Implementation of SEPIC Converter for Solar Powered Induction Motor

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Abstract: - Sun oriented vitality is the most promising non-conventional sources of vitality. This paper proposes the working of single stage acceptance engine utilizing sun oriented clusters and control gadgets.The SEPIC converter is taken as dc-dc converter which is planned and DC investigation has been done in CCM. At that point inverter is utilized to change over dc control to ac control. The execution of SEPIC converter and inverter is measured, and diverse parameters of acceptance engine are analyzed.

Keywords : Solar array,SEPIC converter,
Single phase inverter, induction motor.

1. INTRODUCTION

Due to the depletion of conventional energy resources like coal, oil, and the like, we are learning more about and abusing unconventional energy resources like solar and wind energy. Sun-oriented vitality is one of the more promising non-conventional sources. It is abundantly available to us and has many advantages, including being renewably sourced and free of contaminants. Sun-oriented energy frameworks are therefore highly sought after for power generation. We obtain solar energy from the sun, which is subsequently converted into power by solar panels and control devices. Sun-powered cells transform solar energy into dc voltages, which are then managed by dc-dc converters. . At that moment, an inverter is used to convert the domestic DC control to AC control. DC-DC converters using MPPT are used to eliminate problems caused by yield control variations from sun-oriented clusters, which can cause voltage variations from apparent values or repetition.

Initially, Wu and Chang used MPPT to model and actualize sun-based clusters [1]. Yakov and Adar carried out the SEPIC converters[2]. Additionally, Katsuya H. Manabu used the single stage inverter in sun-based control applications[3].

1.1 SOLAR PHOTOVOLTAICS

The most common way to describe it is as the rise in electric voltage that occurs between two terminals attached to a strong or flexible framework when light shines on it. Solar-powered devices that use photovoltaic energy to convert light from the sun are known as energy-transformation devices. A single converter cell is known as a "sun powered cell," or more commonly, a "photovoltaic cell." ." When several of these cells are combined with the intention of increasing the electric control yield, the resultant term "photovoltaic arrays" refers to the combination of these cells. Sun-oriented cells can be arranged into large collections known as clusters. Sun-based cell boards, or simply boards, are the terms used to refer to sun-oriented cells in considerably smaller settings. Essentially, every photovoltaic device connects to a P-N intersection in a semiconductor, which generates the photovoltaic voltage. Silicon is most frequently used in semiconductor fabric, which makes up the majority of solar-powered boards.

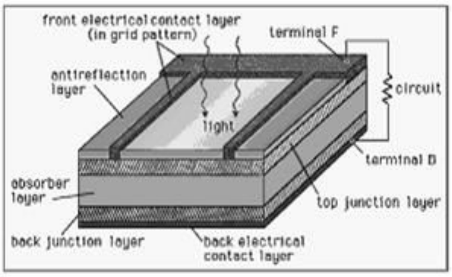
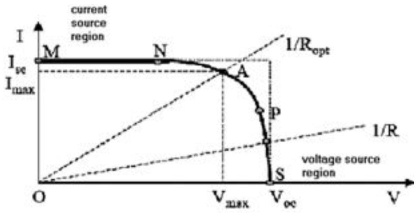


Fig:1. Basic of solar cell

The vast majority of solar cells are made of silicon, which is becoming more and more efficient as silicon shapes range from indeterminate to polycrystalline to crystalline (single precious stone). Sun-oriented cells don't use chemical reactions or need fuel to produce electric control, unlike batteries or fuel cells. They also don't have any moving parts, unlike electric generators.

1.1.1.SOLAR CELL MODELLING



Temperature also affects semiconductor materials' band-gap vitality. The band crevice liveliness of the cloth will increase with a rise in temperature. Higher band crevice vitality means that in order for the electrons in the valence band to transfer to the conduction band, more photon vitality is needed. This suggests that a greater number of photons won't have enough energy to be captured by the valence band electrons, resulting in a lower number of electrons reaching the conduction band and a less effective solar cell.

Table 1.1.1. The solar MSX-60 PV panel's primary specifications

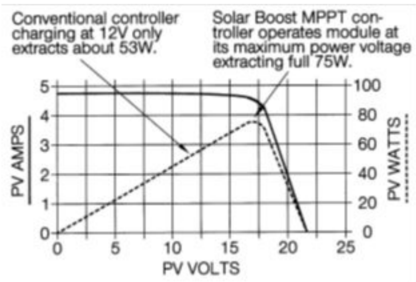
At Temperature T = 25°C, Insulation G=1000W/m^2		
Open circuit voltage	V_{oc}	21.0 V
Short circuit current	I_{sc}	3.74A
Voltage at max.power	V_m	17.1V
Current at max power	I_m	3.5A
Maximum power	P_m	60.0W

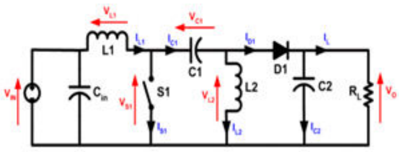
1.2.MAXIMUM POWER POINT TRACKING

Maximum Excessive Control Point The electronic architecture that operates the photovoltaic (PV) modules in a way that enables the modules to deliver all of the following is commonly referred to as MPPT.
The modules are not "physically

moved" by MPPT, which is a mechanical following framework, so that they point more directly toward the sun.

- Fragmentary Open-Circuit Voltage
- Fractional Short-Circuit Current
- Perturb and Observe
- Incremental Conductance





1.3.Single-ended primary-inductor converter

A type of DC-DC converter known as a single-ended primary-inductor converter (SEPIC) allows the electrical potential (voltage) at its yield to be greater than, less than, or equal to that at its input. The control transistor's obligation cycle regulates the SEPIC's yield.

<u>Continuous mode</u>

If the current flowing through the inductor L1 never drops to zero, a SEPIC is said to be in continuous-conduction mode, also known as "ceaseless mode". The typical voltage across capacitor C1 (VC1) is break even with respect to the input voltage (Vin) during a SEPIC's steady-state operation. Due to the fact that capacitor C1 pieces coordinate current (DC), inductor L2 is effectively the source of stack current because the usual current flowing over it (IC1) is zero. As a result, regardless of the input voltage, the normal current flowing through inductor L2 (IL2) is equal to the normal stack current.

<u>Discontinuous mode</u>

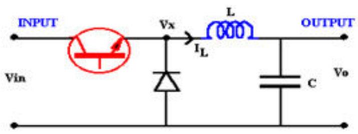
If a SEPIC allows the current through the inductor L1 to go to zero, it is said to be in discontinuous-conduction mode, also known as irregular mode.

2.CONVERTERS

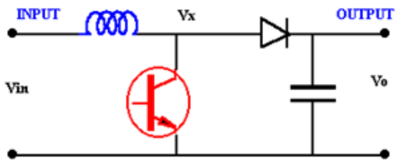
2.1 A device that recognizes a DC input voltage and generates a DC yield voltage is called a DC-to-DC converter. The yield that is delivered is consistently higher in voltage than the input. DC-to-DC converters are used in expansion to provide noise segregation, regulate transport direction, and other functions.

2.2 BUCK CONVERTER STEP-DOWN CONVERTER

When the transistor in this circuit turns ON, voltage Vin is applied to one of the inductor's ends. The inductor current tends to increase with this voltage. The current will continue to flow via the diode and the inductor when the transistor is turned off.

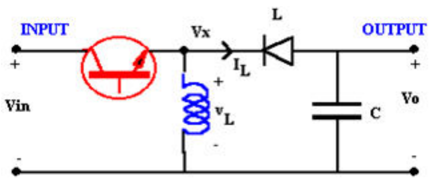


2.3 BOOST CONVERTER STEP-UP CONVERTER



The schematic appears the essential boost converter. This circuit is utilized when a higher yield voltage than input is required.

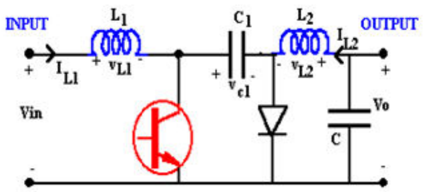
In the ON state of the transistor, Vx = Vin, and in the OFF state, Vx = Vo is produced by the inductor current flowing through the diode. It is agreed upon for this test that the inductor current will run continuously (nonstop conduction).



2.4 BUCK-BOOST CONVERTER

For the Buck-Boost converter, with continuous conduction When the transistor is ON, Vx = Vin, and when it is OFF, Vx = Vo. Over time, the normal voltage across the inductor is zero when there is no net current alteration.

2.5 CUK CONVERTER

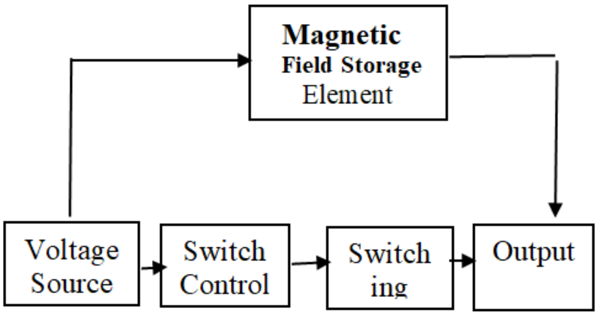


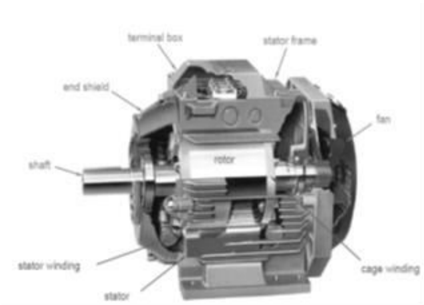
The inductor was used by the buck, boost, and buck-boost converters to transfer energy between input and yield; the voltage adjustment across the inductor provides the basis for analysis.

The CUK converter uses capacitive energy exchange, and its analysis is dependent on the capacitor's current adjustment. The CUK converter circuit in Figure Below is deduced using the DUALITY guideline for the buck-boost converter.

2.6.1 BLOCK DIAGRAM

The basic building blocks of a boost converter circuit are shown in Fig.





The voltage source provides the attractive field capacity component and the switch control with the input DC voltage. While the yield rectifier and channel supply the yield with a suitable DC voltage, the switch control manages the activity of the exchanging component.

3.INDUCTION MOTOR

3.1.INTRODUCTION OF INDUCTION MOTOR:

An acceptance engine (IM) is a type of nonconcurrent AC engine in which electromagnetic acceptance is used to provide control to the pivoting device. Because the rotor bars with short circuit rings resemble a squirrel cage (hamster wheel), another term for the engine is squirrel cage engine.

• Simple and tough development

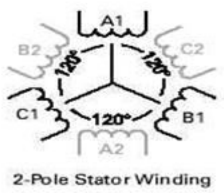
• Low taken a toll and least upkeep

• High unwavering quality and adequately tall productivity

• Needs no additional beginning engine and require not be synchronized.

3.2.INDUCTION MOTOR GENERAL PRINCIPLE

Electrical control is typically converted into mechanical control in the rotating components of an electrical engine. In a DC engine, electrical control is directly applied to the armature, which turns the engine through brushes .As a result, DC engines are referred to as conduction engines. In an acceptance engine, electrical control is applied through acceptance rather than conduction, in the same manner that an auxiliary of a two-winding transformer receives control from the essential.



3.3.TYPES OF ROTOR:

Rotor with squirrel-cage

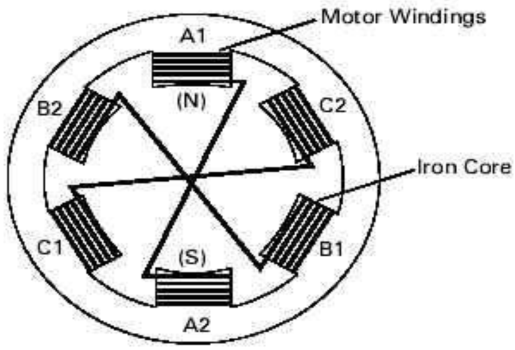
A squirrel-cage rotor is the most widely used type. It is composed of bars that run the length of the rotor and are connected by rings at both ends. The bars are typically made of robust copper. In order to reduce noise and clamor, the rotor bars of squirrel-cage acceptance engines are somewhat skewed rather than straight.

Rotor with squirrel-cage

A squirrel-cage rotor is the most widely used type. It is composed of bars that run the length of the rotor and are connected by rings at both ends. The bars are typically made of robust copper. In order to reduce noise.

Changing Magnetic Field

The shaft turn of an AC engine is made clear by electromagnetic standards. Recall that an AC engine's stator is essentially an empty barrel into which protective wire coils are put. Stator Coil Configuration.



3.3.Figure indicating coli arrangements in stator.

The relationship between the coils is shown in the following schematic. Six coils are used in this instance, two for each of the three stages. Coils function in sets. The stator's delicate press center cloth is encircled by the coils. Engine windings are a reference to these coils. Every engine winding becomes an own electromagnetic field. Because of the way the coils are coiled, one coil acts as a north post and its corresponding coil acts as a south post when current flows through them.

Power Supply:

An AC control supply with three phases is connected to the stator. Stage A of the control supply is linked to stage A in the taking after outline. Additionally, phases B and C would correspond to the corresponding stages of the control supply separately.

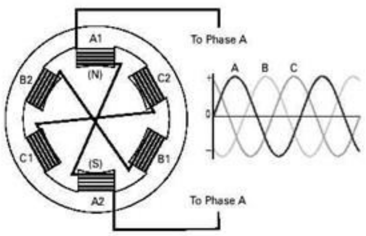


Fig.phase currents in stator windings

The A, B, and C stage windings are arranged 120 degrees apart. A moment set of three-phase windings is introduced in this instance. The number of times a stage winding appears determines the number of shafts. Each stage winding appears twice in this picture. This stator has two poles. A four-pole stator would be present if every stage winding appeared four times Current flows through the windings of the stator when AC power is applied. The direction of the current stream through a stage winding determines the attractive field that is formed there. It anticipates that a north pole will be produced by a positive current stream in the A1, B1, and C1 windings.
it will be easier to imagine an attractive field. For example, a start time has been selected in the following outline where stage A has no current stream, stage B has a current stream in a negative heading, and stage C has a current stream in a positive direction. B1 and C2 are south posts, whereas B2 and C1 are north posts, according to the above chart. Eye-catching flux lines depart from the B2 North Post and arrive at the closest South Post, C2.

Table:2 indicating the formation of poles in phase windings

Winding	Current Flow Direction	
	Positive	Negative
A1	North	South
A2	South	North
B1	North	South
B2	South	North
C1	North	South
C2	South	North

3.4.Synchronous Speed:

Synchronous speed (NS) is the speed of the pivoting attractive field. When the number of postings (P) is divided by the recurrence (F), synchronous speed is break even up to 120 times that value.

$$Ns = 120 F / P$$

Synchronous speed is 3600 RPM if the associated control supply's recurrence is 60 Hz for the two-pole stator used in the previous example.

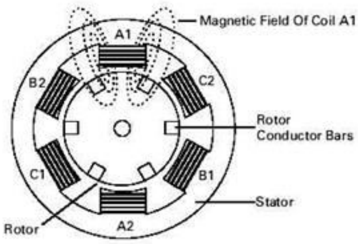
$$N s =(120 x60)/ 2$$

$$N = 3600 RPM$$

Table:3. for synchronous speed

no of poles	synchronous speed
2	3600
4	1800
6	1200
8	900

3.5.Electromagnet with Induced Voltage:



The rotor of a squirrel cage functions similarly to that of a magnet. Current flows through the winding when the control is connected to the stator, creating an increasing electromagnetic field that crosses the rotor bars.

An attractive field causes a conductor, like a rotor bar, to initiate a voltage (emf) in the conductor. In the conductor, a current stream is produced by the activated voltage. Current flows around the last ring and through the rotor bars. An attractive field causes a conductor, like a rotor bar, to initiate a voltage (emf) in the conductor. In the conductor, a current stream is produced by the activated voltage

3.6.Slip:

There must be a relative distinction in speed between the rotor and the pivoting attractive field. If the rotor and the turning attractive field were turning at the same speed no relative movement would exist between the two, subsequently no lines of flux would be cut, and no voltage would be actuated in the rotor.
A diminish in stack will cause the rotor to speed up or diminish slip. Slip is communicated as a rate and can be decided with the taking after formula.
% Slip = (Ns - Nr) x 100/Ns

4. PROPOSED SCHEME

4.1.SOLAR ARRAY, P & O ALGORITHM

When exposed to light, a sun-powered cell, a p-n intersection semiconductor device, generates direct current. Sun-powered clusters are composed of solar cells arranged in a parallel fashion. In MATLAB, scientific modeling is realized through the use of a single diode circuit design. Under typical conditions, a photovoltaic cluster is realized at 1kW/m2, 1.5 AM, and 25˚C. A yield of 73V for the open circuit voltage and 4.75A for the brief circuit current is assumed.

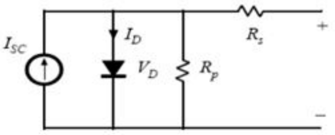


Fig.4.1: Equivalent circuit model of solar cell. S

Mathematical modeling of the solar cell is implemented on MATLAB using the equations below

$$I_{SC} - I_D - \frac{V_D}{R_P} - I_{PV} = 0 \quad (1)$$

$$I_D = I_O\left(e^{V_D/V_T} - 1\right) \quad (2)$$

$$V_{PVCell} = V_D - R_S \times I_{PV} \quad (3)$$

Condition (2) is a diode characteristics condition, while conditions (1) and (3) are obtained by applying KCL and KVL separately.

Then current is incremented by the factor of ΔIref till we achieve maximum power. Flowchart of P&O algorithm is shown in Fig. 2.

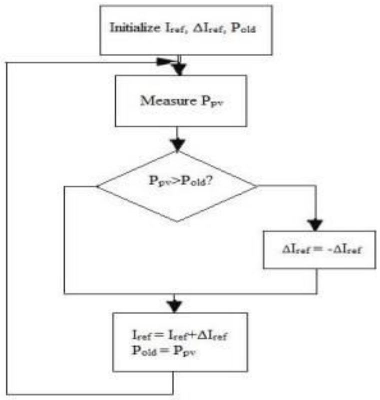


Fig.4.1.2: P&O algorithm flowchart

4.2. SEPIC Converter Design

The following computation is completed in order to design the passive components of the SEPIC converter. Where fs is the switching frequency, ΔiL is the inductor ripple current, iout is the output current, and Δvout is the output ripple voltage. D is the duty cycle.

5.SIMULATION RESULTS.

Solar array produce 73 V as output voltage, which is then fed to SEPIC converter. It worked in boost mode and increased the input voltage to 110 V. MPPT algorithm is used to track maximum power point. The value of the passive components are obtained through equations from (8-12). Table I shows the values of components of SEPIC converter. Vin is 73 V, Vout is 110 V, switching frequency fs is taken as 50 kHz.

Table I: Values of passive components of SEPIC converter

The output of SEPIC Converter is shown in Fig. 5. Its efficiency is about 90%.

Inductor [L_1(H)]	Inductor [L_2(H)]	Capacitor [C_1(F)]	Capacitor [C_1(F)]
2.19 x10^{-4}	2.19 x10^{-4}	1.14x10^{-4}	1.456X10^{-3}

120
100
80
60
40
20
0 0 0.5
1 1.5 2 2.5
Time(s)

Fig. 5: Output voltage of SEPIC Converter.

Inverter is then used to convert 110 V dc to 110 V ac, which leads to some harmonic distortion. Fig. 6. shows the current THD. The current THD of inverter is 2.05%.

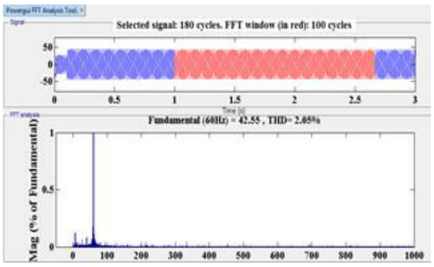
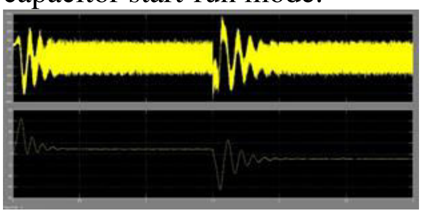


Fig. 6: Current THD of inverter

Then induction motor is fed at 110 V ac at 60 Hz. This motor starts at no load and at 2 seconds, step of 1 Nm torque is applied. Graph with rotor speed and electromagnetic torque of induction motor in capacitor start and capacitor start-run mode.



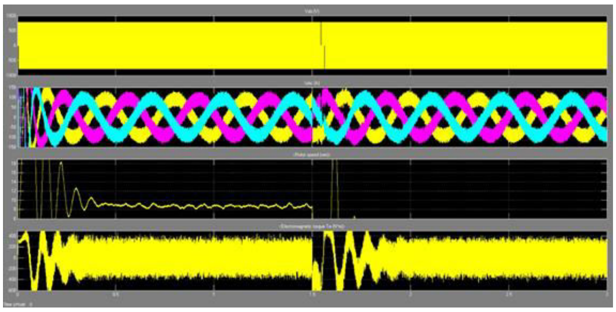


Fig. 7: Rotor speed and Electromagnetic Torque of induction motor.

Conclusion:

With the use of a SEPIC converter, the voltage obtained from the solar cluster is increased from 73 V dc to 110 V dc. The criteria for the SEPIC converter DC inquiry have been deduced, and the detachable components are additionally scheduled with a productivity of roughly 90%. With a single stage inverter that adds up to 2.05% in current, 110 V dc is converted to 110 V ac. The rotor speed of the acceptance engine is roughly 1600 rpm, and the electromagnetic torque in the capacitor is more intense at first. Because the torque swell at the constant state is approximately 3% of the stack torque, the capacitor start run engine looks to be the preferable operation mode.

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