www.ijecs.in
International Journal Of Engineering And Computer Science ISSN:2319-7242
Volume – 5 Issue -02 February, 2016 Page No. 15755-15760

Smart Power Generation Using Radio-Frequency Waves

Mrs.A.Sudha, M.P.Vishnu, R.Deepan, M.Ramesh kumar

Assistant Professor EEE
Vichu.vishnu44@gmail.com
asudhame0612@gmail.com
Jaya College of Engineering and Technology, Poonamallee By-Pass Road, Poonamallee, Chennai-56.

Abstract:- **The aim of our project is to analyze the amount of power that may be harvested from the encircling surroundings and processed to realize levels of energy that are sufficient to charge up low power electronic circuits and devices. Radio-Frequency energy gather holds a promising future for energizing low power electronic devices in wireless communication circuits and Extended for top power necessities. This project presents RF energy gather system that may harvest energy from the close surroundings at the downlink frequency vary of GSM-900 and GSM-1200 bands. Energy gather may be key techniques that may not be overcome the barriers that forestall the important world preparation of wireless Sensor networks (WSNs). Specially, solar power gather has been unremarkably wont to overcome this barrier. We tend to develop an RF energy gather WSN Circuit to indicate the effectiveness of RF energy gather for the usage of a WSN. The RF energy gather technique is effective in long amount measure applications that don't need high power consumption**

***Keywords:*-Radio-Frequency, Wireless sensor networks, Harvesting**

I.INTRODUCTION

There is a lively analysis space work variety of different ways in which to extract energy from the atmosphere and convert it into voltage for energizing low power electronic circuits directly or store it for later use. One such energy is from oftenness. RF Energy harvest home from the close can have a crucial role within the future electronics circuits. This work is being allotted by several researchers for the subsequent reasons: i. The energy is freely offered in house. ii. Complementing the low power sources used for energizing the low power electronic devices, as associate application to inexperienced technology. RF energy harvest home from close sources have nice potential to impact on the cellular phones and transportable electronic devices. this idea wants associate economical antenna beside a circuit capable of changing RF signals into DC voltage, therefore on replace the requirement for batteries.

Energy harvest home is one among the key techniques wont to solve this downside. we have a tendency to specialize in exploitation associate close RF field as associate energy supply to power wireless device nodes. the utilization of this unutilized energy as an influence supply won't solely cut back the battery replacement cost but additionally change a protracted amount operation in WSNs. The energy generated from associate
energy harvester varies in time and house. thus the utilization of RF energy harvesters additionally needs a modification in each the hardware and also the computer code of wireless device nodes. Since WSNs may be applied to several kinds of applications like atmosphere and surroundings observation, attention applications, and process observation and management. Putting an oversized variety of spatially distributed inexpensive device nodes can increase the number and responsibility of the device knowledge.

A number of the foremost distinguished sources of RF Energy area unit FM radio systems ((88-108 megacycle, transmitted power few tens of KW), TV Transmission (180-220 megacycle, transmitted power few tens of KW), Cell Tower Transmission (10 to twenty W per carrier), Wi-Fi (2.45GHz, 5.8GHz), AM Transmission (540-1600 kHz, transmitted power few hundred KW) and mobile phones (transmitted power 1W to 2W), etc. Cell towers may be used as an eternal supply of renewable energy as they transmit twenty four hours. In Bharat cell towers transmit within the frequency vary of 869- 890 megacycle in CDMA, 935-960 megacycle in GSM 900 and 1810-1880MHz in GSM 1800 bands. It transmits ten to 20W per carrier; there perhaps three to four carriers and three to four operators on one tower or adjoin the roof high of buildings. Gain of the cell tower transmitter antenna is usually 17dB. The 0.5 power beam dimension (HPBW) of the antenna in horizontal direction perhaps between 60o to 90o and in vertical direction varies between 5o to 10o. most power is received once the receiver is within the main beam. For cell website consisting of transmission towers of GSM900 band, signal strengths area unit calculated in Table I at numerous distances consistent with Friis transmission equation.

$$Pr = PtGtGr\,[\lambda/(4R)]^2$$

Where,
Pr = Received Power
Pt= Transmitted Power
Gt= Gain of the transmitted Antenna
Gr= Gain of the receiver Antenna
R= Distance between the transmitter and receiver antennas

TABLE I
POWER RECEIVED FROM CELL TOWERS (GSM 900 BANDS)

Distance (m)	200	100	50	10	5
Number of Carriers	1	1	1	1	1
Number of Operators	1	1	1	1	1
Power Received(mW)	0.13	0.50	6.03	50.28	201.12
Power Received(dBm)	-9.01	-2.99	7.81	17.01	24.01

DOI: 10.18535/ijecs/v5i2.17

Through a power generating circuit linked to a receiving antenna this free flowing energy can be captured, harvested and converted into usable DC voltage to power up small devices and Extended for large power applications.

II RF ENERGY HARVESTER

Fig. 1 show the system diagram, where RF signals received by antenna. Using matching circuits for the antenna along with a rectifier, generated DC power is used by charging controller to run mobile device terminal functions or recharge its battery. This circuit will charge the battery by utilizing the ambient RF signal. Circuit will convert the RF signal to DC signal, and using the DC signal to charge the battery.

Complexities arise when we try to harvest energy from multiple RF sources. A RF energy harvesting system performance was demonstrated by using maximum of four similar antennas in same space. An energy harvesting system was studied through simulation and experimentally obtained data for practical design of the Smart energy harvesting circuit, as shown in the figure-2. The basic idea behind system was to use multiple antennas to harvest RF energy from different frequencies. The circuits need to be adjusted by using a controller to overcome the problem of frequency hopping and frequency tuning of signals. Also a wideband receiver antenna can be used which would be able to capture signals from multiple sources

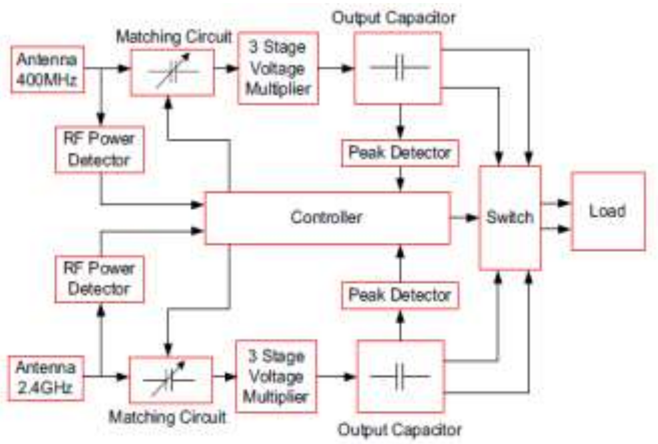

Fig.1 System Diagram of Proposed Smart RF Energy Harvester

Using Commercial of the Shelf (COTS) (commercially available discrete circuitry) Components the system was crudely tested for the functionality and performance. RF power detector IC (LTC5505) was used with both the antennas. Ctune of Matching Circuit was manually tuned in response to the *RF Power Detector* and output power. Antenna was matched using trial and error ("annealing") empirical approach. Three-Stage voltage multiplier, consisting of schottky diodes is explained in section–V. The charging controller or Power Management circuit acts as a switch. Using the battery power level as a reference it charges the device battery or run the device terminal functions if battery is fully charged or only running the terminal functions is required as in battery less devices. The switch can easily be designed using a low power MOSFETs as comparator.

III. SCHOTTKY DIODE BASED RF ENERGY HARVESTING SYSTEM

Schottky diode offer low forward voltage and high switching speed, and consider as an ideal component for RF energy harvesting.

A. Antenna and Matching Circuit

The RF alerts can be captured the use of Multiband antenna as shown in Fig.2. Antennas along with quad band are without problems available in market and normally paintings at 900MHz/1800MHz/1900MHz/2.4GHz. these are of typically whip type, but small size together with published, patch, spiral antennas are also testable. For a 50Ω antenna, matching circuit (C_{tune}) is used as proven in Fig.2, to capture the most energy at required frequency range. using only C in antenna matching circuit we can song the antenna at its resonant frequency. The tuning Capacitor (C_{tune}) may be proven the use of following system to resonate with antenna inductance ($L_{antenna}$), where f is the frequency of operation.

$$2\pi f = \frac{1}{\sqrt{L_{antenna} \times C_{tune}}}$$

At better frequencies inclusive of 800 or 1900MHz the low values of inductors are hard to construct specifically at board level circuit layout. But the use of the inductor in conjunction with capacitor at integrated circuit degree layout significantly improves the performance. Resonant frequency is likewise influenced by diode capacitance as it's far related with opposite diode voltage and enter voltage.

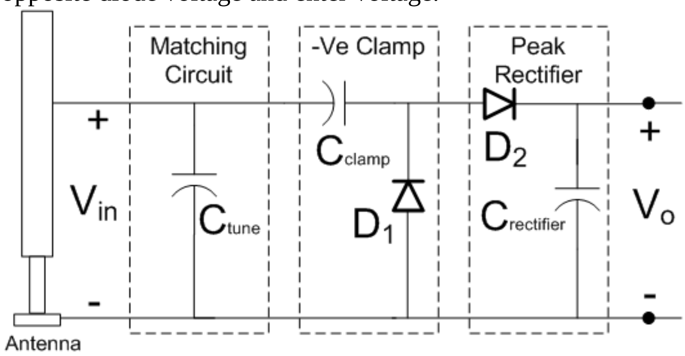

Fig.2 Single stage Voltage Doubler Circuit for converting ambient RF waves to DC

B. Voltage Doubler Rectifier

The Radio Frequency is AC signal, to get a DC sign out of the AC signal, a rectifier circuit is hired. The price pump circuits, along with voltage doubler (Villard voltage multiplier on this paper) are used to rectify the input voltage (V_{in}), by using using more than one levels the required output voltage (V_0) can be acquired. The voltage output is two times the input height voltage, minus two times the diode threshold voltage. under load, output voltage drops because of capacitor rate drain. price tired (Δq) by using the load Current (I_{load}) according to duration, where f is input sign frequency, is

$$\Delta q = I_{load}/f$$

The circuit may be prolonged to n tiers, generating theoretical $2nV_{in}$ for output voltage. Underneath best situation the output of an n- level rate pump circuit, with stage capacitance (C) can be

$$V_o = nV_{in} - \frac{n-1}{fC} I_{load}$$

Because the energy obtained by way of the receiver might be enormously low and the signal frequency is excessive, the diodes are required to have a totally low switch on voltage and high running frequency. We tested a Schottky diode for rectifier as a safe operation. C_{clamp} and D1 form the negative clamp, at the same time as Crectifier and D2 shape peak rectifier. $C_{rectifier}$ also smooth the output. different sorts of voltage multiplier or rate pumps circuits schemes can be used like Cockcroft-Walton (and Resonant- Villard) voltage multiplier and Dickson (and Resonant- Dickson) rectifiers. A changed Villard Voltage doubler as an RF strength harvesting circuit is offered with the aid of for enhancing the performance.

C. Villard Voltage Doubler Rectifier simulation results

The Villard voltage multiplier was simulated the use of the circuit degree simulator. The simulation employed the tool stage model of HSMS-2850 parameters to achieve the results provided in Figures 3.

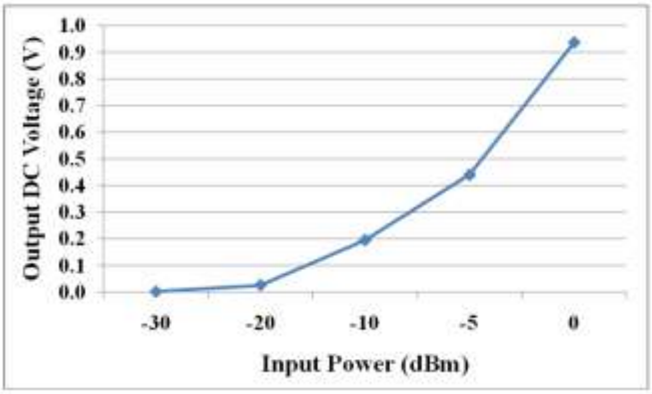

Fig.3: Output voltage and Input Power relation of schottky diode based single stage Villard voltage doubler circuit

From the simulation, it is able to be concluded that the output of voltage doublers circuit is:

$$V_{out} \approx 0.95\ (n)\ (2V_{in})$$

The output voltage V_o of an *n* level Villard voltage multiplier may be calculated the usage of the expression

$$V_{out} = \frac{nV_o . R_L}{nR_o + R_L} = \frac{V_o}{\frac{R_o}{R_L} + \frac{1}{n}}$$

Where, V_o is the open circuit voltage, Ro is the internal resistance, RL is the weight resistance and n is the quantity.

IV EXPERIMENTAL PERFORMANCE OF 3-STAGE SCHOTTKY DIODE BASED ENERGY CONSERVATOR

The rectification circuit (Charge Pump) was simulated the usage of Multisim 10.0.1 to determine the most efficient values of the capacitors and the suitable sort of Diode for use. Assuming an AC voltage input to the circuit of the cost 0.5 Vrms, exceptional varieties of Schottky Diodes have been examined and the overall performance of the circuit was observed. in addition various values of capacitors had been tried in the simulation to pick out between them according to the maximum output brought to the burden. The Voltage of the AC supply changed into set to be 0.five Vrms at 2.four GHz. the subsequent figures show the simulation results for all experimented frequencies beginning from 50MHz as much as 9GHz.

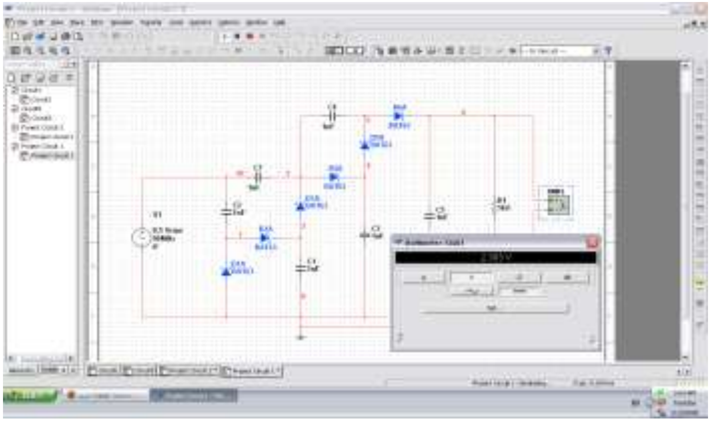

Fig.4 3-stage model for 50 MHz

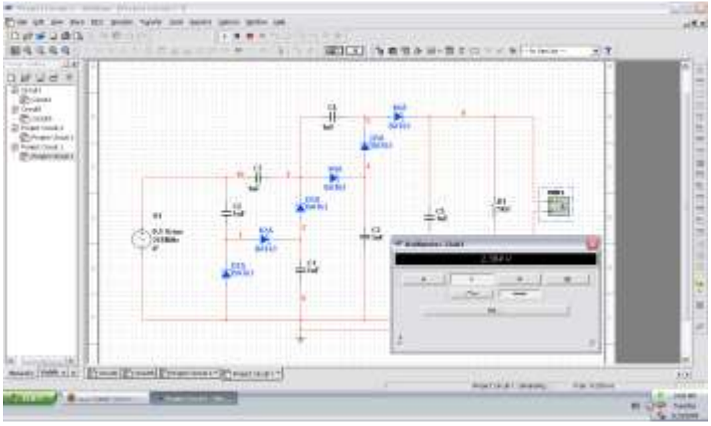

Fig.5 3-stage model for 315 MHz

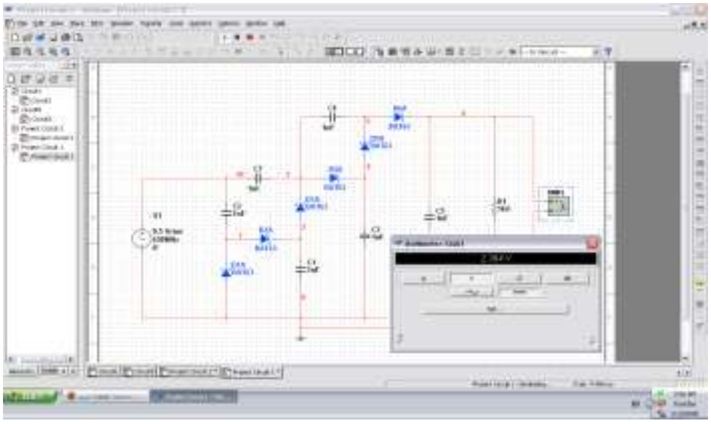

Fig.6 3-stage model for 430 MHz

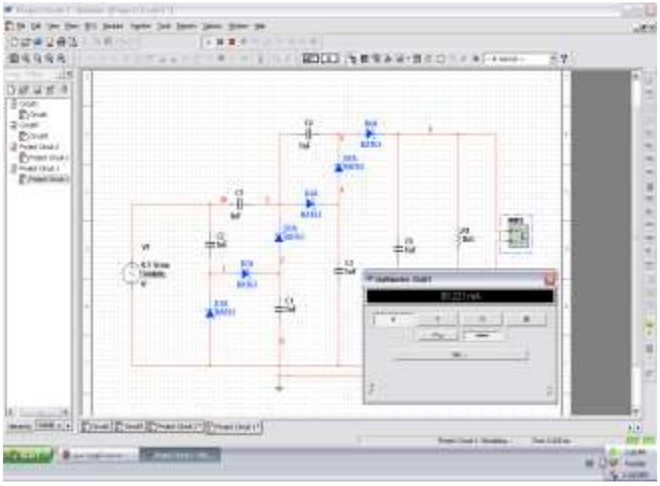

Fig.7 3-stage model for 500 MHz

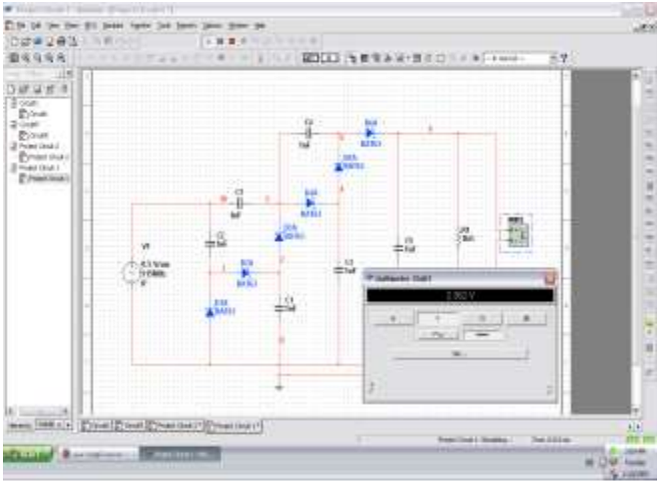

Fig.8 3-stage model for 915 MHz

According to the above-simulated consequences, a complete version turned into designed with the chosen kinds of diodes and capacitors. The below tables represent the precise info for the selected model. desk II represents the effect of growing degree quantity on the output voltage. desk III represents the effect of the level capacitor on the output voltage. Eventually, desk IV represents the effect of the chosen diode type at the output voltage.

TABLE II: STAGE NUMBER EFFECT ON OUTPUT VOLTAGE

Number of stages	Output voltage (V)
1	0.867
3	1.634
5	2.347
7	3.014
9	3.64
11	4.222

TABLE III: STAGE CAPACITOR EFFECT ON OUTPUT VOLTAGE

Capacitor value (F)	Output voltage (V)
1 u	0.419
470 n	0.711
100 n	1.789
1 n	3.014
750 p	3.004
560 p	2.991

TABLE IV: DIODE TYPE EFFECT ON OUTPUT VOLTAGE

Diode type	Output voltage (V)
BAT14_098	0.419
10BQ015	0.339
BAT63	0.867
BAT15_04	0.730
BAT17	0.113
BAT54	0

The antenna subsystem affords the enter for the rectification circuit. The antenna used became based totally on a Omni directional antenna, the omnidirectional antenna is used to capture the radio frequency energy at various range and supply that present day produced by way of the incident wave to the pump to be rectified and multiplied. A monopole antenna is composed basically of a chunk of copper cord with one quit related to the circuit, and the opposite quit left open. The antenna is characterized through having a ground plane to make it efficient, and ideally the ground plane must spread out at the least 1 / 4 wavelength, or more, around the feed-point of the antenna. the scale of the ground aircraft is considered one of the major aspects that affects the benefit, resonance frequency and impedance of the antenna.

V HARDWARE IMPLEMENTATION

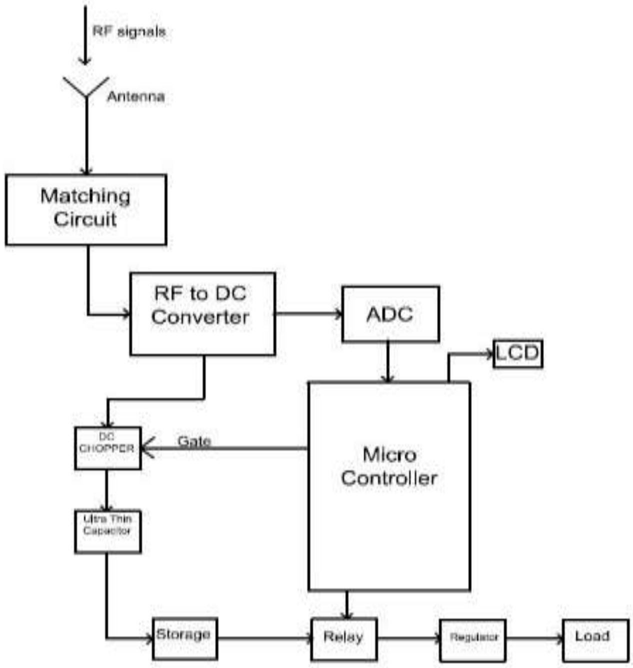

Fig.9 Proposed Block Diagram for Hardware Implementation

Fig.9 Shows the Proposed Block Diagram for Hardware Implementation of RF Energy Harvesting unit. It consists of RF signal Receiving Piggy tail Antenna which receives any Kind of RF signals and Connected to a Matching Circuit. The Matching Circuit pre-Matches the value of upcoming RF signal and given to the RF to DC converter unit.

A.MATCHING CIRCUIT:

This circuit consists of a Matching antenna called piggy tail antenna along with a 0.01µf capacitor to match the upcoming RF signal from the Antenna and boost the signal according to the requirement and gives it to the rectifier circuit for Conversion

B.RF to DC CONVERSION UNIT:

The upcoming signal from the Matching circuit was given to the RF to DC conversion unit. This unit consists of four Germanium IN34 or IN34A diode to convert upcoming RF signal to DC output.

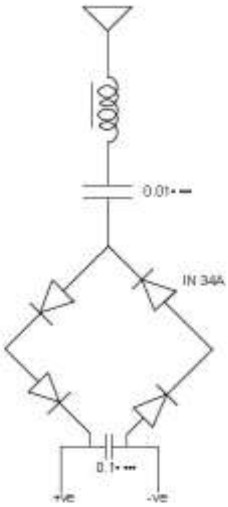

Fig.10 Matching and Rectifier circuit

The four Germanium Diode was connected as similar to the Bridge Rectifier circuit to convert any kind of RF signal to a DC Voltage. To store the RF signal there is a ceramic capacitor connected in series which collects the RF signals very easily and from the two ends of the capacitor the +ve and –ve terminals are connected. From the simple circuit we can able to collect the RF signal at any form and convert it completely to a DC voltage.

Fig.11 Practical Implementation of proposed Simple Circuit

The Converted DC voltage was parallely separated into two parts and given to the DC chopper and ADC unit.

C.DC CHOPPER:

The DC chopper mainly consists of three signal ports such as input, output and Gate. The Input was given directly from RF to DC Rectifier unit and the output was given to the Ultra thin capacitor and for the Gate signal we are using a Microcontroller circuit which helps to automatically boost up the DC voltage by given the Gate signals based upon the deviations and requirement from the Rectifier unit. Based upon the gate signal and upcoming voltage the Chopper boosts the voltage to a certain level.

D. ADC (Analog to Digital Converter):

In order to give the Gate signal to the DC chopper a Microcontroller was connected parallel to the Rectifier unit. The upcoming voltage from the Rectifier is a Analog signal to give it to the MC an ADC circuit was used to convert analog signal to Digital signal and gives it to the Microcontroller. The input signal to the ADC consist of a Input, Normal ground and a Noises ground.

E. Microcontroller and LCD:

The upcoming power from the ADC was displayed on the LCD. The generated power from the Rectifier was converted into Digital signal and was displayed. Based upon the generated voltage from the rectifier unit the Microcontroller generates the gate signal according to the deviations from the Rectifier and gives the gate signal to the Chopper circuit to boost up the power. The MC was also connected with a Relay circuit and a Battery level Indicator.

F.ULTRATHIN CAPACITOR:

It is a capacitor with charging time is very much more less than the discharging time of the capacitor. This capacitor is mostly used to boost up the voltage to the enormous level. It is very small in size but it delivers required amount of voltage. The boosted output power from the capacitor was stored in a battery.

G. STORAGE:

In order to store the generated power a 12V battery is used in between the capacitor and battery a diode is connected to maintain the power only in Forward-Bias condition. The Diode which helps power to undrawn it from the Battery. In between the diode and battery a switch was connected to store and consume the power whenever its required. The battery can be connected as per the requirement as 5V, 12v,25v etc…

H.RELAY:

From the Battery to the Load a Relay is used mainly for the switching purpose. The relay which is used to charge the battery whenever the RF energy is available and is used to use it whenever it is necessary. The relay is simple and economically used switching device which works automatically based on the requirement.

I.REGULATOR and LOAD:

From the relay a regulator circuit was made with the help of simple Resistors. It act as a bridge and regulates the flow of power between the storage and load. The load which connected can be either DC or AC connect a DC load a Inverter circuit was developed to convert the upcoming DC power into AC power or DC power can be directly connected based upon the requirement. The power which developed and stored from the battery can be also used directly.

DOI: 10.18535/ijecs/v5i2.17

Based upon the RF signals received from the Antenna the Rectifier circuit developes the power and based upon the DC chopper and ADC circuit the required amount of power can be developed and it was regulated with help of chopper and ultrathin capacitor and then it is stored and can be used for the Application. Fig.12 shows the Hardware Implementation model for the Smart power Generator.

Fig.12 Hardware Implementation Model

VI CONCLUSION

In this paper, an RF-to-DC converter using a new architecture has been designed covering the GSM900, GSM1800, UMTS, and WiFi bands is presented. It consists of a One sided directional flexible antenna and a cross-coupled charge capacitors which generates non-overlapping anti-phased clock signal. The voltage drop and reverse leakage current of the germanium diode is minimized using the cross-coupled circuit configuration. A high output voltage is achieved using a charge pump which operates with a non-overlapping clock whose frequency is upto 40GHz. The implemented RF-to-DC converter exhibited an output voltage of as high as 2.05 V at an RF input power of -6 dBm with a load resistance of 100 k. This RF-to-DC converter can be applied to an RF energy harvesting systems for small scale applications.

VII REFERENCES

[1] A Multi-Band Stacked RF Energy Harvester With RF-to-DC Efficiency Up to 84%,Véronique Kuhn, Cyril Lahuec, Fabrice Seguin, and Christian Person, Member, IEEE

[2] RF Energy Harvesting System and Circuits for Charging of Mobile Devices, Hamid Jabbar, Young. S. Song, Taikyeong Ted. Jeong*, Member, IEEE

[3] Novel Radio Frequency Energy Harvesting Model, Hossam Mahmoud Gamal ElDin Mohammed ElAnzeery, Mohamed Abd ElAziz Saad ElBagouri, Rafik Guindi, Department of Microelectronics System Design, Nanoelectronics Integrated Systems Center, Nile University,2012 IEEE International Power Engineering and Optimization Conference, Malaysia

[4] RF Energy Harvesting with Multiple Antennas in the Same Space Minhong Mi1, Marlin H. Mickle1, Chris Cape/li2, and Harold Switf,
Department of Electrical Engineering, University of Pittsburgh,348 Benedum Hall, Pittsburgh, PA 15261 USA

[5] DESIGN OF RF ENERGY HARVESTING SYSTEM FOR ENERGIZING LOW POWER DEVICES, N. M. Din, C. K. Chakrabarty, A. Bin Ismail, K. K. A. Devi and W.-Y. Chen, Progress In Electromagnetics Research, Vol. 132, page:49-69, 2012

[6] DESIGN COCEPTS FOR RF-DC CONVERSION IN PARTICLE ACCELERATOR SYSTEMS, F. Caspers, M. Betz, A. Grudiev CERN, Geneva, H. Sapotta, Karlsruhe University of Applied Sciences, Germany, Proceedings of IPAC’10, Kyoto, Japan

[7] Prototype Implementation of Ambient RF Energy Harvesting Wireless Sensor Networks, Hiroshi Nishimoto, Yoshihiro Kawahara, Tohru Asami, Graduate School of Information Science and Technology, The University of Tokyo, Japan 113-8656

[8] RF Energy Harvesting System from Cell Towers in 900MHz Band, Mahima Arrawatia, Maryam Shojaei Baghini, Girish Kumar, Electrical Engineering Department, Indian Institute of Technology Bombay, Powai

[9] RF Energy Harvesting, Deep Patel, Rohan Mehta, Rhythm Patwa, Sahil Thapar, Shivani Chopra, International Journal of Engineering Trends and Technology (IJETT) – Volume 16 Number 8 – Oct 2014

[10] HIGH EFFICIENCY RF TO DC CONVERTER WITH REDUCED LEAKAGE CURRENT FOR RFID APPLICATIONS, Maziar Rastmanesh, Dalhousie University, Halifax, Nova Scotia, April 2013,pp:17-85.

[11] Design Optimization and Implementation for RF Energy Harvesting Circuits, Prusayon Nintanavongsa, Ufuk Muncuk, David Richard Lewis, and Kaushik Roy Chowdhury, Member, IEEE