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UNIVERSAL ELECTRICAL VEHICLE CHARGER USING PWM CONVERTER

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Abstract: Electric Vehicles (EVs) are gaining importance day by day due to their increasing demand. An extensive research in EVs is required for its global acceptance as an alternative to petroleum and other fuels. EVs are successful in providing comfort and efficiency compared to combustion engine vehicles but still, EVs need attention towards charging of EV. The charging time of EVs is still longer, and every manufacturing company has different battery arrangements therefore chargers are of different ratings. We have come forward with the motive to design a universal system for EV for battery charging using Pulse Width Modulation. We are developing a MATLAB simulation on "PWM CONTROLLED UNIVERSAL ELECTRIC VEHICLE BATTERY CHARGER". The proposed System will be smart enough to identify the voltage rating of the EV Battery. After identifying the battery PWM controlled battery charger will charge the EV battery in minimum time. This system will play an important role in the field of EV research.

***Index Terms* – MATLAB Simulation.**

INTRODUCTION

Charging infrastructure of electric vehicles (EVs) becomes important nowadays as the EV market grows. Two mainstreams charging connector protocols are Charge de Move (CHADEMO) and Combined Charging System (CCS), and they have different ranges of battery voltage. Usually, CHADEMO covers relatively low-voltage batteries up to 500 V, and CCS covers high-voltage batteries up to 950 V. To be compatible with all EVs adapting either CHADEMO or CCS, it is required to develop a universal EV charger that covers an extremely wide range of the battery voltage. DC/DC converter for the universal charger needs to achieve high efficiency over the entire output voltage range.

SRC has a smaller circulating loss due to its large magnetizing inductance, resulting in higher efficiency at the resonant frequency However, SRC provides only step down voltage conversion ratio, whereas LLC converter achieves a booting gain when the switching frequency becomes smaller This is because the circulating current is stored in the resonant capacitor and the energy is delivered to the output side in the next switching period, From these aspects, it can be noted that SRC has a smaller circulating current but also a limited range of the gain.

Therefore, if a wider range of gain can be achieved in SRC, it would be possible to have both a small circulating current and a wide range of gain. For these reasons, there have been several approaches to provide SRC with a wider range of gains. The first approach is pulse width modulation (PWM) adapted resonant converters. In this approach, a boosting period caused by PWM signals boosts the resonant current so that a resonant converter can achieve boosting gain. By doing so, a wide range of voltage conversion ratios can be covered with a narrower switching frequency range.

The size of magnetic components can be reduced with a narrower switching frequency range. The only concern is a large peak of the resonant current when a high boosting gain is required. This large peak of the resonant current causes a large RMS current and turnoff loss from the boosting switches. The second approach is a topology-morphing technique. In this approach, a certain switching component is controlled to reconfigure the inverter or rectifier structure. For example, a full-bridge inverter can be used also as a half-bridge inverter by completely turning on a switch.

By doing so, the gain can be reduced by half and the converter can cover a wide range of gain with full bridge and half bridge inverter operation. Abrupt changes in the configuration of the converter can cause the output voltage to dip and swell. Therefore, a solution for a smooth transition between full bridge and half bridge configuration is investigated.

The proposed system presents a PWM-controlled series resonant converter for a universal EV charger that requires an extremely high wide range of gain. This work focuses on the boost mode of a series resonant converter. As the output voltage increases, the secondary side rectifier of the proposed converter gradually converts from a full bridge rectifier to a voltage doubler rectifier LLC with a simple PWM control. Since the switching frequency is fixed to the resonant frequency in boost mode, the proposed converter naturally achieves "two peak efficiency points" with full bridge and voltage doubler rectifiers. Since two peak SRC efficiency points to limit the efficiency drop over a wide range of gain, the proposed converter achieves a high and flat efficiency loss curve.

NEED OF THE STUDY

Series resonant converters (SRC) and LLC converters have been widely used in various applications due to soft switching and a small number of components. SRC and LLC converters are similar to each other in that they utilize series-connected resonant inductors and capacitors as the main resonant components. The difference between SRC and LLC converters is the magnetizing inductance value of the transformer SRC converter has a large magnetizing inductance of the transformer, whereas LLC has a small one.

RESEARCH METHODOLOGY

The methodology section outlines the plan and method that how the study is conducted. This includes the Universe of the study, a sample of the study, Data and Sources of Data, the study's variables, and the analytical framework. The details are as follows;

PROPOSED CONVERTER AND CONTROL

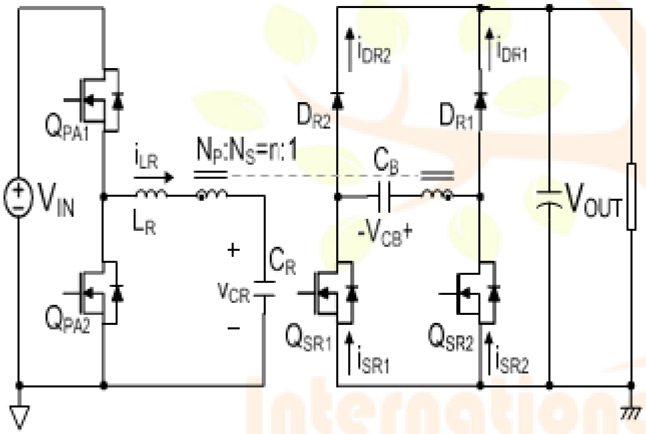

Fig 1. Proposed Converter

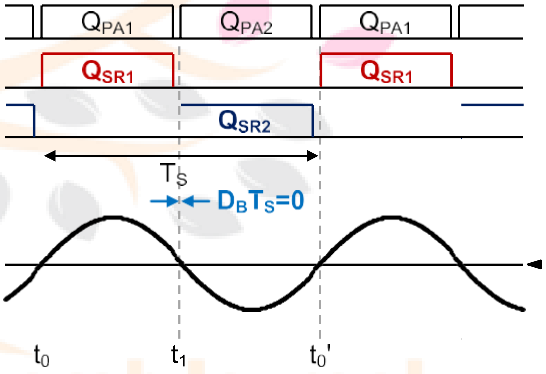

Fig 2. Output Waveform

Figures 1 and 2 represent the proposed converter and its output. As shown in Fig. 1, the proposed converter has an input voltage source with the input voltage V in half-bridge switches QPA1 and QPA2 resonant inductor L_R. Resonant capacitor C_R and transformer with the turn(s) ratio N_P: N_S = n: 1 in its primary side. The secondary side rectifier of the proposed converter is a full bridge rectifier, but it employs two switches QSR1 and QSR, and a blocking capacitor C_B. QPA and QPA2 are driven with complementary signals with a 0.5-duty cycle.

The switching frequency remains at the resonant frequency in the boost region, and the proposed converter has two resonant operating points at VOUT-VIN/2n and VIN/n. Since a series resonant converter shows the highest efficiency with the resonant point operation, the proposed converter can have the two highest efficiency points over a wide gain range.

The efficiency of a conventional PWM resonant converter decreases as the output voltage increases. The efficiency drops significantly especially when a high boosting voltage conversion ratio is required. This is because the conventional PWM-adopted resonant converter gets far away from the resonant point operation as the gain increases. In a deep boosting region, the resonant current waveform becomes triangular with a larger peak and RMS values, causing larger conduction and core losses. Also, the boosting switches are turned off with the large peak current resulting in large turnoff losses On the other hand, as V_{OUT} increases from V_{IN} /2n to V_{IN}/n, the proposed converter gets closer to the "second" resonant point operation. The second resonant point limits the large peak and RMS currents caused by PWM gain boosting. In addition, the constant switching frequency operation allows simple control and easier efficiency optimization, so that the efficiency of the proposed converter can be high over the entire output voltage range.

EXCEPTED RESULTS

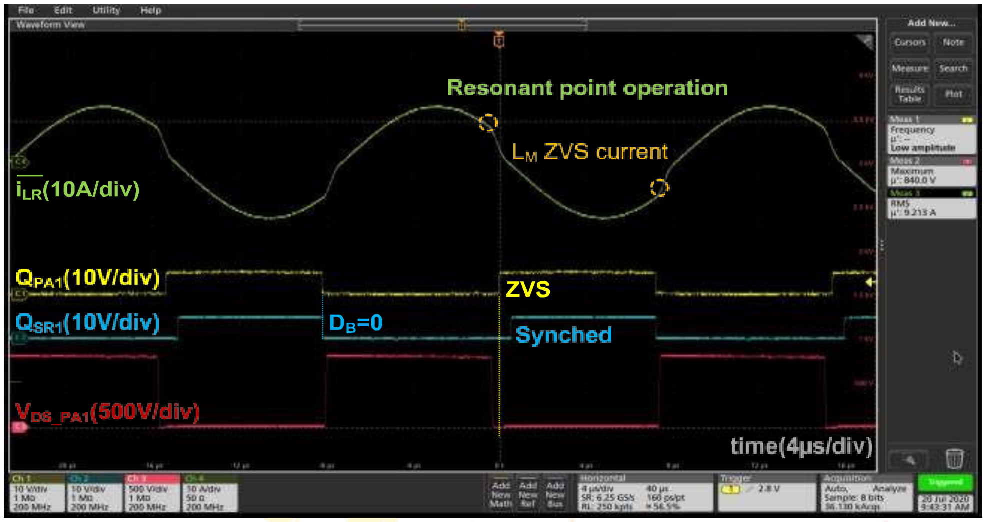

Fig 3. The key waveform of the prototype at 400V/3.3 KW

Fig.3. represents the key waveforms of the prototype converter at 400 V/3.3 kW output condition. The resonant current is nearly sinusoidal. Duty cycles for primary and secondary side switches are 0.5. Gate signals for synchronous rectifiers are synchronized to the resonant current. To drive synchronous rectifier switches, the duration t is calculated by the microcontroller.

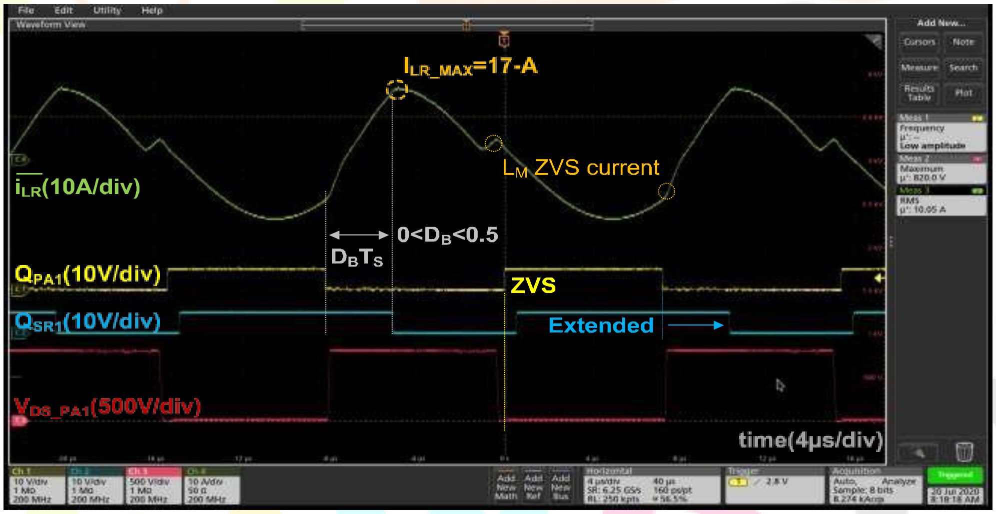

Fig 4. The key waveform of the prototype at 500V/3.3 KW

Fig.4 represents the key waveforms of the prototype converter at 500 V 3.3 kW output condition. To boost the resonant current, the duty cycle of queue is extended by Du ILR and is boosted during Dust and ILR MAX is about 17 A. ZVS of the primary side switch is achieved by the magnetizing current. Fig. 18 represents the key waveforms of the prototype converter at 600 V 3.3 kW output condition. DOSR is further extended to further increase VOUT. ILR_MAX increases to 19-A. ZVS are achieved by the magnetizing current.

RESULTS

1. Switching Circuit for MOSFET

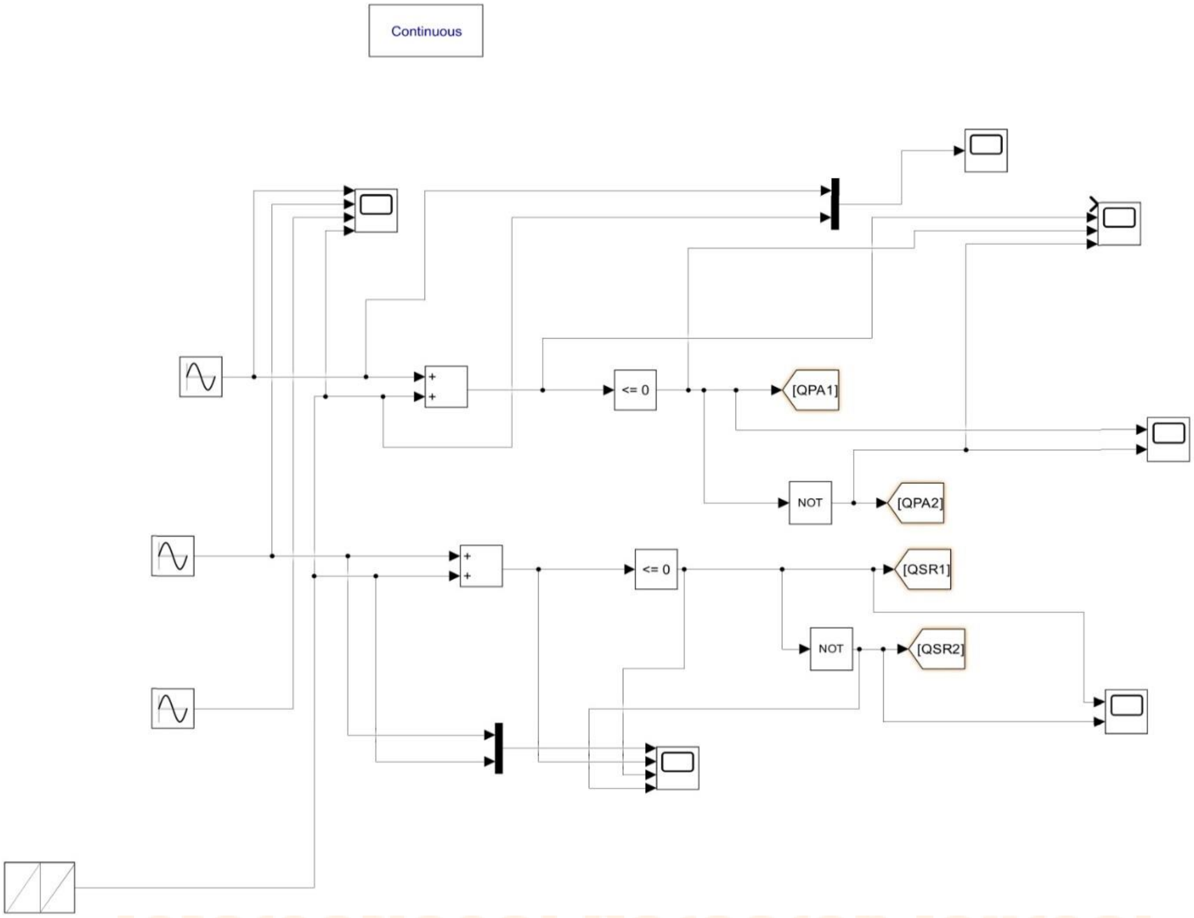

Fig 5. MATLAB SIMULATION MODEL STAGE 1

2. Output of Switching Circuit for MOSFET

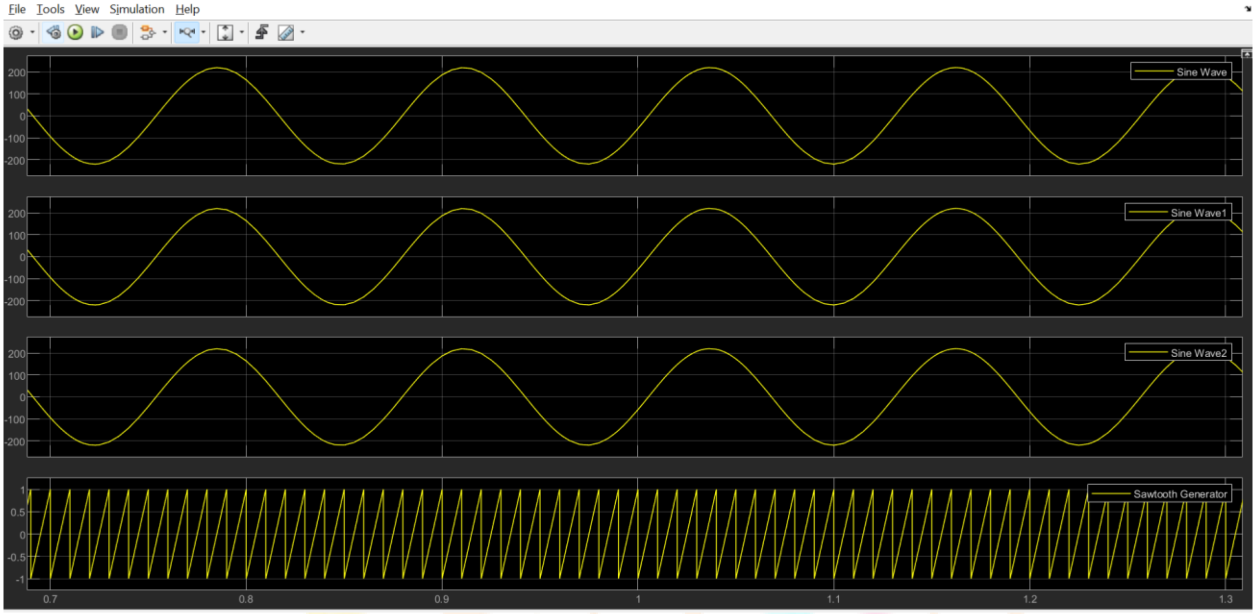

Fig 6. Input Sine wave and Triangular Wave

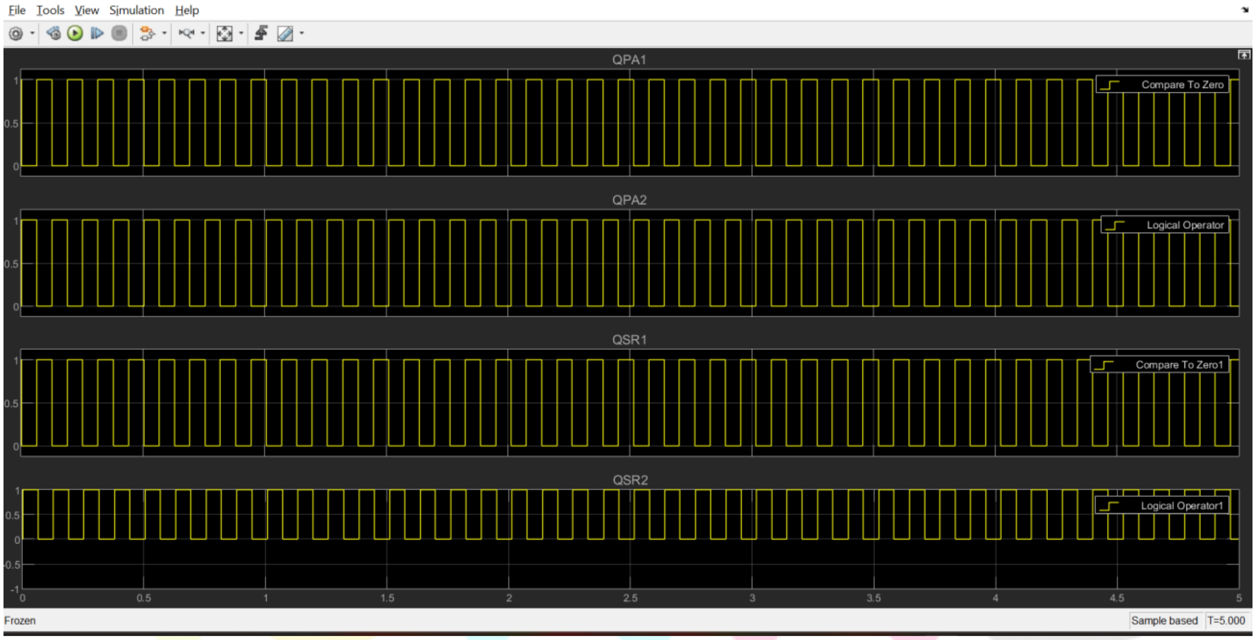

Fig 7. Input to the MOSFET

CONCLUSION

This proposed system presents a PWM-controlled SRC for EV chargers with a very wide range of gain. By adopting two PWM boost switches and a blocking capacitor with a full bridge rectifier. The configuration of the secondary side rectifier gradually converts from a full bridge to a voltage doubler as the output voltage increases. Thus, the proposed converter can achieve two peak efficiency points over the entire operating range The proposed converter and control limits the efficiency drop of PWM control by limiting peak resonant current caused by boosting action, so the efficiency curve is high and flat over very wide output voltage range Therefore the proposed converter and control can be a strong enough for the universal EV charger applications.

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