3374 VCO Test Report

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Rev 1

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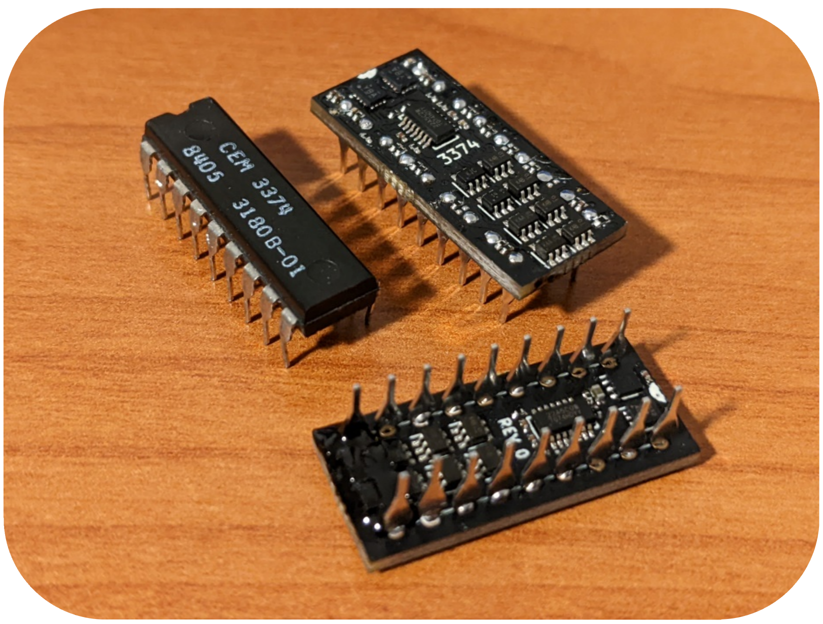


1. Background

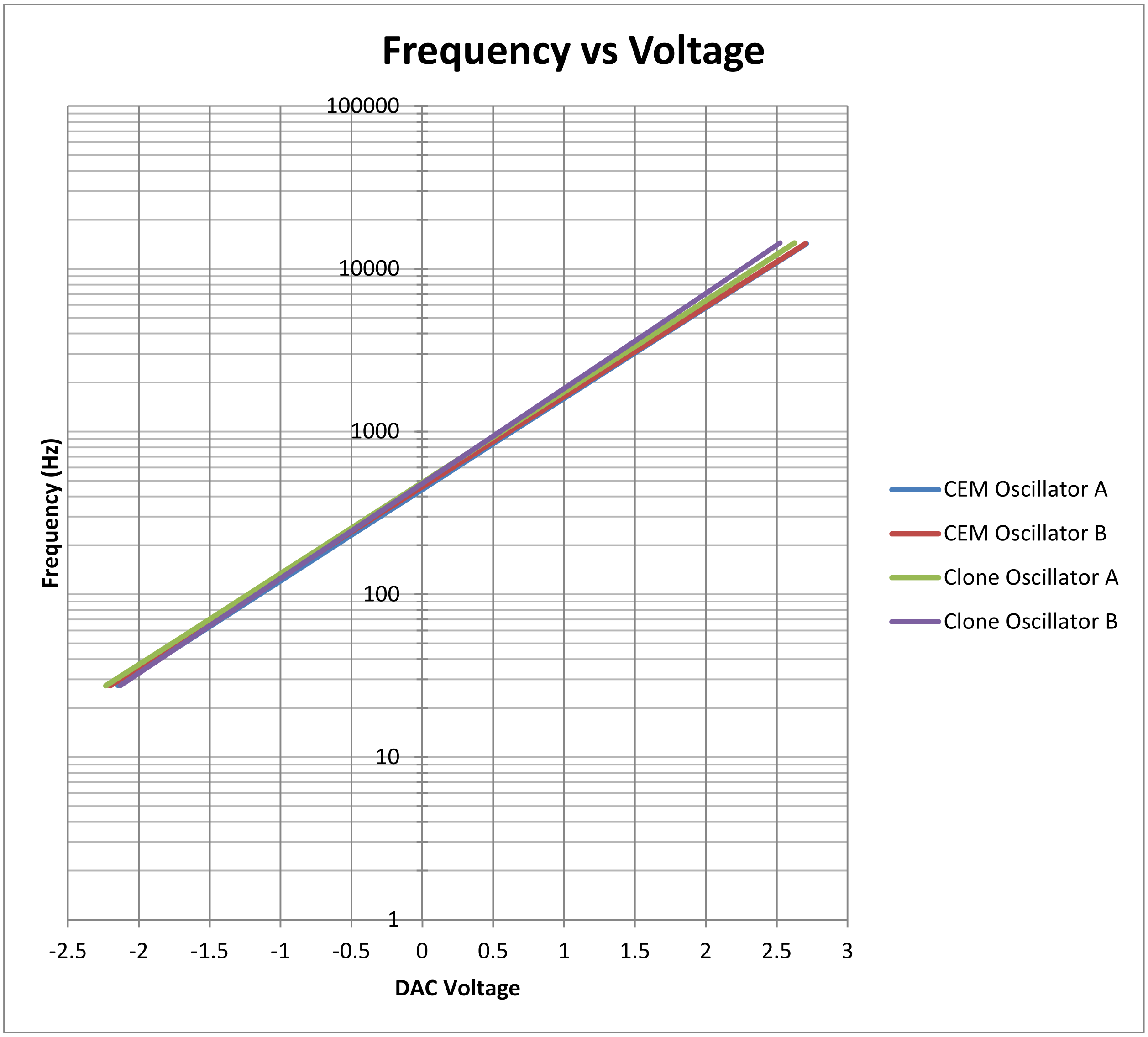
The purpose of these tests is to verify the functionality of the 3374 VCO clone PCB and to compare the performance to an original CEM 3374 IC. All tests were conducted using a Fender Chroma Polaris running firmware version 8, but the performance characteristics should be similar for other synthesizers using the CEM 3374. The Chroma Polaris supplies the 3374 with 12V and -5V. The Oberheim Matrix 12 and Xpander use the same supply voltages, so performance is expected to be the same. The Akai VX600 also has a 12V positive supply, but the negative supply is -6V (which is unlikely to affect performance).

Revision 1 of this board has modified oscillators, so tests relating to the frequency or wave shape have been retested.

2. Frequency vs Voltage

Revision Tested: 1

The frequency and voltage was measured for both oscillators in a CEM 3374 and a clone at increments of one octave. The voltage was measured at the output of the DAC before the voltage divider going to the VCO's input. The actual voltage at the VCO's input will be around 1/28th of this voltage. The results are plotted below with a logarithmic vertical axis. Synthesizers using these VCOs use digital calibration, so it is not necessary for the curve to be exactly the same, but it should be close.



3. Frequency Drift

Revision Tested: 0

After automatic calibration, the frequency of several notes was measured on both oscillators of the CEM 3374 and the clone. After one hour, the frequency was measured again without recalibrating first. The temperature in the synthesizer’s enclosure near the VCOs was 20°C measured by a thermocouple at the beginning of the test, and although it was expected that the temperature would rise, it was still 20°C at the end.

	Note	CEM A	CEM B	Clone A	Clone B
Initial	**110Hz (A2)**	110.7	110.6	110.6	110.4
	440Hz (A4)	442.3	442.4	442.4	442.3
	1760Hz (A6)	1768	1769	1770	1769
After 1 hour	**110Hz (A2)**	111.1	111.1	111.5	111.2
	440Hz (A4)	444.1	444.1	444.7	444.2
	1760Hz (A6)	1775	1776	1779	1775

Both the CEM 3374 and the clone's frequencies drifted slightly higher by around the same amount. This is likely due to the supply voltages drifting slightly as the power supply heated up and not the VCOs themselves.

4. Temperature Compensation Output

Revision Tested: 0

The VCOs contain a temperature compensated voltage output that is intended to be used as a reference voltage for the DAC that controls the frequency. The voltage should ideally have a temperature coefficient of 1/T where T is the temperature in Kelvin. This is around 3400ppm/°C when near room temperature. In the case of the clone VCO, this voltage is generated from a thermistor circuit that is bonded to the transistors used in the exponential converter with thermally conductive epoxy. As I don't have equipment to accurately characterize the voltage output at different temperatures, the voltage was measured only at 20°C. This exact voltage is not too important other than to verify that it works.

VCO	VTC output voltage at 20°C
CEM 3374 Rev 0	2.47V
Clone	2.30V

5. Waveform Outputs

Revision Tested: 1

The sawtooth and triangle wave outputs were captured on an oscilloscope at multiple frequencies in two-octave increments. The CEM 3374 and the clone produce similar results, but with a couple minor differences:

1. The clone restarts each cycle faster when the triangle wave falls below 0V. This means that the CEM 3374 has a slightly larger portion of the triangle wave below 0V. This should not affect the timbre of the sound.
2. The CEM 3374 has small negative spikes after the falling edge of the sawtooth waves that the clone does not have. Almost all of the harmonics added from these spikes will be above the human hearing range. The filters and amplifiers in the synthesizer should eliminate them, so the difference to the sound is negligible.

There does not appear to be a large difference in the waveform shape between low frequencies and high frequencies in both the CEM 3374 and the clone.

Figure 1 - Waveforms at 27.5Hz (A0)

Figure 2 - Waveforms at 110Hz (A2)

Figure 3 - Waveforms at 440Hz (A4)

Figure 4 - Waveforms at 1760Hz (A6)

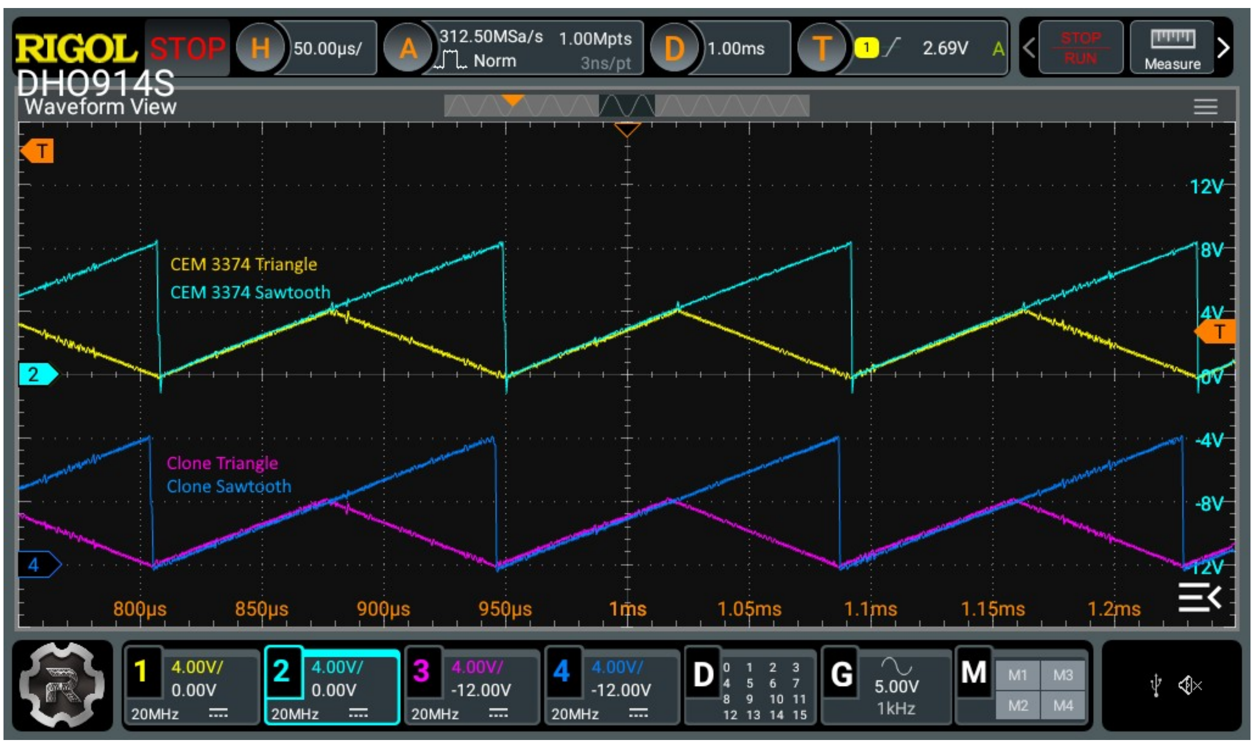


Figure 5 - Waveforms at 7040Hz (A8)

6. Sync Input

Revision Tested: 0

Oscillator A of the VCOs contains a sync input that causes the waveform cycle to reset when it is pulled low. In a typical synthesizer design, it can be configured to be connected to the sawtooth output of oscillator B through a capacitor so that the frequency of oscillator A is synced to oscillator B.

In these tests, the sawtooth outputs from both oscillators of the CEM 3374 and rev 0 clone were captured with an oscilloscope with sync enabled while both VCOs played similar notes (one semitone apart).

When the sync occurred in the first half of channel A's cycle, the outputs of the CEM 3374 and the clone look almost identical.

Figure 6 - Sawtooth outputs with sync enabled, sync in first half of wave

When the sync occurred in the second half of channel A's cycle, there was a brief pulse to 8V before the sawtooth wave restarted at 0V. In the CEM 3374, this pulse was just a couple of microseconds, which was short enough that it didn't always show up on the oscilloscope at the zoom level shown. In the clone, the pulse lasted around 12μs. These pulses are caused by the triangle-to-sawtooth converters that invert the falling portion of the triangle wave to form the second half of the sawtooth waves. When the sync input causes the capacitor to discharge, there is a short delay before the triangle-to-sawtooth converter detects that it should stop inverting the signal.

The pulses caused from this sync feature appear to be one of the biggest differences in the output waveforms of the CEM 3374 and the clone, but in reality, this difference is still negligible. The sounds produced from these spikes are almost entirely outside of the human hearing range, and they will most likely be eliminated by the time the signal makes it though the synthesizer's filters and amplifiers. For example, a screenshot of a recording in Ableton Live of the same note played on the clone is shown in Figure 8. The synthesizer's filter cutoff frequency was turned up all the way during the recording.

Figure 7 - Sawtooth outputs with sync enabled, sync in second half of wave

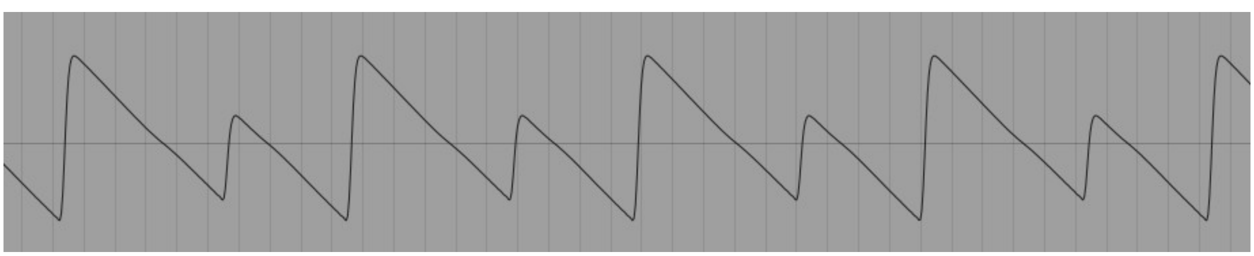


Figure 8 - Screenshot from Ableton Live of a recording of the same waveform from oscillator A of the clone VCO