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Improvement of Power Quality in Low Voltage Distribution Grids

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Abstract

Nowadays, The main concern in the electrical power system is the quality of power. Electrical devices are affected by power quality disruptions such as voltage sags which swells and cause severe damage. Therefore, to ensure regular and efficient operation of the power system, the disruptions must be acknowledged and compensated. In this paper, a compensatory control method using the voltage restorer is demonstrated. The proposed system is capable of restoring voltage in such a way that it maintains constant voltage and restores the power quality. Thus, improvement in voltage profile will reflect in power factor, reactive power and efficiency of the system. Power quality issues are gaining considerable attention as the number of sensitive loads increases. Nearly all energy performance issues are caused by failures in the distribution networks. The voltage regulator is used to overcome the problems of the power system stability. MATLAB / SIMULINK performs simulation tests to evaluate the performance of the system proposed.

Keywords: *Quality, Dynamic Voltage restorer, voltage sag, power factor, voltage swell.*

I. INTRODUCTION

At power stations, the high quality sinusoidal waveform is produced. The widespread applications of nonlinear power-based electronic devices and the occurrence of faults cause deviation from pure sinusoidal waveform. In order to continue production, customers need constant sine wave shape, constant frequency and symmetric voltage with a constant root mean square value. The disruptions must be eliminated from the network to satisfy these demands. Typical disruptions in power performance include voltage drops, voltage swells, transients, interruptions, and harmonics and phase changes. These problems are faced by electricity customers and suppliers. So, one of the major concerns in electricity industry is power quality.

Slow voltage and swell can result in failure or shutdown of sensitive equipment (such as those originate in semiconductor or chemical plants) as well as a large current imbalance that could misfortune breakers or fuses. For the consumer, such results can be very costly, ranging from minor variations in performance to the creation of downtime and damage to the equipment.

As they are fewer frequent in distribution systems, voltage swells are not as critical as voltage drops.

Meanwhile the delicate loads are exact vulnerable to transient voltage changes and voltage sag which is considered the most serious cause. Given their short duration, a wide range of equipment may have serious problems with such incidents.

To mitigate voltage drops and improve power quality, the wide area solution is required. There are many different ways to mitigate voltage sags and swells, but it is considered the most effective approach to use a custom power unit.

An industrial firm, which have a solar farm with the installed (generating) capacity of 10MW power. But only 7MW of power is consumed by the load and further loads cannot be connected. This is because most of the loads connected in the load side are inductive in nature. Inductive motors consume a lot of reactive power from the bus and here power factor reduces which also suppresses voltage and causes increase in current. Thus, increased current flow can lead to copper losses or I^2R losses. These issues can affect the power quality as there is a deviation in the electrical parameters (Voltage, current, frequency) from the normal range.

When synchronizing two buses (A and B) for transformer maintenance work, the bus coupler is unable to close when the conditions for parallel operation are not satisfied, especially voltage parameters are widely affected. Hence to improve the voltage level, voltage restoring methods can be used for synchronizing the buses.

In order to maintain the rated parameters in the grid and to improve power quality we have designed the voltage restorer. By using this model, efficiency can be improved and maximum number of loads can be connected.

This paper's main goal is to design a simple system using the Voltage Restorer concept. The importance of this system is to protect a sensitive load from wilt or engorge and supply side deviations by rapid succession voltage booster to reward the drop or rise in supply voltage. When installed between the supply and a critical load feeder, a voltage restorer with its excellent dynamic capabilities can compensate for voltage deviations, restore line voltage within a few milliseconds to its nominal value and thus avoid any power disruption to the load.

The proposed system allows the renewable energy sources for mitigating voltage disturbances [4]. Solar panels are used as the energy source which provides clean source of energy eliminating air pollution. The important objective of this project is to provide uninterrupted power supply in the load side and to maintain constant voltage and power factor. It is also used for reactive power (VAR) compensation and to improve voltage regulation. Ultimately, improving power quality will increase the lifetime of the equipment by protecting them from damage.

II. DYNAMIC VOLTAGE RESTORER

A. Block Diagram

The voltage restore is a simple, versatile and efficient solution to the problem of voltage decay and swells. Within a few milliseconds, it can restore the load voltage and thus prevent any power interruption to that load. Figure-1 shows Voltage Restorer's block diagram.

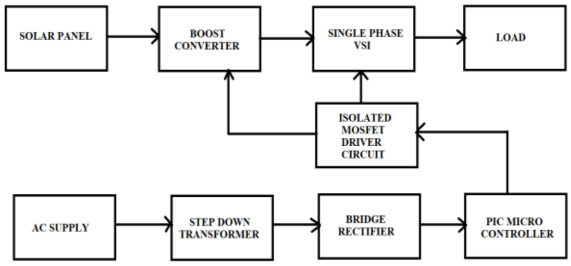

Figure-1. Block Diagram of Voltage Restorer

B. Energy Source

Energy storage is necessary to afford active power to the load throughout flywheel, Super-Capacitors, deep voltage sags, Superconducting Magnetic Energy Storage, Lead-acid batteries can also be worn for energy storing. But, we are using renewable energy source like solar panels. For precautionary measures, we connect a 12 V, 7.5 Ah sealed lead acid rechargeable battery to get uninterrupted power supply.

C. Inverter

Used to convert the DC voltage of the energy storage device to an AC voltage. This voltage is enhanced through the injection transformer to the foremost system. Thanks to the use of step-up transformers for injection, the Inverter level is usually low voltage and high current. It consists of switching devices such as MOSFETs, Gate Turn-Off (GTO) thyristors, Integrated Gate Commutated Thyristor (IGCT) and Insulated Gate Bipolar Transistors (IGBTs).

D. Transformer

A transformer is a device that transfers power between two or more circuits. A variable current in one transformer coil generates a variable magnetic flux, which in turn causes a variable electromotive force across a second coil wrapped around the same core.

Specifications

Step-down Centre tapped Transformer

Input Voltage: 220V AC at 50Hz

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Output Voltage: 24V, 12V or 0V

Output Current: 1A

Working

The Center tapped transformer's function and concept is identically closed to a standard secondary transformer. Even a primary voltage is induced in the primary coil (I1 and I3) and the voltage is transferred to the secondary coil due to magnetic induction. There will be an extra wire (T2) in the secondary coil of a center tapped transformer, which will be positioned precisely in the middle of the secondary coil, so the voltage will always be zero here. We get a 12V AC voltage if we combine this zero potential wire (T2) with either T1 or T2. If this wire is ignored and consideration is given to T1 and T2 voltage, a 24V AC voltage will be provided. This feature is very useful for a full wave rectifier application.

POWER SUPPLY CIRCUIT

The 230 V AC source is dropped down to 12V worn a step down transformer and is given to the bridge rectifier where the AC voltage is converter into DC voltage. This 12V DC is delivered from side to side of a capacitor to filter out ripple and then given to the voltage regulator L7805CV which provides 5 V to the micro-controller for its operation. Figure-2. shows the power supply circuit for the microcontroller, boost converter and the drive circuit.

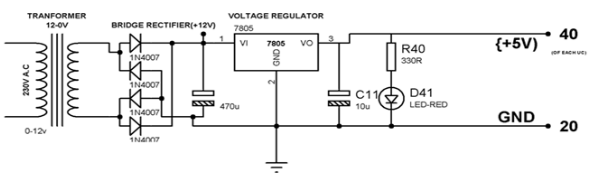

Figure-2. Power Supply Circuit

Whenever there is a voltage deviation from the normal rated voltage, it is sensed by the controller and then it gives pulses to the drive circuit. The control supply for the micro-controller is taken from the 220V AC source.

Energy source is used to supply constant voltage to the load. In this paper, PV is used as an energy source. A 12V battery is used as a backup in case of unavailability of solar energy. A DC to DC boost converter is used to step up the voltage and then the DC voltage is converted into AC voltage by the use of an inverter. The firing pulses are given to the boost converter and inverter through the drive circuit. The AC supply from the inverter is then given to the load.

In this work, we focused on the new integration of the Dynamic Voltage Restorer based on solar PV-Battery, which is implemented in the distribution system to meet the required power and improve the power quality.

III. DESIGN AND SIMULATION

A. Circuit Simulation Model of Uncompensated System

Figure-3 illustrates the circuit simulation prototype of uncompensated system.

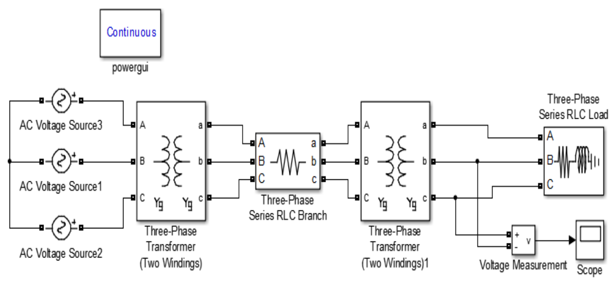

Figure-3. Circuit Simulation Model of Uncompensated System

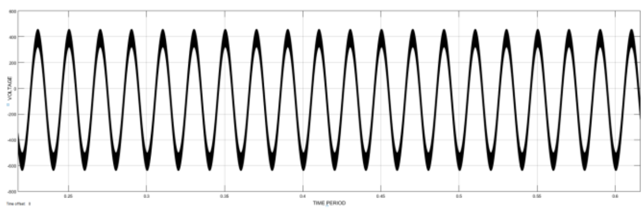

Figure-4 Simulation Output of Uncompensated System

Figure-4 shows the simulation output of the uncompensated system.

DESCRIPTION

Let us consider the above system as a general power system which delivers power to the load from the generating station. While coming to the distribution side, the voltage gets distorted due to the occurrence of voltage unbalances. Therefore, in order

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to overcome these voltage unbalances, we have designed this voltage restorer.

B. Circuit Simulation Model of Voltage Restorer

Figure-5 shows the circuit simulation model of Voltage Restorer and figure-6 shows the simulation result of the voltage restorer

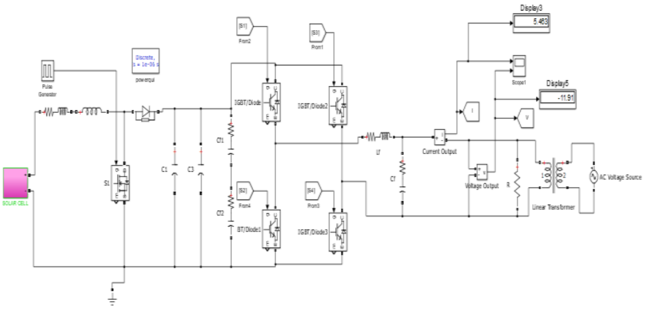

Figure-5. Circuit Simulation Model of Voltage Restorer

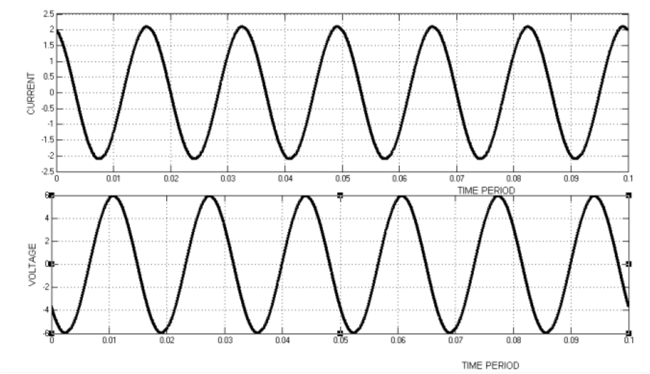

Figure-6. Simulation Result of Voltage Restorer

IV. RESULT AND DISCUSSION

The simulation is done and the compensated and uncompensated wave-forms are obtained. The results show the performance of voltage restorer. In case of voltage sag or swell, the wave-forms are distorted due to the disturbances when it is uncompensated and after compensation pure sine wave is obtained as shown in the above graph.

V. CONCLUSION

The objective of the work is to explain issues in power quality issues in the low-voltage distribution network and their critical load defect. The voltage restorer is designed to offset voltage sags, oscillating components of disturbing loads, harmonic currents, current imbalances, reactive power and ' active power. MATLAB / SIMULINK is used to design and model the voltage restorer's control circuit and power circuit parameters. The reliability and efficiency of the proposed system-connected voltage restorer will be tested. The voltage restorer injects the required voltage part too rapidly to the accurate value of any error in the supply voltage to maintain the balance of the load voltage.

REFERENCES

[1] M. Mishra, A. Ghosh and A. Joshi, “Operation of a DSTATCOM in voltage control mode,” IEEE Trans. Power Del., vol. 18, no. 1, pp. 258264, Jan. 2003.

[2] Chen, Zhong, Research on the Key Techniques of Shunt Active Power Filter, PH.D Dissertation, Zhejiang University, Hangzhou, China, 2005.

[3] G. Ledwich and A. Ghosh, “A flexible DSTATCOM operating in voltage or current control mode,” IEE Proc.-Gener., Transmiss. Distrib., vol. 149, n. 2, pp. 215-224, Mar. 2002.

[4] T. P. Enderle, G. da Silva, C. Fischer, R. C. Beltrame, L. Schuch, V. F. Montagner and C. Rech, “D-STATCOM applied to single-phase distribution networks: Modeling and control,” in Proc. IEEE Ind. Electron. Soc. Annu. Conf., Oct. 2012, pp. 321 - 326.

[5] P.K. Steimer, 2010, “Enabled by high power electronics - Energy efficiency, renewables and smart grids”, Power Electronics Conference (IPEC 2010), 21-24 June, Sapporo (Japan), pp.: 11 – 15.

[6] P. Acuna, L. Moran, M. Rivera, J. Dixon, 2014, “Improved Active Power Filter Performance for Renewable Power Generation Systems”, Power Electronics, IEEE Transactions on, Vol. 29, Issue: 2, pp. 1-6.

[7] S.K. Khadem, M. Basu, M.F. Conlon, 2014, “Harmonic power compensation capacity of shunt active power filter and its relationship with design parameters”, Power Electronics, IET, Vol. 7, Issue: 2, pp. 1-6.

[8] Shuai, Z.K., Luo, An, Combined System of Static Var Compensator and Active Power Filter, Proceeding of the China Society of Electrical Engineering, 2009,29(3):56-64

[9] S. W. Mohod and M. V. Aware, “Power quality issues & its mitigation technique in wind energy

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ISSN: 0193 - 4120 Page No. 1701 - 1705

conversion," in Proc. of IEEE Int. Conf. Quality Power & Harmonic, Wollongong, Australia, 2008.

[10] P. Acuna, L. Moran, M. Rivera, J. Dixon, 2014, "Improved Active Power Filter Performance for Renewable Power Generation Systems", Power Electronics, IEEE Transactions on, Vol. 29, Issue: 2, pp. 1-6.

[11] J. Rocabert, A. Luna, F. Blaabjerg, P. Rodrigues, "Control of power converters in AC microgrids," IEEE Trans. on Power Electronics, vol. 27, pp. 4734-4749, Nov. 2012.

[12] H. Akagi, "Active harmonic filters," Proceedings of the IEEE, vol. 93, pp. 2128-2141, Dec. 2005.

[13] F. Blaabjerg, R. Teodorescu, M. Liserre., A. Timbus, "Overview of control and grid synchronization for distributed power generation systems," IEEE Trans. on Industrial Electronics, vol. 53, pp. 13981409, Oct. 2006.

[14] IEEE Special Stability Controls working Group. Static Compensator Models for Power Flow and Dynamic Performance Simulation. IEEE Trans on Power System, 1994,9(1)：229-239

[15] G. Jegadeeswari, "The Power Factor Correction Improvement For A Single Phase Ac/Dc Converter Using An Enabling Window Control", International Journal of Mechanical and Production Engineering Research and Development (IJMPERD), October 2018/ Volume 8, Issue: 5/ Page no: (41-48)/ ISSN 2249-6890/ Impact Factor: 7.612

[16] G. Jegadeeswari, "Performance Analysis of Power Quality Improvement using Shunt Active Power Filter", International Journal of Recent Technology and Engineering (IJRTE), ISSN: 2277-3878, Volume-7 Issue-5S2, January 2019