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Design of Building Integrated Photovoltaic System and Energy Storage Using DC Network Distribution

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Abstract—To meet the current growing demands utility grid incorporates renewable energy resources. These are the necessary complement to the traditional electricity generation.
Still the demand is never ending. One solution to meet the current growing energy demand is to expand the role of microgrids that interact with the utility grid and operate independently during peak time. We have proposed a system, for urban areas, a building integrated photovoltaic (BIPV) primarily for self-feeding of buildings equipped with PV array and storage. A DC network distribution is considered, for elimination of multiple energy conversions. The purpose is to integrate the DC BIPV into future smart grid with advanced energy management strategy that gives the possibility to a more scalable and more flexible control and regulation. The hierarchical control is designed as an interface to expand the system ability for advanced energy management control having regard to the grid availability and users commands. It comprises four layers: human machine interface, prediction, cost management, and operation.The experimental could show that the system is able to maintain stable operation and response to the grid limits, calculates the powers reference of storage and grid, and could constraint the load. Hence we would be validate this approach to be a solution for the future smart grid communication between BIPV and utility grid.

Keywords— *BIPV, PV array, energy storage, distributed power generation, energy management, smart grid*

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I. INTRODUCTION

Photovoltaic system applications have grown in the last years along with the increasing preoccupation of governments and customers with energy sustainability. Much of this growth was driven by government initiatives, offering subsidies and tax breaks for those who have some type of renewable generation installed in residences, commerce or industry. Also, the development of the photovoltaic market and the gradual reduction in equipment prices has made solar energy a competitive alternative, increasing the consumer interest. A sustainable technology that provides the opportunity for generating electricity and replacing conventional construction materials is building integrated photovoltaic (BIPVs). BIPV systems generate electricity by converting solar energy into useable power to supply building electrical loads.

Due to the PV power purchase conditions, the grid-connected system for permanent energy injection is proposed in most applications. However, this increased development leads to grid-connection incidents, which became true technical constraints. The fluctuations in both energy demand and renewable power generation, even for few minutes, induce an effort to supplementary setting on conventional production units. The number of conventional production units in operation must grow to ensure the balance between power generation and power demand. This is due to the fact that the renewable energy generation, hardly predictable and very unsettled, is not participating in technical regulations for grid connection (setting voltage and frequency, islanding detection) and behaves as passive electric generators [1]. In response to these technical constraints, research works are being carried out on grid integration of renewable decentralized generation [2]. In urban areas and for buildings equipped with renewable electricity, an alternative solution could be the off-grid/grid-connected system seen as building integrated PV (BIPV): low-voltage distribution system with distributed energy sources, storage devices, and controllable loads. This BIPV represents a form of power local generation, often multisource, and can operate both in grid-connected and in islanded operation [3], [4]. There is a maximum power point (MPP) under certain atmospheric conditions. To absorb maximum power from PV panel, a large number of researchers have proposed maximum power point tracking (MPPT) algorithms. The perturb-and-observe method (POM) [5], the incremental conductance method (ICM) [6], [7].

We propose in this study an energy management modelling of a multi-source power system consist of photovoltaic (PV) array, storage and power grid connection, and taking into account messages from smart grid. The designed system can supply a tertiary building at the same time as PV may produce energy. The control strategy aims to manage the power flow through the load with respect to its power demand and public grid constraints. The proposed energy management modelling is based on interpreted Petri Nets formalism.

II. DC BIPV GENERAL OVERVIEW

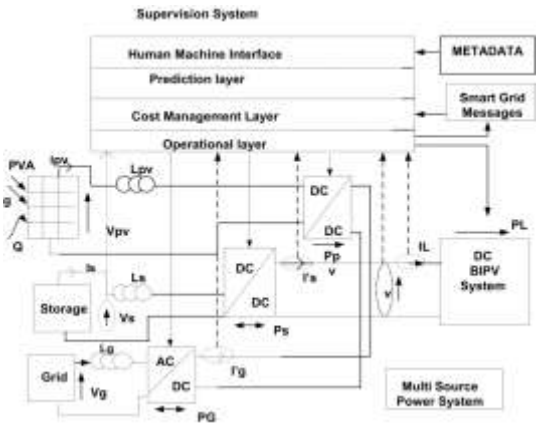

Fig.1. DC BIPV Safety System

A DC or AC BIPV should keep running off-network and on lattice. The DC BIPV building arrangement introduced in this paper could keep running on-network and off-matrix, however the utility lattice is constantly interfaced to the framework, and the off-lattice perspective is less considered for the occasion. By and by, the framework could keep running without network control supply. The DC BIPV worldwide framework is made out of a multi-source power neighborhood era combined with a supervision framework. Fig. 1 demonstrates this arrangement; PV A, capacity gadget, and utility framework are associated with a typical DC voltage transport through their devoted converters. As appeared in fig. where g and θ are, individually, sun powered irradiance and PV cell temperature. The DC transport bolsters a DC load. With a point of disposal of various vitality transformations, this DC burden could speak to DC system dispersion of a tertiary building [8], [9]. The PV created vitality is earlier for self sustaining [10]. In any case, the DC BIPV requirements to react to the heap request with a solid force circulation; thusly, reinforcement with vitality stockpiling and lattice association is important. Additionally, abundance force can be exchanged back to the utility lattice.

The multi-source power framework is intended to guarantee persistent safe supply to the heap. The harmony in the middle of supply and load power interest is the most essential necessity of vitality administration, however different destinations, for example, network accessibility or vitality cost administration should be incorporated

III. MULTI SOURCE POWER SYSTEM

The multi-source power framework, is made out of one DC burden and three sources: PV generator, electrolytic stockpiling, and utility network. Electrolytic stockpiling and utility lattice are reversible: supply and infusion. This framework extricates greatest force from PVA and it deals with the force move so as to bolster specifically the DC load (working), regarding accessible capacity level and considering the utility lattice association. If there should arise an occurrence of deficient vitality toward the heap, the framework security is guaranteed on account of the lattice association and by method for capacity, which is fundamentally included in smoothing the asked for force. In the event that any overabundance PV power, the framework association gives the likelihood to exchange it back.

A. PV Array

The power supplied by *PVA* depends on the solar irradiance, PV cell temperature, array voltage, and the current through the *PVA*. In order to maximize the produced energy from the *PVA*, a maximum power point tracking (MPPT) method is needed to find and maintain the peak power. Two direct algorithms are commonly used to track the maximum power point: Perturb & Observe and Incremental Conductance (INC). They act in real time on the voltage reference or current reference variable, to produce the maximum power from the PV system. In this work, we are interested in INC MPPT strategy.

B. Battery Energy Storage System

Battery energy storage has shown a lot of potential in the recent past to be effective in various grid services due to its near instantaneous ramp rates and modularity. BESS in a rooftop Photovoltaic system (PV) provides a means of storing excess of solar energy during daytime for its use later in the day when the sun ceases to shine. Battery energy storage system is the Power Conditioning System (PCS) providing bidirectional power conversion.

C. Grid

The grid refers to the electric grid, a network of transmission lines, substations, transformers and more that deliver electricity from the power plant to your home or business. It is what you plug into when you flip on your light switch or power up your computer. Our current electric grid was built in the 1890s and improved upon as technology advanced through each decade.

IV. ENERGY MANAGEMENT MODELING BY PNS

A Petri net is a specific sort of bipartite coordinated charts populated by three sorts of articles. A Petri net comprises of spots, moves, and coordinated circular segments. Circular segments keep running from a spot to a move or the other way around, never between spots or between moves. The spots from which a bend hurries to a move are known as the information spots of the move; the spots to which circular segments keep running from a move are known as the yield spots of the move. Graphically, puts in a Petri net might contain a discrete number of imprints called tokens. Any appropriation of tokens over the spots will speak to a design of the net called a checking. Spot is indicated by circle, bar or box speaks to a move, Directed curves (bolts) interface places and moves, with a few bends guided from spots to moves and different circular segments guided from moves to puts.

As appeared in Fig.2 brilliant lattice educates supervision framework at various times about the matrix vigorous requirements, for example, vitality value, control supply, and power infusion confinements. This correspondence is structure with a timed deciphered PN spoke to by two spots (P0, P1) and two moves (T1, T2).The place P0 speaks to the savvy framework in a standby mode and the matrix working mode will be changed when the P1 is come to. This occasion is the terminating state of the transitionT1. After the tG time, measured in hours from the entry of the token from P0 to put P1, the move T2 can be let go and the supervision framework is educated of the exchanging working mode moment.

Once the supervision framework is educated about the matrix working mode, it controls the multi-source power framework as per the chose network working mode and considering every subsystem conduct.

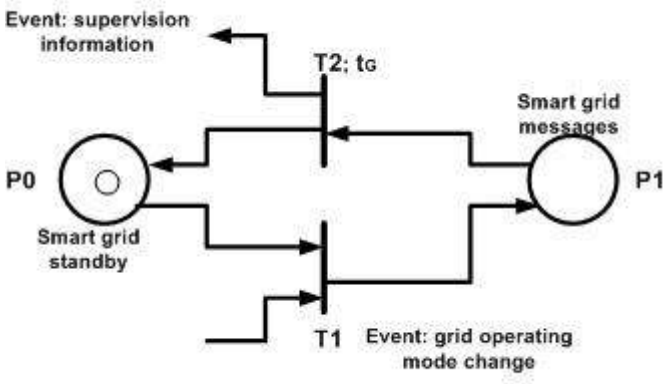

Fig. 2. Smart grid interaction by Petri Net

V. SUPERVISION SYSTEM

For configuration of supervision framework for progressive layer control is to be considered.

• HMI layer: HMI layer is the human machine interface layer it permit clients to pick working modes, for example, ordinary load, requirement load, basic burden, vitality cost minimized.
• Prediction layer: Prediction layer is utilized to decide the PV power and the heap power advancement and/or confinement;
• Cost administration layer: Cost administration layer in which it choose the best trade off between vivacious limitations and burden (building offices) operation administration;
• Operation layer: In operational layer controlling of force adjusting of the multisource power framework happens. The objective of the supervision framework is to control powers adjusting of multi-source power framework according to the diverse requests and requi

$$P_S + P_G = P_L - P_{PV} \quad (1)$$

Power balancing is maintained by the operation layer

that involves regulation by a power adjustment .In order to manage powers between batteries and grid, P_S and respectively, P_G, a distribution coefficient K_D is introduced by (2):

(2)

with $0 \leq K_D \leq 1$, and taking into account that the powers

references and should not exceed the corresponding physical subsystem limitations.

VI. CONCLUSION

Lasting vitality infusion from matrix associated framework and because of PV force buy conditions, this framework is proposed in many applications. Along these lines because of expanded improvement prompts lattice association episodes, turned out to be genuine specialized requirements. Subsequently this paper proposes a DC BIPV with various leveled control framework and brilliant matrix correspondence. The design is to incorporate the DC BIPV into future shrewd framework with cutting edge vitality administration framework that gives more versatile and more adaptable control and regulation. In this paper for vitality administration Petri Net demonstrating is utilized.

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