§9. Study on Cryogenic Characteristics of Advanced Uni-Polar Power Electronics Devices and Their Application to High Efficiency AC/DC Converter

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The super junction type power-MOSFET is one of advanced power electronics devices to achieve lower on-state resistance value in higher voltage region, which has excellent electrical characteristics to be applied to high current AC/DC converter. A super junction type power-MOSFET is investigated on its static voltage-current characteristics and the on-resistance value. The super junction type power-MOSFET SPA20N60C3 has the voltage and current ratings of 650Vand 20.7A respectively, and also, the temperature dependence of its voltage-current characteristics is clarified. Considering to cool down the power electronics device for high current operation, the static voltage-current characteristics are measured in room and liquid nitrogen temperature.

Fig. 1 shows the schematic diagram of single phase full-bridge synchronous rectifier for testing operation with small voltage and current. The symbol of power-MOSFET means one super junction type power-MOSFET SPA20N60C3 investigated in the previous section. Two switching units of super junction type power-MOSFET devices are used for converting AC to DC in full cycle period. According to the AC voltage polarity, each device is supplied with synchronized gate signal voltage to flow the current through main part of power-MOSFET element, not through the body diode. Each power-MOSFET device is triggered in every half cycle synchronizing to the AC voltage. In the positive half cycle, the upper side power-MOSFET (FET1) turns on to flow the current as mentioned in the previous section. To output the current in the negative half cycle period, the inverse side power-MOSFET (FET2) is to flow the current as same process as in the positive half cycle.

In Fig. 2, The AC voltage (V1) is the voltage appearing in secondary side of transformer and the drain-source voltage (VDS1) is the voltage appearing in the upper side power-MOSFET (FET1). It is observed that the power-MOSFET (FET1) is turning on and turning off in every 180 electrical degrees with synchronizing to the applied AC voltage (V1). The final waveform of output voltage (V0) is similar to that of a normal single phase full-bridge circuit with diode rectifier, and it is also shown that the inverse side power-MOSFET (FET2) is switched on/off according to the corresponding gate signal voltage. The converter system including power-MOSFET devices will be cooled down in liquid nitrogen to make its operational loss extremely low. And, as another type advanced uni-polar power device, SiC-based power-MOSFET will be developed for lower on-state resistance and higher operational temperature than that of conventional Si-based power-MOSFET. The advantage of synchronous rectifier using power-MOSFET is to minimize total on-state resistance of parallel connected devices. The principle of basic operation of synchronous rectifier is described, and is tested experimentally with single phase full-bridge circuit. The operational results of single phase synchronous rectifier are successful, and super junction type power-MOSFET device, which is an advanced uni-polar power electronics device, is demonstrated to be applied to synchronous rectifier.

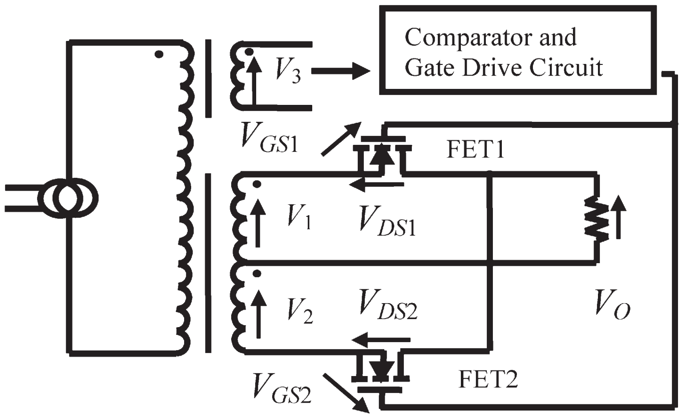

Fig. 1. Diagram of single phase full-bridge synchronous rectifier

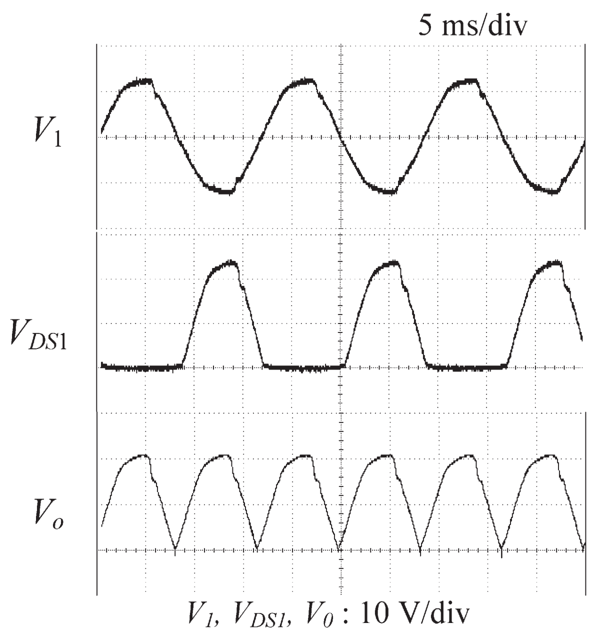

Fig. 2. Voltage waveforms of single phase full-bridge synchronous rectifier