PAIA

EKx-20

EXPONENTIAL VOLTAGE CONTROLLED FILTER

SPECIFICATIONS

POWER REQUIREMENT:	+15v. @ 25 ma. -15v. @ 25 ma.
F_c CONTROL SCALE:	1v./octave nominal.
FREQUENCY RESPONSE:	5 Hz. - 20 kHz.
CORNER FREQUENCY CONTROL RANGE:	5 Hz. - 20 kHz.
FREQUENCY CONTROL VOLTAGE RANGE:	-2 to 10 v. nominal
RESONANCE CONTROL:	0v. for no resonance.
JUMPER PROGRAMMABLE FUNCTIONS:	Low Pass, Band Pass, High Pass, All Pass.

The PAIA EKx-20 utilizes the CEM 3320 Integrated Circuit to realize an exponential response Voltage Controlled Filter. Using the EKx-20 programming header the filter can be used in a number of different configurations including low pass, high pass, band pass and all pass. Voltage control of resonance is included in all filter configurations.

The exceptionally low noise, low control voltage feedthrough and internal temperature compensation of the CEM3320 make this filter appropriate for any audio or low frequency use.

PARTS LIST

4 - 91K resistors (white-brown-orange)
9 - 100K resistors (brown-black-yellow)
4 - 220K resistors (red-red-yellow)
2 - 47K resistors (yellow-violet-orange)
1 - 68K resistor (blue-grey-orange)
1 - 1800 ohm resistor (brown-grey-red)
3 - 100 ohm resistors (brown-black-brown)
1 - 1000 ohm resistor (brown-black-red)
1 - 1K trimmer resistor
2 - 50K trimmer resistors
1 - .47 mylar capacitor
4 - 330 pf. polystyrene capacitor
1 - 1 mfd., 16v. electrolytic capacitor
1 - 100 pf. ceramic disc capacitor
2 - 33 mfd.,16v. electrolytic capacitor
1 - CEM 3320 Integrated Circuit
1 - 748 op-amp Integrated Circuit
1 - 6 inch length of bare wire,
1 - 8 pin DIP socket
1 - 16 pin DIP socket
1 - 18 pin DIP socket
1 - 16 pin DIP header
1 - length of insulated wire
1 - EKx-20 printed circuit board

ASSEMBLY

As mentioned in the PAIA Technical Services note which accompanies the Curtis Chips, care during assembly is essential to fully realize the wide operating range possible from these state-of-the-art devices. CLEAN the circuit board thoroughly with steel wool or Scotch Brite pads prior to assembly, a clean board is essential for proper solder adhesion. When assembly is complete, clean all rosin left over from soldering from the board using Acetone, denatured alcohol or some similar solvent.

Following the parts placement diagram to the right and the designators printed on the circuit board, install the components.

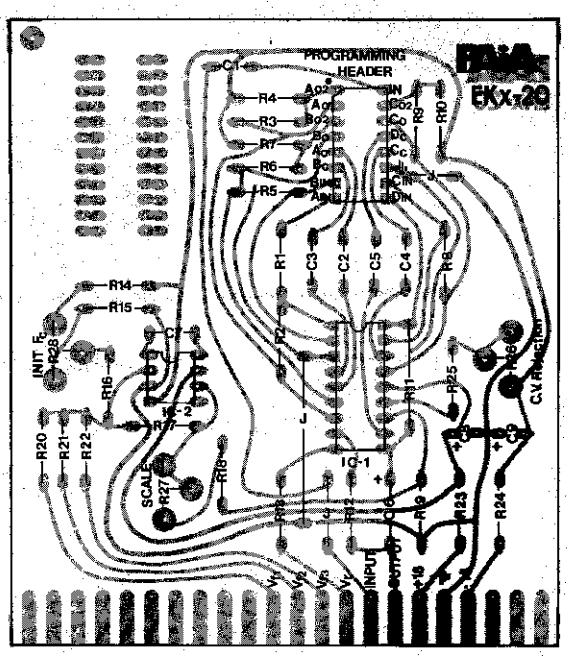


Figure 1

FIXED RESISTORS

DESIGNATION		VALUE	COLOR CODE
( )	R1	91K	white brown-orange
( )	R2	100K	brown-black-yellow
( )	R3	91K	white brown-orange
( )	R4	220K	red-red-yellow
( )	R5	100K	brown-black-yellow
( )	R6	91K	white-brown-orange
( )	R7	220K	red-red-yellow
( )	R8	100K	brown-black-yellow
( )	R9	91K	white-brown-orange
( )	R10	220K	red-red-yellow
( )	R11	100K	brown-black-yellow
( )	R12	47K	yellow-violet-orange
( )	R13	100K	brown-black-yellow
( )	R14	100 ohm	brown-black-brown
( )	R15	47K	yellow-violet-orange
( )	R16	220K	red-red-yellow
( )	R17	100K	brown-black-yellow
( )	R18	68K	blue-grey-orange
( )	R19	1800	brown-grey-red
( )	R20	100K	brown-black-yellow

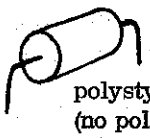
( )	R21	100K	brown-black-yellow
( )	R22	100K	brown-black-yellow
( )	R23	100 ohms	brown-black brown
( )	R24	100 ohms	brown-black-brown
( )	R25	1000	brown-black-red

TRIMMER RESISTORS

( )	R26	1K Trimmer
( )	R27	50K Trimmer
( )	R28	50K Trimmer'

CAPACITORS

( )	C1	.47 mylar
( )	C2	330 pf. poylstyrene
( )	C3	330 pf. polystyrene
( )	C4	330 pf. polystyrene
( )	C5	330 pf. polystyrene



polystyrene capacitor (no polarity)

( )	C6	1 mfd. 16v. electrolytic, observe polarity
( )	C7	100 pf. ceramic disc
( )	C8	33 mfd. 16v. electrolytic, observe polarity.
( )	C9	33 mfd. 16v. electrolytic, observe polarity.

( ) Using the bare wire provided, form and install the three jumpers indicated by the solid lines broken with a "J".

( ) Install the 18 pin socket at IC1. Observe the polarizing notch.

( ) Install the 8 pin socket at IC2. Observe the polarizing notch.

( ) Install the 16 pin socket at the programming header. Observe the polarizing notch.

( ) Install the CEM 3320 Voltage Controlled Filter chip at IC1. Observe polarization.

( ) Install the 748 type operational amplifier at IC2. Observe polarization.

PROGRAMMING

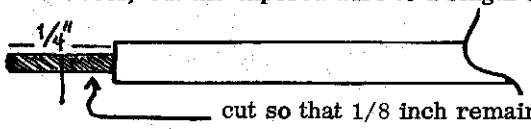
The EKx-20 can be easily wired to perform any one of the four most common filter functions by changing only those connections which appear on the pins of the 16 pin programming socket. These pins are indicated by the square terminations in the schematic diagram, figure 4.

These hints will make the job of wiring the header easier:

Insert the header into the socket while wiring and soldering. This will keep the heat of soldering from melting the header and allowing the pins to displace.

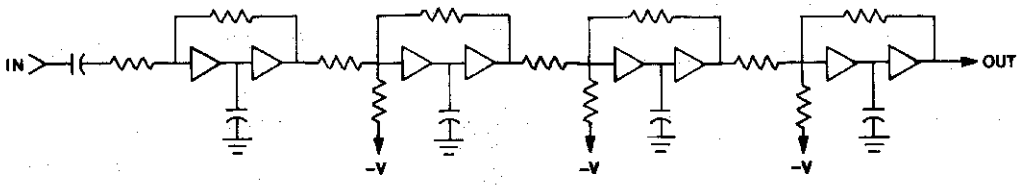
Pre-tin the header pins before soldering.

Cut the insulated wire provided slightly (1/2") longer than needed for the jumper, strip 1/4 inch of insulation from each end and twist and tin the exposed wire strands. When cool, cut the exposed wire to a length of 1/8 inch.



Resistor clippings may be used for the shorter wires that connect adjacent pins (or, for all so long as care is taken to prevent shorts).

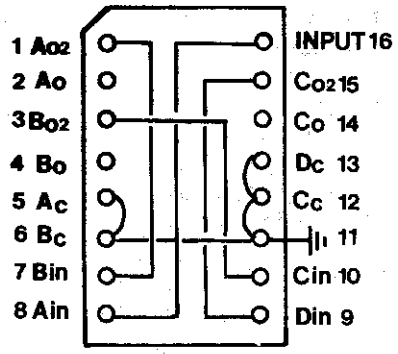
LOW PASS



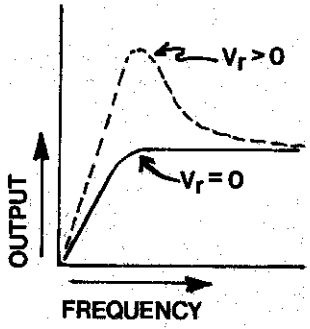
Since the resonators of almost all natural instruments are low pass elements, it is not surprising that the low pass filter is the function most frequently used in electronic music synthesis.

Wiring the programming header as shown makes each filter section a 6 db/octave low pass element and cascades all four stages in series for a 24 db/octave total response.

Increasing F_c control voltages increase the corner frequency of the filter.



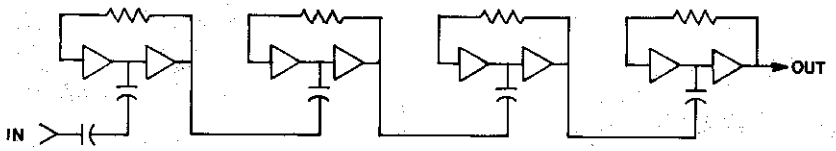
LOW PASS



When the resonance control voltage (V_r) is at zero volts, the filter behaves as a normal low pass filter. Increasing V_r introduces a resonant hump at the corner frequency. Resonance control voltages in the range of 9 - 10 volts will cause the filter to oscillate.

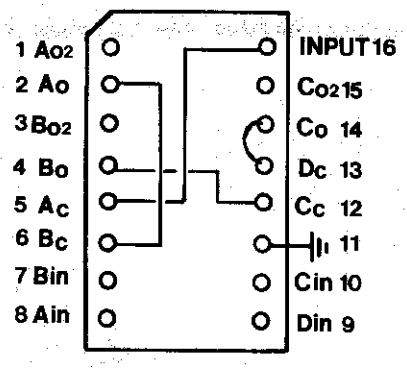
Note that because of the input coupling capacitor, the filter will not pass D.C. voltage.

HIGH PASS

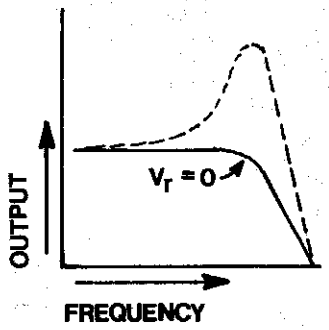


In this configuration all 4 elements are wired as 6 db/octave high pass sections and cascaded to produce a 24 db/octave high pass filter response.

As with the low pass filter, increased resonance introduces a hump in the response at the corner frequency. Resonance control voltages in the range of 4 - 5 volts will cause the filter to oscillate.

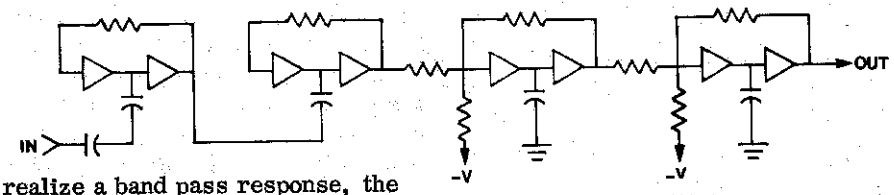


HIGH PASS



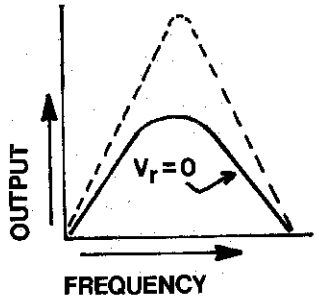
As mentioned in the CEM 3320 Tech Notes, for a given control voltage, the corner frequency of this configuration is somewhat more than an octave higher than with the low pass configuration. This difference can be compensated using the INIT F_c trimmer R28.

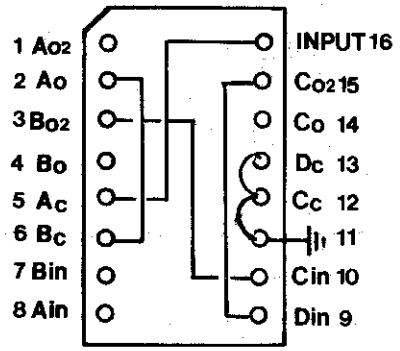
BAND PASS



To realize a band pass response, the high frequencies remaining at the output of two cascaded high pass sections (12 db/octave response) is applied to two cascaded low pass sections.

Increased resonance has the effect of increasing the out of band rejection of the filter. Oscillation will occur at 4 - 5 volts.

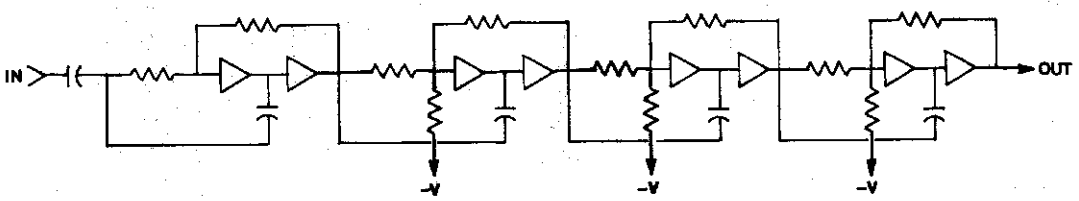




BAND PASS

For a given control voltage, the center frequency in this configuration is slightly more than an octave lower than the corner frequency of the low pass configuration.

ALL PASS

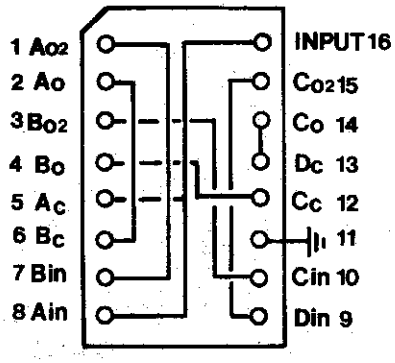


In the all pass configuration, each of the four filter sections is connected as a 180^{o} phase shifter. The four cascaded sections produce a total of 720^{o} of phase shift.

As the frequency control voltage (V_f) increases, signal components at the frequency of interest shift so that at the F_c corresponding to V_f they are 360^{o} out of phase with the input.

It is important to note that because our ears are not sensitive to static phase relationships, an all pass filter has no audible effect in response to a constant control voltage. Only when the phase relationships are changing is the effect evident.

The all pass filter tends to oscillate at very low resonance control voltages (1 - 2 volts).



ALL PASS

CALIBRATION

Apply power to the supply pins on the EKx-20 card; +15v. to connector pin 17, -15v. to connector pin 19 and the common ground of the two supplies to pin 18.

It will also be useful to have a variable voltage source applied to the EKx-20's Resonance Control input (V_r, pin 14) and a second source applied to one of the corner frequency control inputs (V_{f1}, pin 11 is good.

The equipment and interconnections shown in figure 2 can be used during calibration.

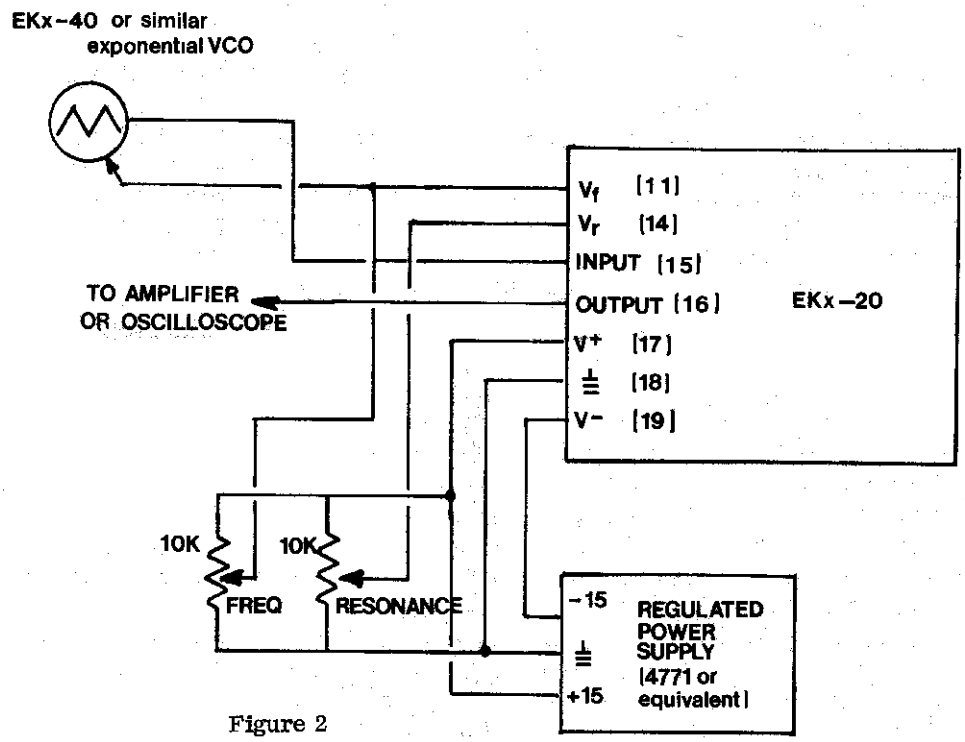


Figure 2

Begin the procedure by installing a programming header configured for low pass operation and setting the three trimmer resistors as follows:

C.V. Rejection	(R26)	Mid-range
SCALE	(R27)	mid-range
INIT F_c	(R28)	CCW (viewed from edge of board)

Also set the external resonance and corner frequency controls to their minimum voltage settings.

C.V. REJECTION

If any of the corner frequency control voltage is allowed to couple into the audio path of the filter it will respond to changes in the control voltage as if they were signal inputs. At low resonance settings this fault produces a "thump". At higher resonances, control voltage feed-through results in drum-like ringing transients.

Even untrimmed, control voltage rejection of the CEM 3320 IC is more than ample when working with high level audio signals - in the range of several volts peak to peak.

For the purist, on the other hand, C.V. Rejection can be trimmed to essentially nil by measuring the voltage at pin 10 of IC 1 (this voltage should be between 6 and 7 volts) and adjusting R26 (C.V. Rejection) so that the pin 10 voltage remains unchanged while the corner frequency control voltage is varied between 0 and 10 volts.

SCALE

The SCALE adjust is used to set the filter's corner frequency control voltage response to be 1 volt/octave.

The easiest way to accomplish this is to drive the audio input of the filter with a low harmonic content signal from a VCO (triangle or sine). The frequency control inputs of both the oscillator and filter should be driven from the same control voltage source and the resonance of the filter adjusted so that it is just slightly below the point of self oscillation.

While monitoring the output either by listening through an amplifier or watching on a 'scope, proceed with the calibration by applying a 5v. control voltage to the oscillator and filter and adjusting the EKx-20's INIT F_C trimmer (R28) for maximum signal output.

Return the VCO and filter control voltage to ground (0v.) and adjust the EKx-20's SCALE trimmer (R27) for maximum output.

Alternate between adjusting INIT F_C at a 5v. input and SCALE at 0 v. until both voltages produce maximum output without further adjustment.

The SCALE of the filter may also be calibrated by raising the resonance control voltage to the point that the filter oscillates and then utilizing a lissajous technique like that in the CALIBRATION section of the EKx-40 VCO manual.

If you use this approach, stick to a 5 octave control range and adjust the filter's INIT F_C trimmer at the higher control voltage and the SCALE trimmer at the lower. Since the filter has no control corresponding to the VCO's Hi Freq. Track trimmer, the section of the procedure dealing with this control is not pertinent.

In any case, the pitch accuracy of the filter is not intended to be of the order of magnitude as that of an oscillator. While you should expect only a few cents error in filter corner frequency over a 5 octave range, the error will become more significant as you try for ranges much greater than this.

INIT F_C

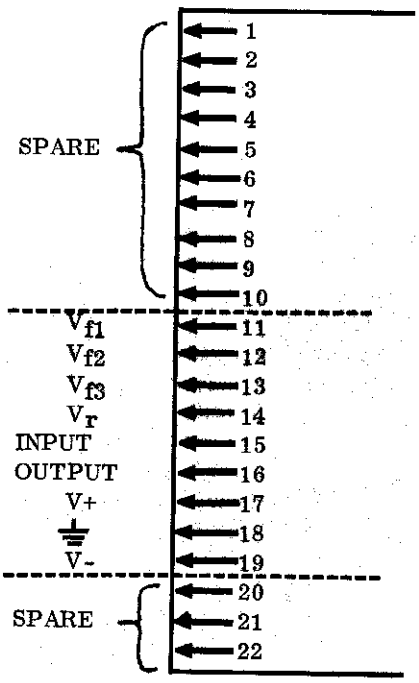
The Initial Corner Frequency trimmer (R28) may be set as required depending on filter configuration and desired control voltage range.

The edge connector pads on the EKx-20 have these labels and uses:

1 - 10 SPARE pads

11 - 13 V_{f1-3} - Corner frequency control voltage. The algebraic sum of the voltages applied to these pads set the frequency of interest of the filter. Increasing voltages raise the frequency. Control scale of this voltage is one volt/octave. Maximum recommended range of the control control voltage sum is -2v. to 10v.

14 V_r - Resonance control voltage. The voltage applied to this pad sets the gain of the transconductance amplifier in the filter's feedback loop and consequently the resonance of the filter. Useful control voltage range is dependent on the configuration of the filter but in general should be held at less than 10 volts. Zero control voltage turns the feedback amp off for minimum resonance.



EKx-20 EDGE CONNECTIONS
(from component side of circuit board)

Figure 3

15 INPUT - This pad is the audio input to the filter. Input impedance is approximately 100K. Input signal level should not exceed 10v. peak to peak.

16 OUTPUT - This pad is the signal output of the filter. Signal gain within the pass-band at zero resonance is essentially unity. Output impedance is low, on the order of 100 ohms.

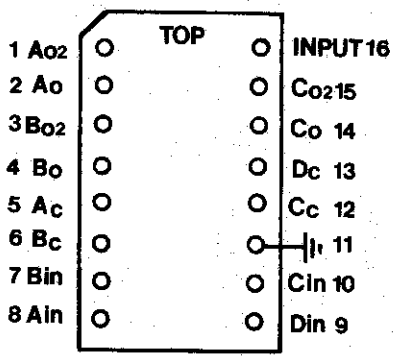
17 V+ - A well regulated +15 volt supply should be connected to this pad.

18 Ground - System ground, common point for the bipolar power supplies and reference for all control voltages.

19 V- - A well regulated -15 volt supply should be connected to this pad.

20 - 22 SPARE pads.

To the right is an illustration of the configuration of patch points that appear on on the programming header. Designations refer to the schematic diagram, figure 4 .



PROGRAM SOCKET

SCHEMATIC

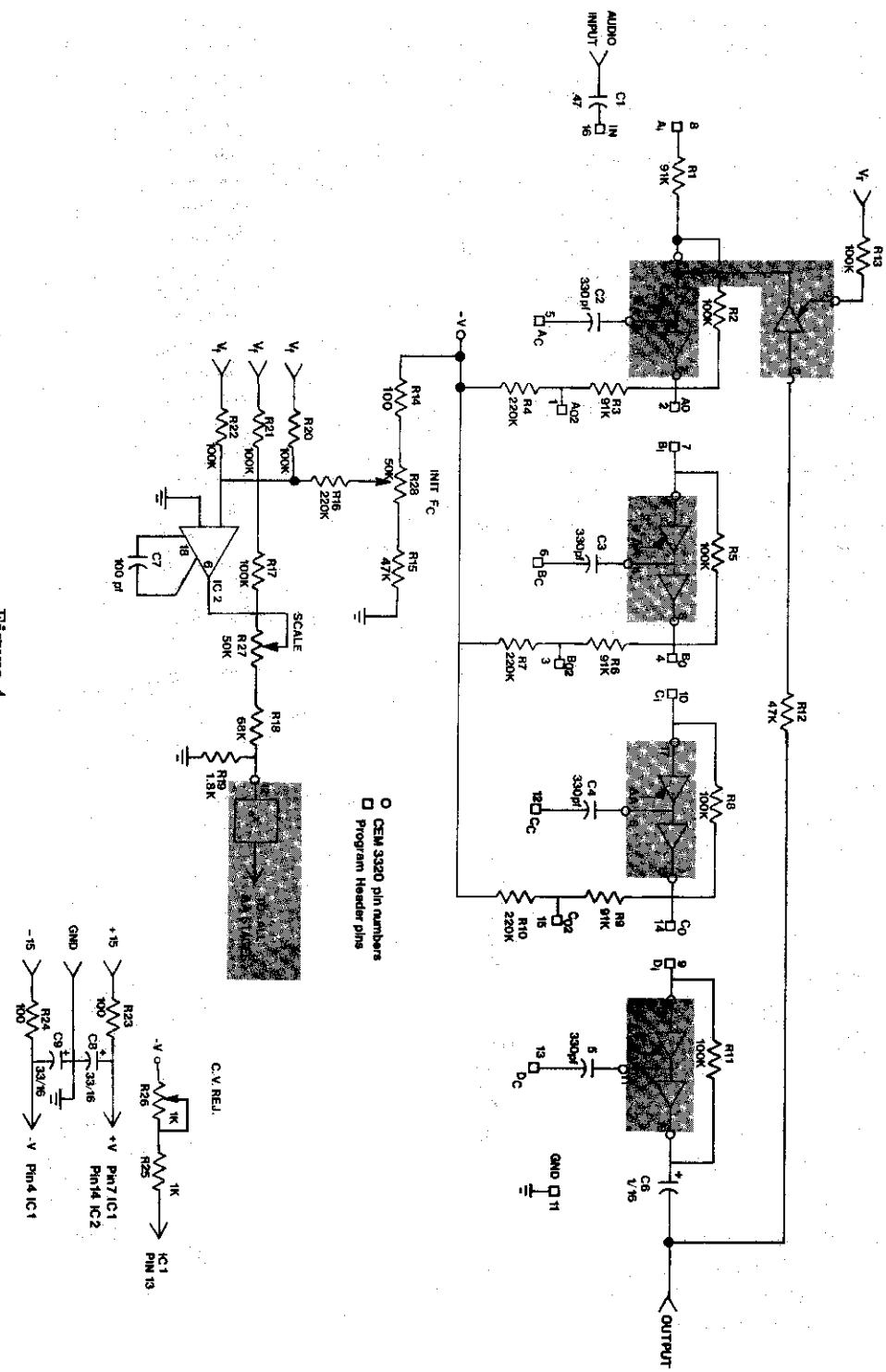


Figure 4