PAIA

EKx-40

EXPONENTIAL
VOLTAGE CONTROLLED OSCILLATOR

SPECIFICATIONS

POWER REQUIREMENT:	±15 volts @ 10 mA
CONTROL SCALE:	1 volt/octave
CHROMATIC CONTROL RANGE:	0 - 10 v. @ worst case error of 5 cents
NOMINAL 0 C.V. FREQUENCY:	10 Hz.
NON-CHROMATIC FREQ. RANGE:	0.2 Hz. - 40 KHz.
OUTPUT WAVEFORMS:	Ramp, Triangle, Pulse
NOMINAL OUTPUT LEVEL:	5 v. peak to peak
MINIMUM DRIVEN IMPEDANCE:	50K ohms (any output)
NOMINAL PULSE WIDTH CONTROL RANGE:	0 - 5 v. for 0 - 100% duty factor

The EKx-40 Exponential Voltage Controlled Oscillator experimenter's kit is a typical application of the CEM 3340 VCO Integrated Circuit. The EKx-40 provides an exceptionally stable and easily calibrated state of the art oscillator featuring both industry standard 1v./octave control of frequency and linear response voltage control inputs for the exploitation of FM synthesis techniques. Triangle, ramp and voltage controlled pulse output waveforms are simultaneously available and both hard and soft synchronizing inputs are provided. Temperature compensation is internal to the Integrated Circuit. The pitch of the oscillator is accurate to any reasonable tolerance over a 10 octave range and waveforms are useable from less than one cycle every five seconds to over 40,000 cycles per second.

PARTS LIST

1 - 27K resistor (red-violet-orange)
1 - 6800 resistor (blue-grey-red)
1 - 1800 ohm resistor (brown-grey-red)
1 - 10K resistor (brown-black-orange)
1 - 3900 ohm resistor (orange-white-red)
1 - 330K resistor (orange-orange-yellow)
1 - 680 ohm resistor (blue-grey-brown)
1 - 2.2 meg resistor (red-red-green)
1 - 680 K resistor (blue-grey-yellow)
2 - 1 Meg resistor (brown-black-green)
2 - 470 ohm resistor (yellow-violet-brown)
3 - 5600 ohm resistors (green-blue-red)
2 - 10K trimmer resistors
2 - 100 ohm resistors (brown-black-brown)
1 - 1200 pf. polystyrene capacitor
2 - .01 ceramic disc capacitor
2 - .001 ceramic disc capacitor
2 - 33 mfd. 16 v. electrolytic capacitor
1 - 16 pin DIP Socket
1 - CEM 3340
1 - EKx-40 printed circuit board

3 - 100K 1/4 watt 1% resistors (brown-black-black-yellow)

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.

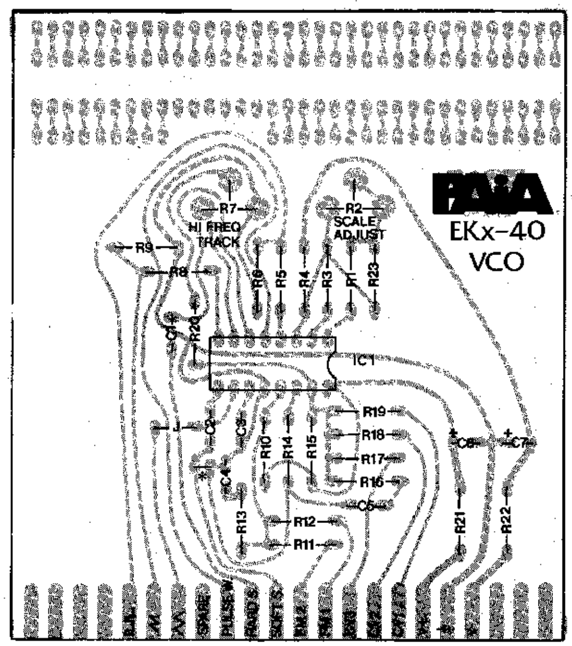


Figure 1

FIXED RESISTORS

DESIGNATION		VALUE	COLOR CODE
( )	R1	27K	red-violet-orange
( )	R3	5600	green-blue-red
( )	R4	680	blue-grey-brown
( )	R5	6800	blue-grey-red
( )	R6	3900	orange-white-red

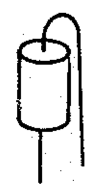
( )	R8	5600	green-blue-red
( )	R9	5600	green-blue-red
( )	R10	2.2 meg.	red-red-green
( )	R11	1 meg	brown-black-green
( )	R12	1 meg	brown-black-green
( )	R13	470	yellow-violet-brown
( )	R14	1800	brown-grey-red
( )	R15	330K	orange-orange-yellow
( )	R16	470	yellow-violet-brown
( )	R17	100K, 1%	brown-black-black-yellow
( )	R18	100K, 1%	brown-black-black-yellow
( )	R19	100K, 1%	brown-black-black-yellow
( )	R20	680K	blue-grey-yellow
( )	R21	100	brown-black-brown
( )	R22	100	brown-black-brown
( )	R23	10K	brown-black-orange

TRIMMER RESISTORS

( )	R2	10K Trimmer
( )	R7	10K Trimmer

CAPACITORS

( )	C1	.001 ceramic disc
( )	C2	.001 ceramic disc
( )	C3	1200 pf polystyrene (install on end)
( )	C4	.01 ceramic disc
( )	C5	.01 ceramic disc
( )	C6	33 mfd., 16v. electrolytic
( )	C7	33 mfd., 16v. electrolytic



MISCELLANEOUS

( ) Install the wire jumper using resistor clipping. The jumper is indicated by the solid line broken with a "J". Note that the (*) marked jumper should be installed if the soft sync input is not going to be used. (see USING THE EKx-40)

( ) Install the 16 pin DIP socket at IC 1, observe the polarizing notch on the socket.

INTEGRATED CIRCUIT

( ) Install the CEM 3340 in the DIP socket, observe polarity.

THIS COMPLETES ASSEMBLY OF THE EKx-40

CALIBRATION

The easiest and most accurate way by far to calibrate the VCO is by tuning to intervals that are octave multiples of a reference frequency. If you're a purist, you can also monitor the results with a frequency counter, but the inherent measurement delay in these instruments (they actually count the transitions of the input signal and that takes time) makes them entirely inappropriate as the primary calibration standard. Also, while it will not be said, the final test should be to play the VCO and listen to the result. In the final analysis, this is the test that counts.

As is shown in the calibration set-up drawing figure 2 , the major pieces of equipment that you'll need are a reference oscillator and oscilloscope. A little more detail on these instruments.

The reference oscillator can be practically any bench type audio oscillator; or, in fact, can be another VCO. Our only requirement on this piece of equipment is that its frequency be stable for the duration of the procedure. It need not be precisely calibrated since we will be setting it for a constant frequency and then comparing the VCO under calibration to octave multiples of its output. Either sine or triangle wave outputs are appropriate waveforms from the reference oscillator.

The accuracy of calibration of the oscilloscope is similarly non-critical because we will be using it to produce lissajous patterns which indicate the frequency of oscillator being calibrated to the reference. In fact, the oscilloscope can be eliminated entirely and the task of comparing VCO to reference frequency accomplished by mixing the two outputs into an amplifier and listening to the result. It's extremely easy to recognize octave intervals by ear and by listening for a zero beat note (that point at which the "throbbing" associated with oscillators running at close to octave multiples of one another disappears), this procedure can produce results that are as valid as those obtained with the more elaborate equipment.

Notice that there are three control voltages coming into the VCO; two from external pots (coarse and fine frequency controls), and the third from the pitch controller. The pitch controller can be an analog keyboard or DAC connected to a computer or other digital source, but whichever it is, it must be calibrated to produce 1 volt/octave. During the procedure we will assume that the controller is capable of 5 octaves, but the points that we will calibrate to are available from a three octave keyboard. If you have a 5 octave controller, the first and last octaves can be used to verify and touch up the calibration.

A program that can be used with the PAIA 8700 (with encoded keyboard, if available) and an 8785 linear DAC is included in the appendix of this manual.

After assembling the equipment and interconnecting it as shown, turn on the power, verify that everything is working and immediately perform the most important part of the procedure; go away for a half hour. The time lapse is needed for equipment temperatures to stabilize and for new parts in the VCO to age some. Even after calibrated, a 5 - 10 minute warm up prior to using the oscillator is highly recommended.

When all of the equipment has warmed up and stabilized, begin the procedure by setting the reference oscillator for a frequency of about 250 Hz. and activate the pitch controller key that will produce a control voltage output of 1 volt. Center the fine frequency control and adjust the coarse control so that the 'scope shows an output from the VCO being calibrated that is 1/2 the frequency of the reference (). Use the fine control to produce a stable pattern.

Activate the pitch key corresponding to a control voltage of 4 volts (3 octaves higher than the previous calibration point) and adjust the EKx-40's SCALE ADJUST trimmer (R2) for a stable lissajous indicating that the VCO frequency is now four times the reference (◇◇◇◇).

When you now go back to the first frequency (corresponding to 1v.) the pattern will no doubt be spinning again. Adjust the fine frequency control for a stable pattern again (◇◇).

Go back and forth between the two calibration points, adjusting the fine frequency control for a stable pattern at the lower VCO frequency and the SCALE ADJUST for a stable pattern at the higher frequency.

Eventually, you will reach a point at which both patterns are stable with no further adjustments. When you reach this point, readjust the reference oscillator for a frequency of about 1000 Hz.

Again activate the 1v. pitch control voltage and use the coarse and fine frequency pots to produce a stable lissajous indicating that the VCO output is half that of the reference (◇◇), and when stable again activate the 4v. pitch control.

This time, adjust the EKx-40's HI FREQ. TRACK trimmer (R7) for a stable lissajous 4 times the reference. As before, it may be necessary to go back and forth between the high and low end a couple of times before the patterns are stable at both points; and note that at these higher frequencies a slight spin of the patterns represents a much smaller error than the corresponding rate of spin at lower frequencies. Absolutely stable patterns are not a reasonable goal.

When both calibration points produce fairly stable lissajous (or beat-free tones if you're doing it by ear), once again set the reference oscillator for 250 Hz. and check to see that the calibration here has not changed. If it has, iterate the lower frequency procedure again, alternating between the fine frequency control pot and the EKx-40 SCALE ADJUST trimmer.

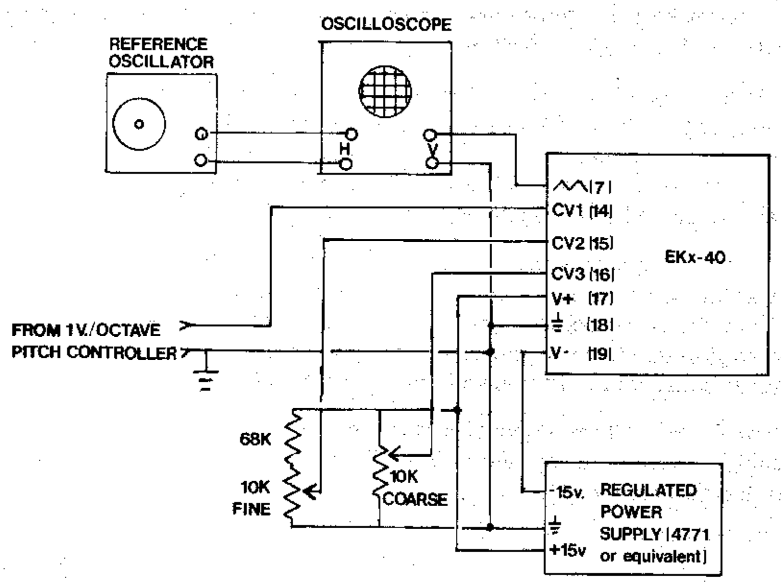


Figure 2 - CALIBRATION EQUIPMENT CONNECTIONS

USING THE EKX-40

The edge connector pads on the EKx-40 have these labels and uses:

1 - 4 SPARE pins

5 PULSE OUT - This connector pad provides a nominal 5 volt peak amplitude pulse waveform with a level from ground of +5v. The duty factor of the pulse is linearly proportional to the voltage applied to the Pulse Width control voltage input pin 9. The frequency of the waveform is exponentially proportional to the sum of the voltages on the three exponential input pins 14, 15 and 16 and linearly proportional to the sum of the voltages on the FM inputs pins 12 and 13.

6 RAMP OUT - This connector pad provides a nominal 5 volt peak amplitude ramp waveform with a level from ground to +5 volts. The frequency is the same as the pulse output.

7 TRIANGLE OUT - This connector pad provides a nominal 5 volt peak amplitude triangle waveform with a level from ground to +5 volts. The frequency is the same as the pulse and ramp outputs.

8 SPARE

9 PULSE WIDTH - A control voltage applied to this connector pad determines the duty factor of the pulse waveform produced from pin 5. Duty factor is directly and linearly proportional to control voltage with 0 volts corresponding to 0% duty factor (no output) and a nominal 5 volts corresponds to 100% duty factor (also no output).

10 HARD SYNC - Synchronizing pulses applied to this input may be either positive or negative going (as in the AC coupled leading and trailing edges of a square wave) with results as outlined in the CEM 3340 data sheet. It is important to note that the period of the waveform which results from the use of this input will always be the same as the period of the sync pulses.

11 SOFT SYNC - Negative going pulses applied to this input produce a type of synchronization which constrains the period of the final output waveform to be an integral multiple of the period of the sync pulses. If this input is not being used, it should be tied to ground either at the connector pad or by putting in place the jumper on the circuit board which is marked with an "*"

12, 13 LINEAR FM - These connector pads provide linear voltage control of the oscillator frequency. Their primary use will be in generating comples tone colors using frequency modulation techniques (1).

EKx-40 EDGE CONNECTIONS (from component side of the circuit board)

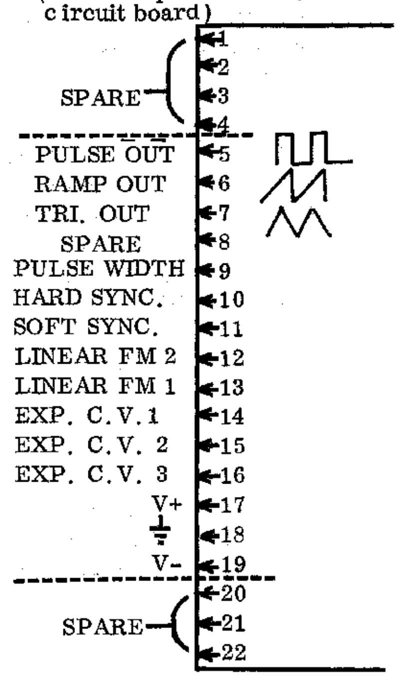


Figure 3

(1) The Synthesis of Complex Audio Spectra by Means of Frequency Modulation; John M. Chowning; Journal of the Audio Engineering Society, Vol. 21, No. 7, September, 1973.

14-16 EXP. C.V. - The sum of the voltages present on these three edge connector pads set the pitch of the oscillator with a control scale of 1 volt/octave. For maximum pitch accuracy, the sum of these voltages should be in the range of 0 to +10v. Typical oscillators will respond to control voltage sums as high as 14 volts and as low as -4v.

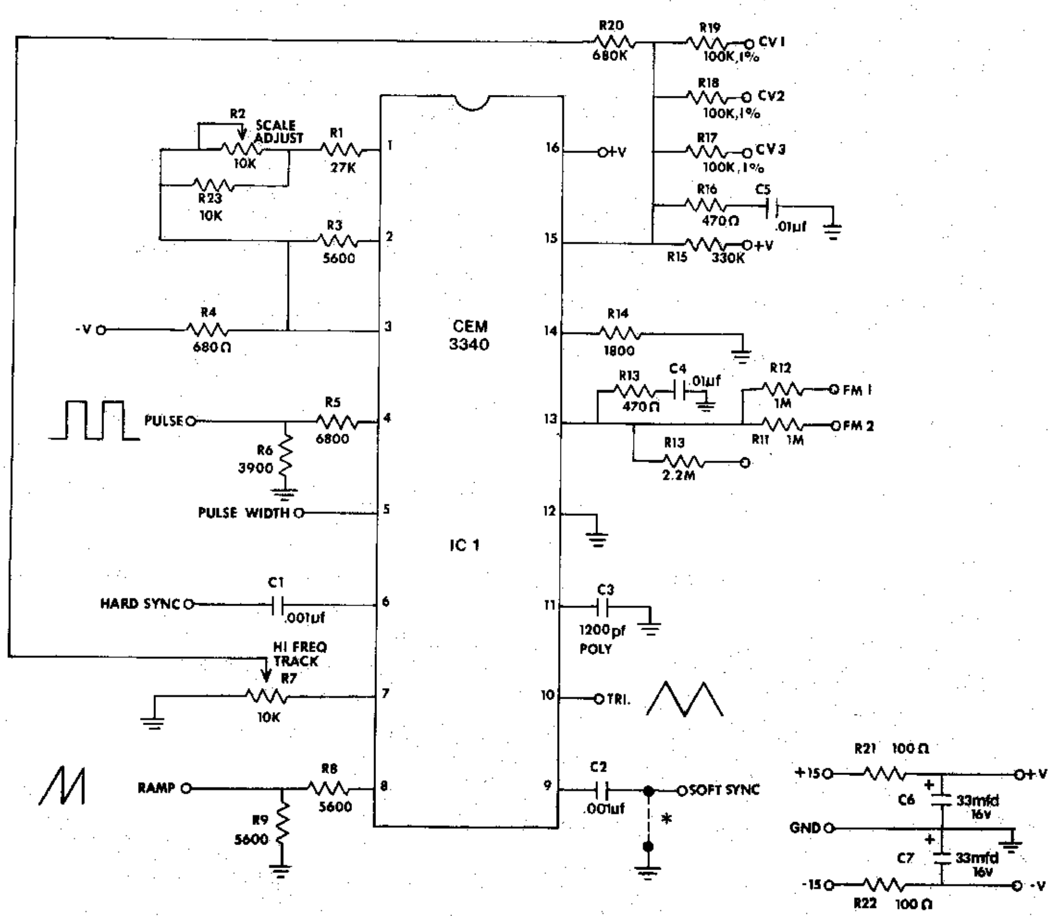
17 V+ - A well regulated +15 volt supply should be connected to this connector pad.

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

19 V- - A well regulated -15v. supply should be connected to this edge connector pad.

20 - 22 SPARE

SCHEMATIC



APPENDIX

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                 :********************************
                 :*                              *
                 :*            CAL1              *
                 :*    VCO CALIBRATION ROUTINE   *
                 :*             BY               *
                 :*     JOHN S SIMONTON, JR      *
                 :*(C)1980 PAIA ELECTRONICS, INC.*
                 :*                              *
                 :********************************
                 :
                      .OR 1000
                 :
000-  A9 00       STAR LDA 00        :INITIALIZE TEMP BUFFER
002-  85 23            STA *TEMP
004-  20 50 1D    LOOP JSR LOOK      :READ AGO KEYBOARD AND DELAY
007-  A5 E7            LDA *KTBL+07  :GET LOWEST KEY DOWN
009-  D0 0E            BNE SNX0      :IF KEY DOWN, BRANCH TO OUTPUT
00B-  20 00 1F         JSR DECD      :NO KEYS, CHECKFOR COMMAND
00E-  A9 40            LDA 40        :PREPARE
010-  B0 09            BCS SOUT      :BUT IF NO NEW COMMAND,  OUTPUT LAST RESULT
012-  88          SLP0 DEY           :A COMMAND, COUNT DOWN TO FIND OCTAVE NUMBER
013-  30 04            BMI SNX0      :AND WHEN DONE, BRANCH TO OUTPUT RESULT
015-  69 0C            ADC 0C        :IF HERE, NOT DONE YET - CALCULATE NEXT OCTAVE
017-  10 F9            BPL SLP0      :AND IF NOT OUT OF RANGE, BRANCH TO CONTINUE
019-  85 23       SNX0 STA *TEMP     :SAVE OUTPUT FOR WHEN NO KEYS OR COMMANDS
01B-  A5 23       SOUT LDA *TEMP     :GET MOST RECENT RESULT
01D-  8D 00 19         STA SYNT      :AND OUTPUT IT TO DAC
020-  4C 04 10         JMP LOOP      :THEN LOOP TO CONTINUE
                 :
                  TEMP .HS 00        :TEMPORARY BUFFER
                 :
                  END  .EN
```

This calibration routine provides for the generation of 5 octaves of control voltage from a PAIA 8785 Linear DAC driven from a PAIA 8700 Computer/Controller. The program is written in 6502 assembler language and assumes that an encoded AGO keyboard occupies address $ø81ø and that the DAC is memory mapped into location $19øø. Firmware for both PIEBUG and MUS1 proms is exploited.

Hand load the program from locations øøøø to øø22 and begin running from location øøøø.

While running, this program provides DAC outputs in 1 volt steps from 0 - 5 volts by touching the 8700's command keys 0 - 5 respectively. When following the calibration procedure outlined in this manual, the 1 and 4 command keys should be used for lower and higher calibration points respectively.

Any AGO keyboard activity overrides the last octave set point selected from the command keyboard, so that at any time you can play the DAC and VCO to observe tuning at other than octave intervals.