AMPHENOL CUTS CYCLE TIME ON ENGINEERING PRODUCTS

ABSTRACT: The typical engineering development cycle includes understanding the customer's needs, initial design, model shop fabrication, test and redesign if necessary. More often than not, several cycles of fabrication, test and redesign are required before the product performs as required. About 10 years ago, with the development of high speed UNIX based computer workstations, several software products were released by manufacturers such as HP and ANSOFT that allowed engineers to design the product on a computer and then simulate it's electrical performance. Parameters such as Return Loss, Antenna Radiation Patterns, Insertion Loss, Crosstalk, and RF Leakage among others could be realized using a computer without having to actually make and test the sample. Designs could be varied on the computer and tried out in a matter of hours instead of days or weeks. These High Frequency Structure Simulator (HFSS) programs were extremely expensive, required dedicated workstations and were typically slow by today's standards, but still much better than actually fabricating samples.

Over the past few years, the software manufacturers have developed programs that work on PC's using WINDOWS operating systems and operate at greatly increased speed. The cost of the software, as well as the hardware has become affordable for many more users and Amphenol Communications and Network Products Division recently purchased HFSS software from ANSOFT Corporation after a 6 month evaluation period.

HISTORY: The action of electromagnetic waves within defined boundaries has been well defined for over 100 years. James Clerk Maxwell developed the mathematical relationships that bear his name, Maxwell's Equations. Until recently, these differential equations would be applied only to simple problems due to the complexity of their solutions. The computer has changed all of that, and with the refinement of Finite Element Analysis techniques, very complex problems can now be solved in a very short time.

FINITE ELEMENT METHOD: The Finite Element Method is a mathematical method of analyzing a complex structure by breaking it into numerous small tetrahedron and analyzing these smaller structures. The field across each element is approximated by a simple algebraic expression. Each corner of an element is a node and the electric and magnetic field quantities must be determined at each node. The problem can then be solved using linear algebraic expressions.

TYPICAL DESIGN: After the customer's requirements are understood, the engineer will develop the mechanical design using PRO-E 3D CAD Software. Basic formulas and programs are utilized to determine dimensions that will give "ball park" electrical performance. Except for the most basic 2D designs, these programs cannot synthesize the interactions of the different sections of the connector and are not capable of analyzing 3D structures of any configuration. In contrast, HFSS can analyze any 3D structure. At this point in the design cycle, the drawings would be given to the SRF facility for samples to be made. Depending on the complexity of the design, it could take several weeks for the parts to be completed. At this time, the initial test-redesign-test cycle is started. Several more weeks can pass before the design is finalized.

MINIMIZING THE DESIGN CYCLE: Now, before the drawings are submitted to SRF, the following procedure is followed:

1) The drawings for the individual components are imported from PRO-E into HFSS.
2) The drawing is modified to be compatible with HFSS.
3) The material of each component is specified.
4) The "PORTS" , "BOUNDARIES", frequency range, and error limits are specified.
5) The analysis is run and the results are evaluated.
6) If necessary, changes to the drawing are made and the problem is re-run..

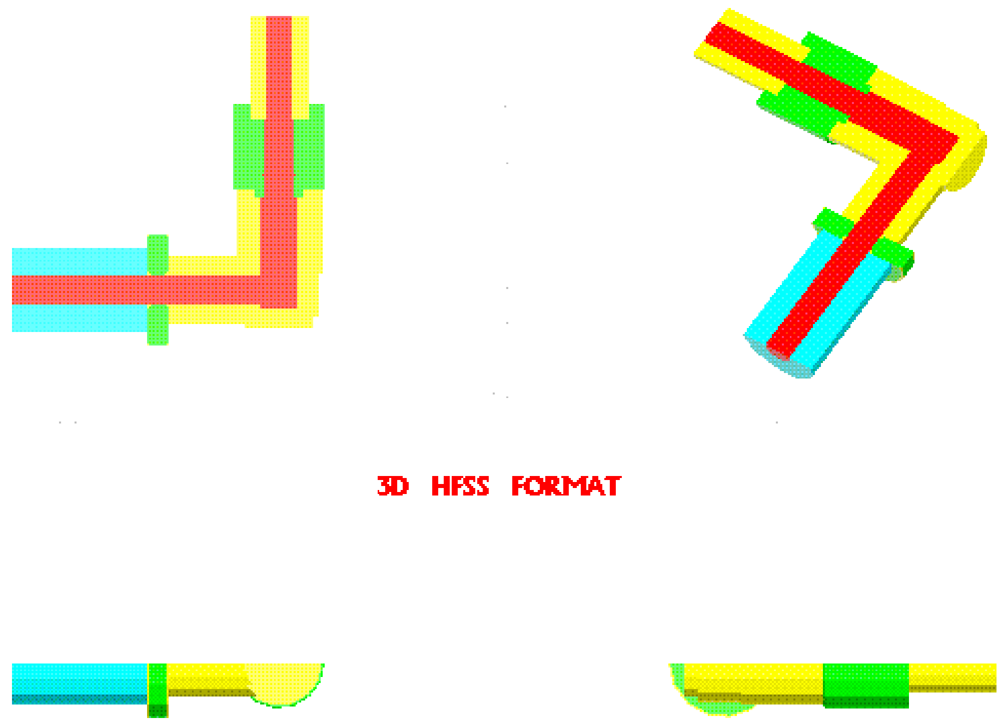
Depending on the complexity of the problem, this process can be completed within a matter of minutes or hours. A typical problem is illustrated below.

A requirement is received for a Type "N" right angle connector with a Return Loss requirement of 32 dB to 2.5 Ghz and 20 dB to 4 Ghz. when used on .5 inch cable.

The initial design is drawn in PRO-E .

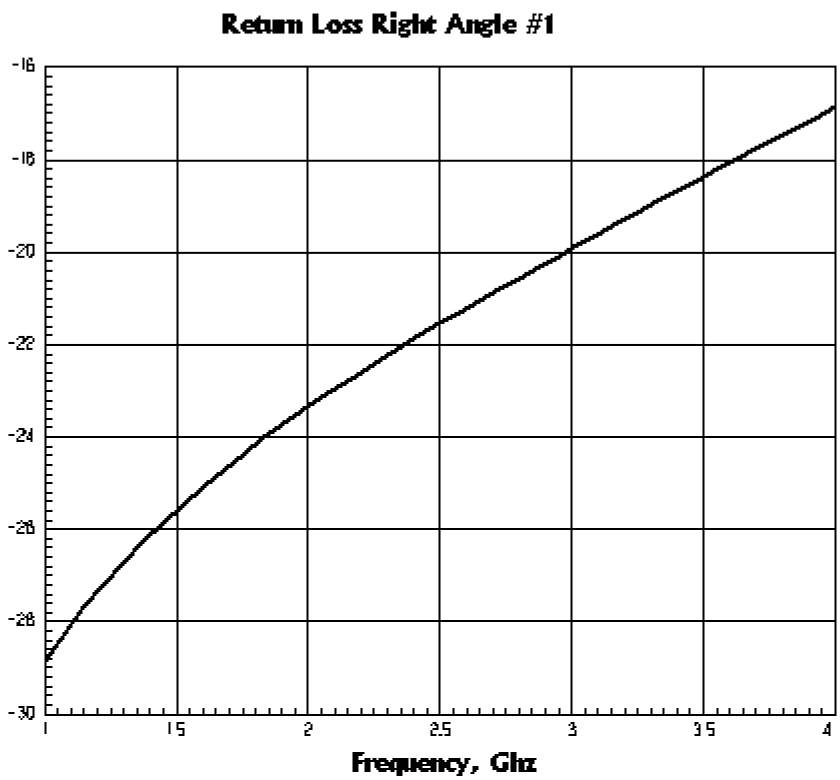
PROE-E Drawing

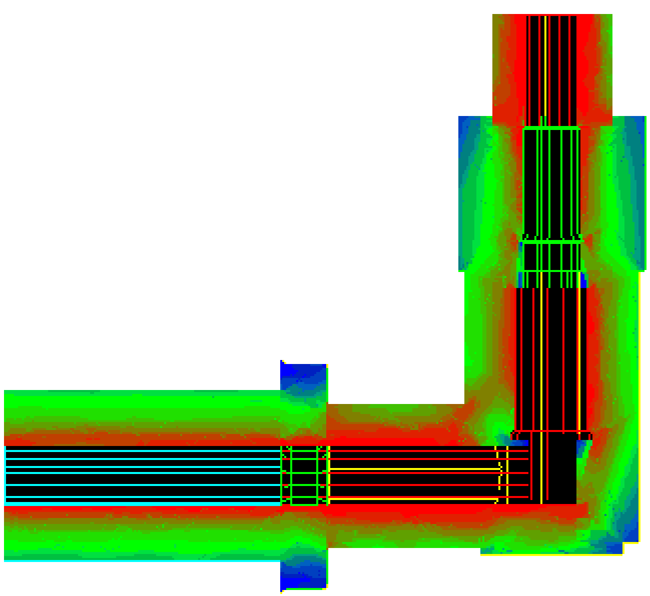
Next, it is imported into HFSS and modified to be compatible with it's format.



After defining the materials, PORTS and BOUNDARIES, the simulation is run.

The results can be viewed in several different formats, but RETURN LOSS is the most common. As can be seen below, the initial results do not meet the customer specifications. In the past, we would have had to wait at least a week for the connector to be made before being able to test it. Now, it took about 30 minutes to set up the problem in HFSS, and in this case it took less than 10 minutes to run the simulation.

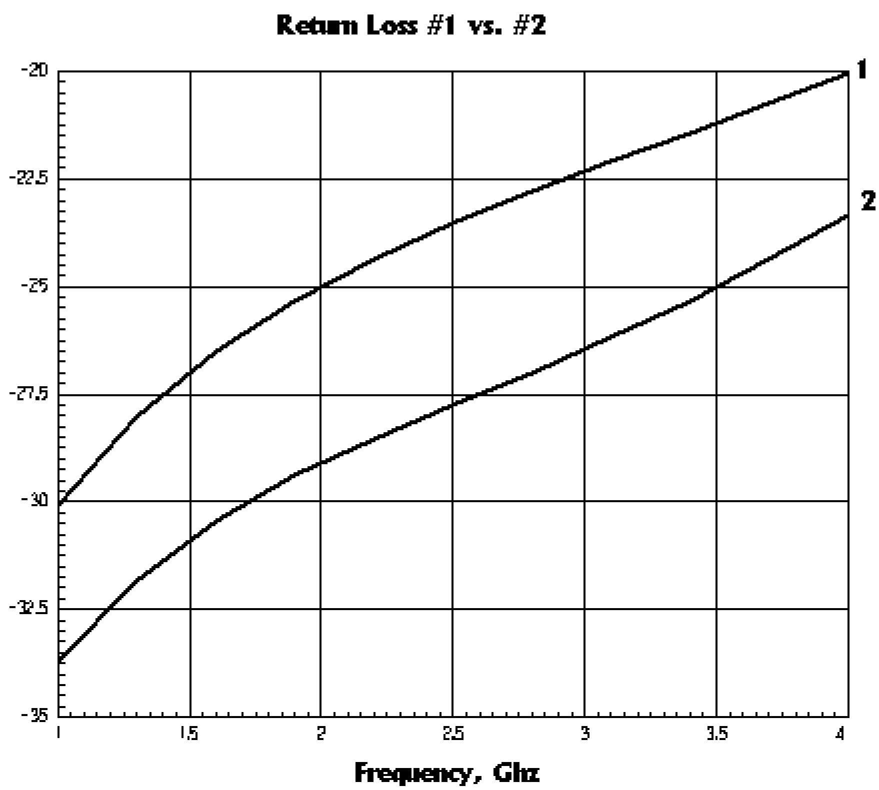

Return Loss Right Angle #1
-16
-18
-20
-22
-24
-26
-28
-30
1
1.5
2
2.5
3
3.5
4
Frequency, Ghz



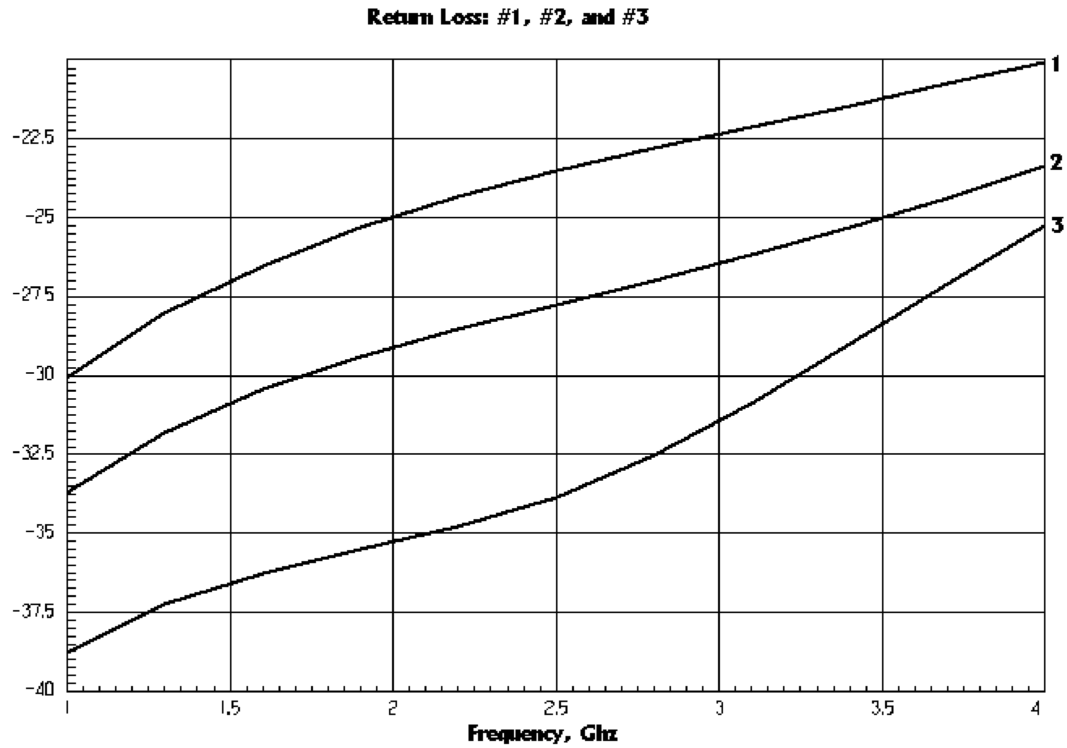
E Field Plot

After viewing the Return Loss graph and analyzing the E-Field plots, the design was modified by reducing the contact diameter to .168 from .173 and the analysis was run again.

Reduced Diameter Contact

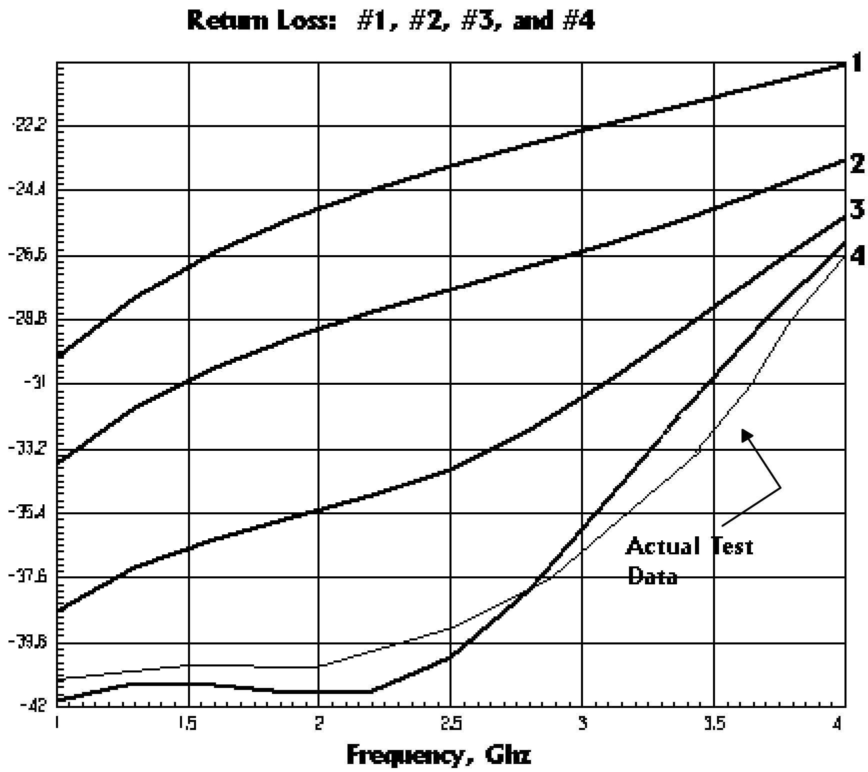


An improvement can be seen, however, it is still not enough to pass the customer requirements. The diameter of the contact in the right angle cavity is turned down some more from .168D to .163D and another simulation is run.



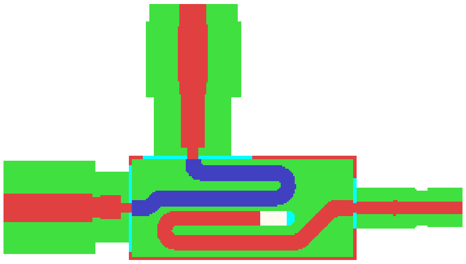
This change results in a Return Loss that now passes the customer specification. However, there isn't enough margin to allow for manufacturing and assembly variations. So another attempt to improve the performance is made. This time, a drill point is "machined" into the right angle cavity and a new simulation is run.

DRILL POINT

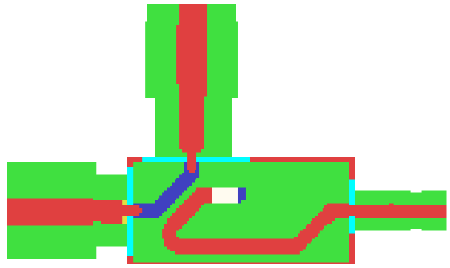


This final change results in a Return Loss well below the level necessary to guarantee reliable performance. All of this was accomplished in a matter of a few hours compared to several weeks that would have been necessary before we had this powerful tool. The actual test data tracks very closely with the simulated results as the graph shows.

THE FUTURE: One of the very powerful features of this software is that we are not limited to coaxial structures. Any 3D structure can be modeled. This allows us to design devices other than connectors. One such application is an RF Sniffer. This is a device which is similar in some respects to a directional coupler. In this particular application, 2 frequency ranges were required and the device was designed using microstrip technology. It includes three connectors (2-TNC and 1-SMB) mounted on a box. The HFSS models are shown below. As you can see, this now opens up a new area for Amphenol RF. With this capability, we can attempt designs that we would not have been able to address previously.



Low Frequency Sniffer
869-894 Mhz



High Frequency Sniffer
1930-1990 Mhz

FUTURE SOFTWARE ENHANCEMENTS: The next generation of this software (Version 6) is due out shortly. There are several enhancements that will give us additional analysis capabilities and further reduce the cycle time. Among them are TDR (Time Domain Reflectometry), Manual Meshing, and faster analysis times. The TDR should prove to be especially helpful in determining exactly where a discontinuity is within a device and whether it is capacitive or inductive. This information will help the design engineer determine the direction he needs to take in order to improve the design. Manual meshing allows one to further refine an area within the connector and run additional analysis without adding excessive tetrahedra to the entire example. In addition to this powerful High Frequency Analysis Tool, we are expecting delivery of a Mechanical Finite Element Analysis software package. This tool will allow us to analyze mechanical designs for structural integrity including deformation and fatigue. This will be the subject of a future article.