Power Control in Hybrid Renewable Energy Sources Connected Systems Using MPPT Based Boost Converter

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Abstract- The paper proposes a way for operational a grid connected hybrid system. This technique composed of a electrical phenomenon (PV) array and a nucleon exchange membrane cell (PEMFC) is taken into account. Because the variations occur in temperature and irradiation throughout power delivery to load, Photo voltaic (PV) system becomes uncontrollable. In coordination with PEMFC, the hybrid system output power becomes manageable. 2 operation modes ar the unit-power management (UPC) mode and therefore the feeder-flow management (FFC) mode, are often applied to the hybrid system. All MPPT strategies follow constant goal that's increasing the PV system output power by chase the utmost power on each operational condition. Most electrical outlet chase technique (Incremental conductance) for electrical phenomenon systems was introduced to maximize the created energy. The coordination of 2 management modes, coordination of the PV array and therefore the PEMFC within the hybrid system, and determination of reference parameters ar bestowed. The projected operational strategy systems with a versatile operation mode amendment invariably operate the PV array at most output power and therefore the PEMFC in its high potency performance band. Conjointly therefore rising the performance of system operation, enhancing system stability, and reducing the amount of operational mode changes.

Index Terms- Distributed generation, fuel cell, hybrid system, micro grid, photovoltaic.

I. INRODUCTION

Demand has raised for renewable sources of energy. One amongst these sources is solar power. The electrical phenomenon (PV) array usually uses a most electrical outlet chase (MPPT) to incessantly deliver the very best power to the load once there ar variations in irradiation and temperature. The disadvantage of PV energy is that the PV output power depends on weather and cell temperature, creating it associate uncontrollable supply. what is more, it's not offered throughout the night. So as to beat these inherent drawbacks, different sources, appreciate PEMFC, ought to be put in within the hybrid system. By dynamical the FC output power, the hybrid supply output becomes manageable. However, PEMFC, in its flip, works solely at a high potency inside a particular power vary.The hybrid system will either be connected to the most grid or work autonomously with relation to the grid-connected mode or islanded mode, severally. In order to implement the MPPT formula, a buck-boost dc/dc device is employed. The buck-boost device consists of 1 switch device (GTO) that permits it to show on and off looking on the applied gate signal. The gate signal for the GTO are often obtained by examination the saw tooth wave shape with the management voltage [3]. The output voltage is of the alternative polarity than the input within the buck-boost device. this can be the most disadvantage of the buck-boost device, to beat this flinch boost device is employed. in a very boost device, the output voltage is usually on top of the input voltage.

II. SYSTEM DESCRIPTION

Structure of Grid-Connected Hybrid power grid within the grid-connected mode the hybrid supply is connected to the most grid at the purpose of common coupling (PCC) to deliver power to the load. once load demand changes, the ability equipped by the most grid and hybrid system should be properly modified. the ability delivered from the most grid and PV array still as PEMFC should be coordinated to satisfy load demand. The hybrid supply has 2 management modes: 1) unit-power management (UPC) mode and feeder-flow management (FFC) mode.In the UPC mode, variations of load demand ar stipendiary by the most grid as a result of the hybrid supply output is regulated to reference power. Therefore, the reference worth of the hybrid supply output should be determined. within the FFC mode, the feeder flow is regulated to a relentless, the additional load demand is picked up by the hybrid supply, and, hence, the feeder reference power should be proverbial. The projected operational strategy is to coordinate the 2 management modes and confirm the reference values of the UPC mode and FFC mode so all constraints ar happy. This operational strategy can minimize the amount of operational mode Changes, improve performance of the system operation, and enhance system stability.

A. PV Array Model

The mathematical model [4], [5] for PV array can be expressed as

$$I = I_{ph} - I_{sat}\left\{\exp\left[\frac{q}{AKT}(V + IR_s)\right] - 1\right\} \quad (1)$$

Equation (1) shows that the output characteristic of a solar cell is nonlinear and vitally affected by solar radiation, temperature, and load condition.

Photocurrent Iph is directly proportional to solar radiation

$$I_{ph} = I_{sc} \frac{G_a}{G_{as}} \qquad (2)$$

The short-circuit current of solar cell Isc depends on cell temperature

$$I_{sc}\,(\mathrm{T}) = I_{scs}[1 + \Delta I_{sc}(T - T_s)] \qquad (3)$$

Thus, Iph depends on solar irradiance and cell temperature

$$I_{sc}\,(G_a, \mathrm{T}) = I_{scs}\; G_a/G_{as}\,[1 + \Delta I_{sc}(T - T_s)] \quad (4)$$

Isat also depends on solar irradiation and cell temperature and can be mathematically expressed as follows:

$$I_{sat}\,(G_a\,, \mathrm{T}) = \frac{I_{ph}\,(G_a\,,T)}{e^{\left(\frac{V_{oc}(T)}{V_t}\right)} - 1} \qquad (5)$$

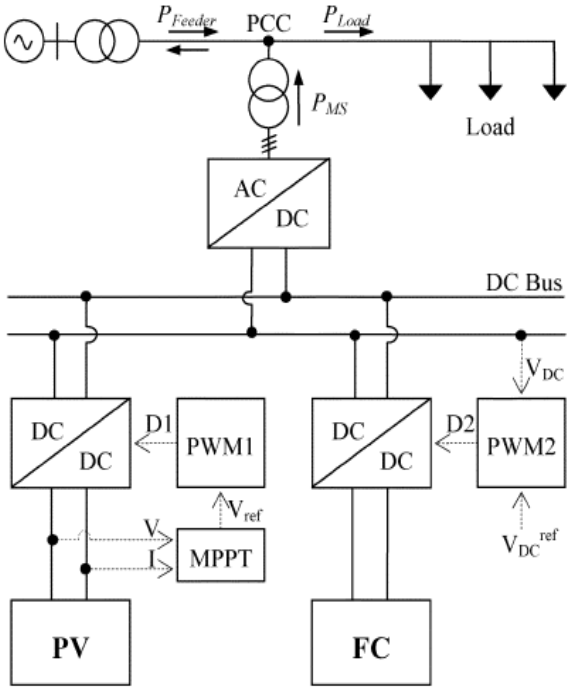


Fig.1: Grid-connected PV-FC hybrid system

B. PEMFC Model

The PEMFC steady-state feature of a PEMFC source is assessed by means of a polarization curve, which shows the

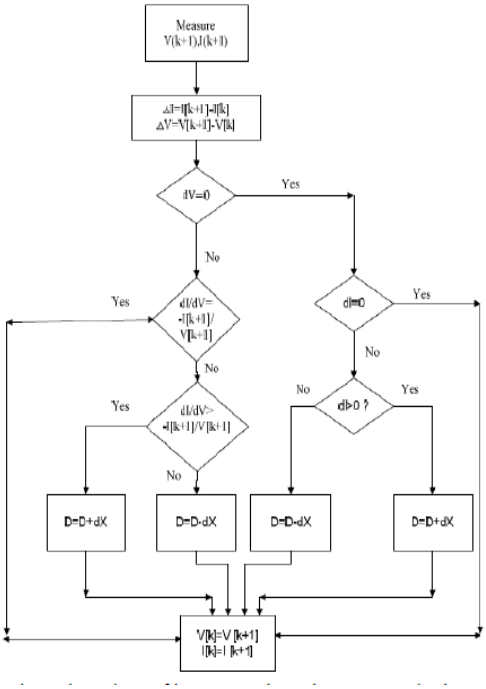


Fig. 2: Flow chart of incremental conductance method

Nonlinear relationship between the voltage and current density. The PEMFC output voltage is as follows [6]:

$$V_{out} = E_{Nerst} - V_{act} - V_{ohm} - V_{conc} \qquad (6)$$

Where ENerst is the "thermodynamic potential" of Nerst, which represents the reversible (or open-circuit) voltage of the fuel cell. Activation voltage drop Vact is given in the Tafel equation as

$$V_{act} = T[a + bln(I)] \qquad (7)$$

where a, b are the constant terms in the Tafel equation (in volts per Kelvin). The overall ohmic voltage drop Vohm can be expressed as

$$V_{ohm} = IR_{ohm} \qquad (8)$$

The electric resistance of PEMFC consists of the resistance of the compound membrane and electrodes, and also the resistances of the electrodes. The concentration drop is expressed as MPPT management most point trackers (MPPTs) play a main role in electrical phenomenon (PV) power systems as a result of they maximize the facility output from a PV system for a given set of conditions, and thus maximize the array potency. Thus, associate degree MPPT [19] will minimize the general system price. There square measure several MPPT strategies out there the foremost widely-used technique is progressive electrical phenomenon methodology represented within the following sections. They conjointly vary in complexness, detector demand, speed of convergence, cost, vary of operation, popularity, ability to discover multiple

native maxima and their applications [7-8]. Specifically the facility purpose hunter may be a high frequency DC to DC device. They take the DC input from the star panels, modification it to high frequency AC, and convert it go into reverse to a distinct DC voltage and current to precisely match the panels to the masses. MPPT's operate at terribly high audio frequencies, sometimes within the 20-80 kilocycle vary. The advantage of high frequency circuits is that they'll be designed with terribly high potency transformers and tiny elements. Some MPPTs square measure a lot of speedy and correct and so a lot of spectacular which require special style and familiarity with specific subjects similar to formal logic or neural network strategies. MPPT formal logic managementlers have smart performance underneath variable atmospherical conditions and exhibits higher performance in distinction with P&O control methodology [11]; but the most disadvantage of this methodology is that its effectiveness is extremely obsessed on the technical data of the engineer in computing the error and springing up with the rule base table. it's greatly contingent on the however designer arranges the system which needs talent and skill. Incremental conductivity formula The progressive electrical phenomenon methodology [9-13] offers smart performance underneath speedily dynamic atmospherical conditions. The by-product of output power P with several to panel voltage V is adequate to zero at most Power Point(MPP). MPP. the essential equations of this methodology square measure as follow.

$$\frac{dP}{dV} = 0 \quad \text{for } V = V_{mp} \qquad (10)$$

$$\frac{dP}{dV} > 0 \quad \text{for } V < V_{mp} \qquad (11)$$

$$\frac{dP}{dV} < 0 \quad \text{for } V > V_{mp} \qquad (12)$$

The Incremental Conductance MPPT method works with two sensors measuring panel's operating voltage V and current I. The necessary incremental changes dV and dI approximated by comparing the most recent measured values for V and I with those measured in previous values.

$$dV(k) = V(k) - V(k-1) \qquad (13)$$

$$dI = I(k) - I(k-1) \qquad (14)$$

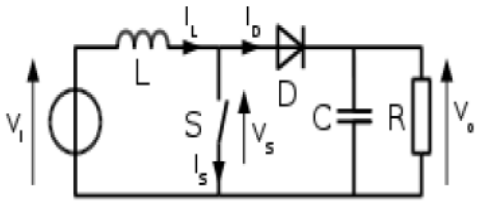


Fig.3 Boost Converter topology

III. MANAGEMENT OF THE HYBRID SYSTEM

The management modes within the small grid embody unit power management, feeder flow management, and mixed management mode. The 2 management modes were initial planned by Lasserter [14]. Within the UPC mode, the DGs (the hybrid supply during this system) regulate the voltage magnitude at the affiliation purpose and also the power that supply is injecting. During this mode if a load will increase anyplace within the small grid, the additional power comes from the grid, since the hybrid supply regulates to a relentless power. Within the FFC mode, the DGs regulate the voltage magnitude at the affiliation purpose and also the power that's flowing within the feeder at affiliation pointP feeder. With this management mode, further load demands area unit picked up by the DGs, that maintain a relentless load from the utility viewpoint. Within the mixed management mode, a similar metric weight unit may management either its output power or the feeder flow power. In different words, the mixed management mode could be a coordination of the UPC mode and also the FFC mode.

Both of those ideas were thought of in [15]–[18]. During this paper, a coordination of the UPC mode and also the FFC mode was investigated to work out once every of the 2 management modes was applied and to work out a reference worth for every mode. Moreover, within the hybrid system, the PV and PEMFC sources have their constraints. Therefore, the reference power should be set at Associate in Nursing acceptable worth in order that the constraints of those sources area unit happy. The planned operation strategy given within the next section is additionally supported the decrease of mode amendment. This planned operational strategy is ready to improve performance of the system's operation

IV. OPERATIONAL STRATEGY OF THE HYBRID SYSTEM

As mentioned before, the aim of the operational algorithmic rule is to work out the management mode of the hybrid supply and also the reference worth for every management mode in order that the PV is ready to figure at most output power and also the constraints area unit consummated. Once the constraints (PFclow, PFcup and PFmax)area unit famed,the management mode of the hybrid supply (UPC mode and FFC mode) depends on load variations and also the PV output. The management mode is set by the algorithmic rule shown in Fig. 7, section B. within the UPC mode, the reference output power of the hybrid supply PMsref depends on the PV output and also the constraints of the FC output. The algorithmic rule decisive PMsref is given in section A and is delineated in Fig. 4.The given algorithmic rule determines the hybrid supply works within the UPC mode. This algorithmic rule permits the PV to figure at its most wall plug, and also the FC to figure among its high potency band. within the UPC mode, the

hybrid supply regulates the output to the reference worth. Then

$$P_{Pv} + P_{FC} = P_{Ms}^{ref} \qquad (15)$$

Equation (15) shows that the variations of the PV output are paid for by the FC power and, thus, the entire power are regulated to the reference price. However, the FC output should satisfy its constraints and, hence, PMsref should set at associate degree acceptable price. Fig. four shows the operation strategy of the hybrid supply in UPC mode to work out PMsref . The rule includes 2 areas: space one and space a pair of. In Area 1, PPv is a smaller amount than PPv1 , then the reference power PMs1ref is ready at PFcup wherever

$$P_{Pv1} = P_{Fc}^{up} - P_{Fc}^{low} \qquad (16)$$

$$P_{Ms1}^{ref} = P_{Fc}^{up} \qquad (17)$$

If PV output is zero, then (11) deduces greenhouse emission to be capable PFcup . If the PV output will increase to PPv1 , then from (15) and (16), we tend to acquire greenhouse emission capable PFclow . In different words, once the PV output varies from zero to PPv1 , the FC output can modification from PFcup to PFclow. As a result, the constraints for the FC output continually reach space one. it's noted that the reference power of the hybrid supply throughout the UPC mode is fastened at a continuing PFcup .Area a pair of is for the case during which PV output power is larger than PPv1. As examined earlier, when the PV output will increase to PPv1 , the FC output can decrease to its lower limit PFclow. If PV output keeps increasing, the FC output can decrease below its limit PFclow .During this case, to control the PV at its most electric outlet and also the FC inside its limit, the reference power should be redoubled. As pictured in Fig. 4, if PV output is larger than PPv1 the reference power are going to be redoubled by the quantity of ΔPMS , and that we acquire

$$P_{Ms2}^{ref} = P_{Ms1}^{ref} + \Delta P_{MS} \qquad (18)$$

Similarly, if PPv is greater than PPv2 , the FC output becomes less than its lower limit and the reference power will be thus increased by the amount of ΔPMS . In other words, the reference power remains unchanged and equal to PMs2ref if PPv is less than PPv2 and greater than PPv1 where

$$P_{Pv2} = P_{Pv1} + \Delta P_{MS} \qquad (19)$$

it is noted that ΔPMS is limited so that with the new reference power, the FC output must be less than its upper limit PFcup . Then, we have

$$\Delta P_{MS} \le P_{Fc}^{up} - P_{Fc}^{low} \qquad (20)$$

In general, if the PV output is between PPvi and between PPvi−1 (i=1, 2, 3, 4……..), then we have

$$P_{Msi}^{ref} = P_{Msi-1}^{ref} + \Delta P_{MS} \qquad (21)$$

$$P_{Pvi} = P_{Pvi-1} + \Delta P_{MS} \qquad (22)$$

Equations (21) and (22) show the method of finding the reference power when the PV output is in Area 2. The relationship between PMsiref and PPvi obtained by using (16), (17), and(22) in (21), and then

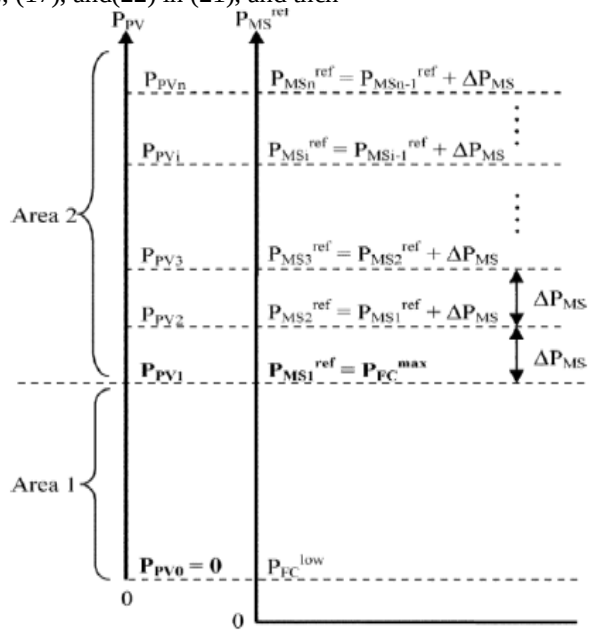


Fig. 4. Operation strategy of hybrid source in the UPC mode

$$P_{Msi}^{ref} = P_{Pvi} + P_{Fc}^{min}, \quad i=1, 2, 3, 4\ldots\ldots\ldots \qquad (23)$$

The determination of in Area 1 and Area 2 can be generalized by starting the index i from 1. Therefore, if the PV output is

$$P_{Pvi-1} \le P_{Pv} \le P_{Pvi}, \qquad i = 1, 2, 3, 4\ldots\ldots\ldots$$

then we have

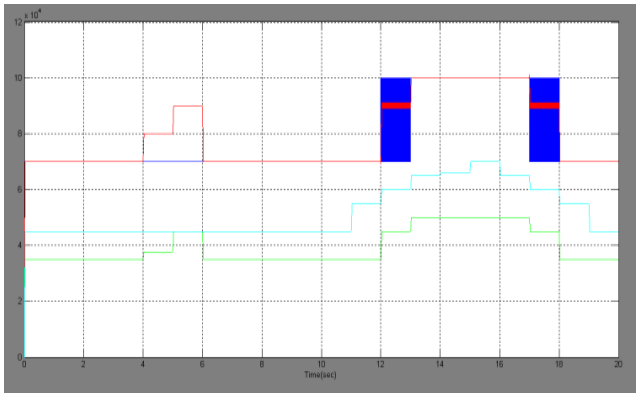
$$P_{Msi}^{ref} = P_{Pvi} + P_{Fc}^{min}, \quad i = 1, 2, 3, 4\ldots\ldots\ldots \qquad (24)$$

$$P_{Pvi} = P_{Pvi-1} + \Delta P_{MS}, \quad i = 1, 2, 3, 4\ldots\ldots\ldots \qquad (25)$$

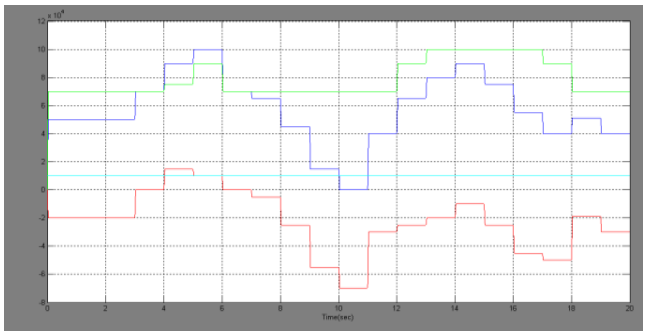
it is noted that when is given in (16), and

$$P_{Pvi-1} = P_{Pv0} = 0 \qquad (26)$$

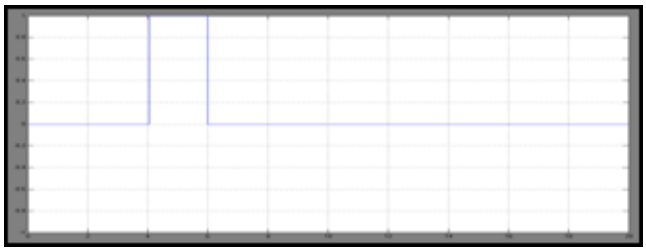
V. RESULTS & DISCUSSIONS



(a) RESULT 1



(b) RESULT 2



(c) RESULT 3

A. Simulation leads to the Case while not physical phenomenon Controller

It is seen from Fig. nine that the system solely works in FFC mode once the load is significant. The UPC mode is that the major operative mode of the system and, hence, the system works a lot of stably. Throughout FFC mode, the hybrid supply output power modifications with relevancy the change of load demand, as in Fig. 9(b). On the contrary, in UPC mode, PMschanges following PMsref , as shown in Fig. 9(a). It also can be seen from Fig 9(a) that at twelve s and seventeen s, changes unceasingly. this is often caused by variations of PPv within the MPPT method. As a result, PMs and PFC oscillate and area unit unstable. so as to beat these drawbacks, a physical phenomenon was accustomed management the modification of PMsref , as shown in Fig. 6. The simulation results of the system, as well as the physical phenomenon, area unit delineate in Fig 10

VI. CONCLUSION

A hybrid system composed of a PV array and PEMFC, connected to grid is considered. The operating strategy of the system is based on the UPC mode and FFC mode. The purposes of the proposed operating strategy presented in this paper are to determine the control mode, to minimize the number of mode changes, to operate PV at the maximum power point, and to operate the FC output in its high efficiency performance band. The proposed system works flexibly, exploiting maximum solar energy; PEMFC works within a high-efficiency band and, hence, improves the performance of the system's operation. The system can maximize the generated power when load is heavy and minimizes the load shedding area. When load is light, the UPC mode is selected and, thus, the hybrid source works more stably.

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