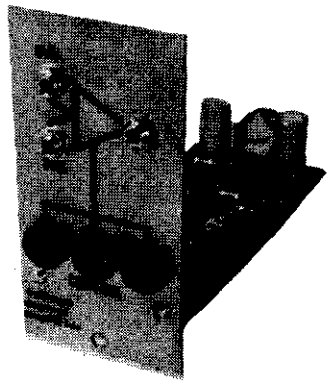
PAIA Electronics

2720-1

Voltage Controlled Amplifier



The 2720-1 Voltage Controlled Amplifier provides the synthesist with a versatile means of shaping the amplitude contour of synthesized sound. The gain of the amplifier module is dependent on the sum of the voltages at three control inputs. Two audio input jacks allow the VCA to be used as a mixer/amplifier and weighting of the audio inputs allows one signal to have a 3 db. boost over the other without using external attenuators. The excellent low frequency response permits this module to process not only audio but also control voltages under some conditions.

SPECIFICATIONS

POWER REQUIREMENTS:	18v. @ 2.5ma. 9v. @ less than .5ma. sink
OUTPUT IMPEDANCE:	1K ohm short circuit protected.
INPUT IMPEDANCE:	nominal 47K ohm
MAX. AUDIO IN:	2v. peak to peak
FREQUENCY RESPONSE:	1 Hz. to 40 kHz. @ 3db. points
GAIN CHARACTERISTICS:	@5v. control in: Odb. input ; Odb. 3db. input; 3db. @ov. control in: Odb. input; approx. - 80db. 3db. input: approx. - 80db.
CONTROL INPUT IMP.:	150K ohms.

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.

DESIGNATION	VALUE	COLOR CODE A-B-C
( ) R1	22K	red-red-orange
( ) R2	47K	yellow-violet-orange
( ) R3	2200	red-red-red
( ) R4, R5, R6	150K	brown-green-yellow
( ) R7	680K	blue-grey-yellow
( ) R8	22K	red-red-orange
( ) R9, R10	6800	blue-grey-red
( ) R11	10K	brown-black-orange
( ) R13	2200	red-red-red
( ) R14, R15	6800	blue-grey-red
( ) R16, R17	15K	brown-green-orange
( ) R18	82K	grey-red-orange
( ) R19	100K	brown-black-yellow
( ) R20	470	yellow-violet-brown
( ) R21	1K	brown-black-red

Install the mylar and ceramic disk capacitors. In most cases these components will have their value written on the body of the part but in some kits the mylar capacitors may be color coded as shown below.

DESIGNATION	VALUE	COLOR CODE A-B-C
( ) C1	100pf. disk	none
( ) C2	0.1 mfd, mylar	brown-black-yellow

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

( ) C3.....100mfd. 10v.
( ) C4.....100mfd. 10v.

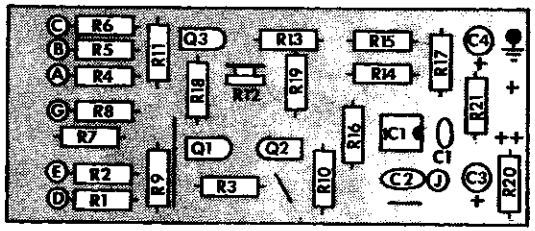


Figure 1

Install the transistors. Orient the transistors as shown in the parts placement diagram fig. 1 and parts placement designators shown on the printed circuit board. All semi-conductors 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. Note that the 2N3391 transistors are identified by a white color coding spot covering the top surface of the part.

DESIGNATION TYPE NO.

( ) Q1 ..... 2N3391 (see text above)
( ) Q2 ..... 2N3391 (see text above)
( ) Q3 ..... 2N2712

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 the orientation is correct before soldering, once the unit is in place it cannot be removed without destroying it.

( ) IC-1 .....748 type op-amp

( ) Install 50K trimmer Potentiometer R12 and solder in place.

In the following steps wires will be soldered to the circuit board which will later connect to the front panel controls and jacks. At each step prepare the wire by cutting it to the specified length and stripping 1/4 inch of insulation from each end of the wire. "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 4 inch length to point "D".
( ) a 4 1/2 inch length to point "E".
( ) a 3 1/2 inch length to point "G".
( ) a 6 1/2 inch length to point "J".
( ) Solder a 3 inch length of the tinned bare wire provided to circuit board point "A".
( ) Solder a 3 inch length of bare wire to circuit board point "B".
( ) Solder a 2 inch length of bare wire to circuit board point "C".

There are three wire jumpers on the circuit board designated by two dots connected with a solid line. Using three pieces of the excess lead clipped from the resistors form and install these jumpers.

( ) ---- Wire jumper
( ) ---- Wire jumper
( ) ---- Wire jumper

THIS COMPLETES THE 2720-1 CIRCUIT BOARD ASSEMBLY. TEMPORARILY PUT THE CIRCUIT BOARD ASIDE AND PROCEED TO THE MOUNTING OF THE FRONT PANEL JACKS.

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

( ) Place a black pin jack (J4) in the hole provided as shown in figure 3 and fasten in place with a tinnerman nut as shown in detail figure 2. Press the tinnerman nut down firmly.
( ) In a similar manner mount pin jack J5
( ) In a similar manner mount pin jack J6

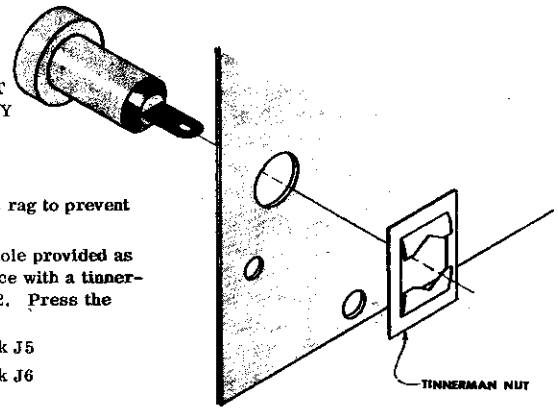


Figure 2

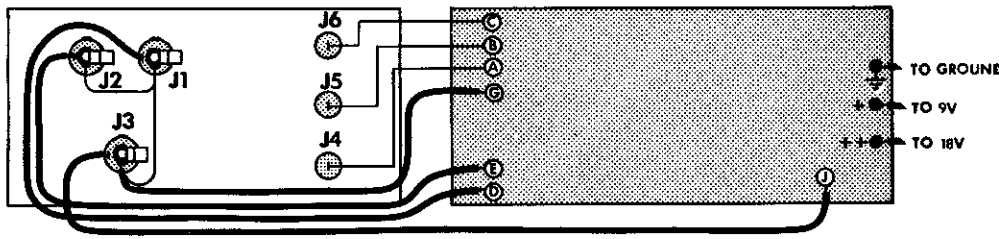


Figure 3

( ) Mount the miniature phone jack (J1) to the front panel in the position shown in figure 3. 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.

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

( ) In a similar manner mount the miniature phone jack J3

( ) Using the bare wire provided make the common connections to the left hand lugs of J1, J2 and J3 as shown in figure 3. Do not solder the connection at J3.

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 and one 4-40 nut on each bracket. Note that the unthreaded hole on the "L" bracket is used in this operation.

( ) Fasten the circuit board to the front panel "L" brackets by passing two 4-40 X 1/4" machine screws up through the holes in the circuit board and threading them into the threaded holes in the "L" brackets. As you are joining the front panel and the circuit board arrange the bare wires coming from circuit board points "A", "B" and "C" so that they pass through the eyes in the solder lugs of pin jacks J4, J5 and J6 respectively. Properly arranging these wires at this time will produce a much neater looking job than trying to bend the wires around to pass through the solder lugs in some later step. Securely tighten all screws.

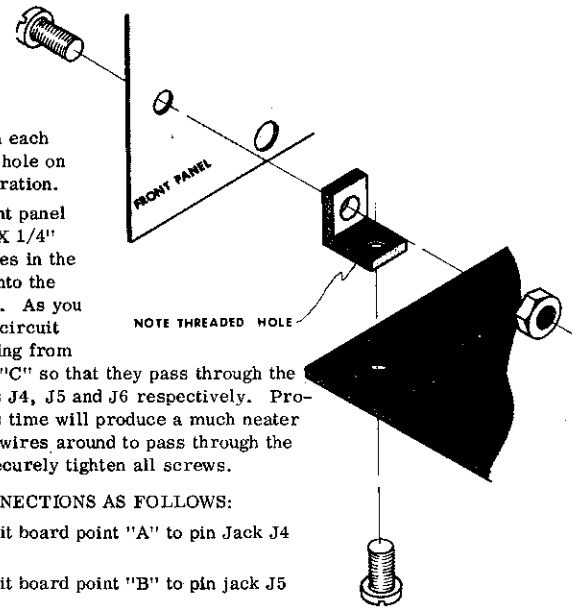


Figure 4

MAKE THE FINAL FRONT PANEL CONNECTIONS AS FOLLOWS:

( ) Solder the wire coming from circuit board point "A" to pin Jack J4 and cut off any excess wire.

( ) Solder the wire coming from circuit board point "B" to pin jack J5 and cut off any excess wire.

( ) Solder the wire coming from circuit board point "C" to pin jack J6 and cut off any excess wire.

( ) Connect and solder the wire coming from circuit board point "D" to the uppermost lug on miniature phone jack J1 as shown in figure 3.

( ) Connect and solder the wire coming from circuit board point "E" to the uppermost lug on miniature phone jack J2 as shown in figure 3.

( ) Connect and solder the wire coming from circuit board point "J" to the uppermost lug on miniature phone jack J3 as shown in figure 3.

( ) Connect the wire coming from circuit board point "G" to the left hand lug of miniature phone jack J3 as shown in figure 3. Solder both wires connected to this lug.

THIS COMPLETES ASSEMBLY OF THE VOLTAGE CONTROLLED AMPLIFIER MODULE.

TESTING

The 2720-1 VCA may be tested using only an audio signal source and amplifier. Connect the power supply to the terminals on the rear edge of the circuit board. Note that the negative supply terminal of the 2720-7 power supply is not used on this module. If a power supply other than the 2720-7 is used it must supply 18v. to the ++terminal and 9v. to the +. Two 9 volt transistor batteries may be used for the power supply.

Turn on the amplifier you will be using and temporarily jumper its input to the output of the audio signal source. If you are using the 2720-2 Voltage Controlled Oscillator, set an audible pitch by using the -5 to +5 volt bias tap of the power supply as a control input. Adjust the volume of the amplifier for a comfortable listening level. If a signal source other than the VCO is used set it for about 1,000 Hz. with a peak to peak amplitude of .5v.

Disconnect the jumper between the oscillator and amplifier. Jumper the output of the oscillator to the "0 db" input of the VCA. Make sure that there is d.c. isolation between the VCA and oscillator (the 2720-2 is already d.c. isolated) If there is no isolation put a .1 mfd. ceramic disc or mylar capacitor in series with the connection between the VCA and oscillator. Jumper the output of the VCA to the input of the amplifier. Using the 0 to 5v. bias tap on the 2720-7 power supply apply a 5v. bias to one of the control inputs of the VCA and observe that the volume is approximately the same as when the oscillator was feeding the amplifier directly (some adjustment of trimmer resistor R12 may be necessary). Turn the 5v. bias control fully counter-clockwise and observe that the tone is turned off.

With the control voltage still at 0v., change the oscillator output from the "0 db" to the "3 db" input of the VCA. Note that there is still no tone. Once again rotate the 5v. bias control fully clockwise and note that the tone is significantly louder than when the signal was being applied to the "0 db" input.

Disconnect the 5v. bias supply from the VCA control input pin jack. Tap the point of the pin plug against the metal contact inside the pin jack and observe popping sound from the amplifier. Adjust trimmer R12 to minimize this pop. Because of the electrical noise generated from mechanically making and breaking this connection there will always be a little popping associated with this test. Unless the pop is severe regardless of the setting of R12 it will present no problem when the amplifier is driven from any of the electronic control voltage sources.

Test all three of the control voltage input jacks to make sure that a 5v. input to each one turns on the amplifier.

USING THE 2720-1 VOLTAGE CONTROLLED AMPLIFIER

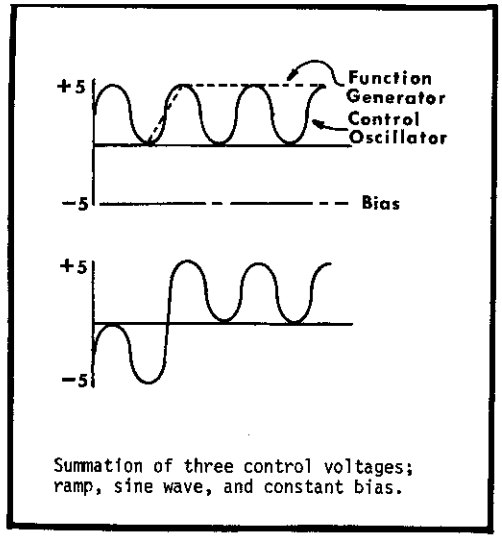
There are some design constraints that must be placed on a Voltage controlled amplifier that are peculiar to this module and primary among these constraints is its response to a very rapid increase in control voltage. Most of the time you will be using the VCA to contour the amplitude of an audio signal. In order that percussion effects, such as drums, sound realistic the amplifier must go from a completely isolating condition to unity gain in about 2ms. (.002 second). None of this control voltage can be allowed to transfer into the audio channel or there will be ferocious "pops" and "thunks" heard from the speaker. Using a differential input stage with a common constant current source as described in the design analysis section guarantees that this won't happen.

Control voltage summation is not as important in the VCA as it is in the VCO because the human ear is not particularly sensitive to changes in the amplitude of a sound. Thanks to this, the summation performed on the VCA control voltages need not be exact and a simple resistive summing network can be used.

Function and use of the various jacks is described below.

CONTROL The gain of the amplifier is set by the algebraic summation of the control voltages that are present at the three control pin jacks arranged along the lower half of the module. The amplifier is designed so that if the voltages at the control input add up to +5v. there is zero insertion loss between the 0db. audio input and the audio output. Voltages less than +5v. cause the amplifier to present a greater and greater attenuation to the audio signal, until at a total control input of 0v. the amplifier can be considered off. Negative control voltages and voltages greater than +5v. will not damage the amplifier but if the control voltage input goes higher than 6v. distortion will develop.

The need for algebraicly summing the control voltages can most easily be explained with a simple common-place example. Assume that you want to process an audio tone so that it has the maximum tremolo (cyclic amplitude variation) possible. Obviously you will use the VCA to vary the amplitude of the tone and also obviously you will use the control oscillator to supply the tremolo control signal and the function generator to give the final sound the attack and decay characteristics you need. So you route the control oscillator into one of the control inputs on the VCA and crank the tremolo voltage up all the way (+5v. peak to peak) and out comes the greatest tremolo ever, the sound is going from full on to full off. Now you can connect the output of the function generator to one of the remaining two control inputs of the VCA - but the sound is still there because the amplifier is already being turned all the way on and off by the control oscillator. Not only that, but when you hit the function generator trigger button a bunch of distorted mush comes out because at some points the sum of the +5v. function generator output and the +5v. peak of the control oscillator add up to +10v. , way above the permissible control voltage input. You could use two VCA's, one to process the tremolo effect while the other does the attack and decay but thanks to the algebraic summing there is an easier way. Simply sum a constant -5v. bias into the remaining VCA control input. The overall effect of these summations is shown in figure 5 but in words, the -5v. bias cancels out the +5v. peaks of the control oscillator so that the amplifier is off until the function generator is triggered at which time its +5v. output cancels the -5v. bias leaving only the 0 to +5v. signal from the control oscillator to produce maximum tremolo.



Summation of three control voltages; ramp, sine wave, and constant bias.

Figure 5

0 db. INPUT At the maximum control voltage of +5v. there is no gain or attenuation between this input and the audio output.

3 db. INPUT At the maximum control voltage of +5v. there is a 3 db. gain between this input and the output. Both of the audio inputs may be used simultaneously for mixing putposes. These two input terminals have a slight D.C. potential and must be capacitatively coupled to audio sources. All audio sources associated with the 2720 Synthesizer already have capacitive output coupling but if sources such as the dynamic pickups used on most electrified musical instruments are being processed this capacitor must be externally supplied. An external capacitor must also be supplied if the 2720-1 is being used to process control voltages from the 2720-5 control oscillator. Two coupling capacitors have been provided on the patch panel of the 2720-7 Power Supply Module for use in cases such as this.

OUTPUT The output line is capacitively coupled. This output can be used either as the input for the next processing module (filters, etc.) or as the output to your power amplifiers. The output is high (line) level - on the order of 1/2 volt - and in most cases a preamplifier will not be necessary.

DESIGN ANALYSIS

Referring to figure 6, the three control voltage inputs are summed by resistors R4, R5 and R6 and used to set the amount of current that the constant current source Q3 supplies to the differential pair Q1 and Q2. The amplification produced by the pair is proportional to their collector currents so as Q3 supplies more current the gain of the pair increases.

Along with increased gain the greater current flow also produces a greater quiescent voltage drop across the load resistors R9 and R10. When the circuit is properly balanced using trimmer R12 the increase in this voltage is equal while the audio signal applied to the base of Q1 appears inverted at the collector of Q1 and non-inverted at the collector of Q2.

Using the balanced input of an operational amplifier the in phase collector voltages caused by the gain-setting current can be eliminated while the out of phase audio signal is amplified. This eliminates any "popping" as the amplifier is switched from full off to full on.

Two inputs through summing resistors R1 and R2 allow the amplifier to be used as a mixer and the ratio of these two resistors is such that the input through R1 produces a 3db. greater output than the input through R2.

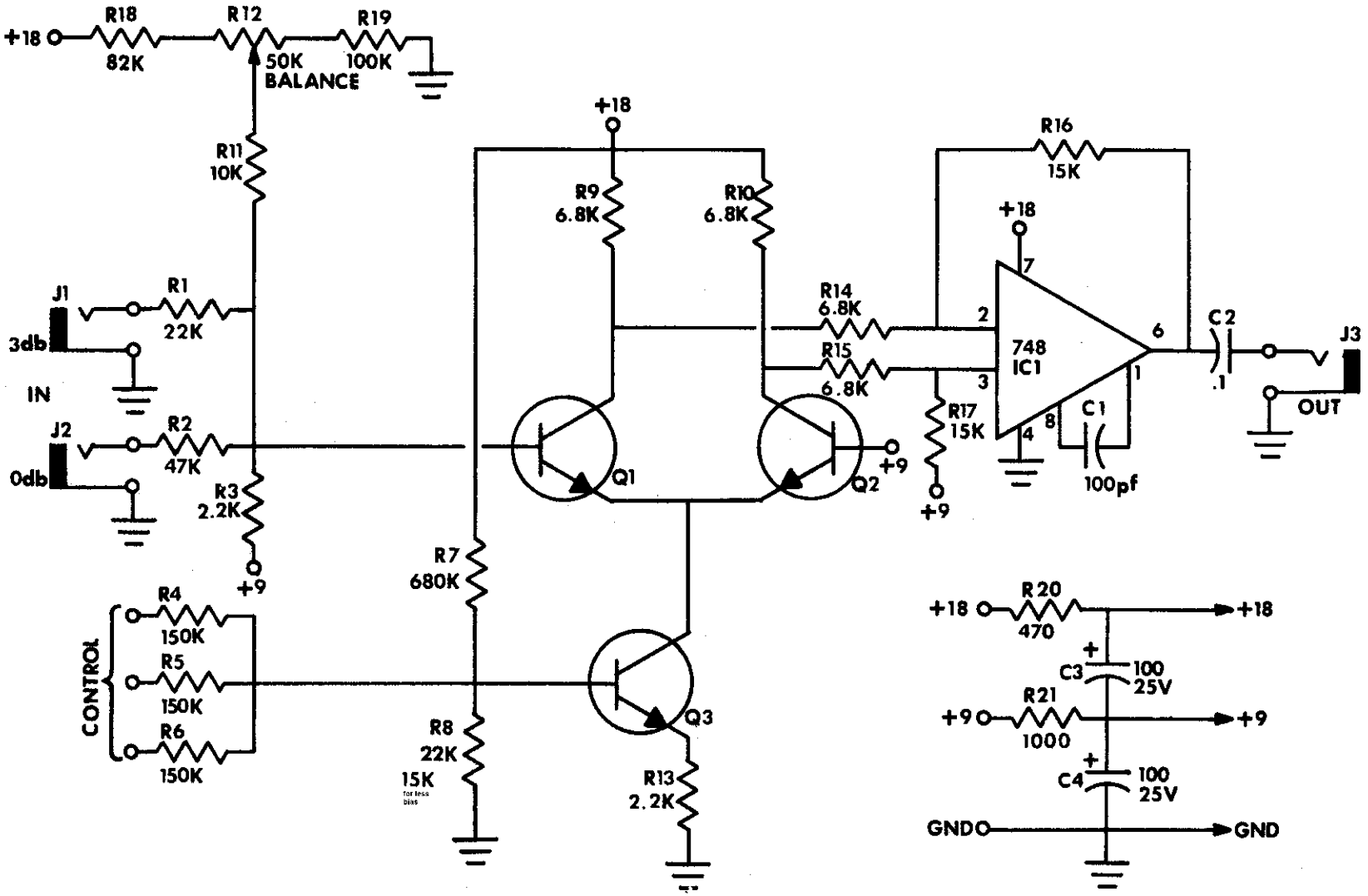

+18
R18
82K
R12
50K
BALANCE
R19
100K
R11
10K
J1
3db
IN
R1
22K
J2
0db
R2
47K
R3
2.2K
+9
CONTROL
R4
150K
R5
150K
R6
150K
R7
680K
R8
22K
15K
R9
6.8K
R10
6.8K
Q1
Q2
Q3
R13
2.2K
R14
6.8K
R15
6.8K
R16
15K
R17
15K
748
IC1
C1
100pf
C2
.1
J3
OUT
R20
470
C3
100
25V
R21
1000
C4
100
25V
GND

figure 6