Ferdowsi Rectifiers – Single-Phase Buck-Boost Bridgeless Rectifiers

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ABSTRACT— The Ferdowsi rectifiers, often known as FRs, are two new power factor correction (PFC) rectifiers with voltage buck-boost capabilities that are proposed in this major project. Comparatively to the rivals, the proposed rectifiers use fewer semiconductors. Additionally, MOSFETs can be used easily because the reverse recovery issue with anti-parallel transistor switch diodes is avoided. This enables significantly greater switching frequencies and smaller passive component sizes. In order to enhance the current quality, two parallel capacitors also act as a channel for the input current while the buck-boost inductors are operating in the discharge mode. The suggested rectifiers discontinuous conduction mode (DCM) operation ensures a high-quality input current with a minimal total harmonic distortion (THD). All aforementioned features offer a highly efficient operation and at the same time a purely sinusoidal current drawn from the AC source compared to the previous well-developed competitors.
Keywords: buck-boost, high efficiency, Ferdowsi rectifier.

I.INTRODUCTION

From household products to commercial buildings, rectifiers are frequently used in things like telecom, uninterruptible power supply (UPS), adapters, LEDs, and motor drivers. A DC-DC stage, sometimes referred as the power factor correction (PFC) circuit, is typically used after a normal diode-bridge rectifier to modify the input current waveform. The boost type DC-DC circuit gives rise to the most well-known bridge-based PFC rectifier. However, many applications call for a DC voltage lower than the source peak voltage, which this form of PFC rectifier is unable to supply. From household products to commercial buildings, rectifiers are frequently used in things like telecom, uninterruptible power supply (UPS), adapters, LEDs, and motor drivers. A DC-DC stage, sometimes referred to as the power factor correction (PFC) circuit, is typically used after a normal diode-bridge rectifier to modify the input current waveform. The boost type DC-DC circuit gives rise to the most well-known bridge-based PFC rectifier. However, many applications call for a DC voltage lower than the source peak voltage, which this form of PFC rectifier is unable to supply.

Power factor correction technology has been quickly created and put to use in order to reduce harmonic pollution and enhance the quality of the power system. PFC strategies that are now stated generally refer to active PFC because it can reach a high PF and a small size compared to passive PFC. The conventional PFC's ability to increase circuit efficiency is constrained by the presence of the input bridge. Many innovative topologies and control algorithms for bridgeless PFC (BPFC), based on traditional boost PFC, have been presented in order to reduce the losses of the rectifier bridge. This makes the application of bridgeless PFC approaches in many fields viable. At the same time, bridgeless design ideas applied to other areas can also reduce the number of devices, the losses and it could improve the power density as well.

II. LITERATURE SURVEY

1. Ashta, a single-phase supply is given to the zeta converter through diode bridge converter. Instead of two stage converters, a single stage Zeta converter is used for DC link voltage control and power factor correction. The controlled voltage is fed to voltage source inverter. The main objective of this paper is to control Output of Zeta converter to achieve speed control of BLDC motor

2. Nevertheless, a Zeta converter based MPPT is still unexplored in any kind of SPV array-based applications. An incremental conductance (INC) MPPT algorithm is used in this work in order to generate an optimum value of duty cycle for the IGBT (Insulated Gate Bipolar Transistor) switch of Zeta converter such that the SPV array is constrained to operate at its MPP. Various configuration of Zeta converters such as self-lift circuit, re-lift circuit, triple lift circuit and quadruple-lift circuit using voltage lift (VL) technique have been reported in aforementioned topologies have high voltage transfer gain but at the cost of increased number of components and switching devices. Therefore, these topologies of Zeta converter do not suit the proposed water pumping system.

III. PROPOSED METHODOLOGY

The block diagram of the project and design aspect of independent modules are presented in the figure-1. The block diagram is divided into two major circuit boards (1) bridge rectifier circuit and (2) bridgeless circuit known as Ferdowsi Rectifier with additionally connected step-down transformer, reset button, crystal oscillator and LED to the PIC 16F72 Microcontroller.

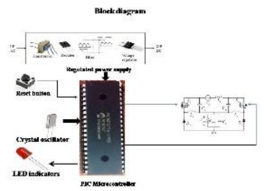

Figure 1: BLOCK DIAGRAM

Bridge rectifier circuit consists of transformer to step-down the voltage level from 230v AC to 12v DC. The output of the transformer is connected to the rectifier circuit to convert the 12v AC to DC Supply. Further it is connected to filter circuit i.e, capacitor to convert the pulsating DC to pure DC. The output of this again connected to the voltage regulator to stabilize the overall output of the circuit.

The PIC 16F72 microcontroller is used for temperature sensing and controlling device connected to both rectifier circuits to sense the voltage levels and the output is connected to the LCD to display the output voltages of the two rectifier circuits.

IV. HARDWARE COMPONENTS

Here, In this project we are using the following components to get desired output:

Figure 2: HARDWARE KIT

A. TRANSFORMER:

Transformer is a static device which is used to step up and step down the voltage level. It has two windings called as primary winding and secondary winding. We are giving 230Volts input voltage at primary side. The output of transformer is 12v (ac only) receiving from secondary side without changing its frequency.

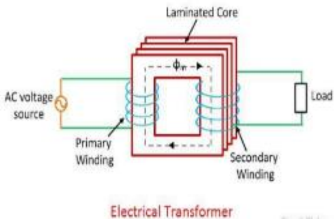

Figure 3: STEP DOWN TRANSFORMER

B. RECTIFIER:

A bridge rectifier IC is used to convert 12VAC into unidirectional current.

Figure 4: RECTIFIER

C. FILTER:

The output of rectifier is not pure DC. It may contain some ripple components that is pulsating DC. To eliminate this ripple components which are present in output we are using filter. Filter is a circuit which is used to eliminate the ripples present in rectified output. Most of the power supplies are using capacitor filter to filter out the ripples present in output.

Figure 5: FILTER

D. VOLTAGE REGULATOR:

Regulator is a device which is used to maintain constant output irrespective of changes in the input. The most popular regulator series is 78xx series. This series have more advantages.
We are using 7805 voltage regulator to maintain constant 12v output voltage irrespective of changes in input voltage.

Figure 6: VOLTAGE REGULATOR

E. PIC MICROCONTROLLER:

This is the main block of our project. The 16F72 micro controller is powerful (200 nanosecond instruction execution) yet easy-to-program (only 35 single word instructions) CMOS FLASH-based 8-bit microcontroller. The PIC 16F72 is a 28 pin IC in the physical structure in with 3 different ports in which port-A consists of (6)pins, port-B consists of (8)pins, port-C consists of (8)pins, (3)source pins, (2) clock pins and (1) ground pin.

Figure 7: PIC MICROCONTROLLER

It uses 16 Bit instructions for its operation. A push button is connected to the RST pin of the microcontroller to restart the code every time operation is started. Two LEDs are connected in the circuit to indicate whether the board is operating or not. This simply takes the input from the user and processes it according to the code and sends output to the LED to display the output voltages.

F. MOSFET:

The metal–oxide–semiconductor field-effect transistor (MOSFET, MOS-FET, or MOS FET) is a transistor used for amplifying or switching electronic signal s. Like other field-effect transistors, a MOSFET is usually a three-terminal device with source (S), gate (G), and drain (D) terminals.

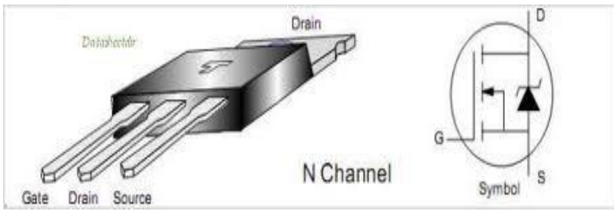

Figure 8: MOSFET

G. CRYSTAL OSCILLATOR:

An oscillator is an electronic circuit that produces a repetitive electronic signal. The maximum operating frequency of PIC Microcontrollers is 20 MHz. PIC Microcontroller has internal 4 MHz internal oscillator. In this project we are using crystal oscillator because the crystal is more stable to temperature variations than other types of oscillators.

Figure 9: CRYSTAL OSCILLATOR

H. LED:

LED (Light Emitting Diode) is a semiconductor light source used as indicators. In this project we are using LED indicators for checking Microcontroller working status and various status indications. This usually works on 2 volts, 10 mA.

Figure 2: LED

I. FERDOWSI RECTIFIER CIRCUIT:

The circuit configurations of the proposed FERDOWSI RECTIFIER are depicted in the above Figure. As seen from this figure, both types benefit from two high frequency (HF) switched MOSFETs - Sp and Sn, two HF diodes - Dp and Dn, two inductors - Lp and Ln, and two capacitors - Cp and Cn. In addition, one input inductor-Lf and one output capacitor-Cf, are also required for current and voltage smoothing, respectively.

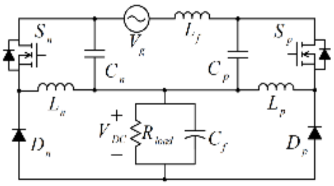

Figure 3: CIRCUIT DIAGRAM

J. LCD DISPLAY:

Liquid Crystal Display is a flat, thin electronic visual display which uses the light modulating properties of liquid crystal. LCD'S are widely used in computer monitors, television, aircraft, cockpit displays, instrument panels, signage etc.

Figure 4: LCD

V. SOFTWARE DESCRIPTION:

This project is implemented using following software's:

- Express PCB – for designing circuit.
- PIC C compiler - for compilation part.
- Proteus 7 (Embedded C) – for simulation part.

➢ **Express PCB:**

Breadboards are great for prototyping equipment as it allows great flexibility to modify a design when needed; however the final product of a project, ideally should have a neat PCB, few cables, and survive a shake test. Not only is a proper PCB neater but it is also more durable as there are no cables which can yank loose.

Express PCB is a software tool to design PCBs specifically for manufacture by the company Express PCB (no other PCB maker accepts Express PCB files). It is very easy to use, but it does have several limitations.

Express PCB has been used to design many PCBs (some layered and with surface-mount parts. Print out PCB patterns and use the toner transfer method with an Etch Resistant Pen to make boards. However, Express PCB does not have a nice print layout. Here is the procedure to design in Express PCB and clean up the patterns so they print nicely.

➢ **PIC C compiler:**

PIC compiler is software used where the machine language code is written and compiled. After compilation, the machine source code is converted into hex code which is to be dumped into the microcontroller for further processing. PIC compiler also supports C language code.

It's important that you know C language for microcontroller which is commonly known as Embedded C. As we are going to use PIC Compiler, hence we also call it PIC C. The PCB, PCM, and PCH are separate compilers. PCB is for 12-bit opcodes, PCM is for 14-bitopcodes, and PCH is for 16-bit opcode PIC microcontrollers. Due to many similarities, all three compilers are covered in this reference manual. Features and limitations that apply to only specific microcontrollers are indicated within. These compilers are specifically designed to meet the unique needs of the PIC microcontroller. This allows developers to quickly design applications software in a more readable, high-level language. When compared to a more traditional C compiler, PCB, PCM, and PCH have some limitations. As an example of the limitations, function recursion is not allowed.

➢ **Proteus:**

Proteus is software which accepts only hex files. Once the machine code is converted into hex code, that hex code has to be dumped into the microcontroller and this is done by the Proteus. Proteus is a programmer which itself contains a microcontroller in it other than the one which is to be programmed. This microcontroller has a program in it written in such a way that it accepts the hex file from the pic compiler and dumps this hex file into the microcontroller which is to be programmed. As the Proteus programmer requires power supply to be operated, this power supply is given from the power supply circuit designed and connected to the microcontroller in proteus. The program which is to be dumped in to the microcontroller is edited in proteus and is compiled and executed to check any errors and hence after the successful compilation of the program the program is dumped in to the microcontroller using a dumper.

VI. WORKING:

The performance principle of FR's are presented in the following, according to the equivalent circuits during the positive and negative half cycles of the input voltage as shown in figure.

- The operation modes are analyzed with assuming a same pulse width modulated (PWM) gating signal goes to both MOSFETs Sp and Sn simultaneously, which simplifies the control and means that there is no need to determine the zero crossings of the input voltage waveform.
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1) Mode-I (0~DTs):

The equivalent circuit of mode I of the FR type I is depicted in Fig.2(a) in which the MOSFET *Sp* turns ON to charge *Lp* from the input voltage and the capacitor *Cp*.

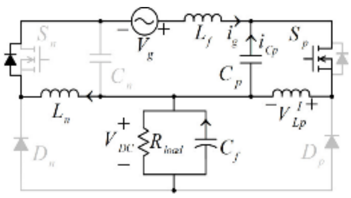

Figure 5: OPERATION IN MODE-1

2) Mode-II (D'Ts)

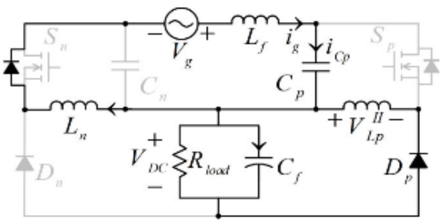

Figure 6: OPERATION IN MODE-2

As obvious from Figs. 2(b), the stored energy in *Lp* discharges to the output load through the HF diode *Dp*. At the same time, the input current flows through the capacitor *Cp* to charge it. On contrary to the previous mode of operation, the input current of the proposed FR type I does not flow through *Lp* and its inductor current decreases to zero.

3) **Mode-III ((D+D')Ts~Ts)**

From the end of the previous mode to the end of mode III, the voltage across the inductor *Lp* becomes zero. The input current flows through

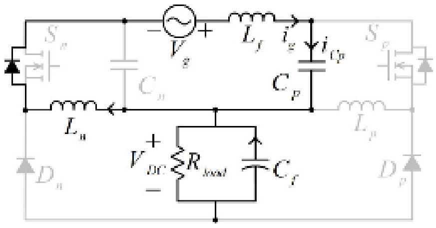

Figure 7: OPERATION IN MODE-3

the capacitor *Cp*. The capacitor *Cp* keeps being charged during this mode and the output load is fed from the output filter capacitor. As seen from all three operation modes shown in Fig. 2, the body diode of the MOSFET *Sn* is always conducting the input current during the whole positive half cycle of the input voltage, which is evident from its corresponding switch current waveform given in Fig. 3. Thus, any reverse recovery problem and its related power losses is not concerned, since, the body diode does not turn OFF during the whole half cycle. The operation principles of the FRs during the negative half cycle of the input voltage are the same as that analyzed above for the positive one.

VI. HARDWARE & RESULTS:

Figure 16: NO-LOAD CONDITION

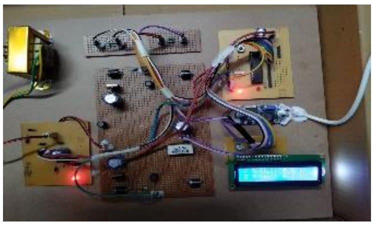

Figure 17: ON-LOAD CONDITION

S.No	TYPE OF LOAD	BRIDGE RECTIFIER VOLTAGE (VOLTS)	FERDOWSI BRIDGE RECTIFIER VOLTAGE (VOLTS)
1.	NO-LOAD	14.3	16.5
2.	ON-LOAD	10.2	13.3

VII. CONCLUSION:

This project introduced a new single-phase buck-boost bridgeless PFC rectifiers, called the Ferdowsi rectifiers (FRs). Both type of proposed rectifiers employ the lowest number of semiconductors with two integrated inductors on a common magnetic core.
The proposed rectifiers utilize only two MOSFET switches without the reverse recovery problem of their body diodes. In addition, the proposed rectifiers employ two parallel capacitors to provide a current path for the input current during the discharge mode of the inductors to improve the power quality factors, known as PF and THD.

VIII. REFERENCES:

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