High-voltage Auxiliary Power Supply Design with San’an 1700V/1Ω SiC MOSFET

Best Candidate for High Efficiency and Miniaturization

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As the burgeoning market demand for Photo-voltaic (PV) power generation systems, energy storage system, EV-charger, and motor drives, the performance and demand for high-voltage auxiliary power supplies (HV APS) used in these fields are also increasing. For the application field of HV APS, San’an Semiconductor has released a new wide band gap (WBG) power device 1700V/1Ω SiC MOSFET (SMS1701000K) with a maximum conduction current up to 6.8A. Compared with other products, it has lower conduction resistance $R_{DS(on)}$, less switching charge loss E_{oss}, and smaller drain-source leakage current I_{DSS}. It assists in the rapid advancement of HV APS system products towards high reliability, miniaturization, high efficiency, and low cost.

In the application field of high-voltage flyback APS up to kilovolt level, the system puts forward higher standards for the voltage level of its power devices. By using 1700V/1Ω SiC MOSFET as the power switch transistor, the system topology can be simplified into a single end flyback, reducing the number of required MOS device and effectively improving the system reliability; Along with higher switching frequency, volume of passive component in system can be compressed, which helps to obtain higher power density; The switching loss and conduction loss generated from power devices are significantly decreased, and the system efficiency can be increased finally; SiC MOSFET enables less heat during switching process, further optimizing system thermal management costs.

Figure 1 shows the reference board for the design of a 1700V SiC MOSFET HV APS independently devised by San’an Semiconductor. The corresponding circuit topology diagram of the reference board is illustrated by figure 2. The reference board, mainly composed of a power main-board and a detachable power sub-board, can be used to quickly evaluate the performance of SiC MOSFET power devices in high-voltage applications such as PV, energy storage system, automotive system, and motor drive system.

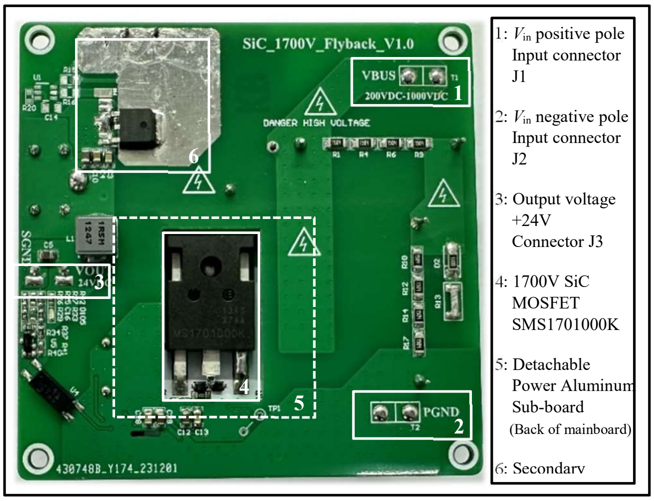

Fig 1 Picture of Reference Board

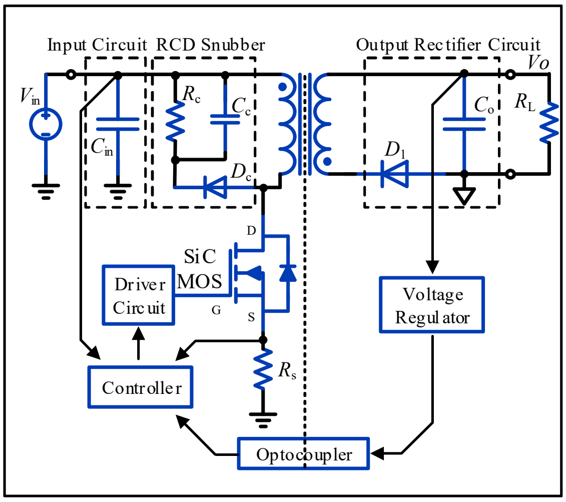

Fig 2 Topology of Reference Board

The reference board was developed to support customers designing APS using the 1700V SiC MOSFET SMS1701000K from San'an Semiconductor in a TO-247-3L package as shown in figure 3. The transistor has extremely low reverse recovery charges Q_{rr} and Q_{gd}, which makes the device switch faster and generate less switching loss under high frequency operation. At the same time, the smaller $R_{DS(on)}$ also diminishes the conduction loss of the device, which further boosts overall system efficiency. The V_{DS} of the device has a higher withstand voltage, and the system designed based on this SiC MOSFET will have a wider operating voltage range, thereby meeting the high voltage input requirements of the APS.

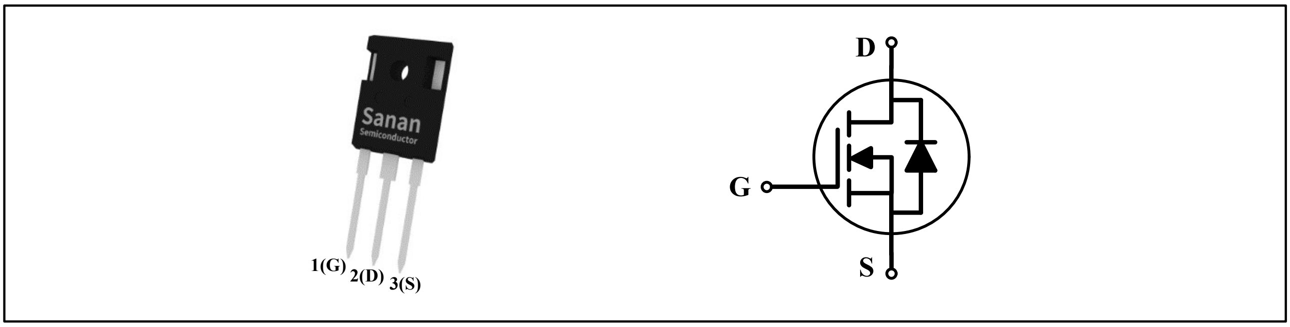

Fig 3 1700V/1Ω SiC MOSFET SMS1701000K

The reference board adopts a quasi-resonant control flyback circuit, with a DC input voltage covering a wide voltage range of 300V~1000V, a DC output voltage of 24V, and a maximum output power up to 65W, satisfying the operating needs of conventional HV APS. Figure 4 displays the efficiency curve of the reference board under the condition of DC input voltages (V_{in}) of 300V, 600V, and 900V respectively, corresponding to different output powers. According to the results, the peak efficiency are 91.1% at 300V, 89.9% at 600V, and 87.5% at 900V. Figure 5 demonstrates the system efficiency corresponding to different DC input voltages at a full load of 65W power output. As can be seen from the figure, with the increasing of input bus voltage, the overall efficiency of the system shows a slight downward trend.

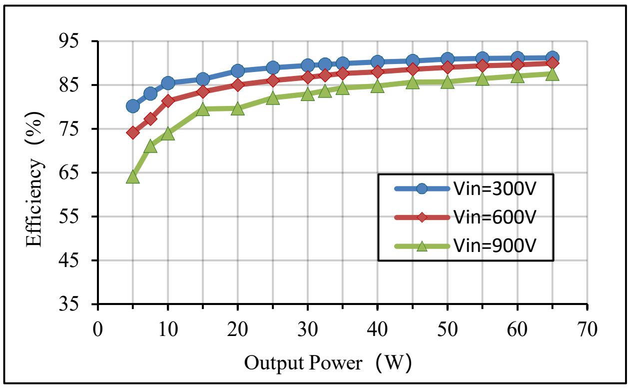

Fig 4 Measured efficiency versus Output power

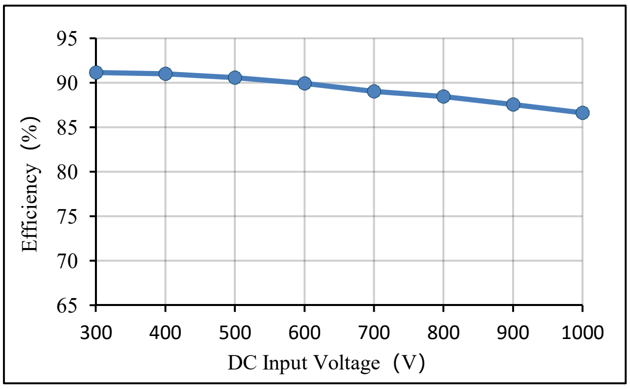

Fig 5 Measured efficiency versus DC input voltage

The following two figures show the operating waveform of the device in the HV APS system at input voltage of 300 V_{DC} in figure 6 and 1000V_{DC} in figure 7 with full load of 65W. And in these two waveforms, Channels 1 to 6 represent the V_{gs} of the SiC MOSFET, primary side current of transformer, secondary side current of transformer, V_{ds} of the SiC MOSFET, auxiliary winding voltage and rectifier diode voltage respectively. SiC MOSFET exhibits excellent switching characteristics in the input voltage range of 300V to 1000V, which totally fits the performance criteria of HV APS.

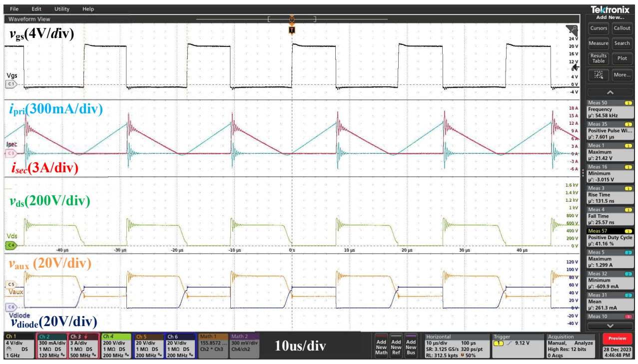

Fig 6 Full-loaded waveform at V_{in} of 300V_{DC}

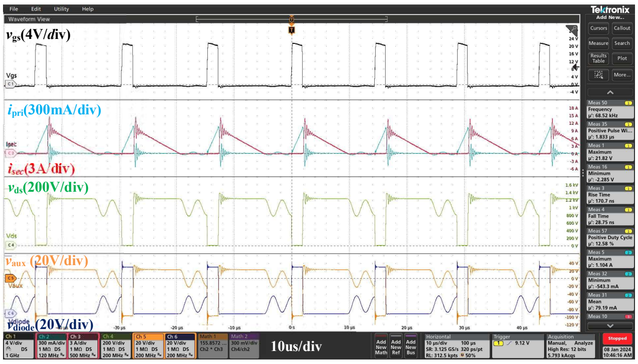

Fig 7 Full-loaded waveform at V_{in} of 1000V_{DC}

The power sub-board of the reference PCB board is made of aluminum-based plate. Its good thermal conductivity can quickly dissipate the heat generated by SiC MOSFET and other power components, substantially lowering the operating temperature of the corresponding components. The system operates in a natural cooling mode without the need of additional coolers, further slashing the thermal management cost of the system. Figure 8 represents thermal image at 900V_{DC} with full load of 65W and ambient temperature at 22.4°C. The thermal image in figure 9 reveals that even with a full load output of 65W the T_c value of SiC power devices measured at the same ambient temperature still does not exceed 92°C at a maximum 1000V_{DC}.

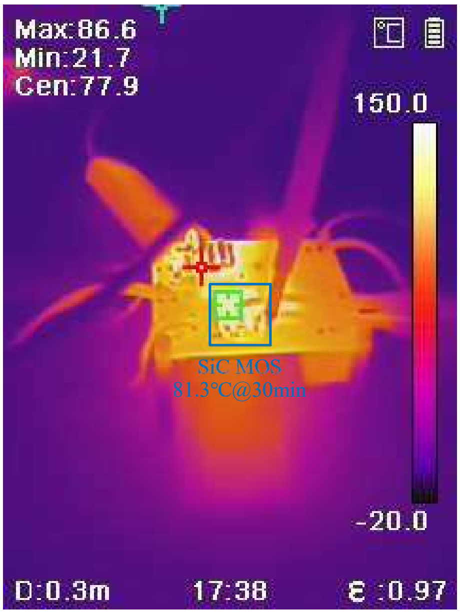

Fig 8 Thermal image at 900 V_{DC} with full load of 65W

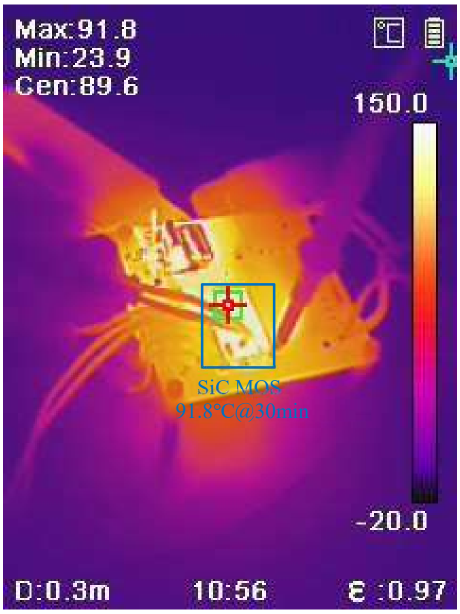

Fig 9 Thermal image at 1000 V_{DC} with full load of 65W

San'an Semiconductor is deeply involved in the technological innovation of SiC power devices, continuously iterating and optimizing device performance, and committed to providing high-quality products that meet various customer needs. The excellent performance of San'an's SMS1701000K will help the rapid iterative development of high-voltage flyback power systems towards high efficiency, miniaturization and low cost, promoting the technological transformation of large-scale application of SiC in PV, energy storage system, automotive system, electric-driving system and other fields.