PPG-J and PPG-S Potentiometer Digitizer Kit Instructions

The Potentiometer Digitizer is a circuit which converts the position of two potentiometers into binary data that can be fed to, and interpreted by a microcomputer. The potentiometers may be conventional circular movement potentiometers, slide controls or potentiometers attached to a joystick. The digitizer's circuitry alternately converts each potentiometer's resistance into a seven bit binary count that is fed to your microcomputer thru the input side of a standard eight bit parallel interface. An updated value of each potentiometer's position is generated by the circuitry approximately fifty times a second. The eighth bit generated by the digitizer tells the computer which potentiometer's data is being presented. A "DATA READY" strobe and its compliment are generated by the circuitry making the board usable in either polling or interrupt driven computer systems.
This product as with all other Southwest Technical Products Corp. peripherals was designed to be as universal and as software independent as possible. All of the counting, timing and latching is done by hardware on the circuit board rather than software in the computer system. This not only makes the digitizer easier to use but saves computer time in an application where the computer needs all the time it can get just to update the graphics display. Interfacing can often be done thru the input side of the same interface that feeds the graphic terminal. If the graphic terminal is interfaced thru an eight bit parallel interface as is the SWTPC GT-61. Some applications will require the use of both the joystick and linear controls. In this case it will be necessary to use two separate digitizers with separate interfaces.
The entire unit is constructed on a 3" x 8" single sided circuit board. Since the voltage requirements for the board are a mere +12 to 18 VDC @ 20 ma., power for the board may be drawn from the computer system to which it is interfaced.

Circuit Board Assembly

Note: When assembling this kit, it is best that none of the components be soldered until all of the components of each group have been installed on the circuit board. This makes it much easier to interchange components if a mistake is made during assembly. Be sure to use a low wattage iron (not a gun) with a small tip. Do not use acid core solder or any type of paste flux. We will not guarantee or repair any kit on which either product has been used. Use only the solder supplied with the kit or a 60/40 alloy resin core equivalent.

( ) Clean the copper side of the printed circuit board with Scotchbrite[R] to remove the oxidation if there are any tarnished areas on the board.

( ) Install all fifteen of the jumpers on the circuit board. Solder.

( ) Install all of the resistors on the board excluding resistors R16 and R17. If you will be using the digitizer with the GT-61 Graphic Terminal, you may wish to use a different value of resistor for R6. See the "Inputting Data into your Computer" section of this instruction set. Solder.

( ) Install all of the capacitors on the circuit board. Be sure to orient electrolytic capacitor C10 to match with the outline shown in the component layout drawing. Solder.

( ) Install all of the diodes and transistors on the circuit board. Here again be sure to orient these components to match with the component layout drawing. Solder.

Note: MOS integrated circuits are susceptible to damage by static electricity. Although some degree of protection is provided internally within the integrated circuits, their cost demands the utmost in care. Before opening and/or installing any MOS integrated circuits you should ground your body and all metallic tools coming into contact with the leads, thru a 1 M ohm 1/4 watt resistor (supplied with the kit). The ground must be an "earth" ground such as a water pipe, and not the circuit board ground. As for the connection to your body, attach a clip lead to your watch or metal ID bracelet. Make absolutely sure you have the 1 Meg ohm resistor connected between you and the "earth" ground, otherwise you will be creating a dangerous shock hazard. Avoid touching the leads of the integrated circuits any more than necessary when installing them, even if you are grounded. On those MOS IC's being soldered in place; the tip of the soldering iron should be grounded as well (separately from your body ground) either with or without a 1 Meg ohm resistor. Most soldering irons having a three prong line cord plug already have a grounded tip. Static electricity should be an important consideration in cold, dry environments. It is less of a problem when it is warm and humid.

( ) Install the integrated circuits on the circuit board. Integrated circuits IC1 thru IC3 are not MOS but IC4 thru IC7 are and should be installed as directed in the note above. Be sure to orient the IC's as shown in the component layout drawing. Solder.

( ) Attach the fifteen pin female Molex connector to the edge of the circuit board. Solder.

( ) Insert the small nylon indexing plug into the female connector pin marked with a small triangle on the bottom side of the board.

( ) If you are building the joystick version of the digitizer, cut the four mounting tabs on the frame of the joystick using a pair of heavy duty wire cutters.

( ) Depending upon which version of the digitizer you have, attach either the joystick or the slide controls to the R16 and R17 positions on the circuit board. Solder.

( ) Carefully check the board over to be sure that all components have been installed correctly and that all connections have been soldered. This completes the PC board assembly.

How It Works

The joystick or potentiometer is wired as a voltage divider with its output going to an integrated, voltage to frequency converter. The voltage to frequency to converter (VFC for short) does just as its name implies. It generates a pulse output whose frequency is dependent upon the input voltage.

The relationship is linear so that no voltage in gives zero frequency out, maximum voltage in gives F_m frequency out and half voltage in gives $F_{m/2}$ frequency out. A separate VFC, IC1 and IC2, is provided for each potentiometer. A two input multiplexer alternately gates the output of either one or the other converter into seven bit counter, IC7. A separate timebase oscillator, IC3, constantly oscillates at a frequency of approximately 100 Hz. This oscillator's output is inverted by multiplexer IC5A where it appears as the "NEW DATA" strobe. Upon the negative transition of this strobe, seven bit counter IC7 is reset and starts counting at a rate dependent upon the frequency of the VFC being gated into the counter. Upon the positive transition of the "NEW DATA" strobe, six bit latch IC4 and D flip-flop IC6B latch onto and hold the counter's data until the completion of the next measuring cycle. This same positive transition flips D flip-flop IC6A to let the computer gate in the ouput of the other VFC and being that it is the V/H output lets the computer know which VFC data is being presented at its outputs. A logical one at the V/H output means the vertical or IC2 data is being presented while a logical zero at the output means that horizontal or IC1 data is being presented. Of course the vertical/horizontal terminology depends on the orientation of the circuit board so in this case vertical is defined to be in the same axis as the length of the board while horizontal is in the same axis as the width of the board. Power for the board is provided by two integrated on board regulators. One provides the 5 VDC required by the CMOS IC's while the other provides the +8 VDC power required by the two VFC's.

Attaching the Unit to your System

All connections to the board are made thru a fifteen pin connector along the edge of the circuit board. A minimum, twelve wire multiconductor or flat ribbon cable (not supplied with the kit) is recommended for connecting the board to the computer's parallel interface. The drivers on the digitizer are CMOS for simplicity and low power consumption and thus require that you kiip your interconnecting cable as short as possible. Do not try to drive a load greater than one standard TTL load with any of the data or data ready outputs. A chassis has not been provided for the digitizer since some users will wish to have more than one board mounted in the same enclosure.

Inputting Data into your Computer

New data is latched into the data holding registers IC4 and IC6B every time the "NEW DATA" line goes high and the "NEW DATA" line goes low. If you try to simultaneously latch this data into your computer's interface latches, you may have problems because the "NEW DATA" strobe gets to the interface before the new data does. This problem can best be solved by clocking data into your computer's interface on the falling edge of the "NEW DATA" strobe. If your interface will respond to rising edges only, then use the "NEW DATA" output. If you try to use the full seven bits that are output by the unit, you will not get valid data if the count is so high that it overflows and starts the counter over again. To avoid this problem, it is best to just use six of the seven available data bits and use the seventh bit to check for overflow. Having six bits will give you a miximum count of 111111_2 or 40_{16} which is more than enough resolution. When inputting data, you should first look at bit seven, the overflow bit, and if set, define the data as 40_{16} in your program.

This gives the unit 64_{10} vertical and 64_{10} horizontal data positions which is more than enough resolution for most applications.

If you are using the unit with the SWTPC GT-61 Graphic Terminal, you will find it advantageous to make the unit's vertical count a maximum of 96_{10} or 60_{16} rather than 40_{16} to match the vertical count of the GT-61 Graphic Terminal. This may be done by changing resistor R6 from a 6.8K ohm 1/4 watt resistor to a 4.7K ohm 1/4 watt resistor. You will then have to look at the full seven bits of data in your program and define the output as being 60_{16} if the count output is greater than 60_{16}.

Testing and Calibration

To calibrate the unit you will need to write a program to continually read and display the data outputs of the digitizer. You should then set the joystick control or potentiometers for maximum count and adjust potentiometers R14 and R15 for the maximum numerical count that you desire from the board. You will see a maximum one digit fluctuation in the count being displayed. This is normal and if it creates a problem in your particular application, it can be taken care of in software. A sample program for the SWTPC 6800 Computer System is listed and may be used for reference if you will be using the digitizer with a computer other than a SWTPC 6800.

Parts List – PPG Potentiometer Digitizer Kit

Resistors

___	R1	10K ohm 1/4 watt resistor
___	R2	100K ohm 1/4 watt resistor
___	R3	6.8K ohm 1/4 watt resistor
___	R4	10K ohm 1/4 watt resistor
___	R5	100K ohm 1/4 watt resistor
___	R6	6.8K ohm or 4.7K ohm 1/4 watt resistor (see instructions)
___	R7	4.7K ohm 1/4 watt resistor
___	R8	150K ohm 1/4 watt 1% resistor
___	R9	4.7K ohm 1/4 watt resistor
___	R10	4.7K ohm 1/4 watt resistor
___	R11	47K ohm 1/4 watt resistor
___	R12	2.2K ohm 1/4 watt resistor
___	R13	2.2K ohm 1/4 watt resistor
___	R14	5K ohm precision trimmer resistor
___	R15	5K ohm precision trimmer resistor
___	R16	10K ohm potentiometer on joystick or slide potentiometer
___	R17	10K ohm potentiometer on joystick or slide potentiometer
___	R18	2.2K ohm 1/4 watt resistor

Capacitors

___	C1	1000 pfd film capacitor
___	C2	0.01 mfd film capacitor
___	C3	0.022 mfd film capacitor
___	C4	1000 pfd film capacitor
___	C5	0.01 mfd film capacitor
___	C6	0.022 mfd film capacitor
___	C7	0.1 mfd film capacitor
___	C8	0.1 mfd disk capacitor
___	C9	1000 pfd film capacitor
___	C10*	33 mfd @ 25 VDC electrolytic capacitor

Note: All components flagged with a * must be oriented as shown in the component layout drawing.
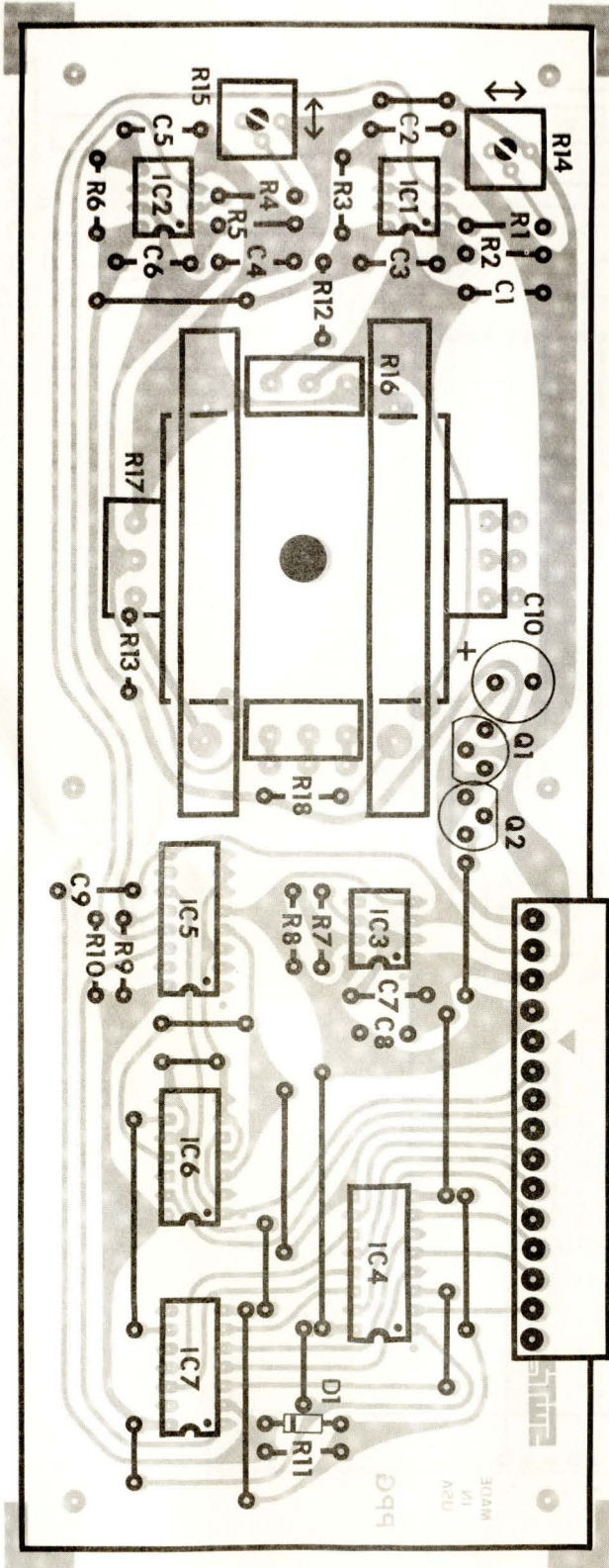
Diodes and Transistors

____ Q1*   78L08 voltage regulator
____ Q2*   78L05 voltage regulator
____ D1*   1N4148 silicon diode

Integrated Circuits

____ IC1*   4151 voltage to frequency converter (Raytheon)
____ IC2*   4151 voltage to frequency converter (Raytheon)
____ IC3*   555 timer integrated circuit
____ IC4*   4174 or 14174 6 bit latch
____ IC5*   4053 or 14053 triple 2input MUX
____ IC6*   4012B or 14013B dual D flip-flop
____ IC7*   4024 or 14024 7 bit counter

Note: All components flagged with a * must be oriented as shown in the component layout drawing.

R15

R14

C2

C5

IC2

R6

R4

R5

R3

IC1

C3

R1

R2

C1

C4

C6

R12

R16

R17

R13

C10

+

Q1

Q2

R18

C9

R9

R10

IC5

R7

R8

IC3

C7 C8

IC6

IC4

IC7

D1

R11

+12 to +18 IN
NEW DATA
GND
+5 OUT

V/H
bit 2
NEW DATA
bit 1
bit 0
bit 3
bit 4
bit 5
bit 6

PPG

POTENTIOMETER DIGITIZER

Wiring Diagram - Potentiometer Digitizer to Computer Interface

TO +12 to 18 VDC
ON THE COMPUTER
SYSTEM

I/O CABLE

+12 to +18 IN
NEW DATA
GND
+5 OUT
V/H
bit 2
NEW DATA
bit 1
bit 0
bit 3
bit 4
bit 5
bit 6

0
1
2
3
4
5
6
7
GND
C2 (OUT)
C1 (IN)

INPUT SIDE

OF COMPUTER'S

PARALLEL INTERFACE
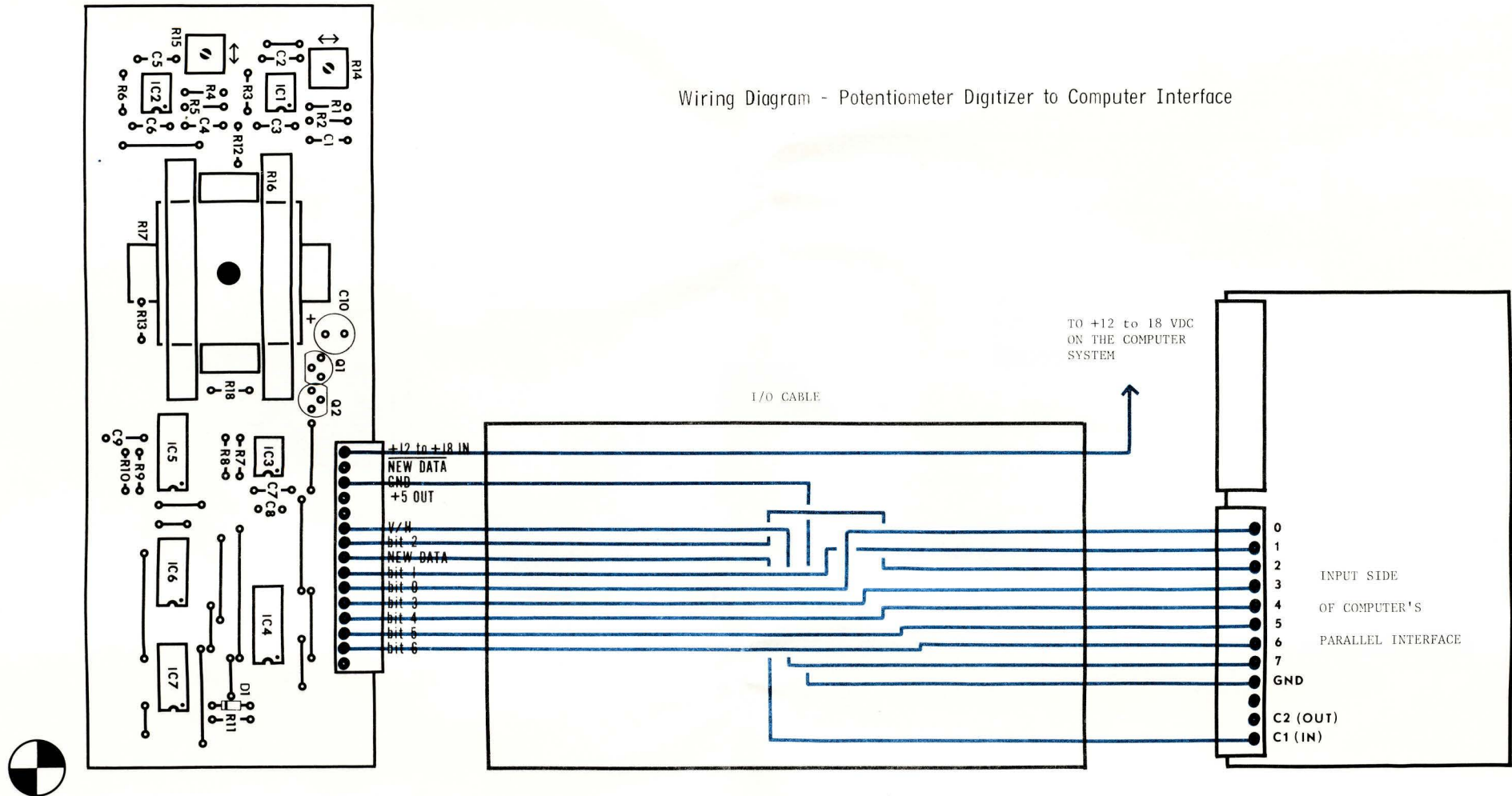
PPG Potentiometer Digitizer Diagnostic for the SWTPC 6800 Computer System PPGTST-1

This diagnostic is one designed to locate problems in, or calibrate the PPG Potentiometer Digitizer when it is interfaced to a SWTPC 6800 Computer System thru a MP-L Parallel Interface board. It is assumed that before loading this program, the rest of the system is functioning normally with no problems. The program itself uses 128 words of memory and it is meant to be loaded into the computer system's lower 2K memory board. The diagnostic may be loaded either from tape or instruction by instruction using Mikbug[R] starting from address 0020_{16} and going thru address $009F_{16}$. The address of the parallel interface to which the digitizer is attached must be loaded into addresses A002 and A003 using Mikbug[R] before the program is initiated. The most significant byte goes into A002 while the least significant byte goes into A003. The starting addresses of the various interface ports are given below:

Port	Address in Hex	
I/O #0	8000	
I/O #1	8004	(reserved for control interface)
I/O #2	8008	
I/O #3	800C	
I/O #4	8010	
I/O #5	8014	
I/O #6	8018	
I/O #7	801C	

The program counter addresses, A048 and A049, must also be set to 0020 before the program is initiated. The program may then be started as described in the "Go to User's Program" section of the Engineering Note 100 in the Operating System section of your yellow notebook. Once initiated, the program may be stopped only by depressing the "RESET" button. The program may then be restarted after resetting the program counter addresses to 0020_{16} and retyping a G for "Go to User Program".

The diagnostic reads the horizontal and vertical data being output by the digitizer and displays the data in hexidecimal form on the control terminal's display. The data is output in column form with the horizontal data first followed by the vertical data. The data is continually read and displayed for calibration and test purposes. As the digitizer control(s) are moved the data should change accordingly. The unit may be calibrated by setting the control(s) for maximum count and adjusting potentiometers R14 and R15 for the desired maximum numerical count which will usually be 40_{16} unless you are using the SWTPC GT-61 Graphic Terminal where you will want to make a resistor change on the digitizer as called for in its assembly instructions and set potentiometer R15 for a maximum count of 60_{16} instead of 40_{16}.

Don't forget when using the digitizer that it must get its power from the computer system to which it is interfaced, otherwise you won't get any data out of the unit. You can derive power from the SWTPC 6800 Computer System from the +12 buss available at the lower connector edge of the MP-L Parallel Interface board to which is is attached.

Never install or remove the interface board when the system is powered up. Doing so is not only hazardous to the equipment, but bypasses the normal power-up sequence required by the internal registers within the 6820 integrated circuit in order to guarantee proper operation. Also be careful when attaching the computer's +12 volt supply to the digitizer board since the +12 volt buss is not fused.

```
00010                               NAM     PPGTST-1
00020                               OPT     O
00030                               OPT     S
00040  0020                         ORG     $0020
00050  0020  CE 0085                LDX     #CLRSCN
00060  0023  BD E07E                JSR     PDATA1
00070  0026  86 3D      START   LDA A   #$3D
00080  0028  FE A002                LDX     PARADR
00090  002B  C6 00                  LDA B   #$00
00100  002D  E7 02                  STA B   2,X
00110  002F  A7 03                  STA A   3,X
00120  0031  A6 03      LOOP1   LDA A   3,X
00130  0033  84 80                  AND A   #$80
00140  0035  27 FA                  BEQ     LOOP1
00150  0037  A6 02                  LDA A   2,X
00160  0039  16                     TAB
00170  003A  84 80                  AND A   #$80
00180  003C  26 F3                  BNE     LOOP1
00190  003E  C4 7F                  AND B   #$7F
00200  0040  F7 0083                STA B   LOPOS
00210  0043  A6 03      LOOP2   LDA A   3,X
00220  0045  84 80                  AND A   #$80
00230  0047  27 FA                  BEQ     LOOP2
00240  0049  A6 02                  LDA A   2,X
00250  004B  16                     TAB
00260  004C  84 80                  AND A   #$80
00270  004E  26 08                  BNE     SKIP1
00280  0050  FE 0091                LDX     ERRSTR
00290  0053  BD E07E                JSR     PDATA1
00300  0056  20 D9                  BRA     LOOP1
00310  0058  C4 7F      SKIP1   AND B   #$7F
00320  005A  F7 0084                STA B   HIPOS
00330  005D  B6 0083                LDA A   LOPOS
00400  0060  BD E067   SKIP2   JSR     OUTHL
00410  0063  B6 0083                LDA A   LOPOS
00420  0066  BD E06B                JSR     OUTHR
00430  0069  BD E0CC   SKIP3   JSR     OUTS
00440  006C  B6 0084                LDA A   HIPOS
00510  006F  BD E067   SKIP4   JSR     OUTHL
00520  0072  B6 0084                LDA A   HIPOS
00530  0075  BD E06B                JSR     OUTHR
00540  0078  CE 008B   SKIP5   LDX     #CRLF
00550  007B  BD E07E                JSR     PDATA1
00560  007E  FE A002                LDX     PARADR
00570  0081  20 AE                  BRA     LOOP1
00580  0083  00         LOPOS   FCB     $00
00590  0084  00         HIPOS   FCB     $00
00600  0085  0D         CLRSCN  FCB     $0D,$0A,$10,$16,$00,$04
       0086  0A
       0087  10
       0088  16
       0089  00
       008A  04
00610        A002       PARADR  EQU     $A002
```

```
00620 008B OD          CRLF    FCB     $0D, $0A, $00, $00, $00, $04
      008C 0A
      008D 00
      008E 00
      008F 00
      0090 04
00630 0091 53          ERRSTR  FCC     /SEQUENCE ERROR/
      0092 45
      0093 51
      0094 55
      0095 45
      0096 4E
      0097 43
      0098 45
      0099 20
      009A 45
      009B 52
      009C 52
      009D 4F
      009E 52
00640 009F 04                  FCB     $04
00670 A048                     ORG     $A048
00680 A048 0020                FDB     $20
00690 A002                     ORG     $A002
00700 A002 801C                FDB     $801C
00710      E07E       PDATA1   EQU     $E07E
00720      E067       OUTHL    EQU     $E067
00730      E06B       OUTHR    EQU     $E06B
00740      E0CC       OUTS     EQU     $E0CC
00750                          END
START  0026
LOOP1  0031
LOOP2  0043
SKIP1  0058
SKIP2  0060
SKIP3  0069
SKIP4  006F
SKIP5  0078
LOPOS  0083
HIPOS  0084
CLRSCN 0085
PARADR A002
CRLF   008B
ERRSTR 0091
PDATA1 E07E
OUTHL  E067
OUTHR  E06B
OUTS   E0CC

TOTAL ERRORS 00000
```
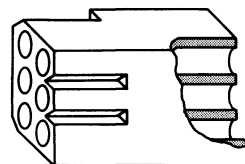
Connector Reference Sheet

In order to avoid confusion in distinguishing between the various connectors supplied with our many kits, we are including this connector reference sheet with the kit instruction set. We have had a great many customers interchange the male and female connector shells when assembling their kits so we have clearly illustrated each connector along with its proper name and gender on this reference sheet. All are shown actual size.
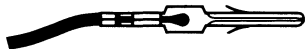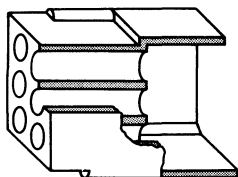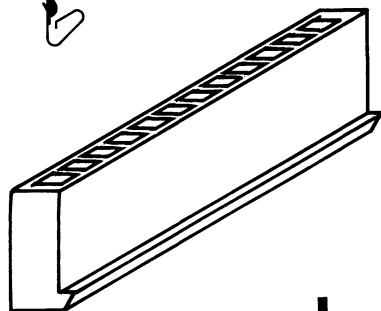
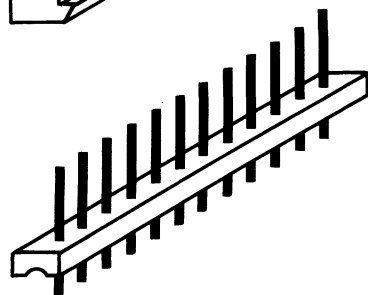Male Pin   Molex Female Shell Connector   Molex Male Shell Connector   Female Pin
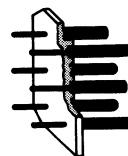
Pin for Harness Connector
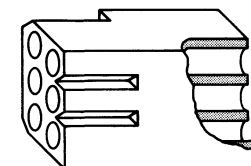
Harness Connector

Molex Wafercon ®   Molex Male Shell Connector

Straight Pin
Edge Connector

Male Solder Tail Pin
PC Type

Female Solder Tail Pin
PC Type