סימולציות של אנטנות

מגוון רחב של תוכנות מדף לביצוע סימולציות אנטנות

מוצרים מובילים עם תמיכה טובה :

CST ,HFSS, Zeland

סימולציות של אנטנות

[1]	**ANSOFT HFSS**	www.ansoft.com
[2]	**CST Microwave Studio**	www.cst.com
[3]	**Zeland Software**	www.zeland.com
[4]	**SuperNEC**	www.supernec.com
[5]	**Ticra**	www.ticra.com
[6]	**FEKO**	www.feko.com
[7]	**FEMLAB**	www.comsol.com
[8]	**Remcom**	www.remcom.com
[9]	**WIPL-D Software**	tsarkar@syr.edu

סימולציות של אנטנות

<u>שיטות עיקריות</u>

פתרון על ידי סריג נקודות במרחב הממשי:

1) אלמנטים סופיים FE - מתאימה במיוחד לבעיות צרות פס

2) הפרשים סופיים FDTD - מתאימה לבעיות רחבות פס

פתרון על ידי סריג פונקציות במרחב פורייה:

3) שיטות מומנטים MOM – מסוגלות לתת את הפתרון המדויק ביותר (קרוב לאנליטי) אם בוחרים פונקציות מבחן נכונות

סימולציות של אנטנות

<u>עד כמה הפתרון מדויק ?</u>

צריך להשקיע כמה חודשי עבודה עד ששולטים ברזי התוכנה

יש די הרבה KNOW HOW אינטימי שדורש התנסות רבה

צריך מחשבים חזקים במיוחד

הדיוק תלוי במספר המשתנים (מספר נקודות הסריג)

מבחינת המשתמש – אין חשיבות רבה מדי לסוג השיטה

סימולציות של אנטנות

<u>עד כמה הפתרון מדויק ?</u>

בהנחה שמשתמשים במחשבים חזקים במיוחד...

ובהנחה שיש מספיק סבלנות לבנות סריג צפוף...

ניתן לצפות לדיוק של 1% בתדר הרזוננס,

ולדיוק של 1 dB -/+ בשבח (ובעקומות הקרינה של אנטנות קטנות).

סימולציות של אנטנות

<u>עד כמה הפתרון מדויק ?</u>

הדיוק במקדם ההחזרה וברמת אונות הצד של אנטנות גדולות אינו גבוה במיוחד.

נוכחות מתכות קרובות לאנטנה במרחק קטן מ-$\lambda/4$ אינן באות לידי ביטוי מדויק.

גלי שטח אינם זוכים לטיפול מדויק (בייחוד לא אם הם קורנים ומשפיעים על אונות הצד).

סימולציות של אנטנות

<u>עד כמה הפתרון מדויק ?</u>

כאשר מדובר במבנה מרחבי מורכב במיוחד, או בנוכחות רקמות חיות (לחישובי SAR) הדיוק עוד נמוך יותר.

פרופ' STUCHLY ממובילות הדעה בנושא סימולציות של אנטנות בנוכחות גוף האדם טוענת כי:
FDTD – פופולרית, פשוטה, דורשת משאבי חישוב רבים
FEM - מעשית אך המודלים של הגוף לא מספיק טובים
MOM - מעשית אך המודלים של הגוף לא מספיק טובים
ולכן ממליצה לשלב שיטות חישוב שונות

סימולציות של אנטנות

<u>עד כמה הפתרון מדויק ?</u>

Ooi ממוטורולה מדווח על דיוקי SAR של 10% בHFSS

הרוב המכריע של יצרני הטלפונים הסלולריים מסתמכים על מדידות ולא על סימולציות.

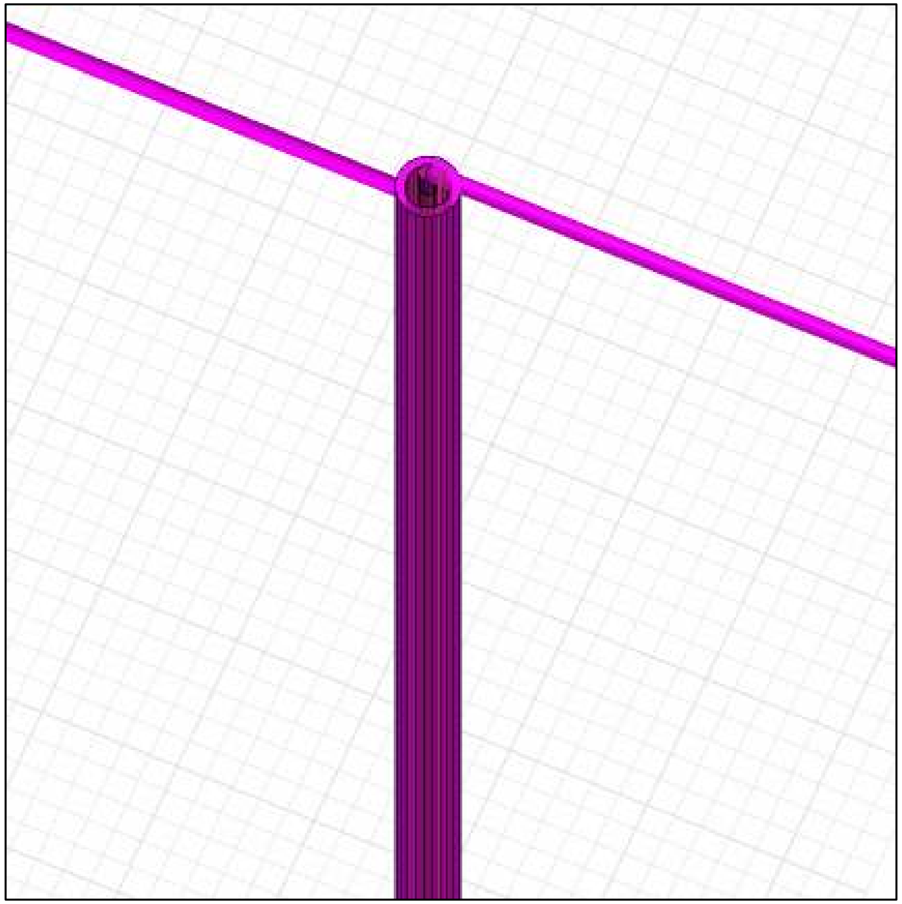
סימולציות של אנטנות

<u>אז בשביל מה זה טוב ?</u>

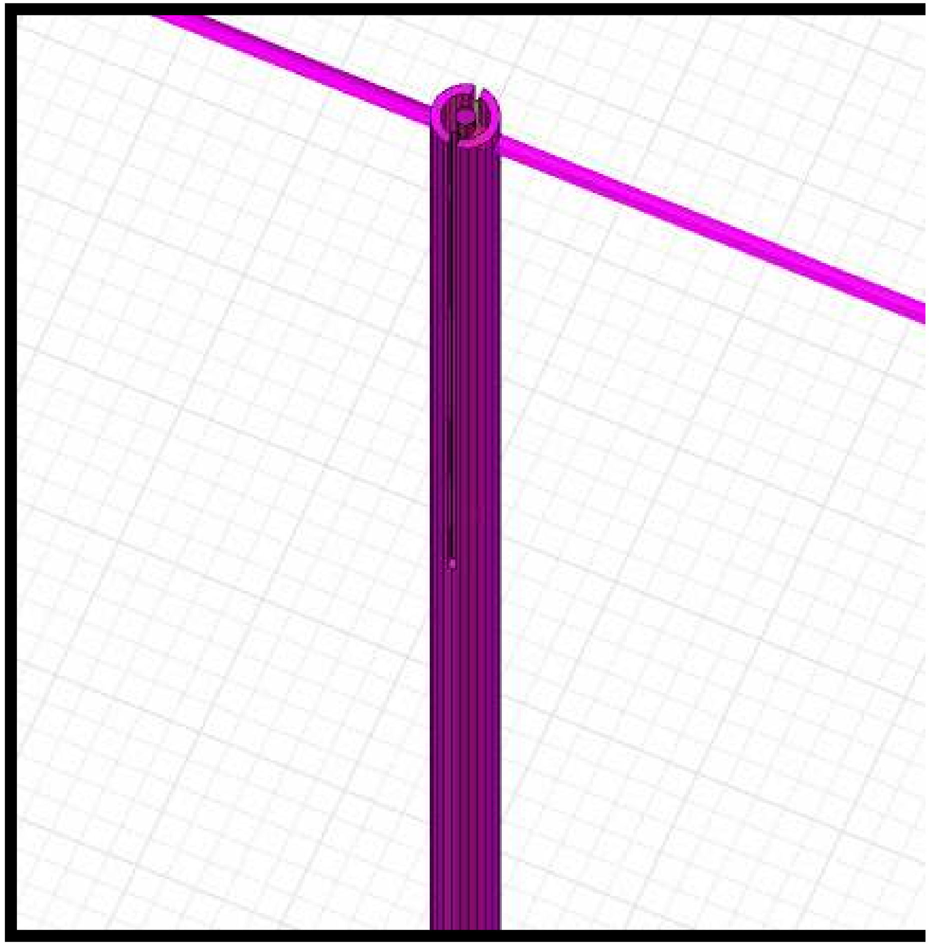
- **צריך לעבוד צעד-צעד עם בניית דגמים ומדידתם**
- **הסימולציות נותנות מענה מצוין לבדיקות היתכנות מהירות**
- **הסימולציות נותנות מענה מצוין אם יש משתנים רבים**
- **הסימולציות נותנות מענה מצוין להשוואה בין פתרונות**

Examples of ANSOFT library

Dipole (unbalanced)

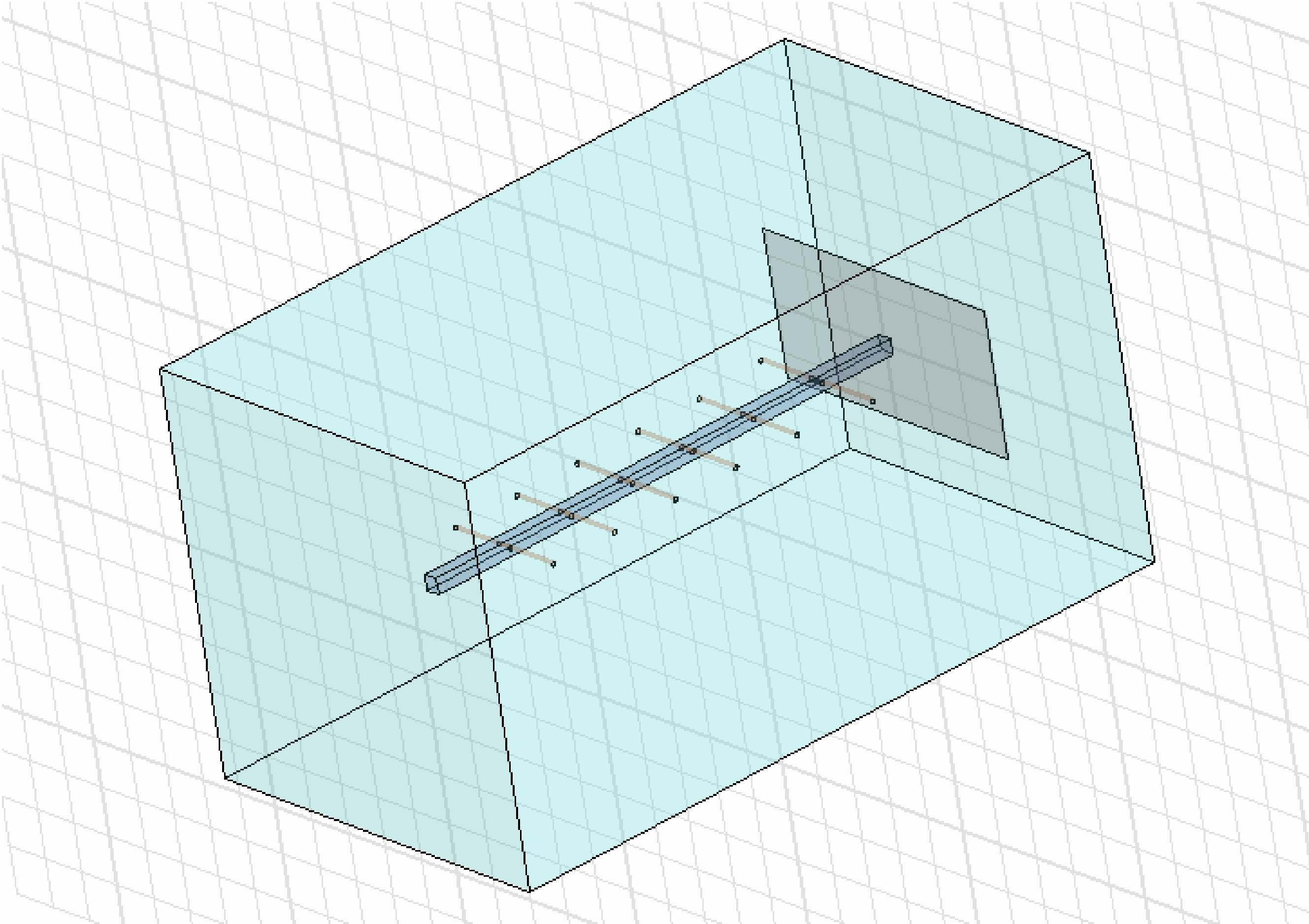


Dipole (balanced –split coax balun)



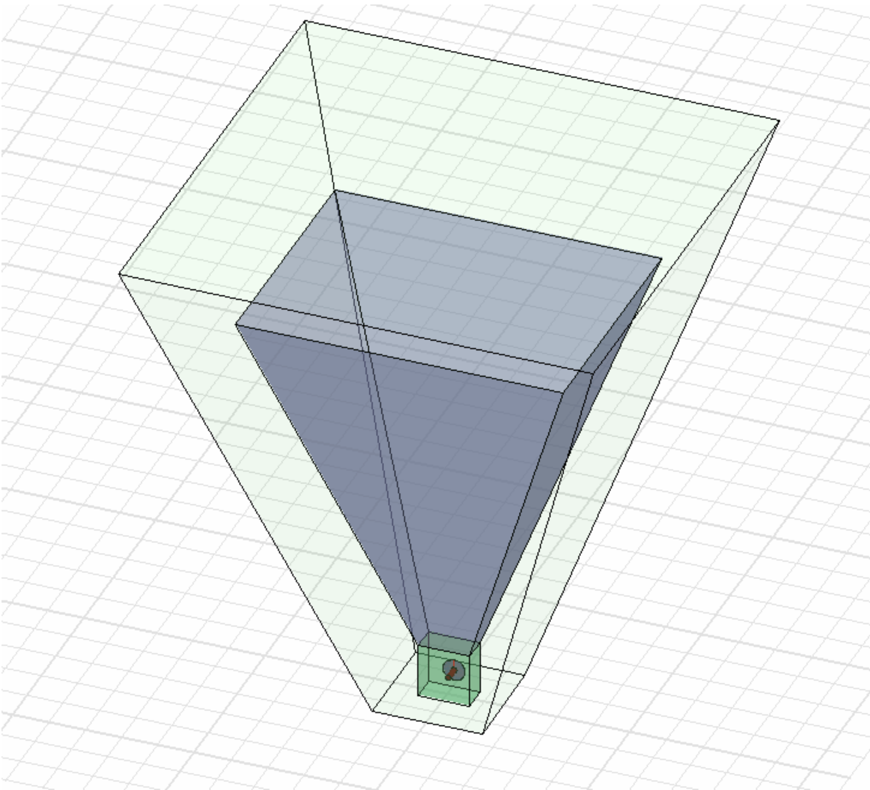
Examples of ANSOFT library

UHF Yagi antenna

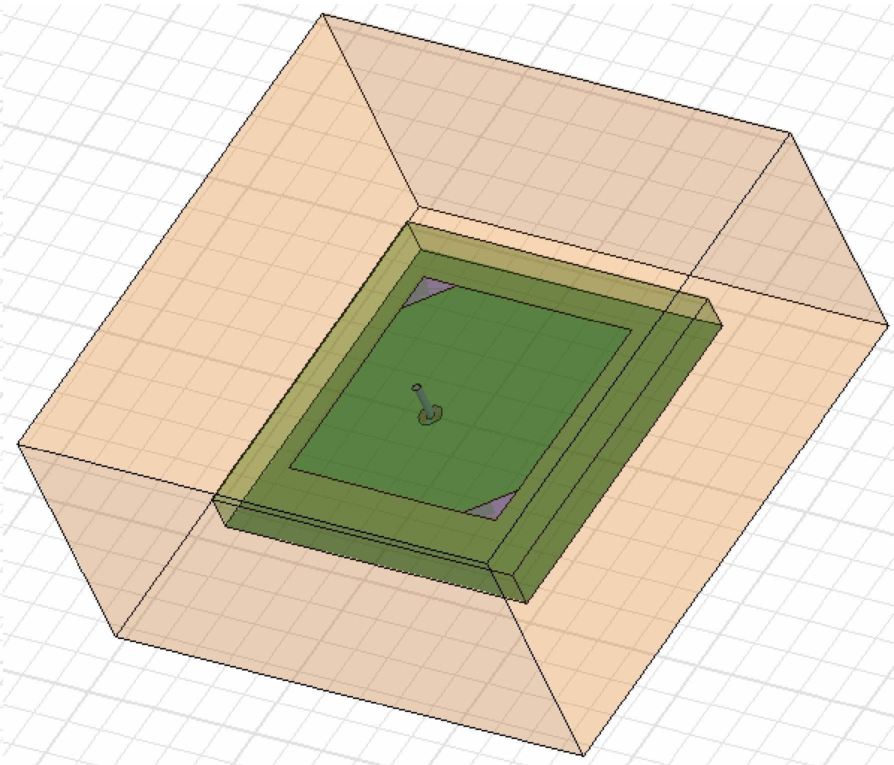


Examples of ANSOFT library

Horn (Ka band)

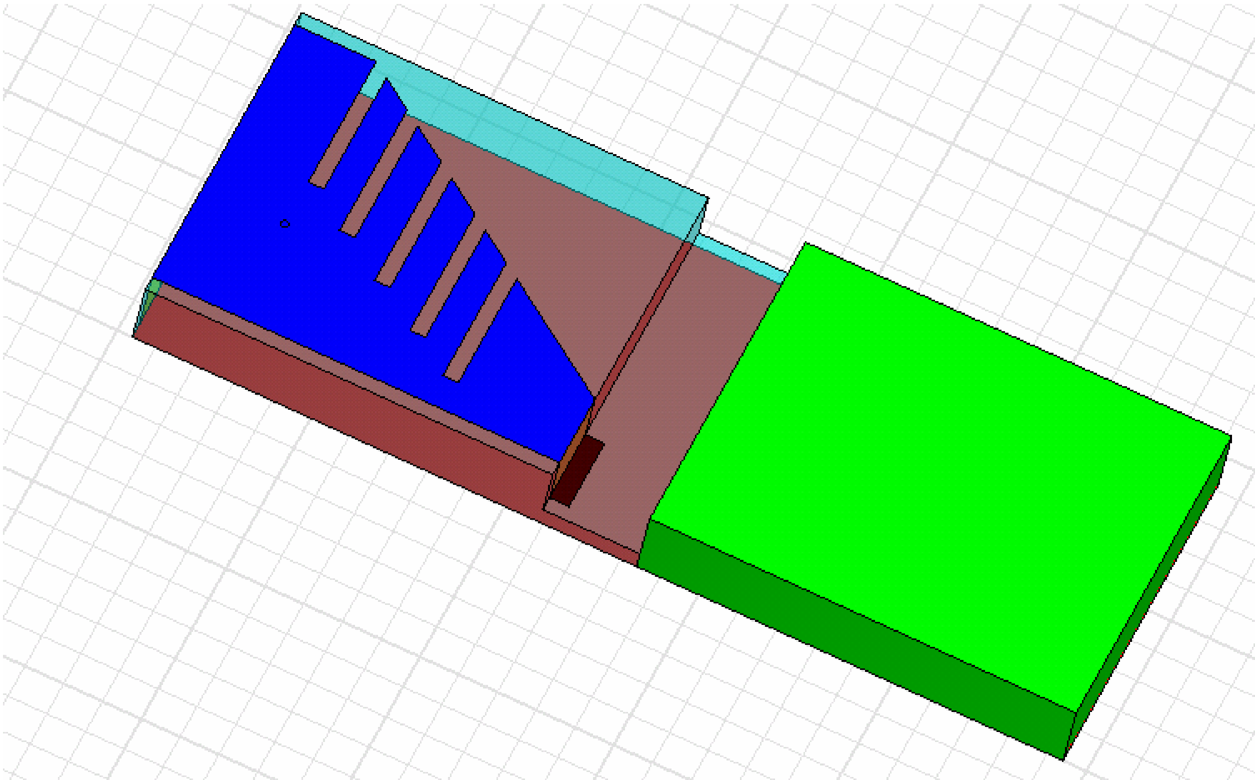


Patch antenna (2.4 GHz)



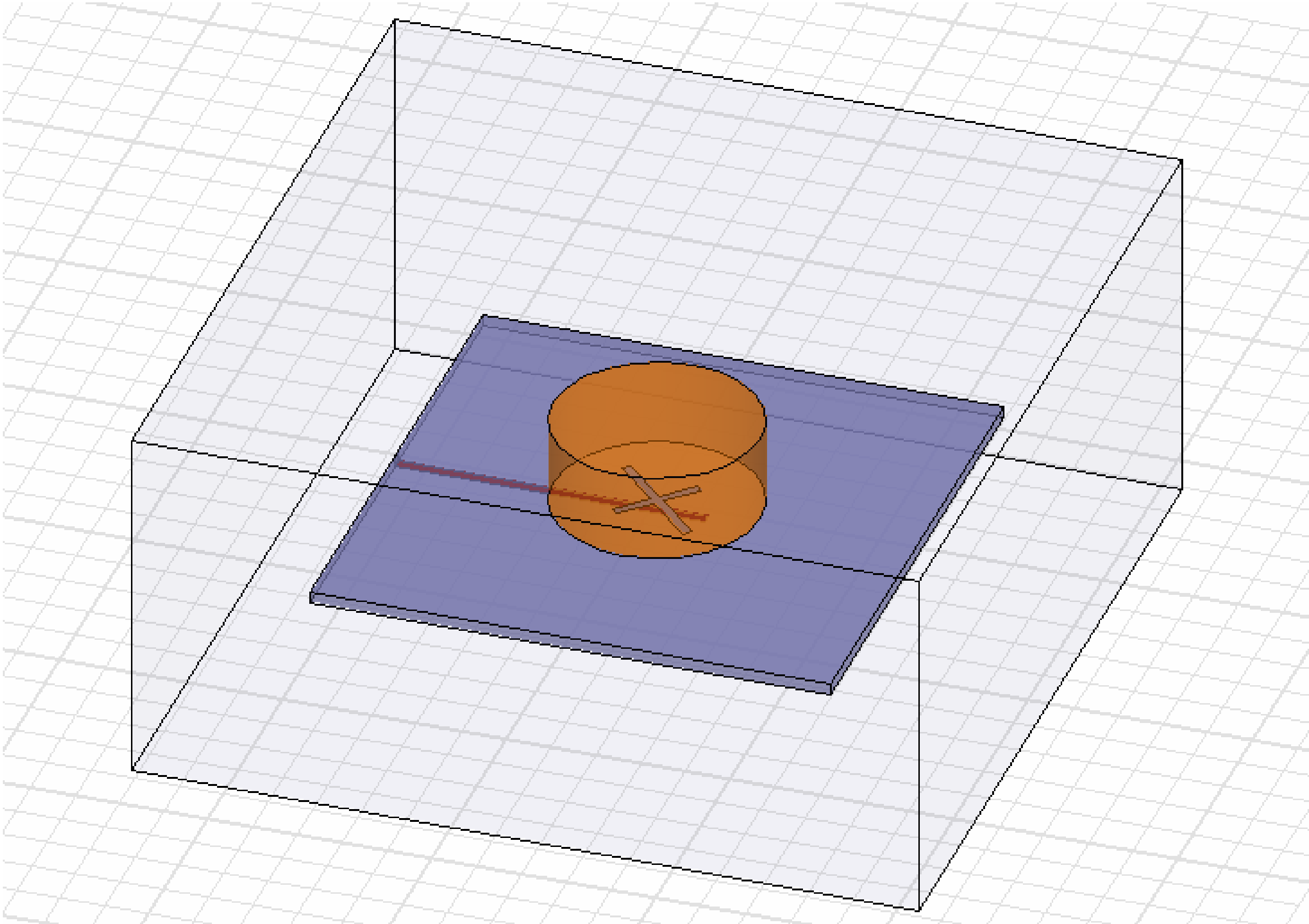
Examples of ANSOFT library

UHF PIFA with the circuit enclosure



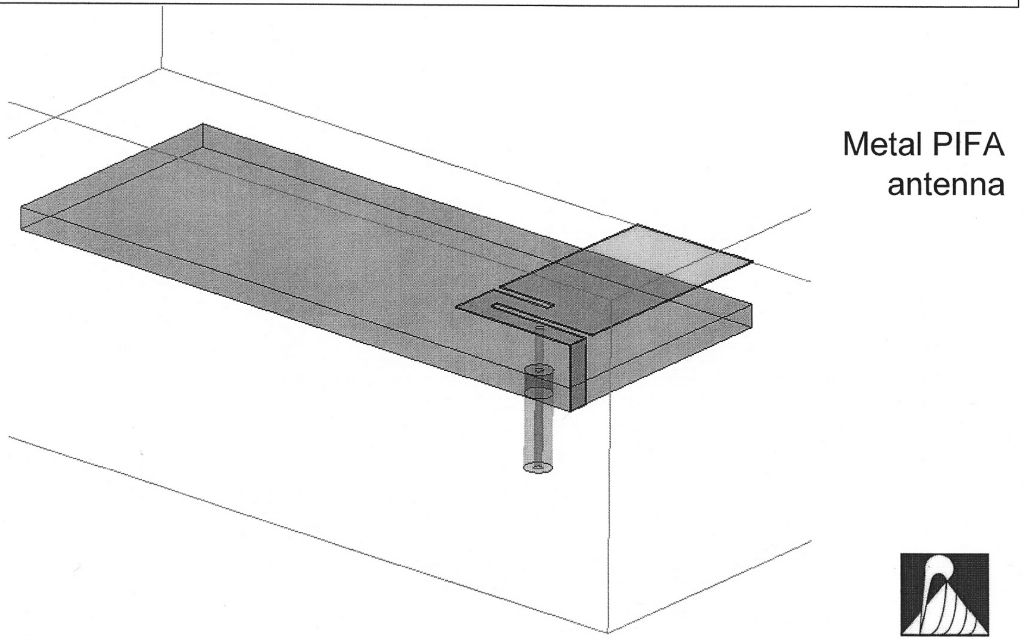
Examples of ANSOFT library

Ka band dielectric resonator antenna



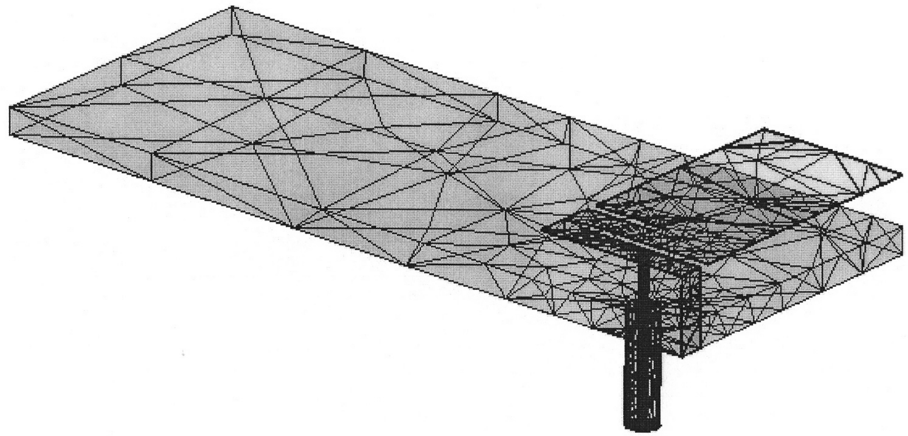
Examples of ANSOFT simulations

Automatic, Adaptive Meshing (I)



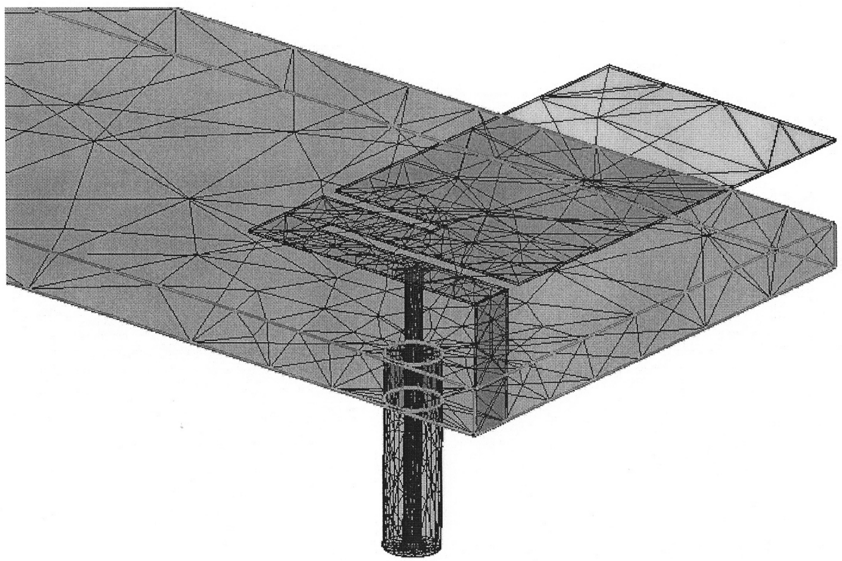
Examples of ANSOFT simulations

Automatic, Adaptive Meshing (II)

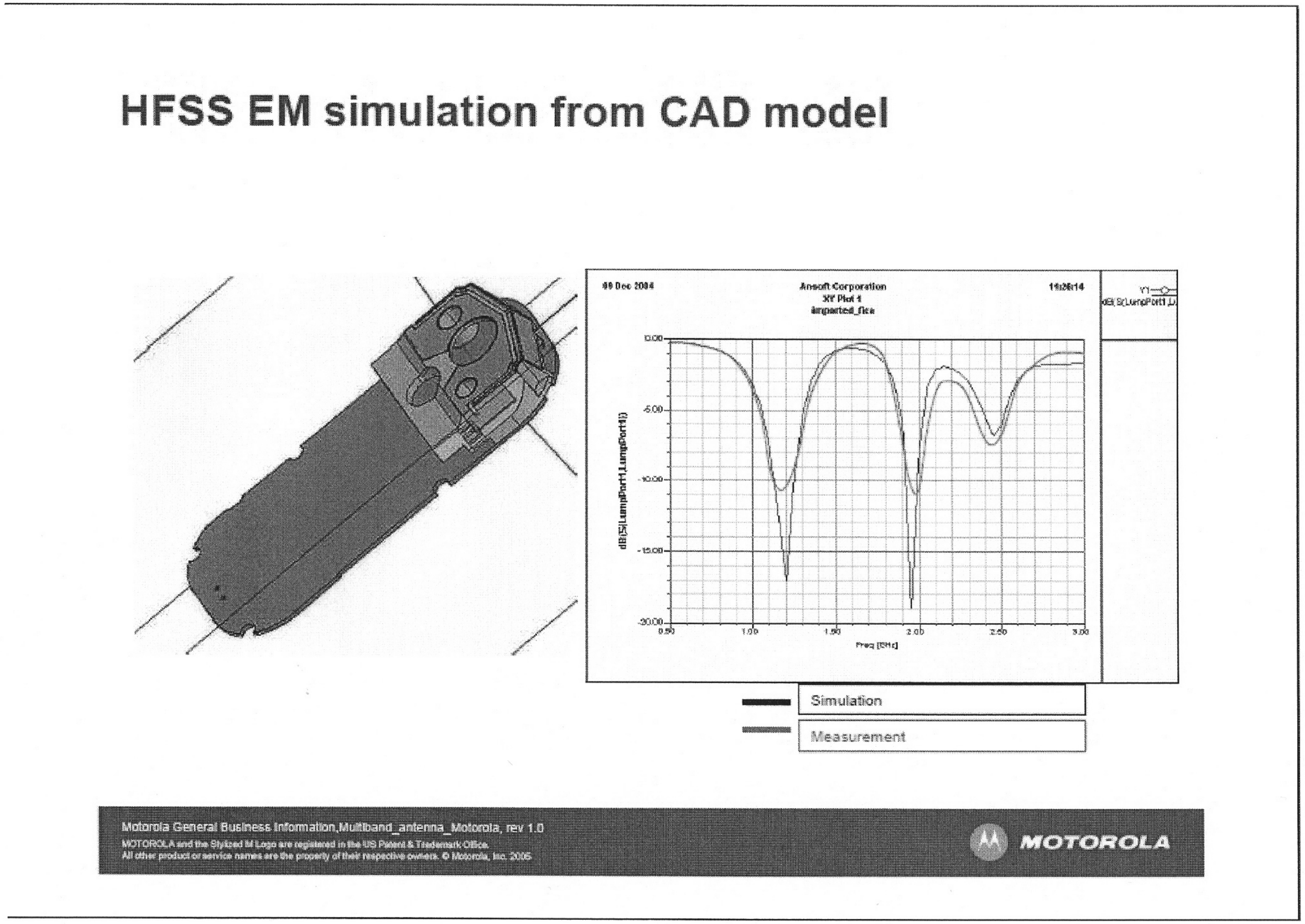


Examples of ANSOFT simulations

Automatic, Adaptive Meshing (III)

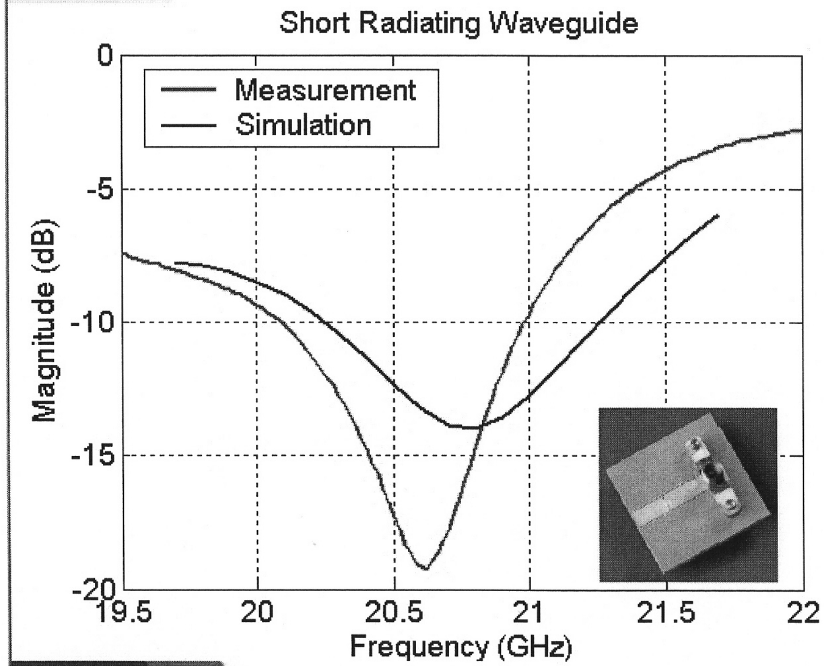


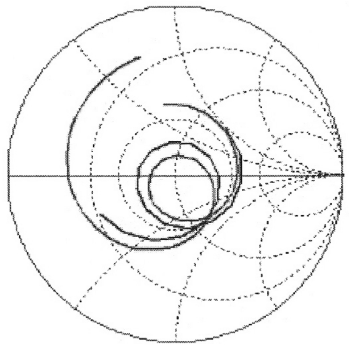
Examples of ANSOFT simulations



Examples of ANSOFT simulations

Results – The Short Radiating Waveguide : Input Impedance





Bandwidth

Simulation : 20.25-21.25 GHz

Measurement : 20.1-21.0 GHz

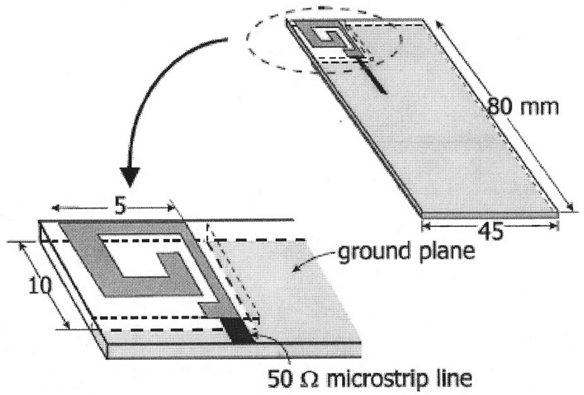
Defence R&D Canada - Ottawa R et D pour la défense, Canada - Ottawa

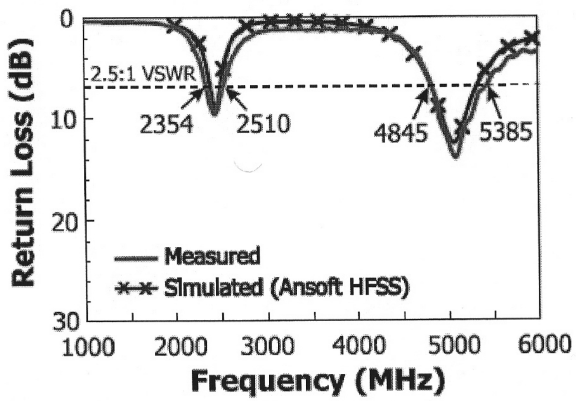
Examples of ANSOFT simulations

NSYSU, Taiwan

WLAN Printed Monopole- Dual-band monopole (2)

Dual-band spiral monopole for 2.4/5.2 GHz WLAN bands





Patent pending

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Examples of CST simulations

Vivaldi Antenna

Microwave Engineering Europe's (MWEE) EM simulation benchmark has become quite a tradition over the last few years, enticing some of the best known software providers to put their diverse simulation methods to the test. The results are always eagerly awaited as they represent the current status of simulation technology and permit revealing comparisons between individual methods and software packets.

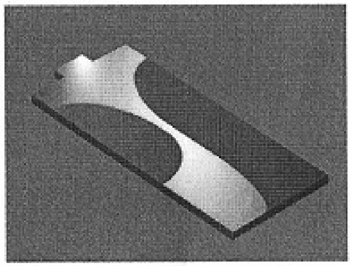


Figure 1: Geometry of a vivaldi antenna

For the first time in MWEE benchmark's history an antenna problem was set. The balanced Vivaldi antenna posed a worthy challenge to the benchmark participants due to its complex form and size (Fig.1). The CAD benchmark was presented in the October 2000 edition of MWEE and results from six contributors were published in the subsequent editions with the measured results ending the series in February 2001.

The comparison between the published measured and simulated results from all software producers revealed significant differences. No possible reason for this striking discrepancy was put forward by MWEE. CST calculated the Vivaldi structure with great diligence and, having carried out a detailed convergence study, consider our results to be highly accurate.

We would therefore like to share our thoughts with you, commenting on some of the results.

Over the next few pages you will find a discussion of performance and accuracy, commentary on the differences between measured and simulation results, remarks on model input time, and the benchmark results achieved with CST MICROWAVE STUDIO® illustrated with a wide range of plots and animations.

In conclusion we can only recommend that interested readers accept our offer of a CST MICROWAVE STUDIO® test licence. See for yourself what today's 3D EM field simulation tools are capable of.

Examples of CST simulations

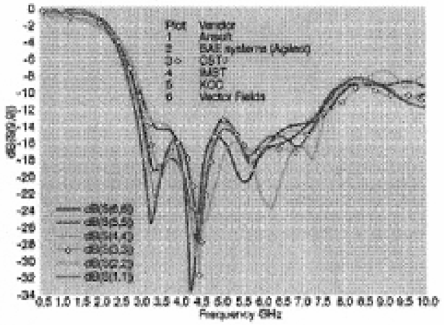


Figure 2: Benchmark results

Figure 1 illustrates the results published in the February 2001 edition of MWEE submitted by six benchmark participants. At first glance all curves - at least in the frequency range from 0-5 GHz - are similar. But when you take a closer look they demonstrate clear differences. The importance of these differences is shown by the following convergence study performed with the help of CST MWS®'s automatic mesh adaptor.

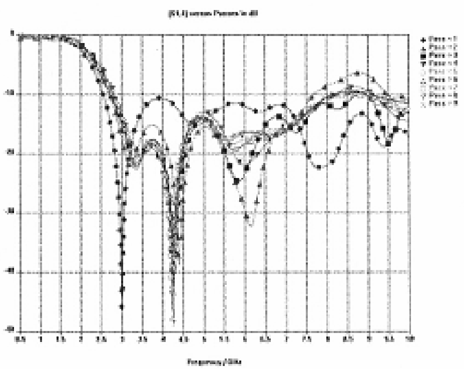


Figure 3: Final solution in a rough mesh with 10.000 mesh nodes

Figure 2 illustrates large variations with the final solution in a rough mesh with 10.000 mesh nodes (Pass 1). After the fifth run (with 53.000 mesh nodes, 12 min. calculation time) hardly any deviation is present in the results and strong convergence can be seen. It has been mathematically proven that our method must always converge and so is absolutely reliable.

Examples of CST simulations

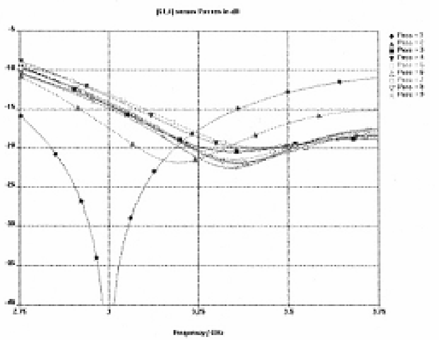


Figure 4: Frequence band section

We will now take a closer look at one section of the frequency band (Figure 3). The resonance peak around 3 GHz decreases in intensity and the resonance frequency shifts until a mesh density of 330.000 nodes is used where an extremely high accuracy is attained (pass 9). The difference between the absolute minimum of these peaks for runs 1 and 9 is, nevertheless, 25 dB, the frequency shift 330 MHz. A renewed look at the results submitted by the benchmark participants, clearly reflects the time spent and reliability of the various methods. The difference between the individual resonance peaks amounts to 12dB / 250 MHz for this frequency range. This enormous difference impressively clarifies the importance of a carefully carried out convergence study. It should be noted that the 9 runs made here, were only carried out in order to clearly illustrate the convergence process. In practice, substantially fewer runs are sufficient to reach a reliable result.

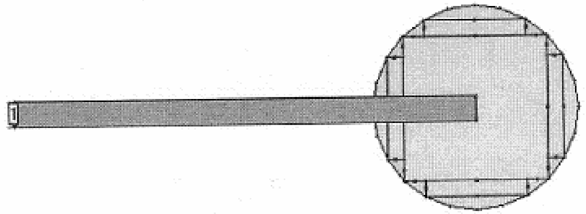
As an optional extra, MWEE had challenged the participants to calculate results for the 10 to 20 GHz range. Unfortunately MWEE neither presented the measured results for this range, nor published a comparison between the submitted simulation results. It is precisely in this frequency range that the widely differing abilities of the methods would have appeared most clearly, due to the problem size in wave lengths and the resulting increase in the number of mesh nodes points.

A comparison of the data provided by the individual competitors revealed the clear superiority of the Time Domain with regards computation time and memory requirements. The Finite Element program Ansoft's "HFSS" needed 143 minutes for the frequency range 0 to 10 GHz, whereas CST MICROWAVE STUDIO® only needed 15 minutes and with a memory requirement eight times smaller. No results from HFSS were published for the frequency range 10 - 20 GHz. CST MICROWAVE STUDIO® produced results for this frequency range within 15 minutes, but as it turned out, to achieve our desired high levels of accuracy at 20 GHz, a finer discretisation and therefore a longer computation time (up to 64 minutes) was necessary.

Examples of IE3D simulations

COUPLED-FED CIRCULAR PATCH ANTENNA

Structure on IE3D



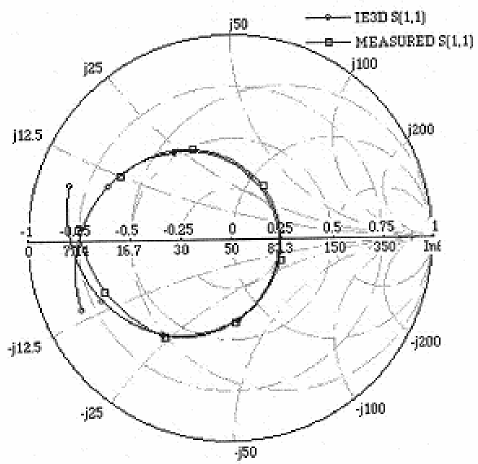
Parameters: No.1 and No.2 substrate thickness = 0.159 mm, permittivity = 2.62

Circular patch is on the No.2 substrate, and feed line is on the No.1 substrate. Circular patch diameter is 35 mm. Feed line width is 4.373 mm. The feed line ends at the center of the circular patch and the feed line is 79 mm long.

Simulation Result: The structure and measured data are from M. Davidovitzand Y. T. Lo, "Rigorous analysis of a circular patch antenna excited by a microstrip transmission line". ***IEEE Trans. Antennas Propagat.***,Vol, AP-37, Aug. 1989, pp. 949-958.

Information on IE3D

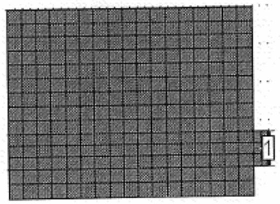
Simulation Cases	IE3D(1)	IE3D(2)
Platform	Pentium 133	Pentium Pro 200
Geometry File	cirpc2c.geo	cirpc2c.geo
Number of Cells	164	164
Number of Unknowns	272	272
Time (sec/freq)	20	9



Examples of IE3D simulations

EDGE-FED RECTANGULAR PATCH ANTENNA

Structure on IE3D



Parameters: The substrate is of thickness 0.794 mm and er = 2.2. The patch is of dimensions 16 mm and 12.448 mm. The feed line width is 2.334 mm. The center of the feed line is 3.112 mm from the other edge. The reference plane is at the edge.

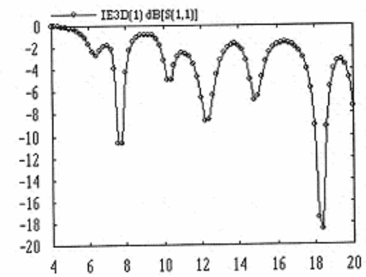
Simulation Result: Other results are from: S.-C. Wu, N. G. Alexopoulos, and O. Fordham, "Feeding structure contribution to radiation by patch antennas with rectangular boundaries," ***IEEE Trans. Antennas Propagat.***, Vol. AP-40, Oct. 1992,pp.1245-1249.

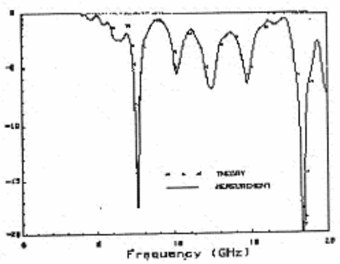
Information on IE3D

Simulation Cases	IE3D(1)	IE3D(2)	IE3D(3)	IE3D(4)
Option	12 cell/l at 20 Pentium 133	7 cell/l at 20 Pentium 133	12 cell/l at 20 Pentium Pro 200	7 cell/l at 20 Pentium Pro 200
Geometry File	alex12.geo	alex7.geo	alex12.geo	alex7.geo
Number of Cells	256	100	256	100
Number of Unknowns	478	178	478	178
Time (sec/freq)	76	9	29	4

Notes: Geometry file alex12.geo is for simulation up to about 20 GHz.Geometry file alex7.geo is for simulation up to about 8 Ghz.

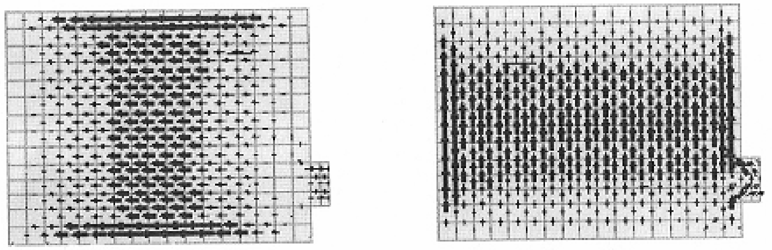
IE3D Simulation Result Calculated and Measured Results from Literature



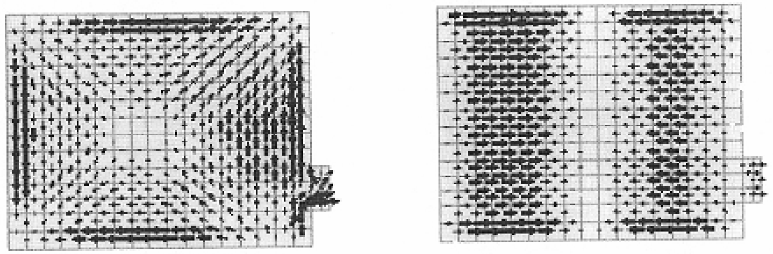


Examples of IE3D simulations

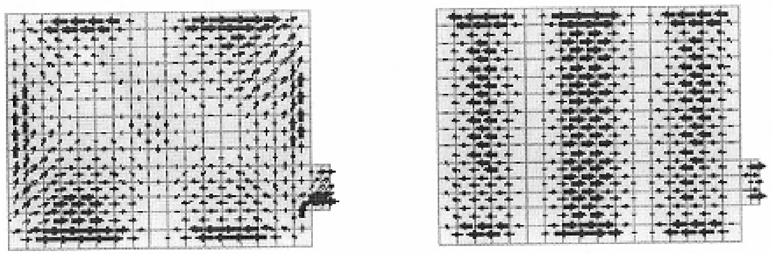
Vector Current Distribution for Different Modes



6.25 GHz, (1,0) Mode 7.65 GHz, (0,1) Mode



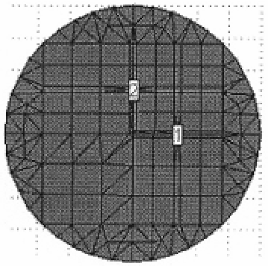
10.25 GHz, (1,1) Mode 12.25 GHz, (2,0) Mode



15.0 GHz, (2,1) Mode 18.32 GHz, (3,0) Mode

Examples of IE3D simulations

Structure on IE3D



Parameters: Substrate thickness = 0.21844 mm, permittivity = 2.33.

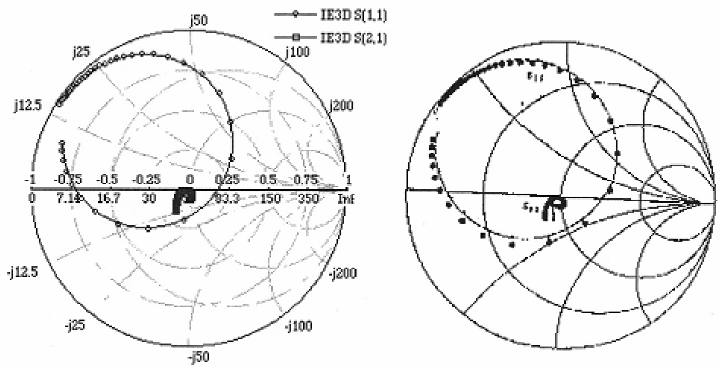
Conductor thickness = 0.005 mm, conductivity = 4.9 ´ 107 s/m.

Simulation Results: Measured and other calculated results are from J. T. Aberle, D. M. Pozar, and C. R. Birtcher, " Evaluation of input impedance and radar cross section of probe-fed microstrip patch element using an accurate feed model," ***IEEE Trans. Antennas Propagat***., Vol. AP-39, Dec. 1991, pp. 1691-1696.

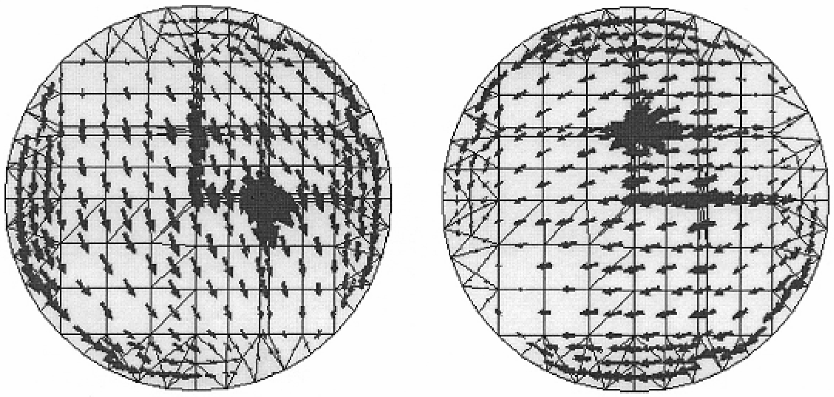
Information on IE3D

Simulation Cases	IE3D(1)	IE3D(2)	IE3D(3)	IE3D(4)
Option	Flat Probe Pentium 133	Tube Probe Pentium 133	Flat Probe Pentium Pro 200	Tube Probe Pentium Pro 200
Geometry File	pfed1.geo	pfed2.geo	pfed1.geo	pfed2.geo
Cells/Unknowns	189/275	243/395	189/275	243/395
Time (sec/freq)	24	93	12	49

IE3D Result Calculated and Measured Results from Literature

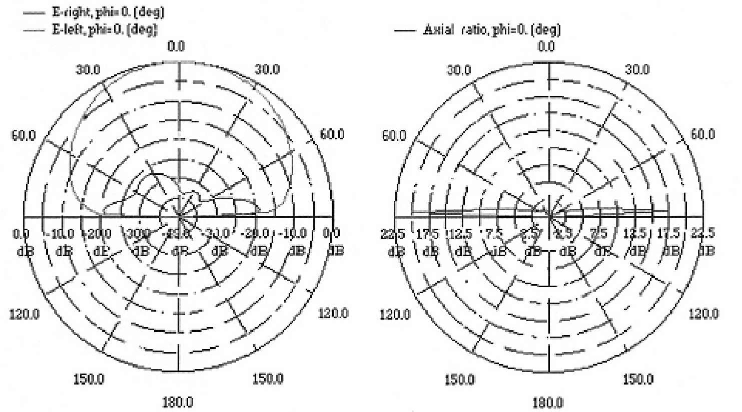


Vector Current Distribution, Circular Polarization Patterns and Axial Ratio Display of the Antenna



0 degree   90 degrees

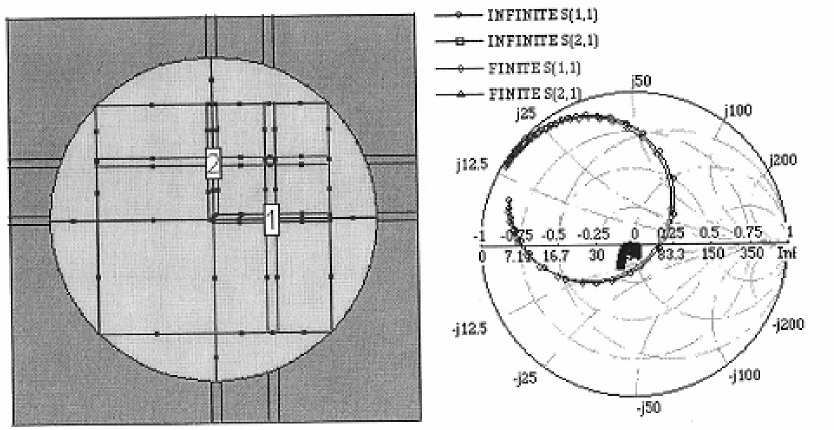
IE3D allows you to display the current distribution, radiation pattern and axial ratio with different excitations and loads. For this example, we feed the port 2 with a 90· phase difference from port 1. Shown above is the current distribution at a time difference of 90·. The rotation of vectors is an indication of circular polarization.



<u>Effect of Finite Ground Planes</u> The square finite ground plane is 50 mm long, compared to the 40 mm diameter of the circular patch. Little difference is observed between the infinite ground plane and finite ground plane structures in the frequency response. The forward radiation patterns for the two antennas are also very close. The directivity and efficiency of the antennas are significantly different.

Examples of IE3D simulations

Examples of IE3D simulations



Radiation Pattern with Infinite Ground Plane Radiation Pattern with Finite Ground Plane

(Directivity = 8.25 dB, Efficiency = 72%) (Directivity = 7.23 dB, Efficiency = 89%)