NOMENCLATURE

Stripline – A medium that is used to transmit electromagnetic energy. It is a thin copper line that is sandwiched between two substrate materials that have their outer surfaces grounded.

Coax – A medium that is used to transmit electromagnetic energy. It has an inner cylindrical conductor that is surrounded by cylindrical substrate which further surrounded by a cylindrical ground plane.

PROCESS

The SMA launch is used as a 50Ω interface from stripline to coax and is designed over the frequency range of DC to 18 GHz. The assembly concept, seen below in *Figure 1*, was modeled in HFSS and simulated while varying different parameters to optimize transmission across the bandwidth. Because of the inherent three-dimensionality of this component, all simulations were done directly in HFSS.

Values that were able to be tuned included the amount of clearance between the center pin and the ground plane, the radius of the 'pad' where the center pin connects to the fifty ohm line, the radius of the air cylinder into which the center pin protrudes, the positions of the thru-holes, the length of the center pin below the fifty ohm line, etc. Another license that was able to be taken with the launch was the ability to amputate one of its four legs. It was decided that this would be best to allow for more clearance for the trace. Also, it was initially thought that the length of the center pin was a variable but it was later discovered that the center pin material is actually toxic when cut, so this variable was not tuned.

Several different views of the SMA connector, the modifications to the connector and the final assemblies are shown below in *Figure 2* and *Figure 3*. This shows a brief review of the design process's flow.

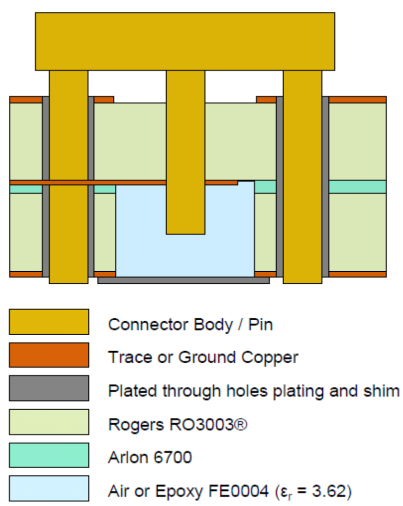


Figure 1: SMA Launch Assembly Concept (Provided by Anaren)

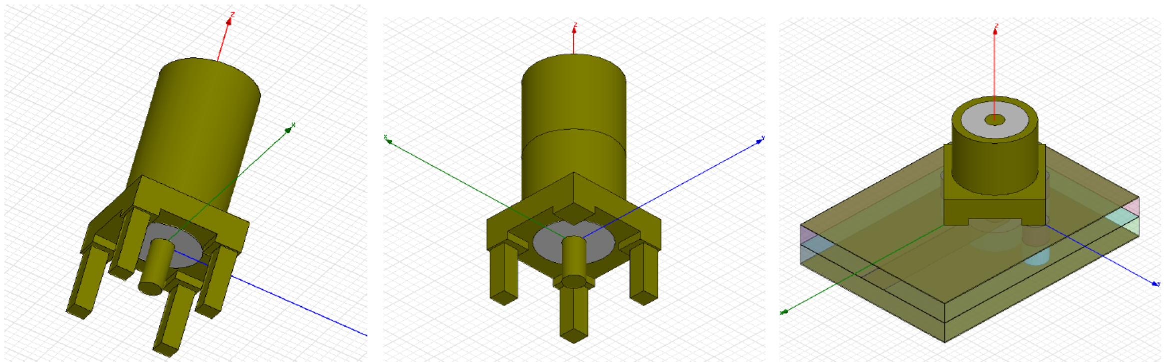


Figure 2: SMA Connector / Modified Connector / Assembly without Thru Holes

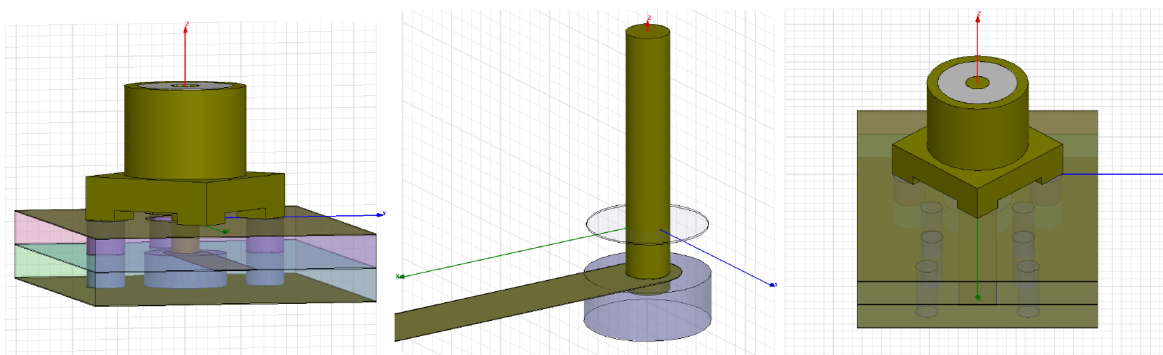


Figure 3: Assembly without Thru Holes / Signal Path / Final Assembly

RESULTS AND DISCUSSION

The final results of the HFSS simulation for the SMA Launch can be seen in *Figure 4* and *Figure 5*.

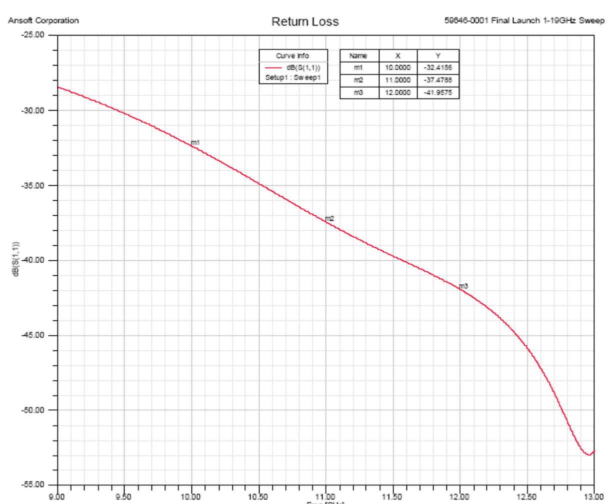


Figure 4: SMA Launch, HFSS Model, Return Loss, 9-13GHz

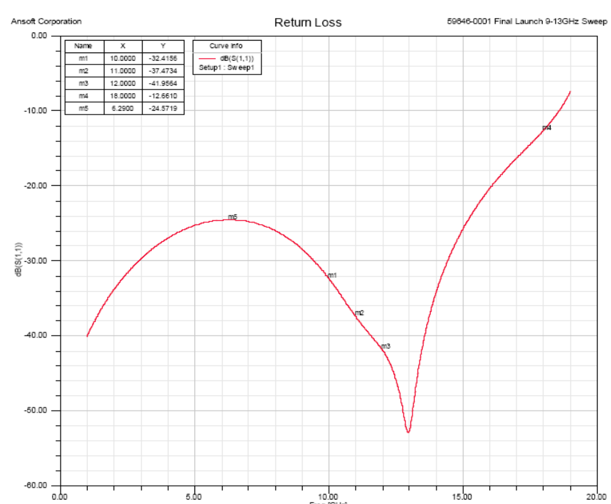


Figure 5: SMA Launch, HFSS Model, Return Loss, 1-19GHz

The final results of the SMA Launch, over the component bandwidth of 10-12GHz, had a maximum of 32.4dB down. This translates into a minimum of 99.94% of the power being transmitted through the launch. If you look at the entire bandwidth, up to 18GHz, the maximum return loss is only 12.5dB down. This is because the higher frequency range, 15-18GHz, was the hardest to tune. This range seemed to stay fairly constant no matter what was tuned. Even so, this return loss value translates into 94.38% percent of the power being transmitted through the launch.

Only after the circuits were sent for manufacture could tolerance analysis be done. This analysis was done to be sure that variation in circuit parameters resulted in tolerable changes in our results. Several tests were done including: manufacturing placement tolerances (up to a 5mil placement tolerance), epsilon variation (3.00 +/-0.04), and top and bottom dielectric thickness variation (60mil +/-5mil). Some of the results can be seen below.

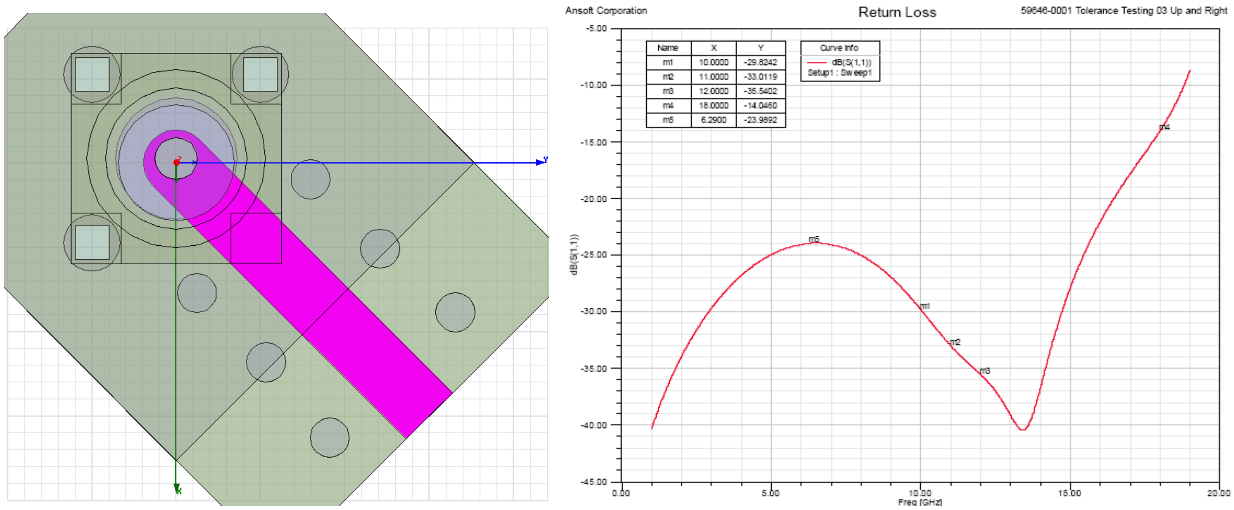


Figure 6: SMA Launch, HFSS Model, Placement Tolerance, Return Loss

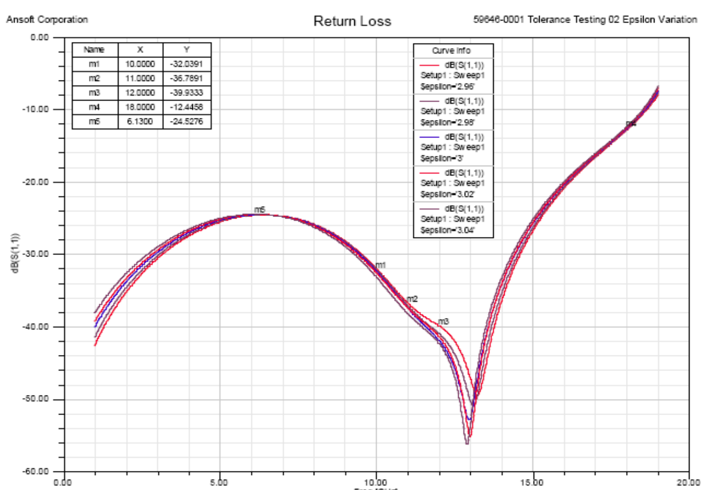
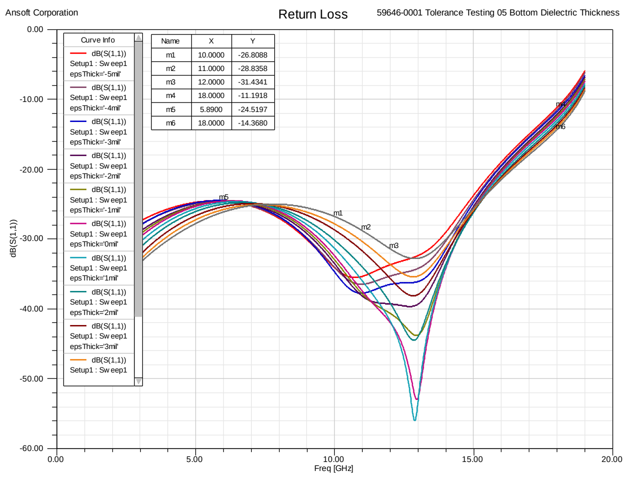


Figure 7: SMA Launch, HFSS Model, Epsilon Tolerance, Return Loss



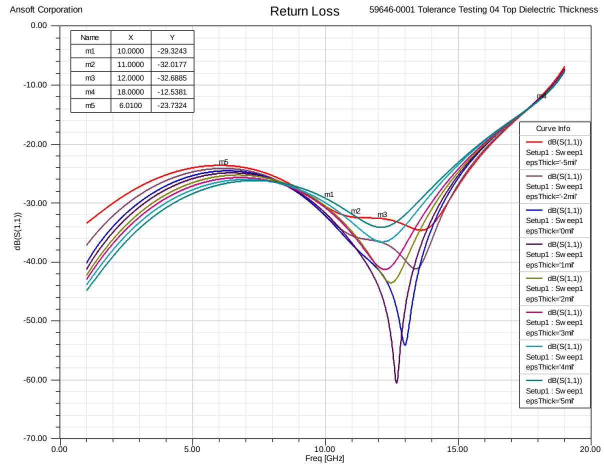


Figure 8: SMA Launch, HFSS Model, Bottom Dielectric Thickness Variation, Return Loss

Figure 9: SMA Launch, HFSS Model, Top Dielectric Thickness Variation, Return Loss

The tolerance analysis did not show many significant changes. The epsilon variation did not change return loss more than 1dB over any of our important frequency ranges and the dielectric thickness variation, although it caused increases in the return loss over the 10-12GHz range, still resulted in 25dB down or better.

Results for the experimental SMA Launches can be seen below. It should be mentioned that initial measurements of the SMA Launches, some of which can be seen in *Figure 10*, were quite off. Through examination of the physical launch structures, it was noted that the launches were not flush with the ground plane. This caused the amputated leg to be 'floating' above the top ground plane. When simulated, this caused the return loss to increase significantly (sometimes up to 20dB) across the bandwidth. The solution to this problem was to apply solder to the amputated leg to connect it to the ground plane. With that being said, there are two sets of results that are shown in this report: before and after soldering. Both of these measurements were taken using the gating feature of the network analyzer which allows us look at the performance of only the SMA Launch no matter which component it was attached to. The systems SMA Launches were not characterized before soldering because of their proximity to the components – the individual components had extra transmission line added to ensure an easy characterization of the launches.

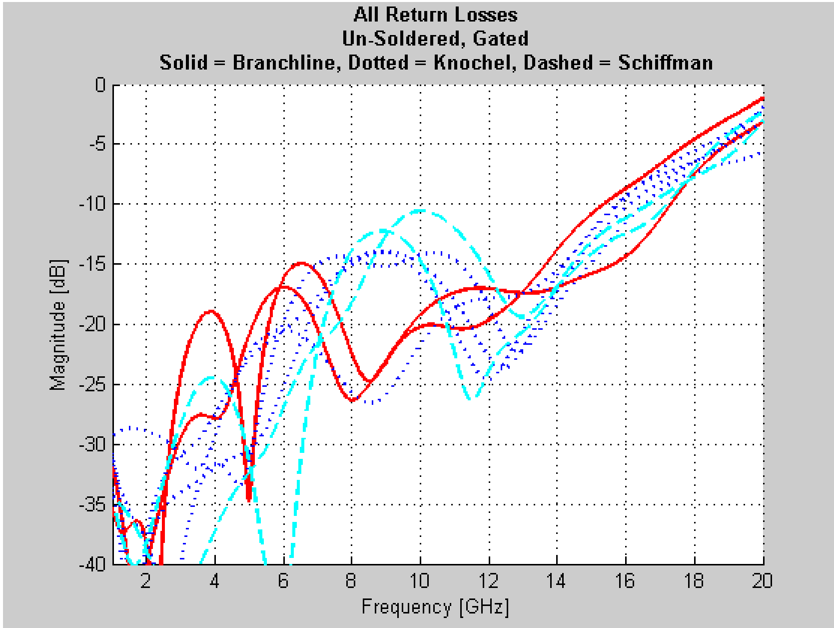


Figure 10: SMA Launch, Experimental Results, Unsoldered Gated Return Loss

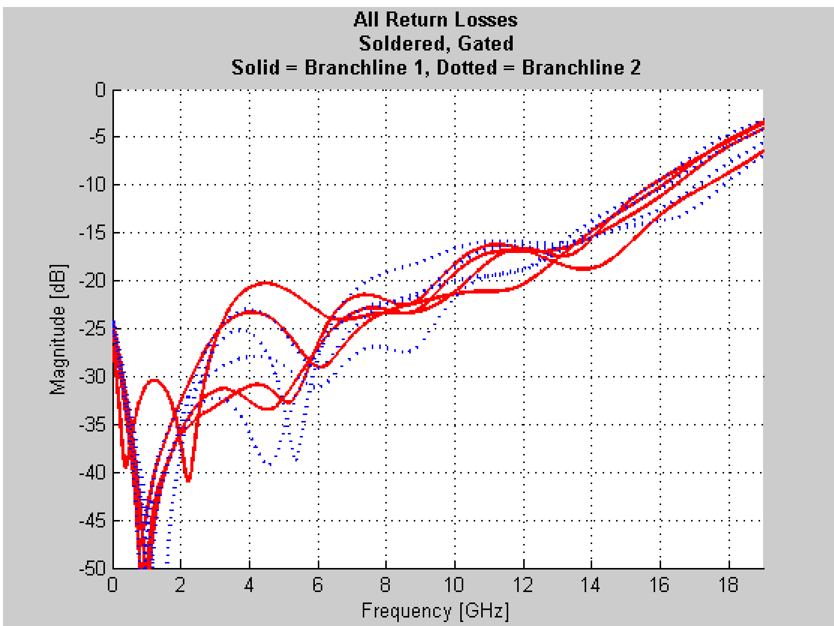


Figure 11: SMA Launch, Experimental Results, Soldered Gated Return Loss

Table 1: Theoretical / Designer / HFSS / Tolerance / Experimental Results Comparison

	HFSS	Tolerance: Placement	Tolerance: Epsilon	Tolerance: Dielectric Thickness	Experimental: Unsoldered	Experimental: Soldered
Return Loss						
10-12GHz	-32.42 dB	-29.82 dB	-32.04 dB	-26.81 dB	-10.5791 dB	-15.8364 dB
18GHz	-12.66 dB	-14.05 dB	-12.45 dB	-11.19 dB	-4.5668 dB	-4.7055 dB

Much can be said about the final results for the SMA Launches. The initial experimental results, seen in *Figure 10* (the unsoldered launches), show return losses in our bandwidth of as high as -10.5791dB; almost 15dB worse than our tolerance analyses predicted. Note also that these initial measurements vary from component to component as well as from launch to launch. This suggests weakness in the repeatability of correctly assembling the launch structure. Once soldered, the results, seen in *Figure 11* and *Table 1*, show improvement of at least 5dB over the 10-12GHz range. The results, however, still do not match very well to the predicted results. There does seem to be a local maximum around 6 to 7GHz, but the predicted trough that the 10-12GHz range was simulated to sit in, does not exist. Other factors, such as the slight rotation of the launches – i.e., if a launch is slightly tipped back – were simulated and also could also have caused large increases in return loss.

Further design could be done to improve the launch in the future. Some redesign was done on the launch, but it certainly could not be considered exhaustive. The main idea of this redesign was to add and tune a 'neck' on the fifty ohm transmission line that runs to the center pin of the SMA; this type of tuning network is shown below in *Figure 12*. Even of the redesign options that were investigated, the best results changed very little from the results of the model that was eventually sent for manufacturing.

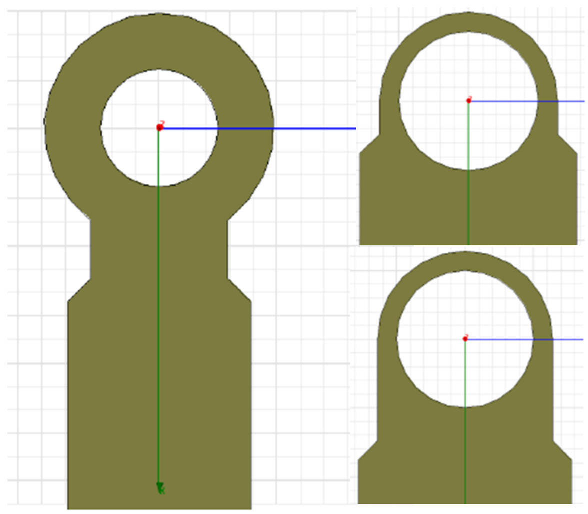


Figure 12: SMA Launch, Possible Redesign Options – (the model in the top-right yielded the best results)