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Maximum Power Point Tracking of Renewable Energy

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Abstract- This paper discusses an overview of the maximum power point tracking method for Photovoltaic (PV) System. The output of a PV system fluctuates nonlinearly with temperature and radiation, and the maximum power point arises as a result. The PV system's MPPT can increase output by roughly 25%, and it's critical to keep it on this setting at all times. Several ways for tracking the PV system's MPP have been investigated and proposed. In this study, we explore common MPPT approaches for PV systems, artificial intelligence control methods, and blended approaches, as well as the characteristics, benefits, and drawbacks of each technique.

Indexed Terms- MPPT, PV system, radiation, MPP.

I. INTRODUCTION

MPPT (Maximum Power Point Tracking) is an electrical system that permits photovoltaic modules to produce all of the power they are capable of. MPPT is not a mechanical tracking system in which the modules are physically moved to aim more directly at the sun. MPPT is a totally electronic system that changes the electrical operating point of the modules to allow them to deliver the greatest amount of power available. Increased battery charge current is available as a result of the extra power gathered from the modules. Although MPPT can be used in conjunction with a mechanical tracking system, the two are not the same.

A typical MPPT system is depicted as a block diagram represented in Fig 1. The energy source is a solar panel. The solar PV module's maximum power is transferred to the load via a DC-DC converter. The maximum power is tracked by the MPPT Controller.

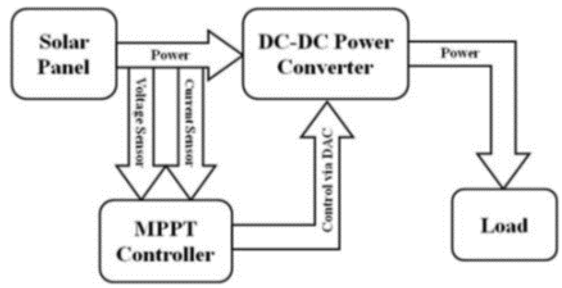

Fig 1: Block diagram of MPPT

II. NEED FOR MPPT

Maintaining the PV operating at its maximum achievable efficiency at all times is great for lowering energy costs. However, nonlinear current-voltage (I-V) and power-voltage (P-V) characteristics are unknown due to changes in intrinsic and extrinsic factors, making this goal difficult to achieve. The maximum power point is a distinct point on the P-V curves where the PV system generates the most power. Although several factors influence energy conversion efficiency, maximum power point tracking is the most important part of PV generation control design. In many ways, the MPPT is a nonlinear control issue. This is due to PV's nonlinear nature and the fact that its parameters are always changing due to the unpredictability of external conditions. As a result, tracking control of the maximum power point is a difficult task to solve. Many tracking control systems have been developed to address these issues, including P&O, pi controller, neural networks, and fuzzy logic controllers (FLC). These tactics have a number of drawbacks, including high costs, intricacy, complexity, and unpredictability. Simple and low-cost implementation, rapid tracking under changing conditions, and minimal output power fluctuation are key requirements for MPPT.

III. CHARACTERISTICS OF PV SYSTEM

3.1 Current vs voltage characteristics of PV array

The characteristics of PV array at various atmospheric conditions is shown in Fig 2.

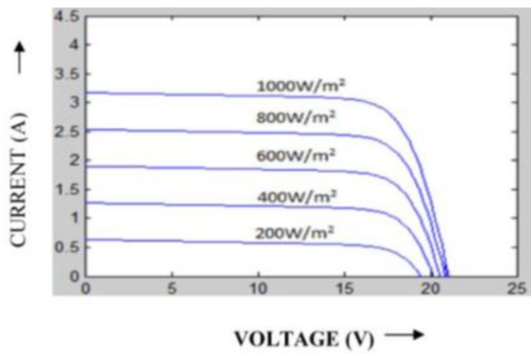

Fig. 2: Current vs Voltage characteristics of PV array

3.2 Power vs voltage characteristics of PV array

Power vs voltage characteristics of photovoltaic array at varying atmospheric conditions is shown in Fig 3.

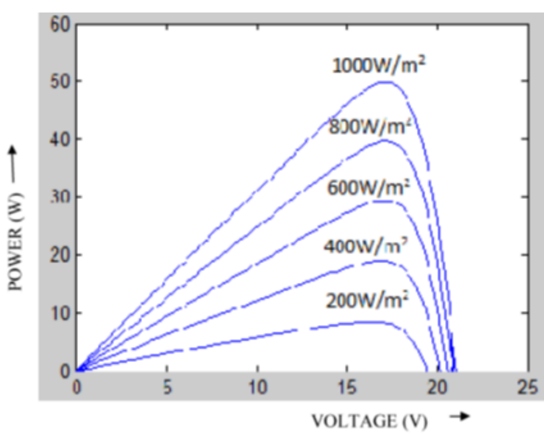

Fig 3: Power vs Voltage characteristics of PV array

IV. CONVERTER TECHNOLOGY FOR PV SYSTEM

4.1 Hard Switching Converters

The converters which obey conventional switching phenomenon are known as Hard Switching converters. There are several topologies of these conventional hard switching converters of which we discuss mainly 5 types of converters:

Buck Converter
Boost Converter
Buck – Boost Converter
Cuk Converter
SEPIC Converter

4.1.1 Buck Converter

Buck Converter is also known as Step-down Converter. The voltage across the load is Vs, when the MOSFET switch is ON. The current flowing through the load is same as shown in the Fig 4.

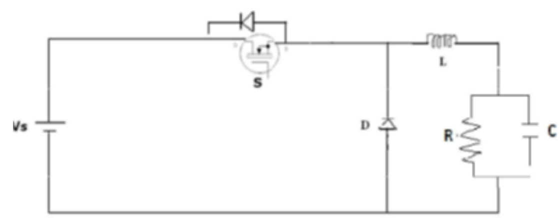

Fig 4: Schematic diagram of buck converter

The current through the load is in the same direction as before when the MOSFET switch is switched off, but the voltage across the load is zero. Power is transferred from the source to the load. As a result, the average voltage across the load is lower than the source voltage, which is dictated by the duty cycle of the MOSFET switch pulse. The inductor smoothes the load current and converts it to a DC current, while the capacitor reduces output voltage ripples and provides a constant voltage.

4.1.2 Boost Converter

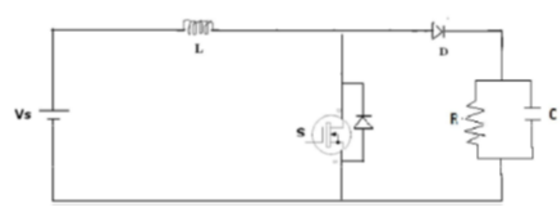

Fig 5: Schematic diagram of boost converter

A boost converter is a DC-DC converter that has a higher output voltage than the input voltage. The current through the inductor grows when the MOSFET switch is turned on, and the inductor begins to store energy. The energy stored in the inductor begins to dissipate when the MOSFET switch is closed. The current passes from the voltage source and inductor to the load via the flyback Diode D. The voltage across the load is greater than the input voltage and is determined by the inductor current rate of change. As a result, the average voltage across the load is higher than the input voltage, which is calculated using the duty cycle of the gate pulse to the MOSFET switch.

4.1.3 Buck Boost Converter

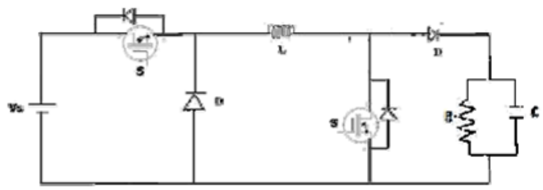

Fig 6: Schematic converter of buck-boost converter.

When it comes to A Buck-Boost Converter is a DC-to-DC converter with an output voltage that is either higher or lower than the input voltage. The input voltage crosses the inductor when the MOSFET switches are turned on. As a result, energy is stored in the inductor. The output voltage of a buck-boost converter is either larger than or less than the input voltage. The input voltage crosses the inductor when the MOSFET switches are turned on. As a result, energy is stored in the inductor. The energy stored in the inductor is given to the load and capacitor when the MOSFET switches are turned off. As a result, the output voltage can be adjusted dependent on the duty cycle of the MOSFET switches' gate pulse. Depending on the duty cycle of the pulse, the buck – boost converter acts as both a buck and a boost converter.

4.1.4 Cuk Converter

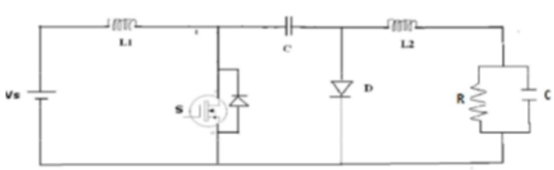

Fig 7: Schematic diagram of cuk converter

Cuk converter output voltage is either larger than or less than the input voltage, just like the Buck – Boost Converter. In contrast to other converters, the major energy storage element is a capacitor. The electrical energy is transferred by connecting the capacitor to the input and output alternately. When the MOSFET switch is turned off, the input voltage charges the capacitor through the inductor, L1. The energy held in the capacitor is discharged to the load through the output inductor, L2, when the MOSFET switch is turned on.

4.1.5 SEPIC Converter

The output voltage of a Single Ended Primary Inductor Converter (SEPIC) is greater than, equal to, or less than the input voltage. It's similar to a Buck – Boost converter, but with the added benefit of producing non-inverting output

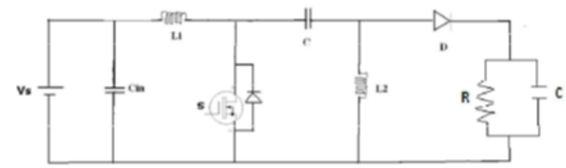

Fig 8: Schematic diagram of SEPIC converter

To convert from one voltage to another, the SEPIC converter exchanges energy between inductor and capacitors. When the MOSFET switch S is turned on, the capacitor C1 charges the inductor L2. When the MOSFET switch S is turned off, the inductor L1 charges the capacitor. During the off-time interval, power is transferred from the inductors L1 and L2 to the load.

The Table 1 shows the overall comparison of the hard switching converters discussed above.

Table 1: Hardware switching Dc-Dc converter topologies

DC-DC converter	No. of switches	Range of Average Output Voltage	Average Output Voltage	Relation between duty cycle and output Voltage
Buck converter	1	0-V_i	DV_{in}	Linear
Boost converter	1	V_i-inf	-	Non-linear
Buck Boost converter	2	0-V_i and V_i-inf	-	Non-linear
Cuk converter	1	0-V_i and V_i-inf	-	Non-linear

SEPIC converter	1	0-V_i and V_i-inf	-	Non-linear

V. SOURCES OF RENEWABLE ENERGY

5.1 Wind Power
Wind turbines can be used to capture the energy that exists in airflows. The rated power of today's turbines ranges from 600 kW to 5 MW. Because the power output is proportional to the cube of the wind speed, it rises rapidly as the available wind velocity rises. Recent technological advances have resulted in the development of aerofoil wind turbines, which are more efficient due to their improved aerodynamic structure.

Fig 9: Wind Power

5.2 Solar Power
The British astronomer John Herschel, who notably utilised a solar thermal collector box to prepare food during a voyage to Africa, is credited with the invention of solar energy harvesting. There are two main ways to use solar energy. To begin with, the captured heat can be used as solar thermal energy for room heating. Converting incident solar radiation to electrical energy, which is the most useable kind of energy, is another option. Solar photovoltaic cells or concentrated solar power plants can be used to do this.

Fig 10: Solar Power

5.3 Small hydropower
Small hydropower plants with a capacity of less than 10 megawatts are classified as renewable energy sources. This entail using water turbines to convert the potential energy of water held in dams into useful electrical energy. The goal of run-of-the-river hydropower is to exploit the kinetic energy of water without the need for reservoirs or dams.

Fig 11: Hydropower

5.4 Biomass
Photosynthesis is the process by which plants harness the sun's energy. These plants release the trapped energy when they burn. In this way, biomass acts as a natural battery, storing solar energy and releasing it as needed.

Fig 12: Biomass

5.5 Geothermal
The thermal energy that is generated and stored within the layers of the Earth is known as geothermal energy. The gradient so formed results in continual heat conduction from the earth's core to the surface. This gradient can be used to heat water to produce superheated steam, which can then be used to power

steam turbines. The fundamental disadvantage of geothermal energy is that it is mainly restricted to areas near tectonic plate boundaries, though recent developments have contributed to its spread.

Fig 13: Geothermal

CONCLUSION

The characteristics of PV are calculated at various atmospheric conditions. From the results, the MPPT is able to produce maximum power directly from Sun at different conditions i.e, it is used to improve the efficiency of the solar panel. Types of converters used for PV system is discussed.

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