Mppt Based High Gain Boost Converter for Pv Applications

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Abstract –This method proposed uses the circuit of a solar photovoltaic energy conversion system with simple and efficient additional components like fixed DC to variable DC converter, a Maximum power point tracking system to obtain desired outputs for variable product requirements. The system acts as a replacement of the battery usually used for the storage of the DC power supply that has been obtained from the Solar PV array. This, especially helps when we only get a specific power that can be used for the later use of the stored charges. To get variable voltages for the load supply, a DC-DC converter with a maximum power point tracking system is used. When compared with the buck and boost converter, the boost converter gives a much more efficient output. However, we can choose a closed loop circuit for getting the variable DC output voltage from the fixed DC voltage source which is being obtained from the solar panel. The obtained voltage can be used without batteries which is because generally DC-DC converter stores energy periodically within and releases from a magnetic field in an inductor that is present inside it. To get a different voltage for a different purpose, for example, charging of laptops, charging of mobile, glowing a bulb, a specific voltage can make better for the particular usage.

Key Words: Closed loop system, DC-DC converter (Chopper), Energy storage, Maximum Power Point Tracking system, Solar PV System

1. INTRODUCTION

In our everyday life, we use different forms of energy resources. It can either be non-renewable or renewable form of it. In most cases, coal became the only trustable source. Despite being trustable, a question in-built arises. The reserves of coal are fast depleting. For this, first-world countries are going for sustainable energy resource since it is renewable.

Despite having many forms of renewable energy resources like Wind, Tidal, Biomass, etc., we often go for Solar energy. In the tropical regions, where we face the sun the majority of the time, heat plays a vital role. The above decides that we can use the Solar as the power source. This promotes the decision by providing much more efficient output when compared to other forms of energy and is easy to access, install and maintain.

Even though everything seems good, solar photovoltaic power generation finds its efficiency over 60 to 70 percent. Yet practically it gives only about 30 percent [1]. But still, we use them by generating energy daytime and storing the excess energy generated for the night. This usually is made possible using batteries and other form of storage devices. But when we use batteries, a fixed value of output is only retrieved from it. This is sent to the load and the circuit embedded in it obtains the actual amount of voltage required. This has been upgraded with a transformer-based boost converter and a typical closed loop circuit. This tends to give a high gain.

In this project, the dc is first converted to ac by an inverter (dc to ac converter). The obtained ac is then stepped-up or down by a transformer and then rectified back to dc by a rectifier. As the conversion is in two stages, dc to ac and ac to dc, this technique is therefore, costly, bulky but efficient. [2,3] The ac link chopper is shown in Figure 1. However, the transformer provides isolation between load and source [4].

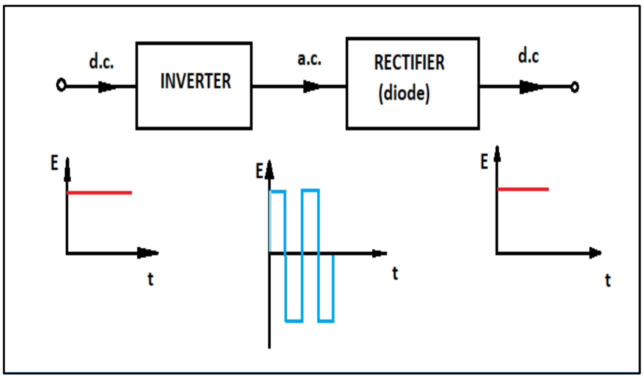


FIG 1: AC LINK CHOPPER

2. CHOPPER DESIGN CONSIDERATION:

The chopper configuration is capable of giving a maximum voltage that is slightly smaller than the input dc voltage (i.eEo<Edc) [5,6]. However, the chopper configuration can be used to produce higher voltages at the load than the input voltage (i.eEo ≥ Edc) [8]. This is called as step-up chopper and is illustrated in below Figure 2.

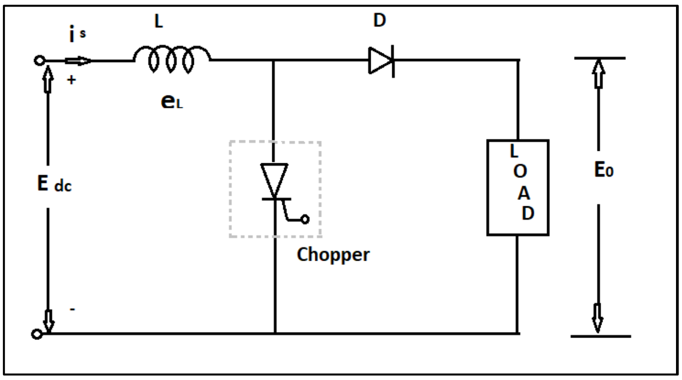


FIG 2: BOOST CHOPPER

When the chopper is on, the inductor L is connected to the supply Edc, and inductor stores energy during on-period Ton. When the chopper is off, the inductor current is forced to flow through the diode and load for a period Toff. As the current tends to decrease, polarity of the emf induced in inductor L is inversed to that of shown and as a result, voltage across the load Eo becomes

$Eo=Edc+L\ di/dt$

That is, the inductor voltage adds to the source voltage to force the inductor current into the load. In this manner, the energy stored in the inductor is released to the load. Here, higher value of inductance L is preferred for getting lesser ripple in the output. During the time Ton, when the chopper is on, the energy input to the inductor from the source is given by

$Wi=Edc.Is.Ton$

Now, during the time T_{off}, when chopper is off, energy released by the inductor to the load is given by,

$Wo=(Eo-Edc).Is.Toff$

Considering the system to be lossless, and in the steady-state these two energies will be equal.

$Edc.Is.Ton=(Eo-Edc).Is.Toff$

$Eo=Edc.\ (Ton+Toff)/Toff$

$Eo=Edc.\ T/(T-Ton)$

But, since we know, $Ton/T= \alpha$, the above equation means,

$Eo=Edc.\ 1/(1-\alpha)$

For $\alpha=0, Eo=Edc$; and $\alpha=1, Eo=\infty$.

Hence, for variation of a duty cycle α in the range $0< \alpha <1$, the output voltage Eo will vary in the range $Edc< E0< \infty$. This concept is used for regenerative braking of dc motors even at lower operating speeds [16][17].

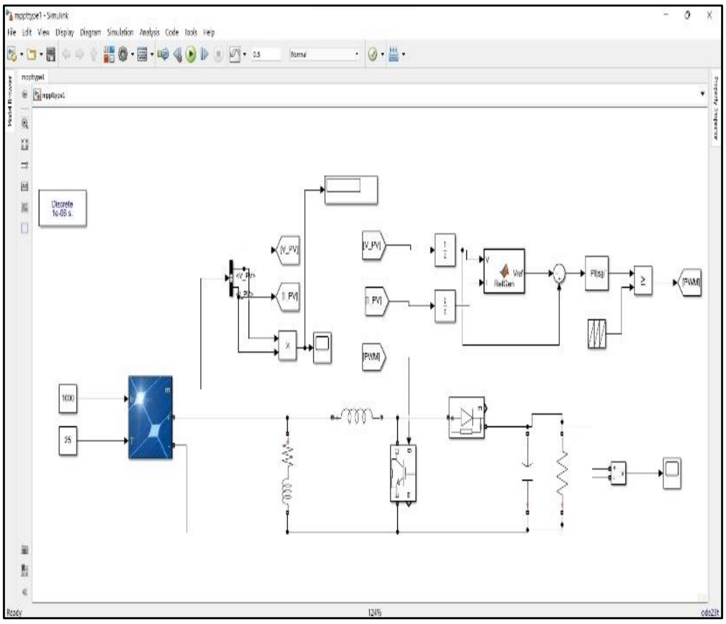


FIG 3: SIMULATION OF CLOSED LOOP BOOST-CHOPPER WITH MPPT

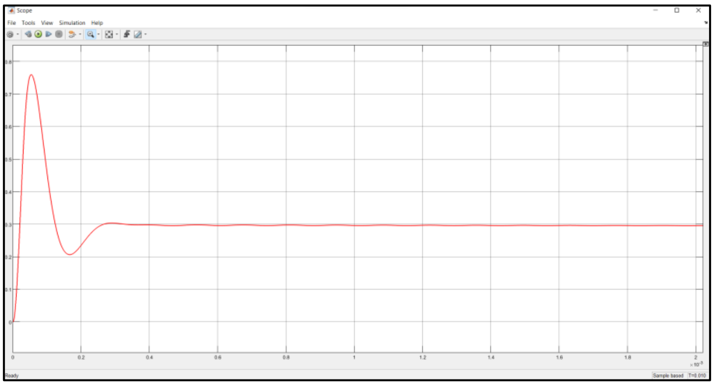


FIG 4: OUTPUT SCOPE OF CLOSED LOOP BOOST-CHOPPER AT IRR= 1000 W/m2 AND TEMP= 25 ℃

The simulation circuit with MPPT controller and the output of the closed loop boost chopper at 1000 W/m^2 are shown in Figure 3 and Figure 4.

3. TRANSFORMER BASED CHOPPER- DESIGN CONSIDERATIONS:

The basic design of the converter circuit involves the proper selection of the commutating capacitor C and autotransformer T[7,9]. Initially, maximum load current Ion is flowing through L1. During turning off of SCR T1, the energy stored in inductance L1 is being transferred to capacitor C.

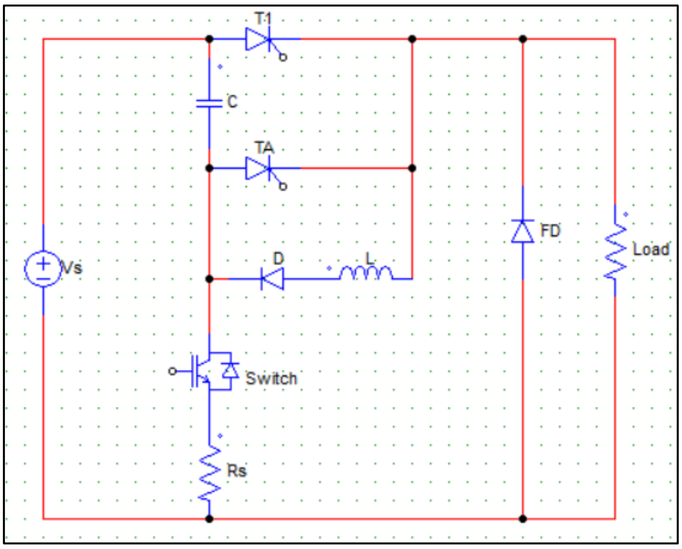


FIG 5: TRANSFORMER BASED CHOPPER CIRCUIT

Thus,

$1/2\ L_1.I_{om}^2=1/2\ C.V^2$

(or) $V= I_{om}.\sqrt{L/C}$

During the turn-off time, tq, the capacitor voltage changes from Vc to 0. Hence,

$Tq= (Vc.\ C)/(I\ om)$

Substituting the value of Vc, from the above equation to the latest, we get,

$Tq=\sqrt{L.C}$

Now dividing voltage equation by Edc yields,

$Vc/Edc=Iom/Edc.\sqrt{L/C}$

Depending on the values of l, C and Edc and Iom, the value of Vc/Edc is greater than 1.
The voltage across SCRs T1 and T2 is
Vc= g. Edc
Hence, a large value of g would require an increase in the voltage rating of the thyristor in the circuit.
In this chopper circuit, only dissipative elements are windage resistance and the forward conducting resistance of the SCRs and the diodes. Therefore, this circuit is basically very efficient [10][11]. The inductance L maintains the load current through diode Df when SCR T1 is not conducting. Hence, the load torque which is proportional to the load current is smooth rather than pulsating. If the inductance in the load circuit is small, the change in the load current is substantial, which would result in substantial torque ripple in the inductive load[12][13][14].

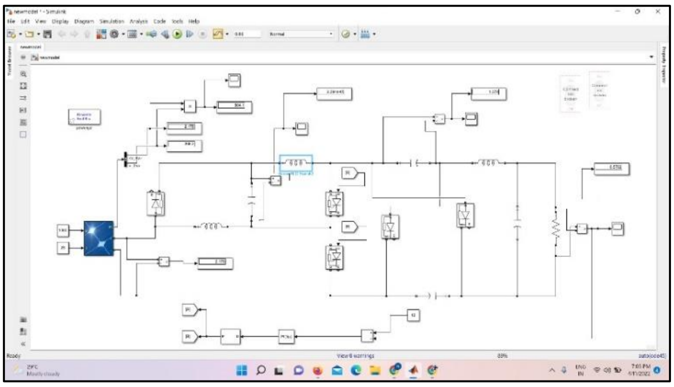


FIG 6: SIMULATION OF TRANSFORMER BASED CHOPPER CIRCUIT

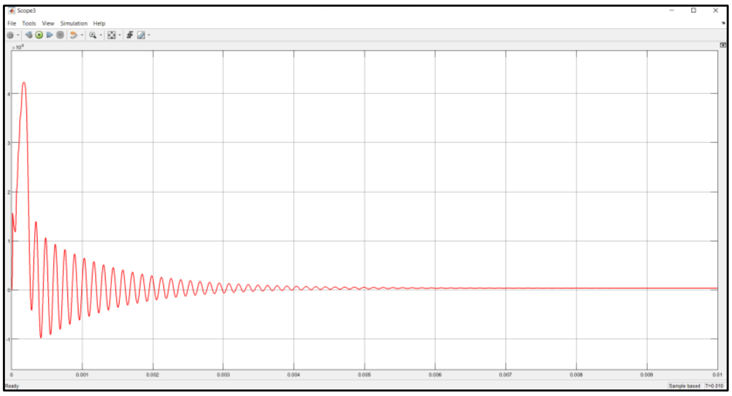


FIG 7: MPPT OUTPUT OF PANEL FOR IRR= 500 W/m2 AND T=20℃

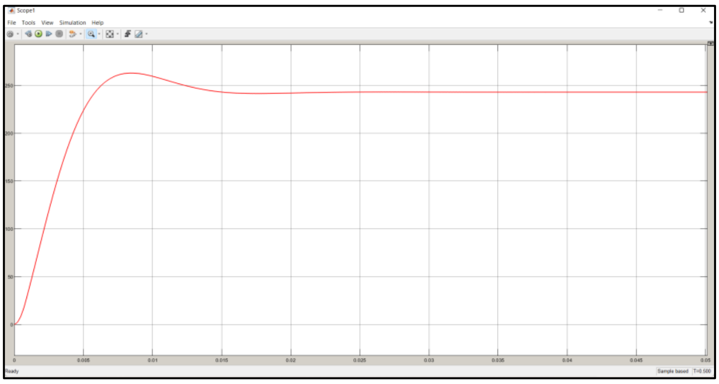


FIG 8: OUTPUT SCOPE OF A TRANSFORMER BASED CHOPPER AT ABOVE IRRADIANCE AND TEMPERATURE

4. HARDWARE DESIGN:

In this proposed system, we are using boost converter to improve the voltage that we reap from the solar panel.The circuit basically contains a solar panel which acts as primary power source. The secondary source would be a rechargeable energy storage system or a battery.

Since we also use the battery, it acts as a back-up whenever the power from the panel is not enough for the load to reap or any other unavailability issues.The maximum output is retrieved by using MPPT circuit by boosting current using a inductor and the voltage is boosted using a boost circuit [13].

The voltage is sent to load through the transformer-based converter. The voltage is sent to the safety circuit , that is, the MOSFET circuit.Excessive amount of voltage or the unused voltage is stored in a 12V battery so it can be reaped whenever the power fails.

The charge for the battery is just the excessive amount or the unused amount of charge that is obtained from the panel.

The status of the circuit is displayed in a LCD display using the ATMega826p microcontroller which is actually programmed to display the sentences programmed to it as per the pin cases.

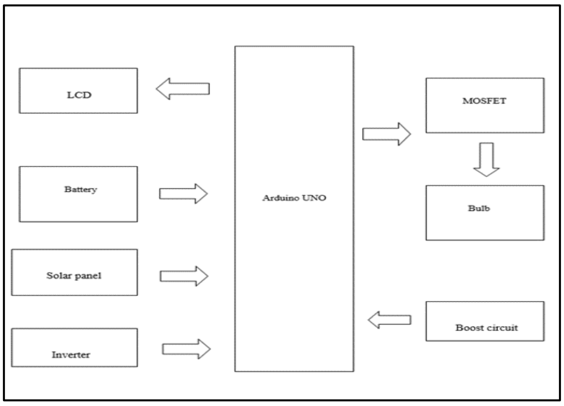
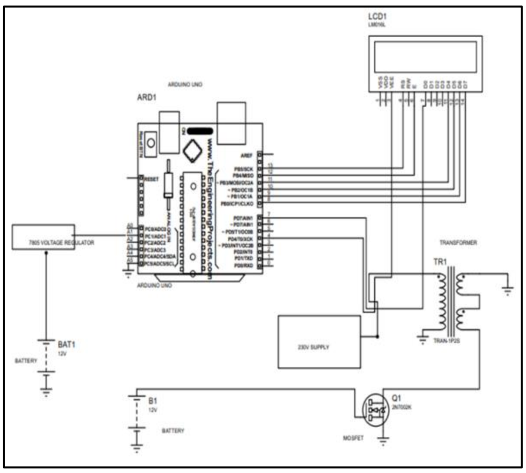


FIG 9:BLOCK DIAGRAM

5. CIRCUIT DIAGRAM



.FIG 10:CIRCUIT DIAGRAM

6.HARDWARE RESULTS

OUTPUT 1:

The hardware setup and output without MPPT control is shown in the Figure 11 below which shows low voltage display from the solar panel connected.

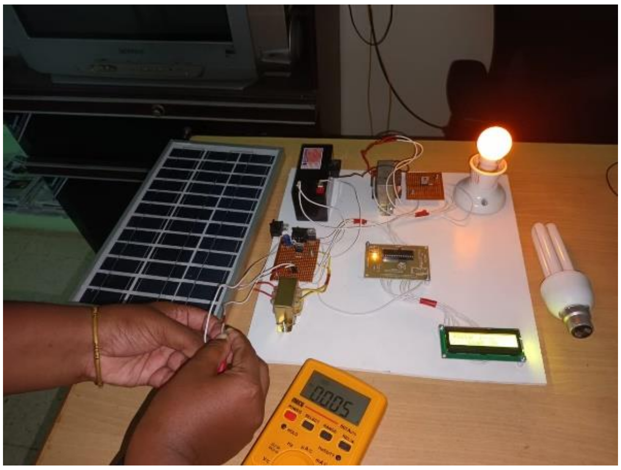


FIG 11: VOLTAGE WHEN THE MPPT CIRCUIT IS DISABLED

OUTPUT 2:

The output voltage on enabling the MPPT circuit is shown in the Figure 12 given below, which gives the 12 V range from the circuit. The basic rated voltage level is obtained.

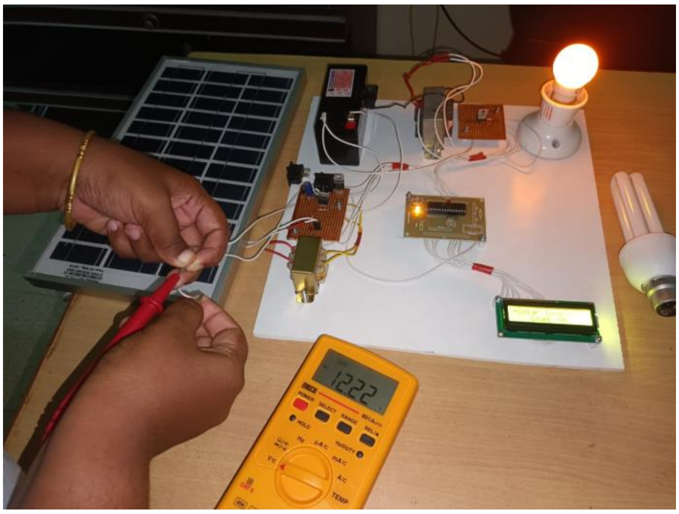


FIG 12: VOLATGE WHEN THE MPPT CIRCUIT IS ENABLED

OUTPUT 3:

The voltage range boosted using the boost converter circuit is shown in Figure 13, where 22V range is obtained from the booster circuit.

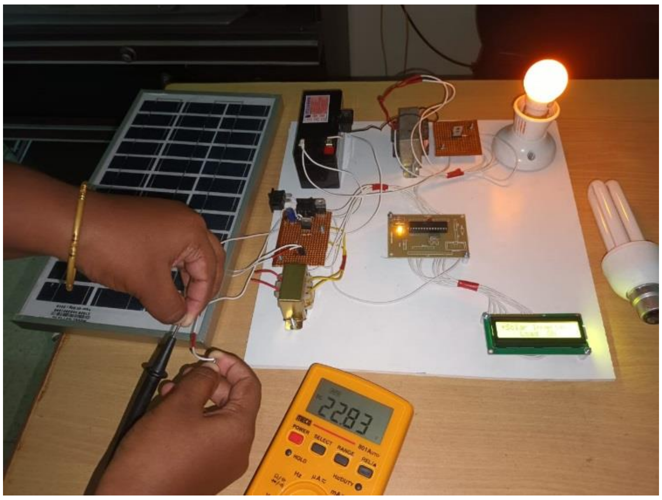


FIG 13: VOLATGE WHEN BOTH THE MPPT AND THE CONVERTER CIRCUIT IS ENABLED

7.CONCLUSION

The ongoing technological progress in high-voltage step-up dc–dc converter has five primary drivers—energy efficiency, power density, cost, complexity, and reliability [15], all of which also influence each other to some extent. This view facilitates quick selection between related alternatives for special load and application requirements. Each voltage-boosting technique has its own unique features and suitable applications, and there is no one-size-fits-all solution. Nevertheless, it is generally not fair to permanently favor any particular technique or solution. The converter topology and control method, which was seen as complex and inefficient a decade back, has now become a key solution for many industries and applications. In this manner, new topologies based on different and often merged voltage-boosting techniques will continue to appear in order to meet and improve the performance of different applications. Thanks to the progress in power-semiconductor devices, new wide bandgap devices (GaN, SiC, etc.), advanced magnetic materials, high-performance digital control platforms.

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