www.ijaceeonline.com ISSN: 2456 - 3935

International Journal of Advances in Computer and Electronics Engineering
Volume 4, Issue 9, September 2019, pp. 7–11

Protection Scheme for Photovoltaic Interface in DC Distribution Systems

Rajendran Manivasagam
Associate Professor, Department of Electrical and Electronics Engineering,
K. Ramakrishnan College of Engineering, Tiruchirappalli-621112, Tamil Nadu, India.
Email: manivasagammn3@gmail.com

Abstract: *This manuscript proposes a technique to protect a photovoltaic (PV) generation system interfaced with a DC distribution system from islanding. The efficiency of PV generation system will be enhanced by fully utilized the dc based renewable sources and storage devices while interfacing with DC distribution system. To begin with, the problems on PV interface for dc distribution systems are discussed first for energy efficient and reliable system implementation. Then Direct Current (DC) PV interfaces are mathematically analyzed.*

Keyword: *Anti-islanding; DC distribution system; Injected current perturbation; Islanding; Renewable sources; Storage devices.*

1. INTRODUCTION

In-today's life electricity is compulsory each and every second of our life. The electric power demand is increased continuously hence this problem. According to increasing of power demand need to plan, design and implement the large generation, transmission and distribution [1]-[2].

All the power system tools were designed to survive high effectiveness and to resist worst case situation. It is also having the inbuilt GPS interface due to this software is best for smart grid and smart city applications [3]. Therefore, an engineer is always concerned with effective and cost-effective operation and planning in electric power generation system with interconnected transmission network in the power industry.

Due to this large interconnection network the energy crisis problem will occur in the earth and also continuously increases the cost of the system, the power flow study reduces this type of running charges. These statistics are important for nonstop observing and control of present and future expansion of the power system [4]-[5].

Better economy in power stream estimation; along these lines depend basically on fast and practical PCs and in addition precise and effective PC supported programming. The proposed investigation of intensity stream arrangement additionally can be connected to industry and worldwide utilized [6]-[7].

Therefore, decipher is enormously significant to manage the speed and size. The researchers have studied the load or power flow decipher enormously in last spans. In the electric power system for the design, planning, control and operation at the current time and upcoming forecasting expansion of systems the power study or load flow analysis is essential. The effect of interconnections, add or remove generations, loads, transmission lines, etc. known before the installation gives the top, financial and effectual operation [8]-[9].

The power quality distortion is due to the power electronics devices and solution to this problem is also derived from the same power electronic devices. However, the rising uncertainties in AC system and increasing dynamics and nonlinearity of loads have attracted more attention of engineers/researchers to evolve improved methods. This leads to evolution of universal control technique of compensation having substantially improved transient performance under unbalanced load conditions [10].

Figure 1 and 2 shows the AC and DC distribution systems.

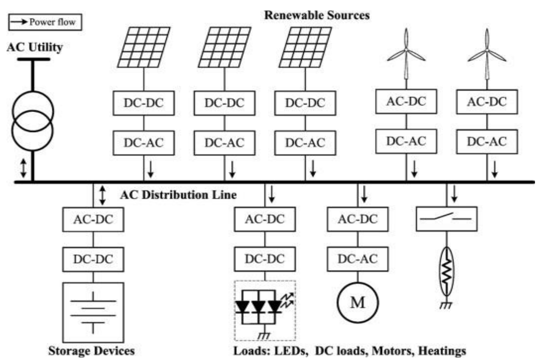


Figure 1 Schematic of AC Distribution [5].

Cite this paper:

Rajendran Manivasagam, "Protection Scheme for Photovoltaic Interface in DC Distribution Systems", International Journal of Advances in Computer and Electronics Engineering, Vol. 4, No. 9, pp. 7-11, September 2019.

ISSN: 2456 - 3935
International Journal of Advances in Computer and Electronics Engineering
Volume 4, Issue 9, September 2019, pp. 7–11

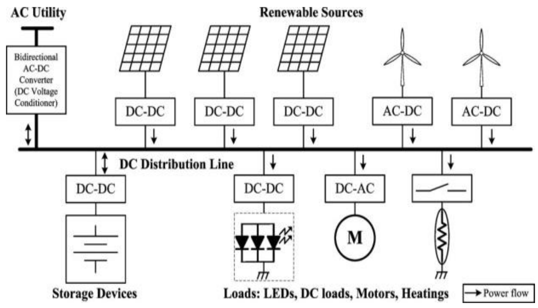


Figure 2 Schematic of DC Distribution. [5]

2. PV GENERATION IN DISTRIBUTION SYSTEMS

2.1 Mathematical Model of PV Module

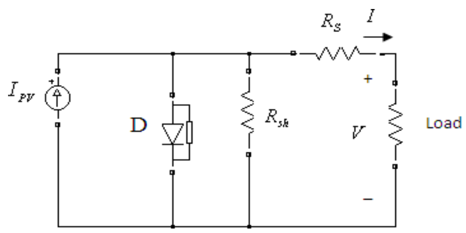


Figure 3 Equivalent circuit of PV cell [3].

The Characteristics equation of Photovoltaic cell is

$$I = I_L - I_d - I_{sh} \quad (1)$$

$$I = I_L - I_D\,[\,eq\,(V + IR_s) / mKT - 1] - I_{sh} \quad (2)$$

The PV cell power is

$$P = V.I \quad (3)$$

The power rating and the maximum voltage of the solar PV panel has shown in the Table II. Using the PV Cell Power equation (3), the rating of the module is proposed.

TABLE I PARAMETERS OF PV MODULE

Parameters	Values
Rs	0.62 Ω
Is	7.244 A
Rsh	250.57 Ω
Voc	44.816 V
Ig	1.13 A
N	1.3
Tc	298

TABLE II RATING OF PV MODULE

Parameters	Values
Power(W)	500 W
Current (A)	10.41 A
Voltage (V)	24 V

$$VL = Vin - Vout \quad (4)$$

Inductance (L) can be calculated by,

$$L = (Vo - Vs)\, Vo/\Delta I\, f\, Vs \quad (5)$$

Where, Vo = Output voltage

Vs = Supply voltage ΔI = Current ripple of the inductor

f = Switching Frequency

Capacitance(C) can be calculated by,

$$C = \Delta I / 8\, \Delta Vsf \quad (6)$$

Where ΔI = Current ripple of the inductor f = Switching Frequency.

ΔVs = Voltage ripple.

The output voltage of the buck converter is calculated as,

$$V o = \alpha\, Vs \quad (7)$$

Where, α= Duty cycle Vo = Output voltage Vs = Supply voltage

TABLE III DESIGN SPECIFICATION OF CONVERTER

Parameters	Values
Vs	44.826 V
V0	24 V
f	50Hz
α	0.53
L	4777 µH
C	5400 µF
R	2.304 Ω

The Table III shows the Specification of the converter, which is derived from the converter design equations (4), (5), (6) and (7).

2.2 DC Distribution Interactive PV Generation System

2.2.1 Rating of Dc Distribution System

Design calculation for DC Grid:
By using the Power equation formula

$$P = V\, I;\ I = P/V \quad (8)$$

TABLE IV PARAMETERS OF DC DISTRIBUTION SYSTEM

Parameters	Values
Power(W)	1KW
Voltage (V)	24V
Current(A)	20.83A

ISSN: 2456 - 3935
International Journal of Advances in Computer and Electronics Engineering
Volume 4, Issue 9, September 2019, pp. 7–11

The Table IV shows the Parameters of DC Distribution system. The values of DC Distribution system are obtained using the Power equation and Ohms law (8), (9).

2.3 Literature Review

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 [1]. In this trend, the research on optimization of the traditional power system by utilizing state-of-the-art power electronics is widely expanding [2]. 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, such as photovoltaics (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 [3].

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 [4] – [5][6]. An analytical evaluation of a variety of data center system architectures is presented in [4], 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 [6].

System performance of dc systems is maximized when the system components, such as dispersed generation sources, storage devices, and loads, are efficiently configured and managed, as shown in numerous studies related to system configuration and control schemes [7] – [8][9][10][11]. Low-voltage bipolar-type dc microgrid for a residential complex is proposed in [7]. Each house can share its generated power with others within the dc system. Minimization of the energy exchanged with the ac utility, using a super capacitor as a storage device, enables the system energy efficiency to be optimized. Issues related to current-controlled bidirectional inverters are discussed in [8], where cost effective approaches are presented for system realization. In addition, several control methods are presented in [9] – [10][11] for dc system operation.

Research on dc system feasibility evaluation has also been widely conducted [12] – [13]. Loss comparison of dc distribution with conventional ac is made based on the system component models in [12] and [13], where an ac and dc hybrid system is also considered. Availability evaluation of dc microgrids is presented considering the system configurations and power converter topologies. Economic feasibility considering replacement and installation cost is discussed.

Based on previous research, it is clear that a dc distribution system is an effective solution considering the increasing use of renewable sources and storage devices with dc preferred loads.

3. NEW ANTI-ISLANDING TECHNIQUE FOR DC PVGENERATION SYSTEM

The ac utility can be well thought-out as an immeasurable source, which means that it is not affect by other system components. Therefore, subsystems can be separately considered and implemented in AC distribution systems. However, it is harder to design dependable systems in DC distribution because all system components are directly connected to the DC link, which is easily exaggerated by their operation. In a traditional system, bidirectional AC-DC converters are engaged to tightly adjust 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 detached from the utility [3]. With the AC-DC converter disabled, the dc distribution voltage must be synchronized by another component or the system should be shut down for protection.

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 falling the energy exchange with the AC utility. For effective DC system operation, several schemes have been proposed [7], [11], [13].

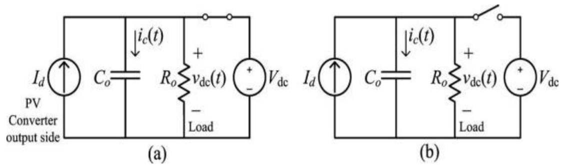


Figure 4 Shows the Equivalent circuits of normal and island conditions. (a) Normal condition. (b) Island condition.[1]

The anti-islanding method may seem to not be necessary, given the utilization of the AC-DC converter and energy buffer interface. However, it is still necessary for system defence. The AC-DC converter and energy buffer interface cannot make correctly in some conditions, such as when the devices are detached from a DC distribution system or renewable sources are islanded by an accident. Therefore, anti-islanding is necessary in DC distribution system for safety and protection. The Fig. 4 Shows the Equivalent circuits of normal and island conditions. (a) Normal condition. (b) Island condition.

4. RESULTS AND DISCUSSION

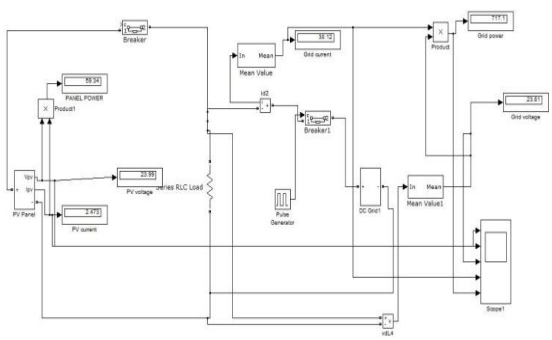
For Grid connected system, the two breakers are getting closed, now the output of the grid current and

ISSN: 2456 - 3935
International Journal of Advances in Computer and Electronics Engineering
Volume 4, Issue 9, September 2019, pp. 7–11

the power will be increasing. The Figure 5 shows the modeling of proposed system setup using MATLAB-Simulink. From the Figure 5 we can observe that, when the DG(Distributed Generation)is connected to the DC grid ,the output of the grid current increases from 20.83A to 30.12A and the power increases from 500 W to 750W .The graph showing the ranges of Grid output current as well as the DC grid power[11]-[12].

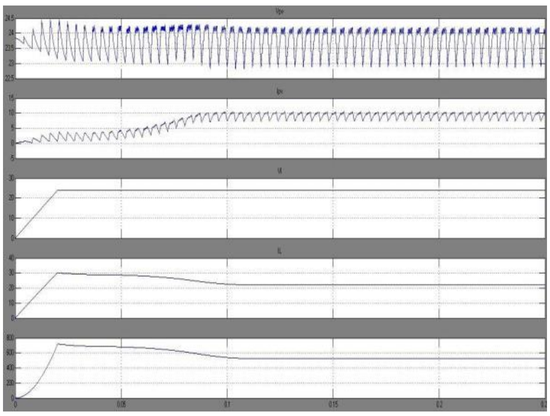
MATLAB is a special app. To generate and correct the practical work the Matlab is flexible. This is model for math fans who are observing for an application that will support them to make equations, tables, graphs. MATLAB is a multiparadigm arithmetical calculating atmosphere and exclusive coding language established by Mathworks. The term MATLAB opinions for matrix work room.

4.1 DC Grid Connected PV System



(a)

Figure 5 Modeling of DC grid connected System. (a) Modeling of Grid connected DG system



(b)

(b) Output waveform for Grid Connected DG system

4.2 Anti-Islanding Scheme

In this operation, distributed generators must detect islanding and to immediately stop producing power. For that we are taking the maximum load current range from the DG system. We know the Maximum load current of DG system as 10.41A. When the load Increases, the load current get increases. Once the load current increase from 10.41A, the DG side breaker makes open and isolate the DG System from the Load to protect the DG System as well as the utility workers.

4.3 Experimental Result Analysis Using Matlab Simulink

TABLE V ISLANDING DETECTION SCHEME

S.No.	Load Utilization in KW	Grid current	PV panel current	Detection time CB2(grid) CB1(panel)
1	300 W	0A	12.5A	0.2ms OFF
2	430 W	0A	17.91A	0.19ms OFF
3	500 W	0A	20.83A	0.187msOFF
4	600 W	0A	25A	0.177msOFF
5	720 W	0A	30A	0.162msOFF
6	800 W	0A	33.33A	0.149msOFF
7	880 W	0A	36.66A	0.11ms OFF
8	1000W	0A	41.6A	0.09ms OFF

TABLE VI ANTI-ISLANDING SCHEME

S.No.	Load Utilisation in KW	Grid current	PV panel current	Detection time CB2(grid) CB1(panel)
1	150W	0A	7.5A	0.2ms OFF
2	200W	0A	8.33A	0.2ms OFF
3	240W	0A	10A	0.2ms OFF
4	300 W	0A	12.5A	0.2ms 0.2ms
5	430 W	0A	17.91A	0.19ms 0.19ms
6	500 W	0A	20.83A	0.187ms0.187ms
7	600 W	0A	25A	0.177ms0.13ms
8	720 W	0A	30A	0.162ms0.12ms
9	800 W	0A	33.33A	0.149ms0.09ms
10	880 W	0A	36.66A	0.11ms 0.06ms
11	1000W	0A	41.6A	0.09ms 0.05ms

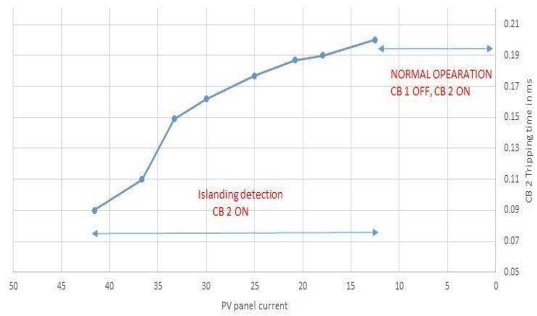


Figure 6 Graphical representation for Islanding detection scheme

Anti-Islanding scheme: In anti-islanding scheme when the fault occurs both CB1 and CB2 is in ON

ISSN: 2456 - 3935
International Journal of Advances in Computer and Electronics Engineering
Volume 4, Issue 9, September 2019, pp. 7–11

condition. From this operation we can obtained a protection over islanding condition. It refers anti islanding scheme. The following data are collected from MATLAB simulink which is shows the islanding detection time, panel current and CB conditions in the Table no VI. In addition, this result analysis shows the graphical representation of islanding detection schemes and Anti Islanding schemes which shows in the Figure 6 and Figure. 7.

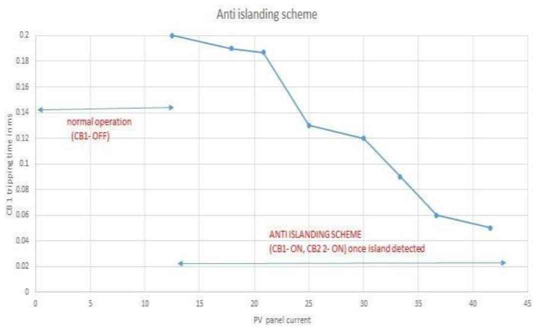


Figure 7 Graphical representation for Anti Islanding detection scheme

5. CONCLUSIONS

Here a PV interface concept for dc distribution has been projected. As well, DC distribution systems to attain high efficiency with simple DC power converters by eliminating the AC-DC interface. Islanding recognition is a key necessity for DC distribution systems to make certain protection and safety. An anti-islanding algorithm has been projected for DC systems. Based on examination, the controls parameters can be designed to assurance detection time and maintain the system efficiency. A prototype converter was executed using MATLAB Simulink and results were discussed with graphical representation.

REFERENCES

[1] D. Boroyevich, I. Cvetkovic, D. Dong, R. Burgos, F. Wang, and F. Lee, (May 2010) "Future electronic power distribution systems a contemplative view," inProc. *IEEE Int. Conf. Optim. Electr. Electron. Equip.*,pp. 1369–1380.

[2] D. Salomonsson, L. Soder, and A. Sannino, (Nov./Dec. 2008) "An adaptive control system for a DC microgrid for data centers," *IEEE Trans. Ind. Appl.*, vol. 44, no. 6, pp. 1910–1917.

[3] F. Blaabjerg, Z. Chen, and S. B. Kjaer, (Sep. 2004) "Power electronics as efficient interface in dispersed power generation systems," *IEEE Trans. PowerElectron.*, vol. 19, no. 5, pp. 1184–1194.

[4] H. Kakigano, Y. Miura, and T. Ise, (Dec. 2010) "Low-voltage bipolar-type DC microgrid for super high-quality distribution," *IEEE Trans. Power Electron.*, vol. 25, no. 12, pp. 3066–3075.

[5] J.M. Guerrero, F. Blaabjerg, T. Zhelev, K. Hemmes, E. Monmasson, S. Jemei,M. P. Comech, R. Granadino, and J. I. Frau, (Mar. 2010) "Distributed generation:SEOet al.: NEW DC ANTI-islanding technique of electrolytic capacitor-less photovoltaic interface 1641 Toward a new energy paradigm," *IEEE Ind. Electron. Mag.*, vol. 4, no. 1, pp. 52–64.

[6] K. Hirose, (May/Jun. 2011) "DC power demonstrations in Japan," *in Proc. IEEE Int. Conf. Power Electron. -ECCC Asia*,pp. 242– 247.

[7] Pratt, P. Kumar, and T. V. Aldridge, (Sep./Oct. 2007) "Evaluation of 400V DC distribution in telco and datacenters to improve energy efficiency," in Proc. IEEE Int. Telecommun. *Energy Conf.* pp. 32–39.

[8] R.Manivasagam & D Aarthi (2017)"Design of UPFC using Ten Switch Converter with Switch Reduction", International Journal for Scientific Research & Development,vol.5,Issue.4, pp. 490-493.

[9] R.Manivasagam, Raghavi,R (2015)"Modeling of a Grid Connected New Energy Vehicle Charging Station" International Journal of Applied Engineering Research (IJAER), Volume 10, Number 20, Special Issues, pp. 15870-15875.

[10] R.Manivasagam, Dharmalingam, Velayutham (2014) "Power Quality Problem Mitigation by Unified Power Quality Conditioner: An Adaptive Hysteresis Control Technique", International Journal of Power Electronics(IJPE), Volume 6, No.4, pp. 403-425.

[11] T.-F. Wu, K.-H. Sun, C.-L. Kuo, and C.-H. Chang, (2010) "Predictive current controlled 5-kW single-phase bidirectional inverter with wide inductance variation for DC-microgrid applications," *IEEE Trans. Power Electron.*, vol. 25, no. 12, pp. 3076–3084.

[12] Y.-C. Chang and C.-M. Liaw, (2011) "Establishment of a switched-reluctance generator-based common DC microgrid system," *IEEE Trans. Power Electron.*, vol. 26, no. 9, pp. 2512–2527.

[13] Gab-su seo, Kyu-Chan Lee, Bo-Hyung Cho (2013) "A New DC Anti-Islanding Technique of Electrolytic Capacitor-less Photovoltaic Interface in DC Distribution systems," *IEEE Trans. Power Electron.*, vol. 28, no. 4, pp. 1632–1641.

Author Biography

Rajendran Manivasagam obtained his Bachelor of Engineering in Electrical and Electronics Engineering from Bharathidasan University, Tiruchirappalli, obtained his Master of Engineering in Power Electronics and Drives from Anna University, Coimbatore and obtained his Doctor of Philosophy (Ph.D.,) in Electrical Engineering from Anna University, Chennai. Currently, he is an Associate Professor in the Department of Electrical and Electronics Engineering at K. Ramakrishnan College of Engineering, Samayapuram, Tiruchirappalli – 621 112. He has teaching experience of over 14 years and has presented papers in various national and international conferences. His research interests are in power quality improvement using unified power quality conditioner.

Cite this paper:

Rajendran Manivasagam, "Protection Scheme for Photovoltaic Interface in DC Distribution Systems", International Journal of Advances in Computer and Electronics Engineering, Vol. 4, No. 9, pp. 7-11, September 2019.