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Improvements of antenna's gain using grounded and ungrounded metamaterials

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ABSTRACT – This paper presents the performances enhancement of horn-shaped antenna with grounded and ungrounded metamaterials. The antenna and metamaterials structures were printed on 0.254 mm thickness of RT/Duroid 5880 high frequency laminate. The performances of the antenna with and without grounded and ungrounded metamaterials were evaluated. The metamaterials were positioned at the back of the antenna with 6 mm air gap. The antenna works at 12 GHz, shifted to 11.92 GHz, 12.82 GHz and 11.73 GHz as worked with grounded, ungrounded and stack structure work respectively. The horn-shaped antenna is incorporated with stack of grounded and ungrounded structures which resulted in a gain enhancement from 4.43 dB to 9.73 dB. The antenna with grounded and ungrounded metamaterials can reduced the radiation that penetrates into human body.

1. INTRODUCTION

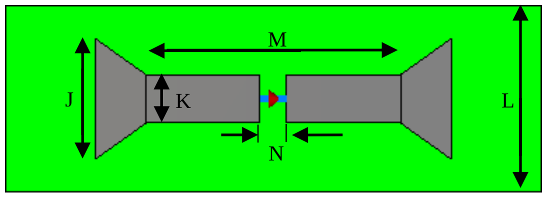
Research in wideband and flexible antennas have received remarkable interest. Design of small, light-weight and conformable antennas. Thus retain a good radiation efficiency and at the same time support large enough bandwidth to accompany the requirements of high data rates in modern communication systems are certainly more desirable and have become increasingly studied [1-2].

Antennas can experience performance degradation, i.e. frequency detuning, bandwidth reduction and radiation distortions when placed on human body [5,6]. Moreover, the radiation that penetrates into the human cells is a major health concern [7]. Metamaterials such as AMC and FSS were first used due to its ability to increase gain [8-9]. The materials were found to reduce radiation exposure [10-14].

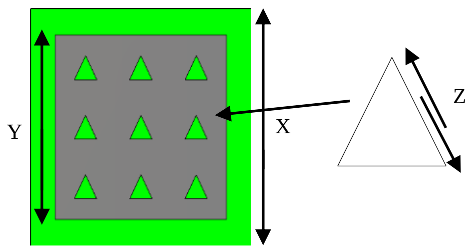
This paper presents the performance evaluation of the grounded and ungrounded metamaterials horn-shaped antenna. The structures were printed on RT/Duroid 5880 with 0.254 mm thickness. The antenna's initial frequency was 12GHz. When grounded, ungrounded and stack structure was incorporated the frequency shifted to 11.92GHz, 12.82 GHz and 11.73 GHz respectively. The realized gain of the horn-shaped antenna was 4.43 dB. It was enhanced to 9.73 dB when the antenna ws incorporated witk grounded and ungrounded structures.

2. METHODOLOGY

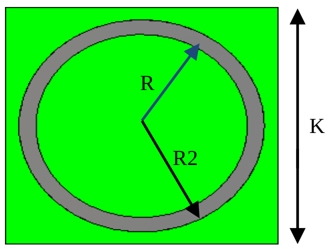
Figure 1(a) shows the structure of the horn-shaped antenna. The horn-shaped antenna is symmetrical on both left and right sides and connected with 50 Ω SMA connector. A unit cell of grounded and ungrounded metamaterials with triangular and ring shapes are shown in Figure 1(b) and Figure 1(c) respectively.



(J=9.04 mm, K=3.62 mm, L=14 mm, M=18.96 mm, N=2 mm)
(a)



(X=10 mm, Y=7.79 mm, Z=1 mm)
(b)



(K=10 mm, R1=3.88 mm, R2=4.50 mm)
(c)

Figure 1 (a) horn shaped antenna, (b) grounded and (c) ungrounded.

3. RESULTS AND DISCUSSION

Figure 2 plots the reflection phase for grounded metamaterials and the reflection and transmission coefficient for ungrounded metamaterials. The grounded structure operates at 12 GHz, where the reflection phase is varied from -180° to 180°. Based on ±90° of reflection phase, the useful bandwidth is 3.75%. The reflection magnitude of the grounded structure is -0.57 dB ≈ 0.94.

Meanwhile, the reflection of ungrounded metamaterials is around -0.03 dB, which can be approximated to zero, whereas the transmission is around -48.46 dB. Hence contributes to 8.06 GHz bandwidth, which is around 67.16%.

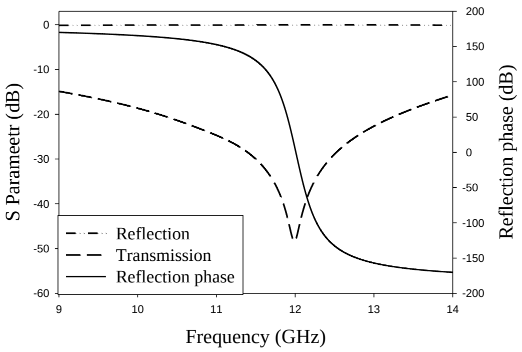


Figure 2 Reflection phase of grounded, reflection and transmission coefficient of ungrounded

The changes in return loss of the antenna operating with both grounded and ungrounded mematerials are shown in Figure 4. The antenna's frequency was shifted from 12 GHz to 11.92 GHz, 12.82 GHz and 11.73 GHz when grounded, ungrounded and stack structure respectively, was used. The realized gain of the horn-shaped antenna with grounded and ungrounded structures was increased from 4.43 dB to 9.73 dB

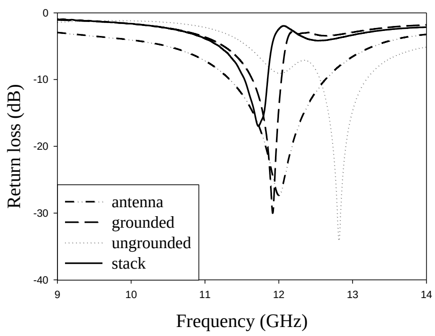


Figure 3 Return loss of antenna alone and with grounded, ungrounded and stack.

4. CONCLUSIONS

Incorporating grounded, ungrounded and stack structures to the antenna shifted the antenna's frequency. While the gain in the grounded and ungrounded structures increased. The antenna with grounded and ungrounded metamaterials reduces the emission of radiation that penetrates into human as on body applications

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REFERENCES

[1] Moradi, E., Kosk, K., Hasani, M. and Ukkonen, L. (2015). Antenna Design Considerations for Far Field and Near Field Wireless Body-Centric Systems. *Computational Electromagnetics* 59–60.

[2] Jiang, Z. H. Brocker, D. E. Sieber, P. E. and Werner, D. H. (2014). A Compact, Low-Profile Metasurface-Enabled Antenna for Wearable Medical Body-Area Network Devices. *IEEE Transaction on Antennas and Propagation* 4021–4030.

[3] Choi, J. (2014). Low-Profile Antennas for On-Body Surface Communications. *International Workshop on Antenna Technology* 288–291.

[4] Cure, D. (2014). Study of a Flexible Low Profile Tunable Dipole Antenna Using Barium Strontium Titanate Varactors. *The 8th European Conference on Antennas and Propagation (EuCAP)* 31–35.

[5] Dewan, R. Rahim, S. K. A. Ausordin, S. F. D. Zaidel, N. A. Sa'ad, B. M. and Purnamirza, T. (2014). Bandwidth Widening, Gain Improvement and Efficiency Boost of an Antenna using AMC Ground Plane. *Jurnal Teknologi* 2180-3722.

[6] Liu*, N.* (2013). Design of a Miniaturized Ultra-wideband Compound Spiral Antenna. *Microwave Technology & Computational Electromagnetics* 255-258.

[7] Kamardin, K. Rahim, M. K. A. and Hall, P. S. (2015). Textile Diamond Dipole and Artificial Magnetic Conductor Performance under Bending, Wetness and Specific Absorption Rate Measurements. *Radio Engineering* 729–738.

[8] Abu, M. H. Hassan, Zin, M. S. I. M. Ali, S. A. M. (2016). Design of single-band geometric pattern artificial magnetic conductor. *ARPN Journal of Engineering and Applied Sciences*.

[9] Munawwar, R. F. Abu, M. Ali, S. A. M. (2016) "8 connected brances AMC-EBG and FSS for circle connected dipole at 5.8 GHz. *International Journal of Applied Engineering Research* 6932-6939.

[10] Ali, S. A. M. Abu, M. and Hassan, H. (2016). Dipole antenna backed by 8-CBU AMC-EBG and 8 CBU FSS at 5.8 GHz. *Journal of Telecomunication, Electronic and and Computer Engineering (JTEC)* 108-114.

[11] Ali, S. A. M. Abu, M. Mohammad, N. R. M. Muhamad, and Hassan, H. (2015). Flexible-dipole antenna incorporated with flexible frequency selective surface. *ARPN Journal of Engineering and Applied Sciences* 5054-5059.

[12] Muhamad, M. Abu, M. Zakaria Z. and Hassan, H. (2017). Novel Artificial Magnetic Conductor for 5G Application. *Indonesian Journal of Electrical Engineering and Computer Science.*

[13] Nafe, M. Syed, A. and Shamim, A. (2015). Gain Enhancement of Low Profile On-chip Dipole Antenna via Artificial Magnetic Conductor at 94 GHz. *Antennas and Propagation*.

[14] Ram Krishna V. S. and Kumar R. (2015). Slotted ground microstrip antenna with FSS reflector for high-gain horizontal polarization. *Electronics Letters.*