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Integration of Renewable Energy Generating Sources with Micro-Grid

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ABSTRACT- This paper shows the control of microgrids at isolated sites powered by hybrid wind and solar energy sources. The machine used for wind energy conversion is a double fed induction generator (DFIG) and the battery bank is connected to a common DC bus from them. Photovoltaic (PV) arrays are used to convert solar energy. Solar energy is consumed in a cost-effective manner with a DC-DC boost converter on DFIG's common DC bus. The voltage and frequency are adjusted by the indirect vector control of the line-side converter with drooping characteristics. It changes the frequency reference based on the energy level of the battery, slowing the overcharging or discharging of the battery. This system can be operated without wind power. Control algorithms for wind and solar systems include maximum power point tracking (MPPT). This system is designed for fully automated operation, taking into account all the actual conditions of the system also has external power support to charge the battery without additional requirements. The simulation model of the system is developed in the MATLAB environment, and the simulation results are displayed under various conditions. wind or sun impermeable, unbalanced load is equally non-linear, low battery charge state. Finally, the prototype of the system is implemented using a 5kW photovoltaic array simulator and a 3.7kW wound rotor asynchronous machine to generate experimental results to validate the theoretical model and design.

KEYWORDS— DFIG, Vector Control, Wind Energy; Power quality, photovoltaic solar energy, micro-grid, battery energy storage system, renewable energy system

I. INTRODUCTION

There are large remote areas in the world that did not have enough electricity to generate electricity. There are many substations connected to the grid, but you don't need to get enough power. In general, there are three types of renewahble energy sources: biomass, wind power, and solar energy. Compared to biomass, wind and solar energy are more efficient. We use wind and solar energy sources. The main advantages of these sources are low -capacity utilization and high efficiency [1]. But nature is unpredictable, so we do not always generate energy. As a result, the autonomous system will not be able to generate power. To overcome this problem, you need to use battery storage (BSE) [2]. Operating each power supply at its maximum operating point helps avoid power fluctuations and surges [3-4]. Many authors have proposed autonomous solar systems and wind energy systems. In these systems, only one power supply required a very large system power supply and power electronics components [5].

In these, both energy sources are integrated and connected to battery energy storage [6]. Wind and solar energy are a natural ally of hybrids. By using these two sources, you can develop daily and yearly behavior patterns.

II. MICRO GRID

Connecting two or more renewable energy sources such as wind, solar, electric cells, microturbine generators to generate power for local loads or connecting to a grid / microgrid is a hybrid An energy system is formed. Due to the characteristics of photovoltaics and wind energy, photovoltaic systems and wind turbines support much higher combined power reliability than single-power generation. To draw most of the energy from wind and PV arrays, the load requires a significant battery bank [7]. Recently, the DC power grid has been revived with the development and deployment of renewable DC power supplies and the benefits to DC loads in commercial, industrial and residential applications [8-9]. DC microgrids have been proposed for integration with various distributed generations. However, AC power must be converted to DC before connecting to the DC grid, By integrating the two renewable resources into the optimal combination, it partially addresses the effects of the variable nature of solar and wind resources, increasing the reliability and economics of the overall system operation [10]. There are several configurations that provide a state-of-the-art overview of both gridtide and stand-alone hybrid solar and wind systems.

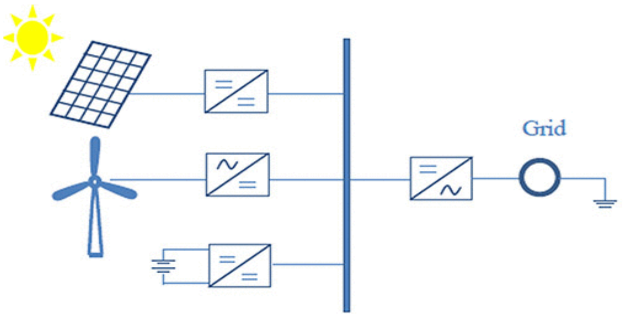

Figure 1: Grid connected hybrid system at common DC bus

III. SYSTEM MODELING

It was designed for locations with maximum and average power requirements of 15kW and 5kW, respectively. The nominal power of both REGS wind and solar energy blocks is assumed to be 15kW. A utilization of 20% is considered for both energy blocks. This is enough to cover the village's all-day energy demand. As shown in the schematic, if the wind speed is too low, the wind energy source will be disconnected from the grid via a 3-pole circuit breaker. The DC side of the RSC and LSC is connected to the battery bank along with the HV side of the solar converter. The RSC helps run the wind energy system at the optimum rotational speed required by the WMPPT algorithm. The LSC controls the voltage and frequency of the grid. The energy flow diagram of the system is shown in Figure 3.

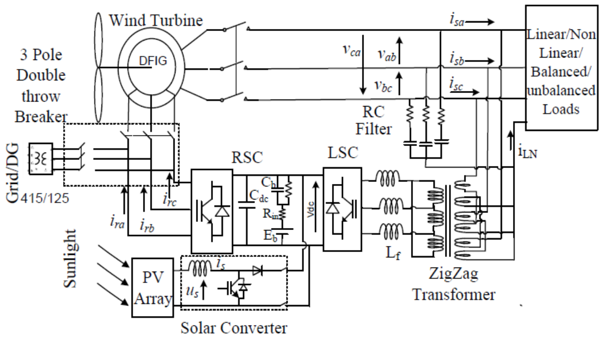

Figure 2: Schematic of isolated micro-grid network fed by renewable energy source using-battery-storage.

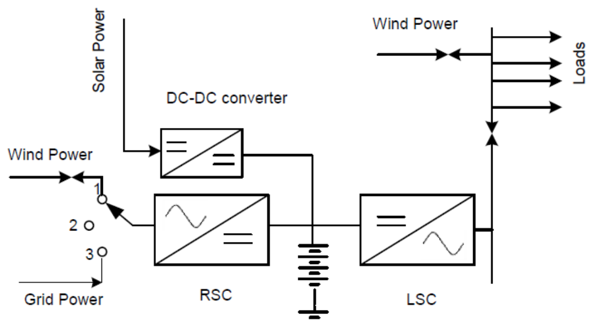

Figure 3: Energy flow diagram of isolated micro-grid network fed by renewable energy source using battery storage.

Wind turbines absorb the kinetic energy of the wind and provide drive torque to DFIGURE When the wind turbine is in operation, all the magnetization force needs of the machine are provided by RSC. Therefore, 11.83 kW of power from DFIG is sufficient to convert the mechanical power of a 15kW wind turbine into electrical energy. The load and stator terminals are connected to the LSC via a zigzag transformer, providing neutral for single-phase loads on the 415V side as well. Since the maximum absolute value of the rotor slip is 0.3, the maximum rotor voltage Vmax is 125 V (0.3 x 415 V). The voltage on the LV side of the zigzag transformer is also selected to be equal to Vmax. Therefore, the voltage ratio of the transformer is 415/125 V and its HV winding is connected to the stator and load.

The zigzag transformer must meet the total kVA requirement for the load and the connected filter. Therefore, a 20 kVA transformer is selected. This is sufficient to transfer the rated power while at the same time meeting the disabled power demand of the connected load and filter during peak demand.

Lead-acid battery banks can operate safely at 2.25V to 1.8V per cell. This results in a maximum battery voltage Vbmax and a minimum battery voltage Vbmin of 270V and 216V, respectively. It can be assumed that the battery bank has a fictitious capacitor Cb and an internal resistance Rin connected in series with a DC power supply. In addition to this, another resistor Rb is connected to both ends of the battery to indicate the energy consumption of the battery's self-discharge.The basic element of a solar PV system is the solar cell.

A solar converter that is a boosted DCDC converter used for evacuation of solar energy incorporating SMPPT logic. It is based on the incremental conductivity method. SMPPT controls us by intelligently switching the way our solar system works with MPP. Onshore wind turbines generate only 6070% of the time, so the system must be designed to work when wind is not available. Like the control diagram in the figure 4, i*qs consists of two components.

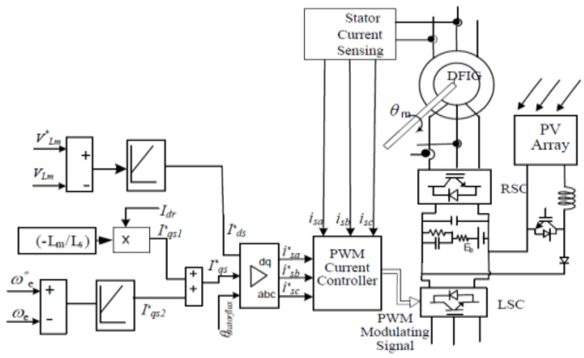

Figure 4: Control diagram of LSC for REGS energy fed micro-grid

The stator frequency is controlled by the LSC. The system needs to generate a nominal frequency, but it has built-in drooping characteristics. Vdcmax is assumed to be 272.5V. This is the bus voltage corresponding to Vbmax during charging. Similarly, Vdcmin is assumed to be 213.5V, this bus voltage corresponds to Vbmin and the battery is discharged. Using these numbers, the frequency will vary from 49Hz to 51Hz. The RSC regulates the speed of the turbine so that the system operates in MPP regardless of changes in wind conditions. It also supplies magnetization force to the generator. As shown in Figure 5, the control philosophyincludes control algorithms for determining the orthogonal component of the rotor urrent and the DC components

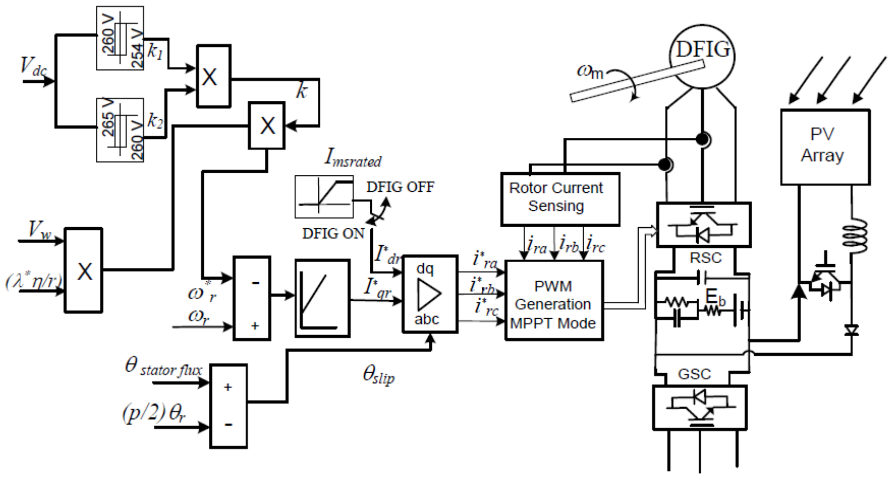

Figure 5: Control diagram of RSC for REGS fed micro-grid

The value of k is determined by two relays, k1 and k2, as shown in Figure 5. When the voltage in the intermediate circuit exceeds the threshold, the output of the relay drops to 0.85. The thresholds for both relays are kept at 260 and 265, respectively. When Vdc exceeds 260V and 265V, k reaches values of 0.85 and 0.72, respectively. Hysteresis currentThe reference current and detection current (ira,irb, irc) error signals that pass through the controller generate an RSC control signal.

IV. SIMULATION RESULTS

The Simulink model of micro-grid fed by REGS is developed in Matlab. The solar panels and wind turbine are model using their functions.

CASE-A: Performance of System at Constant Load and Cut-in and Cut-out of Wind Power

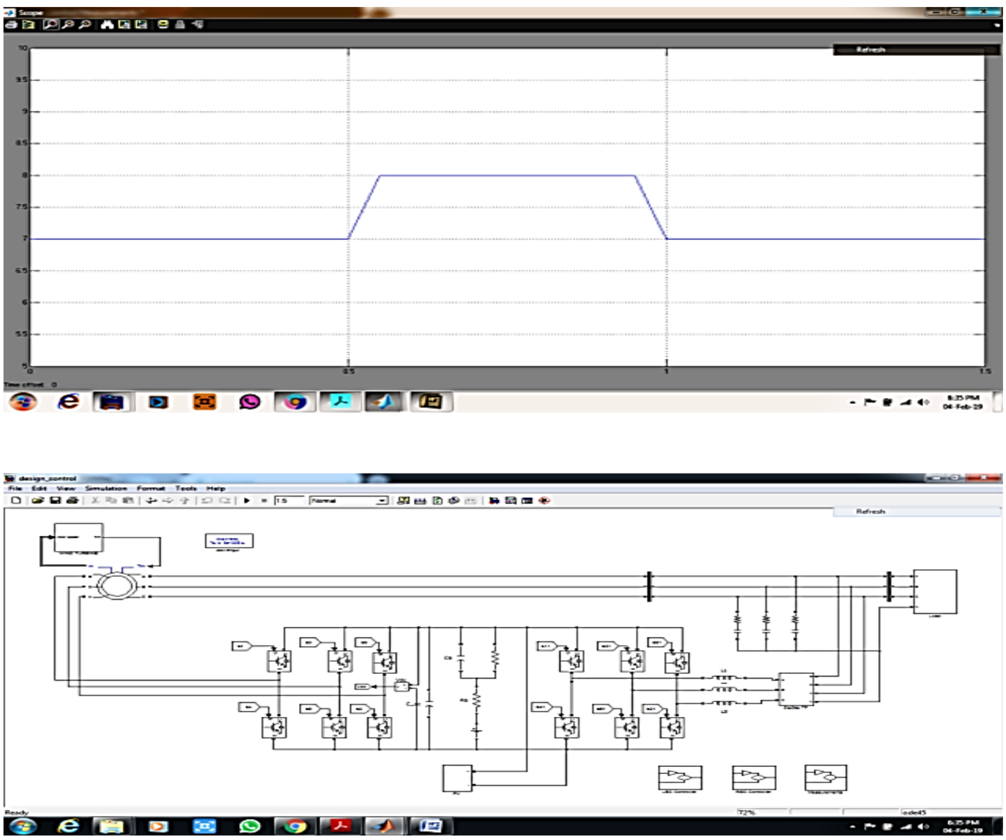

Figure 6: Performance of System at Constant Load and Cut-in and Cut-out of Wind Power

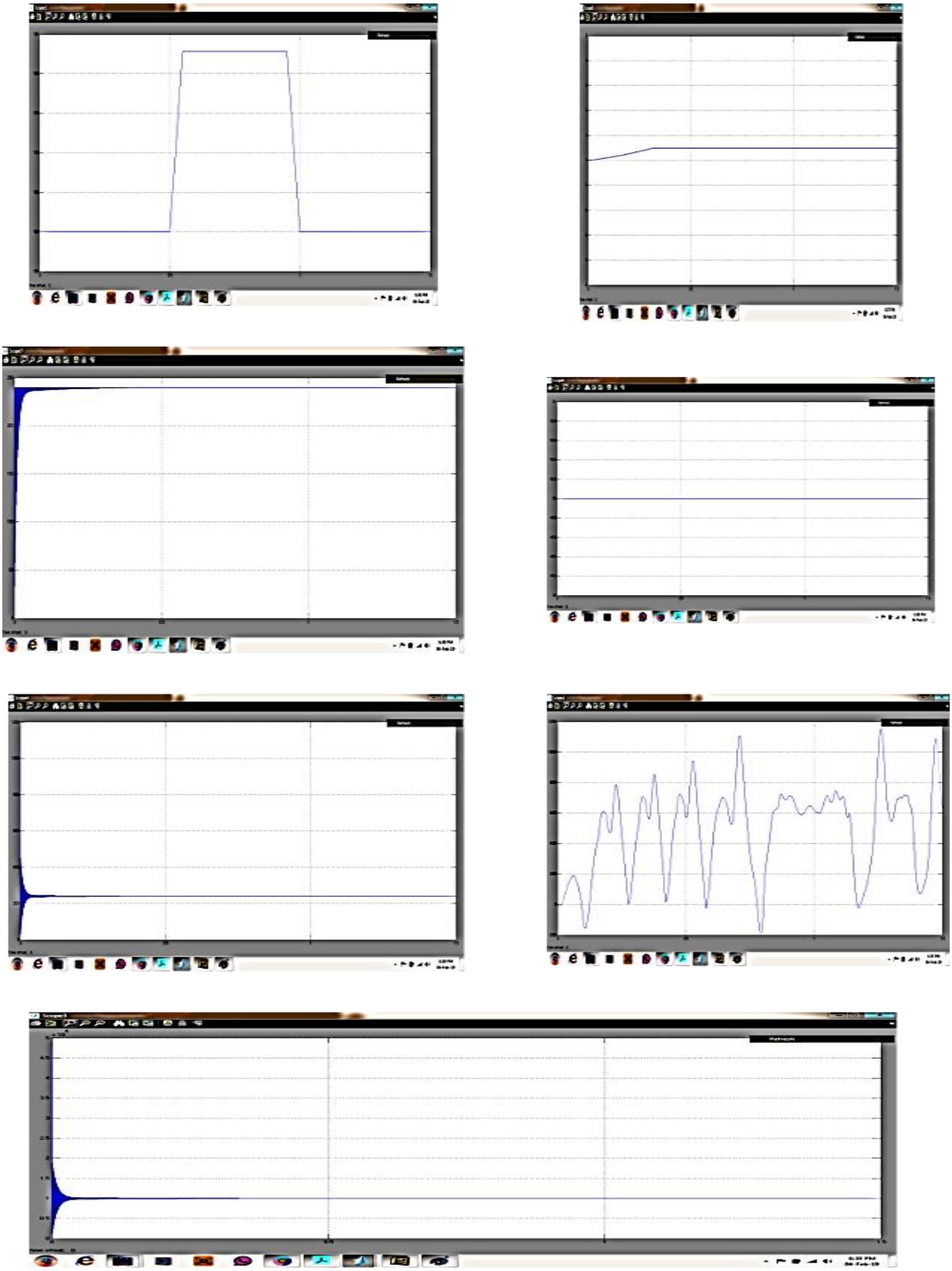

Figure 7: Performance of REGS fed micro-grid with wind energy source

As shown in Figure 7, the system is booted with a load of 10kW and 6kVAR without the use of wind or solar energy sources. At t = 0.25 s, the wind turbine operates at a wind speed of 7 m / s. As a result, momentary fluctuations in system voltage are observed. At t = 0.6 s, the turbine wind speed increases from 7 m / s to 8 m / s, then at t = 0.1 s the wind speed decreases to its original value. The rotor control operation maintains the desired rotational speed according to the WMPPT algorithm. At t = 0.14 seconds, the wind turbine will shut down.

CASE-B: Performance of System at Constant Load and Cut-in and Cut-out of Solar Power.

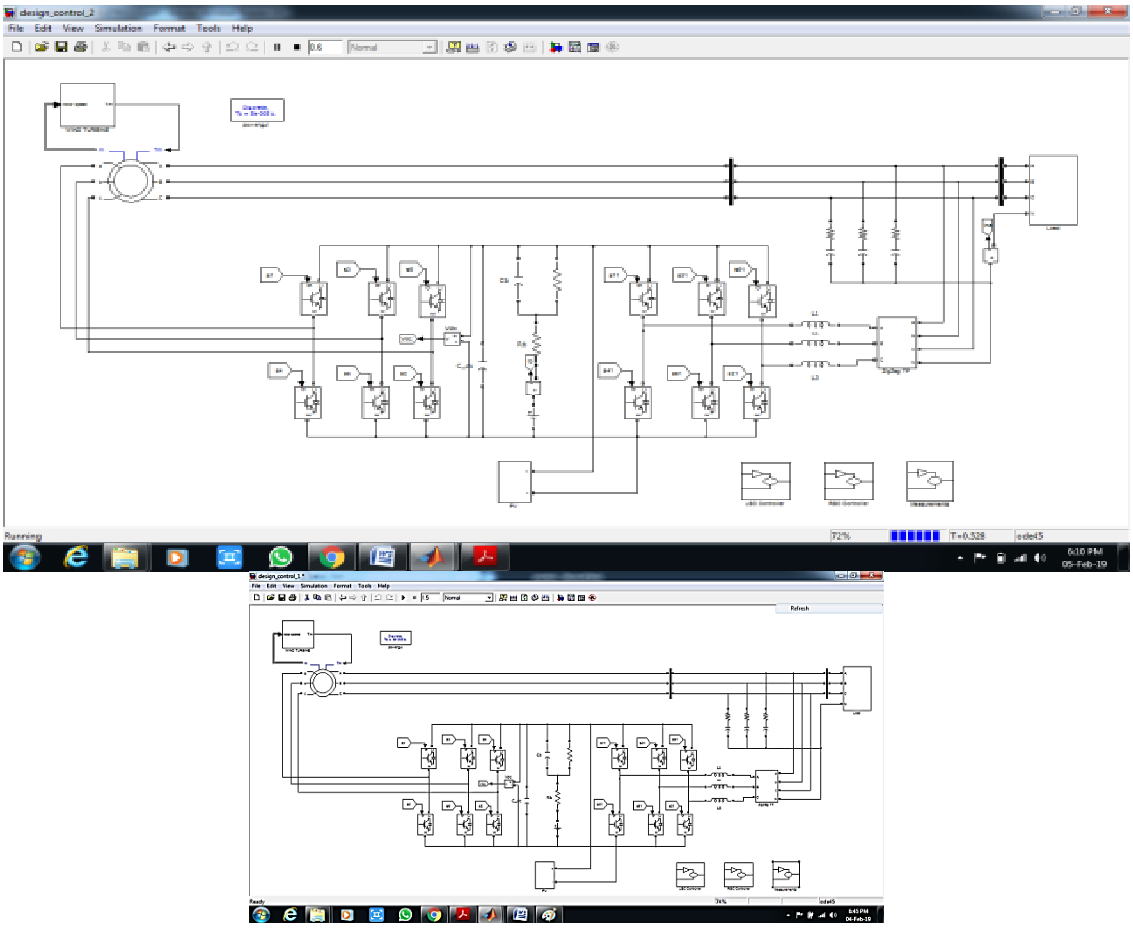

Figure 8: Performance of System at Constant Load and Cut-in and Cut-out of Solar Power

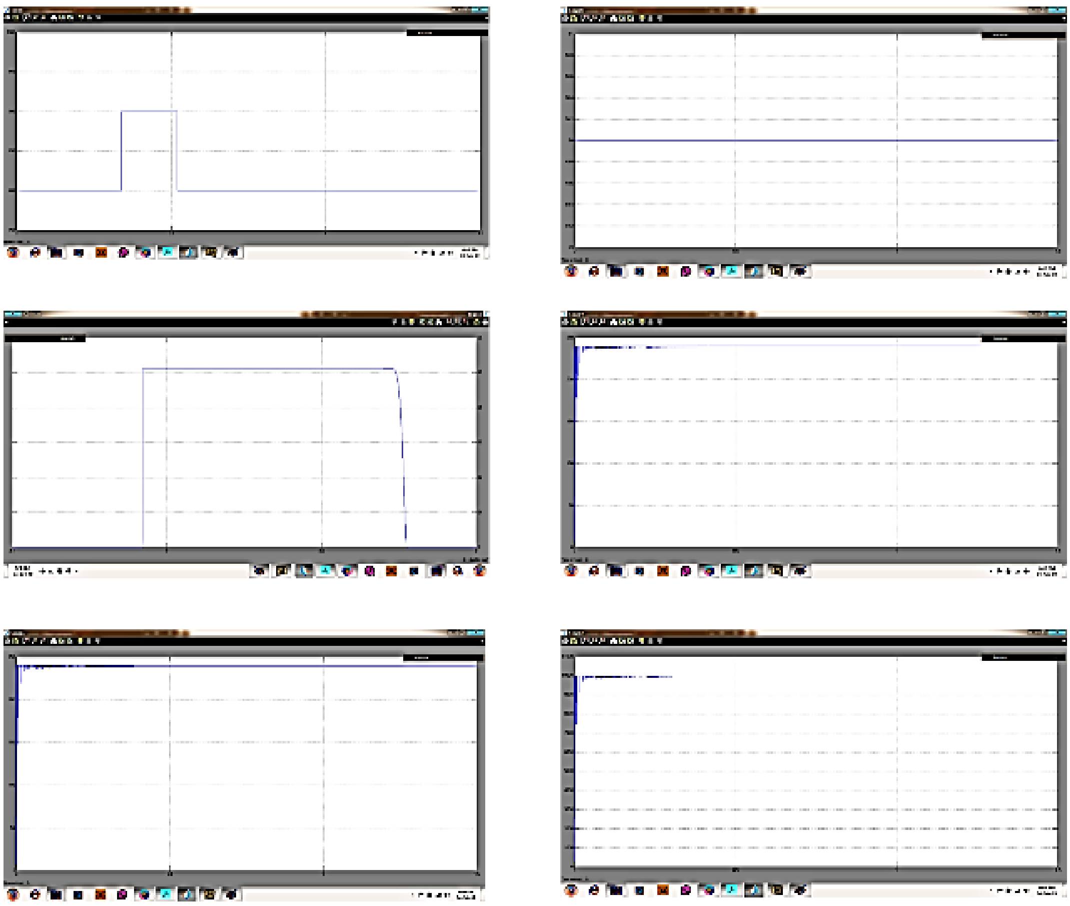

Figure 9: Performance of the system without generating source and solar system is taken in the service.

The system is started with 10 kW and 6 KVAR loads without using wind or solar energy. As shown in Figure 9, at t = 0.25 s, the solar system is put into operation with radiation of 800 W/m2. At t = 0.4 s, the solar irradiance increases to 900 W/m2 and again decreases to 800 W/m2 at t = 0.6 s. The solar converter regulates the solar PV voltage and operates at SMPPT. At t = 0.7 s, the solar system turns off. No significant changes in system voltage were observed at any of the transition points.

CASE-C: Performance of System at Unbalanced Nonlinear Load

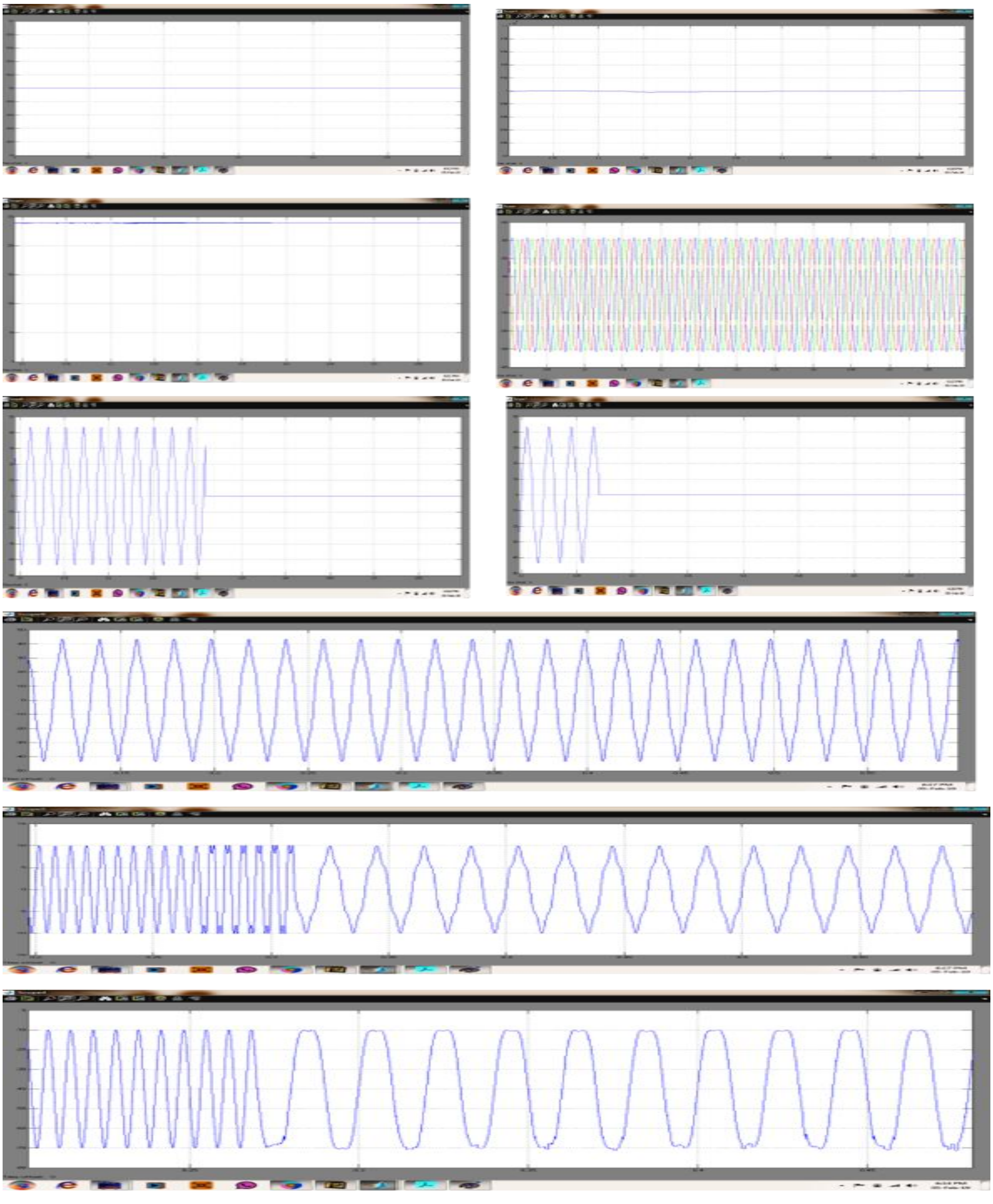

Figure 10: Performance of the system at unbalanced and nonlinear load

Figure 10 shows the performance of a system with imbalanced non-linearity. The microgrid must be able to meet the requirements for unbalanced nonlinear loads. If there is no source, the worst scenario is assumed. The connection load consists of a 2kW linear load and an 8kW non-linear load. At t = 0.325s, the a-phase load is disconnected from the grid, followed by t = 0.346s, the b-phase load is disconnected. The results show that the system can provide high quality performance to customers with both unbalanced and non-linear loads.

V. CONCLUSION

The proposed REGS power supply microgrid system is found to be suitable to meet thecharging-needs of a remote site with few households. REGS consists of wind and solar energy blocks, designed to extract maximum energy from renewable energy sources, and at the same time, it provides quality energy to consumers. The system has been designed to operate fully automatically. This work also covers the determination of the dimensions of the principal components. System performance has been demonstrated for varying input conditions for different types of load configurations. Under all conditions, the power quality at the charging terminals remains within acceptable limits. The effectiveness of the system is also demonstrated by the results of tests with prototypes in the laboratory. The system also considers external battery charging using a rotor-side converter and its sensors to achieve uniform power factor rectification.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

[1] H. Zhu, D. Zhang, H. S. Athab, B. Wu and Y. Gu, “PV Isolated Three- Port Converter and Energy-Balancing Control Method for PV-Battery Power Supply Applications,” IEEE Transactions on Industrial Electronics, vol. 62, no. 6, pp. 3595-3606, June 2015.

[2] M. Das and V. Agarwal, “Novel High-Performance Stand-Alone Solar PV System With High-Gain High-Efficiency DC–DC Converter Power Stages,” IEEE Transactions on Industry Applications, vol. 51, no. 6, pp. 4718-4728, Nov.-Dec. 2015.

[3] A. B. Ataji, Y. Miura, T. Ise and H. Tanaka, “Direct Voltage Control With Slip Angle Estimation to Extend the Range of Supported Asymmetric Loads for Stand-Alone DFIG,” IEEE Transactions on Power Electronics, vol. 31, no. 2, pp. 1015-1025, Feb. 2016.

[4] N.A. Orlando, M. Liserre, R.A. Mastromauro and A. Dell’Aquila, “A survey of control issues in PMSG-based small wind turbine system,” IEEE Trans. Industrial Informatics, vol.9, no.3, pp 1211-1221, July 2013.

[5] T. Hirose and H. Matsuo, “Standalone Hybrid Wind-Solar Power Generation System Applying Dump Power Control Without Dump Load,” IEEE Trans. Industrial Electronics, vol. 59, no. 2, pp. 988-997, Feb. 2012.

[6] Z. Qi, “Coordinated Control for Independent Wind-Solar Hybrid Power System,” 2012 Asia-Pacific Power and Energy Engineering Conference, Shanghai, 2012, pp. 1-4.

[7] M. Rezkallah, S. Sharma, A. Chandra and B. Singh, “Implementation and control of small-scale hybrid standalone power generation system employing wind and solar energy,” 2016 IEEE Industry Applications Society Annual Meeting, Portland, OR, 2016, pp. 1-7.

[8] A. Hamadi, S. Rahmani, K. Addoweesh and K. Al-Haddad, “A modeling and control of DFIG wind and PV solar energy source generation feeding four wire isolated load,” IECON 2013 - 39th Annual Conference of the IEEE Industrial Electronics Society, Vienna, 2013, pp. 7778-7783.

[9] S. K. Tiwari, B. Singh and P. K. Goel, "Design and control of autonomous wind-solar energy system with DFIG feeding 3-phase 4-wire network," 2015 Annual IEEE India Conference (INDICON), New Delhi, 2015, pp. 1-6.

[10] S. K. Tiwari, B. Singh and P. K. Goel, “Design and control of micro-grid fed by renewable energy generating sources,” 2016 IEEE 6th Inter. Conference on Power Systems (ICPS), New Delhi, 2016, pp. 1-6.