◆ SSB-MPF-IP

SPEECH
SYNTHESIZER
BOARD
OPERATION
MANUAL

SSB-MPF-IP

SPEECH SYNTHESIZER BOARD OPERATION MANUAL

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CONGRATULATIONS

Your SSB-MPF-IP will help you discover the mystery of
speech synthesis.   Unpacking your SSB-MPF-IP package,
you will   find:

1) The SSB-MPF-IP board, a complete speech synthesis
    system.
2) Operation Manual.
3) A 40-pin double-head female cable connector.
4) An audio jumper wire.
5) A two-pin male connector.
6) A 9V, 200mA power adaptor.

audio cable

two-pin female
double-headed plastic
socket.
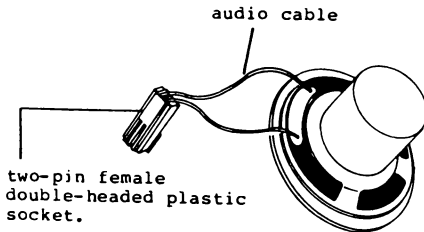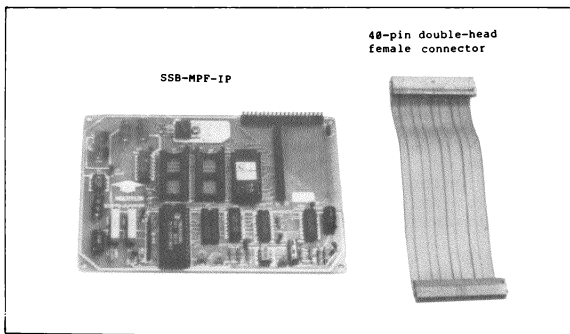
I. INTRODUCTION

SSB-MPF-IP is a Speech Synthesizer Board especially designed to be used with MPF-IP. It is a low-cost, programmable printed circuit board based on Texas Instruments' Voice Synthesis Processor TMS5220. However, SSB-MPF-IP itself is a complete speech synthesis system.

Before we go into details of our SSB-MPF-IP, we would like to introduce briefly the principles on how speech synthesis system works and what is a speech synthesis system.

The diagram below shows a speech synthesis system. Varying air pressure of sound and voices, after being received by the microphone, is transformed into varying voltages and frequency. Varying electrical voltages frequencies are further converted through a converter to digital signals which afterwards go through the digital speech analyzer and a coding process, and are eventually stored in the Read Only Memory (ROM). To reproduce the sound signals stored in the ROM, the data in the ROM should go through a decoding process, a digital speech synthesizer before being converted into analog electrical voltages and frequencies which activate a speaker.

PROCESS OF SPEECH SYNTHESIS
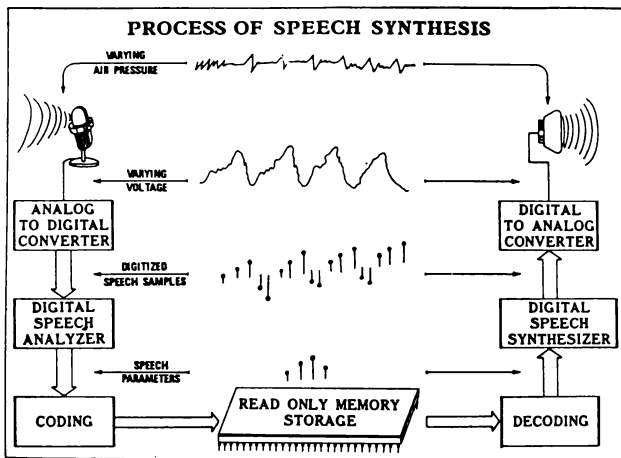
Figure 1-1 Process of Speech Synthesis

In short, a speech synthesis board is a printed circuit board which can reproduce different voices and sounds. The Multitech SSB-MPF-IP is a typical speech synthesis board with these functions.

Users can easily operate the SSB-MPF-IP after connecting the SSB-MPF-IP to MPF-IP with a flat 40-pin female double-head cable.

The technology of speech synthesis, first commercially introduced by TI for use on automobile gadgetry, has been used for applications on modern daily life for some time. The Multetich SSB-MPF-IP speech board will lead you discover the interesting and mysterious world of "speaking" boards at the lowest possible cost.

II. FEATURES

The most outstanding feature of SSB-MPF-IP is that it is a basic as well as complete speech synthesis system. Therefore, a beginner can use the system with ease to understand every aspect about speech synthesis systems. Yet, the simplicity in design of the SSB-MPF-IP makes the machine highly reliable and cost-efficient. The major features of the SSB-MPF-IP are as follows:

A. Structure: (See Figure 2-1)
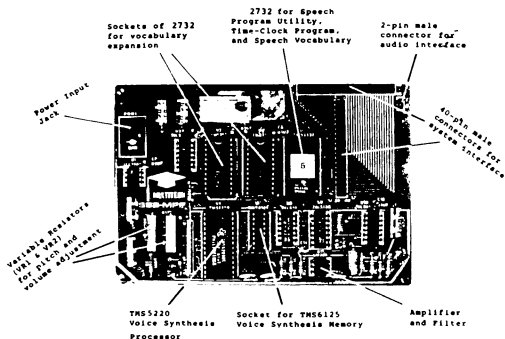
Figure 2-1

B. System Control Unit

1) TI's TMS5220 Voice Synthesis Processor is the speech synthesizer of the speech synthesis system.
2) The host controller of the system (SSB-MPF-IP) is the Z-80 CPU on MPF-IP.

C. Memory: featuring strong vocabulary expansion ability.

1) The memory chip 2732 on the board is used to store speech data and utility programs for demonstration purpose.

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```
5000 ┌─────────┐
     │         │
     │         │
     │ PROGRAM │
     │         │
     │         │
525E ├─────────┤
     │         │
     │ DATA    │
     │         │
     │         │
     └─────────┘
```
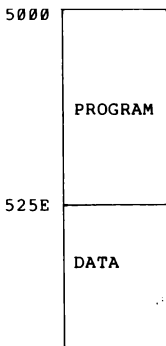
The functions of the on-board memory are list below.

*   Talking clock

*   Speak the built-in vocabulary

*   Speak the vocabulary in expansion memory

*   Speak a single word

2) The two sockets, U3 and U4, are reserved for two optional memory chips of TMS2732 to expand SSB–MPF–IP vocabulary.

3) A socket (U7) is reserved for TMS6125, the 32K bits ROM, which functions as the advanced Voice Synthesis Memory (VSM) for storing speech data.

D. System input/output devices:

1) The data input device of the speech synthesis system is the keyboard of the MPF–IP.

2) The data output devices of the system are the speaker and a six–digit display panel above the keyboard.

3) An external speaker can be connected to the SSB–MPF–IP with audio jumper wire, Jumper 2.

E. System power supply: It only needs 5V, 200mA to operate.

F. System interface: Two 40–pin male double–head cable connectors are used for any possible external connection such as interfacing with MPF–IP or with our EPB–MPF–IP (EPROM Programmer Board).

III. FUNCTIONAL DESCRIPTION

The major functional units of the SSB-MPF-IP are shown in figure 3-1 and described below:
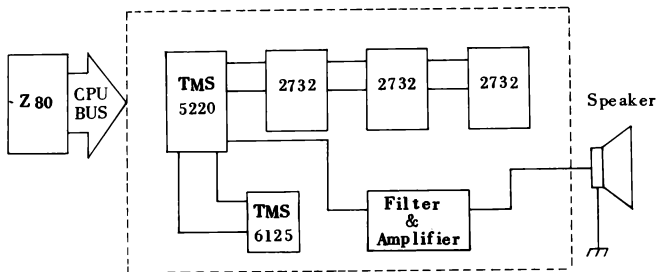
Figure 3-1 Block Diagram of SSB-MPF-IP

1) Voice Synthesis Processor:

   a) TI's solid state speech chip TMS5220 is used as VSP of the unit.   It can fetch speech data and programs stored in memory chips such as 2732, and reproduce or synthesize human voice through filter/amplifier and speaker.
   b) The TMS5220 VSP operates on Linear Predictive Coding (LPC) method, which converts analog speech data to digital data that are suitable for processing by VSP.   The TMS5220 can access LPC-encoded data stored in memory and convert the data into sound signal of specific pitch and amplitude.

2) Speech Data EPROM: The maximum memory capacity of
   the system can be expanded to 12K bytes by adding
   two more additional 2732 memory chips to the
   system.   The speech data is encoded in LPC which
   provides a speech quality comparable to that of
   voices generated by Pulse-Coded Modulation (PCM)
   system.   Furthermore, it only takes 1200 bits to
   memorize the speech data that is produced in one
   second in the LPC system.   In the PCM system, it
   takes 64,000 bits to memorize the speech data
   that is produced in one second.

3) System Z-80 Controller: The Z-80 CPU on the MPF-IP
   is used as speech synthesis system controller.   It
   accepts the commands from MPF-IP keyboard and
   fetches the speech programs.

4) Filter: A low-pass filter is used to generate
   smooth and clear speech signal.

5) Amplifier: An audio amplifier is used to drive the
   8 Ohm speaker.

IV. INSTALLATION PROCEDURES

1. Before connecting the SSB-MPF-IP to the MPF-IP, make sure that the electricity power source for both are not plugged.

2. Connect the speech synthesis system (SSB-MPF-IP) to the external speaker in the following steps:

   A. Locate the external speaker and the two-pin audio cable that come in with the package of SSB-MPF-IP. The two-pin audio cable is soldered to the speaker as shown in Fig. 4-1 below:
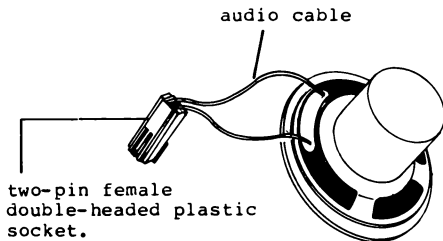
Fig. 4-1 Speaker with soldered audio cable.

The other end of the audio cable is fitted with a two-pin female double-headed plastic socket.

B. Locate the audio socket on the upper right corner of the SSB-MPF-IP as shown in Fig. 4-2.
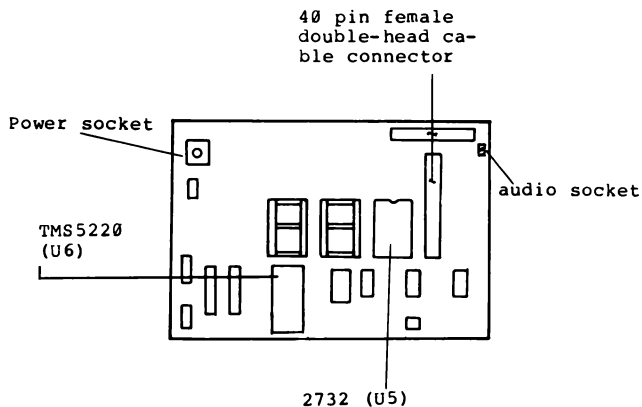
Fig. 4-2 Audio socket on the SSB-MPF-IP

C. Plug the two-pin female double-head socket from
    the speaker to the 2 pins of the audio socket
    in the upper right corner of the SSB-MPF-IP as
    shown below in Fig. 4-3.

speaker

audio socket
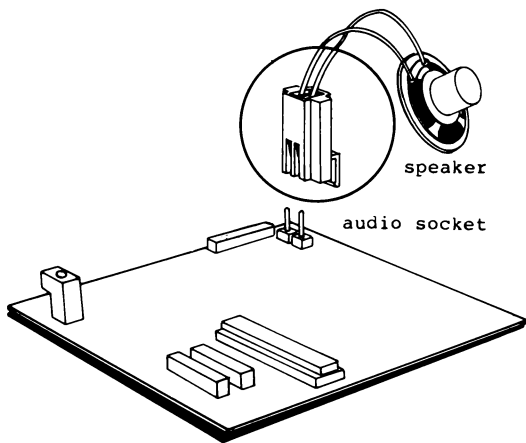
Fig.4-3 Connection of SSB-MPF-IP to the speaker

3. Connect the SSB-MPF-IP to the MPF-IP with a 40
    pin female double-head cable connector as shown in
    Fig. 4-4.
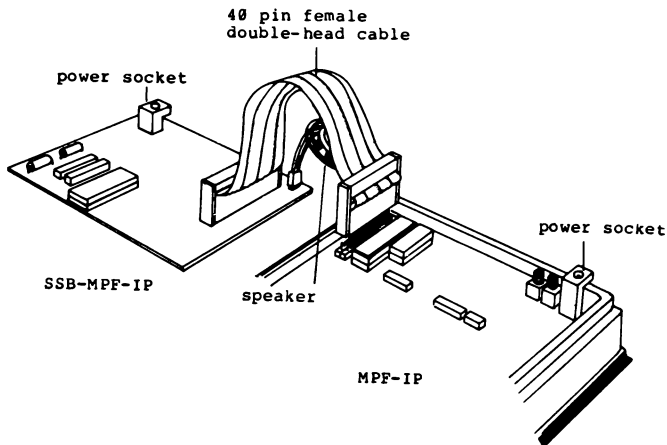
Fig. 4-4 Connection of SSB-MPF-IP to MPF-IP

4. Connect the SSB-MPF-IP and MPF-IP to their respective
    power sources:

    A. An adaptor (9V, 600mA, output) is plugged to the
        power socket in the upper right corner of the MPF-
        IP.

    B. An adaptor (9V, 200mA, output) is then plugged to
        the power socket in the upper left corner of the
        SSB-MF-IP.

    Note: The power source for the SSB-MPF-IP can ONLY be
            connected after the power source for MPF-IP has
            been connected.

        Now, we have completed the installation
procedures, and will proceed to test our speech
synthesis system, SSB-MPF-IP.

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V. OPERATION PROCEDURES

I. TALKING CLOCK

Once your SSB-MPF-IP have been interfaced, the system is ready for test run. To test run the system, our Time-clock Program is used for you to familiarize with the operations of the system. The running of our time-clock Program is as easy as adjusting the time of a digital watch.

Before running the Time-clock Program on the system, you have to set the time of the system to the current time. After you have keyed in the time, press key (G), 5000 and ◄——. The system will start displaying time on its display panel, and it will announce the time in English in an interval of one minute. For example, if the display panel of the system shows 09:21:58, the system will announce in English "Nine, twenty-two" after two seconds, while the display panel showing 09:22:00. A full sentence --"It is X o'clock AM (or PM)"--will be heard each hour as long as the Time-clock Program is kept on.

If the current time is 9:53 a.m., the steps you have to follow in executing the Time-clock Program are as follows:

Step 1: Press key M.
Step 2: Press key F800.
Step 3: Press key :
Step 4: Set hour: press key 09; then press space key.
        Set minute: Press key 53; then press space key.
        Set second: press key 00; then press space key.
        Set AM/PM : press key 10/11; then press key ►——
        Please take note that 10 signifies AM, while 11 signifies PM.
Step 5: press key "G" 5000, then press key ◄——.

You will be amazed at how the system works. If it doesn't work, please check if the SSB-MPF-IP is operated correctly and try again.

2. SPEAKS ALL THE BUILT-IN VOCABULARY

Run the program starting at memory 51F9. The operation sequence is pressing "G" 51F9 and < ⬅️ . Then it will speak the first word in the built-in vocabulary—"THE" and display "SPEECH". Any time it displays "SPEECH" means it is ready to accept the command from the keyboard. Press the "R" key will repeat the same word and press the "N" key will speak the next word. It will speak the first word after speaking the last word.

3. SPEAKS THE VOCABULARY IN EXPANSION MEMORY

a) Before running this program, you should put the 2732 with speech data in either socket U3(or U4). And there should have a look-up table in your 2732. The format of the look-up table is shown below.

2732 address	Data
FFF	low order byte of starting address of first speech data
FFE	high order byte of first speech data
FFD	low order byte of starting address of second speech data
FFC	high order byte of starting address of second speech data
XXX	low order byte of starting address of last speech data
XXX	high order byte of starting address of last speech data
XXX	FF
XXX	FF(end of speech data)

b) After putting the 2732 into the U3 (or U4), set the starting address of your speech data in memory location F00C and F00D , ie, set 7000 (or 6000) in memory location F00C and F00D. Then run the program starting at 51FF. The operation sequence is:

Step 1: press key M.
Step 2: press key F80C.
Step 3: press key :
Step 4: press key 00; then press space key.
    press key 60(70): then press ⬅️ .
Step 5: press key "G", 51FF: then press ⬅️ .

After finishing the five steps, the SSB-MPF-IP will speak the vocabulary in the expansion memory the same way as it speaks the built-in vocabulary.

c) If you want to put the speech data in other 4K
   memory segment, you can set the starting address of
   your speech data memory in location F00C and F00D
   and run the program starting at 51FF. It will
   speak the vocabulary too.

4. SPEAK A SINGLE WORD

"Set the starting address of the speech data of the
word in memory location F00E and F00F and run the
program starting at 5179. For example, if you want to
speak the word with its speech data starting at memory
location 525E, first set 525E in memory location F00E
and F00F then run the program starting at 5179. The
operation sequence is:"

Step 1: press key M
Step 2: press key F80E
Step 3: press key :
Step 4: press key 5E,then press space key
        press key 52, then press [⟵——]
        press key "G" 5179, then press [⟵——]

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VI. VOICE VOLUME AND PITCH ADJUSTMENT

Sound reproduced by the system can be easily adjusted for desirable effects.

A. The Adjustment of VR-1:

1) To lower the voice pitch, turn the adjusting screw of VR-1 (Variable resistor-1) clockwise.

2) To increase the voice pitch, turn the adjusting screw of VR-1 counterclockwise. This may require more than one or two turns, depending on the efficiency of the speaker used.

B. The Adjustment of VR-2:

1) To lower the voice volume, turn the adjusting screw of VR-2 clockwise.

2) To increase the voice volume, turn the adjusting screw of VR-2 counterclockwise.

This also may require more than one or two turns, depending on the efficiency of the speaker used.

Please take note that the position of the VRs with respect to the SSB-MPF-IP should be the same as Fig. 6-1 below:

TMS 5220

clockwise
(to lower
the volume)

counter clockwise
(to increase the
volume)
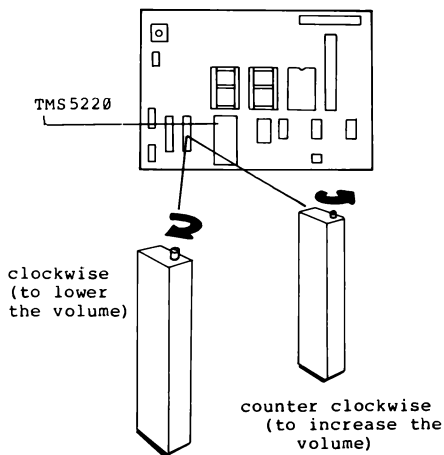
Fig. 6-1 Position of the VRs.

VII. SPECIFICATIONS

1) Power Requirement: +5V, ±5%, 200mA

2) Connector   : D-Connector double-head 40
                         holes

3) Size   : Width - 10.9 cm
                         Length - 15.8 cm

4) Environment   : Operating temperature 0° C
                         to 40° C
                         Storage temperature 125° C
                         to 80° C
                         Relative Humidity
                         Noncondensing up to 90%

VIII. APPENDICES

1. SCHEMATIC
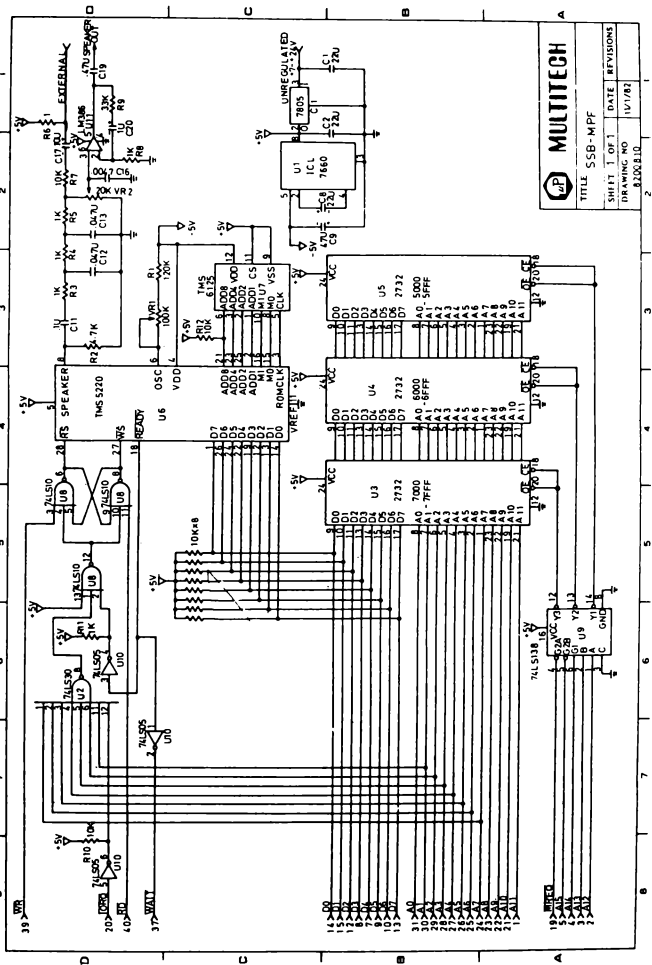
2. SSB-MPF-IP PROGRAM

```
                    1  ;
                    2  ;        *********************************
                    3  ;        *                               *
                    4  ;        *           SSB-MPF-IP           *
                    5  ;        *                    .           *
                    6  ;        *********************************
                    7  ;
                    8  ;COPYRIGHT, MULTITECH INDUSTRIAL CORP. 1982.
                    9  ;Written by the engineer of R&D department
                   10  ;Routine address is 5000H
                   11  ;Demo program of SSB-MPF-IP. Talking clock in English.
                   12  ;This program is to tell you the current time.
                   13  ;Before you run this program, set the time buffer
                   14  ;including SECOND, MINUTE, HOUR, and AM PM flag.
                   15  ;For example:     buffer adds       time indicate
                   16  ;        HOUR            F800H              10
                   17  ;        MINUTE          F801H              40
                   18  ;        SECON           F802H              55
                   19  ;        AM/PM           F803H              10/11
                   20  ;
                   21  SCAN    EQU     0246H      ;Utility subroutine of MPF-IP
                   22  SCAN1   EQU     029BH      ;Utility subroutine of MPF-IP
                   23  DEC-SP  EQU     0399H      ;Utility subroutine of MPF-IP
                   24  PORT    EQU     0FEH       ;I/O port of SSB-MPF-IP
                   25  CLEAR   EQU     09B9H      ;Utility subroutine of MPF-IP
                   26  DISP    EQU     0FF84H     ;The buffer of display buffer
                   27                             ;pointer
                   28  MSG     EQU     09CAH      ;Utility subroutine of MPF-IP
                   29  DISPBF  EQU     0FF2CH     ;Display buffer
                   30  CONVER  EQU     0821H      ;Utility subroutine of MPF-IP
5000               31          ORG     5000H
                   32  ; ONESEC loop takes one second to execute,include
                   33  ; six subroutine and one delay loop.
5000   CDB909      34  ONESEC  CALL    CLEAR               ;clear display buffer,
                   35                                      ;make OUTPTR and DISP
                   36                                      ;initial position
5003   3A03F8      37          LD      A,(APMFLG)
5006   CB47        38          BIT     0,A                 ;cheak AM or PM
5008   2805        39          JR      Z,AMD
500A   21C851      40          LD      HL,PM
500D   1803        41          JR      MID
500F   21C351      42  AMD     LD      HL,AM
5012   CDCA09      43  MID     CALL    MSG                 ;convert ascii code to
                   44                                      ;display format
5015   CD9903      45          CALL    DEC-SP              ;delete cursor
5018   CD7B50      46          CALL    BFUPDT
501B   063E        47          LD      B,62
501D   DD212CFF    48          LD      IX,DISPBF            .
5021   CD9B02      49  LOOP1   CALL    SCAN1               ;the time of SCAN1 is
                   50                                      ;about 15.667mS
5024   C5          51          PUSH    BC
5025   0601        52          LD      B,01H
5027   10FE        53  TEMP    DJNZ    TEMP                ;addition delay
5029   C1          54          POP     BC
502A   10F5        55          DJNZ    LOOP1
502C   CD3150      56          CALL    TMUPDT
502F   18CF        57          JR      ONESEC
                   58  ;TMUPDT is a time buffer updata subroutine
```

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```
5031   217A50       59  TMUPDT  LD      HL,MAXTAB+2
5034   1102F8       60          LD      DE,SEC
5037   0603         61          LD      B,3
5039   37           62          SCF
503A   1A           63  TMINC   LD      A,(DE)
503B   CE00         64          ADC     A,0
503D   27           65          DAA
503E   12           66          LD      (DE),A
503F   96           67          SUB     (HL)              ;compare with MAX_TABLE
5040   3801         68          JR      C,COMPL
5042   12           69          LD      (DE),A
5043   3F           70  COMPL   CCF
5044   2B           71          DEC     HL
5045   1B           72          DEC     DE
5046   10F2         73          DJNZ    TMINC
5C48   3A00F8       74          LD      A,(HOUR)
504B   A7           75          AND     A
504C   2815         76          JR      Z,SUC             . ;if reach max, jump to
       77                                                 ;routine SUC
504E   3C           78          INC     A
504F   FE13         79          CP      13H
5051   2015         80          JR      NZ,HAL            ;over twelve o'clock ?
5053   3A03F8       81          LD      A,(APMFLG)
5056   CB67         82          BIT     4,A
5058   2016         83          JR      NZ,CONT
505A   EE01         84          XOR     01H               ;change AM to PM; PM
       85                                                 ;to AM
505C   F610         86          OR      10H
505E   3203F8       87          LD      (APMFLG),A
5061   180D         88          JR      CONT
5063   3E01         89  SUC     LD      A,1H
5065   3200F8       90          LD      (HOUR),A
5068   3A03F8       91  HAL     LD      A,(APMFLG)
506B   E6EF         92          AND     0EFH
506D   3203F8       93          LD      (APMFLG),A
5070   3A02F8       94  CONT    LD      A,(SEC)           ;one minute is up ?
5073   A7           95          AND     A
5074   CCA750       96          CALL    Z,SPEAK
5077   C9           97          RET
5078   13           98  MAXTAB  DEFB    13H
5079   60           99          DEFB    60H
507A   60           100         DEFB    60H
       101 ;BFUPDT is a subroutine where display time buffer
       102 ;is updataed
507B   1138FF       103 BFUPDT  LD      DE,DISPBF+12
507E   ED5384FF     104         LD      (DISP),DE
5082   0603         105         LD      B,3
5084   2100F8       106         LD      HL,TMBF
5087   3E30         107 LOOP2   LD      A,30H
5089   ED6F         108         RLD
508B   F5           109         PUSH    AF
508C   CD2108       110         CALL    CONVER            ;convert ascii code to
       111                                                ;display format
508F   F1           112         POP     AF
5090   ED6F         113         RLD
5092   F5           114         PUSH    AF
5093   CD2108       115         CALL    CONVER
5096   F1           116         POP     AF
```

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```
5097  ED6F         117        RLD
5099  23           118        INC     HL
509A  ED5B84FF     119        LD      DE,(DISP)
509E  13           120        INC     DE
509F  13           121        INC     DE
50A0  ED5384FF     122        LD      (DISP),DE
50A4  10E1         123        DJNZ    LOOP2
50A6  C9           124        RET
                   125    ;
                   126    ;SPEAK routine is executed when every minute
                   127    ;is reach. It include many subroutines as the
                   128    ;following:
                   129    ;            1. APMDEC- AM or PM decision
                   130    ;            2. CHKOCK- check the o'clock
                   131    ;                       time
                   132    ;            3. SPKPM - speak PM and save
                   133    ;                       the speech address
                   134    ;            4. GO*   - tell time routine
                   135    ;            5. CNTMIN- check and count the
                   136    ;                       updated time
                   137    ;
                   138    ;
50A7  3E02         139 SPEAK  LD      A,2
50A9  3202F8       140        LD      (SEC),A              ;compensate timing
                   141                                     ;lose during the
                   142                                     ;speech routine
50AC  21AF51       143        LD      HL,HOUR_MIN
50AF  3A00F8       144        LD      A,(HOUR)
50B2  87           145        ADD     A,A
50B3  5F           146        LD      E,A
50B4  1600         147        LD      D,0
50B6  19           148        ADD     HL,DE
50B7  2204F8       149        LD      (TLKHOR1),HL         ;this routine decide AM
                   150 APMDEC                              ;or PM
50BA  3A03F8       152        LD      A,(APMFLG)           ;define bit0=0,AM
                   153                                     ;       bit0=1,PM
50BD  CB47         154        BIT     0,A
50BF  2008         155        JR      NZ,SPKPM             ;PM is speaking
50C1  2AF551       156        LD      HL,(AMADDS)
50C4  220AF8       157        LD      (APMTLK),HL          ;APMTLK choice talk
                   158                                     ;AM or PM
50C7  1806         159        JR      CHKOCK
50C9  2AF751       160 SPKPM  LD      HL,(PMADDS)
50CC  220AF8       161        LD      (APMTLK),HL
50CF  3A01F8       162 CHKOCK LD      A,(MIN)              ;check the o'clock
50D2  A7           163        AND     A
50D3  2025         164        JR      NZ,CNTMIN            ;if minute is not
                   165                                     ;zero check the
                   166                                     ;actual minute no.
                   167    ;
                   168    ;GO routine is to tell o'clock time
                   169    ;include AM,PM
                   170    ;GO* routine save all the update time
                   171    ;HOUR and MINUTE. Speech routine is
                   172    ;called now.
                   173    ;
                   174 GO
```

```
50D5   21EF51      175          LD        HL,THE
50D8   CD7251      176          CALL      START           ;speak "the"
50DB   21F151      177          LD        HL,TIME
50DE   CD7251      178          CALL      START           ;speak "time"
50E1   21F351      179          LD        HL,IS
50E4   CD7251      180          CALL      START           ;speak "is"
50E7   2A04F8      181          LD        HL,(TLKHOR1)
50EA   CD7251      182          CALL      START
50ED   21CD51      183          LD        HL,JUST
50F0   CD7251      184          CALL      START           ;speak "o`clock"
50F3   210AF8      185          LD        HL,APMTLK
50F6   CD7251      186          CALL      START           ;speak AM or PM
50F9   C9          187          RET
                   188
                   189   ;
                   190   ;CNTMIN routine to count the updata minutes
                   191   ;for the GO routine to tell actual time reach
                   192   ;including hour and minutes.
                   193   ;
50FA   3A01F8      194   CNTMIN  LD        A,(MIN)
50FD   FE10        195          CP        10H
50FF   3837        196          JR        C,CNTMN2
5101   FE20        197          CP        20H
5103   3854        198          JR        C,CNTMN1
5105   3A01F8      199   CNTMN3  LD        A,(MIN)
5108   E60F        200          AND       0FH
510A   21AF51      201          LD        HL,HOUR-MIN
510D   87          202          ADD       A,A
510E   85          203          ADD       A,L
510F   6F          204          LD        L,A
5110   2208F8      205          LD        (TKMIN2),HL
5113   3A01F8      206          LD        A,(MIN)
5116   0F          207          RRCA
5117   0F          208          RRCA
5118   0F          209          RRCA
5119   0F          210          RRCA
511A   E60F        211          AND       0FH
511C   21E351      212          LD        HL,TXBLE-MIN
511F   87          213          ADD       A,A
5120   85          214          ADD       A,L
5121   6F          215          LD        L,A
5122   2206F8      216          LD        (TLKMIN1),HL
                   217   ;
                   218   ;GO3 routine is to tell minute time
                   219   ;above 20.
                   220   ;
5125   2A04F8      221   GO3     LD        HL,(TLKHOR1)
5128   CD7251      222          CALL      START
512B   2A06F8      223          LD        HL,(TLKMIN1)
512E   CD7251      224          CALL      START
5131   2A08F8      225          LD        HL,(TKMIN2)
5134   CD7251      226          CALL      START
5137   C9          227          RET
5138   3A01F8      228   CNTMN2  LD        A,(MIN)
513B   E60F        229          AND       0FH
513D   21AF51      230          LD        HL,HOUR-MIN
5140   87          231          ADD       A,A
5141   85          232          ADD       A,L
```

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```
5142  6F          233          LD       L,A
5143  2208F8      234          LD       (TKMIN2),HL
                  235  ;
                  236  ;GO2 routine is to tell time
                  237  ;range from 01 to 09 minutes.
                  238  ;
5146  2A04F8      239  GO2      LD       HL,(TLKHOR1)
5149  CD7251      240          CALL     START
514C  21E351      241          LD       HL,OH            ;speak HOUR
514F  CD7251      242          CALL     START            ;speak word "OH"
5152  2A08F8      243          LD       HL,(TKMIN2)
5155  CD7251      244          CALL     START            ;speak minute
5158  C9          245          RET
5159  3A01F8      246  CNTMN1   LD       A,(MIN)
515C  21AF51      247          LD       HL,HOUR-MIN
515F  87          248          ADD      A,A
5160  85          249          ADD      A,L
5161  6F          250          LD       L,A
5162  2208F8      251          LD       (TKMIN2),HL
                  252  ;
                  253  ;GO1 routine is to tell minute time
                  254  ;range between 10 to 19.
                  255  ;
5165  2A04F8      256  GO1      LD       HL,(TLKHOR1)
5168  CD7251      257          CALL     START
516B  2A08F8      258          LD       HL,(TKMIN2)
516E  CD7251      259          CALL     START
5171  C9          260          RET
                  261  ;
                  262  ;
                  263  ;
                  264  ;    **********************************
                  265  ;    *                                *
                  266  ;    *    SSB-MPF-IP-DEMO-SUBROUTINE   *
                  267  ;    *                                *
                  268  ;    **********************************
                  269  ;
5172  4E          270  START    LD       C,(HL)
5173  23          271          INC      HL
5174  46          272          LD       B,(HL)
5175  ED430EF8    273          LD       (CODAD),BC
5179  2A0EF8      274  START1   LD       HL,(CODAD)
517C  0610        275          LD       B,10H            ;reset counter
517E  3EFF        276  RESET    LD       A,0FFH           ;TMS 5220 reset code is
                  277                                     ;*111****
5180  D3FE        278          OUT      (PORT),A         ;send the reset command
5182  CDA851      279          CALL     DELY
5185  10F7        280          DJNZ     RESET            ;reset routine
5187  3E60        281          LD       A,60H            ;enable speak external
                  282                                    ;command
5189  D3FE        283          OUT      (PORT),A         ;VSP is ready
518B  CDA851      284          CALL     DELY
518E  7E          285  SEND1    LD       A,(HL)           ;fetch speak data
518F  D3FE        286          OUT      (PORT),A         ;send data to TMS 5220
5191  CDA851      287          CALL     DELY
5194  23          288          INC      HL               ;next data
5195  DBFE        289          IN       A,(PORT)         ;read the status of VSP
5197  CB7F        290          BIT      7,A              ;check talking status
```

                                    32

```
5199   28F3      291            JR      Z,SEND1       ;need more data to VSP
519B   7E        292   SEND2    LD      A,(HL)        ;load the next data of
                 293                                  ;send1 loop
519C   D3FE      294            OUT     (PORT),A      ;send data continue
519E   CDA851    295            CALL    DELY
51A1   23        296            INC     HL            ;next address
51A2   DBFE      297            IN      A,(PORT)      ;check the talk status
                 298                                  ;activate or not
51A4   CB7F      299            BIT     7,A           ;get the stop code?
51A6   20F3      300            JR      NZ,SEND2      ;if no,send the rest
                 301                                  ;data and check
51A8   C5        302   DELY     PUSH    BC            ;delay routine
51A9   06FF      303            LD      B,0FFH        ;delay counter
51AB   10FE      304            DJNZ    $
51AD   C1        305            POP     BC
51AE   C9        306            RET
                 307   HOUR-MIN                       ;table used in both
                 308                                  ;HOUR and MINUTE
51AF   BE5F      309            DEFW    5FBEH         ;PAUSE
51B1   3355      310            DEFW    5533H         ;ONE
51B3   9955      311            DEFW    5599H         ;TWO
51B5   CC55      312            DEFW    55CCH         ;THREE
51B7   3456      313            DEFW    5634H         ;FOUR
51B9   9156      314            DEFW    5691H         ;FIVE
51BB   0F57      315            DEFW    570FH         ;SIX
51BD   4257      316            DEFW    5742H         ;SEVEN
51BF   9A57      317            DEFW    579AH         ;EIGHT
51C1   E157      318            DEFW    57E1H         ;NINE
51C3   2020414D  319   AM       DEFM    ' AM'
51C7   0D        320            DEFB    0DH
51C8   2020504D  321   PM       DEFM    ' PM'
51CC   0D        322            DEFB    0DH
51CD   D554      323   JUST     DEFW    54D5H         ;o'clock data
51CF   5558      324            DEFW    5855H         ;TEN
51D1   BC58      325            DEFW    58BCH         ;ELEVEN
51D3   4959      326            DEFW    5949H         ;TWELVE
51D5   C459      327            DEFW    59C4H         ;THIRTEEN
51D7   645A      328            DEFW    5A64H         ;FOURTEEN
51D9   DB5A      329            DEFW    5ADBH         ;FIFTEEN
51DB   6E5B      330            DEFW    5B6EH         ;SIXTEEN
51DD   065C      331            DEFW    5C06H         ;SEVENTEEN
51DF   C15C      332            DEFW    5CC1H         ;EIGHTEEN
51E1   5C5D      333            DEFW    5D5CH         ;NINETEEN
                 334   TXBLE_MIN
51E3   9954      335   OH       DEFW    5499H         ;SPEECH DATA "OH"
51E5   5558      336            DEFW    5855H         ;TEN
51E7   1E5E      337            DEFW    5E1EH         ;TWENTY
51E9   875E      338            DEFW    5E87H         ;THIRTY
51EB   F25E      339            DEFW    5EF2H         ;FORTY
51ED   5D5F      340            DEFW    5F5DH         ;FIFTY
61EF   5E52      341   THE      DEFW    525EH         ;word "the" address
51F1   8052      342   TIME     DEFW    5280H         ;word "time" address
51F3   0D53      343   IS       DEFW    530DH         ;word "is" address
51F5   7253      344   AMADDS   DEFW    5372H         ;AM data address
51F7   1954      345   PMADDS   DEFW    5419H         ;PM data address
                 346
```

```
                      347  *H
                      348  ;
                      349  ;       **********************************
                      350  ;       *                                *
                      351  ;       *   SPEAK THE WORDS IN THE        *
                      352  ;       *   SPEECH DATA MEMORY WITH       *
                      353  ;       *   MANUAL CONTROL                *
                      354  ;       *                                *
                      355  ;       **********************************
51F9  210050          356  SPALL   LD     HL,5000H          ;code memory start address
51FC  220CF8          357          LD     (CODST),HL
51FF  DD2A0CF8        358  SPALL1  LD     IX,(CODST)
5203  01FF0F          359          LD     BC,0FFFH
5206  DD09            360          ADD    IX,BC
5208  DD6E00          361  LOOP3   LD     L,(IX)
520B  DD2B            362          DEC    IX
520D  DD6600          363          LD     H,(IX)
5210  DD2B            364.         DEC    IX
5212  23              365          INC    HL
5213  7D              366          LD     A,L
5214  B4              367          OR     H
5215  28E8            368          JR     Z,SPALL1          ;end of look up table
5217  2B              369          DEC    HL
5218  ED4B0CF8        370          LD     BC,(CODST)
521C  09              371          ADD    HL,BC
521D  220EF8          372          LD     (CODAD),HL
5220  CD7951          373          CALL   START1
5223  DDE5            374          PUSH   IX
5225  CDB909          375          CALL   CLEAR
5228  214E52          376          LD     HL,SPEECH
522B  CDCA09          377          CALL   MSG
522E  CD9903          378          CALL   DEC_SP
5231  DD212CFF        379          LD     IX,DISPBF
5235  CD4602          380  LOOP4   CALL   SCAN
5238  FE4E            381  .        CP     4EH               ;next?
523A  2806            382          JR     Z,NEXT
523C  FE52            383          CP     52H               ;repeat?
523E  2806            384          JR     Z,REPEAT
5240  18F3            385          JR     LOOP4
5242  DDE1            386  NEXT    POP    IX
5244  18C2            387          JR     LOOP3
5246  DDE1            388  REPEAT  POP    IX
5248  DD23            389          INC    IX
524A  DD23            390          INC    IX
524C  18BA            391          JR     LOOP3
524E  20202020        392  SPEECH  DEFM   '     SPEECH'
525B  0D              393          DEFB   0DH
                      394  ;
                      395  ;RAM Buffer starting address
                      396  ;
F800                  397          ORG    0F800H
                      398  TMBF                             ;Time Buffer for HOUR,
                      399                                   ;MINUTE and SECOND.
F800                  400  HOUR    DEFS   1
F801                  401  MIN     DEFS   1
F802                  402  SEC     DEFS   1
F803                  403  APMFLG  DEFS   1
F804                  404  TLKHOR1 DEFS   2
```

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```
F806                405  TLKMIN1 DEFS   2
F808                406  TKMIN2  DEFS   2
F80A                407  APMTLK  DEFS   2
F80C                408  CODST   DEFS   2
F80E                409  CODAD   DEFS   2
                    410          END
```

```
AM       51C3     319    42
AMADDS   51F5     344   156
AMD      500F      42    39
APMDEC   50BA     150
APMFLG   F803     403    37    81    87    91    93   152
APMTLK   F80A     407   157   161   185
BFUPDT   507B     103    46
CHKOCK   50CF     162   159
CLEAR    09B9      25    34   375
CNTMIN   50FA     194   164
CNTMN1   5159     246   198
CNTMN2   5138     228   196
CNTMN3   5105     199
CODAD    F80E     409   273   274   372
CODST    F80C     408   357   358   370
COMPL    5043      70    68
CONT     5070      94    83    88
CONVER   0821      30   110   115
DEC_SP   0399      23    45   378
DELY     51A8     302   279   284   287   295
DISP     FF84      26   104   119   122
DISPBF   FF2C      29    48   103   379
GO       50D5     174
GO1      5165     256
GO2      5146     239
GO3      5125     221
HAL      5068      91    80
HOUR     F800     400    74    90   144
HOUR_M   51AF     307   143   201   230   247
IS       51F3     343   179
JUST     51CD     323   183
LOOP1    5021      49    55
LOOP2    5087     107   123
LOOP3    5208     361   387   391
LOOP4    5235     380   385
MAXTAB   5078      98    59
MID      5012      43    41
MIN      F801     401   162   194   199   206   228   246
MSG      09CA      28    43   377
NEXT     5242     386   382
OH       51E3     335   241
ONESEC   5000      34    57
PM       51C8     321    40
PMADDS   51F7     345   160
PORT     00FE      24   278   283   286   289   294   297
REPEAT   5246     388   384
RESET    517E     276   280
SCAN     0246      21   380
SCAN1    029B      22    49
SEC      F802     402    60    94   140
SEND1    518E     285   291
SEND2    519B     292   300
SPALL    51F9     356
SPALL1   51FF     358   368
SPEAK    50A7     139    96
SPEECH   524E     392   376
SPKPM    50C9     160   155
START    5172     270   176   178   180   182   184   186   222   224   226   240
```

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```
                        242  244  257  259
START1 5179     274  373
SUC    5063      89   76
TEMP   5027      53   53
THE    51EF     341  175
TIME   51F1     342  177
TKMIN2 F808     406  205  225  234  243  251  258
TLKHOR F804     404  149  181  221  239  256
TLKMIN F806     405  216  223
TMBF   F800     398  106
TMINC  503A      63   73
TMUPDT 5031      59   56
TXBLE_ 51E3     334  212
```

CLOCK-ENGLISH.S
Flowchart

```
        ┌─────────────┐
        (   ENTRY     )
        └─────────────┘
              │
    ┌─────────┼
    │         ▼
    │  ┌──────────────────┐
    │  │ One Second Counter│
    │  │    Routine        │
    │  └──────────────────┘
    │         │
    │         ▼
    │  ┌──────────────────┐
    │  │ Display AM/PM(MSG)│
    │  │ and updated timing│
    │  │ (BFDPDT)          │
    │  └──────────────────┘
    │         │
    │         ▼
    │  ┌──────────────────┐
    │  │ Compensate an    │
    │  │ addition delay   │
    │  └──────────────────┘
    │         │
    │         ▼
    │  ┌──────────────────┐
    │  │ update clock     │
    │  │ data (TMUPDT)    │
    │  └──────────────────┘
    │         │
    │         ▼
    │      ◇─────────◇   NO
    │     ╱ one minute ╲──────────┐
    │     ╲ is up ?    ╱          │
    │      ◇─────────◇           │
    │         │ YES               │
    │         ▼                   │
    │  ┌──────────────────┐      │
    │  │ Tell time        │      │
    │  │ speech Routine   │      │
    │  │ (speak)          │      │
    │  └──────────────────┘      │
    │         │                   │
    └─────────┴───────────────────┘
```

38
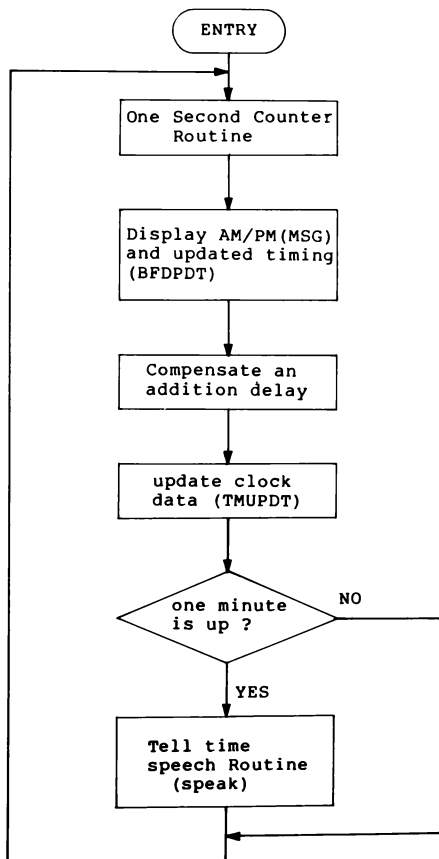
Time Bufffer Update
Flowchart
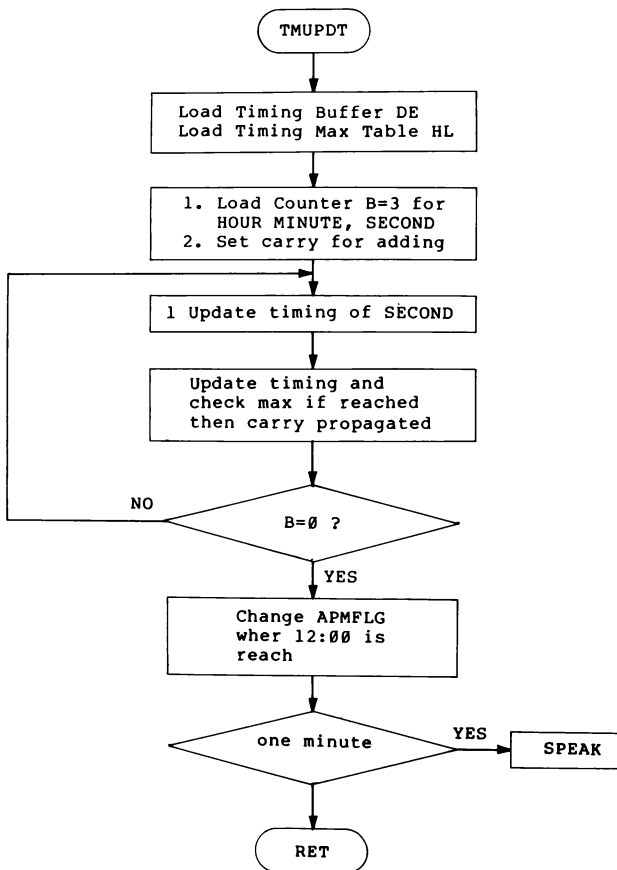
Update Display Buffer
Flowchart

```
                    ( BFUPDT )
                         |
                         v
   +-------------------------------------------+
   | 1. Load display buffer to (DISP)          |
   | 2. Load time buffer to DE                 |
   +-------------------------------------------+
                         |
                         v
   +-------------------------------------------+
   |          Set Counter B=3                  |
   |          for HOUR, MINUTE,                |
   |          and SECOND                       |
   +-------------------------------------------+
                         |
         +-------------->|
         |               v
   +-------------------------------------------+
   |          Display timing                   |
   |          from HOUR TO SECOND              |
   +-------------------------------------------+
                         |
                         v
   +-------------------------------------------+
   |          Decrease B                       |
   +-------------------------------------------+
                         |
     NO                  v
     +------<  <        B=0        >
                         |
                         | YES
                         v
                    (  RET  )
```

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AM. PM. Decision
Floechart

```
                    ( APMDEC )
                         |
                         v
        +-----------------------------------+
        | Load AM/PM Flag into              |
        | Accumulator                       |
        +-----------------------------------+
                         |
                         v
             /\                    /\
            /  \                  /  \
           / Bit 0 = 0 \  ------> ( Set PM )
            \          /
             \        /
              \      /
               \  /
                |
              YES
                |
                v
        +-----------------------------------+
        |        Set AM, PM                 |
        |       Buffer Address              |
        +-----------------------------------+
                         |
                         v
        +-----------------------------------+
        | Load the AM/PM                    |
        | Speech Data Address               |
        | To APMTLK buffer                  |
        +-----------------------------------+
                         |
                         v
                    (   RET   )
```

41
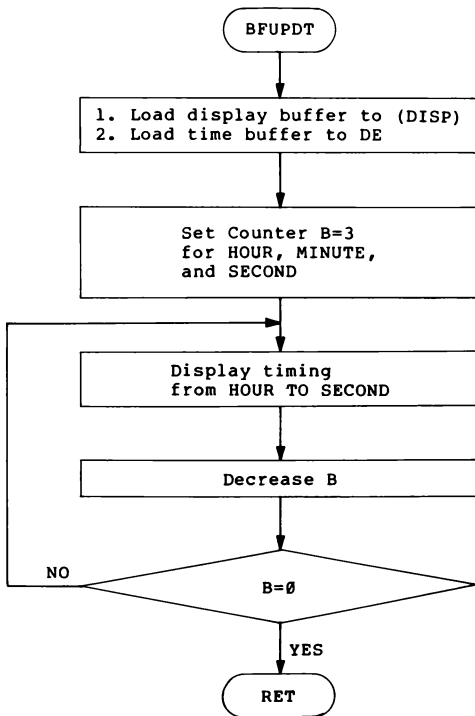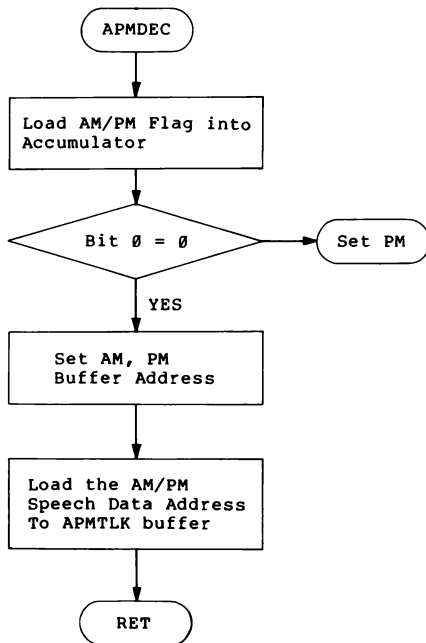
Speech Routine Flowchart

```
        ┌─────────┐
        │  SPEAK  │
        └─────────┘
             │
             ▼
  ┌───────────────────────┐
  │ Save Register and     │
  │ carry flag            │
  └───────────────────────┘
             │
             ▼
  ┌───────────────────────┐
  │ Second Compensation   │
  │ for speaking          │
  └───────────────────────┘
             │
             ▼
  ┌───────────────────────┐
  │ Save update HOUR      │
  │ Buffer                │
  └───────────────────────┘
             │
             ▼
  ┌───────────────────────┐
  │ AM or PM              │
  │ Decision              │
  │ (APMDEC)              │
  └───────────────────────┘
             │
             ▼
          Check                   NO    ┌─────────┐
      the o'clock              ───────→ │ CNTMIN  │
      time is up ?                      └─────────┘
        (CHKOCK)
             │
           YES
             │
             ▼
  ┌───────────────────────┐
  │       GO 1            │
  │ Tell time Routine     │
  └───────────────────────┘
             │
             ▼
        ┌─────────┐
        │   RET   │
        └─────────┘
```
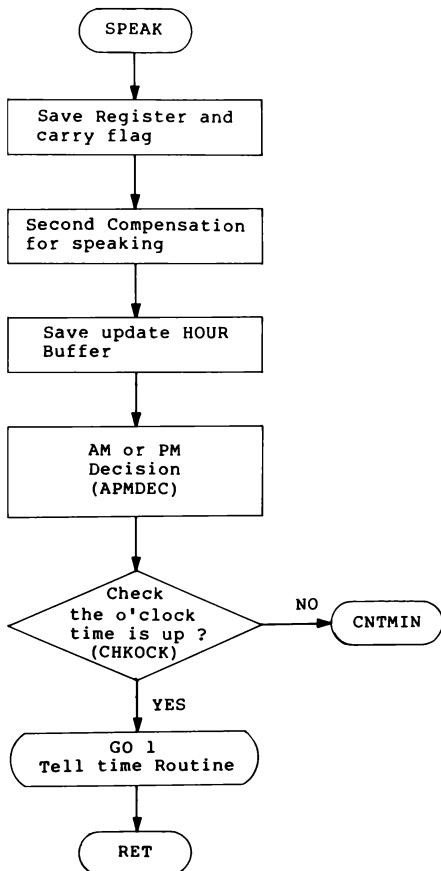
**Count MINUTE Buffer
Flowchart**
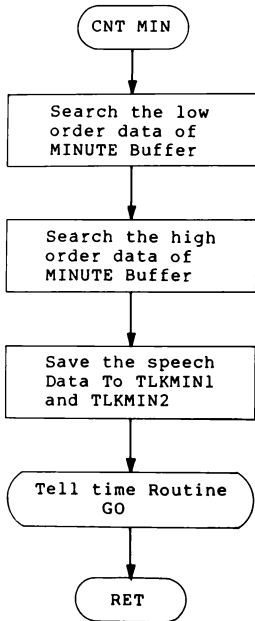
**Tell Time Routine
Flowchart
GO & GO1**

```
     ( CNT MIN )
```

```
  ┌─────────────────┐
  │ Search the low  │
  │ order data of   │
  │ MINUTE Buffer   │
  └─────────────────┘
```

```
  ┌─────────────────┐
  │ Search the high │
  │ order data of   │
  │ MINUTE Buffer   │
  └─────────────────┘
```

```
  ┌─────────────────┐
  │ Save the speech │
  │ Data To TLKMIN1 │
  │ and TLKMIN2     │
  └─────────────────┘
```

```
  ( Tell time Routine
         GO         )
```

```
     ( RET )
```

```
        ( GO )
```

```
  ┌──────────────────────┐
  │ Load Speech Data      │
  │ Starting Address to HL│
  └──────────────────────┘
```

```
  ┌──────────────────────┐
  │ Call Speech Subroutine│
  │        START          │
  └──────────────────────┘
```

```
        ( RET )
```
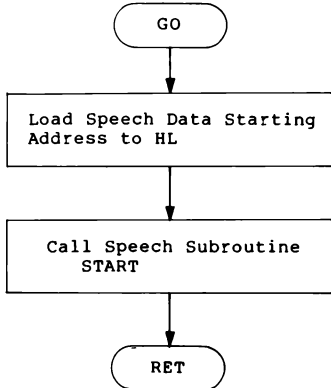
SUBROUTINE START is the
same as DEMO-SUBROUTINE.S

```
                    ┌─────────┐
                    │  START  │
                    └────┬────┘
                         │
                         ▼
              ┌──────────────────┐
              │ EXECUTE          │
              │ VSP POWER        │
              │ CLEAR ROUTINE    │
              └────────┬─────────┘
                       │
                       ▼
              ┌──────────────────┐
              │ ENABLE VSP       │
              │ SPEAK            │
              │ EXTERNAL         │
              │ COMMAND          │
              └────────┬─────────┘
                       │
                       ▼
              ┌──────────────────┐
              │ LOAD THE         │
              │ START            │
              │ ADDRES OF        │
              │ SPEAKING DATA    │
              └────────┬─────────┘
                       │
                       ▼
              ┌──────────────────┐
              │ OUT THE DATA     │
              │ TO V.S.P.        │
              └────────┬─────────┘
                       │
             NO        ▼
            TALK    ╱CHECK╲
   ┌─────────────╱ TALK STATUS ╲
   │             ╲ OF V.S.P.   ╱
   │              ╲         ╱
┌──────────┐        │ TALK
│ LOAD THE │        ▼
│CONTINUOUS│   ┌──────────────────┐
│ DATA S   │   │ LOAD NEXT        │
└──────────┘   │ DATA ADDRESS     │
               │ UNTIL STOP       │
               └────────┬─────────┘
                        │
                        ▼
                   ╱TALK IS END╲    NO
                   ╲    ?     ╱─────────
                    ╲      ╱
                      │ YES
                      ▼
                 ┌─────────┐
                 │ RETURN  │
                 └─────────┘
```
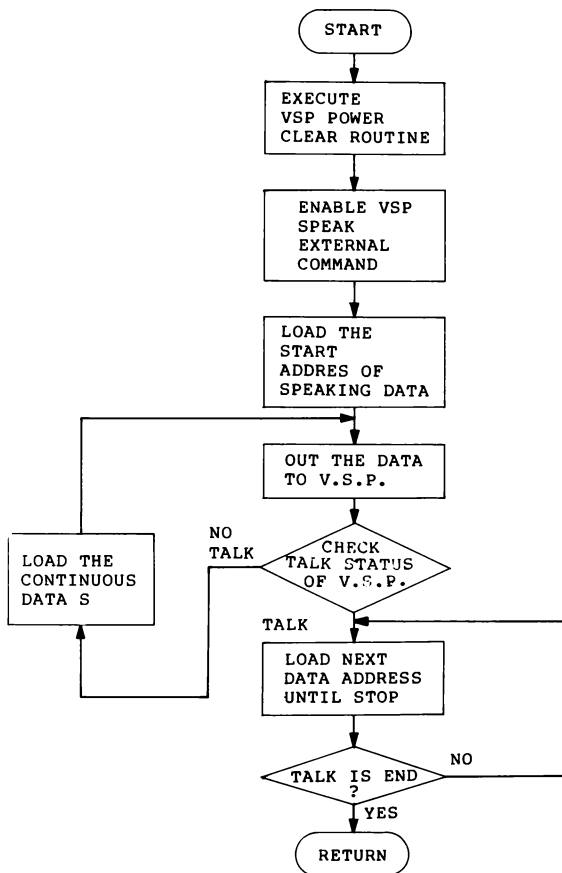
3. TMS5220 VOICE SYNTHESIS PROCESSOR
DATA MANUAL

TABLE OF CONTENTS

SUPPLEMENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

1. INTRODUCTION

1.1 SCOPE

This manual describes in detail the functional characteristics of a linear predictive coding (LPC) speech synthesis device, the TMS 5220. In addition to this document, the user may wish to refer to the TMS 6100 128K bit ROM electrical specification.

1.2 KEY FEATURES

- High-quality voice communication from a microcomputer system
- Low-data-rate LPC encoding
- Low-cost P-channel MOS technology
- +5 V and −5 V supplies only
- Interrupt-based service requests
- TTL compatible

1.3 DEVICE OPERATION

The TMS 5220 Voice Synthesis Processor (VSP) enables verbal communication with a microcomputer based system. The VSP is fabricated using P-channel MOS technology and is TTL compatible.

Speech data that has been compressed using pitch-excited linear predictive coding (LPC), is supplied to the VSP either by the CPU or by direct serial access of a Voice Synthesis Memory (VSM). The VSP decodes this data to construct a time-varying digital filter model of the vocal tract. This model is excited with a digital representation of either glottal air impulses (voiced sounds) or the rush of air (unvoiced sounds). The output of this model is passed through an eight-bit digital-to-analog converter to produce a synthetic speech waveform.

The VSP has been designed to minimize the data rate required to produce synthetic speech and to simplify the interface with the host CPU. The CPU may service the device either in a polled fashion, by monitoring device status, or by responding to interrupt service requests generated by the VSP. A simplified block diagram of the VSP is shown in Figure 1.

2. SYSTEM CLOCK

This manual describes all VSP timing based on an 8-kHz sample rate (limiting the output frequency to 4 kHz) and a 40-Hz frame rate (the rate at which new speech data is processed and processed). This requires the internal RC oscillator in the VSP to run at 640 kHz. The user has the mask-programmable option of balancing the internal oscillator with a resistor (completing the RC network).

The 640-kHz clock is divided by four to produce two major phases, PHI-1 and PHI-2, with corresponding precharge clocks, PHI-3 and PHI-4 (see Appendix A). All control and timing operations within the VSP occur on one of the two 6.25-microsecond major phases. Twenty of these 6.25-microsecond bit times comprise each sample period (8-kHz sample rate). Twenty-five of these 125-microsecond sample periods make up one 3.25-millisecond interpolation interval, eight of which (IC0-IC7) make up the 25-millisecond frame period. During IC0, new speech data is transferred to the Synthesizer, at a 40-Hz frame rate.

3. CPU INTERFACE

The CPU interface consists of an eight-bit bidirectional data bus (D0-D7), separate selects for read operations and write operations ($\overline{RS}$ & $\overline{WS}$), a ready line for synchronization ($\overline{READY}$) and an interrupt line ($\overline{INT}$) to indicate a status change on the VSP that requires CPU attention.
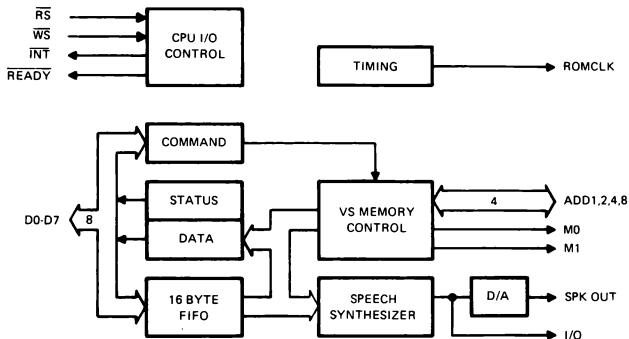
49

FIGURE 1 — VOICE SYNTHESIS PROCESSOR BLOCK DIAGRAM

3.1 $\overline{RS}$ AND $\overline{WS}$

VSP activity on the memory data bus is controlled by the select lines as shown below.

TABLE 1 — $\overline{RS}$ AND $\overline{WS}$ FUNCTION

$\overline{RS}$	$\overline{WS}$	BUFFER CONDITION
H	H	High impedance state
H	L	Input to VSP. Some other device must be driving the bus (typically the CPU)
L	H	Output from VSP. No other device should be driving the bus at this time.
L	L	Illegal condition. Results not predictable.

It is important to note that no device can successfully complete a Read cycle (from the VSP) while $\overline{WS}$ is active (low) nor can a successful Write cycle (to the VSP) be carried out while $\overline{RS}$ is active (low). Device behavior cannot be predicted if both $\overline{WS}$ and $\overline{RS}$ go active simultaneously. System logic should be designed to prevent this condition from occurring.

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3.2 $\overline{\text{READY}}$

The VSP is a "Slow Memory"[1] device requiring wait states from the CPU to successfully complete a memory cycle. The effect of inserting wait states into memory access cycles is to extend the minimum allowable access time by one clock period for each wait state. The VSP controls the number of wait states executed by the CPU with the $\overline{\text{READY}}$ signal. The logic timing for typical read and write cycles to the VSP is shown in Figure 2.
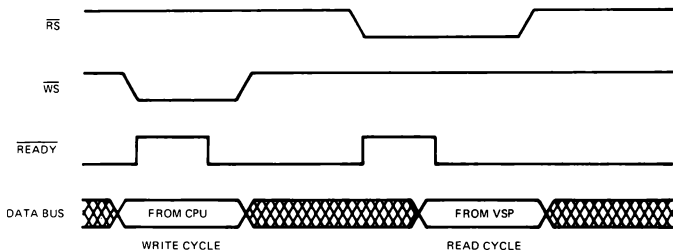

FIGURE 2 – READ AND WRITE CYCLES TO THE VSP

The $\overline{\text{READY}}$ line on the VSP goes high 100 ns after $\overline{\text{RS}}$ or $\overline{\text{WS}}$ goes active (low) to let the CPU know that the data transfer cycle cannot yet be completed. When the VSP has established stable data on the data bus (in the case of $\overline{\text{RS}}$) or has completed latching data in from the data bus (in the case of $\overline{\text{WS}}$), the $\overline{\text{READY}}$ line will go low indicating that the CPU may complete the data transfer cycle.

3.3 INTERRUPTS

The interrupt line ($\overline{\text{INT}}$) indicates changes in the status of the VSP that may require CPU attention. $\overline{\text{INT}}$ goes active (low) when any of the following occur:

- Talk Status (TS) makes a one-to-zero transition indicating the end of speech processing.
- Buffer Low (BL) makes a zero-to-one transition indicating that more phrase data needs to be supplied to the FIFO for Speak External Command.
- Buffer Empty (BE) makes a zero-to-one transition indicating that the CPU failed to supply data fast enough for a Speak External Command.[2]

$\overline{\text{INT}}$ goes inactive (high) when the Status Register is read, or if the Reset instruction is executed.

4. VOICE SYNTHESIS MEMORY (VSM) – (TMS 6100)

In addition to receiving speech data from the CPU, the VSP may directly access up to 16 TMS 6100's (128K-bit serial ROM) with no external hardware required. This is accomplished with a four-bit parallel bus (ADD8,4,2,1), (ADD8 is multiplexed as the Data Out line out of the TMS 6100 as well as the most-significant bit of the 4-bit address bus into the TMS 6100), two control lines (M0, M1), and a synchronizing clock (ROMCLK).

---

[1]Slow Memory devices are those devices that cannot properly respond to system memory cycles within the minimum access time as determined by the CPU clock rate.

[2]An interrupt will be generated at the initiation of a Speak External Instruction if BE was previously low.

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The TMS 6100 is a mask programmable 128K-bit Read-Only Memory internally organized as 16K words of eight bits; externally it appears as 128K X 1. Once the 20-bit address (14 bits to select a byte within the device, four chip select bits, two bits ignored) is loaded through ADD1, ADD2, ADD4, and ADD8 in five Load Address sequences, data is read out bit-wise by toggling a control pin (M0). The ROM contains an on-chip address counter that is incremented every eight bits (eight toggles of M0). The four internal chip select bits are a mask programmable option, and allow parallel connection of up to 16 ROMs (about 30 minutes of speech) without the need of external select circuitry.

M0	M1	FUNCTION
L	L	Idle — The passive NOP state of TMS 6100
L	H	Load Address — The four bits of data on ADD8,4,2,1 are loaded to the internal address register at the location indicated by the TMS 6100 Load Pointer. After each Load Address function, the Load Pointer is advanced to the left by four bit positions to allow the next most-significant nibble of the address to be properly loaded. The first read function[3], following a Load Address function, resets the Load Pointer to the LS bit and initiates a ROM access to fetch the address data byte. This is the only function of this "Dummy Read". No data is transferred out of VSM until the second read function following a Load Address.
H	L	Read — When the addressed data byte has been fetched and stored in the VSM Data Register, it is ready to be serially transferred out starting with the MSB. Each successive read function causes the next least-significant bit to be driven on the Data Out line of the VSM that is currently selected. The next data byte is being fetched at the same time the serial transfer is taking place so that when the last bit of the current byte is transferred, the VSM Data Register can be reloaded without delay. When the Read function immediately follows a Load Address function, it is treated as a "Dummy Read". No data is transferred, but the Load Pointer is reset and ROM access is initiated.
H	H	Read and Branch — Starting at the current address, two bytes are fetched from the ROM to form a 16-bit word. The 14 low-order bits of this word replace the 14 low-order bits of the Address Register. The Load Pointer is then reset and a ROM access initiated to fetch the byte at this new address.*

Figure 3 shows a typical sequence of loading the Address Register and reading two data bits back. For more critical timing constraints, consult the TMS 6100 Electrical Specification.
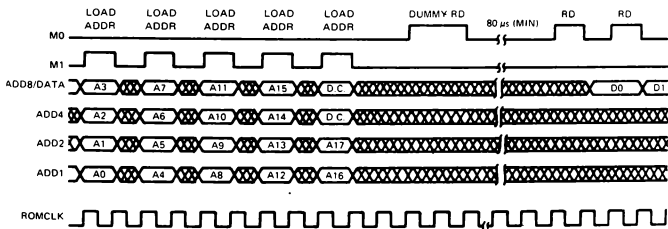
NOTE: A0 is the LSB in 6100 address.

FIGURE 3 – TMS 6100 FUNCTION TIMING

[3]A minimum of two Load Address instructions are required to change the VSM address.
*Read and Branch will not work with multiple VSM systems. Bus contention will occur

A full set of coded parameters for each frame would require a data rate of 40 Hz X 50 bits = 2000 bits per second. Three special cases, in which a full frame is not necessary, allow the data rate to be considerably reduced:

(1) Since the vocal tract changes shape relatively slowly, it is often possible to repeat previous reflection coefficient data. To facilitate the repeat feature, a control bit has been added to each frame (an additional bit following energy). If the repeat bit is 1, only energy and pitch data are accessed from the VSM and the previous K1-K10 values are retained.

(2) Unvoiced speech requires fewer filter reflection coefficients. When Pitch = 000000, only K1-K4 are fetched from the VSM and stored in the Parameter RAM. K5-K10 are zeroed.

(3) When Energy = 0000 no other data is required. Energy = 0000 during interword or intersyllable pauses. The combination of these three cases has reduced average data rate for male speech to approximately 1200 bits per second.

Figure 5 shows the four possibilities of frame data string lengths.
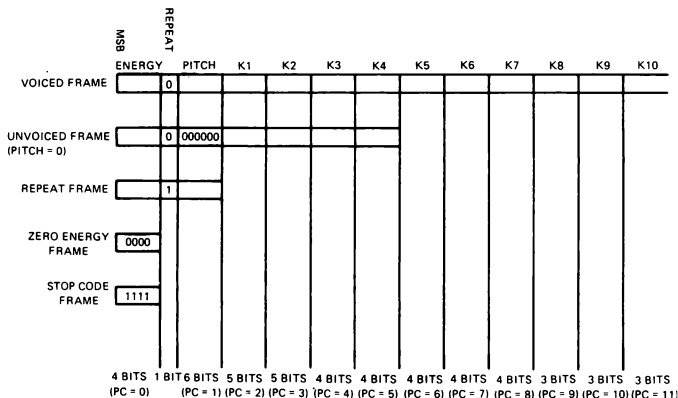
FIGURE 5 — FRAME DATA STRING LENGTHS

One complete set of parameters (12), used as target values during interpolation, is stored in coded form in the synthesizer. The storage medium is a 50-bit RAM of variable word length, e.g., six bits for pitch, three bits for K10. Data is supplied to the RAM via the parallel outputs of a serial shift register which accepts data from some VSM. The Parameter RAM outputs are used as inputs for the Parameter ROM.

8.2 D/A CONVERSION

The VSP contains an eight-bit digital-to-analog converter with 2% linearity LSB resolution. Every 125 microseconds the most-significant 10 bits of the 14-bit lattice filter output are sampled. From this sample, the seven low-order bits and the sign bit (MSB) are sent to the D/A converter. The remaining two bits are combined logically with the sign bit and used to clip the driver to either a full ON or full OFF condition. Table 4 shows the analog output from the D/A converter for various inputs from the lattice filter.

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11. MECHANICAL DATA

11.1 28-PIN 600-MIL PLASTIC PACKAGE (100-MIL PIN SPACING)
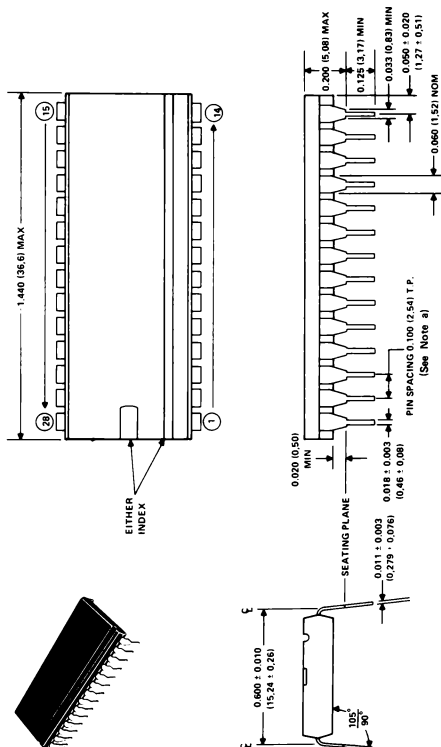
NOTES: a. Each pin centerline is located within 0.010 inch (0,26 millimeters) of its true longitudinal position.

b. All linear dimensions are shown in inches (and parenthetically in millimeters for reference only). Inch dimensions govern.

PIN	NAME	IN/OUT	FUNCTION
1	DBUS 7	I/O	Memory data bus (LSB)
2	ADD1	O	Address bus to VSM (LSB)
3	ROMCLK	O	Clock to VSM
4	V_{DD}	I	Drain supply voltage (−5 V NOM)
5	V_{SS}	I	Substrate supply voltage (+5 V NOM)
6	OSC	I	Oscillator input
7	T11	O	Sync
8	.SPEAKER	O	Audio output
9	I/O	O	Serial data out
10	PROM OUT	O	Testing use only
11	V_{REF}	I	Ground reference voltage (0 V NOM)
12	DBUS 2	I/O	Memory data bus
13	DBUS 1	I/O	Memory data bus
14	DBUS 0	I/O	Memory data bus (MSB)
15	M0	O	Command bit 0 to VSM
16	M1	O	Command bit 1 to VSM
17	$\overline{INT}$	O	Interrupt (active low)
18	$\overline{READY}$	O	Transfer cycle W/CPU complete
19	DBUS 3	I/O	Memory data bus
20	TEST	I	Testing use only
21	ADD8/DATA	I/O	Address to VSM and serial data in (MSB)
22	DBUS 4	I/O	Memory data bus
23	ADD 4	O	Address bus to VSM
24	DBUS 5	I/O	Memory data bus
25	ADD 2	O	Address bus to VSM
26	DBUS 6	I/O	Memory data bus
27	$\overline{WS}$	I	Write select (active low)
28	$\overline{RS}$	I	Read select (active low)

11.3 TERMINAL ASSIGNMENTS

D7	1	28	$\overline{RS}$
ADD1	2	27	$\overline{WS}$
ROMCLK	3	26	D6
V_{DD}	4	25	ADD2
V_{SS}	5	24	D5
OSC	6	23	ADD4
T11	7	22	D4
SPEAKER	8	21	ADD8/DATA
I/O	9	20	TEST
PROM OUT	10	19	D3
V_{REF}	11	18	$\overline{READY}$
D2	12	17	$\overline{INT}$
D1	13	16	M1
D0	14	15	M0
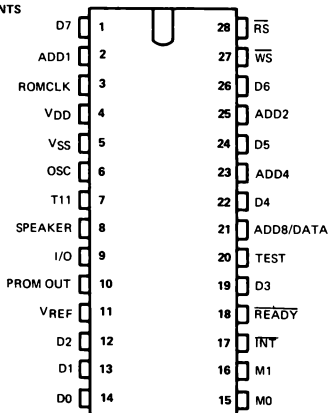
SUPPLEMENTS A

SYSTEM CLOCK
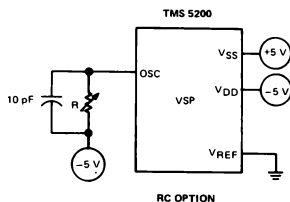
TMS 5200

RC OPTION

TYPICAL VALUES:

SAMPLE FREQUENCY	R
10 kHz	R = 80-100 kΩ
8 kHz	R = 120-200 kΩ

FIGURE A-1 — TMS 5200 OSCILLATOR OPTIONS

A.1 OSCILLATOR TRIMMING PROCEDURE

To avoid capacitive loading of the high impedance OSC input, the following procedure is recommended for setting the TMS 5220 clock frequency. Reference to Table A-1, Comparison of System Times (page 16), shows that an RC oscillator frequency of 640 kHz corresponds to a ROM clock rate of 160 kHz. This signal is buffered and not affected by measurement instrument capacities.

To set the RC oscillator frequency, connect a frequency counter to the ROM clock output of the TMS 5220 and trim the reading to 160 kHz. Use of 10 pF shunt capacitor is recommended to prevent circuit layout and environmental stray noise from affecting device operation.

RC OSCILLATOR
(TMS 5200)

CERAMIC RESONATOR
(TMS 5200 OPTION)

PHI-1

PHI-2 (ROMCLK)

PHI-3 (PHI-1 PRECHG)

PHI-4 (PHI-2 PRECHG)

← 6.25 µs →

BIT TIME

T1 T2 T3 T4 T5 T6 T7 T8 T9 T10 T11 T12 T13 T14 T15 T16 T17 T18 T19 T20

SAMPLE PERIOD

INTERPOLATION INTERVAL

IC0 IC1 IC2 IC3 IC4 IC5 IC6 IC7

FRAME PERIOD

SPEECH PHRASE

(VARIABLE # OF FRAMES)
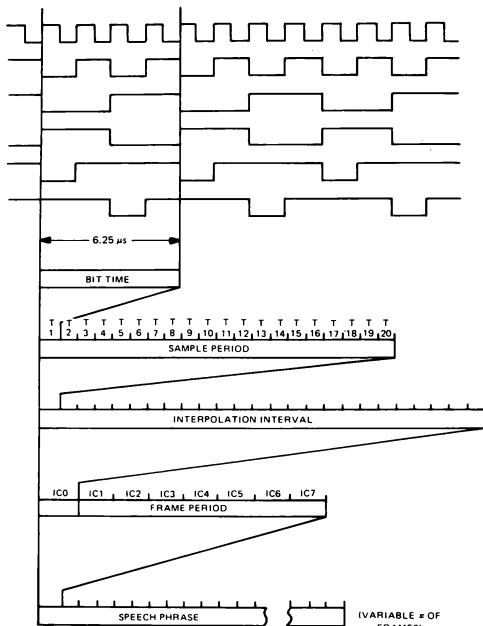
FIGURE A-2 – SYSTEM TIMING SUMMARY

SAMPLE RATE:	10 kHz	8 kHz
FRAME RATE	50 Hz	40 Hz
FRAME PERIOD	20 ms	25 ms
INTERPOLATION RATE	400 Hz	320 Hz
INTERPOLATION INTERVAL	2.5 ms	3.125 ms
SAMPLE RATE	10 kHz	8 kHz
SAMPLE PERIOD	100 μs	125 μs
ROM CLOCK RATE	200 kHz	160 kHz
ROM CLOCK PERIOD	5 μs	6.25 μs
RC OSC RATE	800 kHz	640 kHz
RC OSC PERIOD	1250 ns	1562.5 ns

NOTE: All timing references in this data manual are based on an 8-kHz sample rate.

TMS 5220 INTERNAL COMMAND EXECUTION

```
                    ┌──────────────┐
                   (    START       )
                    └──────┬───────┘
                           │
                           ▼
                   ┌───────────────┐
                   │   EXECUTE      │
                   │ POWER-UP CLEAR │
                   │   (RESET)      │
                   │   ROUTINE      │
                   └───────┬───────┘
                           │
   ┌──────────┐            │
  (   DONE     )◄──────────┤
   └──────────┘            │
                           ▼
                      ╱────────────╲
                     ╱  RS OR WS    ╲   N
                    ╱  ACTIVE (LOW)  ╲──────┘
                    ╲       ?        ╱
                     ╲──────┬───────╱
                            │ Y
                            ▼
                      ╱────────────╲
                     ╱   BOTH RS    ╲   Y      ┌──────────────┐
                    ╱  & WS ACTIVE   ╲────────►│   INVALID    │
                    ╲       ?        ╱         │  CONDITION   │
                     ╲──────┬───────╱          └──────────────┘
                            │ N
                            ▼
                   ┌───────────────┐
                   │  MAKE READY    │
                   │    ACTIVE      │
                   │    (LOW)       │
                   └───────┬───────┘
                           │
                           ▼
                      ╱─────────────╲
                     ╱               ╲
                    │     BRANCH      │
                     ╲               ╱
                      ╲─────────────╱
                           │
                    ┌──────┴──────┐
                    │             │
                    ▼             ▼
                 ╱ RS ╲        ╱ WS ╲
```
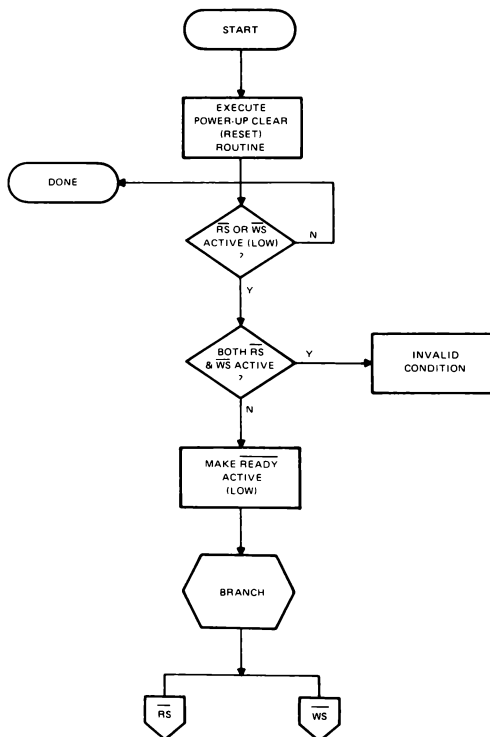
FIGURE B-1 — POWER ON
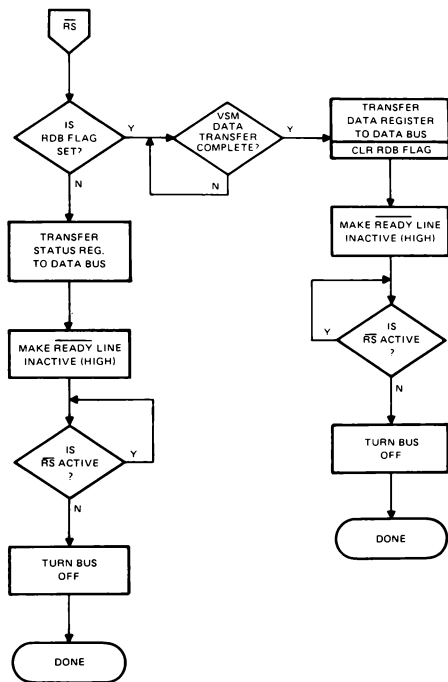
FIGURE B-2 — READ SELECT ACTIVE

66
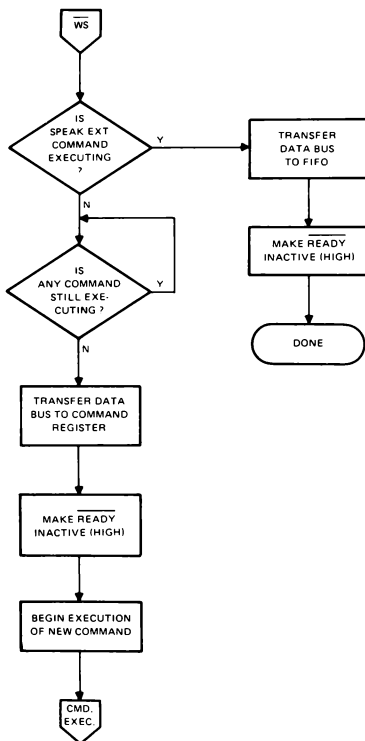
FIGURE B-3 — WRITE SELECT ACTIVE

67
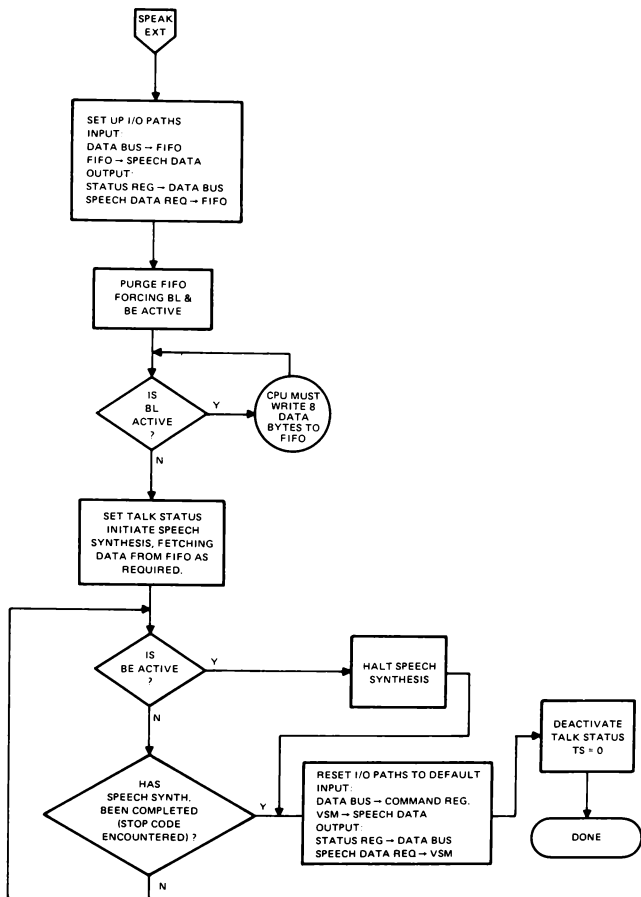
FIGURE B-4 — SPEAK EXTERNAL COMMAND

```
                    ┌─────────┐
                    │  RESET  │
                    └────┬────┘
                         │
                         ▼
                ┌─────────────────┐
                │  HALT SPEECH    │
                │  SYNTHESIS &    │
                │ CLEAR TALK STATUS│
                └────────┬────────┘
                         │
                         ▼
                ┌─────────────────┐
                │   PURGE FIFO    │
                └────────┬────────┘
                         │
                         ▼
        ┌─────────────────────────────┐
        │ RESET I/O PATHS TO DEFAULT   │
        │ INPUT:                       │
        │ DATA BUS → COMMAND REG.      │
        │ VSM SPEECH DATA              │
        │ OUTPUT:                      │
        │ STATUS REG → DATA BUS        │
        │ SPEECH DATA REQ → VSM        │
        └──────────────┬──────────────┘
                       │
                       ▼
        ┌─────────────────────────────┐
        │   EXECUTE A LOAD             │
        │   ADDRESS FUNCTION           │
        │   ON THE VSM                 │
        │   W/ARBITRARY DATA           │
        └──────────────┬──────────────┘
                       │
                       ▼
        ┌─────────────────────────────┐
        │   EXECUTE A DUMMY            │
        │   READ FUNCTION ON           │
        │   VSM                        │
        └──────────────┬──────────────┘
                       │          ╭──────────╮
                       └─────────▶│   DONE   │
                                  ╰──────────╯
```

FIGURE B-5 — RESET COMMAND

```
        ┌─────────┐
        │  SPEAK  │
        └────┬────┘
             │
             ▼
   ┌───────────────────┐
   │   SET TALK STATUS │
   │   INITIATE SPEECH │
   │  SYNTHESIS, FETCHING │
   │  DATA FROM THE VSM │
   │     AS REQUIRED   │
   └─────────┬─────────┘
             │
             ▼
        ╭─────────╮
        │  DONE   │
        ╰─────────╯
```

FIGURE B-6 — SPEAK

```
        ┌─────────┐
        │  READ   │
        │  AND    │
        │ BRANCH  │
        └────┬────┘
             │
             ▼
   ┌───────────────────┐
   │  INITIATE A VSM   │
   │ READ AND BRANCH   │
   │    FUNCTION       │
   └─────────┬─────────┘
             │
             ▼
   ┌───────────────────┐
   │      WAIT         │
   │      240          │
   │  MICROSECONDS     │
   └─────────┬─────────┘
             │
             ▼
        ╭─────────╮
        │  DONE   │
        ╰─────────╯
```

FIGURE B-7 — READ AND BRANCH

SUPPLEMENTS

SYSTEM TIMING DIAGRAMS

Write Cycle for Read and Branch, Load Address, Speak, Speak External and Reset Commands

timing requirements

PARAMETER		MIN	NOM	MAX	UNIT
t_{WSL-DV}	Delay time from $\overline{WS}$ low to data valid			7	µs
t_{RL-DX}	Delay time from $\overline{READY}$ low to data invalid	0			µs
t_{RH-WSH}	Delay time from $\overline{READY}$ high to $\overline{WS}$ high	6			µs
t_{wait}	Read-and-branch command wait time from $\overline{READY}$ high until next allowable* command			595	µs
t_{wait}	Load-address command wait time from $\overline{READY}$ high until next allowable* command			42	µs
t_{wait}	Speak command wait time from $\overline{READY}$ high until next allowable* command — Preceded by load-address command			287	µs
t_{wait}	Speak command wait time from $\overline{READY}$ high until next allowable* command — Not preceded by load-address command	56			µs
t_{wait}	Reset command wait time from $\overline{READY}$ high until next allowable* command			300	µs
t_{wait}	Speak external command wait time from $\overline{READY}$ high until next allowable* command			42	µs

switching characteristics

PARAMETER		MIN	NOM	MAX	UNIT
t_{WSL-RH}	Delay time from $\overline{WS}$ low to $\overline{READY}$ high			100	ns
$t_{w(R)}$	$\overline{READY}$ high pulse width	18		26	µs

All timing is based on a clock frequency of 8 kHz.
* If a new command is issued prior to the completion of the present command (before the end of t_{wait}), then the $\overline{READY}$ signal will go high and stay high until the present command is finished executing in the VSP.
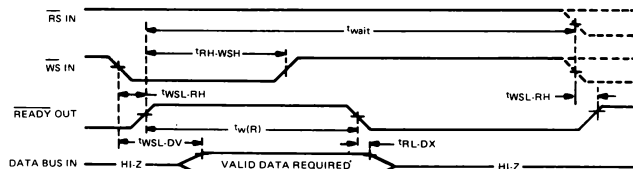
FIGURE C-1

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timing requirements

PARAMETER		MIN	NOM	MAX	UNIT
$t_{WSL\text{-}DV}$	Delay time from $\overline{WS}$ low to data valid			7	µs
$t_{RL\text{-}DX}$	Delay time from $\overline{READY}$ low to data invalid	0			µs
$t_{RH\text{-}WSH}$	Delay time from $\overline{READY}$ high to $\overline{WS}$ high	6			µs
t_{wait}	Wait time from $\overline{WS}$ high until next allowable* access	10			µs

switching characteristics

PARAMETER		MIN	TYP	MAX	UNIT
$t_{WSL\text{-}RH}$	Delay time from $\overline{WS}$ low to $\overline{READY}$ high			100	ns
$t_{w(R)}$	$\overline{READY}$ high pulse width			23	µs

All timing is based on a clock frequency of 8 kHz.

* If a new command is issued to the VSP prior to the completion of the present command then the $\overline{READY}$ command will go high (as usual and remain high until the completion of the present command as defined by t_{wait} above.
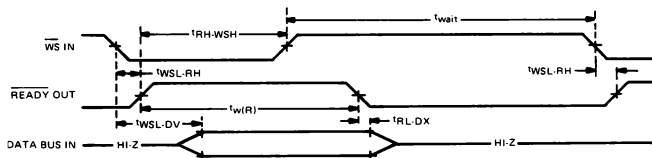
FIGURE C-2

72

timing requirements

PARAMETER		MIN	NOM	MAX	UNIT
t_{RH-RSH}	Delay time from $\overline{READY}$ high to $\overline{RS}$ high		6		μs
t_{wait}	Wait time from $\overline{RS}$ high to next allowable* command		12		μs

switching characteristics

PARAMETER		MIN	TYP	MAX	UNIT
t_{RSL-RH}	Delay time from $\overline{RS}$ low to $\overline{READY}$ high			100	ns
t_{RH-DV}	Delay time from $\overline{READY}$ high to data valid (stable)	6		11	μs
t_{RSL-DX}	Delay time from $\overline{RS}$ low to data bus driven (output unstable)		$t_{RH-DV}-2$		μs
t_{RSH-DZ}	Delay time from $\overline{RS}$ high to data output disabled			10.5	μs

* If a new command is issued to the VSP prior to the completion of the present command, then after the $\overline{READY}$ signal goes high, in its normal response time, it will remain high until the present command has been fully executed by the VSP.
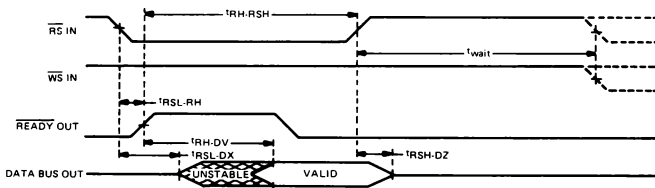
FIGURE C-3

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READ BYTE SEQUENCE

timing requirements

PARAMETER		MIN	NOM	MAX	UNIT
tWSL-DV	Delay time from $\overline{WS}$ low to data valid			7	µs
tRH-WSH	Delay time from $\overline{READY}$ high to $\overline{WS}$ high	6			µs
tWSH-DX	Delay time from $\overline{WS}$ high to data invalid	0			µs
tRH-RSH	Delay time from $\overline{READY}$ high to $\overline{RS}$ high	8			µs
tWSH-RSL	Delay time from $\overline{WS}$ high to $\overline{RS}$ low	12			µs

switching characteristics

PARAMETER			MIN	TYP	MAX	UNIT
tWSL-RH	Delay time from $\overline{WS}$ low to $\overline{READY}$ high				100	ns
tRSL-RH	Delay time from $\overline{RS}$ low to $\overline{READY}$ high				100	ns
tw(R)	$\overline{READY}$ high pulse width (write)				26	µs
tRL-RL	Delay time from $\overline{READY}$ low (write) to $\overline{READY}$ low (read)	No previous load address			320	µs
		Previous load address			440	
tRSH-DZ	Delay time from $\overline{RS}$ high to data output disabled		4		9	µs

FIGURE C-4

74
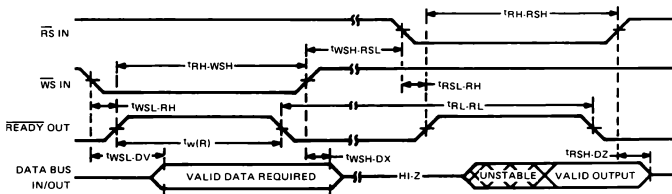
RMS	PITCH	K(1)	K(2)	K(3)	K(4)	K(5)	K(6)	K(7)	K(8)	K(9)	K(10)
0	0	−0.97850	−0.64000	−0.86000	−0.64000	−0.64000	−0.50000	−0.60000	−0.50000	−0.50000	−0.40000
52	15	−0.97270	−0.58999	−0.75467	−0.53145	−0.54933	−0.41333	−0.50667	−0.31429	−0.34286	−0.25714
87	16	−0.97070	−0.53500	−0.64933	−0.42289	−0.45867	−0.32667	−0.41333	−0.12857	−0.18571	−0.11429
123	17	−0.96680	−0.47507	−0.54400	−0.31434	−0.36800	−0.24000	−0.32000	0.05714	−0.02857	0.02857
174	18	−0.96290	−0.41039	−0.43867	−0.20579	−0.27733	−0.15333	−0.22667	0.24286	0.12857	0.17143
246	19	−0.95900	−0.34129	−0.33333	−0.09723	−0.18667	−0.06667	−0.13333	0.42857	0.28571	0.31429
348	20	−0.95310	−0.26830	−0.22800	0.01132	−0.09600	0.02000	−0.04000	0.61429	0.44286	0.45714
491	21	−0.94140	−0.19209	−0.12267	0.11987	−0.00533	0.10667	0.05333	0.80000	0.60000	0.60000
694	22	−0.93360	−0.11350	−0.01733	0.22843	0.08533	0.19333	0.14667			
981	23	−0.92580	−0.03345	0.08800	0.33698	0.17600	0.28000	0.24000			
1385	24	−0.91600	0.04702	0.19333	0.44553	0.26667	0.36667	0.33333			
1957	25	−0.90620	0.12690	0.29867	0.55409	0.35733	0.45333	0.42667			
2764	26	−0.89650	0.20515	0.40400	0.66264	0.44800	0.54000	0.52000			
3904	27	−0.88280	0.28087	0.50933	0.77119	0.53867	0.62667	0.61333			
5514	28	−0.86910	0.35325	0.61467	0.87975	0.62933	0.71333	0.70667			
7789	29	−0.85350	0.42163	0.72000	0.98830	0.72000	0.80000	0.80000			
	30	−0.80420	0.48553								
	31	−0.74058	0.54464								
	32	−0.66019	0.59878								
	33	−0.56116	0.64796								
	34	−0.44296	0.69227								
	35	−0.30706	0.73190								
	36	−0.15735	0.76714								
	37	−0.00005	0.79828								
	38	0.15725	0.82567								
	39	0.30696	0.84965								
	40	0.44288	0.87057								
	41	0.56109	0.88875								
	42	0.66013	0.90451								
	44	0.74054	0.91813								
	46	0.80416	0.92988								
	48	0.85350	0.98830								
	50										
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	153										
	159										

5. SPEECH VOCABULARY LIBRARY

The SSB-MPF-IB or SSB-MPF-IP is shipped to you with a built-in (standard) vocabulary. Multitech provides another 56 optional 2732 EPROMs whose storage capacity is 4K. Each EPROM contains a file of words. The vocabulary contained in these optional EPROMs is listed as follows:

Vocabulary List FOR OPTIONAL EPROMS

FILE NAME : SSB-E1

ADDRESS	WORD	ADDRESS	WORD
000	A	751	ACE
074	ABLE	7CC	ACKNOWLEDGE
12C	ABORT	8A7	ACTION
1BC	ABOUT	965	ADD
242	ABOVE	9E3	ADDER
2CF	ABSOLUTE	A86	ADDRESS
3AE	ACCELERATED	B33	ADJUST
4C4	ACCEPT	BD2	ADVISE
559	ACCESS	CA2	AERIAL
604	ACCESSING	D67	AFFIRMATIVE
6B4	ACCOUNT	E3:	AFTER
		EE7	AGE

FILE NAME : SSB-E2

ADDRESS	WORD	ADDRESS	WORD
000	AGAIN	680	ALMOST
0B3	AGAINST	76F	ALPHA
159	AIM	7FC	ALPHANUMERIC
1CD	AIR	930	ALREADY
24D	AIRCRAFT	9F2	ALSO
307	AIRPORT	A89	ALTERNATE
3D5	AIRSPEED	B41	ALTHOUGH
4B2	ALARM	BF7	ALTIMETER
562	ALERT	CDC	ALTITUDE
5F3	ALL	DB4	ALWAYS
		E74	AM

FILE NAME : SSB-E3

ADDRESS	WORD	ADDRESS	WORD
000	AMERICAN	7B4	ANSWERED
0EE	AMONG	88C	ANY
18B	AMOUNT	90A	ANYWAY
224	AMPS	9E8	APPLE
2A0	AN	A77	APPROACH
31A	ANALOG	B0F	APPROVE
3F5	ANALYZER	BC0	APRIL
4E3	AND	C4B	ARE
567	ANIMAL	CD5	AREA
63F	ANOTHER	D85	AROUND
704	ANSWER	E67	ARRIVAL

FILE NAME : SSB-E4

ADDRESS	WORD	ADDRESS	WORD
000	ARRIVE	6F0	AUTO
0CB	ARROW	799	AUTOMATIC
15B	AS	8A0	AUTOPILOT
1FF	ASK	9D8	AVAILABLE
267	ASSUME	AFC	AWAY
322	ASTONISHED	BD4	AXLE
40B	ASTRONAUT	CA9	BACK
502	AT	D21	BAD
583	ATTENTION	DE1	BALANCE
668	AUNT	EBD	BALL

FILE NAME : SSB-E5

ADDRESS	WORD	ADDRESS	WORD
000	BAND	733	BECAUSE
0B3	BANG	813	BECOME
163	BANK	8E1	BED
1E6	BASE	98C	BEEN
279	BATTERY	A2C	BEFORE
36B	BAUD	B03	BEGIN
418	BE	BCB	BEHIND
4A8	BEAMS	CD6	BEING
597	BEAR	D9B	BELOW
635	BEAUTIFUL	E57	BELT
		EE0	BENCH

FILE NAME : SSB-E6

ADDRESS	WORD	ADDRESS	WORD
000	BESIDE	902	BLOW
0F6	BEST	9B2	BLUE
189	BETTER	A32	BONUS
203	BETWEEN	AE0	BOOK
2D6	BIDIRECTIONAL	B34	BOOLEAN
447	BIG	BE4	BOOTH
4C8	BINARY	C50	BOTH
5A6	BIPOLAR	CD7	BOTTOM
68D	BIRTH	D8C	BOUND
71D	BIRTHDAY	E3F	BOY
7E7	BIT	ECF	BRAKE
873	BLACK	F3D	BRAKES

FILE NAME : SSB-E7

ADDRESS	WORD	ADDRESS	WORD
000	BRAVO	706	BUSINESS
0B1	BREAK	7EF	BUSY
11D	BRIGHT	897	BUT
1C1	BRIGHTNESS	8EF	BUTTON
2B5	BRING	99F	BUY
339	BROKEN	A31	BY
3F3	BROTHER	AB8	BYE
4C0	BUFFER	B4B	BYTE
567	BUILDING	BD7	CABIN
659	BULLET	CD7	CALIBRATE
		DE4	CALIFORNIA

FILE NAME : SSB-E8

ADDRESS	WORD	ADDRESS	WORD
000	CALL	7B0	CARD
0D4	CALLING	85D	CARRY
1CA	CALM	92A	CASSETTE
285	CAN	9CA	CAUGHT
34C	CAN'T	A76	CAUTION
420	CANCEL	B61	CEILING
516	CANNOT	C58	CELSIUS
5D5	CAPACITANCE	D4F	CENT
706	CAR	DD3	CENTER

FILE NAME : SSB-E9

ADDRESS	WORD	ADDRESS	WORD
000	CENTIGRADE	7BE	CHILDREN
13E	CHAIN	8B5	CHIME
1ED	CHANGE	96A	CHIP
2EB	CHANNEL	9E4	CHOICE
3E2	CHARLIE	A76	CHRISTMAS
4CA	CHECK	B53	CHURCH
555	CHECKSUM	BD7	CIRCUIT
62C	CHICKEN	CB3	CITY
6DD	CHILD	D7A	CLEAN
		E2C	CLEARANCE

FILE NAME : SSB-E10

ADDRESS	WORD	ADDRESS	WORD
000	CLIMB	6C8	COLOR
0B8	CLOCK	793	COME.
130	CLOSE	82B	COMES
20D	CLUB	8F7	COMMA
2B2	COAXIAL	9BB	COMMAND
3DE	CODE	AB0	COMMANDER
476	COLD	BA8	COMMON
543	COLLECT	C72	COMPANY
5EC	COLON	D4A	COMPILER
		E64	COMPLEMENT

FILE NAME : SSB-E11

ADDRESS	WORD	ADDRESS	WORD
000	COMPLETE	87F	CONTACT
0C8	COMPUTER	96D	CONTRACT
1B3	CONE	A6C	CONTROL
297	CONFERENCE	B7D	CONVERGING
3C4	CONGRATULATIONS	CC7	COOKING
58C	CONNECT	D6B	COPY
640	CONNECTED	DFF	CORE
765	CONSOLE	E93	CORRECT
		F38	COST

FILE NAME : SSB-E12

ADDRESS	WORD	ADDRESS	WORD
000	COURSE	767	CURRENT
08D	COWL	859	CURSOR
148	CRANE	934	CYAN
1FA	CRASH	A02	CYCLE
290	CRAZY	AAA	CYLINDER
380	CREASE	BA1	D
414	CREST	C0C	DAISY
4A6	CROSS	CAA	DANGER
568	CROWN	D70	DATA
620	CRYSTAL	E1A	DATE
6FE	CUP	E8A	DAUGHTER

FILE NAME : SSB-E13

ADDRESS	WORD	ADDRESS	WORD
000	DAY	768	DEGREE
085	DAYS	81C	DEGREES
126	DEAD	911	DELETE
1C9	DECEMBER	9CC	DELIVERY
2EB	DECIDE	AE4	DELTA
3E1	DECIMAL	BA7	DENSITY
4D6	DECREASE	C76	DEPARTURE
59C	DECREASING	D80	DEPOSIT
6AD	DEFECTS	E8C	DESTROY

FILE NAME : SSB-E14

ADDRESS	WORD	ADDRESS	WORD
000	DESTROYED	731	DINNER
0F9	DETECTOR	7C8	DIRECT
1F2	DETERGENT	85D	DIRECTION
317	DEVICE	942	DIRECTORY
3DF	DID	A39	DISK
463	DIE	AB2	DISKETTE
4F6	DIFFERENT	B59	DISPENSER
5A4	DIFFICULT	C3B	DISPLAY
661	DIGITAL	D04	DIVE
		DCF	DIVIDED

FILE NAME : SSB-E15

ADDRESS	WORD	ADDRESS	WORD
000	DIVISION	7B5	DOWNWIND
101	DO	89E	DRAGON
17F	DOCTOR	95A	DRAIN
240	DOG	A0A	DRAW
2DA	DOING	A9A	DRAWING
38A	DOLLAR	B63	DRINK
449	DOLLARS	BCC	DRIVE
52E	DONE	C7F	DRIVER
5C5	DOOR	D45	DRUM
665	DOUBLE	DD5	DUMP
712	DOWN	E3B	DUPLEX
		EDF	DUPLICATE

FILE NAME : SSB-E16

ADDRESS	WORD	ADDRESS	WORD
000	DURING	6DD	EIGHTH
0A1	DUST	73E	EIGHTY
12A	DYNAMIC	7D2	EITHER
216	EACH	892	ELAPSED
289	EARLY	975	ELECTRICIAN
348	EAST	A84	ELEVATE
3B8	EASY	B4F	ELEVATION
465	EAT	C6C	ELEVEN
4B8	EDITOR	D5D	ELSE
594	EIGHT	DD2	EMERGENCY
604	EIGHTEEN	EE3	EMPTY

FILE NAME : SSB-E17

ADDRESS	WORD	ADDRESS	WORD
000	END	69A	ERASED
097	ENDS	750	ERROR
144	ENEMY	81B	ESTIMATED
1F6	ENGINE	920	EVACUATION
2D5	ENOUGH	A65	EVACUATE
371	ENTER	B6B	EVEN
429	ENTRY	C0B	EVENING
4DC	EQUALS	CF6	EVENT
5C8	EQUIPMENT	D9D	EVER
		E51	EVERY

FILE NAME : SSB-E18

ADDRESS	WORD	ADDRESS	WORD
000	EVERYTHING	7E6	EXPERIMENTAL
10B	EXACTLY	907	EXPLOSION
222	EXCEEDED	A17	EXPRESS
322	EXCELLENT	AC2	EXTENSION
3EB	EXCITED	BB6	EXTERNAL
4EB	EXCLAIM	C97	EYE
5D6	EXECUTE	D27	F
697	EXIT	D89	FAHRENHEIT
746	EXPECT	E8B	FAIL

FILE NAME : SSB-E19

ADDRESS	WORD	ADDRESS	WORD
000	FAILED	72C	FATHRE
0CE	FAILING	80D	FATHOMS
1B9	FAILURE	905	FEBRUARY
2AB	FALSE	9FA	FEED
345	FAMILY	A91	FEEL
426	FAR	B40	FEET
4D2	FARAD	BA8	FIFTEEN
59C	FAST	CA5	FIFTH
62B	FASTEN	D2A	FIFTY
607	FAT	DE0	FILE
		EB1	FILL

FILE NAME : SSB-E20

ADDRESS	WORD	ADDRESS	WORD
000	FINAL	732	FLAG
0E1	FINALLY	7DD	FLAME
1C8	FIND	88A	FLASHER
275	FINISH	94B	FLIER
30F	FIRE	A19	FLIGHT
3C1	FIRES	A9B	FLOW
497	FIRM	B2D	FLUID
53F	FIRST	BF3	FOCUS
5C4	FIT	CA8	FOG
61D	FIVE	D42	FOLLOW
6CF	FIXED	E1C	FOOD
		EBA	FOR

FILE NAME : SSB-E21

ADDRESS	WORD	ADDRESS	WORD
000	FORMAT	7DF	FRIEND
0CB	FORTY	89C	FRIENDLY
173	FORWARD	9BD	FROM
25A	FOUR	A80	FRONT
2E6	FOURTEEN	B02	FUEL
3E8	FOURTH	BC6	FULL
485	FREE	C62	FUSE
516	FREEZING	D36	G
639	FREQUENT	DA8	GAGE
6E6	FREQUENTLY	E44	GAUGE
		EE7	GAIN

FILE NAME : SSB-E22

ADDRESS	WORD	ADDRESS	WORD
000	GALAXY	732	GLAD
0BC	GALLON	7D9	GLIDE
178	GAME	893	GLOW
21B	GAS	934	GO
2A2	GATE	9C2	GOES
30E	GEAR	A82	GOING
3A8	GEGA	B2E	GOLD
43C	GET	BDF	GOLF
493	GETTING	C57	GOOD
53D	GIRL	CE5	GOT
5E7	GIVE	D4C	GRAIN
688	GIVES	DFD	GRAM
		EAA	GRAMMAR

FILE NAME : SSB-E23

ADDRESS	WORD	ADDRESS	WORD
000	GREAT	7A1	HAD
067	GREEN	845	HALE
11A	GREETINGS	8F9	HALF
201	GREY	970	HALT
28E	GRODY	9EF	HAND
361	GROSS	AA6	HANG
3E9	GROUND	B4A	HAPPEN
4B5	GUESS	BFE	HARD
538	GUILT	CBC	HARDLY
5BB	GUN	DCF	HAS
64B	GUNSHOT	E90	HAT
742	H	EF6	HAVE

FILE NAME : SSB-E24

ADDRESS	WORD	ADDRESS	WORD
000	HAZARDOUS	79B	HEXADECIMAL
0F9	HE	86D	HIGH
16B	HEAD	905	HIGHER
213	HEAR	9BC	HIM
29C	HEAT	A69	HIS
308	HEIGHT	B0A	HIT
37F	HELD	B61	HITTING
430	HELLO	C09	HOLD
4F0	HELP	CB7	HOME
569	HENRY	D55	HONEST
626	HER	E0D	HONOR
6A2	HERE	EBF	HOOD
723	HERTZ	F2C	HOOK

FILE NAME : SSB-E25

ADDRESS	WORD	ADDRESS	WORD
000	HOPE	6EA	HUNT
07D	HORIZONTAL	772	HUNTER
195	HOT	826	HURRY
20B	HOUR	8AE	I
2B4	HOURS	935	ICE
366	HOUSE	9A6	ICING
3E3	HOW	A69	IDENTIFICATION
47F	HOWEVER	BA6	IDENTIFY
544	HUNDRED	C89	IGNITE
637	HUNGRY	D5E	IMMEDIATE
		E4B	IMMEDIATELY

FILE NAME : SSB-E26

ADDRESS	WORD	ADDRESS	WORD
000	IN	6FB	INFLIGHT
08D	INBOUND	7D3	INFORMATION
1B0	INCHES	92D	INHABITANT
28E	INCREASE	A51	INNER
34E	INCREASING	B04	INNKEEPER
429	INDEXED	BFC	INSERT
516	INDICATED	CBB	INSPECT
613	INDIRECT	D8E	INSPECTOR
		E86	INSTRUCTION

FILE NAME : SSB-E27

ADDRESS	WORD	ADDRESS	WORD
000	INSTRUMENT	8C5	JETS
111	INTEGRATED	93D	JOB
21B	INTERESTING	9DE	JOURNEY
34F	INTERVAL	A9B	JOY
461	INTRUDER	B2C	JULIET
558	INVALID	C06	JULY
677	IS	CB6	JUMP
704	IT	D2A	JUNE
75B	J	DD7	JUNK
7D6	JANUARY	E40	JUST
		ECF	K

FILE NAME : SSB-E28

ADDRESS	WORD	ADDRESS	WORD
000	KEEP	644	KNOWN
061	KEY	709	KONG
0D1	KEYBOARD	7A2	L
19A	KILL	839	LABRATORY
236	KILO	953	LADY
301	KIND	A18	LAKE
3BE	KNAPSACK	AA5	LAND
48F	KNOCK	B71	LANDING
508	KNOTS	C62	LARGE
598	KNOW	D1E	LARGER
		E01	LARGEST

FILE NAME : SSB-E29

ADDRESS	WORD	ADDRESS	WORD
000	LASER	72D	LEFT
0D9	LAST	7D4	LENT
185	LATE	854	LESS
200	LAUGH	8DB	LESSON
29D	LAUNCH	9AA	LETTER
32C	LAY	A6B	LEVEL
3CC	LAZY	B34	LIAR
47F	LEADER	BE7	LICENSE
542	LEAN	CC7	LIE
5DB	LEARN	D73	LIGHT
67B	LEAVE	E12	LIKE
		E96	LIMIT

FILE NAME : SSB-E30

ADDRESS	WORD	ADDRRESS	WORD
000	LINE	83C	LONG
0C3	LIST	8E8	LOOK
16F	LISTEN	976	LOOP
22C	LITTLE	9FB	LOSE
2F1	LIVE	ACD	LOSS
3B6	LIVE	B66	LOST
485	LOAD	C06	LOUD
53B	LOCALIZER	CCF	LOVE
680	LOCATED	D88	LOW
77B	LOGIC	E3E	LUCK
		EB5	LUCKY

FILE NAME : SSB-E31

ADDRESS	WORD	ADDRESS	WORD
000	M	890	MARCH
084	MACHINE	918	MARGIN
157	MACRO	9F8	MARK
251	MADE	A7C	MARKER
2F4	MAGNETS	B13	MATTER
403	MAINTAIN	BC4	MAX
520	MAKE	C42	MAY
59E	MAN	CD5	MAYBE
64A	MANUAL	D85	MAYDAY
758	MANY	E4E	ME
811	MAP	ED5	MEAN

FILE NAME : SSB-E32

ADDRESS	WORD	ADDRESS	WORD
000	MEASURE	6BA	METROPOLIS
0C3	MEGA	7A2	MICRO
176	MEMORY	84F	MICROPROCESSOR
24E	MENTION	981	MICROPROFESSOR
321	MENU	AA7	MIDDLE
3F9	MERCHANT	B40	MIDPOINT
4BD	MERRY	C2E	MIKE
569	MESSAGE	CA3	MILEPOST
607	METER	DBF	MILLION
		EB0	MINUTE

FILE NAME : SSB-E33

ADDRESS	WORD	ADDRESS	WORD
000	MINUTES	843	MOTHER
0B1	MISS	90E	MOVE
11F	MIST	9D7	MOVING
1A8	MIXTURE	AA9	MR.
270	MOBILE	B5B	MRS.
37E	MODERATE	C17	MS.
455	MODULE	CD6	MUCH
557	MONITOR	D48	MUST
642	MONKEY	DCD	MY
6EB	MOREX	E66	N
77E	MORNING	EE6	NAME

FILE NAME : SSB-E34

ADDRESS	WORD	ADDRESS	WORD
000	NANO	755	NICE
0D8	NATURALLY	7CE	NIGHT
1D8	NEAR	84A	NINE
27B	NEED	8FC	NINER
31B	NEGATIVES	9D4	NINETEEN
3F3	NEUTRAL	AF6	NINETY
4B9	NEVER	BAA	NO
57C	NEW	C43	NOISE
609	NEWSPAPER	D1B	NOISY
6CD	NEXT	DDD	NOON
		E8F	NORMAL

FILE NAME : SSB-E35

ADDRESS	WORD	ADDRESS	WORD
000	NORTH	823	NOW
089	NORTHEAST	8D5	NUMBER
169	NORTHWEST	99F	O
256	NOT	A26	OCTOBER
2E0	NOTEBOOK	B28	OF
3A8	NOTHING	BBF	OFF
477	NOTIFY	C29	OFTEN
586	NOVA	CCF	OH
64B	NOVEL	D49	OIL
724	NOVEMBER	DFB	OK
		E97	OLD

FILE NAME : SSB-E36

ADDRESS	WORD	ADDRESS	WORD
000	ON	7CC	OUT
0A0	ONCE	845	OUTER
128	ONE	8E0	OVER
1AF	ONLY	990	OVERSPEED
27C	OPEN	AB7	OWE
31F	OPERATING	B2B	P
420	OR	B7A	PAC
4A7	ORDER	BDD	PAGE
569	OTHER	C85	PAIN
635	OUGHT	D20	PAPA
6A1	OUNCE	DB3	PAPER
735	OUR	E41	PARENTS
		EFB	PARK

FILE NAME : SSB-E37

ADDRESS	WORD	ADDRESS	WORD
000	PART	6CC	PER
071	PARTIALLY	73C	PERCENT
137	PARTS	7DF	PERIOD
1BA	PARTY	8C0	PERIPHERAL
24C	PASS	9B5	PERMITTED
2DB	PAST	AA6	PERSONAL
362	PATH	B7C	PHASER
3ED	PAUSE	C22	PHONE
4AE	PAY	CC5	PHYSICS
533	PEACE	D75	PICK
5A1	PELLETS	DC5	PICO
647	PEN	E4F	PIECE
		EBC	PLACE

FILE NAME : SSB-E38

ADDRESS	WORD	ADDRESS	WORD
000	PLAN	63B	POLLING
0AB	PLAY	6EF	POOR
141	PLAYER	76E	POPULARITY
1E4	PLAYS	88A	POSITION
2A0	PLEASANT	96B	POSITIVE
345	PLEASE	A52	POSSIBLE
402	PLOTTER	B36	POSTAGE
4BA	PLUS	C12	POUND
536	POCKET	CC4	POUNDS
5C3	POINT	D88	POWER
		E32	PRECISION

FILE NAME : SSB-E39

ADDRESS	WORD	ADDRESS	WORD
000	PREFER	847	PROCEEDING
0BF	PREMISES	958	PROGRAM
1A8	PRESS	A39	PROGRAMMED
217	PRESSURE	B40	PROMISE
2B0	PRICE	BE9	PROPS
334	PRINT	C54	PULL
398	PRINTER	CD5	PUMPS
430	PRIORITY	D43	PURCHASE
511	PRISON	DF0	PUSH
5BC	PRISONER	E52	PUT
685	PROBABLY	E99	PUTTING
76B	PROBLEM	F2B	Q

FILE NAME : SSB-E40

ADDRESS	WORD	ADDRESS	WORD
000	QUESTION	7F1	RAISE
0B7	R	8AF	RANDDMLY
144	RABBIT	9B9	RANGE
1D9	RADAR	A75	RAPID
292	RADIAL	B25	RATE
37A	RADIATOR	BAD	REACHED
478	RADIO	C3A	READ
560	RADIUS	CC8	READ
624	RAILROAD	D5D	READY
74B	RAIN	DF0	REALLY
		E99	REAR

FILE NAME : SSB-E41

ADDRESS	WORD	ADDRESS	WORD
000	RECEIVE	774	REMARK
0DA	RECORDER	815	REMENBER
1D2	RED	919	REPAIR
26C	REENTER	9E6	REPEAT
35D	REFER	A3A	REPLY
438	REFERRAL	B6F	REPORTED
526	REJECT	C55	RESISTANCE
5D6	RELEASE	D5C	RESISTOR
690	REMAIN	E73	RESPONSE

FILE NAME : SSB-E42

ADDRESS	WORD	ADDRESS	WORD
000	RETURN	80C	ROGER
0E8	REVERSED	8CA	ROMEO
1D2	REVOLT	995	ROOM
299	REWIND	A3B	ROUND
39E	RICH	AFD	ROUTE
419	RIDE	B81	RUN
4D0	RIGHT	C14	RUNWAY
54D	RINSE	CF8	S
5D4	RISE	D58	SAFE
68E	RISING	DD6	SAME
76D	ROAST	E7C	SAND

93

FILE NAME : SSB-E43

ADDRESS	WORD	ADDRESS	WORD·
000	SAVE	76B	SELL
0BC	SAY	7FA	SEND
15F	SCATTERED	890	SENT
22A	SCHOOL	903	SEPTEMBER
2DA	SCORE	9F3	SEQUENCE
388	SCREEN	AA9	SERVICE
447	SEARCH	B5D	SET
4C3	SEAT	BB5	SEVEN
534	SECONDS	C68	SEVENTEEN
5F6	SEE	D5E	SEVENTY
683	SELECTION	E2C	SHAPE
		EAA	SHE

FILE NAME : SSB-E44

ADDRESS	WORD	ADDRESS	WORD
000	SHIELDS	6F5	SICK
0B8	SHIFT	759	SIDE
12C	SHIH	80A	SIDES
1AE	SHIP	8F1	SILICON
218	SHOOT	9DF	SILVER
29D	SHORE	A97	SINCE
340	SHORT	B1B	SING
3C0	SHORTER	B9E	SINGLE
479	SHOT	C62	SISTER
4F6	SHOW	D1D	SIT
58D	SHOWERS	D87	SIX
684	SHUT	DF0	SIXTEEN
		ED0	SIXTY

FILE NAME : SSB-E45

ADDRESS	WORD	ADDRESS	WORD
000	SKILL	759	SOME
0C3	SLEEP	7EB	SOMETHING
15F	SLEET	8BE	SON
1EC	SLOPE	952	SOON
288	SLOW	9F6	SORRY
352	SMALL	AAC	SORT
403	SMALLER	B29	SOUND
4DB	SMOKE	BDD	SOUTH
561	SNOW	C6B	SOUTHEAST
611	SO	D46	SOUTHWEST
6A7	SOCKET	E35	SPACE
		EC0	SPACES

94

FILE NAME : SSB-E46

ADDRESS	WORD	ADDRESS	WORD
000	SPEAK	7F7	STALL
081	SPEED	8B8	STAMP
12A	SPELL	94A	STAN
1D2	SPITE	9FB	STAND
25D	SPOON	ABF	STAR
30D	SPRAY	B70	START
3C8	SQUADRON	BFD	STATE
4C5	SQUAK	C90	STATIC
561	SQUARE	D4F	STATUS
61F	STABILIZER	E12	STAY
777	STACK	EB3	STEP
		F2C	STICK

FILE NAME : SSB-E47

ADDRESS	WORD	ADDRESS	WORD
000	STILL	74D	STRICT
0A2	STOCK	7D2	STUDENT
118	STOLEN	88E	STUDY
20B	STONE	939	STUPID
2B4	STOP	9EE	SUBJECT
329	STOPPED	ACC	SUBSTANCE
3C9	STORE	BBF	SUCCEED
46D	STORED	C86	SUCCESSFUL
528	STORM	D7F	SUCH
5F1	STRANGE	DE9	SUM
6C6	STREET	E73	SUMMER

FILE NAME : SSB-E48

ADDRESS	WORD	ADDRESS	WORD
000	SUNNYVALE	827	SYSTEMS
0FE	SUPER	910	T
1A0	SUPERIOR	992	TAB
2CC	SUPPLY	A43	TABLE
3B0	SUPPOSED	B16	TAILOR
4AD	SURRENDER	BD7	TAIPEI
5A7	SUSPECT	CA6	TAIWAN
655	SWEEP	D92	TAKE
6D7	SWITCH	DFE	TANGO
765	SYSTEM	EB9	TANK
		F24	TAPE

FILE NAME : SSB-E49

ADDRESS	WORD	ADDRESS	WORD
000	TAXI	880	THAN
09D	TEACHER	90D	THANK
13C	TEEN	977	THAT
1D4	TELECREDIT	A00	THE
2C8	TELEPHONE	A78	THEATER
3A6	TELEVISION	B2B	THEIR
494	TELL	BD1	THEN
51F	TEMPERATURE	C65	THERE
62B	TEN	CFF	THEREFORE
6A7	TEST	DDA	THEY
727	TESTING	E6A	THIEF
7E2	TEXAS	ECC	THIN
		F3A	THING

FILE NAME : SSB-E50

ADDRESS	WORD	ADDRESS	WORD
000	THINGS	779	TO
08B	THINK	7F1	TODAY
0E0	THINLY	8A9	TOGETHER
189	THIRD	972	TOLL
217	THIRTY	A1A	TOMORROW
2A7	THIS	AF0	TONE
313	THOUSAND	B8F	TOO
3F3	THREE	BFF	TOP
477	THREW	C6B	TOUCH
50A	THROUGH	CCD	TOUCHDOWN
594	TICKET	D95	TOWER
613	TIME	E41	TRACK
6C4	TIMER	EAE	TRAFFIC

FILE NAME : SSB-E51

ADDRESS	WORD	ADDRESS	WORD
000	TRAIN	894	TRIGGER
0A8	TRANSACTION	934	TRIM
1C9	TRANSFERRED	9CD	TROUBLE
2C9	TRANSLATE	A85	TRY
3BE	TRANSMISSION	B2A	TURBULANCE
4D5	TRAVEL	C30	TURN
5A6	TRAVELER	CD7	TWELVE
698	TRAVELING	D98	TWENTIETH
7A6	TREAT	E7A	TWENTY
80A	TREF	F18	TWICE

FILE NAME : SSB-E52

ADDRESS	WORD	ADDRESS	WORD
000	TWO	789	UNQUOTE
088	TYPE	86A	UNTIL
0FE	U	94E	UP
197	UNAUTHORIZED	9A1	UPPER
2F6	UNCLE	A32	USE
3A4	UNDER	AFB	USER
463	UNDERRCARRIAGE	BE2	V
59C	UNDERSTAND	C7B	VACUUM
6D8	UNIT	D51	VALID
		E25	VALLEY

FILE NAME : SSB-E53

ADDRESS	WORD	ADDRESS	WORD
000	VALUE	959	VOLT
0E4	VARIABLE	9F0	VOLTAGE
214	VECTORS	AC4	W
31D	VERIFY	B71	WAIT
40B	VERTICAL	BED	WAKE
505	VERY	C65	WALL
5D0	VICTOR	D00	WAND
6A3	VIDEO	DBA	WANT
787	VISIBILITY	E43	WAR
8B2	VISIT	EE9	WARM

FILE NAME : SSB-E54

ADDRESS	WORD	ADDRESS	WORD
000	WARNING	79B	WELL
0D2	WAS	847	WERE
18D	WASH	8F9	WEST
216	WATCH	988	WHAT
29C	WATER	9F7	WHEEL
36A	WATT	AA2	WHENEVER
3E9	WATTS	B96	WHERE
46B	WAY	C40	WHICH
504	WE	CA9	WHILE
59D	WEAPON	D62	WHISKEY
652	WEATHER	E0A	WHISTLE
721	WEEK	EB7	WHITE

FILE NAME : SSB-E55

ADDRESS	WORD	ADDRESS	WORD
000	WHOEVER	817	WITHOUT
0A8	WHY	8B7	WON
145	WIFE	944	WORD
1D3	WILL	9F0	WORK
273	WIN	A61	WORKING
300	WIND	B07	WORKMAN
3B6	WINDOW	BCC	WORLD
478	WINDOWS	C83	WOUND
594	WING	D3F	WRITE
61B	WINTER	DB9	WRONG
6DB	WISE	E41	X
7A4	WITH	EB0	Y

FILE NAME : SSB-E56

ADDRESS	WORD	ADDRESS	WORD
000	YEAR	1C5	YOU
098	YES	24C	YOUR
113	YELLOW	2EA	Z
		3A9	ZERO

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