PERFORMANCE ANALYSIS OF THERMO ELECTRIC GENERATOR WITH DIFFERENT CONTROLLERS

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Abstract
The thermoelectric generator to converts the thermal energy from the sun into electrical energy through semi conductor. The advantages of thermoelectric generator has made it as emerging trend in the production of green energy. Unlike the solar panels that use the light energy, the thermoelectric generator is utilized for waste heat recovery applications. The performance analysis of thermo electric generator with different controllers such as PI, PID and fuzzy logic controller. The performance is done by using matlab simulation
Keywords: TEG,Boost Converter, Inverter,Load

INTRODUCTION

The Solid state device convert heat energy into electrical energy is called thermo electric generator.There is no moving parts so its operation is silent. So TEG is used in voyager mission of NASA.TEG have low efficiency compared with traditional heat engine.The thermo electric generator works on the principle of seebeck effect.The difference in temperature between the hot and cold surface causes a potential difference.Thermo electric module is fixed on the surface of receiver tube at a particular location .The light from the sun and reflected trough surface concentrated on the thermo electric generator fixed on the receiver tube surface.Parabolic trough solar thermal power plant is one of the most concentrating solar power generations [1]

The power generation with thermo electric conversion using flat plate collector using thermodynamic analysis.

A new modified integration model applied to the parabolic trough collector with vacuum tube receiver ,the optical efficiency is calculated by using integration algorithm.The total heat energy can be easily determined.The errors occurring in this system are also calculated.

There is a chance to reduce the receiver efficiency due to the failure of sealing after several research has been conducted and concluded that put glass to kovar alloy provided at both ends.

Traditional dynamic therml to electric generators such as Rankine or Stirling engine have several times higher efficiency than thermo electric system.But the dynamic system is very expensive and cannot be used for small applications.The system requiring the power rating upto 100W,thermo electric system give good performance than dynamic system.

The proposed system focus on the performance of power generation by parabolic trough using thermo electric generator with different loads, ie linear and non linear load

I. PARABOLIC TROUGH COLLECTOR

Parabolic trough collector is to concentrate solar radiation to a particular point. The cross section of trough is in the shape of a parabola.The trough is usually aligned in north –south direction The overall efficiency of the collector due to cosine loss but only requires the trough to be aligned with the change in seasons, avoiding the need for tracking motors

A. Thermoelectric Generator (TEG)

A thermoelectric generator (TEG), also called a Seebeck generator. It is a solid state device that converts temperature the function of thermo electric generator is same as that of heat engine.

The power production is increased by connecting the p-bar and n-bar together. When more are combined it forms the thermoelectric module and they are connected electrically in series and thermally in parallel.

The efficiency of a material is governed by the figure of merit by which a material is able to generate power. The power generation gets maximized when the thermal conductivity is lower and Seebeck coefficient is greater. The figure of merit is defined as

$ZT=(S^2\sigma)/(k)$………………………….(1)

Where S is the Seebeck coefficient,σ is the electrical conductivityand k is the thermal conductivity [3].

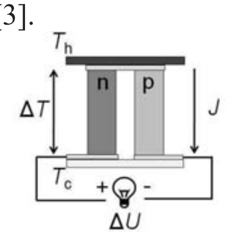

Fig: 1. Thermoelectric Generator [3]

Thermoelectric generators can be used to produce electricity from waste heat and this is increase the thermal efficiency of automobiles

B. Different Configuration of TEG

The TEG can be connected in three different methods they are

a) Series Configuration

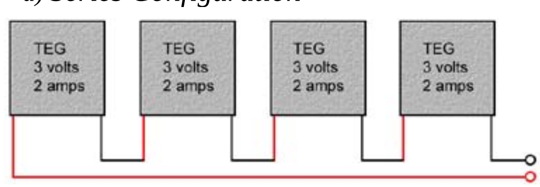

Fig: 2. Series Configuration of Thermoelectric Generator [3]

In series configuration the TEGs are connected in series. This configuration will increase the output voltage .The specification of this connection gives output voltage of 12V, power rating of 24 watts and current carrying capacity of 2A.

b) Parallel Configuration

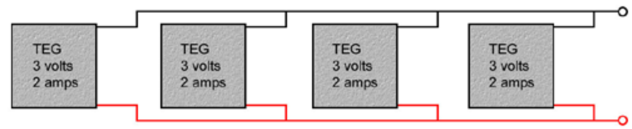

Fig:3. Parallel Configuration of Thermoelectric Generator [3]

In parallel configuration the TEGs are connected in parallel. This configuration increase the output current .The specification of the given parallel configuration is 24watts,3V and 8 A.

c) Series - Parallel Configuration

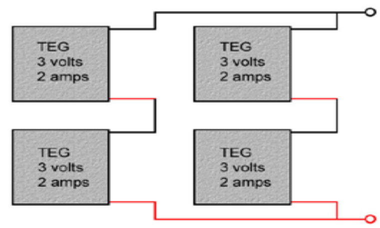

Fig:4. Series- Parallel Configuration of Thermoelectric Generator [3]

This configuration is the combination of series and parallel configurationof TEG.This configuration increase the curent and voltage capacity.The rating of the given configuration is 24 watts ,6V and 4 A.

The comparison of three configuration can be represented by using graph.From the graph series parallel configuration give better output than other two.For this reason I had selected this configuration

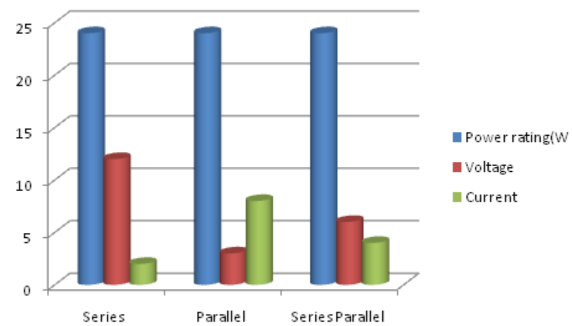

Fig:5. Comparison of different configuration of TEG [3]

II BLOCK DIAGRAM

The block diagram consists of parabolic trough with thermo electric modules, DC-DC boost converter, DC –AC three phase inverter, load and controllers. Thermo electric generator convert thermal energy of sun light into DC voltage, This voltage is step up into suitable voltage by boost converter then converted to

AC by three phase inverter. This AC voltage is connected to a load. The turn on time of switch in a boost converter is controlled by PI, PID and fuzzy logic controllers.

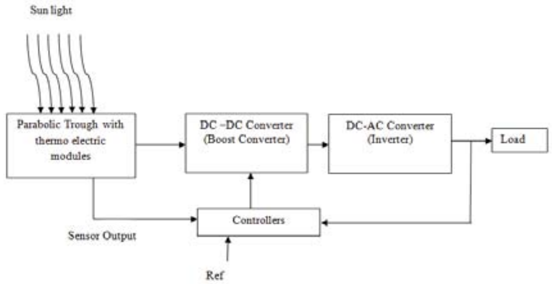

Fig:6. Block diagram of the circuit

III SIMULATION DIAGRAM

The circuit consists of boost converter, three phase voltage source inverter and three phase load.

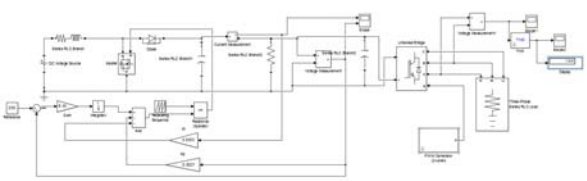

Fig:7. Simulation diagram

In a boost converter, the output voltage is greater than the input voltage so it is called boost converter. A boost converter using a IGBT is shown below

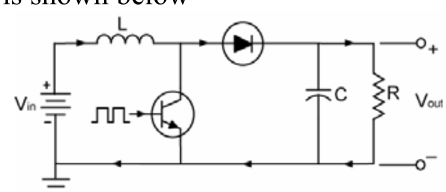

Fig8. Boost Converter

The boost converter works in two modes. The inductor stores energy when switch closed and the capacitor releases energy. The inductor releases energy when switch open and the capacitor stores energy.

In an ideal condition the inductor, capacitor, switch and diode does not consume energy, there exist two fundamental conservation laws between the output and the input.

In the first law the energy balance the input energy equals the output energy:

$$P_{in} = P_{out} \rightarrow I_{in}V_{in} = I_{out}V_{out} \quad \ldots\ldots\ldots\ldots (1)$$

The second law is the input charge equal to output charge. When the switch is open the input current flows from input to output, and the time is (1-d)T in one T-period.

$Q_{in}=Q\_{out}\rightarrow I_{in}$

$(1\text{-}d)T=I_{out}\,T$…………………..…(2)

The relationship between the input voltage and output voltage

$$V_{out} = \frac{V_{in}}{1-d} \ldots\ldots\ldots\ldots (3)$$

Where d is the duty cycle, which is a positive number less than 1.

The DC output obtained from converter is converter to AC by using inverter

IV. SIMULATION RESULT

A) PI controller

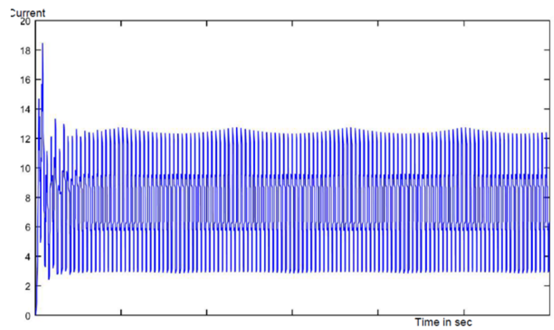

Fig:9. Boost Converter output current waveform using PI controller [3]

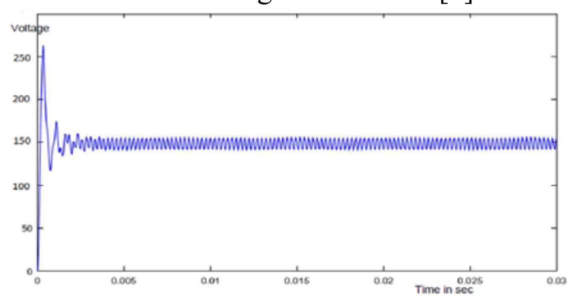

Fig:10. Boost Converter output voltage waveform using PI controller [3]

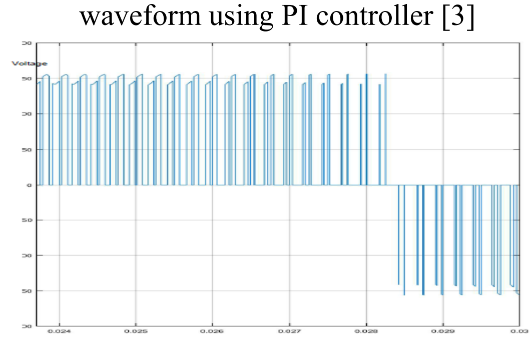

Fig:11. Inverter output voltage waveform using PI controller [3]

B) PID controller

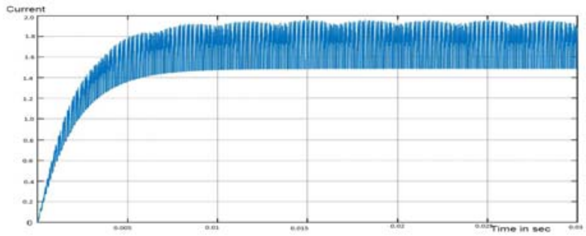

Fig:12. Boost Converter output current waveform using PID controller

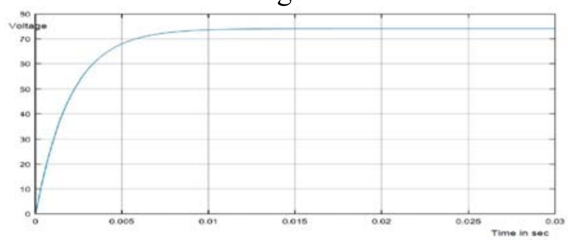

Fig:13. Boost Converter output voltage waveform using PID controller

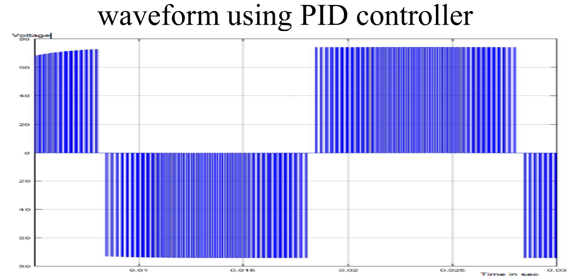

Fig:14. Inverter output voltage waveform using PID controller

C. Fuzzy Logic Controller

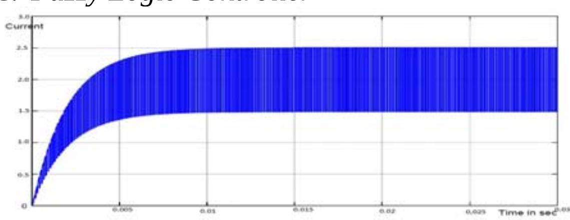

Fig:15. Boost Converter output current waveform using fuzzy logic controller

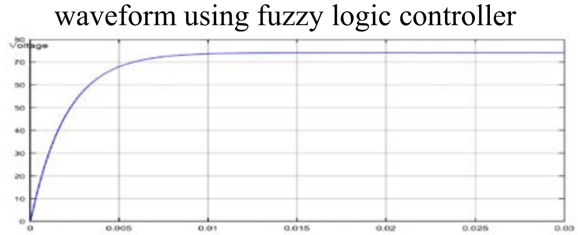

Fig:16. Boost Converter output voltage waveform using fuzzy logic controller

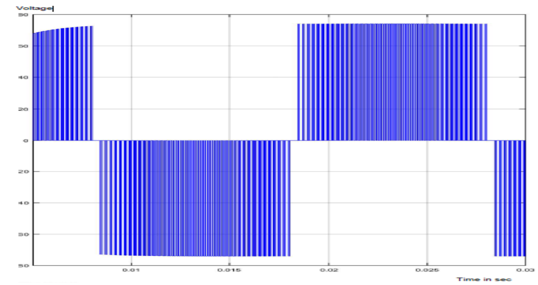

Fig:17. Inverter output voltage waveform using fuzzy logic controller

V. CONCLUSION

The performance analysis of thermo electric generator with different controllers had been analysed and their performances are plotted. This analysis concluded that the fuzzy logic controller gave better performance than PI and PID controllers..

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