Synertek
Systems

TECHNICAL NOTES

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Synertek Systems

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TECHNICAL NOTE
#22
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SYM-1 INPUT/OUTPUT PINS UTILIZATION

The SYM-1 Microcomputer Systems has a large number of general purpose I/O lines available. In addition, it is possible to expand the number of lines by a variety of ways. The purpose of this note is to explain how this can be achieved.

OVERALL I/O STRUCTURE

There are three interface devices in the basic SYM-1 system: one SY-6532 and two SY6522s. There is also an expansion socket for a third SY6522. Each interface device has 16 I/O lines. In addition, the SY-6522s have 4 control pins. The reader should consult the data sheets for these parts for a complete understanding of the operation of the I/O pins. Figure 1 summarizes how the pins for each device are utilized. In the basic SYM-1 system (6522 #2 not installed) there are 25 general-purpose I/O lines and 2 CONTROL lines:

1) 6522 #1 has 15 I/O and no CONTROL.

2) 6522 #3 has 10 I/O (this includes 4 I/O available with or without BUFFERS) and 2 CONTROLS.

The four BUFFERED I/O pins deserve some comments. The circuit for each is shown on page 4-11 in the SYM Reference Manual. Connections for wiring options permit the BUFFERS to be utilized in a variety of ways, such as relay drivers, level converters, D/A Converters, and one-shots. Furthermore, it is possible to by-pass the buffers entirely, thus allowing the 4 lines to be used as general-purpose I/O lines.

The following sections describe how to expand the number of I/O lines further. Figure 2 aids in this description.

<table>
<tr><th rowspan="2">PIN DESIGNATION</th><th colspan="4">PERIPHERAL INTERFACE DEVICE</th></tr>
<tr><th>6532 (U27)</th><th>6522#1 (U25)</th><th>OPTIONAL 6522#2 (U28)</th><th>6522#3 (U29)</th></tr>
<tr><td>PA0</td><td rowspan="12">KEYPAD & DISPLAY</td><td rowspan="14">KIM COMPATIBLE I/O</td><td rowspan="16">AUXILIARY APPLICATION I/O</td><td rowspan="4">WRITE PROTECT OR A-A I/O</td></tr>
<tr><td>PA1</td></tr>
<tr><td>PA2</td></tr>
<tr><td>PA3</td></tr>
<tr><td>PA4</td><td rowspan="2">DEBUG OR A-A I/O</td></tr>
<tr><td>PA5</td></tr>
<tr><td>PA6</td><td rowspan="6">A-A I/O</td></tr>
<tr><td>PA7</td></tr>
<tr><td>PB0</td></tr>
<tr><td>PB1</td></tr>
<tr><td>PB2</td></tr>
<tr><td>PB3</td></tr>
<tr><td>PB4</td><td rowspan="4">CRT & TTY INTERFACE</td><td rowspan="4">A-A I/O THRU BUFFERS</td></tr>
<tr><td>PB5</td></tr>
<tr><td>PB6</td><td>AUDIO</td></tr>
<tr><td>PB7</td><td>KIM I/O</td></tr>
<tr><td>CA1</td><td rowspan="4">NOT AVAILABLE</td><td>NOT USED</td><td rowspan="4">A-A CONTROL</td><td>I/O CONTROL</td></tr>
<tr><td>CA2</td><td>POWER-ON-RESET</td><td>SCOPE</td></tr>
<tr><td>CB1</td><td>NOT USED</td><td>I/O CONTROL</td></tr>
<tr><td>CB2</td><td>SPECIAL FUNC.</td><td>SCOPE</td></tr>
</table>

Figure 1 - SYM-1 I/O SUMMARY

SYSTEM CONFIGURATION	PERIPHERAL INTERFACE DEVICE				TOTAL
	6532	6522#1	6522#2	6522#3	
BASIC SYSTEM	0/0	15/0	---	10/2	25/2
WITH EXPANSION 6522	0/0	15/0	16/4	10/2	41/6
WITHOUT DEBUG, WP, FEATURE	0/0	15/0	16/4	16/2	47/6
WITHOUT KYPD, DISPLAY	11/0	15/0	16/4	16/2	58/6

NOTE: X/Y, where X is no. of I/O and Y is no. of CONTROL pins.

FIGURE 2 - Number of Pins Versus System Configuration

<u>6522#2</u>

By installing another SY6522 device into socket U28, and additional 16 I/O and 4 control lines are immediately made available on the Auxiliary Application Connector.

<u>WRITE-PROTECT FEATURES</u>

6522#3 used pins PA0 through PA3 for WRITE-PROTECT features, as follows (see Figure 3 for schematic):

1) Each pin has a place for a wire jumper to permit using that I/O pin to control the gating of R/W.

2) The gating is as follows:

   PA0 controls writing into the 6532 RAM.

   PA1 controls writing into address 400-7FF (HEX).

   PA2 controls writing into address 800-BFF (HEX).

   PA3 controls writing into address C00-FFF (HEX).

3) Software to perform the WRITE-PROTECT function is a part of the SUPERMON system, activated with the "WP" key. In addition, the user can achieve the same thing by programming the 6522 I/O bits. Note that the jumper must be in place <u>and</u> the bit must a logic "0" output to WRITE-PROTECT the memory block.

Thus, if WRITE-PROTECT is not needed, the jumpers should not be installed and PA0-PA3 may be used as general-purpose I/O. The jumpers are located near the crystal on the board and can easily be traced to the 6522#3.

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September '78

SYM-1 UPDATE'S FOR VIM REFERENCE MANUAL

(MAY, 1978 EDITION)

1. Remote Control Connections

See the instructions in Section 3-8 of the SYM Reference Manual, and use the corrected Figure 3-3 and Table 3-1, attached.

2. Adjusting Your Recorder

The audio signal appears on the T and A connectors in two forms: Aud Out (HI) and Aud Out (LO). The only difference between these signals is their magnitude. For most recorders, the best arrangement is to run Aud Out (LO) into the MIC input of the recorder. Some recorders also have an AUX input, which bypasses the MIC pre-amp, and may work better if Aud Out (HI) is wired into AUX.

Read Appendix F, and follow the procedure for creating a 'SYNC' tape. Rewind the tape and enter the LD command appropriate to the SYNC tape you created. Adjust the tone and volume controls, observing the S on the display. Leave the controls in the middle of the range where the S remains off. (If there are two ranges of volume which cause the S to turn off, the higher range should be used. If a sharp tap causes the S to relight and remain lit, you are in the wrong range.)

If your recorder has an automatic-recording-level defeat switch, it will probably work better in the engaged position.

Now write a short record to tape and read it back to verify correct operation. (Do not use the memory form $F8 to $FF, or the stack area (page 1), as these are used by the cassette software.)

Recommended Tape Equipment

Most moderate quality tape recorders should produce satisfactory results. (A tone control is recommended.) The following models have been used successfully at Synertek Systems:

Sanyo M2533A	GE IC #3-5002B
Sony TC-205	Superscope C-190
Sony TC-62	Realistic Ctr-40

Almost any tape will suffice, so long as it winds smoothly (does not produce a jittery tape motion). A very short tape will be more convenient. The following tapes have been used successfully at Synertek Systems:

TDK
AMPEX
MALLORY
REALISTIC

		READING A (center tip voltage)		
		-6v to -8v	GND	+6v to +8v
READING B (shield voltage)	-6v to -8v		READING C GND Type VIII -8v Type V	
	GND	READING C GND Type VII -8v Type VI		READING C GND Type I +8v Type IV
	+6v to +8v		READING C GND Type II +8v Type III	

Reading C (shorted)

Table 3-1 Audio Cassette remote control type determination

SYM-1 Monitor Addenda

1. While tracing or single stepping, SUPERMON uses G01ENT ($83FA) to return to the user program. G01ENT write protects System RAM. If you must trace a program that needs access to System RAM, use a user trace routine and go to G01ENT +3, or remove jumper MM-45 (enables System RAM protect).

2. The DEBUG-ON switch bounces, therefore it should not be used to interrupt user programs while using a user trace routine or while OUTVEC points to a user routine. (This will cause recursive interrupts.)

3. The audio cassette software will not read or write location $FFFF. Use $A67F ($A600 through $A67F is echoed at $FF80 through $FFFF.)

APPLICATION NOTE - Changing Automatic Logon 6/30/78

After power is applies to the SYM, SUPERMON waits for the keyboard or the device connected to PB7 on the 6532 (normally the RS232 device) to become active. PB6 (the current loop device) is ignored because a disconnected current loop always looks active.

If you expect always to logon to a current-loop device, the following jumper change will eliminate the necessity of entering (SHIFT) (JUMP) (1):

Change CC-32 and BB-31 to CC-31 and BB-32

Now the logon for your current loop device is simply a 'Q,' entered at the device. (Note that you cannot now logon automatically to the keyboard unless the current loop device is connected, and powered-up.)

SYM-1 REFERENCE MANUAL - ERRATA

Page 3-11, Figure 3-5	Ignore everything left of 'T' and 'A' connectors.
Page 4-18, Figure 4-10	E000-F7FF unused F800-FFFF echo locations
Page E-3, Table E-3	INCHAR = 8A1B, Read = 1C6A
Page 4-7, Figure 4-2	See corrected pages, attached.
Page 3-7, Figure 3-3	See corrected page, attached.
	Types I-IV, printed B(T-18) now reads B(T-16).
	Types II and VI; inner/outer cable connections were reversed.

TABLE 4-2. (continued)

POWER (P)

1	+5V	A	+VP (optional)
2	GND	B	GND
3	+5V	C	+5V
4	GND	D	GND
5	+5V	E	-VN (optional)
6	GND	F	GND

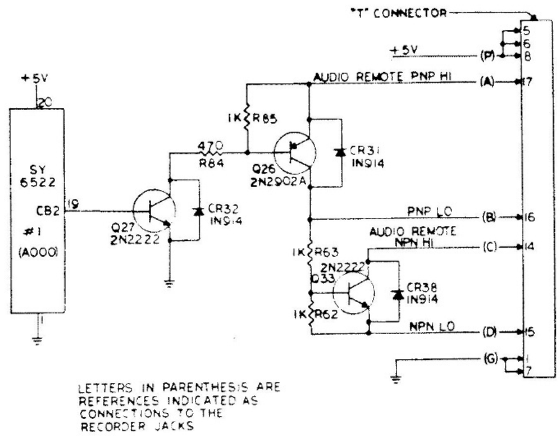
TERMINAL (T)

1	GND	13	N.C.
2	RS-232 IN	14	Audio Remote NPN HI
3	RS-232 OUT	15	Audio Remote NPN LO
4	N.C.	16	Audio Remote PNP LO
5	+5V	17	Audio Remote PNP HI
6	+5V	18	Audio IN
7	GND	19	Audio GND
8	+5V	20	N.C.
9	TTY Keyboard IN +	21	Audio Out (HI)
10	TTY Keyboard IN -	22	N.C.
11	TTY Printer OUT -	23	Audio Out (LO)
12	TTY Printer Out +	24	N.C.
		25	Audio GND

KEYBOARD (K)

1	+5V	8	-VN
2	+5V	9	GND
3	+5V	10	GND
4	+5V	11	GND
5	+VP	12	GND
6	+VP	13	RS-232 IN
7	-VN	14	RS-232 OUT

AUDIO CASSETTE SYM REMOTE CONTROL CONNECTION



AUDIO CASSETTE RECORDER JACKS REMOTE CONTROL CONNECTIONS

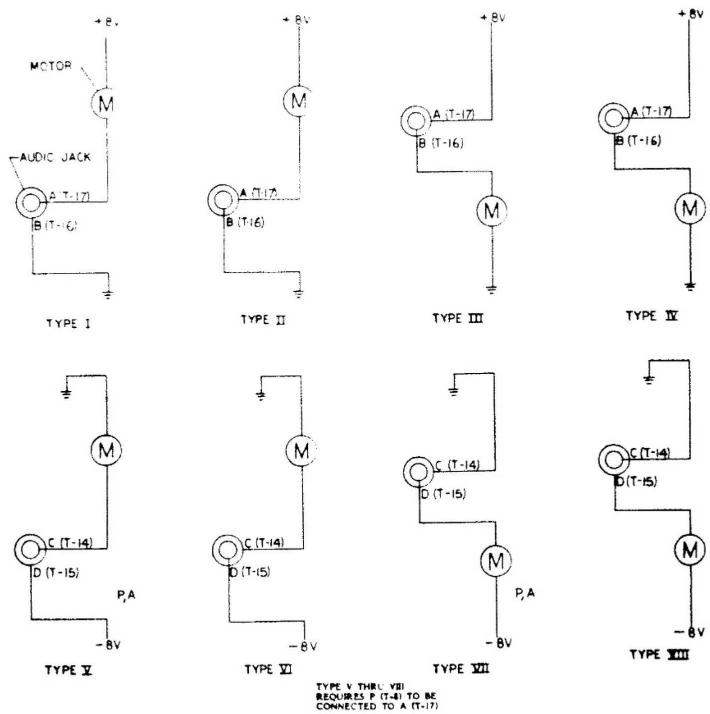


Figure 3-3. REMOTE CONTROL TYPES AND CONNECTIONS

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TECHNICAL NOTE

#49

DEC'78

SYM-1 SAMPLE PROGRAMS

PROGRAM #1 - BEEPER DEMO

This program demonstrates the use of the piezo-electric "beeper" on the SYM-1 board to generate programmable tones.

```
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LOC     CODE         LINE

0000                 ;                    CLASS2 DEMOSTRATION PROGRAM #2
0000                 ;                            THE "BEEPER"
0000                 ;
0000                 CONFIG = $89A5          ;SUBRTN TO SET UP FOR BEEPER
0000                 PBDA   = $A402          ;BEEPER DATA REGISTER
0000                 PBDDR  = $A403          ;DATA DIRECTION FOR FOR BEEPER
0000                 TONE   = $10            ;TONE STORAGE
0000                 LENGTH = $11            ;HOW LONG FOR EACH NOTE
0000                 IRQVEC = $A67E          ;PLACE FOR INTERRUPT BVECTOR
0000                 IER1   = $AC0E          ;REG TO ENABLE INTERRUPT FLAG
0000                 IFR1   = $AC0D          ;INTERRUPT FLAG REGISTER
0000                 ACR1   = $AC0B          ;TIMER INTERRUPT SET UP REG.
0000                 T1LL1  = $AC06          ;ADDRESS OF LOW TIMER
0000                 T1CH1  = $AC05          ;ADDRESS OF HIGH TIMER
0000                 ACCESS = $8B86          ;RAM EANBLE SUBRTN
0000                 ;
0000                       * = $0250         ;PROGRAM STARTING LOCATION
0250                 ;
0250    78           START SEI               ;DISABLE ALL INTERRUPTS
0251                 ;
0251    20 86 8B           JSR ACCESS        ;ENABLE SYSTEM RAM
0254                 ;
0254    A9 50              LDA #<INTRPT      ;SET UP INTERRUPT ADDRESS
0256    8D 7E A6           STA IRQVEC        ;AT THE LOCATION IN
0259    A9 03              LDA #>INTRPT      ;MEMORY TO CAUSE THE INTERRUPT
025B    8D 7F A6           STA IRQVEC+1      ;TO BRANCH TO OUR INTERRUPT
025E                 ;                       SUBROUTINE
025E                 ;
025E    A9 0F              LDA #$0F          ;SET UP DATA DIRECTION REG.
0260    8D 03 A4           STA PBDDR
0263                 ;
0263    A9 FF              LDA #$FF          ;INITIALIZE THE TONE
0265    85 10              STA TONE
0267                 ;
0267    A9 01              LDA #$01          ;INITIAL THE TONE LENGTH
0269    85 11              STA LENGTH
026B                 ;
026B    A9 40              LDA #$40          ;SET UP INTERRUPT TIMER
026D    8D 0B AC           STA ACR1          ;WITHOUT HAVING SQ. WAVES
0270                 ;
0270    A9 C0              LDA #$C0          ;ENABLE THE INTERRUPT FLAG
0272    8D 0E AC           STA IER1
0275                 ;
0275    A9 40              LDA #$40          ;CLEAR ANY PENDING FLAGS
0277    8D 0D AC           STA IFR1          ;IF THEY ARE THERE
027A                 ;
027A    A9 20              LDA #$20          ;START THE INTERRUPT TIMERS
027C    8D 06 AC           STA T1LL1
027F    8D 05 AC           STA T1CH1
0282                 ;
0282    A9 0D        BEEPER LDA #$0D         ;CONFIGURE FOR THE BEEPER
0284    20 A5 89           JSR CONFIG
0287                 ;
0287    58                 CLI               ;NOW ENABLE THE INTERRUPTS
0288                 ;                        START THE 'MUSIC?'.
```

```
......PAGE 0002

LOC      CODE        LINE

0288  A9 08       BE1    LDA #$08          ;TURN BEEPER ON
028A  8D 02 A4           STA PBDA
028D  20 9A 02           JSR BE2           ;WAIT AWHILE
0290  A9 06              LDA #$06          ;TURN BEEPER OFF
0292  8D 02 A4           STA PBDA
0295  20 9A 02           JSR BE2           ;NOW WAIT THE SAME WHILE.
0298  90 EE              BCC BE1           ;NOW DO IT ALL OVER AGAIN.
029A              ;
029A  A4 10       BE2    LDY TONE          ;DELAY SUBROUTINE
029C  88          BE3    DEY               ;JUST COUNT DOWN
029D  D0 FD              BNE BE3           ;DO IT AGAIN IN NOT ZERO.
029F              ;
029F  60                 RTS               ;RETURN FROM SUBROUTINE
02A0              ;
02A0                     * = $0350
0350              ;
0350  48          INTRPT PHA               ;SAVE THE ACCUMULATOR
0351  98                 TYA               ;TRANSFER Y REG TO ACC.
0352  48                 PHA               ;SAVE THAT TOO.
0353              ;
0353  A9 40              LDA #$40          ;CLEAR THE PENDING INTERRUPT FLAG
0355  8D 0D AC           STA IFR1
0358              ;
0358  C6 11              DEC LENGTH        ;COUNT DOWN EACH NOTE LENGTH
035A  D0 10              BNE RETURN        ;IF NOT ZERO GO BACK.
035C              ;
035C  A9 01              LDA #$01          ;RESTORE LENGTH REG.
035E  85 11              STA LENGTH
0360              ;
0360  C6 10              DEC TONE          ;MAKE A HIGHER NOTE.
0362  A5 10              LDA TONE          ;IS IT HIGH ENOUGH?
0364  C9 10              CMP #$10          ;10 SHOULD BE A LIMIT.
0366  B0 04              BCS RETURN        ;IF NOT 10, GO BACK.
0368              ;
0368  A9 FF              LDA #$FF          ;RESTORE TO LOWEST NOTE
036A  85 10              STA TONE
036C              ;
036C  68          RETURN PLA               ;REPLACE EVERYTHING.
036D  98                 TYA               ;Y REGISTER IS BACK.
036E  68                 PLA               ;ACCUMULATOR IS BACK.
036F              ;
036F  40                 RTI               ;RETURN FROM INTERRUPT.
0370              ;
0370                     .END

ERRORS = 0000 <0000>
END OF ASSEMBLY
```

PROGRAM #2 - ROTATING DISPLAY

This program demonstrates the use of the 6-digit HEX display to show a rotating message.

```
......PAGE 0001

LOC     CODE      LINE

0000              ;              "SCROLLING" PROGRAM FOR CLASS DEMONSTRATION
0000              ;
0000              FILE    = $0300
0000              DISBUF  = $A640
0000              SCANDS  = $8906
0000              COUNT   = $11
0000              ACCESS  = $8B86
0000              ;
0000              ;            SYMBOL TABLE FOR THE LED DISPLAY
0000              ;
0000              O0      = $3F
0000              O1      = $06
0000              O2      = $5B
0000              O3      = $4F
0000              O4      = $66
0000              O5      = $6D
0000              O7      = $07
0000              O8      = $7F
0000              O9      = $67
0000              OBLANK  = $00
0000              ODOT    = $80
0000              OA      = $77
0000              OB      = $7C
0000              OC      = $39
0000              OD      = $5E
0000              OE      = $79
0000              OF      = $71
0000              OG      = $6F
0000              OH      = $76
0000              OI      = $06
0000              OJ      = $1E
0000              OK      = $74
0000              OL      = $38
0000              OM1     = $33
0000              OM2     = $27
0000              ON      = $54
0000              OO      = $3F
0000              OP      = $73
0000              OQ      = $67
0000              OR      = $50
0000              OS      = $6D
0000              OT      = $46
0000              OU      = $3E
0000              OV1     = $64
0000              OV2     = $52
0000              OW1     = $3C
0000              OW2     = $1E
0000              OX      = $00
0000              OY      = $6E
0000              OZ      = $00
0000              ;
0000                      * = $300
0300              ;
0300                      .OPT GEN
0300              ;
```

```
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LINE # LOC      CODE        LINE

0057  0300              ;
0058  0300              ;                        ALTHOUGH SCANDS SUBROUTINE
0059  0300              ;                        USES ONLY THE LOCATIONS
0060  0300              ;                        A640 THROUGH A645, WE ARE
0061  0300              ;                        GOING TO FILE A646 WITH A BLANK
0062  0300              ;                        SO WE CAN SHIFT A BLANK THROUGH
0063  0300              ;                        TO SEPARATE OUR 6 CHARACTER WORD.
0064  0300              ;
0065  0300  33                .BYTE OM1,OM2,OI,OK,OE,OBLANK,OBLANK
0065  0301  27
0065  0302  06
0065  0303  74
0065  0304  79
0065  0305  00
0065  0306  00
0066  0307              ;
0067  0307                    * = $200
0068  0200              ;
0069  0200  20 86 8B          JSR ACCESS        ;WRITE ENABLE SYSTEM RAM
0070  0203              ;
0071  0203  A0 06             LDY #$06          ;TAKE THE CHARACTERS FROM
0072  0205  B9 00 03    ONE   LDA FILE,Y        ;THE FILE WE HAVE ARBITRARILY
0073  0208  99 40 A6          STA DISBUF,Y      ;ESTABLISHED AND FILL
0074  020B  88                DEY               ;THE DISPLAY BUFFER WITH THEM.
0075  020C  10 F7             BPL ONE
0076  020E              ;
0077  020E  A9 FF       CYCLE LDA #$FF          ;SET THE NUMBER OF TIMES WE
0078  0210  85 11             STA COUNT         ;FLASH THE LEDS WITH THE CONTENTS
0079  0212              ;                        OF DISBUF.
0080  0212  20 06 89    TWO   JSR SCANDS        ;NOW FLASH THE DISPLAYS
0081  0215  C6 11             DEC COUNT         ;DEC THE COUNT FOR EACH FLASH
0082  0217  D0 F9             BNE TWO           ;ARE WE DONE YET?
0083  0219              ;                        IF NOT, FLASH AGAIN
0084  0219  AD 40 A6          LDA DISBUF        ;IF SO, THEN SAVE THE TOP NUMBER
0085  021C  48                PHA
0086  021D  A0 00             LDY #$00          ;SHIFT UP THE REMAINING 6
0087  021F              ;                        REGISTERS
0088  021F  B9 41 A6    THREE LDA DISBUF+1,Y    ;BY LOOPING AND INCREMENTING
0089  0222  99 40 A6          STA DISBUF,Y      ;THE Y REGISTER ON EACH LOOP.
0090  0225  C8                INY
0091  0226  C0 06             CPY #$06          ;AND THEN CHECKING TO SEE
0092  0228  D0 F5             BNE THREE         ;IF WE HAVE INCREMENTED THE
0093  022A              ;                        RIGHT NUMBER OF TIMES.
0094  022A  68                PLA               ;NOW PLACE THE FIRST REGISTER IN
0095  022B  8D 46 A6          STA DISBUF+6      ;THE LAST MEMORY LOCATION
0096  022E              ;
0097  022E  4C 0E 02          JMP CYCLE         ;NOW DO IT ALL OVER AGAIN.
0098  0231              ;
0099  0231                    .END

ERRORS = 0000 <0000>
END OF ASSEMBLY
```

PROGRAM # 3 - COUNT AND BEEP

This program uses the display to count from 00 to FF and then energizes the audio tone generator while displaying the word "beep".

```
......PAGE 0001

LOC     CODE        LINE

0000                ;DEMO PROGRAM WRITTEN BY D. SATTERFIELD
0000                ;11/27/78
0000                ;
0000                BP      =$8972
0000                SEGTAB  =$8C29
0000                IRQVEC  =$A67E
0000                FLAG    =$40
0000                FLAG1   =$42
0000                T1LL    =$AC06
0000                T1CH    =$AC05
0000                NUM     =$41
0000                SCAND   =$8906
0000                D1      =$A645
0000                D2      =$A644
0000                D3      =$A643
0000                D4      =$A642
0000                D5      =$A641
0000                D6      =$A640
0000                ACCESS  =$8B86
0000                ACR1    =$AC0B
0000                IER1    =$AC0E
0000                IFR1    =$AC0D
0000                ;
0000                ;INITIALIZE
0000                ;
0000                        *=$300
0300    20 86 8B            JSR ACCESS      ;UNWRITE PROTECT SYSTEM RAM
0303    A9 20               LDA #$20
0305    85 42               STA FLAG1
0307    A9 55               LDA #<INTCNT
0309    8D 7E A6            STA IRQVEC
030C    A9 03               LDA #>INTCNT
030E    8D 7F A6            STA IRQVEC+1
0311    A9 40               LDA #$40
0313    8D 0B AC            STA ACR1        ;ENABLE T1 CONTINUOUS INTERRUPTS
0316    A9 4E               LDA #$4E        ;LO BYTE OF T1 COUNTER
0318    8D 06 AC            STA T1LL
031B    A9 C0               LDA #$C0        ;ENABLE T1
031D    8D 0E AC            STA IER1        ;INTERRUPTS
0320    A9 00               LDA #$00
0322    85 40               STA FLAG        ;ZERO FLAG
0324    A9 20               LDA #$20        ;T1 HI BYTE
0326    8D 05 AC            STA T1CH        ;START COUNTING
0329    18                  CLC             ;CLEAR CARRY
032A    58                  CLI             ;ENABLE INTERRUPTS
032B                ;
032B                ;DISPLAY ROUTINE
032B                ;
032B    A9 00       DISPL   LDA #$00
032D    8D 40 A6            STA D6
0330    8D 41 A6            STA D5
0333    8D 44 A6            STA D2
0336    8D 45 A6            STA D1          ;BLANK ALL DISLPAYS EXCEPT D3 AND D4
0339    A5 41       DISP    LDA NUM
033B    29 0F               AND #$0F        ;STRIP UPPER BITS
```

```
......PAGE 0002

LINE # LOC     CODE           LINE

       033D   20 73 03               JSR CONV         ;CONVERT TO 7 SEGMENT CODE
       0340   8D 43 A6               STA D3; STORE IT
       0343   A5 41         DISP2    LDA NUM
       0345   4A                     LSR A
       0346   4A                     LSR A
       0347   4A                     LSR A
       0348   4A                     LSR A            ;SHIFT RIGHT 4 TIMES
       0349   20 73 03               JSR CONV         ;CONVERT IT
       034C   8D 42 A6               STA D4           ;STORE IT
       034F   20 06 89               JSR SCAND
       0352   4C 2B 03               JMP DISPL
       0355   48            INTCNT   PHA              ;SAVE ALL REGISTERS
       0356   8A                     TXA
       0357   48                     PHA              ;SAVE X
       0358   98                     TYA
       0359   48                     PHA              ;SAVE Y
       035A   AD 0D AC               LDA IFR1
       035D   8D 0D AC               STA IFR1         ;CLEAR ALL PENDING INTERRUPTS
       0360   E6 40                  INC FLAG         ;INCREMENT NUMBER OF INTERRUPTS COL
       0362   A5 40                  LDA FLAG
       0364   C9 05                  CMP #5           ;5 INTERRUPTS YET?
       0366   F0 02                  BEQ ADD          ;YES,INCREMENT DISPLAY
       0368   50 66                  BVC REST         ;NO,GO BACK AND WAIT
       036A   A9 00         ADD      LDA #$00
       036C   85 40                  STA FLAG         ;ZERO FLAG
       036E   20 78 03               JSR COUNT
       0371   50 5D                  BVC REST
       0373   AA            CONV     TAX
       0374   BD 29 8C               LDA SEGTAB,X
       0377   60                     RTS
       0378   18            COUNT    CLC              ;CLEAR CARRY
       0379   A5 41                  LDA NUM
       037B   69 01                  ADC #$01
       037D   18                     CLC
       037E   B8                     CLV
       037F   85 41                  STA NUM
       0381   C9 FF                  CMP #$FF
       0383   F0 01                  BEQ BEEP
       0385   60                     RTS
       0386   A9 7C         BEEP     LDA #$7C         ;7 SEG CODE FOR B
       0388   8D 41 A6               STA D5
       038B   A9 79                  LDA #$79         ;E
       038D   8D 42 A6               STA D4
       0390   8D 43 A6               STA D3
       0393   A9 73                  LDA #$73         ;CODE FOR P
       0395   8D 44 A6               STA D2
       0398   A9 00                  LDA #$00
       039A   85 41                  STA NUM
       039C   20 72 89      DELAY    JSR BP
       039F   20 06 89               JSR SCAND
       03A2   20 06 89               JSR SCAND
       03A5   20 06 89               JSR SCAND
       03A8   20 06 89               JSR SCAND
       03AB   20 06 89               JSR SCAND
       03AE   20 06 89               JSR SCAND
```

```
......PAGE 0003

LINE # LOC      CODE          LINE

       03B1   C6 42                  DEC FLAG1
       03B3   20 06 89               JSR SCAND
       03B6   20 06 89               JSR SCAND
       03B9   20 06 89               JSR SCAND
       03BC   20 06 89               JSR SCAND
       03BF   20 06 89               JSR SCAND
       03C2   20 06 89               JSR SCAND
       03C5   A5 42                  LDA FLAG1
       03C7   C9 00                  CMP #$0
       03C9   D0 D1                  BNE DELAY
       03CB   A9 20                  LDA #$20
       03CD   85 42                  STA FLAG1
       03CF   60                     RTS
       03D0   68              REST   PLA
       03D1   A8                     TAY              ;RESTORE Y
       03D2   68                     PLA
       03D3   AA                     TAX              ;RESTORE X
       03D4   68                     PLA              ;RESTORE A
       03D5   40                     RTI
       03D6                          .END

ERRORS = 0000 <0000>
END OF ASSEMBLY
```

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TECHNICAL NOTE

No. 50

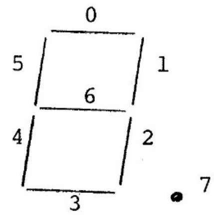
NOVEMBER 1978

SYM-1 DISPLAY ROUTINE

This routine allows the user to display his own message on the SYM-1 6-digit display.

To use the routine, the user must first load memory locations 0250 through 0255 with segment codes from Figure 1, using the M or D commands of SUPERMON. Note location 0255 will contain the segment code for the right-hand digit. Next the user must enter and execute the code shown in Figure 2. To stop the display and return to the monitor, press the RST and CR Keys.

This routine may be structured as a sub-routine and incorporated in user programs to display various values and results.



SEGMENTS

Byte in momory: b_7 b_6 b_5 b_4 b_3 b_2 b_1 b_0

b_o =1 lights segment 0
b_1 =1 lights segment 1
etc.

Figure 1a.— Segment pattern

CHARACTER	SEGMENT CODE	CHARACTER	SEGMENT CODE
A	77	P	73
b	7C	r	50
C	39	S	6D
c	58	U	3E
d	5E	Y	6E
E	79	Z	5B
e	7B		
F	71	0	3F
G	7D	1	06
H	76	2	5B
h	74	3	4F
I	06	4	66
J	1E	5	6D
L	38	6	7C
n	54	7	07
O	3F	8	7F
o	5c	9	67

Figure 1 b. Segment Codes

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Figure 2. Display Routine

ADR	INSTRUCTIONS B1	B2	B3	LABEL	NMEMONIC	OPERAND	COMMENTS
						ACCESS = $8B86	
						DISBUF = $A640	
						SCAND = $89A6	
						* = $200	
200	20	86	8B		JSR	ACCESS	Un-write-protect system RAM
203	A2	05			LDX	#$05	Transfer characters from temporary
205	BD	50	02	L1	LDA	$250,X	locations at 250 to 255
208	9D	40	A6		STA	DISBUF,X	to DISBUF
20B	CA				DEX		
20C	10	F7			BPL	L1	
20E	20	06	89	L2	JSR	SCAND	Light display (single scan)
211	4C	0E	02		JMP	L2	Repeat for continuous display

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TECHNICAL NOTE

NO. 52-SSC

January, 1979

SYM-1 TIME DELAY USING 6532 TIMER

The internal interval timer in device U27, SY6532, provides a method for generating time delays from one microsecond to 262,144 microseconds.

To use the timer, the user must load the desired count into the 8-bit counter and set the prescaler to the desired mode. These two operations are accomplished simultaneously by control of the address lines, Figure 1.

Since the $\overline{IRQ}$ line from U27 is not connected to the CPU chip, it is necessary to test bit 7 in the Interrupt Flag Register (IFR) to determine when timeout has occurred. The count remaining in the timer may be read at any time without affecting the count. Reading or writing to the timer after the interrupt is set will clear the interrupt.

An example of a subroutine to generate a one millisecond delay is given in Figure 2. Note that the total delay is counted from the JSR in the calling program to the return to the calling program as shown in the Timing Analysis, Figure 3, and Timing Diagram, Figure 4.

ADDRESS	FUNCTION
A404	Read Timer
A405	Read Interrupt flags
A41C	Load Timer; set prescaler to ÷1
A41D	Load Timer; set prescaler to ÷8
A41E	Load Timer; set prescaler to ÷64
A41F	Load Timer; set prescaler to ÷1024

Figure 1. Address table for 6532 timer, device U27.

Another example, a 60 second timer, is given in Figure 5. This routine shows how the delay routine might be used in a larger program. The dela routine, Figure 6, is nearly the same as that of Figure 2 except the timing has been adjusted to 993 microseconds to compensate for overhead time lost in the calling program.

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PROGRAMMING SHEET

Program Title: 1 ms delay. - FIGURE 2

Programmer:

Date:

Address	Instructions B1	B2	B3	Label	Nmemonic	Operand	Comments
						*= $300	
0300	48			DELAY	PHA		SAVE ACCUMULATOR
0301	A9	79			LDA	# $ 79	Load Accumulator for count of 121_{10}
0303	8D	1D	A4		STA	$A41D	Store Count; set prescaler to ÷ 8
0306	2C	05	A4	DI	BIT	$A405	Test bit 7 of IFR
0309	10	FB			BPL	DI	Loop if not set
030B	25	FF			AND	$FF	Waste three cycles
030D	68				PLA		Restore Accumulator
030E	60				RTS		Return

JSR DELAY	6 cycles
PHA	3
LDA	2
STA	4

loop ... 138 times
BIT 4 cycles
*BPL 3 cycles

7 cycles x 138 = 996

last loop	
BIT	4
*BPL	2
AND	3
PLA	4
RTS	6
	1000 cycles

1000 cycles @ 1 microsecond/cycle = 1 ms

*NOTE: BPL takes 3 cycles to branch back to beginning of loop but only 2 cycles when the branch is not taken.

Figure 3. 1 ms Delay Timing Analysis

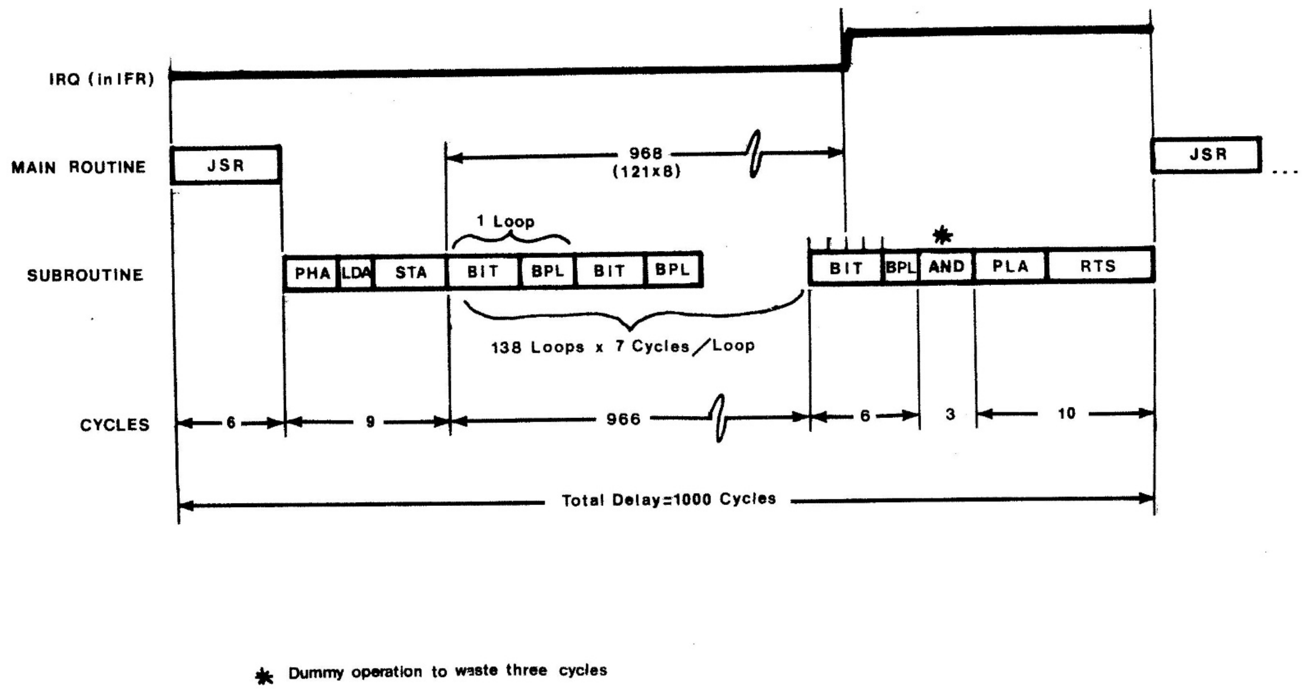

FIG. 4 Timing Diagram for 1MS Delay

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PROGRAMMING SHEET

Programmer:

Program Title: FIGURE 5. 60 SEC. CLOCK {Uses 993 µs delay

Date:

Address	B1	B2	B3	Label	Nmemonic	Operand	Comments
						*= $200	
0200	A9	00			LDA	#00	Initialize counter
0202	85	00			STA	00	in page zero
0204	85	01			STA	01	
0206	20	72	89		JSR	BEEP	Sound beeper
0209	A9	EA			LDA	#$EA	Load A for 234_{10} passes
							thru loop 1
020B	20	00	03	L1	JSR	DELAY	Loop 1: Call delay (993 µs)
020E	E6	00			INC	$00	subroutine 256 times
0210	D0	F9			BNE	L1	
0212	E6	01			INC	$01	REPEAT Loop 1
0214	C5	01			CMP	$01	234_{10} times (as set by
0216	D0	F3			BNE	L1	value in A)
0218	A9	22			LDA	#$22	Load A for 34_{10} passes
021A	85	00			STA	$00	thru loop 2
021C	20	00	03	L2	JSR	DELAY	Loop 2: Call delay (993 µs)
021F	C6	00			DEC	$00	subroutine 34 times
0221	D0	F9			BNE	L2	
0223	20	72	89		JSR	BEEP	Sound beeper
0226	00				BRK		

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PROGRAMMING SHEET

Programmer:

Program Title: DELAY - 993 μS -- FIGURE 6

Date:

Address	Instructions B1	B2	B3	Label	Nmemonic	Operand	Comments
						*= $300	
0300	48			DELAY	PHA		Save Accumulator
0301	A9	78			LDA	#$78	Load Accumulator for count of 120_{10}
0303	8D	1D	A4		STA	$A41D	Store Count; Set prescaler to ÷8
0306	2C	05	A4	D1	BIT	$A405	Test bit 7 of IFR
0309	10	FB			BPL	D1	Loop if bit not set
030B	EA				NOP		Waste two cycles
030C	68				PLA		Restore Accumulator
030D	60				RTS		Return

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TECHNICAL NOTE

53-SSC

April 1979

Trigonometric Functions for Synertek BASIC

This note describes the incorporation of trig functions into Synertek BASIC, BAS-1. Using the procedures described allows trig functions to be loaded from cassette tape when needed and called by a simple function call.

FEATURES

* SIN, COS, TAN, ATN

* Accuracy to 10^{-7} (for arguments between minus two Pi and plus two Pi)

* Calculates SIN in less than 28mS

* Takes up only 313 bytes of RAM

* May be located on any two consecutive pages in memory

GETTING TRIG ON YOUR SYSTEM

For a 4K RAM system, the listing of Figure 1 should be typed in as shown. This will locate the trig functions at the top of memory. If you have more (or less) memory, then you will need to relocate it at the top of your memory space. The first byte of the listing is 0B at location 0EC7. The last byte is 01 at location 0FFF. Type in the bytes as shown using the monitor Memory or Deposit modes. After you are done, do a Verify listing. The checksum value should be 9476 if you have not made any mistakes. See Figure 2.

Now save the bytes on cassette. You will probably want to save it as the first file on a tape which contains BASIC programs that require trig functions. The following monitor command will do this:

```
.S2 54,EC7,FFF
```

By using file number 54, this can be read back in BASIC as file T. Be sure this won't conflict with any BASIC programs named T on the same tape.

USING TRIG FUNCTIONS

After a .J 0 from monitor to get to BASIC, type in the memory size that will reserve enough room for trig functions (and machine language if necessary) at the top of memory. On a 4K RAM system this would be 3782 if no machine language space is reserved. When BASIC responds with OK, insert the cassette that contains the trig functions and type LOAD T. After it is loaded, you must type either NEW or LOAD x. Next type the following line to attach the trig functions to BASIC:

```
POKE 196,104 : POKE 197,15
```

Instead of typing this line each time you load BASIC, you may use this as the first line in any BASIC program that uses trig functions. See Figures 3 and 4.

In the case where it is desired to load the trig functions when a BASIC program already exists in RAM, exit BASIC to SUPERMON, load the trig functions and return to BASIC. Be sure to un-write-protect system RAM and to attach the trig functions to BASIC. See Figure 5.

RELOCATING TRIG FUNCTIONS

Trig functions have been written so that they may reside on any two consecutive pages in RAM. However, the relative location on the page must stay as it is. In other words, the 0B at location 0EC7 must be at location XXC7, where XX is the page on which it is located, and the 01 at location 0FFF must be at location YYFF, where YY is one greater than XX. When attaching trig functions using the POKE statements, the number 15 must be replaced by the decimal equivalent of page YY.

Figure 1. Object Code Listing for Trig Functions

```
.V EC7,FFF
0EC7 0B 76 B3 83 BD D3 79 1E,DE
0ECF F4 A6 F5 7B 83 FC B0 10,27
0ED7 7C 0C 1F 67 CA 7C DE 53,AC
0EDF CB C1 7D 14 64 70 4C 7D,66
0EE7 B7 EA 51 7A 7D 63 30 88,6A
0EEF 7E 7E 92 44 99 3A 7E 4C,D9
0EF7 CC 91 C7 7F AA AA AA 13,8D
0EFF 81 00 00 00 00 A5 B6 48,B1
0F07 10 03 20 36 DD A5 B1 48,95
0F0F C9 81 90 07 A9 72 A0 D7,08
0F17 20 C5 D8 A9 C7 A4 C5 88,26
0F1F 20 C2 DD 68 C9 81 90 07,2E
0F27 A9 35 A4 C5 20 06 D6 68,D9
0F2F 10 03 4C 36 DD 60 81 49,75
0F37 0F DA A2 7F 00 00 00 00,7F
0F3F 05 84 E6 1A 2D 1B 86 28,FE
0F47 07 FB F8 87 99 68 89 01,0A
0F4F 87 23 35 DF E1 86 A5 5D,31
0F57 E7 28 83 49 0F DA A2 A1,38
0F5F 54 46 8F 13 8F 52 43 89,21
0F67 CD C0 72 F0 4A 90 41 C0,EB
0F6F 76 F0 92 20 80 D9 A9 00,05
0F77 85 16 A5 C5 48 A9 85 48,C8
0F7F A5 C5 48 A9 B5 48 60 A2,22
0F87 9E A0 00 20 8A D9 A9 A7,33
0F8F A0 00 20 58 D9 A9 00 85,52
0F97 B6 A5 C5 48 A9 A7 48 A5,F7
0F9F 16 48 A5 C5 48 A9 E7 48,DF
0FA7 60 A9 9E A0 00 4C C5 D8,0F
0FAF A9 35 A4 C5 20 1D D6 20,89
0FB7 C2 D9 A9 59 A4 C5 A6 BE,F3
0FBF 20 BD D8 20 C2 D9 20 82,05
0FC7 DA A9 00 85 BF 20 09 D6,CB
0FCF A9 3A A4 C5 20 06 D6 A5,B8
0FD7 B6 48 10 0D 20 FF D5 A5,6C
0FDF B6 30 09 A5 16 49 FF 85,E3
0FE7 16 20 36 DD A9 3A A4 C5,78
0FEF 20 1D D6 68 10 03 20 36,5C
0FF7 DD A9 3F A4 C5 4C C2 DD,75
0FFF 01,76
 9476
.
```

Figure 2. Example of Loading and Verifying Trig Function Code

```
.M EC7
0EC7,00,0B
0EC8,00,76     <-- Type in
0EC9,00,B3         trig
0ECA,00,83         functions
0ECB,00,

    . . .

0FFB,00,C5
0FFC,00,4C
0FFD,00,C2
0FFE,00,DD
0FFF,00,01
1000,10,         Verify
.V EC7,FFE  <--  your work
0EC7 0B 76 B3 83 BD D3 79 1E,DE
0ECF F4 A6 F5 7B 83 FC B0 10,27
0ED7 7C 0C 1F 67 CA 7C DE 53,AC
0EDF CB C1 7D 14 64 70 4C

    . . .

0FD7 B6 48 10 0D 20 FF D5 A5,6C
0FDF B6 30 09 A5 16 49 FF 85,E3
0FE7 16 20 36 DD A9 3A A4 C5,78
0FEF 20 1D D6 68 10 03 20 36,5C
0FF7 DD A9 3F A4 C5 4C C2 DD,75
0FFF 01,76
 9476   <--  Checksum must
.            be 9476

     Save on one
     or more
     cassettes
```

Figure 3. Loading Trig Functions and a Program Using the Trig Functions

```
.J 0
MEMORY SIZE? 3782        ← Save room for trig
WIDTH?_

 3269 BYTES FREE

BASIC V1.1
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OK
LOAD T          ← Load trig functions
LOADED
OK
LOADA           ← Load rec/polar
LOADED                       program
OK
RUN
TO WHAT? P
X,Y? 3 , 4
MAG= 5              ANGLE= 53.1301024
TO WHAT? R
MAG,ANGLE? 5 , 53.1301024
X= 3                Y= 4
TO WHAT?_

OK
```

Figure 4. Coordinate Conversion Program Which Uses Trig Functions

Note Line 110

```
100 REM RECTANGULAR/POLAR COORDINATE CONVERSION
110 POKE 196,104 : POKE 197,15 : REM ATTACH TRIG FUNCTIONS
120 INPUT "TO WHAT? ";A$
130 IF A$="P" GOTO 210
140 IF A$="R" GOTO 160
150 PRINT"USE P OR R" : GOTO 120
160 INPUT "MAG,ANGLE? ";M,T : T=T*3.141592654/180 : REM CONVRT TO RADS
170 X=M*COS(T)
180 Y=M*SIN(T)
190 PRINT"X=";X,"Y=";Y
200 GOTO 120
210 INPUT "X,Y? ";X,Y
220 M=SQR(X*X+Y*Y)
230 T=ATN(Y/X)*180/3.141592654 : REM CONVRT RADS BACK TO DEGS
240 PRINT"MAG=";M,"ANGLE=";T
250 GOTO 120
999 END
OK
```

Figure 5. Loading Trig Functions when Another Program Already Exists in Memory

```
.J 0
MEMORY SIZE? 3782      <-- Always
WIDTH?__                   save
                           room
 3269 BYTES FREE           for
                           trig

BASIC V1.1
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OK
100INPUT Y
200X=LOG(Y*5)          <-- Type in
300PRINT X                 a program
400Z=SIN(Y/3)
500PRINT Z
999END

RUN
? 4
 2.99573227

?FC ERROR IN  400      <-- Trig
OK                         is needed
Q=USR(&"8035",0)       <-- Go to
                           monitor
CB6D,3
.L2 54                 <-- Load trig
.G 0                   <-- Go back to basic

OK                     ↙ Un-write protect
Q=USR(&"8B86",0)           monitor
                           RAM !!
OK
50POKE 196,104 : POKE 197,15
RUN                    ↖ Attach trig
? 4
 2.99573227
 .971937901            <-- Now it's OK !

OK
```

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TECHNICAL NOTE

No. 54-SSC

DECEMBER 1978

SYM-1 POWER-UP TO USER ROM

Many applications for the SYM-1 require that user-written code be executed upon power-on reset. To understand how this is done, we will describe the normal power-on reset sequence, show how to modify this sequence, and give an example.

In response to the $\overline{RES}$ signal from the power-on circuit, the SY6502 microprocessor attempts to fetch a reset vector from locations FFFC and FFFD. $\overline{RES}$ also sets CA2, pin 39, from device U25 (SY6522 #1) to a high state, generating $\overline{POR}$. While $\overline{POR}$ is active, all select lines from decoder U10 and U11 are deselected, disabling all peripheral circuits. $\overline{POR}$ additionally enables ROM device U20 through a jumper from 19 to N.

ROM U20 generally contains the SUPERMON monitor program. Since this is the only device enabled by the $\overline{POR}$ signal, the reset vector is fetched from this chip at locations 8FFC and 8FFD, even though the microprocessor "thinks" it is fetching from FFFC and FFFD. The reset vector points to the location of the reset routine, in this case 8B4A, which <u>must be in this same physical ROM</u>.

Once the reset vector is fetched, the microprocessor begins execution of the reset routine (at location 8B4A for SUPERMON). Among other things, the reset routine initializes the stack pointer, initializes the status register, disables $\overline{POR}$, initializes system RAM, and jumps to the monitor.

Note that the power-on reset signal, $\overline{POR}$, is disabled by the program during the reset routine. However, at the time $\overline{POR}$ is disabled, the microprocessor is already fetching its instructions from locations in device U20 so the process proceeds smoothly.

To enable a different ROM at power-on-reset, jumpers 19 and 20 must be changed and a reset routine placed in the new ROM. As an example, consider the requirements for doing a power-on reset to to a 2K byte user program located in device U23, address space D000 to D7FF. First, $\overline{POR}$ would have to be rerouted from device U20 to device U23 by changing jumpers per Figure 1. (These jumpers are locate just above the socket for user supplied SY6422 VIA, device U28.)

1. Delete jumper from 19 to N.
2. Delete jumper from 20 to S.
3. Add jumper from 19 to S.
4. Add jumper from 20 to N.

FIGURE 1. JUMPER CHANGES

The final jumpers should be 19 to S and 20 to N, P, and R. Refer to Table 4-3 in the SYM Reference Manual for additional informati

Next, a new reset vector must be located in the device at locations D7FC and D7FD. This vector must point to a location within this device, say D700.

Finally, install a new reset routine at location D700 with steps to initialize the stack pointer, disable $\overline{POR}$, initialize the status register and system RAM (if used). Other features may be included here as required, such as initializing I/O ports, etc. As a last step in the reset routine, include a jump to the starting location of the user program. The listing in Figure 2 shows a sample reset routine. Also, refer to the listing of the SUPERMON reset routine (program location 8B4A) in the SYM Reference Manual.

NOTE: System RAM must be initialized if any SUPERMON subroutines are to be used.

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FIGURE 2. Sample Reset Routine

ADR	INSTRUCTIONS B1	B2	B3	LABEL	NMEMONIC	OPERAND	COMMENTS
						PCR1 = $A00C	
						ACCESS = $8B86	
						DFTBLK = $8FA0	
						RAM = $A620	
						* = $D700	
D700	A2	FF		RESET	LDX	#$FF	
D702	9A				TXS		; Initialize Stack Pointer
D703	A9	CC		POR	LDA	#$CC	
D705	8D	0C	A0		STA	PCR1	; Disable POR, tape off
D708	A9	04			LDA	#4	
D70A	48				PHA		
D70B	28				PLP		; Initialize Flags, disable IRQ
D70C	20	86	8B		JSR	ACCESS	; Un Write Protect System RAM
D70F	A2	5F		DFTXFR	LDX	#$5F	; Initialize System RAM
D711	BD	A0	8F		LDA	DFTBLK,X	
D714	9D	20	A6		STA	RAM,X	
D717	CA				DEX		
D718	10	F7			BPL	DFTXFR+2	
D71A	4C	X	Y		JMP	USER	; Jump to User Code
						* = $D7FC	
D7FC	00				.BYT	$00, $D7	
D7FD	D7						

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TECHNICAL NOTE

No. 59-SSC

January 24, 1979

SYM-1 MODIFICATION FOR INPUTTING LOWER CASE CHARACTERS

The normal input routine for SYM-1 converts all incoming alpha data from a terminal to upper case. This is useful in those cases where a terminal nomrally sends lower case alpha characters unless the shift key is held down.

In other cases, however, it is desirable to be able to input lower case characters; for example, to enter text and character strings in Synertek BASIC (BAS-1).

The following short routine bypasses the upper-case conversion and allows lower case alpha characters to be input to the SYM-1 for further processing. After entering the routine, the vector INVEC (location $A661) must be changed to point to the new routine. For example, for the routine given in the listing, change INVEC to point to $0FF0:

```
.SD 0FF0,A661
```

INVEC must be changed to point to the new location after each reset (RST key depressed). The program will not have to be re-entered, however, unless power is removed.

When using Synertek BASIC, be sure to allow space in memory for the new input routine. Since BASIC expects all values to be in decimal, 4K of RAM is actually 4096 bytes. Allowing 16 bytes for this routine (only 12 are actually used), we have available 4096 minus 16, or 4080 bytes of memory available. Therefore, when logging onto BASIC, answer the question "Memory size" with "4080."

Remember that after entering the new input routine and changing INVEC all commands to the SYM-1 and to BASIC will have to be entered in upper case letters only.

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PROGRAMMING SHEET

Program Title: LOWER CASE INPUT FOR SYM-1

Programmer:

Date:

Address	B1	B2	B3	Label	Nmemonic	Operand	Comments
						* = FFO	
OFFO	68				PLA		ALLOWS INPUTTING LOWER CASE
OFF1	68				PLA		ALPHA CHARACTERS TO
OFF2	20	58	8A		JSR	INTCHR	SYM-1 WITHOUT THEM BEING
OFF5	29	7F			AND	#$7F	CONVERTED TO UPPER CASE.
OFF7	C9	OD			CMP	#$OD	INVEC MUST BE CHANGED
OFF9	4C	3E	8A		JMP	RESXAF	TO POINT TO THIS ROUTINE
							USING "STORE DOUBLE" COMMAND
							SD OFFO, A661
							ASSUMES 4K OF RAM
							INSTALLED

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TECHNICAL NOTE
No. 72-SSC
April, 1978

CASSETTE DATA READING USING SYM-1 HIGH SPEED FORMAT

In most cases, the best setting for cassette-player controls is found by the sync-tape procedure (SYM Reference Manual, Appendix F), or simply by a small amount of experimentation. This note discusses topics and techniques for consistant cassette reading by determining the characteristics of your recorder and SYM-1 board. These methods utilize the advantages of SYM-1 SUPERMON V 1.1 but are also applicable using SUPERMON V 1.0.

READ TIMING OPTIMIZATION

In some cassette players, peculiarities of the frequency response affect the read waveform enough to cause inconsistent data reading. Such players need not be of poor quality--indeed, the units with good high-frequency response are sometimes the worst offenders. (Good high-frequency response is sometimes achieved at the expense of severe phase distortion. The human ear is not sensitive to phase distortion, but computer data circuits are.)

An indication of this sort of problem is a very narrow or non-existent range of control settings which provide reliable reading. In such a case, it may be possible to widen the satisfactory range by adjusting timing parameters in the read program. The programs shown in Figures 1 and 2 will assist the adjustment. A test pattern is generated with the Pattern Generator program, and the resulting tape is read by the Timing Measurement program to determine data timing and margins.

BIT WAVEFORMS

Figure 3 shows idealized pictures of the waveforms for a "0" bit and a "1" bit. During reading the squared waveform continually alternates states. The direction of the transitions, and the levels between transitions (high or low), are not important. The information is contained entirely in the time between transitions (regardless of their direction).

If one inter-transition time is about 730 microseconds, a "0" has just been read. If two inter-transition times add up to about 730 microseconds, a "1" has just been read. (Actually, the 1/0 decision is based on the first of the two inter-transition times. If the bit is a "1," the second time is ignored.)

Figure 3 is idealized because it ignores the distortions which can occur in a real cassette player. Variations in amplitude and phase shift with frequency distort the waveform. The distortions cause variations in the zero-crossing times of the analog waveform, and hence in the timing of the squared waveform. (An additional cause of timing distortion is tape-speed variation. See later in this note.)

When reading, the system distinguishes a "1" from an "0" by comparing the inter-transition time with a boundary value. If the time is less than the boundary value, the bit is a "1;"if greater, a "0." Sufficiently large timing distortions will convert a "1" to an apparent "0" or vice versa. This can occur at different volume and tone settings on your cassette recorder.

The timing boundary is normally set to its default value, which is the best compromise for most cassette players. However, it may be changed by the user if desired.* (It is restored to the default value after every power-on or Reset.) The two programs discussed in the following paragraphs provide guidance for such changes.

PATTERN GENERATOR PROGRAM

The Pattern Generator Program places a known, fixed test pattern on a tape. This pattern is required by the Timing Measurement Program, and may also be used for other purposes if desired.

The pattern consists of a contiguous series of 256-byte blocks, each containing all possible 8-bit combinations in order: 00, 01, ..., FE, FF. The pattern is preceeded by a string of SYNs and a * character.

The procedure for pattern generation is as follows:

1. Key in or read from tape the Pattern Generator Program (GEN).

2. Select the memory region to be used as temporary storage for the pattern. The region should have an integer number of 256-type pages, and should start on a page boundary (location xx00). It should not include pages 00, 01, or 02. It should be as long as possible, up to 15 or 20 pages, depending on available memory.

3. Using M commands, set the high byte of the regions start address into location $01, and the number of 256-byte blocks (pages) into location $02. (The low byte of the start address is always $00, and need not be entered.)

4. Start the program with a G command (normally at $2E2). The program will execute, filling the region with the pattern. If more than a few pages are filled, the pause due to execution will be perceptible.

5. Check two or three random locations in the region. The contents of the bytes should be equal to the low bytes of their addresses.

6. Write the test pattern to tape with a S2 command. Any file number may be used. The addresses will be the start and end of the memory region (xx00 to yyFF).

7. Rewind the tape. The pattern is now ready for use. You may wish to save the program on another tape.

NOTE: 1. To minimize the data to be keyed in, tape control is manual. If you have automatice control, remove the Remote plug, and start the tape at the same time you press CR for the S2 command.

2. If your recorder has capability to disable the automatic recording level circuit, you may have better results using a low-medium manual setting.

TIMING MEASUREMENT PROGRAM

The Timing Measurement Program reads the test-pattern tape, and calculates the following times:

MINT0--shortest "0" interval found in any byte of any block read
MAXT1A--longest "first part of a 1" found in any byte of any block read
MAXT1B--longest "second part of a 1" found in any byte of any block read

The times displayed are the number of 8-microsecond intervals in the time between transitions. For example, a value of 30 (hex) is 48 x 8 or 384 microseconds.

The optimum setting for the timing boundary (HSBDRY-- see monitor listing) is halfway between MINT0 and MAXT1A. If tape speed variations are suspected, this can be displaced somewhat toward MINT0, since most tape speed problems are slowdowns.* Conversion to microseconds is not requried; HSBDRY is in the same units as MAXT1A and MINT0.

Procedure for using the Timing Measurement Program is as follows:

1. Key in or read from tape the Timing Measurement Program (TIMEAS).

2. Place the test-pattern tape in cassette player.

3. Select the number of 256-byte blocks to be analyzed. This must be equal to or less than the number of such blocks in the test-pattern record.

4. Using the M command, store the desired number of blocks (hexadecimal) into location $26.

5. Start the program by a G200. The program will begin like an ordinary L2 read, with an S display. The S display will go out when the sync region is encountered. When the test pattern proper begins, a display consisting of only an underline in the first character will appear. Upon completion, this will disappear and the program will return to the monitor.

6. Display the results by an M command as follows:

   $20 - MINTO
   $21 - MAXT1A
   $22 - MAXT1B

7. If you wish to change HSBDRY for future reads, store the new value in $A632.* This must be restored after every power-on or Reset.

NOTE: Tape control is manual. See note on Pattern Generator procedure.

IMPORTANT: Repeated use of the program with different volume and tone control settings will make evident the setting with the best margins (Largest MINTO-MAXT1A difference).

In extreme cases, it may not be possible to synchronize well enough to turn out the S and turn on the underline. The program is not useful when this happens. In less extreme cases, the data may be invalidated by loss of an entire transition (or transition pair), or MAXT1A may be greater than MINTO. Control adjustment may sometimes show the proper direction for improvement in this case.

TAPE SPEED VARIATION

If the read waveform is reasonably good, with good timing margins, most tape speed variations are within the timing tolerance of the system. However, tight read-timing margins or excessive tape-speed variation can cause tape speed to be a significant factor in read errors.

Tape speed variation has two major causes: binding in the cassette and contamination in the roller and capstan mechanism. Slight binding in the cassette, due perhaps to unevenness in the way the tape winds on the reel, can cause occasional data errors. The effect is made worse by a dirty capstand or pinch roller, which allows some slippage when the tension increases because of binding.

Most cassettes will have occasional slight binding, especially after they have been used for a time. The higher the mechanical quality, the less likely this is to be a problem. Cassettes designed specifically for data processing are reported to be better in this respect

(Note that this need not have anything to do with the audio properties of the tape, which are what is usually thought of when cassette quality is mentioned.) Some improvement may be noticed when short tapes are used.

Cleaning of the capstan and pinch roller periodically will also help reduce speed variation.

The basic design and manufacture of the cassette player has some effect on speed variation, but this is usually a small factor. Wow and flutter which are large enough to be clearly audible are normally still small enough to have little effect on data read reliability.

TAPE DROPOUTS

Dirt, crinkling or creasing, and poor manufacturing control can cause momentary dropouts in a record. The dropout need not go all the way to zero amplitude to cause a data error--all it has to do is shift the apparent timing of one or more transitions. It may be inherent in the tape or temporary.

Again, tapes made for data processing will suffer less from this. Alternatively, it is possible to certify a tape before using it, by writing long records and assuring that they read back correctly.

The probability of a dropout is lower after the first ten to twenty seconds of a tape. (For this reason, the Kansas City standard uses a 30 second leader interval.) If desired, the parameter TAPDEL may be altered to change the length of the pre-data SYN interval.* TAPDEL (location $A630) is set to its default value of about 9 seconds at every power-on or Reset. It may be changed; each unit changes causes about 1.5 seconds additional delay.

MOTOR NOISE

Sometimes, the sync-tape process shows a wide range of control settings over which the reading is almost, but not quite, consistent Typically, if the controls are set to the center of the good range, the S display flashes occasionally--once per second to once per minute, usually irregularly. This may be due to excessive motor-noise pulses from the player motor.

In order to reduce the effect of this motor-noise, you may wish to install a capacitor from the input of the read comparator (U26 pin 3) to ground. Depending on the noise the value should be between .05uf to .1uf. One convenient place to install it is shown in Figure 4. Installation of this capacitor may effect the largest MINT0-MAXT1A difference as determined earlier from the Timing Measurment Program.

If the problem persists, suspect an incorrect location for the capacitor, a poor solder joint, or a bad capacitor. If none of these is the cause, try a different brand of cassette player. A small percentage of players has noise so bad that the capacitor does not eliminate its effects. The trial replacement player should preferable be one which has worked on another SYM.

* Values for HSBDRY and TAPDEL may be changes only in SUPERMON V 1.1.

TWENTY IMPORTANT CASSETTE RECORDING GUIDELINES

1. Use high quality tape (Maxell UD or equivalent).
2. Use shortest tapes possible. You can shorten tapes to several minutes in length if you enjoy splicing.
3. Use shielded cable between your computer and the cassette recorder.
4. Keep heads and pinch rollers clean.
5. Keep heads aligned for tape interchangability.
6. Avoid recording too close to beginning of tape.
7. Make sure cassette is properly seated in recorder.
8. If you have trouble with a cassette try another.You can have have a bad spot on tape or a warped cassette.
9. Highest setting of tone control is usually best.
10. A dirty recorder volume control can cause tape dropouts.
11. Make sure cassette connection plugs make good contact.
12. Rewind cassettes before removing them from recorder.
13. Store cassettes in dust-proof containers.
14. Avoid exposing cassettes to heat or magnetic fields.
15. Before recording, wind cassette to one end and fully rewind.
16. Cassette recorders will give you problems once in a while (They don't like certain cassettes, etc.). If one gives you problems most of the time replace it.
17. Make sure that MIKE plug is connected before recording. On most recorder the TAPE light will glow while recording.
18. You may have to record with the EAR plug out for some tape recorders.
19. Always use AC adaptor with recorder for best results.
20. When a tone control is available, adjust it to the highest possible setting (maximum treble).

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PROGRAMMING SHEET

Programmer: SSC

Program Title: TEST PATTERN GENERATION PROGRAM

Date: APRIL 21, 1979

1 OF 1

Address	Instructions B1	B2	B3	Label	Mnemonic	Operand	Comments
							; FILL MEMORY REGION WITH REPETITIVE
							; 00, 01, ..., FE, FF PATTERN
							; BEFORE STARTING, FILL "ADDRH" WITH HIGH
							; BYTE OF START ADDRESS, AND "PAGES" WITH
							; # OF 256-BYTE BLOCKS TO FILL. DATA REGION
							; MUST START ON A PAGE BOUNDARY. PROGRAM
							; CAN BE RELOCATED ANYWHERE.
							;
				ADDRL	= $00		
				ADDRH	= $01		
				PAGES	= $02		
					* = $02E2		
2E2	A9	00		GEN	LDA	#0	
2E4	AA				TAX		
2E5	A8				TAY		
2E6	85	00		BYTE	STA	ADDRL	
2E8	91	00			STA	(ADDRL), Y	
2EA	E8				INX		
2EB	8A				TXA		
2EC	D0	F8			BNE	BYTE	
2EE	E6	01			INC	ADDRH	
2F0	C6	02			DEC	PAGES	
2F2	D0	F2			BNE	BYTE	
2F4	60				RTS		

FIGURE 1 TEST PATTERN GENERATION PROGRAM

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PROGRAMMING SHEET

Program Title	Programmer	Date
	SSC	APRIL 21, 1979

Address	Instructions B1	B2	B3	Label	Mnemonic	Operand	Comments 1 OF 6
							;TAPE TIMING MEASUREMENT PROGRAM
							;START AT $0200
							;RESULTS APPEAR IN PAGE 0 MEMORY:
							; $20 = MINTO 8µs CTS IN MIN. "0"
							; $21 = MAXT1A 8µs CTS IN MAX 1ST
							; HALF OF "1"
							; $22 = MAXT1B 8µs CTS IN MAX 2ND
							; HALF OF "1"
							;
							;TEST TAPE:
							; NORMAL S2 RECORDING CONTAINING
							; ONE OR MORE 00, 01, ..., FE, FF
							; BLOCKS, EACH 256 BYTES LONG.
							;
							; BEFORE STARTING, "PASSES" (LOC. $26)
							; MUST BE SET TO THE DESIRED #
							; OF BLOCKS TO BE RUN. THIS MUST
							; BE ≤ # OF BLOCKS IN TEST RECORD.
							;
							; ANY VALUE OF "HSBDRY" WHICH ALLOWS
							; THE READ ROUTINE TO CAPTURE SYNC
							; MAY BE USED.
							;
							;

FIGURE 2 TAPE TIMING MEASUREMENT PROGRAM

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PROGRAMMING SHEET

Programmer: SSC

Program Title:

Date: APRIL 21, 1979

Address	B1	B2	B3	Label	Mnemonic	Operand	Comments
				TEMP	= $23		; BYTE
				BYTE	= $24		; EXPECTED BYTE
				PASS	= $25		; COUNT 256-BYTE BLOCKS
				PASSES	= $26		; MAX. "PASS"
							;
				LOADT	= $8C78		;
				LT7H	= $8CF5		; FOR V1.0 ($8CDE FOR V1.1)
							;
					*= $0200		
200	A9	00		TIMEAS	LDA	#0	
	85	23			STA	TEMP	
	85	24			STA	BYTE	; FIRST DATA BYTE WILL BE 0
	85	20			STA	MINTO	; INITIALIZE MAX & MIN TIMES
	A9	FF			LDA	#$FF	
	85	21			STA	MAXT1A	
	85	22			STA	MAXT1B	
	A5	26			LDA	PASSES	; INITIALIZE PASS COUNT
	85	25			STA	PASS	
	A0	80			LDY	#$80	; INITIALIZE H.S MODE
214	20	86	8B		JSR	ACCESS	; ALLOW MONITOR SUBROUTINE USE
							;
							;

Synertek Systems CORPORATION

PROGRAMMING SHEET

Program Title:

Programmer: SSC

Date: APRIL 21, 1979

Address	B1	B2	B3	Label	Mnemonic	Operand	Comments 2 OF 6
							; BEFORE STARTING, BLOCK MOVE
							; "LOADT" THRU "LT7H-1" TO
							; 217 - 27C (V1.0 MONITOR)
							; 217 - 27D (V1.1 MONITOR)
							; THIS IS:
							; .B 217-8C78-8CF4 (V1.0)
							; .B 217-8C78-8CDD (V1.1)
							;
							; PROGRAM REQUIRES MOST OF
							; PAGE 2 MEMORY
							;
				DIG	=$A400		; DISPLAY OUTPUT
				GETTR	=$8DB3		; FROM TAPE READ ROUTINE (V1.0)
							; GETTR = $8DCA (V1.1)
				ACCESS	=$8B86		; MONITOR WRITE ACCESS
				MODE	=$FD		; MODE MARK FOR LOADT
				BDRY	=$F8		; 0/1 BOUNDARY TIME FOR GETTR
							;
				MINTO	=$20		; COUNT MIN "0"
				MAXT1A	=$21		; COUNT MAX FIRST "1" HALF
				MAXT1B	=$22		; COUNT MAX SECOND "1" HALF
							;
							;
							;

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PROGRAMMING SHEET

Programmer: SSC

Program Title:

Date: APRIL 21, 1979

4 OF 6

Address	B1	B2	B3	Label	Mnemonic	Operand	Comments
							; BLOCK MOVE "LOADT" THROUGH "LT7H-1"
							; TO HERE
							;
							; .B 217-8C78-8CDE (V1.0 MONITOR)
							; .B 217-8C78-8CDE (V1.1 MONITOR)
							;
							;
217					.RES	LT7H-LOADT	; $7D IN V1.0 MONITOR
							;
							; AT END OF BLOCK MOVE, INSERT
							; NOP'S (EA's) OR INSERT A
							; JUMP TO NUBYT TO LOCATION 294
							; 027D 4C 94 02 (V1.1)
							;
294	A2	08		NUBYT	LDX	#8	; BIT COUNT & DISPLAY
296	8E	00	A4		STX	DIG	; DISPLAY UNDERLINE
299	20	B3 (CA FOR V1.1)	8D		JSR	GETTR	; PASS START BIT OF BYTE ("0")
29C	46	23		BIT	LSR	TEMP	; EXPECTED BIT
29E	B0	0E			BCS	ONE	; "1" OR "0"
2A0	20	B3 (CA FOR V1.1)	8D	ZERO	JSR	GETTR	; TIME FOR EXPECTED 0
2A3	38				SEC		; A = 255 - COUNT + BDY
2A4	E5	F8			SBC	BDRY	; A = 255 - COUNT
2A6	C5	20			CMP	MINTO	; COUNT < OLD MIN?
2A8	90	1C			BCC	NXTBIT	;

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PROGRAMMING SHEET

Programmer: SSC

Program Title:

Date: APRIL 21, 1979

Address	B1	B2	B3	Label	Mnemonic	Operand	Comments 5 OF 6
2AA	85	20			STA	MINTO	; YES, STORE NEW MIN. COUNT
2AC	B0	18			BCS	NXTBIT	
							;
2AE (A or 1.1)	20	B3	8D	ONE	JSR	GETTR	; TIME FOR EXPECTED FIRST HALF "1"
2B1	38				SEC		
2B2	E5	F8			SBC	BDRY	; A = 255 - COUNT
2B4	C5	21			CMP	MAXTIA	; COUNT > OLD MAX?
2B6	B0	02			BCS	ONE1	
2B8	85	21			STA	MAXTIA	; YES, STORE NEW MAX. COUNT
2BA (A or 1.1)	20	B3	8D	ONE1	JSR	GETTR	; REPEAT FOR SECOND HALF OF "1"
2BD	38				SEC		
2BE	E5	F8			SBC	BDRY	
2C0	C5	22			CMP	MAXTIB	
2C2	B0	02			BCS	NXTBIT	
2C4	85	22			STA	MAXTIB	
							;
2C6	CA			NXTBIT	DEX		; LAST BIT OF BYTE?
2C7	D0	D3			BNE	BIT	; NO, DO NEXT BIT
2C9	E6	24			INC	BYTE	; NEXT EXPECTED BYTE = OLD + 1
2CB	A5	24			LDA	BYTE	
2CD	85	23			STA	TEMP	; REFRESH SHIFTING BYTE
2CF	D0	C3			BNE	NUBYT	; IF NOT END OF PASS, DO NEXT BYTE
2D1	C6	25			DEC	PASS	; END OF PASS. LAST PASS?
2D3	D0	BE			BNE	NUBYT	

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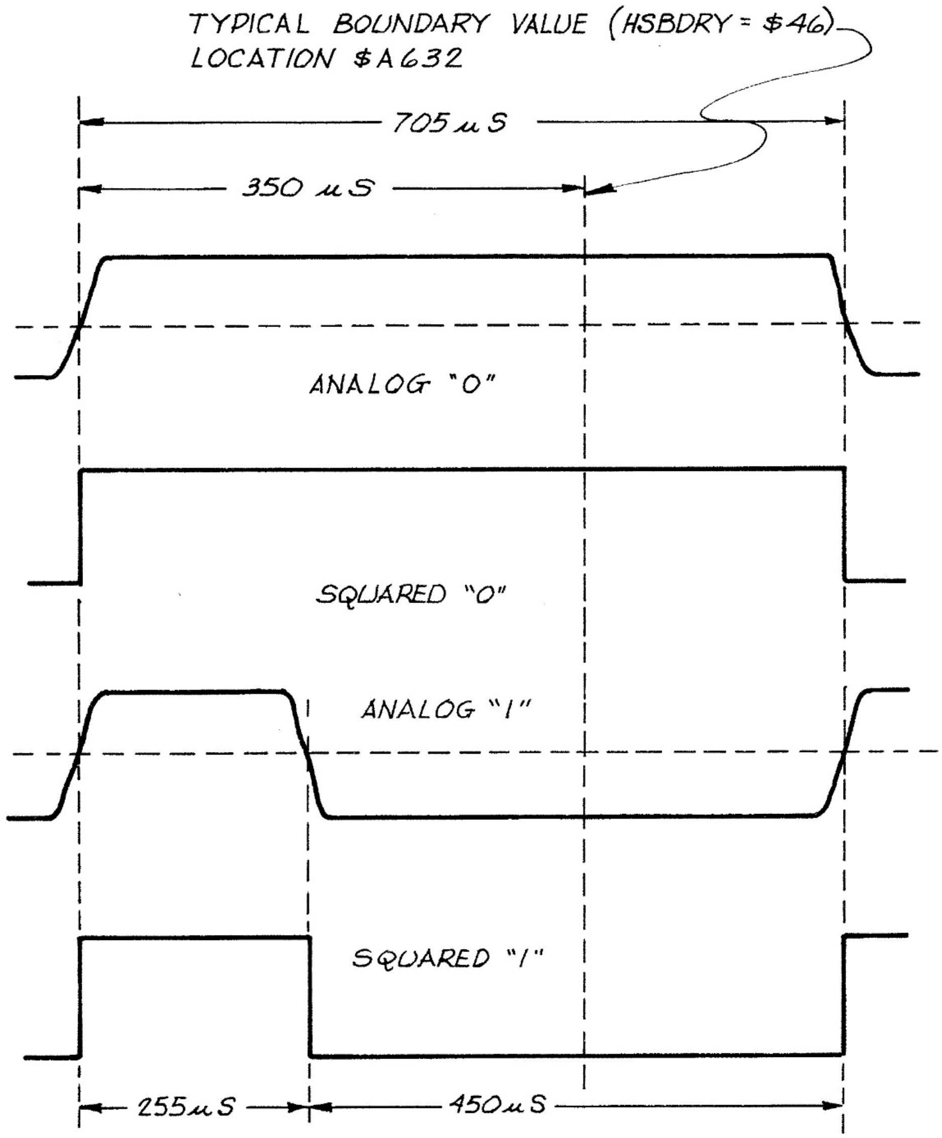
PROGRAMMING SHEET

Programmer: SSC

Program Title:

Date: APRIL 21, 1979

Address	B1	B2	B3	Label	Mnemonic	Operand	Comments 6 OF 6
							; MEASUREMENT DONE, CALCULATE
							; RESULTS
							;
2D5	A2	03			LDX	#3	; 3 RESULTS
2D7	38			CALC	SEC		; COUNT = 255 - (255 - COUNT)
2D8	A9	FF			LDA	#$FF	
2DA	F5	1F			SBC	MINTO-1, X	
2DC	95	1F			STA	MINTO-1, X	
2DE	CA				DEX		
2DF	D0	F6			BNE	CALC	
2E1	60				RTS		
							;
							; MONITOR RETURN KILLS UNDERLINE
							; DISPLAY



NAME	LOCATION	DEFAULT VALUE	DESCRIPTION
HSBDRY	A632	$46 (350 µS)	HS BOUNDARY
TAPET1	A635	$33 (255 µS)	HS FIRST HALF "1" BIT
TAPET2	A63C	$5A (450 µS)	HS SECOND HALF "1" BIT

Figure 3. Bit Waveforms

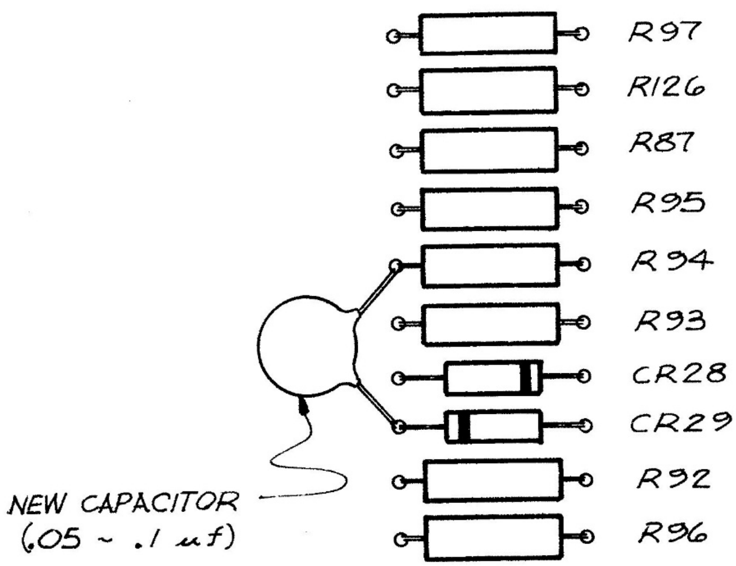


Figure 4. Motor Noise Capacitor Addition (Optional)

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