

CALIBRATION

A variety of methods may be used to calibrate the 2720-2A Voltage Controlled Oscillator. The first method described in this section requires the use of considerable test equipment and will result in the fastest possible tuning. In later paragraphs a method is described which requires only a volt-ohm meter (VOM) and piano, organ or other tuned musical pitch reference. The second method produces a very accurate calibration but at a sacrifice in speed.

It is desirable that you understand not only the "How" but also the "Why" of the calibration procedure. The purpose of any calibration is to compensate for component tolerances between supposedly identical circuits. Specifically, the calibration of the 2720-2A will do three things. 1) adjust pulse circuitry so that the "pulse duration" control will have maximum useful range, 2) align the ramp to triangle converter so that a near perfect triangle is available, and 3) align the control voltage summing circuitry so that at a given control voltage input the oscillator produces a given frequency. After a certain degree of exactness (5% will be the typical error) is reached further tinkering will contribute little to the overall operation of the synthesizer as a system. Small aberrations in the oscillator will be compensated for in the keyboard or other controller.

Before beginning the calibration procedure, apply power to the flea clip connectors on the rear edge of the circuit board. "+9" connects to a +9 volt supply, "-9" to a -9 volt source and "GND" to the common point between the supplies. First choice for power supplies will be the PAIA 2720-7 or 4770 modules but any bench supply that provides +9 and -9 volts will suffice. BECAUSE OF THE POWER DRAIN OF THE 2720-2A, BATTERIES ARE NOT A SUITABLE SOURCE OF POWER.

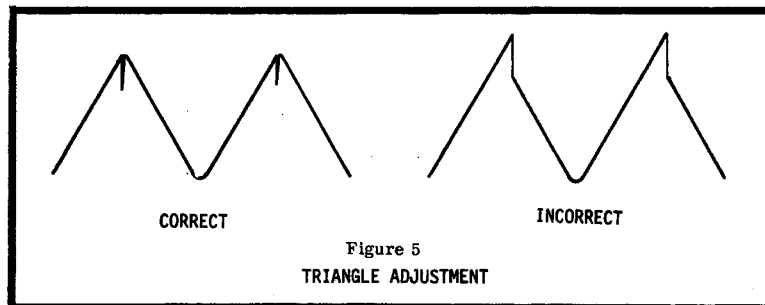
Under normal operating conditions, there is no warm-up time required by the 2720-2A but the first time that power is applied, before calibration, it is advisable to apply about 2.5 volts to one of the control inputs and allow the oscillator to run for 15 to 20 minutes. This will provide a short aging time on the components and allow the electrolytic capacitors in the unit to "form".

Set trimmers R7 (range), R15 (triangle) and R23 (pulse trim) to the midpoint of their rotation.

CALIBRATION METHOD #1

Equipment: Oscilloscope (service bench scopes will do), audio signal generator (service bench types will do), VOM (standard 5% movements are accurate enough), variable power supply (the procedure is written using the 2720-7 power supply module but any source of clean 0 to 5v. will do).

- 1) Connect the +5v. bias supply of the 2720-7 power supply module (or other variable bench supply) to one of the control inputs of the VCO. Monitor this voltage with the VOM by connecting its positive lead to the +5v. bias jack and the negative lead to ground (the front panel of the VCO, for example). Set the VOM to a DC voltage range that will allow convenient measurement of 5 volts. Connect the vertical input of the 'scope to the ramp output of the VCO and the horizontal input to the output of the reference oscillator.
- 2) Set the bias supply to approximately 1 v. (as read on the VOM) and set the sweep rate of the 'scope such that two or three stable ramp waveforms are visible. Verify that the peak to peak amplitude of the ramp is .5v. $\pm 20\%$.
- 3) Connect the vertical input of the oscilloscope to the pulse output of the VCO and adjust trimmer resistor R23 for the narrowest possible pulse without losing peak to peak amplitude. With the front panel "Pulse Duration" control set to its mid-range position, verify that the peak to peak amplitude of the pulse is .5v. $\pm 20\%$ and that rotation of the control varies the duration of the pulse from a narrow spike to greater than 50% duty factor.
- 4) Connect the vertical input of the 'scope to the triangle output of the VCO and adjust trimmer R15 until the two sides of the waveform meet at the top as shown below.



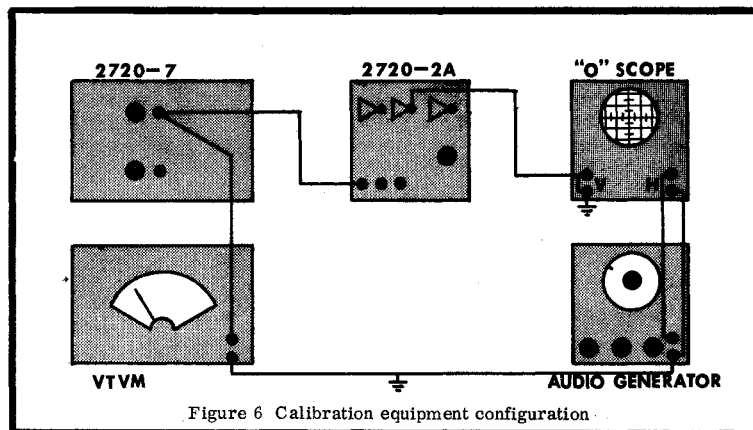


Figure 6 Calibration equipment configuration

- 5) Increase the output of the 5v. bias supply to 5v. as indicated on the VOM. Set the signal generator to 260 Hz. (approximately middle C) and switch the oscilloscope to external horizontal input. Adjust the range trimmer (R7) to obtain the lissajou pattern shown to the right indicating that the VCO frequency is exactly 4 times the frequency of the reference oscillator (1040 Hz.).

For further information on tuning and linearity see the end of the "Design Analysis" section.

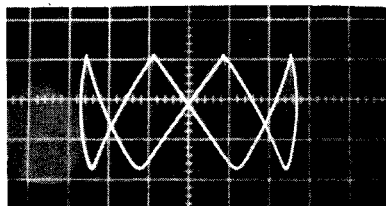


Figure 7

CALIBRATION METHOD #2

Equipment: Tuned musical instrument (piano or organ would be best), amplifier, Volt-Ohm meter(VOM).

- 1) Connect the pulse output of the VCO to the high (line) level input of the amplifier. Turn the pulse duration control fully clockwise.
- 2) Connect the 0 to 5v. bias supply of the 2720-7 power supply to the left hand control voltage input jack of the VCO and use the VOM to monitor this voltage. Set the VOM for a range on which 5 volts can be conveniently read.
- 3) Set the bias supply for 5 volts as measured by the VOM. Press the second C above middle C on the reference instrument. Adjust the Range control R7 for zero-beat* between the pitch of the VCO and the reference instrument.
- 4) Set the bias control to approximately 1 volt and turn the pulse duration control fully counter-clockwise. Adjust trimmer R23 until the buzz of the pulse can barely be heard.
- 5) Transfer the output from the pulse output jack to the triangle output jack. Adjust Triangle trimmer R15 for the mellowest possible tone.

* The "beat note" is a term used to describe the sound produced when two notes that are very close to the same frequency or very close to an octave apart are played at the same time. It can be heard as a slow speed volume change of the sound produced. As the two notes become closer and closer to the same frequency (or an integral number of octaves apart) the beat note slows until it stops when the notes are identical. (zero-beat). The beat note is most noticeable when the two notes are close to the same frequency and decreases in volume as the notes become a greater number of octaves apart.

LINEARITY

Within its specified operating range the 2720-2A Voltage Controlled Oscillator is inherently linear. In practice, however, the user may experience an error when the oscillator is being used with a keyboard which can be transposed through two or more octaves. This error will most likely show up on the lowest notes of a keyboard which is set to its lowest possible pitch and will cause the oscillator to be either slightly sharp or flat. In most cases this error will be noticeable only to a skilled musician and with a properly operating oscillator the error will not exceed 10 cents (there are 100 cents between adjacent semi-tones in the equally tempered scale). Errors as great as 1/4 semi-tone (25 cents) are an indication that the oscillator is not operating properly, or that the controller is improperly calibrated.

The error described above is not a linearity error. Instead, it is an error in the zero intercept of the oscillator - see the PAIA 2720-8 Keyboard/case instruction manual for further information on zero intercept. The problem originates in the input offset voltage of the operational amplifier in the current source. For the purist, provision has been made on the 2720-2A circuit board for input offset voltage nulling by simply adding a 50K ohm trimmer potentiometer and 3.9 meg ohm resistor as shown in figure 10. The holes for these components are not drilled in the circuit board but may be added by using a #60 drill for the two resistor holes and a #53 drill for the three potentiometer holes. This new control becomes a "zero" adjustment and is used as described in the 2720-8 Keyboard/Case instruction manual.

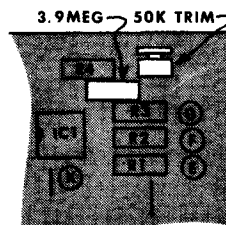


Figure 10
Adding Zero Control

This modification is not supplied as a standard part of this kit because 1) it complicates the oscillator tuning procedure and 2) it is a cure for a problem that does not exist for other than professional users. Anyone who wishes to make this modification can obtain the parts free of charge by sending a self-addressed stamped envelope to:

PAIA Electronics, Inc.
Attention: Technical Services
1020 West Wilshire Blvd.
Oklahoma City, OK 73116

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This added Zero Trim is only effective when the IC1 op-amp on the 2720-2A is a 748 or 301 type with the pin 5 Balance voltage input.

