Voltage Stability Analysis and Harmonic Mitigation In Hybrid Micro grid Using DSTATCOM

Namrata Jain[1], Simardeep Kaur[2]

[1] *M.tech scholar, Department of Electrical and Electronics Engineering, Shri Shankaracharya Technical Campus Junwani, Bhilai*

[2] *Assistant Professor, Department of Electrical Engineering, Shri Shankaracharya Technical Campus Junwani, Bhilai*

---***---

Abstract -Due to the variability of electricity output, boosting solar energy adoption might be a big issue in the current environment. Energy storage systems are one approach for enhance the effectiveness of power supply and ensuring system stability . A photovoltaic (PV), generator, and energy storage system are built in this research, and synchronized management is proposed to regulate the power as per the load demand with D-STATCOM and without DSTATCOM Additionally, bi - directional converters link the AC-DC networks. . If the AC micro grid is unable to meet the reactive power demand, the distributed static synchronous compensator (D-STATCOM) is employed to compensate. A DC-DC Enhance converter is used to boost the voltage level from the photovoltaic (PV)farm and send it to the DC-bus. The system is evaluated with a varying loads connected to the AC-side, such as an inductive, pulse, or non-linear load. The suggested topology is validated using MATLAB R2017b simulations for energy monitoring between two AC and DC sides with excellent efficiency, dependability, and resilience.

Key Words: Hybrid micro grid, PV system, ESS, D-STATCOM, THD

1.INTRODUCTION

Renewable energy generation, such as photovoltaic (PV) and wind generating, is quickly gaining traction. The Hybrid micro grid idea [1] comprises a distributed control method, voltage, power, and energy management, as well as solar energy, energy storage, and critical load. By regulating the active and reactive power flow between the AC and DC sides, a reversible AC-DC inverter is utilised to link them. The voltage profile and transient responsiveness are improved using a novel synchronized voltage control technique with reactive power management scheme (RPMS) [2]. Because of the rising load demand, as well as the need for cost savings and increased dependability.

It is important to be aware of the hybrid power system's improved power quality, which is compensated by DSTATCOM. A hybrid AC/DC model [3] has been proposed to decrease multiple conversion loss while also compensating for active (P) and reactive power (Q) issues. One of the most serious problems with any hybrid micro grid [4]. Power quality deterioration that can be mitigated by employing a shunt active power filter. Because of the problems posed by contamination, the utilisation of renewable energy sources for energy production is becoming extremely prevalent.

A few of the areas where photovoltaic (PV) cells are becoming more prevalent is in electronic circuits. An whole new type of innovation.[5] that may be used to substitute the present inverter in a small and medium magnetic field wind generator (10KW to 20KW) and provide dynamic VAR control and power factor adjustment. The suggested power management framework is focused on the voltage sag and the power flowing in the line. It is known as the D- STATCOM inverter, and it can offer grid with VAR regulation and power factor correction. Although distributed generators (DG) produce “Maximum available active power”, the three-phase D-STATCOM [6] substitutes for the reactive power shortage in the phase.

Non-linear demands, like transformers, computers, saturation coils, and complex power electronics devices, are now being incorporated into distribution networks [7]. Power electronics devices produce undesirable overtones in the system due to their non-linear features and rapid switching action. It creates a slew of issues, including low system efficiency and a low power factor. It also has an impact on other customers. As a result, overcoming these negative characteristics is critical. D-STATCOM uses a shunt active filter to reduce harmonics [8].

The suggested technique controls reactive power from micro grids to reduce voltage changes caused by active power from the hybrid micro grid, while concurrently activating D-STATCOM to decrease distortions from renewable power producers and STATCOM integration [9]. The use of an energy storage unit can help to improve the network efficiency. The active power filter (APF) [10] in the D-STATCOM, on the other hand, reduces the high voltage stress over each power cord. The tolerance of the supervisory controller is used in the AC/DC micro grid to meet the demand for electricity while maximising the use of renewable resources [11].

Furthermore, the entire control scheme incorporates the suggested power management system's tolerance for energy storage system failure in hybrid micro grids. Customers' power demands may be met at any cost by the presence of both AC and DC micro grids [12]. As a result, the research provides an overview of power management techniques for a hybrid AC/DC micro grid system [13], which takes into account a variety of loading circumstances.

2. Modeling of Hybrid Micro grid

The term "micro grid" refers to a grouping of loads and micro sources that work together as a single, controlled system to deliver electricity and heat to a specific region. This concept introduces a new framework for defining distributed generating operations. The micro grid may be conceived of as a controlled cell of the electricity system by the utility. This cell, for instance, may be measured as a singular dispatchable

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 06 | June - 2021 ISSN: 2582-3930

load that can respond in seconds to fulfill the transmission required functionality.

The microgrid can be designed to satisfy the customer's specific needs, such as improved local dependability, reduced feeder inefficiencies, local voltage support, enhanced efficiency through the utilization of waste heat, and voltage sag correction [14]. The major goal of this idea is to hasten the identification of small - scale distributed generators' advantages, such as the capacity to deliver waste heat when it is needed [15]. If micro generation and loads are properly and intelligently coordinated, the micro grid or distribution network subsystem will cause less problems to the utility grid than traditional microgrids [16].

Microgrid is regarded as a "grid compatible unit" that has no negative effects on the linked distribution network, i.e. the distribution grid's management policy does not need to be changed.

2.1 CONFIGURATIONS OF HYBRID MICRO GRIDS

Figure 1 depicts the hybrid system's setup, which includes various AC and DC supplies and demands coupled to the appropriate AC and DC networks. The hybrid grid's AC bus is connected to the utility grid.

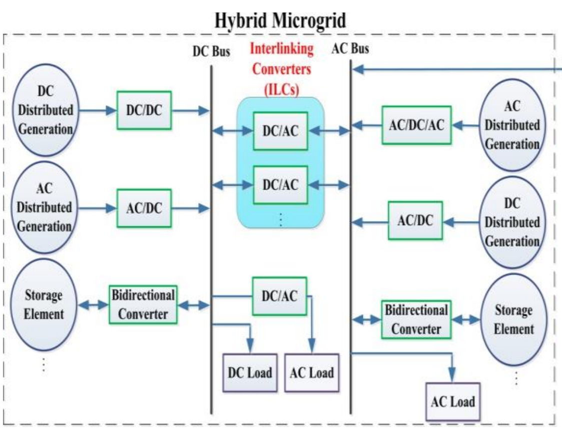

Fig -1: AC/DC Hybrid Micro grid

This configuration have different loads which are inductive load, pulse load and non linear load connected with the hybrid microgrid. The synchronous reference frame theory is used as a control algorithm. This combination is shown in fig (2).

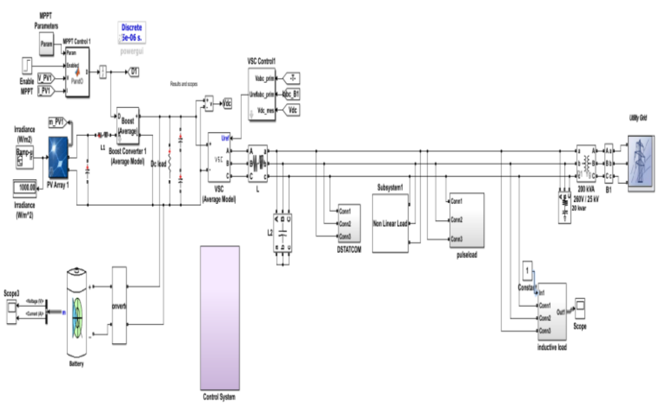

Fig -2: Simulink Model of Hybrid Microgrid with different loads

STATCOM as a FACTS device is connected in the system which provides the necessary compensation.

3 CONTROL STRATEGIES

There are different control strategies which aids in the generation of gating pulses for inverter action. The control strategy aims at the compensated current should be sinusoidal and balanced. Thus the control strategy objective includes the generation of sinusoidal and balanced reference current for the generation of switching pulses of the inverter [8]. Synchronous Reference Frame Theory is proposed in this research.

The block diagram of synchronous reference frame theory is shown in fig(3).

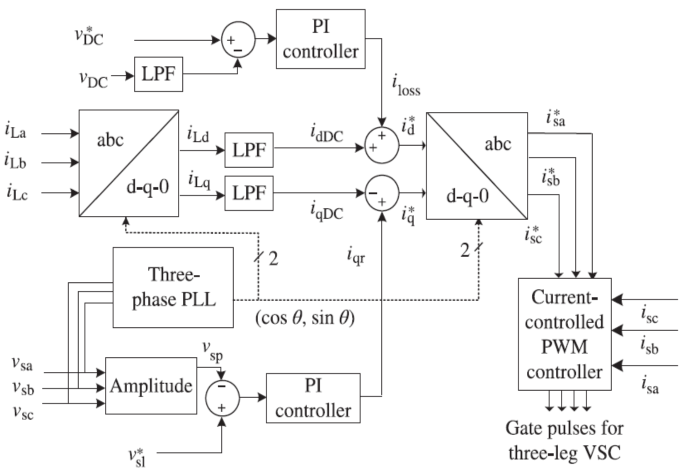

Fig -3: Block diagram of SRF based control algorithm of DSTATCOM

The load currents (i_{La}, i_{Lb}, i_{Lc}), PCC voltages (vsa, vsb, vsc), and DC bus voltage (V_{dc}) of the DSTATCOM are sensed as feedback signals. The load currents in the three phases are converted into the dq0 frame using the Park's transformation as follows:

$$\begin{pmatrix} i_{Ld} \\ i_{Lq} \\ i_{L0} \end{pmatrix} = \frac{2}{3} \begin{pmatrix} \cos\theta & -\sin\theta & \frac{1}{2} \\ \cos(\theta - \frac{2\pi}{3}) & -\sin(\theta - \frac{2\pi}{3}) & \frac{1}{2} \\ \cos(\theta + \frac{2\pi}{3}) & \sin(\theta + \frac{2\pi}{3}) & \frac{1}{2} \end{pmatrix} \begin{pmatrix} i_{La} \\ i_{Lb} \\ i_{Lc} \end{pmatrix}$$

A SRF controller extracts DC quantities by a LPF and hence the non-DC quantities are separated from the reference signals. The reference source current must be in phase with the voltage at PCC but with no zero-sequence component. It is therefore obtain-ed by the following reverse Park's transformation,

$$\begin{pmatrix} i_{sa}^* \\ i_{sb}^* \\ i_{sc}^* \end{pmatrix} = \frac{2}{3}\begin{pmatrix} \cos\theta & \sin\theta & \\ \cos\left(\theta-\frac{2\pi}{3}\right) & \sin\left(\theta-\frac{2\pi}{3}\right) & 1 \\ \cos\left(\theta+\frac{2\pi}{3}\right) & \sin\left(\theta+\frac{2\pi}{3}\right) & 1 \end{pmatrix}\begin{pmatrix} i_d^* \\ i_q^* \\ i_0^* \end{pmatrix}$$

Reference supply quadrature supply voltage:-

$i_q^* = i_{qr} + i_{qDC}$

Three-phase reference supply currents are obtained by reverse Park's transformation.

4. SIMULATION RESULTS

Three different loads are connected to the grid system and are simulated using MATLAB simulation and the results are compared. The various design parameters for the system are as follows:-

Symbol	Description	Value
CPV	Solar panel capacitor	100µF
LPV	Inductor for solar panel boost converter	5mH
Lac	AC filter inductor	1.2mH
Rac	Inverter equivalent resistance	0.003Ω
Lb	Battery converter inductor	3.3mH
Rb	Resistance of Lb	0.5Ω
f	Rated AC grid frequency	50Hz
Vd	Rated DC bus voltage	200V

4.1 Variation of loading condition without DSTATCOM

The power performance of the system is computed by calculating various sorts of loads to the hybrid microgrid.

4.1.1 No load condition grid output voltage and current

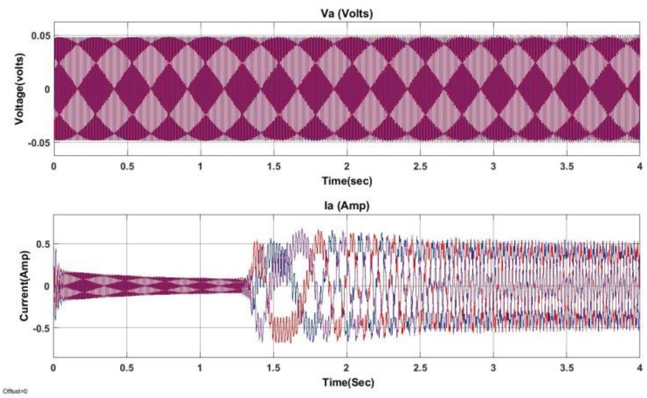

Fig -4: Grid voltage and current without any load

Fig 5 shows the grid voltage and current when inductive load is connected

4.1.2 Inductive load condition grid output voltage and current

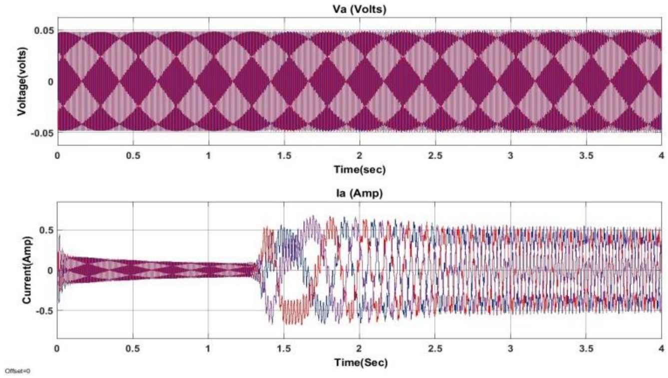

Fig -5: Grid voltage and current with inductive load

4.1.3 Inductive and Pulse load condition grid output voltage and current

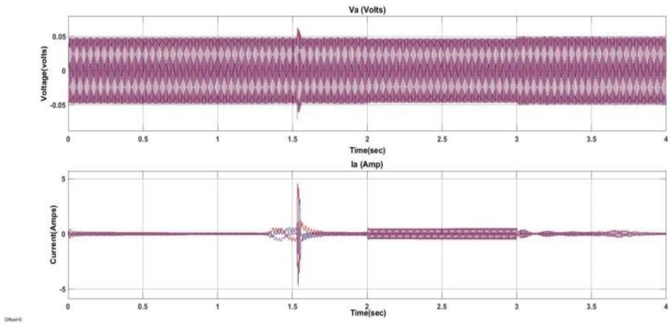

Fig -6: Grid voltage and current with inductive and pulse load

4.1.4 Inductive, Pulse and non linear load condition grid output voltage and current

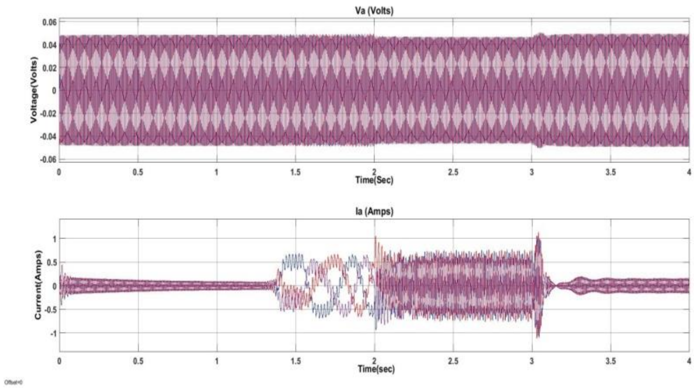

Fig -7: Grid voltage and current with inductive, pulse and non linear load

The above are graphs for different loads connected to the grid when they are not provided with any compensation. The current harmonics without compensation when inductive, pulse and non linear loads are connected is 31.94%.
Now in the following sections the graphs for different loads with compensation is shown.

4.2 Variation of loading condition with DSTATCOM

The power performance of the system is computed by calculating various sorts of loads to the hybrid microgrid.

4.2.1 No load condition grid output voltage and current

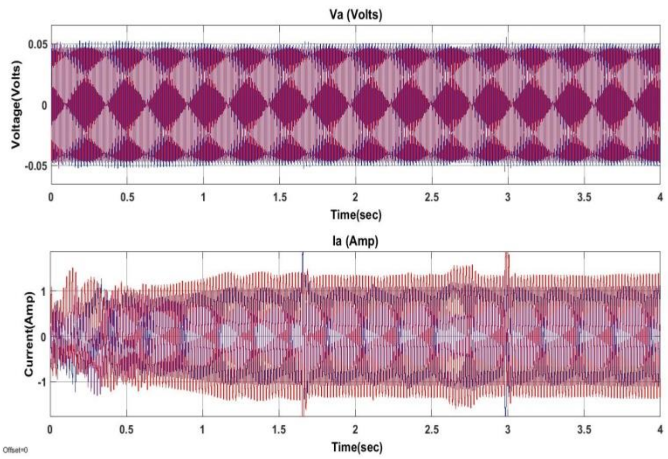

Fig -8: Grid voltage and current with no load

4.2.2 Inductive load condition grid output voltage and current

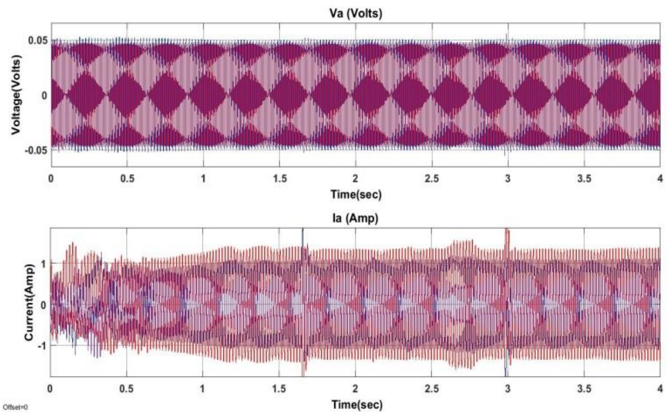

Fig -9: Grid voltage and current with inductive load

4.2.3 Inductive and Pulse load condition grid output voltage and current

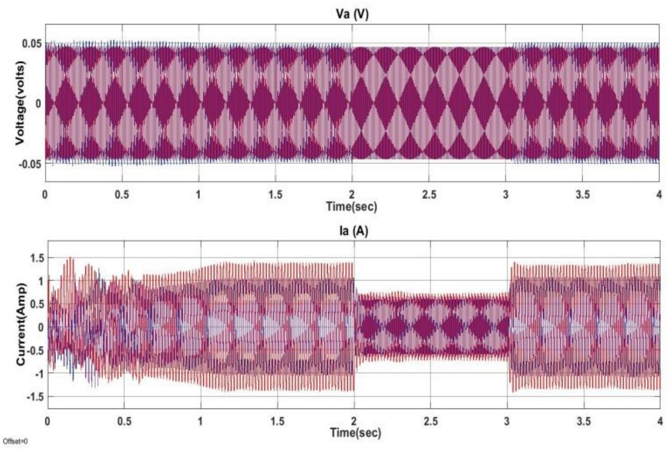

Fig -10: Grid voltage and current with inductive and pulse load

4.1.4 Inductive, Pulse and non linear load condition grid output voltage and current

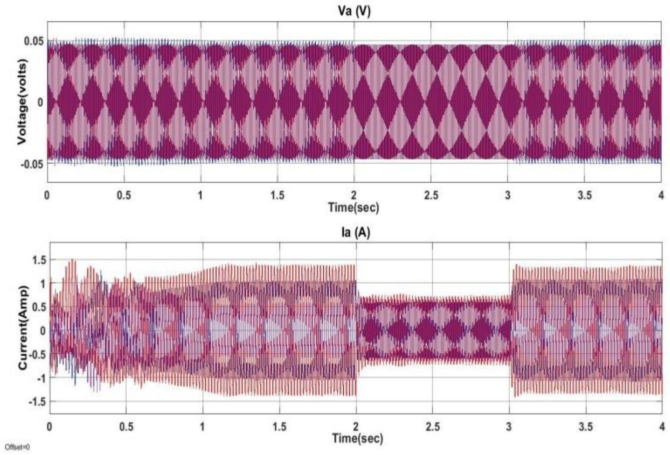

Fig -11: Grid voltage and current with inductive, pulse and non linear load

The above are graphs for different loads connected to the grid when they are not provided with DSTATCOM compensation. The current harmonics without compensation when inductive, pulse and non linear loads are connected is 3.08%.

Table -1: Comparison of variation in voltage harmonics for different types of load

Loads	%THD(Voltage)	
	Without DSTATCOM	**With DSTATCOM**
At No Load	2.93%	0.75%
At Inductive Load	2.93%	0.75%
At Inductive and Pulse Load	2.54%	0.60%
At Inductive, Pulse and Non linear Loads	0.88%	0.47%

The comparative analysis of different loads connected to the grid is shown in table 1. The comparison is done on the basis of %THD(voltage) of different loads with compensation and without compensation.

The comparative analysis of different loads connected to the grid is shown in table 2. The comparison is done on the basis of %THD(current) when inductive, pulse and nonlinear loads are connected to the grid with compensation and without compensation of DSTATCOM.

Table -2: Comparison of variation in current harmonics for different types of load

%THD(Current)	At Inductive, Pulse and Non linear Loads
Without DSTATCOM	31.94%
With DSTATCOM	3.08%

5. CONCLUSIONS

A coordinated power flow among AC/DC and vice versa is presented in this article. The average percent THD value is dramatically decreased from 31.94 percent to 3.08 percent when the percentage of harmonic distortion (THD) is determined. Bidirectional AC/DC inverters manage the ac side voltage amplitude and frequency by taking into account various loading situations. To meet the load requirement, a FACTS control device, DSTATCOM, is used to balance active and reactive power. On the AC side of the hybrid (AC/DC) system, a DSTATCOM is attached to adjust for the power.

REFERENCES

[1] Chamana, M.; Bayne, S.B., "Modeling and control of directly connected and inverter interfaced sources in a microgrid," in North American Power Symposium (NAPS), 2011, vol., no., pp.1-7, 4-6 Aug. 2011.

[2] Tan Ma, Brandy Serrano, Osama Mohammed, “Distributed Control of Hybrid AC-DC Micro grid with Solar Energy, Energy Storage and Critical load”, IEEE Power Systems Conference (PSC), 11-14 March 2014.

[3] Khaled A Alobeidli, Mazheruddin H. Syed, Mohmed Shawky El Moursi, Hatem. H. Zeineldin, “ Noval Coordinated Volatge Control for Hybrid Micro-grid with Islanding Capability”, IEEE Power & Energy Society General Meeting, 26-30 July 2015.

[4] Sandipan Patra, “Power Quality Improvement in Fuel Cell Based Hybrid Power System using STATCOM”, Student Journal of Energy Research: Vol. 1: No. 1, Article 1.

[5] Irani Majumder, Rajender Sarangi, Basab Roy, Sidharth Samantra, Renu Sharma, “Reactive Power Compensation in a Hybrid Micro-grid using Shunt Active Power Filter”, “2015 IEEE Power, Communication and Information Technology Conference (PCITIC) Siksha „O" Anusandhan University, Bhubaneswar, India.

[6] Vijay Kumar K, Md Ershad Ali, “Dstatcom Based Power Quality Improvement Of Microgrid”, International Journal of Professional Engineering Studies (IJPRES) , Volume 4/Issue 1/SEP2014

[7] Rajeswari, Prof. Nagabhushan Patil, “D-STATCOM for Reactive Power Compensation”, International Journal of Electrical and Electronics Research”, Vol. 3, Issue 3, pp: (111-118), Month: July-September 2015

[8] Sateesh Kumar Adepu, R. Usha Sree, G. Manideep, “Power Quality Improvement In Microgrid Distribution System Using Apf With Pi Controller”, International Journal of Electrical and Electronics Engineers”, Vol. No.8, Issue 01, January-June 2016.

[9] Hitromo Miura, Guohong Wu, “Voltage stabilization of distribution system integrated by renewable power generations by cooperated control of STATCOM and interconnecting microgrids” International Journal of Smart Grid and Clean Energy, Manuscript received May 24, 2013; revised July 29, 2013

[10] Arindam Chakraborty, Shravana K. Musunuri, Anurag K. Srivastava, Anil K. Kondabathini, “Integrating STATCOM and Battery Energy Storage System for Power System Transient Stability: A Review and Application”, Hindawi Publishing Corporation, Advances in Power Electronics, Volume 2012, Article ID 676010.

[11] Lei Wang, Chi-Seng Lam, Man-Chung Wong, “A Hybrid-STATCOM With Wide Compensation Range and Low DC-Link Volatge”, IEEE Transactions on industrial Electronics, Vol. 63, No. 6, June 2016

[12] Mehdi Hossesinzadesh, Farzad Rajaei Salmasi, “Fault-Tolerant Supervisory Controller for a Hybrid AC/DC Micro-Grid”, IEEE Transactions on smart grid,

[13] Peng Wang, Chi Jin, Dexuan Zhu, Yi Tang, Poh Chiang Loh, Fook Hoong Choo, “Distributed Control for Autonomous Operation of a Three-Port AC/DC/DS Hybrid Microgrid”, IEEE Transactons on industrial electronics, Vol. 62, No. 2, February 2015.