Top Plate Capacitor Heating Experiment

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7/15/2013

Background

During the Thursday meeting of 7/11 between Tom, Alan, and Raul, discussion centered on possible connection issues of the top plate capacitor as a source of S11 "jumps". Raul and Tom agreed to examine the top plate capacitor in more detail.

Purpose

Examine the sensitivity of the S11 response to temperature changes to the top plate capacitor. There might be an issue with the connectivity of the top plate capacitor and the antenna in the areas of the connection to the rod or the connection to the tube/panel. Check simulations to confirm such an effect can happen.

Procedure:

1) Visually inspect the connection to verify the possibility of connection issues
2) Place the plate connection to the open balun tube such that the plate stub does not touch the panel
    a. Measure the nominal S11 response for 2 minutes
    b. Heat the top plate capacitor with a heat gun for 1 minute
        i. Measure S11
        ii. Repeat 3 times
    c. Measure the S11 response for 8 minutes as the structure cools
3) Place the connection to the open balun such that it touches both the antenna panel and the balun tube firmly.
    a. Heat the top plate capacitor with a heat gun for 1 minute
        i. Measure S11
        ii. Repeat 3 times
    b. Measure the S11 response for 8 minutes as the structure cools
4) Simulate the effect of the short square stub touching the antenna panel vs not touching the panel.

Results

1) Visual Inspections: (see Figs. 1-2)

When visually inspecting the connection to the balun, we discovered that the connection did not touch the antenna panel, but came very close to it. Depending upon the tightening of the top washer nut, we could either make it touch or not touch. This is clearly a point of variability that needs to be addressed.

The set screw clamping the inner balun rod to the top plate capacitor (large section) was not very tight as it was only secured with finger tightness. Also, the connection to the rod may not be occurring below the set screw as the hole through the copper capacitor plate was not a tight fit to the copper rod.

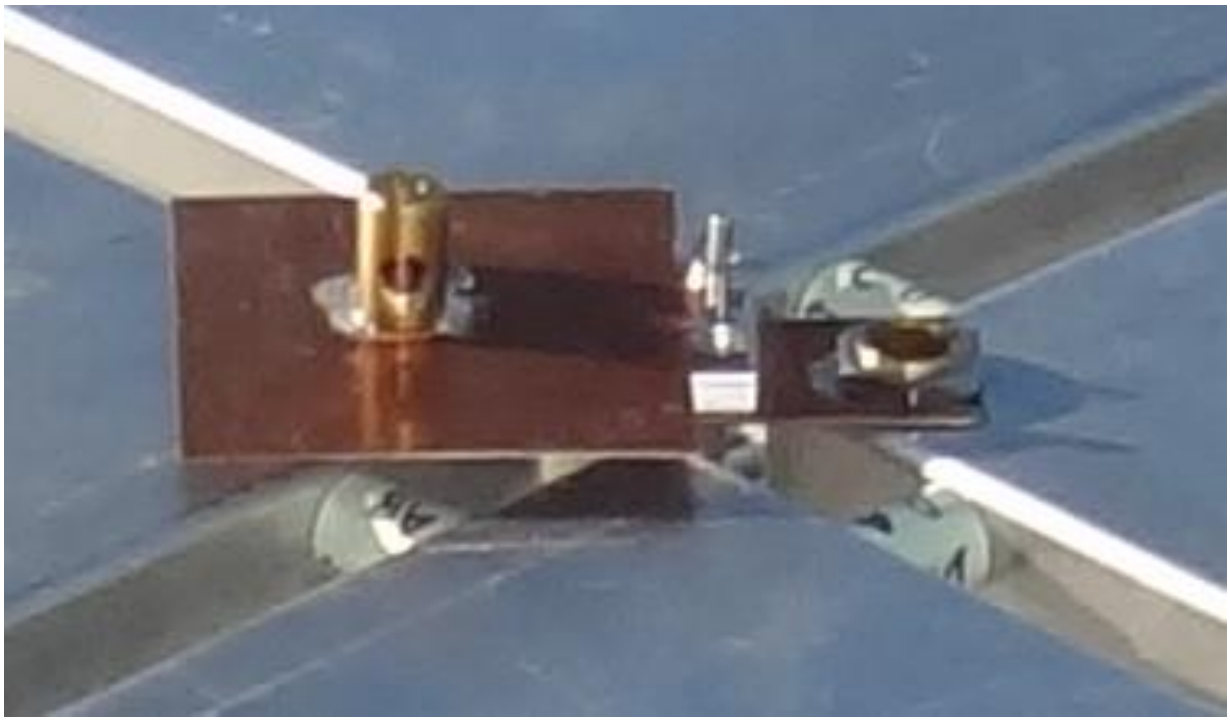

Figure 1. Top plate capacitor. Stub connection on the right open tube balun.

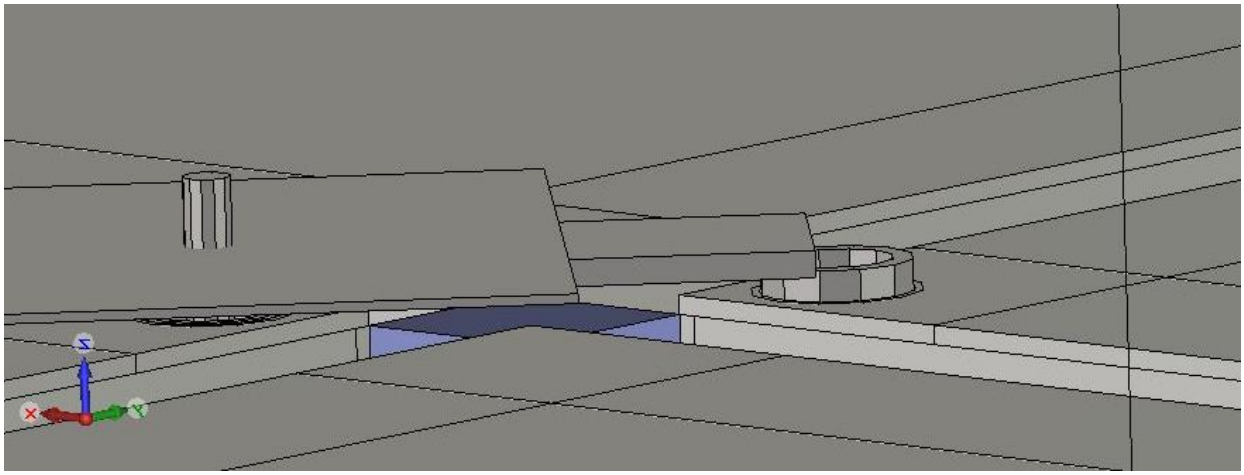

Figure 2. Simulation diagram of the top capacitor.

2) Measurement Results

The measurement, heating, and recovery proceeded as follows:

Configuration 1 – put a metal spacer ring around the balun tube between the stub and antenna panel such that the stub connector and the antenna panel do not touch except right at the balun.

1) Take a measurement every 30 seconds for 2 minutes to establish the nominal case.
2) Repeat the following heating step 3 times:
    a. Heat the top plate capacitor for 60 seconds and take a measurement
3) Take a measurement every 30 seconds for 8 minutes as the antenna recovers
4) Plot the difference between S11 from reading #1.
5) Change the configuration

Configuration 2 – tighten the connection such that the stub connector and the antenna panel do indeed touch as much as possible.

6) Repeat the heating step 3 times:
    a. Heat the top plate capacitor for 60 seconds and take a measurement
7) Take a measurement every 30 seconds for 8 minutes as the antenna recovers
8) Plot the difference between S11 from reading #1 of config 1.

We should have taken 2 minutes worth of nominal readings in config 2, but didn't. However, we have one reading that was nominal before we started heating.

Figure 3 shows the results of the experiment. Cycles 1-8 are nominal readings every 30 seconds. Cycles 9-11 are the heating cycles spaced 2 minutes apart. Cycles 12-27 are the 8 minutes of recovery readings. Cycle 28 is the nominal reading of configuration 2. Cycles 29-31 are the three 2 minute heating cycles of configuration 2. Cycles 32-47 are the recovery cycles of configuration 2.

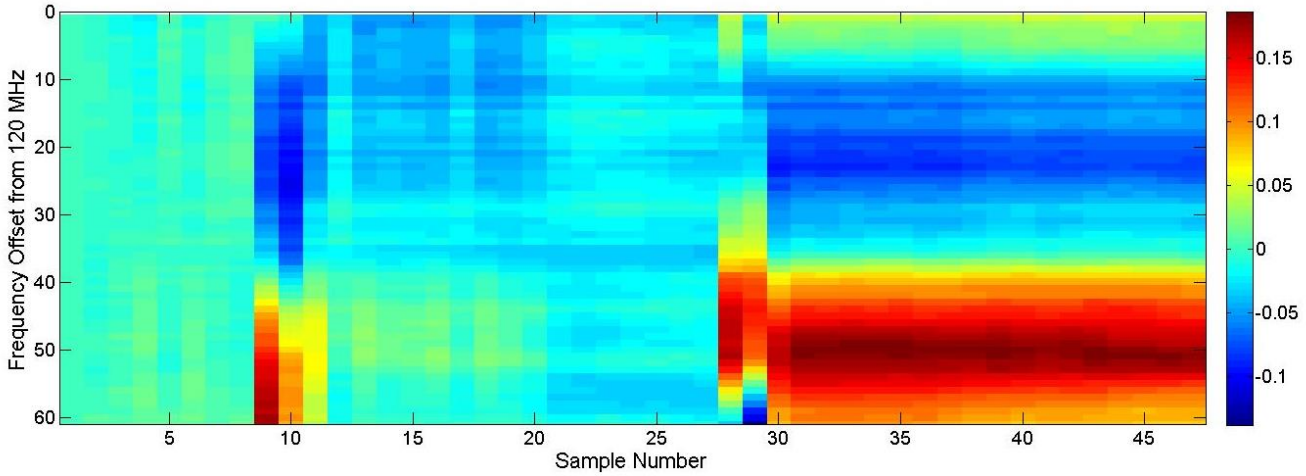

Figure 3. Delta S11 between the first cycle and all other cycles

The interesting observation is that configuration 1 has a changing S11 pattern with heat that recovers. Configuration 2 does not recover but remains stable with an altered S11 pattern. Focusing in on the second configuration, we compare the one reference reading to the subsequent readings and show this in Figure 4 below. The S11 pattern seems to have locked into the new configuration. Even the 3rd heating cycle does not seem to have affected the pattern. The wind had become stronger, but still should not have negated the heating effect.

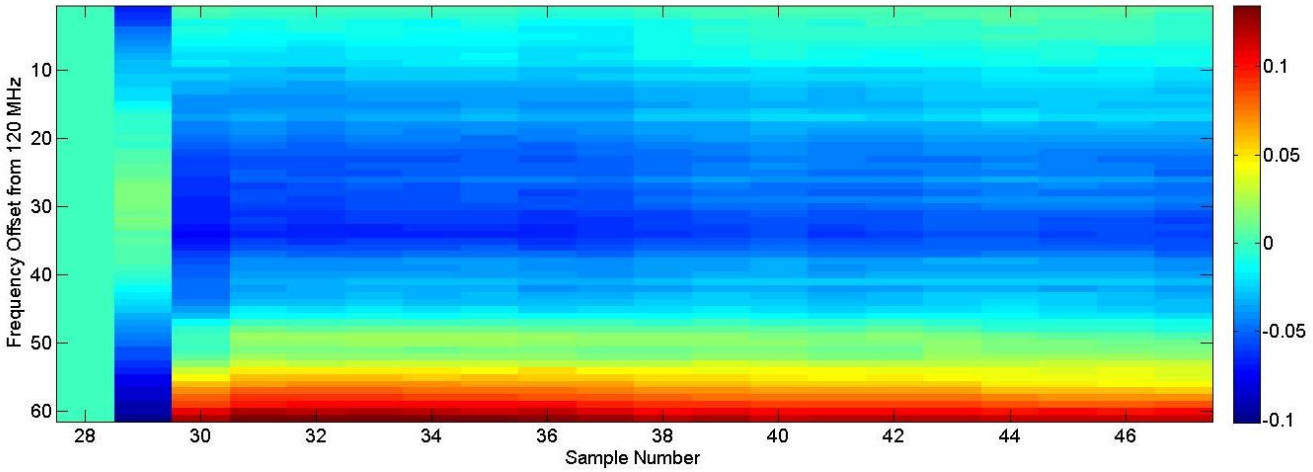

Figure 4. Delta S11 between the 28th cycle and all other subsequent cycles of configuration 2.

3) Simulation Results

The simulations do show that there is a sensitivity to the closeness of the stub connector to the antenna plate. Figure 5 shows the simulation results. The lowest height setting causes the plate stub to actually touch the antenna panel. Again, there is a cross over frequency with the bigger spacing corresponding to the case after heat is applied.

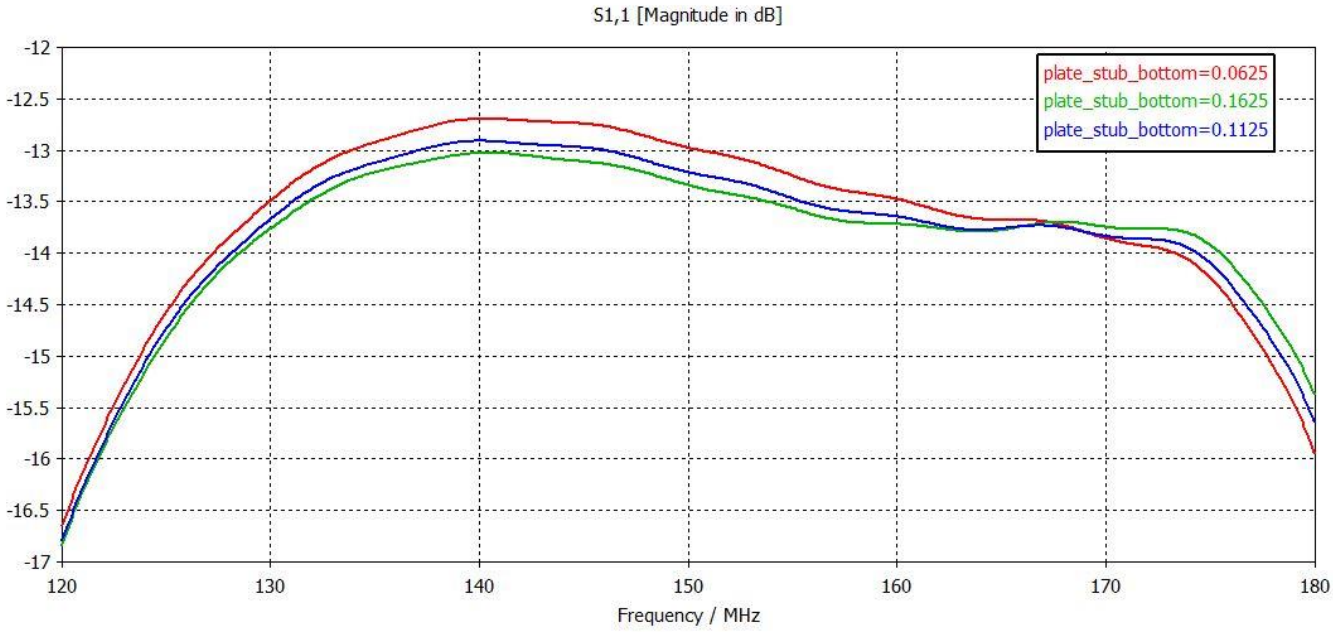

Figure 5. Simulated S11 with the plate stub height above the antenna panel varied.

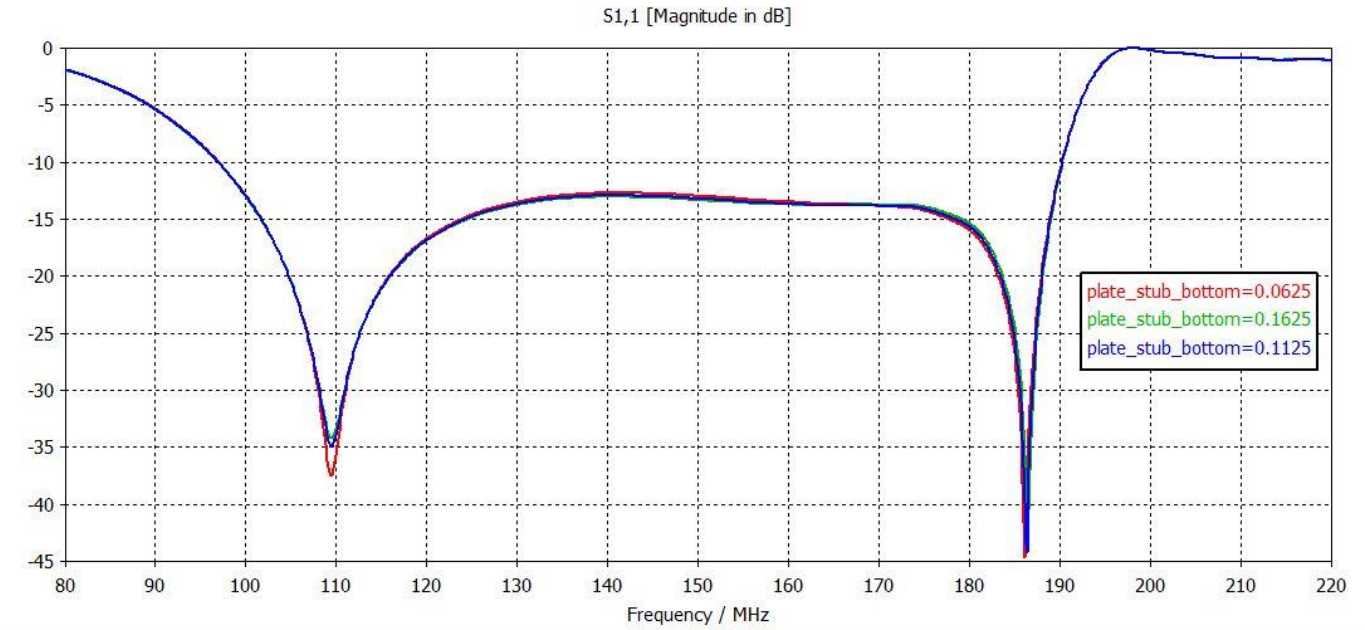

Figure 6. Simulated S11 with the plate stub height above the antenna panel varied. (Zoomed out version of Figure 5).

Conclusions and Suggested Next Steps

The connections of the top capacitor are very important and in this simple experiment have shown that changes can be made to the S11 response via heat. We will repeat this experiment with the modification that the connections will be made as secure as possible. Copper foil will be added to the connection to the center rod of the main top cap plate to insure a robust connection. For the long term, a more robust top plate should be made and deployed.