WASTE HEAT HARVESTING FROM SUNLIGHT USING PHOTOVOLTAIC AND THERMOELECTRIC HYBRID SYSTEM

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Abstract : the recent years most of the electrical engineers focused on renewable energy resources to balance power demand. In earlier solar system light energy only utilized remaining heat from sun is wasted. The objective of this work is to utilize both light and heat energy from the solar radiation. This system converts Light and Heat energy is directly converted into electrical energy by using Solar array and Thermocouple which works on the principle of Photovoltaic and Seeback effect. The efficiency of the hybrid system is much better than the single system. The hybrid system was designed using MATLAB /Simulink software. This work describes the characteristics of the PV and TE array with variation in temperature and irradiation levels. The output power of this system is stored in Battery during day time.

Keywords: photovoltaic panel, Thermoelectric module, MATLAB simulink, Battery

I.INTRODUCTION

Renewable energy can also called as non-conventional energy resource. They can be classified as follows solar, wind, bio-energy, hydro power etc. The Renewable energy majorly comes from sun and wind. We can obtain this energy our entire lifetime, that is why named as Renewable energy resources. Many varieties of conventional energy source available in nature which is in the form of coal, natural gases and oil. But the level of this resource are reducing day by day. Few years later it will end. The advantage of renewable energy resource is pollution free and which reduce Greenhouse effect.

Among all Renewable energy resource the availability of sunlight is high. It is a non-conventional type of energy. The solar energy obtained from the sun can be converted into Electrical energy using photovoltaic panel which is made of semiconducting material. Depends on the solar irradiation the produced electrical energy is stored in the Battery. During this conversion time large amount of Heat is wasted. In earlier system the light energy from the sun is utilized but Heat from the sunlight is wasted. The utilization of wasted heat can be optimized by thermocouple. Thermocouple is a device which consists of two dissimilar metals. When temperature changes occurs the equal amount of electrical voltage is produced. When integrating photovoltaic and Thermocouple we can utilize both light and Heat energy from sun. The can be optimized using maximum power point tracking Algorithm. The mathematical model equivalent circuit and efficiency of this system is discussed here.

II.RELATED WORK

In recent years, the demand of electrical energy is increased. At the same time the availability of fossil fuels, coal has been get reduced[1].We should find alternative energy source that is free from pollution. In last Researchers find solar energy conversion system is more interest alternating energy resources [2].At present photovoltaic panel is used to convert solar energy into electrical voltage which is made of silicon material gives efficiency about 20% [3]. A photovoltaic panel made of crystalline silicon will produce efficiency about 7-13% [4]. Even though the efficiency of Photovoltaic panel is quite low about 67% .

Now a days many Electrical engineers focused on the reduction of losses in the Photovoltaic panel [5]. In earlier photovoltaic panel part of energy comes from sun is wasted has been proved. In this paper the Researchers are focusing to utilize the wasted heat for this purpose they develop new material to Recovering this wasted Heat [6].Therefore, photovoltaic panels are manufactures with thermocouple module. Many cooling and Electronic component produces large amount of heat is wasted to recovery this waste Heat Thermo Electric generator are used [7].

The Utilization of wasted Heat can be very useful in many Industrial application. It can be very useful in many Industrial application. It can be optimized by the difference between High side temperature and Ambient temperature. The conversion of thermal energy into Electrical energy can be optimized using Figure of merit Z. To optimizing this conversion process seeback coefficient, thermal conductivity, electrical conductivity plays a major role. The typical value of Z T_{avg} can be varies from [0.7-0.8].The High value of this can be reached only [8]. A Hybrid system is used in many application which is manufacturing in separate modules thereafter it will integrated . In telecommunication system the waste heat Harvesting system is employed . The integrated system is made to optimize both type of energy source [9].

Depends on the solar irradiation, sunshine and temperature the various performance can be optimized and utilized.

III.SYSTEM DESIGN

The simulation module can be classified as follows

1) Design of PV module
2) Design of TE module
3) Design of PV and TE hybrid system

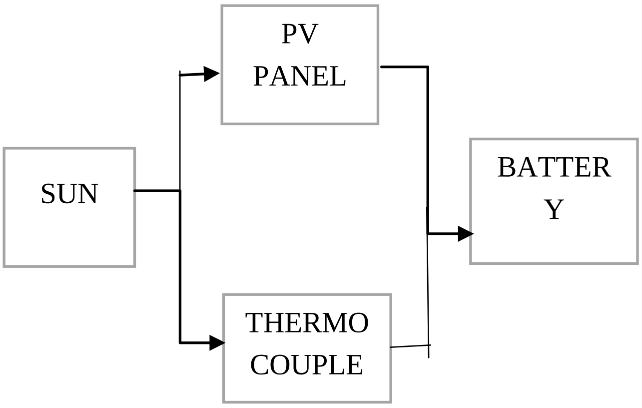

Figure 1; Block diagram for Hybrid system

The block diagram describes the flow of energy conversion system. This is obtained by MATLAB simulink. First we should design separate module for photovoltaic panel and Thermoelectric Generator. Thereafter both system are integrated.

DESIGN OF PV MODULE

A solar cell which is made of semiconducting material such as silicon and germanium. It converts light energy of sunlight into electricity using photoelectric device. The photovoltaic system is the collection of photovoltaic cell. Many cells may combined to form panels or modules. Panels may be combined toform big photovoltaic arrays.

The equivalent circuit of photovoltaic array is modelled mathematically using single diode circuit. The parameters which is involved to characterize PV cell can be classified by means environmental parameters like irradiance and temperature, internal parameter of equivalent circuit is ideality constant, Boltzmann constant, energy band- gap and charge of electron, electrical parameter is open circuit voltage, short circuit current, series resistance, and shunt resistance.The equivalent circuit of single diode solar cell is manufactured depend on volage-current relationship of a PV cell. An ideal solar cell is usually represented by a current source and which is connected with an anti-parallel diode, but practical solar cell having an additional series and a shunt resistance.

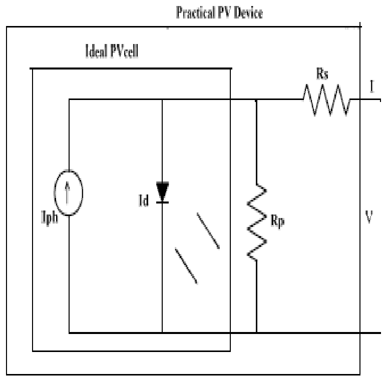

Figure 2: Equivalent circuit of photovoltaic module

The current source whichrepresents photon current absorped from sunlight which use parameter of solar irradiation and cell temperature. The value of R_{sh} should be very large and that of R_s should be small. A single solar cell may produce a small amount of voltage usually 0.5 to 0.8 volts. To increase the output power of a solar cell, which is connected in series and parallel to form PV modules. The relation between output current and voltage of a PV module are non-linear in nature.

Mathematical equation of a solar cell:

The equation for the output current of a module is as Follow

$$I_o = n_p I_{ph} - n_p [\exp\left(ko \frac{v}{n_s}\right) - 1]$$

Where,

I_o is the PV array output current

I_{ph} is the cell photocurrent that is proportional to solar

I_{rs} is the cell reverse saturation current

IV.PV MODULE IN MATLAB SIMULINK

The below simulation diagram shows the complete circuit of photovoltaic system. The PV array has been designed depends upon the irradiance, temperature level. The PV array can be designed by mathematical equations .The different values of voltage and current can be obtained which is plotted in the open circuit I-V curves of the solar array at various insolation level of 1000 mW/cm2. The PV module can be implemented using a MATLAB Simulink model. The electrical parameters are tabulated as follows

Table 1. Electrical parameter of PV module

Parameter	Variable	value
Maximum power	P_{MPP}	87
Voltage at maximum power	V_{MPP}	17.4
Current at maximum power	I_{MPP}	5.02
Short circuit current	I_{sc}	5.4
Open circuit voltage	V_{oc}	21.7

SIMULATION DIAGRAM

The following simulation diagram shows the photovoltaic module which includes following parameters

1. Irradiation
2. Temperature
3. Series resistance
4. Parallel resistance

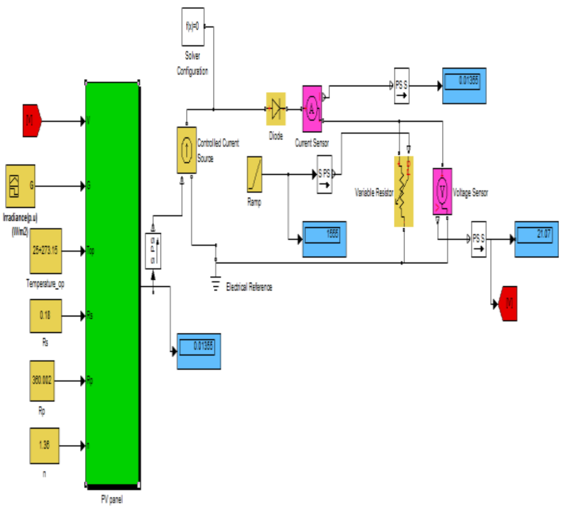

Figure 3: Simulation of PV module

V.SIMULATION RESULT OF PV MODULE

The characteristics of solar array is non-linear, it is very difficult to find the MPP. The below figure gives the characteristic of I-V and P-V curve for fixed level of solar irradiation and temperature.

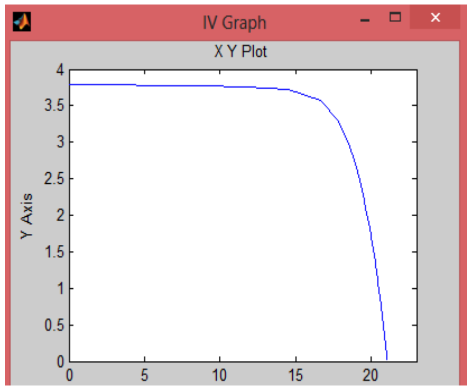

Figure 4: voltage and current characteristics of PV

THERMOELECTRIC MODULE

The manufacturing process of both TECs and TEGs is basically same, and the same equivalent circuit may be used to simulate their characteristics. The basic structure of a TEM is a thermocouple which consists of a p-type and n-type semiconducting material. Many thermocouples combined to form thermopiles that are connected electrically in series to increase the operating voltage and thermally in the form of parallel to decrease the thermal resistance. Their energy processes inTEM pellets are classified into four category: Joule heating,thermal conductivity the Peltier cooling/heating effect, and Seeback effect. The flow of electric current through the TEM will give resistive heating of a thermocouples.The TEM's output voltage is the

$$v = U_S + \mathrm{IR}$$

A good TEM must have large Seeback coefficient S with low electrical resistance R and low thermal conductivity. The figure-of-merit (FOM) parameter is then defined as

$$Z = \frac{S^2}{R.K_{th}}$$

DETERMINATION OF TEM PARAMETERS

In general, the designing of TEG involving following parameters

Table 2: Electrical parameter of Thermocouple

Parameter	Variable	Value
Hot-side temperature	T_H	230 K
Cold-side temperature	T_C	30 K
Seeback co-efficient	S	0.0238 V/K
Resistance function	R	0.2981Ω

FOM function	Z	0.0011187
Thermal conductivity	K_{th}	1.6985 W/K

VI.SIMULATION DIAGRAM FOR THERMOCOUPLE

Depends on the temperature variation the output voltage is produced. The design of Thermocouple can be done using following simulink module

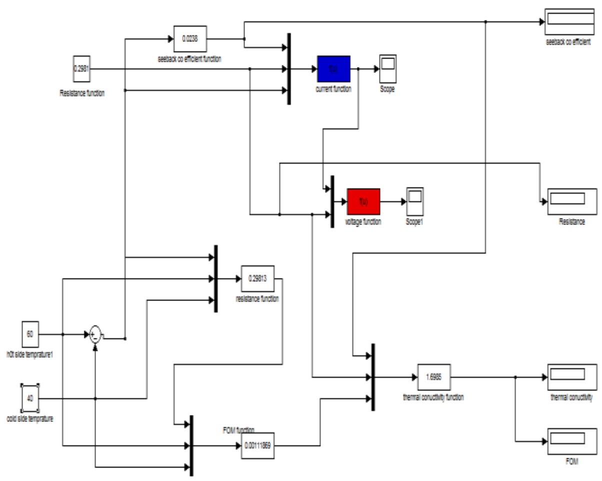

Figure 5: simulation diagram for thermocouple

VII.SIMULATION RESULT OF TE MODULE

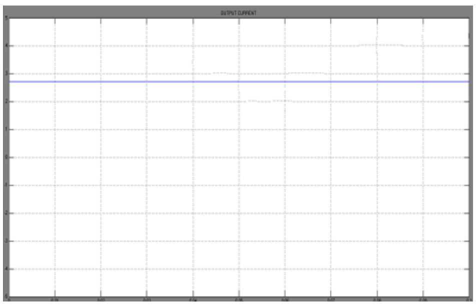

Figure 6: output current for Thermocouple

The simulation result of thermocouple produce Dc output.

VIII.SIMULATION OF HYBRID SYSTEM

The simulation of separate Photovoltaic and Thermoelectric system can be integrated using below simulation circuit

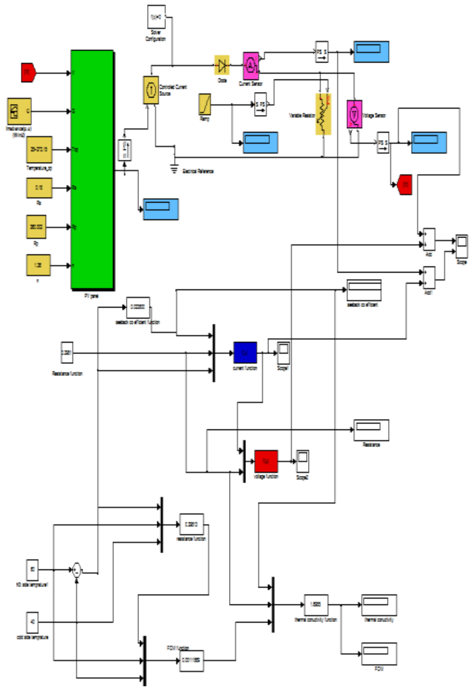

Figure 7: Simulation diagram Hybrid system

IX.SIMULATION RESULT FOR HYBRID SYSTEM

The output characteristics of current, voltage, and power at the matched load depicted in Fig. These results reveal that the maximum power is about 65.8 W at I = 2.8 A and V = 23.5 V, and the maximal efficiency is increased by 4.5% as I approaches about 2.8 A.

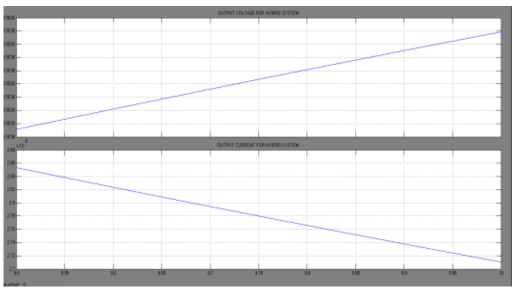

Figure 8: simulation Output for Hybrid System

X.CONCLUSION

In this work both Heat and Light energy from the sun is utilized using Photovoltaic and Thermoelectric Hybrid system. The output power of this system is stored in the Battery during day time. This system was designed and simulated using MATLAB/Simulink software.

XII.FUTURE WORK

The future effort is focused on the Utilization wasted heat energy from the Fan during night time using Thermocouple which is directly connected to the Fan. The output of the system is stored in the same Battery used in PV-TE hybrid system which is connected through the switch during night time.

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