

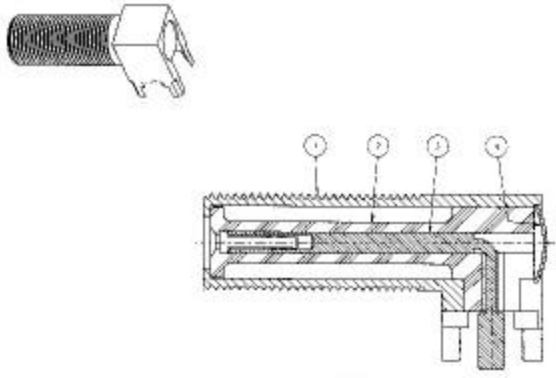
## High Frequency Structure Simulator Software Update (Additional Design Engineering Capabilities)

**ABSTRACT:** In the last issue of Amphenol Signals, we introduced you to the new software tool currently in use by the design engineering department for simulating the electrical design of connectors. This software (Ansoft HFSS) has helped to dramatically reduce the time necessary for designing new connectors. The latest edition (Version 6.0) has the added capability of Time Domain analysis. This additional tool can help the engineer determine the location within the connector that is causing poor electrical performance. Changes can be made to the software model, and an additional analysis can be performed to determine the effect of the changes. Once again, as pointed out in the previous article, all of this is done before any parts are actually made in the model shop resulting in a significant reduction in development time.

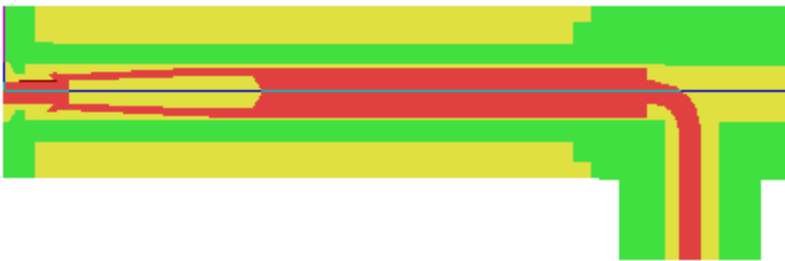
**TIME DOMAIN (TDR):** After viewing the Return Loss (Frequency Domain) graph, a new plot is made in the Time Domain. A Frequency Domain plot will tell us the magnitude of the reflection versus **FREQUENCY**, but a Time Domain plot will show us the magnitude of the reflection versus **TIME**. We can easily determine the distance within the connector by using the formula  $D=V*T$  (Distance=Velocity x Time). The Velocity is calculated by knowing the speed of light (C) and the dielectric constant (E) of the materials within the connector.  $V=C/\text{Square Root}(E)$ . All of these equations are programmed into an Excel spreadsheet and the calculations are done very quickly. Although we can analyze the electric field plots with HFSS, the analysis is qualitative and determining location can be ambiguous. In contrast, TDR is quantitative and far more precise. The position and type of reflection (negative: capacitive or positive: inductive) can be easily determined.

**THE PROBLEM:** Design a right angle PC mount Type "F" receptacle with a Return Loss requirement of -25 dB to 1.5 Ghz and -15 dB to 3 Ghz. This appears to be a difficult requirement to meet because of the relatively high frequency requirement. Typically, F connectors are rarely used much above 1 Ghz. A design exists that performs at low frequencies where it is currently being used, but we don't have any parts to test and we don't think it will meet the Return Loss requirement above 1 Ghz. However, HFSS allows us to run a simulation to any frequency.

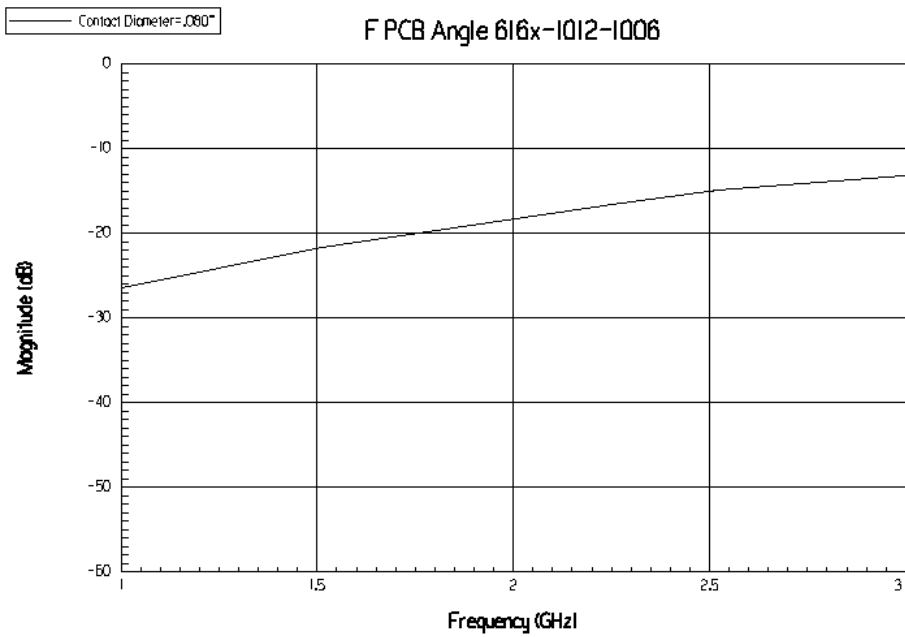
**THE SOLUTION:** The first attempt is to run an analysis on the basic existing design to see where we stand. Figure 1 shows the mechanical drawing and Figure 2 is the HFSS Model. Figure 3 shows the Return Loss as being out of spec, pretty much as we suspected.



**FIGURE 1. Connector Drawing**



**FIGURE 2. HFSS Model**



**FIGURE 3. Return Loss**

Typically, at this point, there are a few options that can be investigated. One would be to plot the Electric Field patterns and attempt to analyze them. As stated earlier, this is a qualitative, ambiguous and somewhat difficult procedure. Another would be to build some samples, test them and examine the TDR results on the Network Analyzer. This would be very time consuming. With Version 6 of ANSOFT HFSS, we can display a Time Domain (TDR) plot and see exactly where the mismatch is located and whether the impedance is too low or too high without building any samples. We can then attempt to correct the mismatch and re-run the analysis. Once again, all of this is done in a matter of a few hours without building any samples. Figure 4 shows the TDR plot of the original connector design. We see that a negative reflection occurs at a time of from .1-.2 ns. We can convert this time to distance and see that it shows us that a capacitive reflection occurs along the length of the contact. There isn't too much we can do to help the situation in the area of the slots. We can't open up the body ID because the wall would become too thin. However, we can turn down the diameter of the contact from .080" which is a 65 ohm impedance to .065" which gives us a 75 ohm impedance from a point behind the slots to just before the bend. Figure 5 shows the HFSS model with the diameter reduced to .065". We also see a higher impedance in the area of the bend, but it appears to be far less significant than the long area of low impedance.

**FIGURE 3. Return Loss**

**FIGURE 4. Time Domain Plot**

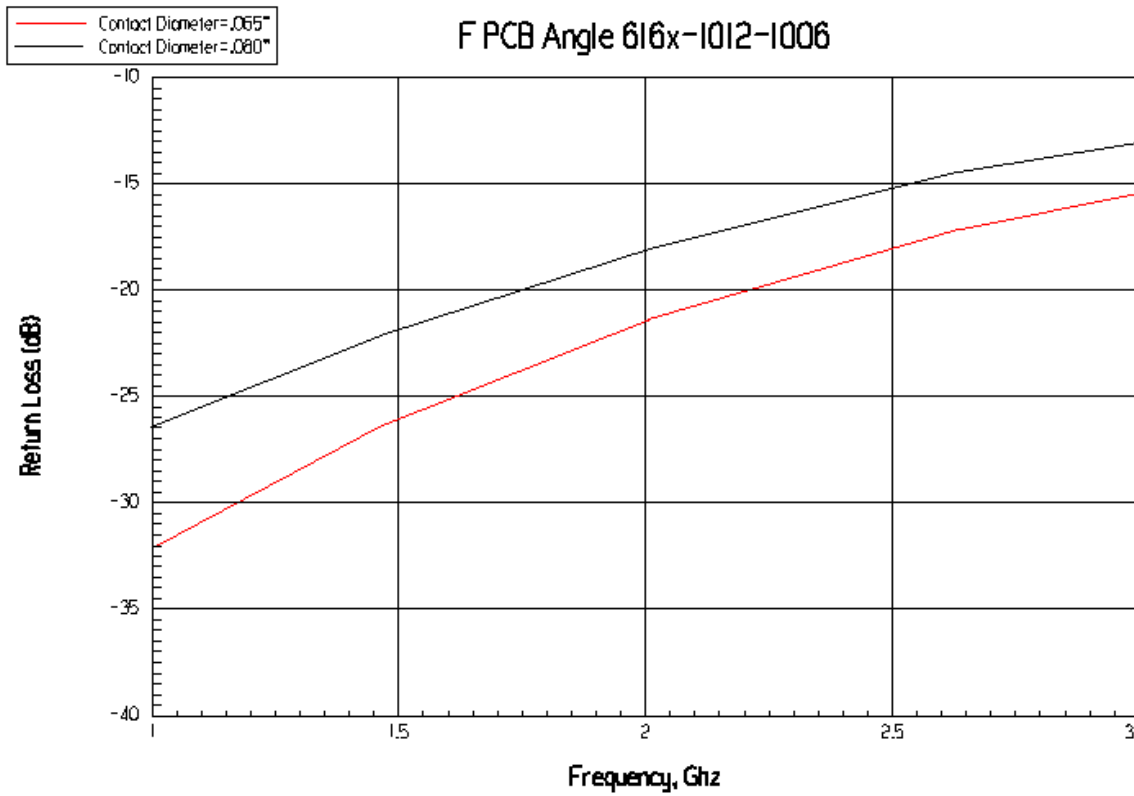
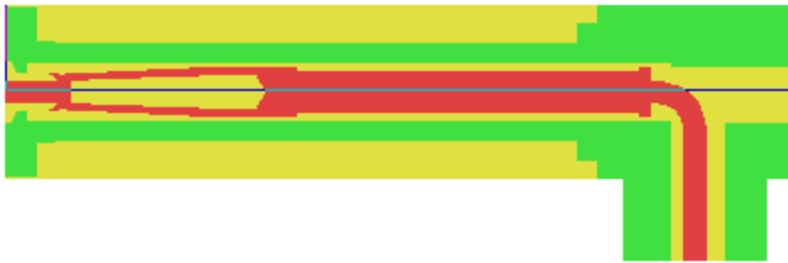
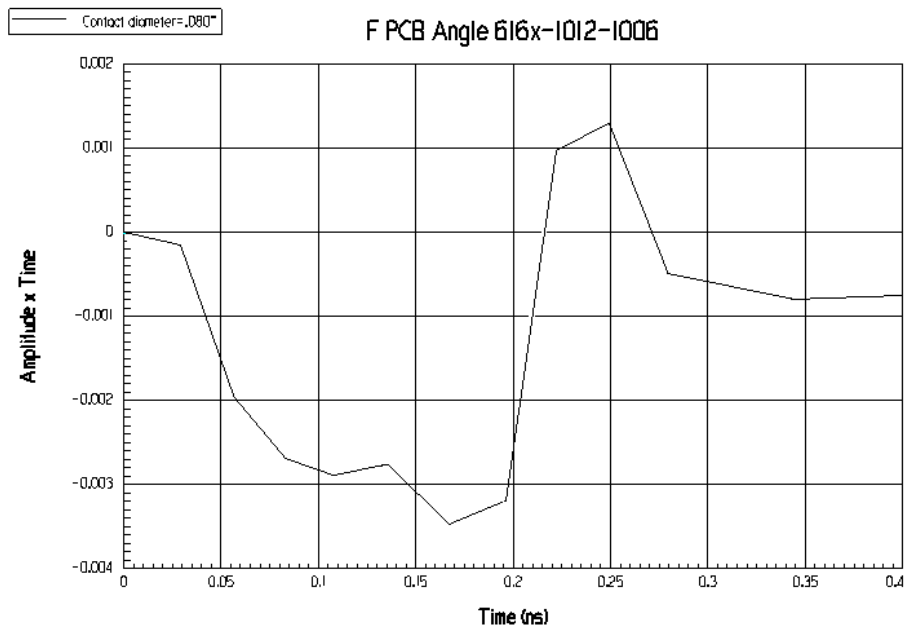
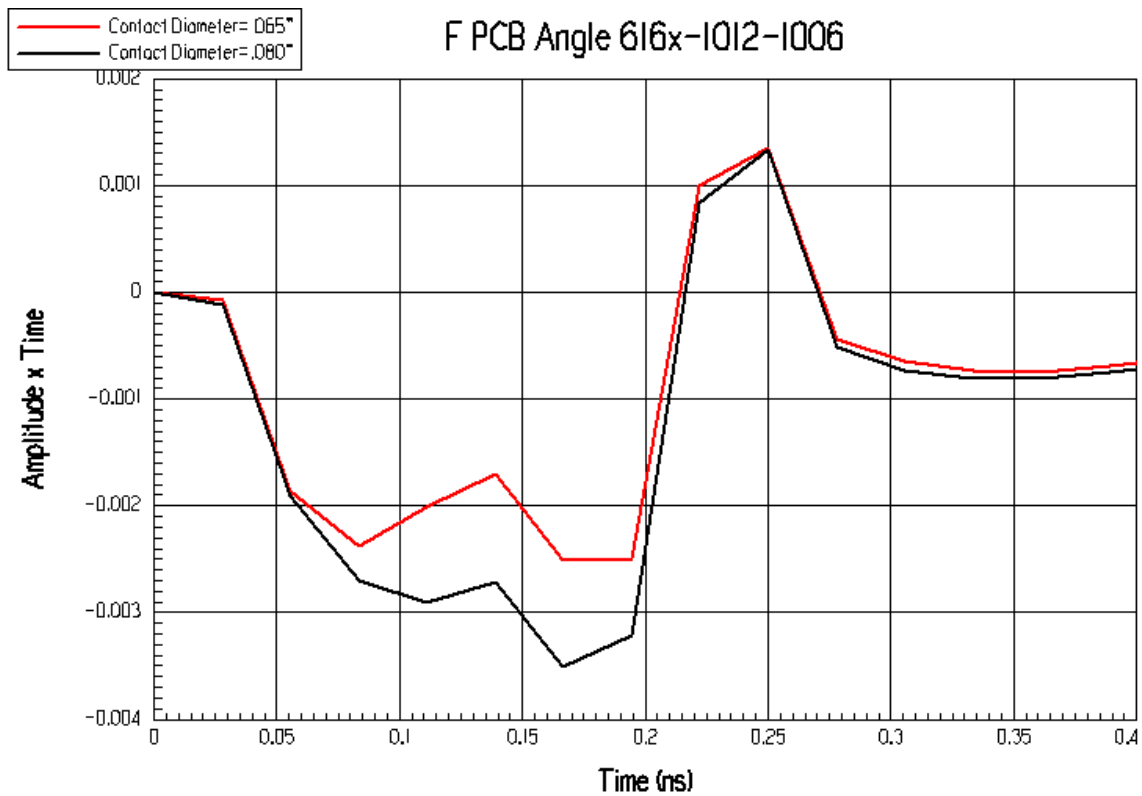


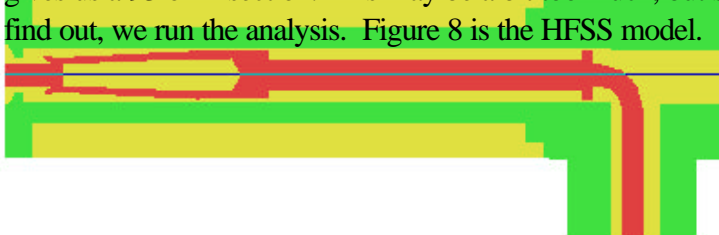
FIGURE 6. Return Loss-

The new Return Loss plot (Figure 6) shows an improvement. The connector now passes the requirement, but with little to spare. The TDR plot (Figure 7) shows a reduction in the capacitance, but it appears that there is still a need to increase the impedance even though according to the calculations it is now at 75 ohms. This points out one of the tremendous advantages of HFSS. Even though the calculations for the impedance of each section of the connector may be close to the desired impedance, there is no way to easily calculate the interaction between these different sections over the frequency range required. HFSS does this for us.

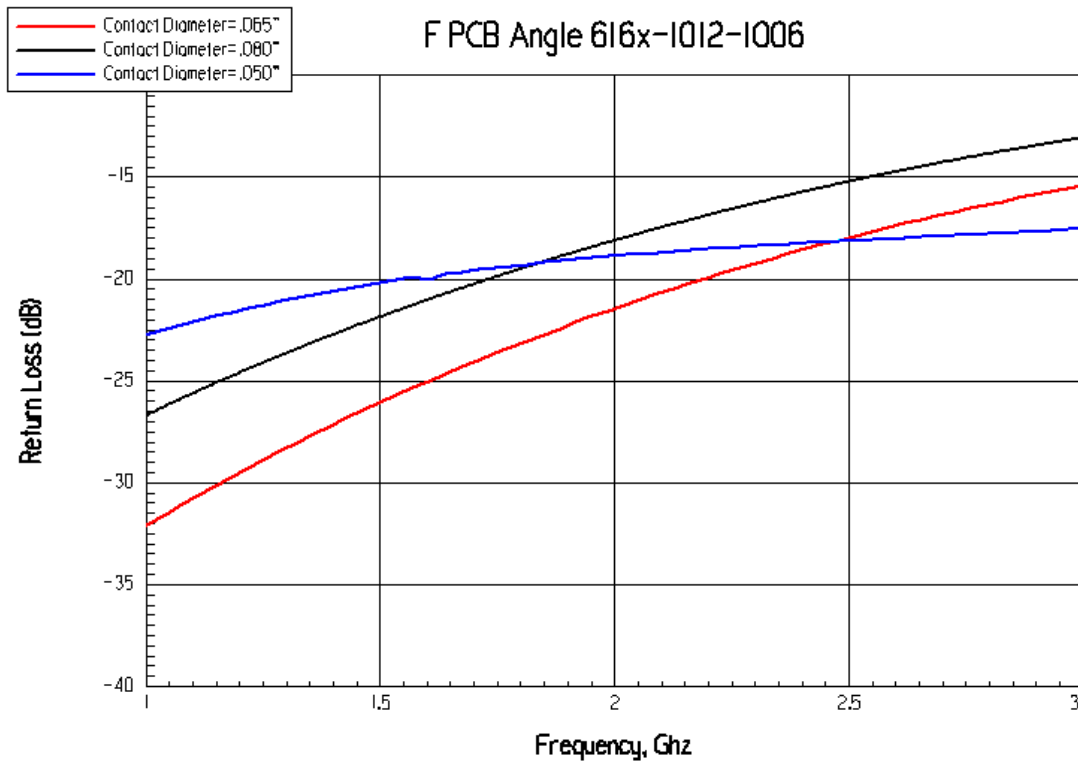


**FIGURE 7. TDR - .065" vs. .080"**

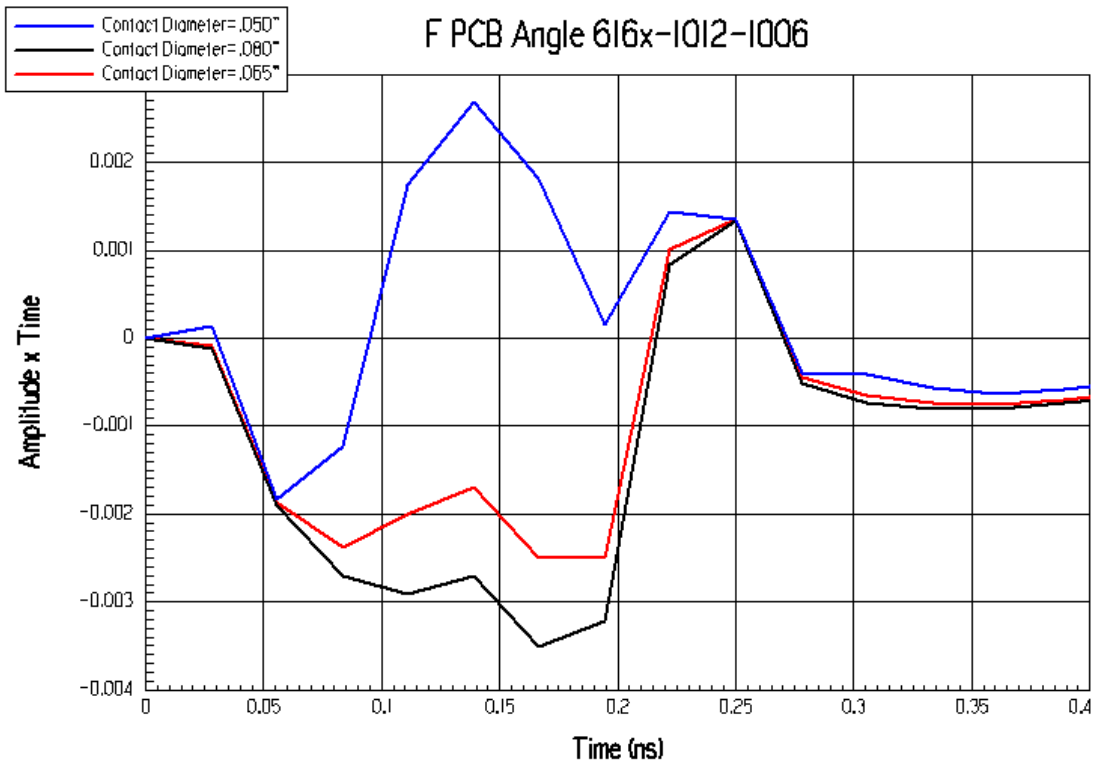
Another reduction in contact diameter is tried. This time it is reduced to .050" which gives us a 93 ohm section. This may be a bit too much, but since it only takes a short time to find out, we run the analysis. Figure 8 is the HFSS model.



**FIGURE 8. HFSS Model .050" Contact Diameter**

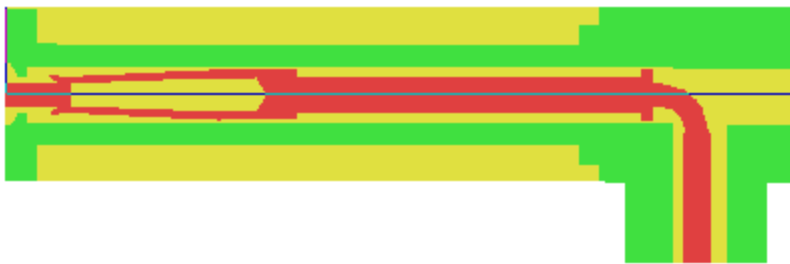


**FIGURE 9. Return Loss- .050"- .065" - .080"**

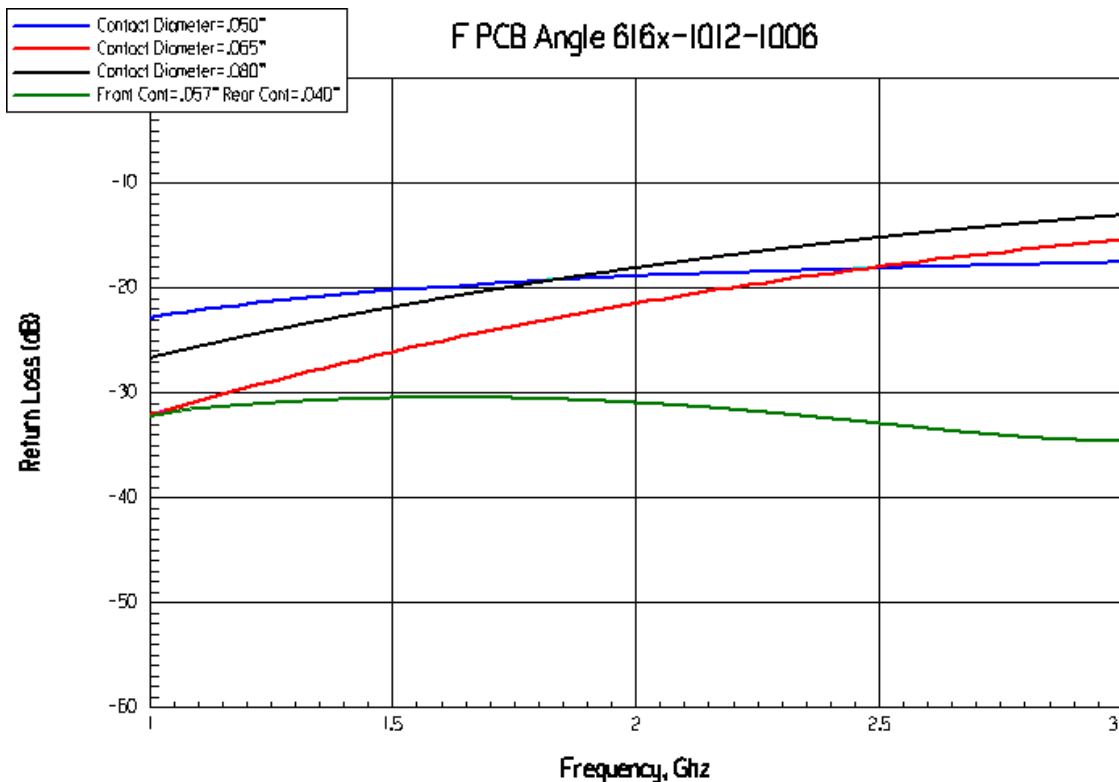


**FIGURE 10. TDR- .050"- .065" - .080"**

It appears that we were a little bit too aggressive in reducing the diameter. The Return Loss improved at 3 GHz but it increased again at 1.5 GHz. This illustrates the point that it is difficult to gauge the interactions within the connector. By examining the Return Loss plot and the TDR plot, it appears that a diameter of approximately .057" would result in the optimum we can achieve in the contact area. However, in order to improve the Return Loss further, we need to look at the area of the bend, which appeared as a higher impedance. Although it was not a large reflection, it appears to be having more of an impact than anticipated. In order to compensate for this, we increase the diameter of the contact section past the bend to .040". Figure 11 is the new HFSS model. Figure 12, the Return Loss Plot, shows a dramatic improvement.

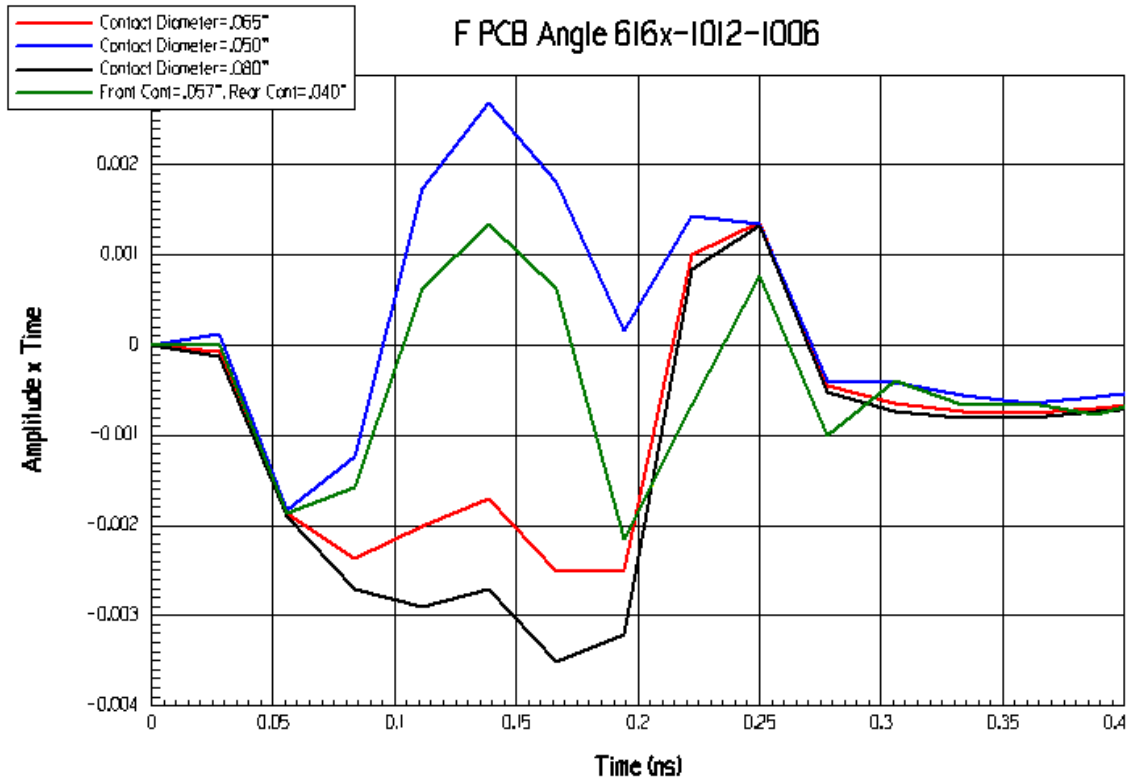


**FIGURE 11. HFSS Model-.057"/.040" Contact Diameters**



**FIGURE 12. Return Loss- .050" - .065" - .080" - .057"/.040"**

If we examine the TDR plot, we can see that we've reduced all of the reflections, both positive and negative. This results in the excellent Return Loss. Not only have we met the customer requirements, we greatly exceeded them. This was all accomplished in a matter of hours without ever making any samples. The TDR capability has greatly enhanced our ability to design well matched, high performing connectors in a very short time.



**FIGURE 12. Return Loss- .050"- .065" - .080"- .057"/.040"**