

## 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

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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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 FACTOR
C
C      IMPLICIT INTEGER (A-Z)
C      REAL DB,DBLPNT,EPSON,XMAXWA
C
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','F01','F2','F3','F4','FNZ'
C      '1','AN','A1','A2','A3','AH','A5','A6','AB','B1','B2'
C      '1','B3','SW','FGP','BGP','FG2','BG2','B4','P5','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
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      1,0,0,1,1,1,1,1,1,1,1
C      1,1,0,0,0,0,0,0,1,0,0
C      1,0,0,0,0,0,0,0,0,0,0/
C
C      DEFAULT VALUES FOR EACH OF 39 CONTROL PARAMETERS
C      DATA VALUES/0,0,0,0,0,450,1450,2450,3300,250
C      1,0,0,0,0,0,0,50,70
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,QUITYES,NO,VAR,CON/'Q','Q','Y','N','V','C'/
C
1000  WRITE (5,1010)
1010  FORMAT ('/ KLATT CASCADE/PARALLEL FORMANT SYNTHESIZER 6/1/79
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)
1020  FORMAT ('/ READING INITIAL SYNTHESIZER CONFIGURATION FROM FILE
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)
1060  CONTINUE
C
C      CHANGE CONFIGURATION, CHANGE WHICH PARS ARE VARIABLE
1140  WRITE (5,1160)
1160  FORMAT ('/ PRINT AND/OR CHANGE CONFIGURATION (QUIT="Q"):$')
1170  READ (5,1180,ERR=1140) ANSWER
1180  FORMAT (A1)
1185  IF (ANSWER.EQ.QUIT) GO TO 1740
C      GO TO 1685
1190  WRITE (5,1220)
1220  FORMAT ('/ NAME OF PARAMETER TO BECOME VAR OR CON (QUIT="Q"):$')
1240  READ (5,1260,ERR=1190) NAMEV
1260  FORMAT (A3)
1270  IF (NAMEV.EQ.QUIT) GO TO 1500
C      DO 1280 N=1,39
C      IF (NAMEV.EQ.NAMES(N)) GO TO 1320
1280  CONTINUE
C      WRITE (5,1300) NAMEV
1300  FORMAT ('/A5/, TYPING ERROR, TRY AGAIN')
C      WRITE (5,1555) (NAMES(M),M=1,39)
C      GO TO 1190
1320  MODPAR=YES
C      IF (N.LT.35) GO TO 1330
C      WRITE (5,1325) NAMES(N)
1325  FORMAT ('/ PARAMETER ',A3,' CANNOT BE MADE VARIABLE')
C      GO TO 1190
1330  IF (VARPAR(N).NE.0) GO TO 1380
C      VARPAR(N)=1
1340  WRITE (5,1360)NAMEV

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1360  FORMAT ('/ ',A3,' IS NOW A VARIABLE')
C      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
1385  FORMAT ('/ ',A3,' CAN NO LONGER BE MADE A CONSTANT')
C      GO TO 1190
1390  VARPAR(N)=0
1400  WRITE (5,1420) NAMEV
1420  FORMAT ('/ ',A3,' IS NOW A CONSTANT')
1440  FORMAT ('/ DONE')
C      GO TO 1190
C
C      CHANGE DEFAULT VALUE FOR A PARAMETER
1500  WRITE (5,1520)
1520  FORMAT ('/ NAME OF PARAMETER WHOSE
1. DEFAULT VALUE TO BE CHANGED (QUIT="Q"):$')
C      READ (5,1260,ERR=1550) NAMEV
1530  IF (NAMEV.EQ.QUIT) GO TO 1140
C      DO 1540 N=1,39
C      IF (NAMEV.EQ.NAMES(N)) GO TO 1560
1540  CONTINUE
1550  WRITE (5,1300) NAMEV
C      WRITE (5,1555) (NAMES(M), M=1,39)
1555  FORMAT ('/ PARS = ',1344)
C      GO TO 1500
1560  IF ((N.NE.36).AND.(N.NE.37)) GO TO 1570
C      IF (DON'T CHANGE NWS OR SR IF READING FROM PARAMETER FILE
C      IF (OPENA.EQ.0) GO TO 1570
C      WRITE (5,1565) NAMEV
1565  FORMAT ('/ CANNOT CHANGE THE VALUE OF ',A3,' ANYMORE')
C      GO TO 1500
1570  WRITE (5,1580) NAMEV
1580  FORMAT ('/ NEW DEFAULT VALUE FOR ',A3,'=$')
C      READ (5,1900,ERR=1560) VALUE
1590  IF (VALUE.LE.MAXVAL(N)) GO TO 1620
C      WRITE (5,1600) VALUE,MAXVAL(N)
1600  FORMAT ('/ ',I6,' EXCEEDS MAXIMUM OF ',I5,' TRY AGAIN')
C      GO TO 1560
1620  IF (VALUE.GE.MINVAL(N)) GO TO 1660
1640  FORMAT ('/ ',I5,' IS LESS THAN MINIMUM=',I5,' TRY AGAIN')
C      GO TO 1560
1660  MODPAR=YES
C      VALUES(N)=VALUE
C      WRITE (5,1440)
C      GO TO 1500
C
C      PRINT CONFIGURATION
1680  IF (MODPAR.EQ.NO) GO TO 1740
1685  WRITE (5,1690)
1690  FORMAT ('/ CURRENT CONFIGURATION (NAME,VAR/CON,DEFAULT-VALUE):')
C      DO 1720 M=1,13
C      N=M+13
C      N1=N+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
1700  FORMAT('/ ',I2,' ',A4,I2,I6,2(' ',I2,' ',A4,I2,I6))
1720  CONTINUE
C      GO TO 1190
C
C      COUNT NUMBER OF VARIABLE PARAMETERS, NVAR,
C      AND PLACE NAMES IN NAMEX(NVAR)
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)
1760  CONTINUE
C      IF (NVAR.GT.0) GO TO 1800
C      WRITE(5,1780)
1780  FORMAT ('/ ILLEGAL CONFIG, NO VARIABLE PARAMS, TRY AGAIN')
C      GO TO 1680
1800  MAXDUR=((WSIZE/NSAMP)*DELTAT)-20
C      WRITE (5,1820) NVAR
1820  FORMAT ('/ THERE ARE ',I2,' VARIABLE PARAMETERS')
C      WRITE (5,1840) DELTAT
1840  FORMAT ('/ PARAMETERS ARE TO BE SPECIFIED EVERY ',I2,' MSEC')
C      IF (OPENA.EQ.0) GO TO 1870
C      READ (1,2625) VALUE
C      WRITE (5,1867) VALUE
1867  FORMAT ('/ LENGTH OF UTTERANCE IN MSEC = ',I5)
C      GO TO 1910
1870  WRITE (5,1880) MAXDUR
1880  FORMAT ('/ DESIRED LENGTH OF UTTERANCE IN MSEC (MAX=',I4,'):')
C      READ (5,1900,ERR=1860) VALUE
1885  IF (VALUE.GE.MAXDUR) GO TO 1920
C      WRITE (5,1930) NAMEV
1900  FORMAT (I5)
C      IF (VALUE.GE.DELTAT) GO TO 1920
C      GO TO 1860
1920  IF (VALUE.LE.MAXDUR) GO TO 1960
C      WRITE (5,1940) VALUE,MAXDUR
1940  FORMAT ('/ ',I4,' ILLEGAL, MAXIMUM DURATION=',I4,', TRY AGAIN')
C      GO TO 1860
1960  UTTDUR=VALUE
C

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C INSERT DEFAULT VALUES INTO PARAMETER TRACKS
NSAMTI=((UTTDUR+20)/DELTAT)-1
DO 2000 M=0,NSAMTI
M1=M#NSAMP
M2=0
DO 1980 N=1,39
IF (VARPAR(N).EQ.0) GO TO 1980
M2=M+2
D(M1+M2)=VALUES(N)
CONTINUE
1980 CONTINUE
2000 WRITE (5,2020)
2020 FORMAT ('/ DEFAULT VALUES INSERTED IN PARAMETER TRACKS')
C PUT VARIABLE DATA FROM FILE PARAM.DOC INTO PARAMETER TRACKS
2040 IF (OPENPA.EQ.0) GO TO 2050
WRITE (5,2041)
2041 FORMAT (' READING VARIABLE PARAMETRIC DATA FROM FILE
1 "PARAM.DOC"')
READ (1,2043) DUMMY,(DUMMY,M=1,NVAR1)
FORMAT (2745)
NVAR1=0
DO 2045 N=1,NVAR
IF (VARPAR(LOC(N)).NE.2) GO TO 2045
NVAR1=NVAR1+1
LOCsav(NVAR1)=N
CONTINUE
IF (NVAR1.GT.0) GO TO 2047
WRITE (5,1780)
STOP
2047 IF (NVAR1.GT.26) NVAR1=26
NSAMTI=(UTTDUR/DELTAT)-1
DO 2048 M=0,NSAMTI
M1=M#NSAMP
READ (1,2060) TIME,(D(LOCsav(N)+M1),N=1,NVAR1)
2048 CONTINUE
CLOSE(UNIT=1)
C ACCEPT MODIFICATIONS TO PARAMETER TRACKS
2050 OLDTIM=0
SETPNT=NO
MAXD1=UTTDUR-DELTAT
WRITE (5,2060)
2060 FORMAT ('/ NAME OF PARAMETER TRACK TO BE MODIFIED (QUIT="Q"):'$)
READ (5,1260,ERR=2090) NAMEV
2075 IF (NAMEV.EQ.QUIT) GO TO 2600
DO 2080 N=1,NVAR
IF (NAMEV.EQ.NAMEX(N)) GO TO 2120
CONTINUE
2080 WRITE (5,1300) NAMEV
2090 WRITE (5,2100) (NAMEX(M), M=1,NVAR)
2100 FORMAT (' VARIABLE PARS= ',10A4)
GO TO 2050
2120 CONTINUE
VARPAR(LOC(N))=2
MAXV=MAXVAL(LOC(N))
MINV=MINVAL(LOC(N))
2180 WRITE (5,2200)
2200 FORMAT (' T=':$)
2220 READ (5,2240,ERR=2550) TIME
2240 FORMAT (13)
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
2255 WRITE (5,2260) TIME,OLDTIM
2260 FORMAT ('/ ILLEGAL TIME=',I3,', LESS THAN OLDTIM=',I3)
GO TO 2180
2280 IF ((TIME.LE.MAXD1)) GO TO 2320
WRITE (5,2300) TIME,MAXD1
2300 FORMAT ('/ ILLEGAL TIME=',I3,', GREATER THAN MAX=',I3)
GO TO 2180
2320 NPTS=TIME/DELTAT
TIME1=NPTS*DELTAT
POINTR=(NPTS)*NSAMP+N
2330 WRITE (5,2340)
2340 FORMAT (' V=':)
2345 READ (5,1900,ERR=2550) VALUE
C SEE IF LEGAL VALUE
2369 IF (VALUE.LE.MAXV) GO TO 2400
2370 WRITE (5,2371) MINV,MAXV
2371 FORMAT (' VMIN=',I5,', VMAX=',I5)
GO TO 2330
2400 IF ((VALUE.GE.MINV)) GO TO 2420
2420 IF ((SETPNT.EQ.YES).AND.(TIME.GE.(OLDTIM+DELTAT))) GO TO 2480
C SET A POINT
D(POINTR)=VALUE
2460 OLDTIM=TIME
OLDVAL=VALUE
SETPNT=YES
GO TO 2180
C DRAW A LINE
2480 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/FLOAT(NPTS)
VALUE2=OLDVAL+IFIX(DBLPNT+EPSLON)
POINTR=((TIME1+M)*NSAMP)+N
2500 D(POINTR)=VALUE2
GO TO 2460
C UNRECOVERABLE I/O ERROR, SAVE PARAMETERS AND QUIT
2550 WRITE (5,2560)
2560 FORMAT (' UNRECOVERABLE TYPING ERROR, SAVE PARAMETERS')
C MAKE FILE OF PARAMETER VALUES VS TIME THAT CAN BE LISTED
C ON LINE PRINTER
2600 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))
CONTINUE
WRITE (1,2625) UTTDUR
FORMAT (' ',I5)
2617
2620
2625

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NVAR1=0  
DO 2630 N=1,NVAR  
IF (VARPAR(LOC(N)).NE.2) GO TO 2630  
NVAR1=NVAR1+1  
LOCsav(NVAR1)=N  
CONTINUE  
IF (NVAR1.GT.0) GO TO 2640  
WRITE (5,1780)  
GO TO 2900  
2640 IF (NVAR1.GT.26) NVAR1=26  
WRITE (1,2650) (NAMEX(LOC(N)),M=1,NVAR1)  
FORMAT (' ',26A5)  
NSAMTI=(UTTDUR/DELTAT)-1  
DO 2665 M=0,NSAMTI  
TIME=M#DELTAT  
M1=M#NSAMP  
WRITE (1,2660) TIME,(D(LOCsav(N)+M1),N=1,NVAR1)  
FORMAT (13,26I5)  
CONTINUE  
CLOSE(UNIT=1)  
WRITE (5,2667)  
FORMAT ('/ PARAMETER FILE "PARAM.DOC" SAVED')  
C SET ALL PARAMETERS IN ARRAY IPAR TO DEFAULT VALUES  
2670 IF (PPSW.EQ.0) GO TO 2676  
WRITE (5,2675)  
FORMAT ('/ BEGIN WAVEFORM GENERATION')  
DO 2680 N=1,39  
IPAR(N)=VALUES(N)  
C INITIALIZE SYNTHESIZER  
MAXWA=-1  
XMAXWA=-1.  
C MAIN SYNTHESIZER LOOP, PUT WAVEFORM IN IWAVE(WSIZE1)  
ADD 20 MSEC TO DURATION TO ENSURE SIGNAL WILL DECAY TO ZERO  
NPTS=(UTTDUR+20)/DELTAT  
TIME1=0  
WSIZE1=1  
DO 2740 M=1,NPTS  
POINTR=(M-1)\*NSAMP  
DO 2700 N=1,NVAR  
IPAR(LOC(N))=POINTR+N  
CALL PARCOE(MAXWA)  
CALL COEWAV(IWAVE(WSIZE1),XMAXWA)  
WSIZE1=WSIZE1+NSAMP  
C MAKE SURE SIGNAL IS LESS THAN OR EQUAL TO 0.0 DB  
DB=20.\* ALOG10(XMAXWA/32767.)  
WRITE (5,2760) DB  
FORMAT ('/ PEAK SIGNAL LEVEL  
1 IN SYNTHETIC WAVEFORM =',F6.1,' DB')  
C SAVE WAVEFORM FILE IWAVE(WSIZE1) ON DISK  
OPEN(UNIT=1,NAME='WAVE.I6',ACCESS='SEQUENTIAL',ERR=2800)  
WRITE (1,2775) WSIZE1  
FORMAT (15)  
WRITE (1,2785) (IWAVE(M),M=1,WSIZE1)  
FORMAT (50I6)  
CLOSE (UNIT=1)  
WRITE (5,2795)  
FORMAT ('/ WAVEFORM FILE "WAVE.I6" SAVED')  
GO TO 2900  
WRITE (5,2805)  
FORMAT ('/ DISK ACCESS ERROR DURING ATTEMPT TO SAVE WAVEFORM')  
STOP  
END

C PARCOE.FOR D.H. KLATT 8/1/78  
C "/PARAM-TO-COE" TRANSFORMATION SUBROUTINE  
C THIS PROGRAM CONVERTS SYNTHESIZER CONTROL PARAMETERS FROM ARRAY I(39)  
INTO DIFFERENCE EQUATION CONSTANTS FOR SYNTHESIZER HARDWARE  
C STORED IN ARRAY C(50)  
C SUBROUTINE PARCOE(INITPC)  
INITPC INITIALIZES THIS ROUTINE IF =-1  
C REAL IMPULS  
DIMENSION I(39),NDBSCA(12),NDBCOR(10),C(50)  
C INPUT PARAMETER VALUES (CONSTANT AND VARIABLE) PASSED THROUGH I  
COMMON /PARS/ I  
COMMON /COFS/ C  
COMMON /PIXX/ PIT,TWOPIT  
C COEFICIENT VALUES IN C(50) ARE REAL  
EQUIVALENCE (C(1),IMPULS),((C(2),SINAMP),(C(3),AFF))  
EQUIVALENCE (C(4),AHH),(C(5),A1P),(C(6),A2P)  
EQUIVALENCE (C(7),A3P),(C(8),A4P),(C(9),A5P)  
EQUIVALENCE (C(10),A6P),(C(11),ABP),(C(12),ANPP)  
EQUIVALENCE (C(13),AGP),(C(14),BGP),(C(15),CGP)  
EQUIVALENCE (C(16),AGZ),(C(17),BGZ),(C(18),CGZ)  
EQUIVALENCE (C(19),AGS),(C(20),BGS),(C(21),CGS)  
EQUIVALENCE (C(22),A1),(C(23),B1),(C(24),C1)  
EQUIVALENCE (C(25),A2),(C(26),B2),(C(27),C2)  
EQUIVALENCE (C(28),A3),(C(29),B3),(C(30),C3)  
EQUIVALENCE (C(31),A4),(C(32),B4),(C(33),C4)  
EQUIVALENCE (C(34),A5),(C(35),B5),(C(36),C5)  
EQUIVALENCE (C(37),A6),(C(38),B6),(C(39),C6)  
EQUIVALENCE (C(40),ANP),(C(41),BNP),(C(42),CNP)  
EQUIVALENCE (C(43),ANZ),(C(44),BNZ),(C(45),CNZ)  
EQUIVALENCE (C(46),PLSTEP)  
C NAMES OF INPUT CONTROL PARAMETERS  
EQUIVALENCE (I(1),NNAV),(I(2),NNAF),(I(3),NNAH),(I(4),NNAVS)  
1,(I(5),NNFO),(I(6),NNFI),(I(7),NNF2),(I(8),NNF3),(I(9),NNF4)  
1,(I(10),NNF5),(I(11),NNF6),(I(12),NNAI),(I(13),NNAA2)  
1,(I(14),NNAS),(I(15),NNNA),(I(16),NN5),(I(17),NN6)  
1,(I(18),NNNA),(I(19),NNB1),(I(20),NNB2),(I(21),NNB3)  
1,(I(22),NNSW),(I(23),NNFG2),(I(24),NNBG2),(I(25),NNFG2)  
1,(I(26),NNBG2),(I(27),NNB4),(I(28),NNF5),(I(29),NNB5)  
1,(I(30),NNF6),(I(31),NNB6),(I(32),NNFP),(I(33),NNBP)  
1,(I(34),NNBN2),(I(35),NNB3),(I(36),NNSR),(I(37),NNNWS)  
1,(I(38),NNCO),(I(39),NNFC)  
C CONSTANTS NEEDED BY SUBROUTINE SETABC  
DATA PI/3.14159265/  
C SCALE FACTORS IN DB FOR GENERAL ADJUSTMENT TO:  
A1 A2 A3 A4 A5 A6 AN AB AV AH AF AVS  
DATA NDBSCA/-58,-65,-73,-78,-79,-80,-58,-84,-72,-102,-72,-44/  
C INCREMENT IN DB TO FORMANT AMPLITUDES OF PARALLEL BRANCH IF  
C FORMANT FREQUENCY DIFFERENCE 50, 100, 150, ... Hz  
DATA NDBCOR/10,9,8,7,6,5,4,3,2,1/  
C PRINT INPUT PAR VALUES AT T=NTIMPR, OR AT ALL TIMES IF NTIMPR=0  
DATA NTIMPR,NPPBEG,NPPEND/-1,1,39/  
C  
C INITIALIZE SYNTHESIZER BEFORE COMPUTING WAVEFORM CHUNK IF ARG.LT.0  
100 IF (INITPC.GE.0) GO TO 130  
INITPC=0  
C SET CUMULATIVE TIME COUNTER TO ZERO  
NTIMEP=0  
NAFLAS=0

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C COMPUTE SAMPLING PERIOD T (ALL CONSTANT CONTROL PARAMETERS
C MUST BE SET BEFORE CALLING INIT)
    SMRAT=NNSR
    T=1./SMRAT
    PIT=PIT#
    TWOPIIT=2.*PIT
    NTIMED=(NNWS*1000)/NNSR
C CONVERT INHERENTLY INTEGER PARAMS TO REAL COEFICIENTS
    C(48)=NNWS
    C(49)=NNSW
    C(50)=NNNFC
110    CONTINUE

C UPDATE ALL COEFICIENTS OF HARDWARE SYNTHESIZER
C COMPUTE PARALLEL BRANCH AMPLITUDE CORRECION TO F2 DUE TO F1
130    DELF1=FLOAT(NMF1)/500.
    A2COR=A2COR*DELF1
C COMPUTE AMPLITUDE CORRECTION TO F3-5 DUE TO F1 AND F2
    DELF2=FLOAT(NMF2)/1500.
    A2SKRT=DELF2*DELF1
    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=NF2-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.0) GO TO 146
135    WRITE (5,140) NTIMEP
140    FORMAT (5,140) INPUT PARS AT T = ',I4,' MS'
    WRITE (5,141) (I(NPP),NPP=NPPEBEG,NPPEND)
141    FORMAT (5,141),135)
    WRITE (5,142)
142    FORMAT ('')
143    NPAB=1
144    NTIMEP=NTIMEP+NTIMED
C SET AMPLITUDE OF VOICING
    NDBAV=NNGO>NNAV+NDBSCA(9)
    IMPULS=GETAMP(NDBAV)
C AMPLITUDE OF ASPIRATION
150    NDBAH=NNGO>NNAH+NDBSCA(10)
    AHH=GETAMP(NDBAH)
C AMPLITUDE OF FRICATION
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)
    A1F=GETAMP(NDB)
    NDB=NNA2+N12COR+N12COR+N23COR+NDBSCA(2)
    A2F=GETAMP(NDB)
    NDB=NNA3+N23COR+N23COR+N34COR+NDBSCA(3)
    A3F=GETAMP(NDB)
    NDB=NNA4+N34COR+N34COR+NDBSCA(4)
    A4F=A3COR*GETAMP(NDB)
    NDB=NNA5+NDBSCA(5)
    A5F=A3COR*GETAMP(NDB)
    NDB=NNA6+NDBSCA(6)
    A6F=A3COR*GETAMP(NDB)
C SET AMPLITUDE OF PARALLEL NASAL FORMANT
    NDN=NNAN+NDBSCA(7)
    ANPP=GETAMP(NDB)
C SET AMPLITUDE OF BYPASS PATH OF FRICATION TRACT
    NDB=NNAB+NDBSCA(8)
    ABF=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)
    CALL SETABC(NNFP,NNBNP,ANP,BNP,CNP)
C AND FOR MASAL ANTIRESONATOR
    MNFNZ=-NNFNZ
    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 NNAB BOTH .LE.0
    IF ((NNAV.LE.0).AND.(NNAB.LE.0)) GO TO 245
C WAVEFORM MORE SINUSOIDAL AT HIGH FUNDAMENTAL FREQUENCY
    NXBGP=(NBBGP*100)/NNFO
    CALL SETABC(NNFGP,NXBGP,AGP,BGP,CGP)
    CALL SETABC(0,NNBGS,AGS,BGS,CGS)
    MNFGZ=-NNFGZ
    IF (MNFGZ.GE.0) MNFGZ=-1
    CALL SETABC(MNFGZ,NNBGS,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 COEFICIENTS
    C(47)=NPULSN
    RETURN
    END

C COEWAV.FOR          D.H. KLATT      8/1/78
C "COEF-TO-WAVE" TRANSFORMATION SUBROUTINE
C (FOR A 16-BIT PDP-11 COMPUTER)
C SIMULATION OF THE HARDWARE KLATT SYNTHESIZER
    TAKE 50 COEFICIENTS FROM COMMON ARRAY C, AND

C SYNTHESIZE NEXT NNXWS SAMPLES OF THE OUTPUT WAVEFORM
C SUBROUTINE COEWAV(IWAVE,OUTMA)
    IWAVE IS AN ARRAY IN WHICH WAVEFORM SAMPLES ARE PLACED
    LEFT-JUSTIFIED IN A 36-BIT WORD
    OUTMA IS RETURN ARG INDICATING MAX ABSOL. VALUE OF WAVE
    IF CALLING PROGRAM SETS TO -1., COEWAV IS INITIALIZED
C REAL NOISE, INPUTS, INPUT, IMPULS
    DIMENSION IWAVE(1),C(50)
    COMMON /COEFS/ C
C COEFICIENT VALUES IN C(50) ARE REAL
    EQUIVALENCE (C(1),IMPULS),(C(2),SINAMP),(C(3),AFRICI)
    EQUIVALENCE (C(4),AASP1),(C(5),APAR),(C(6),A2PAR)
    EQUIVALENCE (C(7),A3PAR),(C(8),A4PAR),(C(9),A5PAR)
    EQUIVALENCE (C(10),A6PAR),(C(11),ABPAR),(C(12),ANPAR)
    EQUIVALENCE (C(13),AGP),(C(14),BG1),(C(15),CGP)
    EQUIVALENCE (C(16),AGZ),(C(17),BG2),(C(18),CGZ)
    EQUIVALENCE (C(19),AGS),(C(20),BGS),(C(21),CGS)
    EQUIVALENCE (C(22),A1),(C(23),B1),(C(24),C1)
    EQUIVALENCE (C(25),A2),(C(26),B2),(C(27),C2)
    EQUIVALENCE (C(28),A3),(C(29),B3),(C(30),C3)
    EQUIVALENCE (C(31),A4),(C(32),B4),(C(33),C4)
    EQUIVALENCE (C(34),A5),(C(35),B5),(C(36),C5)
    EQUIVALENCE (C(37),A6),(C(38),B6),(C(39),C6)
    EQUIVALENCE (C(40),ANP),(C(41),BNP),(C(42),CNP)
    EQUIVALENCE (C(43),ANZ),(C(44),BNZ),(C(45),CNZ)
    EQUIVALENCE (C(46),PLSTEP)

C MAXIMUM VALUE FOR A WAVEFORM SAMPLE (LEFT-JUSTIFY IN 36-BIT WORD)
    DATA WAVMAX,WAVMAX/32767,-32767/
C INITIALIZE COEWAV IF OUTMA=-1.
C ZERO MEMORY REGISTERS IN ALL RESONATORS
    IF (OUTMA.EQ.0) GO TO 250
249    YL11P=0.
    YL12P=0.
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C RADIATION CHARACTERISTIC IS A ZERO AT THE ORIGIN
UGLOT=UGLOT2-UGLOTX
UGLOTX=UGLOT2

C TURBULENCE NOISE OF ASPIRATION AND FRICATION
C GENERATE RANDOM NOISE, RANDOM PRODUCES UNIFORM DIST. (0. TO 1.)
370 NOISE=0.
C MAKE PSEUDO-GAUSSIAN
DO 371 NRANDX=1,16
371 NOISE=NOISE+RANIRAN1,IRAN2)
C SUBTRACT OFF DC
NOISE=NOISE-.8.
C MODULATE NOISE DURING SECOND HALF OF A GLOTTAL PERIOD
375 IF (IMULSE.LE.0.) NOISE=NOISE/2.
MIPULSE=MIPULSE-1
C LOW-PASS NOISE AT -6 DB/OCTAVE TO SIMULATE SOURCE IMPEDANCE
C HIGH-PASS NOISE AT +6 DB/OCTAVE FOR RADIATION CHARACTERISTIC
C (TWO EFFECTS CANCEL ONE ANOTHER)
C GLOTTAL SOURCE VOLUME VELOCITY = VOICING+ASPIRATION
AASPIR=AASPIR+DAHM
UASPIR=AASPIR*NOISE
380 UGLOT=UGLOT+UASPIR
C SET FRICTION SOURCE VOLUME VELOCITY
390 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 UFRIC=AFRIC*NOISE
C
C SEND GLOTTAL SOURCE THRU CASCADE VOCAL TRACT RESONATORS
C DO FORMANT EQUATIONS FOR NNXFC FORMANTS IN DESCENDING ORDER
C TO MINIMIZE TRANSIENTS
IF (NNXFC.EQ.1) GO TO 430
C BYPASS R6 IF NNXFC LESS THAN 6
Y6C=UGLOT
IF (NNXFC.LT.6) GO TO 415
Y6C=A6*UGLOT + B6*YL61C + C6*YL62C
YL62C=YL61C
YL61C=Y6C
C BYPASS R5 IF NNXFC LESS THAN 5
415 Y5C=Y6C
IF (NNXFC.LT.5) GO TO 416
Y5C=A5*Y6C + B5*YL51C + C5*YL52C
YL52C=YL51C
YL51C=Y5C
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 Y2C=CN2*Y1C + BN2*YLN21C + CN2*YLN22C
YLN22C=YLN21C
YLN21C=Y1C
C NASAL RESONATOR RNP:
YPC=ANP*Y2C + BNP*YLN1P1 + CNP*YLN2P2
YLN2P2=YLN1P1
YLN1P1=YPC
ULIPSV=XPC
C ZERO OUT VOICING INPUT TO PARALLEL BRANCH
C IF CASCADE BRANCH HAS BEEN USED
425 UGLOT=0.
UGLOT=0.
C
C SEND VOICING AND FRICTION NOISE THRU PARALLEL RESONATORS
C INCREMENT RESONATOR AMPLITUDES GRADUALLY
430 CONTINUE
C FIRST PARALLEL FORMANT R1' (EXCITED BY VOICING ONLY)
Y1P=A1*APAR*UGLOT + B1*YL11P + C1*YL12P
YL12P=YL11P
YL11P=Y1P
C NASAL POLE RN' (EXCITED BY FIRST DIFF. OF VOICING SOURCE)
UGL0T1=UGLOT-UGLOT
UGL0T1=UGLOT
YNAFP=ANP*UGL0T1 + BN*YLN1P1 + CNP*YLN2P2
YLN2P2=YLN1P1
YLN1P1=YNAFP
C EXCITE FORMANTS R2'-R4' WITH FRIC NOISE PLUS FIRST-DIFF. VOICING

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Y2P=A2*APAR*(UFRIC+UGLOT1) + B2*YL21P + C2*YL22P
YL22P=YL21P
YL21P=Y2P
Y3P=A3*APAR*(UFRIC+UGLOT1) + B3*YL31P + C3*YL32P
YL32P=YL31P
YL31P=Y3P
Y4P=A4*APAR*(UFRIC+UGLOT1) + B4*YL41P + C4*YL42P
YL42P=YL41P
YL41P=Y4P
C EXCITE FORMANT RESONATORS R5'-R6' WITH FRIC NOISE
Y5P=A5*APAR*UFRIC + B5*YL51P + C5*YL52P
YL52P=YL51P
YL51P=Y5P
Y6P=A6*APAR*UFRIC + B6*YL61P + C6*YL62P
YL62P=YL61P
YL61P=Y6P
C ADD UP OUTPUTS FROM RN', R1' - R6' AND BYPASS PATH
ULIPS=Y1P-Y2P+Y3P-Y4P+Y5P-Y6P+YN-ABPAR*UFRIC
440 CONTINUE
C ADD CASCADE AND PARALLEL VOCAL TRACT OUTPUTS
(SCALE BY 170 TO LEFT JUSTIFY IN 16-BIT WORD)
450 STEP=(ULIPSV+ULIPSF+STEP)*(170.)
STEP=995*STEP
C FIND CUMULATIVE ABSOL. MAX. OF WAVEFORM SINCE BEGINNING OF UTT.
500 IF (ULIPS.GE.ULIMA) OUTMA=ULIPS
IF (-ULIPS.GE.ULIMA) OUTMA=-ULIPS
C TRUNCATE WAVEFORM SAMPLES TO ABS(WAVMA)
IF (ULIPS.LE.WAVMA) GO TO 510
IF (ULIPS.GE.WAVMAX) GO TO 520
ULIPS=WAVMA
510 IF (ULIPS.GE.WAVMAX) GO TO 520
ULIPS=WAVMAX
520 IWHITE(NTIME)=ULIPS
530 CONTINUE
540 RETURN
END

C SETABC.FOR D.H. KLATT 8/1/78
C CONVERT FORMANT FREQUENCIES AND BANDWIDTH TO RESONATOR
C DIFFERENCE EQUATION CONSTANTS
C SUBROUTINE SETABC(F,B,A,C)
C
C INTEGER F,FB
COMMON /PIXH/ PIT,TWOPIT
C--REPLACE BY R=EXPTAB(FB) FOR FASTER EXECUTION
R=EXP(-PIT*FLOAT(FB))
C=P*B
C--REPLACE BY B= COSTAB(F) FOR FASTER EXECUTION
B=2.*B*COS(TWOPI*FLOAT(FB))
A1=B-C
A1=-B-C
620 CONTINUE
C IF F IS MINUS, COMPUTE A,B,C FOR A ZERO PAIR
IF (F.GE.0.) RETURN
A1=A/B
B=-A*B
C=A*C
RETURN
END

C GETAMP.FOR D.H. KLATT 8/1/78
C CONVERT DB ATTEN. (FROM 96 TO -72) TO A LINEAR SCALE FACTOR.
C (TRUNCATE NDB IF OUTSIDE RANGE)
C FUNCTION GETAMP(NDB)
C
C DIMENSION DTABLE(11),STABLE(28)
DATA DTABLE/1.8,1.6,1.43,1.26,1.12
1.1,0.89,0.792,0.702,0.623,0.555/
DATA STABLE/65536,,32768,,16384,,8192,
1,4096,,2048,,1024,,512,,256,,128,
1,64,,32,,16,,8,,4,,2,
1,,5,,25,,125,,0625,,0312,,0078,,0039,,00195
1,,000975,,000487/
C
650 NDB1=NDB
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
CONTINUE
RETURN
END


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