

CALIBRATION

A variety of methods may be used to calibrate the 2720-2 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.

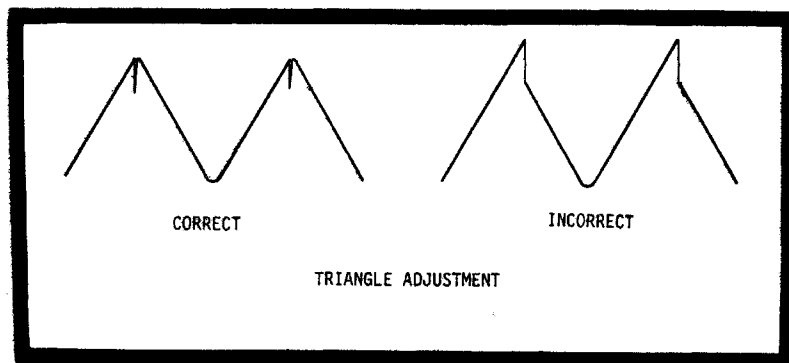
It is desirable that you understand not only the "How" but also the "Why" of the calibration procedure. The purpose of any calibration is to compensate for component tolerances between supposedly identical circuits. Specifically, the calibration of the 2720-2 will do three things. 1) adjust pulse circuitry 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. The third aim of the calibration procedure is an elusive thing, two interacting adjustments must be made and the procedure you will be using will be one of "Successive approximations" where certain steps will be repeated over and over with each pass reducing the error. 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 starting on the calibration apply power to the rear of the VCO. "+" goes to 9v. "-" to -9v. and ground to ground. Any suitable bench supply may be used but because of the heavy current draw BATTERIES ARE NOT A SUITABLE SUPPLY FOR THE 2720-2. Turn the power on and allow 20 to 30 minutes settling time before calibration. Set trimmers R7 (range), R19 (triangle) and R26 (pulse trim) to the midpoint of their rotation. Set trimmer R4 (zero) to the clockwise limit of its rotation. Set the front panel "Pulse Duration" control to its counter-clockwise limit.

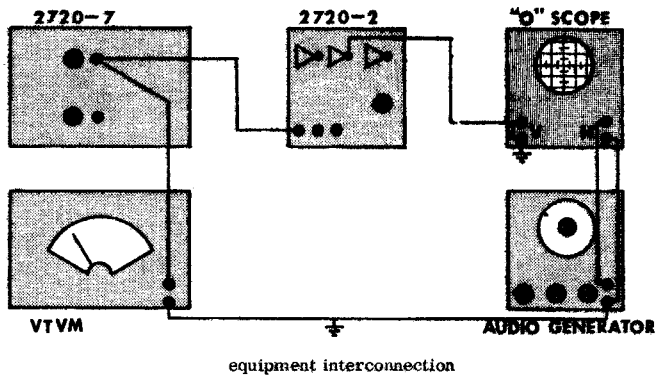
CALIBRATION METHOD #1

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 2720-5 power supply module but any source of clean 0 to 5v. will do).

- 1) Connect the vertical input of the oscilloscope to the ramp output of the VCO and verify that the peak to peak output from this jack is .5v. $\pm 20\%$.
- 2) Connect the vertical input of the oscilloscope to the pulse output of the VCO and adjust the sweep rate so that two or three pulses are visible. Adjust trimmer resistor R26 for the narrowest possible pulse without losing pulse height. Verify that the peak to peak amplitude of the pulse is .5v. $\pm 20\%$ and that rotating the "Pulse Duration" control varies the duration of the pulse from a narrow spike to about 50% or more duty factor without changing the overall period.
- 3) Connect the vertical input of the oscilloscope to the triangle output of the VCO and adjust trimmer R19 until the two sides of the waveform meet at the top as shown below.



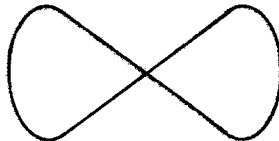
- 4) Connect the +5v. bias supply of the 2720-7 power supply module (or other variable bench supply) to one of the control inputs of the VCO. Monitor this voltage with the VOM by connecting its positive lead to the +5v. bias jack and the negative lead to ground and set the VOM to a 2.5 or 5v. full scale range. Connect the vertical input of the oscilloscope to the triangle output of the oscillator and the horizontal input to the output of the signal generator. Set the oscilloscope for external horizontal input. At this point the equipment should be interconnected as shown in the equipment interconnection drawing.



5) Set the output of the +5v. bias supply to .625v. as indicated on the VOM. Set the signal generator to 260 Hz. (approximately middle C in the musical scale) and use the ZERO adjust of the VCO (R4) to produce the figure 8 waveform shown below. This Lissajous figure indicates that the output of the signal generator is exactly twice the frequency of the VCO. Do not be overly concerned with a slow rotation of the pattern.



figure "8" Lissajous figure



"X" Lissajous figure

- 6) Adjust the +5v. bias supply until the oscilloscope shows the roughly "X" shaped figure shown below indicating that the output of the signal generator is one half the output frequency of the VCO.
- 7) Read the VOM. If the reading is less than 2.5v. rotate the RANGE trimmer (R7) about 1/10 of a turn clockwise. If the reading is greater than 2.5v. rotate the RANGE trimmer about 1/10 of a turn counter-clockwise.
- 8) Re-set the bias output to .625v. on the VOM and once again adjust the ZERO trimmer to produce the "figure 8" Lissajous figure.
- 9) Repeat steps 6 through 8 until the VOM reading in step 7 is 2.5v. On each succeeding pass through steps 6 through 8 the adjustment of the RANGE trimmer should be less corresponding to the decreasing error between the actual reading of the VOM and the ideal 2.5v.

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 (Hns) level input of the amplifier. Turn the pulse duration control fully to the right.
- 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 2.5 to 5 volt full scale range.

- 3) Set the bias supply for .625 volts and press the C below middle C key on the reference instrument. Use the ZERO adjust of the VCO (R4) for zero-beat* between the pitch of the VCO and the reference instrument.
- 4) Press the C above middle C key on the reference instrument and adjust the 5v. bias supply so that the output of the VCO is zero-beat with this pitch.
- 5) Read the VOM. If the reading is less than 2.5v. rotate the RANGE trimmer (R7) about 1/10 of a turn clockwise. If the reading is greater than 2.5v. rotate the trimmer about 1/10 of a turn counter-clockwise.
- 6) Re-set the bias output to .625 volts and once again adjust the ZERO trimmer for zero-beat with C below middle C.
- 7) Repeat steps 3 through 5 until the VOM reading in step 5 is 2.5 volts.
- 8) Set the bias control for approximately one volt and turn the Pulse Duration control fully counter-clockwise. Adjust trimmer R26 until the buzz of the pulse output can just barely be heard.
- 9) Transfer the output from the pulse output jack to the triangle output jack and adjust R20 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.

PA1A 2720-2 VCO SCHEMATIC

