Development of Series Resonant Converter for Universal Electric Vehicle Charger with PWM Control

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Abstract –This study describes a series resonant converter for an all-purpose EV charger that is controlled by pulse width modulation (PWM). The boost mode of a series resonant converter is the topic of this work. A series resonant converter may span a huge range of gain with a high and flat efficiency curve by adopting two PWM boost switches with a complete bridge rectifier. The suggested converter's secondary side rectifier progressively changes from a complete bridge rectifier to a voltage doubler rectifier as the output voltage rises.With complete bridge and voltage doubler rectifiers, the proposed converter automatically achieves "two peak efficiency points" since the switching frequency is locked to the resonant frequency in boost mode. The suggested converter provides a high and flat efficiency curve because two peak efficiency points restrict the efficiency decline across a broad range of gain. On a prototype with an 800 V input and 200-950 V/3.3 kW output, the efficacy of the suggested converter and control has been confirmed.

Keywords: PWM, Bridge rectifier, Resonant frequency.

I. INTRODUCTION

Power electronic components can be utilised as amplifiers or switches. An ideal switch is either open or closed, dissipating no power; it can either pass no current while being applied with a voltage, or it may flow any current with no voltage drop. The majority of power electronic applications rely on switching devices on and off because semiconductor devices employed as switches may approximate this perfect quality. This results in extremely efficient systems since very little power is lost in the switch. In contrast, the current flowing through an amplifier fluctuates continually in response to a regulated input.The power dissipation inside the device is significant relative to the power given to the load, and the voltage and current at the device terminals follow a load line. How gadgets are utilised is determined by a number of factors. Devices like diodes start conducting when a forward voltage is provided; there is no external control over this process. Power devices like mercury valves and thyratrons, as well as silicon-controlled rectifiers and thyristors, provide control of the onset of conduction but depend on periodic reversal of current flow to turn them off. Devices that offer full switching control and may be turned on or off regardless of the current flow through them include gate turn-off thyristors, BJTs, and MOSFET transistors.

DC/AC converters (inverters):

DC to AC converters turn a DC source into an AC output waveform. Variable speed drives (ASD), [[uninterruptible power supply]] (UPS), Flexible AC transmission systems (FACTS), voltage compensators, and solar inverters are examples of applications. Voltage source inverters and current source inverters are two unique groups of topologies for these converters. The independently regulated output of voltage source inverters, often known as VSIs, is a voltage waveform. The regulated AC output of current source inverters (CSIs) is unique in that it has a current waveform.

Current source inverters:

DC current is transformed into an AC current waveform by current source inverters. Quantities like as amplitude, frequency, and phase should all be under control in applications demanding sinusoidal AC waveforms. Because CSIs experience significant fluctuations in current over time, capacitors are frequently used on the AC side while inductors are frequently used on the DC side. The power circuit is smaller and lighter than VSIs because to the removal of freewheeling diodes, and it frequently exhibits higher reliability. Three-phase CSIs are more useful than single-phase topologies, which are still an option. A three-phase CSI uses the same conduction pattern as a six-pulse rectifier in its most generalised version.

Only one common-cathode switch and one common-anode switch are ever turned on simultaneously. Line currents therefore have distinct values of -ii, 0 and ii. Only valid states are used, and states are selected so that the required waveform is produced. This choice is based on modulating approaches, such as space-vector techniques, selective harmonic removal, and carrier-based PWM.

II. EXISITING SYSTEM

Given its built-in advantages, such as over-current protection and a quicker transient response, current-mode control is a common regulation technique for DC-DC converters. Even though the current-mode controller has been successfully used in several higher-order DC-DC converters, some concerns are not entirely covered in these works. The recently developed higher-order converters provide several difficulties, as opposed to the ordinary boost converter, which only has one inductor current available for feedback purposes.

A two-stage cascade boost converter is now being presented with a full comparison analysis of two current-mode controllers (using input inductor current and output inductor current). The major goal of this research is to demonstrate that the current-mode control using the input inductor current fails to operate under specific circumstances (i.e. for specific circuit parameter values), and to address this issue, the current-mode control using the output inductor current is presented. It is determined that the output inductor current is better suited for feedback purposes for a two-stage cascade boost converter with the specified set of circuit parameter values.

III. FLOW DIAGRAM

In this paper, a new adaptive current-mode controller for the regulation of the high step-up dc-dc converter is proposed. The secondary side of the transformer is connected to the load through two series-resonant circuits and a half bridge diode rectifying stage, in which the rise and fall slopes of the diode currents are limited by the slope of the currents in there sonant circuits, resulting in reduced switching losses in the diodes.Moreover, the magnetizing inductor has little influence on the voltage gain, which means that the parameter design process can be simplified, and the magnetizing inductor can be designed as large as possible to reduce the conduction loss.

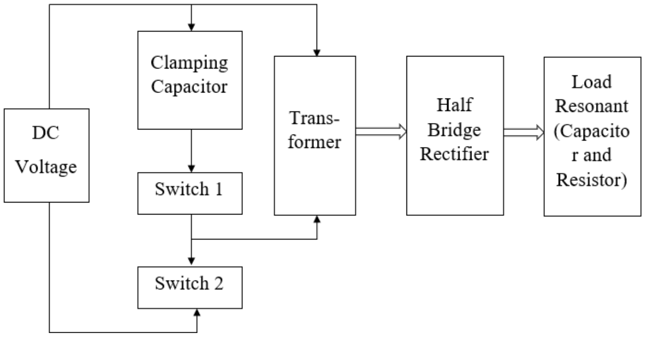


Fig.1. The flow diagram of proposed algorithm

The following modules are available:

Input Source, MOSFET, DC-DC Stage 1, DC-DC Stage 2, Current Controller, and Traditional Current Controller.

Simple definition: A DC component is a non-zero average of the positive and negative half cycles. There is a difference. The signal may have been "biassed" by the addition of a DC signal. So, with a sinusoidal AC voltage source, you may simply compute the time average. It is 0.636 times the Peak value for a half cycle. Electric charge flows in a single direction with direct current (DC). A nice illustration of a DC power supply is a battery. Direct current may move through a conductor like a wire as well as semiconductors, insulators, and even a vacuum in the case of electron or ion beams. Electric current differs from alternating current in that it travels in a consistent direction (AC).

Galvanic current was a prior name for this sort of current. A novel adaptive current-mode controller is presented in this technique for controlling the high step-up dc-dc converter. The suggested controller employs the estimation of the inverse of the load resistance to compute the reference inductor current of the converter, overcoming the limitation of the standard current-mode controller in handling unknown loads. Specifically, this estimate is derived via a suitable adaption method. The suggested adaption procedure produces an optimised and is provided in the normalised form.

Higher DC voltages, such as 48 V to 72 V DC, can be stepped down to 36 V, 24 V, 18 V, 12 V, or 5 V by the use of a DC-DC converter to power various loads. In a 48 V DC telecommunications system, stepping voltage down to 12 V to 24 V DC with a DC-DC converter and powering equipment loads directly at their native DC input voltages is often more efficient than using a 48 V DC to 120 V AC inverter to power equipment.

Input DC Voltage:

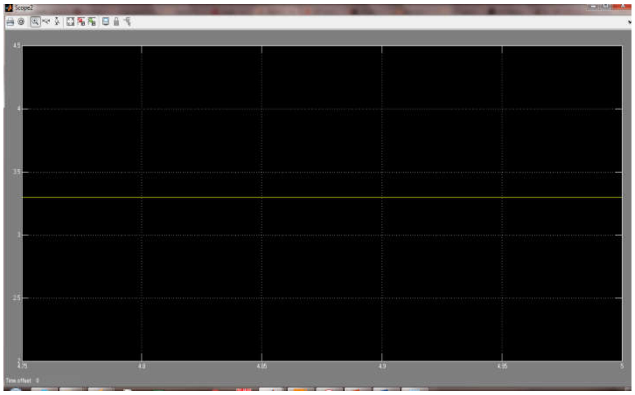


Fig. 2. Representation of DC Voltage

Input DC Current:

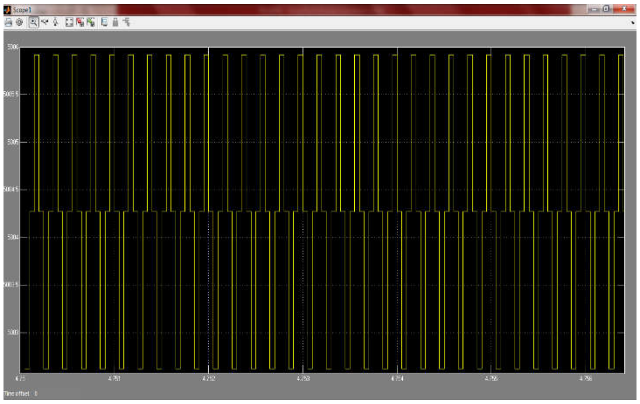
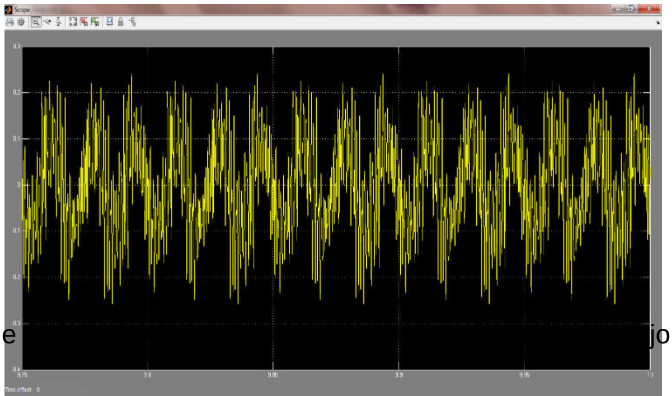


Fig. 3. Representation of DC Current

MOSFET

Field-effect transistors come in several varieties, one of which is the metal-oxide-semiconductor field-effect transistor (MOSFET, MOS-FET, or MOS FET) (FET). The conductivity of the device is controlled by the voltage of an insulated gate. Electronic signals may be amplified or switched using this property of conductivity that changes with the amount of applied voltage. An acronym for MOSFET is a metal-insulator-semiconductor field-effect transistor, or MISFET. Insulated-gate field-effect transistor, or IGFET, is another similar term.



Output Voltage:

Fig. 4. Representation of Output Voltage

CONVERTER:

A DC-to-DC converter is a circuit or electromechanical device that changes the voltage level of a direct current (DC) source. It's a particular kind of electric power converter. Low to extremely high power levels (tiny batteries) (high-voltage power transmission).

Before the advent of power semiconductors and related technologies, converting a DC supply's voltage to a higher voltage for low-power applications required first converting it to AC, which was then processed through a vibrator, step-up transformer, and rectifier. A generator of the necessary voltage was driven by an electric motor for more power (sometimes combined into a single "dynamotor" unit, a motor and generator combined into one unit, with one winding driving the motor and the other generating the output voltage).

When there was no other option, such as to power a vehicle radio (which employed thermionic valves/tubes that required far higher voltages than accessible from a 6 or 12 V car battery), these very inefficient and expensive processes were used. The development of power semiconductors and integrated circuits made it feasible to employ the techniques detailed below, such as converting a DC power supply to high-frequency AC, changing the voltage with a transformer that is small, light, and inexpensive because of the high frequency, and rectifying it back to DC. Even after transistorised power supplies were available, some amateur radio operators continued to utilise vibrator supplies and dynamotors for mobile transceivers that needed high voltages even though transistorised car radio receivers did not need them by 1976.Although a linear electronic circuit or even a resistor might be used to convert a greater voltage to a lower voltage, these techniques only allowed for inefficient energy conversion when solid-state switch-mode circuits were used.

IV. PWM CONTROLLER

Multilevel inverters have been modulated using a variety of methods. These include those of low-frequency-based techniques like space vector control and selective harmonic removal. High switching frequency is used by other rival techniques including multicarrier pulse width modulation and pulse controller (PWM). One of the most popular PWM techniques, known as space vector PWM, is used in this study. The description of how the space vector PWM is modified for the suggested five-level inverter is provided in this section. The key benefit of PWM is the extremely low power loss in the switching devices. Nearly no current flows through a switch while it is off, and there is almost no voltage drop across the switch when power is being transmitted to the load.

Power loss is therefore almost negligible in both situations since it is the product of voltage and current. PWM also functions well with digital controllers, which can quickly determine the required duty cycle due to their on/off nature. In certain communication systems, PWM has also been used to transmit information across a communications channel by using its duty cycle. The load (the device that consumes the power) must perceive the produced waveform as smoothly as possible, hence the PWM switching frequency must be substantially greater than what would impact the load.

Depending on the load and application, the rate (or frequency) at which the power supply must switch can vary significantly. For instance, an electric stove requires switching several times per minute; a lamp dimmer requires 120 Hz; a motor drive requires switching at a rate of a few kilohertz (kHz) to tens of kHz; and audio amplifiers and computer power supplies require switching at rates well into the tens or hundreds of kHz.

Current Controller:

A constant current system in electronics alters the voltage across a load to keep the electric current constant. The drivercircuit acts as a current regulator and must seem to the component as a reliable source of current when it is specified that a component should be driven by a constant current.

LEDs are a significant use for constant current power supply. An LED may be lit with a high series resistance, but occasionally the design has to include protection against excessive current (or risk burning out the LEDs). The Spike SafeTM Current Source is one such gadget that does this. Continuous voltage and current pattern monitoring by Spike SafeTM load protection results in immediate shutdowns when abnormalities are found. Rapid shutdown safeguards the failing device for examination and safeguards the circuit's remaining components.

Fig. 5. First Stage Simulink Model of the Proposed PWM Converster

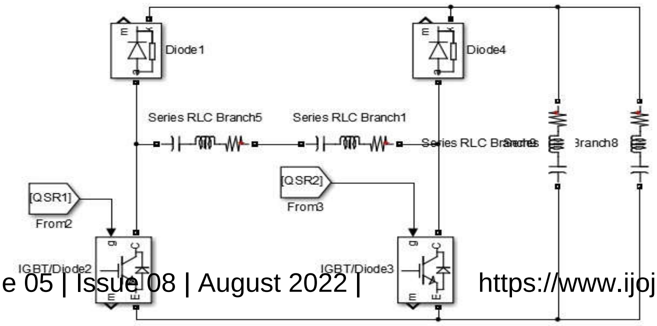
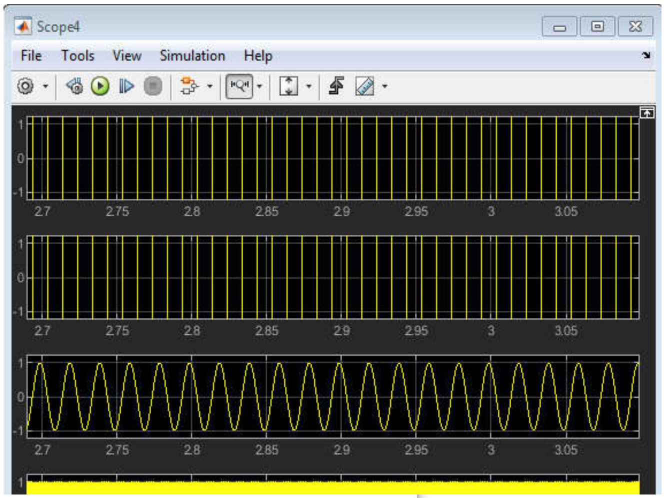


Fig. 6. Second Stage Simulink Model of the Proposed PWM Converster

Fig. 7. Third Stage Simulink Model of the Proposed PWM Converster

VI. EXPERIMENTAL RESULTS

The following snapshts are the outputs of the proposed work



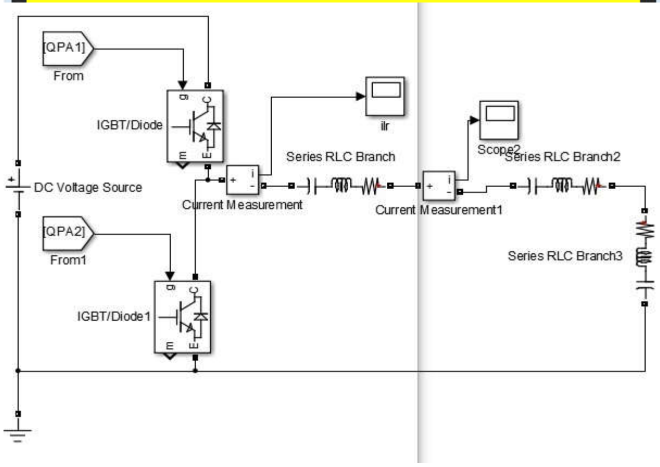


Fig. 8. Volage and Correcnt outputs of the Proposed PWM Converster

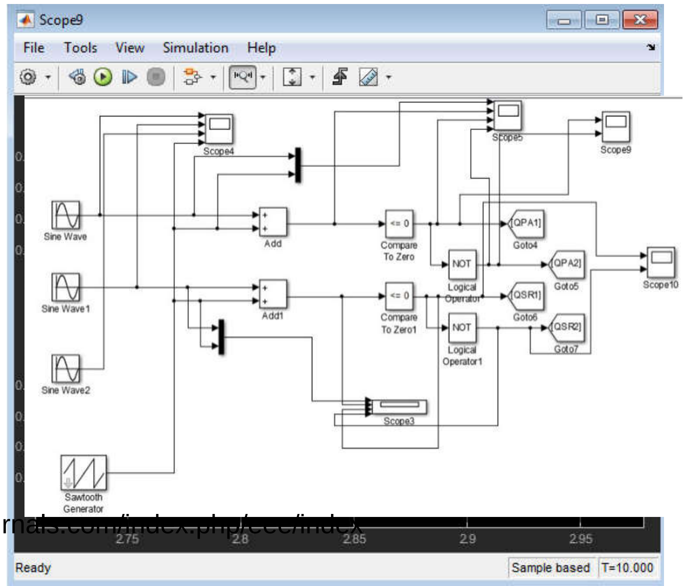


Fig. 9. Volage and Correcnt outputs of the third stage PWM Conversterr

Half Bridge Resonant

- The growing popularity of the LLC resonant converter in its half-bridge implementation is due to its high-efficiency, low level of EMI emissions, and its ability to achieve high power density.

- Such features perfectly fit the power supply demand of many modern applications such as LCD and PDP TV or 80+ initiative compliant ATX silver box.

- One of the major difficulties that engineers are facing with this topology is the lack of information concerning the way the converter operates and, therefore, the way to design it in order to optimize its features.

VII. CONCLUSION

In this study, a PWM-controlled SRC for EV chargers with a very broad gain range is presented. As the output voltage rises, the secondary side rectifier's structure progressively changes from full bridge to voltage doubler by including two PWM boost switches, a blocking capacitor, and a full bridge rectifier. The suggested converter may therefore attain two peak efficiency values across its full working range. The suggested converter and control maintain a high and smooth efficiency curve across a very large output voltage range by reducing the peak resonant current brought on by boosting action. This lowers the efficiency loss of PWM control. Consequently, the suggested converter and control might be a good contender for the applications that require ubiquitous EV chargers.

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