Published by IASE

Annals of Electrical and Electronic Engineering

Journal homepage: www.aeeej.org

On the impact of variable in wireless power transfer

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ARTICLE INFO

Article history:
Received 26 February 2019
Received in revised form
20 June 2019
Accepted 25 June 2019

Keywords:
Resonant frequency
Coil
Power transmission
Distance
Superimposed technique

ABSTRACT

Wireless power transmission is the way to transfer power without using wire. Wireless power transmission helps to connect those areas where people are unable to get a suitable power source. The implementation of this system is to make life better and reduce the usage of wire or cable. The issues for certain applications are needed to put very near between the transmitter and the receiver. The superimposed technique is studied to solve a part of WPT technology. Using DC voltage in series with AC voltage in the coil can increase the voltage in AC type. 100Watt of power transmission had been designed to transmit electrical energy. The method was used to analyze the coil based on two sizes which are 16cm and 160cm of the diameter of the coil. Both experiments were tested in an open area without barriers. The purposed of design to identify the performance of coil transmission based on distance in the WPT system to turn on the 5V of LED. To get longer distance, the superimposed technique had been studying in order to get higher voltage at the transmission coil. The superimposed technique shows the increment of distance up to 2 times compared to the system without the superimposed technique.

1. Introduction

Wireless power transmission is the way to transfer power without using wire. Wireless power transmission helps to connect those area where people are unable to get a suitable power source. The process did not use any physical wire or coil (Agbinya, 2015). Power transmission had been explored in many areas either in power transmission, signal or in data transmission. A lot of methods had been studied such as the resonance frequency (Shvets et al., 2016), far field (Coifman et al., 1993) and near field (Tong et al., 2003). Inductive Power Transmission (IPT) and Capacitive Power Transmission (CPT) are two common techniques in WPT (Ludois et al., 2014; Dai and Ludois, 2015; Liu et al., 2012; Bradley et al., 2001; Singh et al., 2001; Klontz et al., 1994). IPT had been identified by many researchers in their performance of transmitting electrical energy compared to CPT. IPT is higher in the distance.

CPT has a better power transmission, but the distance is shorter (Lee et al., 2016). A lot of technique in wireless power transmission had been proposed in identifying the performance of electrical energy transmission. WPT had been studied in many areas such as in method of power transmission (Akiyama et al., 2015; Jang et al., 2016; Zhang et al., 2016; Li et al., 2015) and application (Chabalko et al., 2017; Samanta and Rathore, 2015). Tesla (1900) was the first transmit the electrical energy up to megawatts of power, but the record was not clear. In a research by Lee et al. (2012), domino technique had been proposed to power up the 18watt of light. The resonator shows the potential of transmission power through the system. However, the system does not indicate specifically on distance and voltage output, since the efficiency will affect the amount of voltage. More study is needed in focusing the frequency and efficiency. In a research by Zambari et al. (2013), quality factor based on the coil type had been studied. 80% of efficiency at a quality factor of 272.62 for spiral coil is the highest with 26cm of distance in power transmission. Increasing the resistance of the coil can increase the quality factor of the WPT. The impact of the coil selection is very important and one of the alternatives to get the better power transmission. Seam application in cable is not the maximum power current can flow in the coil or wire. Another method can be implemented to achieve better power transmission, by maximizing the current flow in the coil that might improve the distance in power transmission. According to Johnson (1993), energy is stored in the coil before propagates as e.m.f in the receiving coil. This implication makes WPT can be explored as the potential of e.m.f in transmit power. In a research by Mur-Miranda et al. (2010) by increasing quality factor up to 1000, power transmission can achieve 9 times from its radius. Coefficient number will be smaller and will make the distance longer. A lot of parameters had been studied, but the maximum utilization of certain parameter has not been indicated and explained in detail. The apparatus using current technique flow was implemented in this study. The objectives are to identify the improvement, utilization in parameter and identify a new concept in WPT especially to improve the purpose. Superimposed technique is studied to improve the performance of power transmission. Superimposed technique is used to increase the AC voltage using DC voltage through the experiment.

2. Methodology

WPT was designed to transmit the electrical energy from one point to another point. The block diagram is as shown in Fig. 1. The input voltage will be supplied the supply to the inverter. The inverter will convert the DC voltage to AC voltage. The output voltage of the inverter will flow to the transmitter coil. The voltage flow through the coil will produce the e.m.f. The e.m.f will be catch by the receiver coil. The voltage captured by the receiver coil can be converted to be used directly. In this system, the AC voltage was converted into DC form.

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https://doi.org/10.21833/AEEE.2019.08.001

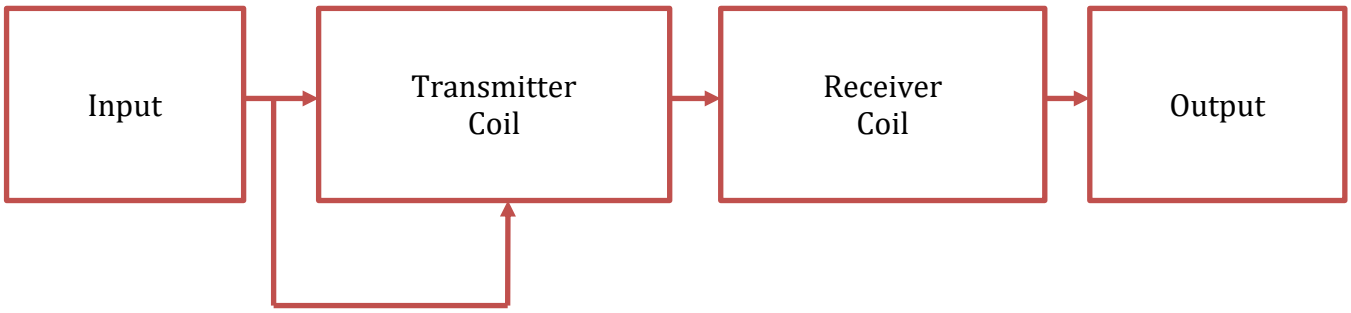

Fig. 1. Block diagram of the system.

The feedback flow from the input voltage into the transmitter coil shows the superimposed technique was used in the WPT system. The advantage of the used of superimposed technique is to improve the distance on the power transmission. One of the factor while transmit the electrical energy using WPT system is a power flow in the coil. The second advantage of using this technique is input power or source of energy can be maximized i.e., the inverter circuit was only designed for 50watt of power, but by using superimposed technique, the flow of the voltage and current can be increased up to 100watt. It is depends on a few factors such as the capability of coil to carry the current and also the input power. A superimposed technique in WPT diagram is as illustrated in Fig. 2.

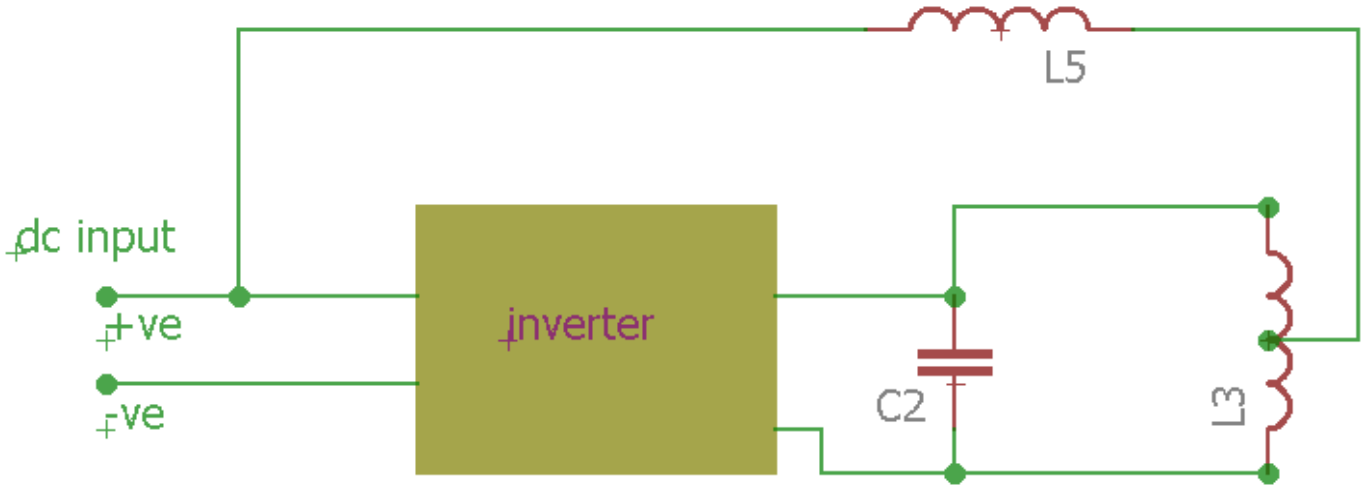

Fig. 2. Superimposed technique in WPT.

The diagram shows the input voltage from input was sent to the transmission coil as to increase the current and voltage in the circuit. Fig. 2 shows the positive input was connected to the inductor and connected to the center of the coil.

Table 1
Output voltage and distance of power transmission for system without superimposed technique.

Input Voltage	The Voltage at A-B without Superimposed	Distance 16cm Coil	Distance 160cm Coil
12	12.63	12.4	70
14	14.83	13	75
16	16.98	14	79.2
18	19.02	15	82
20	21.30	15.2	85.2
22	23.41	15.2	87.5
24	25.57	17.2	90
26	27.87	18.2	91.8
28	29.98	18.4	93.6
30	30.43	19.1	96.7
32	34.05	20.1	98

The physical connection of the coil is as shown in Fig. 3. Based on the coil, there are three points needed to configure which are positive input, negative input and center point. In this coil, 8 turns had been designed. The first step to make a coil is to divide the coil and the center is labeled as a center point. The first four turns were in a circle design with a clockwise direction and another 4 will be turned with anticlockwise direction. The coil needs to be closed each other to make the direction of e.m.f stronger. The most important of power transmission using circle design is a position during the transmission process.

Fig. 4 shows the angle of the transmission process. Fig. 4A shows the vertical position and Fig. 4B is a horizontal position. Table 1 shows the result taken based on WPT system without superimposed technique for 16cm and 160cm diameter coil. Table 2 shows the result with superimposed technique for the both size of coil.

3. Results and discussion

The voltage was increased 2V at every stage of experiment. Fig. 5 shows the result of power produced using superimposed technique and without superimposed technique. Without superimposed technique, the output voltage of the inverter (Mohd et al., 2015) is slightly near to the input voltage from the

supply. Compared to the superimposed technique, the output produces at the point A and B shows the increment of voltage to approximately to double from the input voltage.

Table 2
Output voltage and distance of power transmission for system with superimposed technique

Input Voltage	Voltage at AB with Superimposed	Distance 16cm Coil	Distance 160cm Coil
12	25.76	25.5	141.2
14	30.13	26.2	151.3
16	34.28	28.1	159.5
18	38.82	30.1	164.2
20	43.21	31	171.1
22	47.81	31.3	176.1
24	51.9	34.5	181.2
26	56.3	36.5	184
28	60.53	37.4	188.2
30	64.92	38.6	194.6
32	66.9	40.5	200

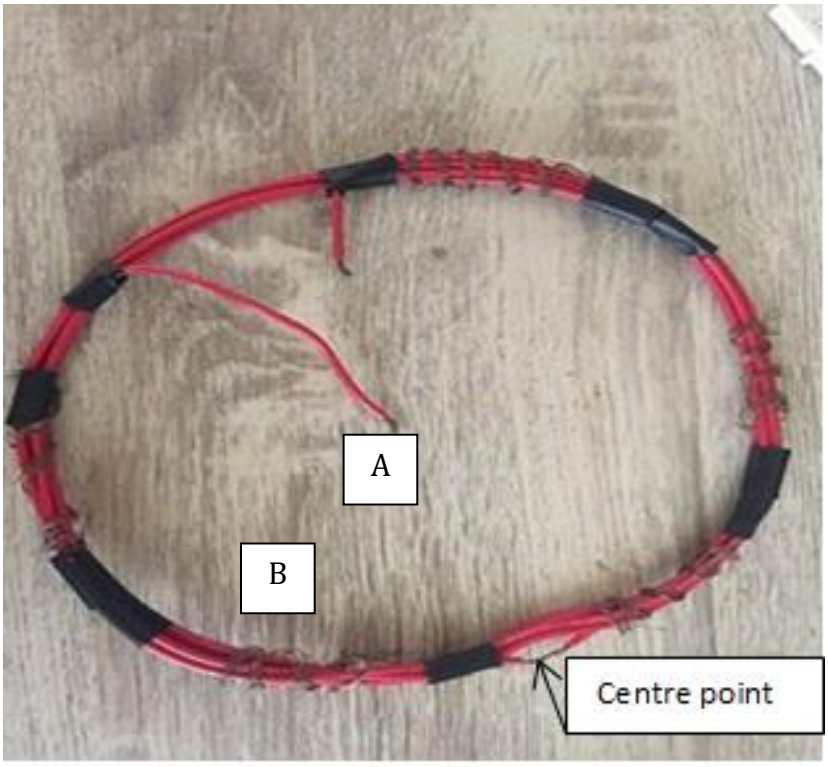

Fig. 3. Centre point at transmitter coil.

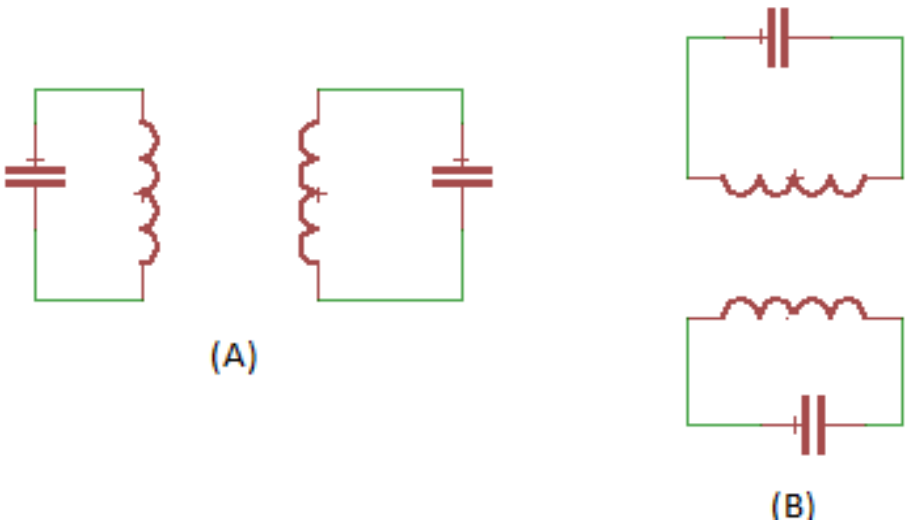

Fig. 4. Position of transmission and receiver coil.

Based on the result in Fig. 5, the experiment was tested into 16cm of the diameter of the coil. In theory, the e.m.f produced when the current flows in the coil. Fig. 6 shows the experiment without superimposed technique was achieved with the maximum of 20.1cm in diameter. As compared to the experiment

with the superimposed technique, the distance achieves with the same maximum input of 32 volts is 40.5cm.

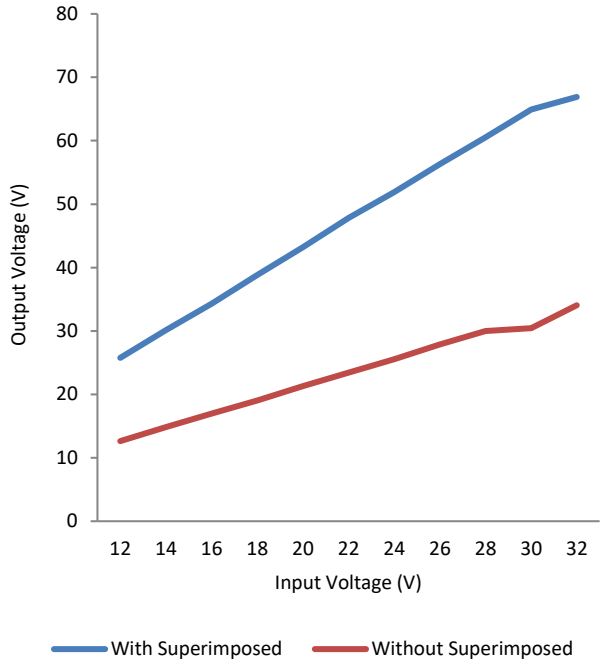

Fig. 5. Input voltage V/S output voltage.

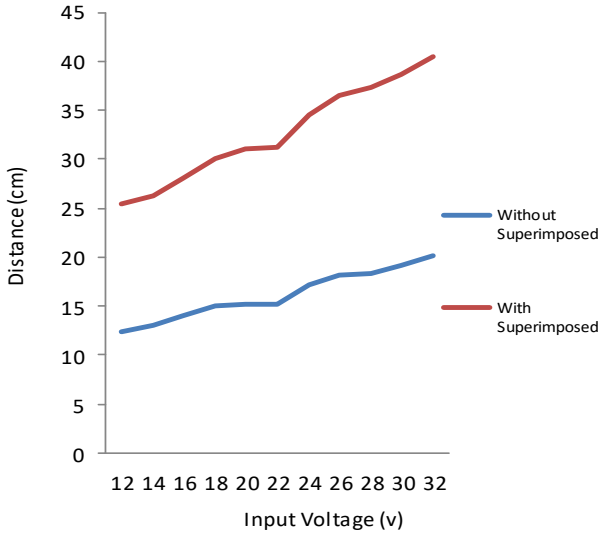

Fig. 6. Experiment for 16cm of coil.

Fig. 5 shows the effect on the voltage that was in the increased the distance in power transmission. The experiment continues with the 160cm. Fig. 7 shows the result of the distance of power transmission increased length. As a compared to without superimposed, the maximum output of 98cm has been achieved. Whereas, the experiment with superimposed technique, the highest distance was 200cm at the 32V of input voltage.

4. Conclusion

WPT needed to be explored in many aspects. Superimposed technique had been proved the transmission power can achieve longer distance when the voltage in the coil increased. The efficiency of the power (Dahalan et al., 2016) transmission increased 100% based on the distance achieved in the system in both experiments of 16cm and 160cm of diameter coil.

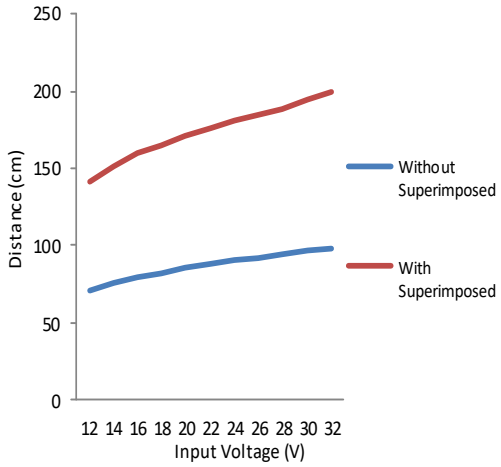

Fig. 7. Experiment for 160cm of coil.

References

Agbinya JI (2015). Wireless power transfer. River Publishers, Aalborg, Denmark.

Akiyama T, Ozaki M, Tsujimoto T, Tanabe M, Kudo H, Abe H, and Yabuta A (2015). Control method of wireless power transfer system for allowing coil position deviation. In the IEEE International Telecommunications Energy Conference, IEEE, Osaka, Japan: 1-3. https://doi.org/10.1109/INTLEC.2015.7572501

Bradley AM, Feezor MD, Singh H, and Sorrell FY (2001). Power systems for autonomous underwater vehicles. IEEE Journal of Oceanic Engineering, 26(4): 526-538. https://doi.org/10.1109/48.972089

Chabalko M, Besnoff J, Laifenfeld M, and Ricketts D (2017). Resonantly-coupled wireless power transfer for non-stationary loads with application in automotive environments. IEEE Transactions on Industrial Electronics, 64(1): 91-103. https://doi.org/10.1109/TIE.2016.2609379

Coifman R, Rokhlin V, and Wandzura S (1993). The fast multipole method for the wave equation: A pedestrian prescription. IEEE Antennas and

Propagation Magazine, 35(3): 7-12.
https://doi.org/10.1109/74.250128

Dahalan WM, Othman AG, Zoolfakar AG, Khalid MR, and Rizman PZM (2016). Optimum DNR and DG sizing for power loss reduction using improved meta-heuristic methods. ARPN Journal of Engineering and Applied Sciences, 11(20): 11925-11929.

Dai J and Ludois DC (2015). Single active switch power electronics for kilowatt scale capacitive power transfer. IEEE Journal of Emerging and Selected Topics in Power Electronics, 3(1): 315-323.
https://doi.org/10.1109/JESTPE.2014.2334621

Jang HS, Yu JW, and Lee WS (2016). 1-port measurement method of the coupling factor and receiver. IEEE Transactions on Antennas and Propagation, 64(9): 4098-4102.
https://doi.org/10.1109/TAP.2016.2583480

Johnson RC (1993). Antenna engineering handbook. Third Edition, McGraw-Hill, New York, USA.

Klontz KW, Divan DM, Novotny DW, and Lorenz RD (1994). Submersible contactless power delivery system (U.S. Patent No. 5,301,096). U.S. Patent and Trademark Office, Washington, USA.

Lee CK, Zhong WX, and Hui SYR (2012). Effects of magnetic coupling of nonadjacent resonators on wireless power domino-resonator systems. IEEE Transactions on Power Electronics, 27(4): 1905-1916.
https://doi.org/10.1109/TPEL.2011.2169460

Lee SH, Lee BS, and Lee JH (2016). A new design methodology for a 300-kW, low flux density, large air gap, online wireless power transfer system. IEEE Transactions on Industry Applications, 52(5): 4234-4242.
https://doi.org/10.1109/TIA.2016.2583407

Li S, Li W, Deng J, Nguyen TD, and Mi CC (2015). A double-sided LCC compensation network and its tuning method for wireless power transfer. IEEE Transactions on Vehicular Technology, 64(6): 2261-2273. https://doi.org/10.1109/TVT.2014.2347006

Liu C, Hu AP, Covic GA, and Nair NKC (2012). Comparative study of CCPT systems with two different inductor tuning positions. IEEE Transactions on Power Electronics, 27(1): 294-306.
https://doi.org/10.1109/TPEL.2011.2158322

Ludois DC, Erickson MJ, and Reed JK (2014). Aerodynamic fluid bearings for translational and rotating capacitors in noncontact capacitive power transfer systems. IEEE Transactions on Industry Applications, 50(2): 1025-1033.
https://doi.org/10.1109/TIA.2013.2273484

Mohd RAG, Nadiyatul AAL, and Zairi IR (2015). Three phase induction motor inverter application for motion control using crusher machine. ARPN Journal of Engineering and Applied Sciences, 10(20): 9549-9552.

Mur-Miranda JO, Fanti G, Feng Y, Omanakuttan K, Ongie R, Setjoadi A, and Sharpe N (2010). Wireless power transfer using weakly coupled magnetostatic resonators. In the IEEE Energy Conversion Congress and Exposition, IEEE, Atlanta, USA: 4179-4186.
https://doi.org/10.1109/ECCE.2010.5617728

Samanta S and Rathore AK (2015). A new current-fed CLC transmitter and LC receiver topology for inductive wireless power transfer application: Analysis, design, and experimental results. IEEE Transactions on Transportation Electrification, 1(4): 357-368.
https://doi.org/10.1109/TTE.2015.2480536

Shvets AV, Nickolaenko P, and Chebrov VN (2016). Effect of solar flares on Schumann resonance frequencies. In the 9th International Kharkiv Conference on Physics and Engineering of Microwaves, Millimeter and Submillimeter Waves, IEEE, Kharkiv, Ukraine: 1-4.
https://doi.org/10.1109/MSMW.2016.7538029

Singh H, Bellingham JG, Hover F, Lemer S, Moran BA, Von der Heydt K, and Yoerger D (2001). Docking for an autonomous ocean sampling network. IEEE Journal of Oceanic Engineering, 26(4): 498-514.
https://doi.org/10.1109/48.972084

Tesla N (1900). Apparatus for transmission of electrical energy (U.S. Patent No. 649,621). U.S. Patent and Trademark Office, Washington, USA.

Tong CY, Meledin DV, Marrone DP, Paine SN, Gibson H, and Blundell R (2003). Near field vector beam measurements at 1 THz. IEEE Microwave and Wireless Components Letters, 13(6): 235-237.
https://doi.org/10.1109/LMWC.2003.814602

Zambari IF, Hui CY, and Mohamed R (2013). Development of wireless energy transfer module for solar energy harvesting. Procedia Technology, 11: 882-894.
https://doi.org/10.1016/j.protcy.2013.12.272

Zhang Y, He F, Liu F, Chen K, Zhao Z, and Yuan L (2016). Comparison of two bidirectional wireless power transfer control methods. In the Asia-Pacific International Conference on Electromagnetic Compatibility, IEEE, Shenzhen, China, 1: 68-70.
https://doi.org/10.1109/APEMC.2016.7522832