Power Flow Control for Dc Microgrid Using MPPT Technique

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Abstract:

The direct current (DC) microgrid exhibits a low level of inertia and is primarily characterized by the prevalence of power converters. Consequently, the rate at which the direct current (DC) voltage changes is significantly rapid when subjected to variations in power. This study proposes the implementation of an incremental conductance maximum power point monitoring algorithm control to enhance the inertia of the DC microgrid and reduce the rate of change of the DC voltage. The proliferation of DC loads is currently occurring at a rapid pace, prompting the consideration of DC microgrids as a viable option for meeting the growing energy demand while incorporating renewable energy sources. To effectively incorporate diverse energy sources such as solar, wind, fuel cell, and diesel generators into the direct current (DC) grid, it becomes imperative to implement efficient power flow management strategies. This work presents a management technique for the efficient control and optimization of power flows in DC micro grids that utilize solar and wind power sources. To regulate the DC link voltage, it is necessary to employ a dedicated converter, as the voltage profile management is essential for the operation of a standalone device. The optimization of power generation from solar and wind sources is crucial for supplying the loads connected to the DC bus. However, the regulation of the DC link voltage is primarily managed by the battery circuit. A novel algorithm, known as the Incremental Conductance Maximum PowerPoint Monitoring Algorithm, has been devised for the purpose of regulating three power sources within a DC Microgrid. The efficacy of the Incremental Conductance Maximum Power Point Monitoring Algorithm in MATLABSIMULINK is evaluated under diverse load circumstances and fluctuations in solar and wind power.

Index: ***DC micro grid; power flow, photovoltaics, systems for wind conversion***

1. INTRODUCTION:

The depletion of fossil fuels has prompted individuals to transition towards renewable energy sources in response to the increasing energy requirements. Recent advancements in Semiconductor technology have facilitated the utilization of solar and wind energy as viable sources of electricity. Since most electronic loads necessitate a direct current (DC) power supply, it is customary to convert alternating current (AC) electricity into DC within the system to effectively supply the loads. Moreover, a wide range of electronic loads are readily accessible. It is feasible to directly deliver direct currents (DCs) to buildings and residential areas. The utilization of a microgrid is deemed appropriate for the structural configuration of a direct current distribution system. A microgrid refers to a self-contained cluster of distributed generation units, primarily sourced from renewable energy sources such as solar, wind, and hydro power. It also incorporates energy storage systems and local storage systems, operating at a low voltage level. DC microgrids are often seen as a favorable choice in distribution networks that include renewable energy sources. Today, there have been significant advancements in technology, encompassing the latest technical discoveries and emerging directions. The regulation of electricity has been found to have a significant impact on the global investment in Distributed Generation (DG) infrastructure. In order to optimize the use of the existing renewable energy sources, it is important to consistently operate in the Maximum Power Point Tracking (MPPT) mode. In the context of standalone systems, the preservation of the voltage profile is achieved through the compromise of the maximum power point tracking (MPPT) mode. This work presents a battery charger discharger circuit that is employed to adjust the DC link voltage, hence optimizing the utilization of renewable energy sources. The Management of Power Flow algorithm will ascertain the operational mode for ensuring consistent and uninterrupted power supply to the load, considering factors such as the availability of solar and wind power, load demand, and battery voltage. In order to effectively monitor three sources within the DC Micro grid, a novel Incremental Conductance Maximum Power Point Tracking Algorithm has been devised.

2. RELATED WORK:

The DC Micro grid consists of a solar PV array, a wind energy conversion system, a battery bank, and a DC bus interface power converter. The DC Micro grid block diagram considered for the analysis is shown in Fig.1.

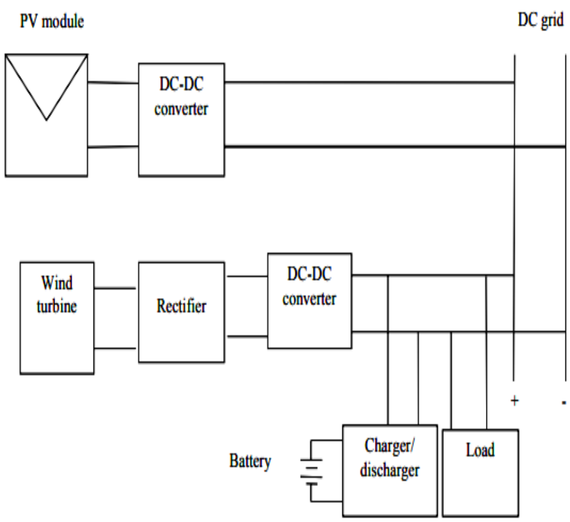


Fig. 1 Block diagram of the DC micro grid with Solar and wind energy sources

The wind turbine power is generated by the induction generator. The power generated from the induction generator is rectified to DC and through a power converter, fed into the DC bus. The MOSFET is used for the purpose of switching. The output is connected to the DC micro grid from the DC-DC boost converter where the loads are connected. The battery work is carried out by a DC-DC boost converter that also regulates the voltage of the DC connection.

2.1 Distributed generator:

2.1.1 Model of Wind and Solar System

As distributed generators, a solar system and a wind system are introduced. The solar system is created by a boost converter connected to photovoltaic arrays. The radiance profile, G, is taken as the input to emulate the PV system, and the output power is calculated to be processed by the converter control in which the wind speed, Vw, is the input of the wind system. The created AC power is converted to DC by a rectifier, so the same control process applied to the PV system is applied to the wind structure. The output power is processed via the control of the converter.

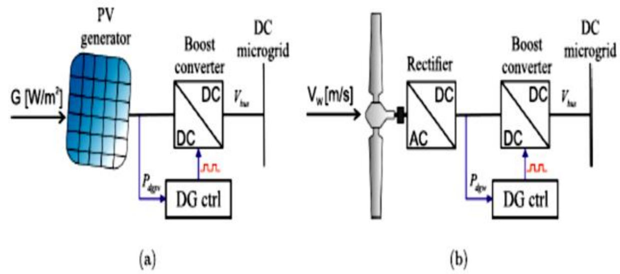


Fig 2. Distributed generation system (a) PV solar system. (b) Wind system

3. MPPT (Maximum power point Tracking) :

The Maximum Power Point Tracker (or MPPT) is a high-efficiency DC to DC converter that provides a solar panel or array with an ideal electrical load and generates a load-appropriate voltage. For a full array, conventional solar inverters perform MPPT. The same current, determined by the inverter, flows through all panels in the chain in such systems. But since different panels have distinct IV curves, i.e., different MPPs (due to production tolerance, partial shading, etc.), this architecture ensures that certain panels can perform below their MPP, resulting in energy loss. In the DC side, continuous power is avoided assistance in power flow algorithm management the battery regulates the DC link voltage. Hence maximum power is extracted from solar and wind energy systems.

3.1 INCREMENTAL CONDUCTANCE METHOD:

This approach consists of using the slope of the current derivative relative to the voltage to achieve the maximum power point. In the real world, what value MPPT offers depends on the collection, its environment, and its seasonal load pattern. Only when the Vpp is more than about 1V higher than the battery voltage does it give us an important current boost. This might not be the case in hot weather unless the batteries have a low charge. The Vpp will increase to 18V in cold weather, however. If the use of energy is highest in the winter (typical in most homes) and the winter weather is cold, when it is most needed, the energy will increase considerably.

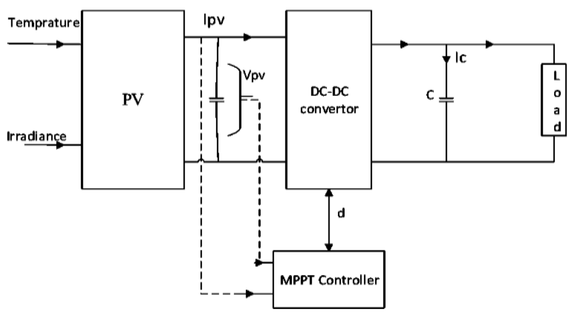


Fig.3: PV System with Power Converter and MPPT Control

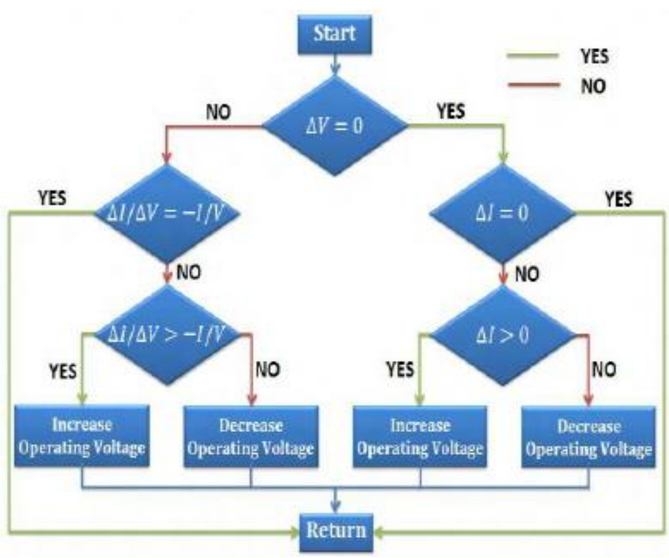


Fig 4: Organigram of incremental Inductance algorithm

Where, $P = V \times I$

$$\begin{cases} \dfrac{\Delta I}{\Delta V} = -\dfrac{I}{V} & \text{at the MPP} \\ \dfrac{\Delta I}{\Delta V} > -\dfrac{I}{V} & \text{left of the MPP} \\ \dfrac{\Delta I}{\Delta V} < -\dfrac{I}{V} & \text{right of the MPP} \end{cases}$$

MPP can be monitored by comparing instant conductance with incremental conductance.

4. RESULTS AND DISCUSSION:

The DC Micro grid consists of a wind generator with 700 W PV array and 500 W. A boost converter links the PV array to the 48V DC bus. A rectifier attaches the induction generator to the DC bus. The MPPT algorithm is used by Incremental Inductance. A 24V battery connects to the DC connection through a charger/discharger circuit. The charger circuit regulates the DC link voltage.

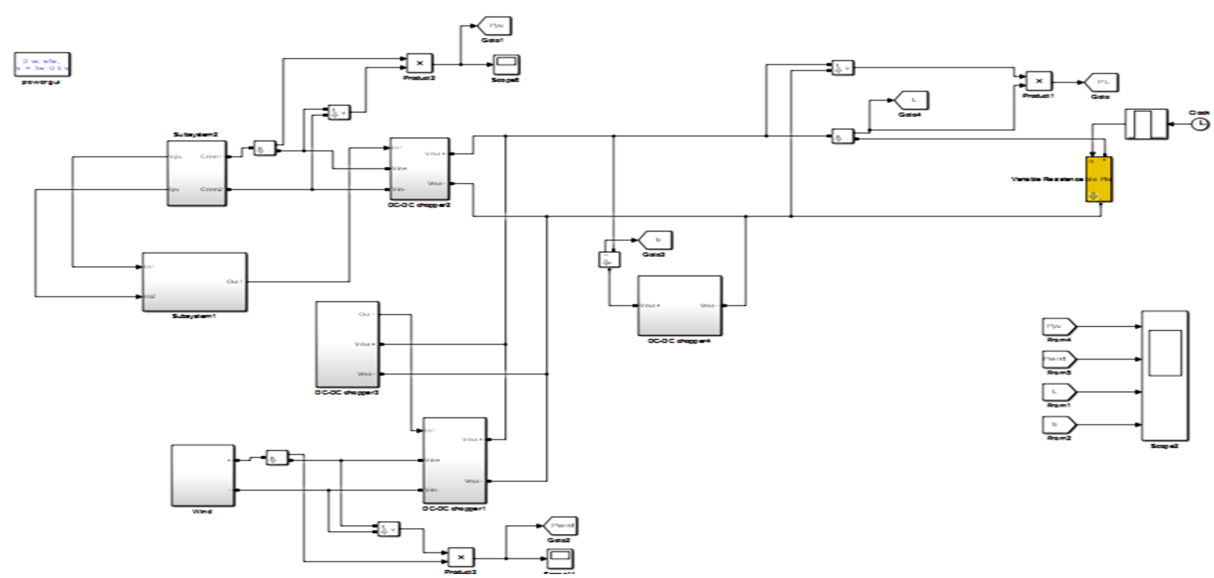
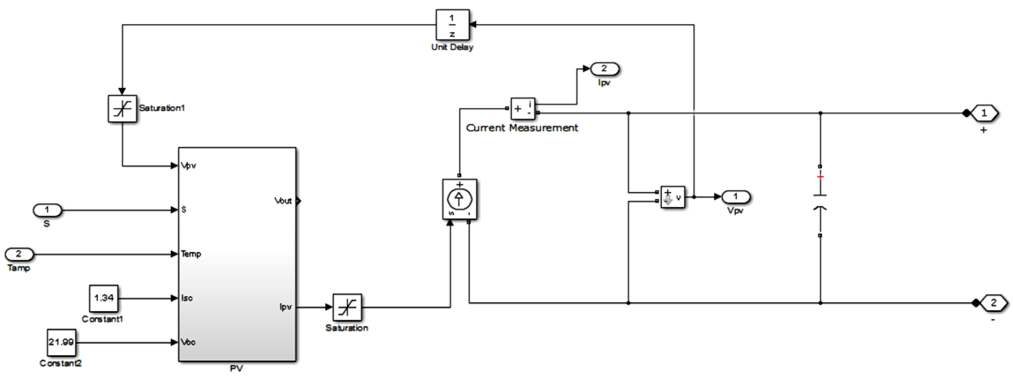
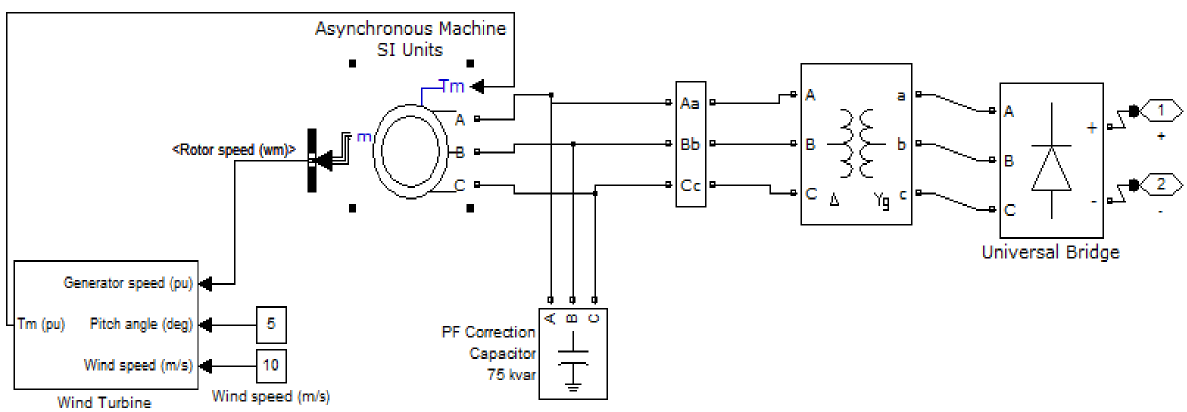


Fig 5 Simulink model of the developed DC Micro grid

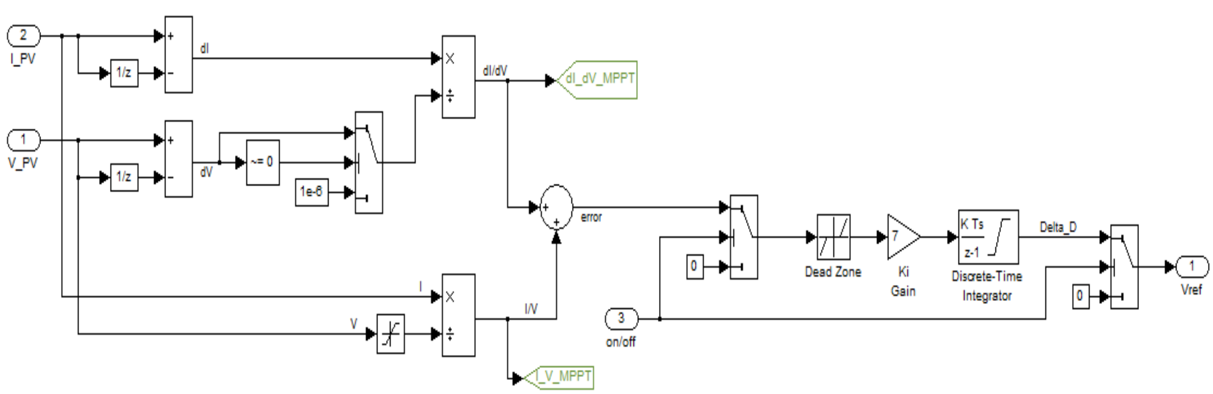
SOLAR POWER GENERATION:



WIND POWER GENERATION:



MPPT-INCREMENTAL CONDUCTANCE:



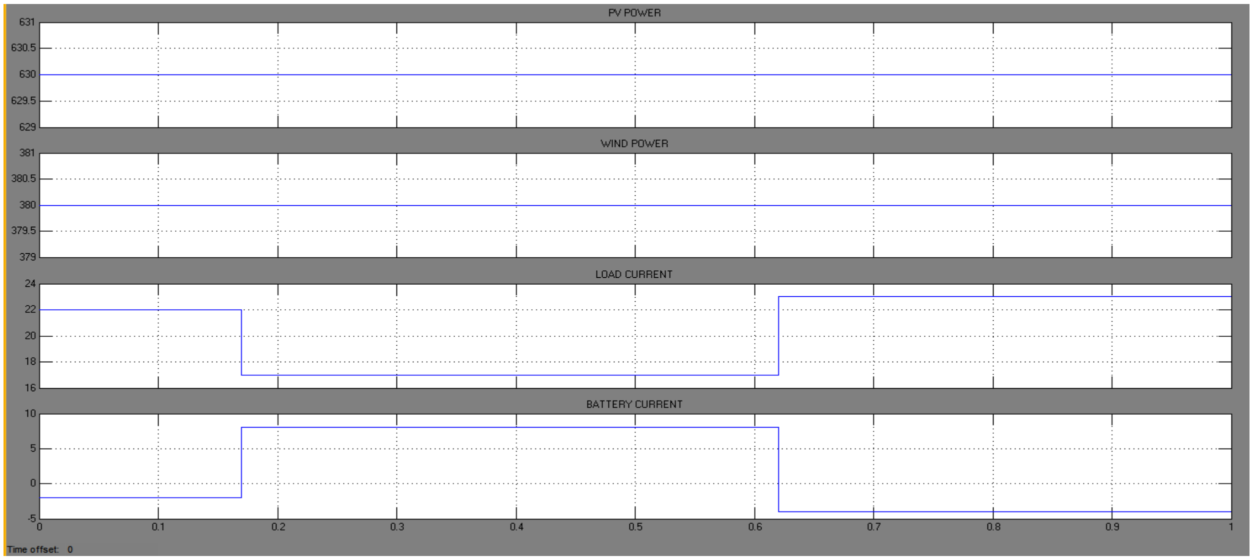


Fig 6: Response of the system for increase& decrease in load power

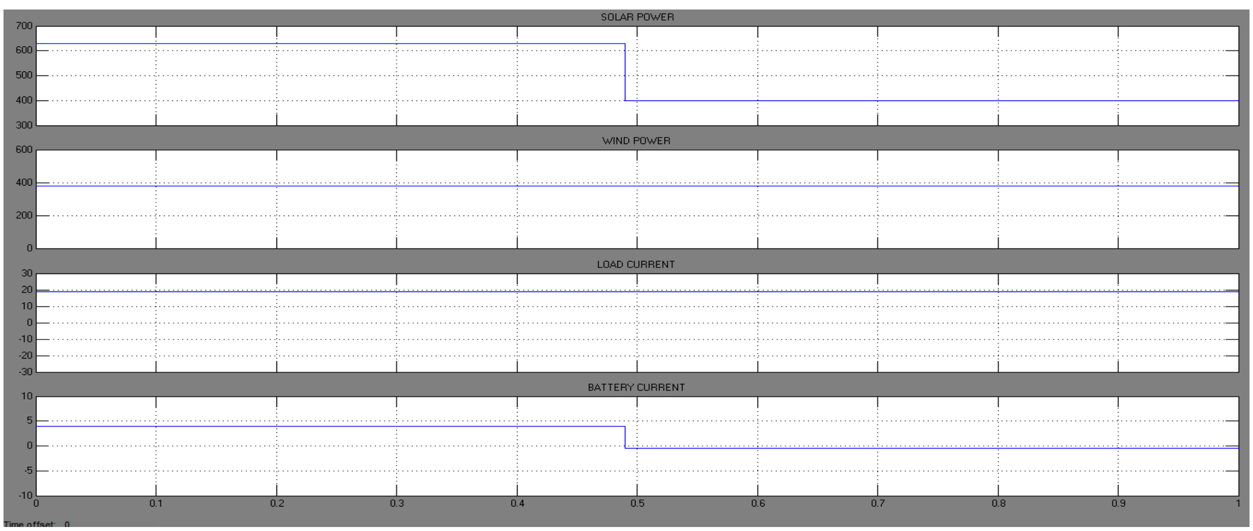


Fig 7: Response of the system during change in Ppv

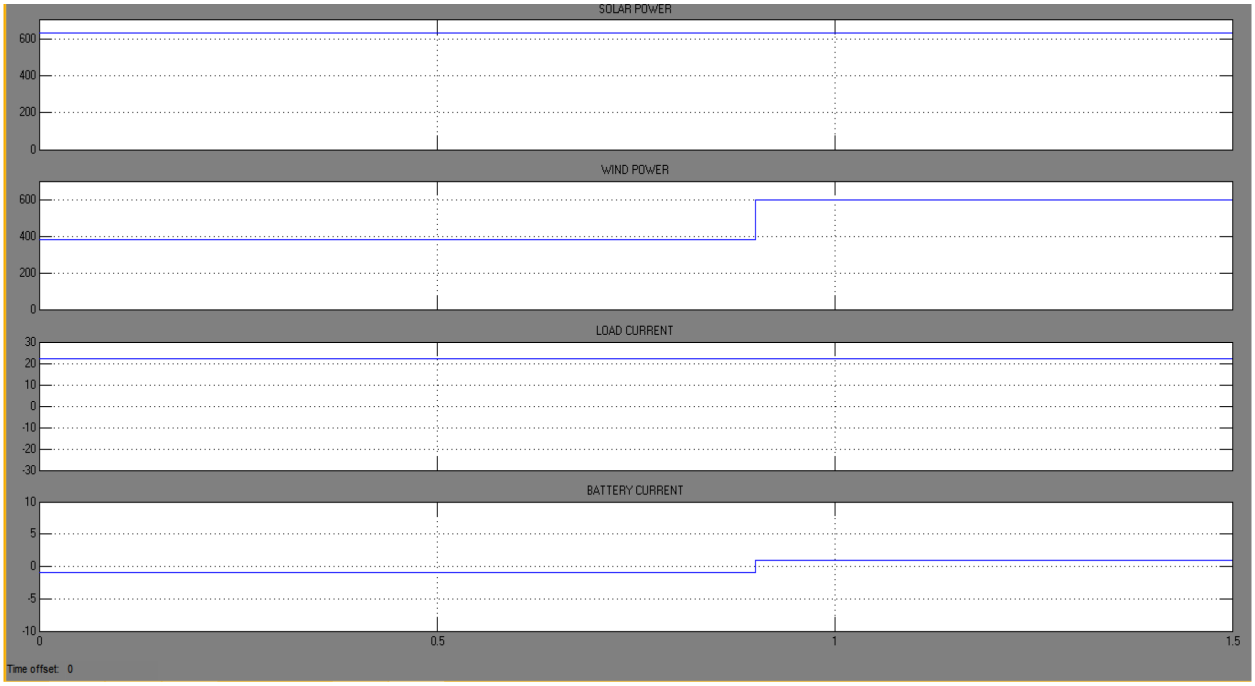


Fig 8: Response of the system during change in Pw

A. Change in load power:

The power from the solar panel (PPV) supplies 630W and the power (PW) from the wind turbine provides about 380W. If the load current (IL) decreases, i.e. the load demand decreases, then the excess energy is used to charge the battery in charging mode The power from the solar panel (PPV) supplies 630W power and the power (PW) from the wind turbine provides about 380W., when the load current (IL) rises, i.e. the demand for load increases, the battery operates in discharge mode to supply the deficit power.

B. Change in PV power.

The power generated from the solar panel (PPV) is reduced from 630W to 415W and the wind turbine produces the same power of 380W to research the response of the system to changes in input power. The battery works in the discharging mode to provide uninterrupted power to the load.

C. Change in Wind power

As the wind turbine (PW) generated power raises from 380W to 590W and the solar panel generates 630W of the same power, the additional power generated is used to charge the battery.

Conclusion:

For power flow management and incremental conductance, a maximum power point monitoring algorithm control algorithm for the DC micro grid with solar and wind power sources is presented. In this study, an incremental conductance maximum power point monitoring algorithm control is suggested to increase the inertia of the dc micro grid and decrease the change rate of the dc voltage. As the scheme involves different intermittent energy sources and loads that can vary in demand for power flow management and incremental conductance, a maximum power point monitoring control algorithm for the DC micro grid must be developed. To provide the loads with unceasing power supply and balance the power flow between the different sources at any time, a power flow algorithm management and incremental conductance maximum power point monitoring control algorithm for the DC micro grid is developed.

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BIOGRAPHIES

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