INTEGRATION OF HYBRID AC/DC MICROGRID WITH ENERGY STORAGE SYSTEM

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Abstract : This paper presents the integration of renewable energy of micro grid control. Micro grid consists of solar and wind energy. The proposed system functions in both the grid-connected mode as well as islanding mode. The bidirectional power electronics converters with different type of strategies are analyzed for the two modes in detail. The DFIG wind energy generation system is used to extract energy from wind. The control strategy is based on active and reactive power flow control technique by selecting the voltage vector on the rotor side. DFIG coupled to the ac bus system. Simulation work has been carried out by using the MATLB/SIMULINK 2014a version software. Result indicates that the stability has been achieved under transient condition within a time period of two seconds. Also UPF is ensured under different loading conditions.

***IndexTerms-* Micro-Grid, Grid connected mode, Islanding mode, Bidirectional converter, DFIG**

I. INTRODUCTION

Hybrid energy systems are growing in popularity due to the increase in microgrid implementing renewable energy systems. These are connected to low voltage AC distribution systems. DC grids are also developing due to the development of new semiconductor techniques and sustainable DC power sources such as solar energy [1]–[3]. Researchers have proposed several ideas and models of AC/DC microgrids [3]-[4], but the systems operate without the influence of critical loads. System stability and coordinate control of power electronics devices during grid-connected and islanding modes. Hybrid power systems face far more challenges when operating in islanding mode than in grid connected mode. During islanding mode, the AC side can no longer be viewed as an infinite bus, which results in load variations adversely affecting the frequency and voltage of the system [5]. If the system has a high penetration of renewable power, the situation can be even worse. At any time, power flow should be balanced between the AC and DC sides to maintain stability on both sides of the grid. Also, both reactive and active power in the AC side of the system should be balanced to keep the frequency and voltage stable.

In this paper, a hybrid AC/DC micro grid with solar energy, wind energy are integrated. The system operation and power converters coordination control are studied in both grid-connected and islanding mode. For many wind farms, wind turbines based on the DFIG technology with converter rated at about 25%-30% of the generator ratings are used [6]. Compared to wind turbines using fixed speed induction generators, DFIG-based wind turbines offer several advantages including variable speed operation, and four-quadrant active and reactive power capabilities. Such systems also results in lower converter costs and lower power losses compared to a system based on a fully fed synchronous generator with full-rated converter.

II. METHEDOLOGY

The configuration of the hybrid micro grid includes PV modules, wind energy and loads and are inter connected to their corresponding ac-dc buses. Buses are associated with 3phase bidirectional converters and transformer. These systems connected with steady and pulse loads in both ac and dc. The scheme could be administered in any of the grid connected mode or islanding mode. To increase the utilization of renewable sources the PV panels utilize the MPP tracking system then using boost converter. In the grid connected mode this system can be viewed as Plug in electrical vehicles (PEVs) car park system; it is replaced by batteries that can play the role of storage systems.

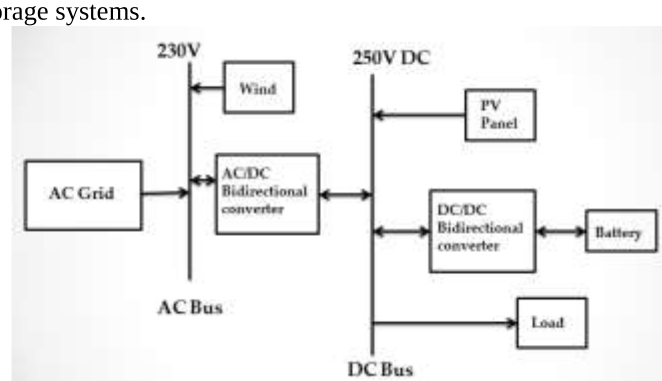


Fig 1: Block diagram of Hybrid microgrid

Fig (1) indicates the block diagram of hybrid microgrid. It consists of AC bus and DC bus of 230V and 250V respectively. Wind farm generation is connected to AC bus. The flow of power is controlled by AC/DC bidirectional converter. The PV panel is coupled to DC bus. Inverter is placed in between panel and AC system for the conversion of generated DC voltage into AC. The excess energy generated by the PV is stored in the battery. The power is controlled by the DC/DC bidirectional converter in the battery system.

III. PROPOSED SYSYTEM

The hybrid microgrid uses a 10.8kW PV farm with a 10kW load is simulated to verify the proposed hybrid micro grid. The rated power of the wind generator is 14kW and having constant load of 10kW is connected in AC side. Five 51.8V 21Ah Lithium ion battery banks are connected individually to the Dc bus through the bidirectional DC/DC converter.

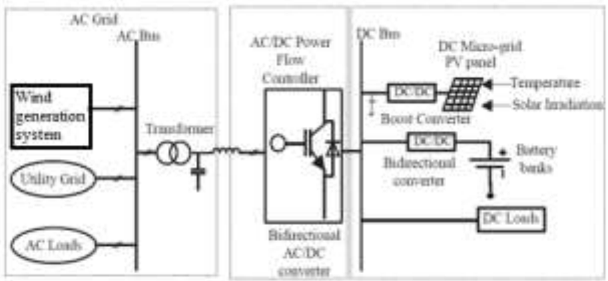


Fig 2: Hybrid AC-DC microgrid power system

Advantages-

- Unidirectional DC/DC converter introduced to command power of PV arrays, while the battery banks are charged or discharged by managing the converter that extends the battery and the dc bus.
- In case of any fault on AC side, the grid is protected by opening the circuit breaker (CB) due to over current.
- There is an ordinary PV battery microgrid system and comparable or same configurations have been generally utilized and explored.

IV. SYSTEM SIMULATION RESULTS

A. SIMULATION MODEL OF HYBRID MICROGRID SYSTEM IN GRID CONNECTED MODE

Simulink model of hybrid power system for grid connected mode is represented in Fig. 3., The two operation modes in hybrid microgrids are namely grid connected & the autonomous (islanding) mode. The PV panel works in MPP in the both modes by regulating DC/DC boost converter to increase the use of the renewable power sources.

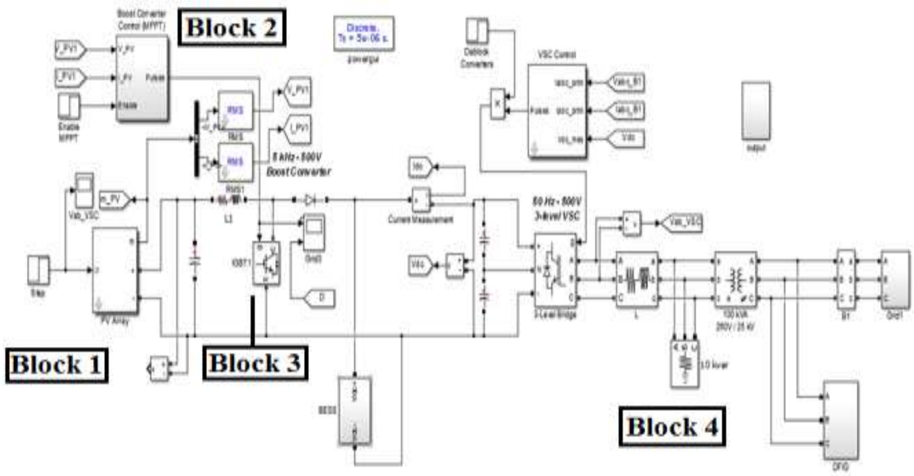


Fig 3: Grid connected mode in hybrid system

In this grid connected mode operation, the system is simulated and also analyzed for the proposed system. The Fig. 3 shows the hybrid micro grid configuration where a DFIG based wind generation system, PV farm and loads are connected to its corresponding AC and DC sides. The AC and DC sides are linked through a bidirectional three phase AC/DC converter and a transformer. The system has constant loads in both sides. The 10.8kW PV panel is connected to the DC bus as a DC energy source through a DC/DC boost converter with MPPT functionality. A wind energy generation (WEG) three phase generators with 14kVA capacity and 208V phase to phase RMS terminal voltage is connected to the AC side. Five 50Ah lithium ion battery banks with 51.8V terminal voltage are connected to the DC bus through bidirectional DC/DC boost converters. The rated voltages for DC and AC sides are 230V and 250V phase to phase RMS respectively. In grid connected mode the DC bus voltage is regulated by the bidirectional AC/DC converter. In this mode the AC side can be viewed as infinite bus, to which the 10kW resistive load is connected to the AC side which will not have an influence on the grid.

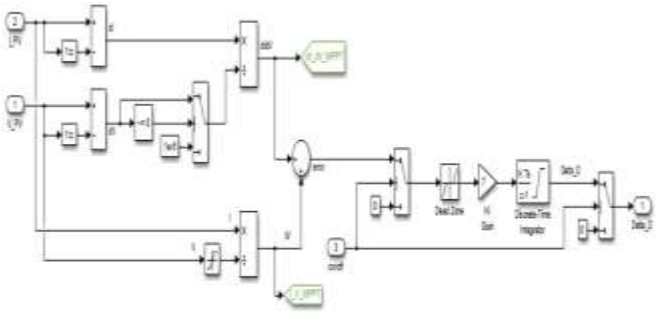


Fig 4: MPPT Control block

The boost converter is taking the RMS value of the PV panel, generated voltage and current both these values are converted into the RMS values by using the formulate given below

$V_{RMS} = \sqrt{\frac{1}{T}\int_{t-T}^{t} f(t)^2}$ ……………….. (5.1)

Where T = 1/fundamental frequency = 1/20

V_{RMS} = 120volts

The RMS values of current and voltage are used in MPPT.

MPPT is working based on the incremental conductance method and integral regulator.

Maximum power point is obtained when dP/dV = 0, Where P = V * I

d (V*I)/dV = I + V*dI/dV = 0 and dI/dV = -I/V

The integral regulator minimizes the error (dI/dV+I/V)

Regulator output = Duty cycle correction

B. SIMULATION MODEL OF HYBRID MICROGRID SYSTEM IN ISLANDIBG MODE

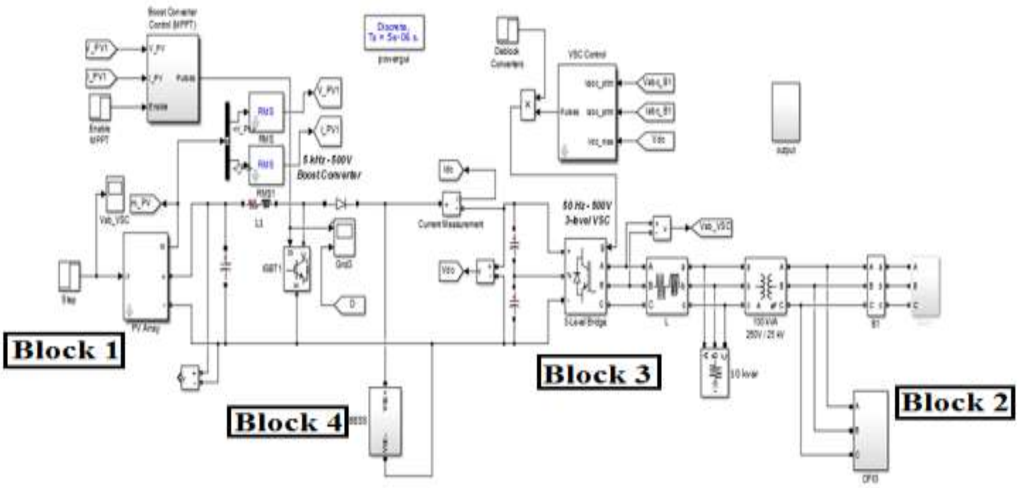


Fig 6: Islanding mode in hybrid system

During islanding mode operation, the frequency and voltage amplitude need to be regulated. Usually, the generator in the microgrid can handle the load with a small varing ratio, but when load is connected to the AC side 9the system frequency may decrease and the voltage may collapse) leads to system unbalance, the bidirectional AC/DC inverter is used to regulate the AC side frequency and voltage amplitude.

Description about simulink model

- The operational difference between connected grids and the islanding modes are simulated in simulink model. Both modes of operations are controlled by the AC-DC converter and the DC-DC converter.
- Boost converter work in an ON-MPPT to keep in search of the maximum energy from the PV, to maximize renewable energy utilization and DFIG works in reactive power control mode to make the utility of active power from wind system.
- At 0.4sec the boost converter MPPT is enabled.
- Within a short response time the maximum power point can be tracked by the MPPT functionality which is shown in the simulation result of boost converter.
- In the AC bus system wind form is connected by using the DFIG based wind generation system.

- By using the speed & voltage of the rotor can be controlled by the reactive power.

V. MODELING OF DFIG BASED WIND GENERATION SYSTEM

Simulation system of planned system for the DFIG oriented wind energy; production system carried out by means of PSCAD / EMTDC. The Fig. 7 shows schematic diagram of system implementation.

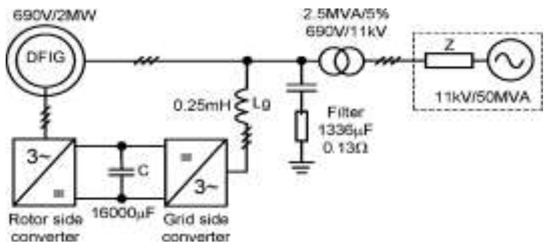


Fig 7: Schematic simulated system diagram

A. Direct active and reactive power control

In order to achieve high dynamic control of active and reactive power, the active and reactive power states and stator flux positions are used to determine position voltage vector. Two three level hysteresis comparators are used to generate the respective active and reactive power states S_p and S_q respectively. Zero voltage vectors have different impact on active and reactive power for different operating rotor speeds. Due to the presence of rotor resistance, the impact of zero voltage vectors becomes more complicated especially when the rotor speed approaches the synchronous speed. Therefore, zero voltage vectors will not be used except when both active and reactive power states are zero.

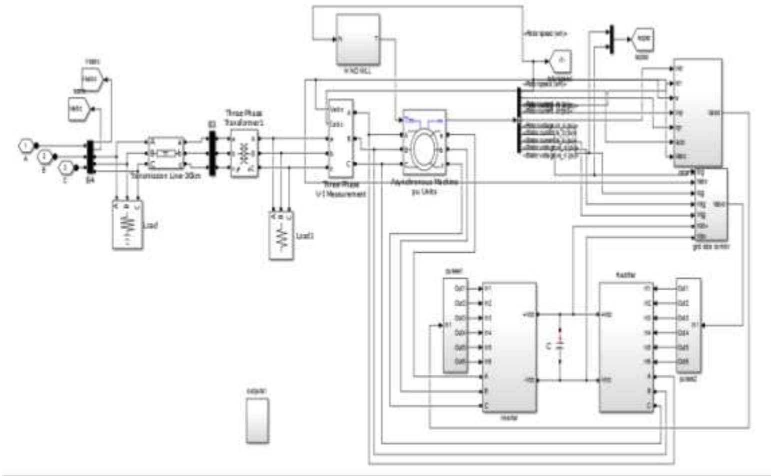
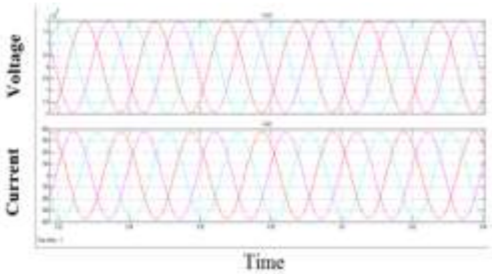


Fig 9: Simulation model of DFIG System

VI. RESULTS

The figure 10 depicted represents AC bus voltage & current and also the transient response (2sec) during load connection. The amplitude returned to its normal value within 3 cycles. During load connection, the current flowing through the AC suddenly increases, may leads system unstable. Hence thereafter loads are disconnected.

In the island mode with DC support, the generation support limitation by 0.2kW. The same figure illustrates that the AC side generators voltage and current reaction. Only for the 2 sec, the load was connected to AC side and soon after 0.2 sec the system collapsed, and frequency and voltage both got dropped down. Due to this reason, the system could not recover even though the load wasn't in connection after 3 sec.



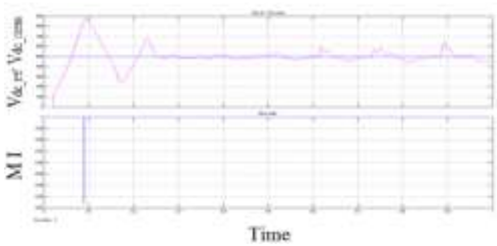


Fig 11: Simulation wave form of measured DC

Fig 10: Simulation output of AC current and voltage in grid connected mode and islanding mode

voltage compared with reference voltage & modulation index for both modes

The system routine with the impact of the PV system power variants and the battery-banks charging rate difference is evidently appeared in the fig. 11., it additionally takes the DC bus voltage. After 0.5 sec the converter connected to AC/DC system was empowered. Prior to this period it works as a rectifier. Empowering the converter the Dc bus voltage achieved the steady state in under 0.3 seconds; in this period solar based irradiance was 1kW/m^2.
The same figure demonstrates the impact of solar based irradiance variance in Dc voltage on the PV models and load was associated via AC & DC. For this situation converter empowered at 0.5 second to manage the Dc voltage, and the bus voltage on Dc side archived relentless state in under 0.2 seconds.

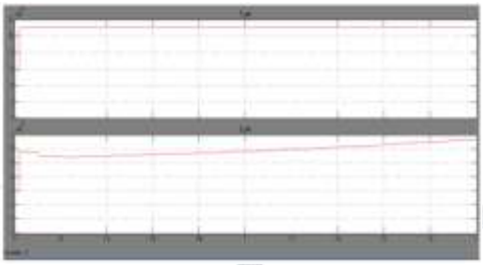


Fig 12: Simulink wave form of active and reactive power wave forms for both modes

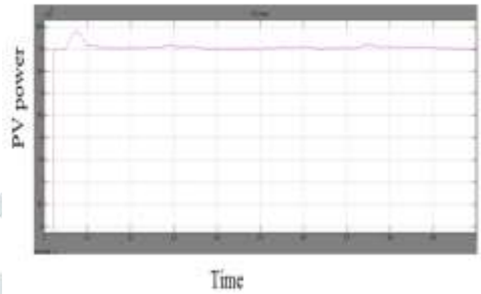


Fig 13: PV module output waveforms

Representation of figure 12 shows the power flow via inverter. This system kept P.F = 1 after it reaches the steady state as the reactive power was 0. With the variation of solar array influence, battery banks control and load influence the kW flows also varies. In order to keep the micro grid in constant the inverter can immediately alter the power flow through it.

The yield from the PV dropped down from 10kW to 2.5kW and immediately improved it back to 10kW in 0.3 sec. Henceforth, it again decreased from 10kW to 2.5kW in next 0.05 seconds at 1.3 sec and soon returned back to 10kW from 2.5kW at 1.6s. Such type of PV power output is described in the above figure 13.

VII. CONCLUSION

In this work integration of MicroGrids with renewable energy sources has been done. The PV system is integrated with DC bus, wind farm and wind generator is coupled with AC bus.

- Simulation of hybrid AC/DC microgrid with energy storage system has been carried out using MATLAB/SIMULINK 2014a.
- A simulation result for islanding mode and grid connected mode operation indicates the achievement of stability under transient condition within a time period of 2 seconds. Also ensured the UPF under all loading conditions.
- The MPPT algorithm is utilized to harness the maximum power from renewable sources and to manage the power exchange between both the grids. DFIG wind energy generation technology is used WEG. It reduces the reactive power generation on the AC side.

VIII. ACKNOWLEDGMENT

I would like to thank my guide, Head of the department, principal, college, friends and all those who have helped me in the completion of this dissertation work.

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