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Line Optimization Technique to Overcome Input and Output Harmonics in DC-DC Converters

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ABSTRACT: In this paper, a single-phase power factor corrector (PFC) based on the line optimization in Sheppard-Taylor topology is presented. Compared to conventional buck, boost or buck-boost PFCs, this topology allows a better current tracking at the AC side, with a relatively reduced voltage at the DC side. Consequently, the high frequency AC filters required by the buck PFCs are avoided, and the voltage stresses on the boost switches are significantly reduced. Furthermore, the control detuning phenomenon from which suffers most of the conventional PFCs, especially at very low input voltage, is avoided. This yields major improvements in the source current waveform. The proposed converter is integrated as a PFC at the DC-end of a single-phase diode bridge. A pulse-width-modulated (PWM) control is developed in order to ensure a unity power factor at the AC-source side and a regulated voltage at the DC-load side. In order to verify the performance of the proposed control scheme, simulation experiments are carried out on a numerical version of the converter with its control circuit. The implemented model of the converter is obtained by using the switching function technique. The control system is tested under both rated and disturbed operating conditions. The system performance is evaluated in terms of source current total harmonic distortion (THD), voltage regulation, robustness and dynamic time response to a set point offset...

KEYWORDS: Sheppard Taylor, Power factor Correction, Voltage Regulation.

I.INTRODUCTION

Every Electronic circuit is assumed to operate some supply voltage which is usually assumed to be constant in nature. A voltage regulator is a power electronic circuit that maintains a constant output voltage irrespective of change in load current or line voltage. Many different types of voltage regulators with a variety of control schemes are used. With the increase in circuit complexity and improved technology a more severe requirement for accurate and fast regulation is desired. This has led to need for newer and more reliable design of dc-dc converters. The dc-dc converter inputs an unregulated dc voltage input and outputs a constant or regulated voltage. The regulators can be mainly classified into linear and switching regulators. All regulators have a power transfer stage and a control circuitry to sense the output voltage and adjust the power transfer stage to maintain the constant output voltage. Since a feedback loop is necessary to maintain regulation some type of compensation is required to maintain loop stability. Compensation techniques vary for different control schemes and a small signal analysis of system is necessary to design a stable compensation circuit. State space analysis is typically used to develop a small signal model of a converter and then depending on the type of control scheme used, the small signal model of converter is modified to facilitate the design of the compensation network. In contrast to a state space approach, PWM switch modeling develops a small signal of switching components of converter.

Behavioral modeling of the IC system represents the functionality of an IC with macro models rather than actual implementation of the circuit using more efficient modeling techniques. ORCAD is powerful tool to develop behavioral models of electronic system. Simulation offers the advantage of its graphical user interface and block diagram implementation of any system. It also supports writing function and integration of C program code. The study undertaken in this thesis develops a system level design approach for switching voltage regulators of the three major control schemes. The basic converter topologies and their waveforms are reviewed. In Particular, a small signal model along with the various transfer functions of a buck converter are derived using stat e space method. A very

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simple and easy technique to arrive at the PWM model and compensation for two types of control schemes: namely voltage control, current control scheme is discussed. System level models are implemented using the in ORCAD. The following study provides details of methodologies for designing each component or blocks mainly the BUCK converter used in the switching regulator. Finally, practical result and simulation results are presented for voltage and current schemes and specified the proper design to get expected values to run the guitar processor

•To overcome the harmonics in converters, line optimization algorithm is implemented
•To obtain unity Power factor and total harmonic distortion using Shephard Taylor converter

II. BLOCK DIAGRAM

The Sheppard-Taylor converter operating in continuous inductor current mode and discontinuous capacitor voltage mode (CICM/DCVM) is studied and implemented. The operation sequences are described and the averaged model of the converter over a switching cycle is developed. With the obtained, the dc characteristics of the converter were derived, and design criteria for components selection to ensure DCVM operation were reported. The converter is then used for power factor correction in a single-phase rectifier with a front-end diode-bridge. This mode of operation provides the converter some desirable features: zero-voltage turnoff switching and natural purely resistive behaviour at low dc output voltage level. This can be achieved by simply using an open-loop control, where feedback control is required. The theoretical study of the converter is presented and validated through experimental measurements carried out on a 500 W laboratory prototype. It is shown that this rectifier exhibits an input power factor higher than 99.7% and a source current distortion lower than 6% at small output voltage level.

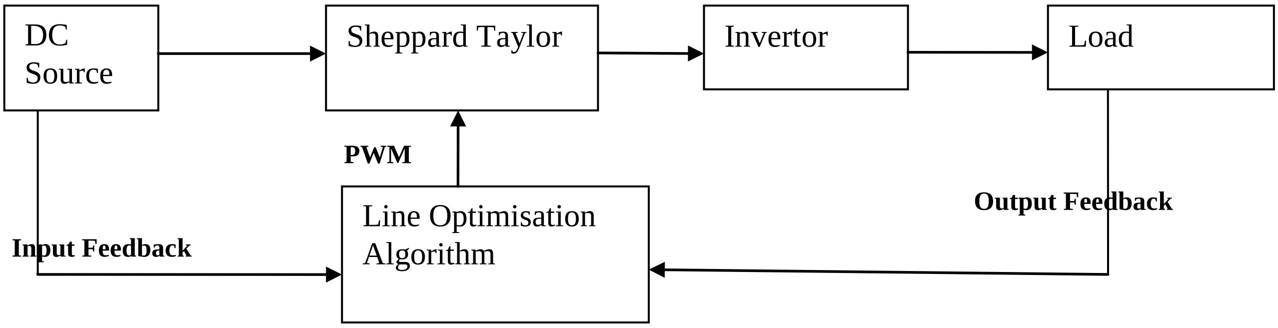

Fig.1. Block diagram of the control unit with the corresponding inputs and output.

III CIRCUIT DESCRIPTION AND OPERATION

There are different topologies used in PFC converters. The topology used in this study is the Sheppard–Taylor converter that is shown in Fig. 1. In this study, the single-phase Sheppard–Taylor converter op- erates in continuous conduction mode (CCM) of the input cur- rent. CCM means that the current in the energy transfer inductor never goes to zero between switching cycles. In discontinuous conduction mode (DCM), the current goes to zero during part of the switching cycle. High-power applications (> 200 W) need CCM PFC to have high efficiency and small system sizes. Lower power motor has three windings like an induction motor or a permanent magnet synchronous motor. The electrical torque and the back emf of BLDC is applications (< 200 W) traditionally use DCM systems for simplicity and low system cost [22], [23].

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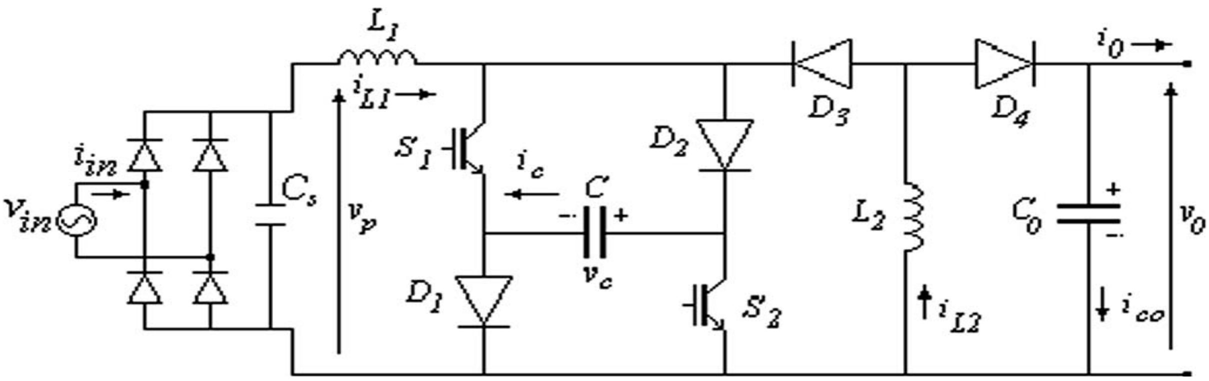

Fig.2. Topology of the Sheppard–Taylor converter.

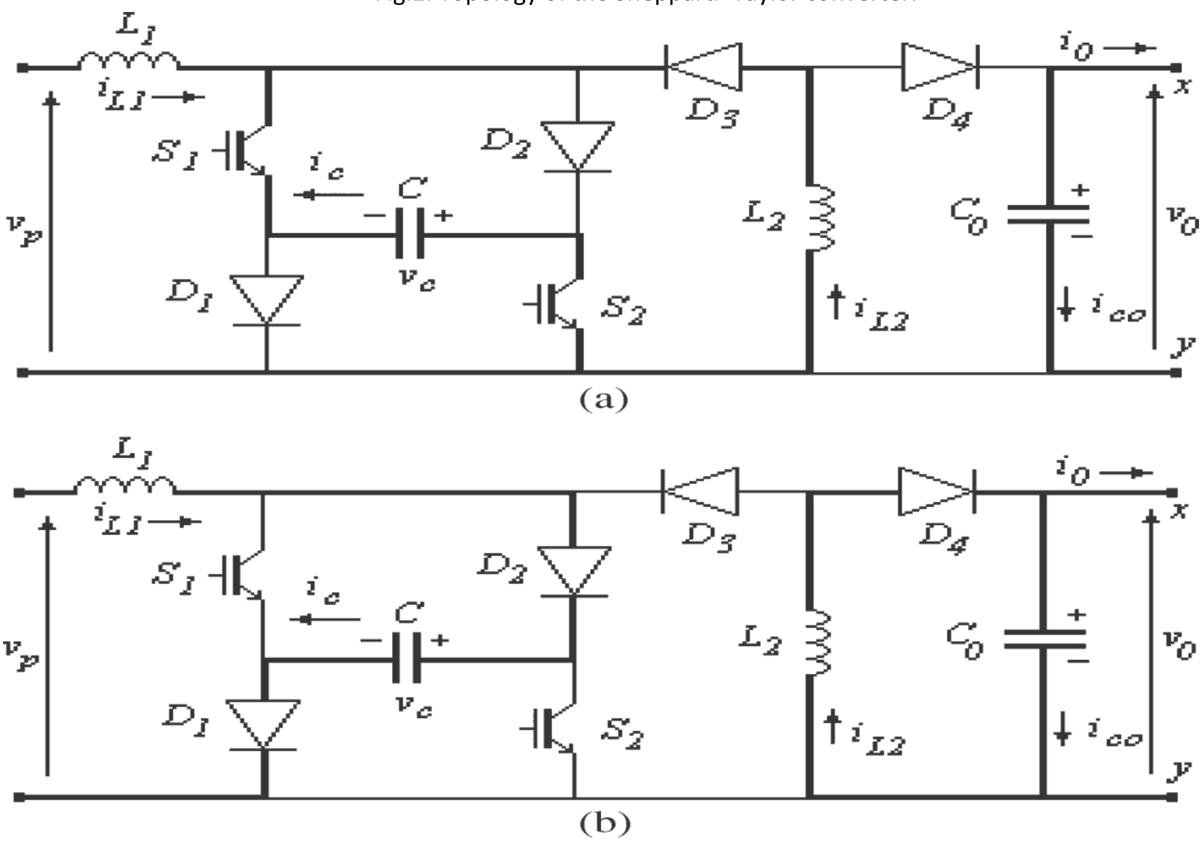

Fig. 3. Operation principles of the Sheppard–Taylor converter. (a) S1 and S2 are turned on. (b) S1 and S2 are turned off.

There are two operations of the circuit configuration during a switching period when the input current of the converter is in continuous mode. The different switching operations of the circuit configuration (on/off) are shown in Fig. 2(a) and (b), respectively [8], [9].Circuit Configuration 1 ($0 < t < dTs$): During this config- uration, switches S1 and S2 are in ON state, the input current (iL1) increases, and the energy is stored in the input inductor (L1). The energy stored in the intermediate capacitor (C) transfers to the output stage, and the capacitor current (iC) decreases. It is shown in Fig. 2(a). diode of the output current. The operating point of the converter is shown in Fig. 2(b).

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Therefore, both inductors (L1 and L2) operate in CCM, and both capacitors (C and C0) operate in continuous voltage mode (CVM).

IV. SIMULATION RESULTS AND INFERENCE

Simulink, developed by Math Works, is a graphical programming environment for modelling, simulating and analysing multi domain dynamic systems. Its primary interface is a graphical block diagramming tool and a customizable set of block libraries. It offers tight integration with the rest of the MATLAB environment and can either drive MATLAB or be scripted from it. Simulink is widely used in automatic control and digital signal processing for multi domain simulation and Model-Based Design. Math Works and other third-party hardware and software products can be used with Simulink. For example, State flow extends Simulink with a design environment for developing state machines and flow charts. Math Works claims that, coupled with another of their products, Simulink can automatically generate C source code for real-time implementation of systems. As the efficiency and flexibility of the code improves, this is becoming more widely adopted for production systems in addition to being a tool for embedded system design work because of its flexibility and capacity for quick iteration[citation needed]. Embedded Coder creates code efficient enough for use in embedded systems

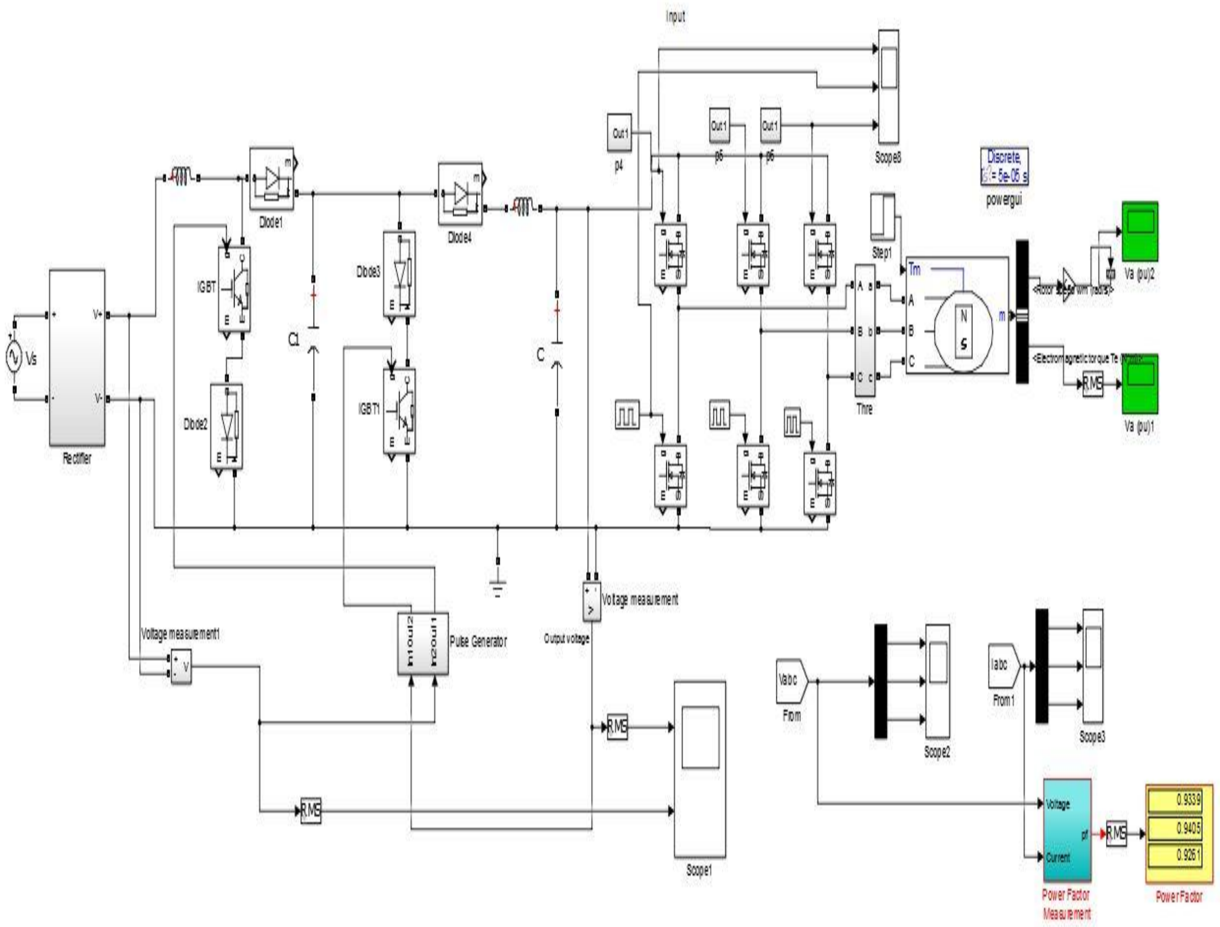

Fig: 4 Simulation Diagram

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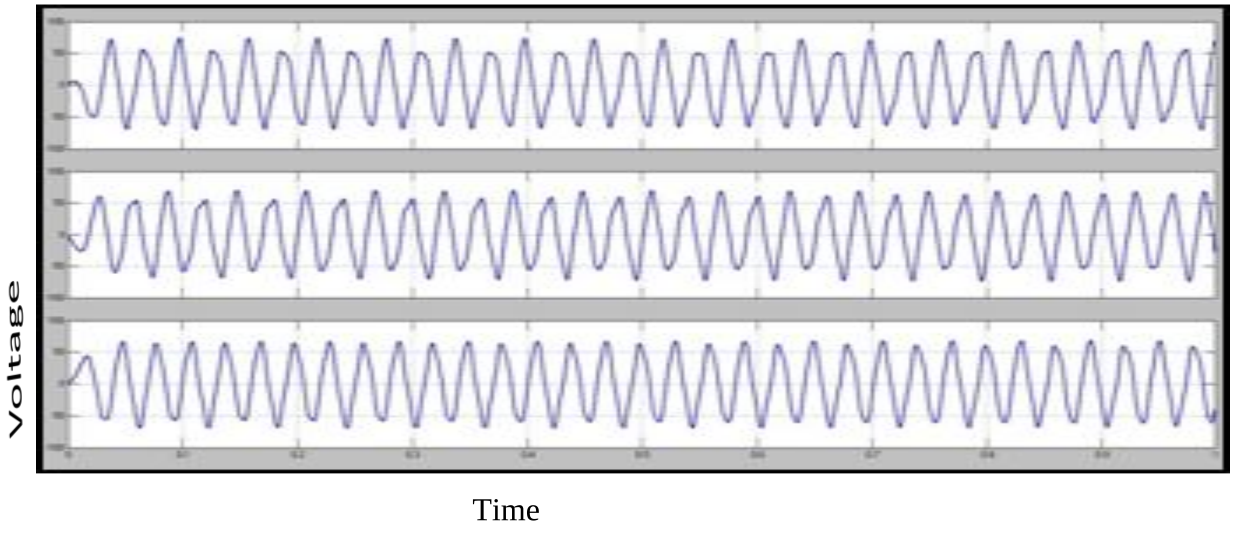

Fig: 5 Three phase motor voltage

The reason for transforming the voltage to a much higher level is that higher distribution voltages implies lower currents for the same power and therefore lower I2R losses along the networked grid of cables. These higher AC transmission voltages and currents can then be reduced to a much lower, safer and usable voltage level where it can be used to supply electrical equipment in our homes and workplaces, and all this is possible thanks to the basic Voltage Transformer

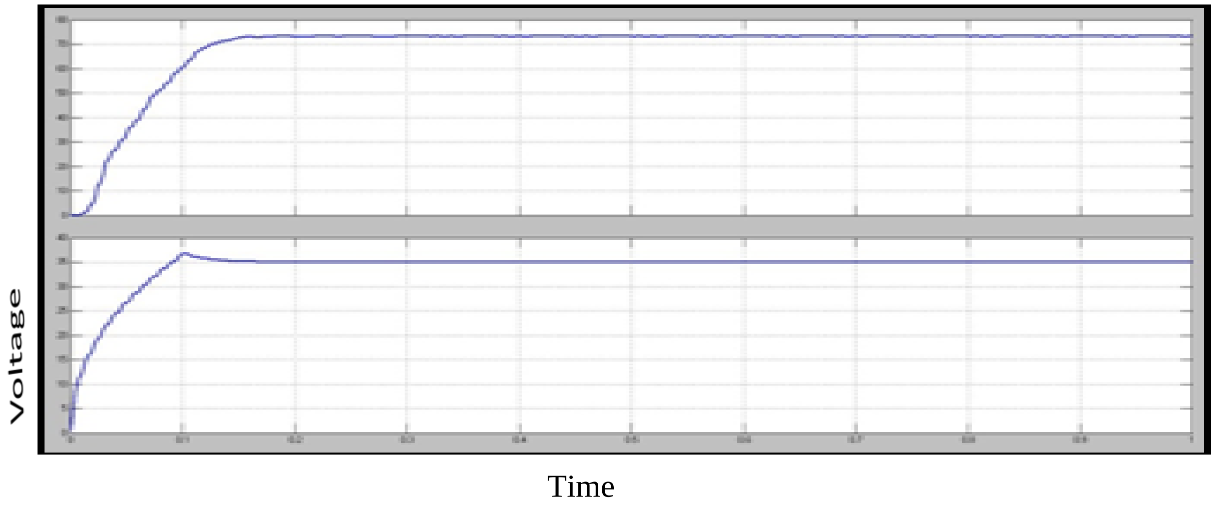

Fig: 6 Input and output voltage for converter

The rotor speed is slightly less than the stator magnetic speed. if the stator has P poles and supply frequency if f Hz. then the stator magnetic field speed is 120xf/P R.P.M. the rotor speed will be less than this speed. Most induction motors have a slip speed of 40-60 R.P.M. slip speed is the difference of stator magnetic field speed and rotor speed.

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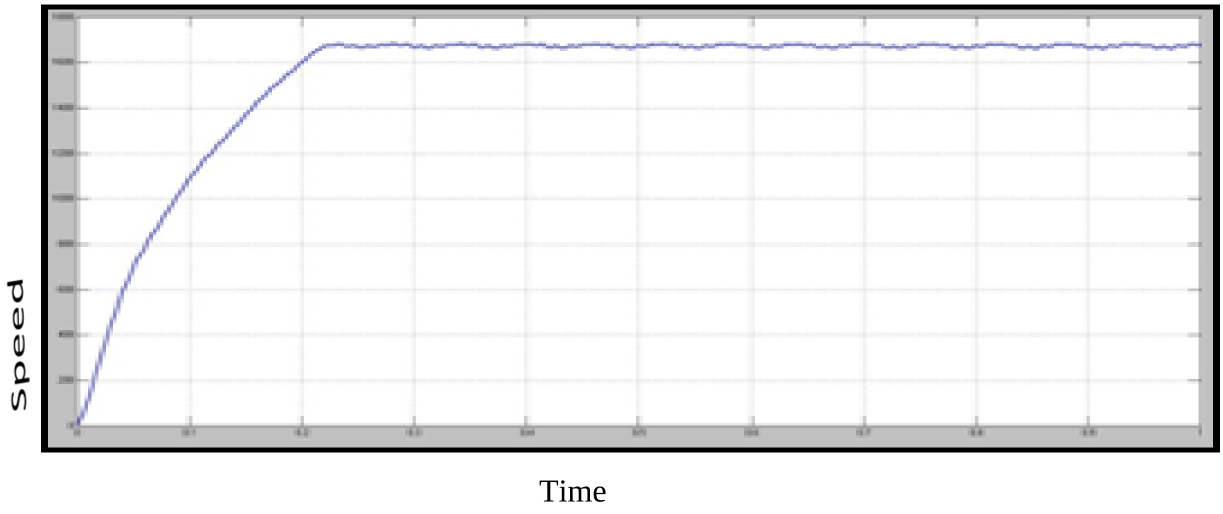

Fig: 7 Rotor speed

Torque is a vector quantity. The direction of the torque vector depends on the direction of the force on the axis. Anyone who has ever opened a door has an intuitive understanding of torque. When a person opens a door, they push on the side of the door farthest from the hinges. Pushing on the side closest to the hinges requires considerably more force

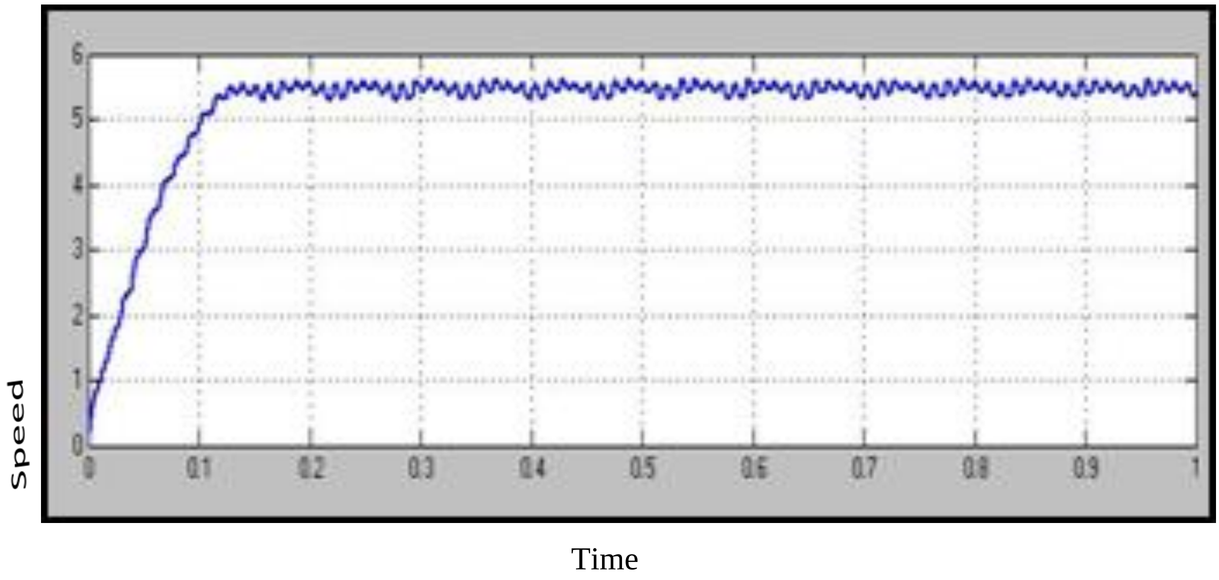

Fig: 8 Torque

The power of alternating current (AC) fluctuates. For domestic use for e.g. light bulbs this is not a major problem, since the wire in the light bulb will stay warm for the brief interval while the power drops. Neon lights (and your computer screen) will blink, in fact, but faster than the human eye is able to perceive. For the operation of motors etc. it is useful, however, to have a current with constant power.

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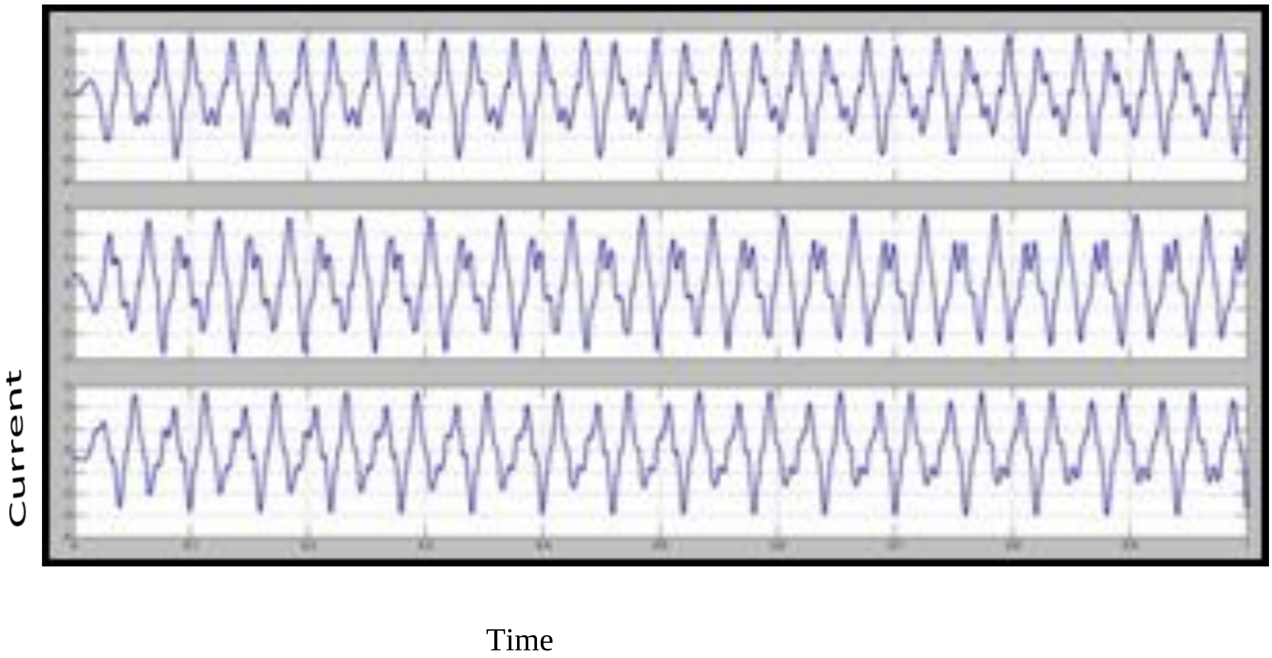

Fig: 9 Three phase motor current

The total harmonic distortion, or THD, of a signal is a measurement of the harmonic distortion present and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency. Total Harmonic Distortion (THD) is expressed in Root-Sum-Square (RSS) in percentage. The THD is usually calculated by taking the root sum of the squares of the first five or six harmonics of the fundamental. In many practical situations, there is negligible error when only the second and third harmonics are included.

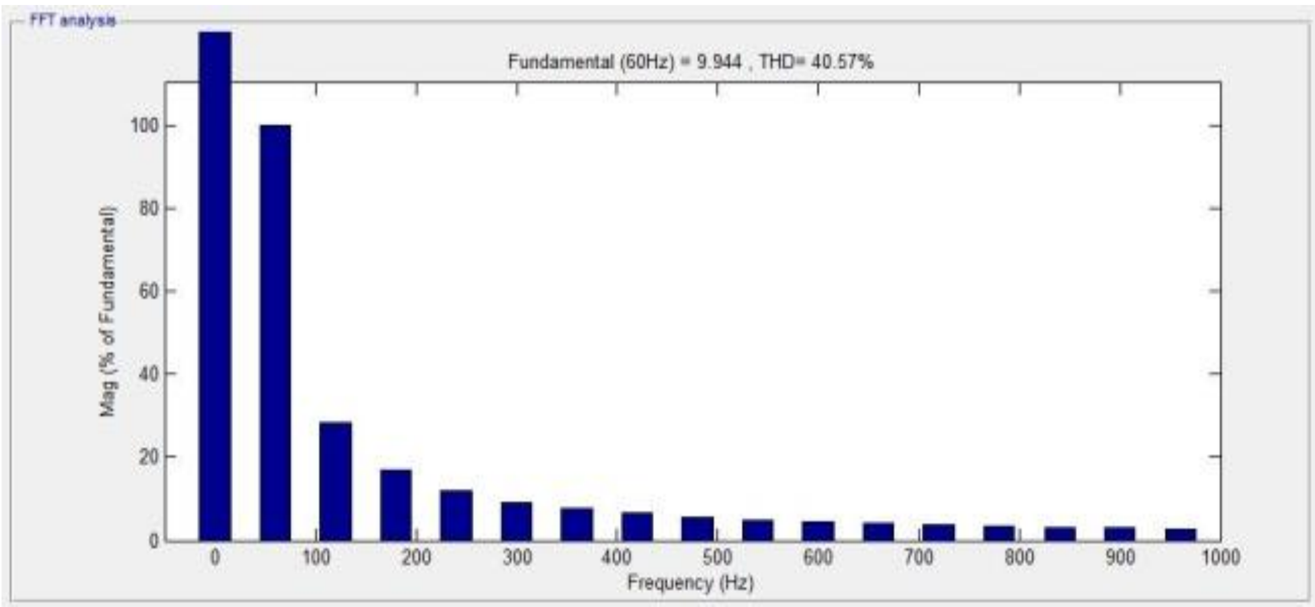

Fig. 10 FFT analysis of proposed system using MATLAB

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V CONCLUSION

The required output voltage and power from a 12 V battery is gained from the buck converter. Though it is inefficient it meets the primary target of the thesis of achieving 6W and 9 volt supply for Guitar processor Boss-ME-50. Parameters for each converter were calculated approximately. Besides the properties of other converters were verified by simulations and their output results were shown for different duty cycle and different parameters. Efficiency was calculated for each converter as well. A PWM circuit was constructed for the switching frequency to drive the switch gate.

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