Radiotelevisione Italiana (RAI), Italy

PROTOTYPING ANTENNAS FOR MOBILE RECORDING OF TV SPORTS EVENTS WITH SIMULATION

by **DIXITA PATEL**

Researchers at Radiotelevisione Italiana (RAI) are designing and optimizing new circularly polarized antennas to record live sporting events with the help of multiphysics simulation.

Every year in Italy (and its neighboring countries), hundreds of thousands of fans surround one of the most prestigious cycling events, *Giro d'Italia*, or Tour of Italy. This multiple-stage bicycle race is one of the world's three grand cycling tours, the others being the *Tour de France* and the *Vuelta a España*. In addition to the fans at the race, millions of viewers are able to join from home thanks to RAI, Italy's national public broadcasting company.

Recording live sports events on the move has been a traditional activity of RAI for decades. To do so, typically eight motorcycles are equipped with various facilities, including radio cameras, audio radio links for commentators, and geolocalization means (Figure 1). A complex infrastructure, including two recording helicopters and two aircraft relaying the signals to a remote outside broadcast (OB) van, is needed to convey live TV to the broadcasting distribution. In this framework, the Center for Research, Technological Innovation and Experimentation (RAI-CRITS) has been providing technical support in this TV production segment.

FIGURE 1 Motorcycles used for the *Giro d'Italia*, or Tour of Italy, cycling event.

Recently, issues on the commentary radio link from motorcycle to helicopter required a specific investigation. RAI researchers Assunta De Vita, Alessandro Lucco Castello, and Bruno Sacco identified the problem and proposed a solution based on the design of a low-profile, circularly polarized (CP) antenna. The proposed radiating system has been modeled and simulated with the COMSOL Multiphysics® software. The results have been confirmed in the prototypes by means of laboratory measurements and field tests.

» TV SHOOTING OF LIVE SPORTS EVENTS: TRANSITION TO DIGITAL

In recent years, recording live sports events on the move has been progressively digitized. For RAI, when it comes to shooting *Giro d'Italia*, it is important for the commentary to be effectively coordinated throughout the duration of the race. During the live event, motorcycles are equipped with video cameras and audio radio for the commentators that live shoot alongside the racers. Three helicopters and an airplane are employed above the race; two of them for video shooting and the others acting as a "bridge", relaying the signals

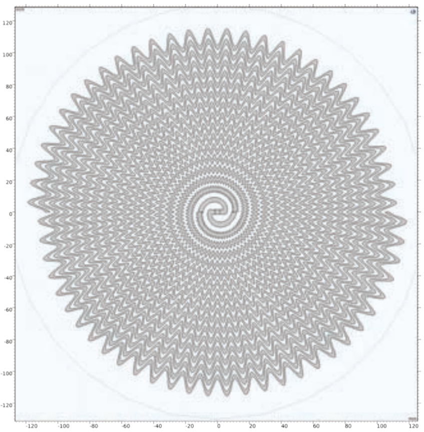

FIGURE 2 Work plane view of the meander spiral UHF CP antenna.

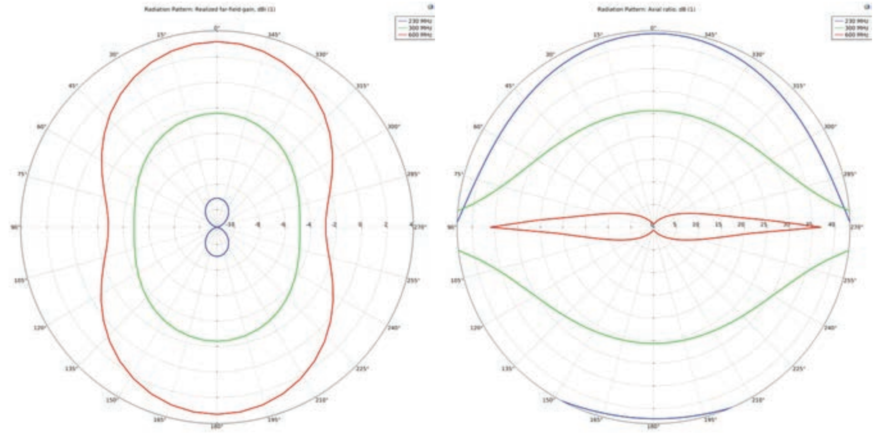

FIGURE 3 Radiation pattern plots showing the antenna gain (left) and axial ratio (right).

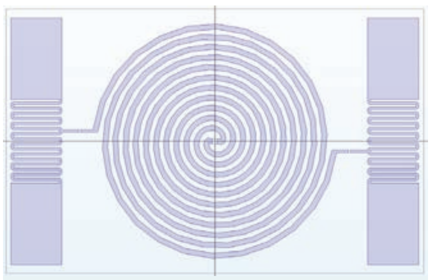

FIGURE 4 The dual-band VHF/UHF CP antenna with a two-arm Archimedean spiral and two inductive-loaded dipoles.

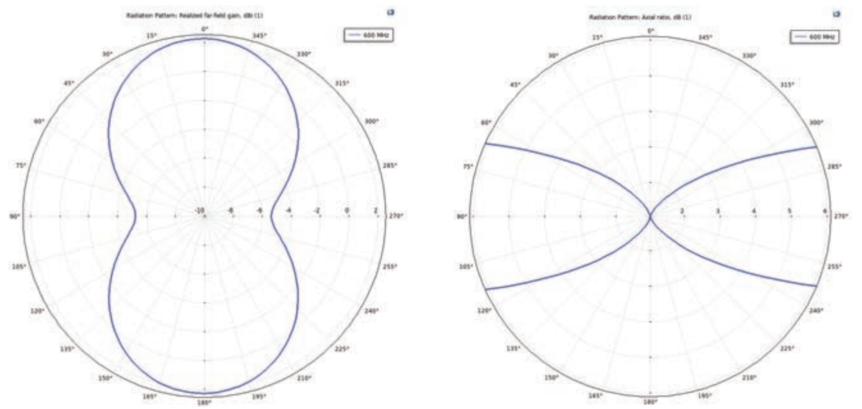

FIGURE 5 Radiation pattern plots showing the antenna gain (left) and axial ratio (right) at 600 MHz.

received from the motorcycles to the OB van at the finish line, where technicians mix the signals from the motorcycles, helicopters, still cameras, mobile interview team cameras, and commentary.

In some cases, the team encounters problems, such as sporadic signal interruptions. "There was an issue when we experienced a break of the radio link between the motorcycles and helicopters. Our investigation identified the problem in the polarization misalignment: a known aspect in airborne radio applications," said Sacco. To improve the communication link, RAI's solution was to design an antenna based on circular polarization (CP) to allow for the correct reception from any reciprocal orientation.

This new antenna design was required to operate in a dual-band, very high frequency/ultrahigh frequency (VHF/UHF), configuration. The antenna also needed to be compact enough to be placed in a motorcycle top case. However, the limited space available in the top case (about 40 cm x 20 cm) is conflicting with the VHF operation that would require somewhat larger dimensions. With these stringent requirements, the researchers modeled and tested many antenna designs in the frequencies' band of interest, in terms of impedance matching, realized gain, and axial ratio.

» PROTOTYPING COMPACT ANTENNA SOLUTIONS WITH NUMERICAL MODELING

To design a compact antenna solution that meets the desired requirements, the researchers implemented various antenna prototypes using COMSOL Multiphysics® along with the RF and Optimization modules. They tested several configurations for the best performance in the frequency range of interest, including an Archimedean spiral CP antenna and a dual-crossed, double-folded dipole (DCDFD) antenna. The gain enhancement and the impact on the bandwidth and polarization purity with the introduction of a reflector was also studied.

The first attempt involved a circularly polarized antenna design based on a conventional two-arm Archimedean spiral structure. After simulating the spiral antenna alone, results showed good CP performance in the UHF band at 500–600 MHz, but not at 230 MHz due to the size limit. "The antenna needed to work simultaneously in both bands. While it worked well for UHF, it definitely suffered for limited size to properly perform in the VHF band," said Sacco. To maximize the RF energy conveyed toward the receiver, the adoption of a conducting plane reflector is often desirable. In order to estimate the influence of the geometrical and electrical parameters on the antenna performance,

FIGURE 6 The deployment into the real system environment, the motorcycle top case.

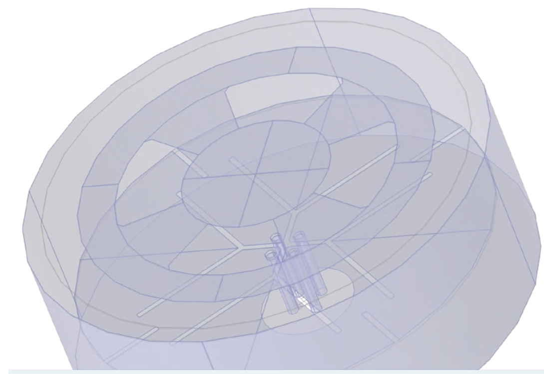

FIGURE 7 Geometry of the DCDFD circularly polarized UHF antenna.

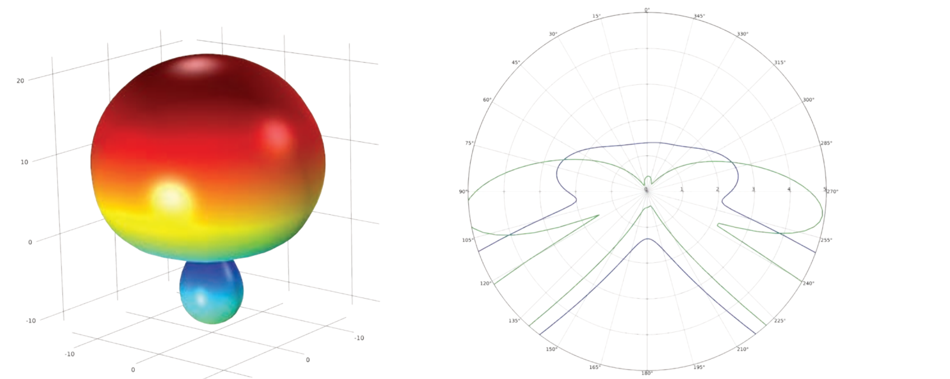

FIGURE 8 3D plot of the realized gain (left), and the axial ratio (right) of the DCDFD CP UHF antenna at 500 and 600 MHz.

the *Parametric Sweep* feature was used. In particular, the influence of the reflector distance on the far-field radiation pattern and axial ratio was investigated. As expected, the reflector improves the antenna gain but worsens the axial ratio (Figure 3), requiring further optimization.

An attempt to extend the operating frequency range downward without increasing the overall size has been done using a meander line in the two-arm Archimedean spiral periphery with a radial perturbation, as shown in Figure 2. To this purpose, the spiral geometry was parameterized within the COMSOL® software. "We adopted the *Parametric Curve* feature because of the geometry complexity," said De Vita. In this case, although simulations showed that the minimum usable frequency was actually extended toward the VHF range, the goal of 230 MHz was not yet fully reached within the available antenna diameter.

The next attempt involved the addition to the flat spiral of two inductive-loaded dipoles (Figure 4) tuned to the desired VHF of 230 MHz. With multiple iterations, the authors optimized the design parameters of this new model in the VHF band for antenna gain and axial ratio (Figure 5) at both 230 MHz and low-UHF bands. "The *Axial Ratio* feature is a nice tool for evaluating the quality for circular polarization," said Sacco.

The prototype antenna has been measured in the laboratory by means of a very near field scanner EMscan RFX2 (Figure 6). The simulated far-field antenna performance has been confirmed by such laboratory measurements, as well as by field tests.

In a second phase, since the operating frequencies have been reassigned and the VHF requirement has been dropped, another design session has been started for the new frequencies (UHF, 500 and 600 MHz). "We continued the analysis of antennas and prototyped another kind that was a bit more complicated because it requires a four-phase feeding network," said Sacco.

The new design was a dual-crossed, double-folded dipole (DCDFD) antenna (Figure 7). This approach would achieve a fair impedance in the presence of the reflecting cavity. Simulation analysis showed good axial ratio, antenna gain, and impedance matching (Figure 8). At present, further tests are ongoing to evaluate the bandwidth performance optimization and the four-phase feeding network design.

» THE FUTURE OF MOBILE TV

In terms of future research, RAI has an ongoing project to study antennas that can receive mobile TV services for smartphones, tablets, and other mobile devices. "We have the possibility to provide TV services to mobile devices, but many problems are to be solved in order to allow for this service," said De Vita. Indeed, the possible integration of antennas in mobile terminals, in the lower part of the UHF band, poses a great challenge for antenna designers, since the limited dimensions of the mobile devices physically set an upper bound to the achievable bandwidth, introducing basic restrictions to the expected performance.

In addition, in the case of a mobile device, the antenna behavior is also influenced when placed in an individual's hand, so this will be an issue to overcome for the researchers at RAI. "This next activity is somewhat complimentary with shooting on the move. Shooting is a professional application, so you have to make sure that the antenna is as good and reliable as possible," said Sacco.

RAI has found that the simulation results appear very promising and will help them continue to make further improvements in their research. ◎