Decentralised- Autonomous Energy Supply And Monitoring System For Rural Areas

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Abstract*-Autonomous and decentralised energy with renew-able sources exhibit a powerful approach for a monetary energy supply to rural areas. Advanced control strategies are relied upon to upgrade the energy dispatch, enable a cost proficient operation besides, guarantee a persistent power supply. A constant real-time energy monitoring system for grid-tied Photovoltaic (PV) installations is to be developed. This system includes a propelled control framework for the perfect microgrid operation using a two-layer demonstrate prescient technique. The principal enhancement layer exhibits a perfect control issue, in light of persistent desires of future power issues, for the calculation of the perfect imperativeness dispatch. To enhance the power of the control procedure toward forecast blunders, a limit esteem issue is illuminated to conform the diesel generator control in the second stage. And after ward at the other getting end shows the real time graph of the generated solar energy and the total energy consumed by the load, in this case, a residential load.*

Keywords-Photovoltaic systems, Diesel generator, storage devices, autonomous and decentralised energy system, Two-layer model predictive method.

I. INTRODUCTION

As of late decentralized energy era has increased consider- ably more fame in the energy part. Autonomous energy supply system are generally utilized as a part of assortment of utilizations, extending from crisis reinforcement frameworks in clinics to rustic telecom tower stations, military applications and con-trolling off-framework islands. Taking a gander at the present situations the expansion in fossil fuel costs and the ascent of vitality request requirements for feasible vitality frameworks are expanding. Energy consumption reduction is becoming very difficult for most of the consumers mainly because of not monitor the energy consumption. Also a lack of utilization of renewable energy sources to increase the household's energy requirement for long-term savings. As a result, a trend of using hybrid energy supply solutions, including renewable sources, expenses with monitoring system that can tracks the users consumption and measures the generated energy from a grid-tied solar PV system can be observed to reduce the operation.[1] Decentralised energy and Autonomous energy supply systems:

In many region of the world there is no infrastructure for distributing energy. In such areas autonomous and de-centralized energy systems are needed for supplying electric power. This sort of system are comprised of solar (sun based) modules, a little wind turbine, a discretionary diesel generator, battery and a control system for this portable joined heat and power unit. The system is planned with the goal that it can be effortlessly utilized as a part of any part of the world and introduced at any place. Decentralized energy is created near where it will be utilized, instead of producing it at a huge plant somewhere else and sent it through the national grid. This neighbourhood generation diminishes transmission misfortunes and brings lowers emission of carbon.

Security of supply is expanded broadly as clients don't need to share a supply or depend on substantial and remote power stations. Long haul decentralized energy can offer more aggressive costs than conventional energy.

This way to deal with low carbon energy arrangement gives us the chance to advance a privately gave, practical, aggressive and more astute energy decision.

The kind of hybrid power supply proposed here belongs to the category of microgrids. They work autonomously, either parallelly with an existing utility grid, or as a stand-alone grid, dependent on the field of application.

The energy system proposed can be found in rural communities or areas where no electrical grid is approachable. The concentration of the ideal control lies in the enhanced vigor towards forecast mistakes of load request and power from renewable while attempting to get a continuous power supply and cost decrease. Such system can be found in remote regions to control up small towns and villages. All parts that are to be utilized are associated by a power matrix and power hardware without overabundance to the national lattice. The diesel generator which is exchange to the renewable supply normally goes about as fundamental power source and ischaracterized by a high operation cost coming about because of the fuel utilization. The use of a storage system, here a lead acid battery, gives more flexibility by storing additional energy and providing it when it is needed[2]. Photovoltaics are basically alluring for remote regions and areas since they offer a spotless and clear source of force in areas that can't be financially served by method for lattice expansion.

Utilization of PV lessens the cost of system yet represents extra difficulties for the framework control and underscores the requirement for an opened up and upgraded control methodology because of unpredictive nature of renewable.

The advanced control for off-grid breed energy systems is critical not simply because of the unpredictive and discontinuous nature of renewable sources additionally the huge measure of monetary advantages picked up by a cost ideal operation of all energy sources. This framework concentrates on microgrids situated in country ranges that are excessively remote for association, making it impossible to the grids. Due to the remote location and absence of cutting edge control hardware, demand side administration won't be considered for the control change. This causes additional requirements for the control of the system with respect to robustness and higher precision, by using the detailed models can guaranty a short computation time which can allow the implementation on a real system [2]. The operation of remote zone energy systems requires a hearty control arrangement which limits the impact of unsettling influences and instabilities coming about because of renewable, is continuous able, gives a precise impulsion of the accessible power in framework, all misfortunes and exact demonstrating of the charging and releasing conduct of the battery to ensure a continuous influence supply. This system gives a structure for the upgraded control of microgrids in country zones. The emphasis is on the improvement of a propelled show based advancement approach utilizing a MPC system to enhance the heartiness of the control towards expectation blunders and further instabilities following up on the system.

The new created control technique in this system incorporates the advancement and expansion of a streamlining layer to build the power towards instabilities. The using the diesel generator power and the state of charge from the first layer to adjust the diesel generator on and off time solving a boundary value problem is the novelty of this system. An addition of detailed component models restricts uncertainties resulting due to modelling errors. Significant attention is given to the development of a suitable representation of the battery model, the diesel generator operation constraints, the PV module and the power efficiency curves resulting in a nonlinear mixed integer optimization problem (MINLP) in the first stage [2].

Along with this system consists of a monitoring system that tracks the users power consumption and measures the generated energy from a solar PV system. The hardware monitoring system has telemetry capability for solar PV. An application is to provide the user with real-time and historical information of their household consumption and solar powergeneration by connecting a display of the real-time graph of the generated solar energy and the total energy consumed by the load.

II. RELATED WORK

Recently more importance is being given to the change of microgrid control with the utilization of cutting edge control calculations to expand the monetary advantages. An extensive variety of ideas for the continuous control of energy system can be found in papers [1][6][9] where authors have presented the real time control of energies. And most of the previously mentioned work presents appropriate approaches and techniques which could prompt to optimal arrangements. In [2] Two state prediction model with model predictive control (MPC) has drawn attention due to its adaptively, robustness towards uncertainties and the inclusion of PV power and load forecasts. The MPC presents an advanced control algorithm that can deal with a high level of complexity and guarantee improved robustness. The formulation of a linear mixed in- teger optimization problem within the MPC for the optimal operation of energy systems comprising renewable, battery and diesel generators ,with a forecast algorithm and evaluated using experiments where authors have presented mathematical formulation for algorithms along with simulations.

As the energy consumption reduction is inherently difficult for majority of consumers mainly because they do not monitor their energy consumption. There is also a lack of utilization of renewable energy sources to augment the household's energy requirement that can introduce long-term savings. A monitoring system that can measure the voltage, current and power generated by the solar PV system and the total energy consumption of the household. Aside from this, web and mobile applications were developed providing the user with real-time and historical information of their household consumption and solar power generation. A forecasting algorithm was also incorporated to project the monthly electricity bill based on the current MERALCO rates and on the recent consumption data of the household. The three options (Ave, Min, Max) give the users a preview of the outcome of their daily habits and allow the user to regulate their energy usage is covered in paper [1]. Papers [3] deals with the MPPT incremental conductance algorithm, paper [5] explains the MPPT algorithms with it's types comparison of all types, with simulation and design of MPPT algorithm. Along with the explanation of all the hardware used in the design of MPPT and components included when planning circuit that relies on upon both advanced and simple parts of the hardware.

III. PROPOSED SYSTEM

After reviewing different methods some drawbacks associated with above mentioned architectures analysed are: Improve the strength or robustness against instabilities coming about because of load request and PV control while limiting the operation cost in view of definite part models.

Propelled control strategies are expected to enhance the vitality dispatch, empower a cost effective operation and certification a continuous power supply. Monitoring of energy generated and consumption, After these problems and drawbacks of above architectures mentioned in literature decided to implement PV-Diesel Microgrid Operation and Monitoring System for Ruler Areas to enhance the strength of the control system toward forecast blunders, a limit esteem issue is understood to conform the diesel generator power. The adequacy of control system as far as computational achievability, exactness, expanded strength, and diminished cost. Development of a PV-Diesel Microgrid Operation and Monitoring System for Ruler Areas with:

- Hybrid system consisting of PV cell, diesel generator and Storage battery;
- Increase robustness and reduced cost;
- Monitoring of total household consumption and solar power generation.

A. System Block diagram

This system has three sources for power supply one is photovoltaic cell second is the Diesel generator and the third source is storage battery. The primary supply is Photovoltaic cell it is an electrical gadget that changes over the vitality of light specifically into power. In some conditions if it is not able to supply energy the alternative source that is diesel generator or the storage battery is used. These sources are applied to the electric load using a switch which helps to identify and switch between different sources. the electrical on the other end is connected to an monitoring device that is current and voltage sensor which senses the amount of current, voltage, and power generated and used in the house hold activities, this monitoring system is connected to a computer installed with MATLAB 2013.a to display the graphs the measured parameters: DC Voltage Generation, DC Current Generation and DC Power Generation. MPPT algorithm is used so as to get most extreme power from the sun powered boards, they need to work at their greatest power point not with-standing the adjustments in the ecological conditions, SPARTAN6 FPGA is used for MPPT controller.

B. MPPT (Maximum Power Point Tracking)

The rule of MPPT is to extricate the greatest accessible power from PV module by making them to work and no more productive voltage (greatest power point).MPPT checks yield of the PV module, contrasts it and the heap then fixes what is the best power that PV module can create for load and can be used to charge the battery and believers it to the most suited voltage to get greatest current into battery.

MPPT is most appropriate and proficient under these conditions: Cloudy or dim days, Cold climate: Normally, sunbased PV module can't work in overcast and murky subsequently MPPT is used to concentrate most extreme power accessible from them.

When storage device (battery) is fully discharged: MPPT can extract more current and charge the battery.

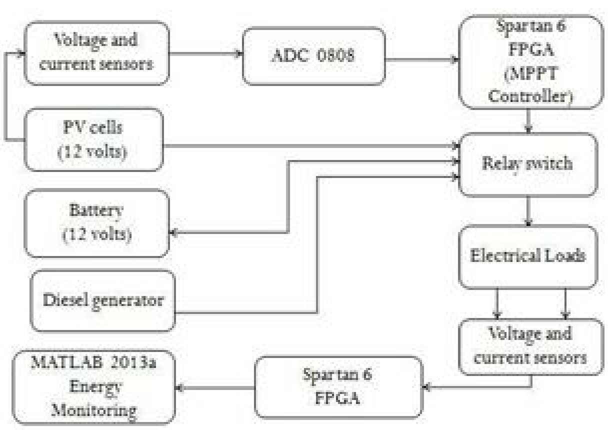


Fig. 1. Basic system block diagram

C. MPPT Methods

The MPPT methods are broadly classified in two types:

- Indirect method
- Direct method

Indirect method: Maximum power point is determined from various parameters like voltage, current, irradiance temperature, using mathematical expression or empirical data. This estimation is carried for specific PV system. Some of these techniques are:

- Fraction SC method
- Curve fitting method

- Fractional SC method
- Lookup table method

Direct methods: These methods do not require any prior knowledge about PV panel and are independent of temperature, degradation levels. They use current and/or voltage information about PV to track MPP. These methods are computationally demanding. Some of these methods are:

- Pertube and Observe,
- Current sweep
- Incremental conductance
- Constant voltages
- Hill climbing method
- Fuzzy Control

Among all these immediate strategies Perturb and watch (PO) and Incremental conductance are for the most part utilized in view of their effortlessness. In this paper Incremental Conductance is utilized to stay away from themistakes because of estimation in Perturb perceptions [5].

D. Incremental Conductance:

Incremental conductance strategy utilizes two sensors, i.e. current and voltage sensors to detect the yield current and voltage of the PV cluster. Calculation works by looking at the proportion of subsidiary of conductance with the immediate conductance [3]. When this instantaneous conductance equals the conductance of the solar then MPP is reached. The basic equations of this method are as follows:

$$\frac{dI}{dV} = \frac{I}{V} \quad (1)$$

$$\frac{dI}{dV} > \frac{I}{V} \quad (2)$$

$$\frac{dI}{dV} < \frac{I}{V} \quad (3)$$

Where I and V are the PV cluster current and voltage individ- ually. The right-hand side speaks to the immediate conductance and the left-hand side of the conditions speaks to the IncCond of the PV module. It is evident that when the proportion of change in the yield conductance is equivalent to the negative yield conductance, the sun powered PV exhibit will work at the MPP(maximum control point)[3]. Here both current and voltage are detected at the same time. Thus the mistake brought on because of the adjustment in seclusion is wiped out. However the intricacy and the cost of usage increment. There are fundamentally two downsides of this strategy: The first and vital one is that can without much of a stretch forget about the MPP because of quick change in the sun oriented confinement level. The other one is the motions of the current what's more, voltage around the MPP in the relentless state. This is because of the way that the control is discrete and the current and voltage are not consistent at the MPP but rather the wavering around it.

IV.SIMULATION RESULTS

In this section the presented real MATLAB simulink simulation for PV module and the diesel generator. To extract the greatest accessible power from PV module by making them to work and no more productive voltage MPPT is simulated with PV module. MPPT result shows the IV and PV plot for maximum power point values, depending on the varying Ipv and Vpv values. of microgrids. A novel viewpoint of the monitoring sys-tem that tracks the users power consumption and measures the generated energy from a solar PV system. The system provides the user with real-time and historical information of their household consumption and solar power generation by connecting a display of the real-time graph of the generated solar energy and the total energy consumed by the load, hence can control the energy consumption.

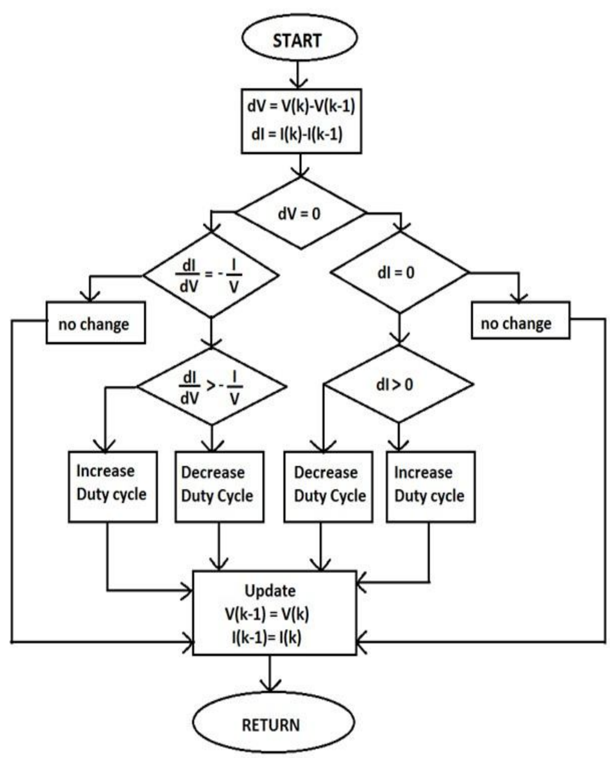


Fig. 2. Flowchart of the Incremental Conductance method

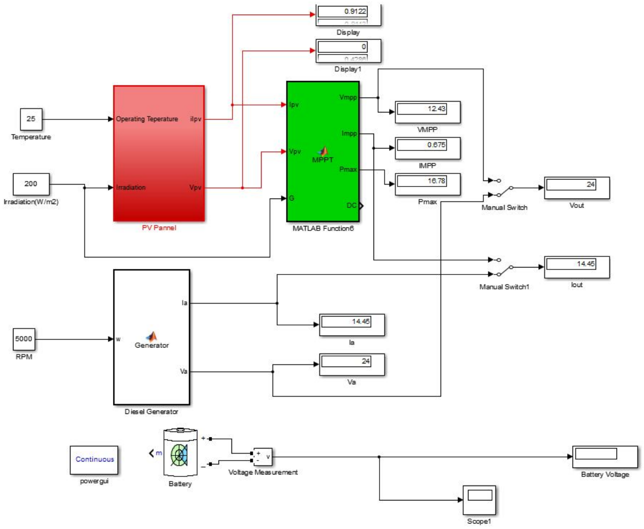


Fig. 3. Simulation model for integration of all the subsystems with interconnection of switch

V. CONCLUSION

This paper exhibits a successful two layer display prescient control strategy for control of microgrids presenting hybrid energy systems consisting of PV module, diesel generator and storage battery. The presented model-based control scheme satisfies all complex operation constraints, increases the robustness towards uncertainties, and is computationally modest and consequently appropriate for the ongoing control. Monitors the generated energy and energy consumption in house hold activities, hence controls the energy usage.

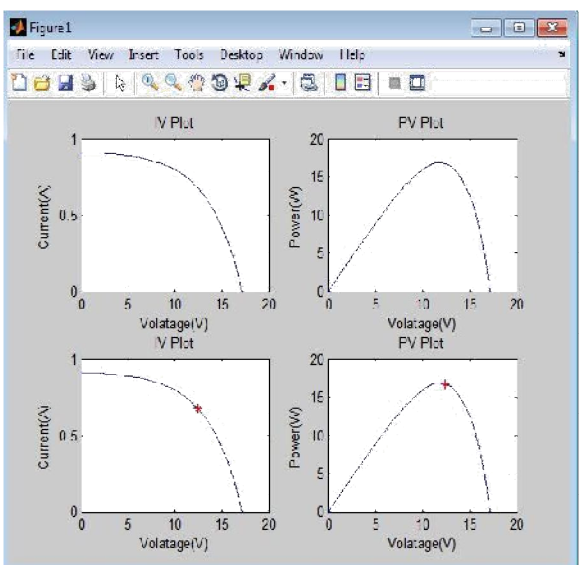
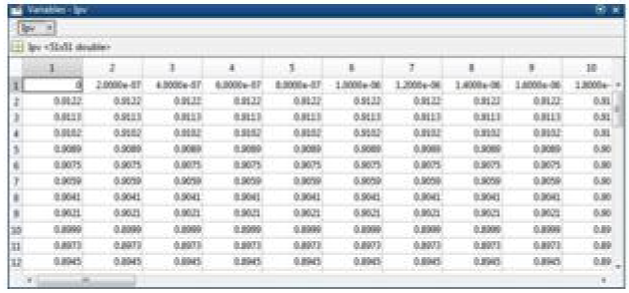
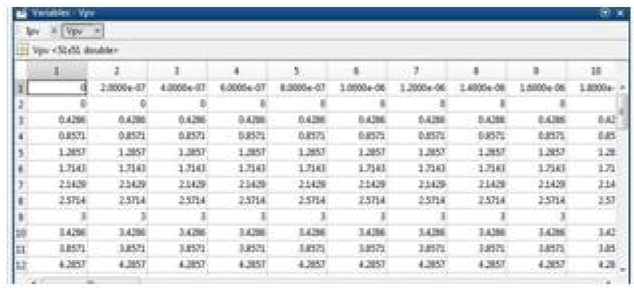


Fig. 4. Results from MPPT



	1	2	3	4	5	6	7	8	9	10
1	0	2.0000e-07	4.0000e-07	6.0000e-07	8.0000e-07	1.0000e-06	1.2000e-06	1.4000e-06	1.6000e-06	1.8000e-
2	0.9122	0.9122	0.9122	0.9122	0.9122	0.9122	0.9122	0.9122	0.9122	0.91
3	0.9113	0.9113	0.9113	0.9113	0.9113	0.9113	0.9113	0.9113	0.9113	0.91
4	0.9102	0.9102	0.9102	0.9102	0.9102	0.9102	0.9102	0.9102	0.9102	0.91
5	0.9089	0.9089	0.9089	0.9089	0.9089	0.9089	0.9089	0.9089	0.9089	0.90
6	0.9075	0.9075	0.9075	0.9075	0.9075	0.9075	0.9075	0.9075	0.9075	0.90
7	0.9059	0.9059	0.9059	0.9059	0.9059	0.9059	0.9059	0.9059	0.9059	0.90
8	0.9041	0.9041	0.9041	0.9041	0.9041	0.9041	0.9041	0.9041	0.9041	0.90
9	0.9021	0.9021	0.9021	0.9021	0.9021	0.9021	0.9021	0.9021	0.9021	0.90
10	0.8999	0.8999	0.8999	0.8999	0.8999	0.8999	0.8999	0.8999	0.8999	0.89
11	0.8973	0.8973	0.8973	0.8973	0.8973	0.8973	0.8973	0.8973	0.8973	0.89
12	0.8945	0.8945	0.8945	0.8945	0.8945	0.8945	0.8945	0.8945	0.8945	0.89

Fig. 5. Varying values of Ipv



	1	2	3	4	5	6	7	8	9	10
1	0	2.0000e-07	4.0000e-07	6.0000e-07	8.0000e-07	1.0000e-06	1.2000e-06	1.4000e-06	1.6000e-06	1.8000e-
2	0	0	0	0	0	0	0	0	0	
3	0.4286	0.4286	0.4286	0.4286	0.4286	0.4286	0.4286	0.4286	0.4286	0.42
4	0.8571	0.8571	0.8571	0.8571	0.8571	0.8571	0.8571	0.8571	0.8571	0.85
5	1.2857	1.2857	1.2857	1.2857	1.2857	1.2857	1.2857	1.2857	1.2857	1.28
6	1.7143	1.7143	1.7143	1.7143	1.7143	1.7143	1.7143	1.7143	1.7143	1.71
7	2.1429	2.1429	2.1429	2.1429	2.1429	2.1429	2.1429	2.1429	2.1429	2.14
8	2.5714	2.5714	2.5714	2.5714	2.5714	2.5714	2.5714	2.5714	2.5714	2.57
9	3	3	3	3	3	3	3	3	3	
10	3.4286	3.4286	3.4286	3.4286	3.4286	3.4286	3.4286	3.4286	3.4286	3.42
11	3.8571	3.8571	3.8571	3.8571	3.8571	3.8571	3.8571	3.8571	3.8571	3.85
12	4.2857	4.2857	4.2857	4.2857	4.2857	4.2857	4.2857	4.2857	4.2857	4.28

Fig. 6. Varying values of Vpv

Fig.7. The graph shows the daily energy consumption of the user in kWh. The blue line represents the user’s total consumption while the red line represents the energy consumption from the grid.

REFERENCES

[1] Ngo, Genevieve C., et al. ”Real-time energy monitoring system for grid-tied Photovoltaic installations.” TENCON 2015-2015 IEEE Region 10 Conference. IEEE, 2015.

[2] Sachs, Julia, and Oliver Sawodny. ”A Two-Stage Model Predictive Con-trol Strategy for Economic Diesel-PV-Battery Island Microgrid Operation in Rural Areas. IEEE,2016.

[3] Chafle, Srushti R., and Uttam B. Vaidya. ”Incremental Conductance MPPT Technique for PV System.” International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering 2.6 (2013).

[4] Pandiarajan, Natarajan, and Ranganath Muthu. ”Mathematical modeling of photovoltaic module with

Simulink.” International Conference on Electrical Energy Systems (ICEES 2011). Vol. 6. 2011.

[5] Shankarrao, Jadhav Pankaj. FPGA Implementation of Maximum Power Point Tracking Algorithm for PV System. Diss. 2013

[6] L. Zhang, N. Gari, and L. V. Hmurcik, Energy management in a microgrid with distributed energy resources, Energy Convers. Manage., vol. 78, pp. 297305, 2014.

[7] D. Tenfen and E. C. Finardi, A mixed integer linear programming model for the energy management problem of microgrids, Elect. Power Syst. Res., vol. 122, pp. 1928, 2015

[8] A. Parisio and L. Glielmo, Energy efficient microgrid management using model predictive control, in Proc. 50th IEEE Conf. Decis. Control Eur. Control Conf. (CDC-ECC), Dec 2011, pp. 54495454.

[9] Bayrak, Gkay, and Ersan Kabalci. ”Implementation of a new remote is-landing detection method for windsolar hybrid power plants.” Renewable and Sustainable Energy Reviews58,(2016):15