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A novel anti-islanding technique in a Distributed generation systems

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Abstract— This paper proposes a photovoltaic generation system interfaced with a dc distribution system. DC interface allows for the improvement of system efficiency by fully utilizing dc-based renewable sources and storage devices. In this paper, issues on PV interface for dc distribution systems are discussed for energy-efficient and reliable system implementation. AC and dc PV interfaces are mathematically analyzed. In dc distribution, eliminating electrolytic capacitors in PV interfaces improves system reliability, increases system efficiency, and reduces cost. In addition, this paper proposes a new anti-islanding technique for dc distribution as a system protection scheme. The operating principle is presented in detail and analysis shows that the proposed injected current perturbation technique is an effective solution for anti-islanding operation. A prototype converter features a simple structure with no electrolytic capacitor, which ensures a longer lifetime of the PV power circuit. Experimental results of the prototype circuit show a maximum efficiency of 98.1% and a European efficiency of 97.5%. The proposed anti-islanding technique shows fast response to the islanding condition in less than 0.2 s. It also shows that the average maximum power point tracking efficiency is 99.9% in normal conditions, which verifies the performance of the proposed scheme.
Keywords: Anti-islanding, building integrated photovoltaic (BIPV), dc distribution, islanding, photovoltaic (PV).

I. INTRODUCTION

The penetration rate of distributed generation (DG) has rapidly increased as their feasibility and reliability improve through technology advances, and as environmental issues and sustainable developments have become a major concern. In this trend, the research on optimization of the traditional power system by utilizing state-of-the-art power electronics is widely expanding. Among the efforts, dc application approaches, such as dc distribution systems, are especially promising for the use of renewable power sources and dc loads DC interface can be much more energy efficient than ac because power generated from dc sources, photovoltaic (PVs), can be directly supplied to the loads, which allows for a reduction of conversion loss by eliminating dc-ac and ac-dc conversion stages. DC interface systems have been applied in data centers, such that ac-dc and dc-ac conversions required for traditional uninterruptible power supplies can be completely eliminated. An analytical evaluation of a variety of data center system architectures is presented where the feasibility of a 400-VDC distribution system is discussed. In view of system realization, design and control issues, such as operation modes and transition conditions, are discussed for data center applications in System performance of dc systems is maximized when the system components[3]. A wind turbine is a device that converts kinetic energy from the wind into electrical power. A wind turbine used for charging batteries may be referred to as a wind charger. The result of over a millennium of windmill development and modern engineering, today's wind turbines are manufactured in a wide range of vertical and horizontal axis types [5]. The smallest turbines are used for applications such as battery charging for auxiliary power for boats or caravans or to power traffic warning signs [3]. Slightly larger turbines can be used for making small contributions to a domestic power supply while selling unused power back to the utility supplier via the electrical grid. Arrays of large turbines, known as wind farms, are becoming an increasingly important source of renewable energy and are used by many countries as part of a strategy to reduce their reliance on fossil fuels [2]. Thus, the short lifetime electrolytic capacitors can be eliminated, extending the PV generation system lifetime toward PV panel lifetime of 25 years [5]. For system protection, there are many implementation challenges. In PV applications, anti-islanding technology is a key requirement for human safety and equipment protection. This paper proposes a new anti-islanding technique for dc-interfaced PV generation systems [5]. The solution detects the island and disconnects the PV system from dc distribution in 0.2 s. Depending on the system configuration and operation principle, the technique can be utilized not only for system protection but also as a system control signal for operation mode change. In Section II, PV generation system structures are reviewed for system cost, efficiency, and reliability. In Section III, the analysis of PV voltage variation in an ac- and dc-interfaced PV generation system is presented and the feasibility of electrolytic capacitor-less converter implementation in dc distribution is verified [7]. In Section IV,

islanding operation is discussed and a new dc anti-islanding technique is proposed. In Section V, a dc PV interface is designed for building integrated photovoltaic (BIPV) modules and the prototype PV converter is implemented. Experimental results of the prototype PV converter are shown to verify the
feasibility of this study.

II. PV GENERATION IN DISTRIBUTION SYSTEMS

Although PV panel cost has been continuously declining as a result of PV technology advances, it is still relatively expensive compared to conventional energy sources. In many countries, the installation of PV generation systems is driven by government grant and it is still an efficiency driven market due to the high cost. Therefore, efficiency and cost are the most important driving factors in the PV market [4], [5]. The centralized inverter architecture has been widely employed due to its high efficiency and low cost. Because one integrated inverter controls a group of PV modules in the centralized structure, as shown in Fig. 1(a), the efficiency of the PV power circuit is relatively high and the cost per watt is reduced due to its high power capacity. However, mismatch between panels caused by partial shading and a panel characteristic difference makes it difficult to achieve individual maximum power point tracking (MPPT) for each PV module [6]. String and multi string structures have been used for improved harvest efficiency. In the string structure, energy lost due to mismatch is reduced by conditioning a single string of PV modules as shown in Fig. 1(b). However, the structure is not suitable for applications such as residential rooftop or BIPV generation system due to the partial shading problem and safety issues of high voltage wiring [7].

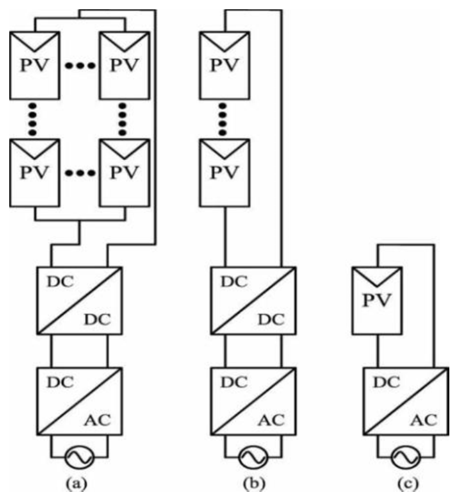


Fig.1. PV generation system configurations in ac distribution :(a) centralized,(b) string, (c) ac module.

Another solution is to have individual modules controlled by their own conditioners, as shown in Fig. 1(c). Harvest energy can be maximized and safety issues can be eliminated by attaching the conditioner at the back of the module such that users are not exposed to high dc voltage and installation becomes easier [7]. By applying the ac module concept, harvest efficiency can be kept high even in mismatch conditions. However, its relatively high cost and low efficiency compared to the centralized structure have been obstacles for its wide application.

In addition, the lifetime issue caused by the use of electrolytic capacitors for ac decoupling is also a drawback for this approach [5]. Because the module-integrated inverter is installed on the back of the PV module frame, the power circuit must sustain harsh conditions and high temperature. The lifetime of electrolytic capacitors, which is much shorter than that of other components and heavily depends on operating temperature, becomes the main obstacle to extending the lifetime of PV module generation systems.

In this paper, a dc PV generation interface based on dc distribution is proposed as a compensatory solution to ac module concept. Retaining the advantages of the a module concept, dc interfaced PV generation systems have lower cost and higher power conversion efficiency due to lower part count and less conversion stages from source to load. In addition, reliability issues are addressed by eliminating the short lifetime electrolytic capacitors in the PV power circuit.

III. ELECTROLYTIC CAPACITOR-LESS PV INTERFACE WITH DC DISTRIBUTION

Figs. 2 and 3 show the schematic of ac and dc distribution systems, respectively. Renewable sources, storage devices, and loads that are connected through their own ac-dc interfaces in the ac distribution system are directly connected to the dc link in the dc distribution system. An integrated ac dc converter, shown in Fig. 3, controls the dc-link voltage and balances the power flow with the ac utility.

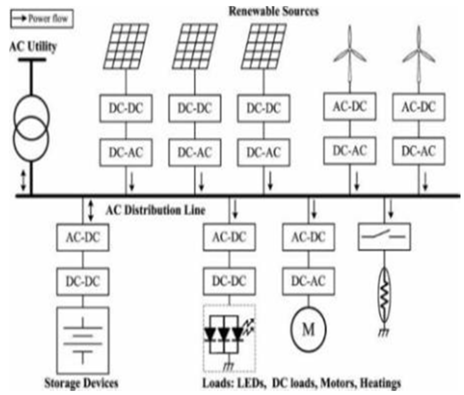


Fig. 2. Schematic of ac distribution with renewable generations and storage devices.

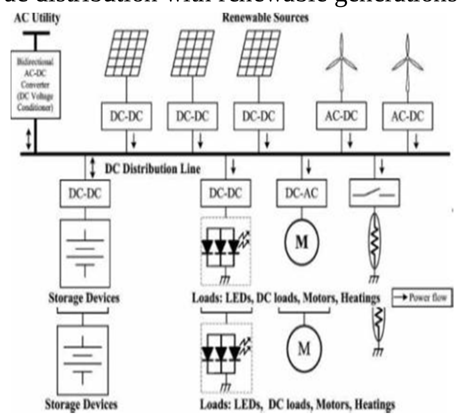


Fig. 3. Schematic of dc distribution with renewable generations and storage devices.

In the ac module concept, a PV converter enacts MPPT and output commutation current control. Because the output current must be injected to the ac utility in a sinusoidal manner, as shown in Fig. 4, large decoupling capacitors are required to keep PV operation near its maximum power point (MPP) regardless of the sinusoidal alternate current. Electrolytic capacitors have been widely used for decoupling due to their high energy density and relatively low cost. Due to the short lifetime of electrolytic capacitors, research focusing on increasing system lifetime is being widely investigated [7].

IV. NEW ANTI-ISLANDING TECHNIQUE FOR DC PV GENERATION SYSTEM

Anti-islanding is a key requirement for PV conditioners interfaced with the ac utility to guarantee human safety and equipment damage protection. A variety of anti-islanding technologies have been developed that utilize the amplitude of voltage, frequency, phase, and harmonic characteristics [13]. DC distribution systems also require anti-islanding technology. In this section, a new anti-islanding technique is proposed for dc PV generation system.

A. Need for Anti-Islanding Method in DC Distribution

The ac utility can be considered as an infinite source, which means that it is not affected by other system components. Therefore, subsystems can be independently designed and implemented in ac distribution systems. However, it is more difficult to design reliable systems in dc distribution because all system components are directly connected to the dc link, which is easily affected by their operation. In a conventional system, bidirectional ac-dc converters are employed to tightly regulate the dc distribution voltage. The ac-dc converter balances energy exchange with the ac utility and the system goes into island condition when the converter is disconnected from the utility [3].With the ac-dc converter disabled, the dc distribution voltage must be regulated by another component or the system should be shut down for safety.

In this case, charging/discharging of storage device can be enabled for dc-link voltage regulation. Using the storage interface, system efficiency can be improved by reducing the energy exchange with the ac utility. For effective dc system operation, several schemes have been proposed [5], [6], [7]. The anti-islanding method may seem to not be required, given the utilization of the ac-dc converter and energy buffer interface. However, it is still required for system protection. The ac-dc converter and energy buffer interface cannot perform properly in some conditions, such as when the devices are disconnected from a dc distribution system or renewable sources are islanded by an accident. Therefore, anti-islanding is essential in dc distribution systems for safety and protection.

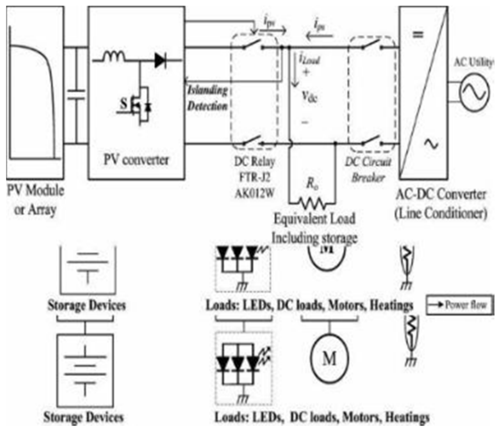


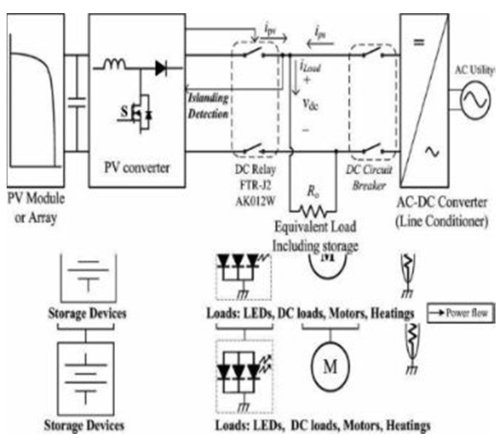
Fig. 4. DC system diagram with PV generation and line conditioner including protection devices.

V. SIMULATION OF NEW ANTI-ISLANDING TECHNIQUE FOR WIND AND SOLAR POWER GENERATION

Simulation diagram of hybrid power system show in figure 5.1 the solar and wind system is used 2 module of solar and 1 module of wind can be used to generate the power.

VI. SIMULATION OF NEW ANTI-ISLANDING TECHNIQUE FOR WIND POWER GENERATION

A simulation diagram shows wind energy conversion system. This uses permanent magnet synchronous motor. Simulation also implements variable wind speed controller and pitch control.



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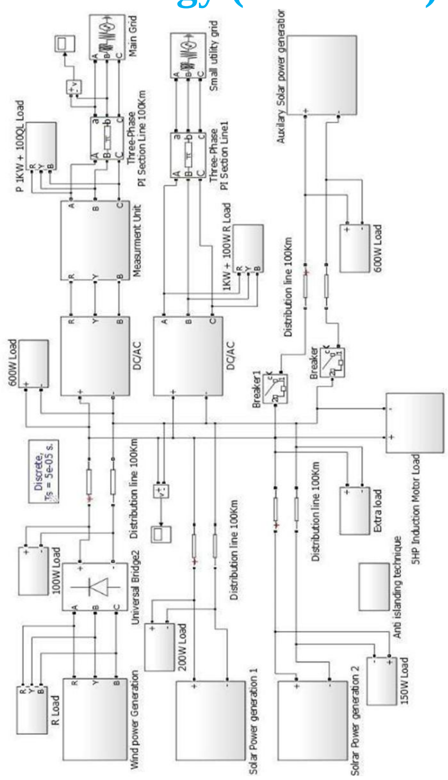

Fig 5.1 simulation diagram for hybrid power system

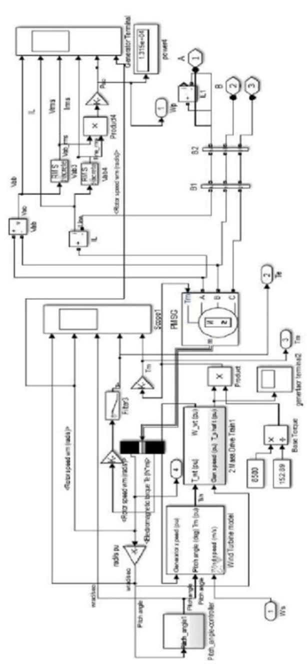
Fig 6.1 simulation for wind power system

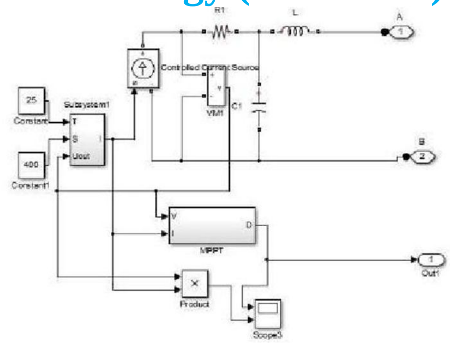

Fig 6.2 Solar Panel

Fig 6.2 shows the simplified equivalent circuit of solar panel. It consists of controlled current source in series with a resistance. It also implements maximum power point tracking control. The input to solar panel is temperate and irradiance.

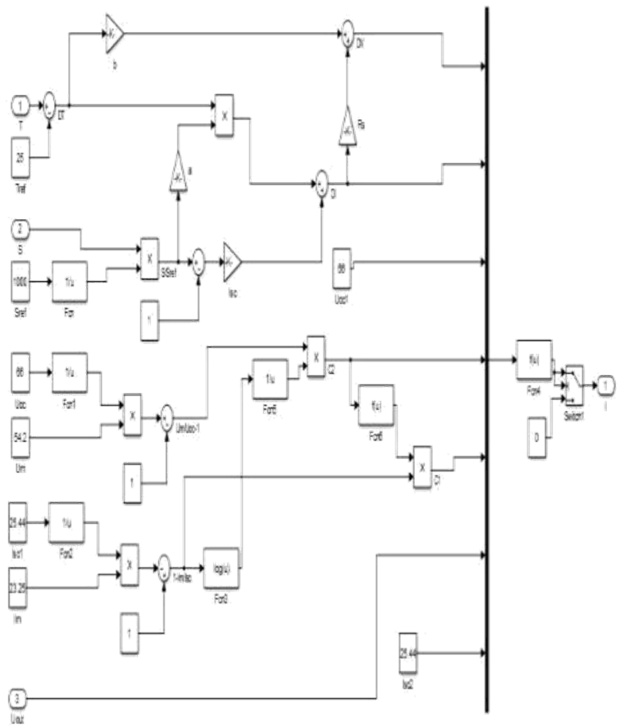

Fig 6.3. solar panel equivalent circuit

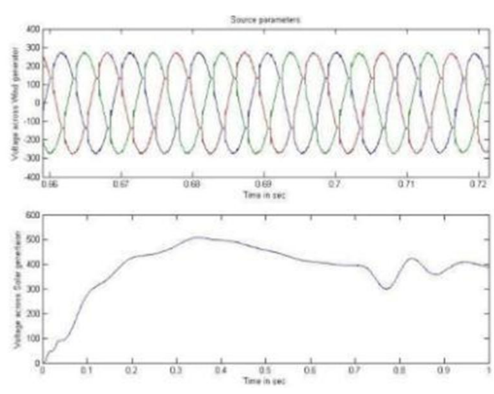

Fig 6.4. input voltage of solar panels

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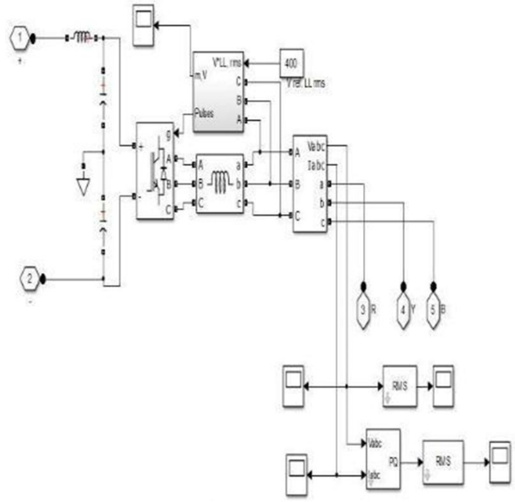


Fig.6.5. simulation of DC-AC converter circuit

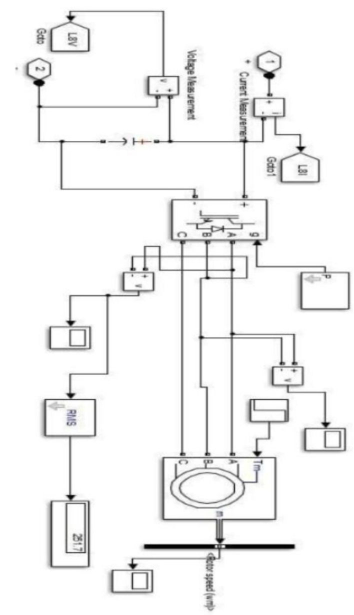
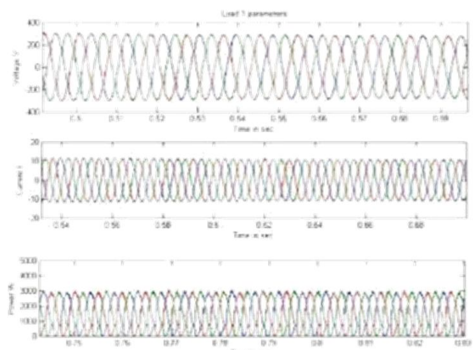


Fig 6.6 Simulation of 5 Hp induction motor circuit



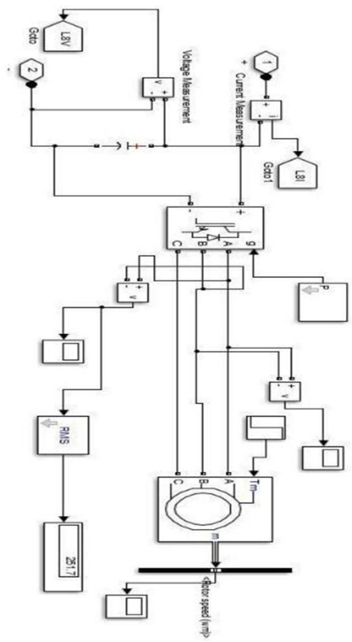


Fig 6.7. output voltage of load 1 circuit

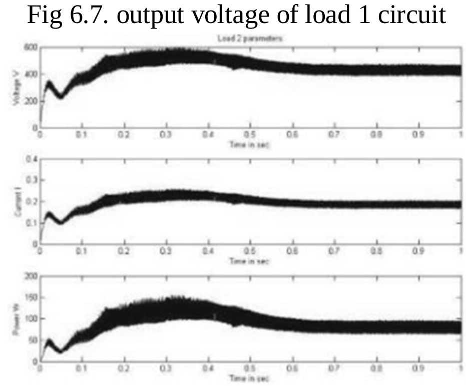


Fig 6.8. output voltage of load 2 circuit

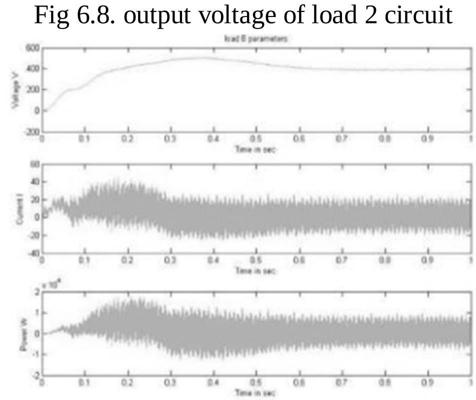


Fig 6.9 output voltage of L8

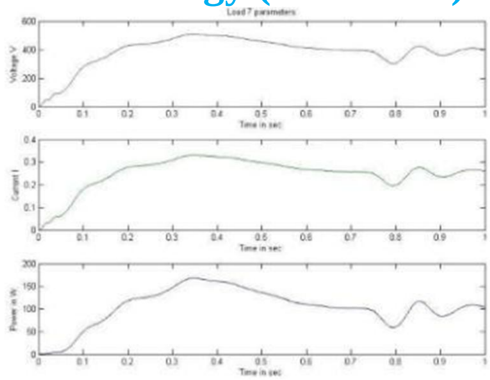


Fig 6.11. output voltage of L7

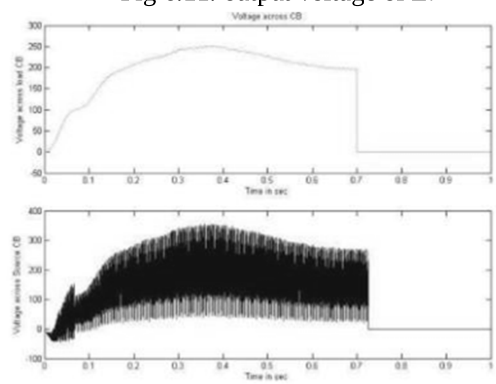


Fig 6.12. output voltage of circuit breaker

VII. CONCLUSION

In this project, a new photo voltaic and wind interface concept for distribution has been proposed and simulated using MATLAB/SIMULINK tool. Utilizing the dc distribution system, electrolytic capacitors can be replaced with film capacitors at the PV dc link, which extends PV product lifetime. Also, dc distribution systems achieve high efficiency with simple dc power converters by eliminating the ac-dc interface. A new anti-islanding algorithm has been proposed for dc systems. In simulation, an additional load is introduced in 0.7 second which makes voltage oscillations. An additional PV power is connected to the grid to balance the grid voltage. The voltage stabilizes at around 0.75 second. The load is uninterrupted. By eliminating electrolytic capacitors in PV and WIND system reliability and system efficiency has been improved reducing the overall cost.

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