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Development of Short-Range Wireless Energy Transfer Module (Y-Less) for TVET Education

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ABSTRACT – One of the new developing technologies that will bring significant change to human existence is wireless power transmission using inductive coupling. The Wireless Energy Transfer Module (Y-Less) is developed as teaching and learning trainer to provision in understanding the basic concepts of wireless communication and able to support the syllabus available in educational institutions. This Y-Less design based on inductive-coupling technology, which employed two coils induce a current in the receiving circuit from transmitter coils that could be converted to usage energy reveals to the students the basic idea of what is meant by wireless communication. It demonstrates energy transfer of power supply from one point to another without any connecting cable that uses the concept of wireless. Output with $12V_{DC}$ and $5V_{DC}$ is shown in charging the phone or turning on the lamp/fan at a distance between the receiver and the transmitter up to 10 cm. The usage of inverter and USB is included in the resulting output application to enhance the technical knowledge.

KEYWORDS : energy transmission, wireless energy transfer, induction-coupling

1.0 INTRODUCTION

Teaching theories and concepts in a practical way to undergraduate students requires both a teaching and learning modality with a laboratory infrastructure. It is a general knowledge that laboratory based activities form a critical component of the overall support for teaching and learning. It would be better if students were given exposure in practical learning activities that illustrates the theoretical concepts [1]. This paper outlines the development of Y-Less module prototype based on a cheap, readily available IC component and coils that introduces the latest applications of wireless power transmission in life. Y-Less module focuses on fabricating a relatively simple, inexpensive, and reliable wireless energy transfer kit that can be used to support the teaching of communication fundamental and wireless communication. The both courses are included in the Technical and Vocational Education and Training (TVET) education level in Malaysia, which emphasizes students to have a practical skill [2].

Understanding wireless communication is a mandatory and basic thing in the field of telecommunications. It is contained in most of Engineering Course Information in Electrical Engineering field. However, the introduction to the concept or method of transmitting information wirelessly and without real medium practically makes it difficult for students to describe the processes. On this initiative, the research is done to develop the trainer to help students in understanding the concept of wireless communication. The development of a simple module but achieving the goal is necessary in mastery of the concept. The Y-Less Module is the teaching and learning trainer that can demonstrate a method of wireless energy transfer to obtain useful electricity supply from one place to another without the need of electricity transmission medium. This wireless energy transfer reveals to the students the basic idea of what is meant by wireless communication that will be learned further. This process of energy transfer involves a phenomenon known as electromagnetic induction. Microwaves can move at greater distances than simple induction coils. The receiving antenna collects the transmitted microwave energy and the converter circuit (receiver) converts the microwave energy into usable electrical energy.

Due to its rapid speed and dependable operation, wireless power transfer has made tremendous progress in its effective transferring approach. Wireless transmission is employed in cases where instantaneous or continuous energy transfer is needed, but interconnecting wires

are inconvenient, hazardous, or impossible. Wireless energy transfer technology has attracted much attention nowadays because of the capability to transfer energy from one place to another place without using any contacted wire [3]. Since the 19th century, research has been conducted in order to attain the goal of delivering power wirelessly. Wireless transmission has been used in the telecommunications industry for a long time, with various transmission methods. Radio waves, cellular broadcast, and Wi-Fi are all instances of wireless transmission [4]. Inductive coupling between transmitter and receiver, which are only a few millimetres away, is an efficient technique of delivering electricity wirelessly.

The technology of sending power wirelessly via inductive-coupling has been deemed the most effective and dependable means to transmit power across an air gap utilising weak magnetic coupling in research work over the past decade [5]. It has a high efficiency of 80-90 percent, as well as a high level of resilience and reliability. The system's main circuitry is based on the Primary and Secondary sides. Over an air gap, the power created in the primary side copper tube is inductively connected to the secondary side copper tube. The secondary coil's induced power is then redistributed to loads across it. As it provides electricity along a path of a few millimetres, distance and voltage are inversely linked. With more distance between the primary and secondary sides, the voltage starts to drop. This study focuses on the ground-breaking idea of transmitting electricity without requiring wires via inductive coupling and the behaviour of various loads.

2.0 WIRELESS POWER TRANSFER

Wireless power transmission is a technology that utilizes radio to transmit power energy, mainly through electromagnetic induction, electromagnetic resonance, RF, microwave, laser to realize non-contact power transmission [6]. The wireless power transmission illustrates a good prospect in the medical, transportation, military, aerospace, communications, industrial, electric power, energy environmental protection and other areas. The wireless power transfer is to transmit electrical energy from one point (transmitter) to another point (receiver) through the air, vacuum or other environment without the use of wires (intermediate materials) [7]. Wireless power transmission can be broadly divided into short-range wireless power transmission, medium-range wireless power transmission and remote wireless power transmission due to the different power distance that wireless power transmission can achieve. The equivalent circuit of Wireless Power Transfer system can be seen in Figure 1.

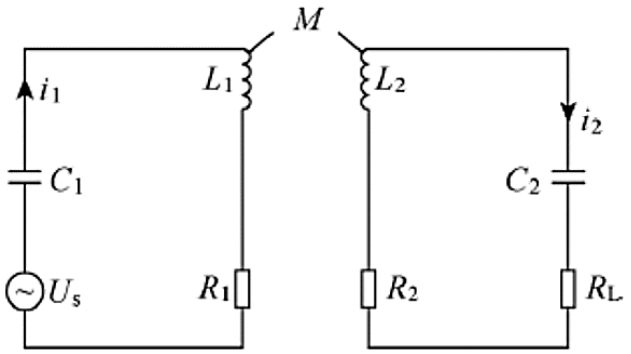

Figure 1. Equivalent circuit of Wireless Power Transfer [5]

Wireless electricity proposed in Y-Less module is based on short-range concept that work on the mutual electromagnetic induction. This inductive-coupling technology [8] of electromagnetic induction is usually used for power supply of small electronic equipment because of the limit of transmission distance. The idea of mutual induction can be used to transfer electrical power without any physical contact between the coils [9]. The simplest example of how mutual induction works is the transformer, where there is no physical contact between the primary and the secondary coils. Using a transformer coupling, the primary and secondary coils can generate induced currents which may form an alternating electric field in the medium, so that power can be transmitted via the most non-metallic materials and the energy can be transferred from the

transmitter to the receiver, enabling wireless transmission of electricity. The transfer of energy takes place due to electromagnetic coupling between the two coils as shown in Figure 2.

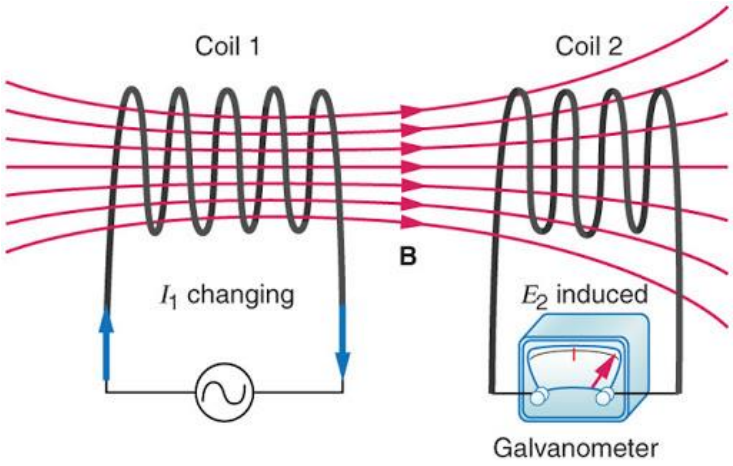

Figure 2. Mutual Induction [10]

Mutual inductance occurs when an emf is formed in a coil as a result of a change in current in a connected coil. Faraday's law describes the emf, and its direction is always in opposition to the change in the magnetic field produced by the connected coil (Lenz's law). Self inductance L causes the induced emf in coil 1. The shift in current I1 induces an electromotive force (E.M.F) in coil 2. Mobile devices or smart phone that is capable to take charge from wireless charger is also a great use of this technology. The principle can be shown in wireless telephone charger, the Splashpower recharging mat as shown in Figure 3 and Edison Electric's Power desk to recharge several devices at once [4]. The chargers use coils to create a magnetic field. Electronic devices use corresponding built-in or plug-in receivers to recharge while resting on the mat. These receivers contain compatible coils and the circuitry necessary to deliver electricity to devices' batteries.

Figure 3. A Splashpower mat uses induction to recharge multiple devices simultaneously [3]

3.0 WIRELESS ENERGY TRANSFER MODULE (Y-LESS) DESIGN

The Y-Less module is applied for short distance range, reaching at most a few centimetres up to 10 cm only [11]. Common applications include inductive charging of electric toothbrush, mp3, universal wireless power pad and other small power electronic devices. The action of an electrical transformer is the simplest instance of wireless energy transfer. The module is developed for transmitting the electrical power from a transmitting source to load wirelessly using

coils. Two coils are used, one on the transmitter side called as primary coil and another at the receiver side called as secondary coil as shown in Figure 4. The primary and secondary circuits of a transformer are electrically isolated from each other. The circuit windings, sensitively dependent upon the position of the coils relative to each other, perform ideally when the distance between the primary and secondary winding is no greater than the thickness of the primary [12].

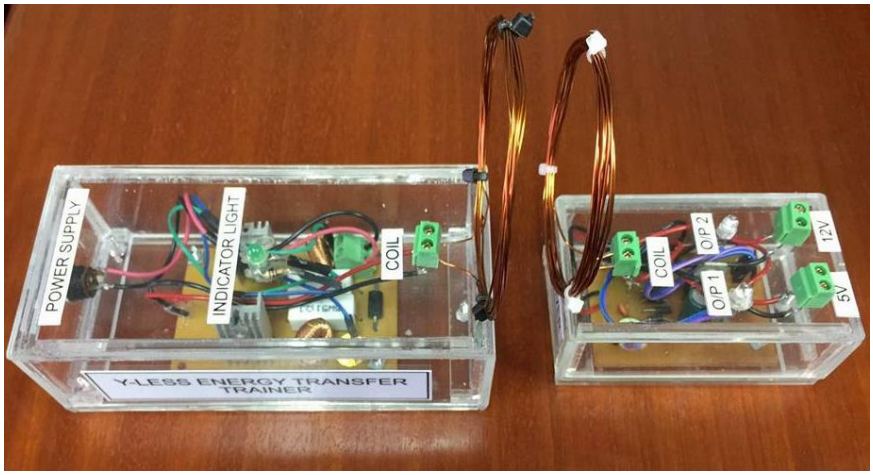

Figure 4. Y-Less Module

The transfer of energy takes place by electromagnetic coupling through a process known as mutual induction between coil. The AC power is supplied to the transmitting circuit which converts the AC Power into magnetic flux using primary coil. When secondary coil interacts with this flux, an E.M.F. will be induced in the secondary coil. In this way, electrical power will be transmitted without using wires. A larger distance between coils, stronger field could induce current from farther away, but the process would be extremely inefficient. Since a magnetic field spreads in all directions, making a larger one would waste a lot of energy. The output of the module can be connected to optical mouse for 5 V_{DC} dan to inverter and fan for 12 V_{DC} output as shown in Figure 5.

Figure 5. Output connected with 5 V_{DC} and 12 V_{DC}

The transfer of energy takes place by electromagnetic coupling through a process known as mutual induction between coil. The AC power is supplied to the transmitting circuit which converts the AC Power into magnetic flux using primary coil. When secondary coil is connected to the appliance/device at the receiving end. When the power is turned on, the transmitting coil converts the supplied input power to magnetic flux, which oscillates at specific frequency. This

magnetic flux gets induced into the coil at the receiver in the proximity to the transmitting coil, which in turn induces E.M.F. in the receiving coil. This induced E.M.F. can be used to supply power to electrical and electronic devices. The circuit diagram of the transmitter and receiver is shown in Figure 6 and 7 respectively.

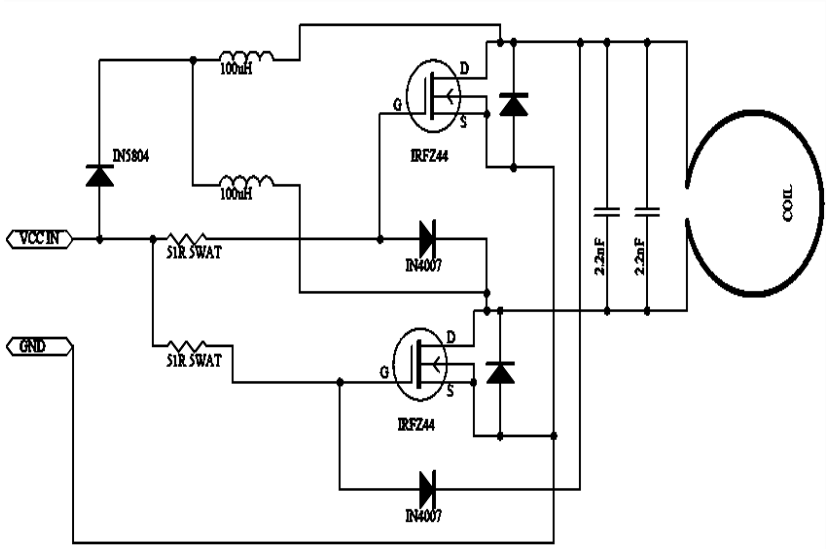

Figure 6. Transmitter Circuit

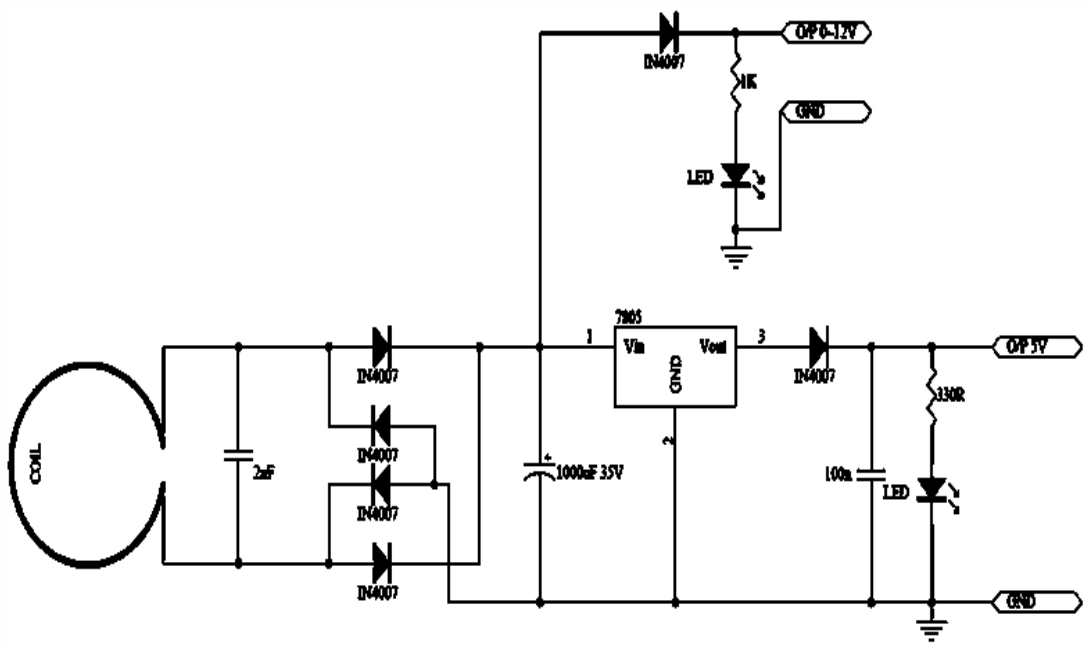

Figure 7. Receiver Circuit

5.0 MODULE EVALUATION

The development of Y-Less module is evaluated in terms of response from users such as lecturers and students. The evaluation of the module is tested the all functions specified and personal sense based on laboratory manual distributed to the experts and students, who have been involving and teaching an engineering course to answer the questionnaire of the module. The collected data were analysed through Mean Score application of required statistical techniques. The first objective was to study the response of students and lecturer towards the

development of Y-Less module in increasing the understanding of student in wireless communication. The result has been shown in the following Table 1.

Table 1: Response of Users in Mean Score

Item	Question	Likert Scale (Number of Respondents)						
		1	2	3	4	5	Mean Score	
1	Easy to use and operate	0	10	30	70	10	3.67	Student
		0	2	3	10	5	3.90	Lecturer
2	Standard of Procedure (SOP) clear and easy to understand	0	10	15	80	15	3.84	Student
		0	1	1	12	6	4.15	Lecturer
3	Labelling on trainer	0	5	5	90	20	4.05	Student
		1	1	1	10	6	3.80	Lecturer
4	Block diagram clear and easy to understand	0	10	16	85	5	3.59	Student
		2	2	3	12	3	3.90	Lecturer
5	Attractive design	2	10	25	76	7	3.63	Student
		1	3	5	9	2	3.40	Lecturer
6	Helps in understanding concept	0	0	24	90	6	3.85	Student
		1	1	3	11	4	3.80	Lecturer
7	Stimulate interest	1	4	25	76	14	3.82	Student
		0	0	0	15	5	4.25	Lecturer
8	Results of experimental are useful in improving knowledge	0	7	14	76	23	3.95	Student
		0	0	2	14	4	4.10	Lecturer
9	Suitable for individual/group	0	1	40	65	14	3.77	Student
		0	0	0	17	3	4.15	Lecturer
10	Recommended in Teaching and Learning activity	2	2	16	78	22	3.95	Student
		0	0	0	10	10	4.50	Lecturer

The interpretation of the mean score for this research is based from [13] . Referring to the data obtained from Table 1 with respect to the comment and recommended of using the trainer as a teaching aid in communication system fundamentals and wireless communication course, it was shown that most of the score for each question shows the high range value which is 3.67 to 5.00. It can be concluded that most respondents agree that the trainer developed by thorough research is benefit the students a deeper understanding in wireless communication.

5.0 FUTURE DEVELOPMENT

Induced voltage at secondary coil is inversely proportional to the distance between primary coil and secondary coil so by increasing distance E.M.F become low so we have to increase the primary coil. For future development, the module will be embedded with variable numbers of coil turns for increasing voltage with selecting high rating transformer. Besides, the advancement to the module is intended for one coil could send electricity to several receiving coils, as long as they all resonate at the same frequency. This non-radiative energy transfer involves stationary fields around the coils rather than fields that spread in all directions.

6.0 CONCLUSION

Based on the result on developing the trainer for teaching aid, it shows that the research is needed in all field especially in education for all educators. The use of trainers in teaching and learning process is welcomed by students and lecturers because it can improve student's understanding of the concept of wireless communication . By research on the content of the syllabus, existing facilities with the expertise and capabilities of lecturers, a promising result in developing the hardware/trainer for teaching, research papers, videos and so on can be produced for the use of students and lecturers.

REFERENCES

[1] A. O. Ajao, K. O. Kadiri, and O. O. Bamigboye, "Local Fabrication of Digital Logic Trainer for Laboratory Demonstration," *Int. J. Innov. Sci. Math.*, vol. 2, no. 1, pp. 43–46, 2014.

[2] A. Nordin and M. K. Ali, "Conducting Hands-on Task in Vocational Education: Teaching Method in Automotive Courses," *J. Tech. Educ. Train.*, vol. 7, no. 1, pp. 23–34, 2015.

[3] I. F. Zambari, C. Y. Hui, and R. Mohamed, "Development of Wireless Energy Transfer Module for Solar Energy Harvesting," *Procedia Technol.*, vol. 11, no. Iceei, pp. 882–894, 2013, doi: 10.1016/j.protcy.2013.12.272.

[4] V. Bhavya Keerthi, V. Swetha, and E. Annadevi, "Wireless Power Transmission," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 590, no. 1, pp. 3–5, 2019, doi: 10.1088/1757-899X/590/1/012031.

[5] M. Shidujaman, H. Samani, and M. Arif, "Wireless power transmission trends," *2014 Int. Conf. Informatics, Electron. Vision, ICIEV 2014*, no. May, 2014, doi: 10.1109/ICIEV.2014.6850770.

[6] L. W. & Z. C. Tao Li, "matecconf_iceta2015_02021," in *MATEC Web of Conferences*, 2015, vol. 22, no. 02021, pp. 1–4.

[7] J. S. Jin, S. Jung, and H. J. Kim, "Development of wireless power transmission system for transfer cart with shortened track," *Appl. Sci.*, vol. 10, no. 14, pp. 14–16, 2020, doi: 10.3390/app10144694.

[8] Y. Zeng, B. Clerckx, and R. Zhang, "Communications and Signals Design for Wireless Power Transmission," *IEEE Trans. Commun.*, vol. 65, no. 5, pp. 2264–2290, 2017, doi: 10.1109/TCOMM.2017.2676103.

[9] N. Tesla, "The Transmission of Electric Energy Without Wires (The Thirteenth Anniversary Number of the Electrical World and Engineer)," 1904.

[10] Dr. C. L. Davis, "Mutual Induction," *Physics Department University of Louisville*. http://www.physics.louisville.edu/cldavis/phys299/notes/mag_mutualind.html.

[11] Y. Wang, J. Qiao, J. Du, F. Wang, and W. Zhang, "A view of research on wireless power transmission," *J. Phys. Conf. Ser.*, vol. 1074, no. 1, 2018, doi: 10.1088/1742-6596/1074/1/012140.

[12] C. A. Tucker, K. Warwick, and W. Holderbaum, "A contribution to the wireless transmission of power," *Int. J. Electr. Power Energy Syst.*, vol. 47, no. 1, pp. 235–242, 2013, doi: 10.1016/j.ijepes.2012.10.066.

[13] D. S. Hamzah, M. S. Ibrahim, and S. Ghavifekr, "Change orientation and organizational climate: Experience from Malaysian primary schools," *Malaysian Online J. Educ. Manag.*, vol. 6, no. 2, pp. 83–109, 2018, doi: 10.22452/mojem.vol6no2.5.