFRC.LT.5) GO TO 416
  Y5C=A5*Y6C + B5*YL51C + C5*YL52C
  YL52C=YL51C
  YL51C=Y5C
416 C Y4C=A4*Y5C + B4*YL41C + C4*YL42C
  YL42C=YL41C
  YL41C=Y4C
  Y3C=A3*Y4C + B3*YL31C + C3*YL32C
  YL32C=YL31C
  YL31C=Y3C
  Y2C=A2*Y3C + B2*YL21C + C2*YL22C
  YL22C=YL21C
  YL21C=Y2C
  Y1C=A1*Y2C + B1*YL11C + C1*YL12C
  YL12C=YL11C
  YL11C=Y1C
C NASAL ZERO-PAIR RNZ:
420 C YZC=ANZ*Y1C + BNZ*YLN21C + CNZ*YLN22C
  YLN22C=YLN21C
  YLN21C=Y1C
C NASAL RESONATOR RNP:
  YPC=ANP*YZC + BNP*YLN21C + CNP*YLN22C
  YLN22C=YLN21C
  YLN21C=YPC
  ULIPSV=YPC
C ZERO OUT VOICING INPUT TO PARALLEL BRANCH
C IF CASCADE BRANCH HAS BEEN USED
425 C UGLOT=0.
  UGLOTL=0.
C
C SEND VOICING AND FRICATION NOISE THRU PARALLEL RESONATORS
C INCREMENT RESONATOR AMPLITUDES GRADUALLY
430 C CONTINUE
C FIRST PARALLEL FORMANT R1' (EXCITED BY VOICING ONLY)
  Y1P=A1*U1PAR*UGLOT + B1*YL11P + C1*YL12P
  YL12P=YL11P
  YL11P=Y1P
C NASAL POLE RN' (EXCITED BY FIRST DIFF. OF VOICING SOURCE)
  UGLOT1=UGLOT-UGLOTL
  UGLOTL=UGLOT
  YN=ANP*ANPAR*UGLOT1 + BNP*YLN21P + CNP*YLN22P
  YLN22P=YLN21P
  YLN21P=YN
C EXCITE FORMANTS R2'-R4' WITH FRIC NOISE PLUS FIRST-DIFF. VOICING
  Y2P=A2*A2PAR*(UFRIC+UGLOT1) + B2*YL21P + C2*YL22P
  YL22P=YL21P
  YL21P=Y2P
  Y3P=A3*A3PAR*(UFRIC+UGLOT1) + B3*YL31P + C3*YL32P
  YL32P=YL31P
  YL31P=Y3P
  Y4P=A4*A4PAR*(UFRIC+UGLOT1) + B4*YL41P + C4*YL42P
  YL42P=YL41P
  YL41P=Y4P
C EXCITE FORMANT RESONATORS R5'-R6' WITH FRIC NOISE
  Y5P=A5*A5PAR*UFRIC + B5*YL51P + C5*YL52P
  YL52P=YL51P
  YL51P=Y5P
  Y6P=A6*A6PAR*UFRIC + B6*YL61P + C6*YL62P
  YL62P=YL61P
  YL61P=Y6P
C ADD UP OUTPUTS FROM RW', R1' - R6' AND BYPASS PATH
  ULIPSF=Y1P+Y2P+Y3P+Y4P+Y5P+Y6P+YN-ABPAR*UFRIC
440 C CONTINUE
C ADD CASCADE AND PARALLEL VOCAL TRACT OUTPUTS
  (SCALE BY 170 TO LEFT JUSTIFY IN 16-BIT WORD)
450 C ULIPS=(ULIPSV+ULIPSF+STEP)*(170.)
  STEP=.995*STEP
C FIND CUMULATIVE ABSOL. MAX. OF WAVEFORM SINCE BEGINNING OF UTT.
500 C IF (ULIPS.GT.OUTMA) OUTMA=ULIPS
  IF (-ULIPS.GT.OUTMA) OUTMA=-ULIPS
C TRUNCATE WAVEFORM SAMPLES TO ABS[WAVMA]
  IF (ULIPS.LE.WAVMA) GO TO 510
  ULIPS=WAVMA
510 C IF (ULIPS.GE.WAVMAX) GO TO 520
  ULIPS=WAVMAX
520 C TWAVE(TWTIME)=ULIPS
530 C CONTINUE
540 C RETURN
  END
C
C SETABC.FOR D.H. KLATT 8/1/78
C
C CONVERT FORMANT FREQUENCIES AND BANDWIDTH TO RESONATOR
C DIFFERENCE EQUATION CONSTANTS
C
C SUBROUTINE SETABC(F,FB,A,B,C)
C
C INTEGER F,FB
C COMMON /PIXX/ PIT,TWOPIT
C
C---REPLACE BY R=EXPTAB(FB) FOR FASTER EXECUTION
  R=EXP(-PIT*FLOAT(FB))
  C=-R*R
C---REPLACE BY B=COSTAB(F) FOR FASTER EXECUTION
  B=2.*R*COS(TWOPIT*FLOAT(F))
  A=1.-B-C
620 C CONTINUE
C IF F IS MINUS, COMPUTE A,B,C FOR A ZERO PAIR
  IF (F.GE.0) RETURN
630 C A=1./A
  B=-A*B
  C=-A*C
  RETURN
  END
C
C GETAMP.FOR D.H. KLATT 8/1/78
C
C CONVERT DB ATTEN. (FROM 96 TO -72) TO A LINEAR SCALE FACTOR.
  (TRUNCATE NDB IF OUTSIDE RANGE)
C
C FUNCTION GETAMP(NDB)
C
C DIMENSION DTABLE(11),STABLE(28)
C DATA DTABLE/1.8,1.6,1.43,1.26,1.12
C 1,1.0,0.89,0.792,0.702,0.623,0.555/
C DATA STABLE/65536.,32768.,16384.,8192.
C 1,4096.,2048.,1024.,512.,256.,128.
C 1,64.,32.,16.,8.,4.,2
C 1,1.,.5.,.25.,.125.,.0625.,.0312.,.0156.,.0078.,.0039.,.00195
C 1.,.000975.,.000487/
C
C NDB1=NDB
C GETAMP=0.
  IF (NDB1.LE.-72) RETURN
  IF (NDB1.GT.96) NDB1=96
  NDB2=NDB1/6
  NDB3=NDB1-(6*NDB2)
  XX1=STABLE(17-NDB2)
  XX2=DTABLE(6-NDB3)
  GETAMP=XX1*XX2
660 C CONTINUE
  RETURN
  END

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