The Investigation of Lateral and Angular Misalignment in the New Witricity Device

M. H. M. Salleh[1], N. Seman[1] and J. Din[2]
[1]Wireless Communication Centre (WCC), Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia
[2] Communication Engineering Department, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia
eday_89@yahoo.com, huda@fke.utm.my and jafri@fke.utm.my

***Abstract* – The design of the Witricity device is shown in this paper and its lateral and angular misalignment are investigated. The device, which includes transmitter and receiver, has identical design purposely to resonate at a same frequency range. The coupling efficiency degrades as the lateral and angular misalignments are increased. The Witricity device is able to transfer power efficiently at 2 cm distance with lateral and angular misalignment of 10 mm and 25^0, respectively.**

***Index Terms* — Contactless power transfer, magnetic resonance coupling; wireless; Witricity**

I. INTRODUCTION

In line with the technological developments, people tend to own a gadget or device featured by small, fast, accurate, portability and energy-efficient characters. These features are parts of achieving fifth generation (5G) technology that will be deployed beyond 2020, which emphasize a fast data transmission. Thereby, the new smaller Witricity (wireless electricity) device compared to other Witricity devices such in [1-4] is required. The Witricity device is using the magnetic resonant technique in transferring energy. Where, the transmitter and receiver are strongly coupled at certain resonant frequency [5], which the power can be efficiently transferred. This efficient power transfer is also expected when the misalignment happened to the position of transmitter and receiver. Therefore, it is significant to investigate the performance of Witricity device in the case of lateral and angular misalignment.

II. WITRICITY MODEL

The model of Witricity device is shown in Fig. 1 with 10 mm lateral misalignment and 2 cm air gap separation. The Witricity device has 3 layers of top, substrate and bottom layer. The input power is connected to a single loop coil with two capacitor plates of the transmitter at bottom layer, which inductively coupled to the top layer of 20 loops spiral coil. The transmitter and receiver are then resonating at the same frequency. The received energy in term of magnetic field at the receiver device can be expressed by (1) [6]:

$$H_{Rx} = \frac{I \bullet n}{4\pi} \frac{\oint \vec{dl} \, x \, \vec{r}}{r^3} \qquad (1)$$

where, H_{Rx}, I, n, dl, and r are the induced magnetic field at receiver, input current, number of turns, tangential vector around single loop coil and distance between the center and the coil, accordingly. The proposed Witricity device has smaller size of 40 mm x 40 mm compared to [1-4].

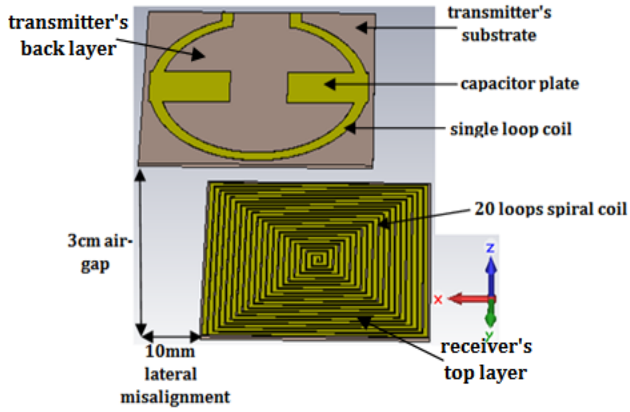

Fig. 1 The Witricity device model with 10 mm lateral misalignment and 2 cm air gap separation.

III. RESULT AND DISCUSSION

Fig. 2 shows the S_{21} results of the Witricity device, when the transmitter and receiver are coupled at 2 cm air gap with the variation of 0 mm to 15 mm lateral misalignment. The result clearly shows the S_{21} is decreasing as the lateral misalignment increased. This is due to the decrement of facing surface area. However, the result is still acceptable for up to 15 mm lateral misalignment as it is greater than -3 dB benchmark.

The next concern is to observe the performance of the device when it has experienced 5^0 to 25^0 angular misalignments. The air gap separation is fixed at similar distance of 2 cm. From the plotted result of S_{21} in Fig. 3, it can be noted that the performance of S_{21} is decreased proportionally to the increment of angular misalignment. As the transmitter and receiver has less facing surface, the response of S_{21} reduces accordingly. However, the reduction is not as much when compared to the variation of lateral misalignment.

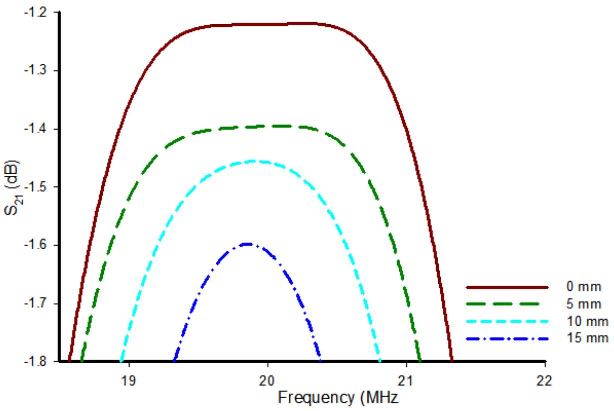

Fig. 2 Witricity device performance with varied lateral misalignment from 0 mm to 15 mm

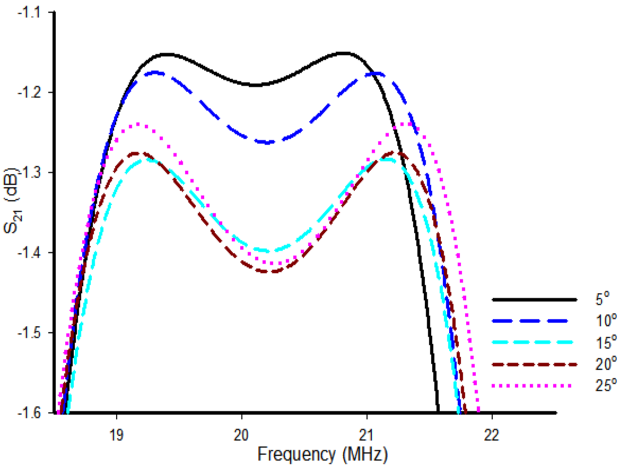

Fig. 3 Witricity device performance with varied angular misalignment from 5° to 25°

Then, further investigation is performed for the both variations of lateral and angular misalignment. The transmitter and receiver are still positioned at the distance of 2 cm. The lateral misalignment is fixed at 10 mm, while the angular misalignment is varied from 5^0 to 25^0. It can be seen from Fig. 4 that the value of S_{21} decreases to -1.4 dB at 25^0 compared to -1.2 dB when no lateral misalignment happened. Therefore, it is proven that both lateral and angular misalignment contribute to the reduction of coupling efficiency, which shown by S_{21} performance in this paper.

IV. Conclusion

The new compact Witricity charger has been presented with the investigation on lateral and angular misalignment towards the S_{21} (coupling efficiency) performance. The device has shown -1.4 dB or 72.5% coupling efficiency at 2 cm distance with lateral misalignment of 10 mm and 25^0 of angular misalignment. This indicates a good potential in the application of wireless power transfer.

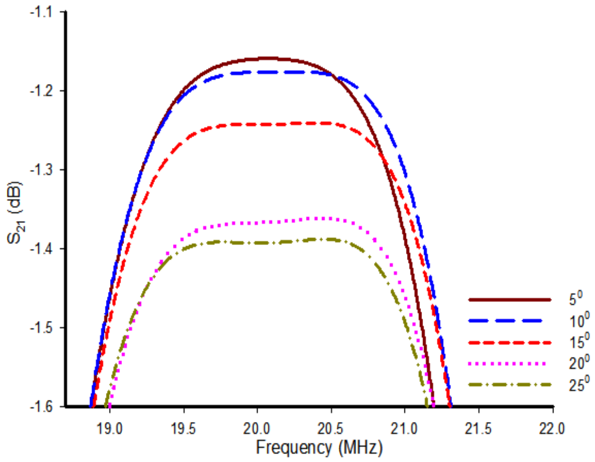

Fig. 4 Witricity device performance with fixed lateral misalignment of 10 mm and varied angular misalignment from 5° to 25°

Acknowledgment

This work is carried out with the financial support from the Malaysian Ministry of Education (MOE) via Fundamental Research Grant Scheme (FRGS) with vote number of 4F206 and MyPhD program, and Universiti Teknologi Malaysia (UTM) via GUP Grant with vote number of 05H43.

References

[1] Z. Xiu, S. L. Ho, and W. N. Fu, "Quantitative Analysis of a Wireless Power Transfer Cell With Planar Spiral Structures," *IEEE Transactions on Magnetics,* vol. 47, pp. 3200-3203, 2011.

[2] S. L. Ho, W. Junhua, W. N. Fu, and S. Mingui, "A Comparative Study Between Novel Witricity and Traditional Inductive Magnetic Coupling in Wireless Charging," *IEEE Transactions on Magnetics,* vol. 47, pp. 1522-1525, 2011.

[3] W. Junhua, S. L. Ho, W. N. Fu, and S. Mingui, "Finite element analysis and corresponding experiments of resonant energy transmission for wireless transmission devices using witricity," in *2010 14th Biennial IEEE Conference on Electromagnetic Field Computation (CEFC),* 2010, pp. 1-1.

[4] C. Kainan and Z. Zhengming, "Analysis of the Double-Layer Printed Spiral Coil for Wireless Power Transfer," *IEEE Journal of Emerging and Selected Topics in Power Electronics,* vol. 1, pp. 114-121, 2013.

[5] Y. Ning, X. Guizhi, Y. Qingxin, Z. Jun, Y. Xuewen, J. Jianqiang, *et al.*, "Analysis of Wireless Energy Transmission for Implantable Device Based on Coupled Magnetic Resonance," *IEEE Transactions on Magnetics,* vol. 48, pp. 723-726, 2012.

[6] W. Junhua, S. L. Ho, W. N. Fu, and S. Mingui, "Analytical Design Study of a Novel Witricity Charger With Lateral and Angular Misalignments for Efficient Wireless Energy Transmission," *IEEE Transactions on Magnetics,* vol. 47, pp. 2616-2619, 2011.