Design and Performance Analysis of Parabolic Type Solar Thermoelectric Generator

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***Abstract*:- Waste heat is by necessity produced both by machines that do work and in other processes that use energy. Machines converting energy contained in fuels to mechanical work or electric energy produce heat as a by-product. The electrical efficiency of thermal power plants is typically only 30%. Thermoelectric Modules can directly convert these waste heat into useful electricity.**

The simplest form of heat available is by solar energy and will be used through a concentrator for the generation of electricity in this paper. This can be used as a chief power source for a satellite as an alternative to solar photovoltaic. The solar radiation trapped using the Parabolic concentrator and it is directed towards point of convergence at which intensity of radiation will be high. Generated electricity is fed to a MPPT converter in order to obtain the stable output.

General Terms:- Thermoelectricity, Green Energy, Renewable Energy, Waste Heat Recovery.

Keywords:- Thermoelectric generator, Seebeck Effect, MPPT Controller, Arduino Uno.

1. INTRODUCTION

A TEG, also called a Seebeck generator, is a solid state. A thermoelectric generator (TEG), also called a Seebeck generator, is a solid-state device that converts heat flux (temperature differences) directly into electrical energy through a phenomenon called the Seebeck effect (a form of thermoelectric effect). Thermoelectric generators function like heat engines but are less bulky and have no moving parts. However, TEGs are typically more expensive and less efficient.

Thermoelectric generators could be used in power plants in order to convert waste heat into additional electrical power and in automobiles as automotive thermoelectric generators (ATGs) to increase fuel efficiency. Another application is radioisotope thermoelectric generators which are used in space probes, which has the same mechanism but use radioisotopes to generate the required heat difference.

Several MPPT methods such as the perturbation and observation method, incremental conductance method, ripple 0correlation control method, fuzzy logic models, and neural network-based models have been proposed for implementation in photovoltaic applications. However, these methods are not optimized for the power–current characteristics of TEGs.

A technique with seamless mode transfer MPPT and an MPPT scheme for a thermoelectric battery storage system have been proposed for vehicular applications of a TEG. A practical MPPT power conditioner comprising a buck-boost converter, an internal power supply, and a microcontroller for the TEG was developed to reduce the mismatch power loss and enhance the load matching ability of the TEG system. These methods provide smooth transition between operating modes; however, they require a microcontroller unit to calculate the instantaneous power and peak power points.

2. METHODOLOGY

The solar radiation trapped using the Parabolic concentrator and it is directed towards point of convergence at which intensity of radiation will be high. The TEG is sandwiched between two heats sink as shown in Fig. 1. The heat obtained from solar radiation is supplied to hot side of heat sink and other side of heat sink will be cooler. The TEG converters temperature difference on either side of the heat sink to electric energy through phenomenon called See beck effect.
The temperature difference is directly proportional to the voltage and current produced. There will be a fluctuation in the voltage and current produced, hence converter is used for the stable output.

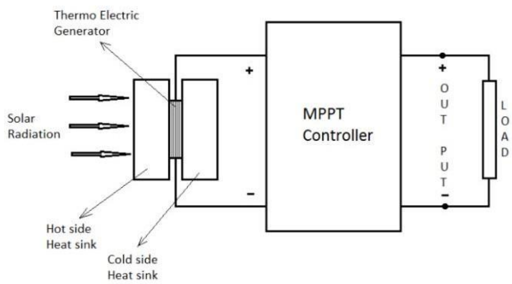

Fig. 1. Overall Block Diagram

3. BLOCK DIAGRAM

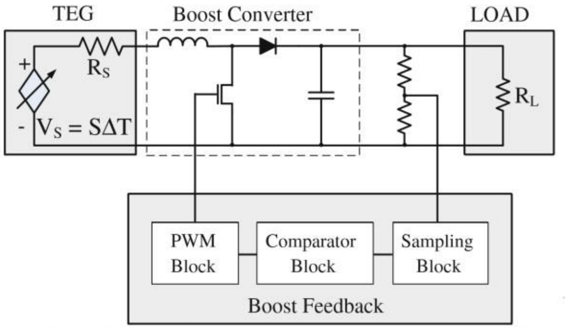

Fig. 2. Block Diagram of Proposed MPPT Circuit using a Boost converter

Fig. 2 shows a block diagram of the proposed MPPT circuit composed of a boost DC–DC converter and a Feedback circuit including sampling, comparator, and pulse width modulation (PWM) blocks. We consider the booster converter in the MPPT circuit, having a non-ideal input voltage source with internal resistance RS and load resistance RL.

Under the steady-state condition of the boost DC–DC converter, the average value or DC components of the inductor voltage waveform must be zero. Further, the average current that flows through an ideal capacitor must be zero, because the inductor current is supposed to have the same value at the beginning and at the end of the commutation cycle.

3.1 Experimental setup

In Fig. 3 the positive terminal of the TEG is connected to 50 Ω Rheostat and another end of rheostat is connected to the ammeter, which is connected back to the negative terminal of TEG. The voltmeter is connected across the TEG.

Concentrator is mounted in opposite to the sun's direction on which the silver coated reflectors of particular size are pasted. The radiation which falls on the concentrator are made to reflect at focal point which is the hot side of TEC. Now the rheostat is varied from maximum to minimum position, Current starts increasing, simultaneously voltage decreases. As in DC power is the output of voltage and current, corresponding power is calculated.

The actual hardware set up is shown in Fig. 4. The parabolic concentrator is on the extreme left of the Fig. 4.

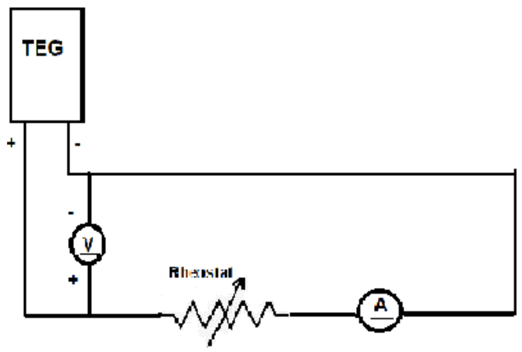

Fig. 3. Circuit Diagram for experimental setup

Fig. 4. Experimental set up hardware

3.2 Results and discussions

The experiment was carried as mentioned in procedure for different time duration on different days.

Few sample observations from the conducted trails is recorded in table I, II & III.

Table I
14-02-2018, 2:30PM

Voltage in volts	Current in mA	Power in mW
2.06	30	61.8
1.95	40	78
1.76	60	105.6
1.47	75	110.25
1.25	100	125
1.02	110	112.2

Table II
11-02-2018, 1:15PM

Voltage in volts	Current in mA	Power in mW
1.97	35	68.95
1.71	45	76.95
1.58	60	94.8
1.38	70	96.3
1.27	80	101.6
1.08	100	108
0.68	130	88.4

For the various set of readings, the maximum power obtained is 128mW at 1.25V on 14-02-2018, at 2:30PM.

These values will be used for the design consideration of the MPPT Boost converter.

Table III
16-02-2018, 11:00AM

Voltage in volts	Current in mA	Power in mW
2.05	30	61.5
1.35	40	54
1.27	45	57.15
0.97	50	48.5
0.62	80	49.6
0.44	100	44

4. CONCLUSION

It is observed that min power of 44mW and maximum power of 125mW is recorded. A suitable MPPT design for the above-mentioned power range is in progress.

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6. REFERENCES

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[1] N. Mohan, T. M. Undeland and W. P. Robbins, Power Electronics Converters, Applications and Design, John Wiley & Sons,Inc, 2003.

[2] D. W. Hart, Power Electronics, McGraw Hill. L. Kutt, J. Millar, M. Lehtonen and M. Marss, "Optimization of Concentrated Solar Thermoelectric

[3] Generator System for Highest Yearly Electric Output," in *56th International Conference on Power and Electrical Engineering of Riga Technical University (RTUCON)*, 2015

[4] J. M. Gruber and S. Mathis, "Efficient Boost Converter for Thermoelectric Energy," in *AMA Conferences 2017 –SENSOR 2017 and IRS2*, 2017

[5] http://www.electrochem.org/dl/interface/fal/fal08/fal08_ p54-56.pdf

[6] Maximum Power Point Tracking Controller for Thermoelectric Generators with Peak Gain Control of Boost DC–DC Converters

[7] https://en.wikipedia.org/wiki/Thermoelectric_generator