



# THREE DIMENSIONAL 8 PORT MONOPULSE COMPARATOR

Tom McWalters  
Dr. Gordon Riblet



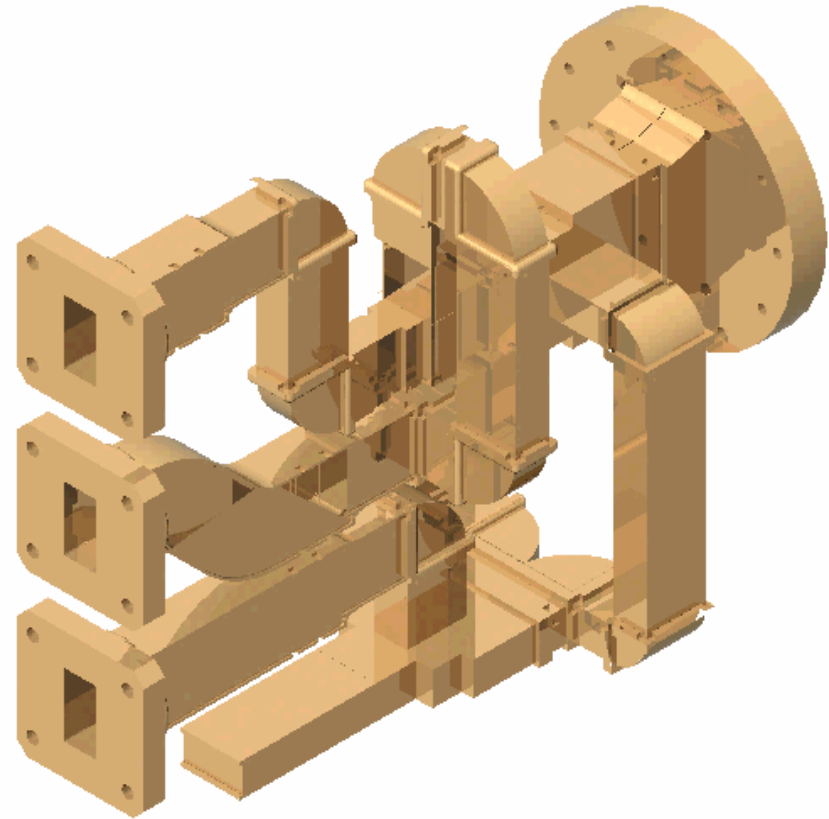
## COMPUTING PLATFORM

- SUN ULTRA 60
- DUAL 400 MHZ PROCESSORS
- 1.024 GIGABYTES OF RAM
- HFSS VERSION 8
- OPTIMETRICS VERSION 2
- MODELERS
  - \* *HFSS NATIVE (ACIS)*
  - \* *SOLIDWORKS (PARASOLID) TRANSLATED TO ACIS*



# MECHANICAL CONFIGURATION

- INTERNAL COMPONENTS WR-62 (BENDS, WAVEGUIDE & TEES)
- INPUT & OUTPUT PORTS TRANSFORMED TO WR-75
- 3 INPUT PORTS (WR-75)
- 4 OUTPUT PORTS (WR-75)
- 1 TERMINATED PORT (WR-62)
- UNIQUE CENTERWALLS ON OUTPUT FLANGE





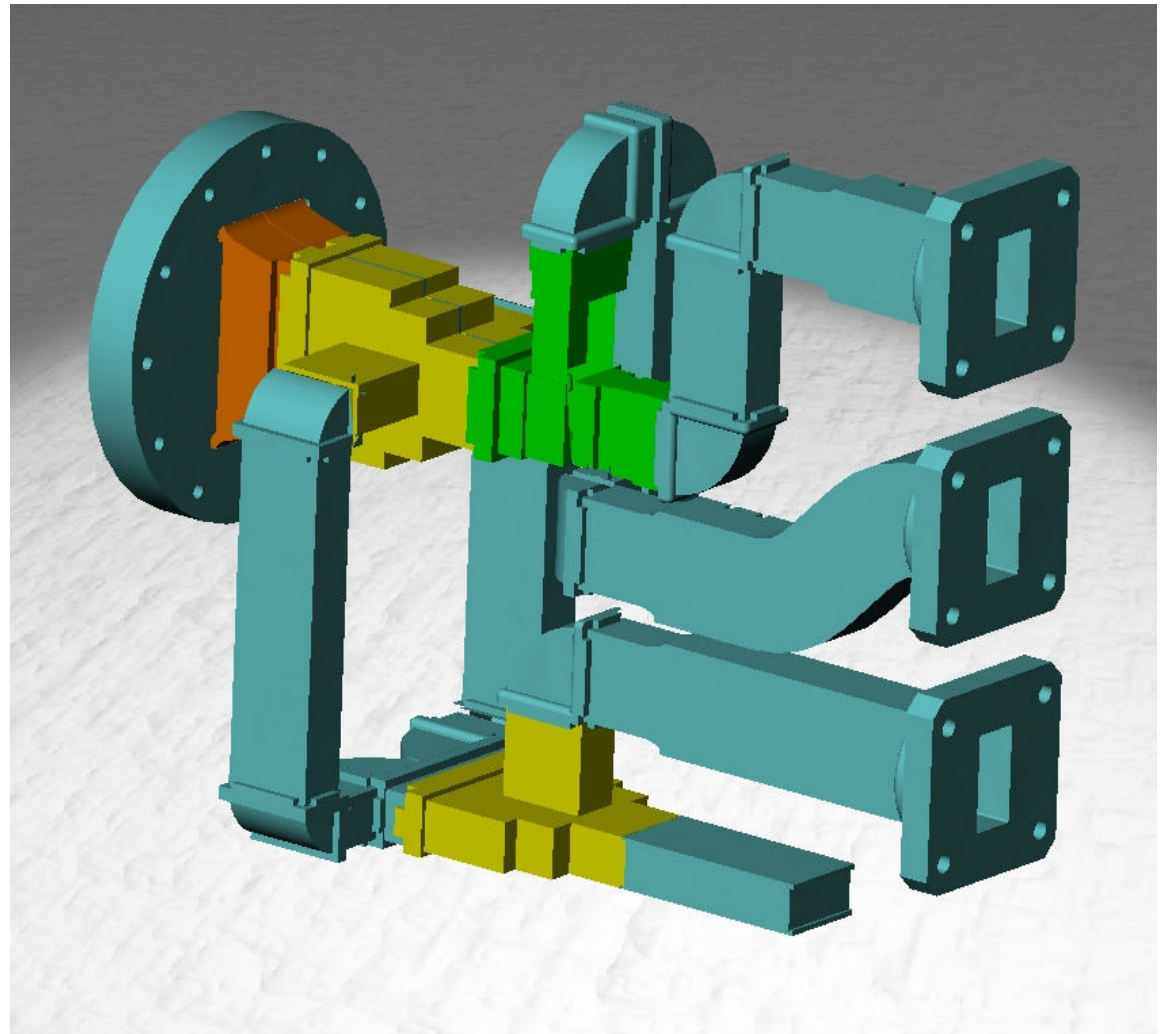
# CUSTOMER ELECTRICAL REQUIREMENTS

- FREQUENCY  
RANGE: 12.5 - 14.4  
GHZ
- W/G SIZE: WR-75
- VSWR (SUM &  
DIFF): 1.35:1 MAX  
@ 13.5 - 14.4 GHZ
- VSWR (SUM &  
DIFF): 1.7:1 MAX @  
12.5 - 13.5 GHZ
- OUTPUT PHASE  
ERROR: +/- 3  
DEGREES MAX
- ISOLATION (SUM-  
DIFF), (DIFF-DIFF):  
-35 DB MIN



# KEY COMPONENTS

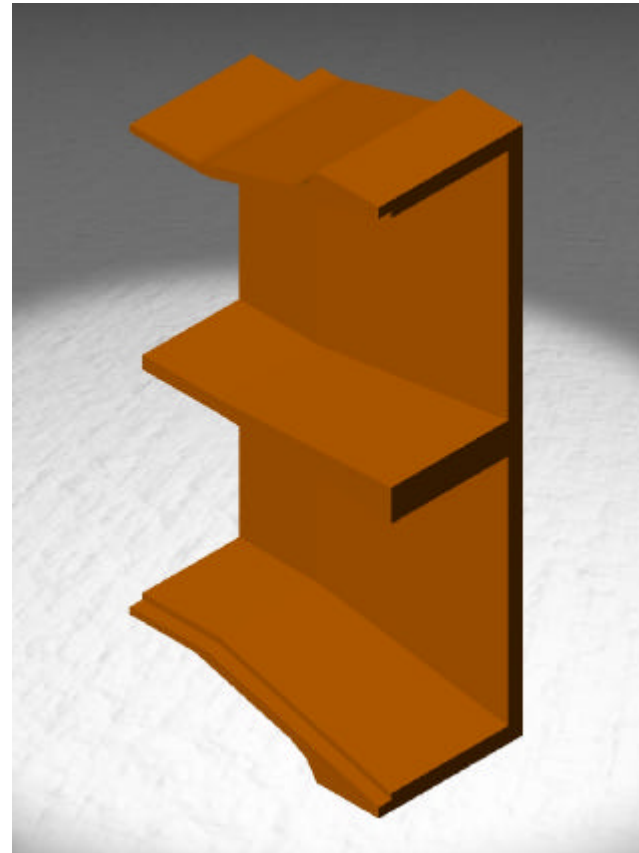
- WR-62 TO WR-75  
TAPER
- WR-62 H-PLANE  
FOLDED TEE
- WR-62 E-PLANE  
FOLDED TEE





## WR-62 TO WR-75 TAPER

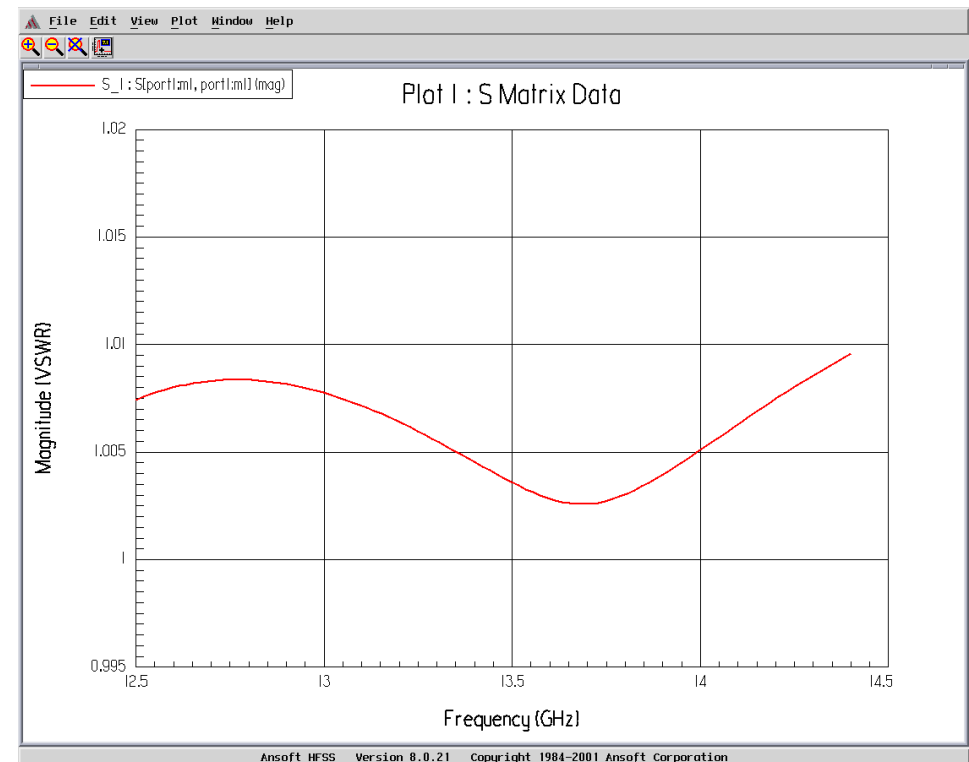
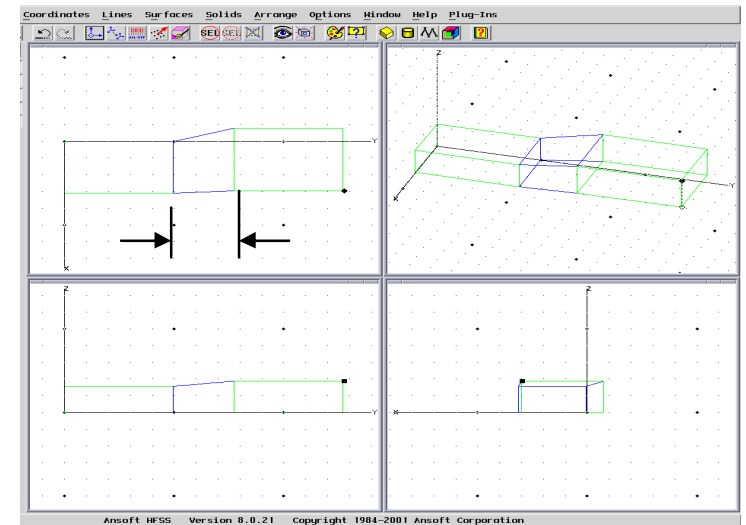
- OPTIMIZED USING PARAMETRICS
- DESIGN GOAL:  
LOWEST POSSIBLE  
VSWR, IN SMALLEST  
MECHANICAL  
PACKAGE





# DESIGN AND OPTIMIZATION OF TAPER

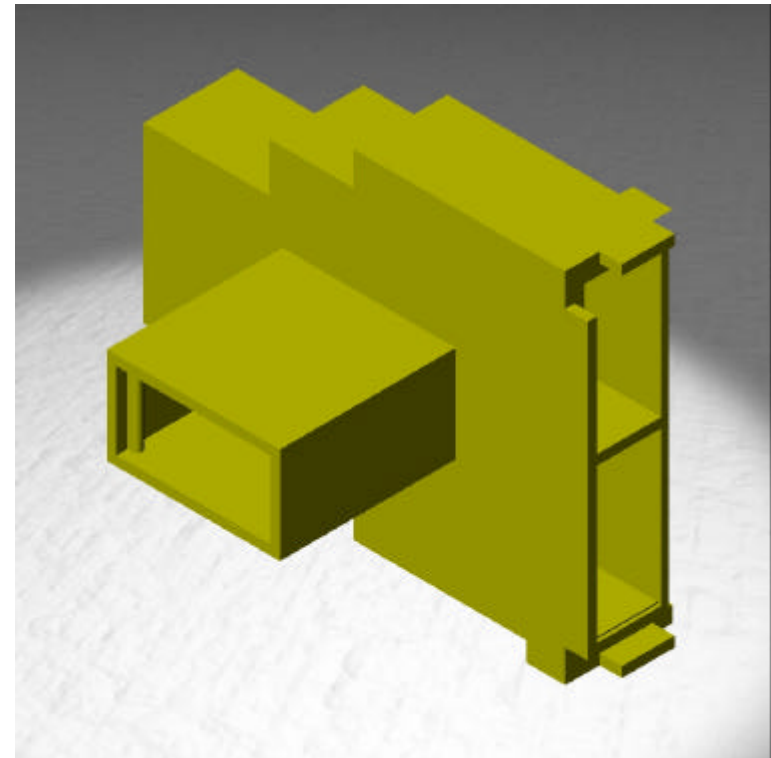
- LENGTH OF TAPER ONLY VARIABLE USED IN OPTIMIZATION
- VSWR LESS THAN 1.01:1
- HFSS INFO: FAST FREQ SWEEP, MAX DELTA S= .004, 2100 TETRAHEDRA, APPROX 15 MINUTES RUN TIME PER SET-UP





## WR-62 H-PLANE FOLDED TEE

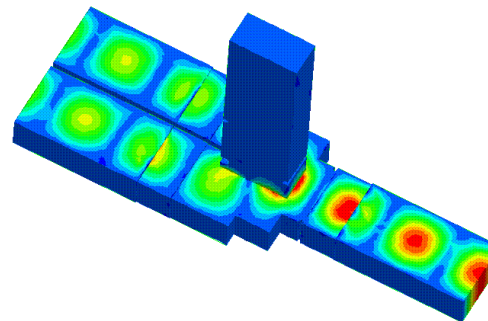
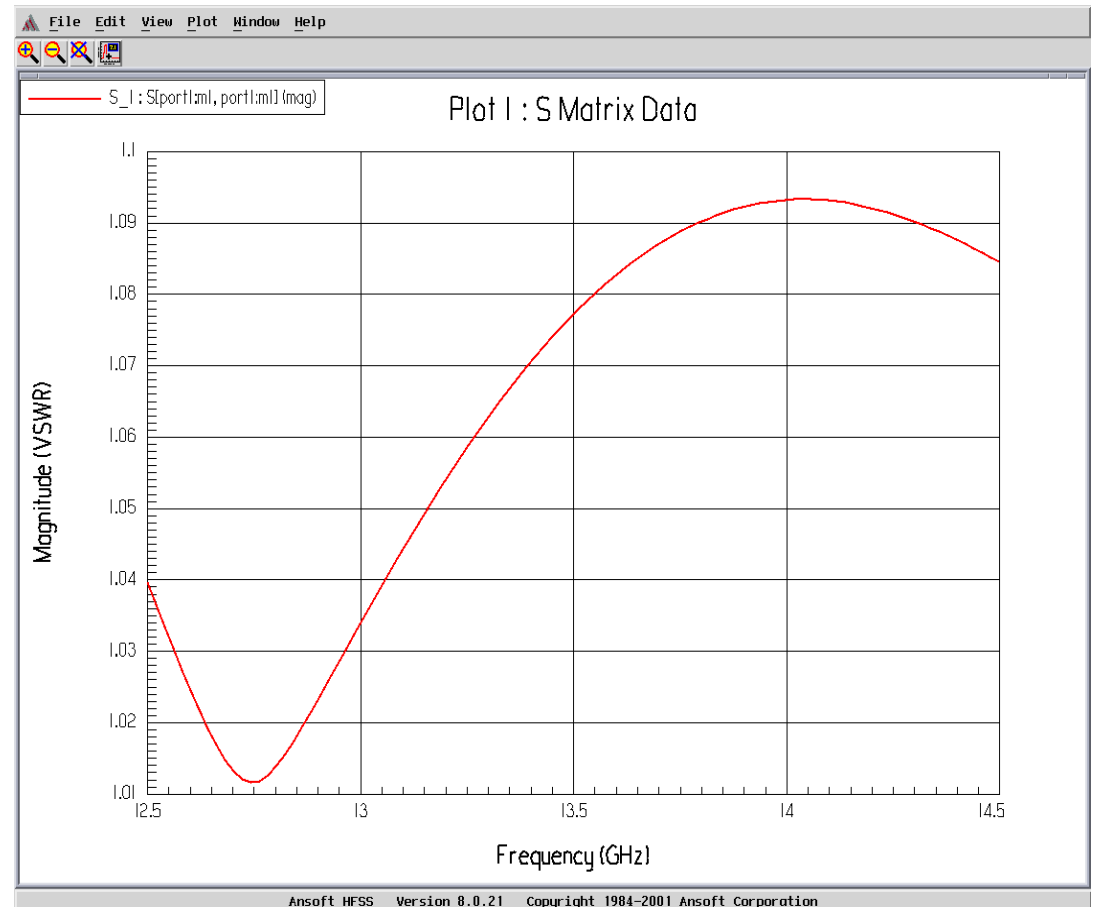
- GEOMETRY BASED ON EXISTING MDL CATALOG DESIGN
- VERIFY IN HFSS PERFORMANCE OF TEE IN CUSTOMER FREQUENCY RANGE
- DESIGN GOAL: VSWR LESS THAN 1.2:1 IN BOTH H-ARM AND E-ARM, ISOLATION BETWEEN H-ARM AND E-ARM -45 DB MIN





# HFSS DATA (VSWR) H-ARM

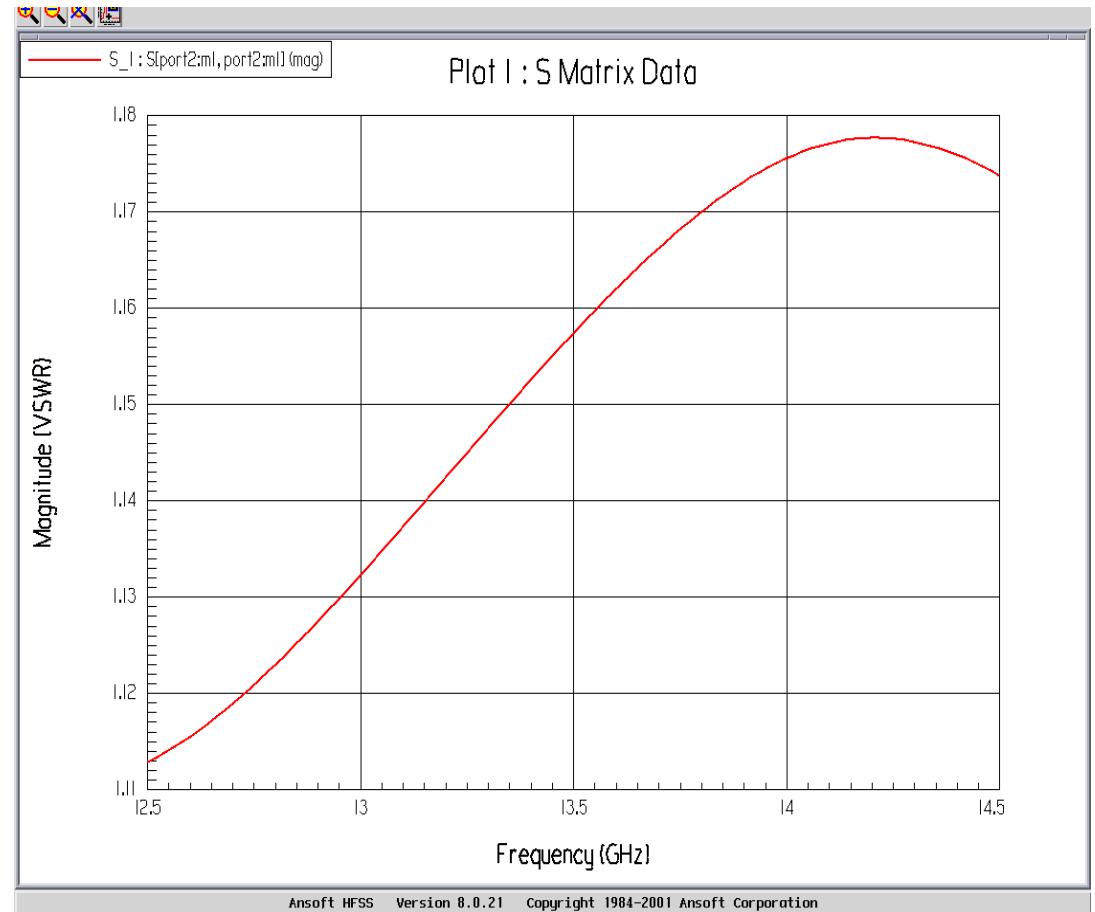
- VSWR LESS THAN 1.1:1 ACROSS CUSTOMER FREQUENCY RANGE
- NO OPTIMIZATION OR CHANGE IN GEOMETRY REQUIRED, TEE MEETS ELECTRICAL REQUIREMENTS





## HFSS DATA (VSWR) E-ARM

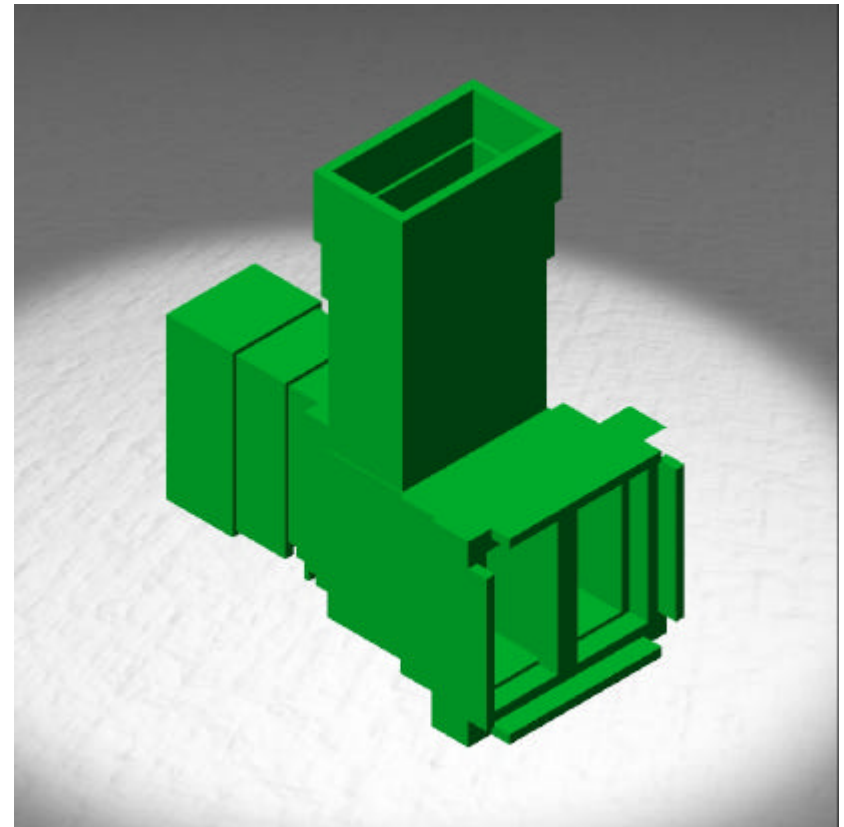
- VSWR LESS THAN 1.18:1 ACROSS CUSTOMER FREQ RANGE
- NO OPTIMIZATION OR CHANGE IN GEOMETRY REQUIRED, TEE MEETS ELECTRICAL REQUIREMENTS
- HFSS INFO: FAST FREQ SWEEP, MAX DELTA S= .004, 12300 TETRAHEDRA, APPROX 12 MINUTES RUN TIME





# WR-62 E-PLANE FOLDED TEE

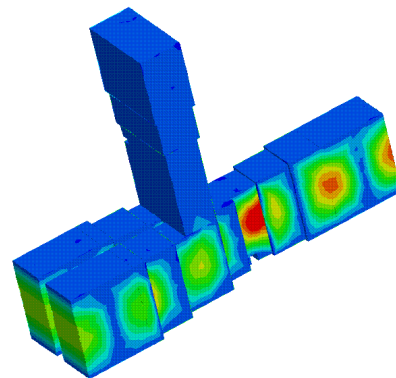
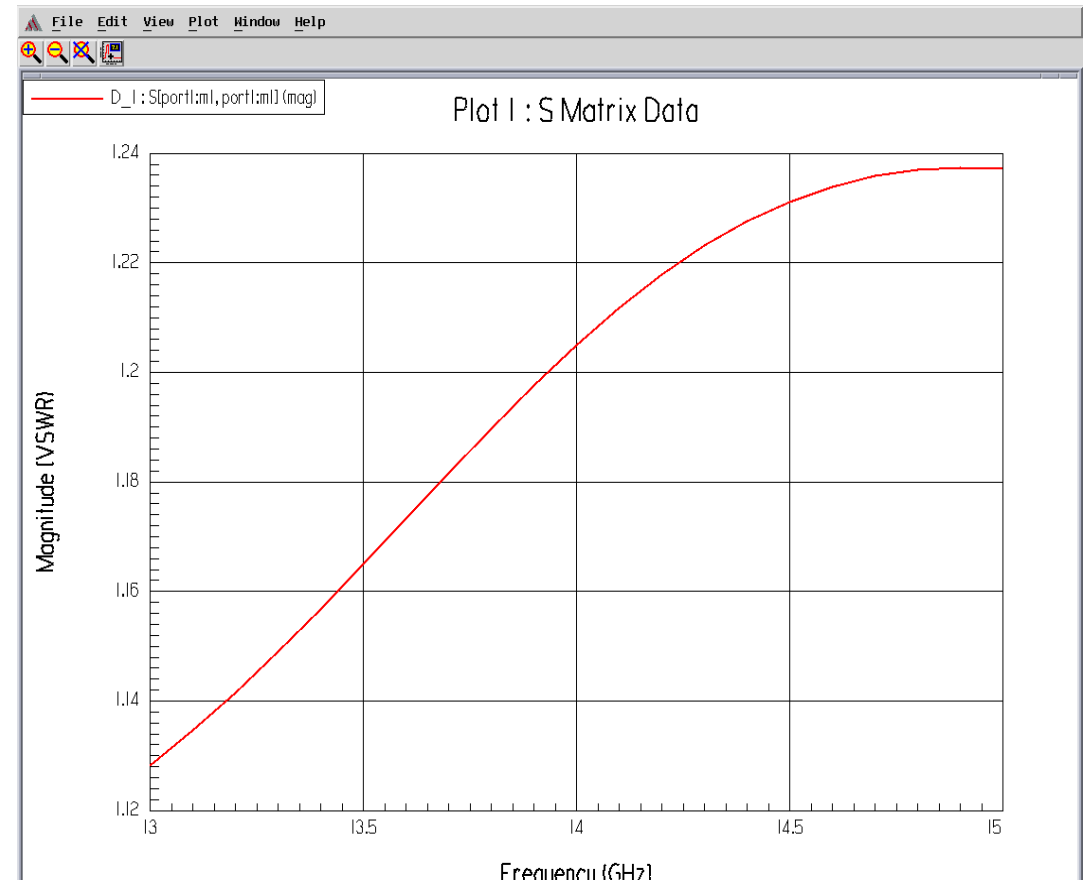
- GEOMETRY BASED ON EXISTING MDL CATALOG DESIGN (DIFFERENT FREQUENCY RANGE)
- VERIFY IN HFSS PERFORMANCE OF TEE IN CUSTOMER FREQUENCY RANGE
- DESIGN GOAL: VSWR LESS THAN 1.2:1 IN BOTH H-ARM AND E-ARM,





# HFSS DATA (VSWR) E-ARM

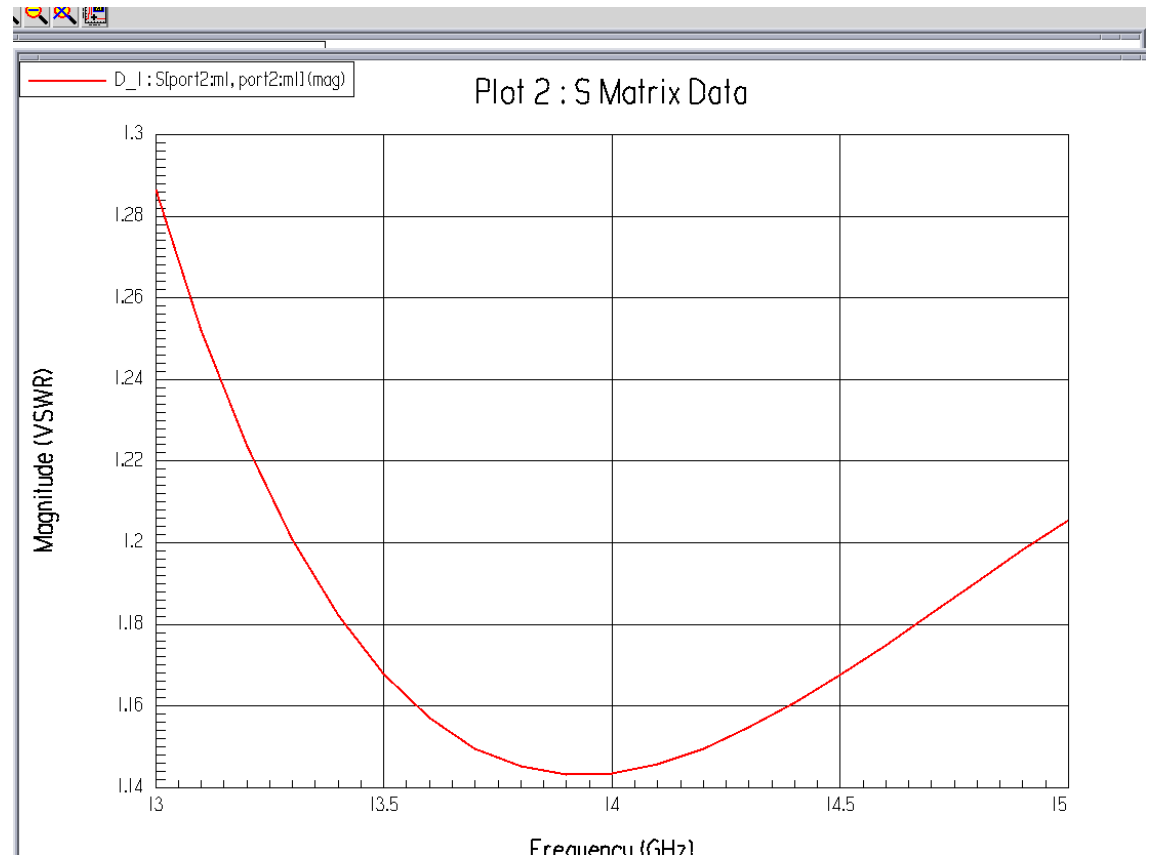
- VSWR GREATER THAN 1.22:1 ACROSS CUSTOMER FREQUENCY RANGE
- OPTIMIZATION AND CHANGE IN GEOMETRY REQUIRED, TEE DOES NOT MEET ELECTRICAL REQUIREMENTS





# HFSS DATA (VSWR) H-ARM

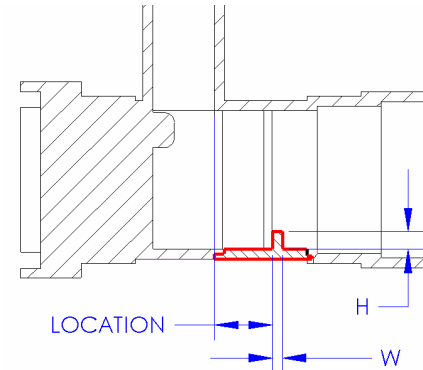
- VSWR GREATER THAN 1.28:1 AT LOW END OF CUSTOMER FREQ RANGE
- OPTIMIZATION AND CHANGE IN GEOMETRY REQUIRED, TEE DOES NOT MEET ELECTRICAL REQUIREMENTS
- HFSS INFO: FAST FREQ SWEEP, MAX DELTA S= .004, 12300 TETRAHEDRA, APPROX 12 MINUTES RUN TIME





# OPTIMIZATION PROCESS OF E-PLANE TEE

- USING SYMMETRY PLANE SOLVE IN HFSS
- ANALYZE SMITH CHART
- DE-EMBED E-ARM PORT & DETERMINE LOCATION OF NEW TUNING STRUCTURE
- SET UP OPTIMIZATION OF EXACT LOCATION AND SIZE OF NEW STRUCTURE



Executive Commands									
<input type="checkbox"/> Nominal Project ✓ <input type="checkbox"/> Setup Solution Options... ✓ <input type="checkbox"/> Setup Output Parameters ✓ <input type="checkbox"/> Edit Functions... ✓ <input type="checkbox"/> Setup Analysis ✓ <input type="checkbox"/> Add/Remove Output Columns... <input type="checkbox"/> Run ✓ <input type="checkbox"/> Post Process Table...  <input type="checkbox"/> Help ✓ <input type="checkbox"/> Exit									
Table	Model	Solutions	Convergence	Profile					
Setup	BASEX	BOXX	BOXY	Solved	Sensitivity Done	Save Fields	Solve	GOAL	
setup1	-0.49	0.02	0.02	Y	N	N	N	0.00058096	
setup2	-0.49	0.02	0.03	Y	N	N	N	0.00045538	
setup3	-0.49	0.02	0.04	Y	N	N	N	6.43469E-01	
setup4	-0.508	0.03	0.03	Y	N	N	N	0.00069634	
setup5	-0.503	0.03	0.03	Y	N	N	N	0.00079642	
setup6	-0.508	0.033	0.03	Y	N	N	N	4.99132E-01	
setup7	-0.508	0.03	0.033	Y	N	N	N	7.4332E-01	
setup8	-0.513	0.03	0.03	Y	N	N	N	0.00023123	
setup9	-0.508	0.027	0.03	Y	N	N	N	6.87784E-01	
setup10	-0.508	0.03	0.027	Y	N	N	N	0.00022251	
setup11	-0.513	0.0302782	0.0321848	Y	N	N	N	0.00027029	
setup12	-0.518	0.0305563	0.0343697	Y	N	N	N	0.00020571	
setup13	-0.503	0.033	0.03	Y	N	N	N	0.00070389	
setup14	-0.508	0.036	0.03	Y	N	N	N	0.00018832	
setup15	-0.508	0.033	0.033	Y	N	N	N	0.00014282	
setup16	-0.513	0.033	0.03	Y	N	N	N	0.00019321	
setup17	-0.508	0.033	0.027	Y	N	N	N	0.00026356	
setup18	-0.509601	0.0339709	0.0305908	Y	N	N	N	0.00013410	
setup19	-0.508541	0.0333283	0.0301998	Y	N	N	N	0.00018788	
setup20	-0.508	0.03	0.04	Y	N	N	N	0.00015900	
setup21	-0.518	0.03	0.03	Y	N	N	N	0.0001892	
setup22	-0.518	0.03	0.04	Y	N	N	N	9.1999E-01	

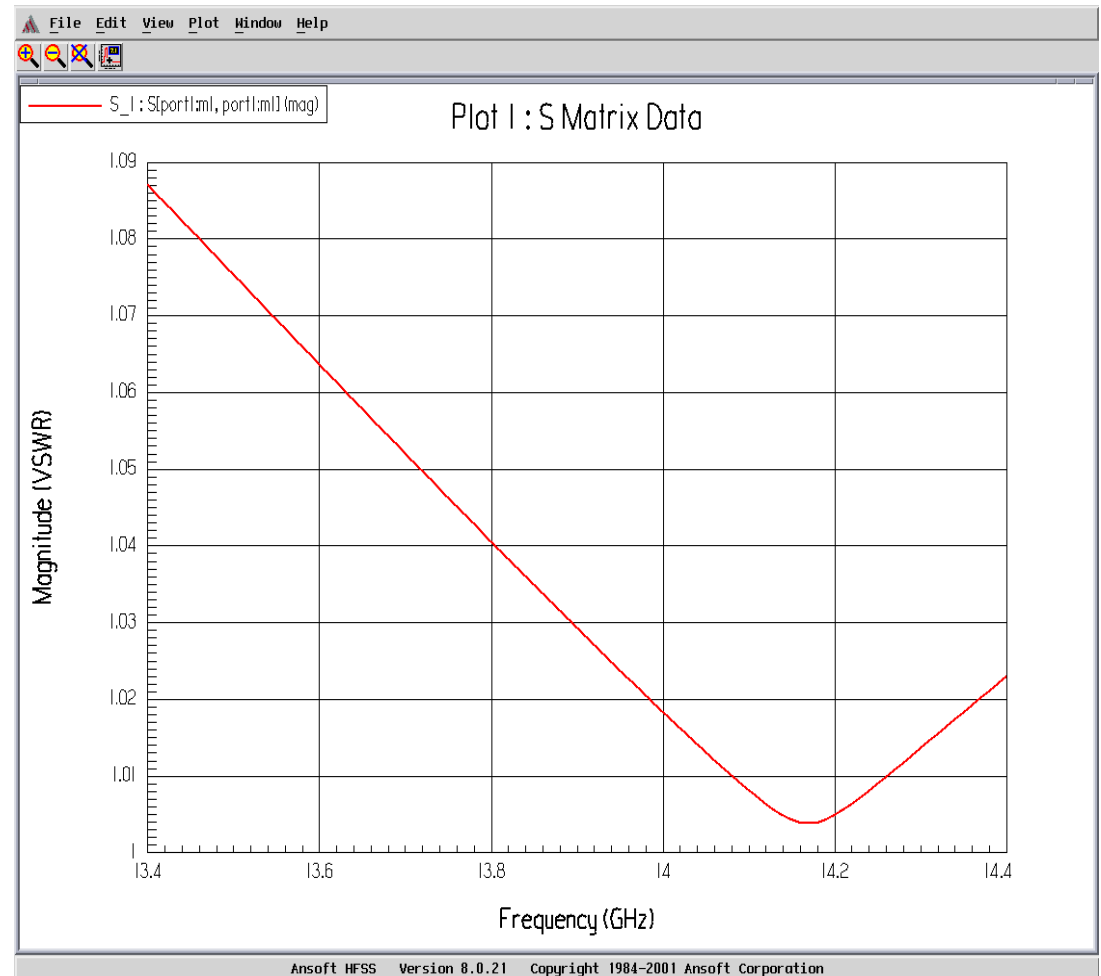
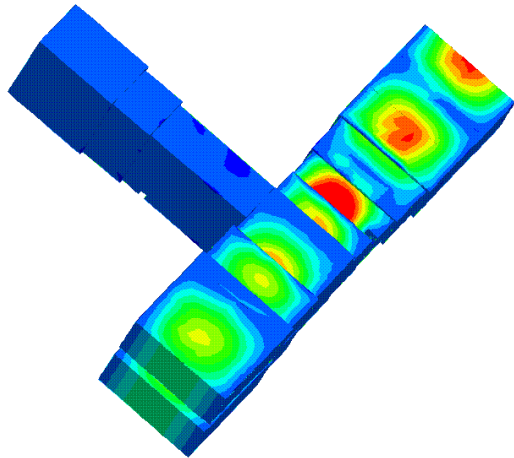
Solution Monitoring

optinetrics Version 2.0.21 Copyright 1984-2001 Ansoft Corporation



# OPTIMIZED DATA (VSWR) E-ARM

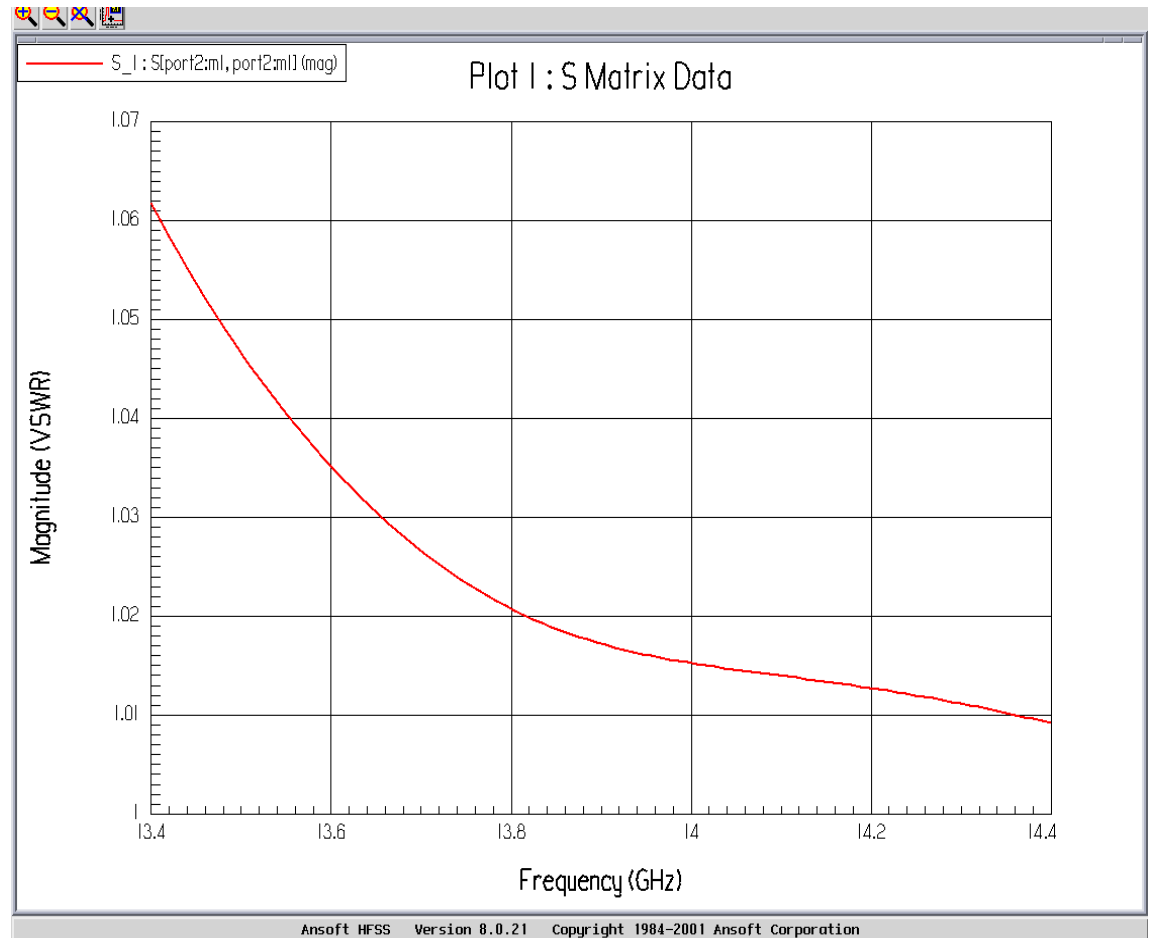
- VSWR LESS THAN 1.09:1 ACROSS CUSTOMER FREQUENCY RANGE
- E-ARM NOW MEETS DESIGN GOAL





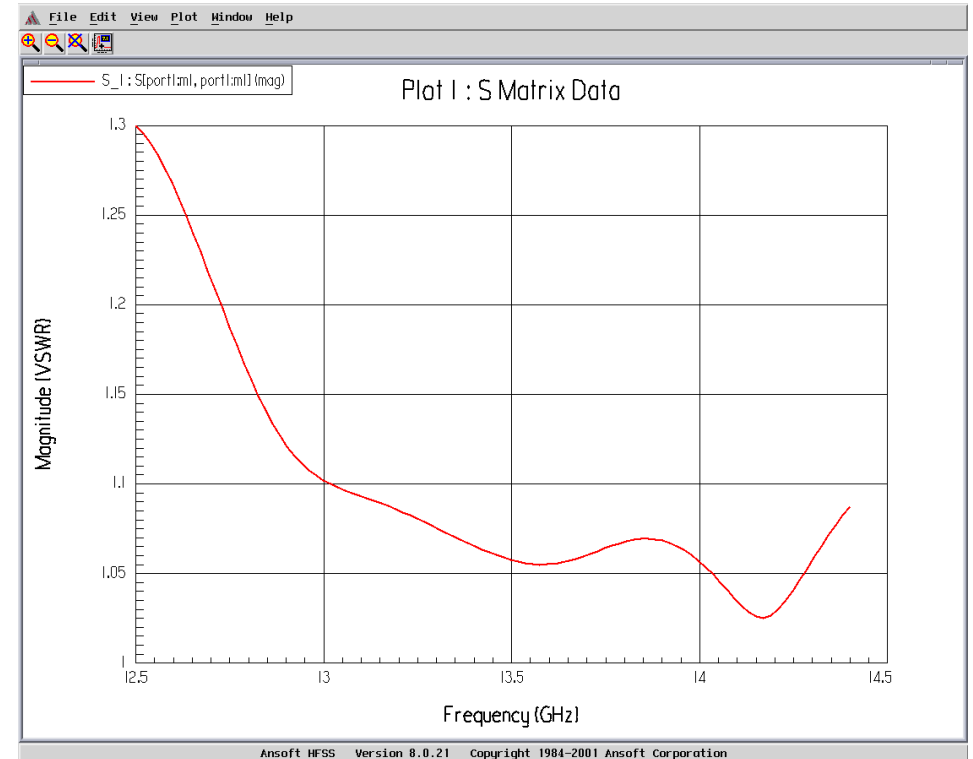
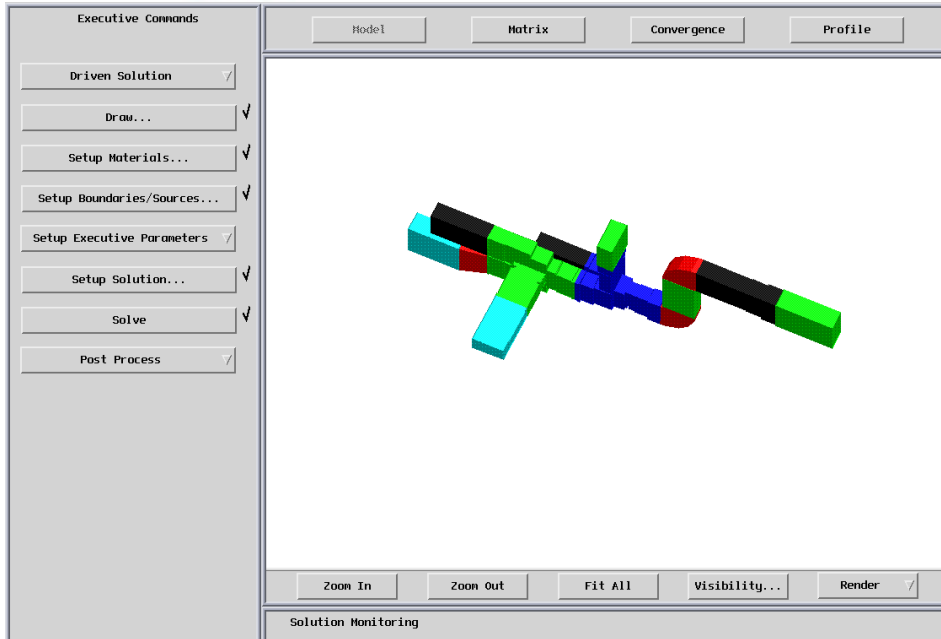
## HFSS DATA (VSWR) H-ARM

- VSWR LESS THAN 1.07:1 ACROSS CUSTOMER FREQ RANGE
- OPTIMIZATION COMPLETE TEE NOW MEETS ELECTRICAL REQUIREMENTS
- HFSS OPTIMIZER INFO: SYMMETRY PLANE, FAST FREQ SWEEP, MAX DELTA S= .005, 7550 TETRAHEDRA, APPROX 13 MINUTES RUN TIME





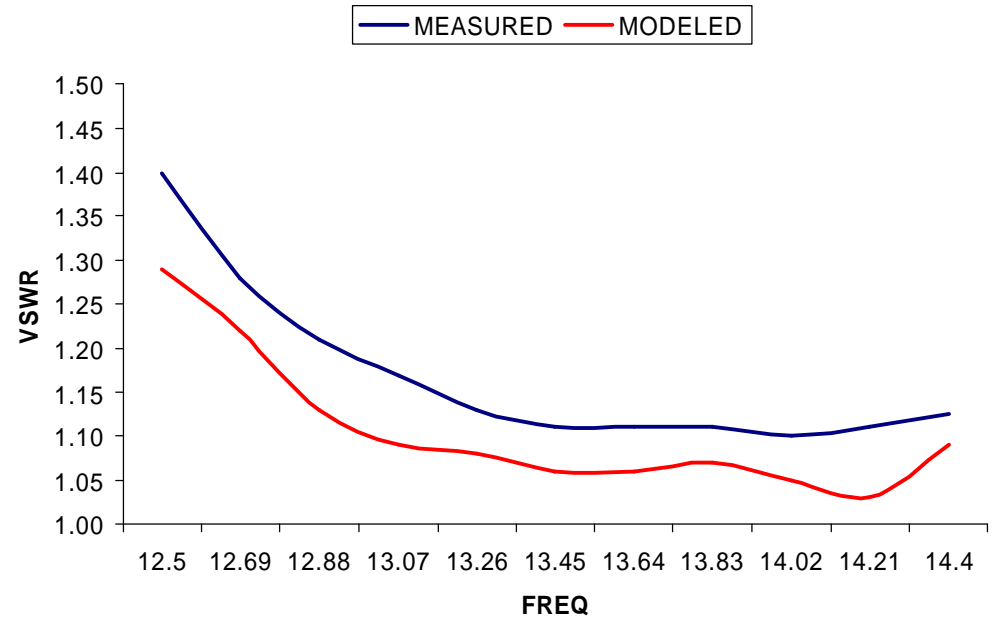
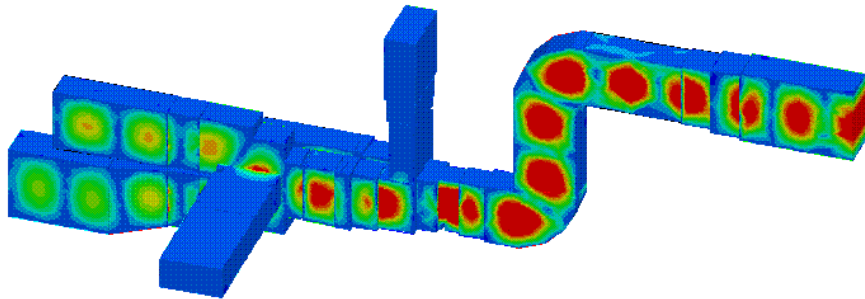
# HFSS DATA SUM PATH VSWR



- SUM PATH MODELED TO OPTIMIZE CALCULATION TIME
- VSWR LESS THAN 1.3:1 ACROSS CUSTOMER FREQ RANGE
- RESULTS MORE THAN EXCEED CUSTOMER REQUIREMENTS



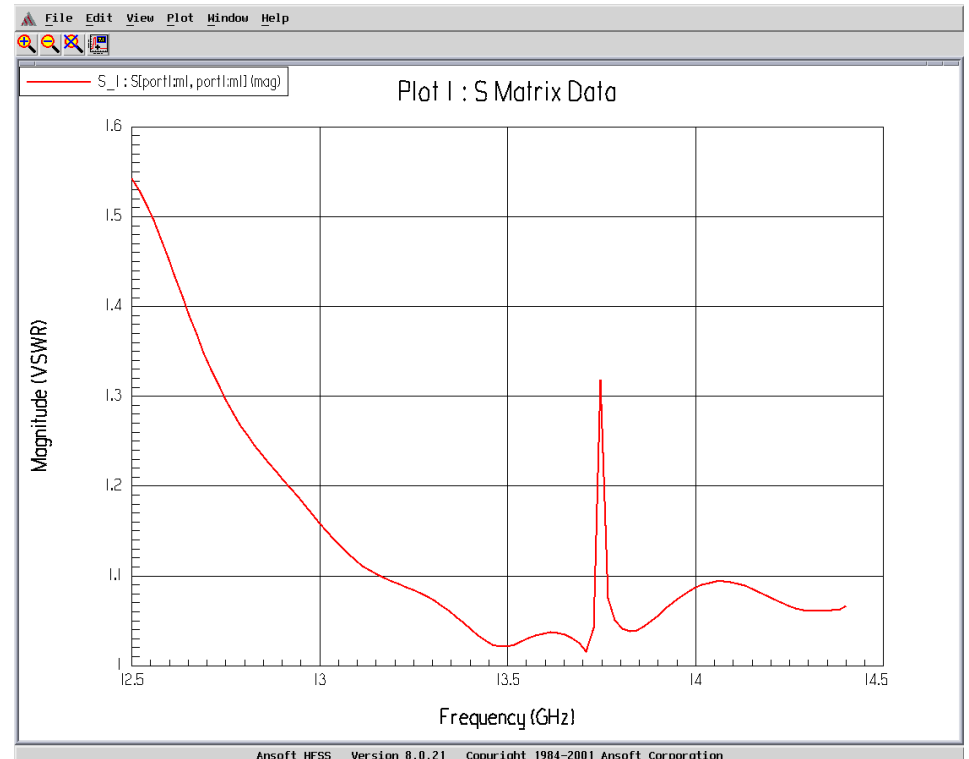
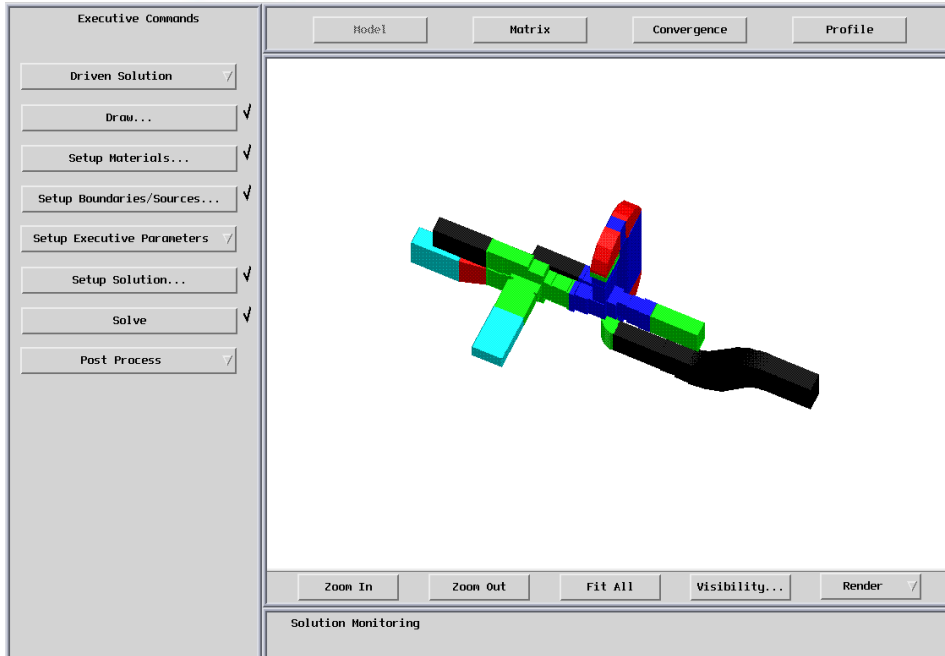
# SUM PATH MEASURED VS MODELED DATA



- DIFFERENCE IN DATA DUE TO MANUFACTURING IMPERFECTIONS (BRAZE JOINTS) AND TERMINATION IMPERFECTIONS ON MEASURED UNIT
- HFSS INFO: FAST FREQ SWEEP, MAX DELTA S= .005, 28401 TETRAHEDRA, APPROX 1 HOUR-46 MINUTES RUN TIME



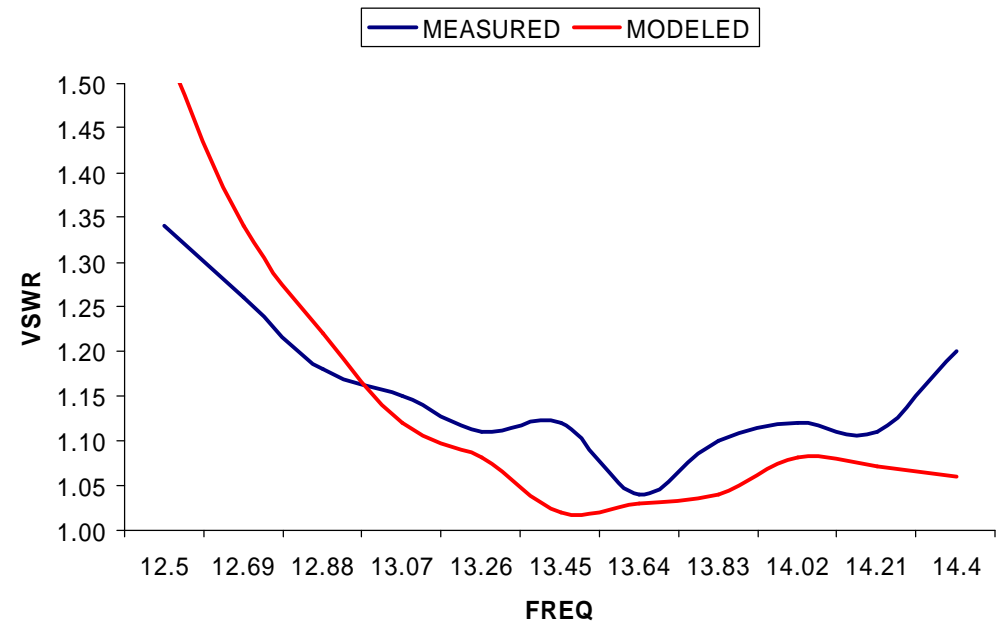
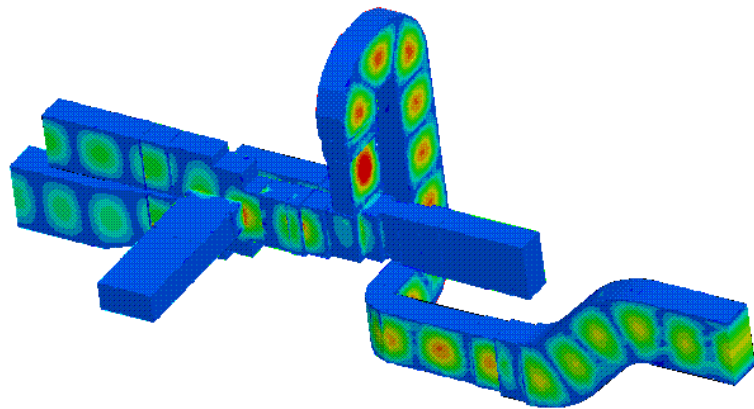
# HFSS DATA DIFF-1 PATH VSWR



- DIFF-1 PATH MODELED TO OPTIMIZE CALCULATION TIME
- VSWR LESS THAN 1.6:1 ACROSS CUSTOMER FREQ RANGE
- RESULTS MEET CUSTOMER REQUIREMENTS AT LOW END OF FREQ BAND
- RESULTS EXCEED CUSTOMER REQUIREMENTS AT HIGH END OF BAND



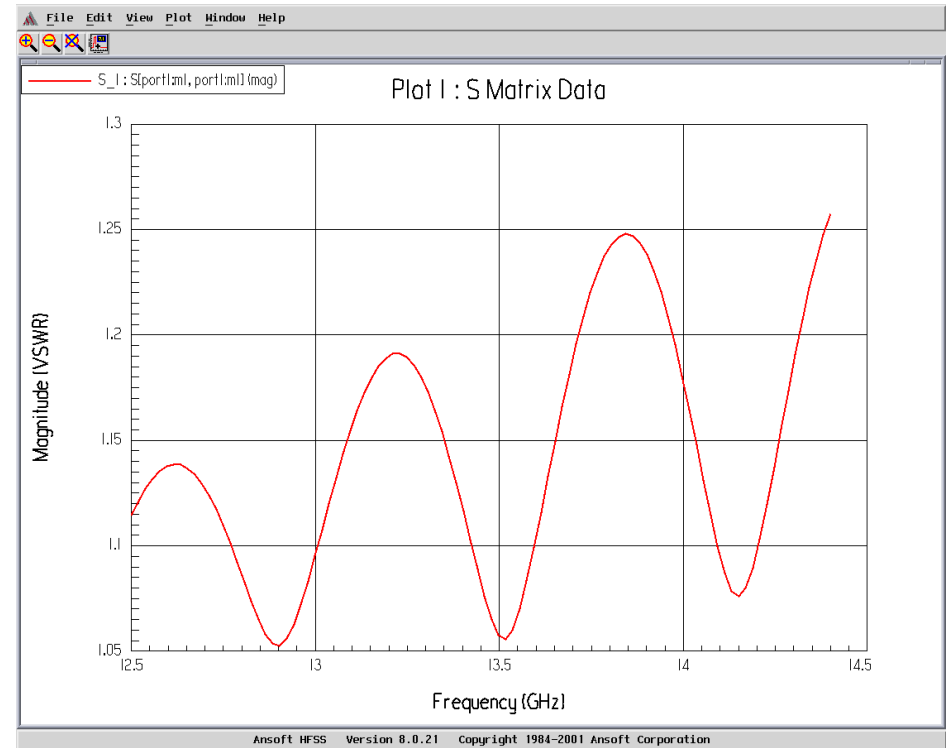
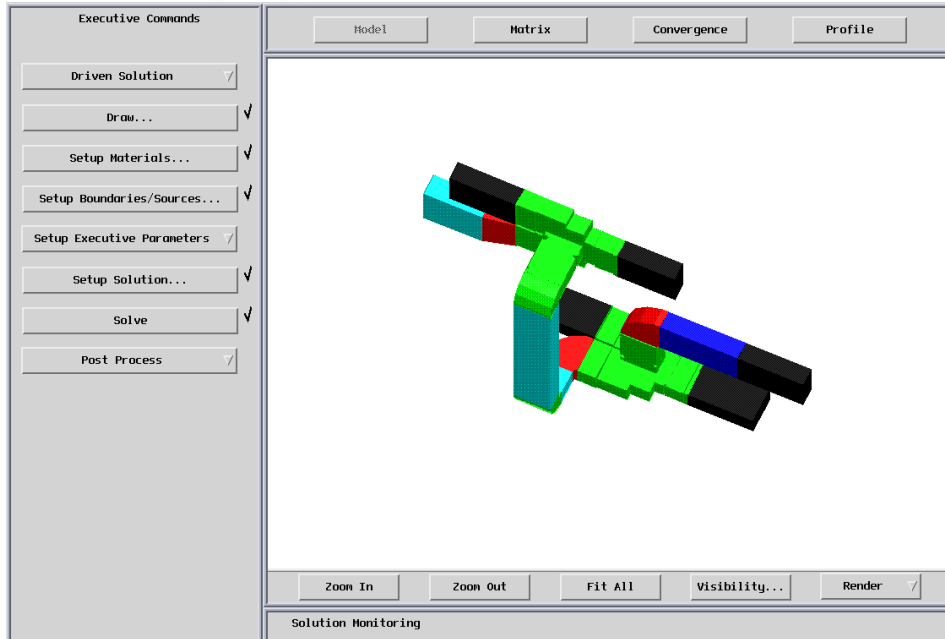
# DIFF-1 PATH MEASURED VS MODELED DATA



- DIFFERENCE IN DATA DUE TO MANUFACTURING IMPERFECTIONS (BRAZE JOINTS) AND TERMINATION IMPERFECTIONS ON MEASURED UNIT
- HFSS INFO: FAST FREQ SWEEP, MAX DELTA S= .005, 43054 TETRAHEDRA, APPROX 5 HOURS-9 MINUTES RUN TIME



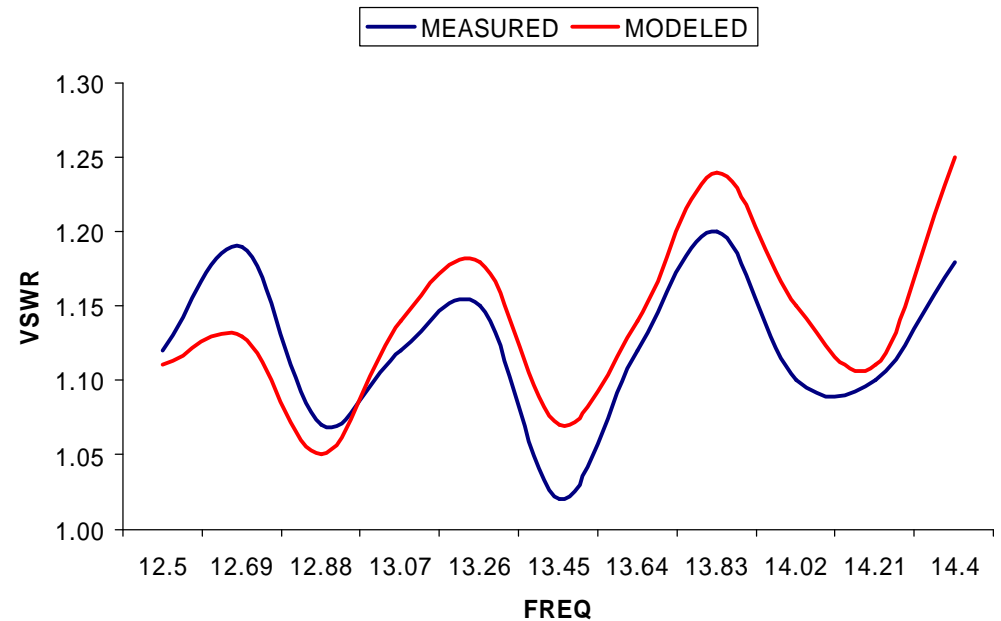
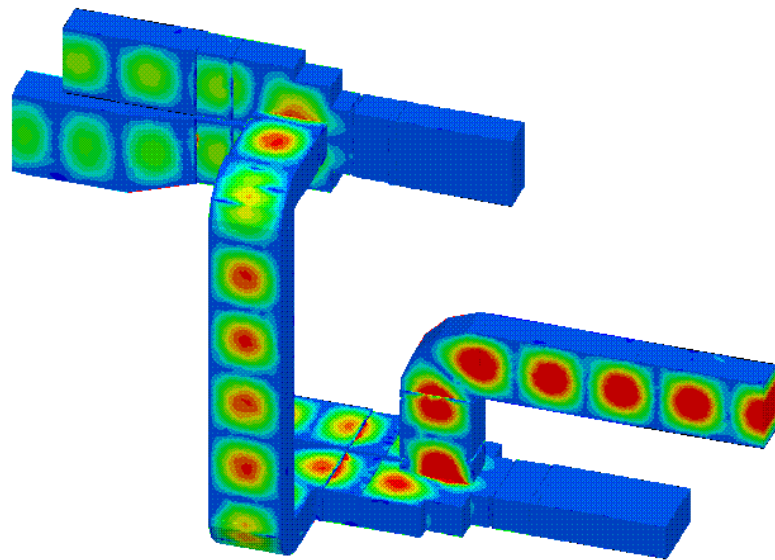
# HFSS DATA DIFF-2 PATH VSWR



- DIFF-2 PATH MODELED TO OPTIMIZE CALCULATION TIME
- VSWR LESS THAN 1.26:1 ACROSS CUSTOMER FREQ RANGE
- RESULTS EXCEED CUSTOMER REQUIREMENTS ACROSS FREQ BAND



# DIFF-2 PATH MEASURED VS MODELED DATA

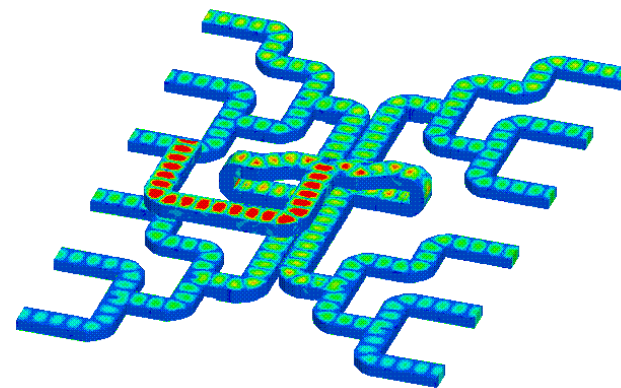
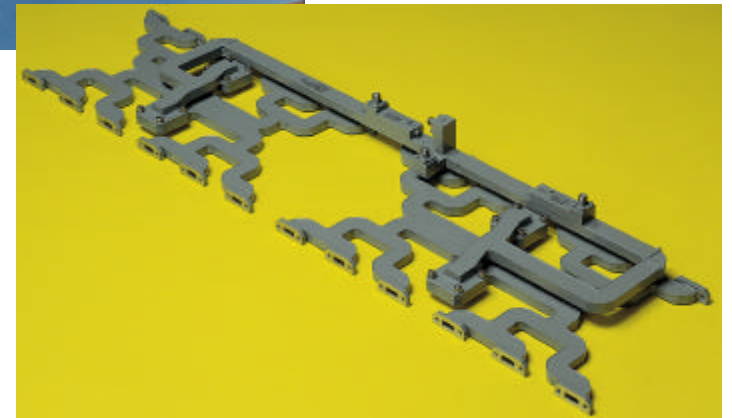
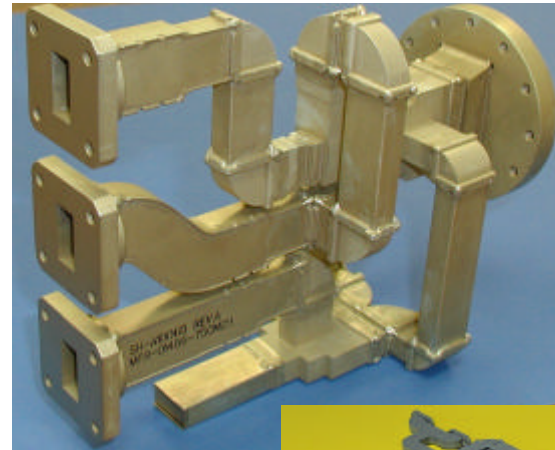


- DIFFERENCE IN DATA DUE TO MANUFACTURING IMPERFECTIONS (BRAZE JOINTS) AND TERMINATION IMPERFECTIONS ON MEASURED UNIT
- HFSS INFO: FAST FREQ SWEEP, MAX DELTA S= .005, 42236 TETRAHEDRA, APPROX 3 HOURS-38 MINUTES RUN TIME



# CONCLUSIONS

- OPTIMIZED COMPONENTS WILL PRODUCE AN ASSEMBLY THAT MEETS DESIGN REQUIREMENTS
- ELIMINATES THE NEED FOR “TUNING” THE COMPARATOR AFTER MANUFACTURING
- DESIGN TIME OF WAVEGUIDE COMPONENT ASSEMBLIES (COMPARATORS) HAVE EVOLVED FROM TAKING WEEKS OF DESIGN TIME TO ONLY DAYS
- UNLIKE PAST DESIGNS ON HFSS (PLANAR POWER DIVIDER) THIS COMPARATOR IS TRULY 3-D (FIELDS) AND IS A STRINGENT TEST FOR HFSS





**MICROWAVE DEVELOPMENT LABORATORIES**  
**135 CRESCENT RD, NEEDHAM HEIGHTS, MA 02494**

**TEL: 781-292-6680/6684 FAX: 781-453-8629**

**E-MAIL: [mdlsales@mdllab.com](mailto:mdlsales@mdllab.com)**

**[www.mdllab.com](http://www.mdllab.com)**