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The first design of IPB wireless energy transfer system (IWETS) based on the tesla coil

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The first design of IPB wireless energy transfer system (IWETS) based on the tesla coil

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Abstract. In this paper, we report the development of the first IPB wireless energy transfer system (IWETS) based on Tesla coil device. The Tesla coil was built from C1970 transistor while the receiver was built from the LC circuit. The transmitted electromagnetic waves have a sinusoidal form with the frequency of ~ 2.9 MHz. The actual testing has shown that IWETS was able to transmit the electromagnetic energy to the receiver with the highest efficiency obtained of 0.00516%. The amount of the transmitted energy to the receiver linearly depends on the distance between transmitter and receiver, the further the distance between the transmitter and the receiver, the smaller the energy transferred to the receiver as shown by a lower amplitude of AC voltage detected in the receiver.

1. Introduction

The scientist had long sought the idea of transmitting energy (electric power) without using any wire. One of the famous examples is the idea from Nikola Tesla who used the electromagnetic induction principle to spread the electromagnetic energy wirelessly around the Warden cliffy tower in Long Island New York using a Tesla coil [1]. Although the Tesla coil only had a small success by powering the small light bulb, research interest in this field had continuously grown until now. The recent effort by MIT team has successfully sent a 60 W of energy in a 2.0-meter distance with the power efficiency of 40% [2]. Some innovations in conceptual and applied technology of Tesla coils have been proposed by researchers such as Solar based power satellites [3] and the electric vehicle battery charges [4].

Due to the richness of physics and engineering deployed in a wireless power transmission project based on Tesla coils, this subject has become a popular project both for physics or electrical engineering major, such as in Reference [5,6,7]. In this paper, we will report the Tesla coil project which has been developed by the Department of Physics Bogor Agricultural University (IPB), named IWETS IPB Wireless Energy Transfer System). This paper mostly based on the undergraduate physics thesis project by Mr. Pratama (Prandika Nur Pratama).

2. Methods

We start by designing the transmitter coil circuit following the diagram is shown in Figure 1. The 12 V DC from power supply generated the current to flow past the 22) k Ω resistor before flow into the base of the C1970 transistor. On the other side, the 19 V DC from Voltage supply (V_{SUP}) allows current to flow from collector to emitter through the primary coil. This emitter to collector current then stop and breaks the circuit. The frequency of stop and go current of this circuit is by following the transistor C1970 characteristic, i.e. 175 MHz. This on-off current condition in a primary coil will induce the



secondary coil and produce electromagnetic waves which will be transmitted to the receiver. Since the ratio between primary to secondary coil is 1 to 100, so the maximum voltage produced by the primary coil is enough to be transmitted to the surrounding area.

The second block is the receiver circuit as seen in Figure 2. The AC voltage signal received by the receiver's antenna and coil then harmonized with the signal produced by the LC circuit. The variable capacitor was fine-tuned to resonate the incoming AC signal from the transmitter. Once the resonant condition is achieved, the signal then rectified by diodes and converted into a DC signal to light up the diodes. In the receiver circuit, the coil has the inductance of $162.4 \mu H$ and the capacitance of $18.502 pF$ to produce the resonance frequency at 2.90 MHz.

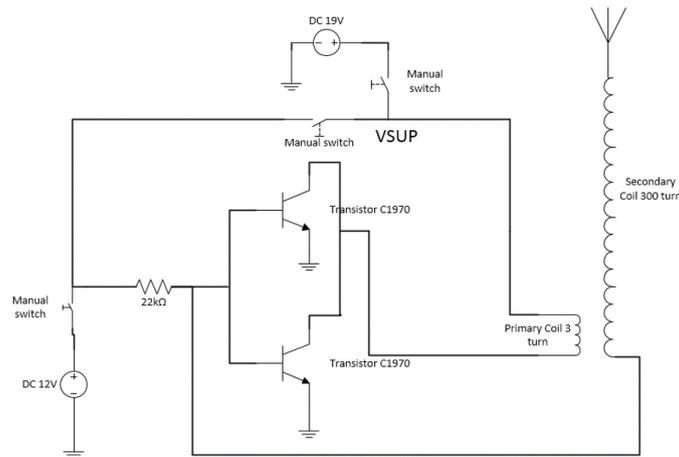


Figure 1. The electronic circuit of the transmitter.

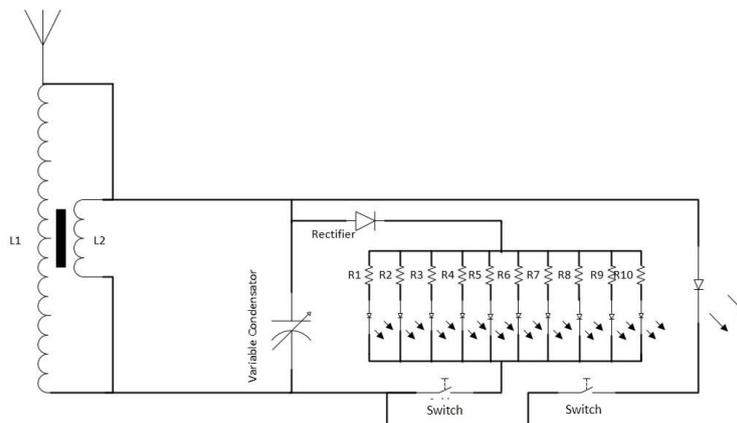


Figure 2. The electronic circuit of the receiver.

3. Results and Discussions

The prototype of IWETS in an off-condition was shown in Figure 3a. As the transmitter was switched on, the electromagnetic energy was produced and transmitted to the receiver. As the input power in the transmitter was increased, the amount of received electromagnetic energy (output power) was also increased as shown in Figure 3b (lighting up one LED) and in Figure 3c (lighting up 8 LEDs). The radiated electromagnetic energy from the transmitter would also disturb other electronically-sensitive objects such as a neon lamp (see Figure 3d).

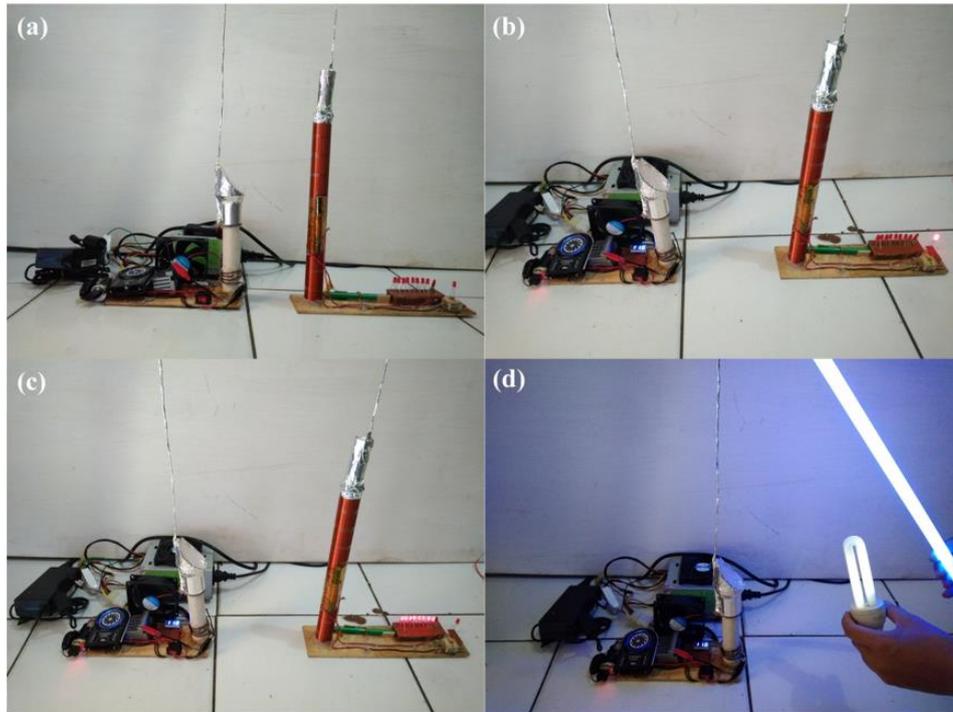


Figure 3. The IWETS prototype in a condition of (a) transmitter off (b) transmitter is on and the receiver lighting up one LED, (c) transmitter is on, and the receiver is lighting up 8 LEDs, and (d) transmitter is on, and the receiver is lighting up neon lamps.

The characteristic performance of IWETS can be shown in Figure 4. As the input power in the transmitter was increased (from about 1.0 to 10 Watt) the received power in the receiver will also increase (from 0.00005 to 0.00035 Watt). The recorded efficiency of this IWETS instrument was found to be 0.00516 %. The distance between transmitter and receiver also determines the output power in the receiver (see Figure 4b) as the transmitter-receiver distance is getting bigger; the output power in the receiver is getting lower. This result was expected as the electromagnetic radiation will be attenuated as a function of a distance. This result is also in agreement with Ref [5,6,8]. The efficiency received at the receiver will be attenuated as a function of the input power in the transmitter as can be seen in Figure 5.

The characteristic of signal forms produced by the transmitter is shown in Figure 6. In Figure 6a, when the distance between transmitter and receiver is very close (1.0 cm) the transmitted sinusoidal signal is very strong with the amplitude of the voltage around 45 Volt. In Figure 6b, the transmitter-receiver distance was increased to 4.0 cm, and as we expect the transmitted signal now decreased to 40 Volt. Figure 6c and 6d only confirm the trend, and showing a decreasing signal from 32.5 Volt to 27.5 Volt, as the distance increase from 8.0 to 11.0 cm.

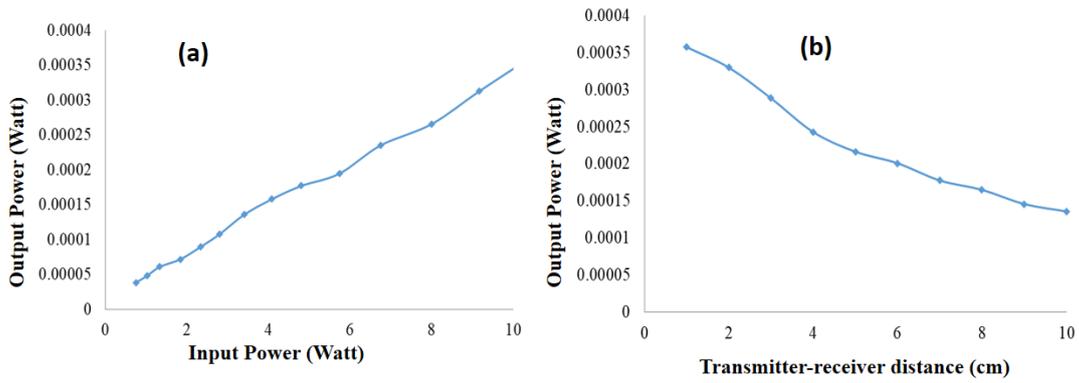


Figure 4. The characteristic of the signal received as (a) the input power increases, and (b) the transmitter-receiver distance grows.

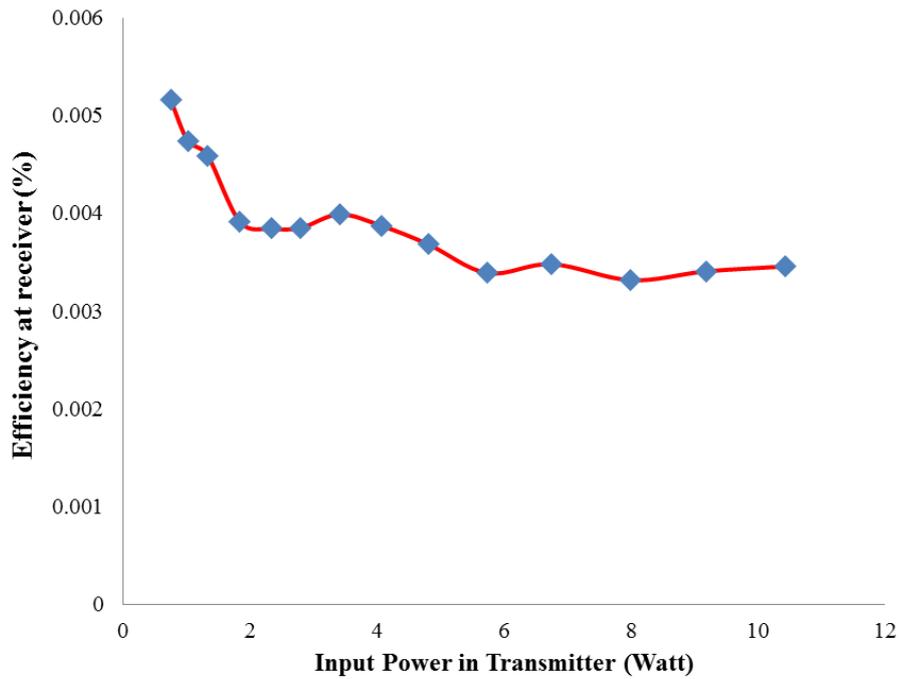


Figure 5. The efficiency at receiver as a function of the input power in the transmitter.

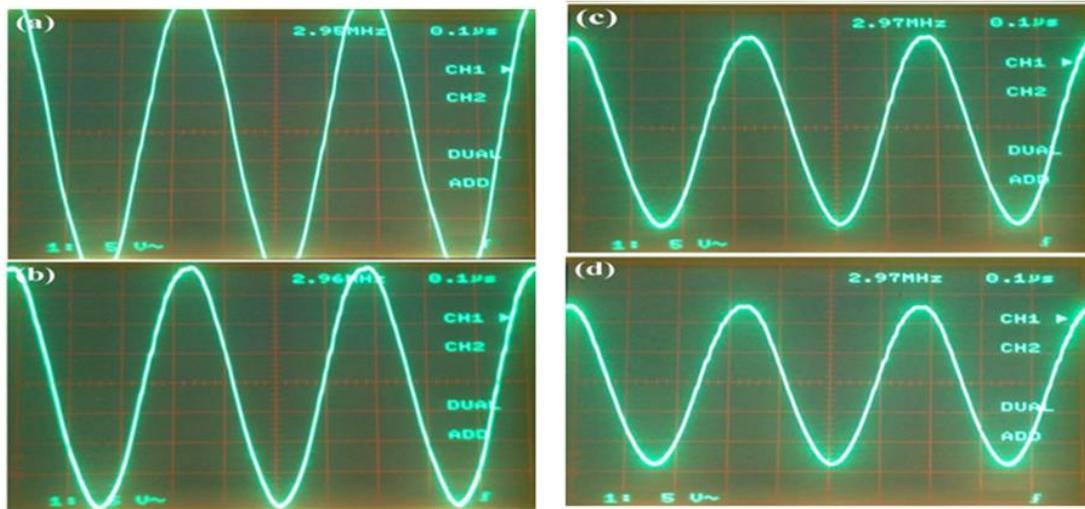


Figure 6. The shape of some of the transmitted signals detected at (a) a distance of 1.0 cm and $V = -45.0$ Volt, (b) a distance of 4.0 cm, and $V = -40$ Volt, (c) a distance of 8.0 cm and $V = -32.5$ Volt, and (d) a distance of 11.0 cm and $V = -27.5$ Volt.

4. Conclusion

Throughout this paper, we have demonstrated the characteristics and performances of IWETS prototype. We have shown that IWETS have the Tesla coil characteristic such as the attenuation of transmitted energy due to the increasing of the separation distance between transmitter and receiver. The transmitted signal takes the sinusoidal shape, and its voltage amplitude becomes smaller as the separation distance increased. The received electromagnetic energy at the receiver increases as the transmitted energy in transmitter getting bigger. The highest efficiency that can be reached in this instrument is 0.00516%. In the future, we will modify the coils and increase the power produced by the transmitter and using a better variable capacitor to stabilize the resonant frequency.

Acknowledgments

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