International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 07 | July -2017 www.irjet.net p-ISSN: 2395-0072

A NEW OPTIMUM POWER CONTROL SCHEME FOR LOW POWER ENERGY HARVESTING SYSTEM

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ABSTRACT: *Energy Harvesting has become a popular source for low-power electronic systems such as wireless sensors and biomedical implants .Energy can be extracted from a number of ambient conditions such as vibration ,solar ,and thermal gradient .Just like renewable sources, the associated switching power converters can be controlled to harvest maximum power from these miniature systems .However conventional maximum power point tracking(MPPT) controller for solar cell ,are complex and cannot be utilized in low-power energy systems due to their cost and power requirements .In this paper, a novel optimum energy harvesting scheme is proposed in which maximum power is obtained from three different modules connected in parallel . The control system employs only simple mixed signal components and can be applied to low-power systems. The proposed scheme does not depend on the characteristics of a specified source and is applicable for different energy systems. It is utilized to achieve optimized energy harvesting from three different power generation modules .Boost converter and buck converter are used to utilize the maximum power extracted from this new optimum energy harvesting scheme .*

Key Words: EMR, PV, DC, TEG.

INTRODUCTION:

Energy harvesting *(also* known *as power harvesting or energy scavenging or ambient power)* is the process by which energy is derived from external sources captured and stored for small, wireless autonomous devices like those used in wearable electronics and wireless sensor networks. The choice of the energy-harvesting source depends on the nature of the application and power requirements of the particular electronic load. One of the principal topics under research for energy harvesting systems is the associated power processing circuit. Such systems are generally low in voltage and very low in power, making the design of power converter quite challenging. The main objective of this new optimum power control scheme for low-power energy harvesting systems is

- To improve the efficiency of the system
- To produce maximum energy extraction which is used for low power electronics application

SOURCES OF ENERGY HARVESTING:

- Mechanical energy
- Thermal energy
- Light energy
- Electromagnetic energy
- Natural energy
- Human body

TYPES OF ENERGY HARVESTING:

The classification can be organised on the basis of the form of energy they use to scavenge the power.

- Piezoelectric material harvesting
- Electrostatic harvesting
- Electromagnetic energy harvesting
- Thermoelectric generators harvesting

PROCESS OF MAXIMUM ENERGY EXTRACTION:

The new optimum power control; scheme is applicable for different low-power energy resources from which maximum power extraction can be done.

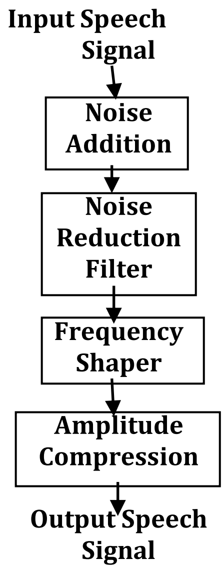

Fig 1: System Block Diagram

In this scheme we have taken solar, wind and Peltier modules that are all connected in parallel. Implementation of boost converter for maximum energy application with an improved power factor is an added advantage. Also, a buck converter has been used for reduction in voltage if required. The process of this maximum energy extraction is shown in fig

STAGE 1:

A 12V battery stores all the energy extracted from the three modules

- Energy extracted from the solar module when it is subject
- Energy extracted from the peltier module when subjected to the temperature of about 50 to 100 degree Celsius
- Energy extracted from the wind module when it is subjected to wind

EXTRACTION FROM SOLAR MODULE:

In this solar generation module, photovoltaic cells, commonly called a solar cell or PV, is the technology used to convert solar energy directly into electrical power. A photovoltaic cell is a non-mechanical device usually made from silicon alloys.

Sunlight is composed of photons, or particles of solar energy. These photons contain various amounts of energy corresponding to the different wavelengths of the solar spectrum. When photons strike a photovoltaic cell, they may be reflected, pass right through or be absorbed. Only the absorbed photons provide energy to generate electricity.

The performance of a photovoltaic array is depend upon sunlight. Climate conditions have a significant effect on the amount of solar energy received by a photovoltaic array and in turn, its performance. Most current technology photovoltaic modules are about 10% efficient in converting sunlight .Further research is being conducted to raise this to 20% efficiency.

EXTRACTION FROM WIND MODULE:

Wind mills or turbines works on the principle of converting kinetic energy of the wind in to mechanical energy.

Power available from wind mill=1/2 PAV^3
Air density, which linearly affects the power output at a given speed, is a function of altitude, temperature and barometric pressure. Variation in temperature and pressure can be affect air density up to 10% in either direction.

EXTRACTION FROM PELTIER MODULE:

Peltier found that the use of a current at an interface between two dissimilar materials results in the absorption of heat and release of heat at subatomic level, this is a result of the different energy levels of materials, particular n and p type materials

The thermoelectric phenomenon deals with the conversion of thermal energy into electrical energy and vice-verse. The sources of thermal energy manifest itself as a temperature difference across the thermoelectric generator (TEG). Thermoelectric devices are solid-state mechanisms that are capable of producing these three effects without any intermediary fluids or processes.

STAGE-2:

Energy stored in battery is supplied to boost converter and buck converter where boost converter step up the voltage for low power electronic applications and buck converter step down the voltage.

METHODOLOGY OF BOOST CONVERTER:

Power for the boost converter can come from any suitable DC sources, such as generators, batteries and solar panels. Generally, a boost converter is a DC-to-DC converter with an output voltage greater than the source voltage called as step up converter. Boost converter can increase the voltage and reduce the cell numbers. Two battery-powered applications that use boost converters are hybrid electric vehicles (HEV) and lighting systems.

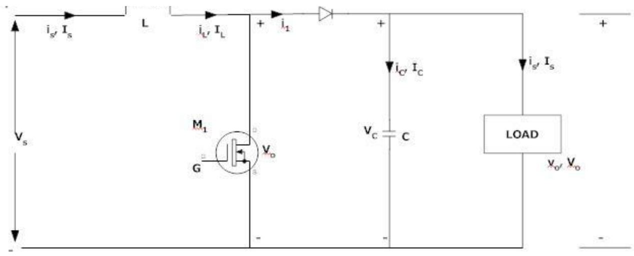

Fig2: Circuit diagram of a boost converter

The function of boost converter can be divided into two modes, mode1 and mode 2. Mode 1 begins when transistor M1 is switched on at time t=0.the input current rises and flows through inductor L and transistor M1. The two modes of boost converter are as shown in the fig

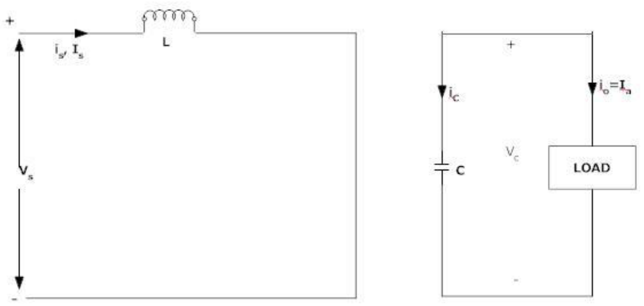

Fig3: Mode1 of boost converter

Mode 2 begins when transistor M1 is switched off at time t=t1. The input current now flows through L, C, load, and diode $D_{m.}$ The inductor current falls until the next cycle. The energy stored in inductor L flows through the load.

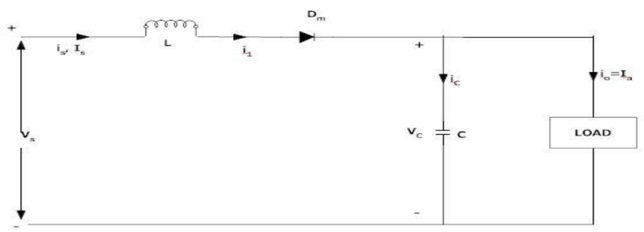

Fig4: Mode 2 of boost converter

METHODOLOGY OF BUCK CONVERTER:

The buck converter can operate in different modes ;continuous (CCM) and discontinuous conduction mode(DCM).In switching power converter control the controller output has one of two states: "ON or "OFF". A switching technique involving hysteresis is commonly used for these types of power converters .Similarly to the analysis of ac-dc converter ,it is essential to calculate the effective impedance R_e offered by the buck converter to the solar cell as a function of the duty cycle .
In continuous conduction mode, it can be calculated as
$R_{e} = Rl/D^2$
Therefore, Reoffered by the buck converter is
$R_e = V_l/I_m$

A buck converter, or step down voltage regulator, provides non-isolated, switch mode dc-dc conversion with the advantage of simplicity and low cost.

SOME MAIN COMPONENTS USED IN NEW OPTIMUM SCHEME ARE:

- Solar Generation Module
- Wind generation Module
- Peltier Module
- Diodes
- Voltage Regulator

SOLAR GENERATION MODULE:

In this solar generation module, photovoltaic panels of 6V are used. Solar energy can be converted into other forms of energy such as heat and light. Sunlight is composed of photons, or particles of solar energy. These photons contain various amounts of energy corresponding to the different wavelengths of the solar spectrum. When photons strike a photovoltaic cell, they may be reflected, pass right through, or be absorbed. Only the absorbed photons provide energy to generate electricity.

Each photon with enough energy will normally free exactly one electron and resultant a free hole as well. This causes further disruption of electrical neutrality and if we provide an external current path, electrons will flow through the path to their original side to unite with holes, doing work for us along the way. The electron flow provides the current, and the cells electric field causes a voltage.

WIND GENERATION MODULE:

Wind results from air in motion due to pressure gradient that is caused by the solar energy irradiating the earth. Any device capable of slowing down the mass of moving air can extract part of the energy in convert into useful energy. Wind is simple air in motion. It is caused by the uneven heating of the earth's surface by the sun.

Today, wind energy is mainly used to generate electricity and is called a renewable energy source because the wind will blow as long as the sunshine's .This wind generation is only used to harvest energy for low power electronic devices, which uses wind fan.

PELTIER MODULE:

A Thermoelectric module is a solid-state energy converter. It normally consists of an array of pellets from dissimilar semi conductor material, which are joined thermally in parallel and electrically in series. This module can be used for cooling, heating and energy generation.

In this Peltier module, a temperature differential is created on each side. One side gets hot and the other side gets cool. It is designed for cooling and heating up to 90^0C applications. Generally, a thermoelectric peltier cooler of TEC112706 is used.

DIODES:

Diodes are used to protect circuits by limiting the voltage (clipping and clamping).Diode consists of 2 terminals, Anode and Cathode. Diodes conduct when

$$V_{anode} > V_{cathode}$$

Recovery time and sensitivity to temperature are the characteristics of diode.

VOLTAGR REGULATOR:

The voltage regulator IC maintains the output voltage at a fixed value.7805 provides +5 volts regulating power supply. Capacitors of suitable values can be connected at input and output pins depending upon the respective voltage values.

S.NO	FEATURES	RANGE
1	Output Current	1.5Am
2	Output Voltage Tolerance	5%
3	Internal Short Circuit	Limited
4	External Component	No
5	Output Voltage	5V,6V,8V,9V,10V,12V,15 V,18V, 24V

RESULT:

From this new optimum scheme of low power energy harvesting, maximum energy extraction is done. The energy harvesting is stored in battery, applied to boost converter for low power electronic applications like this light load, and applied to buck converter for other application like cell phone charging. Boost converter step up the battery voltage of 12v to a maximum of 22.3v. Buck converter step down the battery voltage of 12v to about 5.5v, which is used for charging as shown in table.

Table: Output details of boost converter and buck converter

Converter used	Input voltage	Output voltage
Boost converter	12V	22.3V
Buck converter	12V	5.5V

CONCLUSION:

A new optimum power control scheme for low-power energy harvesting systems improves the efficiency of energy harvesting by providing maximum energy extraction for low power electronic applications. Here we are introducing a boost converter to set up the battery voltage obtained from this new optimum energy harvesting and supplied to the load for low power electronic applications. We are introducing a buck converter to step down the available battery voltage and applied for other low power applications like cell phone charging

The main advantage is maximum energy extraction can be done using renewable sources which improves the energy harvesting efficiency.

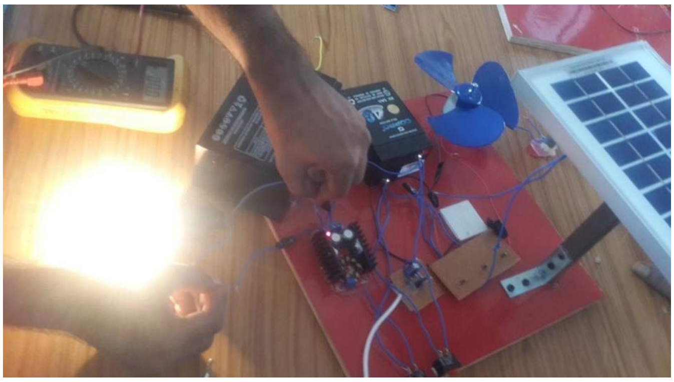

Fig5: Output voltage of Boost converter fed to Bulb load

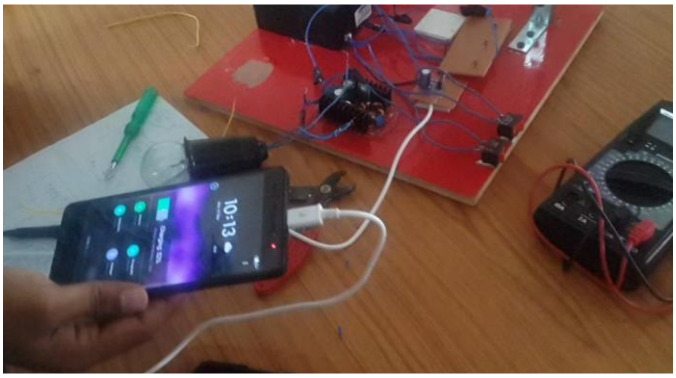

Fig6: Output voltage of Buck converter fed to Cell phone charging

FUTURE SCOPE:

Energy harvesting is the process by which energy is derived from external sources. Many energy sources are available to extract energy like piezoelectric, human motion and more. In this new optimum scheme, three types of sources are used to extract maximum amount of energy. This scheme of low power energy harvesting is used for maximum efficiency. Further advancements can be done on the energy harvesting by using more no. of renewable sources. Application of this type of energy harvesting is used for many low power electronic devices.

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