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Quasi Active Power Factor Correction Scheme for High Efficiency Ac/Dc

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ABSTRACT: *Harmonic pollution and low power factor in power systems caused by power converters have been of great concern. To overcome these problems several converter topologies using advanced semiconductor devices and control schemes have been proposed. This investigation is to identify a low cost, small size, efficient and reliable ac to dc converter to meet the input performance index of UPS. The performance of single phase and three phase ac to dc converter along with various control techniques are studied and compared. This project presents a novel ac/dc converter based on a quasi-active power factor correction (PFC) scheme. In the proposed circuit, the power factor is improved by using an auxiliary winding coupled to the transformer of a cascade dc/dc fly back converter. The auxiliary winding is placed between the input rectifier and the low-frequency filter capacitor to serve as a magnetic switch to drive an input inductor. Since the dc/dc converter is operated at high-switching frequency, the auxiliary windings produce a high frequency pulsating source such that the input current conduction angle is significantly lengthened and the input current harmonics is reduced. Since the use of a single inductor, the cost z reduced a lot and the efficiency of the system is improved. The power factor is maintained constant by using a buffer capacitor in parallel to the system for compensating the inductive components. It eliminates the use of active switch and control circuit for PFC, which results in lower cost and higher efficiency. Finally an R- load is applied and simulation results are presented*

I. INTRODUCTION

Conventional offline power converters with diode capacitor rectifiers have resulted in distorted input current waveforms with high harmonic contents. To solve these problems, so as to comply with the harmonic standards such as IEC 61000-3-2, several techniques have been proposed to shape the input current waveform of the power converter. A common approach to improving the power factor is a two-stage power conversion approach .The two-stage scheme results in high power factor and fast response output voltage by using two independent controllers and optimized power stages. The main drawbacks of this scheme are its relatively higher cost and larger size resulted from its complicated power stage topology and control circuits, particularly in low power applications. In order to reduce the cost, the single-stage approach, which integrates the PFC stage with a dc/dc converter into one stage, is developed .These integrated single-stage power factor correction (PFC) converters usually use a boost converter to achieve PFC with discontinuous current mode (DCM) operation. Usually, the DCM operation gives a lower total harmonic distortion (THD) of the input current compared to the continuous current mode (CCM). However, the CCM operation yields slightly higher efficiency compared to the DCM operation. A detailed review of the single stage PFC converters is presented.

Generally, single-stage PFC converters meet the regulatory requirements regarding the input current harmonics, but they do not improve the power factor and reduce the THD as much as their conventional two-stage counterpart. The power factor could be as low as 0.8, however, they still meet the regulation. In addition, although the single-stage scheme is especially attractive in low cost and low power applications due to its simplified power stage and control circuit, major issues still exist, such as low efficiency and high as well as wide-range intermediate dc bus voltage stress. To overcome the disadvantages of the single-stage scheme, many converters with input current shaping have been presented in which a high frequency ac voltage source (dither signal) is connected in series with the rectified input voltage in order to shape the input current (Fig.1.1). The auxiliary winding is placed between the input rectifier and the low-frequency filter capacitor to serve as a magnetic switch to drive an input inductor. Since the dc/dc converter is operated at high-switching frequency, the auxiliary windings produce a high frequency pulsating source.

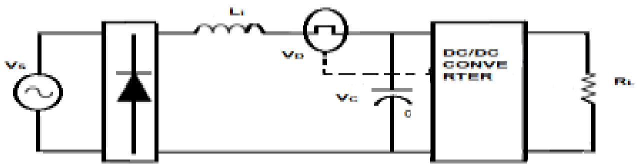
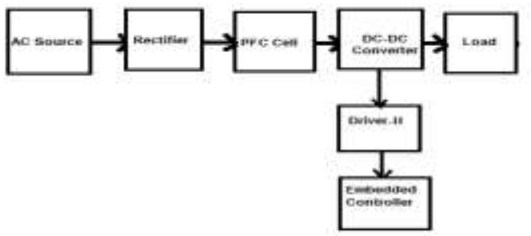


Fig.1.1 General Circuit diagram of dither rectifier with PFC cell.

Another technique based on parallel connection of this dither signal is presented however; the harmonic content can meet the regulatory standard by a small margin. A new concept of quasi-active PFC is proposed to improve the efficiency of a single-stage converter by preventing the input current or voltage stress due the PFC cell from being added to the active switch. In this circuit, the dc/dc cell operates in DCM so that a series of discontinuous pulses is used to shape the input inductor current and the PFC is achieved. As the circuit uses resonance of circuit parameters to achieve PFC, the control of the power factor will be very sensitive to the variation of components values.



BASIC CONCEPTS OF PROPOSED CIRCUIT

Fig Block diagram of proposed circuit

AC source: It is the first stage of this project. So it is give the AC supply to rectifier. The input side having one inductive filter. It is used to improve the input power factor.

Inverter: It is used to convert dc to ac voltage.the phase shift pulse methosd is used to control the inverter as a result to achieve the ZVS

High Frequency Transformer: It is used for step down purpose. It is also used for isolation purpose. The transformer size should be small due to high frequency.

Rectifier: It converts AC supply to DC supply. DC supply having some ripples. It is filtered with the help of capacitor filter.

Filter: Rectifier converts AC to DC. This output has ripples.It is filtered with a help of Capacitor filters.

Dc Load: The output has DC output votlage. It is used to run the motor, battery charging, and telecommunication applications.

AC Load: Multi level inverter is generate ac output voltage . it is used to run single phase ac motor and any appliance required for ac voltage.

Driver 1 & 2: It is also called as power amplifier because it is used to amplify the pulse output from micro controller. It is also called as opto coupler IC. It provides isolation between microcontroller and power circuits.

Regulated Power supply (RPS): RPS give 5V supply for micro controller and 12V supply for driver. It is converted from AC supply. AC supply is step down using step down transformer

II. PROPOSED QUASI-ACTIVE PFC CIRCUIT

In this project, a new technique of quasi-active PFC is proposed. The PFC cell is formed by connecting the energy buffer (L_B) and an auxiliary winding (L_3) coupled to the transformer of the dc/dc cell, between the input rectifier and the low-frequency filter capacitor used in conventional power converter. Since the dc/dc cell is operated at high frequency, the auxiliary winding produces a high frequency pulsating source such that the input current conduction angle is significantly lengthened and the input current harmonics is reduced. The input inductor L_B operates in DCM such that a lower THD of the input current can be achieved.

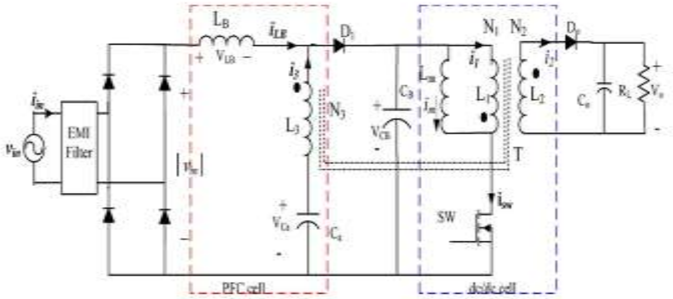


Fig. Proposed quasi-active PFC circuit diagram.

The proposed quasi-active PFC circuit is analyzed in this section. As shown in Fig. 2.2, the circuit comprised of a bridge rectifier, a boost inductor L_B , a bulk capacitor *Ca* in series with the auxiliary windings L_3 , an intermediate dc-bus voltage capacitor C_B ,and a discontinuous input current power load, such as fly back converter. The fly back transformer (*T*) has three windings N_1 , N_2 , and N_3 . The secondary winding N_2 = 1 is assumed. In the proposed PFC scheme, the dc/dc converter section offers a driving power with high-frequency pulsating source. The quasi active PFC cell can be considered one power stage but without an active switch.

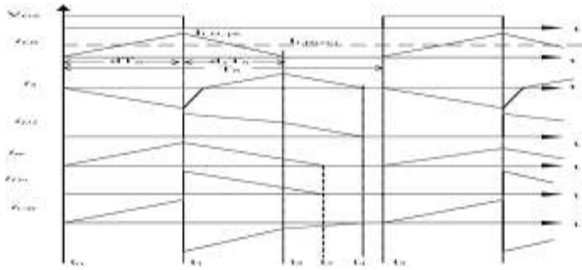


Fig key switching waveforms of the PFC circuit.

To simplify the analysis, the following assumptions have been made.

1.All semiconductors components are ideal. According to this assumption, the primary switch and the rectifiers do not have parasitic capacitances and represent ideal short and open circuits in their ON and OFF states, respectively.

2.The power transformer does not have the leakage inductances because of the ideal coupling.

3.All the capacitors are high enough so that the voltage across them is considered constant.

4.Finally, the input voltage of the converter is considered constant during a switching cycle because the switching frequency is much higher than the line frequency.

Conventional circuit Drawbacks

Low output power
Low efficiency
Poor power factor
More input current harmonics

Advantages of Conventional Circuit

Less voltage spike
High output power
High efficiency
Improve the input power factor
Reduce the input current harmonics

Applications of Conventional Circuit

Battery charging
Battery operated Electric vehicle
Telecom applications
Power supply for DC motor

III. POWER FACTOR AND CONVERTERS

DEFINITION OF POWER FACTOR : Power Factor is a measure of how efficiently electrical power is consumed. In the ideal world Power Factor would be unity (or 1). Unfortunately in the real world Power Factor is reduced by highly inductive loads to 0.7 or less. This induction is caused b The power factor of an *AC* electric power system is defined as the ratio of the real power flowing to the load to the apparent power in the circuit,and is a dimensionless number between 0 and 1 (frequently expressed as a percentage, e.g. 0.5 pf = 50% pf). Real power is the capacity of the circuit for performing work in a particular time. Apparent power is the product of the current and voltage of the circuit. Due to energy stored in the load and returned to the source, or due to a non-linear load that distorts the wave shape of the current drawn from the source, the apparent power will be greater than the real power.

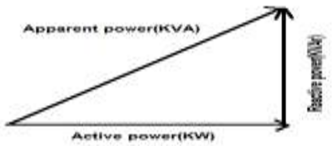


Fig. power factor Triangle

In above figure Active Power is the base line and is the real usable power measured in kW. Reactive power is the vertical or that part of the supply which causes the inductive load. There active power in is measured in kVAr (kilo volt-amperes reactive) Apparent Power is the hypotenuse. This is the resultant of the other two components and is measured in kVA

In an electric power system, a load with a low power factor draws more current than a load with a high power factor for the same amount of useful power transferred. The higher currents increase the energy lost in the distribution system, and require larger wires and other equipment. Because of the costs of larger equipment and wasted energy, electrical utilities will usually charge a higher cost to industrial or commercial customers where there is a low power factor.

Linear loads with low power factor (such as induction motors) can be corrected with a passive network of capacitors or inductors. Non-linear loads, such as rectifiers, distort the current drawn from the system. In such cases, active or passive power factor correction may be used to counteract the distortion and raise the power factor. The devices for correction of the power factor may be at a central substation, spread out over a distribution system, or built into power-consuming equipment.

IV. POWER FACTOR CORRECTION

In general, the term Power Factor represents the ratio of power actually used to the power actually supplied and varies with the losses encountered in a particular system. What are the causes of a low power factor? All inductive circuits within a distribution system require current for the purpose of the excitation of magnetic fields. This applies to:

- Induction motors
- Transformers
- Induction furnaces
- Welding plant
- Induction regulators
- Fluorescent lighting
- High Bay Discharge lighting
- Solenoids
- Electric Clocks

All require excitation currents to establish the magnetic field necessary for the function of each item of plant. Magnetic fields are a fact of electrical life and must be lived with.

Disadvantages without power factor Correction

The following are some of the disadvantages that occur because of the presence of inductive circuits. First of all, the calculation for energy required at the load is:

Watts (W) = Volts (V) x Amps (A) x Power Factor

Initially, as the power factor falls below unity the current in the system increases and in so doing causes the system.voltage decreases with the following effects:

1.Lower voltage on lighting will result in reduced lumen output.

2.Induction motors will run at reduced speeds (increased slip) which will necessitate increased currents to meet the required loads.

3.Because of the increased currents the I2R power loss increases in cables and windings leading to overheating and consequent reduction in equipment life.
4.Capacities of contacts, switches, circuit breakers and fuses may be exceeded with reduction in working life.
5.Efficiency as a whole suffers because more of the input is absorbed in meeting losses.

Advantages of Improved Power Factor

Having looked at the disadvantages let us now consider the advantages of an improved power factor.
1.Ensures that the rated voltage is applied to motors, lamps etc. to obtain optimum performance.
2.Decreased losses in circuits and cables.
3.Decreased losses in distribution transformers.
4.Ensure maximum power output of transformers is utilized and not used in making-up losses.
5.Enables existing transformers to carry additional load without overloading or the necessity of capital cost of new transformers to obtain the financial benefits which will result from lower maximum demand charges?

Simplified Graphical Presentation

Power factor is defined as the Cosine of the angle between W and VA shown above i.e. Cos (W/VA). Thus using trigonometry, for any two given figures, the rest can be worked out. So, if we know the consumption (kWh) and the reactive power (kVArh) we can calculate the Power Factor.

HOW TO IMPROVE POWER FACTOR

How do we approach the problem of improving the power factor? The usual method of making a system capacitive is achieved by introducing static capacitors which consist of chlorinated biphenyl impregnated paper dielectric elements in a sealed case, into the circuits either in the load-source (i.e. in a Sub-Station) or adjacent to the inductive plant.

Due to the fact that these electrostatic capacitors take a leading current they can be used to compensate for the lagging currents of the inductive circuits. When connected in circuit the capacitors act as a reservoir for energy which can be interchanged between the dielectric field of the capacitor and the magnetizing needs of the inductive plant.

Other methods of power factor correction include synchronous motors and synchronous condensers. Synchronous motors are excited by direct current and do not therefore impose a lagging current for magnetizing purposes on the system. These machines are intended primarily for situations where constant speeds are necessary over a wide range of loads, but in addition are able to operate at power factors between unity and 0.8 leading. This feature enables the system generally to benefit and an improved power factor results. However, unless the speed control properties are essential, the high cost of these machines would, for power factor correction purposes only, be quite uneconomic. Synchronous condensers are used purely for situations where larger amounts of corrective kVAr are required and carry no mechanical load. These are not usually considered for normal industrial purposes.

Example: If the consumption was 100,000 kWh and reactive consumption 65,000 kVArh, then, using the methodology earlier, the power factor will be 0.838. If we need to get this above 0.95 to prevent penalty charges, capacitance should be installed. This can be calculated by the installer.

Control of Capacitors : Control of static capacitor banks is carried out by means of contractor equipment which in turn is controlled by a sensing relay. Basically a single phase current and voltage supply is applied to the relay such that at unity power factor the current and voltage vectors are displaced by 90 degrees.

Changes in this angular displacement either lagging or leading are sensed by the relay which then switches the contractors which connect the reactive kVAr required for correction of the power factor, in or out of the system. Control relays can be single or multi-stage depending on the extent of the capacitor equipment in use.

In a smaller installation the capacitor bank would probably be located adjacent to the incoming supply. In progressively larger installations the capacitors would be positioned at different load centres i.e. adjacent to distribution boards. In practice however, it is more economical to group capacitor banks together, using multi-stage control, possibly in a sub-station (which also reduces the possibility of interference to relays).Individual correction should then be limited for example to motors of 37 kW and above. In this case control relays would not be required as capacitors would be switched in and out with the operation of the motor. Individual correction can also be an advantage with welding plant.

V. LEVEL OF CORRECTION

Having established that a need for power factor correction exists, what level of correction should be applied? This depends to a large extent on the geographical location of the plant in question. While improvements in plant efficiency are desirable it is the savings that accrue from lower tariff/contract charges that invariably dictate whether or not an installation shall be carried out. The power factor below which penalty charges are applied varies according to the grid charging zone and is between 0.85 and 0.98. In general the considered optimum lies between 0.95 and 0.98 lagging. At this level both factors of tariff and efficiency are covered.

VI. PARACETIC CAPACITANCE

The parasitic capacitance was reduced using various methods like increasing the width of the kapton layer, placing an air layer between the windings and shifting the windings. This paper presents the method of EPC cancellation with an embedded ground layer placed so that the electric field energy will be shifted from the unwanted space to ground. The aim of this study, besides eliminating parasitic capacitance, is to maintain the self-capacitances of the windings as close as possible to their original values. Considering the other studies and their results, two different methods of parasitic capacitance reduction are combined to determine if it is possible to have an even lower EPC.The influence of the embedded ground layer on the whole structure is analyzed, considering the shape, position and thickness of the copper layer and modeling a multitude of structures with varying parameters. The obtained results are compared to ones determined with an energetic parameter method in order to evaluate their accuracy.

VII. DC-DC CONVERTERS

DC to DC converters are extremely important in battery-powered electronic devices, such as MP3 players and laptop computers. Those electronic devices often contain several sub circuits, each requiring a voltage level different than that supplied by the battery. Even worse, the voltage of a battery declines as its stored power is drained, so it does not output a constant voltage level. DC to DC converters offer a method of generating multiple controlled voltages from a single battery voltage, thereby saving space instead of using multiple batteries to supply different parts of the device. A boost converter is simply is a particular type of power converter with an output DC voltage greater than the input DC voltage. This type of circuit is used to 'step-up' a source voltage to a higher, regulated voltage, allowing one power supply to provide different driving voltages.(OR) Dc-dc power converters are employed in a variety of applications, including power supplies for personal computers, office equipment, spacecraft power systems, laptop computers, and telecommunications equipment, as well as dc motor drives. The input to a dc-dc converter is an unregulated dc voltage Vg. The converter produces a regulated output voltage V, having a magnitude (and possibly polarity) that differs from Vg. For example, in a computer off-line power supply, the 120 V or 240 V ac utility voltages is rectified, producing a dc voltage of approximately 170 V or 340 V, respectively. A dc-dc converter then reduces the voltage to the regulated 5 V or 3.3 V required by the processor ICs. Required , since cooling of inefficient power converters is difficult and expensive. The ideal dc-dc converter exhibits 100% efficiency; in practice, efficiencies of 70% to 95% are typically obtained. This is achieved using switched-mode, or chopper, circuits whose elements dissipate negligible power. Pulse-width modulation (PWM) allows control and regulation of the total output voltage. This approach is also employed in applications involving alternating current, including high-efficiency dc-ac power converters (inverters and power amplifiers), ac-ac power converters, and some ac-dc power converters (low-harmonic rectifiers).

FLY BACK CONVERTER : Fly-back converter is the most commonly used SMPS circuit for low output power applications where the output voltage needs to be isolated from the input main supply. The output power of fly-back type SMPS circuits may vary from few watts to less than 100 watts. The overall circuit topology of this converter is considerably simpler than other SMPS circuits. Input to the circuit is generally unregulated dc voltage obtained by rectifying the utility ac voltage followed by a simple capacitor filter. The circuit can offer single or multiple isolated output voltages and can operate over wide range of input voltage variation. In respect of energy-efficiency, fly-back power supplies are inferior to many other SMPS circuits but its simple topology and low cost makes it popular in low output power range. The commonly used fly-back converter requires a single controllable switch like, MOSFET and the usual switching frequency is in the range of 100 kHz. A two switch topology exists that offers better energy efficiency and less voltage stress across the switches but costs more and the circuit complexity also increases slightly. The present lesson is limited to the study of fly-back circuit of single switch topology.

VIII. SIMULATION RESULTS

VIII.1 SIMULATION RESULTS FOR PROPOSED PFC CIRCUIT

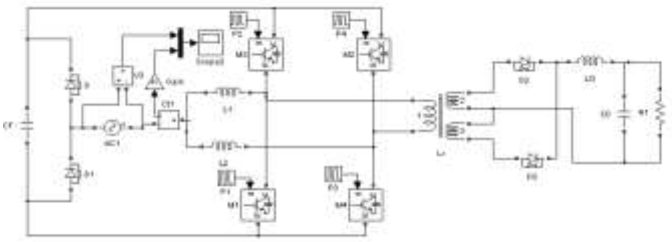
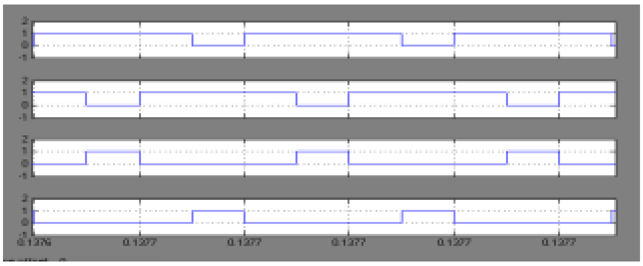


Fig : Simulation circuit diagram for proposed PFC circuit

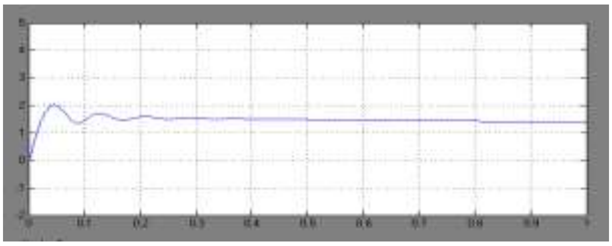
VIII.2 WAVE FORMS FOR PROPOSED PFC CIRCUIT

Voltage (V



g Transformer input

Current



Time (t)

(i)

Fig: Output Current

Voltage (V)

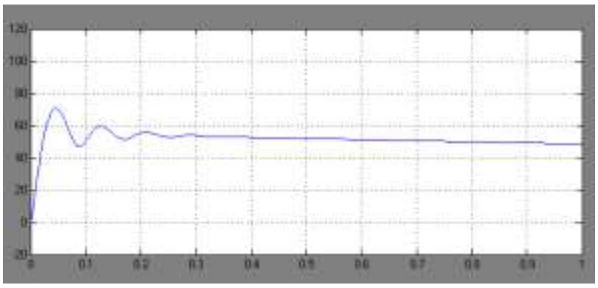
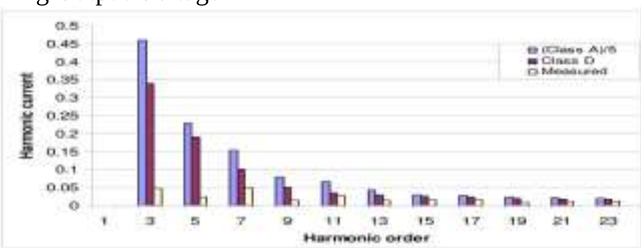


Fig Output Voltage

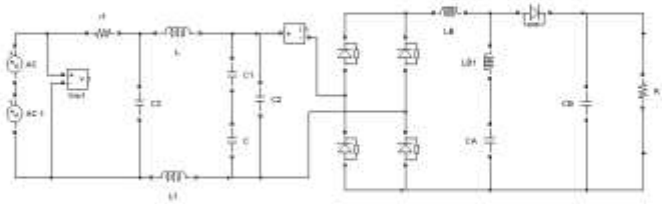
Time (t)



Time (t)

Fig Measured harmonics content o f the input current.

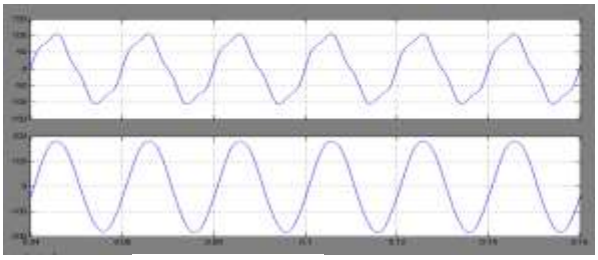
VIII.3 SIMULATION DIAGRAM FOR EMI AND PFC CONVERTER



FigCircuit Diagram With Emi And PFC Converter

VIII.4 WAVE FORMS FOR EMI FILTER AND PFC CONVERTER

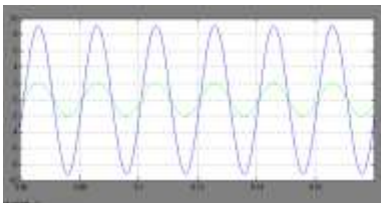
Voltage (V)



Time (t)

Input Voltage with noice and without noice

Current (i)

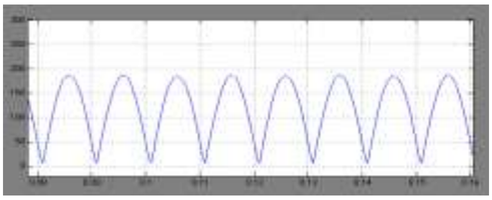


Voltage (t)

Current (i)

Fig Input Voltage and Current

Voltage (V)



Time (t)

Fig Rectifier Output Voltage

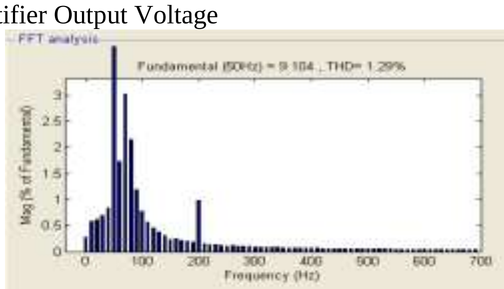


Fig FFT Analysis for Voltage

IX. APPLICATIONS OF PROPOSED CIRCUIT:

1) Power supply regulator

2) Digital logic inputs

3) Microprocessor inputs

X. CONCLUSION

Summary of the Work Done: The proposed method shapes the input current based on a quasi-active power factor correction (PFC) scheme. In this method, high power factor and low harmonic content are achieved by providing an auxiliary PFC circuit with a driving voltage which is derived from a third winding of the transformer of a cascaded dc/dc flyback converter. It eliminates the use of active switch and control circuit for PFC. The auxiliary winding provides a controlled voltage-boost function for bulk capacitor without inducing a dead angle in the line current. The input inductor can operates in DCM to achieve lower THD and high power factor. By properly designing the converter components, a tradeoff between efficiency and harmonic content can be established to obtain compliance with the regulation and efficiency as high as possible.

Scope Of Future Work

- Implementation of transformer less boost ac/dc converter with power factor correction.
- Battery charging load.
- X-Ray unit .
- Electrolyer plant.

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