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On-Grid Power Synchronization and Load Sharing of Wind-Solar-Diesel Power System

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***Abstract*--Hybrid Power Systems are highly explored by researchers nowadays and became a key research area. Hybrid Power system is a system which combine together the output power of two or more different power sources mostly renewable power sources such as wind-turbine and solar-photovoltaic (PV), in order to drive a common load. To synchronize more than two powers is a difficult task, technically a lot of effort is consumed to make capable two different power sources to drive a common load. This paper is about power synchronization of four different power sources (solar-PV, wind-turbine, Diesel-generator and local-grid). As the available power from PV-modules and wind-turbine is highly dependent on solar radiations and wind flow, which are not always available. To overcome this deficiency solar-PV-system and wind-turbine are integrated with diesel-generator and gird. The proposed system provides an efficient way for power synchronization and load sharing. This work concentrates on the scenarios where synchronized power (wind-solar-diesel-grid) drives a common load as well as the wind-solar-diesel power system can feed the load until the grid power is not needed. Similarly grid will also provide independent load until the wind-solar-diesel power is not needed. The wind-solar power system output energy can also be stored (in batteries) when power requirements are on lower side. The modeling of this system is done in Matlab/Simulink environment. Blocks of solar-PV-system, wind-turbine-system, diesel-generator-system and local- grid are designed and results of simulations are also presented. A real time monitoring is implemented which make decision based upon the load statistic and switches the sources when the load is increased or decreased from a pre-defined value. Transients were witnessed when diesel-generator output power is synchronized initially into the system. Over all stability of the system was observed.**

Software Used: Matlab2015b

Key Words: Synchronization, load sharing, PVC, PWM Inverter.

I. INTRODUCTION

The electric power generation around the world is due to non-renewable sources and because of its finite resources there will be a time when all these conventional sources will come to their end. Conventional energy sources such as coal, petroleum, natural gas etc. are used plentifully at current time because the power demand is increasing on each successive day. Due to continued and enormous use of non-renewable reservoirs these resources are fast depleting. And if it continuous the exhaustion of fossil fuel will occur soon. Besides, the persistence use of fossil fuel causes environmental pollution and global warming, which is extremely hazard to both animals and plants on the planet earth.

On the other hand, renewable energy sources, such as wind energy, solar energy, tidal energy, geothermal energy etc. are flow resources and there is no anxiety that these reservoirs will ever be depleted. Power generation from renewable sources is friendly to environment. By taking into account the benefits of renewable energy many countries, including Pakistan, have started to produce this energy in large scale. This energy is most cost effective than nonrenewable energy. Researchers are continuously evaluating this field to develop a technology to overcome fossil fuel and to make renewable energy generation more cost effective. Renewable energy is considered the energy of the future.

Nowadays wind-solar hybrid systems have gained attentions of the researchers around the globe. It is one of the best techniques to generate electricity, and to feed power to the load simultaneously. Wind-solar hybrid system can produce electricity when we need it, but what if we need power keenly, on cloudy days or when there is no sufficient air flow to rotate turbine's blades. In order to get rid of this situation we have to add one more source (nonrenewable) and synchronize it (such as diesel generator) to wind-solar hybrid system. This system can be made more efficient by connected all the three sources (wind turbine, solar panels and diesel generator) to local grid. But it required great effort to make use of all these four sources to drive load on common line. It mean frequency, phase sequences, phase angles and magnitudes of all the four independent sources should match exactly. A real time monitoring circuitry is necessary which should turn on and off the sources when load exceeds or decreases from a pre-set value.

The proposed methodology, simulation results and conclusion is presented in the upcoming sections.

II. PROPOSED METHODOLOGY

Four different power sources (wind-turbine, solar-PV-system, diesel-generator, local-grid) are synchronized to supply power to a common load. The two of them diesel-generator and local-grid supply alternating power, while solar panels generates direct power and wind-turbine produces pulsating AC. Difficulty in synchronization has reduced, firstly by converting the pulsating sinusoidal output of wind-turbine into pure DC, and then by combining it with solar-PV-system. Afterword it is fetched to inverter (PWM inverter) and finally synchronized with diesel-generator

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output. Subsequently it is synchronized with the local grid and drive particular loads on common line.

This project is about concerning matter of electricity in rural areas. At first the load will be driven by combine power of wind-solar power system. Once the load increases the power supplied by wind-solar power system, or, when there is no sufficient air-flow to rotate the wind-turbine's blades, or, when there is no enough sun rays to produce required voltage then a circuitry has made which would switch on the other sources (diesel-generator or local-grid or both of them) regarding the statistics of loads, whose output power will be synchronized with the alternative sources, and so the load will be driven by the synchronized sources simultaneously.

Similarly if the load decreases from a pre-set value, local-grid and diesel-generator can be disconnected and the load can be fed by the synchronized power of wind-solar power-system. A rough sketch of proposed methodology is shown in figure 1.

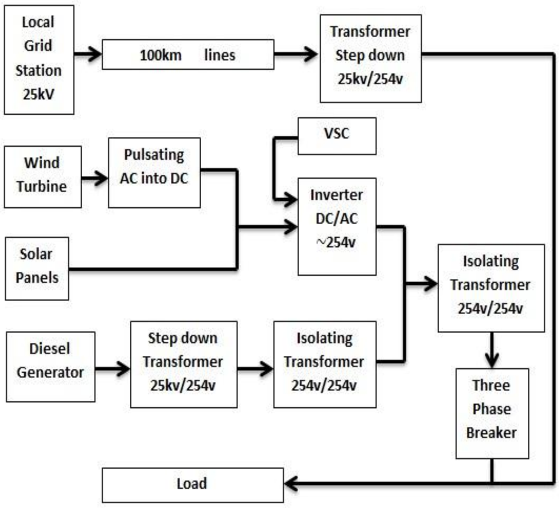

Figure 1: Block Diagram of proposed System

III. PROJECT DESIGN AND RESULT DISCUSSION

Simulation

Simulation circuit-diagrams for the proposed system are shwon in figure 5 and figure 6. Figure 5 shows wind-solar-diesel power-system, while in figure 6, wind-solar-diesel power-system has synchronized with grid.

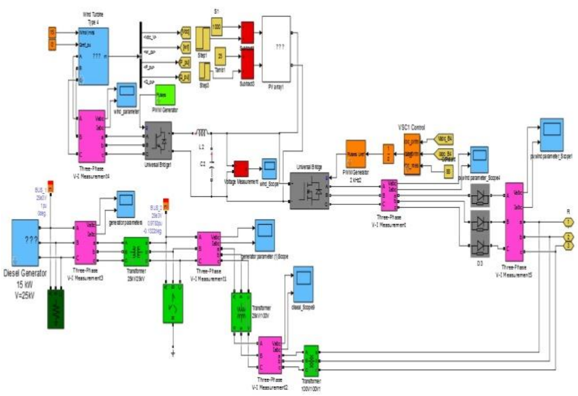
Figure 5: Proposed Module 1.1

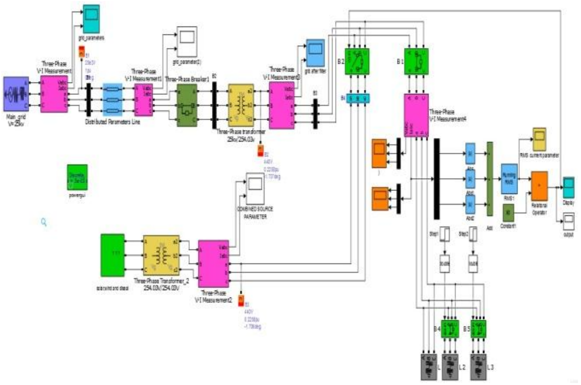
Figure 6: Proposed Module 1.2

Rectifier

As the output voltage from wind turbine is not pure sinusoidal, so it must be converted into DC through rectifier. A three phase bridge (three arms six pulses) rectifier has been used for converting the wind-turbine output into DC. These rectifiers have six IGBTS-diodes connected in bridge arrangement as shown in the figure 5.4.

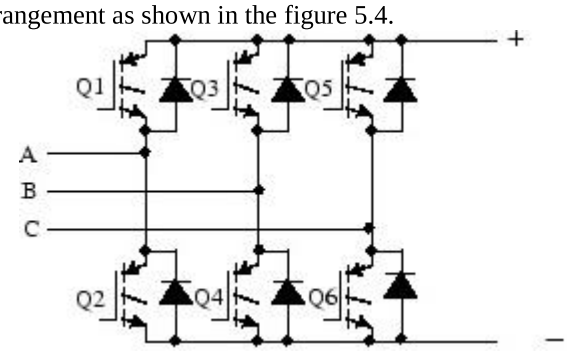

Figure 2: Three phase rectifier Circuit Diagram

In order to have voltage across the output terminal of the rectifier, two switches each on the different legs must be conducting at the same time. Two switches on the same leg must not be conducting simultaneously. Switches are turned on and off by the pulses which are produced by the PWM generator. PWM generator produces pulses to turn the switches on and off according to the voltages appears at the input of the rectifier. For three phase source, six pulse signals are required, because polarity must be taken into consideration. By considering the rectifier circuit diagram, the voltage from A to B is the opposite from B to A and similar case for the other voltages. PWM generator generates six signals similar in frequency and in phase to those voltages that appear at the input terminals of rectifier. The signal which has the highest value in given interval of time, produces a pulse which then switch-on the corresponding switch and a rectified output is obtained. The rectified output is then filtered to get pure DC. It is then added to the solar-PV-system obtaining combined DC output, as shown in figure 3.

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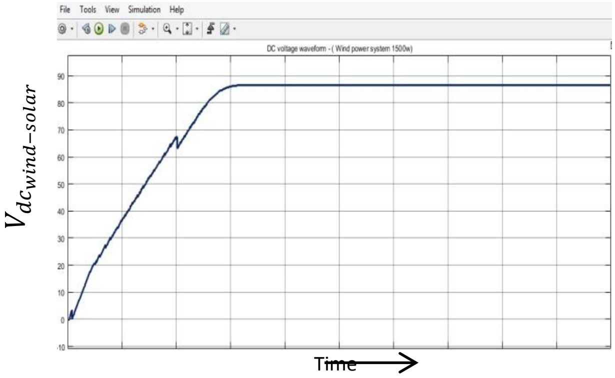

Figure 3: Synchronized DC Output of Wind-Solar

Voltage Source Inverter (VSI)

The combined DC output from wind-solar power-system feeds the three phase inverter (VSI). VSI employ self-commutating switches e.g. IGBTs, which turns on and off in a controlled manner, converts DC power into AC with 120 degrees phase displacement. There are several ways to control the AC output voltage from DC input. One of the well-known method in which the switching devices in the invertor circuit are turned on and turned off in such a passion that a zero periods of equal length is produced, while the DC source is considered a constant level of voltage V. [2] [6] [7]

In order to obtained a pure sinusoidal output from a fixed DC input an improvement in the method mentioned above is required. The ON and OFF periods are varied in such a way that the switching devises are ON for longest period at the peak of the wave and vise-versa. This is called Pulse Width Modulation technique.

To synthesize correctly pulse width modulated waves for three-phase inverter, three reference sine waves of the desired frequency are required. These reference waves determine the firing instants of the switches. Each IGBT in the inverter acts as a switch, conducting for 180 degrees, which can be turned on and off in such a manner to give desired AC output. So in this mode of operation the DC power source is always appears at one IGBT on one side with two IGBTs in parallel on the other side, hence three IGBTs are conducting at a particular time while the remaining three IGBTs must be closed at the same time. For this purpose 6 pulses are required, three for the upper half arms and three for the lower half arms. PWM generator block produces these six pulses by comparing three reference (modulating) signals with a triangular carrier-signal. Whenever the reference-signal-1 is greater than the carrier signal, pulse-1 is high while pulse-2 is low, similarly when reference-signal-2 is greater than carrier single, pulse-3 is high while pulsle-4 is low and so on. Hence 6 pulses are produced at same time. These pulses are then given to the switching devices (IGBTS) turning it on and off obtaining the desired output. The output can also be filtered by connecting inductances and capacitances of required value in series and in parallel to achieve pure sinusoidal output, as shown in figure4.

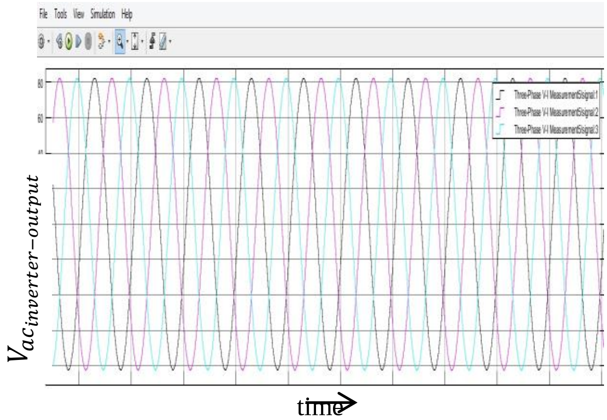

Figure 4: Inverter Output after Converting Wind-Solar DC into AC

The output from wind-solar system has now exactly synchronized with the diesel-generator and grid through VSI-main-controller shown in figure 5(A), which has a sub-block "Phas locked loop" inside it.

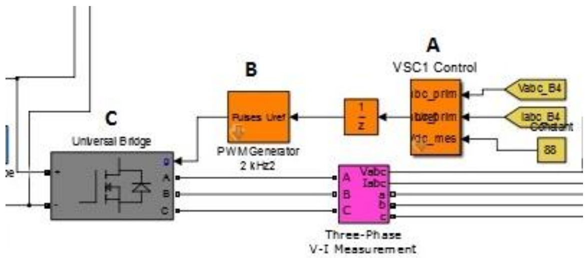

Figure 5: VSC controller

VSI-main-controller takes grid voltages, these voltages are given to Phase Locked Loop (PLL), as a reference voltages. PLL compare the incoming voltages to it and acordingly gives the reference singals to PWM –generator(B), PWM-generator generates pulses for inverter(C), as discussed above. The inverter now produces output which hase the same frequency and and phase-angle as the grid voltages have. It is now added to diesel and then to grid obtaining a synchronized volages as shown in figure 6 and figure 7. [8] [9]

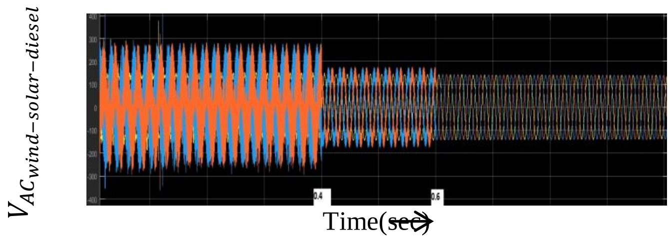

Figure 6: Wind-Solar-Diesel power System output

As shown I figure 6. a trasients are wetnessed when a desiel-generator is conncted to the system. The system is then come into steady state after somtime, as required by the load.

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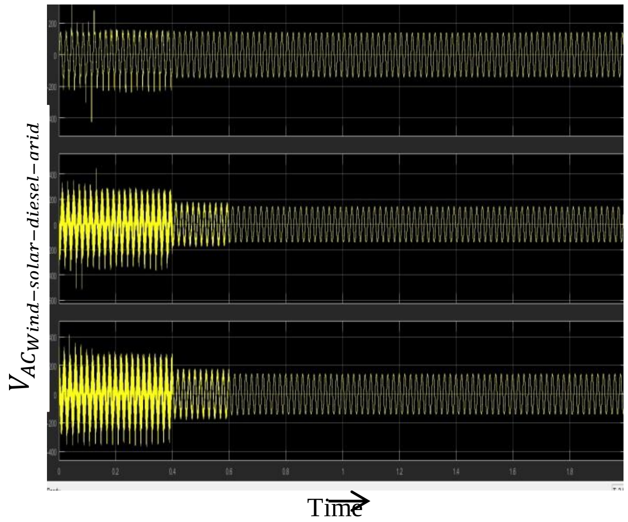

Figure 7: Synchronized Three-Phase to Ground Voltages of Proposed System

As the solar-wind system has been connected to diesel generator through VSI. If the solar-wind system is at grid connected mode, the VSI should operate at PQ control mode. While at autonomous mode the VSI should operate at voltage/frequency (vf) control mode. Since the power output from the solar-wind system is normally not constant, i.e, it fluctuates as wind-flow or sun -rays or other factors changes, it is then not appropriate to employ the VSI to operate on Vf control mode. That is why, the VSI of wind-sloar system always operate on PQ control mode, which mean that it will always carry the active power generated by wind-solar sysem to the grid. MPPT algorithm will extract maximum power from the PV arrays and send it to the VSI. [3,4,5]

IV. LOAD SHARING

Current in conductors feeding the load is continuously sensed. As shown in figure 8, initially power is supplied to the load by grid. As current increases from a pre-set value, a signal is initiated which closes the contacts of circuit breaker, and wind-solar-diesel system is synchronized to the grid, hence supplying power to the load simultaneously.
Initially a single load is connected to the system, at time 0.4 a second load is connected caused increase in drawing current, as shown in figure 8

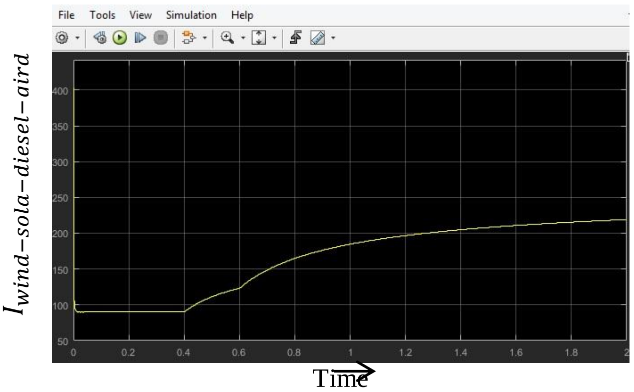

Figure 8: Showing increase in current as the load is increased

A 3rd load is connected at time 0.6, as clear in figure 8 and figure 9, more current is drawing.

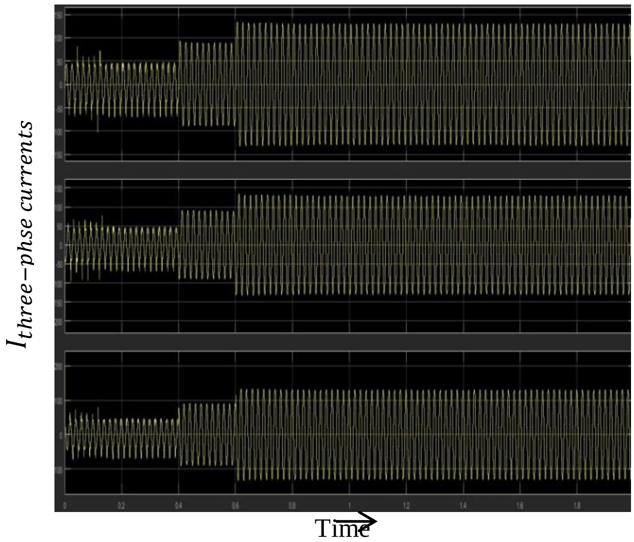

Figure 9: Three Phases currents of Proposed System

As shown in figure 9. The three-phase currents have increased at 0.4 because load had increased. As more load is added to the system at 0.6, more currents are required to drive the load hence further increase in currents occurred, thus at this time all the sources (wind-turbine, solar-PV, diesel-generator and local-grid) supplying power to the load simultaneously.

V. CONCLUSION

The proposed system was successfully tested on using the Simulink software, and results showed the combination of four power sources i.e. diesel generator, wind turbine, solar PV system and grid. The system observed transient's when initially the diesel power source was synchronized into the system. The overall system showed stability over the loads.

VI. FUTURE WORK

A future research could be done by introduction of HVDC transmission line and smart grid system, which will provide end to end connectivity of devices. Thus better fault tolerances and detection capability.

REFERECNES

[1] Fast and Accurate Measurement of Power System FrequencyDr.-Ing. Tevfik Sezi Siemens A.G.Nuremberg tevfik.sezi@siemens.com
[2] Power Electronics third edition by "Cyril W. Lander". Department of Electronic and Electrical Engineering De Montfor University, Leicester.
[3] H. Chen, "Research on the control strategy of vsc based hvdc system supplying passive network," in Power Energy Society General Meeting, 2009. PES '09. IEEE, july 2009, pp. 14.
[4] G. Li, M. Yin, M. Zhou, and C. Zhao, "Modeling of vsc-hvdc and control strategies for supplying both active and passive systems," in Power Engineering Society General Meeting, 2006. IEEE, 0-0 2006, p. 6 pp.
[5] P. Piagi and R. Lasseter, "Autonomous control of microgrids," in Power Engineering Society General Meeting, 2006. IEEE, 0-0 2006, p. 8 pp.
[6] N.Sambasiva Rao, Associate Professor & Head, Department of Electrical & Electronics Engineering, NRI Institute of Technology, A.P. "Design & Simulation of Hybrid Solar – Wind Electric Power System Interface to Grid System" IJREAT International Journal of Research in Engineering & Advanced Technology, Volume 1, Issue 4, Aug-Sept, 2013 ISSN: 2320 – 8791.

[7] Cristian Dragoş Dumitru, Adrian Gligor, Petru MaiorUniversity of Târgu Mureş, Romania. "Modeling and Simulation of Renewable System Using Matlab/Simulink Environment". Scientific Bulletin of the „Petru Maior" University of Târgu Mureş Vol. 7 (XXIV), no. 2, 2010, ISSN 1841-9267.

[8] J. Svensson, "Synchronisation Methods for Grid Connected Voltage Source Converter," Submitted to IEE Proceedings Electric Power Applications.

[9] J. Svensson, "Voltage Angle Control of a Voltage Source Inverter — Application to a Grid-Connected Wind Turbine," 6th European Conference on Power Electronics and Applications (EPE'95), Sevilla, Spain, 19- 21 September 1995, Proceedings, Vol. 3, pp. 539-544.