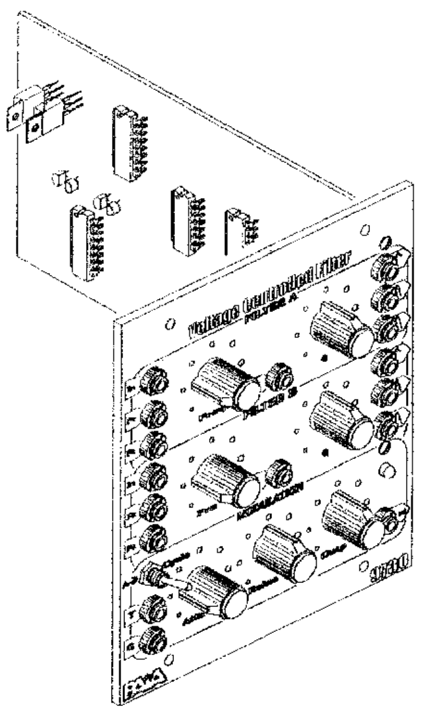
PAiA Dual VCF w/Modulator

Model 9730
Assembly and Using Manual



The PAiA 9730 Dual VCF is two independent Voltage Controlled Filters, each with Lo Pass, Band Pass, and Hi Pass outputs. A dual filter offers a lot of flexibility and can be used as two independent 12 dB/oct (2 pole) filters or a single 24 dB/oct (4 pole) filter. Using the two sections together provides complex, dynamic filter responses not possible with a single filter. Nominal Corner Frequency (Fc) range is from 16Hz. to 16kHz. with a Control Voltage scaling of 1V/oct. Resonance ("Q") has both a front panel knob and Control Voltage inputs.

Modulation sources are such an important part of creating interesting sounds that the 9730 has one built in. The Modulator is an Attack/Release Envelope Generator that has a separate Trigger input for A-R envelopes and Gate input for A-R with Sustain (ASR). Attack time is adjustable from 0.5 mS to 6 Seconds, Release time from 5 mS to 9 Seconds. The Cycle switch allows self-triggering for an LFO function with independently adjustable rise and fall times and a range from a cycle every 15 Seconds to over 100 Hz.

The 9730's high level normalization makes it like a complete system behind a single panel and many useful multi-filter modulation-rich configurations can be implemented with only input and output patch cords.

ASSEMBLING THE 9730 DUAL VCF W/MODULATOR

Before beginning assembly, go through the manual. Look at the drawings. Feel the parts. You're naturally eager to plunge right in, but take a few deep breaths first. Check the parts supplied against the packing list on the last page of this manual.

In some cases, notes packed with the parts will be used to call your attention to special situations. These notes may be in the yellow "MISSING PARTS" postcard. ***If parts are missing*** *please notify PAiA at p405.340.6300, f340.6378, or damn!@paia.com .*

Notice that each step in the manual is marked with a checkoff box like this:

DESIGNATION	VALUE	COLOR CODE
( ) R27	100 ohm	brown-black-brown

Checking off each step as you do it may seem silly and ritualistic, but it greatly decreases the chance of omitting a step and also provides some gratification and reward as each step is completed.

Numbered figures are printed in the Illustrations Supplement in the center of this manual. These pages may be removed for easy reference during assembly.

THE CIRCUIT BOARD

The 9730 VCF is built on a double-sided circuit board. No special preparation or cleaning is necessary before assembly. The "top" of the board is the side that is printed with component designations and parts are mounted from this side. The "bottom" of the board is also called the solder side and is masked with a conformal coating to lessen the chance of solder bridges. Solder pads are tin-lead plated for ease of soldering and assembly.

TOOLS

You'll need a minimum of tools to assemble the kit - a small pair of diagonal wire cutters and pliers, screwdriver, sharp knife, ruler, soldering iron and solder.

Modern electronic components are small (in case you hadn't noticed) and values marked on the part are often difficult to see. Another handy tool for your bench will be a good magnifying glass. Also use the magnifier to examine each solder joint as it is made to make sure that it doesn't have any of the problems described in the SOLDERING section which follows.

SOLDERING

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

Use only a high quality 60/40 alloy rosin core solder (acid core solder is for plumbing, and silver solder is for jewelry - neither is for electronics work). A proper solder joint has just enough solder to cover the soldering pad and about 1/16-inch of 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 when 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.

Too much solder may produce a conducting bridge of excess solder between adjacent pads causing a short circuit. If WAY too much solder is used it may flow through the hole and cause bridges between conductors on the component side of the board or even impede the action of mechanical components such as trimmer potentiometers. Accidental bridges can be cleaned off by holding the board upside down and flowing the excess solder off onto a clean, hot soldering iron.

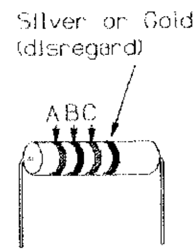
Use care when mounting all components. Never force a component into place.

Special thanks to the beta crew -

Scott Lee
Tim Furry
Johnny Klonaris
David Hillel Wilson
and me - John Simonton

Resistors

Solder each resistor in place following the parts placement designators printed on the circuit board and the assembly drawing fig 1. Note that resistors are nonpolarized and may be mounted with either lead in either of the holes in the board. Before mounting each resistor, bend its leads so that they are at a right angle to the body of the part. Put the leads through the holes and then push the resistor firmly into place. Cinch the resistor in place by bending the leads on the solder side of the board out to an angle of about 45 degrees. Solder both ends of each resistor in place as you install it. Clip each lead flush with the solder joint and save a few of the clippings for use in later steps.



5% Resistors have
4 color bands

The 9730 VCF uses 1% film resistors in precision circuitry and 5% carbon film resistors in non-critical locations. Not all resistors are mounted on the circuit board, some will be "left over" when the board is finished and will be installed later in the assembly procedure.

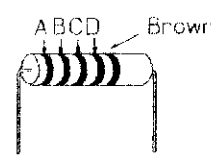
First we'll install the 5% resistors. These resistors are identified by their 4 color bands. A tip: If you can't find the location for a resistor, go on to the next one and come back. DO NOT CHECK OFF A PART UNTIL IT IS INSTALLED AND SOLDERED.

DESIGNATION	VALUE	COLOR CODE A-B-C	
listed below:	100	brown-black-brown	
( ) R11	( ) R12	( ) R17	( ) R19
( ) R45	( ) R54		
listed below:	100k	brown-black-yellow	
( ) R8	( ) R21	( ) R58	( ) R61
( ) R65			
( ) R57	10k	brown-black-orange	
( ) R46	1300	brown-orange-red	
( ) R55	1300	brown-orange-red	
( ) R7	150k	brown-green-yellow	
( ) R22	150k	brown-green-yellow	
( ) R10	15k	brown-green-orange	
( ) R16	15k	brown-green-orange	
( ) R9	1800	brown-grey-red	
( ) R20	1800	brown-grey-red	
( ) R47	18k	brown-grey-orange	

( ) R48	18k	brown-grey-orange	
( ) R67	1k	brown-black-red	
( ) R66	1megohm	brown-black-green	
( ) R1	22	red-red-black	
listed below:	220	red-red-brown	
( ) R4	( ) R5	( ) R24	( ) R25
( ) R27	( ) R30	( ) R36	( ) R38
( ) R59	5600	green-blue-red	
( ) R60	5600	green-blue-red	
( ) R62	2200	red-red-red	
( ) R71	220k	red-red-yellow	
( ) R75	220k	red-red-yellow	
listed below:	22k	red-red-orange	
( ) R6	( ) R26	( ) R29	( ) R31
( ) R34	( ) R35	( ) R37	( ) R39
( ) R68	270k	red-violet-yellow	
listed below:	470	yellow-violet-brown	
( ) R3	( ) R28	( ) R41	( ) R43
( ) R73	4700	yellow-violet-red	
listed below:	47k	yellow-violet-orange	
( ) R23	( ) R32	( ) R33	( ) R69
( ) R2	56	green-blue-black	
( ) R56	3300	orange-orange-red	
( ) R13	6800	blue-grey-red	
( ) R18	6800	blue-grey-red	
( ) R70	68k	blue-grey-orange	
( ) R72	82k	grey-red-orange	
( ) R53	910k	white-brown-yellow	
( ) R63	910k	white-brown-yellow	
( ) R74	91k	white-brown-orange	

1% FILM RESISTORS

The 1% metal film resistors are identified by their 5 color bands.



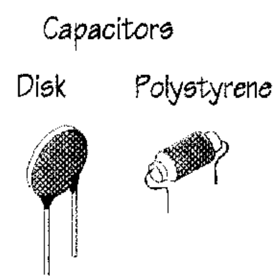
1% Resistors have 5 color bands

DESIGNATION	VALUE	COLOR CODE A-B-C-D	
listed below:	100k 1%	brown-black-black-orange	
( ) R40	( ) R42	( ) R44	( ) R49
( ) R51	( ) R52		

Disk and Polystyrene Capacitors

Many of the capacitors used in the 9730 are nonpolarized Ceramic Disk and Polystyrene types. For each of these, either lead can go in either of the holes in the circuit board. The leads of the Ceramic Disk capacitors are already parallel to each other but still may need to be bent slightly to match the spacing of the circuit board holes. The leads of the Polystyrene capacitors will need to bend down prior to installation and may be further apart than the spacing of the circuit board holes. Like the resistors, insert the leads of these parts through the holes in the board and push the part against the circuit board as far as it wants to go. Don't force it, it's OK if it sits a little off the board.

Capacitors are often marked with obscure codes that indicate their values. The 3 digit number that specifies value may be preceded or followed by letters indicating such things as tolerance. If you get confused about which capacitors are which, it may help to group them by same type and check them against quantities on the packing list at the end of this manual.

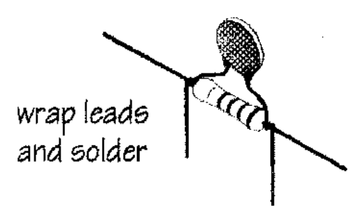


Ceramic Disk Capacitors

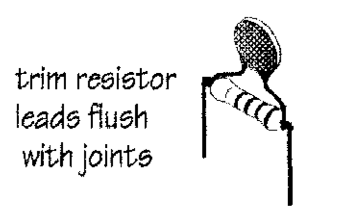
DESIGNATION	VALUE	MARKING	
( ) C21	0.001uF	102	
listed below:	0.01uF	103	
( ) C3	( ) C4	( ) C7	( ) C8
( ) C9	( ) C10	( ) C15	( ) C16
( ) C17	( ) C18	( ) C19	( ) C20
( ) C22			

Polystyrene Capacitors

DESIGNATION	VALUE	MARKING	
listed below:	1000pF	1000J -or- 102	
( ) C11	( ) C12	( ) C13	( ) C14

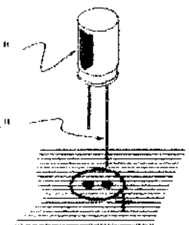


( ) Locate a 4700 ohm 5% resistor (yellow-violet-red) and a 100pF Ceramic Disk capacitor (may be marked 101) and wrap the leads of the capacitor around the resistor leads as shown. Solder the wrapped connection and clip the resistor leads off flush with joints. Install this compensation network as R14 by pushing the capacitor leads through the holes in the circuit board. Solder and clip the excess lead off flush with the bottom of the board.



( ) In a similar manner, install another 4700 ohm 5% resistor (yellow-violet-red) and 100pF Ceramic Disk capacitor (101) as R15.

Electrolytic Capacitors

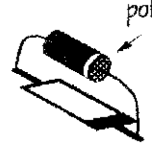


The remaining capacitors are electrolytic types. Unlike the previous components, electrolytic capacitors are polarized and the leads are not interchangeable. Leads are marked "+" and/or "-" and the "+" lead must go through the "+" hole in the circuit board. Frequently the positive lead of the capacitor is significantly longer than the negative lead. Usually the Negative lead of the capacitor is marked rather than the positive. It naturally goes through the unmarked hole.

Capacitors supplied with specific kits may have a higher Voltage (V) rating than the minimum specified below.

DESIGNATION	VALUE
( ) C23	1uF / 16V
( ) C1	470uF / 25V
( ) C2	470uF / 25V
( ) C5	4.7uF / 16V
( ) C6	4.7uF / 16V

Diodes



Like the Electrolytic Capacitors, diodes are polarized and must be installed so that the lead on the banded end of the part corresponds to the banded end of the designator on the circuit board. Bend the leads so they are at right angles to the body of the part and insert them through the holes provided in the circuit board.

Diodes are also somewhat heat sensitive so the soldering operation should be done as quickly as possible.

DESIGNATION	TYPE
listed below:	1N4148 Silicon Diode

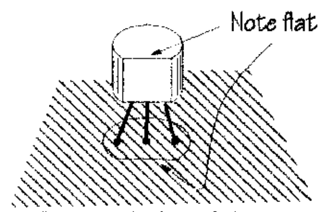
( ) D1 ( ) D2 ( ) D3 ( ) D4

Transistors

Install the transistors by inserting their three leads through the holes provided for them in the circuit board. Note that the transistors are polarized by the flat side of the case. When the transistors are properly installed this flat will align with the corresponding mark on the circuit board legending.

Eight of the transistors are supplied as pairs that have been specially selected to have matching characteristics and will be packed together. Keeping these pairs together is important for optimum circuit performance.

Notice that two different types of transistors (2N3904 and 2N3906) are used. The type will be written on the body of the part.



The straight line of the pc graphic symbol corresponds to the flat face of the transistor case.

DESIGNATION TYPE

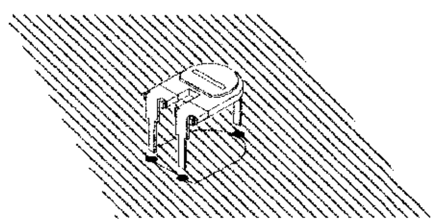
listed below: 2N3906 PNP Silicon Transistor
( ) Q1/Q2 *pair* ( ) Q3/Q4 *pair*
( ) Q5/Q6 *pair* ( ) Q7/Q8 *pair*
( ) Q11 *not matched*

( ) Q9 2N3904 NPN Silicon Transistor
( ) Q10 2N3904 NPN Silicon Transistor

Trimmer Potentiometers

Mount the two trimmer potentiometers by inserting their three pins into the holes provided. Press them down until the "shoulders" of the solder pins are resting on the surface of the circuit board. Solder all three pins on each part.

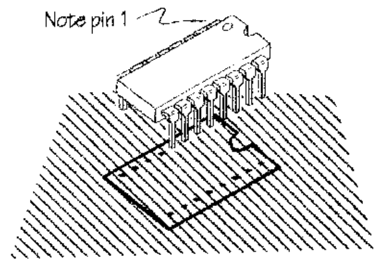
CAUTION: Too much solder here may flow though and cause problems



DESIGNATION	VALUE	MARKING
( ) R50	1000	1K
( ) R64	1000	1K

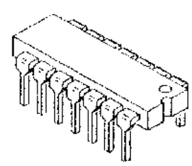
Integrated Circuits

Of all the parts, the ICs are the most easily damaged and should be treated with some respect. In particular, they may be destroyed by discharges of static electricity. Modern ICs are not nearly as sensitive to this kind of damage as were earlier versions, but it is still good practice to handle these parts as little as possible. Also good practice: don't wear nylon during assembly. Don't shuffle around on the carpet immediately before assembly (or if you do, touch a lamp or something to make sure you're discharged). Don't be intimidated. It's rare for parts to be damaged this way.



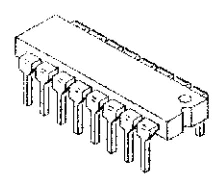
ICs are polarized in one or both of two ways; A dot formed into the case of the IC corresponding to pin 1 or a semicircular notch that indicates the end of the package with pin 1. Take care that this polarizing indicator corresponds to the similar indicator on the circuit board graphics.

The pins of the ICs may be splayed somewhat and not match the holes in the circuit board exactly. Carefully re-form the leads if necessary so that they are at right angles to the part.



TL084
LM324
14 pins

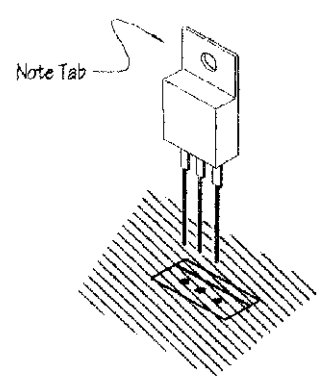
Solder each IC in place as it is installed by initially soldering two pins in diagonal corners of the pattern. Make sure that the part is seated firmly against the circuit board by pressing it down while re-melting the solder joint at first one corner, then the other. Finally, solder the remaining connections.



LM13700
16 pins

DESIGNATION	PART NO.	DESCRIPTION
( ) IC3	LM13700	Dual Operational Transconductance Amp
( ) IC4	LM13700	Dual OTA
( ) IC6	LM13700	Dual OTA
( ) IC5	TL084	Quad J-FET OpAmp
( ) IC7	LM324	Quad OpAmp
( ) IC8	LM324	Quad OpAmp

Voltage Regulators



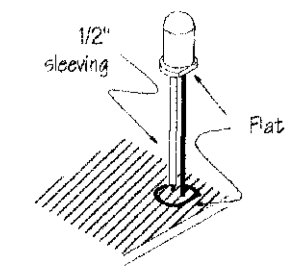
The voltage regulators are polarized and must be mounted so that their tabs correspond to the tab markings on the circuit board graphics. Solder all three leads and clip any excess off flush with the solder joint.

( ) IC1	7912	-12V Voltage Regulator
( ) IC2	7812	+12V Voltage Regulator

LEDs

LEDs are polarized by the flat in the collar at the base of part. When properly installed, this flat will align with the corresponding flat in the LED symbol printed on the circuit board.

When the 9730 is installed behind its front panel, the LED will engage the holes in the front panel and be supported by its leads.



Use 1/2" length of the small diameter sleeving as a spacer and insulator on the LED.

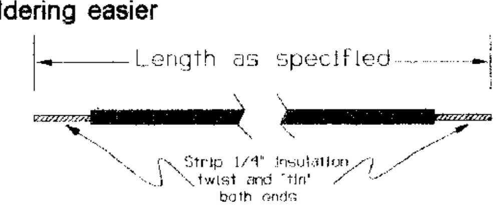
Cut a 1/2" length of the small diameter sleeving supplied over the lead opposite the polarizing flat. Push the two leads through the holes in the circuit board; if the sleeving is too long to allow soldering trim it slightly. When satisfied with the spacer length, confirm the orientation of the LED and solder both leads. Trim the longer lead off flush with the solder joint - the shorter lead may need no trimming.

DESIGNATION	TYPE
( ) LED1	Red LED

Note: If you also have the 9730frm FracRak Accessory kit do not use the wire from that kit in these steps. 9730frm wires are already cut to length for use with the power connector.

"Flying" Wires
(i.e. those which go from circuit board to panel mounted parts.)

In the following steps, wires will be soldered to the 9730 board which in later steps will be connected to the front panel controls and switches. At each step, cut a piece of wire to the specified length and strip 1/4" of insulation from each end. Twist the exposed wire strands together and "tin" them by melting a small amount of solder into the strands. This will make soldering easier when the wires are installed and prevents fraying of the wire strands when they are pushed through the holes. Solder each connection as it is made and clip any excess wire from the solder side of the board.



PC POINT	WIRE LENGTH	PC POINT	WIRE LENGTH
( ) "A"	6-3/4"	( ) "B"	7-1/4"
( ) "C"	6-1/4"	( ) "D"	6"
( ) "E"	5-1/2"	( ) "F"	7-3/4"
( ) "H"	6"	( ) "I"	5"
( ) "J"	5-1/2"	( ) "K"	5-1/2"
( ) "M"	6-3/4"	***Note:** No wire to point "L"*	

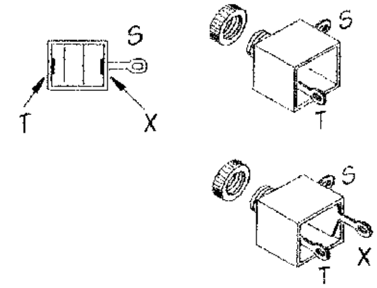
PC POINT	WIRE LENGTH	PC POINT	WIRE LENGTH
( ) "N"	6"	( ) "O"	5"
( ) "P"	5-1/4"	( ) "R"	6-3/4"
( ) "S"	6-1/2"	( ) "T"	7"
( ) "U"	6"	( ) "V"	7"
( ) "W"	4-1/2"	( ) "X"	5-1/4"
( ) "Y"	6-1/4"	( ) "Z"	6-1/2"
( ) "AA"	6-1/2"	( ) "AB"	6-3/4"
( ) "AC"	6-1/4"	( ) "AD"	5-1/4"
( ) "AE"	5-1/4"	( ) "AF"	6-1/2"

This completes assembly of the 9730 circuit board. Admire your work for a few minutes then take a break. When you come back, admire your work again but this time be critical. It would be a good time to double check the orientation of polarized parts and that the right resistors and capacitors are in the right places. Examine the solder joints. On the component side make sure excess solder has not flowed though the hole. On the solder side, are they all nice and shiny? If they have the "lumpy" granular look that indicates a cold joint, reheat them. Solder bridges are less likely with a solder masked circuit board but they can still happen. If you're not sure about a bridge refer to the foil patterns in fig 1.

Front Panel Controls

Now we will put the circuit board aside temporarily and mount the controls, switch and jacks on the front panel. If you have the optional panel available from PAiA, you will be installing these parts at the locations shown in fig 2.

Mono Jack
has 2 lugs



Closed Circuit Jack
has 3 lugs

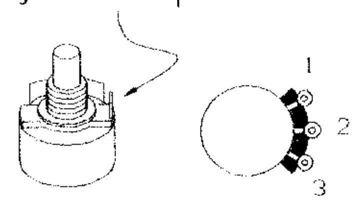
( ) Using the nuts supplied with them, mount the seventeen 1/8" Phone Jacks as shown in fig 2. Note that while both Mono and Closed Circuit Jacks are shown in the schematic (Fig 6) your kit may use CC jacks for both types. If different types are supplied be careful that the correct type is used in a given panel location (J9,J11,J12 and J13 are CC types). Orient the jacks as shown in fig 3 before fully tightening the nuts to secure them.

It will be easier to do the ground wiring of J1-J6 before the rest of the panel controls are mounted.

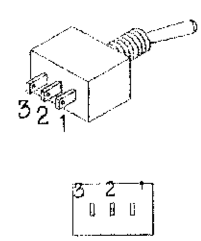
( ) Cut a 4" length of the bare wire supplied and pass it through the holes in the "S" lugs of J1 and J6 (lift these two lugs away from the panel and twist them so the wire can pass through). Push the wire through until a stub 5/8" long extends beyond the "S" lug of J6. The stubs that extend beyond J1 and J6 will connect in later steps (see Fig 3). Solder the connections between the wire and J1 and the wire and J6, before connecting the "S" lugs of J2-J5 to the wire by bending them up until they touch the wire then soldering the two together.

( ) Using the flat washers and nuts supplied, mount the seven potentiometers to the panel as shown in fig 2. Note that two different values are used so be careful that the correct value is placed in the correct location. Value is stamped or printed on the body of the part. Orient the pots with the solder lugs as shown in fig 3 and fully tighten the nuts to secure them. A tip: marking the part number (e.g. R85) on the back of the pots with an indelible pen will make later wiring easier and less prone to error.

Bend or remove this tab so that the pot will seat flush against the front panel.



( ) Using the nut and washer supplied, mount the miniature toggle switch as shown in fig 2. While the circuitry only requires a SPST switch (with two solder lugs) the part supplied will most likely be SPDT types (with three lugs) and only two of the lugs will be used. Orient the switch as shown in fig 3 and fully tighten the nut to secure it. The switch is symmetrical so whichever soldering lug is on the right is #1.



A SPDT switch may be supplied even though only SPST is required.

Now we'll continue wiring of the front panel parts as shown in fig 3. First, notice that Individual solder lugs are identified by part number and lug number. For example, R85-1 means the lug labeled "1" of the Potentiometer R85.

Also, this convention will be followed in these steps: Do not solder a connection to a lug until told to do so with an instruction such as (s2), which means that at that point there will be two wires on the lug in question. If there are not the number of wires specified at the lug when you get ready to solder, recheck to see what has gone wrong. Connections which should not be soldered yet will be marked (ns) for NO SOLDER. On these unsoldered connections simply push the end of the wire through the lug and crimp it back to mechanically secure it.

( ) Connect the free end of the solid wire extending beyond J6-S to R89-1 (ns) and the free end extending beyond J1-S to R85-1 (ns).

( ) Cut a 5-1/2" length of bare wire and pass it through the holes in the "S" lugs of J8 and J15 so that the wire ends at J15. Solder the connections to the "S" lugs of J8 and J15 first, then bend the "S" lugs of J9-J14 up and solder them to the wire as was done on the previous jacks.

( ) Connect the free end of the wire extending from J8-S to R86-3 (ns)

In the following steps cut a piece of bare wire to the length indicated and use it to connect the component lugs specified. Route the wires as shown in Fig 3 and push them down close to the front panel so they will not short against the lugs of switches and jacks and future wiring.

LENGTH	FROM	TO
( ) 1-3/8"	J7-S (s1)	R89-1 (s2)
( ) 1-3/4"	R85-1 (ns)	R86-3 (ns)
( ) 2-7/8"	R87-1 (ns)	R85-1 (s3)
( ) 2-1/8"	R86-3 (s3)	J16-S (ns)
( ) 1"	J16-S (s2)	R88-3 (ns)
( ) 2"	R88-3 (s2)	J17-S (s1)
( ) clipping	R90-2 (s1)	R90-3 (ns)
( ) clipping	R91-2 (s1)	R91-3 (ns)

Four point-to-point panel connections are made using the insulated stranded wire. For each of these cut a length of wire to the length specified, strip 1/4" of insulation from each end and twist and tin the exposed strands.

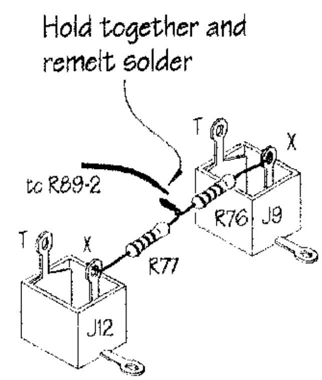
LENGTH	FROM	TO	LENGTH	FROM	TO
( ) 2-1/2"	J7-T (s1)	R89-2 (ns)	( ) 5"	J11-X (s1)	J3-T (ns)
( ) 2"	R87-3 (s1)	R85-3 (ns)	( ) 2"	J13-X (s1)	J10-T (ns)

( ) Locate the .001uF ceramic disk capacitor (marked 102) and cut its leads off to a length of 3/8". Connect one lead of this capacitor to J14-T (s1) and the other to J15-T (ns). This is C24.

The resistors not used during circuit board assembly will now mount directly on the lugs of the controls (see fig 3).

( ) Locate the 330 ohm 5% resistor (orange-orange-brown). Cut two 1/2" lengths of the small sleeving supplied and slip one over each resistor lead and trim the lead so that 1/4" extends beyond the sleeving. Use this part as R78 to make the connection from R90-1 (ns) to R91-1 (s1).

( ) Locate the two 100k **1%** (brown-black-black-orange) resistors (R76 and R77) and twist one lead of each together for a few wraps. Solder the joint and when cool, clip the joint so that a 1/8" stub remains. Clip the free lead of each resistor to 3/8" and use this network to make the connection between J9-X (s1) and J12-X (s1) as shown in the illustration and Fig 3.



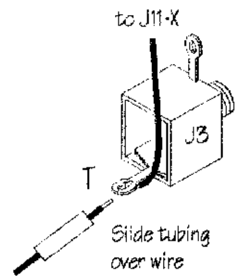
( ) Prepare a 3-3/4" length of stranded wire by stripping 1/4" of insulation from each end and twisting and tinning the strands. Clip one end so that 1/8" tinned stub remains and connect this end of the wire to the junction of R76 and R77. Solder by holding the tinned wire against the resistor leads and heating until the solder of each has melted and flowed together. Remove the heat and hold the connection still until the solder has cooled ... then count to 5 before giving the connections a slight pull to test it.

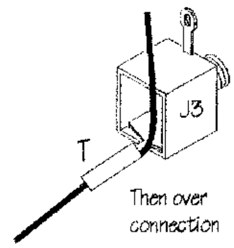
( ) Connect the free end of the above wire to R89-2 (s2)

This completes the wiring between parts on the front panel. Before going further, make sure that the bare wire is dressed down against the panel and not in danger of shorting to unintended solder lugs. Dress the insulated wires down also - they need not be close to the panel but should not loop out away from the assembly.

A few connections will be made between the circuit board and front panel before the two are fastened together. These connections will be close to components on the circuit board when the board is attached to the panel so sections of clear tubing are used to make insulating sleeves. Cut a 3/8" long piece of large tubing from the length supplied and slip it over the wire before soldering the connection. When the solder joint has cooled, slide the tubing down over the lug.

FROM	TO		FROM	TO	
( ) "O"	J4-T (s1)	*Fig 4*	( ) "I"	J1-T (s1)	*Fig 5*
( ) "J"	J5-T (s1)	*Fig 5*	( ) "K"	J6-T (s1)	*Fig 5*
( ) "W"	J3-T (s2)	*Fig 5*	( ) "X"	J2-T (s1)	*Fig 5*





Now it's time to use the #4 hardware and "L" brackets to attach the front panel to the circuit board. Before beginning, take a good look at the "L" Brackets and note that one of the holes is threaded and the other is not.

( ) Attach the "L" brackets to the circuit board using two 4-40 X 1/4" Machine Screws through the board from the solder side and then through the **unthreaded** holes in the "L" brackets. Secure each with a #4 nut. Some adjustment will be required when the board is attached, so do not fully tighten the screws.

( ) Bend the LED over so that it engages the hole provided for it in the front panel as shown in fig 2. Attach the circuit board to the front panel by passing 4-40 X 1/4" Machine Screws through the panel from the front and into the **threaded** hole in the "L" brackets. When satisfied with the alignment of panel, LED and circuit board, fully tighten the hardware.

Finish panel assembly by connecting the remaining wires from the circuit board to the jacks and controls on the front panel. Solder as indicated. (See Fig 4)

FROM	TO	FROM	TO
( ) "A"	R87-2 (s1)	( ) "B"	J17-T (s1)
( ) "D"	R85-3 (s2)	( ) "E"	J16-T (s1)
( ) "F"	J8-T (s1)	( ) "H"	R85-2 (s1)
( ) "M"	J11-T (s1)	( ) "N"	R86-1 (s1)
( ) "P"	R88-1(s1)	( ) "S"	R88-2 (s1)
( ) "T"	J13-T (s1)	( ) "Y"	R86-2 (s1)
( ) "AB"	S1-1 (s1)	( ) "AC"	S1-2 (s1)

Note: Be careful when soldering the wires to the switch. Too much heat can soften the body of the part causing the solder lugs to shift position. If you are using a 30W or less soldering iron there is little danger, but higher power irons should not be left on the lugs too long.

See Fig 5 for an illustration of the rest of the wiring:

( ) "C"	R87-1 (s2)	( ) "R"	J12-T (s1)
( ) "U"	R90-3 (s2)	( ) "V"	R91-3 (s2)
( ) "Z"	J10-T (s2)	( ) "AA"	J9-T (s1)
( ) "AD"	R90-1 (s2)	( ) "AE"	R89-3 (s1)
( ) "AF"	J15-T (s2)		

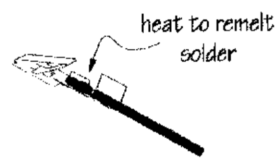
POWER CABLE AND CONNECTOR

If you have the 9730frm accessory kit, locate the power connector housing and pins. You will be connecting wires to the pins and will need to be able to hold the pin steady while soldering. Using an old-fashioned wooden clothes pin as a vise is a good choice, but try to find one these days. A pair of needle-nose pliers with a rubber band around the handle to hold the jaws closed works but too heavy a rubber band can apply too much pressure and crush the pin.

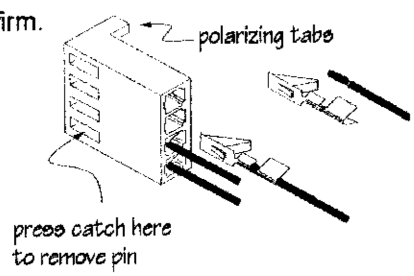
Proceed with assembly of the power connector as follows:

( ) Prepare the four 16" lengths of stranded insulated wire supplied with the 9730frm kit by stripping 1/4" of insulation from one end of each wire only. Twist and tin the exposed wire strands then clip off the tinned end so that a 1/8" stub remains.

( ) Solder one of the power connector pins to the end of each wire. Steady the pin as discussed above and lay the tinned end of the wire in the "trough" of the pin as shown in the illustration. Solder the connection by holding the soldering iron against the wire and pin until the solder remelts. You should not need to add more solder. Allow the joint to cool and test it by wiggling the wire to make sure the joint is firm. Do not wrap the "wings" of the pin around the wire.

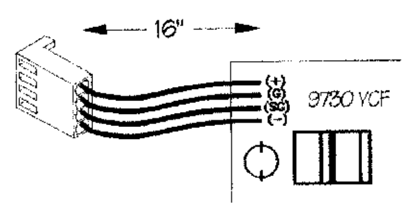


( ) Slide the power pins into the connector body. Note the orientation of the pin as shown in the illustration. Slide the pin in until the catch on the back of the pin engages the slot in the connector body and you feel the "snap" as it locks in place. Give the wire another good tug to test the solder joint and that the pin is latched in place.

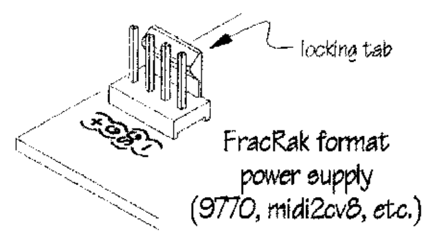


If the wire comes loose, don't panic. The pins can be released from the connector by using a knife blade or small tool to reach through the slots in the connector body to press down the catch.

( ) Prepare the free ends of the wires by stripping 1/4" of insulation from the end and twisting the exposed wire strands tightly. Do not tin these wires. Push each wire though the "+", "G", "SG" and "-" holes in the board as shown in the illustration (note the polarizing tabs on the connector body) and check to make sure there are no stray wire strands that did not make it through the hole before soldering in place. Clip off any excess on the solder side of the board.



Use the 3 nylon wire ties to group the four wires together by placing one in the middle and the other two halfway to either end. Cinch the ties tight and clip off the excess.



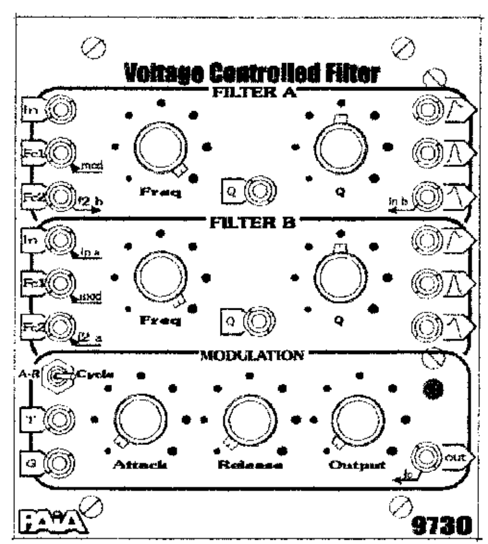
( ) Locate the power connector header and install it in the appropriate location on the FracRak format power supply you will be using. Note the orientation of the locking tab shown in the illustration. Push the 4 pins through the board but solder one pin only. Examine the header to see that it is seated flush on the board and if not, remelt the single joint and push the connector fully into place. When satisfied, solder the remaining three pins.

( ) Turn the control shafts of all the potentiometers fully counter clockwise and mount each knob in turn by placing it on the shaft and aligning the pointer with CCW end of the panel graphic. Tighten the set screw slightly and rotate the control back and forth to see that its range of rotation is centered with respect to the panel graphic. Loosen the screw and realign the knob as needed and fully tighten when done.

The moment of truth is at hand, the next step will be to power up the filter and start testing. This is an excellent time to take another break, stretch and think about something else for a while. When you come back take the time to do a final check. The flying wires to the panel aren't bundled with wire ties yet, and we'll leave them that way for now, so move them around a little to check the connections. Inspect the wiring on the panel and make sure none of the bare wire used as the panel ground is in danger of shorting against other connections. One more pass of inspecting the board for component polarity and quality of solder joints is a good idea too.

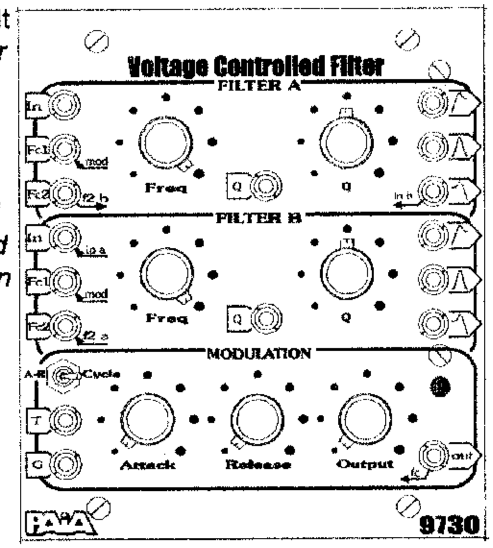
TESTING

Set Scale A and Scale B trimmers (R64 and R50) to the midpoint of their rotation, corresponding to a 1V/oct scale. Make sure the power supply is turned off and mate the power connectors. No signal inputs or outputs are needed for these first tests.



1) Set the 9730 knobs and switch as shown and turn on power. First observe the POWER light on the power supply and if it doesn't come on stop and find out why. *It may be just a dead outlet or some more serious problem such as a solder bridge on the 9730 board. If the power supply light comes on when the 9730 is disconnected, it's a sure sign of a problem on the 9730 board. The most likely area for this problem is in the area around the power connector, R1, R2, C1, C2 and the voltage regulators IC1 and IC2.*

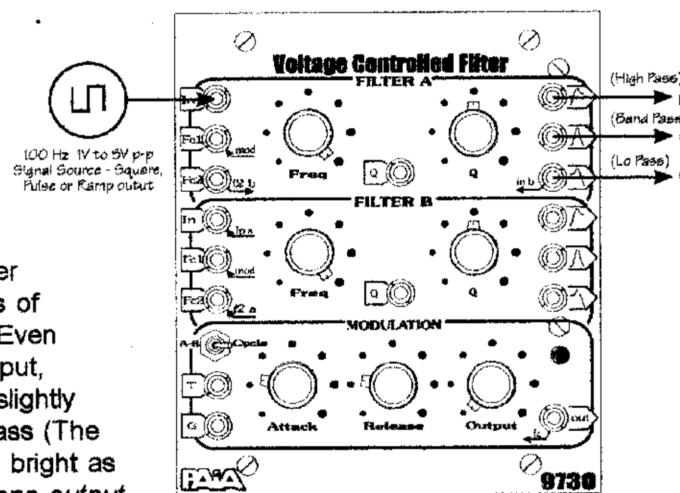
2) Check the modulator light on the 9730 front panel. It should be lit, but not very brightly. *If the LED is dark or seems fairly bright, quickly feel around on the circuit board to see if any parts are hot or very warm. If you find any, disconnect the power and carefully examine the circuitry around the hot part looking for solder bridges, backward capacitors or other polarized parts. If nothing seemed warm but the LED is dark and the panel switch is set to "Cycle" it may be a problem in the Modulator circuit. Carefully check the modulator parts (Q9-Q11, IC8, panel controls R89-R91 and associated components). Check the LED, it may be in backwards or may be bad.*



3) Rotate the Modulation Attack control to the mid-point of its rotation. The LED should now increase in intensity over a 2 second period then suddenly go dark and repeat the cycle. Turn the Modulation Release control to about the mid-point off its rotation and observe that the LED slowly brightens and slowly dims with about a 5 second period. If that goes well, crank both Attack and Release controls full ClockWise and observe that the period is about 15 seconds. *If there are problems here, check the modulator components outlined in step 2, paying particular attention to correct values. If cycle times are significantly different (half or twice more, for instance) it may indicate an incorrect component value or power supply lines that are out of spec - check for hot parts among the power supply components mentioned in step 1, and if a Volt Meter is available check the regulated supply lines - pins 11 (+12V) and 6 (-12V) of IC3 are handy places.*

Plug a signal source with a square, pulse or ramp (sawtooth) waveform into the Filter A input. Set the source's frequency to about 100 Hz and it's amplitude to 5V peak-to-peak or less. Temporarily connect the signal source to the amp and adjust the volume for a comfortable listening level. You'll find .wav file samples of what you should hear during these tests at `http://paia.com/9730test.htm` .

4) Set the panel controls as shown in the illustration. Disconnect the amp input from the signal source and connect it to the Low Pass output of Filter A . Observe that the LP output is about the same volume level as the source but much mellower in tone because the higher harmonics of the input signal are being removed. Even if you hear no sound from the LP output, connect the amp to the Band Pass (slightly brighter than the LP) and the High Pass (The brightest of the three but not quite as bright as the source. *If you hear nothing from one output*



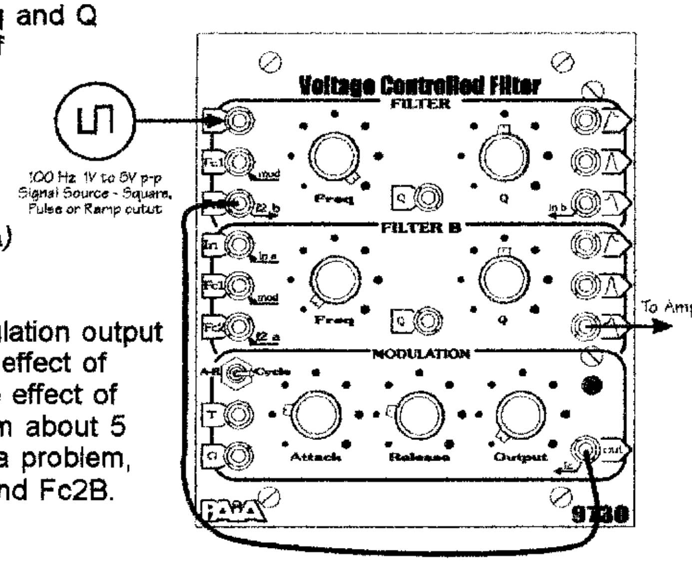
but the others are OK, check the wiring around the jack that isn't working. If you hear no sound from any of the outputs, check the Filter A parts (IC3:B, IC5:B&C, IC6, IC7:B, IC8:A&B, Q3, Q4, Q7, Q8 and associated components) for orientation, correct placement and soldering.

If Filter A is still not working, check out Filter B by connecting the signal source to Input B and listening to the Filter B LP, BP and HP outputs. If Filter B is not working also, check out the power supply components (as in step 1). If Filter B is passing signal OK, continue trouble shooting Filter A. The Design Analysis section may help. Even though it may read like a foreign language at first, it will start to make sense after a couple of readings and an understanding of how the filter works can't hurt in trouble shooting.

5) If Filter A passed the static test, reconnect the amp to the Filter A Low Pass output and advance the Modulation Output control. Observe the characteristic swept filter sound and that the range of sweep increases as the control is rotated more CW. Rotate the Q control back and forth to see that resonance increases as the control is rotated CW. If everything has worked so far, it's only pro-forma to check the BP and LP outputs - they will be working - but it's a good time to listen to the effect of the other filter functions on the signal. *If the Modulation Output control has no effect check the wiring of the Modulation Output control and Fc1A input jack (R89 and J9). On the circuit board check the components associated with the frequency CV summing amp IC8: A&B, Q7 and Q8. If there's no response to the Q control check the wiring of the Q control (R85) and the board components associated with IC3:B, Q3 and Q4.*

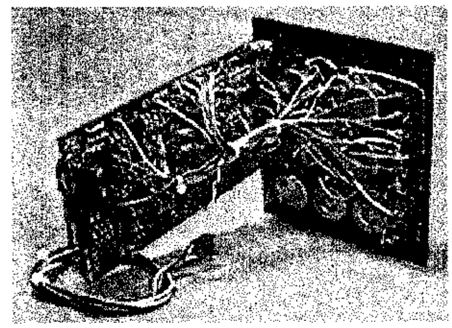
Repeat steps 4 and 5 substituting Filter B controls and outputs for the equivalents on Filter A.
In step 4) Filter B parts consist of IC3:A, IC4, IC5:A&D, IC7:A, IC7:C&D, Q1, Q2, Q5, Q6 and associated passive components.
In step 5) The Filter B frequency summing amp is IC7:C&D,Q5 and Q6 and the Fc1B input is J12. Q control is R87 and Q control parts are those associated with IC3:A, Q1 and Q2.

6)Move the signal source back to the A input and listen to the B Lo Pass output. Set controls as shown and Increase the Modulation Output control to verify that both filters are following the modulation sweep but with corner frequencies as set by the difference between the two Freq. controls. Try various setting of Freq and Q controls to develop a feel for the range of effects. Before moving on, Insert a plug into the Fc1A and Fc1B input jacks to verify that the normalization to the Modulation output is interrupted. *If there are problems here, focus your attention on the wiring of jacks J11 (InB), J9 (Fc1A) and J12 (Fc1B).*



7) Use a patch cord to connect the Modulation output to Fc2A as shown in the illustration. The effect of this simple patch should be to double the effect of the modulation output on both filters (from about 5 octaves to about 10 octaves). If there is a problem, check the normalization wiring of Fc2A and Fc2B.

Switch the modulator from Cycle to A-R and connect a gate source to Modulation input G (Gate). Gate signals should be "true positive" (transition from ground to a positive voltage between 4 and 15V to trigger the Modulator). Activate the gate and by watching the LED or listening to the filter verify that the modulation output rises when the gate signal goes on and stays high as long as the gate signal is present. When the gate signal is removed the modulator output should return to zero volts. Apply the same gate signal to the T (Trigger) input and observe that the output rises in response to the gate but releases as soon as it reaches the peak, even if the gate is still present. *If there are problems with these tests check the wiring of jacks J14 and J15. On the circuit board check Q10 and the associated resistors and diode D4*

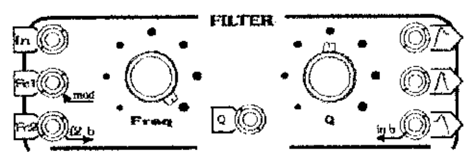


Successful completion of these tests is a good indication that the filter is working properly.

( ) Gather the wires from the circuit board to the front panelcontrols together and cinch the bundle with the three Nylon Wire Ties supplied as shown in the photo. Cinch the ties tight and clip off the excess.

THE PANEL CONTROLS

You got to know the panel controls pretty well during testing. Here's a different perspective on what they do.

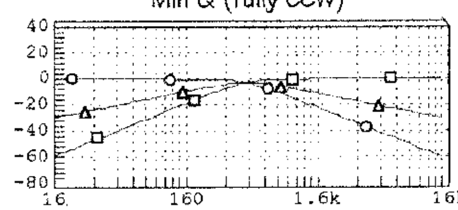


FILTER CONTROLS

Audio Input. 5V p-p nominal max input. At high Q settings input signal may need to be reduced to prevent distortion and uncontrolled oscillation

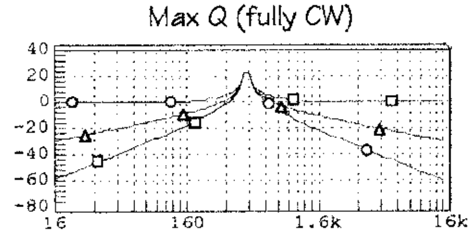
Frequency Control Voltage Input 1. Scaling is 1V/oct with the Scale A and B trimmers centered. The Filter Corner Frequency is the sum of Fc1, Fc2 and the setting of the Freq control. The arrow indicates that this input is normalized to the output of the Modulator. Inserting a plug interrupts the normalization.

Min Q (fully CCW)



Frequency Control Voltage Input 2. The arrow indicates that this input is normalized to the corresponding input of the B filter section. A Control Voltage applied to this input is also routed to the B filter Freq CV. A plug inserted into this jack on the B filter disables the normal and allows independent control of B Freq.

Max Q (fully CW)



Ref=Ground X=frequency(Hz) Y=voltage(db

Q (Resonance) CV Input. 0-10V nominal, increasing voltage increases Q.

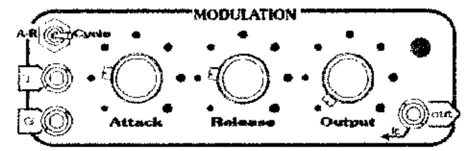
High Pass Output - Square marker in the plots

Band Pass Output - Triangle marker. Frequencies above and below Fc rejected.

Low Pass Output - Circle marker. Frequencies above Fc rejected. The arrow indicates that this output is normalized to the input of Filter B.

Freq Control - Sets initial filter Corner Frequency. CW rotation increases Fc over a 4 octave range.

Q Control - Sets initial Q. CW rotation increases Q.



MODULATOR CONTROLS

Trigger input - A transition from ground to 4V or greater triggers the Modulator. Attack cycle followed immediately by Release with no Sustain interval.

Gate Input - A voltage greater than 4V gates the modulator. Attack cycle is followed by Sustain for as long as the Gate is present. Release when Gate returns to ground.

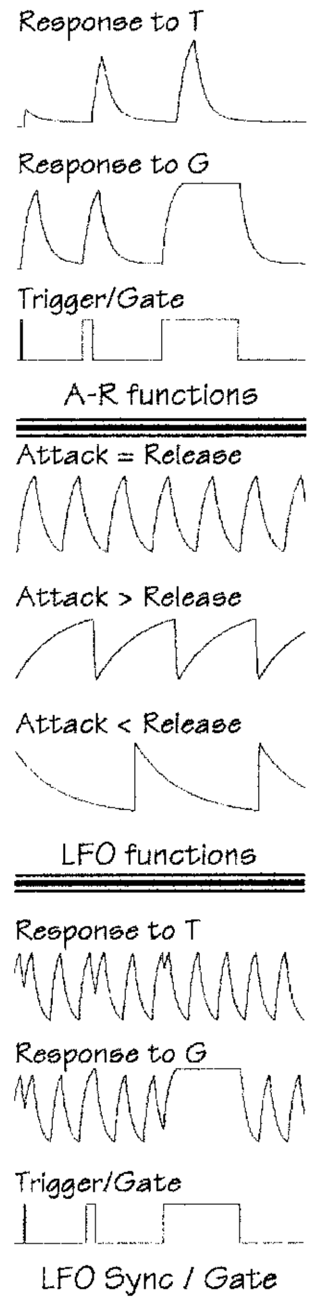
A-R - The normal Attack (Sustain) Release function of the modulator.
Cycle - In this mode the Modulator self-triggers for a Low Frequency Oscillator function. Repetition period is the sum of the Attack and Release times. Cycle mode responds to a true Gate input by interrupting the cycle with the output high. Periodic Trigger pulses hard sync the LFO.

Output - Amplitude of the Control Voltage from this output is set by the Output control. The arrow indicates that the Modulator Output is normalized to the Corner Frequency of each filter (Fc2A and Fc2B). Inserting a plug does not interrupt the normal.

Attack - Sets the time required for the output to rise to it's peak level. Time range is 500 uS (0.5 mS) at the CCW extreme to 6S when the control is fully CW.

Release - Sets the time required for the output to return to "zero". Time range to return to less than 1V is 2mS at the CCW extreme to 10S when the control is fully CW.

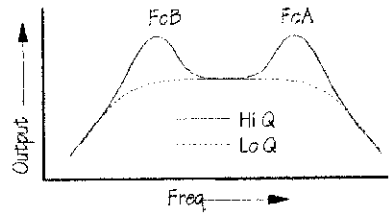
Output - Sets the output Level. Range of control is 0V at the CCW extreme and about 11V peak when the control is fully CW.



THE BLOCK DIAGRAM Fig 6 in the illustrations supplement shows the organization and normalization of the panel controls, inputs and outputs.

TIPS ON USING THE 9730

High Q settings also produce high output levels. To allow greater input signal levels, each Filter section is designed with a 6 dB attenuation at lowest Q, but input signals may need to be attenuated at higher Qs to prevent distortion. High Q and high Corner Frequency may produce uncontrolled oscillation. Reduce Q and/or input signal level to stop oscillation.



When using the two filters in the normalized configuration, Filter A's Fc should be set to a higher value than Fc of Filter B. Remember that Filter A's Lo Pass output, which is the one normalized, will have harmonic content lower than Fc while higher frequencies are attenuated. For example, using the HP B output produces a filter with a pass-band corresponding to the difference between FcB and FcA with resonant peaks at either, both or neither of the Corner Frequencies and 12 dB/oct skirts. Setting FcA and FcB so they are the same and using the LP-B output produces a 24 dB/oct low pass filter.

The Scale A and Scale B trimmers allow the Corner Frequency of the respective filters to be scaled from 0.8V/oct. (fully CCW) to 1.2 V/oct (fully CW). Centering the adjusting disk sets the response to the most commonly used scale of 1V/oct with sufficient accuracy for most purposes. A filter's Corner Frequency accuracy is not as critical as pitch accuracy in an oscillator and errors that would be unacceptable in an oscillator cannot be heard in a filter.

To precisely calibrate Fc to a specific scaling connect a CV source that can be adjusted in voltage increments corresponding to octaves (e.g. a keyboard or MIDI to CV converter) to the Fc2 CV input of Filter A, which is normalized to control Fc of Filter B so that both . Use a sine wave, triangle wave or other low harmonic content source as the filter you will be scaling and listen to the Band-Pass output of that same filter. Adjust the front panel Fc control for maximum output when the CV is low and adjust the Scale trimmer for maximum output when the CV is high. Go back and forth between high and low end until no further adjustment is required.

DESIGN ANALYSIS

The two filter sections are essentially identical state variable topologies consisting primarily of a pair of gain controlled integrators. Taking Filter A as typical, input signals are first applied to one input of a mixing amp (IC7:B) where the integrator outputs are also summed for a state variable response. Fc is set by varying the gain of a pair of Operational Transconductance Amplifiers (OTAs) feeding the integrators. The integrators comprise IC5:B, IC5:C, C12 and C14. The OTAs associated with the integrators are IC6:A and IC6:B respectively and their outputs (which are currents from pins 5 and 12) drive the integrators directly.

Exponential control of the current that sets the gain of the OTAs is provided by a summing exponential converter consisting primarily of the amp IC8:B and the discrete transistor Q7.

This common approach exploits the natural exponential relationship of a transistor's collector current to the voltage across its base-emitter junction. Q8 is added to cancel major temperature sensitivity and to scale the output current to a useful range, Q8 is biased by IC8:A to have a constant collector current of about 13uA. Taking the converter as a block, Input voltages summed by R40, R42 and R44 control Q7's collector current which drives the gain control inputs of the OTAs (IC6 pins 1 and 16)

Q (Resonance) of each filter is controlled by varying the gain of the feedback signal from the Band Pass output to the input. For Filter A the OTA used is IC3:B and increasing the control current flowing into pin 16 increases OTA gain and decreases filter Q. Exponential scaling of the Q response to CV inputs is provided by Q4 with temperature dependency cancelled by Q3. Since high precision is not needed in the CV to Q relationship there is no constant current source for Q3 and no active summing of the CVs (one from J16 and the other from panel control R85 summed by R21 and R22 respectively). The output of the OTA (IC3 pin 12, which is a current) is directly injected to the mixing amp's summing node (IC7 pin 6).

Modulator - To follow the operation of the Modulator as ASR, imagine the Cycle switch S1 is open. A high level at the Gate Input (J15) turns on Q10 so that the voltage at it's collector falls to near ground. A couple of things happen in response to this - Q11 is turned on by the current through R57 and its collector current begins to charge the timing capacitor C23 through the Attack control R91. Also when Q10's collector voltage falls it turns off Q9 and Q9's collector voltage goes high so that the current flow through R51 will hold Q10 on even if the Gate signal goes away. The bistable action of Q9 and Q10 holds the modulator in the attack state until the voltage on the timing cap reaches the peak voltage. IC8:D is a buffer that reads the voltage on the timing cap C23. The output of the buffer drives LED1 through current limiting resistor R73 and also connects to the Output Level control R89.

IC8:C is configured as a comparator with hysteresis set by R72 which couples to the buffered timing capacitor voltage and the positive feedback resistor network R71/R75. These values are chosen so that when the timing voltage reaches 11V the voltage at the "+" input of the comparator (pin 10) exceeds the reference voltage at the "-" input (pin 9) set by R65 and R74 and the comparator changes state with it's output going from -12V to about +10V. This voltage, coupled though R68 turns on Q9 which causes it's collector voltage to go to ground. At this point, if the Gate In is still true nothing further happens and the output Sustains at the peak output level. If the Gate is off, or when it subsequently goes off, Q10 turns off and its collector voltage goes high turning off Q11. With Q11 off the Decay part of the cycle is active and the voltage on the timing capacitor decreasing as charge drains off through R56 and the Decay control R90. Steering Diodes D1 and D2 force C23 to charge through R91 and discharge through R90. R62 and C21 form a network that resets the comparator when an active Gate causes Q11's collector to switch high.

When the timing voltage falls to about 1V the comparator's "+" input becomes less than the "-" reference input and it's output falls from +10V to -12V, ready for the next Gate. When the cycle switch (S1) is closed, this negative transition is coupled by R67 and C22 to the base of Q9 and unconditionally turns this transistor off. Q9's now high collector voltage turns Q10, and consequently Q11, on - starting the Attack cycle again.

9730 VCF

Semiconductors

1	7812	+12V Voltage Reg.	IC2
1	7912	-12V Voltage Reg.	IC1
3	LM13700	Dual OTA	IC3,IC4,IC6
1	TL084	Quad OpAmp	IC5
2	LM324	Quad OpAmp	IC7,IC8
2	2N3904	NPN Transistor	Q9,Q10
4	2N3906	PNP Matched Pair	(Q1,Q2),(Q3,Q4), (Q5,Q6),(Q7,Q8),
1	2N2906		Q11
1	Red LED		LED1
4	1N4148	Silicon Diode	D1,D2,D3,D4

Ceramic Disk Capacitors

2	100pF	C25,C26
2	0.001 uF	C21,C24*
13	0.01 uF	C3,C4,C7,C8,C9, C10,C15,C16,C17, C18,C19,C20,C22

Polystyrene Capacitor

4	1000 pF	C11,C12,C13,C14

Electrolytic Capacitors

1	1 uF / 16VC23	
2	470 uF / 25V	C1,C2
2	4.7 uF/ 16V	C5,C6

Potentiometers

2	1000	Horiz. PC Mount Trim.	R50,R64
5	10k	Panel Mount Pot	R85*,R86*,R87*,R88*,R89*
2	5meg	Panel Mount Pot	R90*,R91*

1/4 W. 5% Resistors - all values in ohms

6	100	brown-black-brown	R11,R12,R17,R19,R45,R54
5	100k	brown-black-yellow	R8,R21,R58,R61,R65
1	10k	brown-black-orange	R57
2	1300	brown-orange-red	R46,R55
2	150k	brown-green-yellow	R7,R22
2	15k	brown-green-orange	R10,R16
2	1800	brown-grey-red	R9,R20
2	18k	brown-grey-orange	R47,R48
1	1k	brown-black-red	R67
1	1m	brown-black-green	R66
1	22	red-red-black	R1
8	220	red-red-brown	R4,R5,R24,R25,R27 R30,R36,R38
1	2200	red-red-red	R62
2	220k	red-red-yellow	R71,R75
8	22k	red-red-orange	R6,R26,R29,R31 R34,R35,R37,R39
1	270k	red-violet-yellow	R68
1	330	orange-orange-brown	R78*
4	470	yellow-violet-brown	R3,R28,R41,R43
3	4700	yellow-violet-red	R14,R15,R73
4	47k	yellow-violet-orange	R23,R32,R33,R69
1	56	green-blue-black	R2
2	5600	green-blue-red	R59,R60
1	3300	orange-orange-red	R56
2	6800	blue-grey-red	R13,R18
1	68k	blue-grey-orange	R70
1	82k	grey-red-orange	R72
2	910k	white-brown-yellow	R53,R63
1	91k	white-brown-orange	R74

1/4 W. 1% Resistors - all values in ohms

8	100k	brown-black-black-orange	R40,R42,R44, R49,R51,R52, R76*,R77*

Misc

7	Set Screw Knobs	
4	54" lengths #22 stranded insulated wire	
1	24" length #24 bare wire	
1	3" length small diameter sleeving	
1	3" length large diameter sleeving	
3	Nylon wire ties	
1	Circuit Board	
1	Assembly Manual	
1	SPDT Mini Toggle Switch	S1

9730 FRM

13	Mono Phone Jacks
4	Closed Circuit Phone Jacks
2	# 4 "L" Brackets
4	4-40 X 3/16" Machine Screws
2	#4 Machine Nuts
1	3W FracRak Panel
4	self-tap screws
1	4 pin .1 friction lock header
1	4 pin .1 terminal housings
4	.1 crimp terminals
4	16" lengths #22 stranded wire
3	Nylon Wire Ties

010226

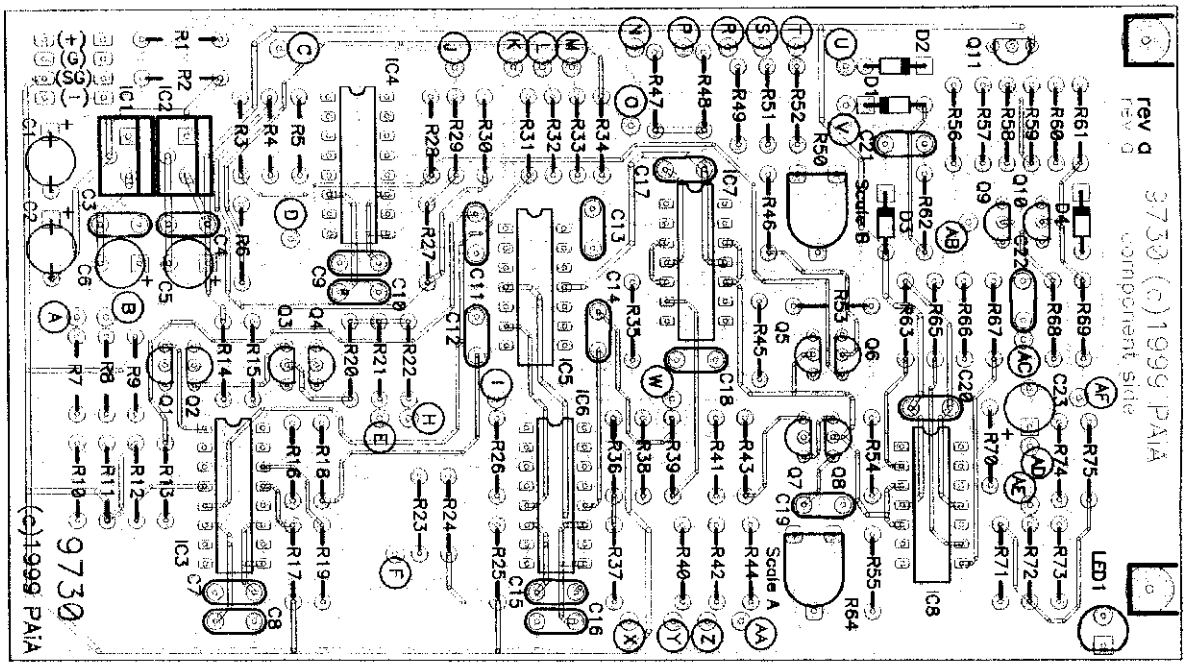


Fig 1. Circuit board parts placement and trace routings. Copper traces on the top of the board are shown in bold outline, useful if you need to trace the circuit though areas covered by ICs or other parts. Traces on the bottom of the board and their connections to components are shown in grey.

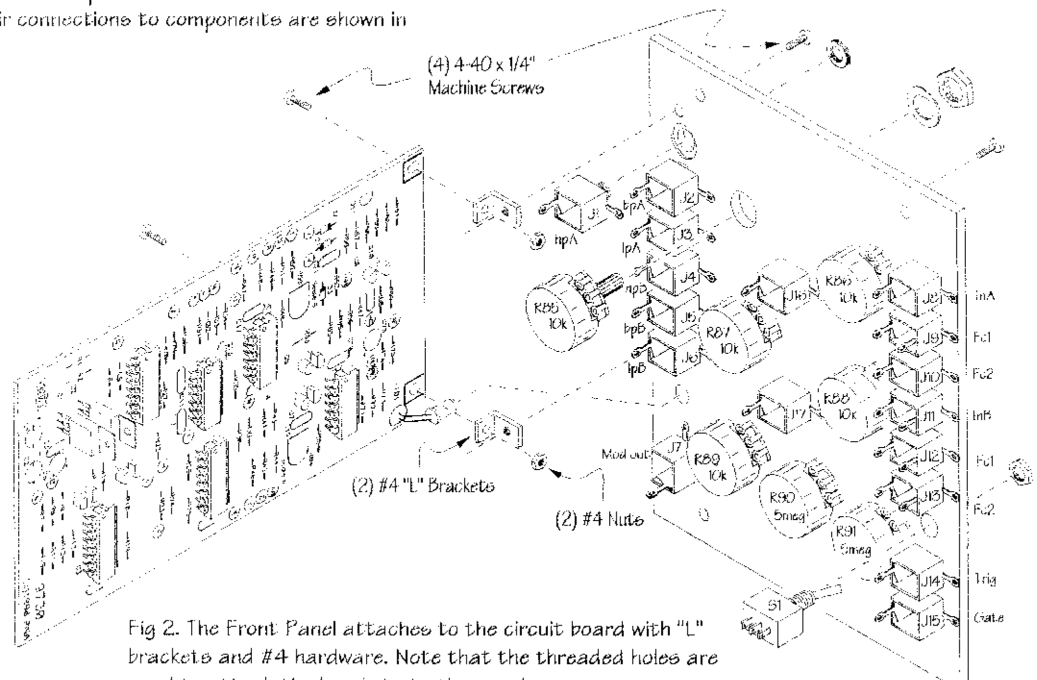


Fig 2. The Front Panel attaches to the circuit board with "L" brackets and #4 hardware. Note that the threaded holes are used to attach the brackets to the panel.

Fig 3 (right). Wiring to the "S" (Sleeve) lugs of J1-J6 will be easier if done before the potentiometers are mounted. Note the insulation over the leads of R78 and R84. Also the connection from the junction of R76 and R77 to R89-2 using insulated wire.

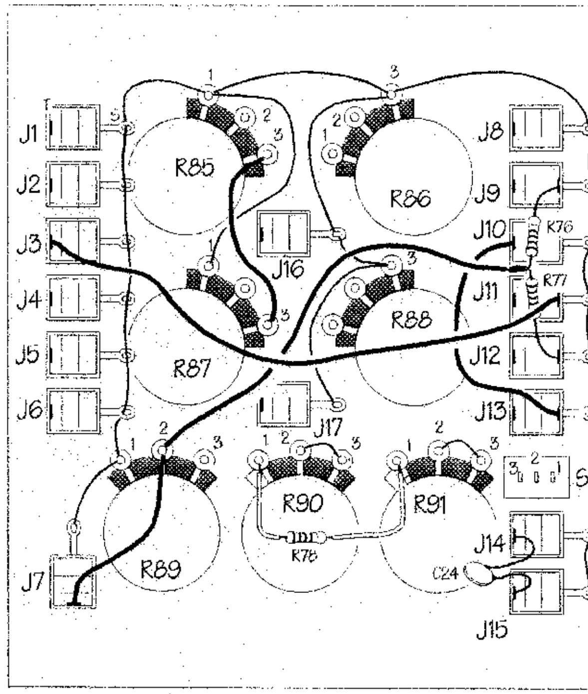
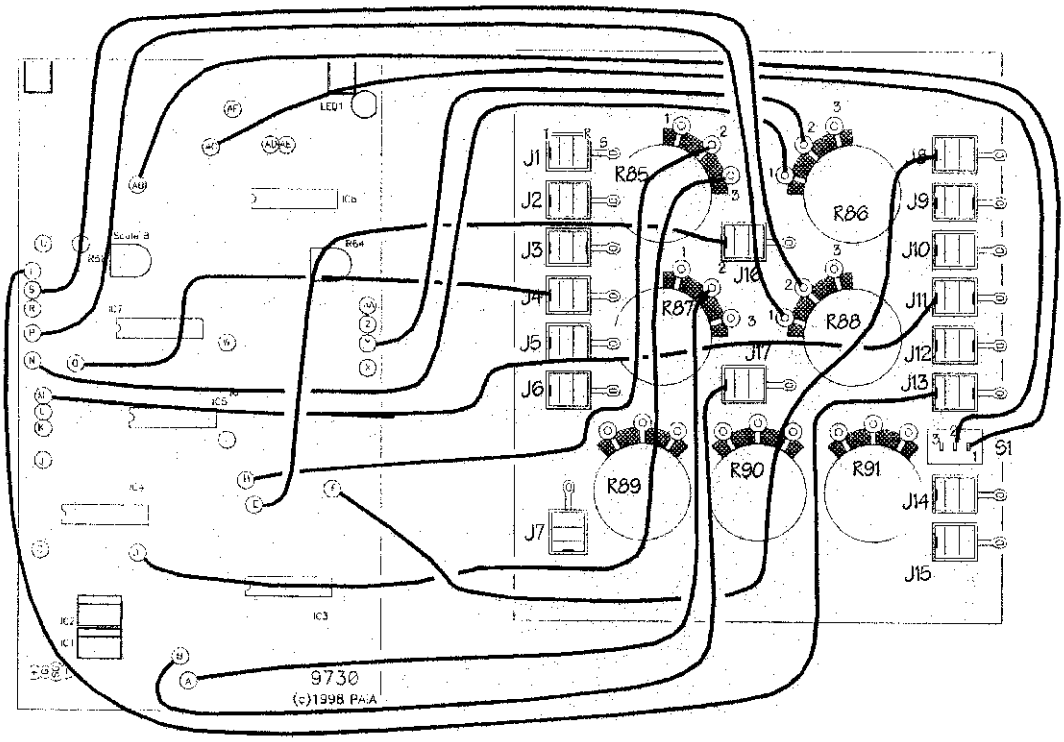


Fig 4 (below). Wiring continues with insulated stranded wire from circuit board to panel controls. Previous wiring has been eliminated for clarity.



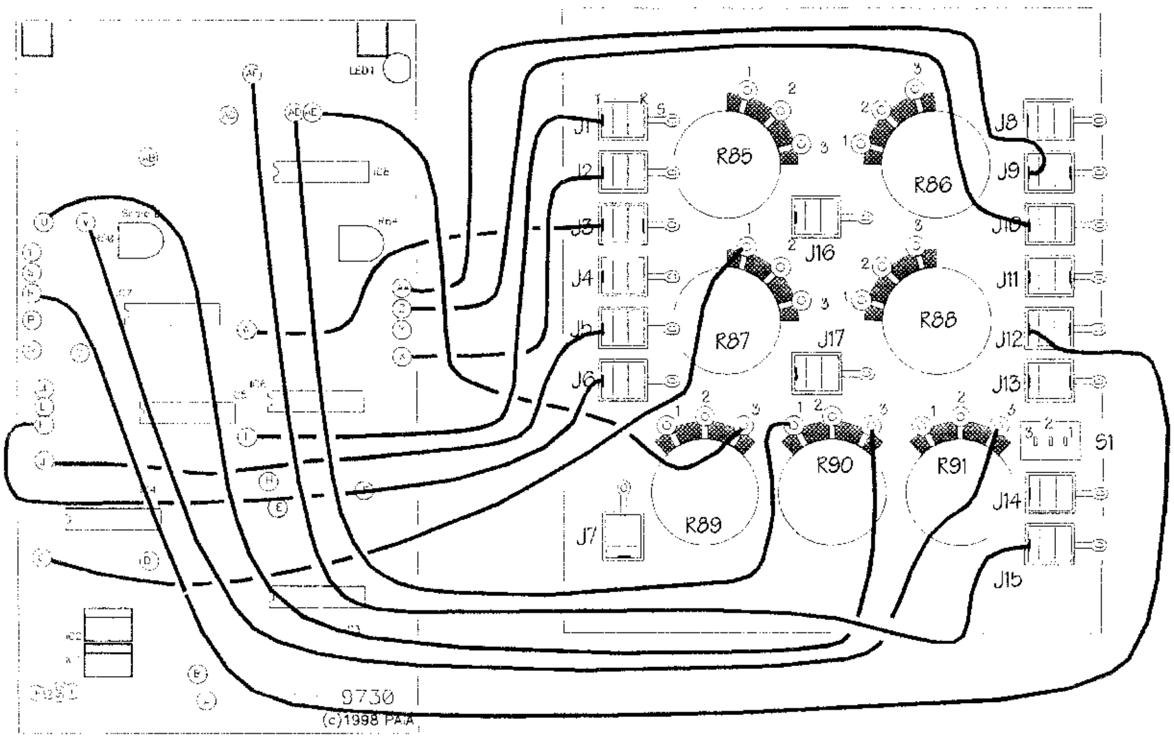


Fig 5. Wiring between panel and circuit board continues as above. Previous wiring omitted for clarity.

Fig 6 - 9730 Dual VCF w/Modulator block diagram shows normalization and organization of the controls..

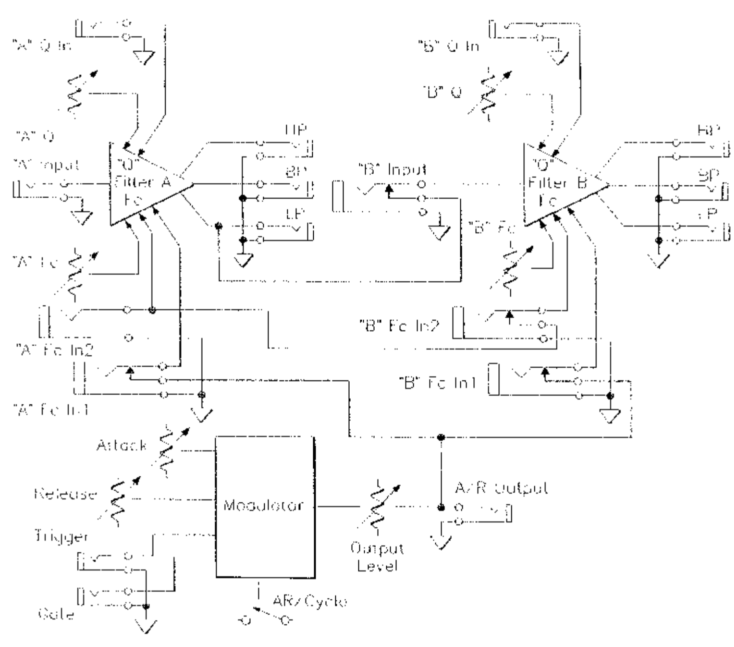
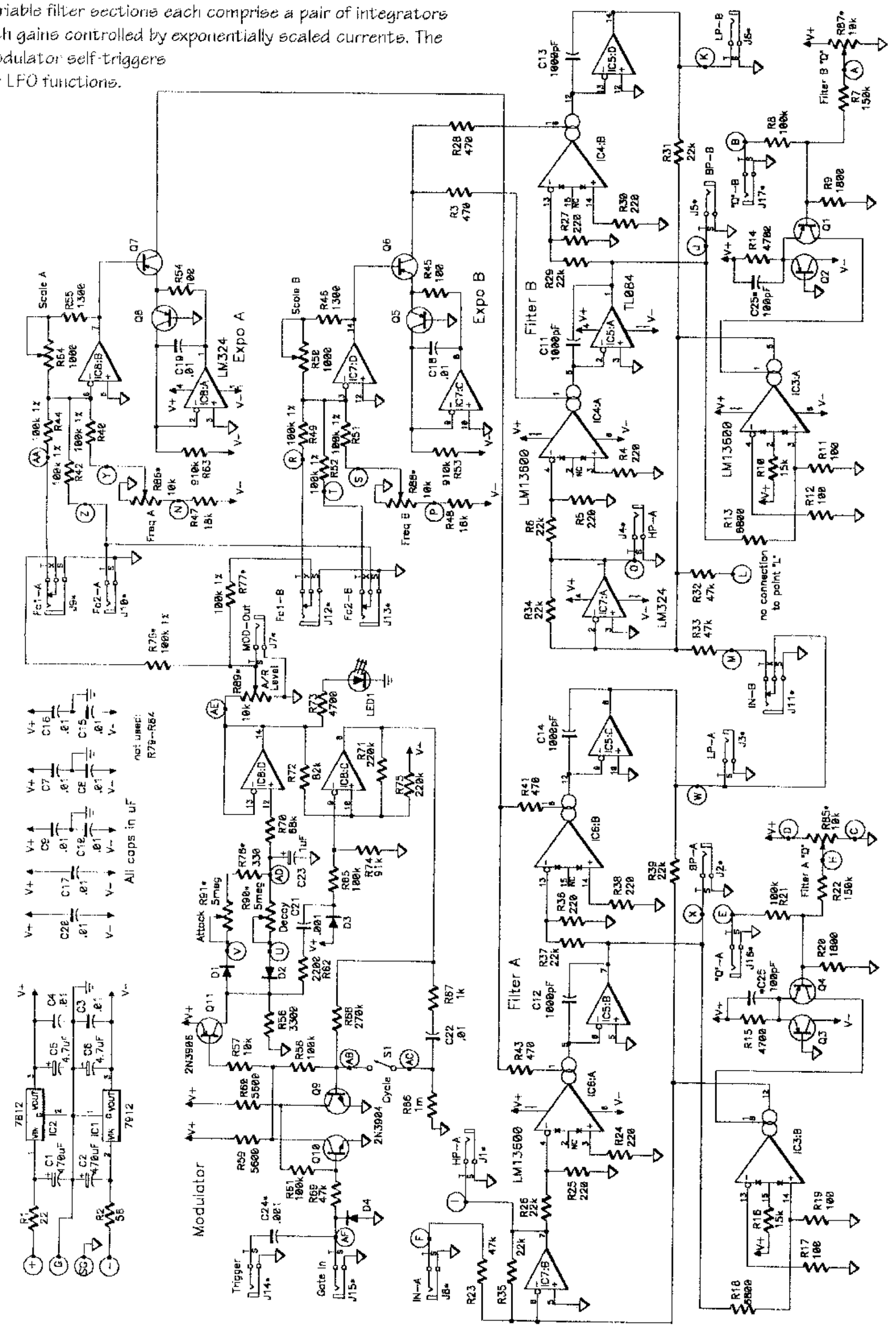


Fig 7. Dual VCF w/Modulator schematic. Identical State Variable filter sections each comprise a pair of integrators with gains controlled by exponentially scaled currents. The Modulator self-triggers for LFO functions.



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