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A PFC Single-Couple-Inductor Multiple Output Led Driver without Electrolytic Capacitor

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ABSTRACT: *In this project, based on a single dual-winding coupled inductor, a SIMO LED driver with PFC function is proposed without the requirement of electrolytic capacitors, where a small storage capacitance is used to actively decouple the ac and dc input powers. Compared with previous works, the proposed PFC SIMO LED driver has some additional benefits, including a smaller line filter, multiple output currents without double line frequency ripple and a faster output regulation. With appropriate control strategy, an independent output regulation can be achieved for each output channel. Meanwhile, to improve the converter efficiency, the energy flow of the converter is optimized with an inductor current programming technique.*
KEYWORDS: ***single dual – Winding Coupled Inductor, SIMO LED driver, PFC function.***

I. INTRODUCTION

In modern times, a tremendous growth in telecommunication and data storage systems has resulted in the installation of millions of internet data centre (IDC) around the globe. As the volume of data centers and servers has grown, the overall amount of electricity consumption also increased. Power distribution systems in a typical data centre consist of several power conversion stages. Especially, electrical power is delivered using an ac grid system that goes through multiple power conversions between ac and dc. Each power conversion increases power the conventional several power delivery architectures which use ac or dc voltage have been presented. A conventional ac power distribution system of the IDC consists of four power conversion stages with a traditional online uninterrupted power supply (UPS), which employs an ac–dc–ac double conversion. Compared with the ac distribution system, the dc distribution system does not need several power conversion stages such as the online UPS and the individual power factor correction(PFC) circuit in front of each power supply unit (PSU).Therefore, the dc distribution system for the data centres can reduce the power conversion loss caused by redundant power stages . Furthermore, in order to obtain high-power conversion efficiency of the dc distribution system, the high efficient isolated ac–dc converter used in the dc distribution system should decrease its power loss .The galvanic isolation in the power conversion stage is not more popular than the isolation of the server level; however, it is one of interesting research topics of isolation applications for IDC since the safety from an electric shock can be required for the operators who are achieving the maintenance operations of the servers.

II. LITERATURE SURVEY

The power conversion efficiency of an isolated ac-dc converter is a dominant factor in the overall efficiency of dc distribution systems. To improve the power conversion efficiency of the dc distribution system, a three-phase interleaved full-bridge LLC resonant converter employing a Y-connected rectifier is proposed as the isolated ac-dc high-frequency-link power-conversion system. The proposed Y-connected rectifier has the capability of boosting the output voltage without increasing the transformer's turn ratio. Especially, the frequency of the rectifier's output ripple is six times higher than the switching frequency, thereby reducing the output capacitor and the secondary transformer's RMS current. However, the tolerance of the converter's resonant components in each primary stage causes the unbalance problem of output ripple current.

A new interleaved single-stage ac-dc converter is proposed in this paper to reduce line current harmonics while achieving power factor correction (PFC). The proposed rectifier can produce input currents that do not have dead band regions with high PFC, operate with a continuous output current, and minimize the input electromagnetic interference filter size. In this paper, the operation of the new converter is explained, its features and design are discussed in results, and its operation is confirmed with experimental results obtained from a prototype

III. PROJECT DESCRIPTION

AC–DC power supplies need to be implemented with some sort of input power factor correction (PFC) to comply with harmonic standards such as IEC 1000-3-2. PFC techniques can generally be classified as follows:

1) Passive methods that use inductors and capacitors to filter out low-frequency input current harmonics to make the input current more sinusoidal. Although these converters implemented with such PFC are simple and inexpensive, they are also heavy and bulky, and thus, passive methods are used in a limited number of applications.

2) Two-stage converters that use a pre regulator to make the input current sinusoidal and to control the intermediate dc bus voltage along with a dc–dc converter to produce the desired output voltage. Such converters, however, require two separate switch-mode converters so that the cost, size, and complexity of the overall ac–dc converter are increased.

3) Single-stage power-factor-corrected (SSPFC) converters that have PFC and isolated dc–dc conversion in a single power converter so that they are simpler and cheaper than two-stage converters. Several single-phase and three-phase converters have been proposed in the literature, with three-phase converters being preferred over single-phase converters for higher power applications.

A.EXISTING SYSTEM

With an AC source input at a line frequency of fl, the multiple-output LED driver can conveniently be designed using two-stage electrical structures. The front-stage power factor corrected (PFC) pre-regulator tightly controls the input current for near unity power factor which results in an output of equal magnitude DC and AC power components. The pre-regulator regulates a constant DC voltage across the capacitor Cs for the required DC output power. Therefore, the AC power component appearing as 2fl-ripple voltage is unregulated or otherwise the input unity power factor needs to be compromised.

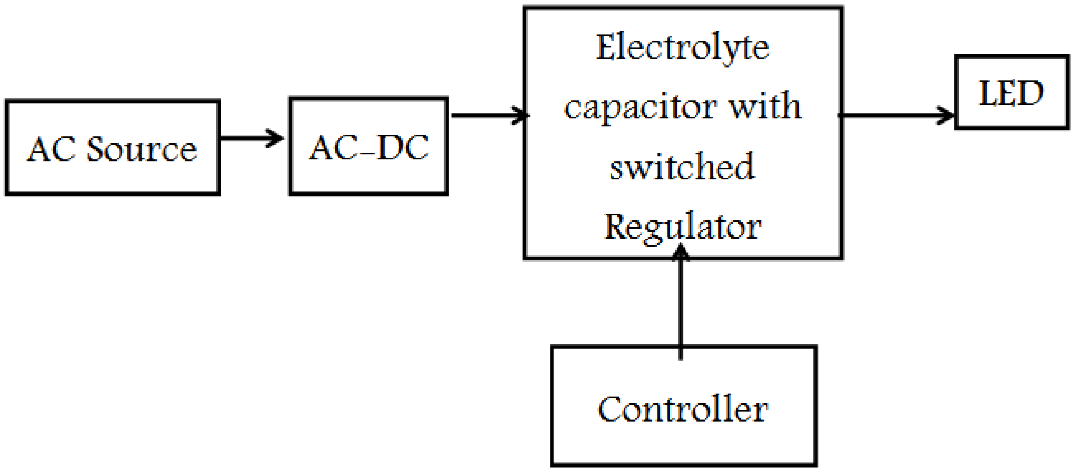


Fig 1. Conventional Block Diagram

B. PROPOSED SYSTEM

In this project, an active power decoupling power-factor corrected single-inductor-multiple-output LED driver is developed. The LED driver is optimized without the requirement of electrolytic capacitors for a better system life span and a wider operating temperature. Compared with an existing single-stage design without active power decoupling, the proposed LED driver has benefits of a design without electrolytic capacitor, a near zero low-frequency ripple current for each output channel, a much smaller line filter and a much faster output current regulation for each output channel. A Coupled inductor can be used as a power factor correction circuit as well as a voltage doublers circuit for switched mode power supplies. This topology also have lesser number of conducting devices than the conventional bridge rectifier due to which it is having lesser conduction and switching losses.

C.VOLTAGE DOUBLER

A voltage multiplier, whose output D.C voltage is double the peak A.C input voltage, is called a voltage doublers below Figure shows the circuit, of a half-wave voltage doublers.

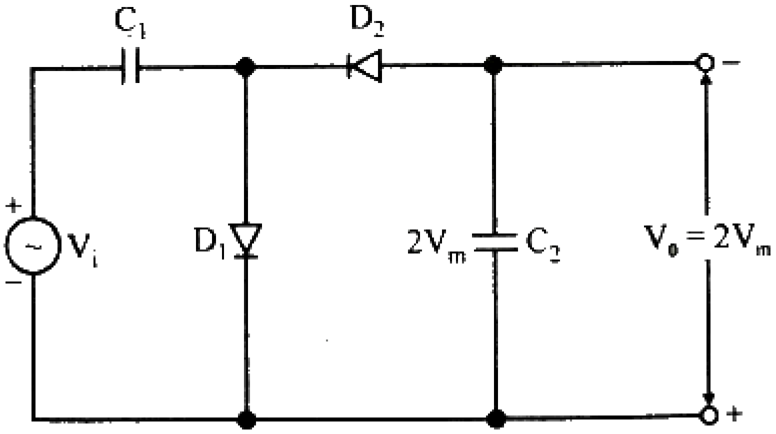


Fig 2 Half wave voltage doubler

During the positive half-cycle of the input signal, the diode DI conducts and diode D2 is cut off, charging the capacitor CI up to the peak rectified voltage i.e., Vm.

During the negative half-cycle, diode, D1 is cut off and diode D2 conducts charging capacitor C2. It may be noted that during negative half cycle, the voltage across capacitor C1 is in series with the input voltage.

D.VOLATGE TRIPLER

During the first positive half cycle, the capacitor C1 charges through diode D1 to a peak voltage Vm. During negative half cycle, capacitor C2 charges through diode D2 to twice the peak voltage2Vm developed by the sum of the voltages across capacitor C1 and the input signal.

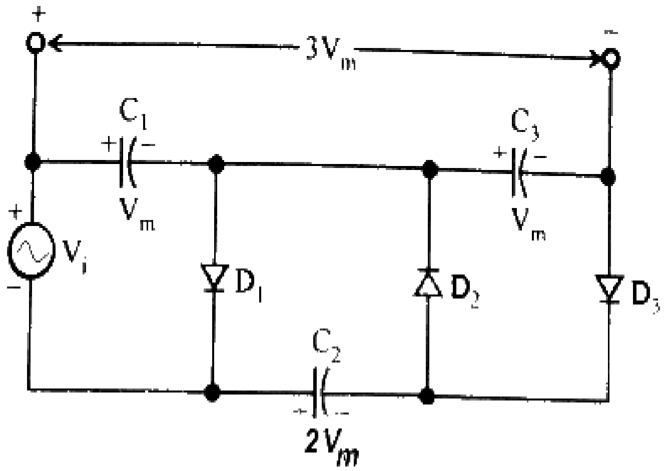
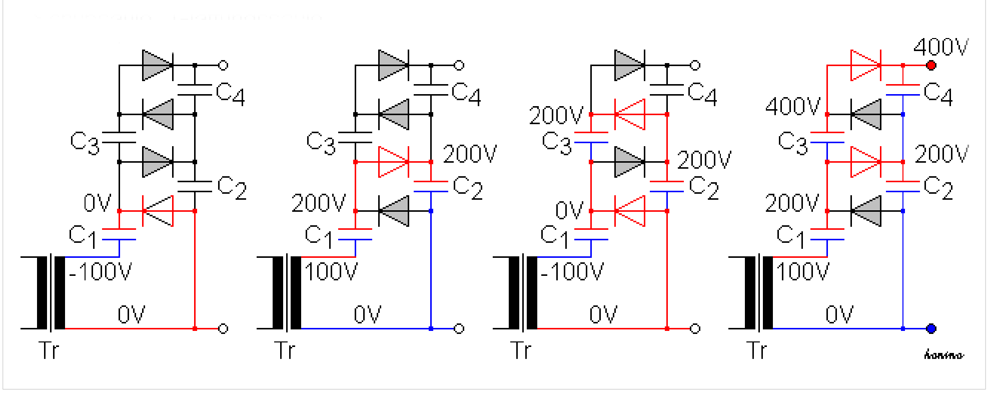


Fig 3. Voltage Tripler

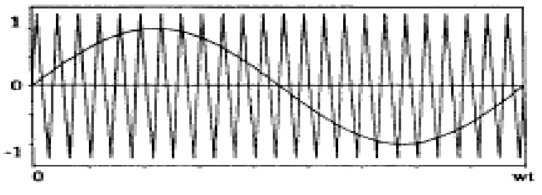
During the second positive half cycle, the diode D2 conducts and the voltage across capacitor C2charges the capacitor C3 to the same 2Vm peak voltage. The triple output taken across C1 and C3connected in series, the output voltage is three times the input voltage. Theoretically there is no upper limit to the amount of voltage multiplication that can be obtain. But practically there is a limit the reason is that total amount of capacitance becomes large to maintain the desired d.c. output except extremely light loads.

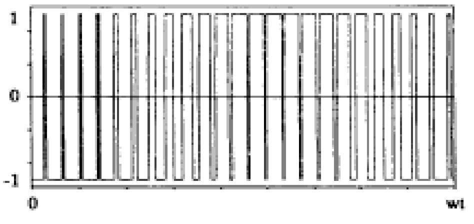


E. PULSE WIDTH MODULATION TECHNIQUE

The advent of the transformer less multilevel inverter topology has brought forth various pulse width modulation (PWM) schemes as a means to control the switching of the active devices in each of the multiple voltage levels in the inverter. The most efficient method of controlling the output voltage is to incorporate pulse width modulation control (PWM control) within the inverters. In this method, a fixed d.c. input voltage is supplied to the inverter and a controlled a.c. output voltage is obtained by adjusting the on and–off periods of the inverter devices.

Voltage-type PWM inverters have been applied widely to such fields as power supplies and motor drivers. This is because: (1) such inverters are well adapted to high-speed self-turn-off switching devices that, as solid-state power converters, are provided with recently developed advanced circuits; and (2) they are operated stably and can be controlled well.





IV. SOFTWARE

Simulation has become a very powerful tool on the industry application as well as in academics, nowadays. It is now essential for an electrical engineer to understand the concept of simulation and learn its use in various applications. Simulation is one of the best ways to study the system or circuit behavior without damaging it .The tools for doing the simulation in various fields are available in the market for engineering professionals. Many industries are spending a considerable amount of time and money in doing simulation before manufacturing their product. In most of the research and development (R&D) work, the simulation plays a very important role. Without simulation it is quiet impossible to proceed further. It should be noted that in power electronics, computer simulation and a proof of concept hardware prototype in the laboratory are complimentary to each other. However computer simulation must not be considered as a substitute for hardware prototype. The objective of this chapter is to describe simulation of impedance source inverter with R, R-L and RLE loads using MATLAB tool.

A.INTRODUCTION TO MATLAB

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses includes

1.Math and computation
2.Algorithm development
3.Data acquisition
4.Modeling, simulation, and prototyping
5.Data analysis, exploration, and visualization
6.Scientific and engineering graphics
7.Application development, including graphical user interface building

MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar non interactive language such as C or FORTRAN.

B.MATLAB DOCUMENTATION

MATLAB provides extensive documentation, in both printed and online format, to help you learn about and use all of its features. If you are a new user, start with this Getting Started book. It covers all the primary MATLAB features at a high level, including many examples. The MATLAB online help provides task-oriented and reference information about MATLAB features. MATLAB documentation is also available in printed form and in PDF format.

C. MATLAB ONLINE HELP

To view the online documentation, select MATLAB Help from the Help menu in MATLAB. The MATLAB documentation is organized into these main topics:

D.THE ROLE OF SIMULATION IN DESIGN

Electrical power systems are combinations of electrical circuits and electro mechanical devices like motors and generators. Engineers working in this discipline are constantly improving the performance of the systems. Requirements for drastically increased efficiency have forced power system designers to use power electronic devices and sophisticated control system concepts that tax traditional analysis tools and techniques.

E.SIM POWER SYSTEMS LIBRARIES

You can rapidly put Sim Power Systems to work. The libraries contain models of typical power equipment such as transformers, lines, machines, and power electronics. In fig 4.1 shown in MATLAB library sim link model .These models are proven ones coming from textbooks, and their validity is based on the experience of the Power Systems Testing and Simulation Laboratory of Hydro-Québec, a large North.

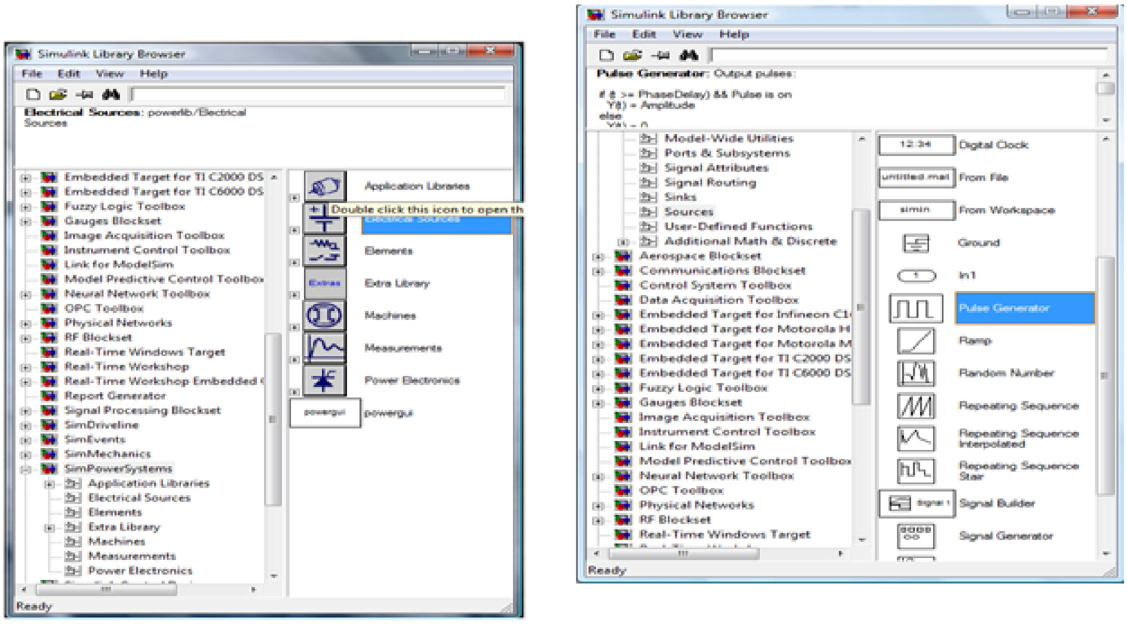
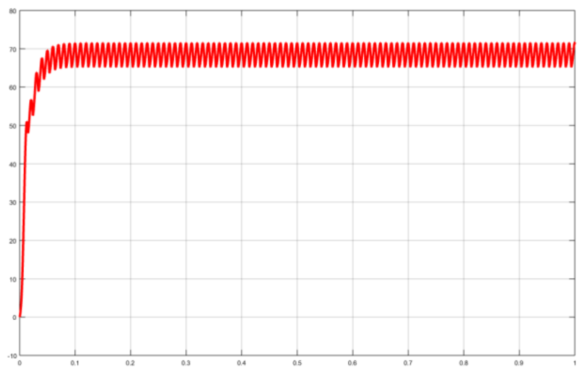
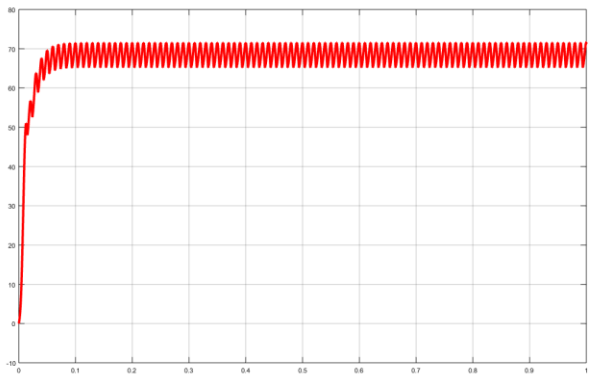


Fig. 4. MATLAB Library

F.SIMULATION RESULT



Output voltage 1



Output voltage 2

V. HARDWARE IMPLEMENTATION

A.INTRODUCTION

For the hardware implementation we use different components. They are listed below as

- PIC MICROCONTROLLER 16F877A.
- VOLTAGE REGULATORS
- 7812 VOLTAGE REGULATOR
- 7805 VOLTAGE REGULATOR
- MOSFET IRF 840
- OPT COUPLER TLP 250
- STEP DOWN TRANSFORMER 230V/12
- CAPACITOR 1000 MF
- OCTAL BUFFER IC 74ALS244A/74ALS244A-1
- DIODE 4007

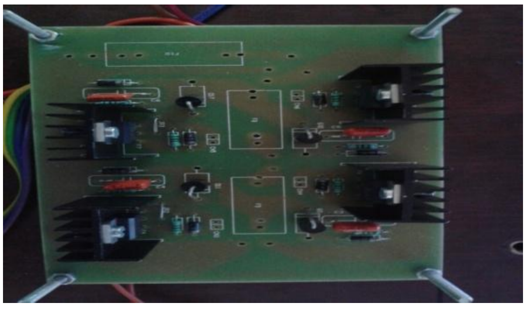
B.CONTROLLER CIRCUIT

The Programmable Interrupt Controller (PIC) is used to provide proper gate pulses to the eight different MOSFETs used at proper time intervals. Proper switching of the MOSFETs ensures obtaining proper sinusoidal waveform. The PIC is programmed to properly switch the MOSFETs.

C. PERIPHERAL FEATURES

- 33 I/O pins; 5 I/O ports
- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules
- Synchronous Serial Port with two modes:
- USART/SCI with 9-bit address detection
- Parallel Slave Port (PSP)
- Brown-out detection circuitry for Brown-Out Reset.

D. MOSFET



A cross section through an n-MOSFET when the gate voltage VGS is below the threshold for making a conductive channel; there is little or no conduction between the terminals source and drain; the switch is off. When the gate is more positive, it attracts electrons, inducing an n-type conductive channel in the substrate below the oxide, which allows electrons to flow between the n-doped terminals; the switch is on.

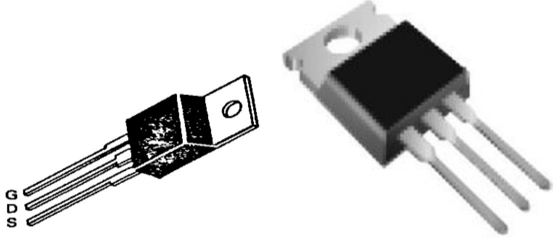


Fig 5. IRF840

E.CAPACITOR

Fig 6. Capacitor

A capacitor (formerly known as condenser) is a passivetwo-terminalelectrical component used to store energy in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors separated by a dielectric (insulator); for example, one common construction consists of metal foils separated by a thin layer of insulating film. Capacitors are widely used as parts of electrical circuits in many common electrical devices.

VI. CONCLUSION

In this project, an active power decoupling power-factor corrected single-inductor-multiple-output LED driver is developed. The LED driver is optimized without the requirement of electrolytic capacitors for a better system life span and a wider operating temperature. Compared with an existing single-stage design without active power decoupling, the proposed LED driver has benefits of a design without electrolytic capacitor, a near zero low-frequency ripple current for each output channel, a much smaller line filter and a much faster output current regulation for each output channel. Prototype converters are built to show the effective control and various benefits of the proposed LED driver.

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