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Enhancement of Power Quality in Domestic Loads using Harmonic Filters

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ABSTRACT: The research enhances power quality through a Simulink-based hybrid filter for non-linear load harmonic distortion reduction. The combined passive and active filters enable the system to effectively reduce Total Harmonic Distortion (THD) while stabilizing the system operation. The research evaluates Phase-Locked Loop (PLL) and PI controllers as different control topologies to achieve higher efficiency in the system. The research analyzes the position of solar PV generation in contemporary power systems. The proposed system achieves harmonic mitigation according to results from MATLAB/Simulink simulations.

KEYWORDS: Power Quality, Harmonic Reduction, Hybrid Filter, Total Harmonic Distortion (THD), MATLAB/Simulink, Solar PV Generation.

I. INTRODUCTION

Electrical systems require power quality as their base component because it sustains steady voltage and current waveforms. The rising number of non-linear loads that include AC-DC converters and variable frequency drives and power electronic devices results in harmonic distortion which causes equipment failures as well as efficiency losses and power wastage. The non-sinusoidal nature of waveforms gets disrupted by harmonics which results in problems that involve overheating and voltage fluctuations and electromagnetic interference.[1]

The widespread implementation of filtering techniques exists to combat such occurrences of distortion. Productivity costs of traditional passive filters remain low but their application remains restricted because of resonance problems. The active filtering solution provides adaptable compensation however it comes at a high price. A hybrid filter solution that unites passive and active devices achieves the best price-efficiency ratio in THD reduction.

Researchers have developed Sysmodel-based hybrid harmonic reduction filters that are the subject of this study. The study evaluates control methods including Phase-Locked Loop (PLL) and PI controllers as well as it investigates the importance of solar PV generation within contemporary power systems.

II. LITERATURE REVIEW

1. M. A. Kabir and U. The paper examines power quality enhancement by evaluating power electronic devices which include Active Power Filters (APFs) together with Dynamic Voltage Restorers (DVRs) and Unified Power Quality Conditioners (UPQCs). Current compensation methods have reached their boundaries which require dynamic solutions to overcome them. The two APF configurations are shunt devices and series devices for dealing with current and voltage interruptions respectively.[2]

2. A. F. H. Nohra, M. Fadel, and H. Y. Kanaan This document examines different control approaches to operate a 3-phase 4-wire Shunt Active Power Filter (SAPF) based on instantaneous power analysis. Simulations analyze different control methods one of them being Direct Control for Active Power (DCAP) which represents a novelty in the field. This investigation studies the best harmonic mitigation approach which occurs when varying the power source intensity to achieve maximum power quality benefits.

3. C. K. Najiya, T. Krishnakumari, G.Sijo the investigation examines the harmonic issues stemming from nonlinear loads by developing a shunt active power filter which uses hysteresis control on a current-controlled voltage source inverter (VSI). Through the Synchronous Reference Frame (SRF) theory the generation process of reference current signals becomes possible. MATLAB/Simulink provides effective simulations of harmonic elimination that improve power quality while accounting for various load circumstances.

4. M. Y. Lada, I. Bugis, M. H. N. Talib Here the study investigates how Active Power Filters (APFs) function as harmonic reducers while enhancing power factor. A three-phase SAPF received assessment through MATLAB/Simulink testing under balanced and unbalanced nonlinear loads. The implementation of Active Power Filters (APFs) achieves desired Total Harmonic Distortion (THD) reduction results per IEEE-519 specifications improving general power quality standards.

III. PROPOSED METHOD

A Simulink-based hybrid filter stands as the proposed system to lower harmonic distortion from non-linear electricity loads. This filter blueprint combines passive elements with active ones to use their separate benefits and create effective Total Harmonic Distortions (THD) evaluations while improving power quality. Phase-Locked Loop (PLL) and PI controllers function together as parts of a control system to maximize harmonic compensation performance. Heat is used in the study to analyze solar PV generation and measure its impact on power quality assessment. The model runs in MATLAB/Simulink 2018a to demonstrate its effectiveness in harmonic reduction while improving system stability through different load conditions.

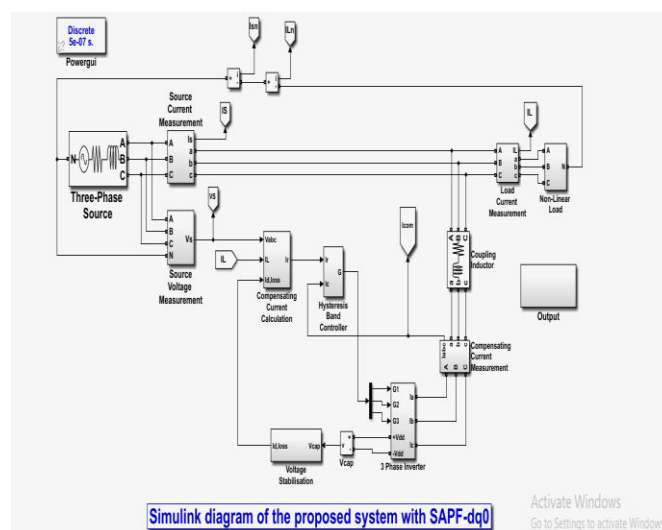


Fig-1 Simulink Diagram of Hybrid System

IV. METHODOLOGY

The process of designing a hybrid filter takes place within MATLAB/Simulink 2018a software to minimize harmonic distortion from non-linear loads. The system begins with a passive filtering stage which lowers lower-order harmonics before activating dynamic compensation using an active filter. The system maintains harmonic suppression through Phase-Locked Loop (PLL) together with PI controllers. A power quality assessment includes the examination of solar PV integration. The Total Harmonic Distortion (THD) measurement occurs before as well as after integrating the hybrid filter. The proposed system achieves harmonic reduction and load stability through prototyped simulations conducted under different power usage scenarios.

V. RESULT

The simulation results in MATLAB/Simulink 2018a demonstrate a significant reduction in Total Harmonic Distortion (THD) using the proposed hybrid filter. The system effectively mitigates harmonics while improving power quality and system stability. Additionally, the integration of PLL and PI controllers enhances dynamic compensation, ensuring efficient operation under varying load conditions.

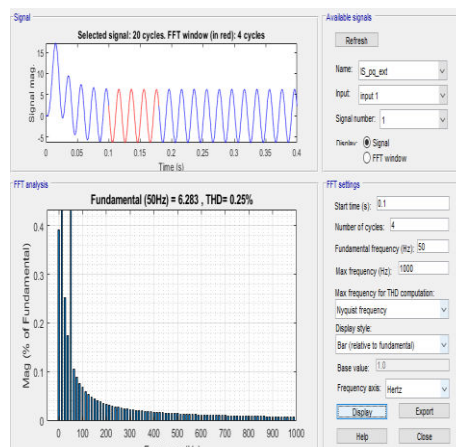


Fig-2 Is with PQ theory

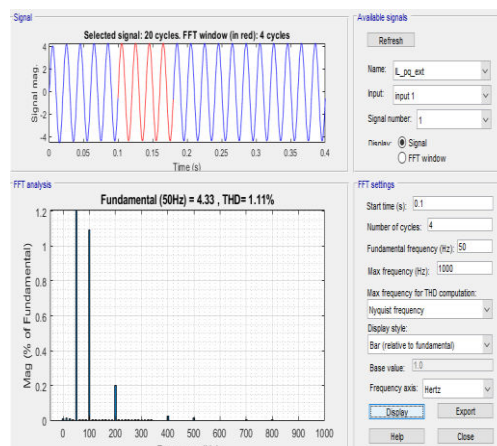


Fig-3 IL with PQ theory

VI. CONCLUSION

This research presents a successful THD reduction method through Simulink-based hybrid filter applications focused on improving power quality performance for non-linear loads. The hybrid system implements passive and active filters which enables it to perform harmonic suppression effectively. The dynamic response of the system improves through implementation of the PLL and PI controllers which enable system stability. The proposed method achieves successful results according to simulation outcomes. The paper studies the function of solar PV generation together with its effect on contemporary power systems.

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