Power Quality Improvement by ANN Optimization

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ABSTRACT

Unavoidable use of non-linear load in all sectors hampered the power waveforms to extreme levels. It may led to distortion of voltage and current waveform which results in poor performance of power supply. Keeping in view of its disadvantages the power quality issue highly analyzed and researched for unfolding all possible benefits of improved power quality. In this work issues like harmonics, reactive power consumption reduction, neutral current adjustment and the power factor correction are handled. Literature revealed that the problem of PQ was corrected by the classical methods like use of shunt filters having tuned LC filter and high pass filters to compensate harmonics and fixed capacitors to improve power factor by supplying reactive power demand. But all of them reflect many disadvantages.

Key words- harmonics, ANN, non linear load

1. INTRODUCTION

The massive use of non-linear load in the domestic and industries, led to distortion of voltage and current waveform. As a consequence, recently the issue of power quality has become important. It is the objective of the electric utility to supply its customers with a sinusoidal voltage of constant magnitude. However, the voltage distortion originates with the non-linear circuits, because they draw non-sinusoidal currents (harmonics and reactive component of current) from the source. Any power fault resulting in voltage, current, or frequency irregularities that cause client equipment to fail or malfunction. As a result, IEEE Standard 519-1992 aims to reduce and attenuate harmonics in power systems.

One of the most common causes of power quality problems is harmonic distortion. Because current is not proportional to applied voltage, it is created by non-linear devices, as shown in Fig. 1.1. The harmonic currents are seen in Figure 1. 2 pass through the system, causing each harmonic's voltage to decrease and voltage harmonics to develop on the load bus, resulting in a power quality problem.

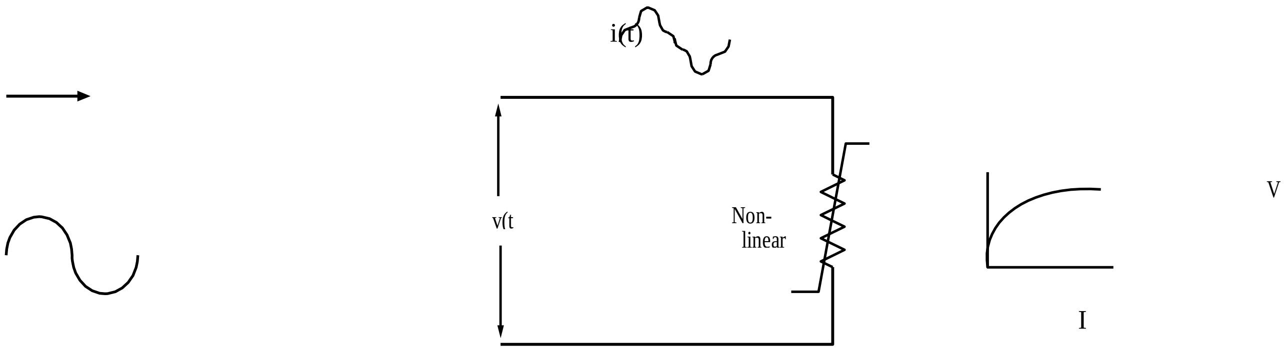


Fig. 1.1 Current distortion caused by non-linear resistor

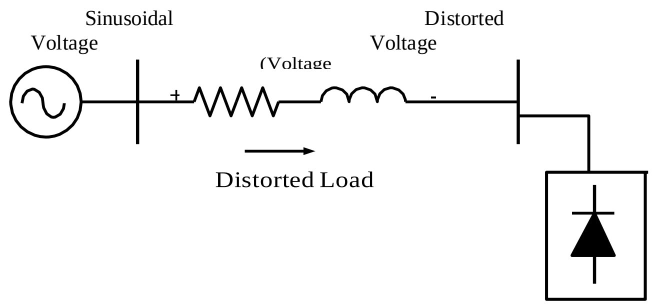


Fig. 1.2 Harmonic currents flow through system impedance result in harmonic voltage at the load bus

1.1 CAUSES AND EFFECTS OF HARMONICS AND REACTIVE POWER

Harmonics are sinusoidal voltages or currents having frequencies that are integral multiples of the fundamental frequency. The main sources of harmonics are listed below:

- Adjustable speed drives
- Arc furnaces
- Fluorescent lamps
- HVDC systems
- Resistance welders
- Solid-state switches
- Switched-mode power supplies
- Switching power factor correction converters
- Uninterruptible power supply.

2. CAUSES AND EFFECTS OF NEUTRAL CURRENT

The neutral current is a vector sum of line currents in three-segment, four-cord machine. The energy is generally disbursed thru three-phase, 4-wire machine, wherein single section loads like domestic home equipment, lightening, traction, etc are linked. The unbalance of machine consequences in growth of impartial modern-day. The non-linear loads like converters, SMPS, UPS, etc draws the non-sinusoidal currents from source. Though the vector sum is balanced, the three-phase currents does not necessarily equal to zero. In three phase circuits, the triplen harmonics in the neutral current are added instead of cancel.

The effects of neutral current are:

- Overloading of feeders
- Overloading of transformers
- Voltage distortion
- Common mode noise

The expensive solution is to oversize the neutral wire. But the best solution is to employee a three-phase, four-wire APLC where harmonics and reactive power is also to be compensated.

2.1 BASIC COMPENSATION

Figure 2.1 depicts the essential compensation of APLC. An energetic filter/APLC is a voltage source PWM converter with passive parts such as an inductor on the AC facet and a capacitor at the DC facet. It's set up to both draw or deliver a repayment present day iC to the utility, compensating for harmonics at the AC side with opposing harmonic present day injections. As a result, the source current has a sinusoidal shape. The graphic shows the numerous waveforms used by the APLC to reduce harmonics, correct for reactive power, and maintain a power factor of almost unity.

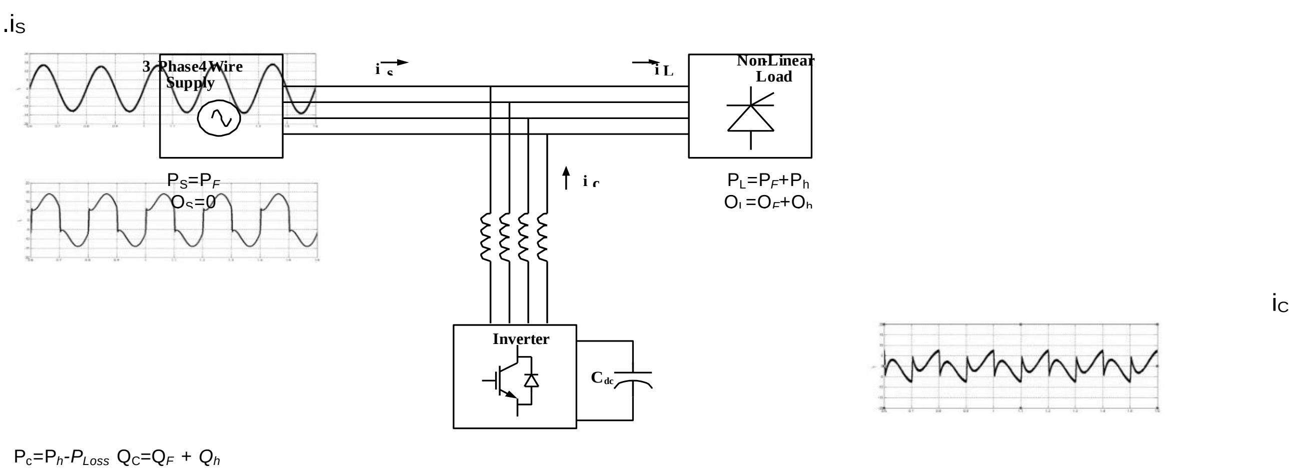


Fig. 2.1 Basic compensation with its waveforms

2.2 ***SIMULATION OF APLC.***

APLC for three phase four wire system have been modeled with the above mentioned parameters.

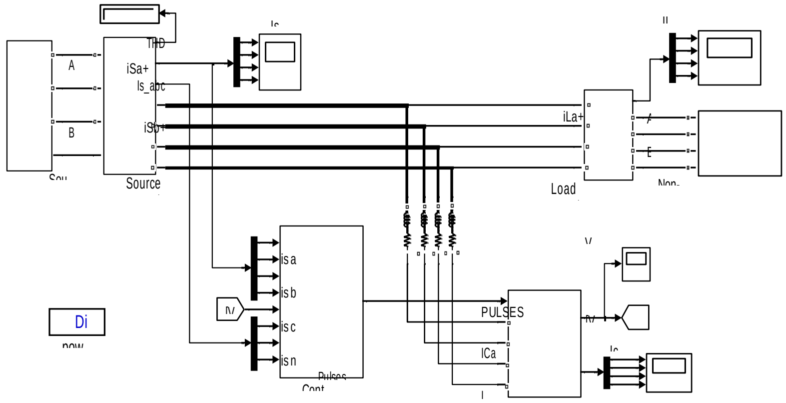


Fig.2.2. Simulation model of APLC

2.2.1 STEADY STATE RESULTS OF BALANCED THREE SINGLE PHASE NON-LINEAR LOAD

The steady state response of APLC has been shown in figure 2.3. In steady state for balanced conditions, the neutral current has been compensated, maintained the DC voltage across capacitor and nearly unity power factor

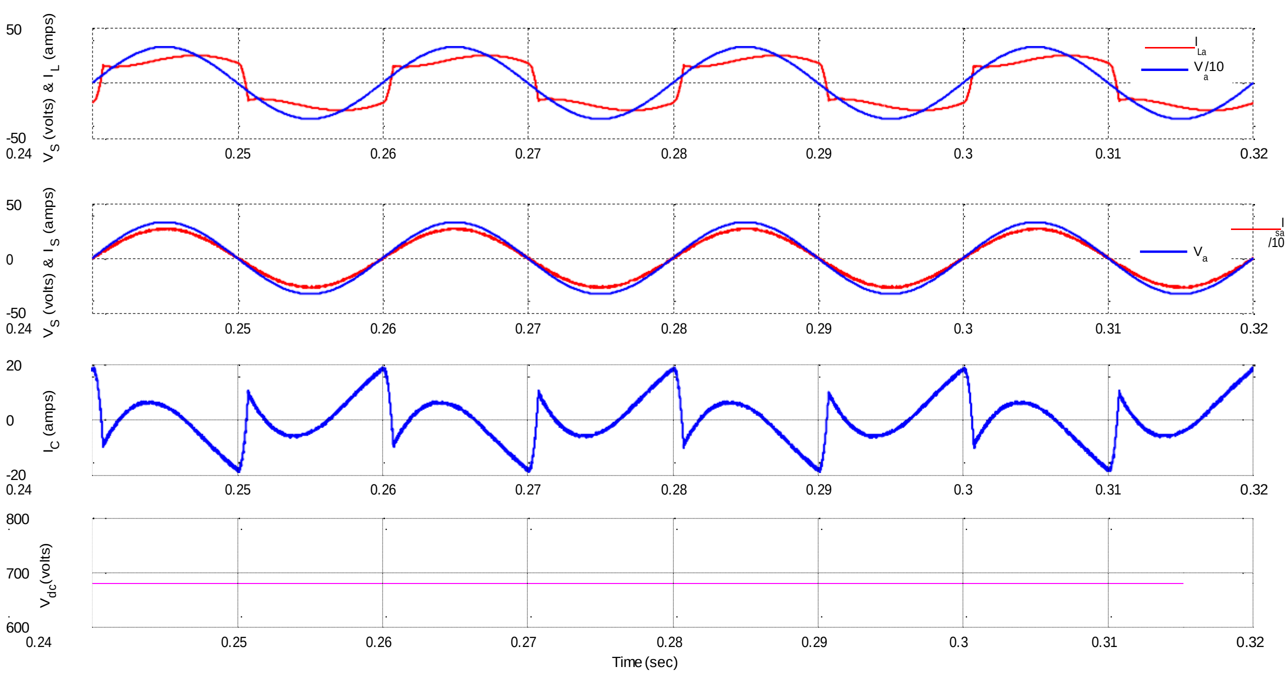
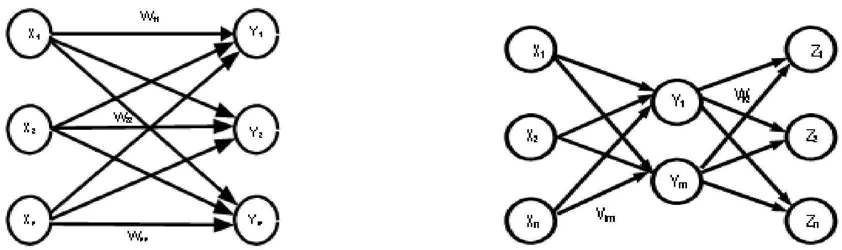


Fig.2.3. Simulation results after compensation in steady state with PI controller (Phase A)

3. FEEDFORWARD NETWORK OR STATIC NETWORK:

In the single layer feedforword neural network, only single layer with single or multiple neurons are present. Input at entering node and output directly from the activation function of neurons as shown in the figure 3.1.

In the Multi-layer feedforword neural network, multi layers with multiple neurons are present.

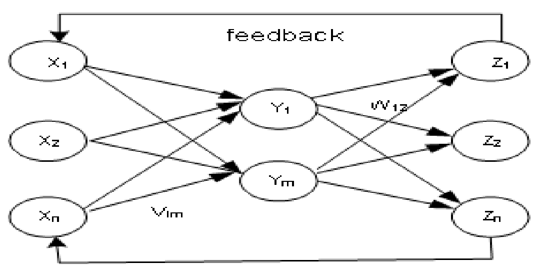


Input neurons (a) Output neurons Input layer Hidden layer Output layer(b)

Fig 3.1 Structure of (a) single layer feedforword (b) Multi-layer feedforword

3.1 RECURRENT NETWORKS OR DYNAMIC NETWORK:

This is similar to feed forward networks but has at least one feedback loop i.e, the output of a neuron is fed back into itself as input as shown in figure 3.2



Input layer Hidden layer Output layer

Fig 3.2 Structure of recurrent neural network

The modern ANNs are with the combination of feedforword and recurrent networks like Elman Recurrent Network, Hamming Network. Here, Multi-layer feedforword network is widely used. Here, in hidden layers tan sigmoidal or log sigmoidal functions are used as activation function and in output layer purine function is used as activation function.

3.2 LEARNING METHODS

In neural networks the learning methods are classified into three basic types; Supervised, unsupervised and reinforced

Supervised learning:

Every input pattern used to train the network is connected with an output pattern, which is the goal or intended pattern, in this sort of learning. When comparing the network computed output to the proper predicted output to identify the inaccuracy, a teacher is supposed to be present during the learning process. The fault can then be utilized to alter network settings, resulting in a performance boost.

Unsupervised learning:

The desired output is not supplied to the network in this sort of learning. It's as if the system learns on its own by identifying and responding to structural elements in the input patterns, as if there is no instructor to offer the desire patterns.

Reinforced learning:

Although an instructor is present, he or she does not offer the intended response, instead indicating whether the computed output is accurate or wrong. The data given is beneficial to the network's learning process. A reward is given for a correctly computed response, and a penalty is given for an incorrect answer. Reinforced learning, on the other hand, is not widely used. The most prominent learning methods are supervised and unsupervised learning. Gradient Descent, Polak-Ribiére Conjugate Gradient, One Step Secant, Gradient Descent with Momentum, Variable Learning Rate Gradient Descent BFGS Quasi-Newton, Levenberg-Marquardt, Bayesian Regularization Scaled Conjugate Gradient, Conjugate Gradient with Powell/Beale Restarts, and Fletcher-Powell Conjugate Gradient are all examples of resilient back propagation. In online learning, the weights updates after each training example. The theoretical difference between the two approaches is that offline learning implements what is called Gradient Descent, whereas online learning implements Stochastic Gradient Descent (also called Incremental Gradient Descent). The only difference is that offline learning will sum the error over all inputs, while the online learning will compute the error for each input (one at a time).

4. RESULTS

4.1 SIMULATION MODEL

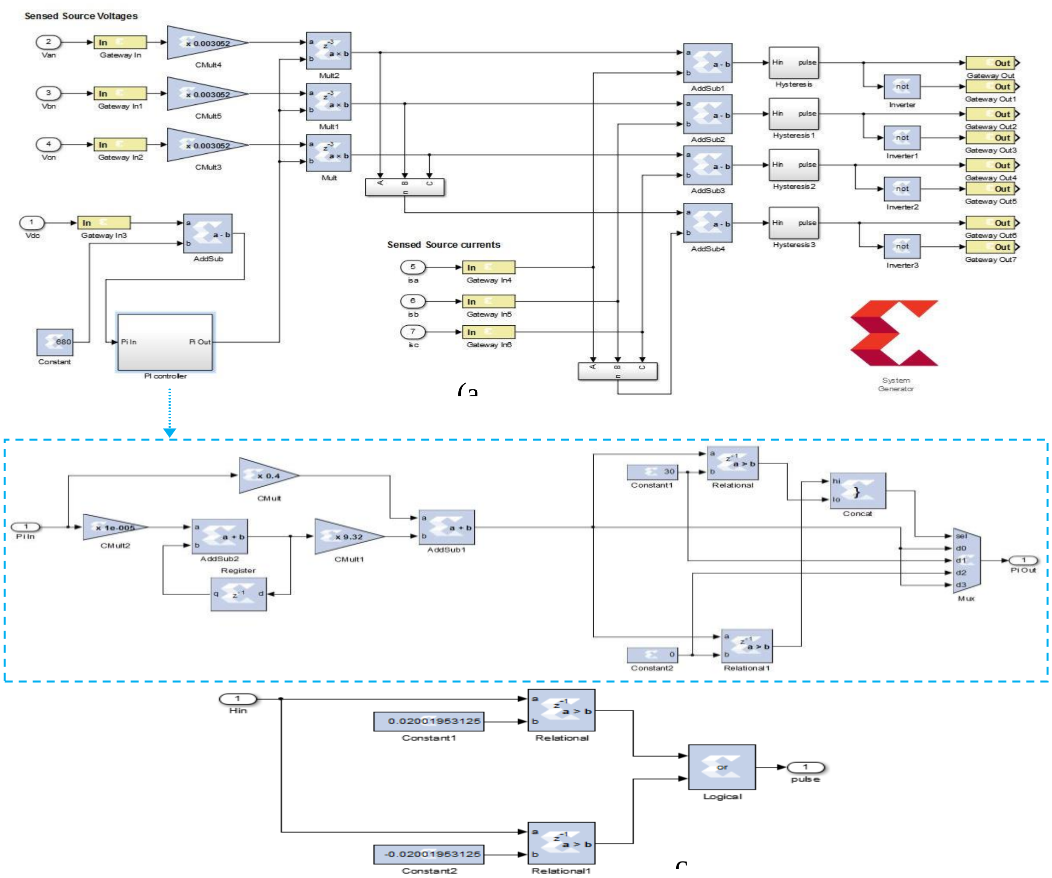


Fig.4.1 Simulation model of FPGA Implementation of conventional APLC (a) control scheme (b) PI controller & limiter

(c) Hysteresis controller

A. *STEADY STATE RESULTS OF BALANCED THREE SINGLE PHASE NON-LINEAR LOAD:*

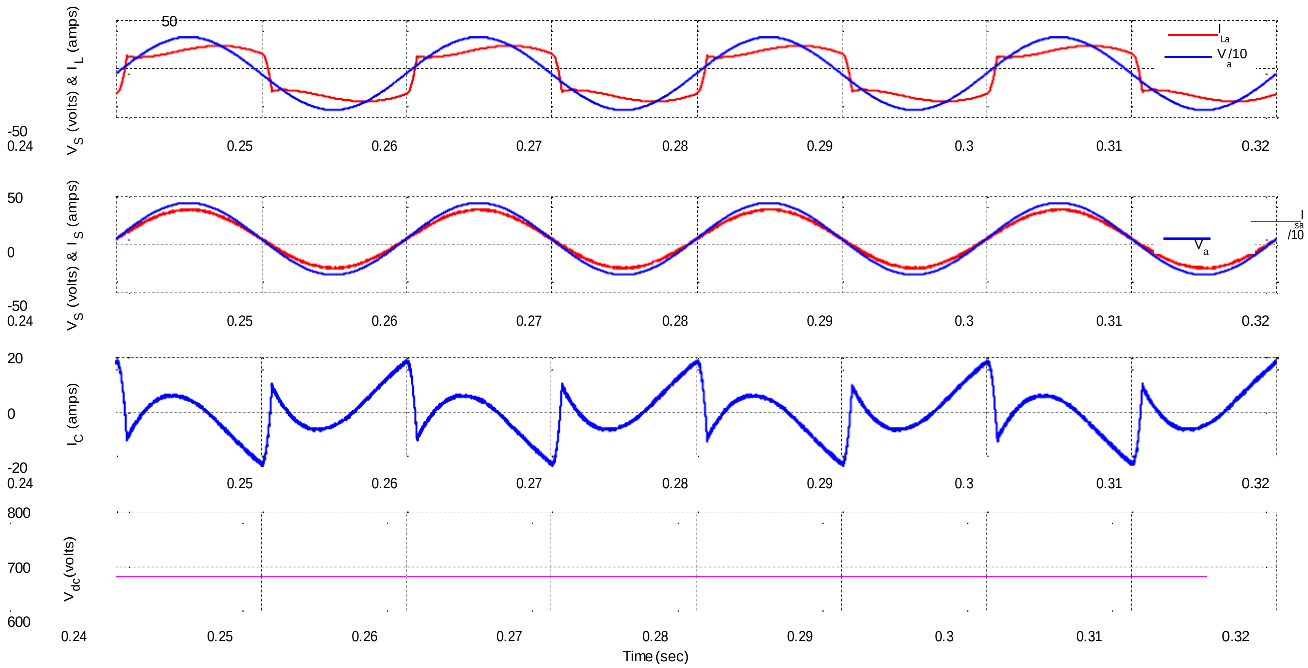


Fig.4.2 Simulation results after compensation in steady state with PI controller (Phase A)

B. *STEADY STATE RESULTS OF BALANCED THREE SINGLE PHASE NON-LINEAR LOAD:*

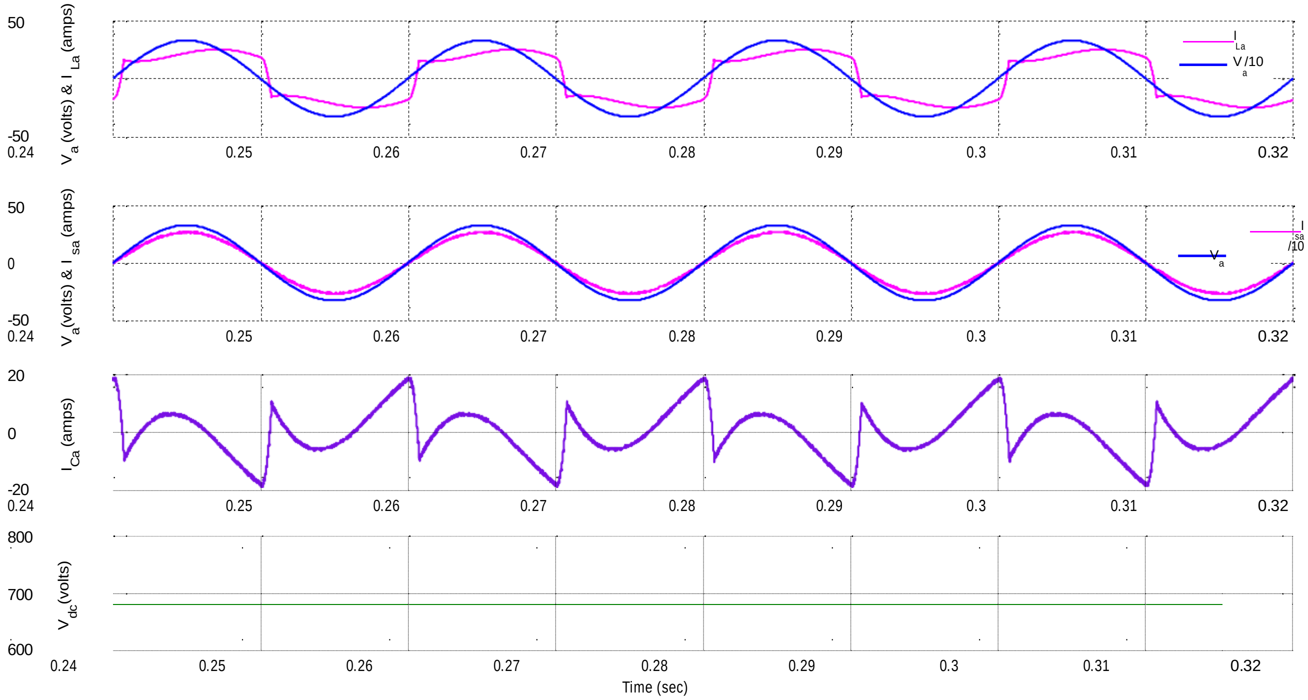


Fig.4.3 Simulation results after compensation in steady state with ANN controller (Phase A)

During the simulation, the sampling time period in powergui and system generator block should be same. The bit size of all the blocks used here are of 32 bit. The gateway in / gateway out blocks are used for interfacing the XSG and simulink blocks (which are real time input and output ports of the controller (FPGA)). In gateway in block, we have to select the fixed or floating point option and have to assign the number of bits. The control scheme which was implemented in chapter 2 and 4 was implemented here with XSG blocks. The PI controller, saturation and hysteresis controller are implemented as shown in figure 4.2

C. TRANSIENT CONDITION (LOAD CHANGE) RESULTS OF BALANCED THREE SINGLE PHASE NON-LINEAR LOAD:

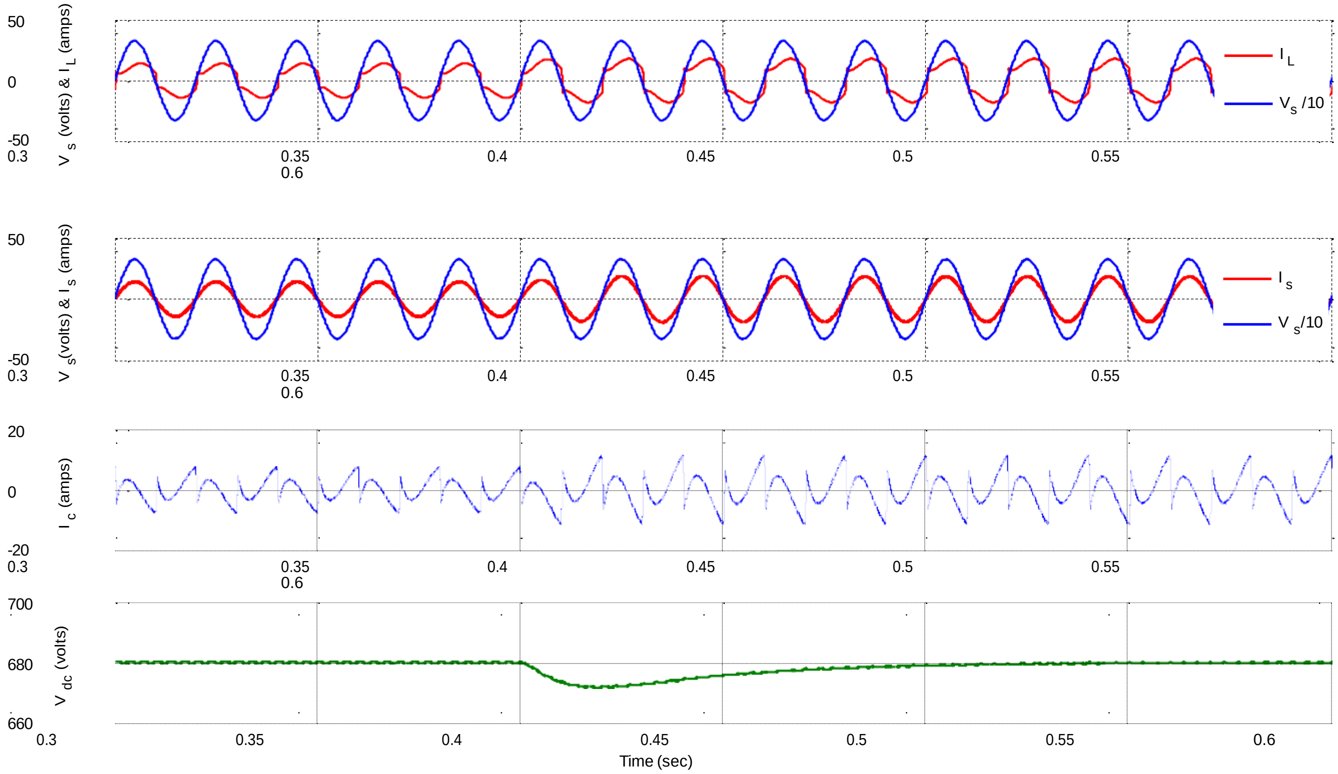


Fig.4.3 Response of change in load (15% increases) with PI controller (Phase A)

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