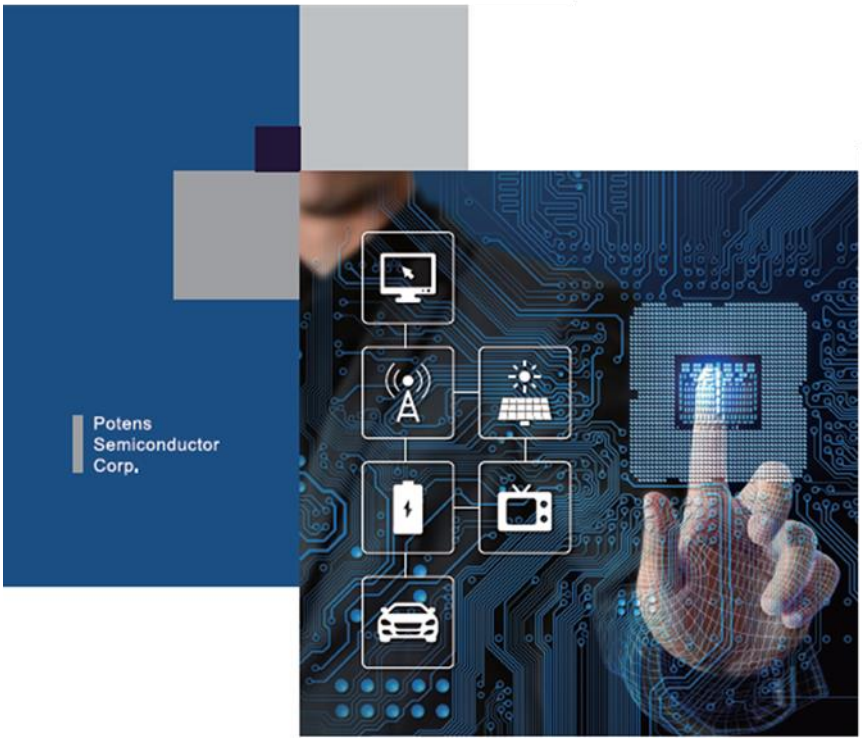
Application Information

SiC MOSFET Driving



Enhancing everyday life

SiC MOSFET is a semiconductor device widely used for high power and fast switching purposes such as server power supplies for communication equipment, electric vehicle (EV) onboard charger, charging station and motor drive system, etc. The main principle of SiC MOSFET is to control the current and voltage through the drain and source pins and works as a power switch by control of the gate voltage. Generally, external gate driver IC is used for driving SiC MOSFET. We can also use a traditional push-pull circuit or a photo couple circuit to drive it. The design of the gate driver is related to applied current/voltage and circuit topology. For circuit topology, the gate drive of SiC MOSFET could be divided into three methods: low-side driving, half-bridge with level shifter, and half-bridge with isolator.

1. Low side driving

Generally, the boost circuit or power factor correction (PFC) circuit is driven by low side driver IC. Function block of low side gate driver IC is shown as Fig. 1. Low side gate driver IC is to improve driving current capability and voltage conversion for PWM control signal from MCU. For cost related or analog circuit control design, the low side gate driver IC could be replaced by push-pull circuit. Fig. 1 shows that a SiC MOSFET is driven by low side gate driver IC.

2. Half-bridge driving with level shifter

For EV onboard charger, charging station and motor drive system application, the main circuit is a half bridge topology with high and low side drivers. Due to control signal of high side switch is high voltage level that is different from low side switch, the level shifter is a circuit used to translate low side signal voltage level to high side signal voltage level. For gate-source voltage of high side switch, the booststrap circuit or isolated voltage source can provide voltage bias to the high side switch. We suggest using isolated voltage source for high side switch to enhance the driving capability for SiC MOSFET. Fig.2 is the circuit diagram of half-bridge driving with level shifter

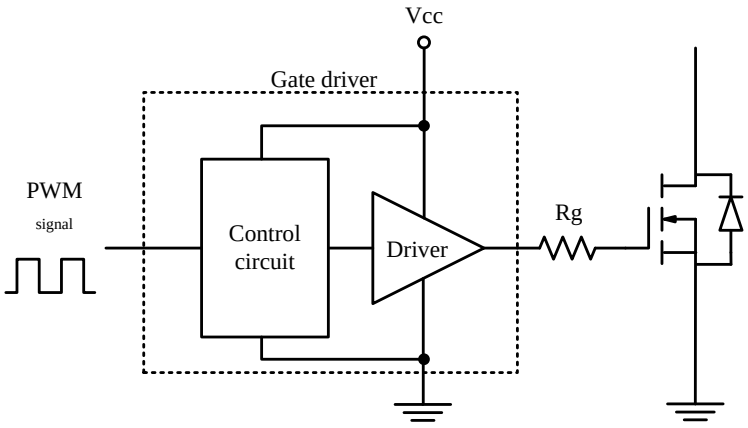


Fig. 1 Low side gate driver with SiC MOSFET.

3. Half-bridge driving with isolator

Another way to replace half-bridge driving with level shifter is using isolated transmission method to provide high signal. There are three types of the isolated gate driver: photo coupler, magnetic and capacitive isolation. However, this drive circuit needs using isolated power supply to provide the high side drive voltage source and the method of driving isolated power supply is close to that of IGBT.

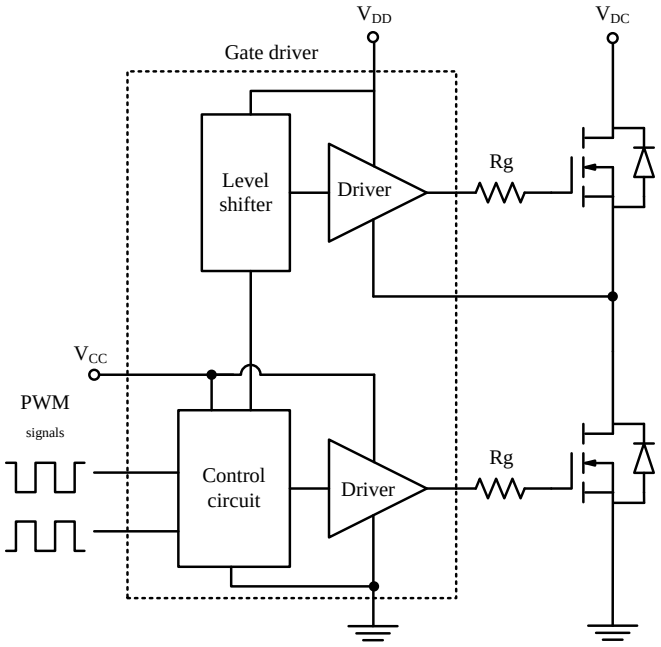


Fig. 2 Half-bridge driving with level shifter.

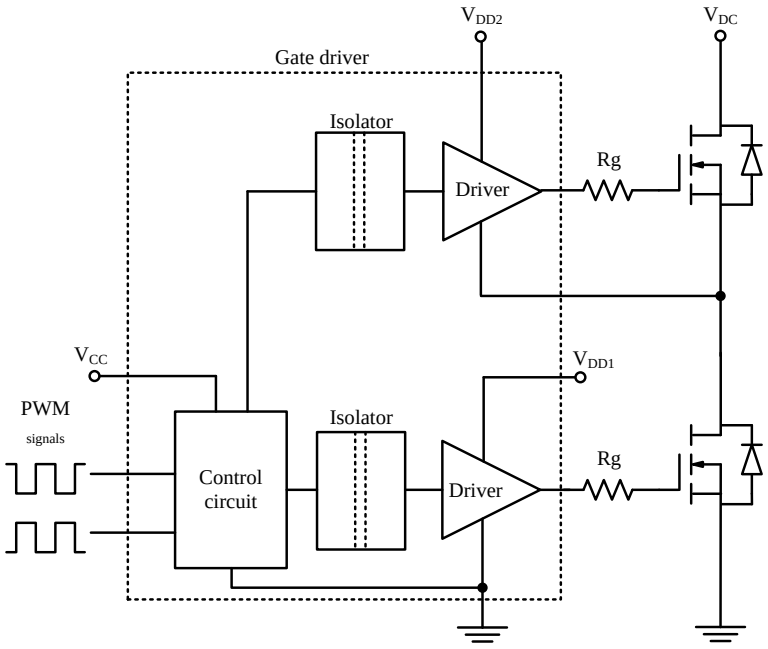


Fig. 3 The basic gate drive circuit.

We have a new idea for SiC MOSFET gate drive of a phase shift full bridge (PSFB) power converter[1]. In generally, a PSFB power converter could not reach zero voltage switching (ZVS) during the light load operation region. We used dynamic gate drive threshold voltage with smart driving design to achieve light load efficiency improving and adopted this gate driving method into SiC-MOSFET-based PSFB for full load range operation and severe environment.

Fig. 4 depicts the dynamic gate drive threshold voltage with smart driving controller of the PSFB converter. Fig. 5 depicts the control block of the dynamic gate drive threshold voltage with smart driving. The output of PWM control includes two parts: duty cycle and amplitude of voltage. The duty cycle is determined by output voltage and the amplitude of PWM voltage is determined by the current of the resonant inductor and relation of gate resistance w.r.t. gate threshold voltage to increase the current of the resonant inductor. Finally, the loss breakdown would be compared to the pre-loading control technique of the PSFB converter. The estimated power loss comparison under light load operation region is shown in Fig. 6. This PSFB DC to DC converter is constructed by dynamic gate drive threshold voltage with smart driving design utilizing SiC-MOSFET features is proposed to improve the efficiency of the PSFB converter during the light load. It mainly discusses the dynamic gate voltage control for changing the loss of the power switch to effectively avoid the operation range where ZVS cannot be reached. The results are shown that power loss of the conventional PSFB converter is worse than the proposed PSFB converter during the light load condition. The proposed PSFB converter could improve the light load efficiency and reduce the operating temperature of power devices during light load operation region. Therefore, the efficiency from light load to heavy load could be optimized by utilizing the proposed PSFB converter.

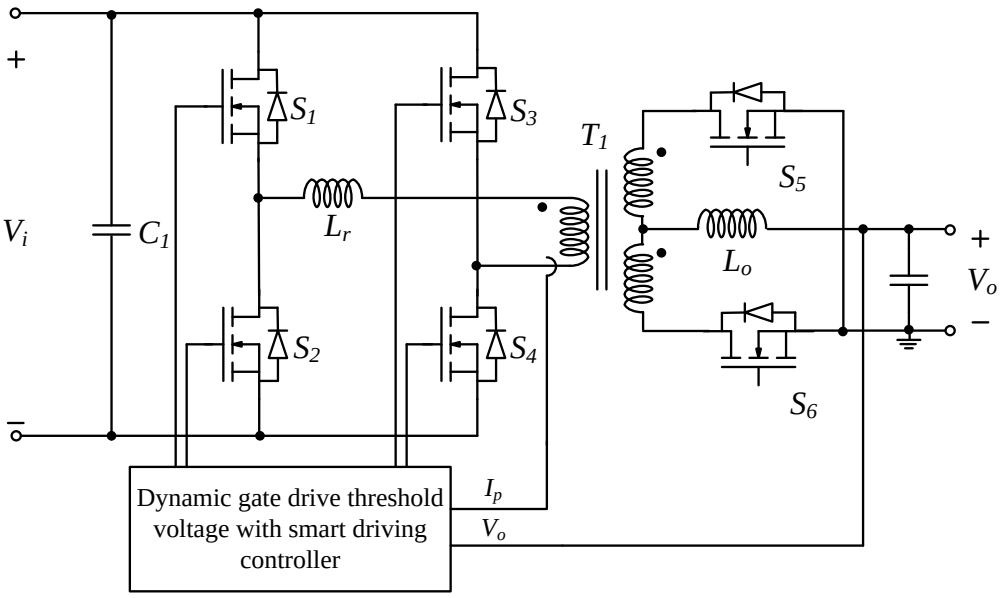


Fig. 4 The dynamic gate drive threshold voltage with smart driving for the proposed PSFB converter.

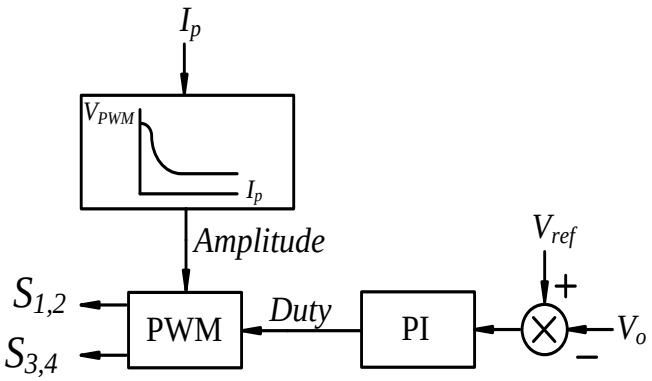


Fig. 5. Control block of the dynamic gate drive threshold voltage with smart driving

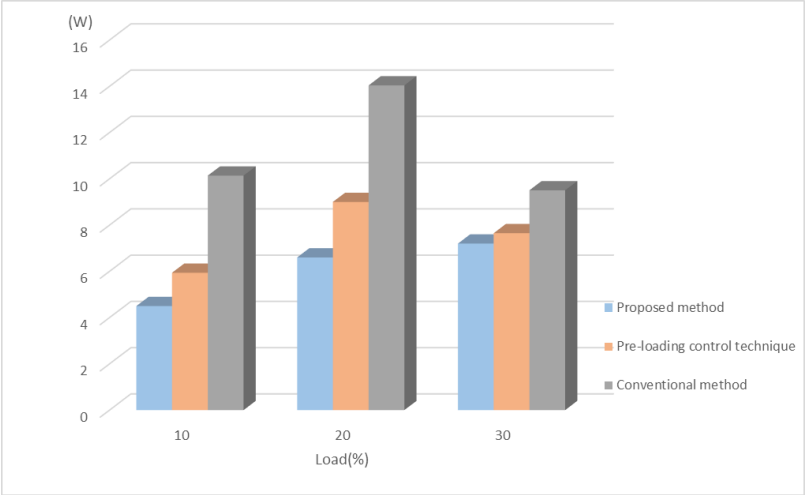


Fig. 5. Control block of the dynamic gate drive threshold voltage with smart driving

Reference

[1] C. G. Chen, W. N. Huang, H. C. Meng and T. M. Lai, “A New Light Load Efficiency Improving Scheme Utilizing SiC-MOSFET Features of Dynamic Gate Drive Threshold Voltage with Smart Driving Design for Phase Shift Full Bridge Converter, ” The 2023 IEEE Transportation Electrification Conference and Expo, Asia-Pacific (ITEC Asia-Pacific 2023).