

### **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 graphics terminal is interfaced thru an eight bit parallel interface as is the SWTPC G-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 @20ma., power for the board may be drawn from the computer 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 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.

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- ( ) 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 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 infrequency 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 output 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/vertical 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 Ifs 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 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 keep 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 latabi 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 maximum count of  $11111_2$ , 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  $9610$  or  $6016$  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

Diodes and Transistors

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

Integrated Circuits

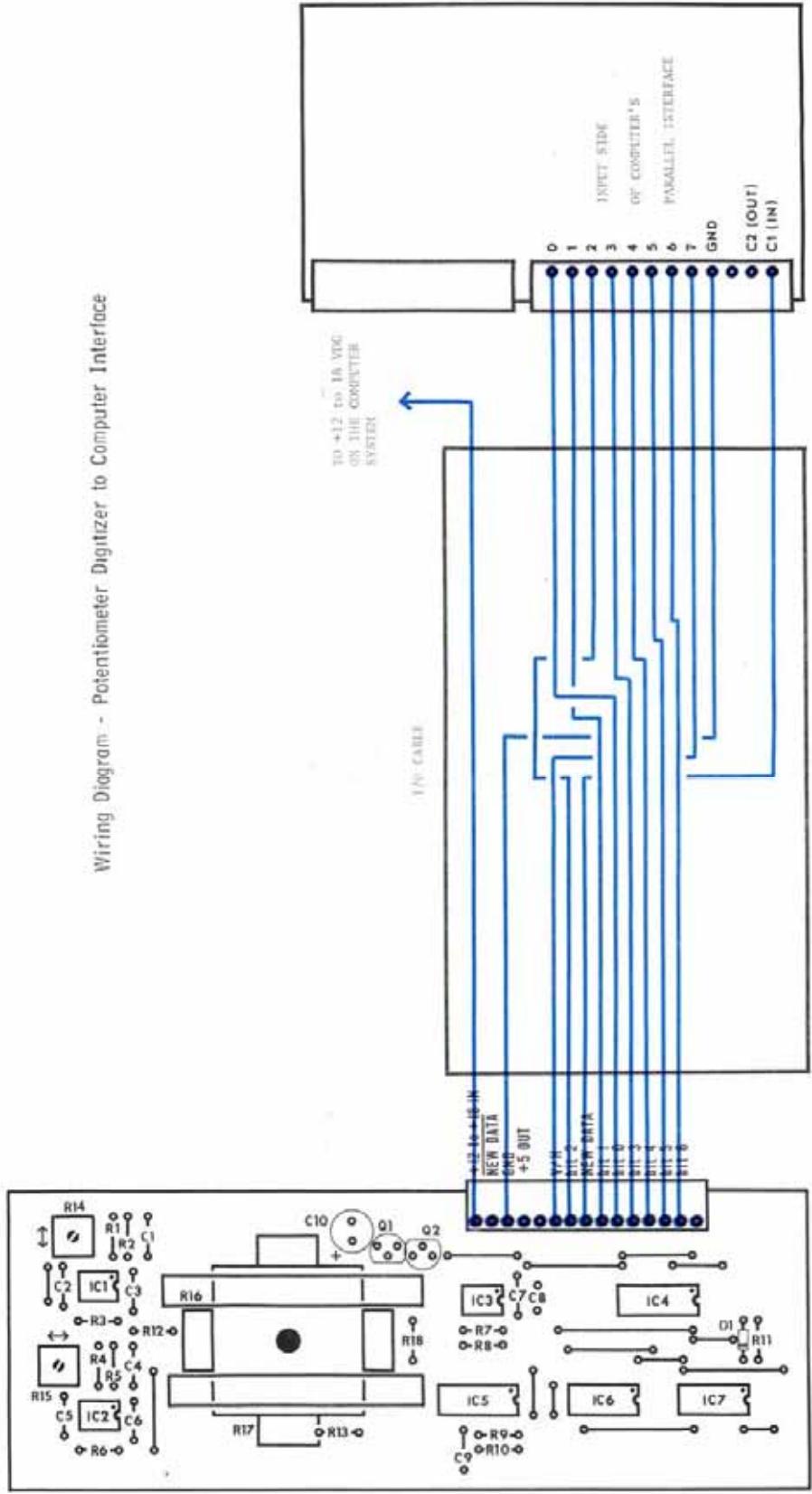
- IC1\* 4151 voltage to frequency converter (Raytheon)
- IC2\* 4151 voltage to frequency converter (Raytheon)
- IC3\* 555 timer integrated circuit
- IC4\* 4174 or 14174 6 bit latch
- IC5\* 4053 or 14053 triple 2input MUX
- IC6\* 4012B or 14013B dual D flip-flop
- IC7\* 4024 or 14024 7 bit counter

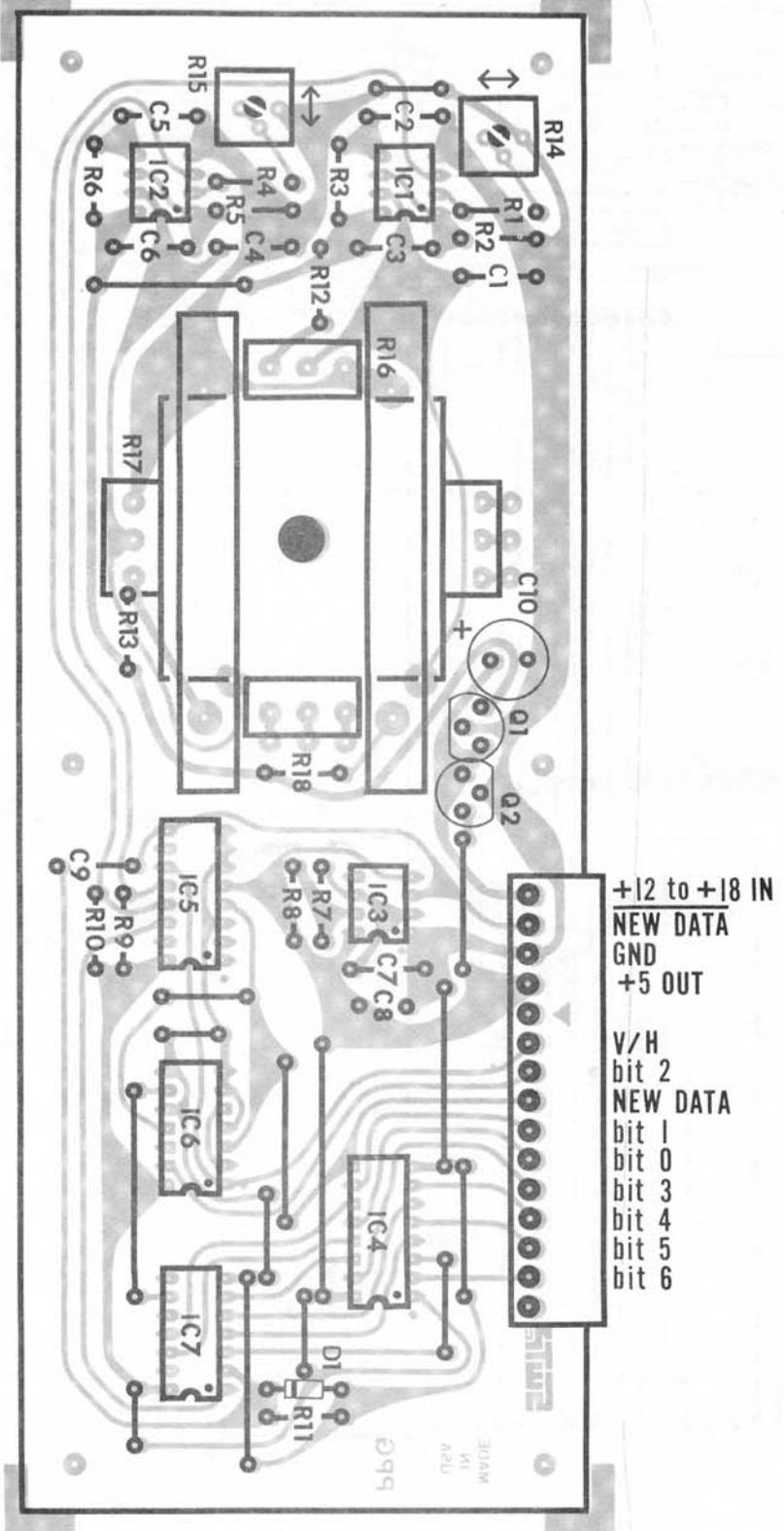
Note: All components flagged with a \* must be oriented as shown in the component layout drawing.

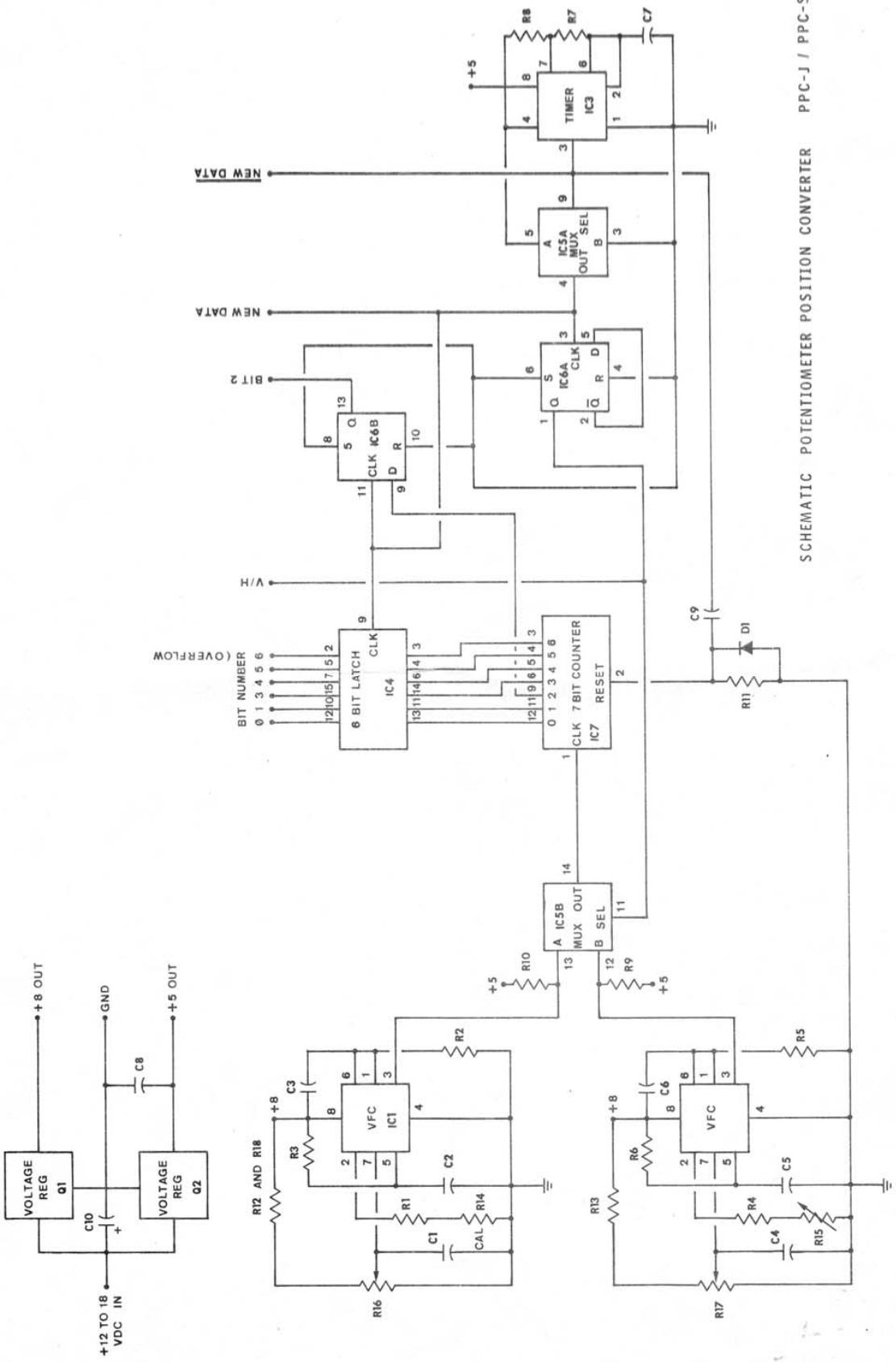


POTENTIALS FOR DIGITALISATION

## Wiring Diagram - Potentiometer Digitizer to Computer 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 starting from address 002016 and going thru address 009F16. The address of the parallel interface to which the digitizer is attached must be loaded into addresses A002 and A003 using Mikbug 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<sub>16</sub> 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 hexadecimal 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<sub>16</sub> 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<sub>16</sub> instead of 40<sub>16</sub>.

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 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.

		NAM	PPGTST-1
0020		ORG	\$0020
0020 CE 00 85		LDX	#CLRSCN
0023 BD E0 7E		JSR	PDATA1
0026 86 3D	START	LDA A	#\$3D
0028 FE A0 02		LDX	PARADR
002B C6 00		LDA B	#\$00
002D E7 02		STA B	2,X
002F A7 03		STA A	3,X
0031 A6 03	LOOP1	LDA A	3,X
0033 84 80		AND A	#\$80
0035 27 FA		BEQ	LOOP1
0037 A6 02		LDA A	2,X
0039 16		TAB	
003A 84 80		AND A	#\$80
003C 26 F3		BNE	LOOP1
003E C4 7F		AND B	#\$7F
0040 F7 00 83		STA B	LOPOS
0043 A6 03	LOOP2	LDA A	3,X
0045 84 80		AND A	#\$80
0047 27 FA		BEQ	LOOP2
0049 A6 02		LDA A	2,X
004B 16		TAB	
004C 84 80		AND A	#\$80
004E 26 08		BNE	SKIP1
0050 FE 00 91		LDX	ERRSTR
0053 BD E0 7E		JSR	PDATA1
0056 20 D9		BRA	LOOP1
0058 C4 7F	SKIP1	AND B	#\$7F
005A F7 00 84		STA B	HIPOS
005D B6 00 83		LDA A	LOPOS
0060 BD E0 67	SKIP2	JSR	OUTHL
0063 B6 00 83		LDA A	LOPOS
0066 BD E0 6B		JSR	OUTHR
0069 BD E0 CC	SKIP3	JSR	OUTS
006C B6 00 84		LDA A	HIPOS
006F BD E0 67	SKIP4	JSR	OUTHL
0072 B6 00 84		LDA A	HIPOS
0075 BD E0 6B		JSR	OUTHR
0078 CE 00 8B	SKIP5	LDX	#CRLF
007B BD E0 7E		JSR	PDATA1
007E FE A0 02		LDX	PARADR
0081 20 AE		BRA	LOOP1
0083 00	LOPOS	FCB	\$00
0084 00	HIPOS	FCB	\$00
0085 0D	CLRSCN	FCB	\$0D,\$0A,\$10,\$16,\$00,\$04
0086 0A 10			
0088 16 00			
008A 04			

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A002          PARADR  EQU    $A002
008B 0D      CRLF     FCB    $0D,$0A,$00,$00,$00,$04
008C 0A 00
008E 00 00
0090 04
0091 53      ERRSTR   FCC    / SEQUENCE ERROR/
0092 45 51
0094 55 45
0096 4E 43
0098 45 20
009A 45 52
009C 52 4F
009E 52

009F 04          FCB    $04
A048          ORG    $A048
A048 00 20      FDB    $20
A002          ORG    $A002
A002 80 1C      FDB    $801C
E07E          PDATA1 EQU    $E07E
E067          OUTHL   EQU    $E067
E06B          OUTHR   EQU    $E06B
E0CC          OUTS    EQU    $E0CC
A004          END
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