Manufacturing *RAYSPAN®* MTM Antennas

Using EZTune™ to Achieve Higher Design Efficiency

Dr. Gregory Poilasne, VP Business Development
email: Gregory@rayspan.com
Phone: 858 259 9596 ext 250
Website: www.rayspan.com

Abstract

Metamaterial antennas are increasingly gaining popularity among manufacturers designing and building wireless devices such as WiFi routers and cellular handsets. Improved OTA performance, reduced SAR values, and reduced BOM costs are only a few of the advantages to be gained through the use of metamaterial antennas. During the design process, the characteristics might be impacted by mechanical changes and other component placement adjustments. Tuning the antenna's resonant frequencies may require the PCB to be rebuilt and components to be remounted and retested. These are costly and lengthy steps for the wireless device manufacturers during the design and validation process. In order to mitigate the cost and risk, Rayspan has brought to market the proprietary *RAYSPAN®* EZTune™ metamaterial (MTM) antenna which can be re-tuned without the need to rebuild the PCB or remount components. The following paper describes the *RAYSPAN®* EZTune™ technology and gives an example of EZTune™ used in a dual band cellular phone.

1 – Introduction and Design Benefits of *RAYSPAN®* Metamaterial Antenna

Metamaterials (MTM) are manmade composite materials engineered to produce desired electromagnetic propagation behavior not found in natural media. They make possible unprecedented improvements in air interface integration, OTA performance and miniaturization while simultaneously reducing BOM costs and SAR values. MTMs enable physically small but electrically large air interface components, with minimal coupling among closely spaced devices.

MTM antenna structures are copper printed directly on the dielectric substrate and can be fabricated by using a conventional FR-4 substrate or a Flexible Printed Circuit (FPC) board.

When designed for cellular handsets, MTM antennas offer several benefits over conventional antennas. They are ultra-compact in size; and as thin as paper. In fact, MTM antennas are typically at least five times smaller than conventional antennas, or 1/10th of the signal's wavelength, while offering equal or better performance. Furthermore, unlike conventional three dimensional (3D) antennas, which must be designed, tooled and fabricated as a complex metal-and-plastic assembly, a MTM antenna is a simple two dimensional (2D) design in which copper artwork is printed directly on a handset's printed circuit board (PCB) using standard PCB manufacturing techniques. This offers manufacturers faster time to market and reduced BOM due to the simplified design and greatly reduced need for fabrication and assembly of antenna components.

MTM antennas can be made very broadband to support today's multiband wireless application requirements. A single MTM antenna can support all cellular frequency bands (from 700MHz to 2.7GHz), using single or multiple feed designs, which eliminates the need for antenna switches. Multi-band MTM functionality for global cellular connectivity covers both low-band frequencies including GSM/WCDMA/ HSPA/LTE (700/800/900 MHz) and high-band frequencies including DCS/PCS/ WCDMA/HSPA/LTE (1700/ 1800/1900/ 2100 MHz). Integration of GPS, Bluetooth, WiFi, and WiMax is also possible within the same antenna array without undesirable coupling, eliminating the need for multiple large external and internal antennas and associated decoupling circuitry.

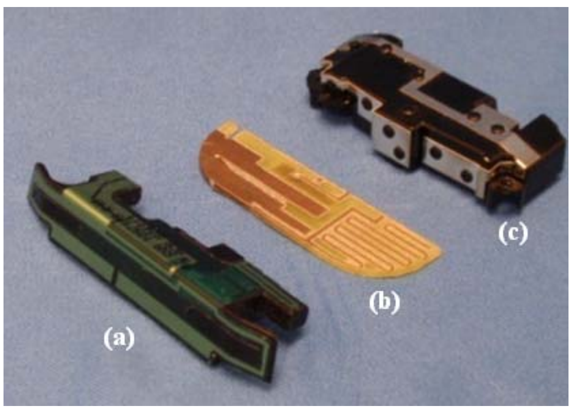

Figure 1-1 (a) F-PC flexible printed circuit, (b) MTM antenna printed on FR4, (c) Sheet metal on plastic carrier.

2 – MTM Antenna Structure

The MTM antenna is composed of four different physical parts: the Meander, the Monopole, the Cell and the Via Line. The basic antenna structure includes one or more cells that are fed by a feed line. The metamaterial cell includes a cell patch that is connected to the ground plane through a via line and via. A feed line is connected to the RF port or a coplanar waveguide (CPW) feed, delivering power from a signal source to the end of the feed line. A narrow gap is provided between the end of the feed line and the cell patch to electromagnetically couple these elements.

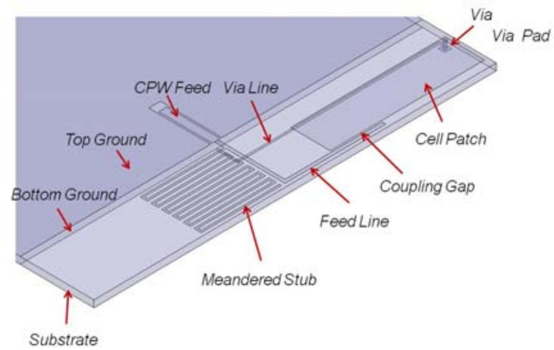

Fig. 2-1 3D Diagram of a typical MTM antenna structure

The resonant frequencies, matching of multiple modes and associated efficiencies can be controlled by changing the size of the cell patch, the length of the via line, the length of the feed line, the distance between the antenna element and the ground, and various other dimensions and layouts.

3 – *RAYSPAN®* EZTune™ Solution for Manufacturing Optimization

The integration of an antenna with an electronic circuit and plastic covers might change the antenna's characteristics. Once an antenna is integrated with the rest of the phone design, tuning the resonant frequencies may even require the PCB to be rebuilt and components to be remounted and retested. These are lengthy and costly steps for the manufacturer.

Rayspan's EZTune™ MTM antenna can be re-tuned by adding or removing electrical components, without the need to rebuild the PCB or remount components. With EZTune™, multiple tuning elements are added to the original structure to provide means for tuning the resonant frequencies.

Fine-tuning of the antenna design, prototyping, repair and other processes that may be necessary after the antenna is printed on the PCB can be simplified by use of these tuning elements. The EZTune™ technique involves coupling of one or more of the tuning elements to the corresponding antenna element by use of a connecting element such as a zero ohm resistor that acts as a bridge or by changing the value of an existing inductor. The resonant frequencies can be shifted lower or higher and the impedance can be adjusted without affecting their efficiencies by manipulating these tuning and connecting elements.

4 – Example of *RAYSPAN*® EZTune™ MTM antenna Tuning for Dual-band GSM900/DCS1800

Antennas are characterized by resonant frequencies, return loss and efficiency. The return loss (in dB) reflects the loss of power due to the reflected signal, and the higher the value, the better the antenna matching. A return loss better than -6 dB or -10 dB is the typical reference for cellular handsets and WiFi routers, respectively. The efficiency (in %) reflects the power actually radiated, and the higher the value, the better the efficiency. The efficiency takes into account losses due to mismatch, conduction and dielectric loss. The resonant frequencies are the frequencies around which the antenna receives and transmits the best.

The following figures show the baseline efficiency for a ***RAYSPAN*® EZTune™ MTM antenna** design for a dual-band GSM900MHz/DCS1800MHz before it is encased in the handset plastics.

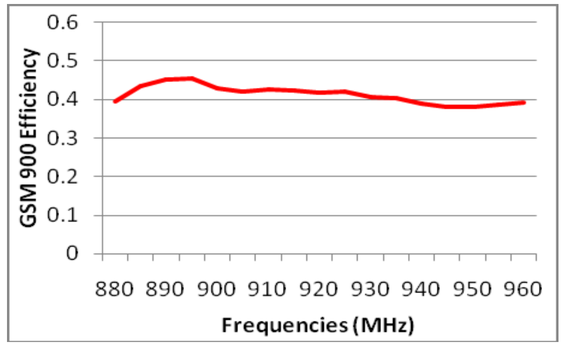

Fig 4-1 a. Baseline design efficience for GSM 900MHz

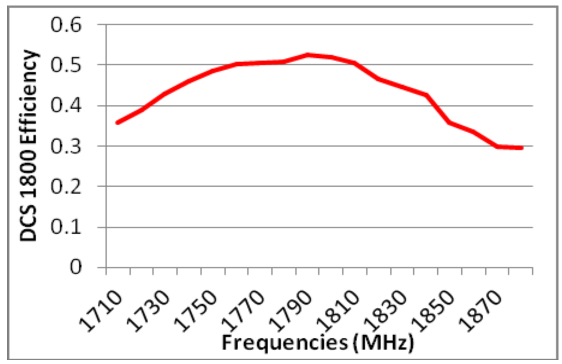

Fig 4-1 b. Baseline design effiency for DCS 1800MHz

In the example below, the MTM antenna has three resonances: two in the low band (F1 and F2), and one in the high band (F3). To ensure that all three resonances are at the right frequencies, the baseline antenna design includes the following EZTuneTM components: R3, R4, R5, R6, R9 at 0 Ω and L1=27 nH.

The following figures show the top and bottom layouts of the design.

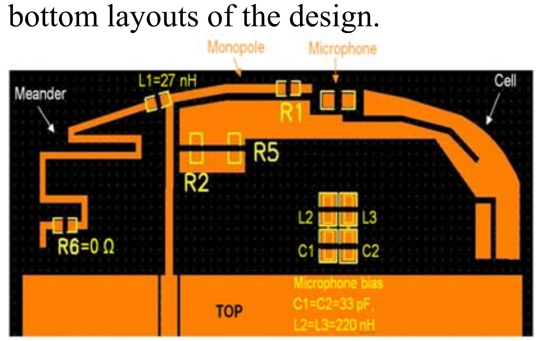

Fig. 4-2 a. Top view baseline MTM antenna

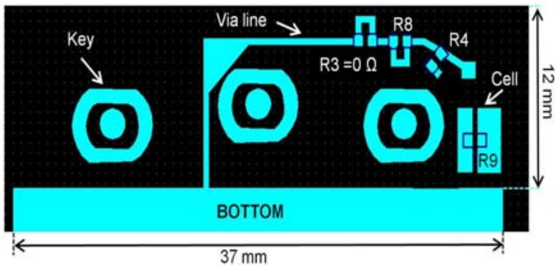

Fig. 4-2 b. Bottom view baseline MTM antenna

- The components on meander (R6 and L1) impact the low band 2nd resonant frequency, F2.
- The components on monopole R1 impact the high band resonant frequency, F3.
- The components on Cell (R5 and R9) impact the low band 1st resonant frequency, F1, and the high band resonant frequency, F3.
- The components on via line (R3, R4 and R8) impact F1 and F3.

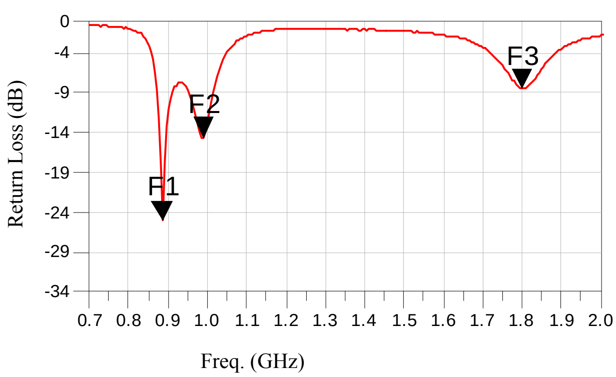

Fig. 4-3 Baseline design - Return loss and resonant frequencies

When the PCB is covered with a plastic case, it impacts the antenna's characteristics. F1 shifts 15MHz lower than the baseline, and F3 shifts 35MHz lower than the baseline, pushing both outside allowable parameters. The return loss is too high (around -3dB) in DCS Band and efficiency is too low in the upper edge of DCS Band.

The following figures show the impact of a plastic case on the baseline design.

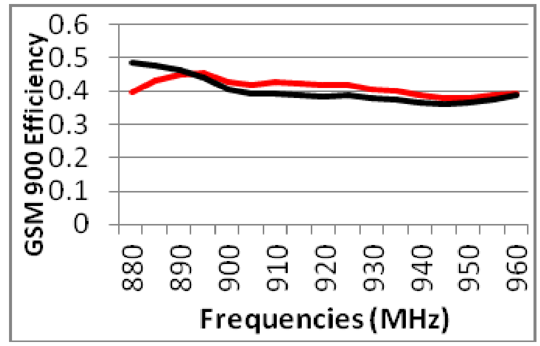

Fig. 4-4 a. GSM 900MHz efficiency with plastic case

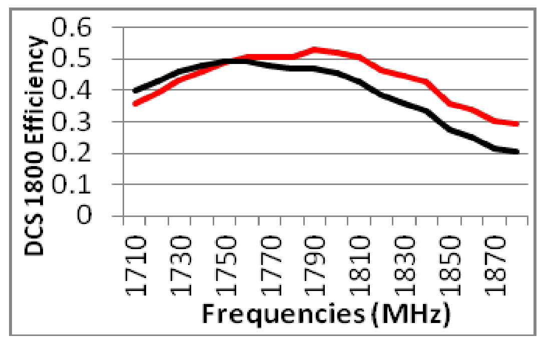

Fig. 4-4 b. DCS 1800MHz efficiency with plastic case

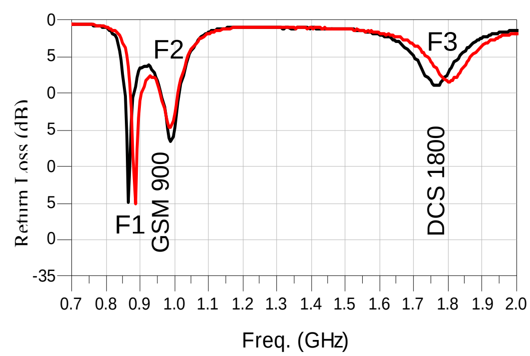

Fig 4-4 c. Return loss and resonant frequencies with plastic case

To bring the antenna back into compliance with the requirements of the device, F1 needs to be shifted higher by 15 MHz and F3 needs to be shifted higher by 35 MHz.

Because the antenna was designed using the EZTune™ method, there are built in resistors (R1 – R9) that can be removed to mitigate the impact of the plastics. By removing the resistor R9, F3 and F1 will shift up bringing the resonant frequencies back within the required parameters. The following graphs show the characteristics of the corrected antenna after removing R9.

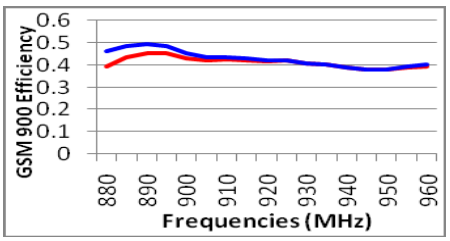

Fig 4-5 a. Efficiency at GSM900 for the corrected antenna

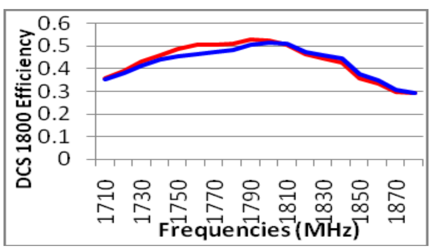

Fig 4-5 b. Efficiency at DCS1800 for the corrected antenna

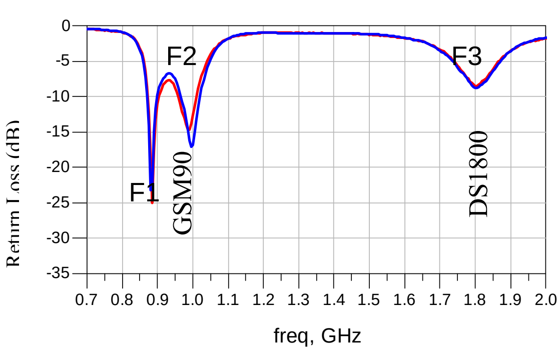

Fig 4-5 c. Return loss and resonant frequencies for the corrected antenna

5 – Conclusion: EZTune™ Achieves Higher Design Efficiency

RAYSPAN® EZTune™ MTM antennas offer several benefits over conventional antennas. They are ultra-compact in size while offering equal or better performance. The simple 2D structure offers manufacturers faster time to market and reduced BOM due to the simplified design and greatly reduced need for fabrication and assembly of antenna components. Improved OTA performance and reduced SAR values are other advantages to be gained through the use of MTM antennas.

MTM antennas allow for unprecedented flexibility in PCB layout and sleek handset design. Design-in for MTM antennas is straightforward and fast, usually requiring no more than two weeks to a month.

Thanks to EZTune™ the need to make last minute mechanical or PCB design changes at the device development/characterization stage is virtually eliminated.

