International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 1 Issue 8, October - 2012

Power Conditioning Of Microgrid by Using a Fast-Acting Dc-Link Voltage Controller for 3-Phase D-Statcom

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ABSTRACT:-

Microgrids are systems with clusters of micro generators, which are installed for distributed power generation. When interfaced to the utility grid, microgrids are exposed to common utility power-quality disturbances. The paper focuses on the combination of wind, FC and for sustained power generation. We propose herein a dynamic model, design and simulation of a wind/FC/ hybrid power generation system with power flow controllers.

This paper presents a novel D-Statcom configuration for voltage quality improvement in MICRO GRID. The transient response of the distribution static compensator (DSTATCOM) is very important while compensating rapidly varying unbalanced and nonlinear loads. Any change in the load affects the dc-link voltage directly. The sudden removal of load would result in an increase in the dc-link voltage above the reference value, whereas a sudden increase in load would reduce the dc-link voltage below its reference value. The proper operation of DSTATCOM requires variation of the dc-link voltage within the prescribed limits .Conventionally, a proportional-integral (PI) controller is used to maintain the dc-link voltage to the reference value. It uses deviation of the capacitor voltage from its reference value as its input. However, the transient response of the conventional PI dc-link voltage controller is slow. In this paper, a fast-acting dc-link voltage controller based on the energy of a dc-link capacitor is proposed

I. INTRODUCTION

This white paper proposes that the significant potential of smaller DER (< 100 kW/unit) to meet customers' and utilities' needs can be best captured by organizing these resources into MicroGrids1. MicroGrids are envisioned as clusters of generators (including heat recovery), storage, and loads that are operated as single controllable systems. MicroGrids can operate both connected to and synchronized with the utility distribution grid and in isolation from the utility distribution grid (as an "island").

Power quality problems like voltage sag, voltage swell and harmonic are major concern of the industrial and commercial electrical consumers due to enormous loss in terms of time and money. Due to the increasing complexity in the power system, voltage sags are now becoming one of the most significant power quality problems and deserves attention. Voltage sag is defined as a momentary decrease in voltage rms value between 10% to 90% of the nominal voltage level, for duration of half a cycle to one minute. A power quality study done recently indicates that 92 % of all disturbances in a power system are caused by voltage sags [1].

Therefore, these adverse effects of voltage changes necessitate the existence of effective mitigating devices. There are various solutions to these problems. The shunt-connected custom power device, called the distribution static compensator (DSTATCOM), injects current at the point of common coupling (PCC) so that harmonic filtering, power factor correction, and load balancing can be achieved. The DSTATCOM consists of a current-controlled voltage-source inverter (VSI) which injects current at the PCC through the interface inductor. The operation of VSI is supported by a dc storage capacitor with proper dc voltage across it.

One important aspect of the compensation is the extraction of reference currents. Various control algorithms are available in literature [7]–[11] to compute the reference compensator currents.

However, due to the simplicity in formulation and no confusion regarding the definition of powers, the control algorithm based on instantaneous symmetrical component theory [11] is preferred. Based on this algorithm, the compensator reference currents (i^*_{fa},i^*_{fb},i^*_{fc}) are given as follows:

$$\begin{aligned} i^*_{fa} &= i_{ta} - \frac{v_{sa}+\gamma(v_{sb}-v_{sc})}{\sum_{i=a,b,c} v_{si}^2}(P_{lavg} + P_{dc}) \\ i^*_{fb} &= i_{tb} - \frac{v_{sb}+\gamma(v_{sc}-v_{sa})}{\sum_{i=a,b,c} v_{si}^2}(P_{lavg} + P_{dc}) \qquad (1) \\ i^*_{fc} &= i_{tc} - \frac{v_{sc}+\gamma(v_{sa}-v_{sb})}{\sum_{i=a,b,c} v_{si}^2}(P_{lavg} + P_{dc}) \end{aligned}$$

where $\gamma = \tan\phi/\sqrt{3}$ is the desired phase angle between the supply voltages and compensated source currents in the respective phases. For unity power factor operation, $\phi = 0$, thus $\gamma = 0$. The term P_{lavg} is the dc or average value of the load power. The term Pdc in (1) accounts for the losses in the VSI without any dc loads in its dc link. To generate, a suitable closed-loop dc-link voltage controller should be used, which will regulate the dc voltage to the reference value.

For the DSTATCOM compensating unbalanced and nonlinear loads, the transient performance of the compensator is decided by the computation time of average load power and losses in the compensator. In most DSTATCOM applications, losses in the VSI are a fraction of the average load power.

Therefore, the transient performance of the compensator mostly depends on the computation of Plavg. In this paper, Plavg is computed by using a moving average filter (MAF) to ensure fast dynamic response. The settling time of the MAF is a half-cycle period in case of odd harmonics and one cycle period in case of even harmonics presence in voltages and currents. Although the computation of is Pdc generally slow and updated once or twice in a cycle, being a small value compared to Plavg, it does not play a significant role in transient performance of the compensator.

In some of the electric power consumers, such as the telecommunications industry, power-electronics drive applications, etc., there is a requirement for ac as well as dc loads [12]–[15]. The telecommunication industry uses several parallel-connected switch-mode rectifiers to support dc bus voltage. Such an arrangement draws nonlinear load currents from the utility. This causes poor power factor and, hence, more losses and less efficiency. Clearly, there are PQ issues, such as unbalance, poor power factor, and harmonics produced by telecom equipment in power distribution networks. Therefore, the functionalities of the conventional DSTATCOM should be increased to mitigate the aforementioned PQ problems and to supply the dc loads from its dc link as well. The load sharing by the ac and dc bus depends upon the design and the rating of the VSI. This DSTATCOM differs from conventional one in the sense that its dc link not only supports instantaneous compensation but also supplies dc loads.

However, when the dc link of the DSTATCOM supplies the dc load as well, the corresponding dc power is comparable to the average load power and, hence, plays a major role in the transient response of the compensator. Hence, there are two important issues. The first one is the regulation of the dc-link voltage within prescribed limits under transient load conditions. The second one is the settling time of the dc–link voltage controller. Conventionally, a PI controller is used to maintain the dc-link voltage. It uses the deviation of the capacitor voltage from its reference value as its input. However, the transient response of the conventional dc-link voltage controllers is slow, especially in applications where the load changes rapidly. Some work related to dc-link voltage controllers and their stability is reported in [16]–[20]. However, the work is limited to rectifier units where switching patterns are well defined and analysis can be easily carried out. In this paper, a fast-acting dc-link voltage controller based on the dc-link capacitor energy is proposed. The detailed modeling, simulation, is given to prove the efficacy of this fast-acting dc-link voltage controller. There is no systematic procedure to design the gains of the conventional PI controller used to regulate the dc-link voltage of the DSTATCOM. Herewith, mathematical equations are given to design the gains of the conventional controller based on the fast-acting dc-link voltage controllers to achieve similar fast transient response.

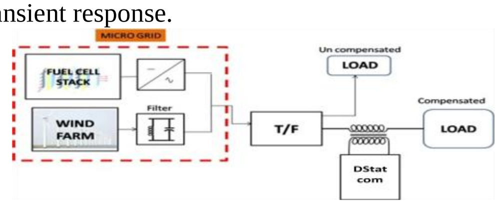

Figure 1: Block diagram of the µgrid with D-Statcom to Load

II Designe of Microgrid

A.Wind Turbine: In this paper the modelling of wind turbine is described. The three bladed rotor is the most important and most visible part of the wind turbine. It is through the rotor that the energy of the wind is transformed into mechanical energy that turns the main shaft of the wind turbine.

B.Fuel Cell: Fuel cells convert the chemical energy of a fuel and an oxidant directly into electrical energy and heat using electrochemical processes—not combustion. Sir William Grove invented the first fuel cell in 1839. Grove knew that water could be split into hydrogen and oxygen by sending an electric current through it (a process called electrolysis). Perhaps the simplest system, a Proton Exchange Membrane Fuel Cell (PEMFC), combines hydrogen fuel with oxygen from the air to produce electricity, water, and heat. A Basic Proton Exchange Membrane Fuel Cell consists of 3 components: an anode (a negative electrode that repels electrons), an electrolyte in the center, and a cathode (a positive electrode that attracts electrons).As hydrogen flows into the fuel cell anode, a catalyst, often a platinum coating on the anode helps to separate the gas into protons (hydrogen ions) and electrons.

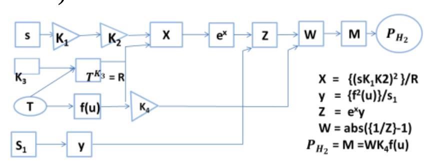

Figure2: Block Diagram of formation of Anode(H_2) of PEMFC

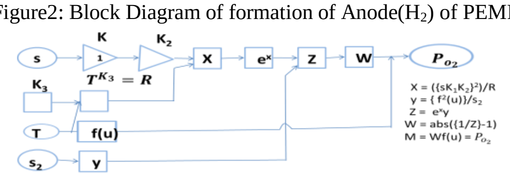

Figure 3: Block diagram of formation of Cathode(O_2) of PEMFC

The PEMFC has a high power density and a relatively low operating temperature (ranging from 60 to 80 degrees Celsius, or 140 to 176 degrees Fahrenheit). The low operating temperature means that it doesn't take very long for the fuel cell to warm up and begin generating electricity.

Fuel Cell Performance Parameters:-Fuel cell performance is affected by design parameters such as cell size, power level, cost and by operating variables such as temperature, pressure, fuel composition andcurrent density.

$$E = E^{0} + \frac{RT}{2F}\ln\{\frac{\alpha \cdot \beta^{\frac{1}{2}}}{\delta}.P_{2}^{\frac{1}{2}}\} \quad ...(2)$$

III MODELLING OF FUEL CELL & WIND TURBINE

A. Fuel Cell Steady State Behaviour:-

The experimental voltage-current data of the 500W Polymer exchange membrane fuel cell (PEMFC) built by Fuel Cell Technologies, Ltd,.Fig. 1shows the data points that are curve-fitted using quadratic, cubic, and fourth order polynomials.In addition, the relation between output power and current (P-I curve) is also shown.

$V = -2.547 \times 10^{-6} I^3 + 1187 \times 10^{-3} I^2 - 0.1967 I + 39.2082$...(3)

where V is the fuel cell terminal voltage and I is the current.

The minimum least squares error method is used to obtain the closest approximation.

$$V * I = I^2 * Z$$

$$V = I * Z \text{...(4)}$$

where Z is the load impedance. Equations (3) and (4) are solved simultaneously to obtain an equation in terms of the current and the load impedance as follows

$f(I) = -2.547 \times 10^{-6} I^3 + 1.187 \times 10^{-3} I^2 - (0.1967 \propto + Z) I + 39.2082 = 0$...(5)

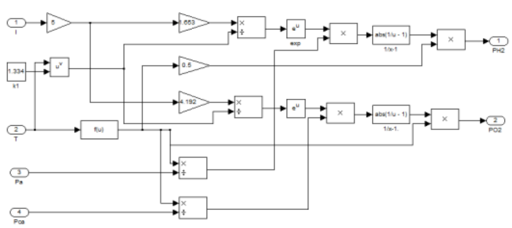

Figure 4: Simulink diagram of Fuel Cell Reaction

The Newton-Raphson iterative method is employed to solve the non-linear equation (5) and determine the fuel cell current. The method for solving an equation f(x) = 0 is outlined as follows [5]

$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$... (6)

wherex_n is the estimate at the nth iteration and x_{n+1} is the updated estimate. The iteration process is terminated when $f(x_{n+1}) <= \epsilon \approx 0$, where $\epsilon$is the tolerance limit and x_{n+1} is the required solution. The method is terminated if $f^1(x_n) = 0$, load impedance is not negative for a fuel cell power system being simulated.

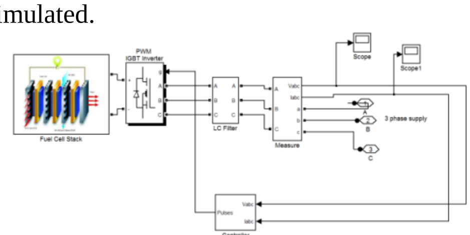

Figure 5: Simulink diag of the Fuel Cell connected to µgird

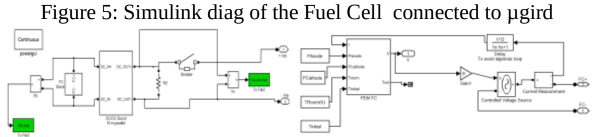

Figure 6: Internal simulink diagram of above Fuel Cell Stack

B. Mathematical Model of Wind Turbine:-

Under constant acceleration, the kinetic energy of an object having mass m and velocity v is equal to the work done W in displacing that object from rest to a distance s under a force F,

i.e.E=W= Fs

According to Newton's law we have,F= ma

Hence E = mas .... (7)

Using Newton's third equation of motion $v^2 = u^2 + 2as$

We can get a = $(\frac{v^2-u^2}{2s})$

Since the initial velocity of the object is zero, i.e. u=0, we get a = $\frac{v^2}{2s}$

Substituting above equation in equation (7), we get that the kinetic energy of a mass in motions is

$$E = \frac{1}{2} m v^2 \text{....(8)}$$

The power in the wind is given by the rate of change of energy

P = $\frac{dE}{dt} = \frac{1}{2} v^2 \frac{dm}{dt}$....(9)

As mass flow rate is given by $\frac{dm}{dt} = \rho A \frac{dX}{dt}$

And the rate of change of distance is given by

$$\frac{dX}{dt} = v$$

We get

$$\frac{dm}{dt} = \rho A v$$

Hence from equation (3.3) the power can be defined as

$$P = \frac{1}{2} \rho A v^3 \text{...(10)}$$

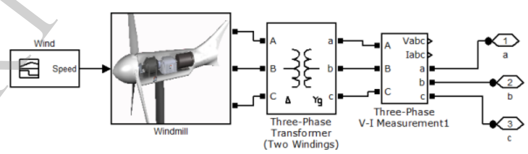

Figure 7: Simulink diag of the Wind Turbine connected to µgird

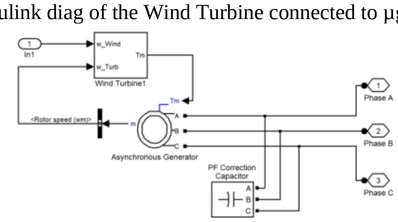

Figure 8: Internal simulink diagram of the Wind Turbine

The swept area of the turbine can be calculated from the length of the turbine blades using the equation for the area of a circle:

$$A = \pi r^2 \text{....(11)}$$

Where the radius is equal to the blade length.

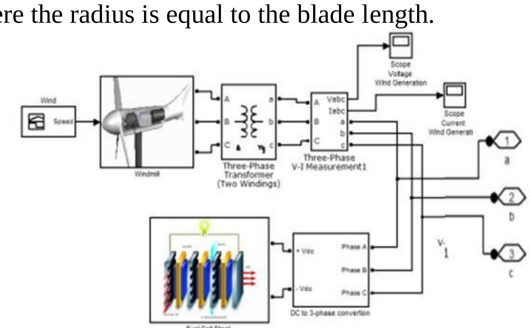

Figure 9: Subsystem of Microgrid

IV Conventional DC-Link Voltage Controller

The conventional PI controller used for maintaining the dc-link voltage is shown in Fig. 2. To maintain the dc-link voltage at the reference value, the dc-link capacitor needs a certain amount of real power, which is proportional to the difference between the actual and reference voltages. The power required by the capacitor can be expressed as follows:

$$P_{dc} = K_p(V_{dcref} - v_{dc}) + K_i \int (V_{dcref} - v_{dc})dt \quad (12)$$

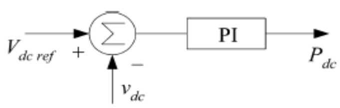

Figure 10.Conventional DC link voltage controller

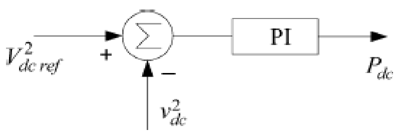

Figure 11.Fast acting DC-link voltage controller

The dc-link capacitor has slow dynamics compared to the compensator, since the capacitor voltage is sampled at every zero crossing of phase supply voltage. The sampling can also be performed at a quarter cycle depending upon the symmetry of the dc-link voltage waveform. The drawback of this conventional controller is that its transient response is slow, especially for fast-changing loads. Also, the design of PI controller parameters is quite difficult for a complex system and, hence, these parameters are chosen by trial and error. Moreover, the dynamic response during the transients is totally dependent on the values of K_p, K_i and P_{dc} when is comparable to P_{lavg} .

V Fast-Acting DC Link Voltage Controller

To overcome the disadvantages of the aforementioned controller, an energy-based dc-link voltage controller is proposed. The energy required by the dc-link capacitor (W_{dc}) to charge from actual voltage (V_{dc}) to the reference value (V_{dcref}) can be computed as

$$W_{dc} = \frac{1}{2} C_{dc}(V^2_{dcref} - v^2_{dc}). \quad (13)$$

In general, the dc-link capacitor voltage has ripples with double frequency, that of the supply frequency. The dc power ($P\square_{dc}$) required by the dc-link capacitor is given as

$$P'_{dc} = \frac{W_{dc}}{T_c} = \frac{1}{2T_c} C_{dc}(V^2_{dcref} - v^2_{dc}) \quad (14)$$

where T_c is the ripple period of the dc-link capacitor voltage. Some control schemes have been reported in [33] and [34].

However, due to the lack of integral term, there is a steady-state error while compensating the combined ac and dc loads. This is eliminated by including an integral term. The input to this controller is the error between the squares of reference and the actual capacitor voltages. This controller is shown in Fig. 3 and the total dc power required by the dc-link capacitor is computed as follows:

$$P_{dc} = k_{pe}(V^2_{dcref} - v^2_{dc}) + K_{ie} \int (V^2_{dcref} - v^2_{dc})dt. \quad (15)$$

The coefficients K_{pe} and K_{ie} are the proportional and integral gains of the proposed energy-based dc-link voltage controller. As an energy-based controller, it gives fast response compared to the conventional PI controller. Thus, it can be called a fast acting dc-link voltage controller. The ease in the calculation of the proportional and integral gains is an additional advantage. The value of the proportional controller gain K_{pe} can be given as

$$K_{pe} = \frac{C_{dc}}{2T_c} \quad (16)$$

For example, if the value of dc-link capacitor is 2200 F and the capacitor voltage ripple period as 0.01 s, then K_{pe} is computed as 0.11 by using (12). The selection of K_{ie} depends upon the tradeoff between the transient response and overshoot in the compensated source current. Once this proportional gain is selected, integral gain is tuned around and chosen to be 0.5. It is found that if K_{ie} is greater than K_{pe} , the response tends to be oscillatory and if is less than K_{pe} , then response tends to be sluggish. Hence, K_{ie} is chosen to be $K_{pe}/2$.

VI Selection of the DC-Link Capacitor

The value of the dc-link capacitor can be selected based on its ability to regulate the voltage under transient conditions. Let us assume that the compensator in Fig. 1 is connected to a system with the rating of *X* kilovolt amperes. The energy of the system is given by *X x* 1000 J/s. Let us further assume that the compensator deals with half (i.e.,*X*/2) and twice (i.e.,2*X*) capacity under the transient conditions for *n* cycles with the system voltage period of *T* s. Then, the change in energy to be dealt with by the dc capacitor is given as

$$\Delta E \ \square \ (2X - X/2)nT \quad (17)$$

Now this change in energy (21) should be supported by the energy stored in the dc capacitor. Let us allow the dc capacitor to change its total dc-link voltage from 1.4 V_m to 1.8 V_m during the transient conditions where V_m is the peak value of phase voltage. Hence, we can write

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 1 Issue 8, October - 2012

$$\frac{1}{2}C_{dc}\left[(1.8V_m)^2 - (1.4V_m)^2\right] = \left(2X - \frac{X}{2}\right)n\mathrm{T} \quad (18)$$

which implies that

$$C_{dc} = \frac{3XnT}{(1.8V_m)^2-(1.4V_m)^2} \quad (19)$$

For example, consider a 10-kVA system (i.e., X = 10 kVA), system peak voltage V_m = 325.2 V, n = 0.5, and T = 0.02 s. The value of C_{dc} computed using (23) is 2216 μF. Practically, 2000 μF is readily available and the same value has been taken for simulation and experimental studies.

SIMULATION & RESULTS

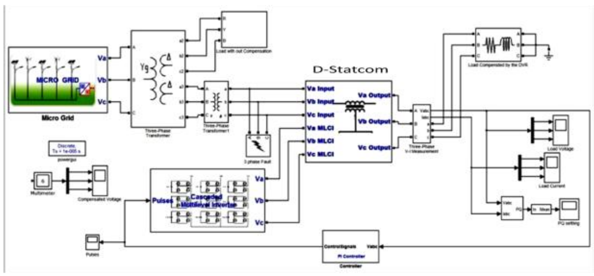

Figure 12: Simulink Diagram of the MicroGrid with MLCI DVR connected to Load

Results of Wind Turbine:-Here we considered Wind turbine as rotate with constant speed i.e 19.4 rpm.

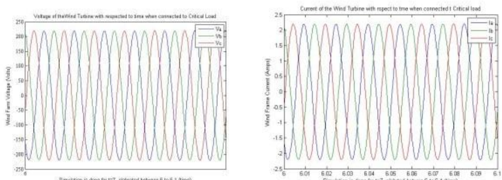

Figure 13: Voltage and Current shared by Wind Turbine

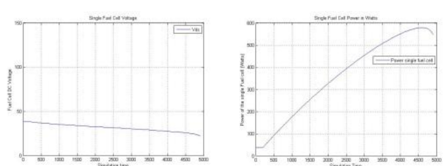

Figure 14: Voltage & Power shared by single Fuel Cell

In the case of conventional, at the instant t = 0.4 s. Due to a sudden reduction in the load, the dc-link capacitor absorbs surplus power from the source. Therefore, there is an increase in dc-link capacitor voltage above the reference value. Based on the values of PI controller gains, the dc-link capacitor voltage controller will be brought back to the reference value after a few cycles. Similarly, when the load is switched back to the full load at instant t = 0.8 s, the dc capacitor supplies power to the load momentarily and, hence, the dc-link voltage falls below the reference value. Due to the PI controller action, the capacitor voltage will gradually build up and reach its reference value. If gains of the conventional dc-link voltage controller are not properly chosen, the dc-link voltage would have undesirable overshoot and considerably large settling time. Consequently, the performance of the load connected to the dc link also gets affected due to the above factors.

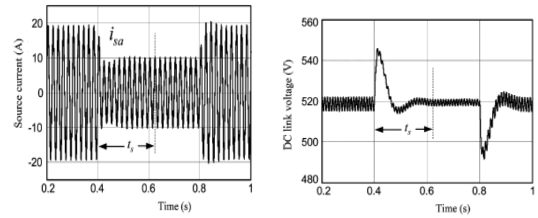

Figure 15: Transient response of the conventional controller.(a).compensated source current in phase a. (b).DC-link voltage

Fast- Acting Dc-Link, at the instant t_s = 0.4 s, the capacitor voltage increases due to the sudden removal of the load. The fast-acting dc-link voltage controller takes action at the instant t_s = 0.41 s. This is because the controller output is updated at every half cycle. It computes the dc load power P_{dc} needed to bring the capacitor voltage to the reference value in a half cycle. Therefore, the dc-link voltage reaches its reference voltage at the instant t_s = 0.42 s. When the dc-link voltage is more than the reference value, P_{dc} is less. Therefore, the source currents are less in magnitude.

At the instant t_s = 0.8 s, the dc-link voltage falls below the reference voltage due to a sudden increase in load. As explained earlier, the fast-acting controller brings the dc-link voltage to its reference value at t_s = 0.82 s with almost the same rise in voltage as that of the conventional dc-link voltage controller. A close observation of the figure would reveal that the fast-acting dc-link voltage controller can regulate the capacitor voltage within a half cycle period which is indicated by t_s. Owing to its good transient performance, it is preferred over the conventional dc-link voltage controller.

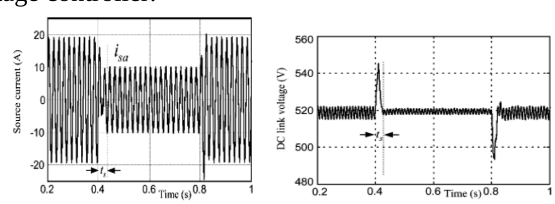

Figure 16:Transient response of the fast acting controller.(a).compensated source current in phase a.(b).DC link voltage

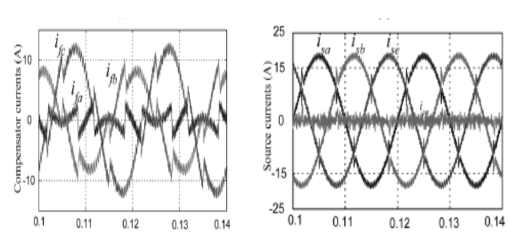

Figure 1: fast acting controller
(a) Compensator currents (b) Compensated load currents

CONCLUSION

In this paper, Matlab&Simulink dynamic models of Wind Turbine and PEMFC are developed. The two developed models of the Wind Turbine and PEMFC are inserted in a complete MG system to deal with the system fast response. The obtained results prove that a Wind Turbine and fuel cell can deal with load changes in the micro grid.

An energy-based fast-acting dc-link voltage controller is suggested to ensure the fast transient response of the compensator. Mathematical equations are developed to compute the gains of this controller. The efficacy of the proposed controller over the conventional dc-link voltage controller is established through the Matlab/simulation . It is observed from these studies that the proposed dc-link voltage controller gives fast transient response under load transients.

REFERENCES

[1] G. Hoogers, *Fuel Cell Technology Handbook*, Boca Raton, FL: CRC Press, 2003.

[2] A. J. Appleby and F. R. Foulkes, *Fuel Cell Handbook*, New York: Van Nostrand Reinhold, 1989.

[3] H. C. Maru, "Fuel cell systems and potential applications," *Symposium Proceedings: Fuel Cells Technology Status and Applications*, Institute of Gas Technology, Chicago, IL, pp. 33–44, November 1981.

[4] D. J. Hall, "Transient modeling and simulation of a solid oxide fuel cell," Ph.D. dissertation, University of Pittsburgh, PA, 1997.

[5] S. Yerramala, A. Davari, and A. Feliachi, "Dynamic modeling and analysis of polymer electrolyte fuel cell," *IEEE Power Engineering Society Summer Meeting*, Edmonton, Alberta, Canada, vol. 1, pp. 82–86, July 2002.

[6] EG&G Technical Services Inc., "Fuel cell handbook (6th edition)," Tech. Rep., U.S. Department of Energy - N.E.T.L., 2002.

[7] U.S. Department of Energy N.E.T.L., "Fuel cell simulator," Solicitation number: DE-RQ26-03NT30094 (Request for proposal), January 2003.

[8] Ren. VSCF wind turbine dynamic models and, and network study. Progress in power and water power. 2008.1

[9] CHEDID R, MRAD F, BASMAM. Intelligent control for wind energy conversion systems.WindEng, 1998

[10] Wu Junling, Zhou Shuangxi, Sun Jianfeng, Chen Shou-Sun, Meng, and. Grid-largest wind farms into the power analysis. Power System Technology. 2004.10

[11] A. Ghosh and A. Joshi, "A new approach to load balancing and power factor correction in power distribution system," *IEEE Trans. Power Del.*, vol. 15, no. 1, pp. 417–422, Jan. 2000.

[12]] S. Kim, M. H. Todorovic, and P. N. Enjeti, "Three-phase active harmonic rectifier (AHR) to improve utility input current THD in telecommunication power distribution system," *IEEE Trans. Ind. Appl.*, vol. 39, no. 5, pp. 1414–1421, Sep./Oct. 2003.

[13] R. Redl and A. S. Kislovski, "Telecom power supplies and power quality," in *Proc. 17th Int. Telecommunications Energy Conf.*, Denmark, Oct. 29–Nov. 1 1995, pp. 13–21.

[14] M. M. Jovanovic and Y. Jang, "State-of-the-art, single-phase, active power-factor-correction techniques for high-power applications—An overview," *IEEE Trans. Ind. Electron.*, vol. 52, no. 3, pp. 701–708, Jun. 2005.

[15] M. M. Jovanovic and Y. Jang, "State-of-the-art, single-phase, active power-factor-correction techniques for high-power applications—An overview," *IEEE Trans. Ind. Electron.*, vol. 52, no. 3, pp. 701–708, Jun. 2005.

[16] A. S. Kislovski, "Telecom power-supply plants using three-phase rectifiers and active filters," in *Proc. 2nd Int. Telecommunications Energy Special Conf.*, Budapest, Hungary, Apr. 22–24, 1997, pp. 127–134.

[17] P. Verdelho and G. D. Marques, "DC voltage control and stability analysis of PWM-voltage-type reversible rectifiers," *IEEE Trans. Ind. Elect ron.*, vol. 45, no. 2, pp. 263–273, Apr. 1998.

[18] A. Prodic´ and G. D. Marques, "Compensator design and stability assessment for fast voltage loops of power factor correction rectifiers," *IEEE Trans. Power Electron.*, vol. 22, no. 5, pp. 1719–1730, Sep. 2007.

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