PAIA®

ELECTRONICS, INC.

8780

EQUALLY TEMPERED DIGITAL TO ANALOG CONVERTER

The multiplying principle on which the PAIA 8780 Equally Tempered Digital to Analog converter is based allows binary input data to be directly converted to equally tempered control voltages without the need for look-up tables, exponential converters or other peripheral devices.

The 8780 accepts 8 bits of data, of which the least significant 6 are converted to a control voltage while the most significant two are reserved for trigger flags.

This module provides for easy interface of PAIA or other linear response synthesizer elements to computers or can be used with a digitally encoded keyboard to provide a digital replacement for the more common analog Sample and Hold devices.

SPECIFICATIONS

Nominal Power	5v. @ 100 ma. ± 9v. @ 15 ma.
C.V. Output Range	5v. to .05 volts
DATA Input	6 bits for control voltage (least significant) 2 bits for flags (most significant)

SOLDERING

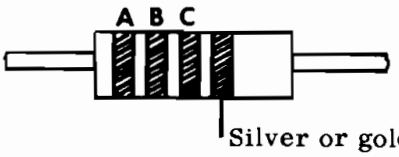
Use care when mounting all components. Use only rosin core solder (acid core solder is never used in electronics work). A proper solder joint has just enough solder to cover the round soldering pad and about 1/16-inch of the lead passing through it. There are two improper connections to beware of: Using too little solder will sometimes result in a connection which appears to be soldered but actually there is a layer of flux insulating the component lead from the solder bead. This situation can be cured by reheating the joint and applying more solder. If too much solder is used on a joint there is the danger that a conducting bridge of excess solder will flow between adjacent circuit board conductors forming a short circuit. Unintentional bridges can be cleaned off by holding the board upside down and flowing the excess solder off onto a clean, hot soldering iron.

Select a soldering iron with a small tip and a power rating not more than 35 watts. Soldering guns are completely unacceptable for assembling transistorized equipment because the large magnetic field they generate can damage solid state components.

CIRCUIT BOARD ASSEMBLY

( ) Prepare the large circuit board for assembly by thoroughly cleaning the conductor side with a scouring cleanser. Rinse the board with clear water and dry completely.

Solder each of the fixed resistors in place following the parts placement designators printed on the circuit board and the assembly drawing figure 1. Note that the fixed resistors are non-polarized and may be mounted with either of their two leads in either of the holes provided. Cinch the resistors in place prior to soldering by putting their leads through the holes and pushing them firmly against the board. On the conductor side of the board bend the leads outward to about a 45° angle. Clip off each lead flush with the solder joint as the joint is made.



Silver or gold - disregard this band.

DESIGNATION	VALUE	COLOR CODE A-B-C
( ) R1	68K	blue-grey-orange
( ) R2	100K	brown-black-yellow
( ) R3	68K	blue-grey-orange
( ) R4	100K	brown-black-yellow
( ) R5	68K	blue-grey-orange
( ) R6	100K	brown-black-yellow
( ) R7	68K	blue-grey-orange
( ) R8	100K	brown-black-yellow
( ) R9	68K	blue-grey-orange
( ) R10	100K	brown-black-yellow

DESIGNATION	VALUE	COLOR CODE A-B-C
( ) R11	68K	blue-grey-orange
( ) R12	100K	brown-black-yellow
( ) R13	2200 ohm	red-red-red
( ) R14	2200 ohm	red-red-red
( ) R15	2200 ohm	red-red-red
( ) R16	2200 ohm	red-red-red
( ) R17	2200 ohm	red-red-red
( ) R18	2200 ohm	red-red-red
( ) R19	2200 ohm	red-red-red
( ) R20	2200 ohm	red-red-red
( ) R21	22K	red-red-orange
( ) R22	22K	red-red-orange
( ) R23	22K	red-red-orange
( ) R24	22K	red-red-orange
( ) R25	22K	red-red-orange
( ) R26	22K	red-red-orange
( ) R27	22K	red-red-orange
( ) R28	22K	red-red-orange
( ) R29	330 ohm	orange-orange-brown
( ) R30	330 ohm	orange-orange-brown

NOTE: Not all fixed resistors are used on the circuit board. The remaining resistors will be installed later.

( ) Using the bare wire provided form and install the twenty-one (21) wire jumpers as indicated by the solid lines in figure 1 and printed on the circuit board.

Install the ceramic disk capacitor. Without exception the value will be marked on the body of the part.

DESIGNATION	VALUE
( ) C2	.01 mfd.

Up to this point all components have been non-polarized and either lead could be placed in either hole provided without effecting operation of the unit. Electrolytic capacitors are polarized and must be mounted so that the "+" lead of the capacitor goes through the "+" hole in the circuit board. In the event that the "-" lead of the capacitor is marked rather than the "+" lead it is to go through the unmarked hole in the circuit board.

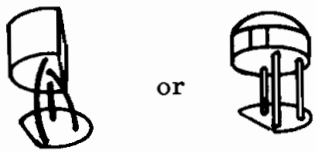
Note that the operating voltage (v.) specified for a capacitor is the minimum acceptable rating. Capacitors supplied with specific kits may have a higher voltage rating than that specified and may be used despite this difference. For instance, a 100 mfd. 25v. capacitor may be used instead of a 100 mfd. 16v. capacitor without affecting the operation of the circuit. Mount the following electrolytic capacitors and solder them into place. The values, voltage rating, and polarization are marked on the body of the part.

DESIGNATION	VALUE
( ) C1	33 mfd. 16v.
( ) C3	100 mfd. 25v.

Install the transistors. Orient as illustrated in figure 1 and the parts placement designators printed on the circuit board. All semiconductors are heat sensitive and may be damaged if allowed to get too hot while soldering. To be on the safe side, heat sink each transistor lead during the soldering operation by grasping it with a pair of needle nose pliers at a point between the circuit board and the body of the transistor.

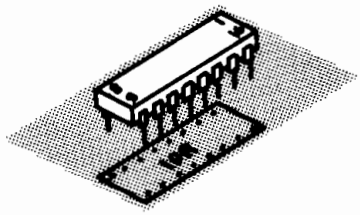
DESIGNATION	TYPE NUMBER
( ) Q1	2N5129
( ) Q2	2N5129
( ) Q3	2N5129
( ) Q4	2N5129
( ) Q5	2N5129
( ) Q6	2N5129
( ) Q7	2N5129
( ) Q8	2N5129
( ) Q9	2N5129
( ) Q10	2N5129
( ) Q11	2N5129
( ) Q12	2N5129
( ) Q13	2N5129
( ) Q14	2N5129

NOTE: The 2N5129 transistors used in this kit may be supplied in one of two different case styles. Install these devices as illustrated below.



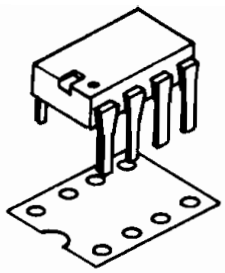
Install the resistor network. Note that this component is installed so that the pin numbers printed on the case of the component agree with the pin numbers printed on the circuit board. Make sure that the orientation is correct before soldering. Once the unit is in place it cannot be removed without destroying it.

DESIGNATION
( ) ICR



Install the integrated circuits. Note that a properly oriented integrated circuit will have a square notch or dimple at one end of the case that aligns with the semicircular designator printed on the circuit board. Use extreme care when installing integrated circuits. Like other semiconductors they are heat sensitive and should not be exposed to high heat for an extended period of time. Make sure that the integrated circuit is properly oriented before soldering it in place, as these units cannot be removed without destroying them.

NOTE: The integrated circuits used in this kit are MOS units that are extra sensitive to static electricity. When installing these units observe the following precautions. Do not wear synthetic materials such as nylon or rayon. Immediately before installing the IC's, touch a cold water pipe, or other source of good ground. Also touch the soldering iron tip to a grounded point. After all of the static electricity has been discharged, remove the IC from its holder, insert into the circuit board, and solder into place. Avoid excessive motion during this operation to keep static build-up to a minimum. Most manufacturers are installing static discharge paths in the IC itself, but we recommend these precautions for added safety.



DESIGNATION	TYPE NUMBER
( ) IC1	4042 Quad Latch
( ) IC2	4042 Quad Latch
( ) IC3	4066 Bilateral Switch
( ) IC4	4066 Bilateral Switch
( ) IC5	4136 Operational Amplifier

In the following steps wires will be soldered to the 8780 D/A circuit board which in later steps will connect to the 8780 LED circuit board. At each step prepare the wire by cutting it to the specified length. Strip away 1/4-inch of insulation and "tin" one end by twisting the exposed strands together and melting a small amount of solder into the wire. This will be the end that will be soldered to the 8780 D/A circuit board. Prepare the remaining end by stripping away 1/16-inch of the insulation and "tinning" the exposed strands. This end will attach to the 8780 LED circuit board in later steps.

Using the insulated wire provided make the following connections to the 8780 D/A circuit board:

( ) A 1-3/8" length to point "A".
( ) A 1-3/4" length to point "B".
( ) A 1-1/2" length to point "C".
( ) A 2-3/4" length to point "D".
( ) A 3-1/2" length to point "E".
( ) A 3-1/4" length to point "F".
( ) A 3" length to point "G".
( ) A 2-3/4" length to point "H".
( ) A 1-1/4" length to point "J".

Prepare the following wires by stripping away 1/4-inch of insulation and "tinning" both ends. These wires will connect to various controls and jacks on the front panel in later steps.

Again, using the insulated wire provided make the following connections to the 8780 D/A circuit board:

( ) A 2-3/4" length to point "K".
( ) A 3-1/2" length to point "L".
( ) A 5-1/4" length to point "M".
( ) A 1-1/2" length to point "Vout".
( ) A 2-1/4" length to point "Vref".

NOTE: The component labeled "*" will be explained later in the testing and calibration text.

THIS COMPLETES ASSEMBLY OF THE 8780 D/A CIRCUIT BOARD. Temporarily lay the board aside and proceed to the mounting of the front panel controls and jacks. Place the front panel face down on a soft cloth to prevent marring the finish.

( ) Place the red pin jack J1 in the hole provided as shown in figure 2 and fasten in place with a tinnerman nut as shown in detail drawing figure 3. Orient the tinnerman nut as shown and press down firmly.

( ) In a similar manner mount the red pin jack J2, orient as shown, and fasten in place.

( ) Locate the 9-lug terminal strip provided and cut as illustrated in detail drawing figure 4.

Install the diode, D9, as illustrated in detail drawing figure 4. Note that this part is polarized and must be installed so that the banded lead connects to lug #2 of the terminal strip.

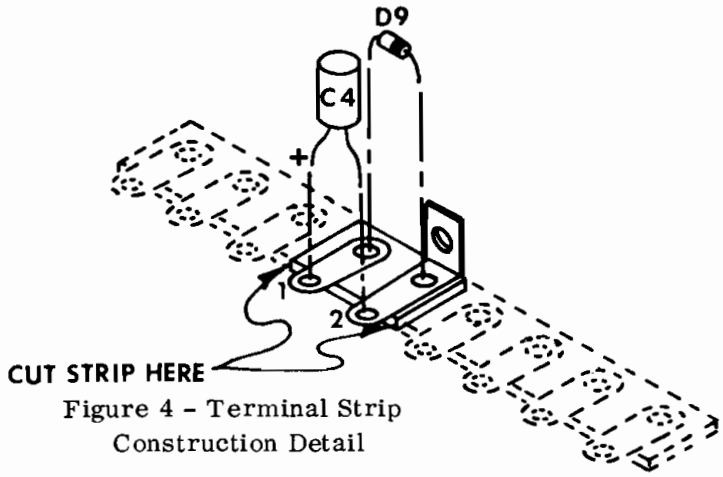


Figure 4 - Terminal Strip Construction Detail

DESIGNATION	TYPE NUMBER
( ) D9	1N914 or 1N4148

( ) Install the 2.2 mfd. 10v. electrolytic capacitor C4. Note that all cautionary notes regarding the installation of electrolytic capacitors on the circuit board apply here also. Install so that the positive (+) lead of the capacitor is attached to lug #1 of the terminal strip, and the negative (-) lead is attached to lug #2. DO NOT SOLDER AT THIS TIME.

( ) Prepare the 8780 LED circuit board for assembly by thoroughly cleaning the conductor side with a scouring cleanser. Rinse the board with clear water and dry completely.

( ) "Tin" the soldering pads numbered 1 through 9 by melting a small amount of solder onto them.

( ) Using one 4-40 X 1/4" machine screw, one 4-40 nut and one #4 internal lock washer, attach the terminal strip to the 8780 LED circuit board as shown in figure 5.

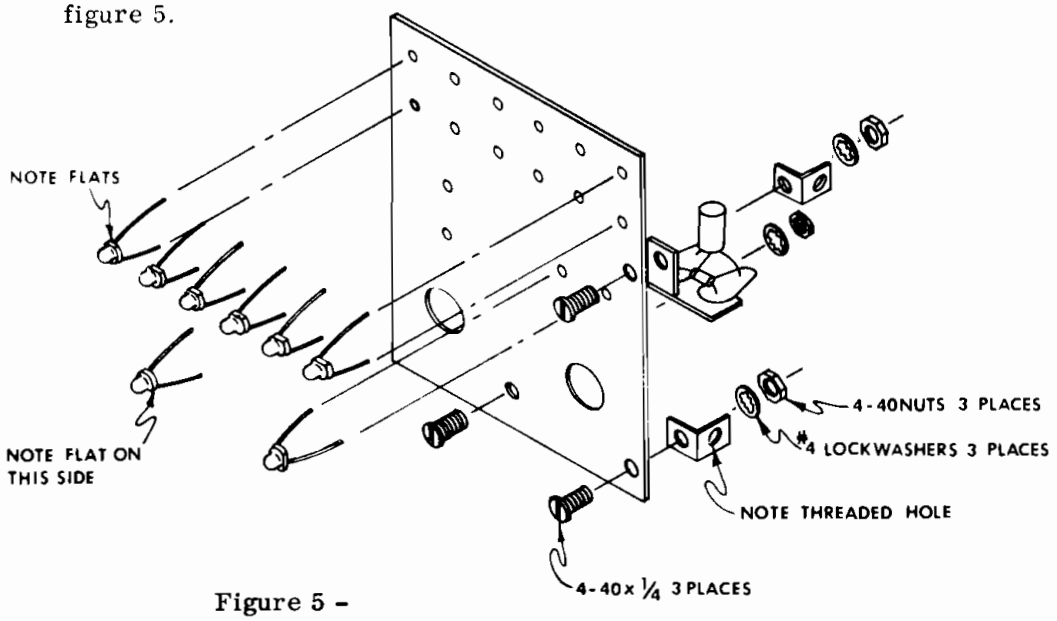


Figure 5 -
8780 LED Circuit Board Construction Detail

( ) Using two 4-40 X 1/4" machine screws, two 4-40 nuts, and two #4 internal lock washers attach the two "L" brackets as shown in figure 5.

( ) Install the eight light emitting diodes (LED's), D1 through D8, as illustrated in figure 5. Note that these parts are polarized and must be installed correctly in order to operate properly. These parts should be installed so that the cathode side, as identified by a flat on one side of the case, goes in the hole marked "-" on the conductor side of the circuit board. Do not attempt to push the LED's all the way against the circuit board. Doing so will crack the epoxy case of the LED rendering it inoperable. Leave a gap of approximately 1/16" between the base of the LED's and the 8780 LED circuit board as shown in figure 6. DO NOT SOLDER AT THIS TIME.

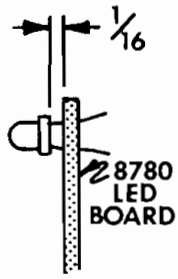


Figure 6

( ) Slip the LED circuit board over the pin jacks J1 and J2, as illustrated in detail figure 3. Using a piece of resistor lead clipping or other such tool move the individual LED's around until all eight LED's align with their respective holes in the front panel. Push the LED board on until all eight LED's protrude through the front panel, and fasten in place with two tinnerman nuts as shown in detail drawing figure 3.

( ) Solder all eight LED's in place. Note that these parts are heat sensitive and should not be subjected to high temperatures for any longer than necessary to achieve a good solder connection.

( ) Connect the wire coming from circuit board point "J" to pad #7 of the 8780 LED board.

PROCEED TO THE TESTING OF THE LED's. Refer to figure 7.

( ) Install a flea clip in the hole marked "+5" on the rear redge of the 8780 D/A circuit board.

( ) Using a clip lead connect the "+" terminal of a 9v. battery, or 5v. power supply, to the point marked "+5".

( ) In a similar manner connect one end of a clip lead to the "-" terminal of the battery or power supply, and connect the remaining end to a 680 ohm (blue-grey-brown) resistor.

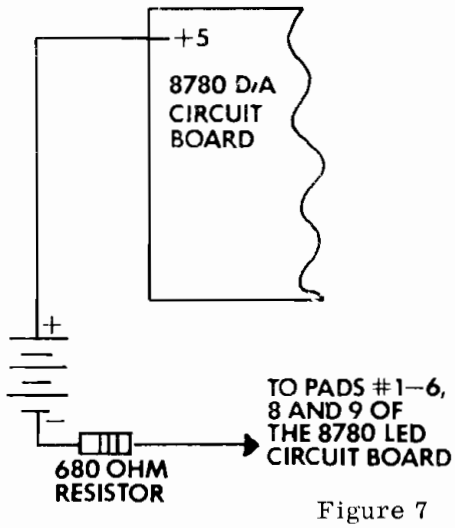


Figure 7

( ) Touch the free end of the 680 ohm resistor to pads #1 - #6, #8, and #9, skipping #7, of the 8780 LED board noting that as each pad is touched the corresponding LED lights. If all eight LED's light according to the instructions proceed to the assembly of the remaining front panel components. If difficulty is encountered contact PAIA Electronics - Tech. Service Dept.

( ) Using a tinnerman nut install the red pin jack J3.

( ) Mount the 75K ohm potentiometer R34 as shown in figure 2. Use two 3/8" nuts, one behind the front panel as a spacer, and the second on the front side of the front panel to secure the potentiometer. Adjust the rear nut so that none of the threaded shaft is exposed when the front nut is tightened down. This will allow the control knob, which will be mounted in a later step, to seat as closely as possible to the front panel. Orient as shown.

( ) Attach a 1K resistor (brown-black-red), R33, to lugs #1 and #3 of potentiometer R34, as shown in detail drawing figure 2. DO NOT SOLDER.

( ) Attach a 1K ohm resistor (brown-black-red), R32, to lug #1 of potentiometer R34, and lug #1 of the terminal strip. SOLDER TWO WIRES AT LUG #1 OF R34 ONLY.

( ) Attach a 680 ohm resistor (blue-grey-brown), R35, to lug #3 of potentiometer R34, and lug #2 of the terminal strip. SOLDER TWO WIRES AT LUG #3 OF R34 ONLY.

( ) Press the 1/2" rubber grommet into place in the hole provided in the front panel.

( ) Using two 4-40 X 1/4" machine screws mount the 8780 D/A circuit board to the front panel as shown in figure 8.

( ) Attach a 4700 ohm resistor (yellow-violet-red), R31, to point "N" on the 8780 D/A circuit board and lug #1 of the terminal strip. SOLDER BOTH PLACES.

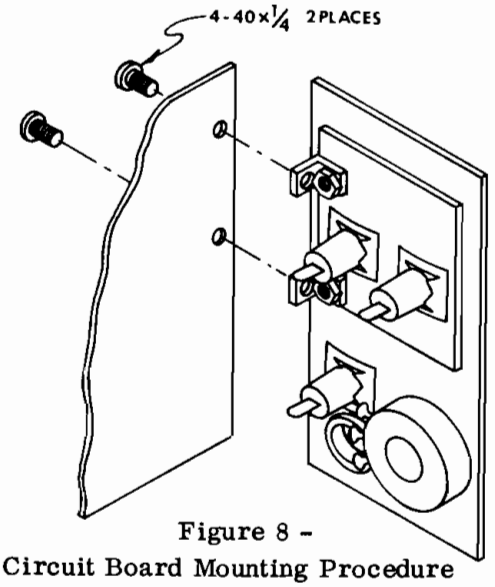


Figure 8 - Circuit Board Mounting Procedure

REFERRING TO FIGURE 2 MAKE THE FRONT PANEL CONNECTIONS AS FOLLOWS. NOTE: In the following steps final connections will be made between the 8780 D/A circuit board and the 8780 LED circuit board. Note that the wire will not pass through the LED board, but will merely be "tacked" to the soldering pad.

( ) Connect the wire coming from point "A" to pad #1 of the 8780 LED board. SOLDER.

( ) Connect the wire coming from point "B" to pad #2 of the 8780 LED board. SOLDER.

( ) Connect the wire coming from point "G" to pad #8 of the 8780 LED board. SOLDER.

( ) Connect the wire coming from point "C" to pad #3 of the 8780 LED board. SOLDER.

( ) Connect the wire coming from point "F" to pad #6 of the 8780 LED board. SOLDER.

( ) Connect the wire coming from point "D" to pad #4 of the 8780 LED board. SOLDER.

( ) Connect the wire coming from point "E" to pad #5 of the 8780 LED board. SOLDER.

( ) Connect the wire coming from point "H" to pad #9 of the 8780 LED board. SOLDER.

( ) Connect the wire coming from point "K" to lug #2 of the terminal strip. SOLDER THREE WIRES.

( ) Connect the wire coming from point "L" to pin jack J1. SOLDER.

( ) Connect the wire coming from point "M" to pin jack J2. SOLDER.

( ) Connect the wire coming from point "Vout" to pin jack J3. SOLDER.

( ) Connect the wire coming from point "Vref" to lug #2 of potentiometer R34. SOLDER.

( ) Install the twelve (12) remaining flea clips into the holes along the rear edge of the 8780 D/A circuit board. SOLDER TWELVE PLACES.

( ) Rotate the shaft of the potentiometer R34 fully counter-clockwise as viewed from the front of the front panel.

( ) Once the control knob is installed it will be difficult to remove. Before installing the knob align the pointer so that it points to the 7 o'clock position.. Push the knob firmly onto its shaft.

THIS COMPLETES ASSEMBLY OF THE 8780 EQUALLY TEMPERED D/A CONVERTER. PROCEED TO THE TESTING AND CALIBRATION SECTION.

PRELIMINARY TESTING

Complete functional tests of the PAIA 8780 Equally Tempered Digital to Analog converter will have to wait until the unit is interfaced to the computer or dedicated system with which it is to operate.

Test procedures for the module interfaced to computer systems is covered in this manual in the section headed "Comprehensive Testing". Test procedures for the module interfaced to dedicated systems (8782 Encoded Keyboard, etc.) is covered in the instruction manuals for those devices.

But, before interfacing to either computer or dedicated system, the following preliminary checks can be performed:

Apply a power souce to the terminals on the rear edge of the 8780 module marked "+5" and "⏚". NOTE that while these terminals are marked as being for a 5 volt supply, these pins power only the CD4042 input latches and front panel LED indicators. While this power supply must be consistent with the DATA source interfaced to the 8780, it does not have to be 5 volts. The CMOS logic used in this module can be powered by any DC source for 3 to 15 volts.

DO NOT MAKE ANY POWER CONNECTIONS TO THE PINS MARKED "+9" and "-9" AT THIS TIME.

Temporarily (with a clip lead or other removable jumper) connect the 8780's $\overline{RDY}$ pin to the pin marked "⏚". With power applied to the module's as described above, temporarily connect each of the DATA lines (D_0-D_7) first to the "+5" pin (check to see that the LED corresponding to the DATA line being tested is lit) and then to the "⏚" pin (check to see that the LED corresponding to the DATA line being tested is extinguished). THE STATE OF OTHER LED's NOT BEING DIRECTLY CHECKED DURING THIS PROCEDURE IS UNDEFINED. They may be fully on or fully off or dim. This test checks only one data line at a time.

Having determined that all of the latches are passing data properly you may now connect the 8780's $\overline{RDY}$ line to the pin marked "+5" to check for the holding condition of the latches.

With the 8780 $\overline{RDY}$ line connected to the positive supply ("+5"), the front panel LED's will be in a random condition - some may be on, others off. While temporarily connecting each DATA line (D_0-D_7) first to the "+5" pin and then to the "⏚" pin; check to make sure that none of the LED's change state. This test verifies that the latches and LED's are working properly.

INTERFACING

OVERVIEW

The 8780 has been designed for ease of interfacing to any computer/micro-processor whether fitted with parallel I/O ports or not. The biggest single contributor to this ease of interfacing is the use of CMOS 4042 latches at the input of the D/A. Unlike the more common "D" type flip-flops, the 4042 type latch circuit is not edge triggered. The significance of this is that 4042's can be put in a "pass" state and in this mode of operation data passes directly through the latches without the need for clocking the $\overline{RDY}$ line.

CONNECTORS

Since it is impossible to know in advance the type of system with which the 8780 will be used, there are no connectors supplied with this kit. Connectors should be chosen to be consistent with the computer system being used.

POWER

The 8780 requires two power sources, one for the input latches and LED's ("+5" and "⏚" on the rear edge of the module) and a second for the analog portion of the module ("+9" and "-9").

> UNDER NO CIRCUMSTANCES SHOULD THE DATA SOURCE THAT IS CONNECTED TO THE DATA INPUT TERMINALS (D_0-D_7) OF THE 8780 BE OPERATING FROM A POWER SUPPLY OF GREATER VOLTAGE THAN THAT SUPPLYING THE LOGIC POWER TO THE 8780. Logic inputs with a greater voltage than that of the 8780 logic supply run a chance of burning out the input latches.

The analog supply will typicly be derived from one of the PAIA power supplies. This must be a double ended supply and should preferably be ±9v., though any balanced double ended supply providing from 7 to 15 volts may be used. This

analog supply need not be heavily filtered as the op-amps used in the analog portion of the circuitry have in excess of 130db of supply rejection.

While only one "⏚" pin is provided on the rear of the 8780 module, THERE MUST BE A COMMON GROUND BETWEEN THE LOGIC SUPPLY AND THE ANALOG SUPPLIES.

When interfacing the 8780 to a computer/micro-processor system you will be faced with one of two situations; either the manufacturer of the machine will have made provision of I/O ports, or there will be no such provision.

Of the two cases, the machines with output ports are obviously the easier to interface.

Typical of the machines with provision for an output port is the 6800 type processor based system manufactured by Southwest Technical Products. The specific provisions that SWTP has made is a parallel interface card sold under their catalog designation MP-L. This interface card is based on an LSI Peripheral Interface Adapter (PIA) and is capable of doing a lot more things than we need done.

Since the PIA contains latches to hold the data that is to be output, the latches on the 8780 are not needed any may be put in the "pass" state by grounding the $\overline{RDY}$ line with a short jumper between the $\overline{RDY}$ and "⏚" pins on the rear edge of the circuit board.

Connections between the 8780 and SWTP MP-L, then, consist simply of tying each data input line of the 8780 to the corresponding data output line of the MP-L (output lines of the MP-L are designated with an O). D_0 ties to O_0, D_1 to O_1, etc.

A slight modification that you may wish to make to the MP-L is to arrange for the computer's +5v. logic supply to appear on the MP-L output connectors. This can easily be accomplished by using the SWTP designated "index" pin. Using a piece of #22 or heavier wire make a connection from this index pin to the output side of the voltage regulator IC2.

The complete connection between the MP-L and 8780 will then appear as in figure 9.

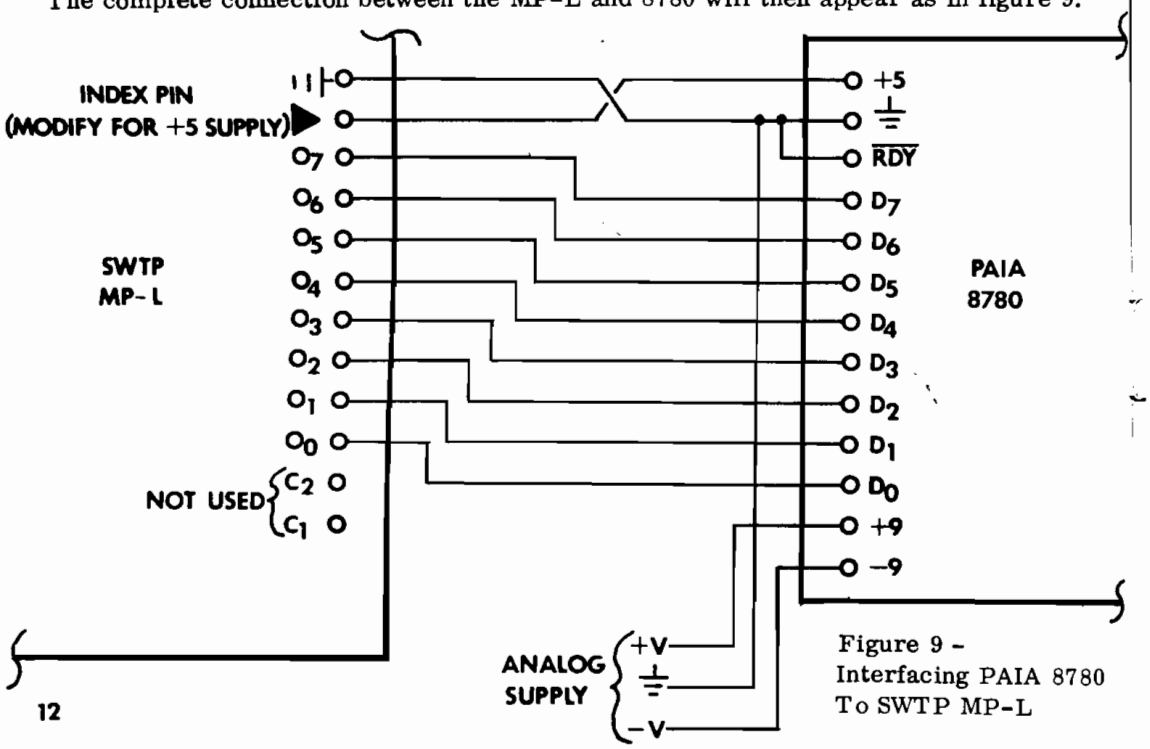


Figure 9 - Interfacing PAIA 8780 To SWTP MP-L

Essentially this same scheme will work with processors whose output ports are nothing more than addressed latches strapped to the data buss. Typical of this type of machine is the 6502 base Familiarizor manufactured by EBKA.

Here again, power for the 8780 input logic should be derived from the processor but in the case of this unit will have to be done on an outboard connector. As with the SWTP system, there is a one-to-one correspondence between the DATA input lines of the 8780 and the DATA output lines of the processor.

NOTE: Units that have output ports based on 7442 type latches may require pull-up resistors on the output DATA lines in order for the TTL output to properly drive the 8780's CMOS input. These resistors should be about 4700 ohms and are connected from each DATA line to the positive logic supply as shown in figure 10.

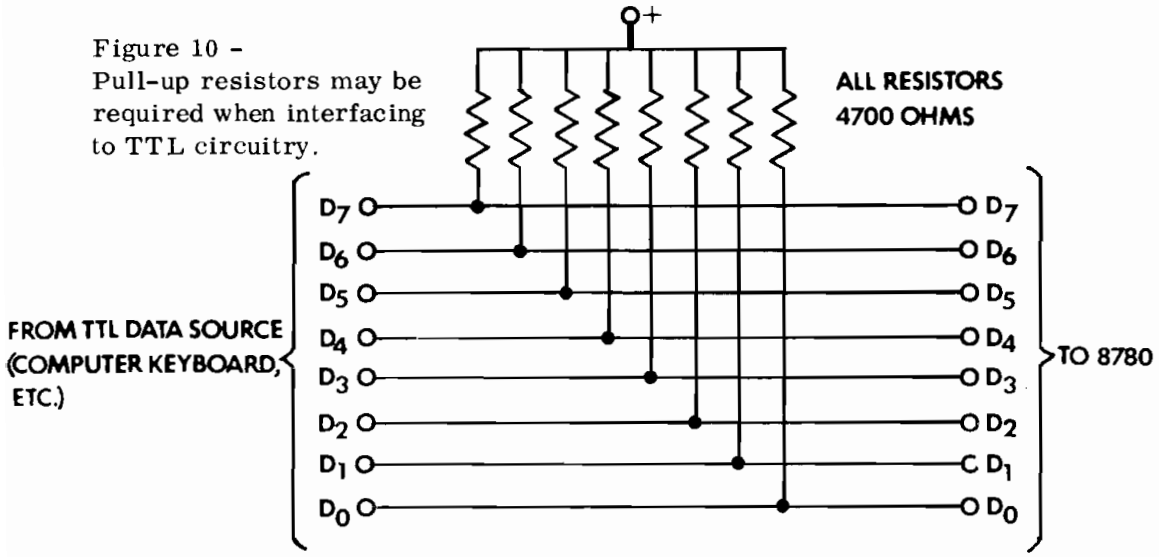


Figure 10 -
Pull-up resistors may be required when interfacing to TTL circuitry.

By far the most challenging situation will be interfacing the 8780 to machines whose manufacturers have made no provision for I/O ports. An example of this type of machine is National Semiconductor's SC/MP ("SCAMP") kit. This machine not only has no provision for parallel output ports, because of it's straight line addressing scheme, there are no "empty" memory slots available, even though the processor has only 512 bytes of ROM and 256 bytes of RAM.

A possible solution to this problem would be to completely re-do the SC/MP kit address decoding scheme. This is not tremendously complicated and can be most easily implemented with a TTL 7442 Decade Decoder tied on to the 4 most significant bits of the address lines.

There is a far easier way, however, and the trick is applicable to most microprocessors. Like most modern "computer kits", the SC/MP has a PROM that is programmed with a monitor program that allows for easy entry of users programs into memory, modification of memory and (in this case) operating routines for serial (teletype) data input and output.

In every system that has such a PROM (or ROM), the address(es) occupied by the PROM may be used as an output port. They are, after all, Read Only Memories which cannot be written into with a normal STORE command. There is no reason for these locations not to serve double duty.

In the SC/MP kit, this modification consists of adding a single TTL quad NOR gate package (7402) to NOR together the Write Select line (NWDS on the SC/MP) and the PROM Chip Select (address bit 9 in the SC/MP). A second gate from the package is used as inverter to provide the 8780 with its $\overline{RDY}$ signal as shown in figure 11.

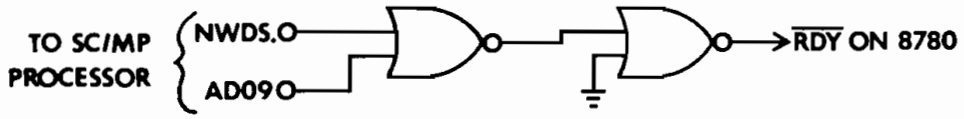


Figure 11 - This simple addition allows the PROM address of a SC/MP to be used as an output port.

The SC/MP's unbuffered data lines are not directly CMOS capatible and consequently must have 4700 ohm pull-up resistors as shown in figure 10. In some small systems such as this you will have to buffer the data lines using (for example) a DM81LS95.

COMPREHENSIVE TESTING

With the 8780 interfaced to a processor, we are ready to perform comprehensive functional tests. NOTE: Testing procedures for 8780's interfaced to PAIA supplied dedicated systems (8782 Encoded Keyboard, EK-3 Encoder Experimenter's Kit, etc. are covered in the manuals provided with the controlling system.

A quick test of the functioning of the 8780 can be performed by writing a short program to simply count into the converter in binary. A flow chart for this type of program is shown on the right.

Specific program listing for the 6800, 6502 and SC/MP systems are included in the appendix.

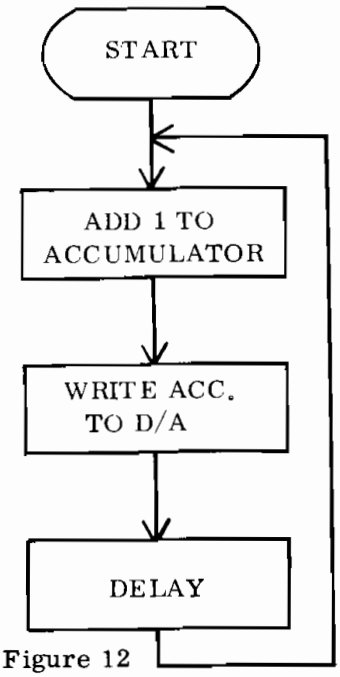


Figure 12

With this program, either a VCO and audio amplifier or an oscilloscope may be used to verify that there are no gross problems in the converter circuitry. With the program running and the Control Voltage of the 8780 applied to a VCO playing through an amplifier the result should be a succession of 64 tones increasing in pitch. At the end of the 64th tone, the VCO should step back to the lowest pitch and begin again. If the delay is long enough you should also be able to watch the trigger flags as they change state after each complete cycle of the pitch increase. If working properly, the two flags (1 - D_6 and 2 - D_7) should follow the 2 bit binary sequence.

FLAGS		
2 (D_7)	1 (D_6)	
0	0	both off
0	1	flag 1 high
1	0	flag 2 high
1	1	both high

By decreasing the delay, the exponential ramp produced by the 8780 can be viewed on an oscilloscope and should appear as shown below:

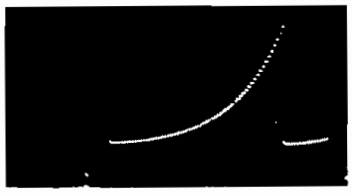


Figure 13

The important points in this trace are that 64 events constitute a complete cycle of the ramp, and that the increases from one step of the ramp to the next increase uniformly.

NOTE: Some processors (such as the 6502) have provision to work either in straight binary or in BCD. The machine MUST BE SET TO WORK IN THE BINARY MODE FOR THE TEST SHOWN ABOVE TO OPERATE PROPERLY.

The tempering of the D/A may be tested using a VCO, test bench oscillator and oscilloscope as follows:

Configure the test oscillator, VCO and 'scope as shown below:

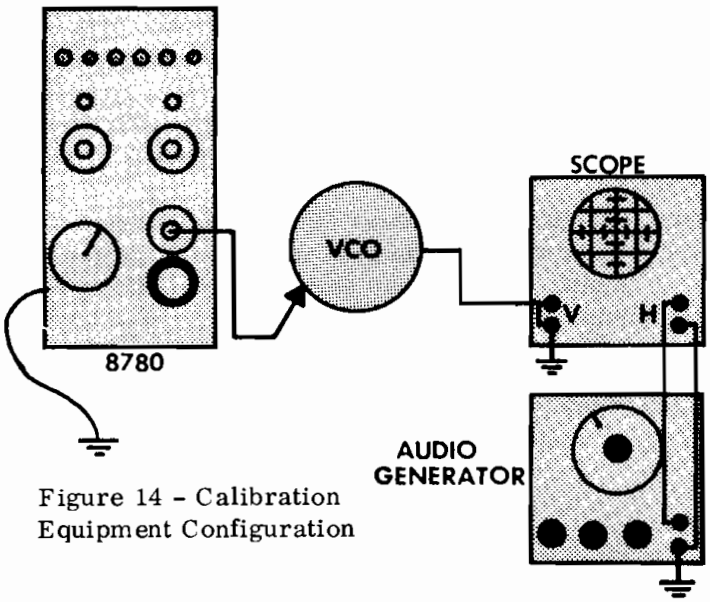


Figure 14 - Calibration Equipment Configuration

This arrangement will produce lissajous figures. Set the test bench oscillator for a frequency of 260 Hz. and using the computer's monitor (or other means as appropriate) write a $1B_H$* into the location occupied by the D/A. Set the pitch knob of the 8780 fully clockwise and adjust the pitch knob of the VCO being used to produce the pattern shown in figure 15 indicating that the VCO is producing a frequency exactly half that of the test oscillator.

*This is meant to imply hexadecimal notation.

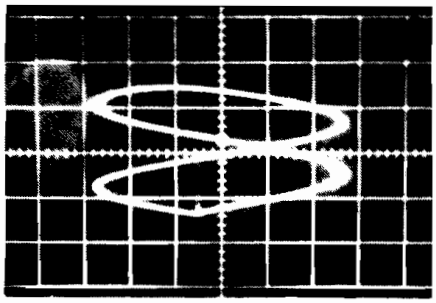


Figure 15

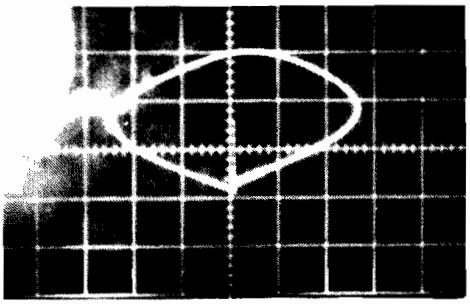


Figure 16

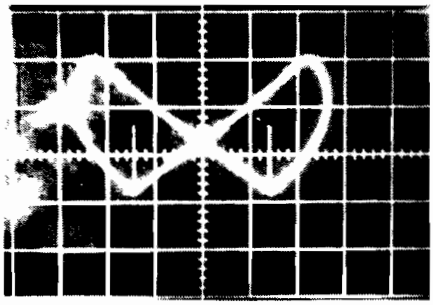


Figure 17

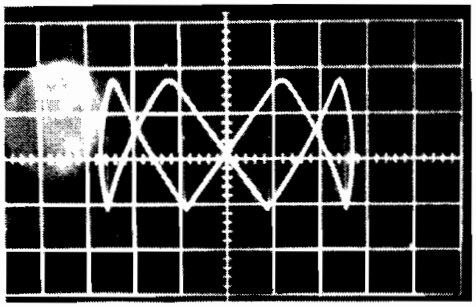


Figure 18

Using the system's monitor, write a 27_H into the D/A and observe that the pattern shown in figure 16 is produced on the 'scope indicating that the test oscillator and VCO are running at the same frequency.

Write a 33_H into the D/A and observe that the pattern shown in figure 17 is produced indicating that the VCO is running at exactly twice the frequency of the test oscillator.

Finally, write a $3F_H$ into the D/A and observe that the pattern of figure 18 is produced indicating that the VCO is running at 4 times the frequency of the test oscillator.

NOTE: It is very difficult to obtain these traces exactly and a more normal situation is to observe some trace rotation. In general, if the trace can be recognized as being one of those shown, you are close enough. Also, it may be easier to obtain stable lissajous figures by starting from the high end ($3F_H$) and working back rather than starting at the low end and working up.

These tests also assume that the VCO being used is entirely linear. A non-linear VCO will cause trace rotation to the point that the figures are unrecognizable.

USING THE 8780

Front panel controls and indicators are as follows:

DATA - These six Light Emitting Diodes along the top edge of the panel indicate the status of the six DATA lines which will be converted to a control voltage. A LED being on indicates that the corresponding DATA line is in a logical 1 state.

FLAGS - Thes two pin jacks and associated LED's in the middle of the panel indicate the status of the two most significant bits of DATA (D_6 and D_7). When these bits are set (in a logical 1 state) the corresponding LED will be on and high voltage level will appear at the corresponding pin jack. The voltage at these trigger jacks is consistent with the requirements of all modules in the PAIA 2720 and 4700 series of synthesizer modules.

OUTPUT - The control voltage corresponding to the current data being presented to the converter appears at the pin jack in this box.

TUNE - This knob allows the control voltage from the D/A to be chromaticly transposed through slightly more than an octave. Turning the knob in a clockwise direction increases the control voltage.

The large hole in the lower right corner of the OUTPUT box provides egress for the cable connecting the D/A to the data source being used.

In almost all cases, the 8780 will be used in synthesizer systems as a direct replacement for the more typical keyboard controller.

A typical module configuration is shown in **figure 19.**

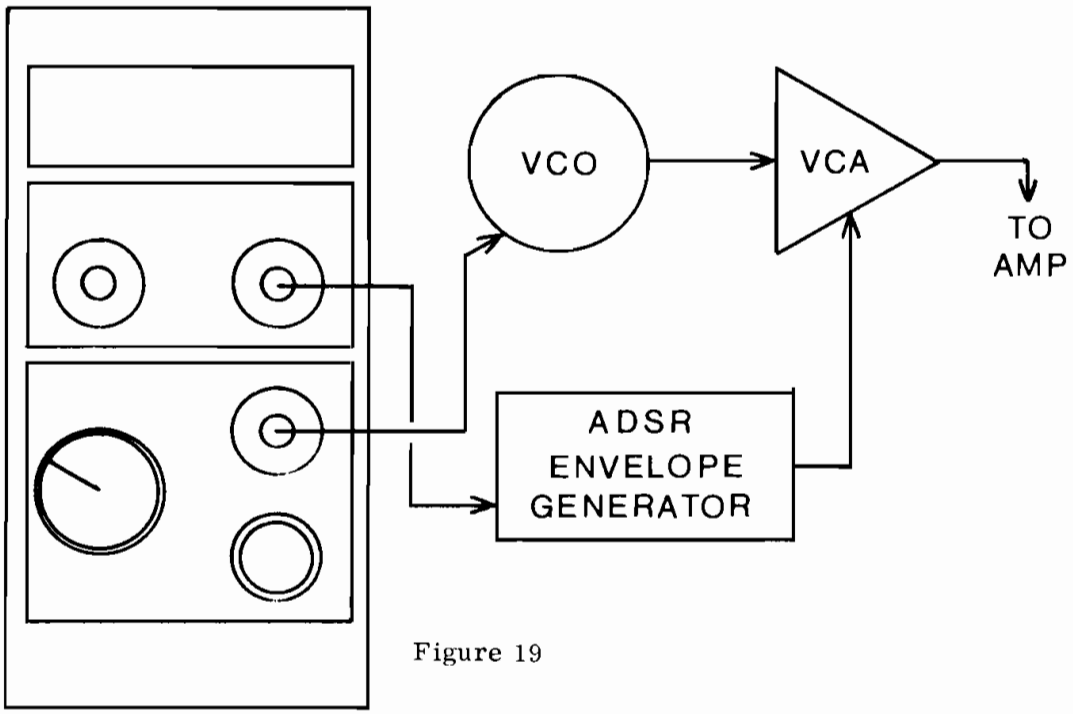


Figure 19

Here the control voltage produced by the 8780 is used to set the pitch of a voltage controlled oscillator. Output waveform attack, decay, sustain and release are handled by the ADSR Envelope Generator which in turn provides a controlling voltage to the Voltage Controlled Amplifier (VCA). When the flag being used as a triggering source to the ADSR (in this case flag #1) is high, the ADSR triggers. Pitch of the oscillator may be set either with the "TUNE" control on the 8780, or with the pitch control of the oscillator being used.

It is handy having two independently controllable trigger flags available because the two flags can be used to select between two separate voices as shown in figure 20.

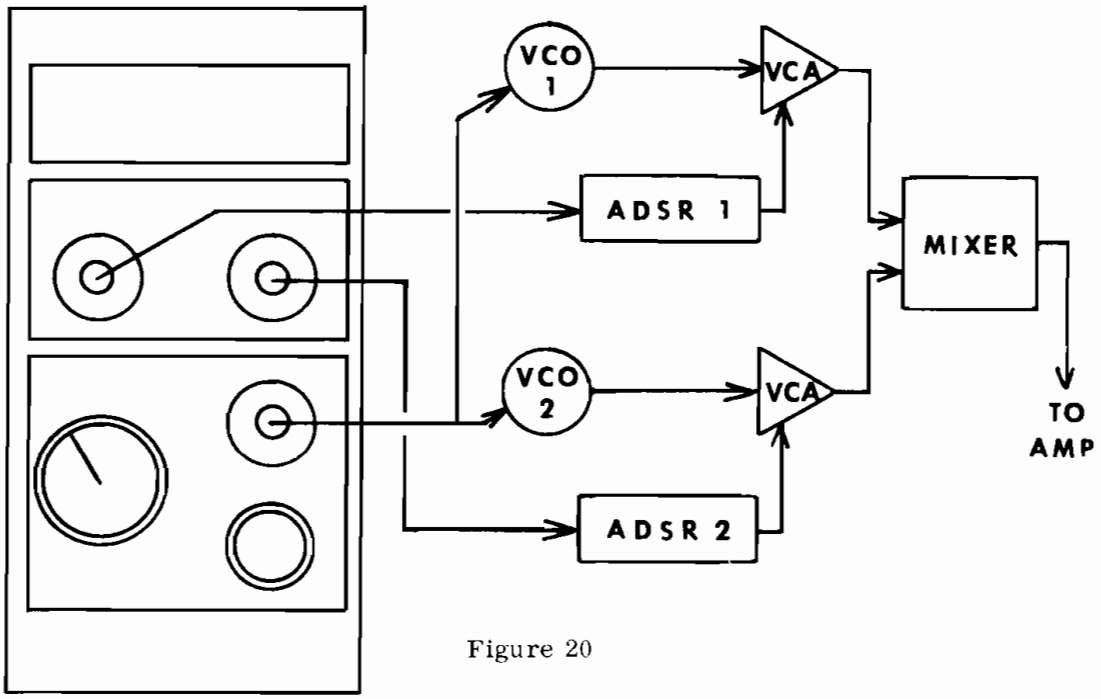
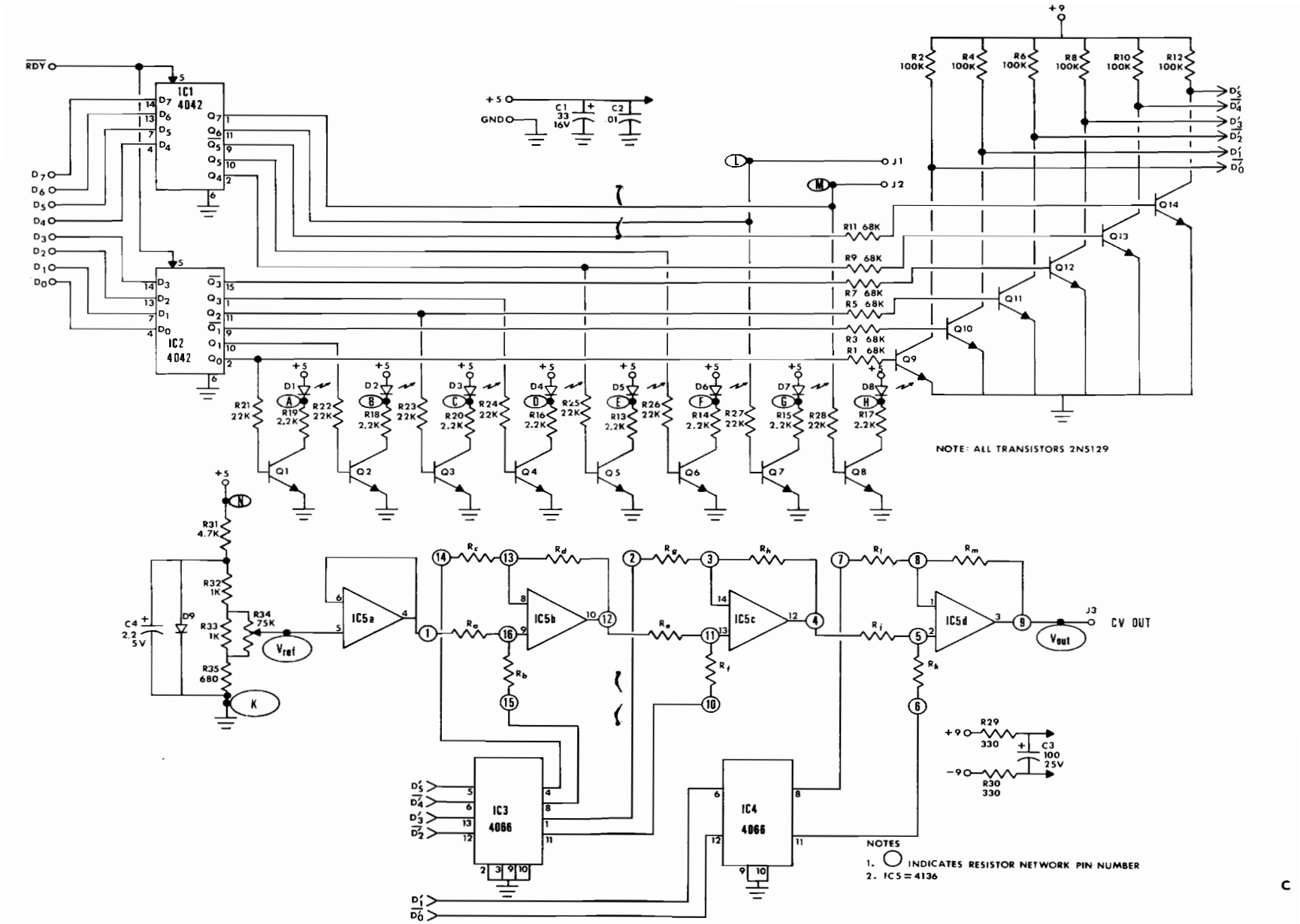


Figure 20

Here, when trigger glag 1 is activated, the voice represented by VCO-1, VCA-1 and ADSR-1 is produced, while activating trigger flag 2 triggers ADSR-2 which "activates" the second voice represented by VCO-2, VCA-2 and ADSR-2.

Activating both trigger flags at the same time will cause both voices to play in unison.


RDY
IC1 4042
IC2 4042
D7
D6
D5
D4
D3
D2
D1
D0
+5
GND
C1 33 16V
C2 .01
+9
R2 100K
R4 100K
R6 100K
R8 100K
R10 100K
R12 100K
D'5/D4
D'3/D2
D'1/D0
J1
J2
R11 68K
R9 68K
R7 68K
R5 68K
R3 68K
R1 68K
Q14
Q13
Q12
Q11
Q10
Q9
D1
D2
D3
D4
D5
D6
D7
D8
R21 22K
R22 22K
R23 22K
R24 22K
R25 22K
R26 22K
R27 22K
R28 22K
R19 2.2K
R18 2.2K
R20 2.2K
R16 2.2K
R13 2.2K
R14 2.2K
R15 2.2K
R17 2.2K
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
NOTE: ALL TRANSISTORS 2N5129
R31 4.7K
R32 1K
R33 1K
R34 75K
R35 680
C4 2.2 5V
D9
Vref
IC5a
IC5b
IC5c
IC5d
Vout
J3
CV OUT
IC3 4066
IC4 4066
R29 330
R30 330
C3 100 25V
NOTES
1. ○ INDICATES RESISTOR NETWORK PIN NUMBER
2. IC5 = 4136

C

8780 ASSEMBLY DRAWINGS

Remove this section for easy reference during assembly.

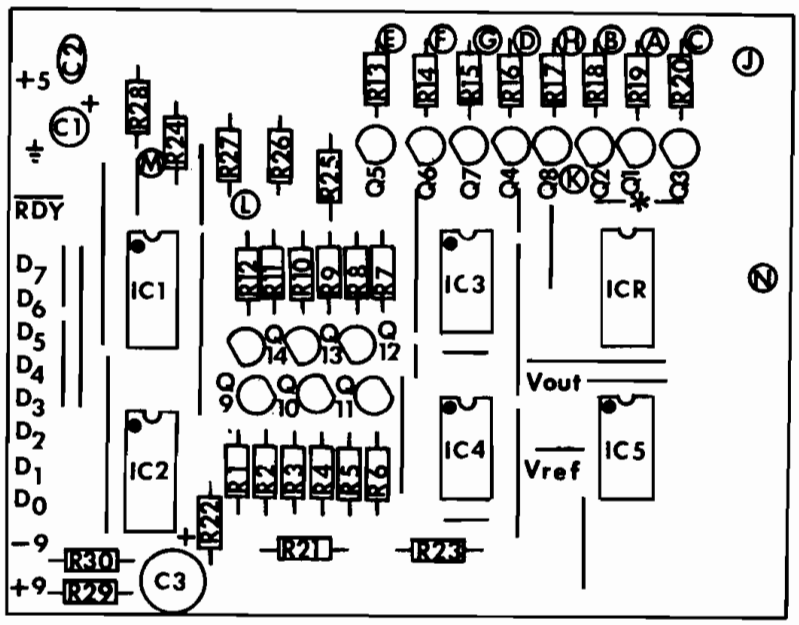


Figure 1 - PC Parts Placement

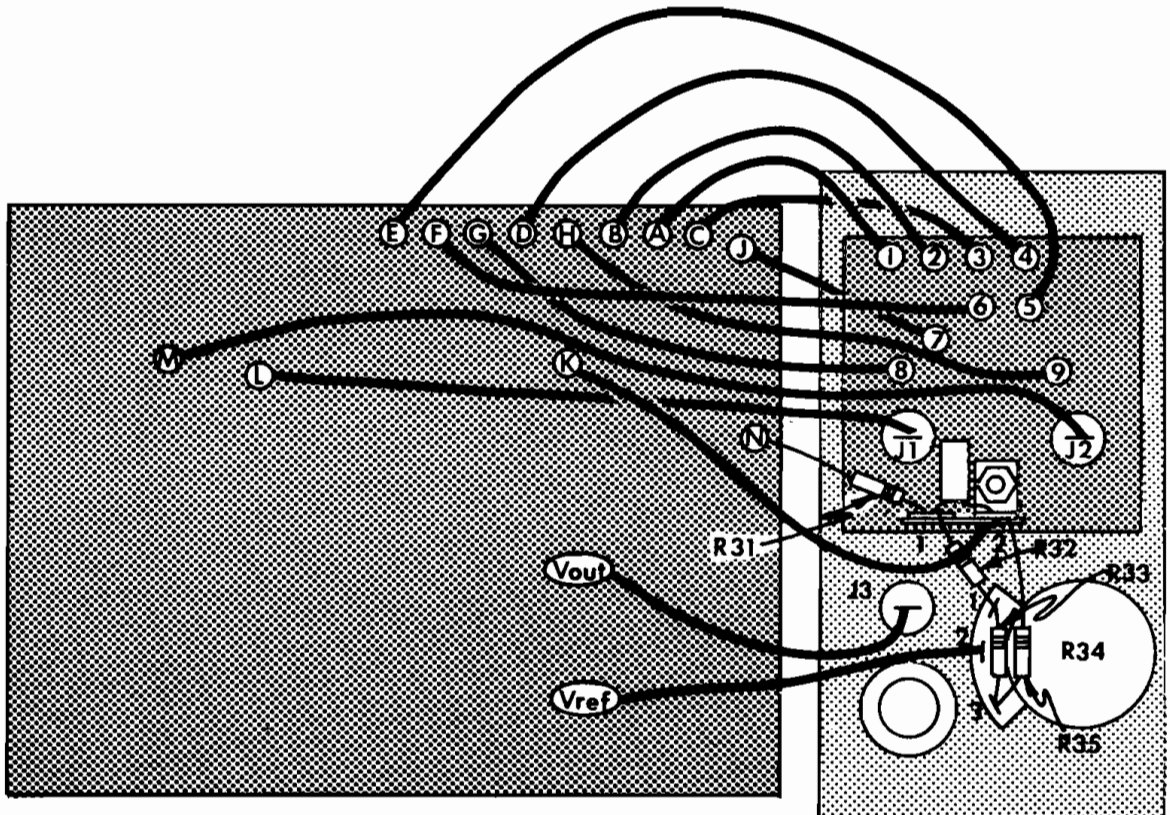
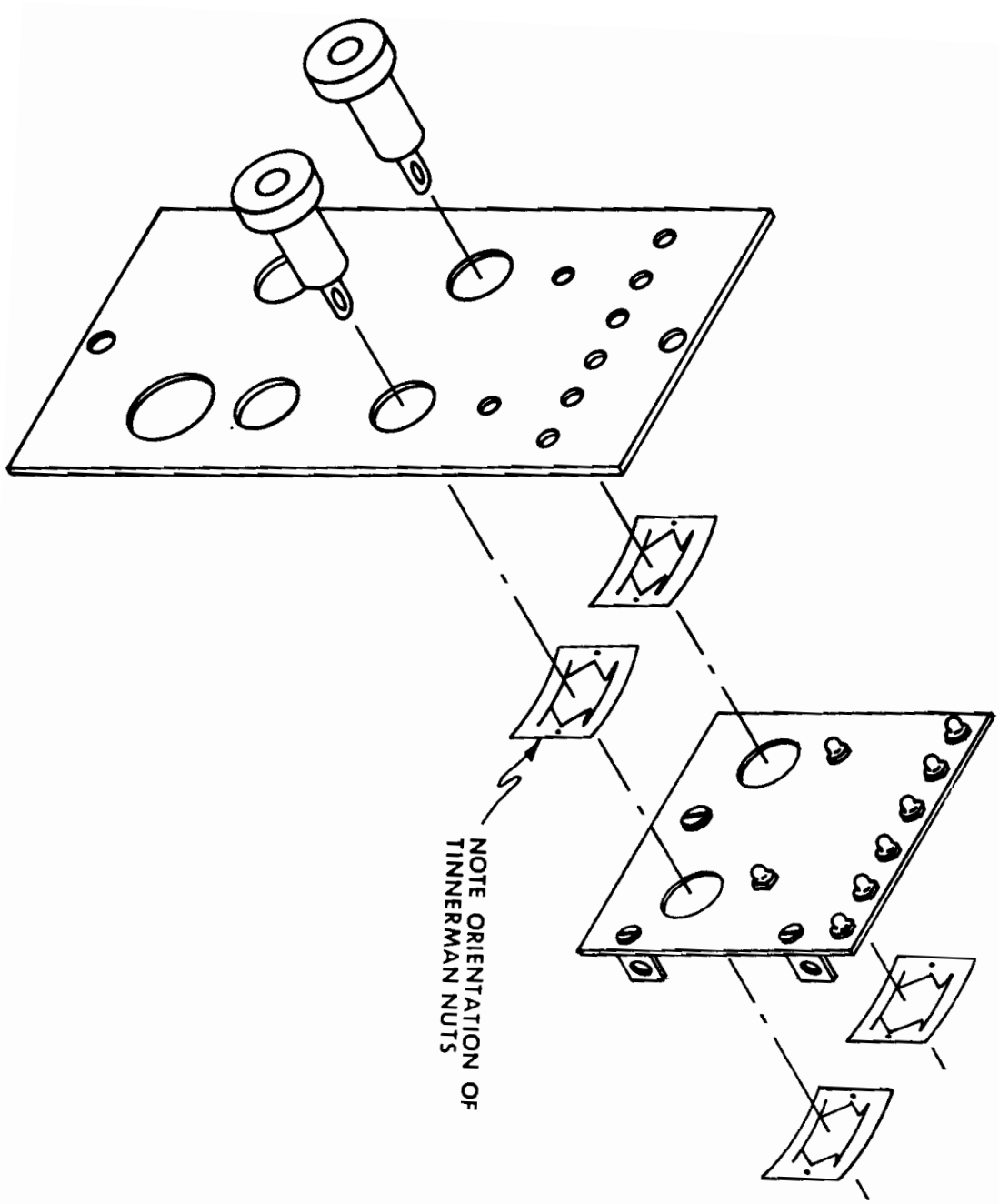


Figure 2 - Front Panel Wiring Diagram and Parts Placement

Diode D9 not shown for clarity.

A



D