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Vertically Polarized Omnidirectional Printed Slot Loop Antenna

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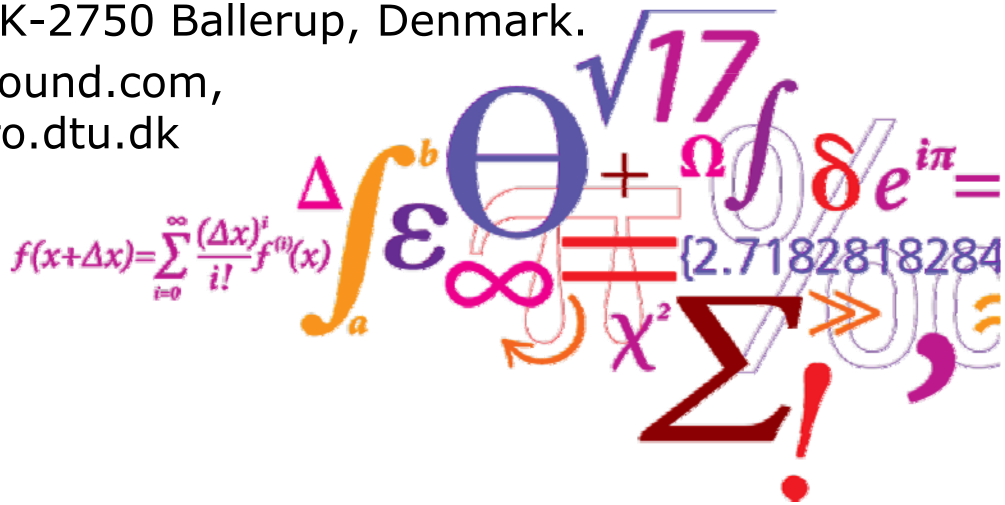

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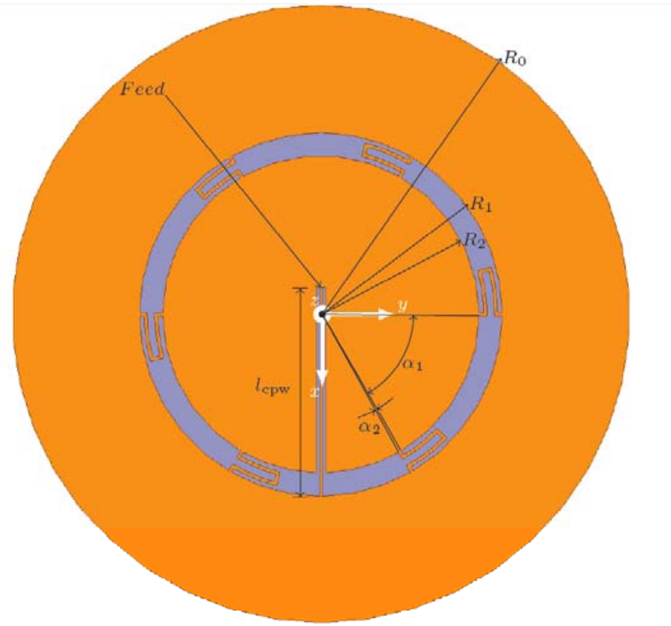
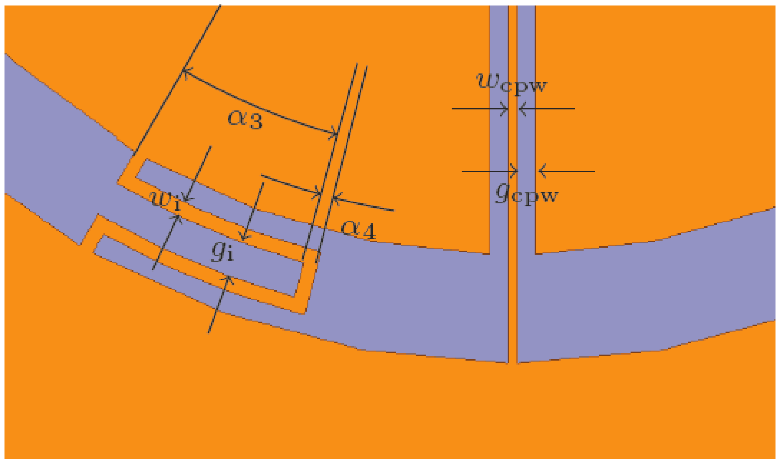
Abstract

A novel vertically polarized, omnidirectional, printed slot loop antenna has been designed, simulated, fabricated, and measured. The slot loop works as a magnetic loop. The loop is loaded with inductors to insure uniform and in-phase fields in the slot in order to obtain an omnidirectional radiation pattern. The antenna is designed for the 2.45 GHz Industrial, Scientific and Medical band. Applications of the antenna are many. One is for on-body applications since it is ideal for launching a creeping waves due to the polarization.
Keywords: Babinet's principle, inductive loading, on-body, polarization, slot antenna





Dimensions

OPTIMIZED ANTENNA DESIGN PARAMETERS

Parameter	Value
g_{cpw}	0.50 mm
g_{i}	1.0 mm
l_{cpw}	27 mm
N	6
R_0	40 mm
R_1	23.5 mm
R_2	20.5 mm
w_{i}	0.40 mm
w_{cpw}	0.25 mm
α_1	59°
α_2	1.0°
α_3	14.5°
α_4	1.0°

Introduction

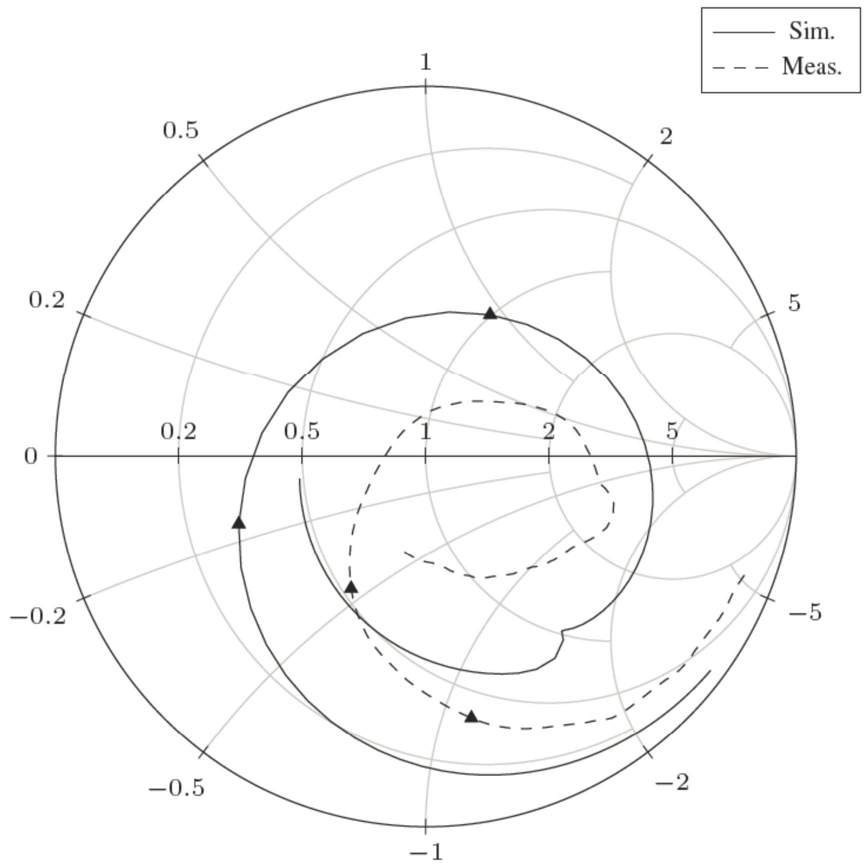
The number of applications for Wireless Body Area Networks (WBAN) has increased rapidly in recent years. The ever smaller electronics enable these applications, which at the same time call for improved antennas. Many of the applications are designed for the worldwide and license free Industrial, Scientific, and Medical (ISM) band at 2.45 GHz. Propagation at 2.45 GHz through the human body is very lossy [1]. Instead, the electromagnetic energy creeps around the human body [2]. It has been shown that when the polarization of the electrical field is perpendicular to the surface of the human body, it is far more efficient in launching creeping waves [3]. The inspiration for the antenna originates from the antenna found in [4], which is an electric loop antenna. The antenna in [4] is horizontally polarized and thus gives a parallel polarization if placed flat on the human body. By the use of Babinet's principle with Booker's extension as found in [5] it is seen that by interchanging the areas covered with copper with those not covered by copper, the polarization can be change to vertical. The impedance of the complimentary antenna is [5]:

$$Z_{\text{magnetic}} = \frac{\eta^2}{Z_{\text{electric}}},$$

where Z_{electric} is the impedance of the original antenna and η is the intrinsic impedance of the media in which the antenna is placed. Since this results in a too large impedance for the complimentary antenna, the antenna design in [4] has been modified.

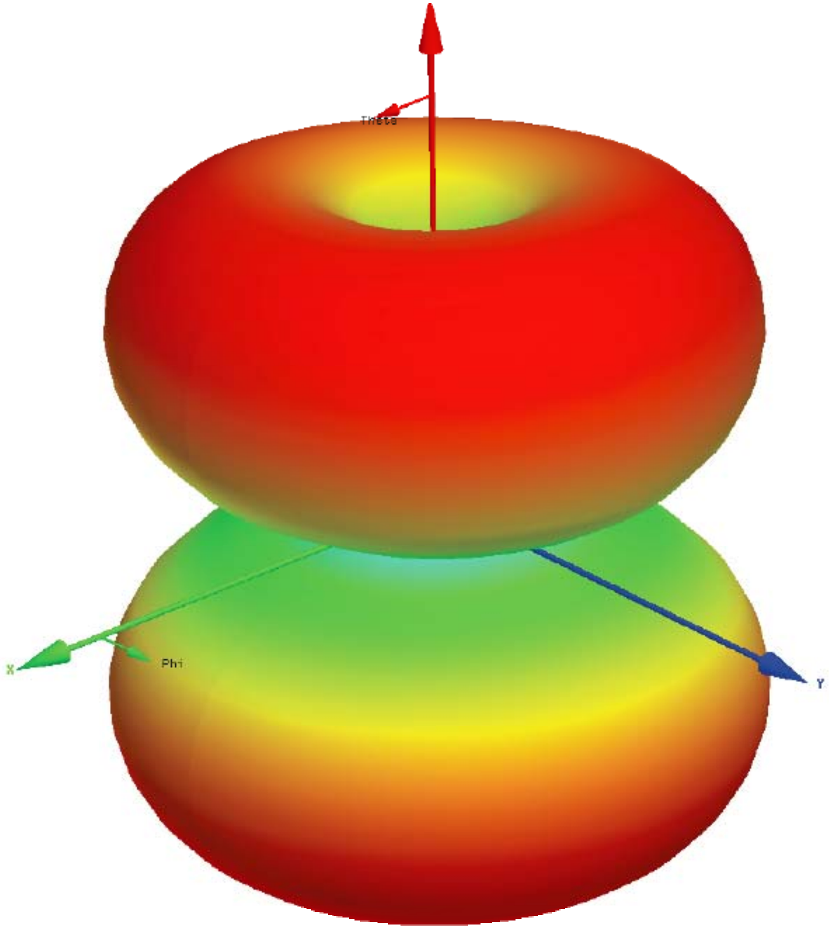
Simulation and Measurement Results (1)

The simulated and measured reflection coefficient between 2 GHz and 3 GHz can be seen in the Smith chart. At 2.45 GHz the magnitude of the simulated and measured reflection coefficient is −8.54 dB and −5.15 dB, respectively. The simulated and measured 6-dB bandwidth is 100 MHz and 285 MHz, respectively. As seen the simulated antenna is well matched for the 2.45-GHz ISM band as intended where as the measured antenna is shifted to a center frequency at 2.54 GHz.



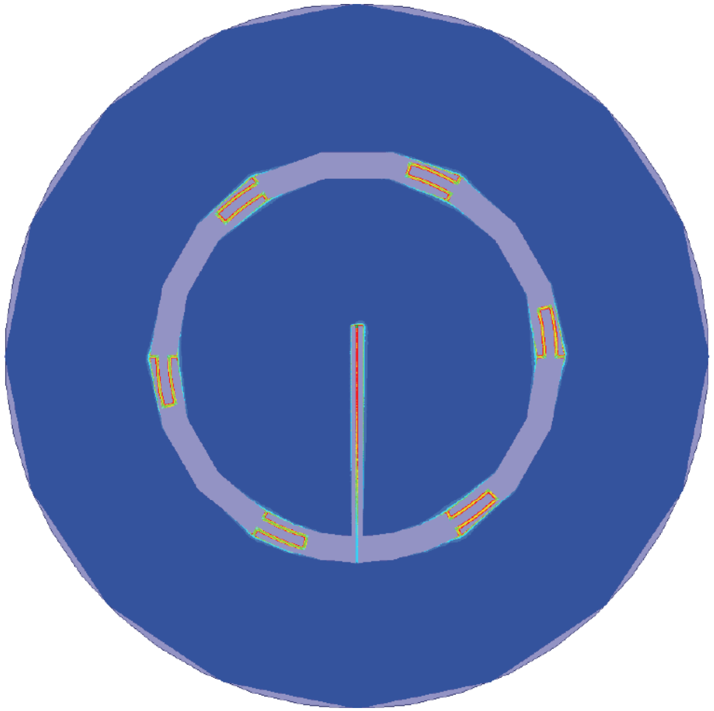
Simulation and Measurement Results (2)

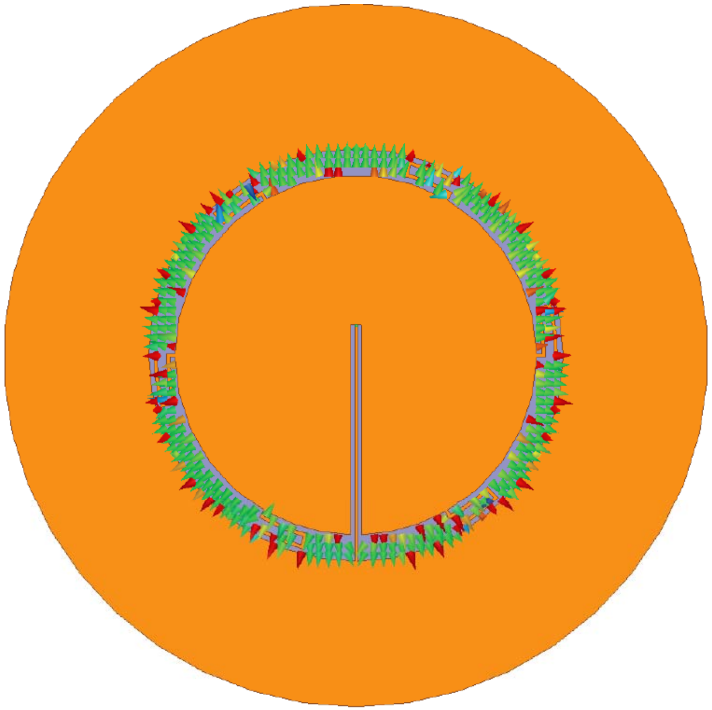
The simulated radiation pattern at 2.45 GHz can be seen. The peak gain is 1.9 dBi and the radiation efficiency is 71.0 %. It is seen that the radiation pattern is not that of a small magnetic loop antenna. The difference is the null in the XY-plane. This is caused by the truncation of the copper plane. The antenna is almost completely θ-polarized with a peak gain for the θ-component and the φ-component of 1.9 dBi and −10.9 dBi, respectively.



Simulation and Measurement Results (3)

The simulated complex magnitude of the surface currents on the antenna can been seen at the bottom (left). It is seen that each of the inductors carry approximately the same current on them. The simulated electric field in the slot is shown at the bottom (right). The field is plotted as vectors at the phase where it is at a maximum.





Conclusion

A novel vertically polarized, omnidirectional, printed slot loop antenna has been successfully designed, simulated, fabricated, and measured. The antenna is designed for the ISM band at 2.45 GHz. The polarization of the antenna and the omnidirectional radiation pattern is obtained by loading the slot with inductors to insure a uniform electric field in the slot. This makes the antenna behave like a small slot loop. Due to the polarization it is suitable for on-body applications. The antenna is well matched in the entire ISM band. The antenna is almost completely θ-polarized. The peak gain is 1.9 dBi and the efficiency 71.0 %. If needed, it is possible to further reduce the size of the antenna, e.g., for smaller applications. One way to do this is to reduce the size of the loop, while the inductance of the shunt inductors are increased.

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