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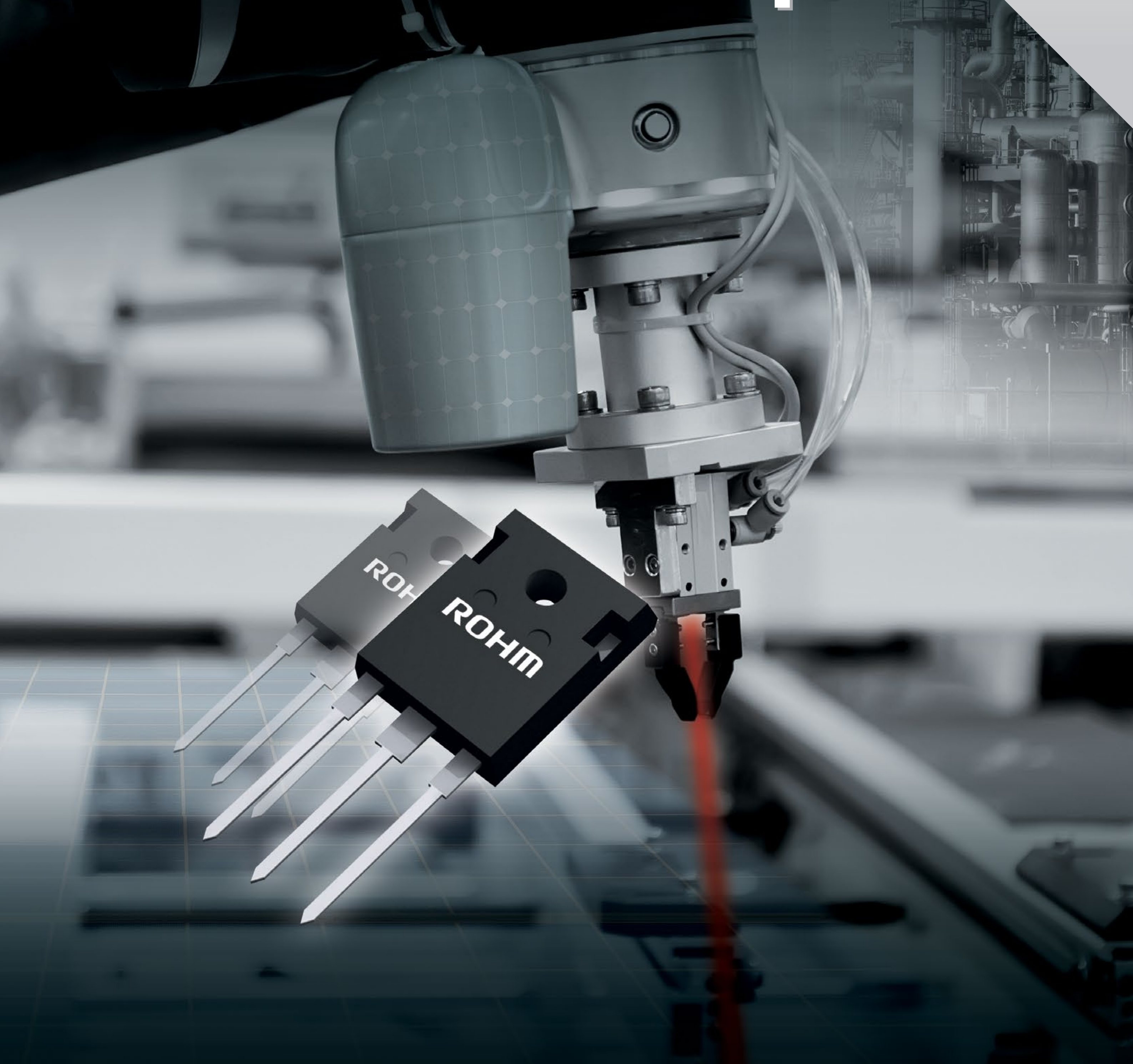

New-Age Power Solutions for Industrial Converters

SiC MOSFET based Auxiliary Power Supply Solution for Industrial Power Converters

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The benefits of Silicon Carbide (SiC) as compared to Silicon (Si) with regards to achieving high switching frequencies and low on-state resistance have been widely accepted. Most of the benefits are associated with the superior material properties of SiC as compared to Si. However, there is a general misunderstanding in the engineering community that the challenges associated with the design and choice of an optimal operating environment (gate driving and the choice of passive components) undermines its benefits thus restricting the usability of SiC devices. To justify the benefits of using SiC and to illustrate the simplicity on the application level, a 100 W Auxiliary Power Solution which is an upgrade to the already existing 40 W version has been designed at ROHM and available as an evaluation board for engineers. The design is based on the ROHM SCT2H12NZ 1700 V SiC MOSFET and the BD7682FJ quasi-resonant Flyback controller IC.

Quasi-resonant Flyback Topology for use in Auxiliary Power Supply

Continuing the trend of achieving higher efficiencies and reducing EMI disturbances, todays power electronic engineers are often faced with the dilemma of choosing whether to drive the MOSFETs at their switching speed limits and hence improve the efficiency assuming that the current and voltage spikes are properly controlled or to stay far away from the actual switching capabilities of the MOSFET in order to ensure agreeability with the applicable EMI norms. A Flyback converter based Auxiliary Power Supply is often used for its simple design and cost effectiveness and the Quasi-resonant mode ensures reduction in switching losses of the MOSFET, resulting in efficiency improvements. A typical power electronic converter consists of an auxiliary or housekeeping stage which generates the control voltages needed for the proper functioning of the power converter.

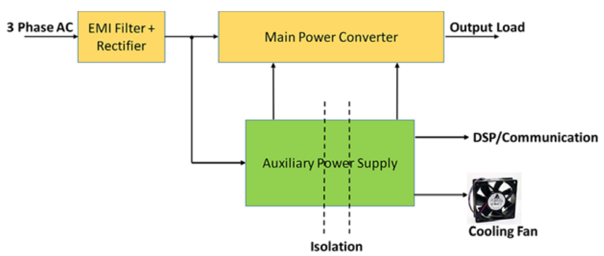

Fig. 1: Block Diagram of a Power Converter

Fig. 1 shows a block diagram of a power converter with the auxiliary power stage connected to the rectified DC bus. The job of the Auxiliary Power Supply unit is to generate the isolated voltages (12 V, 24 V) needed for the functioning of the control stage and the peripherals in the power converter. Depending on the application and the operation conditions, the auxiliary power stage could generate either 5 V or 12 V or 24 V. In the case of industrial power supplies, the auxiliary power supply typically generates 24 V which is either used directly by cooling fans and/or is further stepped down to lower voltages using DC-DC converters for use by controllers and other peripherals.

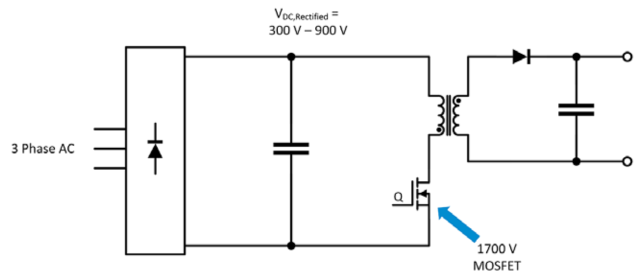

Fig. 2: Flyback Converter as an Auxiliary Power Unit

Fig. 2 shows the circuit diagram of a Flyback converter with its power stage being fed from the rectified DC bus. The rectified DC bus voltage can range from 300 V to 900 V and hence the controller for the Flyback converter needs to ensure a quasi-resonant operation in the entire range of the input voltages. Depending on the input voltage, turns ratio of the transformer and the output voltage, the MOSFET may have to withstand voltages up to 1500 V. Assuming a safety margin for the operation of the MOSFET, a 1700 V MOSFET would be the most logical choice for the use as the switching device. Even though Silicon MOSFETs/IGBTs with such a high breakdown voltage rating are available, the benefits in using SiC MOSFET stem from the low on-state resistance and faster switching capabilities which leads to efficiency improvements. Efficiency improvements have a direct impact in the sizing of the heat sink and hence lead to the development of more compact and smaller systems. The use of high breakdown voltage MOSFETs could be entirely avoided by using a two switch based Flyback topology or a series connection of lower voltage Silicon MOSFETs. However, this complicates the design and is not accepted in the market from the cost point of view. The use of 1700 V SiC MOSFETs allows the designer to use the simpler single switch based topology and at the same time achieve a higher efficiency performance because superior switching and conduction performance of SiC MOSFETs. ROHM Semiconductor offers a huge range of 1700 V SiC MOSFETs that are also AEC qualified ensuring usability in automotive applications.

Realization of the 100 W Power Supply using SiC and BD7682FJ Flyback Controller IC

The BD7682FJ is a quasi-resonant Flyback controller IC which can potentially be used in combination with a wide range of SiC MOSFETs available in the market. The BD7682FJ IC takes care of the control of the circuit and also maintains suitable gate driving of the SiC MOSFET while ensuring gate clamp and overload protection features for the SiC MOSFET. Fig. 3 shows the main circuit for the Aux. Power Supply unit as obtained by the combination of SiC MOSFET and the BD7682FJ controller IC. The 100 W 24 V output Evaluation Board is based on the circuit in Fig. 3 and the final assembly is shown in Fig. 4. The assembly in Fig. 4 is the final product that can be used for testing purposes. The BD7682FJ controller IC is used to drive the 1700 V

SiC MOSFET (SCT2H12NZ) in a quasi-resonant mode which minimizes the switching losses and helps to keep the EMI low. Higher efficiencies at light load conditions are ensured because of the controllers burst mode operation and a frequency reduction capability.

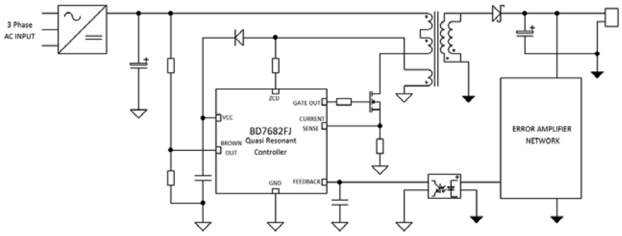

Fig. 3: Circuit Diagram of BD7682FJ and SCT2H12NZ 1700 V SiC MOSFET

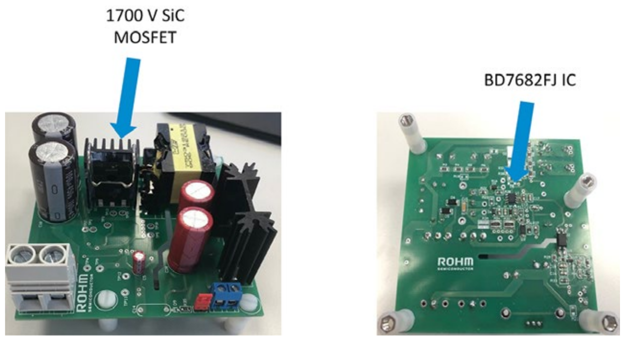

Fig. 4: Final Assembled Evaluation Board

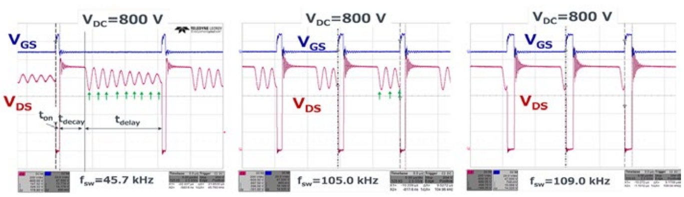

Fig. 5: Waveforms for different Load Conditions

Fig. 5 shows the waveforms of the power supply under different load conditions. At light load conditions (not shown in the figure), the controller switches the MOSFET in a burst mode in order to improve the efficiency and at higher loads the MOSFET is switched at the valley of the oscillating voltage in order to reduce the switching losses. At very high load conditions the frequency decreases slightly to allow an increase in the on-time of the primary switch. Above the maximum power limit set by the current sense resistors, the over-current protection is enabled in order to protect the system from overheating.

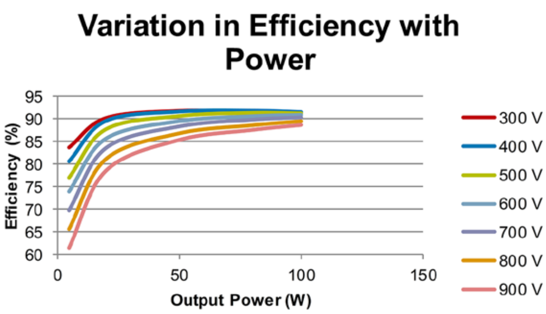

Fig. 6: Efficiency Waveform for different Power and Input Conditions

Fig. 6 shows the efficiency plot of the converter over a wide range of operating conditions. As expected the efficiency increases with increase in output power but shows a marginal decrease with the increase in input voltage. For this circuit the switching losses of the SiC MOSFET increase with an increase in the input voltage, the worst switching loss condition for the MOSFET being at 900 V input voltage. Overall, a peak efficiency of 92 % is obtained which proves the benefits of using SiC in this application. Fig. 7 shows the case temperature of the SiC MOSFET which was measured to be 98 ^{0}C at an input voltage of 900 V resulting in a junction temperature far less than the allowed maximum junction temperature of 175 ^{0}C.

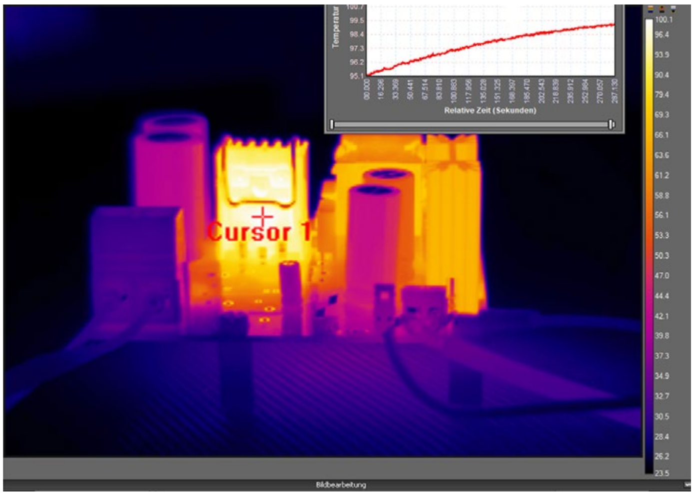

Fig. 7: Case Temperature of the SiC MOSFET

The current version of the Evaluation Board allows operation with DC input voltages in the range of 300 V to 900 V. With the addition of a rectification stage at the input of the PCB can also be operated with a 3 phase AC supply of 400/480 V. For the final application however, appropriate filtering also needs to be implemented to adhere to the applicable EMI norms.

The use of SiC allowed the development of an efficient and a simple auxiliary power supply as compared to Silicon based design. Recently ROHM Semiconductor announced the addition of 4 new ICs in its portfolio of AC/DC controller with an integrated 1700 V 4 A SiC MOSFET. The development of these ICs makes the design of an Auxiliary Power Supply much simpler as the passives surrounding the IC can be easily chosen based on certain design steps. These integrated SiC FET ICs are available in the TO220-6M package as shown in Fig. 8 and are the latest in the list of the quasi-resonant controllers which allow a very high flexibility in the design.

Fig. 8: AC/DC Controller IC with an Integrated 1700 V SiC MOSFET

In the future, an application note with detailed description of the circuit will be released for the 100 W 24 V output evaluation board with a corresponding component list. The evaluation board for the auxiliary power supply unit can be obtained by contacting ROHM Semiconductor directly.

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