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UHF RFID Antennas for Printer-Encoders—Part 3: Mobile Equipment

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The final installment of this series looks at antennas for mobile or portable RFID printer-encoder equipment

Antennas for RFID applications have unique requirements, particularly for the small spaces inside portable or mobile equipment. This final installment of this series of articles looks at antennas for these types of RFID printer-encoders, followed by summary comments for the entire series and an extensive list of references.

UHF Antennas for Mobile Printer-Encoders

Space saving for mobile RFID printer-encoders is the biggest concern. Printers require UHF antennas to be slim, because the space available for their installation is very limited. In addition to the geometric constrains, the antennas must enable the encoding of short labels on a short pitch. Terminated tapered resonant stripline TL antennas are most qualified to meet these stringent requirements of the portable printers. The stripline TL antennas are ultra-compact and conformal. They fit in the space near the printhead and can provide a short transponder placement range. These antennas have received the highest acceptance for transportable and stationary RFID printer-encoders. Antennas are presented by the half-wave stripline (Fig. 10(a)) and a double-conductor stripline (Fig. 10(b)) linear taper width TL.

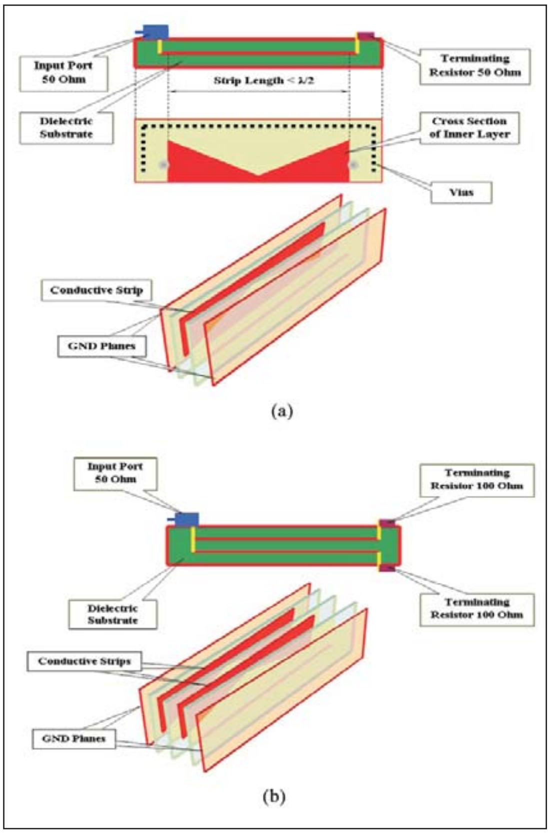

Figure 10 · Structure of terminated tapered stripline TL antennas: (a) single conductor TL antenna; (b) dual-conductor stripline TL antenna.

Antenna Structural Feasibility

Stripline TL antennas, which are arranged in parallel with the transponder in the encoding area, occupy a very small space behind the platen roller (Fig. 11). These antennas allow selective encoding of densely spaced transponders on the liner without activation of adjacent transponders. Examples of a stripline and double-conductor stripline TL antennas are built on PCB substrate and have dimensions of 3.5 × 18 × 100 mm and 6 × 14 × 100 mm, respectively. The internal conductor strip (strips for a double-conductor stripline) is

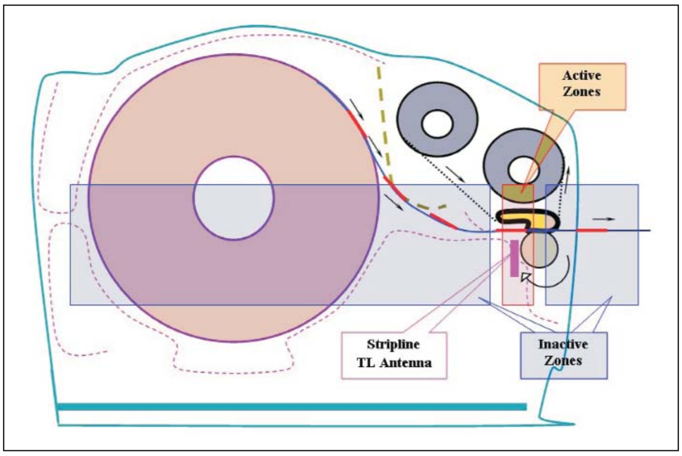

Figure 11 · Printer zones with stripline TL antenna.

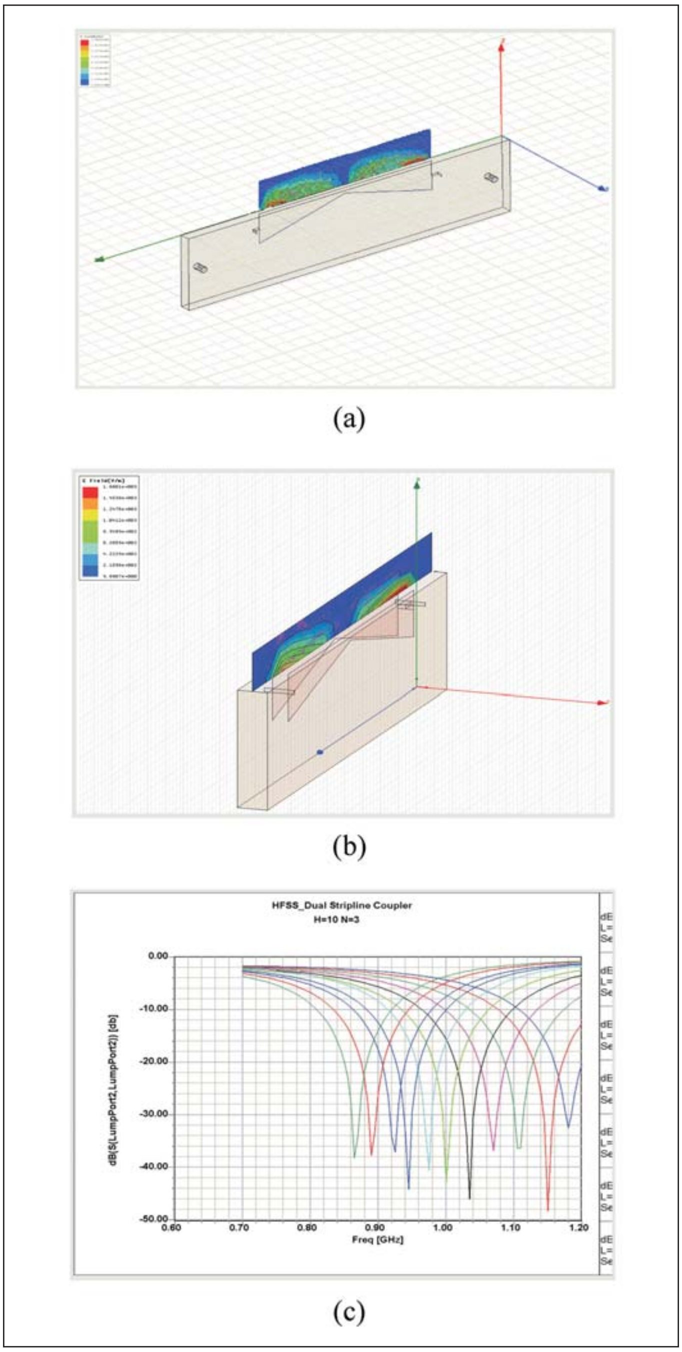

Figure 12 · HFSS simulation of tapered stripline TL. (a) single conductor TL antenna—E field; (b) dual-conductor stripline TL antenna—E field; (c) S_{11} for dual-conductor stripline TL antenna.

enclosed by two ground planes, stitched by vias along the other three sides of the antennas to organize electric walls and reduce parasitic radiation. The inner layer profile (Fig. 10 (a)) is a modified bow-tie shape with the width linearly varied from 9 to 4.5 and back to 9 mm for the stripline and from 10 to 3 to 10 mm for two strips of the double-conductor TL antenna. The dielectric constant of both substrates is 4.25 and their height is 3.5 and 6 mm accordingly. The length of the single stripline TL is 64 mm and for double-conductor line is 57 mm. The narrow center part of the inner layer is positioned close to the active edge of the TL in order to concentrate magnetic field at the center of this edge. This position of the maximum magnetic field usually corresponds to the center of a targeted for encoding transponder and supports an optimal energy transfer for the symmetrical antenna-transponder alignment.

Transponder Placement Boundaries

The single stripline TL antenna with a thickness of only 3.5 mm improves printer's performance by providing a short transponder *placement starting distance* from the label's leading edge. It enables individual encoding of short Smart Labels with a short pitch comparable to the transponders width (Fig. 1 (d)). The double-conductor stripline TL antenna with a thickness of only 6 mm was developed for specific Smart Labels requiring a longer *transponder placement range* and higher antenna energy efficiency than the single stripline TL antenna.

Encoding Field Intensity

Both antennas are in parallel alignment with targeted transponders and are coupled with them by one open long side edge. The electric field strength distribution simulated using Ansoft HFSS for the single stripline TL antenna (Fig. 12 (a)) and for the double-conductor stripline TL antenna (Fig. 12 (b)) shows optimal shape for coupling with a dipole type transponder antenna (Fig. 2). The capacitive coupling maintained by the stripline TL antenna is relatively weak and permits very close positioning to transponders. The stripline TL antenna is less spatially selective than the microstrip TL antenna but its RF power margin is still about 3 dB without a significant

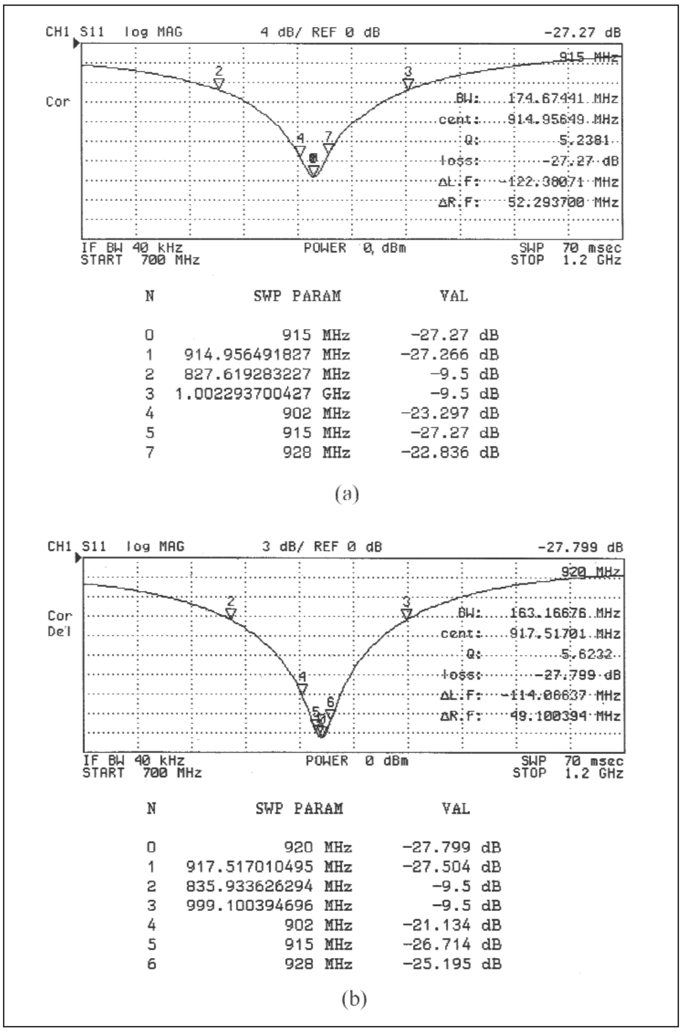

Figure 13 · Reflection loss S_{11} for stripline TL antenna samples. (a) single conductor TL antenna: 4.5 × 9 × 64 mm; (b) dual-conductor TL antenna: 2× (3 × 10 × 57 mm).

change in the encoding range. The double-conductor stripline TL antenna in comparison with a single strip TL has improved field intensity due to a higher SWR generated by an increased load. Its power efficiency, spatial selectivity and coupling grade with a transponder are also increased due to a larger effective edge area. The double stripline TL antenna has an RF power margin in excess of 6 dB.

Impedance Bandwidth

The port impedance of a single conductor stripline TL antenna is 50 ohms. For the double-conductor TL antenna the port impedance of 50 ohms is realized without an additional matching network by connecting in parallel two strips, each loaded by a 100 ohm resistor. Both antennas utilize the same principles for bandwidth improvement as other tapered TL antennas and have a widened bandwidth. They are shorter than $\lambda/2$. A solution for reflection loss S_{11} and geometry calculations for the double-conductor TL antenna are obtained by HFSS simulation (Fig. 12 (c)) and verified empirically. For the above samples the single stripline (Fig. 13 (a)) and double-conductor stripline (Fig. 13 (b)) TL antenna S_{11} parameters demonstrate bandwidths in excess of 150 MHz. By varying individual strip lengths the multi-conductor stripline TL antenna enables further increase in bandwidth, antenna sensitivity, spatial selectivity, power efficiency and transponder placement range.

Conclusions

The article provided a thorough consideration of UHF antennas for stationary and mobile printer-encoders. Terminated TL antennas, while maintaining a considerable system power margin, can selectively interrogate transponders without RF power suppression. Increased available power delivered by the terminated resonant TL antennas to the encoding interval tolerates usage of transponders with large variation of their resonance frequency and activation power threshold. Moreover, enlarged bandwidth of terminated tapered resonant TL antennas allowed using inexpensive RoHS PCB dielectric materials with fairly wide deviations of permittivity, thickness of a substrate and copper cladding.

The proposed miniature stripline TL antennas, with their compressed encoding range, permit portable printer-encoders to work with short, densely spaced Smart Labels. The stripline antennas geometry, their conductive strip dimensions, and bandwidth obtained from Ansoft HFSS modeling for RFID 915 MHz band, have been verified empirically and found to be in a good agreement. Antenna analysis, mostly concentrated on microstrip and stripline terminated TL, imposed no restrictions on the type of TL. Other TL structures, for example, the coplanar waveguide or the slotline, may also be considered as building blocks of antennas for close proximity RFID applications. Conclusively the stripline TL antenna is judged as a vital component for RFID applications involving equipment miniaturization or having spatial constraints for an antenna installation.

Besides RFID printer-encoders, there are many more applications of compact UHF antennas, including access control (Homeland Security market), item-level RFID for conveyors, testing small transponders during their high volume manufacturing, quality validation in the Smart Labels conversion process (Industrial market), and scanners of RFID Smart credit cards (Financial market). It is believed that presented information on UHF antennas will be helpful in selection of UHF Printer-Encoder and as well as a tutorial guide for RFID newcomers. Although the terminated TL antennas have low far-field radiation, they are still a source of UHF electromagnetic energy.

Antenna mounting elements and nearby metal-plastic components can easily create a parasitic wave-guiding structure for this energy transmission, causing excessive unintentional RF radiation that can interfere with the transponder encoding process. UHF terminated TL antennas have relatively low RF power efficiency in exchange for their spatial selectivity and thus, represent an improvement of energy conversion, and can be considered as a subject for further research.

Parts 1 and 2 of this series are available as PDF downloads from the Archives section of this magazine's Web site: www.highfrequencyelectronics.com

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