Australian Journal of Basic and Applied Sciences, 8(4) Special 2014, Pages: 720-725

AENSI Journals
Australian Journal of Basic and Applied Sciences
ISSN:1991-8178

Journal home page: www.ajbasweb.com

Investigation of A Square Loop FSS on Hybrid Material

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ARTICLE INFO

Article history:
Received 20 November 2013
Received in revised form 24 January 2014
Accepted 29 January 2014
Available online 5 April 2014

Keywords:
Frequency Selective Surface (FSS); Hybrid; ISM; Reflection; Transmission

ABSTRACT

The design FSS structure consists of FSS structures placed on the FR4 and glass. The square loop FSS is designed and simulated using the CST Microwave Studio software at 2.4 GHz based on industrial, scientific and medical bands (ISM) standard. The reflection (S11) and transmission (S21) of the design FSS structure is analyzed based on the six types of configuration that have been set up. The hybrid material (FR4 and glass) effect the transmission and reflection signal of the FSS. The highest efficiency is 88.1% by using configuration 1. The frequenycy response of the FSS is shifted to the lower part when the hybrid materials are used. So, the size of the FSS can be reduced by using hybrid materials to achieve the frequency response needed.

To Cite This Article: Md. Shukor,M.Z.A. Abd. Aziz, H. Nornikman, B.H. Ahmad, M.K. Suaidi, M.F. Johar, M.A. Othman, S.N. Salleh, F.A. Azmin, M.F. Abd. Malek., Investigation of A Square Loop FSS on Hybrid Material. ***Aust. J. Basic & Appl. Sci.***, *8(4): 720-725, 2014*

INTRODUCTION

Metamaterials have properties that may not be found in nature. It gains its properties not from their composition but from their designed structures. It consists of periodic structure and subwavelength characteristic which particle smaller than the light wavelength with which it interacts. Others are structured that exhibit the subwavelength characteristics are Frequency Selective Surface (FSS) or also known as Artificial Magnetic Conductor (AMC) or High Impedance Surface (HIS) (Bayatpur F, 2009). FSS is a planar periodic structure of the identical array of patch or aperture type elements arranged in one or 2D plane. FSS have inherent inductive and capacitive properties that useful in designing to get a desired frequency response. Its filtering characteristic is depending on the array element type (Langley R. J *et al*., 1982).

The frequency behavior of the FSS is entirely determined by the geometry of the surface in one period (unit cell), the size of the FSS, the way the surface is exposed to the electromagnetic wave (incidence angle of the incoming wave), substrate parameters, inter-element spacing and materials used (Sakran F, 2008). Previous work has been done on the FSS structure for single materials such as glass, Rogers, biased ferrite substrate and so on (I. Ullah *et al*., 2011). This paper proposed the investigation of the FSS on two materials (hybrid) to observe the performance of the FSS.

2. FSS Design:

The unit cell geometry of the proposed design FSS structure which consists of square loop that etched on the dielectric substrate as shown in Fig. 1. Fig. 1 also shown the unit cell of the square loop FSS. The FSS is made up of copper with thickness 0.035 mm. In this paper the FSS is etched on the FR4 board (210 mm × 210 mm). The two materials of dielectric substrate have been used in this paper which is FR4 board and glass. The dielectric constant of FR4 is 4.4 and a tangent loss of 0.019 with a thickness of 1.6 mm while the glass dielectric constant is 6.9 and conductivity is 5×10^{-4} S/m with thickness of 5 mm. The square loop FSS is chosen in this paper because of the design gave the lowest transmission losses at -0.55 dB at 2.4 GHz compared to others designed. The design chosen is based on the targeted frequency response.

The unit cell geometry of the proposed design FSS structure is designed and simulated by using CST Microwave Studio at 2.4 GHz. The simulation setup of the design FSS structure is as in (M.Z.A. Abd. Aziz *et al*., 2013).

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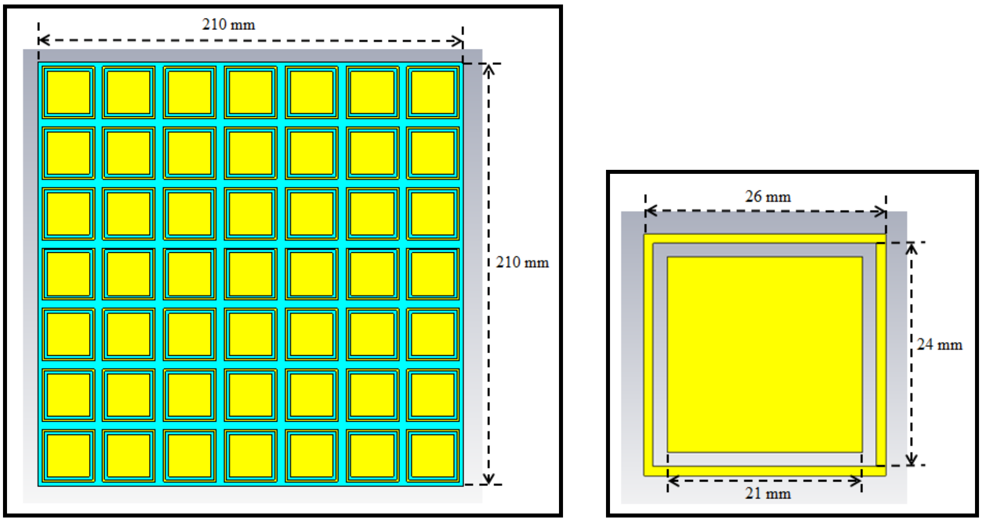

Fig. 1: Geometry of the design FSS structure (a) square loop FSS (7 × 7) (b) unit cell square loop FSS.

FSS hybrid materials:

There are six types of configurations that will be investigated in this paper based on two materials (FR4 and glass) as shown in Fig. 2. The dielectric constant of FR4 is 4.4 and a tangent loss of 0.019 with a thickness of 1.6 mm while the glass dielectric constant is 6.9 and conductivity is 5×10^{-4} S/m with thickness of 5 mm. The square loop FSS is etched on the FR4 board. Then the glass is placed at the back of the FR4 board and on the square loops FSS.

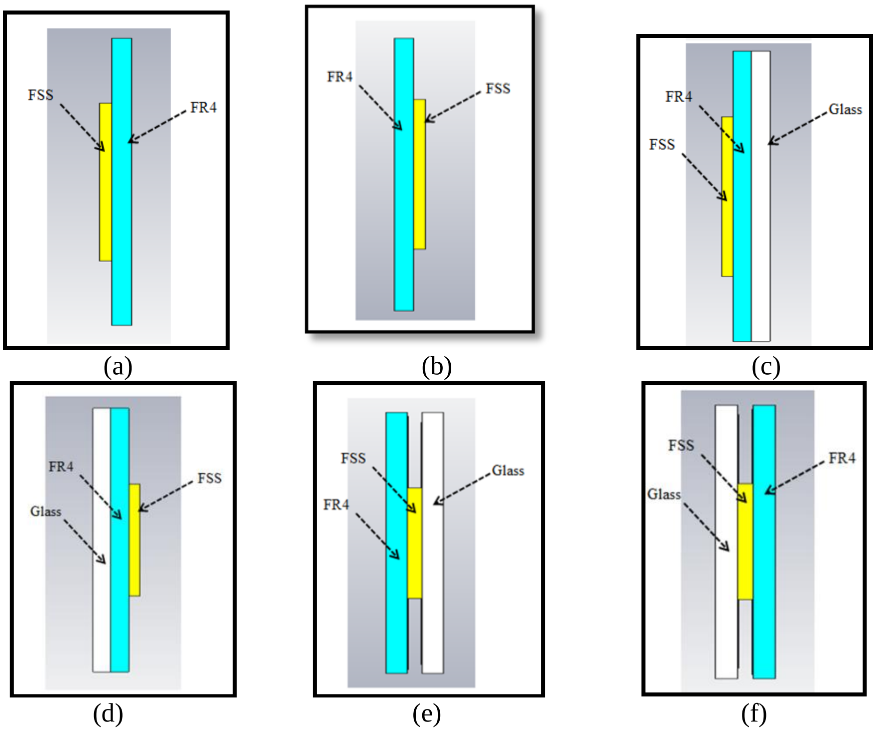

Fig. 2: Design FSS structures from side view (a) configuration 1 (b) configuration 2 (c) configuration 3 (d) configuration 4 (e) configuration 5 (f) configuration 6.

3. Measurement Setup:

Fig.3 shows the measurement setup for design square loop FSS structure (7×7). This measurement setup is for all six types of configurations. Two horn antennas are used as the receiver and the transmitter. Both antennas are connected to the Network Analyzer. Antenna at the transmitter is connected to port 1 and antenna at the receiver is connected to port 2 of Network Analyzer. The distance of the design square loop FSS structure from both antennas is 130 mm. The design square loop FSS structure is placed between both horn antennas. The reflection and transmission results are measured to observe the performance of the FSS. The prototype of the design square loop FSS structure (7×7) is shown in Fig. 4.

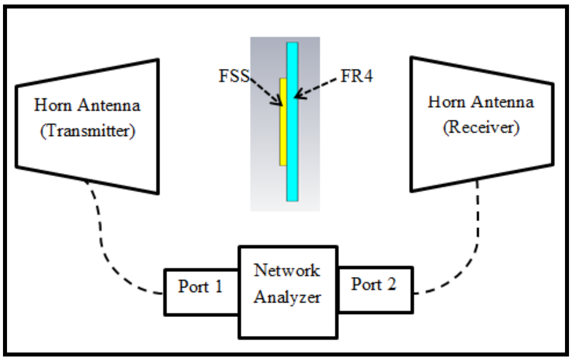

Fig. 3: Measurement setup showing the design square loop FSS structure positioned between two horn antenna.

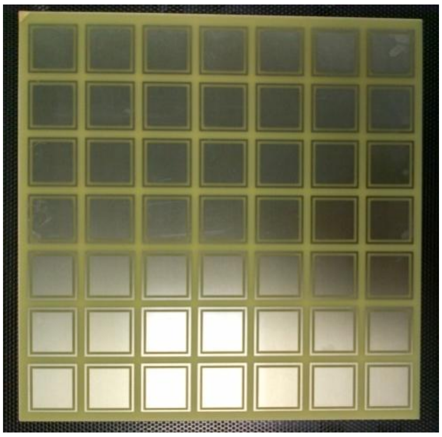

Fig. 4: Square loop FSS prototype.

RESULT AND DISCUSSION

Simulation results:

All configurations are simulated with the same size of the design square loop FSS structure. Fig. 5 and 6 are shown the simulation results for the reflection and transmission of the square loop FSS for all configurations as shown in Table 1. The return loss has big changes in the range of 16 to 18 dB. The transmission losses also effected but in a small range of 2 to 7 dB compared to the return loss. The highest return loss and efficiency are -18.72 dB and 88.1% by using configuration 1 while the lowest return loss and efficiency are -0.88 dB and 17.2% by using configuration 4 and 5. From the results, the frequencies are shifted to the lower part when using hybrid materials. This is shown that the hybrid material can shift the frequency and led to the compact structure. The proposed algorithms were implemented in a TMS320F28335 DSP and the system setup is shown in Fig. 6.

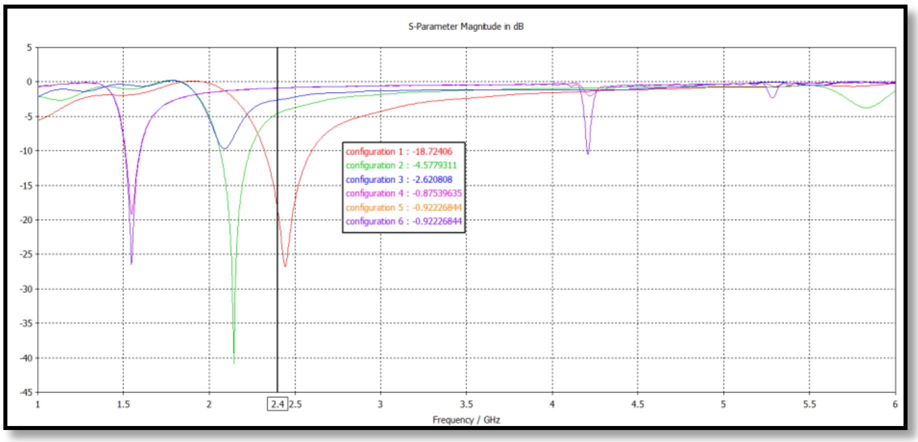

Fig. 5: Simulated reflection (S11) results of the design FSS structure for each configuration.

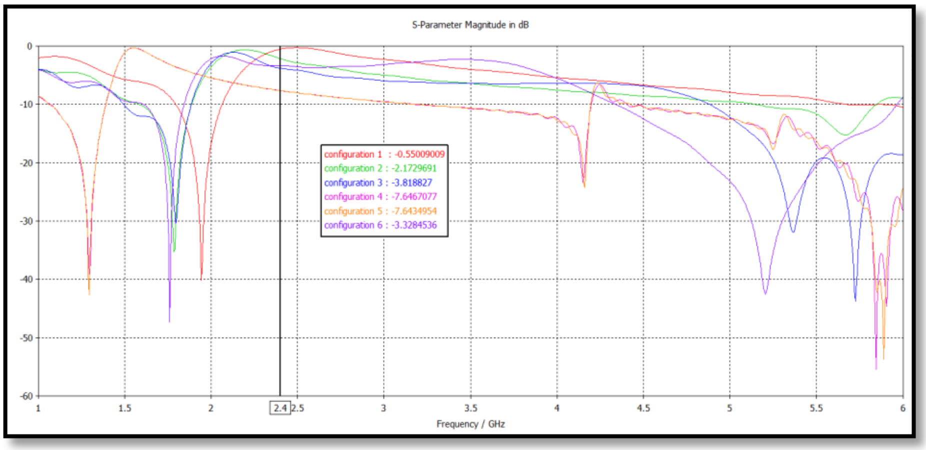

Fig. 6: Simulated transmission (S21) results of the design FSS structure for each configuration.

Table 1: Comparison Of Simulated S11 And S21 Results Between All Configurations At 2.4 GHz.

Configuration	S11(dB)	S21(dB)
1	-18.72	-0.55
2	-4.58	-2.17
3	-2.62	-3.82
4	-0.88	-7.65
5	-0.92	-7.64
6	-0.92	-3.33

Measurement results:

Fig. 7 and 8 are shown the measurement results for the reflection and transmission of the design square loop FSS structure for all configurations. Table 2 is shown the S11 and S21 results for all configurations. The measurement results are tally with the simulation results but the different is due to the transmission losses. The transmission losses are higher due to the measurement environment such as air, temperature and so on. The transmission losses different is about 5.65%. From the results, the transmission and reflection are effected when hybrid materials are used. The return loss decreases about 4 dB while the transmission loss is increased about 3 to 4 dB.

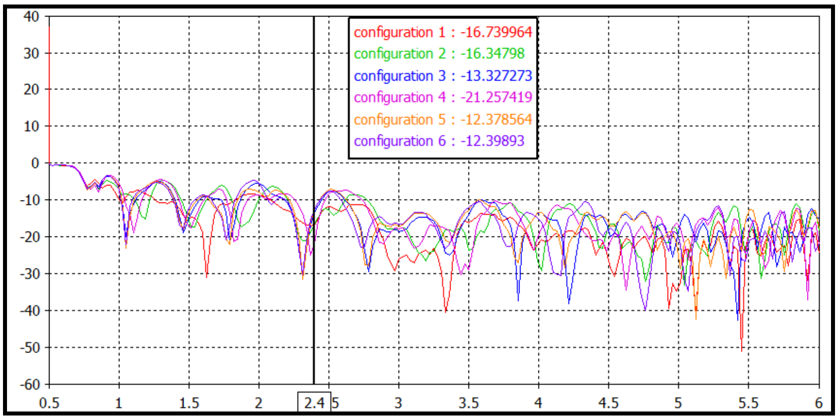

Fig. 7: Measured reflection (S11) results of the design FSS structure for each configuration.

Table 2: Comparison Of Simulated S11 And S21 Results Between All Configurations At 2.4 GHz.

Configuration	S11(dB)	S21(dB)
1	-16.74	-13.03
2	-16.35	-13.27
3	-13.33	-16.42
4	-21.26	-16.44
5	-12.38	-14.56
6	-12.40	-16.54

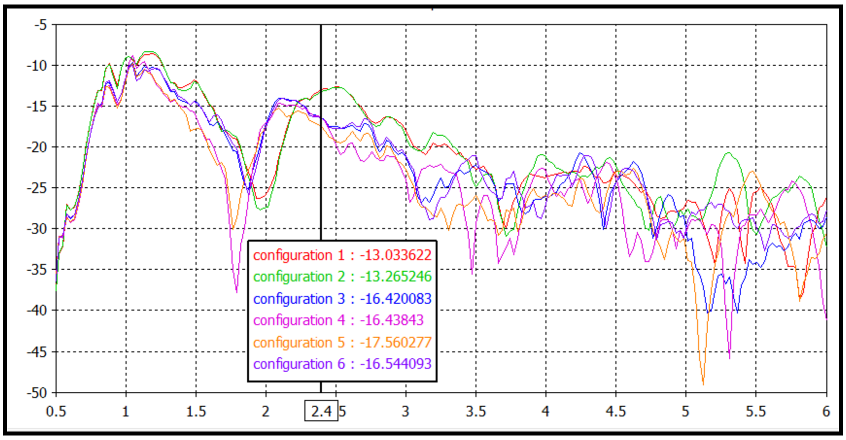

Fig. 8: Measured transmission (S21) results of the design FSS structure for each configuration.

Conclusion:

The design FSS structure of square loop FSS (7×7) is designed and simulated in this paper at 2.4 GHz. Two materials of dielectric substrate which are FR4 board and glass have been used to produce hybrid materials. The effect of this hybrid materials are observed based on the reflection and transmission of the design FSS structure. There are six types of hybrid configurations have been studied in this paper. There are also effects of the return loss and transmission signal by using hybrid which led to the compact structure. So, future work is needed to reduce the size of the FSS so that the cost of the project can be reduced. This design can be used for material scanning based on the material properties.

AKNOWLEDGEMENT

The authors would like to thank UTeM and NSG (Malaysia) Sdn. Bhd. for their support in obtaining the information and material in the development of our work and we also want to thank anonymous referees whose comments led to an improved presentation of our work. Lastly we also thank the Ministry of Higher Education for MTUN/2012/UTeM-FKEKK/5 M00013 research grant.

REFERENCES

A Book: M. Young The Technical Writer’s Handbook Mill Valley. CA: University

A Book: Munk, B.A., 2000. Frequency Selective Surfaces-Theory and Design. John Wiley and Sons, Inc., New York.

A Book: Pozar, D.M., 2005. Microwave Engineering. 3rd edition. United States: John Wiley & Sons, Inc.

A Book: Wu, T.K., 1995. Frequency Selective Surfaces and Grid Array. John Wiley and Sons, Inc., New York.

A Report: Mias, C., C. Tsakonas and C. Oswald, 2001. An investigation into the feasibility of designing frequency Selective windows employing periodic structures, Ref. AY3922, Tech. Rep., Final Report for the Radio-Communications Agency, Nottingham Trent University, Ref. AY3922.

A Thesis: Bayatpur, F., 2009. Metamaterial-Inspired Frequency-Selective Surfaces, thesis, The University of Michigan.

Conference Proceedings: M.Z.A. Abd. Aziz, M. Md. Shukor, M.K. Suaidi, B.H. Ahmad, M.F. Johar, F.A. Azmin, S.N. Salleh, M.F. Abd. Malek, 2013. Impedance Modeling for a Unit Cell of the Square Loop FrequencySelective Surface at 2.4 GHz. In the proceedings of The International Conference on IEEE RFID Technical and Application (IEEE RFID 2013).

Conference Proceedings: I. Ullah, D. Habibi and G. Kiani, 2011. Design of RF/Microwave efficient building using frequency selective surface. In the proceedings of the 2011 IEEE 22nd International Symposium on Personal Indoor and Mobile Radio Communications, pp: 2070-2074.

Conference Proceedings: M.Z.A. Abd. Aziz, M. Md. Shukor, M.K. Suaidi, 2013. Phase Shift Of The Transmission Coefficients For Frequency Selective Surfaces. In the proceedings of 6th International Conference on Information Technology (ICIT'13).

Conference Proceedings: Sung, G.H., K.W. Sowerby and A.G. Williamson, 2005. Equivalent circuit modelling of a frequency selective plasterboard wall. In the proceedings of IEEE Antennas and Propagation Society International Symposium, pp: 400-403.

Conference Proceedings: Y. Liu, Q. Ye, B. Xiao and H. Yang, 2010. A novel application of frequency selective surface in dual-band WLAN antenna. In the proceedings of Isape, pp: 512-514.

Journal Articles: Bardi, I., R. Remski, D. Perry and Z. Cendes, 2002. Plane wave scattering from frequency-selective surfaces by the finite-element method. Journal of IEEE Transactions on Magnetics, 38(2): 641-644.

Journal Articles: D. Wang, W. Che, S. Member, Y. Chang, K. Chin, Y.L. Chow and L. Member, 2013. A Low-Profile Frequency Selective Surface With Controllable Triband Characteristics, 12: 468-471.

Journal Articles: Dubrovka, R., J. Vazquez, C. Parini and D. Moore, 2006. Equivalent circuit method for analysis and synthesis of frequency selective surfaces. Journal of Microwave Antennas Propagation, 153(3): 213-220.

Journal Articles: Kominami, M., H. Wakabayashi, S. Sawa and H. Nakashima, 1994. Scattering from a periodic array of arbitrary shaped elements on a semi-infinite substrate. Journal of Electronics and Communications in Japan (Part I: Communications), 77(1): 85-94.

Journal Articles: Langley, R. J. and E.A. Parker, 1982. Equivalent circuit model for arrays of square loops. Journal of Electronic Letters, 18(7): 294-296.

Journal Articles: Lee, C.K. and R.J. Langley, 1985. Equivalent-circuit models for frequency-selective surfaces at oblique angles of incidence. Journal of IEEE, 132(6): 395-399.

Journal Articles: Liu, H.T., H.F. Cheng, Z.Y. Chu, *et al*., 2007. Absorbing properties of frequency selective surface absorbers with cross-shaped resistive patches. Journal of Material Design, 28: 2166-2171.

Journal Articles: R.J.L. and E.A.P.T.K. Chang, 1994. Frequency selective surfaces on biased ferrite substrates, 30(75): 3-4.

Journal Articles: Sakran, F. and Y. Neve-Oz, 2008. Absorbing frequency-selective-surface for the mm-wave range. Journal of IEEE Transactions on Antennas and Propagation, 56(8): 2649-2655.