RENEWABLE ENERGY BASED SEPIC CONVERTER

A PROJECT REPORT

Submitted by

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BONAFIDE CERTIFICATE

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INTERNAL EXAMINER EXTERNAL EXAMINER

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ABSTRACT

Being a south asia nation, India has a lot of promise as a source of solar energy. Because solar energy is renewable and does not produce any pollution, it is environmentally benign.

Solar energy can replace some of the fossil fuels that can't be replaced. If used consistently, it can be replenished.

Solar energy, such as that found in sunlight, can be transformed into electrical energy by means of solar panels. The design of the SEPIC Converter to Supply Electrical Energy to a Smart Lamp using Solar Energy is presented in depth in this paper.

Solar energy is not constantly at its peak, hence a control system to increase the output power of the converter is required to maximise the power supplied by solar panels.

The design of the SEPIC Converter to Supply Electrical Energy to a Smart Lamp using Solar Energy is presented in depth in this paper The design of the SEPIC Converter to Supply Electrical Energy to a Smart Lamp using Solar Energy is presented in depth in this paper.

Sunlight energy isn't always at its peak, so to increase the amount of power For converter output power to be maximised, solar panels require a control system. In this experiment, two 100 WP solar panels are used, each in parallel.

PI control is used in the control system. The goal is to produce the output voltage needed to charge batteries. According to the set point value of 14 volts for battery charging with a battery capacity of 20 Ah at 12 volts, the PI control's time response is 0.6 s. The PI control parameter is located using the Cohen Coon approach.

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LIST OF ABBREVIATION

PI	**Proportional Integratal**
WP	**Watt Peak**
SEPIC	**Single Ended Primary Inductance Converter**
MPPT	**Maximum Power Point Tracking**
OLTF	**Open Loop Transfer System**
CLTF	**Close Loop Transfer System**

CHAPTER 1

INTRODUCTION

- As we know, solar energy is intermittent in nature and depends on the environment conditions, so, in order to operate the solar system efficiently we need some tracking system.
- The maximum power for the given environmental conditions can be tracked by using some techniques known as Maximum Power Point Tracking (MPPT) techniques.
- There are many MPPT techniques that can be used for such purpose.
- In this project, we are using an Incremental Conductance (INC) MPPT technique.

CHAPTER 2
LITERATURE SURVEY

2.1 INITIALIZATION

For daily life, electricity is a crucial source of energy. Electricity depends on fossil fuels, however as demand for electricity rises owing to people's lifestyles, the amount of fossil fuels available decreases. that use electricity inefficiently. Indonesia has seen a decline in oil production since 1991. Indonesia pioneered nd investigated renewable energy sources as an alternate energy source to address these issues. Solar power is among them. [1-3] Because solar energy can only be produced by solar radiation, it cannot be produced at night. As a result, a battery is required to store the energy generated during the irradiation process. Thus, we can utilise the electricity that is stored in batteries at night [1], [4-5]. Because the power produced by solar panels frequently has an unstable value due to variations in sunshine intensity brought on by variable weather, a DC-DC SEPIC converter is utilised in conjunction with an algorithm employing PI control to set the duty cycle value. A control approach that produces a constant output is the PI controller [5], [7-9] By combining P and I in tandem to form a proportional plus integral controller, the benefits and drawbacks of each controller can be balanced against one another. The components of the P and I controllers, respectively, are designed to quicken a system's reaction and eliminate offsets. Using the Cohen Coon approach, the PI control value was determined in this study [10]. Without reversing polarity, SEPIC converters can convert DC to DC voltages that are larger or smaller than the input voltage.

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2.2 OBJECTIVE

- To extract the maximum available power from pv power system using SEPI converter and MPPT Method.
- To reduce the Partial Shading effect using SEPI Converter.
- To achieve Maximum Efficiency and Less Ripple factor by using the proposed approach.
- The perturb and observe(P&O), as the name itself states that the algorithm is based on the observation of the array output power and on the perturbation (increment or decrement) of the power based on increments of the array voltage or current.

CHAPTER 3

3.1 EXISTING METHOD

- Photo voltaic modules are formed and then the output is fed into the DC/DC converter in order to achieve the maximum power from the panels.
- The DC/DC boost converter is having one fixed set of switching frequency and varying duty cycle.
- The duty cycle of the converter is varied according to the performance of the The perturb and observe MPPT algorithm.
- The perturb and observe(P&O), as the name itself states that the algorithm is based on the observation of the array output power and on the perturbation (increment or decrement) of the power based on increments of the array voltage or current.

3.2 DRAWBACKS

- High peak current flows through to switch.
- Large inductor and capacitor is required to provide ripple free output.
- In P&O Algorithm at steady state, the operating point oscillates around the MPP giving rise to the waste of some amount of available energy

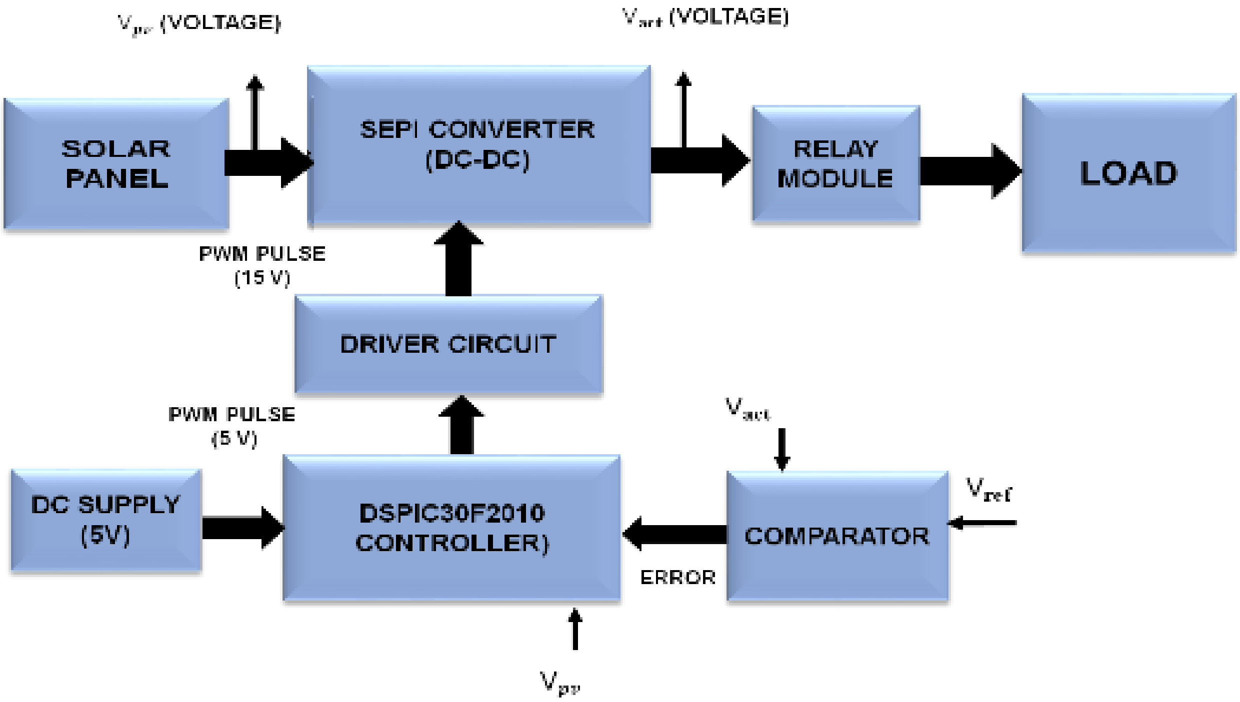
3.3 PROPOSED METHOD

- The power generated by the solar panel array is feed into the SEPI Converter module.
- With the help of an I and C MPPT control algorithm applied to the Sepic Maximum power at a certain instance in extracted from te PV array and is fed to the Load
- The main advantage of INC method is that it provides an effective solution under quickly changing atmospheric conditions. Furthermore, it has less oscillation around MPP in comparison with P&O.

CHAPTER 4

SYSTEM DESIGN

4.1 BLOCK DIAGRAM



4.2 DESIGN SYSTEM CONVERTER

The SEPIC (Single Ended Primary Inductor Converter) converter is a buck-boost derivative topology, and both of these converters may provide output voltages that can be larger or smaller than the input voltage, however the output voltage of a buck-boost converter has an inverse polarity, but a SEPIC converter does not require reversing the polarity. Adding capacitors and inductors to a SEPIC converter can also reduce the output ripple [11–15]. Figure 1 depicts the proposed SEPIC converter's design.

Figure 1. The Proposed SEPIC Converter

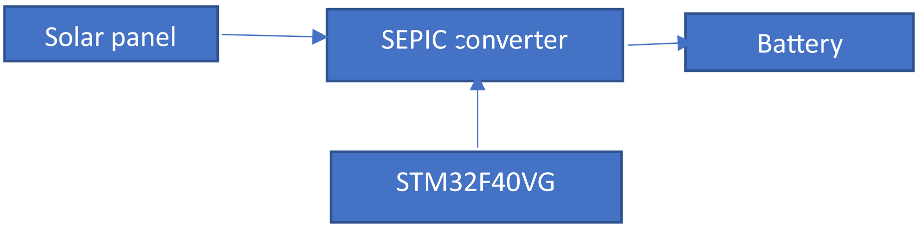


Figure 1. The Proposed SEPIC Converter

Figure. 1 explained that the SEPIC converter is getting an input voltage from the solar panel that will be used for battery charging. The output voltage of the SEPIC converter will be regulated using STM32F40VG microcontroller to match the battery charging process.

A. Planning of SEPIC Converter

In this paper have planned SEPIC converter with the voltage of output is 14 volt. SEPIC converter can generate output voltage which one can be bigger or smaller than input voltage but without reversing polarity [16]. Kirchhoff's Voltage Law around the path containing Vs, L1, C1, and L2 gives,

At the closing of switch, the diode will be off and Figure 2b shows the circuit. The cross voltage L1 for the DT interval is,

$$V_{L1} = V_s$$

At the opening of the switch, the diode will be on and Figure 2c shows the circuit.

$$-V_s + V_{L1} + V_{C1} - V_{L2} = 0$$

KVL on the outer lane is

$$-V_s + V_{L1} + V_{C1} + V_o = 0$$

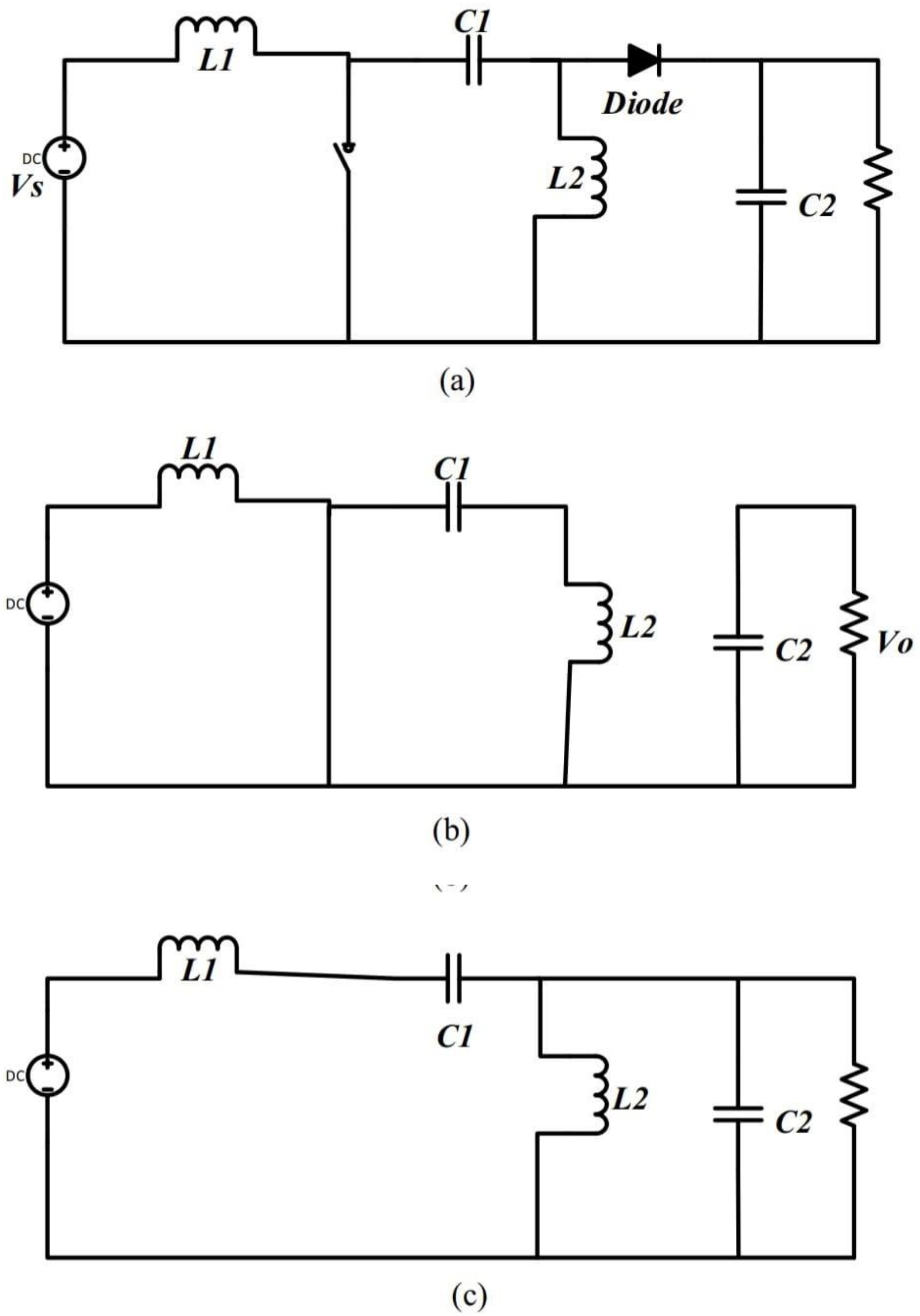


Figure 2. (a) Circuit of SEPIC; (b) Circuit of SEPIC at closing switch and diode off;

(c) Circuit of SEPIC at opening switch and diode on At interval (1 - D) T. Because for periodic operation the average voltage transverse an inductor is zero, the equation becomes

Where the duty cycle of ratio the switch is D, the result is

$$V_S(DT) - V_O(1 - D)T = 0$$

$$D = \frac{V_O}{V_O + V_S}$$

The equation of CUK converter and buck-boost converter are similar to this equation. A capability to have a voltage output larger or lower than input voltage without reversing the polarity made this converter applicable for various appliances. The equation of current source can be examination by,

$$I_{L1} = I_S = \frac{VoIo}{Vs} = \frac{Vo^2}{V_S R}$$

Figure.3 shows the current waveform.in Figure 3c apply Kirchhoff's Law of KVL, it is assumed is no rippling voltage on the capacitor, express an opening of switch the voltage going through

From Figure 3b, diode is off and maximum reverse voltage is Vs + Vo. C2, Diodes and load resistors are part of the output side is equal with boost converter, to determine the output of ripple voltage is,

$$\Delta Vo = \Delta Vcs2 = \frac{Vo\ D}{R.C2.f}$$

$$C2 = \frac{D}{R(\Delta Vo/Vo)f}$$

To determine the variation of voltage in C1 on the figure of the circuit when the switch is closed. The reciprocal of the capacitor current i, which has reversely been searched to have an Io average value. The equation is,

$$\Delta V_{C1} = \frac{\Delta Qc1}{C} = \frac{Io\Delta t}{C} = \frac{Io\ DT}{C}$$

$$C1 = \frac{D}{R(\Delta Vc1/Vo)f}$$

+

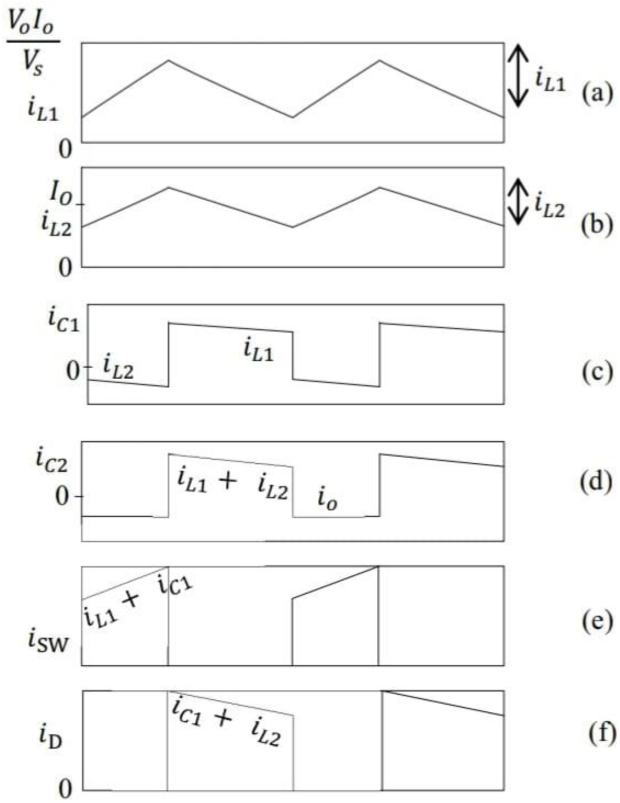


Figure 3. SEPIC converter current. (a) L1; (b) L2; (c) C1; (d) C2; (e) switch; (f) diode

Cohen Coon method is used to improve the oscillation method by using the quarter amplitude decay method. Quarter amplitude decay is defined as the transient response which is the amplitude at the first period has a ratio of a quarter (1/4). The proportional Kp controller is tuned until it is obtained quarter amplitude decay response, the period when this response is called Tp and Ti parameters and Td is calculated from the combination of Kp with Tp. In Table I explain the parameter tuning using Cohen Coon method.

Table 1. Paramerter Tuning Using Cohen-Coon Method

Controller Type	Kp	Ti	Td
P	$\frac{1}{K}(\frac{T}{L})(1+\frac{1}{3}(\frac{L}{T}))$	-	-
PI	$\frac{1}{K}(\frac{T}{L})(0,9+\frac{1}{12}(\frac{T}{L}))$	$L[\frac{30+3(\frac{L}{T})}{9+20(\frac{L}{T})}]$	-

The SEPIC converter is simulated using an open loop and the K parameter is 0.97 and the open loop transfer function (OLTF) generate an equation $\frac{0.97}{0.0028s+1}$. After determine the K parameter and OLTF equation, it can determine the parameters of Kp, Ki, and close loop transfer function (CLTF). By using the Cohen Coon method, the Kp value is 5.155 and the Ki value is 32.21. For the close loop transfer function (CLTF) is $\frac{1}{0.032s+1}$.

4.3. Result and Discussion

In this section, we will discuss the results of testing of the SEPIC converter with open loop and close loop systems.

A. SEPIC Converter Testing in an Open Loop Transfer Function System (OLTF) In this open loop transfer function (OLTF) test the value varied are duty cycle value and irradiation disorders.

In Figure. 4 is shown a simulation circuit of SEPIC converter with an open loop transfer function (OLTF) system using PSIM software.

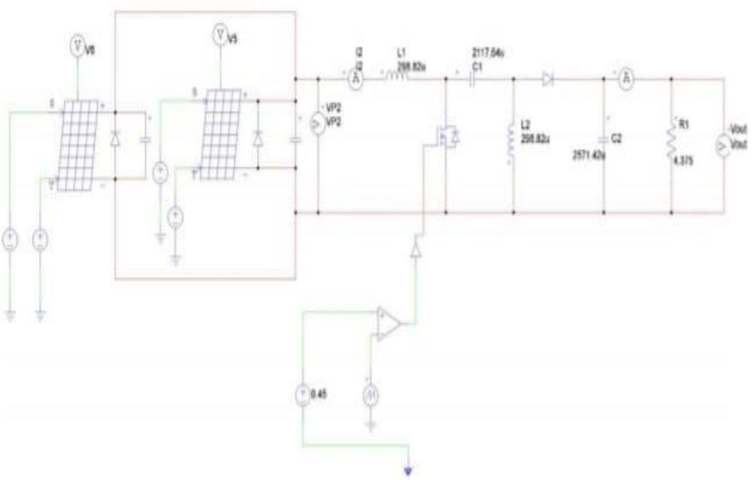


Figure 4. Simulation Circuit of SEPIC Converter with an Open Loop Transfer Function (OLTF) System After simulating, the simulation result will be shown in Table 2.

Table 2. Open Loop Simulation Result

Duty Cycle (%)	V Input (V)	I Input (A)	V Output (V)	I Output (A)
20.00	21.01	0.12	5.25	1.20
25.00	20.94	0.32	6.97	1.59
30.00	20.83	0.62	8.93	2.04
35.00	20.67	1.08	11.13	2.54
40.00	20.44	1.74	13.6	3.11
45.00	20.36	1.96	14.32	3.27

From the result of the open loop transfer function (OLTF) simulation it can be seen that the output voltage can be greater or lower than the input voltage by setting the value of duty cycle. The graph of the simulation result of a SEPIC converter with an open loop system shown in Figure 5.

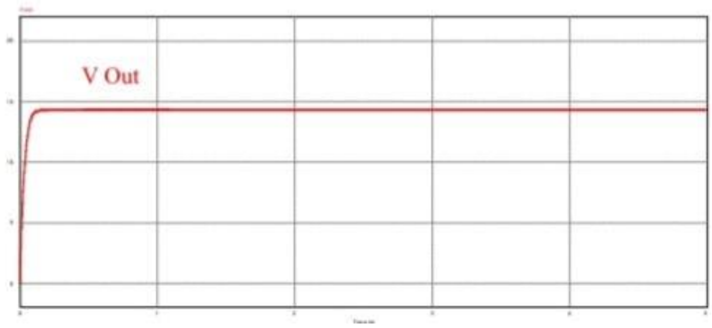


Figure 5. Simulation Result of a SEPIC Converter with an Open Loop Transfer Function (OLTF) System In Figure 5.

SEPIC converter with open loop system and the output voltage is 14.32 V with the duty cycle is 45%. But converter with open loop system have not produced according to set point. In the second test will simulate the SEPIC converter by giving interference to the irradiation of the solar panel.

Figure. 6 show the graph of the simulation result of a SEPIC converter by giving interference to the irradiation of the solar panel in an open loop system

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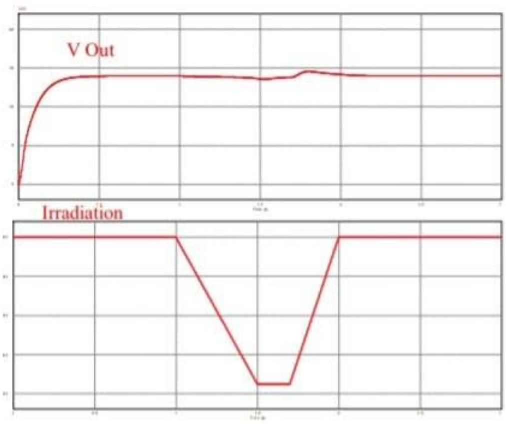


Figure 6. Result of Simulation with Interference to the Irradiation with Open Loop System

The result of Figure.6 can be seen that the output voltage is 14.32 V but has decreased and there are ripples. This happens because the solar panels are given interference with irradiation with the value is 250 W/m2.

SEPIC Converter Testing in an Close Loop System In this close loop transfer function (CLTF) system there are two types of testing, there are STC condition test on the solar panel and solar panel test with giving a disturbance in the value of irradiation. In Figure.7 is shown a simulation circuit of SEPIC converter with a close loop transfer function (CLTF) system using PSIM software. In the SEPIC converter design with a close loop system using Kp value of 5.155 and Ki value of 32.21. The desired set point value is 14 volts. First test is solar panel in STC condition.

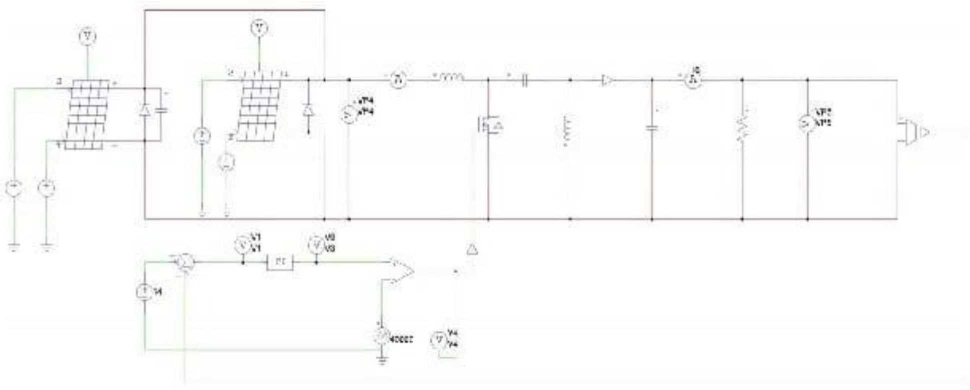


Figure 7. Simulation Circuit of SEPIC Converter with a Close Loop Transfer Function (CLTF) System After simulating,

the simulation result will be shown in Figure.8

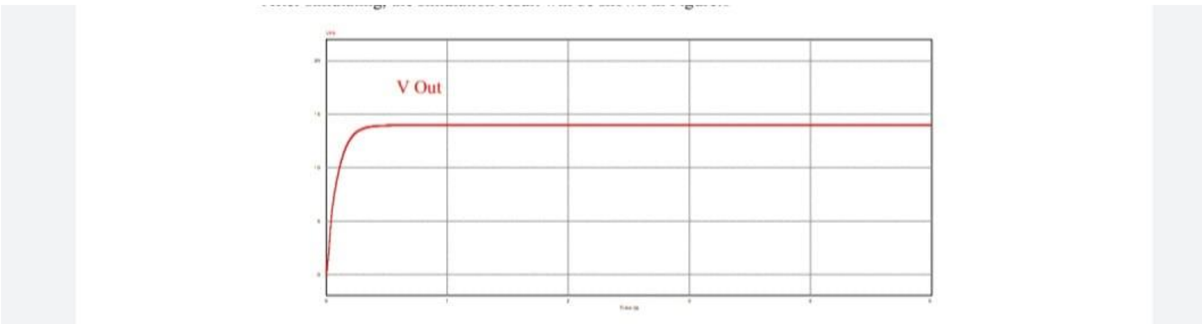


Figure 8. Simulation Result of a SEPIC Converter with a Close Loop System

Figure.8 is shown that the output voltage has reached the set point with a value 14 volt for battery charging. In this simulation using 2 solar panels with the value are 100 WP. The output voltage waveform in Figure 8 shows that the wave has a perfect shape because the solar panel is in the STC condition.

In second test the solar panel will giving a disturbance to the irradiation value, so for a moment the value of irradiations drops. The result of the simulation wave can be seen in Figure.9.

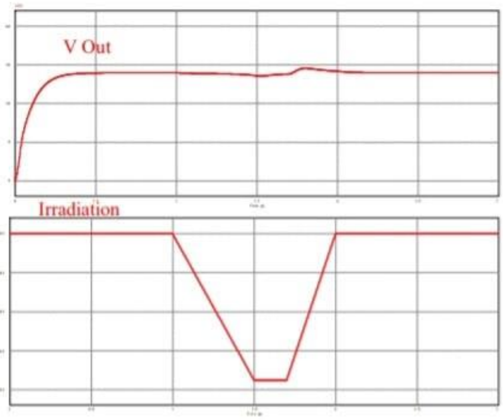


Figure 9. Simulation Result with Interference to the Irradiation with Close Loop System In figure. 9 shown that the value output voltage of SEPIC converter with close loop system is 14 V and have increase about 14.6 V . the result is different from SEPIC converter with open loop system because there is PI control to decrease the error signal.

CHAPTER 5

HARDWARE AND SOFTWARE DESCRIPTION

5.1 SOLAR PANEL

A Solar panel (also known as "PV panels") is a device that converts light from the sun, which is composed of particles of energy called "photons", into electricity that can be used to power electrical loads.

Solar panels can be used for a wide variety of applications including remote power systems for cabins, telecommunications equipment, remote sensing, and of course for the production of electricity by residential and commercial solar electric systems.

On this page, we will discuss the history, technology, and benefits of solar panels. We will learn how solar panels work, how they are made, how they create electricity, and where you can buy solar panels.

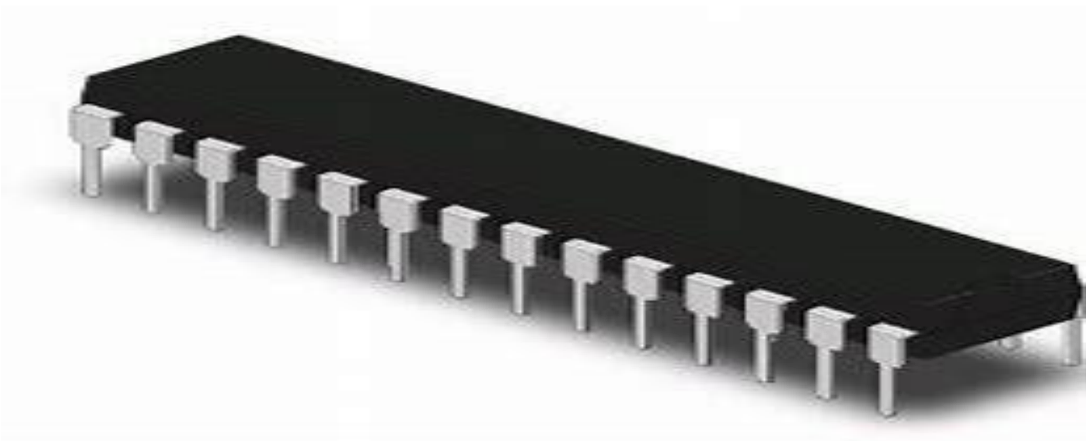
5.2 DRIVER CIRCUIT

In electronics, a driver is a circuit or component used to control another circuit or component, such as a high-power transistor, liquid crystal display (LCD), stepper motors, SRAM memory,[1]:30 and numerous others.

They are usually used to regulate current flowing through a circuit or to control other factors such as other components and some other devices in the circuit. The term is often used, for example, for a specialized integrated circuit that controls high-power switches in switched-mode power converters. An amplifier can also be considered a driver for loudspeakers, or a voltage regulator that keeps an attached component operating within a broad range of input voltages.

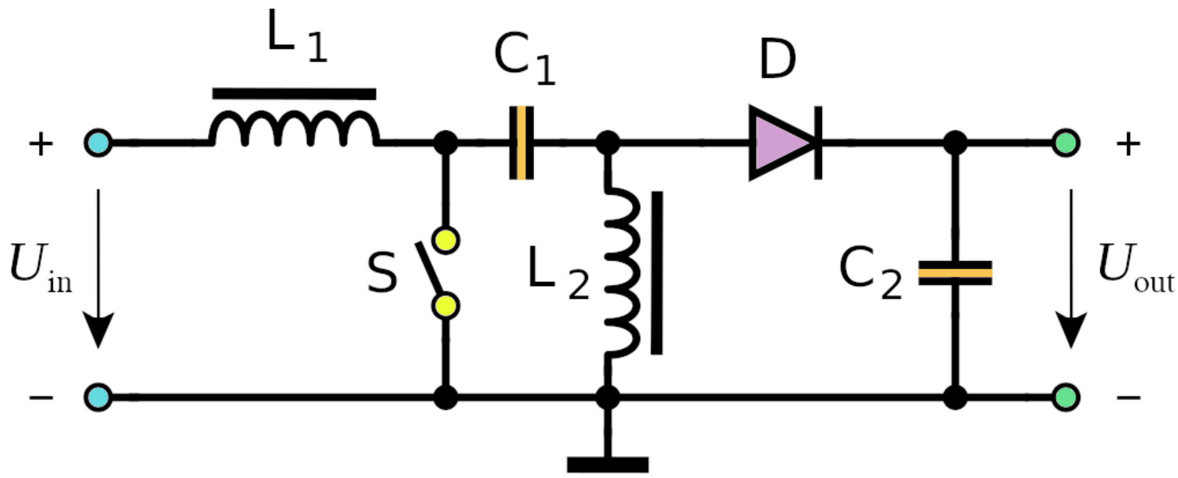
Typically, the driver stage(s) of a circuit requires different characteristics to other circuit stages. For example, in a transistor power amplifier circuit, typically the driver circuit requires current gain, often the ability to discharge the following transistor bases rapidly, and low output impedance to avoid or minimize distortion.

5.3 DSPIC30F2010 MICROCONTROLLER



Mostly consists of 16 x 16-bit working registers. Some registers as like Status Register (SR), DO and REPEAT register, Program Space Visibility Page registers (PSVPAG), Data Table Page register (TBLPAG) and Program Counter (PC) act as address, data or offset registers. These all are memory mapped. Some of them has a shadow register with each of these registers. Actually, the shadow register is used temporarily and these can move its data or contents from its host register on the occurrence of an event. But there is a specific condition occurs that shadow register could not access directly. At working register when a byte operation is performed, at that time just the Least Significant Byte (LSB) of the specific register is affected. N DSPIC DSC devices, SOFTWARE STACK POINTER or FRAME POINTER are used. W15 is software Stack Pointer (SP), which has the ability to modify automatically by processing, calls and returns. However, W15 could be referenced through any order but in the same manner as like all other W registers. It simplifies the reading, writing and many other manipulations of the Stack Pointer. During a Reset, W15 is initialized to 0x0800. You may reprogram the SP (Stack Pointer) during initialization to any position within data space. W14 register has been devoted as a Stack Frame Pointer (SP) as defined by the ULNK and LNK instructions.

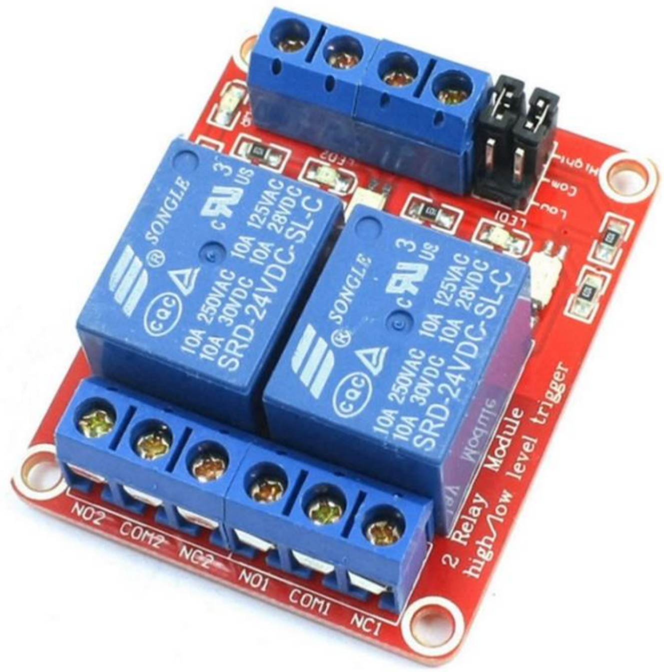
5.4 SEPIC CONVERTER DC TO DC



SEPIC stands for single-ended primary-inductor converter. SEPIC is basically a type of dc-to-dc converter which allows a range of dc voltage at its input side and gives a stable voltage at the output side. This type of converter is quite similar to buck-boost and Cuk converters which provide an output voltage greater than, less than, or equal to its input voltage.

Similar to the buck-boost converter SEPIC converter uses the functions of a buck and boost converter. Compared to the buck-boost converter, a SEPIC converter offers some advantages like the polarities of the input and output voltages being the same, high efficiency, and the capacitor isolating the input and output side.

5.5 RELAY MODULE



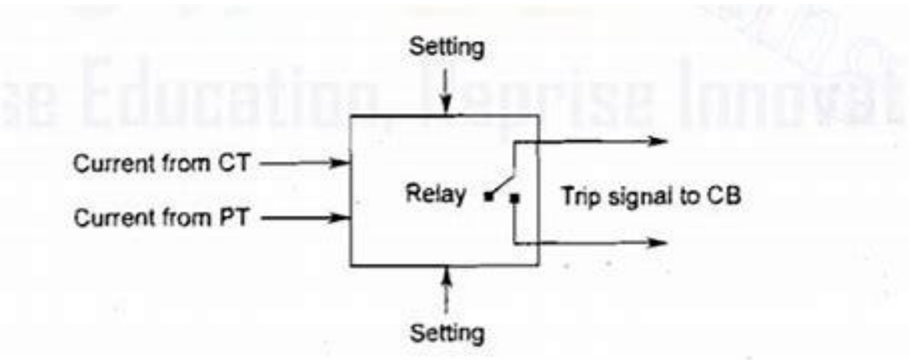
Relays are one of the key electrical components, they are used in the majority of electrical circuits and systems in one way or another. Learning how they operate is a key aspect and should be understood when first learning about electrical components and circuitry. We will now describe how they operate with the use of some images that show the internals of a relay.

A relay consists of two circuits within its body, these can be called the primary circuit and the secondary circuit**.**
As you can see from the image below: we are showing the primary side on the left-hand side and the secondary side on the right-hand side. This can vary from relay to relay but generally, the layout looks something like the image below.

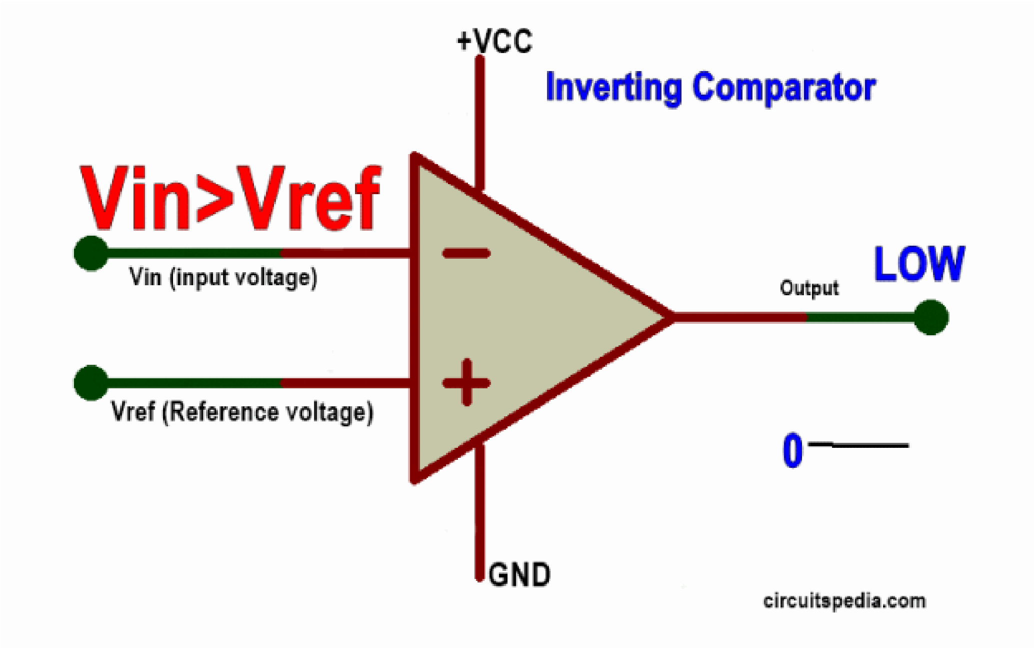
The primary circuit is the side of the relay that receives the signal to control the operation of the relay. Normally a low voltage DC supply (24V) is used to control

the coil on the primary side. Some relays do however require 240V on the primary coil to control them.
The secondary side of a relay controls the switched side of the circuit. This is connected to the load of the component or system that the relay controls. A load could be a machine or electrical component that uses electrical energy to operate such as a motor, fan, generator, or light bulb.

When a relay has a current flowing through its coil (primary side) this produces an electromagnetic field. Once the field is present it will attract the armature (normally made from iron) which will push the other end of the armature (secondary side) together, completing the circuit. When the current has been switched off again it will open the contacts and break the circuit.



5.6 COMPARATOR



A comparator is a circuit that compares two input voltages or currents and gives output High or Low as per input signal. The Output is a digital form according to the input signal compared with the reference. Basically, a comparator is used in electronics to compare the two Analog input signals given on both input terminals and we get the Digital output as High level or Low level.

Comparator is used to sense the signal of a predefined rich level. If I set a level to sense then I can use a comparator to sense it when the input signal of this level cross more or below the level, suddenly the output is changed from Low to high and high to low. The comparators are used for so many electronics instrumentation for automation and drive different logic circuits.

CHAPTER 6

CONCLUSION

After simulate of SEPIC converter with open loop and close loop systems, the output voltage waveform is different. At open loop system with changing the duty cycle value, shown that the duty cycle value is take effect for output voltage of SEPIC converter, the simulation result shown at Table II, when the value is 20% for duty cycle the value is 5.25 V for output voltage and when the value is 55% for duty cycle the value is 22.31 V for output voltage. The simulate result of the output voltage reached the set point value of 14 V, but there is a ripple and unstable output voltage. In the second test is giving a disturbance to the solar panel so at the moment the value of irradiation is drop and makes the output voltage waveform not perfect, because of ripple and the voltage is drop until 5 V, and at two seconds the waveform back to the normal form. In close loop system, the first test is solar panel in STC condition with the irradiation value is 1000W/m2 and the temperature is 25o C. Result of close loop system is the output voltage reach the set point value of 14 V with the response time is 0.6 s, there is no ripple and the output voltage is stable. At the second test is giving a disturbance to the solar panel as same as at open loop system, so that the irradiation value is drop. The result of the simulation is the output voltage is drop until 13.5 V at 1.5 s and increasing until 15.6 V at 1.8 s. The output voltage wave in normal condition when the response time at 2 s, so the output voltage reach to the set point value of 14 V.

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