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Adaptive PI Controller Based Shunt Active Power Filter With Five level Cascaded H-Bridge Inverter

Ms. M. Ragavi[1], Mr. R. Vijayakumar[2], Dr. C. Ramakrishnan[3]
[1] Student, Department of EEE, SNS College of Technology, Anna University, Coimbatore, Tamilnadu - 641035, India.
[2]Assistant Professor, Department of EEE, SNS College of Technology, Anna University, Coimbatore, Tamilnadu - 641035, India.
[3]Professor, Department of EEE, SNS College of Technology, Anna University, Coimbatore, Tamilnadu - 641035, India.

ABSTRACT

The paper presents a shunt active power filter for harmonic elimination in the power system. Shunt power active filter consists of a five level cascaded H bridge multilevel inverter to boost the output voltage of the inverter. Source voltage consists of harmonics due the use of nonlinear loads such as EV loads. In the proposed indirect current controlled APF, the reference current is generated from the DC link capacitor voltage directly, without calculating the reactive current drawn by the load so the compensation process is simple as compared to the control techniques of conventional APFs. The control based on adaptive PI controller, which can self adjust the control gains during a disturbance such that the performance always matches a desired response, regardless of the change of operating condition.

KEYWORDS: *SAPF- PWM inverter- point of common coupling-harmonic elimination*

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I. INTRODUCTION

The continuous rise of nonlinear loads such as electric vehicles and other non linear loads affect the reactive power limits and create harmonics in the system. Thus the basic requirements for compensation process involve precise and continuous var control with fast dynamic response and on-line elimination of harmonics. To satisfy these criterion, the traditional methods of var compensation using switched capacitor and thyristor controlled inductor coupled with passive filters are increasingly replaced by active power filters (APFs) and hybrid APF. The hybrid APFs improve the characteristics of passive filters with smaller rated APFs. The majority of the reported APFs and hybrid APFs use a var calculator to calculate the reactive current drawn by the load and accordingly a reference current is generated. The compensator current is made to follow the reference current for the required compensation. This method exhibits good current profile and fast dynamic response; however the generation of reference current is a complicated process. However, as the number of harmonics to be eliminated increases (up to five harmonics), the degrees of the polynomials in the equations become so large that solving them becomes very difficult. The evolutionary algorithm can be applied for computing the optimal switching angles of the MLI with the objective of optimizing the individual harmonics to allowable limits.

II. CONVENTIONAL SYSTEM.

The VSI is controlled to produce a fundamental terminal voltage in-phase with the AC system voltage. When the fundamental inverter terminal voltage is more than the RMS value of AC system voltage Vs, a leading current is drawn from the AC system and when the inverter terminal voltage is less than Vs, a lagging current is drawn from the AC system. The magnitude of the inverter terminal voltage depends on the DC link capacitor voltage Vc. By controlling the gate signals of the switches, the inverter terminal voltage can be made to lag or lead the AC system voltage, so that real power flows into or out of the inverter circuit. By suitable operation of the switches, a voltage vcomp having a fundamental component Vcomp1 is generated at the output of the inverter. When Vcomp1 > Vs, leading current (with respect to Vs) will be drawn and the inverter supplies lagging vars to the system.

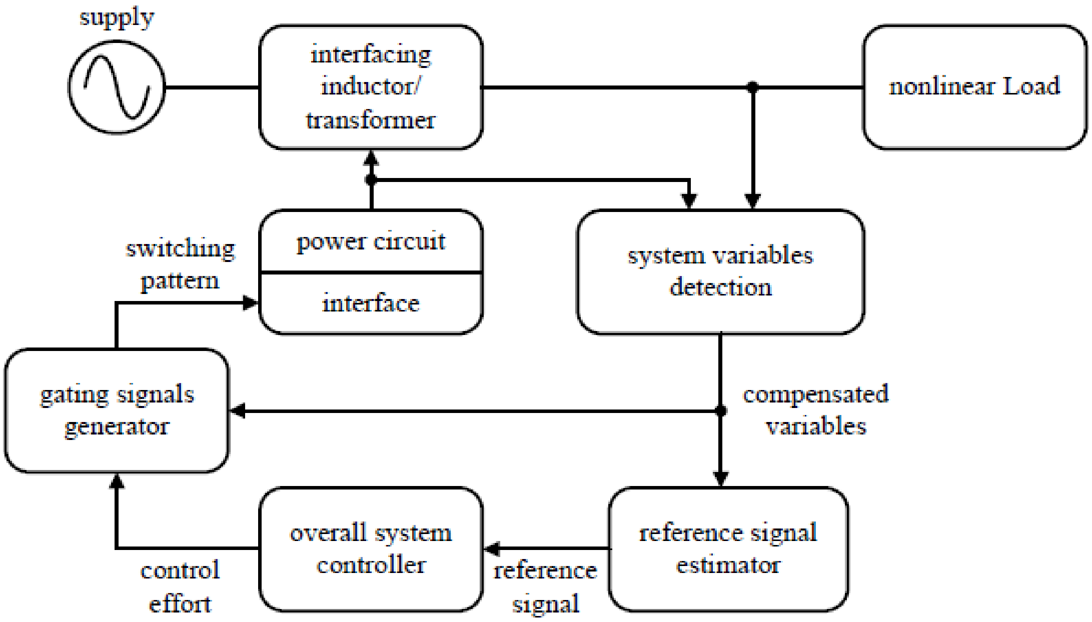

Figure 1: Block diagram for existing system

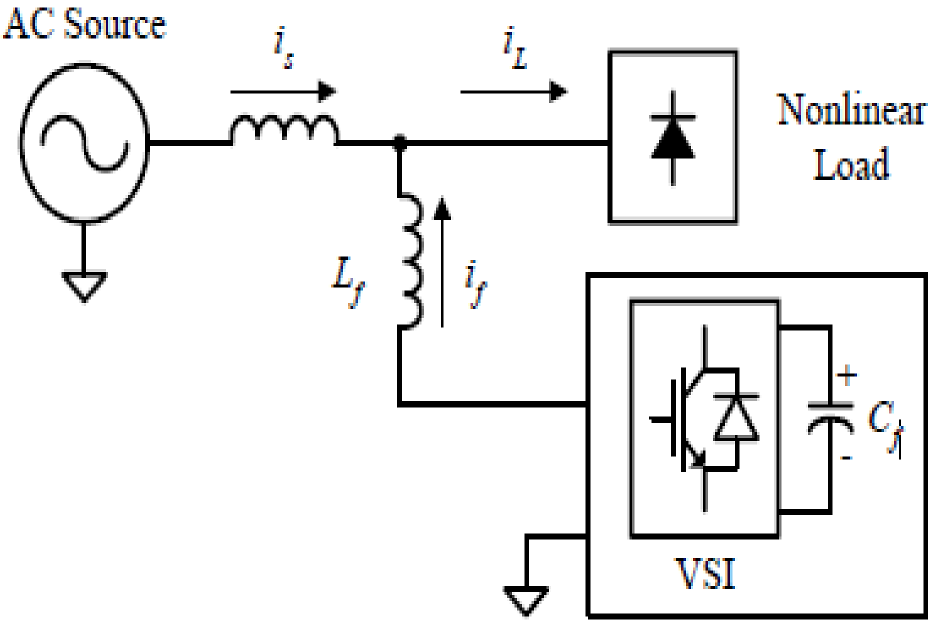

Figure 2: Circuit diagram for existing system

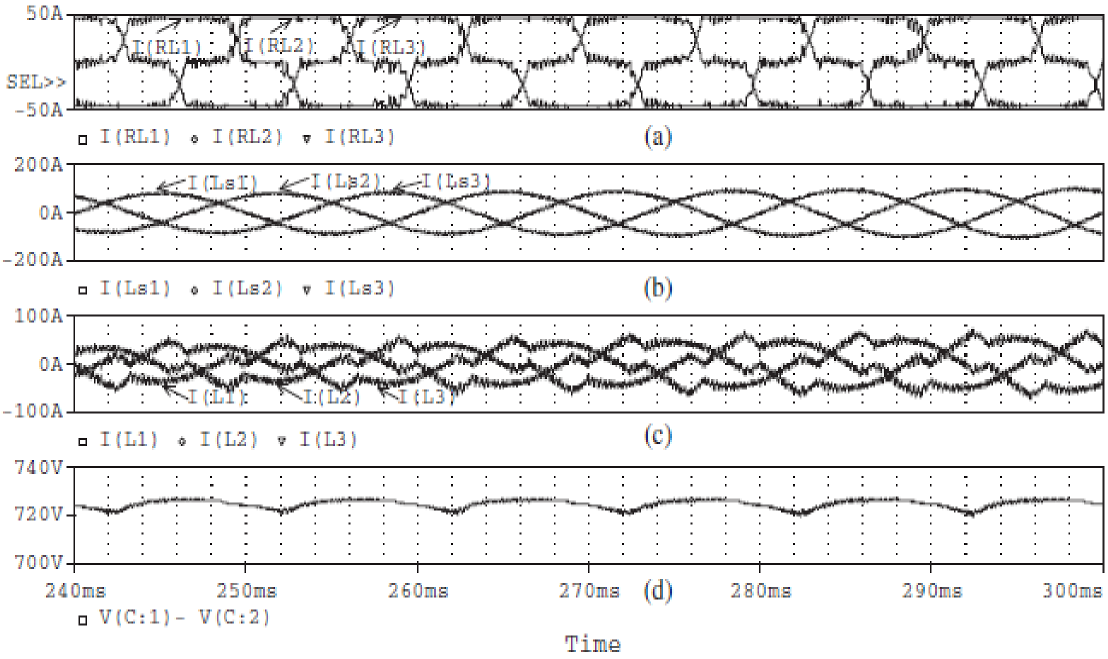

Figure 3: Existing system simulation results

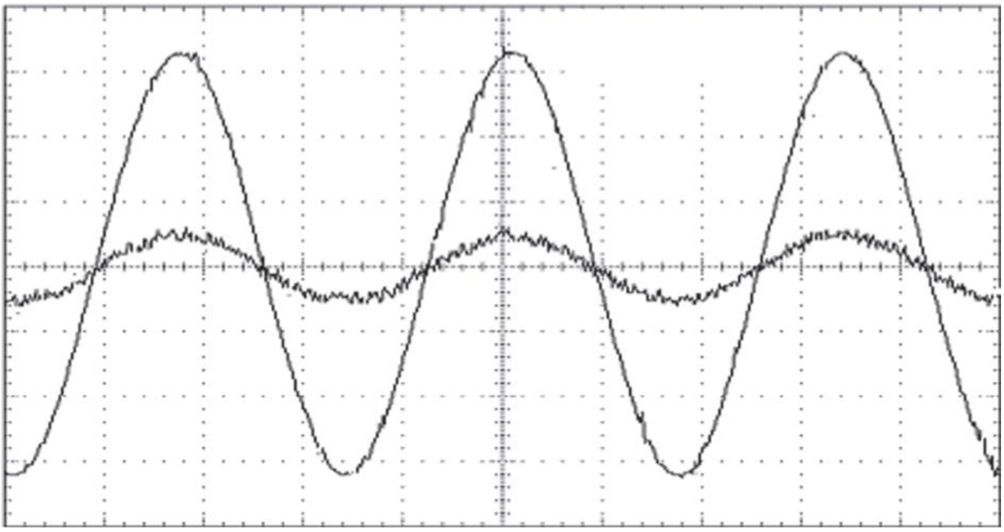

Figure 4: Existing system output

III. PROPOSED SYSTEM

Thus, the SAF control system may not perform well when mostly needed. Different from these previous works, the motivation of this paper is to propose a control method that can ensure a quick and consistent desired response when the system operation condition varies. In other words, the change of the external condition will not have a negative impact, such as slower response, overshoot, or even instability to the performance. Base on this fundamental motivation, an adaptive PI control of SAF for voltage regulation is presented in this paper. With this adaptive PI control method, the PI control parameters can be self-adjusted automatically and dynamically under different disturbances in a power system. When a disturbance occurs in the system, the PI control parameters for SAF can be computed automatically in every sampling time period and can be adjusted in real time to track the reference voltage. Different from other control methods, this method will not be affected by the initial gain settings, changes of system conditions, and the limits of human experience and judgment. This will make the SAF a "plug-and-play" device. In addition, this research work demonstrates fast, dynamic performance of the SAF in various operating conditions.

The aim of shunt APF is to obtain a sinusoidal source current (is) using the relationship:

$$\boldsymbol{is = iL - i f}$$

current component (iL , f) and the current harmonics (iL,h) according to

$$i_L = i_{L,f} + i_{L,h}$$

then the compensation current injected by the shunt APF should be

$$i_f = i_{L,h}$$

the resulting source current is

$$i_L - i_f = i_{L,f}$$

Adaptive PI Control Of SAF For Voltage Regulation

SAF can provide fast and efficient reactive power support to maintain power system voltage stability. In the literature, various SAF control methods have been discussed including many applications of proportional-integral (PI) controllers. However, these previous works obtain the PI gains via a trial-and-error approach or extensive studies with a tradeoff of performance and applicability. Hence, control parameters for the optimal performance at a given operating point may not be effective at a different operating point. This paper proposes a new control model based on adaptive PI control, which can self-adjust the control gains during a disturbance such that the performance always matches a desired response, regardless of the change of operating condition. Since the adjustment is autonomous, this gives the plug-and-play capability for SAF operation. In the simulation test, the adaptive PI control shows consistent excellence under various operating conditions, such as different initial control gains, different load levels, change of transmission network, consecutive disturbances, and a severe disturbance. In contrast, the conventional SAF control with tuned, fixed PI gains usually perform fine in the original system, but may not perform as efficient as the proposed control method when there is a change of system conditions.

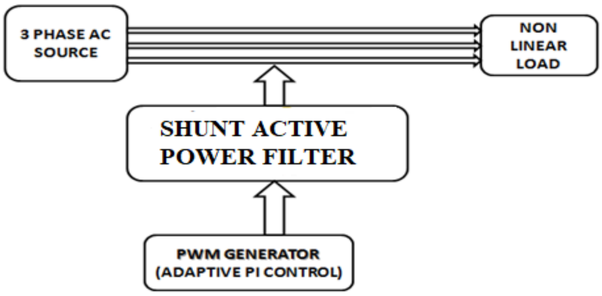

Figure 5: Proposed system block diagram

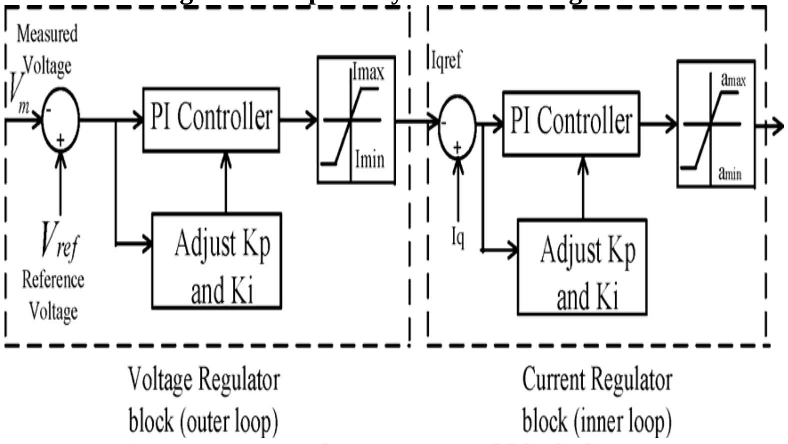

Figure 6: Proposed system control block diagram

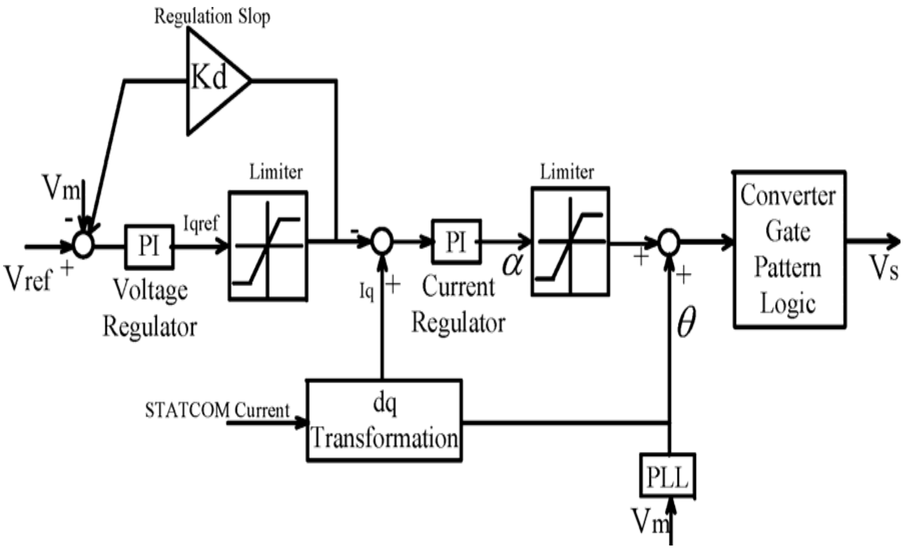

Figure 7: Simulink Diagram of Proposed Control System

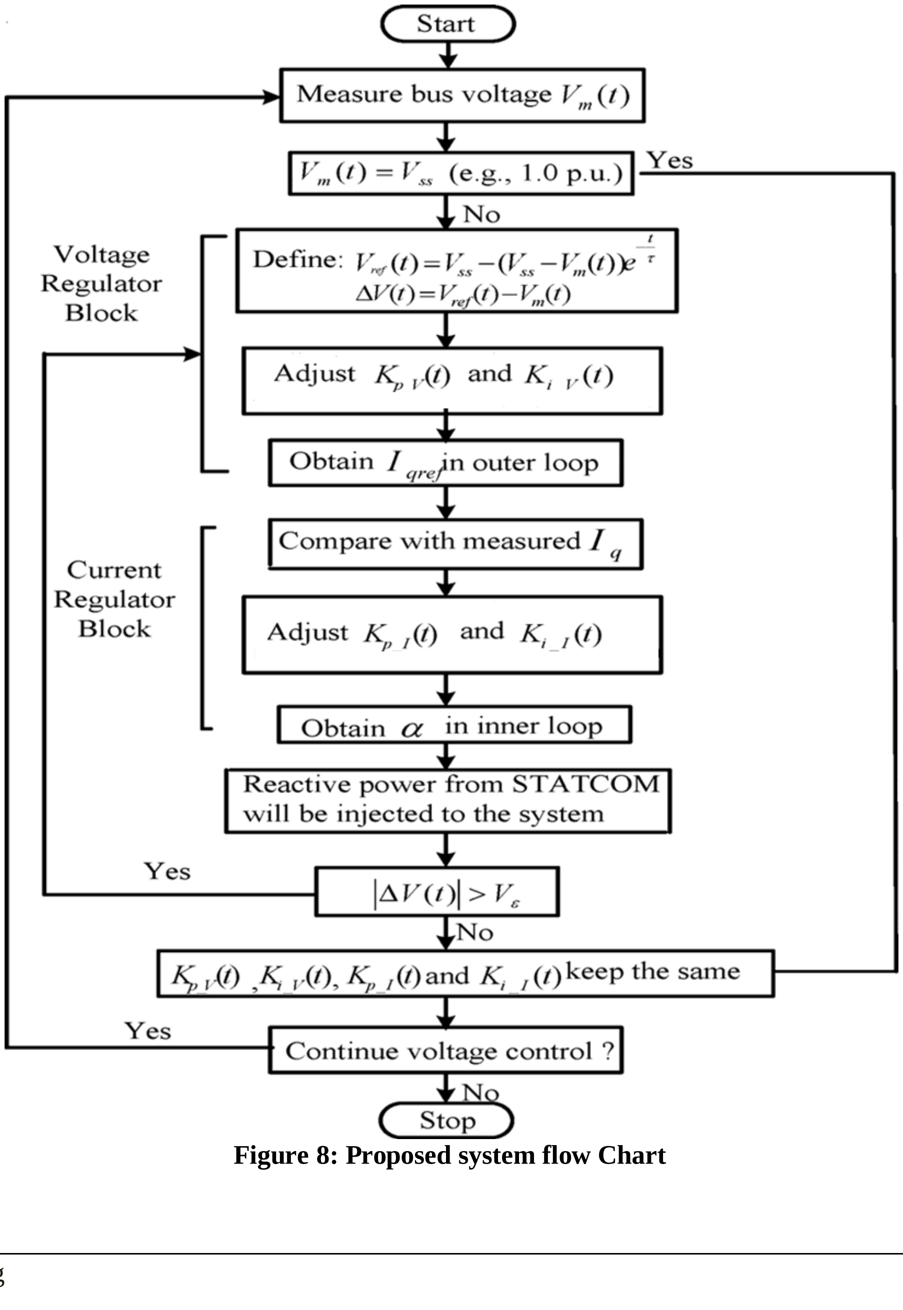

Figure 8: Proposed system flow Chart

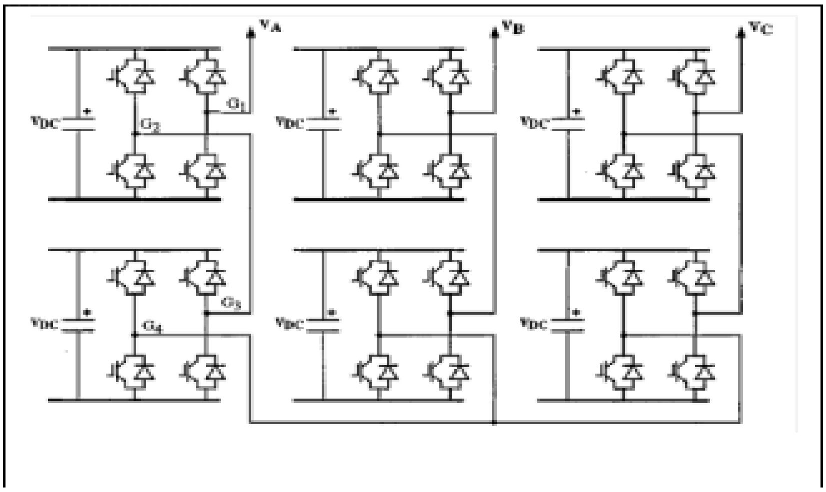

Figure 9: Cascaded H-Bridge Multilevel Inverter

IV. RESULTS AND DISCUSSION

Simulation Data:

Supply – 120KV
Load – 30MW , 2MW , 2MVAtransmission line – 14Km
Power – 100KVA
Frequency– 50 Hz
Primary – 25KV
Secondary – 260V
Rxfo=.002ohm
Lxfo=.06H
R=2e-3Ω
L=250e-6H
Vdc gain – Kp=7
Ki=800
Current gain – Kp=0.3
Ki=20.

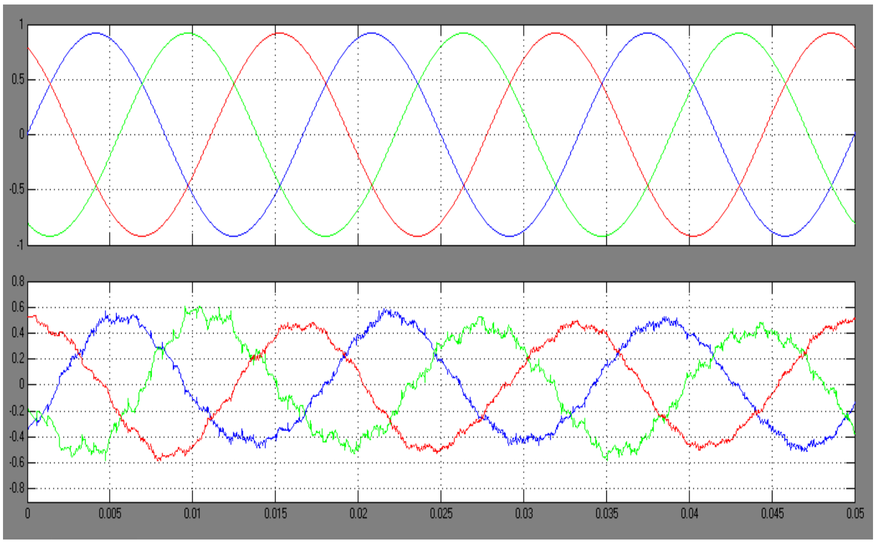

Figure 4.1=Proposed system simulink source ac voltage output and current

Figure 4.2: Proposed systems simulink PWM carrier signal

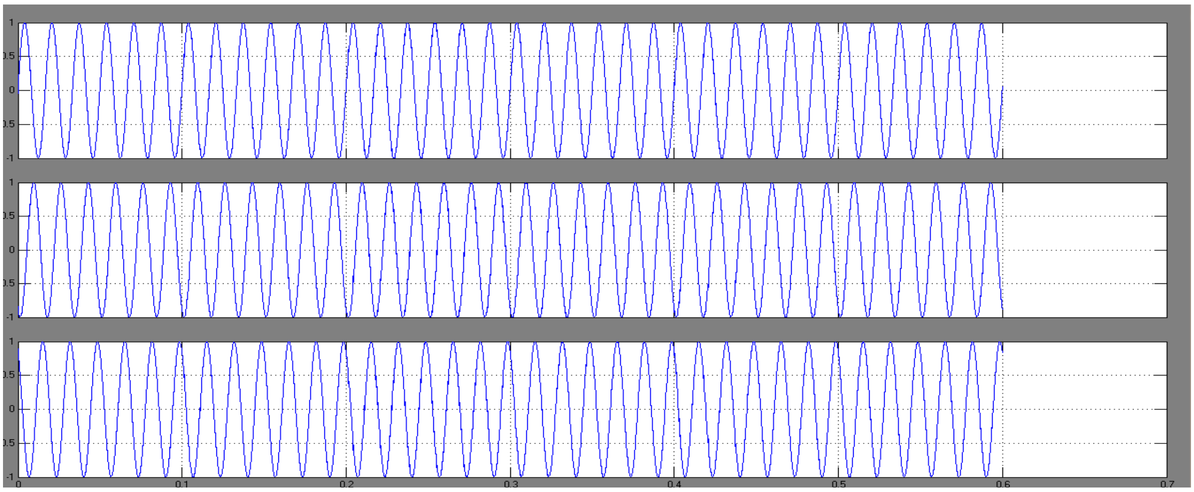

Figure 4.3: Proposed systems simulink PWM reference signal

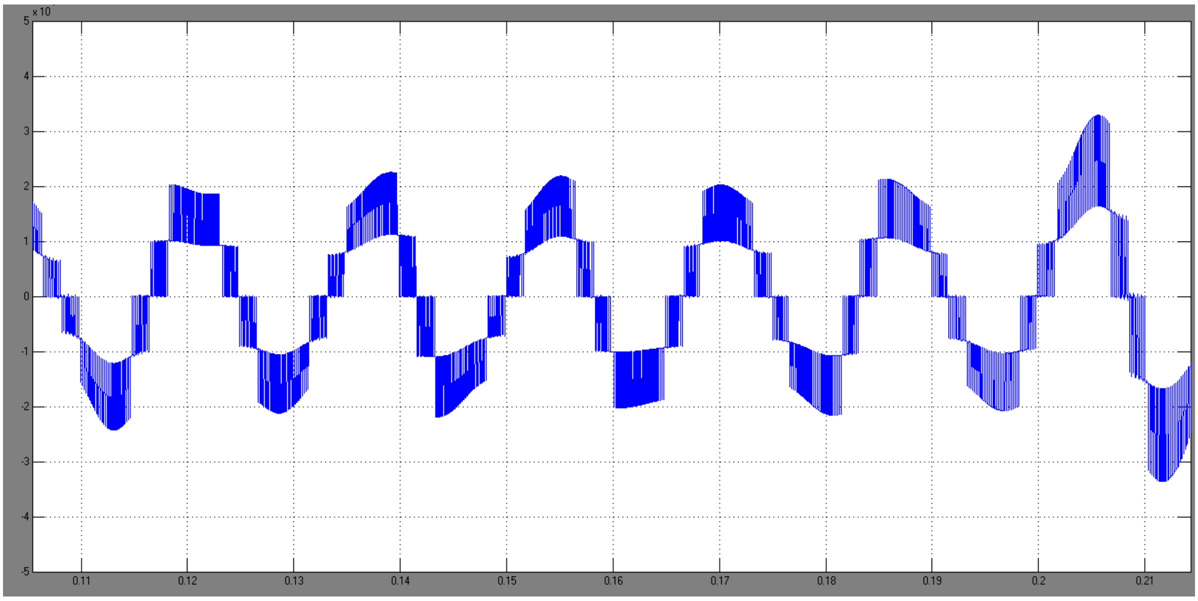

Figure 4.4: Proposed systems Simulink MLI FIVE level output voltage

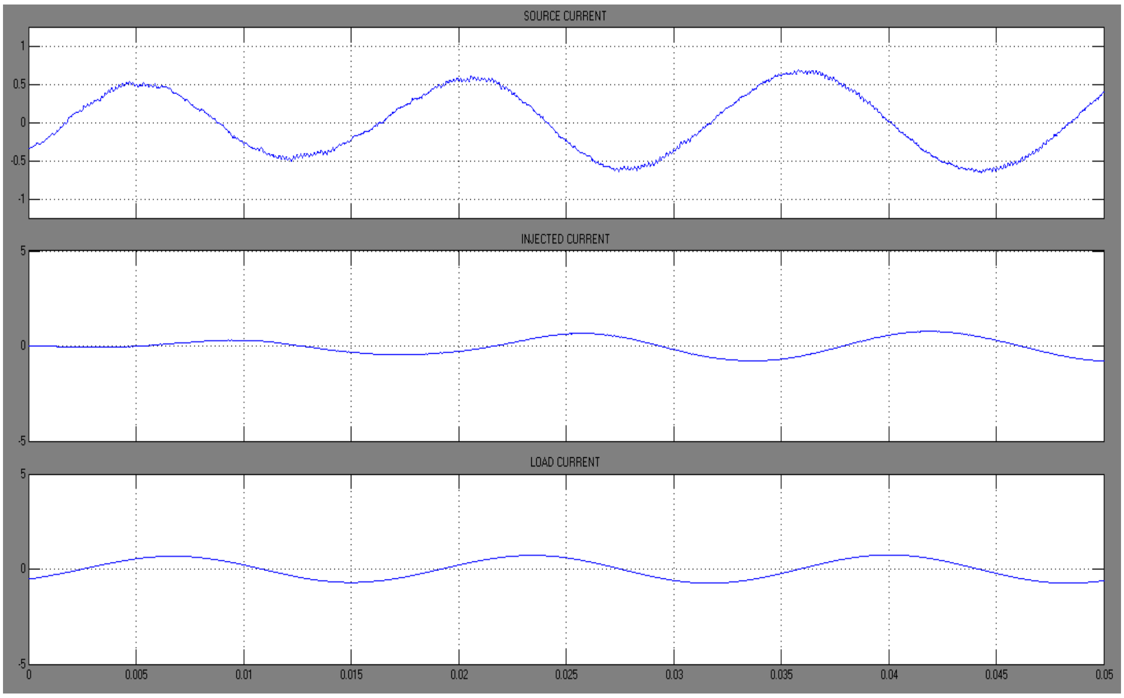

Figure 4.5: Proposed systems simulink source current, injected curremt and load current

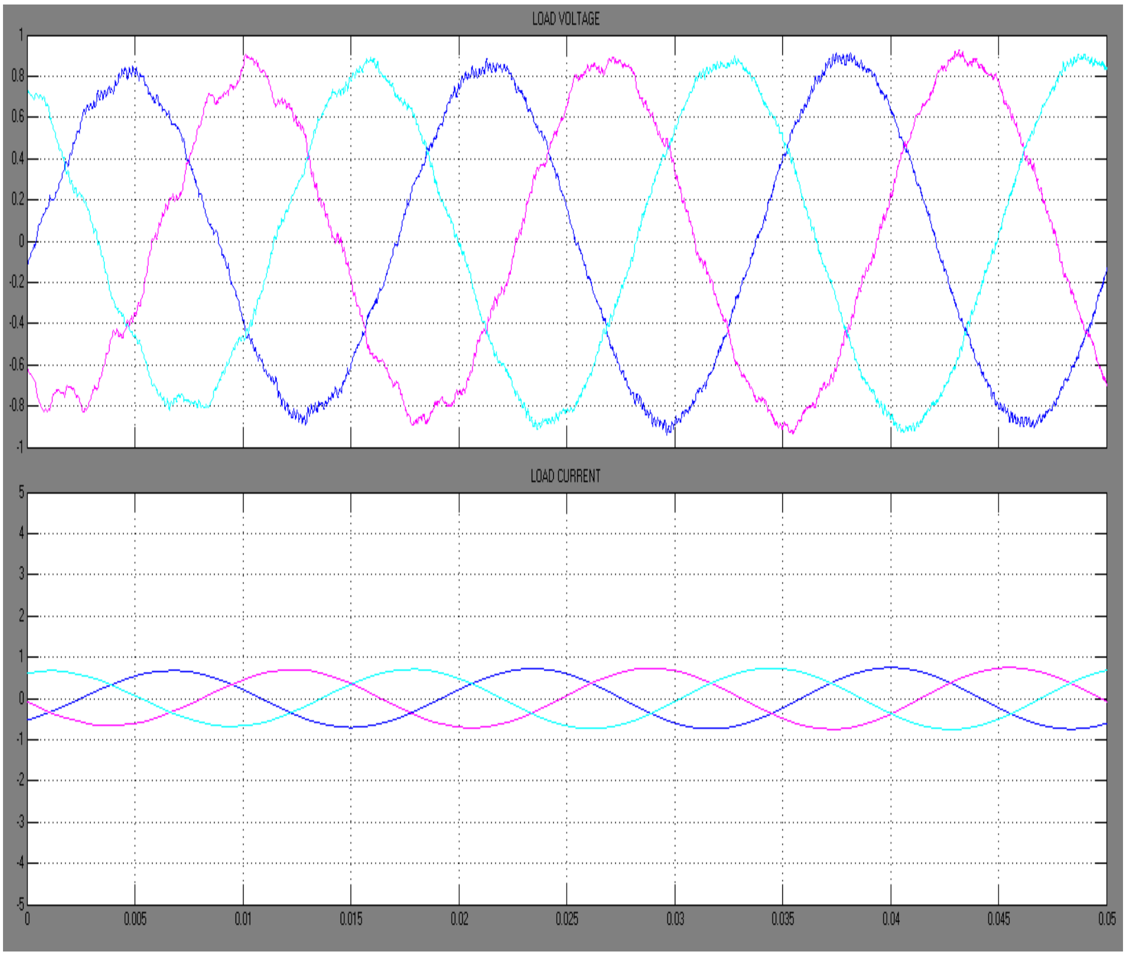

Figure 4.6: Proposed systems Simulink load voltage and load current

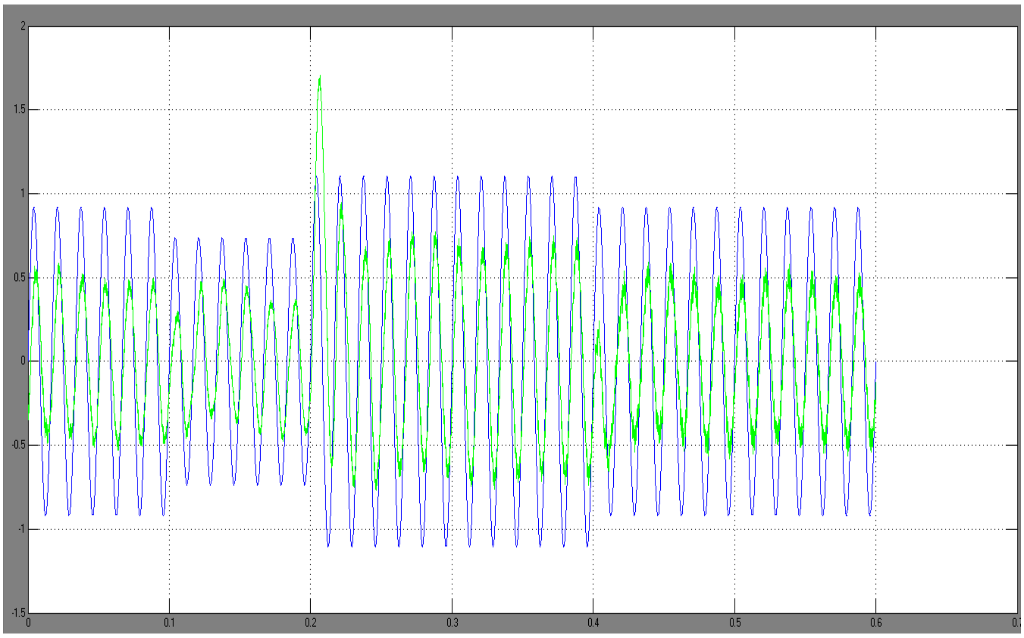

Figure 4.7: Proposed systems Output Voltage and Current

Cascade topology that uses multiple dc levels, which instead of being identical in value are multiples of each other. It also uses a combination of fundamental frequency switching for some of the levels and PWM switching for part of the levels to achieve the output voltage waveform., The number of possible output voltage levels is more than twice the number of dc sources (m = 2s + 1). The THD level absorbed for inverter is 4.85%. The number of levels achieved in Cascaded H Bridge Multilevel inverter five steps.

V. CONCLUSION

In the simulation study, the proposed adaptive PI control for SAF is compared with the conventional SAF control with pretuned fixed PI gains to verify the advantages of the proposed method. The results show that the adaptive PI control gives consistently excellent performance under various operating conditions, such as different initial control gains, different load levels, change of the transmission network, consecutive disturbances, and a severe disturbance and the reactive power has been compensated.

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