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DESIGN AND ANALYSIS OF UNIFIED POWER QUALITY CONDITIONER FOR VOLTAGE STABILIZATION IN DISTRIBUTION GRID

Yuvaraj.S[#1], Thanush.J[#2], Vignesh.S[#3] and Sathya Kumar.H [*4]

[#] *Student, Department of Electrical and Electronics Engineering, Veltech Multitech Dr.Rangarajan Dr.Sakunthala Engineering College, Chennai, Tamilnadu India.*

[*] *Assistant Professor, Department of Electrical and Electronics Engineering, Veltech Multitech Dr.Rangarajan Dr.Sakunthala Engineering College, Chennai, Tamilnadu India.*

***Abstract*— This project deals with the deployment of a local three-phase four-wire (3P4W) electrical power distribution system (EPDS), using a single- to three-phase unified power quality conditioner (UPQC) topology, called UPQC-1Ph-to-1Ph. The topology is indicated for applications in rural or remote areas in which, for economic reasons, only EPDS with single wire earth return are accessible to the consumer. Since the use of three-phase loads is increasing in these areas, access to a three-phase distribution system becomes preponderant. By adopting a dual compensation strategy, the proposed UPQC-1Ph-to-1Ph is capable of draining from the single-phase electrical grid a sinusoidal current and in phase with the voltage, resulting a high power factor. Furthermore, the system is also able to suppress grid voltage harmonics, as well as to compensate for other disturbances, such as voltage sags. Thus, a 3P4W system with regulated, balanced and sinusoidal voltages with low harmonic contents is provided for single- and three-phase loads. An analysis of the power flow through the series and parallel converters is performed in order to aid the designing of the power converters. Experimental results are presented for validating the proposal, as well as evaluating the static and dynamic performances of the proposed topology**

***Index Terms*—Power quality, UPQC, power flow**

I. INTRODUCTION

Electrical power distribution systems (EPDS) with single-wire earth return (SWER) have been commonly adopted as a solution for electrical power supplying. This is due to the fact that the reduction of costs in the distribution of energy to serve large territorial extensions with low demographic densities is an important requirement, since lower installation and maintenance costs are achieved. Other alternatives are the use of energy distribution by means of two conductors (phase-to-neutral) without earth return, or even using two-phase systems (phase-to-phase). Considering these alternatives, capital investments for the realization of SWER distribution grid facilities installations are still lower.

II. RELATED WORK

1)A. Ghosh and G. Ledwich, "Load compensating DSTATCOM in weak ac systems," IEEE Trans. Power Del., vol. 18, no. 4, pp. 1302–1309, Oct. 2003.

The Project discusses load compensation using a distribution static compensator (DSTATCOM). It is assumed that the DSTATCOM is associated with a load that is remote from the supply. It is shown that the operation of a DSTATCOM assuming that it is connected to a stiff source in such situations will result in distortions in source current and voltage at the point of common coupling. To avoid this, the DSTATCOM is connected in parallel with a filter capacitor that allows the high frequency component of the current to pass.

2)A. Elnady and M. Salama, "Unified approach for mitigating voltage sag and voltage flicker using the DSTATCOM," IEEE Trans. Power Del., vol. 20, no. 2, pt. 1, pp. 992–1000, Apr. 2005.

This Project introduces a novel method for the mitigation of the voltage sag and voltage flicker by using Kalman filter and its derivatives (adaptive, and extended). The Kalman filter is used as a tool to extract both the instantaneous envelope of the voltage sags, and to extract the Instantaneous Flicker Level (IFL) of the voltage flicker. Also, this Project demonstrates the advantages of using the Kalman filter instead of the existing tools for tracking and extracting voltage disturbances

3)S.-H. Ko, S. Lee, H. Dehbonei, and C. Nayar, "Application of voltage and current controlled voltage source inverters for distributed generation systems," IEEE Trans. Energy Convers., vol. 21, no. 3, pp.782–792, Sep. 2006.

Voltage source inverters (VSI) have been widely used in uninterruptible power supplies, unified power flow controllers or unified power quality conditioners, and distributed generation systems (DGS). VSIs are inherently

efficient, compact, and economical devices used to control power flow and provide quality supply. VSIs can be classified as voltage-controlled VSIs (VCVSIs) and current-controlled VSIs (CCVSIs), depending on their control mechanism. In this Project, a detailed comparison of VCVSIs and CCVSIs for DGS applications is presented.

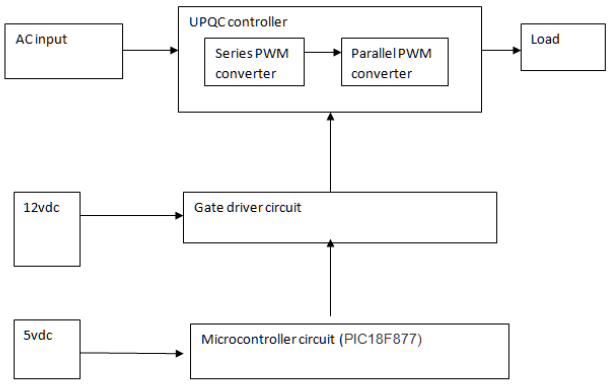
III. PROPOSED SYSTEM

STATCOM and the Power system, such that the AC voltages at the bus bar can be regulated to improve the voltage profile of the power system, which is primary duty of the D-STATCOM. However a secondary damping function can be added in to the D-STATCOM for enhancing power system oscillation stability. The D-STATCOM provides operating characteristics similar to a rotating Synchronous compensator without the mechanical inertia. The D-STATCOM employs solid state power switching devices and provides rapid controllability of the three phase voltages, both in magnitude and phase angle. The DSTATCOM employs an inverter to convert the DC link voltage Vdc on the capacitor to a voltage source of adjustable magnitude and phase. Therefore the D-STATCOM can be treated as a voltage controlled source. The D-STATCOM can also be seen as a current controlled source. The objective of a VSI is to produce a sinusoidal AC voltage with minimal harmonic distortion from a DC voltage. The operation of the D-STATCOM is as follows: The voltage is compared with the AC bus voltage system (Vs). When the AC bus voltage magnitude is above that of the VSI magnitude (Vc); the AC system sees the D-STATCOM as inductance connected to its terminals. Otherwise if the VSI voltage magnitude is above that of the AC bus voltage magnitude, the AC system sees the D-STATCOM as capacitance to its terminals. If the voltage magnitudes are equal, the reactive power exchange is zero. If the D-STATCOM has a DC source or energy storage device on its DC side, it can supply real power to the power system. This can be achieved by adjusting the phase angle of the D-STATCOM terminals and the phase angle of the AC power system. When phase angle of the AC power system leads the VSI phase angle, the DSTATCOM absorbs the real power from the AC system, if the phase angle of the AC power system lags the VSI phase angle, the D-STATCOM supplies real power to AC system. The main function is to regulate key bus voltage magnitude by dynamically absorbing or generating reactive power to the ac grid network, like a thyristor static compensator. This reactive power transfer is done through the leakage reactance of the coupling transformer by using a secondary transformer voltage in phase with the primary voltage (network side). It uses a three-phase, four-wire, two-level, neutral-point-clamped VSI. This structure allows independent control to each leg of the VSI. Variable is a switching function, and can be either or depending upon switching state. Filter inductance and resistance are and , respectively. Shunt capacitor eliminates high-switching frequency components. First, discrete modeling of the system is presented to obtain a discrete voltage control law, and it is shown that the PCC voltage can be regulated to the desired value with properly chosen parameters of the VSI. Then, a procedure to design VSI parameters is presented. A proportional-integral (PI) controller is used to regulate the dc capacitor voltage at a reference value. Based on instantaneous symmetrical component theory and complex Fourier transform, a reference voltage magnitude generation scheme is proposed that provides the advantages of CCM at nominal load. Distribution Static Compensator (DSTATCOM) A D-STATCOM (Distribution Static Compensator), which is schematically depicted, consists of a Voltage Source Converter, a dc energy storage device, a coupling transformer connected in shunt to the distribution network through a coupling transformer. The converter the dc voltage across the storage device into a set of three-phase ac output voltages. These voltages are in phase and coupled with the ac system through the reactance of the coupling transformer. Suitable adjustment of the phase and magnitude of the D-STATCOM output voltages allows effective control of active and reactive power exchanges between the D-STATCOM and the ac system. Such configuration allows the device to absorb or generate controllable active and reactive power. The converter connected in shunt with the ac system provides a multifunctional topology which can be used for up to three quite distinct purposes:

1. Voltage regulation and compensation of reactive power.
2. Correction of power factor and
3. Elimination of current harmonics.

The value of Ish can be controlled by adjusting the output voltage of the converter.

A. BLOCK DIAGRAM



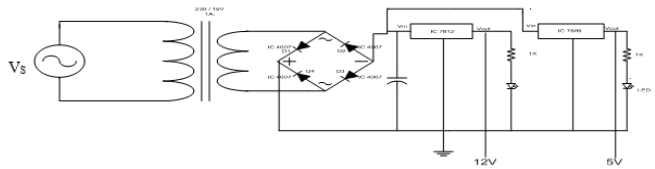
B. FEATURES

1. Power factor correction,
2. Harmonic elimination,
3. Load balancing,
4. Voltage regulation based on the load requirement.

IV. HARDWARE DESCRIPTION

A. POWER SUPPLY DESIGN

Driver circuit needs 12V and 5V. Microcontroller need 5V supply, so we convert 230V AC supply is first step down in to 15V by using step down transformer. Then this 15V AC is converted in to DC by using Full bridge rectifier which has high efficiency than all other methods. This 15V DC is converting into 12V DC and 5v DC by using 7812 and 7805 regulator respectively. The capacitor is used to provide smooth variation in voltage. For indication purpose we used LED with 1K resistor to limit current flow to the LED. The following figure shows the regulated power supply



B. PIC 16F877A:

The microcontrollers played revolutionary role in embedded industry after the invention of Intel 8051. The steady and progressive research in this field gave the industry more efficient, high-performance and low-power consumption microcontrollers. The AVR, PIC and ARM are the prime examples. The new age microcontrollers are getting smarter and richer by including latest communication protocols like USB, I2C, SPI, Ethernet, CAN etc.

C. Microcontroller PIC16F877A

Microcontroller PIC16F877A is one of the PICMicro Family microcontroller which is popular at this moment, start from beginner until all professionals. Because very easy using PIC16F877A and use FLASH memory technology so that can be write-erase until thousand times. The superiority this Risc Microcontroller compared to with other microcontroller 8-bit especially at a speed of and his code compression. PIC16F877A have 40 pin by 33 path of I/O.PIC16F877A perfectly fits many uses, from automotive industries and controlling home appliances to industrial instruments, remote sensors, electrical door locks and safety devices. It is also ideal for smart cards as well as for battery supplied devices because of its low consumption. EEPROM memory makes it easier to apply microcontrollers to devices where permanent storage of various parameters is needed (codes for transmitters, motor speed, receiver frequencies, etc.). Low cost, low consumption, easy handling and flexibility make PIC16F877A applicable even in areas where microcontrollers had not previously been considered (example: timer functions, interface replacement in larger systems, coprocessor applications, etc.).In System Programmability of this chip (along with using only two pins in data transfer) makes possible the flexibility of a product, after assembling and testing have been completed. This capability can be used to create assembly-line production, to store calibration data available only after final testing, or it can be used to improve programs on finished products.

D. POWER MOSFET BASICS

The MOSFET, or Metal-Oxide-Semiconductor, Field-Effect Transistor is by far the most common field effect transistor in both digital and analog circuits. The MOSFET is composed of a channel of n-type or p-type semiconductor material, and is accordingly called an NMOSFET or a PMOSFET. Unfortunately, many semiconductors with better electrical properties than silicon, such as gallium arsenide, do not form good gate oxides and thus are not suitable for MOSFETs. The gate terminal is a layer of polysilicon (polycrystalline silicon) or aluminum placed over the channel, but separated from the channel by a thin layer of insulating silicon dioxide.

E. FEATURES OF POWER MOSFET'S

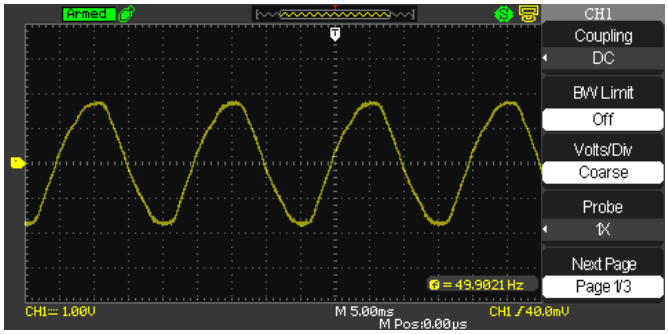
- Power MOSFET has lower switching losses but its on-resistance and conduction losses are more.
- MOSFET is a voltage-controlled device.
- MOSFET has positive temperature co-efficient for resistance. This makes parallel operation of MOSFET easy.
- If a MOSFET shares increased current initially, it heats up faster its resistance rises and this increased resistance causes this current to shift to other devices in parallel.
- In MOSFET secondary break down does not occur, because it has positive temperature co-efficient.
- Power MOSFET's in higher voltage ratings have more conduction losses.
- The state of the art MOSFET's are available with ratings up to 500V, 140A. energy storage.

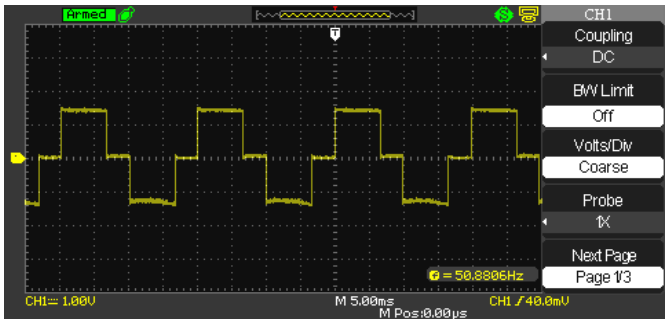
F. RELAY

A relay is an electromagnetic switch operated by a relatively small electric current that can turn on or off a much larger electric current.

V. OUTPUT GRAPH

When there is no fault the output waveform will be like sin wave. When tha fault occurs the output will be square wave.





VI. MATLAB SIMULATION

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation.Typical uses include

- Math and computation
- Algorithm development
- Data acquisition
- Modeling, simulation, and prototyping
- Data analysis, exploration, and visualization
- Scientific and engineering graphics
- Application development, including graphical user interface building

MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar non interactive language such as C or Fortran.

The name MATLAB stands for matrix laboratory. MATLAB was originally written to provide easy access to matrix software developed by the LINPACK and EISPACK projects. Today, MATLAB engines incorporate the LAPACK and BLAS libraries, embedding the state of the art in software for matrix computation

MATLAB has evolved over a period of years with input from many users. In university environments, it is the standard instructional tool for introductory and advanced courses in mathematics, engineering, and science. In industry, MATLAB is the tool of choice for high-productivity research, development, and analysis.

MATLAB features a family of add-on application-specific solutions called toolboxes .Very important to most users of MATLAB, toolboxes allow you to learn and apply specialized technology. Toolboxes are comprehensive collections of MATLAB functions (M-files) that extend the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are available include signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation, and many others.

A. Sim Power Systems:

SimPowerSystems and other products of the Physical Modeling product family work together with Simulink® to model electrical, mechanical, and control systems. SimPower Systems operates in the Simulink environment. Therefore, before starting this user's guide, you should be familiar with Simulink. For help with Simulink, see the Simulink documentation. Or, if you apply Simulink to signal processing and communications tasks (as opposed to control system design tasks), see the Signal Processing Blockset documentation.

B. The Role of Simulation in Design:

Electrical power systems are combinations of electrical circuits and electromechanical devices like motors and generators. Engineers working in this discipline are constantly improving the performance of the systems. Requirements for drastically increased efficiency have forced power system designers to use power electronic devices and sophisticated control system concepts that tax traditional analysis tools and techniques. Further complicating the analyst's role is the fact that the system is often so nonlinear that the only way to understand it is through simulation .Land-based power generation from hydroelectric, steam, or other devices is not the only use of power systems. A common attribute of these systems is their use of power electronics and control systems to achieve their performance objectives. SimPower Systems is a modern design tool that allows scientists and engineers to rapidly and easily build models that simulate power systems. SimPower Systems uses the Simulink environment, allowing you to build a model using simple click and drag procedures. Not only can you draw the circuit topology rapidly, but your analysis of the circuit can include its interactions with mechanical, thermal, control, and other disciplines. This is possible because all the electrical parts of the simulation interact with the extensive Simulink modeling library. Since Simulink uses MATLAB® as its computational engine, designers can also use MATLAB toolboxes and Simulink blocksets. SimPower Systems and Sim Mechanics share a special Physical Modeling block and connection line interface.

C. SimPower Systems Libraries:

The libraries contain models of typical power equipment

such as transformers, lines, machines, and power electronics. These models are proven ones coming from textbooks, and their validity is based on the experience of the Power Systems Testing and Simulation Laboratory of Hydro-Québec, a large North American utility located in Canada, and also on the experience of Evolve de Technologies superior and Universities Laval. The capabilities of SimPower Systems for modeling a typical electrical system are illustrated in demonstration files. And for users who want to refresh their knowledge of power system theory, there are also self-learning case studies. The SimPower Systems main library, power lib, organizes its blocks into libraries according to their behavior. The powerlib library window displays the block library icons and names. Double-click a library icon to open the library and access the blocks. The main SimPower Systems powerlib library window also contains the Powergui block that opens a graphical user interface for the steady-state analysis of electrical circuits.

VII. FUTURE SCOPE

The UPQC model can be enhanced and enriched to terminate the power quality problems in a power system. The various ways for doing that:-

1. The prototype of this UPQC model can be established in laboratory.
2. UPQC model can be established for three phase four wire system for the non-linear load and unstable voltage.
3. Here the UPQC model developed was right shunt UPQC, further we can develop model for left shunt UPQC.
4. We can connect wind turbines, solar energy system that is renewable source of energy to UPQC to get improved power in consumer ends during serious conditions.

VIII. CONCLUSION

This paper exhibited the investigation and the trial approval of a neighborhood three-stage four-wire control dispersion framework. The framework, showed for applications in country or remote territories where three-stage dissemination lattices are not available, was considered dependent on bound together power quality conditioner functionalities.With sequential and parallel separating capacity, two inverter topologies were utilized to create the UPQC-1Ph-to-3Ph. Along these lines, the single-stage arrangement converter was conveyed utilizing a half-connect inverter, while the three-stage parallel converter was executed utilizing a 3-Leg split capacitor inverter. Utilizing the double pay technique, the proposed framework was capable of sustaining direct and non-straight three-stage loads acting with widespread dynamic separating ability, i.e., going about as SAPF and PAPF.

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