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: $61.4\ mm$ - $21.15\ mm = 40.65\ mm$

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.

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

Stator / Rotor gap

Calculating the gap between the rotor plate and the stator plate

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

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.

$$C = (Number\ of\ capacitors)\frac{\in\ x\ 1.0005\ x\ Area}{Spacing} = 10\frac{(8.8542x10^{-12})(1.005)(287.65x10^{-6})}{1.26x10^{-3}} = 20.2\ \text{pF}$$

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SCOPE MEASUREMENTS

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

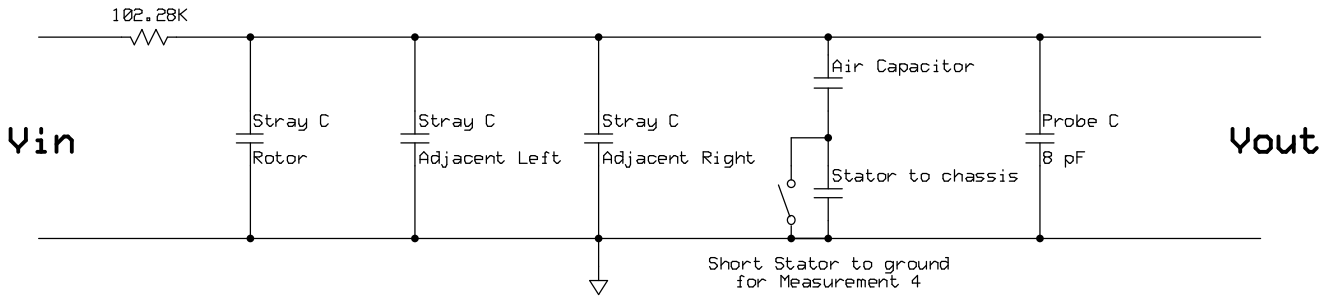


Figure 1: Test setup

The formula for calculating $Ctotal$ is:

$$Ctotal = \frac{\sqrt{\left(\frac{Vin}{Vout}\right)^2 - 1}}{2\ \pi\ (250.1 \times 10^3)(102.28 \times 10^3)}$$

Measurements

1. I removed one stator and measured $Vout$ (Measurement 1). $Ctotal = 17.63\ pF$

2. There is capacitive coupling to adjacent stators so I removed both adjacent stators and measured $Vout$ with the rotor centered (Measurement 2). $Ctotal = 14.96\ pF$

3. I installed the stator but left it floating and left the stators removed on each side (Measurement 3). $Ctotal = 20.50\ pF$

4. I grounded the stator and measured $Vout$ (Measurement 4). $Ctotal = 39.49\ pF$

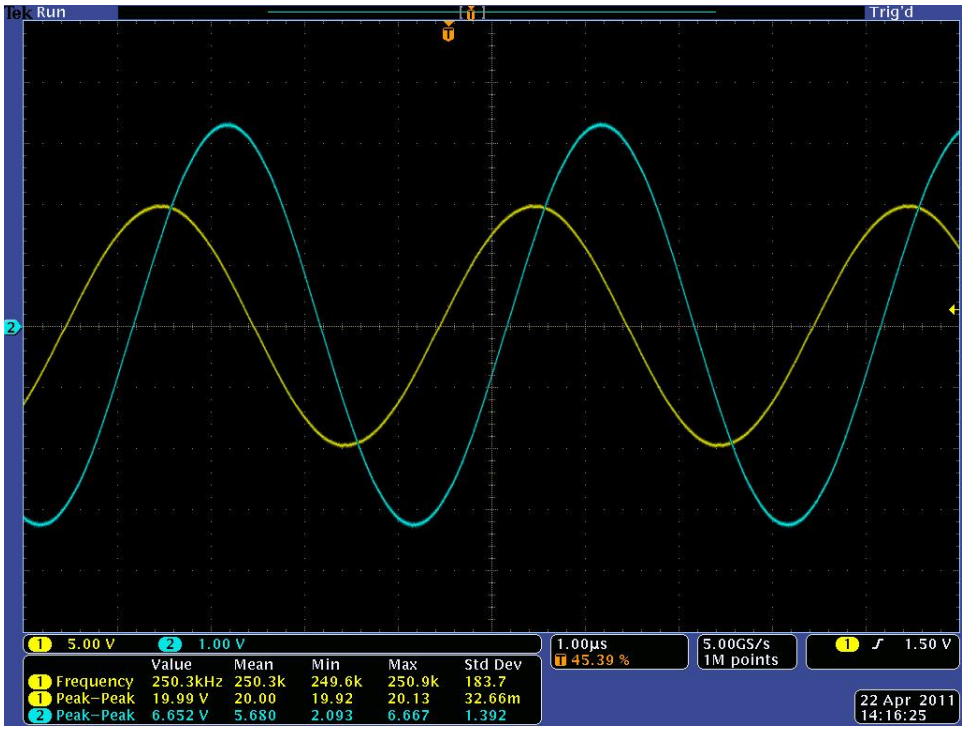
Subtracting the $8\ pF$ oscilloscope probe capacitance, the stray rotor capacitance is $\sim 7\ pF$.

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 $3.25\ pF$.

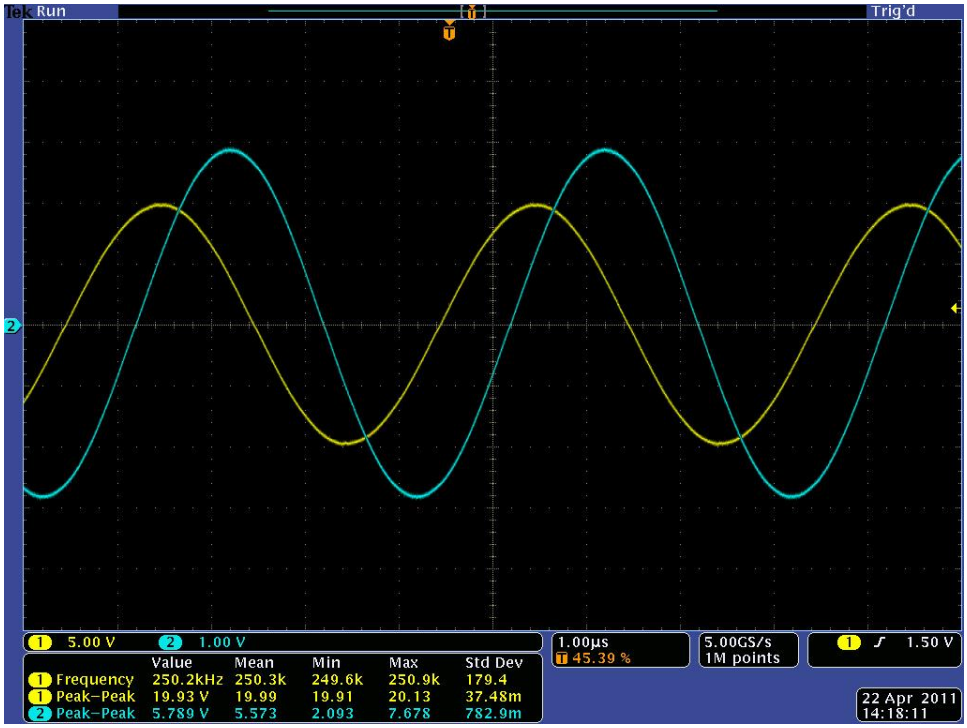
Summary

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.

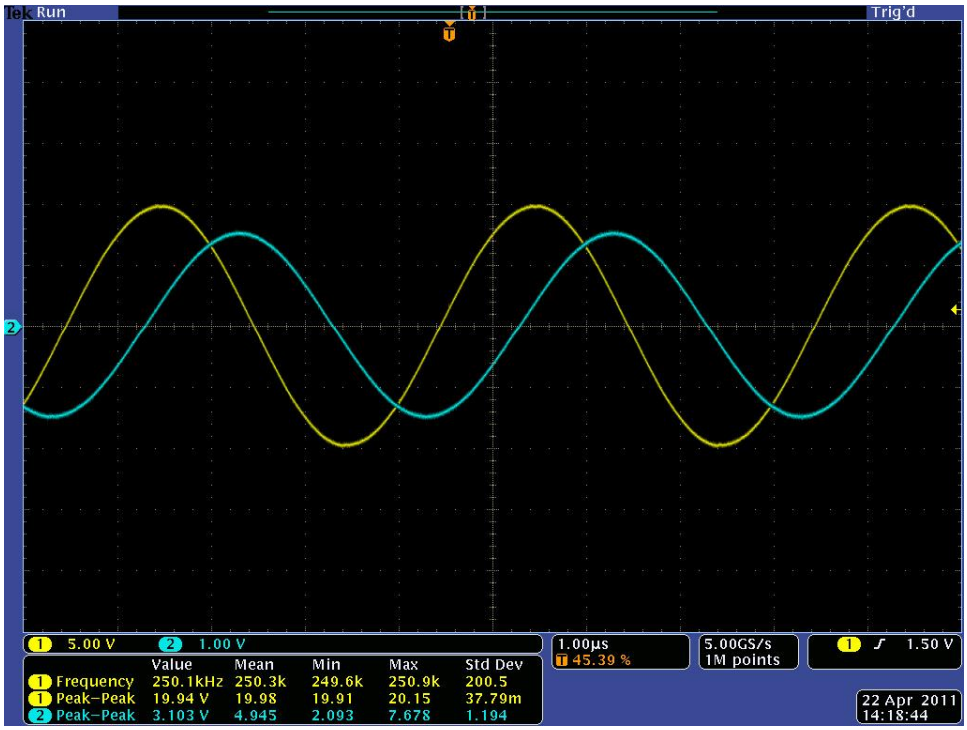


Measurement 1: V*out* and V*in* measurements for a rotor centered over a single vacant stator position. Total capacitance is stray capacitance of the rotor, adjacent stators, and 8 pF probe.

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.



Measurment 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.