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POWER MANAGEMENT STRAGIES FOR A GRID CONNECTEDPV-FC HYBRID SYSTEM

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Abstract: **This paper presents a method to operate agrid connected hybrid system. The hybrid system composed of photovoltaic (PV) array and a Proton exchange membrane fuel cell (PEMFC) is considered. The PV array normally uses a maximum power point tracking (MPPT) technique to continuously deliver the highest power to the load when variations in irradiation and temperature occur, which make it become an uncontrollable source. In coordination with PEMFC, the hybrid systemoutputpowerbecomescontrollable.Twooperationmodes,the unit-powercontrol (UPC) mode and the feeder-flow control (FFC) mode,canbe applied to the hybrid system. The coordination of two control modes, the coordination of the PV array and the PEMFC in the hybrid system, and the determination of reference parameters are presented. The proposed operating strategy with aflexibleoperationmodechangealwaysoperatesthePVarrayatmaxi mumoutput power and the PEMFC in its high efficiency performance band, thus improving the performance of system operation ,enhancing system stability, and decreasing the number of operating mode changes.**

Keywords: Distributed generation, fuel cell, hybridsystem micro grid, photovoltaic, power management**.**

I. INTRODUCTION

Renewable energy is currently widely used. One of these resources is solar energy. The photovoltaic array normally uses a maximum power point tracking technique to continuously deliver the highest power to the load when there are variations in irradiation and temperature. The disadvantage of PV energy is that the PV output power depends on weather conditions and cell temperature, making it an uncontrollable source. Furthermore, it is not available during the night. In order to overcome these inherent drawbacks, alternative sources, such as PEMFC, should be installed in the hybrid system. By changing the FC output power, the hybrid source output becomes controllable. However, PEMFC, in its turn, works only at a high efficiency within a specific power range. The hybrid system can either be connected to the main grid or work autonomously with respect to the grid-connected mode or islanded mode, respectively. In the grid-connected mode, the hybrid source is connected to the main grid at the point of common coupling (PCC) to deliver power to the load. When load demand changes, the power supplied by the main grid and hybrid system must be properly changed. The power delivered from the main grid and PV array as well as PEMFC must be coordinated to meet load demand. The hybrid source has two control modes: 1) unit-power control (UPC) mode and 2) feeder-flow control (FFC) mode.Fig.1.shows the interconnection of the hybrid system.

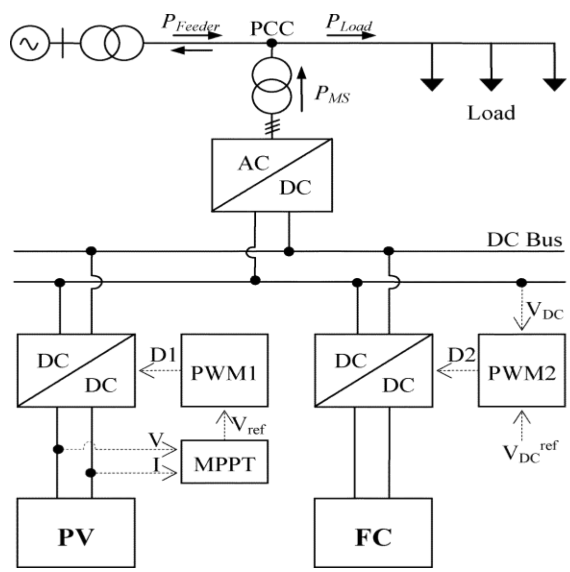


Fig.1. Grid-connected PV-FC hybrid system

II.LITERATURE SURVEY

F. Katiraei and M. R. Iravani, proposed a paper on Power management strategies for a microgrid with multiple distributed generation units from this I can extract the real and reactive power management strategies of electronically interfaced distributed generation (DG) units in the context of a multiple-DG microgrid system. The emphasis is primarily on electronically interfaced DG (EI-DG) units.

J.Larmine and A.Dicks, proposed a paper on Fuel Cell Systems and its operation used for power generation. From this power generation using hydrogen is analyzed.

T.Bocklisch,W.Schufft, and S.Bocklisch, proposed a paper on Predictive and optimizing energy management of photovoltaic fuel cell hybrid systems with short time energystorage.

III.SYSTEM DESCRIPTION

Structure of Grid-Connected Hybrid Power System: The system consists of a PV-FC hybrid source with the main grid connecting to loads at the PCC as shown in Fig. 1. The photovoltaic and the PEMFC are modeled as nonlinear voltage sources. These sources are connected to dc–dc converters which are coupled at the dc side of a dc/ac inverter. The dc/dc connected to the PV array works as an MPPT controller. Many MPPT algorithms have been proposed in the literature, such as incremental conductance (INC), constant voltage (CV), and perturbation and observation (P&O). The P&O method has been widely used because of its simple feedback structure and fewer measured parameters. The P&O algorithm with power feedback control is shown in Fig. 2. As PV voltage and current are determined, the power is calculated. At the maximum power point, the derivative dP/dV is equal to zero. The maximum power point can be achieved by changing the reference voltage by the amount of ΔV_{ref}.

A. PV array model

The mathematical model 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 I_{ph} is directly proportional to solar radiation G_a.

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

The short-circuit current of solar cell I_{sc} depends linearly on cell temperature.

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

Thus, I_{ph} depends on solar irradiance and cell temperature I_{sat} also depends on solar irradiation and cell temperature and can be mathematically expressed as follows.

$$I_{Ph}(G_a, T) = I_{scs}\frac{G_a}{G_{as}}(1 + \Delta I_{sc}(T - T_s)) \quad (4)$$

I_{sat}alsodependsonsolarirradiationandcelltemperatureand can be mathematically expressed asfollows:

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

B. PEMFC Model: The PEMFC steady-state feature of a PEMFC source isassessed by means of a polarization curve, which shows thenon-linearrelationshipbetweenthevoltageandcurrentdensity.ThePEMFC output voltage is as follows [5]:

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

Where E_{Nerst} is the "thermodynamic potential" of Nerst,whichrepresents the reversible (or open-circuit) voltage of the f u e l cell. Activation voltage drop V_{act} is given in the Tafelequationas

$$V_{act} = T[a + b\ \ln(I)] \quad (7)$$

Where *a* and *b* are the constant terms in the Tafel equation (involtsper Kelvin).The overall ohmic voltage drop V_{ohm}can be expressedas

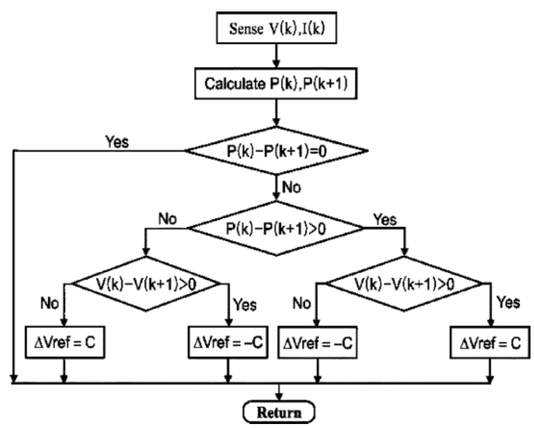


Fig. 2. P&O MPPTalgorithm.

The overall ohmic voltage drop V_{ohm}can be expressedas

$$V_{ohm} = I\,R_{ohm} \quad (8)$$

TheohmicresistanceR_{ohm} ofPEMFCconsistsoftheresistanceofthepolymermembraneand electrodes,andtheresistancesoftheelectrodes.The concentration voltage drop $V_{\mathrm{conc}}$is expressedas

$$V_{conc} = -\frac{RT}{ZF}\ln\left(1 - \frac{I}{I_{limit}}\right) \quad (9)$$

C. MPPTControl: ManyMPPTalgorithmshavebeenproposedintheliterature,such asincrementalconductance(INC),constantvoltage(CV),and perturbation and observation (P&O). The twoalgorithmsoften used to achieve maximum power point tracking aretheP&O and INC methods. The INC method offers goodperformance under rapidly changing atmospheric conditions.How-ever, four sensors are required to perform the computations.If the sensors require more conversion time, then theMPPTprocesswilltakelongertotrackthemaximumpowerpoint.During tracking time, the PV output is less than itsmaximumpower. This means that the longer the conversion time is,thelarger amount of power loss [7] will be. On the contrary, iftheexecution speed of the P&O method increases, then thesystemlosswilldecrease.Moreover,thismethodonlyrequires twosensors,whichresultsinareductionofhardwarerequirements andcost. Therefore, the P&O method is used to control theMPPTprocess.

In order to achieve maximum power, two differentappliedcontrolmethodsthatareoftenchosenarevoltage-feedbackcontrolandpower-feedbackcontrol[8],[9].Voltage-feedbackcontrolusesthesolar-arrayterminalvoltagetocontrolandkeepthearrayoperatingnear itsmaximumpowerpointbyregulatingthearray's voltageandmatchingthevoltageofthearraytoadesiredvoltage.Thedrawback ofthevoltage-feedbackcontrolisitsneglectoftheeffectofirradiationandcelltemperature.Therefore,thepower-feedbackcontrolisusedtoachievemaximumpower.The P&O MPPT algorithm with a power-feedback control[9],[10]isshowninFig.2.AsPVvoltageandcurrentaredeter-mined, the power is calculated. At the maximum powerpoint,the derivative $dP/_{dV}$ is equal to zero. The maximumpowerpoint can be achieved by changing the reference voltage bytheamountof ΔV_{ref}.InordertoimplementtheMPPTalgorithm,abuck-boostdc/dc converter is used as depicted in Fig.3.The parameters and Cin the buck-boost convertermustsatisfy the following conditions.

$$L > \frac{(1-D)^2 R}{2f} \;;\; C > \frac{D}{Rf(\frac{\Delta V}{V_{out}})} \quad (10)$$

The buck-boost converter consists of one switchingdevice(GTO)thatenablesittoturnonandoffdependingontheappliedgatesignal.ThegatesignalfortheGTOcanbeobtainedbycomparingthesawtoothwaveformwiththecontrolvoltage[7].The change of the reference voltageΔV_{ref}obtainedby MPPT algorithm becomes the input of the pulse width modulation (PWM). The PWM generates a gate signal tocontrolthe buck-boost converter and, thus, maximum power istrackedand delivered to the ac side via a dc/acinverter.

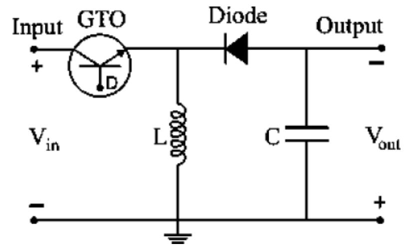


Fig. 3. Buck-boosttopology.

IV.CONTROL OF THE POWER SYSTEM

The control modes in the micro grid include unit powercontrol,feederflowcontrol,andmixedcontrolmode.Thetwocontrol modes were first proposed by Lasserter. IntheUPCmode,theDGs(thehybridsourceinthissystem)regulate the voltage magnitude at the connection point andthepower that source is injecting. In this mode if a loadincreasesanywhereinthemicro grid,theextrapowercomesfromthegrid,sincethehybridsourceregulatestoaconstantpower.IntheFFCmode,theDGsregulatethevoltagemagnitudeattheconnectionpoint and the power that is flowing in the feeder atconnectionpoint P feeder. With this control mode, extra load demands arepickedupbytheDGs,whichmaintainaconstantloadfromthe utilityviewpoint.Inthemixedcontrolmode,thesameDGcouldcontroleitheritsoutputpowerorthefeederflowpower.Inotherwords,themixedcontrolmodeisacoordinationoftheUPCmode and the FFCmode. Inthispaper, a coordination of the UPC mode and the FFC modewasinvestigated to determine when each of the two controlmodeswas applied and to determine a reference value for eachmode.Moreover, in the hybrid system, the PV and PEMFCsourceshave their constraints. Therefore, the reference power mustbesetatanappropriatevaluesothattheconstraintsofthesesourcesare satisfied.The proposed operation strategy presented inthenextsectionisalsobasedontheminimizationofmodechange.Thisproposedoperatingstrategywillbeabletoimproveperformance of the system operation and enhance systemstability.

V.CONTROL OF HYBRBID SYSTEM

As mentioned before, the purpose of the operatingalgorithmistodeterminethecontrolmodeofthehybridsourceandthereferencevalueforeachcontrolmodesothatthePV isabletoworkatmaximumoutputpowerandtheconstraintsarefulfilled.Oncethe constraints ($P_{FC}^{up} P_{FC}^{low}$, P_{FC}^{max}) on load variations and the PV output.. The control mode isdecidedbythealgorithmshowninFig.4

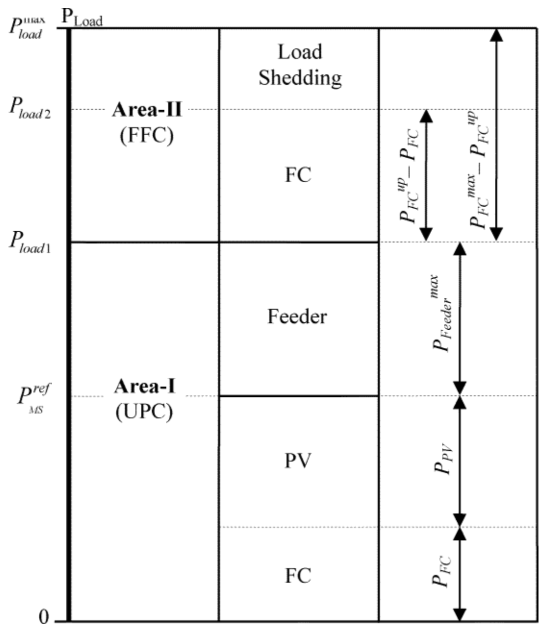
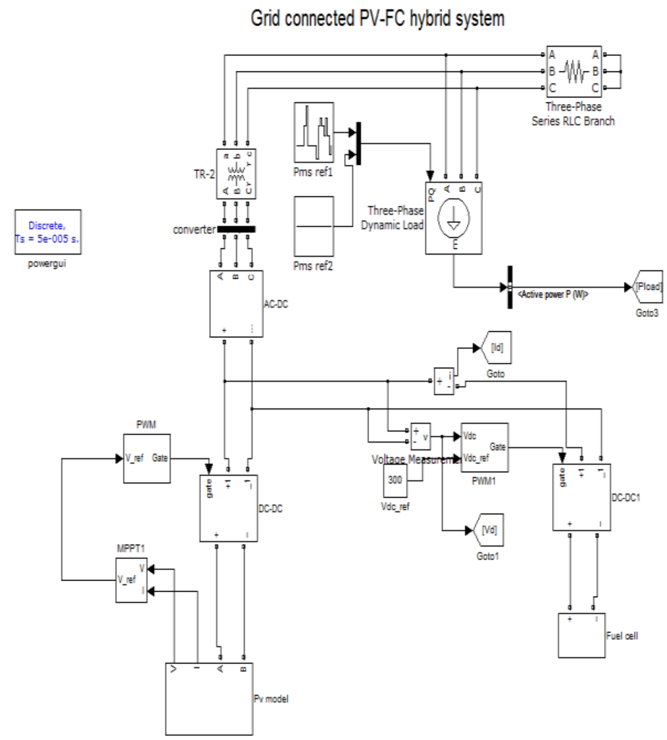


Fig.4. Overall operating strategy for the grid-connected hybridsystem

VII.SIMULATION RESULTS

A simulation was carried out by using the system model shown in Fig. 2 to verify the operating strategies.In order to verify the operating strategy, the load demand and PV output were time varied in terms of step. According to the load demand and the change of PV outputand the operating mode were determined by the proposed operatingalgorithm. The following out puts are describes the unit power flow control mode of operation, feeder flow control mode of operation and mixed operation of the hybrid system shown in the figure



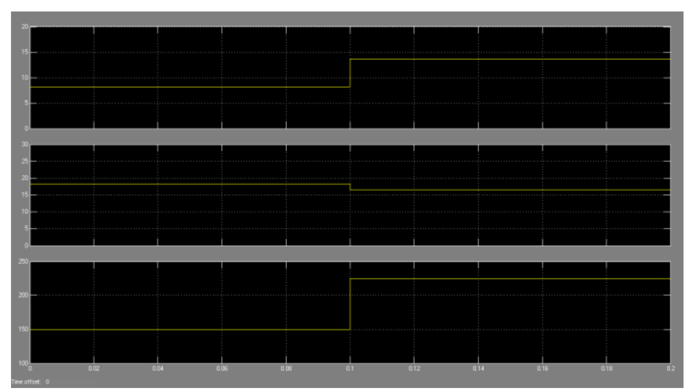


Fig 5.operating strategies of hybrid system

VIII.COCLUSION

Thispaperhaspresentedanavailablemethodtooperateahybrid grid-connectedsystem.Thehybridsystem,composedofaPVarrayand PEMFC,wasconsidered.Theoperatingstrategyof the system is based on the UPC mode and FFC mode.Thepurposes of the proposed operating strategy presented inthispaper are to determine the control mode, to minimizethenumber of mode changes, to operate PV at the maximumpowerpoint,andtooperatetheFCoutputinitshigh-efficiencyperformanceband.The systemworksflexibly, exploiting maximum solar energy; PEMFCworkswithin a high-efficiency band and, hence, improves theperformanceofthesystem'soperation.Thesystemcanmaximizethegeneratedpowerwhenloadisheavyandminimizestheloadsheddingarea.Whenloadislight,theUPCmodeisselectedand, thus, the hybrid source works more stably.

REFERENCES

[1] J. Larmine and A. Dicks, Fuel Cell Systems Explained. NewYork:Wiley,2011.
[2] W. Xiao, W. Dunford, and A. Capel, "A novel modeling methodforphotovoltaic cells," in *Proc. IEEE 35th Annu. Power ElectronicsSpe-cialists Conf., Jun. 2009*
[3] D. Sera, R. Teodorescu, and P. Rodriguez, "PV panel model basedondatasheetvalues,"*inProc.IEEEInt.Symp.IndustrialElectronics,Jun.4–7, 2007, pp.2392–2396.*
[4] C. Wang, M. H. Nehrir, and S. R. Shaw, "Dynamic models andmodelvalidation for PEM fuel cells using electrical circuits*," IEEETrans.Energy Convers., vol. 20, no. 2, pp. 442–451, Jun.2005.*
[5] C. Hua and C. Shen, "Comparative study of peak power trackingtech-niques for solar storage system," in Proc. 13th Annu. AppliedPowerElectronics Conf. Expo., Feb. 2004, vol. 2, pp.679–685.
[6] A.HajizadehandM.A.Golkar,"Powerflowcontrolofgrid-connectedfuel cell distributed generation systems," J. Elect. Eng. Technol.,vol.3, no. 2, pp. 143–151,2008.
[7] C.HuaandJ.R.Lin,"DSP-basedcontrollerapplicationinbatterystorage of photovoltaic system," in Proc.22nd IEEE Int. Conf.Indus-trialElectronics,Control,andInstrumentation,Aug.5–10,2002,vol.3, pp.1750–1810.
[8] C.Hua,J.Lin,andC.Shen,"ImplementationofaDSP-controlledpho-tovoltaicsystemwithpeakpowertracking*,"IEEETrans.Ind.Electron.,vol. 45, no. 1, pp. 99–107, Feb.2000.*