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Research Article

Design and Analysis of Dynamic Voltage Conditioner for Smart Low Voltage Distribution System

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ABSTRACT

Power Quality (PQ) development in circulation level is a rising concern in current electrical power systems. Frequently this difficulty is solved by smart sharing transformers, hybrid transformers, and solid-state transformers, but also Dynamic Voltage Conditioner (DVC) can be an inventive and cost-effective solution. The paper introduces a new control method of a single-phase DVC system able to compensate these long-duration voltage drifts. For these events, it is compulsory to avoid active power interactions so the controller is planned to work with non-active power only. DVC performance for main voltage and load variation is examined. The proposed solution is validated with a simulation study and experimental laboratory tests. Some simulation and experimental results are illustrated to show the sample device's performance.

Keywords: Active Power Filter (APF), Dynamic Voltage Restorer (DVR), DSO, Dynamic Voltage Conditioner (DVC), Power Quality (PQ), PCC, Static Volt-ampere Compensator (STATCOM), Unified Power Quality Conditioner (UPQC)

Introduction

From the last few years, the term Power Quality (PQ) has achieved high importance, especially in the electrical distribution area. According to international standards, the term power quality can be defined as the substantial uniqueness of the electrical supply provided under typical operating conditions that do not interrupt or affect the user's processes. The instability in voltage (harmonics, sags, swells) may affect the tripping of sensitive electronic tools which can lead to a terrible penalty in industrial plants, such as, unpredicted outcome or end of the whole production line. These actions are frequent in industrial sectors and outcome in the high economic breakdown. The increasing utilization of power electronics-based equipment in modern plants is consequential in a load that is receptive and harmonics producing in nature. Interestingly, these tools mostly produce distortion in current and/or voltages. Thus, there is a latest tendency to mount mitigating equipment that can give out the dual purpose, to both the function as well as to the buyer. Thus with the implementation of Custom Power Devices on the distribution side, Power Quality is enhanced. One of the most effective solutions to power quality issues in the distribution side is the installation of the Unified Power Quality Conditioner (UPQC). Unified power quality conditioners that can pact with both current and voltage type power quality issues can control load voltage, mitigate voltage transients, remove input current harmonics and rectify input power factor over a wide operating range. Each unified power quality conditioner acts as an APF (Active Power Filter) and a DVR (Dynamic Voltage Restorer) with their DC links shared with the same energy storage devices. A current controller is used to regulate the input current of the APF and thus figure the current drawn from the AC mains. A voltage controller is used to supervise the DVR to control the load voltage and provide adequate voltage sag or swell ride through capacity. Three typical structures for single-phase UPQCs, including full- bridge, three-leg and half-bridge structures need to be accessible. The full-bridge structure consists of two H-bridge inverters having eight switching devices with or without an isolation transformer. The isolation transformer is used to insert essential compensating voltage between the grid and the load. With the low-frequency isolation transformer, the structure is heavy in size, weighty in mass, and costly. The system to complete fast dynamic behaviors is also one of the design challenges. The three-leg structure consists of two H-bridge inverters with one leg shared. As no isolation transformer is essential, the three-leg structure is highly cost-efficient and packed together than the full-bridge structure. But, the shared leg causes common coupling between the two inverters and consequently introduces operational constraints in shaping the incoming current and stabilizing the load voltage. A difficult modulation technique is used to synchronize the operations of the two inverters and deal with the coupling effects. Special considerations are taken to optimize energy effectiveness and harmonic performance under distinct grid and load conditions. The half-bridge structure consists of two half-bridge inverters and one isolation transformer. Its operation is alike to the operation of the full-bridge one, except that the full-bridge is replaced by a half-bridge with the voltage rating doubled. Its structure requires less number of switching devices, but the isolation transformer still confines the power density of the system. This paper presents a single-phase DVC as an economic voltage controller for LV distribution smart grid systems that proposes a valued solution for DSO. A coupling transformer and device sizing are evaluated. A new single-phase and speedy calculation based controller for the DVC system is planned, and the device operation principle based on a non-active compensation scheme is offered. For the first time in literature, the single-phase DVC operation restrictions of the quadrature voltage injection method are formulated. To guarantee device strength, for the first time in literature, a new PCC reference voltage update procedure is recommended to modernize the VPCC ref if the system goes slight its operation limits. Even if the device has the competence to support short- and fast-term voltage variations for few cycles with active power coming from DC bus capacitor storage system, only DVC long-term operation limits will be analyzed in detail here, so sag/swell will not be exposed by this work because several solutions are just presented, and they can be implemented and added to the DVC functions. MATLAB based simulation and laboratory experimental results are reported to confirm the presented solution.

Problem Formulation

Power Quality (PQ) enhancement in the distribution level is a rising concern in smart power systems. one in all the most issues in 55 networks is expounded to load voltage stabilization on the brink of the par worth and determined by a variety of ideas like sensible sharing transformers, hybrid transformers, and solid-state transformers but the implementation of Dynamic Voltage Conditioner will be the very dynamic and modern answer with value effective entirely different PQ issues has been reported and classified. Among that voltage RMS deviations that will be caused by completely distinct reasons in power systems are quite often reported as necessary problems predominantly, latest quick development and high grid diffusion of renewable energies, produced it tougher and complex to relevancy the RMS voltage standards. so as to hold long length voltage drifts, DSO will adapt sensible distribution transformers, hybrid transformers and solid-state transformers that are amongst a strongly mounting cluster of voltage conditioners, while, seldom AC electronic compensator devices, as STATCOM (Static Volt-Ampere Compensator) DVR (Dynamic Voltage Restorer), UPQC(Unified Power Quality Conditioner) and open UPQC (Open Unified Power Quality Conditioner), are custom-made as an end result of those are too costly or have restricted functionalities, therefore, want an economic active voltage conditioner, that absolutely covers long-run events, has the power to organize ceaselessly so as to cope voltage at PCC and to shield a group of downstream cease users from many voltage disturbances, will be terribly fascinating for DSO.

Methodology

This project will implement a research methodology that combines the theory model with empirical estimation and refinement of the proposed scheme on the MATLAB simulation tool. MATLAB is a valuable high-level development environment for systems that involve mathematical modeling, numerical computations, data analysis, and optimization methods. This is because MATLAB consists of various toolboxes, specific components, and a graphical design environment that helps to model different applications and build custom models easier. Besides, the visualization and debugging features of MATLAB are straightforward. DVC performance for main voltage and load variation is examined. Future solution is validated with a simulation study and experimental laboratory tests. A single-phase DVC as an economic voltage controller for LV distribution smart grid systems, that makes the proposal an appreciated solution for DSO coupling transformer, and device sizing is evaluated. A new single-phase and fast calculation based controller for the DVC system is proposed, and the device operation principle based on non-active damages method is presented. For the first time in literature, the single-phase DVC operation limits of the quadrature voltage injection method are formulated. To guarantee device strength, for the first time in literature, a new PCC reference voltage update procedure is suggested in accordance to update the VPCC ref if the system goes outside its operating limits. Even if the device has the capability to support short- and fast-term voltage variations for few cycles with dynamic power coming from dc bus capacitor storage system, only DVC long-term operation limits will be analyzed in detail here, so sag/swell will not be exposed by this work because numerous solutions are just presented.

Results

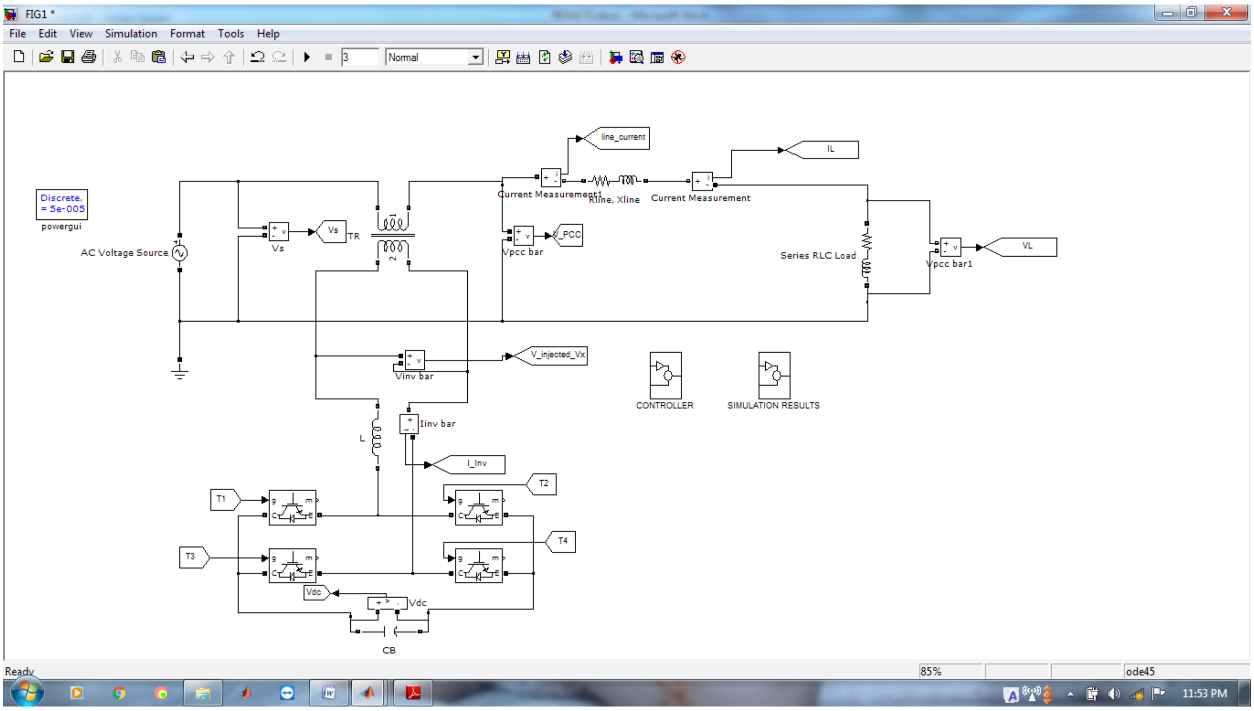

Figure 1.Overview

Simulation - DVC operation limit update procedure under voltage -limits due to:

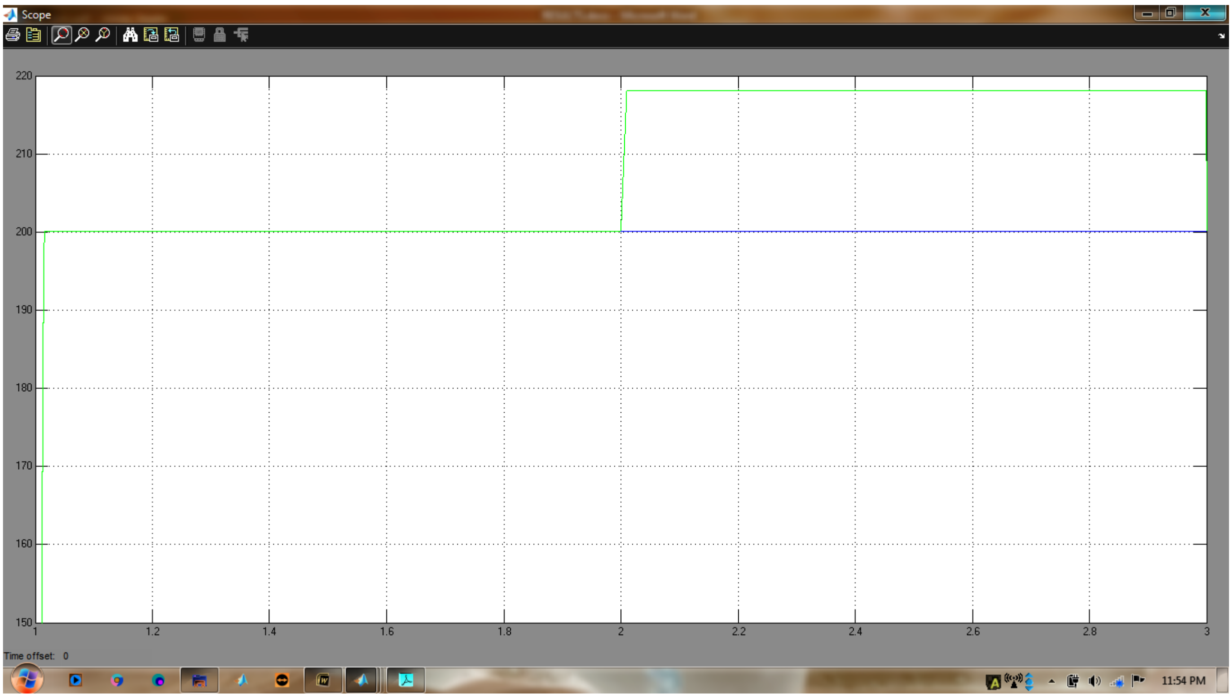

Figure 2.Grid and Minimum Grid Voltage

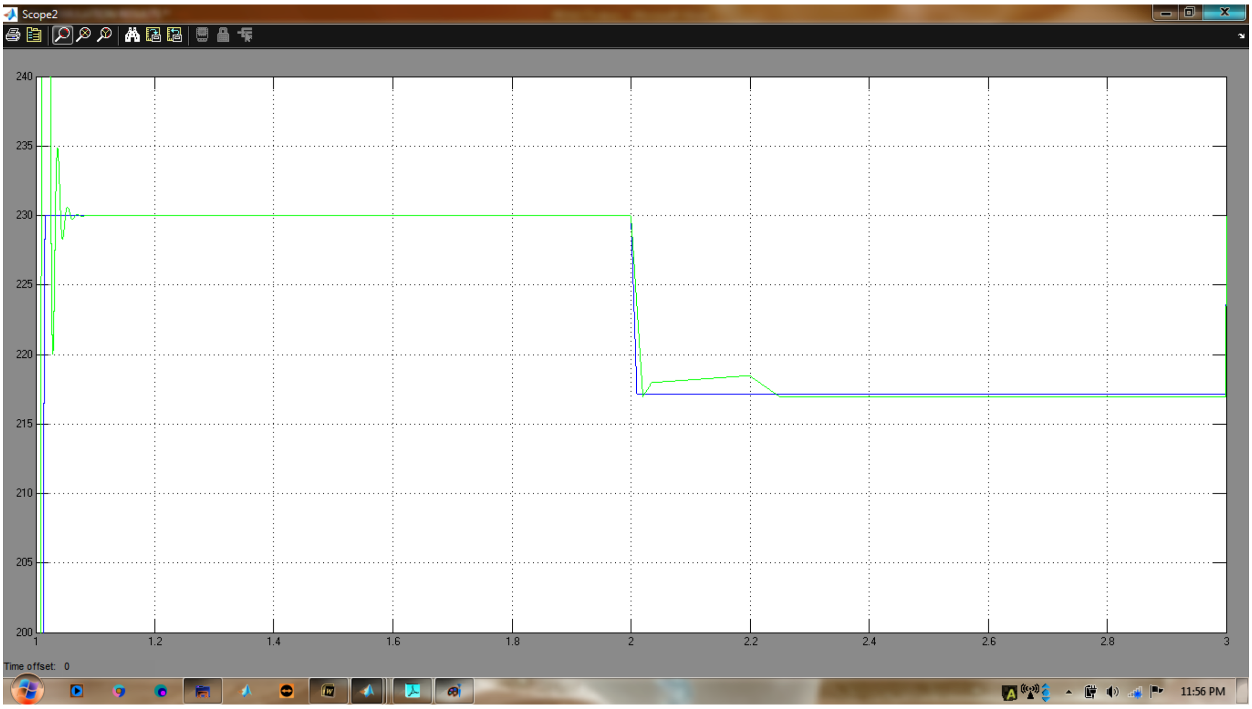

Figure 3.PCC and PCC reference voltage

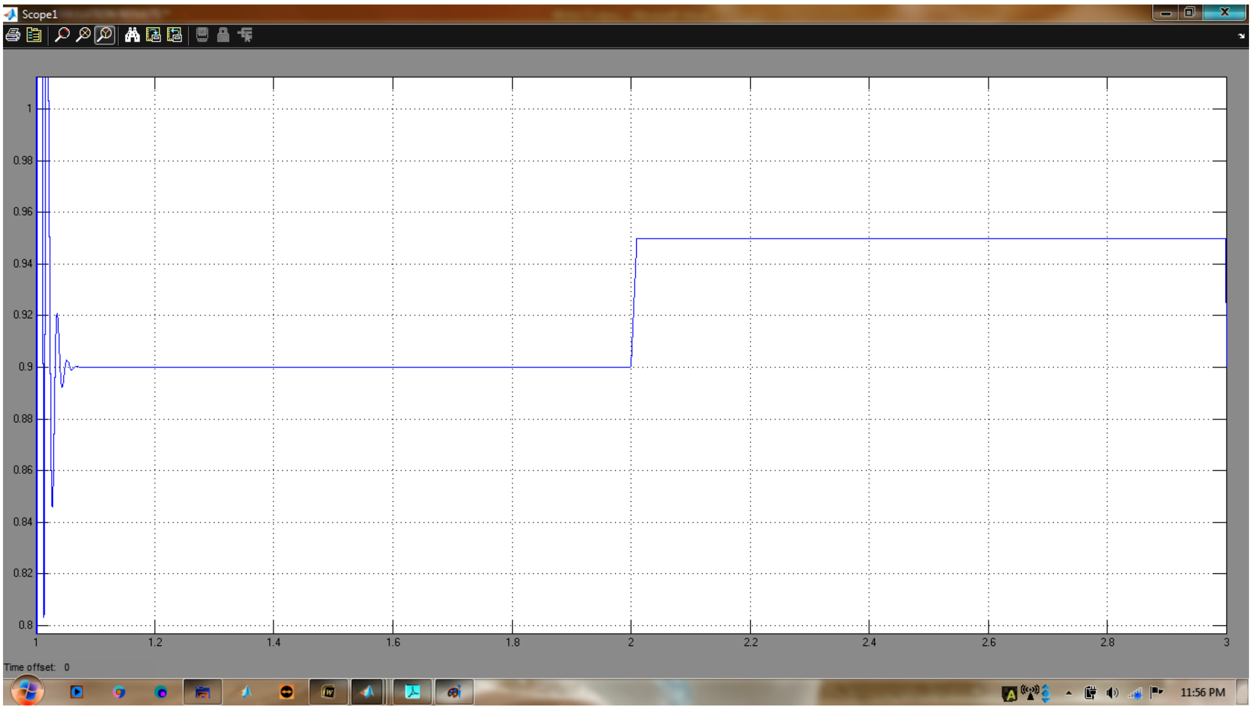

Figure 4.Load power factor

Conclusion

Dynamic voltage conditioner is a dynamic voltage conditioner able to cover up both short and fast events, as a typical DVR, and long events this thesis describes a control method to generate DVC reference voltage in view of its limits moreover single-phase design can decrease device initial rate and it is also more well-suited with LV distribution and mostly single-phase domestic loads. Results show that the device has a superior performance and it can look up the PQ level of the installed distribution smart grid network effectively. This is critical for nowadays modern networks because proposed DVC can give elasticity to the system operator in order to shift all challenging single-phase loads on a specific phase.

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