

Hammond Vibrato Scanner Capacitance Measurements

This paper summarizes my measurements of a Hammond Vibrato Scanner mechanism. The vibrato scanner mechanism consists of an arm with half of a fixed plate air capacitor which rotates through the sixteen other halves of the fixed plate air capacitors. I calculated the capacitance of one air capacitor both by physical measurements and by frequency analysis. I will refer to the plates on the rotating arm as the 'rotor' and the stationary plates around the circumference as the 'stator'.

PHYSICAL MEASUREMENTS

Stator measurements:

Wide: 21.55 mm

Narrow: 15.0 mm

Length: 21.15 mm

Center to outside edge: 61.4 mm

Center to inside edge: $61.4 \text{ mm} - 21.15 \text{ mm} = 40.65 \text{ mm}$

Rotor measurements:

The wide and narrow are the same dimensions as the stator.

Center to outside edge: 60.24 mm

When engaged with the stator the overlap of the plates is 16.4 mm

Plate spacing measurements

Stator outside dimension: 19.7 mm

Plate thickness: 0.64 mm

Gap between stator plates: 3.18 mm

Calculating the gap between stator plates compares approximately to the measurement.

$$19.7 \text{ mm} - \frac{6 \times 0.64 \text{ mm}}{5} = 3.172 \text{ mm}$$

Stator / Rotor gap

Calculating the gap between the rotor plate and the stator plate

$$\frac{3.17 \text{ mm} - 0.64 \text{ mm}}{2} = 1.26 \text{ mm}$$

The stator and rotor are nearly the same width dimensions when engaged with a length of 16.4 mm. The area of the two plates is 287.65 mm^2 and the gap is 1.26 mm. There are a total of 10 capacitors in parallel.

$$C = (\text{Number of capacitors}) \frac{\epsilon \times 1.0005 \times \text{Area}}{\text{Spacing}} = 10 \frac{(8.8542 \times 10^{-12})(1.005)(287.65 \times 10^{-6})}{1.26 \times 10^{-3}} = 20.2 \text{ pF}$$

David J. Brown

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SCOPE MEASUREMENTS

I setup a test circuit with a 250.1 KHz sine wave oscillator V_{in} through a 102.28K resistor to the rotor of the scanner. I measured V_{out} with an oscilloscope with 8 pF probe loading. Measured V_{in} and V_{out} values are shown in the scope measurement 1 - 4.

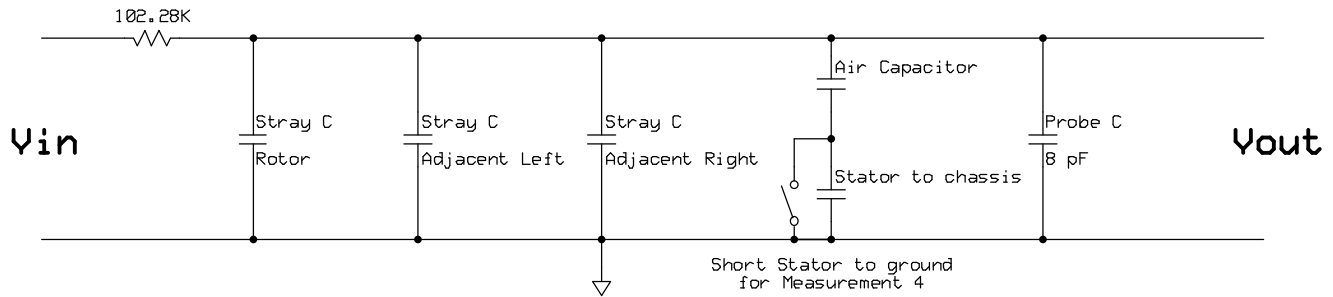


Figure 1: Test setup

The formula for calculating C_{total} is:

$$C_{total} = \frac{\sqrt{\left(\frac{V_{in}}{V_{out}}\right)^2 - 1}}{2 \pi (250.1 \times 10^3)(102.28 \times 10^3)}$$

Measurements

1. I removed one stator and measured V_{out} (Measurement 1). $C_{total} = 17.63$ pF
2. There is capacitive coupling to adjacent stators so I removed both adjacent stators and measured V_{out} with the rotor centered (Measurement 2). $C_{total} = 14.96$ pF
3. I installed the stator but left it floating and left the stators removed on each side (Measurement 3). $C_{total} = 20.50$ pF
4. I grounded the stator and measured V_{out} (Measurement 4). $C_{total} = 39.49$ pF

Subtracting the 8 pF oscilloscope probe capacitance, the stray rotor capacitance is ~ 7 pF.

The stray capacitance to adjacent stators is 2.67 pF, or 1.33 pF to each adjacent stator.

The capacitance of the stator to ground is 3.25 pF.

Summary

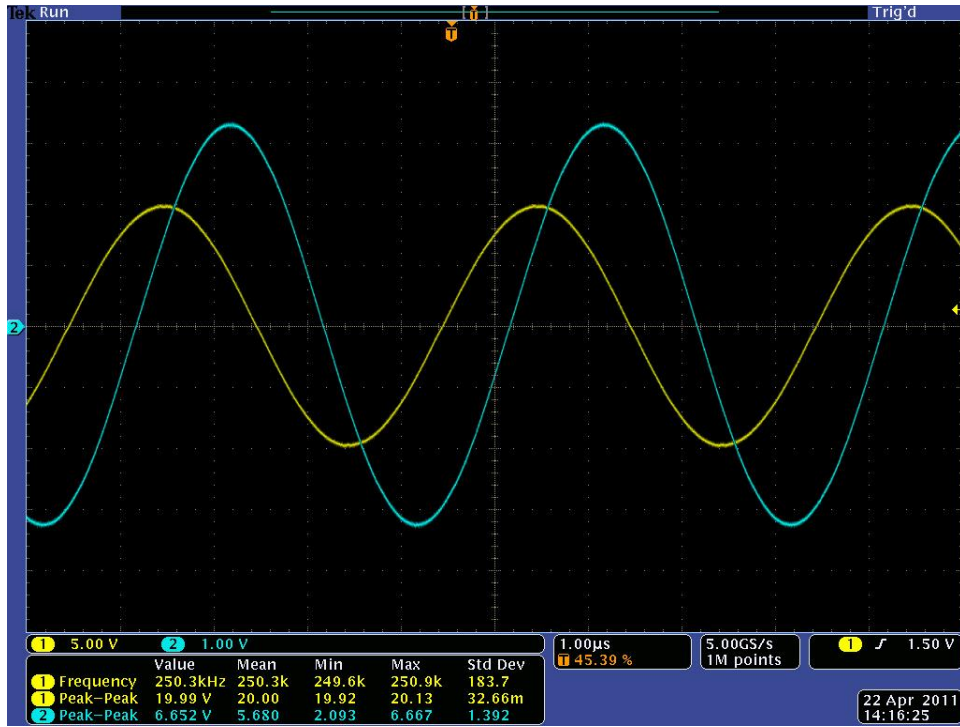
The capacitance of a single vibrato scanner air plate capacitor calculates to 24.5 pF. This compares reasonably with the previous calculations given the accuracy of the physical measurements.

David J. Brown

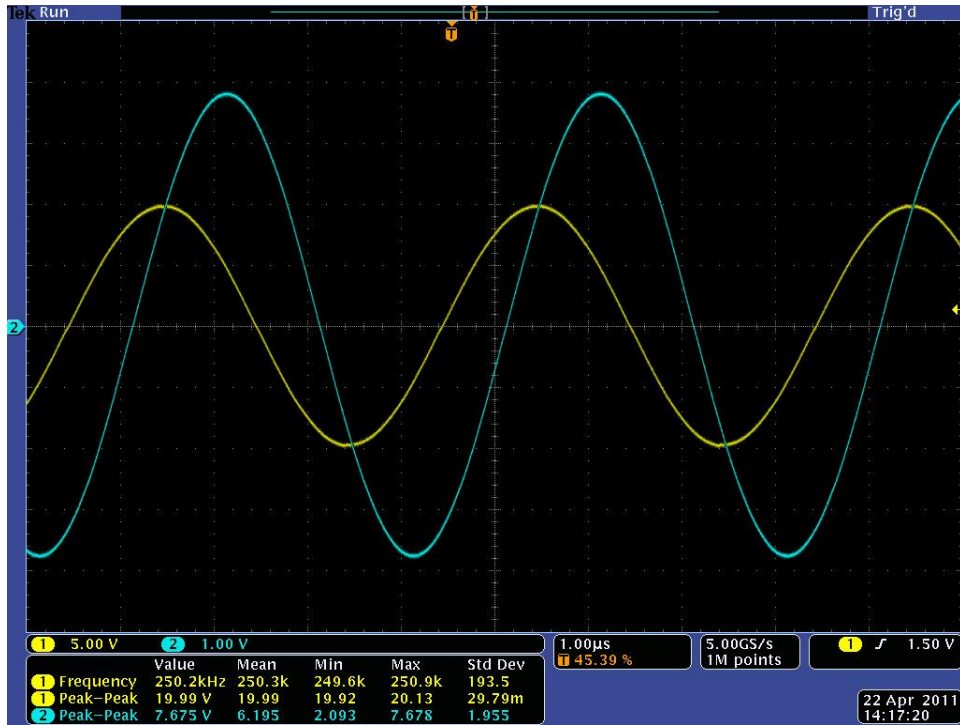
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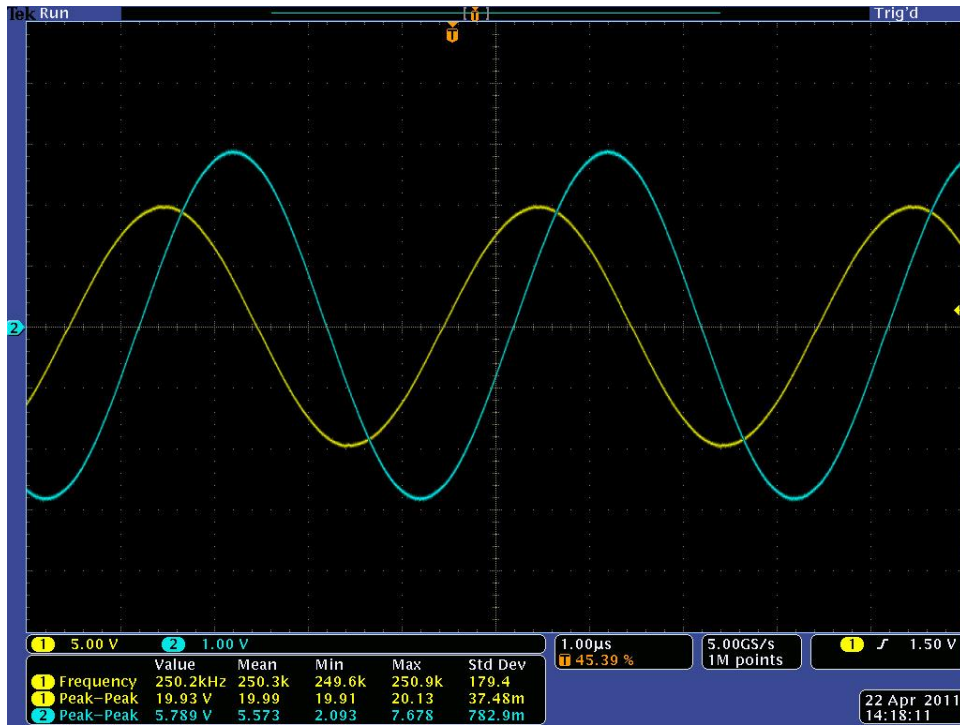
Measurement 1: V_{out} and V_{in} measurements for a rotor centered over a single vacant stator position. Total capacitance is stray capacitance of the rotor, adjacent stators, and 8 pF probe.



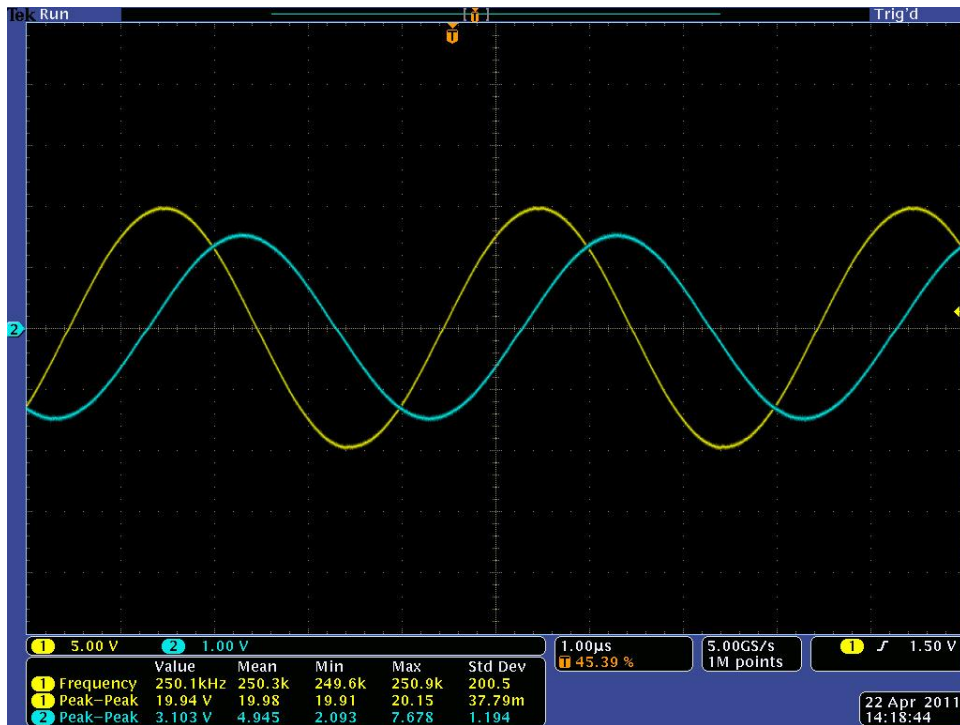
Measurement 2: V_{out} and V_{in} measurements for a rotor centered over three vacant stator positions. Total capacitance is stray capacitance of the rotor and 8 pF probe.

David J. Brown
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Measurement 3: V_{out} and V_{in} measurements for rotor, floating stator and no adjacent stators. Total capacitance is stray capacitance of the rotor, stator to chassis, adjacent stators, and 8 pF probe.



Measurement 4: V_{out} and V_{in} measurements for a single air plate capacitor with no adjacent stators. Total capacitance is air capacitor, stray capacitance of the rotor, adjacent stators, and 8 pF probe.

David J. Brown
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