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RF ENERGY HARVESTING AND MANAGEMENT

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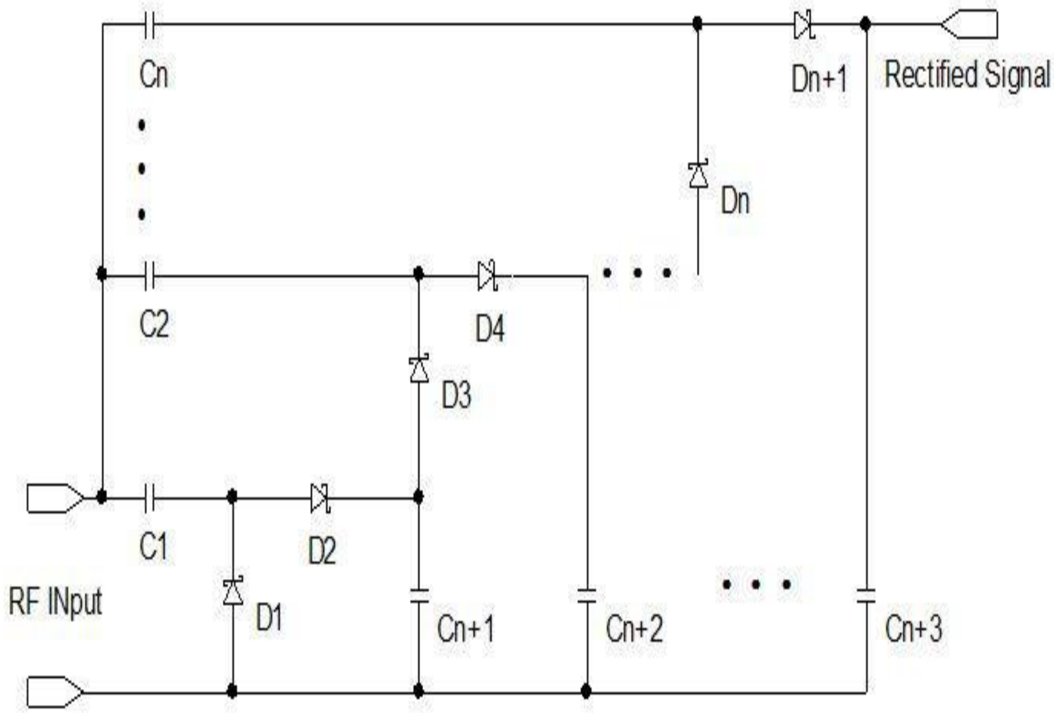
Abstract:- Energy harvesting is the process of electronically capturing and accumulating energy from a variety of energy sources that are wasted or otherwise said to be unusable for any practical purpose. These residual energies are released into the environment as wasted potential energy sources .The main objective of our project is to harvest such a type of residual energy that is released to the environment. This project deals with harvesting of Radio Frequency (RF) energy and utilizing it in an efficient way. Energy harvesting efficiencies are continually improving, and the component manufacturers of devices such as microcontrollers are designing for lower power consumption and lower operating voltages. Building automation and energy management applications are benefiting today from indoor solar and kinetic energy harvesting, with RF energy harvesting (i.e. wireless power) adding the ability to provide power even in low-light conditions.

Keywords: Energy harvesting, environment, consumption, automation, RF energy

INTRODUCTION

The main sources of electricity production available are natural resources like coal, natural gas, petrol, etc. The world is running short of all the natural resources due to their continuous utilization around the globe. So, there is a need for an alternate way for the production of electricity. Energy harvesting from RF signals is meant for the extraction of energy from the surrounding and then transforming it into some usable form. Atmosphere is filled with wide range of frequency signals which are used for different purposes. By capturing them and converting to a useful form, we would be able to achieve enough power to drive a relatively low power circuit. The radio frequencies are electric energies that transmit through the air by ionizing the medium on its paths. In Recent years, there is upsurge of research interests in RF energy harvesting technique. This technique becomes a promising technology to power energy-constrained wireless networks. Recently there is also increasing use of wireless devices in many applications such as cell phones, sensor networks and low power devices. RF energy is continually radiated from devices such as smart phones, FM radio stations, Wi-Fi, TV transmission system etc. The energy transmitted from these wireless sources is very higher but only a small amount can be scavenged in real environment rest is absorbed by other material or dissipated as heat. The output power of RF devices is limited by regulations, such as Federal Communications Commission (FCC), USA due to safety and health concern offered by EM radiations. Thus the ambient energy is present everywhere around us can be harvested by using a rectifying antenna known as rectenna. An antenna with a rectifying circuit which converts RF to DC electrical power.

CIRCUIT DESIGN

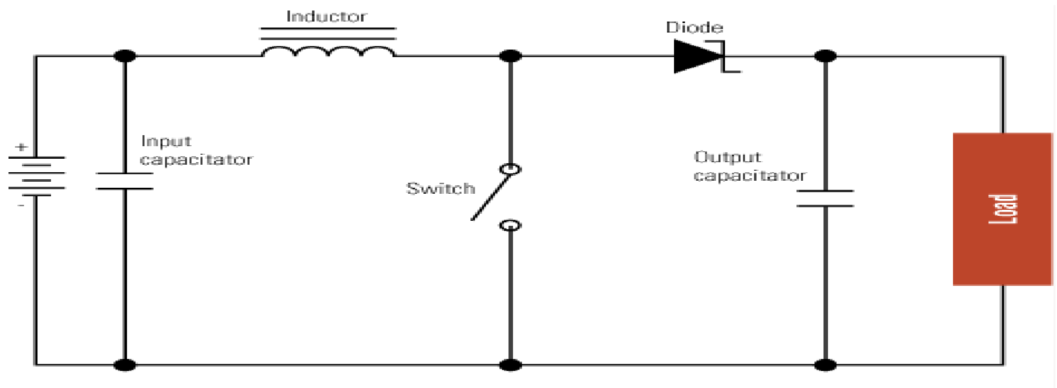


Rectifier circuit

The rectifier presented is this is based on voltage multiplier with Germanium diodes as stated in Figure. Each stage is consisting of two diodes and two capacitors. Typically, output from a single stage rectifier is very low since the captured energy is low, thus by cascading the circuit, a higher DC voltage can be obtained from an AC input. The cascaded circuit is called Dickson Multiplier This circuit is a Dickson multiplier that has been previously modified by Karthaus and Fischer in 2003, where it has fewer requirements than original Dickson topology. The circuit do not need of clock pulses to operate, so did the numbers of coupling and stray capacitors were reduced. The rectify elements in the circuit mainly determines the RF to DC conversion efficiency.

Due to high operating frequency and low input power, diodes should have a very fast switching time and the lowest possible turn on voltage. A Germanium Diode will typically have a forward voltage drop of just 0.3volts which means they are much more efficient. Older germanium diodes had a larger leakage of current at a reverse voltage, but now American Micro semiconductor and others supply a range of improved low current leakage germanium diodes. This lower voltage drop for germanium becomes important in very low signal environments (signal detection from audio to FM frequencies) and in low level logic circuits. As a result germanium diodes are finding increasing application in low level digital circuits. With this increased interest in germanium diodes, certain general germanium characteristics should be understood.

DC-DC Booster circuit



Switch power boost converters always give an output voltage greater than its input voltage. A circuit configuration of DC-DC boost circuit consists of inductor L, diode D, load capacitor C and switch circuit S. The transistor switch is turned ON and OFF depending on the mode of operations at

fs = 1/T. There are two modes of operation for boost converter And the operation can be either one of them at a transition of time: (i) a continuous mode and (ii) a discontinuous mode.

Continuous Mode: When Switch is ON state A continuous mode starts when transistor S is turned ON and conducting a pulse. The diode transistor at this time is turned OFF and is reversed biased. A charge is being stored and inductor current is drawn into the inductor, L. The inductor current, IL will ramp up linearly during the time interval of tON. The relation between the ON state and the inductor Current as in Equation 1:

$$VIN = L\,\frac{I2-I1}{tON} \text{ at } 0<t<ton.$$

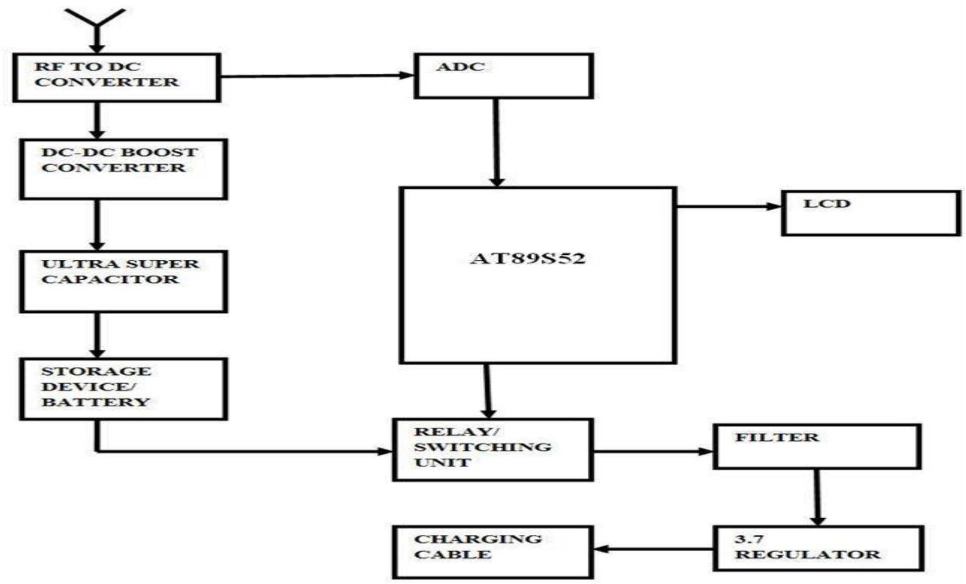
Discontinuous Mode: When Switch is OFF state While in a discontinuous mode, transistor S is switched OFF. Inductor voltage reverses its polarity in order to maintain its constants current since current in the inductor cannot change instantaneously. Inductor voltage starts to build up its energy and when this charge is higher than the combined energy in transistor diode and load capacitor, the inductor delivers its voltages to the load capacitor through the diode transistor. Voltage at the output capacitor is higher than the input voltage. During this time, tOFF inductor current falls linearly fromI2 to I1 and the state of inductor current, decides the operation mode. Equation 2 shows the relation when time is OFF:

$$VOUT-VIN = L\,\frac{I2-I1}{tOFF} \text{ at } ton<t<=T$$

BLOCK DIAGRAM

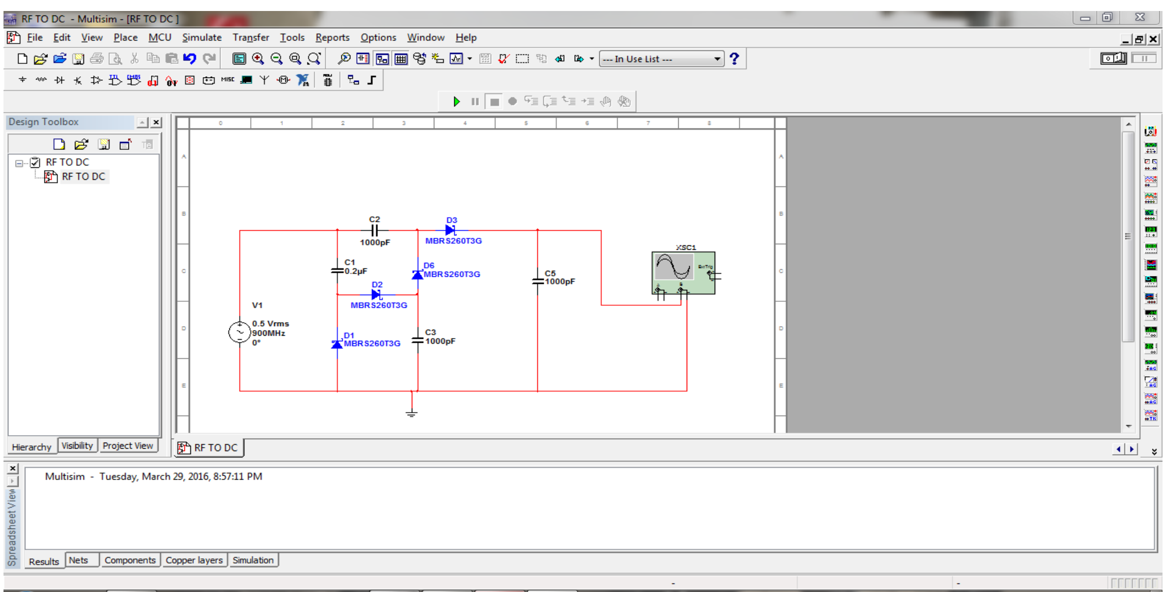
The figure shows the block diagram of proposed methodology. It consist of an RF-DC converter circuit which is used to convert the received RF signals from the antenna to DC by using the impedance matching technique and the effective rectification process improves the output from the converter. From the converter a part of the signal is given to ADC to produce digital signals to the converter through which the Microcontroller controls the relay switching and Displays the amount of RF power received.

The rectified signal from the converter is boosted by using a DC-DC booster circuit and the boosted power is stored in ultra super capacitors and is made to store in battery for further utilization. The stored power in the battery is filtered by using capacitors and then regulated by using the voltage regulator to get the constant voltage. Now the regulated voltage is used for charging low power devices.

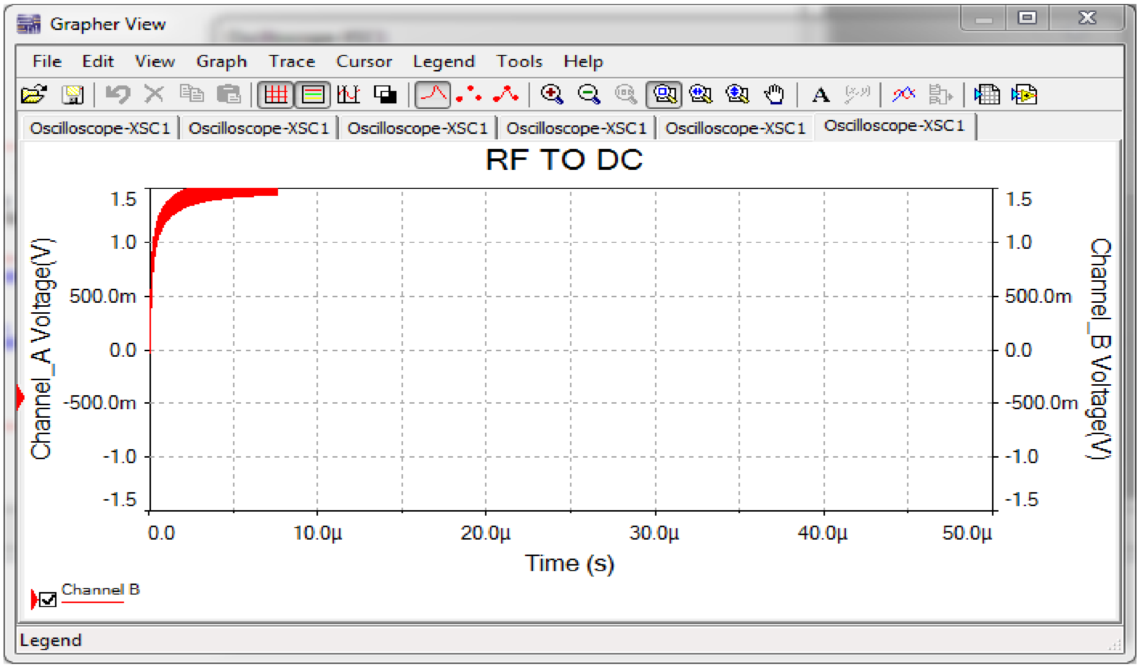


Block diagram

SIMULATION RESULT



Design of simulation circuit using NI MULTIsim tool.



Output of the simulated circuit design

CONCLUSION

In this paper, a novel idea about Radio Frequency Harvesting (RFH) is discussed. The harvesting of RF from variety of sources and the technique used for harvesting Radio Frequencies is explained. Though the energy harvested through the Radio waves is small they are very much useful for providing source for low power device applications. Thus we conclude that RFH will act as alternate source of power for low power applications for the forth coming generation.

FUTURE SCOPE

Ambient RF power levels will increase as more transmitting devices are put into use. A more significant factor in enabling pure ambient RF energy harvesting will be the introduction of devices that operate at lower and lower power levels. As device power consumption decreases, ambient RF energy harvesting will become more practical and available in more areas. The development of efficient multiband or wideband RF energy harvesters will also play an important role in the realization of widespread ambient harvesting over the next several years. RF energy harvesting is a unique technology that can enable controllable, wireless power over distance, and scale to provide power to thousands of wireless sensors. Devices built with this wireless power technology can be sealed, embedded within structures, or made mobile, and battery replacement can be eliminated. With commercial RF energy harvesting components currently available, engineers can integrate this technology to provide embedded wireless power for their low-power wireless devices.

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