Power Quality Improvement in Three Phase Grid Connected PV System using Fuzzy Logic

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Abstract - In modular multilevel converter (MMC), the submodules which perform switching actions, it may produce higher order harmonics when involved with fluctuating capacitor voltages and when it gets superimposed with the circulating currents, it will increase their magnitude which results into increased system losses. In this research work, we have implemented a repetitive control scheme which consists of three components: PI controller, moving average filter and repetitive controller. It is applied to MMC equipped with fuzzy controlled logic, which controls the harmonics by suppressing them up to a significant level. The proposed model is designed for three phase applications and the simulation results clearly define the effectiveness of the control mechanism.

Keywords - MMC, Fuzzy Logic, Harmonic Suppression, Three phase, Repetitive Control, SIMULINK.

I. INTRODUCTION

Many investigations in the field of MMC have led to successful operation in HVDC systems. In recent times, for very long distance HVDC transmission lines based on voltage source converters (VSCs) offered more economic and cost-effective power transmission. Conventional two-level VSCs generates large quantity of harmonics and cause higher power losses due to the high speed switching of IGBTs during its working. In particular, the novel power converter topology for MMC has been intensively researched and developed, for attractive features like high modularity, simple scalability, low expense of filters, robust control, simple in design and redundancy. This converter is composed of several identical power cells connected in series, each one build up with standard components, enabling the connection to high voltage poles. Although the MMC and derived topologies offer several advantages, they also introduce a more complex design of the power circuit and control goals, which have been the main reasons for the recent and ongoing research. Furthermore, Medium Voltage Converters are an interesting area for the application of MMCs such as STATCOMs and drives etc. The evolution of MMCs over the last few years has been used in several commercial applications such as HVDC and flexible alternating current transmission systems (FACTS). From this technology, some insight on future trends can be extracted. In addition, despite industrial presence, the technology has not stabilized yet and there are still several challenges for further development of this technology.

The increased usage of power electronic devices in power system including renewable power generations led to a number of power quality (PQ) problems for the operation of machines, transformers, capacitors in power systems. PQ covers all parts of power framework building from transmission and circulation level investigations to end-client issues. In this way, electric power quality has become a serious concern for both utilities and end users.

The PQ, at conveyance level, comprehensively alludes to keeping up a close sinusoidal power circulation transport voltage at an evaluated extent and frequency. In addition, the energy supplied to a customer must be uninterrupted. Therefore, the term PQ includes two aspects, namely voltage quality and supply reliability [1]. The voltage quality side contains different unsettling influences, for example, fast changes, harmonics, interharmonics, glint, irregularity and drifters, while the dependability side includes wonders with a more drawn out length, for example, intrusions, voltage plunges and hangs, over and under voltages and frequency deviations. The above issues are significant in depicting the actual phenomena that may cause PQ problem

As a consequence, harmonic distortion can have detrimental influences on electrical distribution systems. Identifying the problems associated with sources and impacts of harmonics as well as the methods to decrease the harmonic will increase the overall efficiency of the distribution system. as represented in figure.

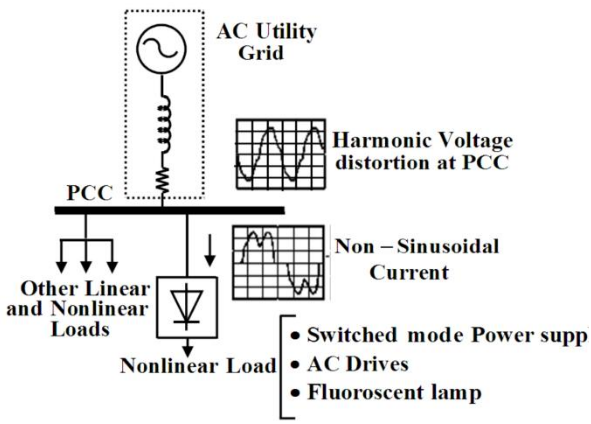

Figure 1.1 Harmonic Distortions at PCC.

When the converter is transferring active power from the DC link to AC side, an immediate DC current is streaming between the DC terminals. This current is charging the submodule capacitors and moves energy from the DC interface into the converter. The alternating current is part equally between the arms and is in phase with the substituting segment of the embedded voltage when dynamic power is exchanged. This implies the substituting current can release the submodule capacitors and subsequently it is conceivable to exchange dynamic power through the converter. The voltage over the submodule capacitors will change as they are charged and released by the direct and alternating current. Using a simplified model, the resulting capacitor voltage ripple in each arm can be estimated by integrating the product of the insertion index and the arm current.

Four types of required control objectives:

- Control the active power in addition to either reactive power or AC voltage.
- Control of the DC link voltage
- Control of the SM capacitors, in terms of both average value and voltage balancing.
- Control of current, where elimination of both circulating currents and zero sequence current should be the desired outcome.

To control the active and reactive power, a dq control similar to conventional VSC dq control can be applied. The dq control decomposes the active and reactive power, so that it can be controlled by the d-axis current and the q-axis current respectively [15]. Unlike in a conventional VSC, there is no DC-link capacitor in an MMC. Therefore, the DC link voltage is controlled by controlling the submodule voltages.

II. PROPOSED MODEL

Brief Description of Simulink Blocks

Power GUI

The Powergui block is compulsory for simulation of any Simulink model, since it gives the information for the type of signal used. It is used to allow discretization of signals, store the equivalent Simulink circuit in the form of the state-space equations of the model, providing phasor solution, variable SIMULINK solver etc.

Scope

The scope blocks of real-time category come in 3 types: Target, File and Host. The block dialog box changes depending on the setting for parameter. The block dialog box by default, displays the parameters for Target scopes.

Subsystem

The subsystem block represents a specific set of blocks contained in a specified library of blocks. The block's context menu lets you choose which block the subsystem represents.

Derivative

This block takes the derivative of its input by computing the differential du/dt, the change in input value is represented by du and the change in time is represented by dt, since the previous simulation time step. The initial output for the block is zero and it takes one input and generates one output.

Fuzzy Logic Controller

To implement the fuzzy inference system (FIS) as described initially, we use fuzzy logic controller.

PWM Generator

This block generates pulses for carrier based PWM; self commutated IGBT, FET or MOSFET bridges. In “generator mode” option, depending on the quantity of bridge arms selected, the block can be used either for 1-phase or 3-phase PWM control.

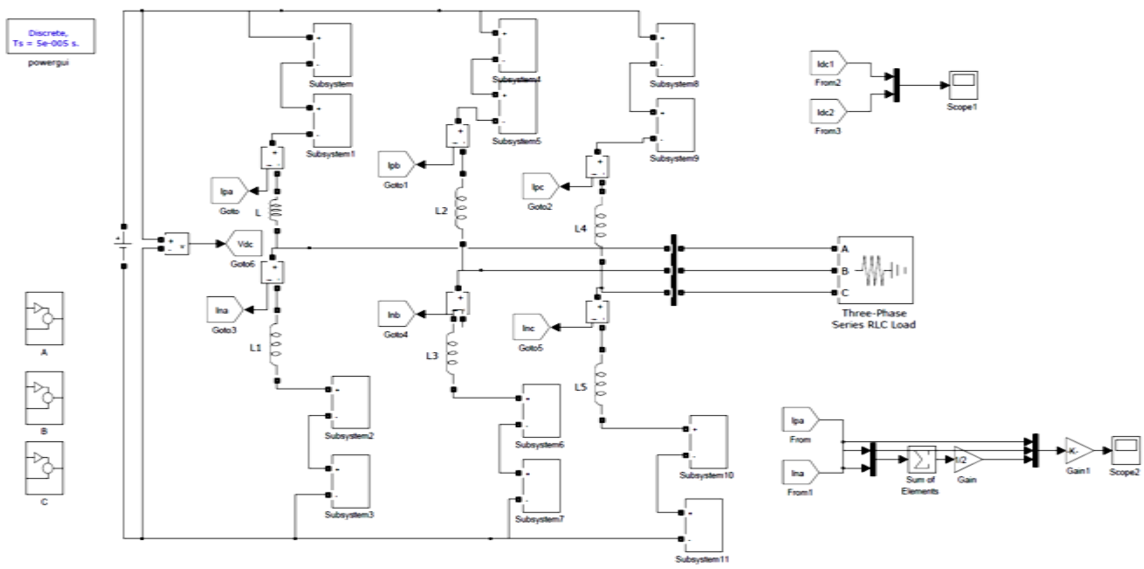

Fig. 2.1 Proposed Model

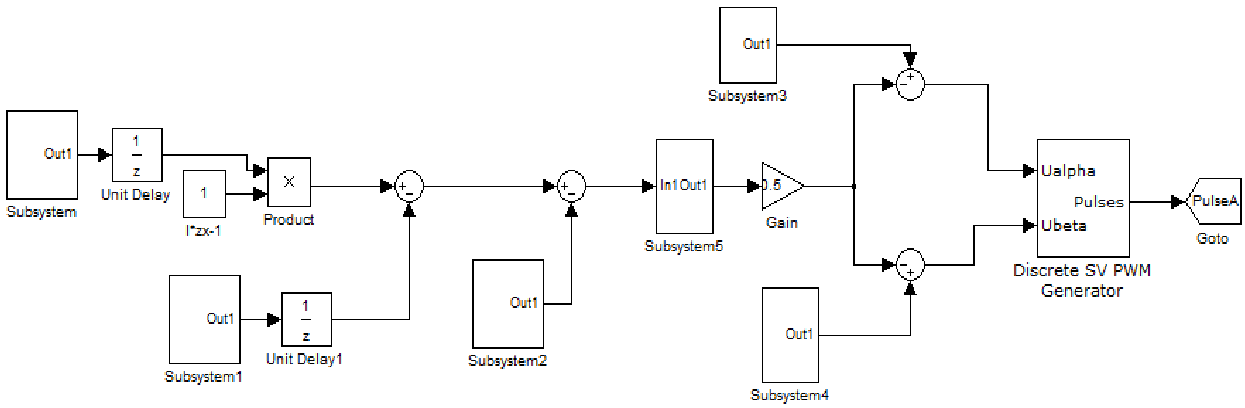

Fig. 2.2 Case A: PI Controller with Proposed Fuzzy Logic Controller

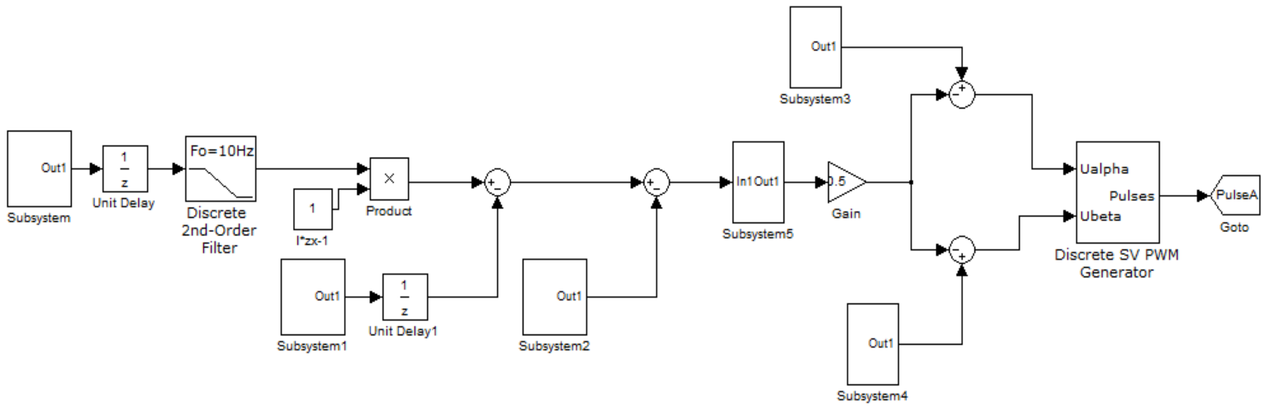

Fig. 2.3 Case B: PI Controller, Moving Average Filter with Proposed Fuzzy Logic Controller

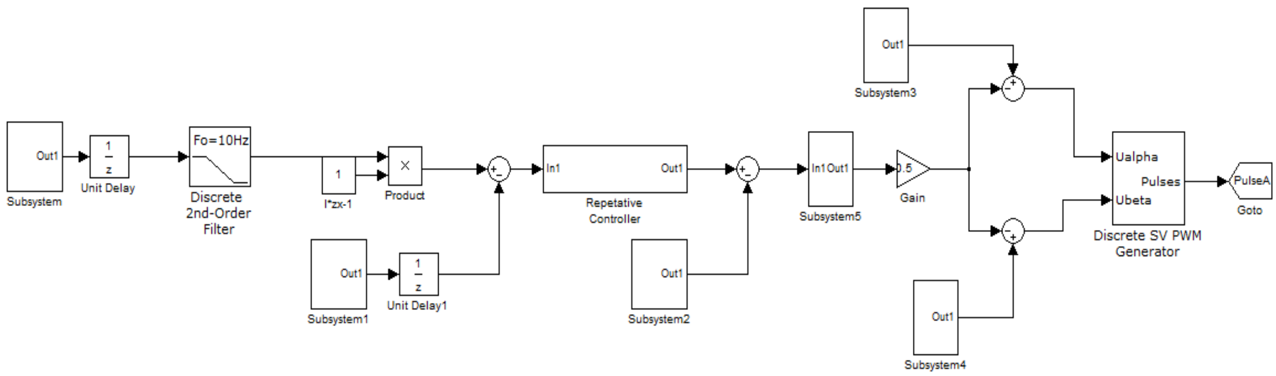

Fig. 2.4 Case C: PI Controller, Moving Average Filter Followed By Repetitive Controller with Proposed Fuzzy Logic Controller

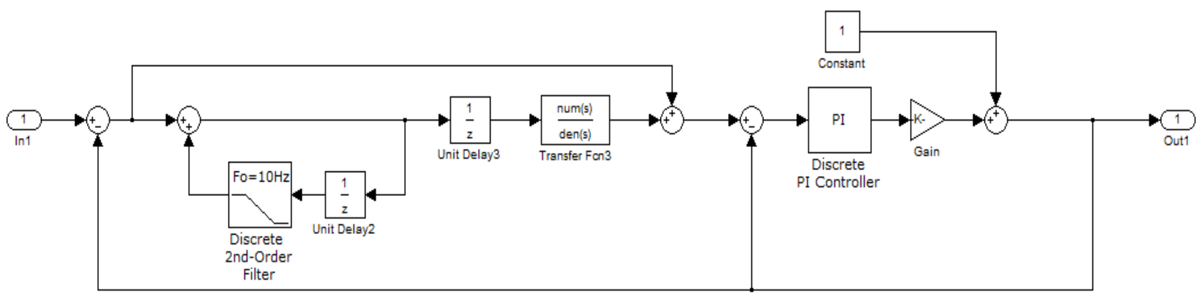

Fig. 2.5 Repetitive Controller

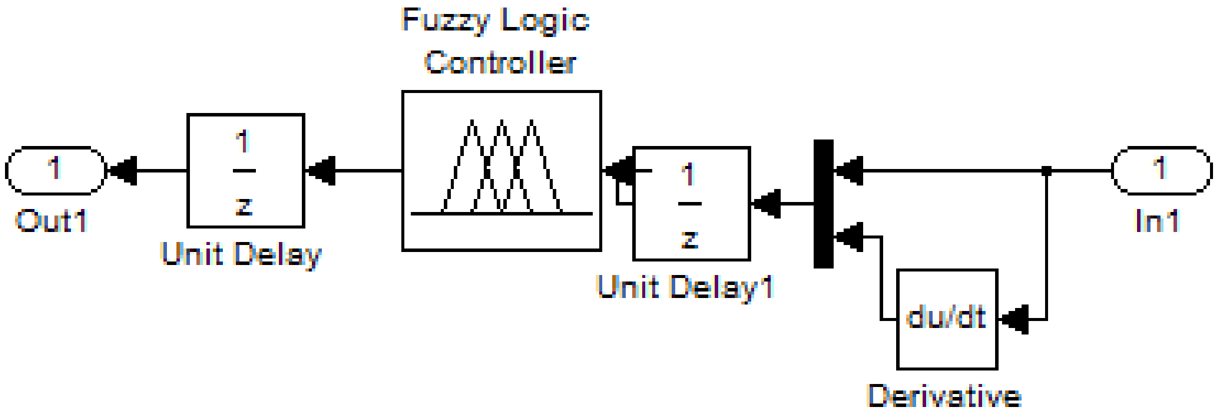

Fig. 5.6 Fuzzy Logic Controller

III. SIMULATION OUTCOMES

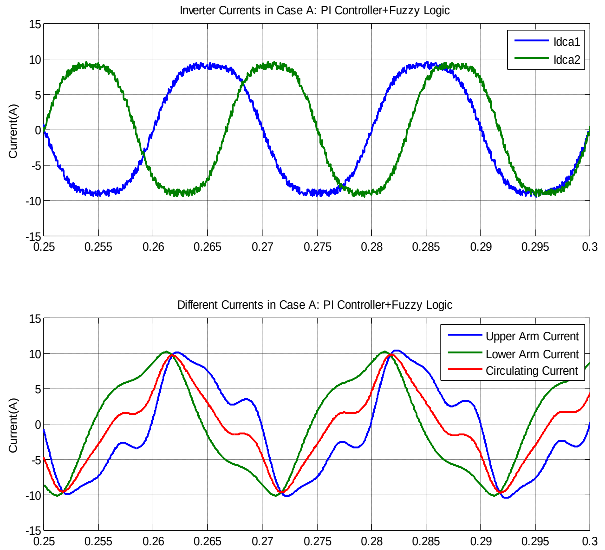

Fig. 3.1 Simulation Waveforms of Case A: PI Controller with Proposed Fuzzy Logic Controller

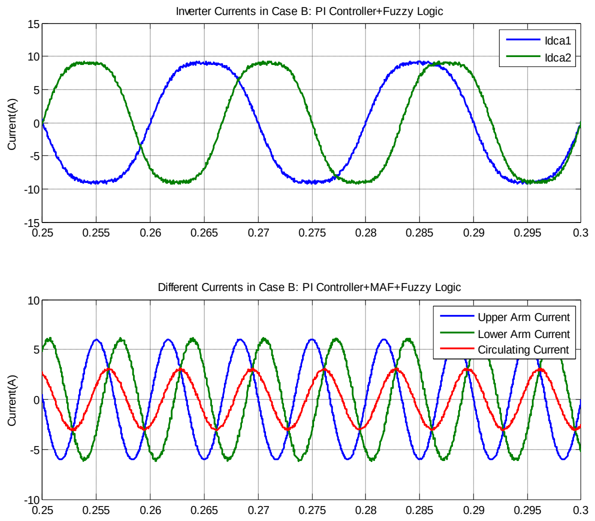

Fig. 3.2 Simulation Waveforms of Case B: PI Controller, Moving Average Filter with Proposed Fuzzy Logic controller.

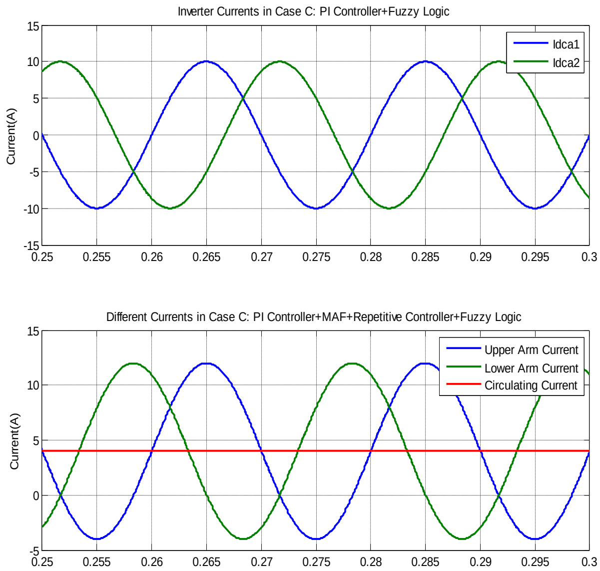

Fig. 3.3 Simulation Waveforms of Case C: PI Controller, Moving Average Filter followed by Repetitive Controller with Proposed Fuzzy Logic Controller

IV. CONCLUSION AND FUTURE SCOPE

With the application of the proposed repetitive controller, the circulating current waveform which was previously having different higher order frequency components or harmonics due to which its magnitude was higher has now been suppressed. Due to the harmonics suppression of this scheme, the reduced magnitude of the circulating currents will result into overall reduction in losses. The fuzzy logic which is itself a very flexible technique, simulates all the parameters and their constraints in an efficient way and helps the simulation process to be carried out in a much simpler manner. The proposed scheme can be utilized with advanced controllers in which some of them are still in research phase for the purpose of harmonics suppression. Here we have used fuzzy logic, but we may also perform simulation with other soft computing techniques. This scheme can also be employed in smart grids which works on advanced automation techniques.

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