Energy transfer provision based on RF-Radio Frequency as an established solution of learning process using laptops and wireless projector

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Energy transfer provision based on RF-Radio Frequency as an established solution of learning process using laptops and wireless projector

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Abstract. Electrical energy is very crucial in whole aspects of our life. No exception with education. Closely related to education, this paper reports the research result concerning with mean, how to overcome power outage in a classroom. Research idea comes up from a situation in which electrical disruption occurs and its purpose is to propose the appropriate solution, namely by creating an apparatus consist of a pair of transmitter and receiver working on the base of radio frequency. There are former articles discussed how to transfer electrical energy by magnetic coupling, but have no invent in radio frequency transmission. It's different to them, the constructed apparatus will transmit the electrical energy through atmosphere media. The concept of radio frequency transmission and electrical generation are background of the creation of the prototype. In order to properly work, the prototype was composed from some modules. The purpose is to make it easier in case of replacement if there are malfunctions. The module consists of transmitter, receiver, multiplier, inverter and converter respectively.

Simulation was carried out to optimize performance of the device before real construction. As a conclusion that the device can work well based on the observed output voltage.

1. Introduction

Success of a learning process is very depends on facilities which supporting it. These facilities cover broad area such as laboratory, workshop and classroom. Among these, the most important is overhead projector and laptop. In spite laptop operation is powered by battery but it still needs alternating current power as well. Renewable and reliable sources of energy needed for the solution [1].

Electrical power interruption will disturb the learning process. For instance, one of case is switching off an overhead projector. Maintaining operation it for the learning process taking place is necessary even though no electrical supply available. Energy-battery transmission from laptop to the overhead projector is way for us to maintain continuity operation. Therefore we must create the new device which will fulfill the task.

Radio frequency (RF) energy harvesting and transfer techniques have recently become alternative methods to power the next generation of wireless networks. This technique has become a promising solution to power energy-constrained wireless networks [2].

The design device has two parts that is transmitter and receiver. The transmitter functions to convert direct current voltage to be electromagnetic wave. On the other side, the receiver accepts the
radiated RF signal from the transmitter and then converting it back to the direct current (DC) voltage [3][4]. Transmitter taking current voltage from laptop’s battery and the receiver convert the electromagnetic wave from the transmitter using Cockroft-Walton circuit. The next step is conversion the DC voltage into alternating current (AC) voltage using converter. The output voltage of converter hereafter used to power an overhead projector.

2. Radio frequency transmission
There are several papers related to this study. The transfer of AC electrical energy can be grouped into radiation and non-radiation [2] [3] [4]. The radiative transfer used to radiate energy remotely and the non-radiative only for short distance purposes. Examples of non-radiative electrical energy transfers are transformers. As a result of the coupling energy, the Electric Motion Style or GGL will appear on the side of the secondary winding of the primary winding compost transformer connected to AC power [5].

The transfer of AC electrical energy cannot be done for low frequencies, so RF frequencies are required. Some basic theories for implementing this research is the application of radiative energy transfer can be found in wireless chargers for smartphones [6] [7][8][9][10][11]. Modulation techniques from simple to complex have been developed. Theory starts from AM modulation up to OFDM modulation and selection of the modulation technique depends on the signal to be transferred, whether analog or digital signals.

Contradicting what happens to AC electrical energy, DC electricity cannot be transferred using wireless. Before transmitting the DC, it needs to be converted to AC sinusoids or another forms such as pulse square. AC sinusoids are obtained from oscillators and square pulses are obtained from multivibrator. Only after alteration, DC can be wirelessly transferred. DC can be transferred directly using a cable.

High voltage DC transmission (HVDC) via a cable will be effective only if the distance between 400 - 600 km for air ducts and 50 km for underground channels. This inefficiency is due to the high power DC generation that requires relatively expensive Converter and Inverter equipment. Research for the use of an oscillator as an electric power transfer tool [12] [13] provides a relation between distance and percentage voltage level. The received voltage will decrease with increasing distance. In addition to the correlation between distance and voltage level, in [14] has observed the relationship between transmitter output voltage and receiver input which shows linear characteristics.

3. System model
The device development method used is a prototype approach. The prototype was built to show that the problem can be overcome by the design of the battery energy transfer equipment from a laptop to a wireless projector. Used in this study. The prototype made consists of a transmitter and receiver prototype. The concept of the system is built as in the following figure.

![Block diagram of transmission system](image-url)

Figure 1. Block diagram of transmission system

The transmitter powered by a laptop which working at 5 V DC. The pulse generator module is applied to generate square wave which modulating the modulator in the transmitter. It also radiates the radio frequency wave at frequency 433 MHz. Method Amplitude Shift Keying (ASK) modulation is
selected. Transmitter has specification among others, namely operating voltage: 3.5-12V, transfer rate: 4KB /S and transmitting power: 10m W.

The receiver powered by battery 5 V DC, working current: 5.5m A, receiving frequency : 433 MHz and sensitivity: -105 dBm. Input of the Cockcroft-Walton circuit module connected to the output terminal of the receiver. The voltage output of Walton circuit is DC voltage hereafter used to drive the step-up module 0.9-5V. The DC-DC Adjustable Boost Step-up Power Supply Module is used to boost this level into higher level. The level will range between 3.5-18V DC.

![Figure 2. Block diagram of the transmitter](image)

The inverter is used to convert the output DC voltage from the adjustable boost step up into AC power voltage. The input on the inverter is 12 Volt DC and the output is 220 Volts AC, 1000 Watt. The chosen inverter is one available on the market with the consideration that the required technical specifications fulfilled.

![Figure 3. Block diagram of the receiver](image)

Procedures perform fabrication of device as follow:

- Preparation. Reading journal, paper and studying specification of electronic components of device carried on this step.
- Assembly. Starting with ordering the electronic component or buying it at market local. Making printed circuit board layout, wiring and also soldering.
- Simulation. To study performance of device based on simulation results.
- Installation. Wiring whole electronic components into unit.
- Measurement. To measure the output voltage and collecting it.
- Data acquisition. To do data processing, manipulate and analyses as well.

4. Implementation

Unit will function according to the block diagram and divided into modules as follow:

- Transmitter
- Pulse generator
- Receiver
- Cockcroft-Walton multiplier
- Current inverter
- Step up converter
- Converter DC to AC

Figure 4 and 5 demonstrate the real module of transmitter and receiver respectively. Adaptor can be substituted by laptop for real applications. Led emitting diode was installed to physically monitor working the square wave generator. Some tapping have been pinned to every stage to check the value of output voltage out. There are ten taps at once meaning will be ten stages at the Cockcroft-Walton circuit module.

![Figure 4. The transmitter module](image)

![Figure 5. The receiver module](image)

5. Results and Discussion

Voltage measurement has been done for some values of voltage both for the step-up module 0.9-5V and also the module DC-DC Adjustable Boost Step-up. The voltage observations were made to see effect of the number of stages of the Cockcroft-Walton circuit. The total number of stages is ten. The collected data is processed to determine the cumulative distribution function.

![Figure 6. The influence number of stage to the output voltage of step-up converter](image)

The CDF has been plotted versus the output voltage for multiple of 2 stages. Lowest probability happened if the number of stages is eight. Probability to find out the voltage output between 3 to 4V is $F(4)-F(3)$ equals to 0.6 – 0.29 or 0.31. The eight stages practice is not best choice since resulting higher voltage drop.

For the DC-DC Adjustable Boost Step-up, lowest probability happened if the number of stages is ten. Highest difference of probability exists at the voltage value is 12.5V. Meanwhile, the difference
is meaningless for the four remaining four groups. Thus, the ten-stage arrangement is also not appropriate to be chose as giving higher voltage drop.

The DC-voltage value above is enough to drive the converter DC to AC provide that the additional module working as voltage regulator is added. Large drop voltage will result while connecting to the DC-AC converter so the expected AC-voltage result cannot be attained.

Figure 7. The influence number of stage to the output voltage of adjustable boost step-up

Waveform observation was showed at Figure 8. This waveform resemble to sinusoid wave, having frequency 523.8 MHz. It is slightly little bit higher than specified value so that will affect overall device performance. It has 12 mV peak to peak which is equal to 6 mV peak. This value is only 0.12% of the supply voltage.

Figure 8. The signal waveform at transmitter output

6. Conclusion

Construction the prototype functions to transfer the battery energy from the laptop to the overhead projector working at the alternating-current electricity was invented. It's working based on the concept of the radio-frequency transmission and electrical generation consisting of a couple the transmitter and
receiver. It is useful on emergency situation such as presence, power outage while learning process taking place.

However, in spite the prototype is a preliminary work, the observed data indicated the real attainment supporting the advanced development in the next future. The number of stages of the Cockcroft-Walton circuit affects performance of the prototype. Higher the number of stages, lower the probability of desired voltage output.

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