DESIGN AND IMPLEMENTATION OF LOCAL RF ENERGY HARVESTING WIRELESS SENSOR NODE USING HIGH FREQUENCY RESONANCE

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Abstract: The work of base paper depends to external tower, means it was directive. It means that it is necessary to keep the antenna in front of the tower. It is not all time possible to keep the antenna in front of the tower. It will be may be improve in future but it may consume 5-10 year. So we need another solution where there will not dependencies to external tower. For this we radiate low frequency EM energy band and for local area network we captured it and give power to wireless sensor node. It will be implementing in room level our work is to provide power to wireless sensor node. We look low frequency band spectrum because magnetic field is more in low frequency. Our range is 100-200 MHZ. Hardware is working in 20 MHz range. RF transmitter and 33 MHz which means it is the frequency where it sends data.
Keywords: WSN ,RF Energy Harvesting

I. INTRODUCTION

Energy harvesting based wireless sensor networks (EHWSNs) are composed of individual nodes that in addition to sensing and wireless communications are capable of extracting energy from multiple sources and converting it into usable electrical power. In this section we describe in details the architecture of a wireless sensor node with energy harvesting capabilities, including models for the harvesting hardware and for batteries.

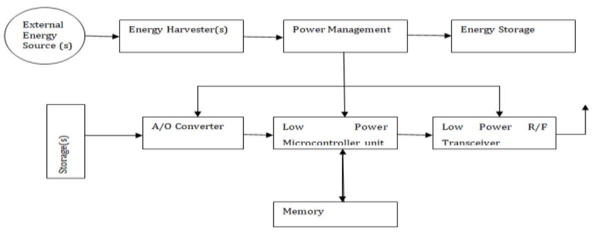

Fig 1. System architecture of a wireless node with energy harvesters

- The system architecture of a wireless sensor node includes the following components (Figure 1):
- The energy harvester(s), in charge of converting external ambient or human-generated energy to electricity;
- A power management module, that collects electrical energy from the harvester and either stores it or delivers it to the other system components for immediate usage;
- Energy storage, for conserving the harvested energy for future usage;
- A microcontroller;
- A radio transceiver, for transmitting and receiving information;
- Sensory equipment;
- AN A/D converter to digitize the analogue signal [4] generated by the sensors and makes it available to the microcontroller for further processing, and Memory to store sensed information, application-related data, and code.

Table 1 Different Parameters Of Wireless Energy Transfer Technique

Wireless energy transfer technique	Effective distance	Efficiency	Applications
Inductive coupling	From a few millimetres to a few centimetres	From 5.81 % to 57.2 % when frequency varies from 16.2 kHz to 508 kHz	Passive RF identification (RFID) tags, contactless smart cards, cell phone charging
Magnetic resonance coupling	From a few centimetres to a few meters	From above 90 % to above 30 % when distance varies from 0.75m to 2.25m	PHEV charging, cell phone charging
RF-energy Transfer	Depend on distance and frequency and the sensitivity of RF-energy harvester (typically from several meters to several kilometres	Depends of the input Power. 0.4%at -40 dBm, above 18.2 % at -20 dBm and above 50 % at -5dBm.	Wireless sensor network, wireless Body network.

II. RELATED STUDY

Cesare Alippi, Fellow, IEEE, and Cristian Galperti [1] , In this paper we propose a low-power maximum PowerPoint tracker (MPPT) circuit specifically designed for wireless sensor nodes (hence effective, flexible, low cost and power-aware),i.e., a power transferring circuit for optimally conveying solarenergy into rechargeable batteries even in not optimal weather conditions. High efficiency is granted by an ad hoc adaptive algorithm which, by keeping the MPPT electronics in its optimal working point, maximizes energy transfer from the solar cell to the batteries. The suggested implementation is particularly effective in critical weather conditions where traditional solutions do not work and is characterized by a flexible enough design for immediately hosting, in a plug in fashion, different solar panelsand battery typologies.

Ming-Yuan Cheng, Yan-Bin Chen and Hung-Yu Wei [2] they propose an event-driven energy-harvesting (EDEH) wireless sensor network (WSN) in which the sensors are powered by the energy harvested from the consequence of the event, e.g. buildings shaking during an earthquake. The scarce amount of energy harvested during the short event occurrence time poses great challenges for the medium access control (MAC) design, which is the focus of our research. Furthermore, when all sensors harvest energy from the event, they become active simultaneously leading to serious channel contention problems. As such, we first examine the amount of harvestable energy and then show analytically that our MAC protocol is able to provide higher packet delivery ratio than conventional wireless technology, e.g. IEEE802.15.4.

XenofonFafoutisa,∗, Thomas Sørensenb, Jan Madsena [3] The paper investigates the feasibility of using IEEE 802.11 in energy harvesting low-power sensing applications. The investigation is based on a prototype carbon dioxide sensor node that is powered by artificial indoors light. The wireless communication module of the sensor node is based on the RTX4100 module. RTX4100 incorporates a wireless protocol that duty-cycles the radio while being compatible with IEEE 802.11 access points. The presented experiments demonstrate sustainable operation but indicate a trade-off between the benefits of using IEEE 802.11 in energy harvesting applications and the energy-efficiency of the system.

Cesare Alippi, Giuseppe Anastasi, Mario Di Francesco, Manuel Roveri [4] Most energy management strategies proposed in the literature assume that data acquisition consumes significantly less energy than their transmission. Unfortunately, this assumption does not hold in a number of practical applications where the power consumption of the sensing activity may be comparable or even greater than that of the radio. In this context, effective energy management strategies should include policies for an efficient use of energy-hungry sensors, which become one of the main components affecting the network lifetime. In this paper, we survey the main approaches for efficient energy management in sensor networks with energy-hungry sensors.

Ryo Shigeta, Rushi J. Vyas [5] A WSN node repeatedly charges and discharges at short intervals, depending on the energy intake. Typically in energy-harvesting systems, a capacitor is used for an energy storage because of its efficient charge and discharge performance and infinite recharge cycles. When the charging time is too short, a node is more likely to experience an energy shortage. On the contrary, if it is too long, more energy is lost because of leakage in the capacitor. In this paper, we introduce an adaptive duty cycle control scheme optimized for RF energy harvesting. This method maximizes the sensing rate by taking into account the leakage problem, a factor that has never been previously studied in this context. Our control scheme improves the efficiency by aggregate evaluation of operation reliability and leakage reduction.

HussainiHabibu, AdamuMurtalaZungeru [6] Wireless sensor nodes are usually deployed in not easily accessible places to provide solution to a wide range of application such as environmental, medical and structural monitoring. They are spatially distributed and as a result are usually powered from batteries. Due to the limitation in providing power with batteries, which must be manually replaced when they are depleted, and location constraints in wireless sensor network causes a major setback on performance and lifetime of WSNs. This difficulty in battery replacement and cost led to a growing interest in energy harvesting. The current practice in energy harvesting for sensor networks is based on practical and simulation approach. The evaluation and validation of the WSN systems is mostly done using simulation and practical implementation. Simulation is widely used especially for its great advantage in evaluating network systems. Its disadvantages such as the long time taken to simulate and not being economical as it implements data without proper analysis of all that is involved ,wasting useful resources cannot be ignored.

R.Hemalatha, R.Ramaprabha and S.Radha[7] In this paper the solar energy harvester requirements for TelosB mote has been analyzed and calculated. Photovoltaic (PV) panel and battery sizing requirements are calculated by assuming that the mote follows SMAC and TDMA-MAC schedule for image communication. The calculations are validated by comparing it with the parameters calculated from the real time current consumption measurement of the mote. Lifetime has been predicted with the physical design of energy harvester. The analysis confirms that the lifetime of the network can be increased to a greater extent, by proper sizing of the harvester and efficient utilization of the available energy.

Mohammad Rahimi, Hardik Shah, Gaurav S. Sukhatme [8] , they study the feasibility of extending the lifetime of a wireless sensor network by exploiting mobility. In our system, a small percent-age of network nodes are autonomously mobile, allowing them to move in search of energy, recharge, and deliver energy to immobile, energy-depleted nodes. they term this approach energy harvesting. We characterize the problem of uneven energy consumption, suggest energy harvesting as a possible solution, and provide a simple analytical framework to evaluate energy consumption and our scheme. Data from initial feasibility experiments using energy harvesting show promising results.

III. PROPOSED CONCEPT

In order to cope up with the power loss we have suggested the two solutions,

- RF Inductive Coupling
- Wireless Power Transmission Technology

3.1 RF Inductive Coupling

Resonant inductive coupling or magnetic phase synchronous coupling is a phenomenon with inductive coupling where the coupling becomes stronger when the "secondary" (load-bearing) side of the loosely coupled coil resonates. A resonant transformer of this type is often used in analog circuitry as a band pass filter. Resonant inductive coupling is also being used in wireless power systems for portable computers, phones, and vehicles. WiTricity type magnetic resonance coupling systems add another set of resonant coils on the "primary" (power source) side which pair with the coils on the secondary (load bearing) side.

Non-resonant coupled inductors, such as typical transformers, work on the principle of a primary coil generating a magnetic field and a secondary coil subtending as much as possible of that field so that the power passing through the secondary is as close as possible to that of the primary. This requirement that the field be covered by the secondary results in very short range and usually requires a magnetic core. Over greater distances the non-resonant induction method is highly inefficient and wastes the vast majority of the energy in resistive losses of the primary coil.

Using resonance can help improve efficiency dramatically. If resonant coupling is used, the secondary coil is capacitive loaded so as to form a tuned LC circuit. If the primary coil is driven at the secondary side resonant frequency, it turns out that significant power may be transmitted between the coils over a range of a few times the coil diameters at reasonable efficiency. It is often explained as increasing the coupling coefficient when the system is resonating, but that is not correct.

Compared to inductive transfer in conventional transformers, except when the coils are well within a diameter of each other, the efficiency is somewhat lower (around 80% at short range) whereas tightly coupled conventional transformers may achieve greater efficiency (around 98-99%) and for this reason it cannot be used where high energy transfer is required at greater distances.

However, compared to the costs associated with batteries, particularly non-rechargeable batteries, the costs of the batteries are hundreds of times higher. In situations where a source of power is available nearby, it can be a cheaper solution. In addition, whereas batteries need periodic maintenance and replacement, resonant energy transfer can be used instead. Batteries additionally generate pollution during their construction and their disposal which is largely avoided.

3.2 WPT (Wireless Power Transmission) Technology

WPT technology is an old technology and it was demonstrated by "Nikola Telsa" in the year 1980. Wireless power transmission mainly uses three main systems such as microwaves, solar cells and resonance. Microwaves are used in an electrical device to transmit electromagnetic radiation from a source to a receiver. Accurately the name WPT states that, the electrical power can be transferred from a source to a device without using wires. Basically, it includes two coils they are a transmitter coil & a receiver coil. Where the transmitter coil is powered by AC current to create a magnetic field, which in turn induces a voltage in the receiver coil.

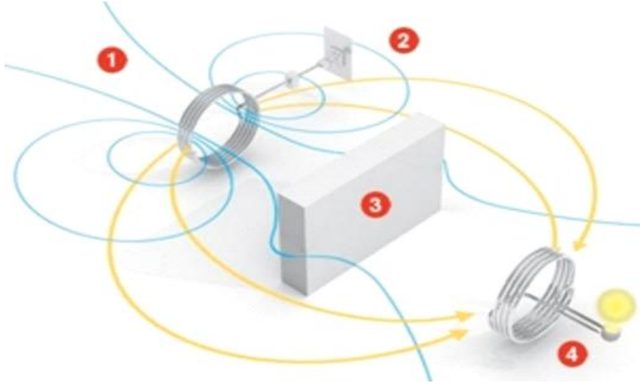

Fig.2 Wireless Power Transmission Technology

The basics of wireless power transmission include the inductive energy that can be transmitted from a transmitter coil to a receiver coil through an oscillating magnetic field. The DC current supplied by a power source is changed into high frequency AC current by particularly designed electronics built into the transmitter. In the TX (transmitter) section, the AC current increases a copper wire that creates a magnetic field. Once an RX (Receiver) coil is located near to the magnetic field, then the magnetic field can induce an AC current in the receiving coil. Electrons in the receiving device, converts the AC current back into DC current that becomes working power.

3.3 WIRELESS POWER TRANSFER CIRCUIT

The simple wireless power transmission circuit is shown below. The required components of this circuit mainly include 20-30 magnet wire (gauge copper wire), A battery-1, transistor (2N2222) and LED. The construction of this circuit comprises of a transmitter and a receiver.

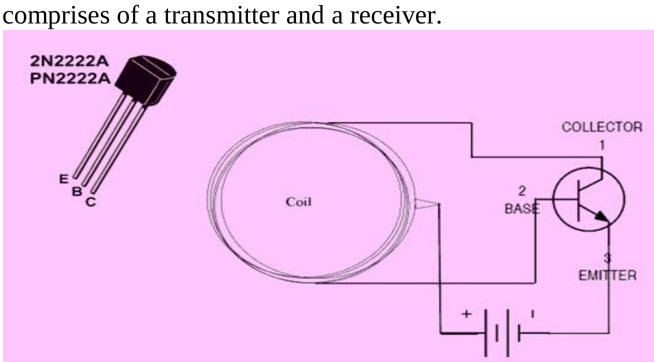

Fig. 3 Wireless Power Transfer Circuit

3.4 Transmitter Circuit

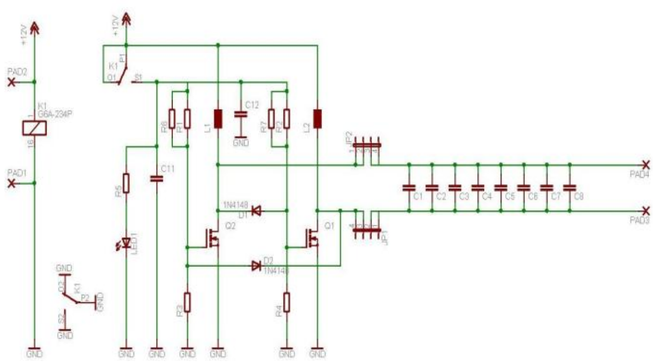

Fig. 4 Wireless power transmitter circuit

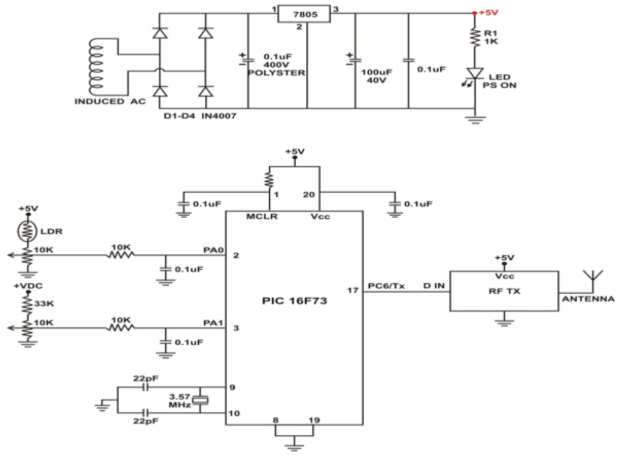

Figure 5 Energy harvesting wireless sensor node (Receiver)

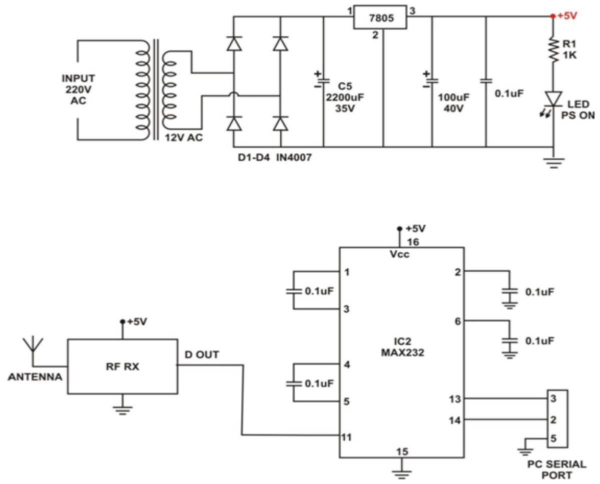

Fig. 6 Circuit Diagram of central receiver hub

Wireless battery charger circuit design is very simple and easy. These circuits require only resistors, capacitors, diodes, Voltage regulator, copper coils and Transformer.

In our Wireless battery charger, we use two circuits. The first circuit is transmitter circuit used to produce voltage wirelessly. The transmitter circuit consists of DC source, oscillator circuit and a transmitter coil. Oscillator circuit consists of two n channels MOSFETS IRF 540, 4148 diodes. When the DC power is given to the oscillator, current starts flowing through the two coils L1, L2 and drain terminal of the transistor. At the same time some voltage is appeared at the gate terminals of the transistors. One of the transistors is in on state while the other is in off state. Thus voltage at drain of transistor which is in off state raises and it fall through the tank circuit made of 6.8nf capacitors and transmitter coil of 0.674. Thus operating frequency is determined by using formula $F=1/[2\pi\sqrt{(LC)}]$.

In the second circuit that is receiver circuit consists of receiver coil, rectifier circuit and regulator. When the receiver coil is placed at a distance near the inductor Ac power is induced in the coil. This is rectified by the rectifier circuit and is regulated to DC 5v using 7805 regulator. The rectifier circuit consists of 1n4007 diode and capacitor of 6.8nf. The output of regulator is connected to the battery.

NOTE: Also get an idea about the Battery Level Indicator Project Circuit and its Working

3.5 Operation of Wireless Power Transfer Circuit: -

- Initially, connect the circuit as shown in the circuit diagram.
- Switch on the supply.
- Connect the battery charger at the output of the circuit.
- Place the receiver coil near the transmitter coil.
- You can observe the charging of battery.

3.6 Wireless Battery Charger Circuit Advantages:

- Usage of separate charger is eliminated.
- Phone can be charged anywhere and anytime.
- It does not require wire for charging.
- Easier than plug into power cable.

3.7 Wireless Power Transfer Circuit Applications:

- Wireless chargers can be used to charge mobiles, camera batteries, Bluetooth headsets etc.
- This can also be used in applications like car battery charger with little modification. Go to Simple Car Battery Charger Circuit post for more information.

3.8 Limitations of the Circuit:

- Power is somewhat wasted due to mutual induction.
- It will work for very short distances only. If you want to use it for long distances, then the number of inductor turns should be high.

3.9 TRANSMITTER CIRCUIT

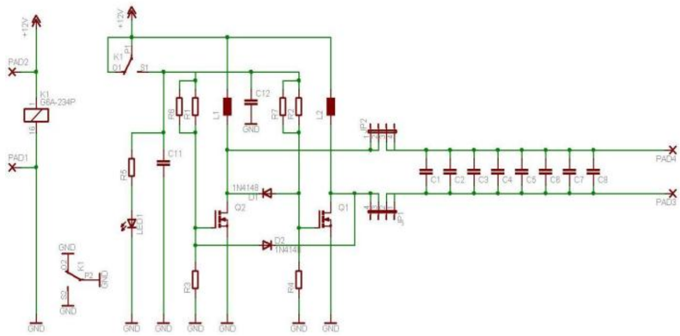

Figure 7 Wireless power transmitter circuit

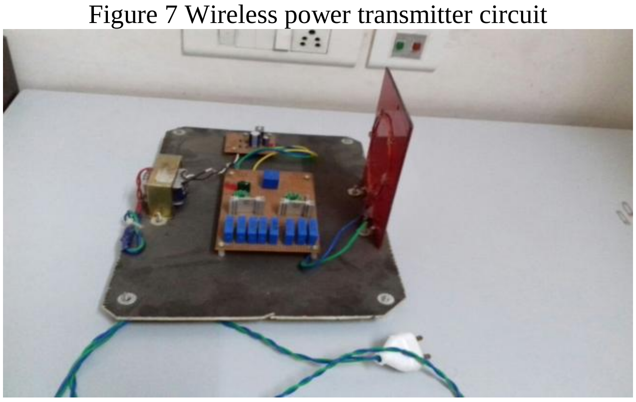

Figure 8 Implemented hardware Transmitter circuit

Input main supply.

We use 220 12/ 1 amp step down transformer.

This will minimize the amplitude of high amplitude waveform. Here we use 12-12 volt voltage so that the resulting voltage will be 24 volt. 4 diode of 1N4007 are used for making of a bridge rectifier. There is a main fitter capacitor which is used for charging at a peak voltage and thus it will convert in DC Volt. Then we receive 24 volt unregulated voltage because it is dependent on mains. Voltage is not fix, sometime it will 23 volt or 25 volt. For voltage regulation we use a 2812 voltage regulator IC. It will give + 12 volt fix voltage. We use 1 additional filter capacitor which is used for noise remove. And it will place on line. There are 3 output, ground, 12 volt and 24 volt. The ground output will give to oscillator and on coil of relay. On another side of relay coil output we give 12 volt. 42 volt will give at relay input. And the output of relay will give to oscillator circuit. When power supply on, then 12 volt and 24 volts will unstable after some milliseconds it will be stable. The relay ON when power will stable and gives 24 volt. There are two inductor in the circuit L1 & L2. There are some frequency is generated which may go to the power supply line and damage the oscillator. So for block the frequency we have used RF chalk.

3.10 Working:

The metal–oxide–semiconductor field-effect transistor (MOSFET, MOS-FET, or MOS FET) is a type of field-effect transistor (FET), most commonly fabricated by the controlled oxidation of silicon. It has an insulated gate, whose voltage determines the conductivity of the device. This ability to change conductivity with the amount of applied voltage can be used for amplifying or switching electronic signals. A metal–insulator–semiconductor field-effect transistor or MISFET is a term almost synonymous with MOSFET. Another synonym is IGFET for insulated-gate field-effect transistor.

There are 2 MOSFET; IRF 540 [39]. At a time only one MOSFET will ON and another will off. The IRF540N is an advanced HEXFET N-channel power MOSFET, from International Rectifier. The device is extremely versatile with its performance capabilities and thus becomes ideal for numerous electronic applications.

Main Features

- Sophisticated, cutting-edge processing technology used.
- Extremely low resistance across load path. Flexible dv/dt plot.
- Operating temperature tolerance capacity as high as 175 degrees Celsius.
- Very fast switching capability.
- Fully resistant against avalanche or peak surge currents.

Applications Areas

This device is best suited for high power DC switching applications, such as in high current SMPS power supplies, compact ferrite inverter circuits, iron core inverter circuits, buck and boost converters ,power amplifiers, motor sped controllers, robotics etc.

At a time only one MOSFET will ON and another will off. There are two resistor R1 = 1K and R2= 10K from R1 and R2 we gave signal to a gate of MOSFET 1. From R4 & R5 gave signal to the gate of MOSFET 2

We consider two cases:

Case-1

When we gave the signal to the gate of MOSFET 1 thus diode D2 will ON or D3 will be OPEN, whereby MOSFET 2 will be OFF because it will ground.

Case- 2

If D3 is ON then first MOSFET will be ground and OFF. Here D2 and D3 diode are used for complimentary ON/OFF. Diode D2 and diode D3 both are inter log diode.

From RF chalk 4 we gave signal to the gate of MOSFET 2, whereby MOSFET will be ON and then it will pull down the diode D3 and diode D3 will be off and diode D2 will be high. And the oscillators will oscillates the frequency of oscillation

$$f = 1/2\ LC \quad .... \quad (1)$$

The oscillator will be ON OFF from diode but how much time to take for ON/OFF will be determine by LC

$$C = 6.8nF \times 8 \quad .... \quad (2)$$

At 1.5 MHz frequency it will be starting oscillation. We transmit this frequency. Sometimes we give direct voltage of 24 volt then capacitor will not charge, it will take some milliseconds. When we plug in the power supply, it will not stable at 12 volt, first 4, 8 …. 10 then 12 volt. It will take some time so that there is lock down problem in oscillator. That means both oscillator will ON H half-half or heated up and oscillator will not work. To solve this problem we give the power supply through the relay. At the IC 7812 we join a relay coil and terminal 1 of Relay we give 24 volt from power supply. Outputs of relay give to oscillator circuit. When we did not get 12 volt from 7812 the relay will not ON. Our oscillator will work on 24 volt unregulated. And we dome switching on 12 volts. 24 volt will be ON/OFF by 12 volt relay. And coil will ON/OFF on 24 volt. Here L and C are circuit, when power is injected then the power will radiate in atmosphere and it may be 1 watt or 2 watt. At the oscillator there is matching of impedance and maximum power will transmit

3.9 RECEIVER CIRCUIT

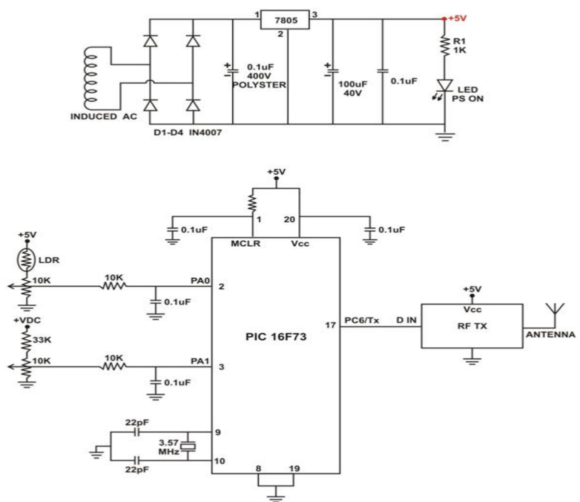

Fig. 9 Wireless sensor node (receiver)

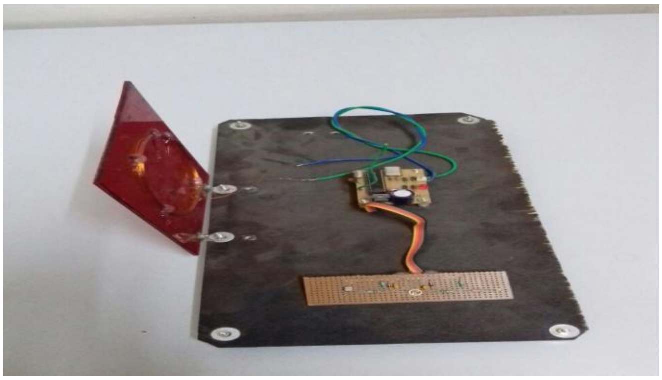
Fig .10 Hardware implemented Wireless Sensor Node

There is a LC tuned circuit. Waveform which is induced at transmitter (1.5 MHz) will receive here. Bridge rectifier is used for conversion of half wave to full wave. Here is a main filter capacitor which is use for charging at peak and convert in dc. Here 7805 a voltage regulator IC Pix16F73 micro controller of 28 pin. B, 19 bin will be ground Bit 6 of a port C of microcontroller pin no 17 use as a transmitter which send the serial Data. This will give to data input of RF transmitter and transmit by antenna. There is +7 volt and +12 unregulated Rx Voltage. For microcontroller or RF we regulate it by +5 volt. Zener diode will clip when voltage is exceed +5 volt. So the microcontroller receive +5 volt. Zener diode is used here for protection.
We have taken 2 parameters:

- Voltage: which is induced will give to analog channel of radio transmitter through potential divider.
- Intensity of light,

Through intensity of light the resistance will change so the voltage will also change. Microcontroller reads both values. Then we measure the both parameter and digitize it transmit it through radio frequency transmitter.

3.10 CENTRAL HUB

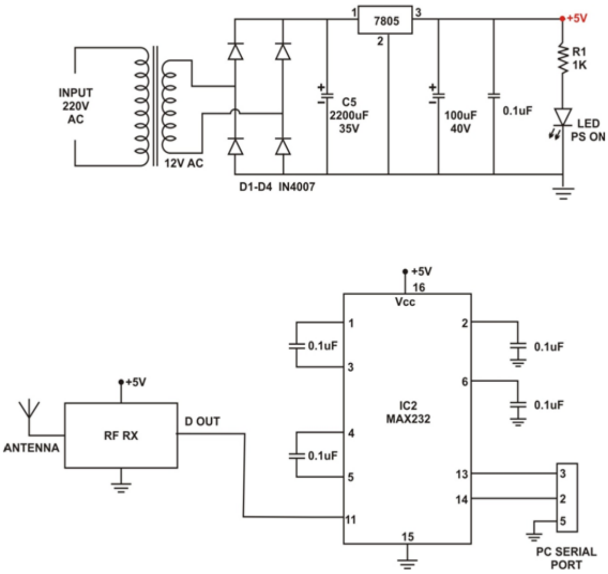

Fig. 11 Circuit diagram of central receiver hub

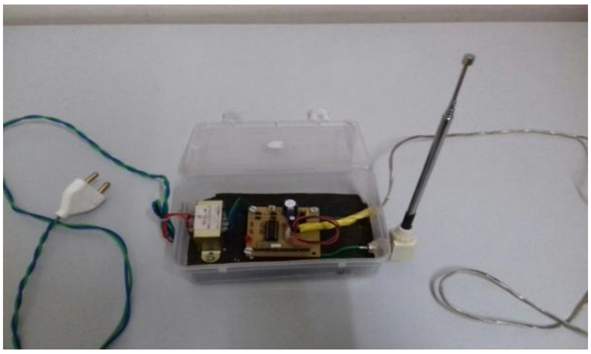
Fig. 12 Hardware implemented Central Hub

There is a transformer of 500 mA, because to operate hub we need 5 volt. Step down transformer; step down 220 volt to 12 volt unregulated. From IC 7805 we get +5 volt regulated which give to RF receiver. Antenna will receive those serial streams, which is send by controller. The TTL signal which was send from transmitter receives here. The receive signal data in TTL form,

Logic 0	0 volt
Logic 1	5 volt

Our computer, it is understand only RS232 signal

‘0’	+ 9volt
‘1’	- 9volt


Fig. 13 Connected RF transmitters

So we take IC Max 232, which converts TTL to RS232. Then the data goes to serial port. Here we use only one node, we can use multiple nodes. From the transmitter the power will transmit wirelessly. Here we don’t use high power EM devices because of highly cost. Here we provide power to transmitter no to node. The transmitter converts AC mains to DC and the RF energy. The central hub receives it. DC will not transmitter because there is no magnetic field will produce. But electronic circuit works on DC so AC converts to DC, and DC to high frequency through oscillator. And take output. In our hardware we take a demo. Here local transmitter and a number of nodes which send all the data to central hub. Hub will receive data of node. The programming of C is in Node. In node there are 2 l sensors. 1 is read the power coming from coil in analog channel. 1 is read the intensity of light. Both of these values will transmit to serial port of microcontroller. In microcontroller there is a RF transmitter, which radiates this signal.

SIMULATION TOOLS

In this, firstly MATLAB software and programming in C used for implementing the proposed work is presented. Secondly, testing the proposed work is discussed in detail.

Specific Requirements

Hardware Requirements

Computer/Processor	:	Any Intel Processor or AMD Processor
Operating System	:	Windows: 7
Memory	:	Windows: 1024 MB (RAM)
Disk Space	:	3 GB (MATLAB)

Software Requirement: MATLAB 7.8

IV. RESULT ANALYSIS

We do not have any external power dependency. In the forthcoming time there will too much nodes, and it is not possible to supply power all the nodes. So it will capture the external power for work like radiation of mobile tower, thermal energy etc. Battery is not easy to use because of too much sensor have battery. And it is not possible to implement the battery, very complicated to change it.

For this we radiate low frequency EM energy band and for local area network we captured it and give power to wireless sensor node. It will be implementing in room level our work is to provide power to wireless sensor node. We look low frequency band spectrum because magnetic field is more in low frequency. Our range is 100-200 MHZ. Hardware is working in 20 MHz range. RF transmitter and 33 MHz which means it is the frequency where it sends data. We made a local RF transmitter.

Comparison Table

Table w – Comparison between base paper and proposed work

S. No.	Parameter	Base Paper	Our Proposed work
1.	Title	Ambient RF energy Harvesting sensor device with capacitor leakage aware duty cycle IEEE 2013	NA
2.	Energy Band Utilized	Microwave RF energy 2.4 GHz and VHF Band 512 MHz to 566 MHz	RF Inductive coupling @ 1.5 MHz 0 -100 MHz
3.	Placement limitation	Yes, Dipole antenna to be pointed towards tower.	No limitation just node to be in field.
4.	Location limitation	Yes, a strong signal RF tower of tuned Bond in the vicinity of 0-10 KMs required	No, local RF field generator employed, to be deployed Room wise, House wise or Building wise.
5.	Other limitation	Effected by LOS obstruction, weather, tower relocation, Antenna orientation.	Limited by local RF field Power generator and range.

MEASURED READING AND DISCUSSION

We measured different voltage reading at different distance between transmitter and receiver at a given time period and measured intensity of light in different situation. The different voltage v/s time graphs are shown in below Figures.

4.3.1Voltage Based Reading Distance 2cm

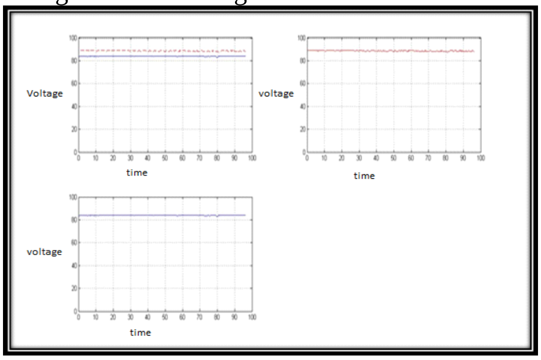

Fig. 14 Voltage Based Reading distance 2cm

The Figure 14 showed the voltage based reading taken at the distance of 2cm and the results which observed are voltage is around 87 volts and intensity of light is 82.

Voltage Based Reading Distance 4cm

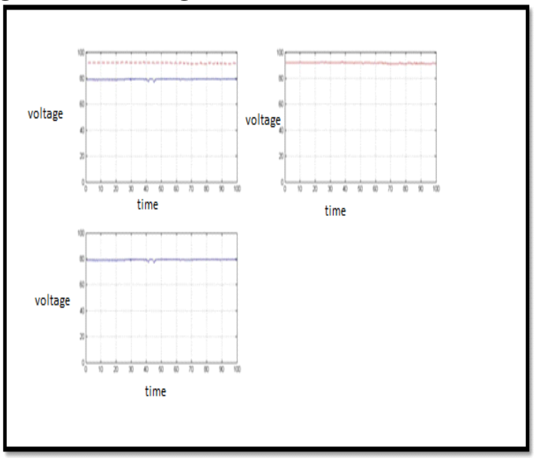

Figure: 15 RF-LDR Reading distance 4cm

The Figure 15 showed the voltage based reading taken at the distance of 4cm and the results which observed are voltage is around volts90 and intensity of light is 80.

V. CONCLUSION

Wireless sensor networks (WSNs) are large networks consisting of small sensor nodes (SNs), with limited computing resources used to gather process data and communicate. A major challenge in a lot of sensor network applications requires long period of life for network survival, which leads to high consumption of energy.

In the presented chapter a study of wireless sensor network is focused and we make a local RF transmitter which work is how to receive power from source wirelessly. The point to notice here is that the reading of voltage doesn't very low in every case but the intensity of light suddenly low or high depends on condition.

We do not take the dependency to external tower, so or dissertation is not directive. We made a local RF transmitter which radiates RF energy to environment, and the receiver received the energy and gives it to us.

The proposed concept wills deployable to IOT because IOT there will need of sensors. And the sensors works is operated by battery or the power devices. But it is very complicated to change the battery. So we need to that we get energy from Environment. Our range is low, so for future work we focus on improving the range of our coverage the

FUTURE SCOPE

One of the motivations to the project was to reduce the amount of battery replacements in an installed node and if one successfully does so it would be of interest to find out how much actually could be saved in terms of real money.

Overall we are satisfied with the outcome of this project; we have effectively shown that it is possible to power a wireless sensor node with an input power that is possible for an energy harvester to achieve. But there is still a lot of further testing to do in order to make a final product, especially one must specify the application and perform long running test with the intended harvester as power supply.

For future work we focus on improving the range of our coverage, because the range is very low for this we can use multiple sensors node for power receive.

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