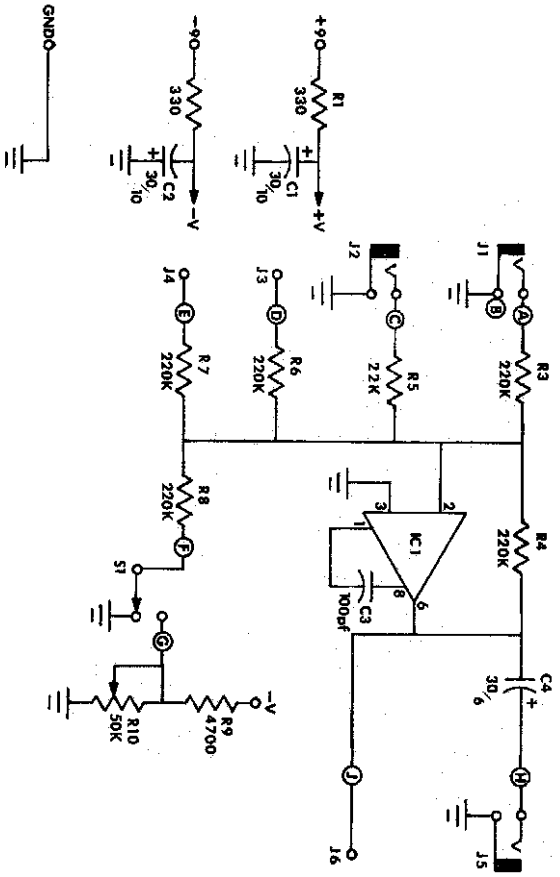


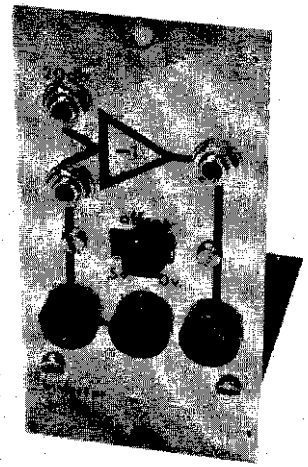
FIGURE 9 SCHEMATIC

PAIA Electronics

2720 -12

P. O. BOX 14359 OKLAHOMA CITY, OKLA. 73114 (405) 842-5480

Inverter/Buffer



The 2720-12 Inverter/Buffer at first glance seems to be one of the simplest and least useful of all the 2720 series processing modules. Simple, it is; its only effect is to perform a 180° phase inversion on any signal applied to its inputs.

Least useful, its not; in addition to the obvious control voltage inversion applications the module also can be used for filter convolution (changing high-pass to low-pass and band pass to band reject) and "Q" multiplication. A 20 db. input port allows the module to be used as a pre-amplifier when using the 2720 series modules as processing elements for conventional instruments with low level outputs and tandem control voltage inputs provide for a low offset error inverting summer.

SPECIFICATIONS

Power requirements:	+9v. @ 2 ma. -9v. @ 2.5 ma.
Input Impedance:	22K at 20 db. input 220K all others
Output Impedance:	less than 100 ohms
Output Offset:	switch selectable 0 or +5v.

SOLDERING

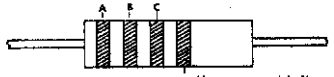
Use care when mounting all components. Use only rosin core solder (acid core solder is never used in electronics work). A proper solder joint has just enough solder to cover the round soldering pad and about 1/16 inch of the lead passing through it. There are two improper connections to beware of: Using 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 re-heating 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 solder bridges can be cleaned off by holding the board up-side 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 for assembly by thoroughly cleaning the conductor side of the circuit board 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	330 ohm	orange-orange-brown
( )	R2	330 ohm	orange-orange-brown
( )	R3	220K	red-red-yellow
( )	R4	220K	red-red-yellow
( )	R5	22K	red-red-orange
( )	R6	220K	red-red-yellow
( )	R7	220K	red-red-yellow
( )	R8	220K	red-red-yellow
( )	R9	4700	yellow-violet-red

Install the ceramic disk capacitor. This component will have its value written on the body of the part.

( ) C3 ..... 100 pfd. ceramic disk

Up to this point all components have been non-polarized and either lead could be placed in either of the holes provided without affecting the 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 in place of a 100 mfd. 16v. capacitor without affecting the operation of the circuit.

Mount the following electrolytic capacitors and solder them in place. The values, voltage rating and polarization are marked on the body of the part.

DESIGNATION		DESCRIPTION
( )	C1	30 mfd. 10v.
( )	C2	30 mfd. 10v.
( )	C4	30 mfd. 6v.

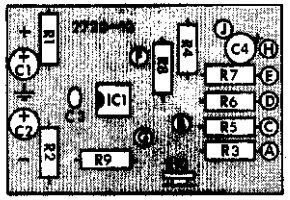


FIGURE 1
PARTS PLACEMENT

Mount the integrated circuit. Note that the orientation of the integrated circuit is keyed by a notch at one end of the case which aligns with the semi-circular key on the designator printed on the circuit board. Use particular care when installing this part, like any other semi-conductor it is heat sensitive and should not be exposed to extraordinarily high soldering temperatures. Make sure that the orientation is correct before soldering, once the unit is in place it cannot be removed without destroying it.

DESIGNATION		DESCRIPTION
( )	IC-1	748 type op-amp

Install the trimmer potentiometer. This part will either be marked with its value or bagged seperately with a printed slip listing its value.

DESIGNATION		VALUE
( )	R10	50K trimmer potentiometer

In the following steps wires will be soldered to the circuit board that in later steps will connect with the front panel controls. At each step prepare the wire by cutting it to the specified length and stripping 1/4 inch of insulation from each end. "Tin" each end of the wire by twisting the exposed strands tightly together and melting a small amount of solder into the wire.

Using the wire provided make the following connections to the circuit board:

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

THIS COMPLETES THE 2720-12 CIRCUIT BOARD ASSEMBLY. TEMPORARILY SET THE BOARD ASIDE AND PROCEED TO THE FRONT PANEL ASSEMBLY.

Place the front panel face down on a soft rag to prevent marring the finish.

( ) Place a red pin jack (J6) in the hole provided as shown in figure 4 and fasten it in place with a tinnerman nut as shown in detail figure 2. Press the tinnerman nut down firmly.

( ) In a similar manner mount black pin jack J3.

( ) In a similar manner mount black pin jack J4.

( ) Mount a miniature phone jack (J1) to the front panel in the position shown in figure 4. Be sure to orient the jack as shown and fasten it in place with the nut provided. Carefully tighten the nut by putting the points of the jaws of a pair of small diagonal cutters into the notches in the nut and using the cutters as a spanner.

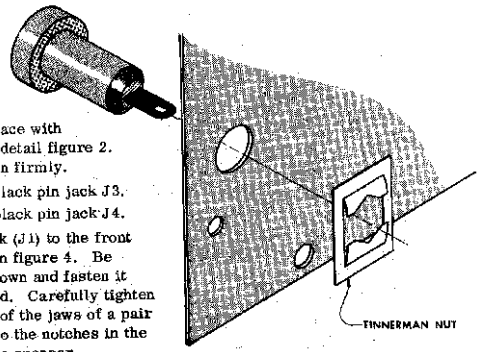


FIGURE 2

( ) In a similar manner mount miniature phone jack J2.

( ) In a similar manner mount miniature phone jack J5.

( ) Using two 4-40 X 1/4 inch machine screws and two 4-40 nuts mount the single pole double throw slide switch S1 as shown in figure 4. Tighten the screws firmly.

( ) Using the bare wire provided make the common connections to the bottom lugs of J1, J2, J5 and S1 as shown in figure 4. At the points where a wire passes through a soldering lug it is not necessary to make a tightly crimped connection, simply pass the wire through the hole. DO NOT SOLDER THE CONNECTION AT J1 AT THIS TIME.

THE FRONT PANEL MAY NOW BE BOLTED TO THE CIRCUIT BOARD AS FOLLOWS:

( ) Fasten the two "L" brackets to the front panel using one 4-40 X 1/4 " machine screw, one lockwasher and one 4-40 nut on each bracket. Note that the unthreaded hole on the "L" bracket is used in this step.

( ) Fasten the circuit board to the front panel "L" bracket by passing a 4-40 X 1/4" machine screw and one lock-washer up through the holes in the circuit board and threading them into the threaded holes in the "L" brackets. Secure all screws.

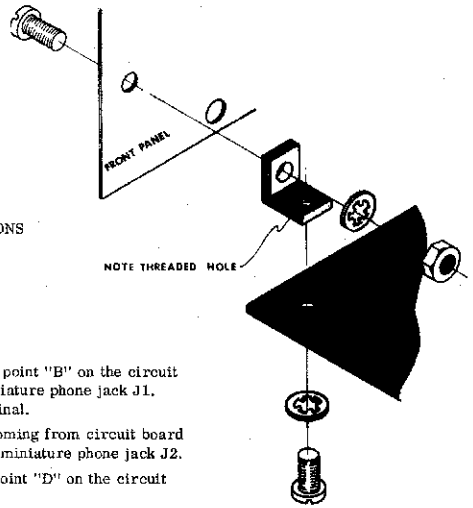


FIGURE 3

MAKE THE FOLLOWING CONNECTIONS FROM THE CIRCUIT BOARD TO THE FRONT PANEL:

( ) Connect and solder the wire coming from point "A" on the circuit board to the middle lug on miniature phone jack J1.

( ) Connect the wire coming from point "B" on the circuit board to the bottom lug on miniature phone jack J1. Solder both wires at this terminal.

( ) Connect and solder the wire coming from circuit board point "C" to the middle lug on miniature phone jack J2.

( ) Solder the wire coming from point "D" on the circuit board to pin jack J3.

( ) Solder the wire from point "E" on the circuit board to pin jack J4.

( ) Connect and solder the wire coming from point "F" on the circuit board to the center terminal of switch S1.

( ) Connect and solder the wire from point "G" on the circuit board to the upper lug on switch S1.

( ) Connect and solder the wire from point "H" on the circuit board to the middle lug on miniature phone jack J5.

( ) Solder the wire coming from point "J" on the circuit board to pin jack J6.

THIS COMPLETES THE ASSEMBLY OF THE 2720-12 INVERTER/BUFFER.

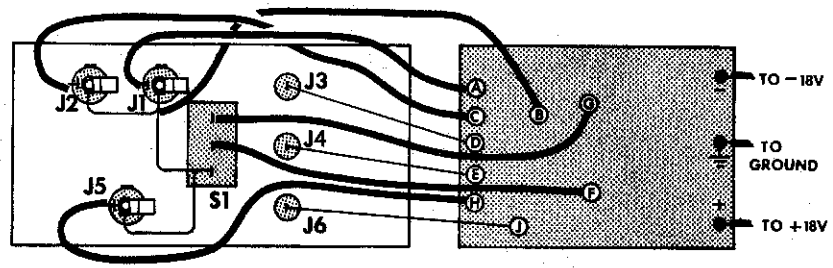


FIGURE 4 FRONT PANEL WIRING

TESTING

Connect a power supply (2720-7 power supply module or other suitable supply such as two 9v. batteries) to the power connections on the rear edge of the circuit board; "+" to +9v., "-" to -9v. and ground to ground. Using a volt-ohm meter set to a 5 or 10 volt range measure the voltage at the red output pin jack in the lower right hand corner of the module. With the "offset" switch in the "0v." position this jack should be at ground potential (0v.). Set the "offset" switch to its "5v." position and adjust the internal "offset" trimmer (R10) for a reading of 5 volts. Connect a variable voltage source (0 to 5v. bias supply on the 2720-7) to one of the inputs of the Inverter/Buffer and observe that as the voltage from this source is increased toward 5v. the output decreases from 5v. toward ground.

Set the "offset" switch to "0v." and apply a signal source of approximately 500 mv. peak to peak amplitude (the triangle output of the 2720-2 VCO, for example) directly to the input of a hi-fi or musical instrument amplifier and set the volume for a comfortable listening level. Route the signal through the unity gain (lower) input jack with the modules output jumpered to the amplifier input and compare the level to that of the direct connection, they should be approximately the same.

Apply the signal source used above to the 20 db. input jack and measure the voltage at the red output pin jack using a VOM set to a 2.5 or 5v. a.c. scale. The meter should read about 2v.

USING THE 2720-12 INVERTER/BUFFER

An inverting gain block is probably the most deceptively simple processing element available to the synthesist. As little as a decade ago a discreet component equivalent of this integrated circuit based module would have typicly sold for 10 to 15 times the price of this unit.

In the 2720-12 the major portion of the design time was invested in organizing the front panel layout so that the user could realize the maximum usefulness from the potential of this unit.

Operation of the controls is as follows:

INPUTS There are a total of four input jacks on the module:

CONTROL On the lower edge of the module front panel are two black pin jacks. Voltages applied to these pin jacks are summed together and inverted before appearing at the output. The sum of these two inputs may be subtracted from either 0v. or 5v. depending on the setting of the "offset" switch.

AUDIO The two miniature phone jacks on the left hand edge of the module provide audio inputs to the circuitry. The lower of these two jacks provides a high impedance, unity gain input. Signals applied to this input appear at the output in an inverted form with no gain or loss in amplitude. The higher of the two jacks provides a moderate impedance input with a voltage gain of 20 db. (X10). Signals applied to this input also appear at the output in an inverted form.

AUDIO OUTPUT The miniature phone jack in the upper right hand corner of the module provides a capacitively coupled output point.

CONTROL OUTPUT The red pin jack in the lower right hand corner of the module provides a direct coupled output point.

OFFSET The slide switch in the center of the front panel allows the user to select a quiescent output offset voltage of either 0 or 5 volts.

There are many times in electronic music synthesis when available control voltages are "going the wrong way" - increasing in magnitude when you want a parameter to decrease or vice-versa. For example, if there is a classic synthesizer voice it is the dynamute sound in which the output of the function generator is used to drive both a VCA for envelope shaping and a band-pass filter simultaneously. With this standard connection the center frequency of the filter is rising as the gain of the VCA is increasing. While this is certainly an interesting sound, an equally interesting effect can be produced if the filter can be made to sweep down while the VCA is going up. Figure 5 shown a connection that produces this effect by first inverting the control voltage that is applied to the filter so that as the output of the function generator rises from 0 to 5v. the output of the inverter falls from 5v. to ground.

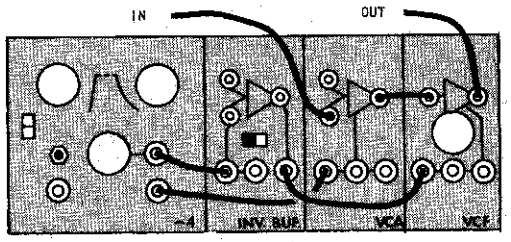


FIGURE 5 CONTROL VOLTAGE INVERSION

Similarly, the inverter may be used to provide two control oscillator signals that are 180° out of phase with each other. Figure 6 shows a connection that produces an automatic "pan" in a stereo system. While the voltage from the control oscillator is increasing and turning on the first VCA the output of the inverter is decreasing causing the second VCA to go off. The net result is a sound that "ping-pongs" back and forth between the two stereo channels.

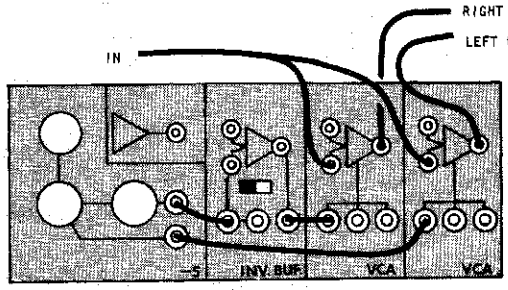


FIGURE 6 PING-PONG

An inverting gain block can be used as a feed-back or summing element to change the characteristics of available filter modules. Figure 7 shown a feed-back arrangement that may be used to appreciably increase the Q of a band-pass filter. The input signal is first applied to the unity gain input of the Inverter/Buffer. The inverter's output is attenuated (using the attenuator on the 2720-7 power supply) and applied to the input of the filter. The output of the filter is fed back to the 20 db. input of the inverter.

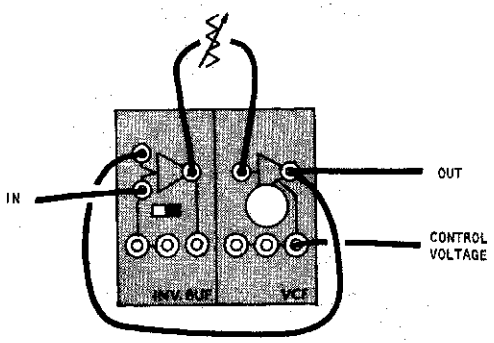


FIGURE 7 HIGH Q FILTER

The "hows and whys" of this connection are relatively complex, but qualitatively it works like this: the original input signal appears at the output of the inverter 180° out of phase, is attenuated and applied to the filter where the frequencies within the pass band are amplified slightly and subjected to another 180° phase shift. As a result of the two 180° shifts, the center frequency output of the filter arrives back at the 20 db. port of the inverter in phase with the input signal so that there is reinforcement of the component of the signal that is at the center frequency of the filter. Components outside the pass-band of the filter are attenuated - so that there is less signal for reinforcement - but more importantly they do not experience the full 180° shift. Because of this they arrive back at the inverter input out of phase with their corresponding component in the original signal and therefore cancel. The net result is a higher output at the frequency of interest along with added suppression of the signals outside that frequecny band.

When using this connection some juggling of the "Q" control of the filter and the attenuator will be required to keep the combination from oscillating. The best procedure to follow for maximum Q is to disconnect the input signal, set the filter's "Q" control fully clockwise and adjust the attenuator so that there is no self-oscillation as the control voltage to the filter is raised and lowered.

Figure 8 shows a combination of the Inverter/Buffer and Band-pass filter that gives a notch response. The input signal is applied to both the filter and the unity gain input of the inverter while the output of the filter is attenuated and applied to the inverter's 20 db. input.

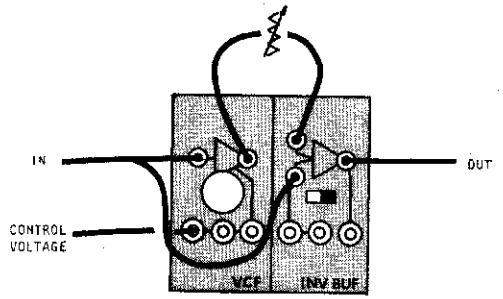


FIGURE 8 NOTCH FILTER

Summing arrangements such as this are considerably easier to explain and understand than feed-back connections. When the output of the filter is summed with the original signal the frequencies within the pass band cancel because they have undergone a 180° phase shift in the filter and therefore arrive out of phase with the unfiltered input.

For complete cancellation of the signal the attenuator must be adjusted so that the output of the band-pass filter at the frequency of interest is the same magnitude as the amplitude of that harmonic in the output of the signal source.

When using this arrangement you will most often have the Q control of the band-pass filter fully advanced and the only adjustment required will be to set the attenuator for maximum rejection at the notch frequency (center frequency of the filter). Much of the time you will simply be adjusting the attenuator to give you the sound you want and won't really care that the notch is not perfect, but for perfectionists there is a relatively simple procedure that can be followed to optimize the filter.

Set the VCO for about concert A (440 Hz.) and use the triangle output to drive the filter. (when the adjustment is complete any input signal may be used) Set the attenuator at about its mid-range position and adjust the control voltage into the band-pass filter until the volume increases appreciably indicating that you've hit a resonance point. Back off on the attenuator until the tone reaches a minimum volume - you should be able to hear the fundamental being suppressed leaving only the higher pitched third harmonic content of the triangle. This is the optimum setting for the combination.

In the same way that the band-pass filter can be used to give a notch response the low pass filter can be used to give a high pass response. Simply substitute the low-pass filter for the band-pass filter in the connection shown in figure 8.