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POWER DISTRIBUTION THROUGH WIRELESS POWER TRANSMISSION TECHNIQUE

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ABSTRACT:

The major losses in power system is mainly happen in transmission and distribution side. Among this the distribution side losses are dominated due to low voltage and small size of conductors. This paper proposes the utilization of the renewable energy which is generated by the photovoltaic cell and to make a better efficient system. The physical complication due to wiring is avoided by using wireless power transmission (WPT) technique. In this WPT the generated power from PV system is transmitted through the transmitter coil and received through the receiver coil .The generated power from the solar PV system is maximized using charge controller and power is converted into ac by using inverters and transmitted through wireless power transmission. The PV system power is converted to high frequency AC signal and transmitted by using wireless power transmitter. In this paper we generate the power from solar photovoltaic and transmit the power to the load through the WPT by using induction principle .The transmitted power is received by using receivers and modified into various ranges based on the requirement of load. By implementing the wireless power transmission technique, the losses occurs during the distribution of power get reduced .This technique requires less cost for the construction when compare to the grid. Also it requires less maintenance. The flexibility of the system is high.

1. INTRODUCTION

Electricity acts as a universal energy source for all inventions. Generating electricity from fossil fuels produces air and water pollution, which offers various health effects to the public. Fossil fuel is also a non-renewable energy source. In contrast there are various eco-friendly renewable sources like wind, tidal and solar energy. India is the world's third largest producer and third largest consumer of electricity. The national electric grid in India has an installed capacity of 370.106 GW as of 31 March 2020[13, 17].Renewable power plants, which also include large hydroelectric plants, constitute 35.86% of India's total installed capacity. During the 2018-19 fiscal year, the gross electricity generated by utilities in India was 1,372 TWh and the total electricity generation (utilities and non-utilities) in the country was 1,547 TWh. The gross electricity consumption in 2018-19 was 1,181 kWh per capita [17]. In 2015-16, electric energy consumption in agriculture was recorded as being the highest 17.89% worldwide. The per capita electricity consumption is low compared to most other countries despite India having a low electricity tariff.

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India's electricity sector is dominated by fossil fuels, in particular coal, which during the 2018-19 fiscal year produced about three-quarters of the country's electricity. The government is making efforts to increase investment in renewable energy. The government's National Electricity Plan of 2018 states that the country does not need more non-renewable power plants in the utility sector until 2027, with the commissioning of 50,025 MW coal-based power plants under construction and addition of 275,000 MW total renewable power capacity after the retirement of nearly 48,000 MW old coal-fired plants[17].

Among all these sustainable energy sources, solar energy provides enormous amount of power. This energy can also be converted into other forms of energy like, electrical energy and heat energy using devices like PV panel and simple heat conducting materials. Everyday earth receives tremendous amount of energy from the sun in the form of light and heat which is called as solar energy. Solar energy is limitless and is available at no cost. This energy can be directly harvested by the use of photovoltaic (PV) solar cells. A photovoltaic system, also PV system or solar power system, is a power system designed to supply usable solar power by means of photovoltaics. It is the everlasting clean energy source and the power intercepted by the earth is about1.8×10^{11}MW. This energy can be converted to other forms of energy. Hence, this work focuses on, the generation of power from solar energy and distributed through wireless power transmission.

1.2 WIRELESS POWER TRANSMISSION

The majority of today's residences and commercial buildings are powered by alternating current from the power grid. Electrical stations generate AC electricity that is delivered to homes and industry via high-voltage transmission lines and step-down transformers. Electricity enters at the breaker box, and then electrical wiring delivers current to the AC equipment and devices that we use everyday lights, kitchen appliances, chargers etc. All components are standardized in arrangement with the electrical code.

Wireless Power transfer makes it possible to supply power through an air, without the need for current carrying wires. WPT can provide power from an AC source to compatible batteries or devices without physical connectors or wires. WPT can recharge mobile phones and tablets, drones, cars even transportation equipment. WPT has been an exciting development in consumer electronics, replacing wired chargers. The concept of transferring power without wires has been around since the late 1890s.

In a wireless power transmission system, a transmitter device, driven by electric power from a power source, generates a time-varying electromagnetic field[16], which transmits power across space to a receiver device, which extracts power from the field and supplies it to an electrical load. The technology of wireless power transmission can eliminate the use of the transmitting wires and batteries, thus increasing the mobility, convenience, and safety of an electronic device for all users. Wireless power transfer is useful to power electrical devices where interconnecting wires are inconvenient, hazardous, or are not possible.

1.2.1 NEAR FIELD AND FAR-FIELD WPT TECHNIQUES

Wireless power techniques mainly fall into two categories, near field and far-field. In near field or non-radiative techniques, power is transferred over short distances by magnetic fields using inductive coupling between coils of wire, or by electric fields using capacitive coupling between metal electrodes[11]. Inductive coupling is the most widely used wireless technology [3]. In far-field or radiative techniques, also called power beaming, power is transferred by beams of electromagnetic radiation, like microwaves or laser beams [4]. These techniques can transport energy longer distances but must be aimed at the receiver. Proposed applications for this type are solar power satellites, and wireless powered drone aircraft.

1.3 INDUCTIVE COUPLED WPT

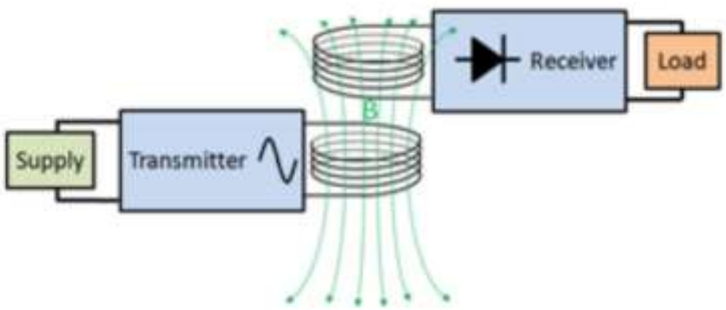

Figure 1: inductive coupling

Wireless power transmission has become a highly active research area. This technique is the transfer of electrical energy through the air without any physical contact .In this paper we use the induction principle for wireless power transmission. Inductive coupled wireless power transmission uses the electromagnetic induction between the two coils [18]. When a coil gets energize by an external supply, it produces a magnetic field in it and the other coil is placed near to it ;An emf gets induced in the another coil, this is an induction principle behind the wireless power transmission technique .Although various wireless power transmission techniques have developed so far ,they have not yet been commercialized except for some noncontact induction coupling methods .In some studies , they had used microwaves at 5.8GHz to transmit large powers of several tens of watts or more ;however they have not yet been commercialized actively owing to their effect on the human body because of the use of high efficiency antennas in their design .In this paper ,the two coils used for wireless power transmission technique generate induced current to transmit power .The transmitting coil and the receiving coil form a pair by the magnetic field produced by the transmitting coil and the electromotive force induced in the receiving coil .Some of the applications of wireless power

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transmission are,1) Biomedical implants which is very important devices in the medical industry. These devices have many use throughout the body and treat a number of conditions which was difficult to made by the doctors. A great examples of such devices are pacemakers, prostheses and cochlear implants. These devices usually made up of the battery. During surgery the batteries under death cause the patient at risk. In such condition WPT can be implemented to recharge the battery. Also the reduction in size of the implant leads to great comfort for the patient. On the other hand any implantable device will have to satisfy strict safety requirements. Improper spacing between the transmitter and receiver can cause both excessive heating in the device and surrounding tissue. Power levels and frequency must be limited satisfying such criteria will undoubtedly lead to compromises the system performance. 2) Radio Frequency Identification Devices (RFID) was the most common example of WPT. These are used for the purposes of identification and tracking, which can be powered wirelessly via radio waves or by electromagnetic induction. These methods can also act as the sole power source. The power associated with background radiation is very low. The low-requirements of power for RFID tags and sensors indicates that the energy harvesting techniques provide a feasible WPT solution. 3) WPT makes a vast improvements in the automotive industry [16]. The increased number of electric and hybrid-electric vehicles on the road makes a keen interest in developing novel wireless charging technologies for this new-age mode of transportation. The implementation of wireless charging technology for electric vehicles can be found, there by the use of inductive charging method, eight public-service electric buses are powered wirelessly. The charging of the electric vehicle can be made in the specially designed bus stops [10]. The systems can be found in some country with an alternative the wirelessly powered road can be provided for the vehicle with a continuous power supply. It rapid increase of wireless charging technology that lead to come more and more electric vehicles in the modern world.

2. THE BLOCK DIAGRAM

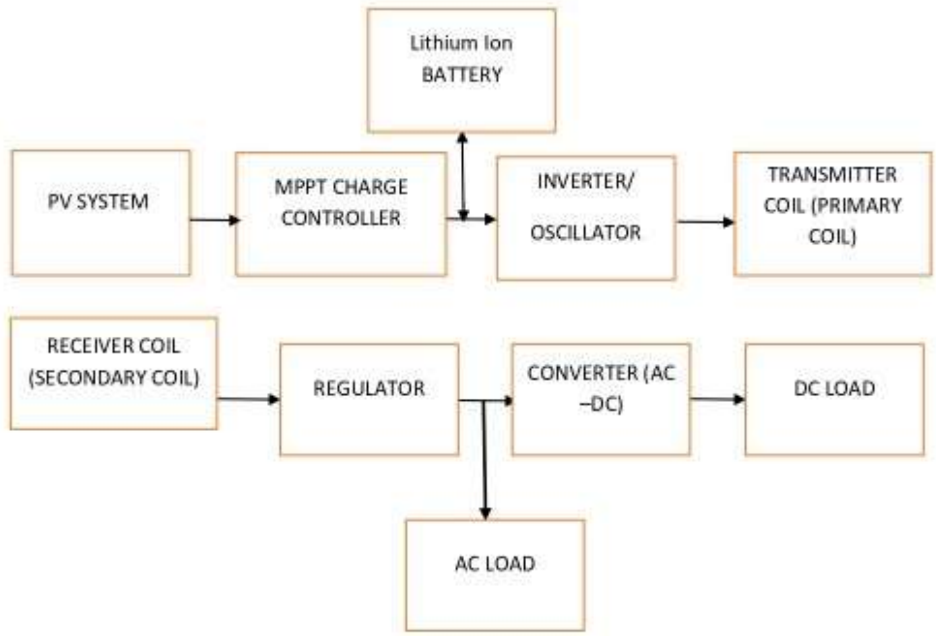


Figure 2: Block diagram

3. BLOCK DIAGRAM DESCRIPTION

In our study we generate the supply power from Photovoltaic (PV) system and then it is fed into the MPPT charge controller .The MPPT charge controller checks the output of the PV module [11], compares it to the battery voltage then fixes the best power that the PV module can produce to charge the battery and convert it to the best voltage to get the maximum current into the battery .Then the power is fed into the oscillator /inverter, the oscillator basically converts the

DC source to an AC source which is of the desired frequency ,as decided by the circuit components .In our study we require the high frequency about several KHZ to MHZ for the purpose to cover the large distance about a feet .The higher frequency increases the distance as well as the lower frequency decreases the distance[8].The oscillated AC power is fed into the transmitting coil ,the transmitting coil transmit the power through free air without any physical contact then the receiver coil receives the power from the transmitter coil[7]. The copper coil in the transmitter and the receiver side is winded in the ratio 1:2 and hence the number of turns in the primary is less than that of the secondary side. The number of turns in the primary and secondary are 161 and 322 respectively. The copper coil used is insulated and of size 10 AWG and 18 AWG [12].The transmission distance between the transmitter and the receiver is about 20 cm. The output from the H bridge inverter is given as the supply to the primary coil. The received AC power is fed into the regulator which regulates the voltage and maintain it constant even if the supply or load condition gets change .For an AC load the power is directly fed from the regulator and for the Dc load the converter is used as an intermediate which converts the AC supply into the DC supply as required.

4. SYSTEM DESIGN

4.1 PRINCIPLE OF WPT SYSTEM

The principle of the inductive WPT system is almost the same as that of a conventional transformer [14, 15]. If a coil gets energize it produces a magnetic field in it. When an another coil is placed near to it, an emf gets induced in another coil due to magnetic flux produced by the primary coil. The equation of the inductive power transfer system can be given by,

$$V_1 = j\omega L_1 I_1 + R_1 I_1 - j\omega M I_2 \qquad (1)$$

$$j\omega M I_1 = j\omega L_2 I_2 + R_2 I_2 + R_L I_2 \qquad (2)$$

Let us assume that V_1 be the supply voltage, R_1 be the resistance, L_1 be the inductance and I_1 be the current of the transmitter coil while R_2 be the resistance, L_2 be the inductance and I_2 be the current of the receiver coil respectively.

The current in the receiver coil is equal to the ratio of the induced emf to the equivalent impedance of the receiver coil.

$$I_2 = \frac{j\omega M I_1}{j\omega L_2 + R_2 + R_L} = \frac{j\omega M I_1}{Z_2} \qquad (3)$$

Where Z_2 is the total impedance of the receiver coil. Substitute Equation (3) in (1), the transmitter side voltage and the total impedance can be written as,

$$V_1 = j\omega L_1 I_1 + R_1 I_1 + \left(\frac{\omega^2 M^2}{Z_2}\right) \qquad (4)$$

$$Z = j\omega L_1 + R_1 + \left(\frac{\omega^2 M^2}{Z_2}\right) \qquad (5)$$

From the equation (1) and (5) we can observed that both the reflected voltage and the induced voltage are described in terms of mutual inductance (M) between the coils. The relation between the mutual inductance and the magnetic coupling coefficient is given

$$K = \frac{M}{\sqrt{L1L2}} \quad (6)$$

The coupling coefficient depends on mutual inductance between the coils, $\sqrt{L1L2}$ self inductance of the transmitter and the receiver coil.

4.2. FULL BRIDGE INVERTER USING MOSFET SWITCHES

It is the most efficient inverter topology which work two wire transformers for delivering the oscillating current in the primary side. This topology can avoid the use of a 3-wire center tapped transformer which are not very efficient due to their twice the amount of primary winding than a 2-wire transformer. With a two wire transformer connected to an h-bridge inverter means the associated winding is allowed to go through the push pull oscillations in a reverse forward manner [5]. This topology allows the use of smaller transformers and at the same time get more power output. The full bridge driver ICs are easily available now and it became utterly simple and making a full bridge inverter circuit. However better things are never easy to implement or to get the correct output. When identical type MOSFETs are involved in an H-bridge inverter [5], driving them efficiently is a very big problem.

In this paper we have design the inverter with the MOSFET switches which gives 230V AC output for a 12 V DC input. The astable multivibrator act as an oscillator in this inverter .The constant 5V external supply is given as input to the astable multivibrator. The output frequency from the oscillator is determined by the capacitors and the resistors and the expression is given by

$$f = \frac{1.45}{(R_A + R_B)C} \quad (8)$$

During the charging portion of the astable multivibrator , the resistor R_B gets short circuited so that,

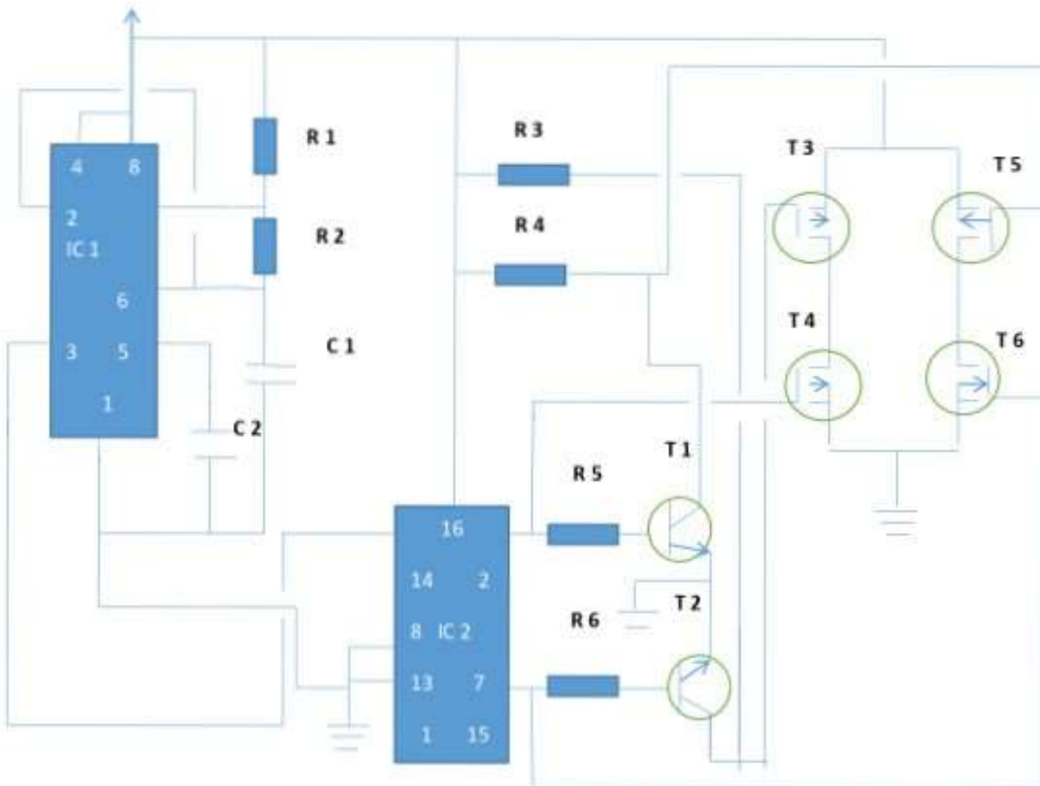
$$t_{HIGH} = 0.69\, R_A C \quad (9)$$

During the discharging portion of the cycle,

$$t_{LOW} = 0.69\, R_B C \quad (10)$$

$$\text{The total time } T = t_{HIGH} + t_{LOW} = 0.69(R_A + R_B)C \quad (11)$$

The resistor R_A and R_B could be made variable to allow adjustment of frequency and pulse width.



The pulses from the timer initiates the process of the inverter. For the IC 555 timer the 12v supply is given to the pin 1. The pulses jumps from one pin out to the another in the following order: 3-2-4-7-1.In respond to the fed each pulse the output of the IC 4017 will become high from pin 3 to pin 1 and the cycle will repeat as long as the input pin 14 persists. Once the output reaches pin 1 it reset the pin 15 of astable multivibrator, so that the cycle can repeat back from pin 3. When pin 3 is high, nothing conducts at the output. The moment the above pulse jumps to pin 2 it becomes high which switches ON T4 the N-channel MOSFET responds to positive signal, simultaneously transistor T1 also conducts, it's collector goes low which at the same instant switches ON T5, which being a P-channel MOSFET responds to the low signal at T1's collector. With T4 and T5 ON, current passes from the positive terminal through the involved transformer winding TR1 across to the ground terminal. This pushes the current through TR1 in one direction from right to left. At the next instant, the pulse jumps from pin 2 to pin 4, since this pinout is blank and again nothing conducts. However when the sequence jumps from pin 4 to pin 7, T2 conducts and repeats the functions of T1 but in the reverse direction. That is, this time T3 and T6 conduct switching the current across TR1 in the opposite direction from left to right. Thus the cycle completes the H-bridge functioning. Finally, the pulse jumps from the above pin to pin 1 where it's reset back to pin 3 and the cycle keeps repeating. The blank space at pin 4 keeps the MOSFETs entirely safe from any possible disfunctioning of the full bridge. The transfer of the pulse across the IC4017 from its pin 3 to pin 1 constitutes one cycle, which must repeat 50 or 60 times in order to generate the required 50 Hz or 60 Hz cycles at the output of TR1

5. CONCLUSION

In this an inductive wireless power transfer system was proposed .The proposed wireless power system was able to transmit high frequency ac signals at a distance of 20 cm. The supply from the photovoltaic system with a battery backup is fed to the inverter and then to the transmitter coil with the increase in frequency. The H bridge inverter is developed to supply power to the transmitter coil.

The oscillator which converts the low voltage DC to low voltage AC is designed. The oscillation produced by the oscillator may be a square wave or sine wave or modified sine wave. The operating frequency of the system is 2.41 KHz the optimal operating frequencies depending on the change of the distance is experimentally verified. The mathematical analysis of the coil to coil system using an equivalent circuit modeling technique is obtained. Then the coil to coil efficiency, copper usage, control stability were calculated. The measured coil to coil efficiency was 77% and the efficiency of the inverter is 93%.

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