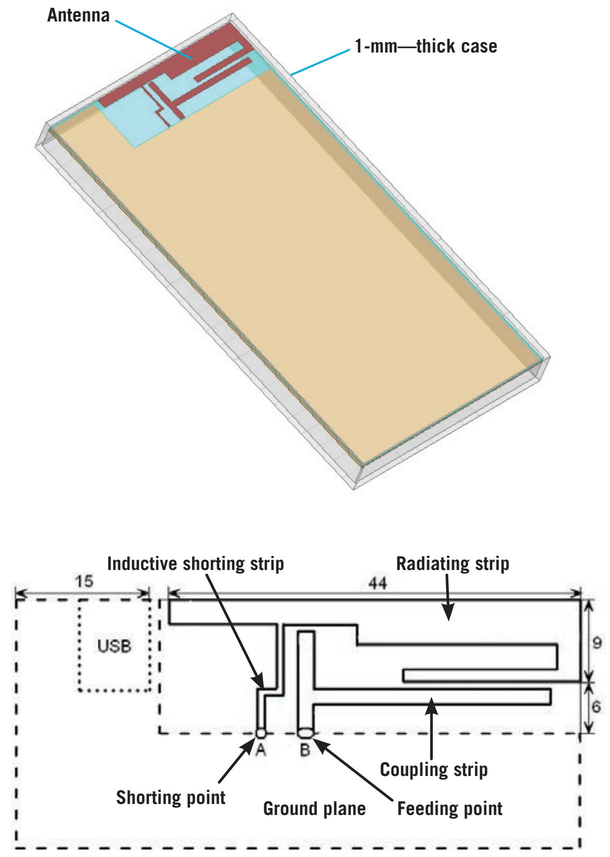
DEVELOPING RELIABLE ANTENNAS FOR SMARTPHONES

A team of researchers used ANSYS technology to design a small multiband internal antenna to successfully operate across eight different frequency bands.

By Jiangsheng Zhou, Principal Engineer, Wireless Terminal Design Team
Jiang Nan Electronic and Communication Research Institute, Jiaxing, China

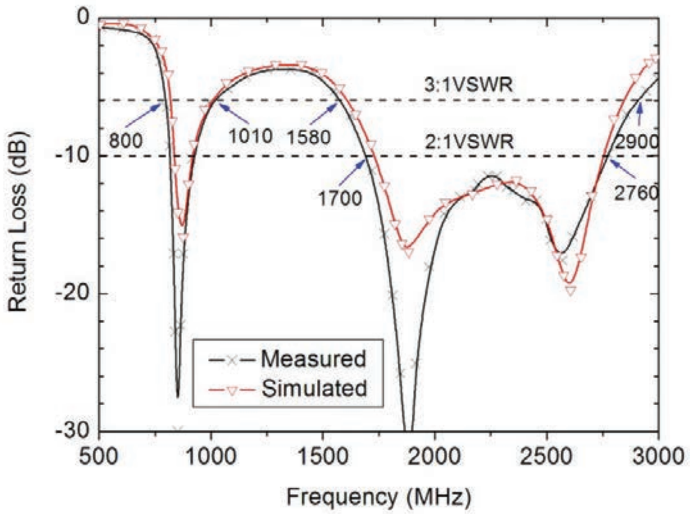


▲(Top): Geometry showing location of proposed coupled-fed printed antenna design on the device PCB. (Bottom): Dimensions in mm of the antenna's metal pattern. The radiating strip is along the top edge. The thin inductive shorting strip extends off the left side of the radiating strip while the T-shaped coupling capacitive strip is below the radiating strip on the right.

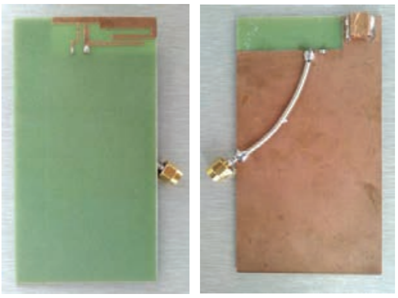
At its introduction in 1983, the first commercially available cell phone was seen as more of an expensive novelty than a necessary tool. Costing the equivalent of more than $9,000 U.S. today, it weighed almost 2 pounds and was notoriously bulky with its rubber whip antenna extending more than 5 inches above its 10-inch body. Despite such hefty dimensions, its battery provided only 30 minutes of talk time before requiring a recharge.

Over the past three decades, mobile phone technology has evolved through many generations, with a rapidly expanding set of features contained within a smaller, lighter and far less expensive package. Modern mobile devices are more like highly portable personal computers than phones. However, a large factor in a device's ability to provide the freedom to communicate from almost anywhere is still its antenna. Designing small-profile, multiband and wideband internal antennas with a simple structure has become a necessary challenge for the mobile phone industry. Phone manufacturers need to keep production costs low while continuing to produce devices with more options. All of these varied capabilities affect one another, increasing the inherent challenges in antenna design.

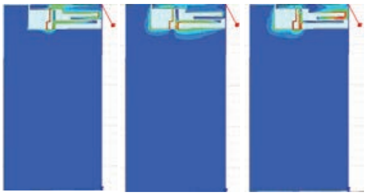
Designing small-profile, multiband and wideband internal antennas with a simple structure has become a necessary challenge for the mobile phone industry.



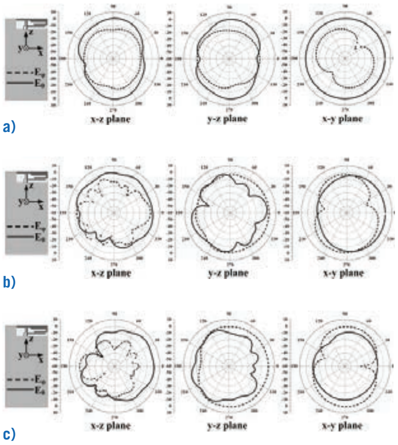
▲ Comparison of measured values of return loss (in dB) versus those predicted by ANSYS HFSS at the range of frequencies for multiband and wideband signals. Dotted lines show the equivalent values of voltage standing wave ratios (VSWR), which indicate the degree of impedance matching at the indicated frequencies.



▲ Front (left) and back (right) views of the manufactured internal planar printed antenna



▲ Contours of surface current density on metal portion of proposed antenna design at 900 MHz (left), 1,900 MHz (center) and 2,600 MHz (right). The colors indicate current density, with red indicating the most dense.



a)

b)

c)

▲ Measured radiation patterns at (a) 900 MHz, (b) 1,900 MHz and (c) 2,600 MHz for the proposed antenna

A team of engineers used ANSYS HFSS to design a small internal multiband antenna that can operate across eight different frequency bands.

At the Jiang Nan Electronic and Communication Research Institute in China, a team of engineers used ANSYS HFSS to design a small internal multiband antenna that can operate across eight different frequency bands. For a wireless device to function properly as both phone and computer, it needs to send and receive wideband (824 MHz to 2,690 MHz) and multiband (GSM 850 MHz, 900 MHz, 1,800 MHz and 1,900 MHz; UMTS 1,920 MHz to 2,170 MHz; WLAN 2,400 MHz; and WiMAX 2,300 MHz, 2,500 MHz) signals. WLAN, WWAN and WiMAX are the most prevalent types of Wi-Fi networks, while WLAN 2,400 MHz is the frequency required for Bluetooth® connectivity. GSM and UMTS bands are used for global cell phone communications, including 2G, 3G, 3.5G and 4G LTE.

The team investigated various antenna designs using simulation. They varied the length and width of the radiating, coupling and inductive shorting strips, as well as the shorting and feeding pin positions. Changing these dimensions for the HFSS simulation led to significant variation in the scattering parameters (S-parameters), specifically the return loss (S11). Return loss can be used to judge antenna performance at different frequencies. The team optimized the dimensions for return loss values at frequencies between 824 MHz and 2,500 MHz.

Additional methods for determining antenna performance include current distributions, far-field patterns, gain and antenna efficiency. The team simulated the current distributions and far-field patterns at 900 MHz, 1,900 MHz and 2,600 MHz. Strong surface current distributions on the radiating and shorting strips indicate that these strips are the main contributors for the lower-frequency band operation. The long coupling strip controls the resonant mode at 1,900 MHz, while the short coupling strip controls the resonant mode at 2,600 MHz. Smooth variations in vertical polarization in all directions indicate good antenna coverage. The radiation efficiency varied between 50 and 64 percent at lower frequencies to a high of 62 to 77 percent at higher frequencies. Antenna efficiencies greater than 45 percent are sufficient for practical mobile phone applications.

The final optimized design required a modest 15-mm by 45-mm area on a small PCB that did not include a ground space at either the top or the bottom. The

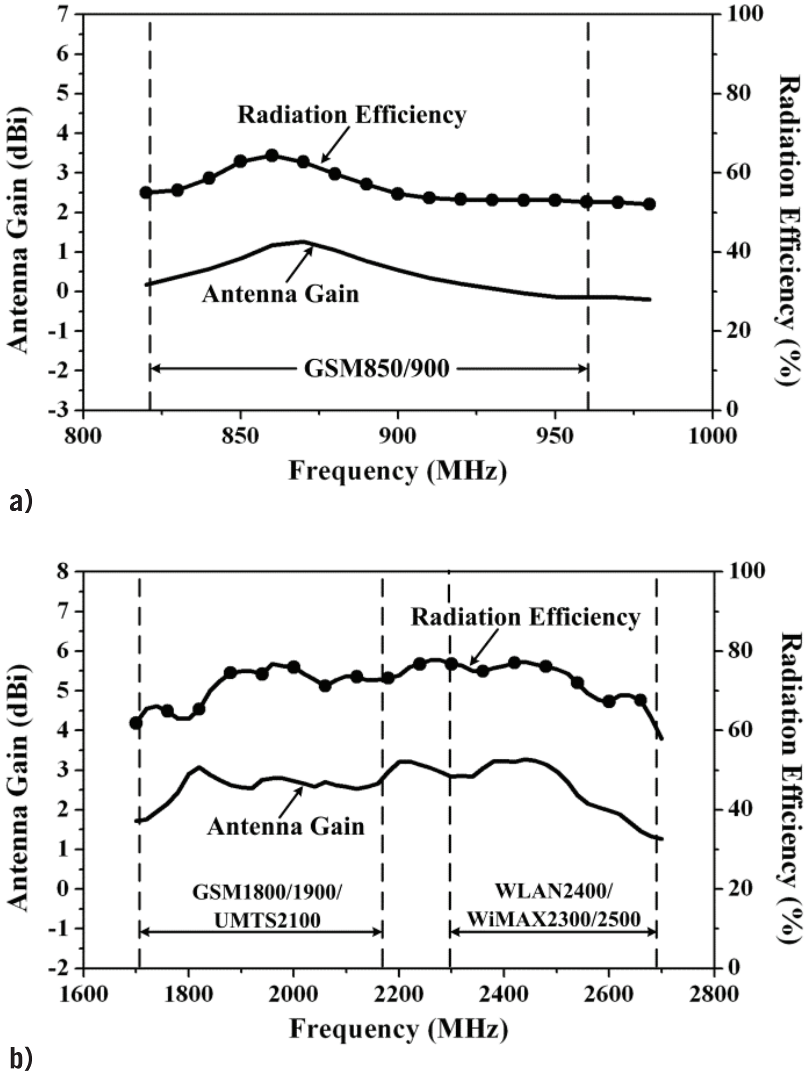
Based on both simulated and experimental results, the design is suitable to be directly printed on the system PCB of the device.

THE ROLE OF SIMULATION IN INNOVATIVE ELECTRONIC DESIGN
ansys.com/91antennas

antenna design consists of a radiating strip, an inductive shorting strip and a coupling strip. The radiating strip is the longest, located on the top edge of the PCB's no-ground space, while the inductive strip is only 0.5 mm wide and is short-circuited to the system ground via a hole in the PCB. The coupling strip is located between radiating and inductive strips. The coupling strip provides an excitation voltage to both the radiating strip and the inductive shorting strip. Together, the radiating and inductive shorting strips produce low-band GSM resonance. The coupling strip has two branches that can generate a wide upper-band range of 1,710 MHz to 2,690 MHz.

To confirm the HFSS results, the team tested the antenna using a vector network analyzer (VNA) and an anechoic chamber. With the antenna printed on the PCB, the team excited the antenna using a 50-ohm coaxial feed at the antenna feed point. To simulate realistic conditions, there was also a 1-mm–thick plastic housing with a 1-mm gap between the housing and the PCB, representing the phone's case. The simulated return loss compared well with the actual return loss determined through physical experiments.

Before engineers started using simulation tools, they had to build prototypes and then test each design variation individually using the same setup required for confirming the simulation results. This was a highly inefficient method that required weeks for each evaluated design, allowing little time for optimization and testing of innovative changes. By incorporating ANSYS HFSS into the design process, the team explored several antenna configurations and optimized the design before building any prototypes, which saved 20 percent in material costs. Engineers were able to run 20 different simulations to analyze various antenna configurations and optimize the final design in just three days.



▲ Measured radiation efficiency and antenna gain for proposed antenna: (a) GSM 850/900 MHz band; (b) GSM 1,800/1,900 MHz/UMTS 2,100 MHz and WLAN 2,400 MHz/WiMAX 2,300/2,500 MHz band

The antenna performance results predicted by ANSYS HFSS for impedance matching showed close agreement with the experimental data obtained through the engineering team's experiments using a vector network analyzer. Based on both simulated and experimental results, the design is suitable to be directly printed on the system PCB of the device. Combined with its low fabrication costs, this makes the antenna a very attractive option for mobile phone applications.