A new design of control & power management strategies of hybrid ac-dc microgrids toward high power quality

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Abstract. The micro grid idea provides for the lack of several reversing switches to unitary AC-DC grid that enables connection and charges (loads) to the electrical systems with changeable regenerative AC and CC sources. Safe operation and gadget safety involve digital integration with utilities / grid through power converters. Enhanced client reliability, decreased input losses, local voltages are supported, and waste heat efficiency increased, voltage drop or interruptible supply of electricity can be customized to satisfy their unique customer demands. Work at present Analyses the performance in grid tie mode of hybrid AC/DC systems. Here are PV systems, PV systems, For the construction of microgrids wind turbine generators and batteries are employed. Convert procedures for the correct coordination of AC sub-grids to DC subs-grids have also been established for converters. MATLAB / SIMULINK environment results are generated.

Keywords. Power management, grid management, grid operation, smart grid hybrid system, wind electricity generation, Photovoltaic system

1. Introduction

In Power industry, significant problems are: a) increasing access to energy by non-grid sectors of the population and b) rising demand by groups of the population. In the upcoming 10 years (by 2020), RE will demand around 20 percent of the world's power generation [1]. For the grid and closed-grid systems, the utilisation of wind, solar, biomass, mini hydro and fuel cells and micro turbines plays an appealing role. Advantages, such as the eco-friendliness, extension and flexibility of distributed power generation, have led to an appealing alternative to configure contemporary, renewable electricity networks and non-conventional re-sources.

The microgrid may be constructed as an electricity system which usually operates through a main grid and can be unplugged and run independently with power generation, storage and loads. Microgrids with an electrical interface have tiny beginnings. These micro grid re-sources are often deployed at the client locations of micro-turbines, PV panels and fuels. They are cost-effective, low voltage, and very minimal carbon emissions. The interface Power Electronics gives control and flexibility to microgrid.

Based on locally accessible sources of energy, the development of hybrid micro-grid systems together with a storage element is frequently possible to combine existing power with the load. Various combinations, Wind fuel, hydro-bio cell, wind solar (PV), hydro-solar. Hydro-solar power supply are conceivable based on local circumstances (PV). Includes fuel cells, batteries, super condensers and pumped storage devices, and flywheels.
2. Existing Systems

The microgrid concept is a way to integrate broad micro-processing without interrupting the functioning of electricity grids. Intelligent load integration and micro-production can be less onerous than traditional micro-power generation by means of distribution network supplies (or microgrid systems). In addition, Net Microgrid provides support services such as local voltage monitoring.

If the main network fails, the microgrids can be separated and run individually. If the system fails. This procedure enhances the user's energy quality. The microgrid has the benefit of being seen as a regulated unit in the electricity system and operating as a single binding load from the grid viewpoint. Microgrids are able to satisfy local heat and power demands and to provide uninterrupted electricity, increase local dependability, reduce feeder losses and support the local voltage/optimal voltage sink.

Microgrids also contain storage, control load and heat recovery equipment as well as technology production. Another essential job is the ability to use the microgrid linked to the grid and to switch from and to the island mode.

3. Hybrid Network Hypothesized

Hybrid power system setup for a hybrid system that connects distinct ac, dc and dc sources with loads for the corresponding dc and ac networks as illustrated in Fig.1. Batteries as electric energy storage devices are recognised as renewable energy sources. Renewable hybrid systems with PV panels and wind turbines The AC and DC buses can be linked through a three-phase transformer as well as the main bidirectional transformer to the DC and AC ends. It permits the AC voltage to be shifted from the main converter into voltage and the separation of the AC and DC networks.

In order to achieve minimal signal strength assessment of an AC / DC micro-grid model and IC micro-grid design, the relevant MATLAB system will be detailed with a Simulink introduction. For individual microgrids during ISLAND and drop control strategies. The features of the frequency drop and reactive voltage management- drop. One of the two decentralised control techniques based on disorder is a revised IC doping control for interfacing DC and AC micro networks. Using the suggested droop technique, in transition from grid to insulating mode, as well as via insulation, the IC is able to execute power sharing between the two micro grids.

This approach will use the modified two-stage dumping system for individual AC and DC micro grids, to bidirectionally regulate the power of the composite AC/DC microgrid deposition system. The real goal is to use local electricity to minimise the grid energy output. DC power is stored within an acceptable range by utilising a drop factor power regulation. Combining the intelligent DC grid with the AC grid to suppress the disturbance into DC bus voltage via controlled load and escalating the AC Grid stability via the grid-side converters that interlink the DC and AC microgrid. The main purpose is to work in the linked grid or in the insulation modes

![Figure 1. Concept of hybrid grid representation](image-url)
A hybrid system configuration is shown in the figure where the corresponding AC and DC networks are linked to various AC and DC applications. The figure illustrates the configuration of the AC and DC grids hybrid version. The AC network and the DC network have their own sources, charges, and energy storage devices linked by a three-phase converter. The AC-bus line is connected to the power grid that used a transformer logic interrupter.

Figure 2. A microgrid hybrid ac/dc system.

4. Hybrid Microgrid Mathematic Modelling and Simulink of Wind-PV

The UPFC explains in this article can enhance electrical network power quality. UPFC also has the ability to maintain an exact voltage w. r. t. Can offer actual and receptive power stream control simultaneously. The goal of this research is to explore and to analyse UPFC's potential to enhance the grades of electricity in the System of Electricity. This article presents different novel topologies for FACTS controllers. It thereby improved the quality of total power.

The scheme for the hybrid network has been seen in Fig. 2. The operation of the system can be controlled at Matlab/Simulink under various loading and feed conditions. The scheme for the hybrid network shown by Fig. 2. The operation of the system can be controlled at Matlab/Simulink under various loading and feed conditions. The AC-bus line as AC source is linked with a 50-kW dual-fed induction generator. The DC Bus is coupled through DC/DC Boost Conversion as DC source for forty kilowatt PV ranges.

A 2-way DC / DC converter connects the 75Ah power storage battery to the DC bus. The dc (30 kW - 50 kW) load variable and dc (30Kw– 50Kw) load are correspondingly linked with the dc and ac buses. Rating voltages are 500V and 500VRM for both AC&DC lines.

The DC bus is connected by an isolation transformer to the AC-bus line through a three phase DC/AC main converter, with R-L-C filter. This wind power generator comprises of a double induction (DFIG) generator, which is linked to the ring between the AC and the AC-bus systems, with a backwards AC/DC/AC PWM converter. The AC-bus line integrates the DFIG-Wind Generator for the simulating with AC sources.

DC & AC variable loads are linked for simulating varied loads using their AC & DC lines. The AC & DC buses are connected to the interchange power between the DC with the AC sides via a three-phase transformer and a principal two-way electric current converter. The transformer enables the primary converter's AC voltage to raise energy voltage levels and the AC and DC grids to be isolated. A typical booster converters, large converter and reversible converter is a Standard DC line. The PV-array result is connected to the Dc boost converter for MPPT functions and enhances the display terminal voltage for network path devices. The DC connection condenser is used with the DC
converter. The inverter output is connected through an LC low-pass filtration to achieve highest frequency that do not spread to the electricity network.[2-5]

The AC-bus line is connected to the power grid via a transformer and otherwise circuit breaker. PV panels will be linked through a boost converter with a DC bus to imitate DC sources in the proposed system. The output of solar panels fluctuates largely depending on solar radiation level and environmental heat.[6-9]

A DC bus is linked as a power storage battery with a double direction DC / DC converter. The condenser is attached to the CPV PV end of the PV output voltage for removing high frequency waves. The DC/DC converter maintains the DC bus voltage steady when the battery is charged.

**Figure 3. Wind Power Generator Model Subsystem**

4.1. Wind Turbine Design in Simlink

The wind turbine aerodynamic model offers a blend of flow speed and wind turbine mechanical torque. The wind turbine rotor may be described as Pm as the mechanical power:

\[ P_m = 0.5 \rho AC_p(\lambda, \beta)W \omega^3 \]

4.2. Modeling Design of PV(Solar) Panel

Solar cell’s equivalent circuit. By the following equations the current output of the panel is produced.

\[ I_{pv} = n_p I_{ph} - n_p I_{sat} \left[ \exp \left( \frac{q(V_{pv} + I_{pv}R_s)}{n_e} \right) - 1 \right] \]

\[ I_{ph} = (I_{sat} + k_i(T - T_r))(S/1000) \]

\[ I_{sat} = I_{rr}(T - T_r) \exp \left( \frac{qE_{gap}/kA}{T_r} \right) \]

\[ I_{rr} = Reverse \ saturation \ current \]

\[ I_{ph} = Photo \ Current \]

\[ I_{sat} = Model \ Reverse \ Saturation \ Current \]

\[ I_{pv} = Photovoltaic \ Current \]

4.3. DFIG modelling

\[ d, q-axis, \ Rotor \ & \ Stator \ each \ are \ represented \ by \ the \ d, \ s, \ and \ r \ axis. \ and, \ respectively, \ the \ angular \ synchronous \ speed \ and \ the \ slip \ speed. \ L \ is \ the \ inductivity \ and \ this \ is \ the \ flow \ connection. \ V \ and \ I \ denote \ respectively \ voltage \ and \ current. \ T_m \ is \ a \ mechanical \ defect, \ T_{em} \ an \ electromagnetic \ defect. \ In \ the \ rotational \ d – q \ coordinates \ the \ voltage \ equations \ of \ the \ inductor \ are \ as \ follows, \]
4.4. Converter Modeling and Control

The power management system is applied to transition between the DC and AC grids and deliver reagent power delivered to the AC connection by means Current-controlled central given strain sources. [10] Figure 4 displays the basic converter manipulation schematic. To achieve real and reactive power regulation, two PI controllers are needed. The DC line voltage converts into stabilise with PI-Control, whenever the position or load of the source changes. If the DC load suddenly falls over the DC load, to transmit power from the DC side to the AC side, the DC converter is controlled. DC connectivity voltage results in the active energy absorbed by the condenser. One of most active mention ID* from the PI-Control results from negative error (Vd*-Vd) induced by VD augmentation. Both the current active ID and the reference ID* are OK. The high positive signal pushes the current active ID to rise by means of the internal control circuit. Consequently, the DC grid power surplus may be transmitted to the AC side. A fast increase in DC demand also leads to performance degradation and Vd enters the DC grid.[7]

The primary converter supplies electricity from AC to DC. Positive tension error (Vd* -Vd) drop causes a PI control to raise the ID*. The number of IDs grows via the internal current control loop as both ID and ID are negative. Power is transmitted from the AC network to DC

![Figure 4. Principal Converter Control Diagram](image)

4.5. Boost Converter Modeling with Control

The DC-DC boost converter increases input voltage by storing power on the L1 inductor for a period of time and then increases the IT to a greater voltage. Is. The boost converter circuit schematic is illustrated in fig. 5. The input source loads the inductor, reverse-biased diode D1, Isolated, if switch Q is shut, between the input and output of the converter. When the switch is opened in the inductor, power is stored and transmitted to the source load. The current equations and voltage in the DC bus are the following

\[ V_{pr} - V_r = L_1 \frac{dI_1}{dt} + R_1 I_1 \]
\[ I_{pr} - I_1 = C_{pr} \frac{dV_{pr}}{dt} \]
\[ V_r = V_r (t - d_t) \frac{dt}{dt} \]
Figure 5. Transition boost

The solar panel terminal voltage reference value must be established using the P&O algorithm, which maximises the energy capture. Dual loop control is meant to supply high-quality DC voltage for DC/DC booster converter. The external voltage loop enables the reference voltage to be monitored using a zero constant state fault and the internal feedback loop improves dynamism.

4.6. Modeling and Control of Battery Converter

The battery adapter is a two-way transformer with a DC / DC connection voltage that is continuous. As shown in fig.6, the battery converter uses a dual-circuit control technique. The current infusion \((1-d_1)\) induces a charging current \(I_{in}\). Before the inner belt is adjusted to the current reference the voltage loop 1 is multiplied

\[
\frac{dI_{in}}{dt} = \frac{V_D - V_b}{L_1} + \frac{R_1 I_1}{C_{PV}}
\]

\[
V_D = V_d \cdot d_3
\]

\[
i_1(1-d_1) - i_{ac} - i_{dc} - i_{bd} = i_c = C_d \frac{dV_d}{dt}
\]

Figure 6. Battery converter - based Control

The current passing through the battery, when the current Loop tension is set to a constant value, this is characterised favorably. Multiplying positive \((V_{dc} - V_{dc})\) voltage error by 1 causes the battery to move from charging to discharge mode, which causes the battery to return the \(V_{dc}\) to its default value. This is because the load or lack of solar radiation suddenly increases. The battery controller shifts the same control from discharge to charge mode. Battery converter modelling equations,

5. Simulation Results

In Figure 7, the solar panels are presented with the voltage in grid connected mode for various thermal radiations from \(W/m^2\) from 500 \(W/m^2\) to 400 \(W/m^2\). The MPPT algorithm records 0 - 0.2 seconds of optimum voltage.
The fluctuating solar radiation and constant grid-connected loads of the panel's solar electricity are displayed in figure 8. Power between 1100 W/m² and 500 W/m² to 500 m² with solar radiation between 15, 7kW and 47, 7kW. Sun radiation ranges from 0.1 W / m² and 1000 W / m² 0.1 seconds. With increasing solar radiation, electricity increases when the charge remains constant. Solar radiation fell in 0.3 seconds to 400 w/m² followed by an energy reduction of 0.3 seconds.

The power voltage (0.2x power in comparison) is displayed on the main side of the current response by the AC side responses when the solar radiation ranges from 1100 W / m² to 0, 3 s to 500 W / m². Displayed in Fig. 9. With continuous dc load, KW drops 20. The energy from the present direction may be observed injecting from the DC grid to AC 0.3 seconds in advance and returning after 0.4 seconds.
Figure 9. AC side voltage and primary converter current with continuous solar irradiance and dc load variable
The AC side conflict (voltage time 0.2) and the main converter's current response when the DC load is increased from 0.26 s at 22 kW to 50 kW in 0.35 Sec. at a constant radiation voltage of 850 W/m² are shown in Fig. 10. at 0.25 secs. before current track and reverse after 0.25 seconds from dc to ac power is injected.

Figure 10. AC voltage and primary converter current for stable photovoltaic and dynamic load for dc radiation levels

Figure 11 illustrates, under the identical conditions, the voltage react on the primary converter's DC side. The picture demonstrates that tension falls to 0.25 C and that the controller is immediately adjusted.
6. Conclusion
For hybrid AC and DC microgrids intended for power system set-up in the MATLAB / Simulink environment, microgrids were developed. The objective of the article is to expedite the realization of the key advantages for the use of renewable energy in small-scale distribution energy generation. Coordinated control is offered under diverse loads and resource circumstances for maintaining consistent system functioning. The notion of microgrids allows DG to be high without the requirement for a new design. While hybrid grids simplify procedures for conversion of DC/AC and AC/DCs to the specified CA or DC grid, there are several practical difficulties to implementing hybrid grids based on existing CA/DC infrastructure. As both the PV and wind turbine generators are incorporated into the main energy source for small isolated industrial systems, hybrid grids may be imagined.

References
[1] S. Bose, Y. Liu, K. Bahei-Eldin, J.de Bedout, and M. Adamiak, “Tie line Controls in Microgrid Applications,” in iREP Symposium Bulk Power System Dynamics and Control VII, Revitalizing Operational Reliability, pp. 1-9, Aug. 2007.
[2] R. H. Lasseter, “MicroGrids,” in Proc. IEEE-PES’02, pp. 305-308, 2002.
[3] Michael Angelo Pedrada and Ted Spooner, “A Survey of Techniques Used to Control Microgrid Generation and Storage during Island Operation,” in AUPEC, 2006.
[4] F. D. Kanellos, A. I. Tsouchnikas, and N. D. Hatzigiorgiou, “Microgrid Simulation during Grid-Connected and Islanded Mode of Operation,” in Int. Conf. Power Systems Transients (IPST’05), June. 2005.
[5] Y. W. Li, D. M. Vilathgamuwa, and P. C. Loh, Design, analysis, and real-time testing of a controller for multi bus microgrid system, IEEE Trans. Power Electron., vol. 19, pp. 1195-1204, Sep. 2004.
[6] R. H. Lasseter and P. Paigi, “Microgrid: A conceptual solution,” in Proc. IEEEPESC’ 04, pp. 4285-4290, 2004.
[7] F. Katiraei and M. R. Iravani, “Power Management Strategies for a Microgrid with Multiple Distributed Generation Units,” IEEE trans. Power System, vol. 21, no. 4, Nov. 2006.
[8] P. Piagi and R. H. Lasseter, “Autonomous control of microgrids,” in Proc. IEEE-PES’06, 2006, IEEE, 2006.
[9] M. Barnes, J. Kondoh, H. Asano, and J. Oyarzabal, “Real-World MicroGrids- an Overview,” in IEEE Int. Conf. Systems of Systems Engineering, pp.1-8, 2007.
[10] Chi Jin, Poh Chiang Loh, Peng Wang, Yang Mi, and Frede Blaabjerg, “Autonomous Operation of Hybrid AC-DC Microgrids,” in IEEE Int. Conf. Sustainable Energy Technologies, pp. 1-7, 2010.