MORE GAIN, LESS PAIN

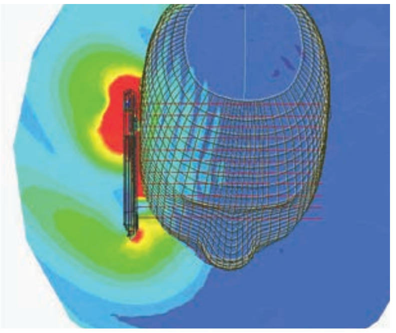
Using simulation, Vortis can design a more efficient cell phone antenna in up to 90 percent less time.

By James R. Johnson, Founder/Chairman, Vortis Technology, Inc., San Carlos, U.S.A.

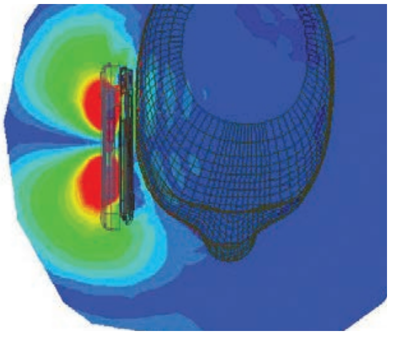
Today's cell phone antennas waste about 50 percent of their power transmitting RF energy into users' heads and bodies. This reduces battery life and produces an annoying buzzing sound in lower-cost hearing aids used around the world. Vortis's new end-fire phased-array cell phone antenna design reshapes the signal pattern so that much less energy goes into the user's head and body. This helps to improve battery life and eliminates the buzzing for hearing aid users.

An antenna that provides the desired figure-eight signal pattern in free space was developed using phased-array theory, but

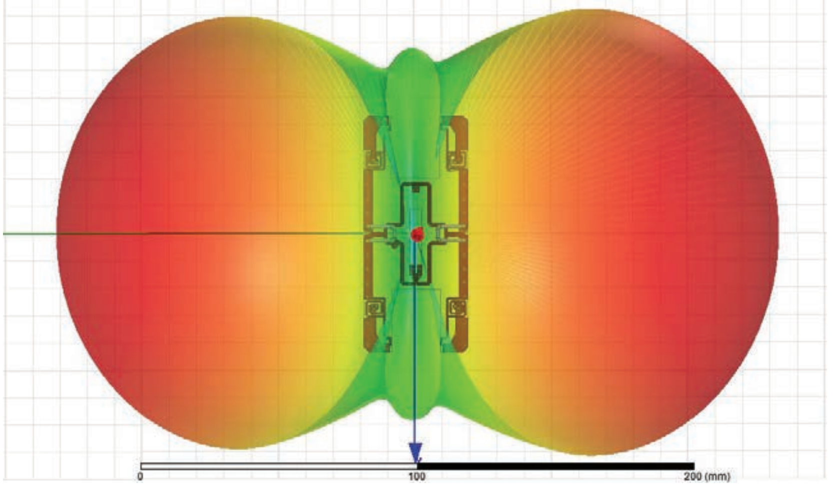
Vortis engineers reduced the time required to customize the design of an antenna by up to 90 percent using simulation.



▲ 2-D radiation pattern of conventional omnidirectional cell phone antenna calculated by ANSYS HFSS



▲ 2-D radiation pattern of Vortis antenna calculated by HFSS . Reduced amount of red at the head indicates a better-distributed signal.



▲ 3-D radiation pattern of Vortis antenna

Vortis engineers have further compressed the design process by using HFSS Optimetrics.

this design must be customized for every phone on which it is used to take into account the effects of the packaging, the cell phone itself and the user's head and hand. Vortis engineers reduced the time required to customize the antenna design for a specific phone by up to 90 percent using ANSYS HFSS. ANSYS Optimetrics evaluated the design space and identified the optimal value for design parameters.

LIMITATIONS OF CURRENT CELL PHONE ANTENNAS

Simple omnidirectional wire antennas that consist of a wire, plated trace or PCB structure sitting on the top, side or bottom of the handset provide adequate performance for most mobile phone applications; they are almost universally used because of their low cost and simplicity. But there are many applications for which these designs are not sufficient or, at the least, higher antenna performance can offer major advantages: industrial and recreational use in fringe areas, devices for the hard of hearing (about 10 percent of the population), and applications in which longer battery life is more important than size.

When cell phones operate, there is a handshake mechanism between the cellular site and the handset. When the signal is strong, the handset reduces energy output to save the battery, and, when the signal is weak, the handset increases power to maintain the connection. As much as 35 percent of the energy radiated by conventional omnidirectional antennas can be absorbed by the head, and as much as 15 percent is absorbed by the hand. This energy must be replaced by increasing the energy output of the phone, which contributes to draining the battery.

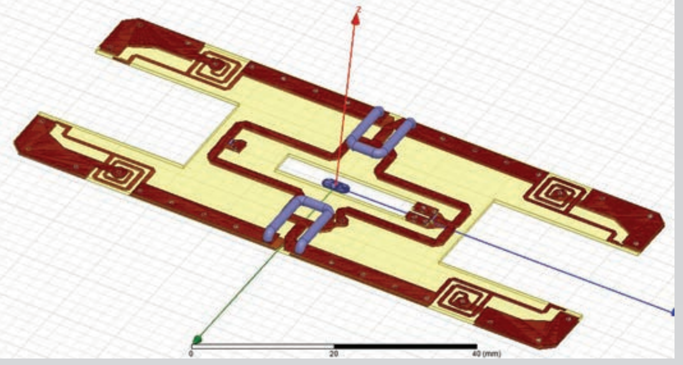
Wearers of hearing aids often experience electromagnetic interference (EMI) problems with conventional omnidirectional cell phone antennas. These antennas radiate a digital pulse that generates currents in the wires in the hearing aid. These currents are amplified by the hearing aid and broadcast by the speaker with a volume to the user of 45 decibels to 85 decibels. The resulting buzz often makes it difficult to use the cell phone and hearing aid at the same time. Most advanced and expensive hearing aids have resolved this under industrial collaborative programs — some with the use of ANSYS HFSS software. However, lower-cost units still suffer from this problem.

NEW ANTENNA DESIGN ADDRESSES THESE PROBLEMS

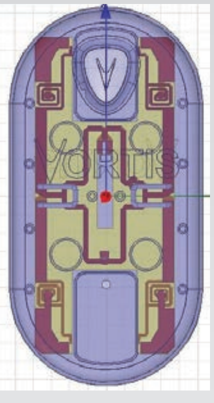
The Vortis antenna overcomes these problems. The end-fire phased-array cell phone antenna radiates a signal in the shape of an eight with deep nulls lateral to the elements and high-gain longitudinal to the elements. The antenna is oriented so that the nulls coincide with the user's head and hand, and the high gain areas enhance the signal forward and rearward of the head to improve the overall uplink.

The efficiency of the Vortis antenna has been tested in free space at 60 percent, which is a 50 percent improvement over the average omnidirectional cell phone antenna. When this number is expanded to incorporate the 40 percent DC to RF energy conversion efficiency typical to handsets, the savings in battery consumption is an estimated 125 percent improvement. This provides 2.25 times more talk time than the traditional antenna. When Vortis is tested against an experimental phantom head, the improvement in efficiency is even greater due to the reduced loss from head absorption. Since the Vortis antenna radiates much less energy around the user's head, the interference to hearing aids is substantially reduced.

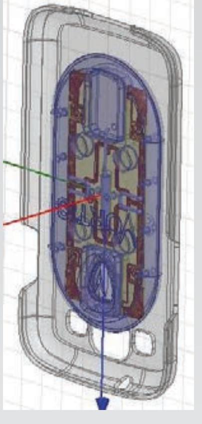
PROCESS



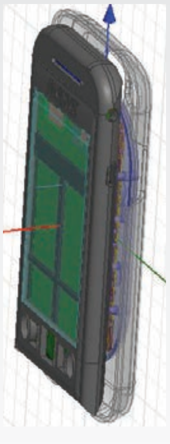
Case I Vortis antenna



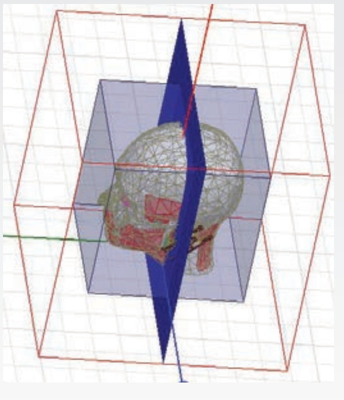
Case II
Vortis + POD (surrounding radome)



Case III
Vortis + POD + rubber wraparound



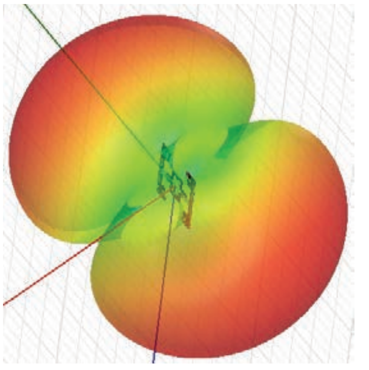
Case VI
Phone + Vortis + POD +
rubber wraparound



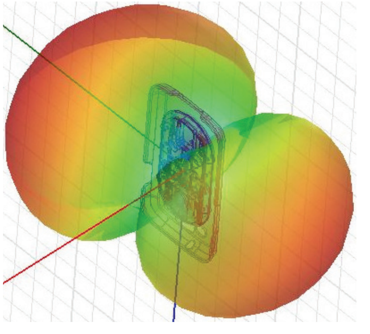
Case V
Simulation with phone + Vortis + POD +
rubber wraparound + human head

▲ Step-by-step process for using ANSYS HFSS simulation to customize antenna design for specific cell phone

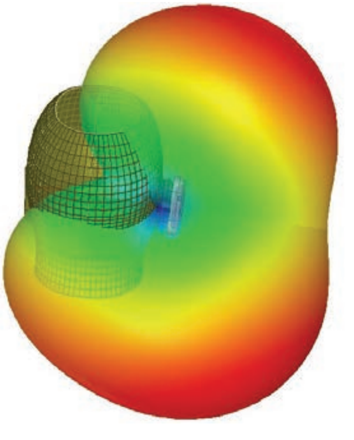
SIMULATION



Case I Free space



Case III
Vortis + POD + rubber wraparound



Case V
Simulation with phone + Vortis + POD +
rubber wraparound + human head

▲ Simulation results show how figure-eight–shaped radiation pattern was restored at each step of the design process.

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When Vortis originally created its concept design, engineers used phased-array theory to create the design of an antenna that would radiate its trademark figure-eight pattern in free space. But in the real world, the antenna design must be adjusted to account for the absorption effects of its package, the phone itself, and the user's head and hand. Therefore, a custom design is required to address individual phone and device requirements with which the antenna is used.

Originally, the company's engineers adapted the design to a new cell phone by building a prototype of the free-space design and testing it with the cell phone and a dummy head and hand. Based on test results, the engineers modified the original design in an effort to recreate the figure-eight pattern under real-world conditions. They then built and tested a prototype. Each design iteration cost about $5,000 and took about one week. An average of 10 design iterations were required to create a satisfactory custom design for a typical application, so the costs were about $50,000, and the lead time was 10 weeks, potentially making the process 10 times faster and easier.

Using HFSS and Optimetrics, Vortis can create a customized antenna design for a specific cell phone in only about one-tenth the time and cost required with the build-and-test method.

SIMULATION REDUCES DESIGN COST AND TIME

With more design variables and tighter schedules, simulation is the only means to meet today's design requirements. A year ago, Vortis began using ANSYS HFSS simulation to adapt its antenna design for specific cell phones. Engineers began by using ANSYS ALinks for MCAD to import the geometry of the Vortis antenna, antenna package, rubber wraparound (sometimes used to connect the antenna package to the cell phone), cell phone and ANSYS human head model. Engineers began with the basic free-space antenna design and added the antenna package, reran the simulation and noted how the radiation pattern was distorted. They adjusted the antenna design and, in the course of several iterations, restored the original figure-eight pattern. Next they added the rubber wraparound and cell phone to the model geometry. They reran the simulation and noted the resulting distortion in the radiation pattern. They created and simulated additional iterations to remove the distortion. Finally, they added a head and a hand to the model and went through the same process.

Recently, Vortis engineers have further compressed the design process to a single step by adding all of the elements that need to be considered in the beginning of the simulation process and then using the Optimetrics parametric analysis tool to generate a designed experiment consisting of a series of iterations to explore the complete design space. The design parameters used in this experiment were those that had been shown in earlier simulations to have the greatest effect on the radiation pattern. The design of experiments results were used to estimate the value of each relevant design variable that would produce the best fit to the desired figure-eight pattern.

Using HFSS and Optimetrics, Vortis can create a customized antenna design for a specific cell phone in one-tenth the time and cost required with the build-and-test method.

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ANSYS HFSS FOR ANTENNA SIMULATION
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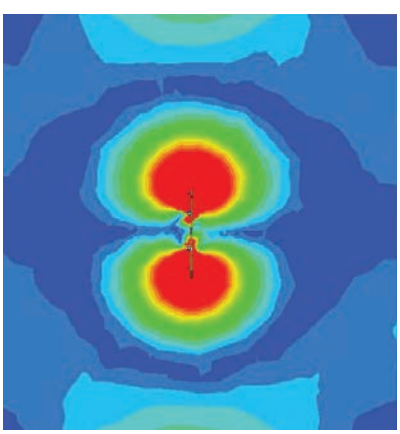
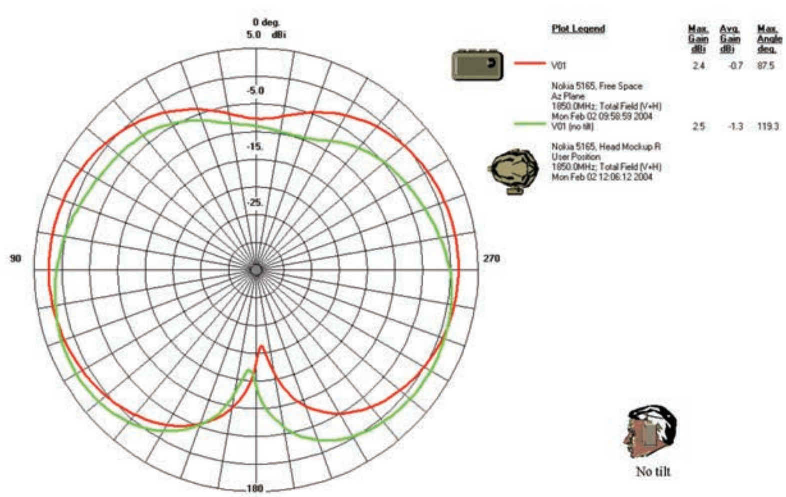


Antenna radiating energy looking top-down in near fields



Test results confirm simulation accuracy.