San’an Gen 6 650V
SiC Schottky Barrier Diode

Lower V_F, higher Efficiency

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High System Efficiency is often pursued in the design of Power Supplies, driving the reduction and minimization of losses. SiC Schottky Barrier Diodes (SiC SBDs) do not have reverse recovery charge since they are majority charge carrier devices whose currents are realized through the flow of electrons. The main source of loss is usually the conduction loss (P_{cond}). Mathematically, this can be expressed as:

$$P_{\text{cond}} = V_{\text{F}} * I_{\text{F}}$$

It can be seen that the conduction losses are directly affected by the Forward conduction current IF and the forward voltage drop V_F. The system operating conditions define the forward current, pushing the designer to select a diode with as low V_F as possible to reduce the diode losses.

The I-V curve of the sixth generation (G6) 650V SiC SBD has a higher slope and a lower V_F than the third generation (G3) SiC SBD. This puts the G6 at an advantage over G3 devices since the losses, and hence the temperature rise, are lower for the same operating point. The Forward characteristics of San’an’s 650V G3 and G6 SiC SBDs are compared in Figure 1. The comparison shows the Forward characteristics for diodes with I_F rated at 4A and 10A measured at 25°C and 175°C.

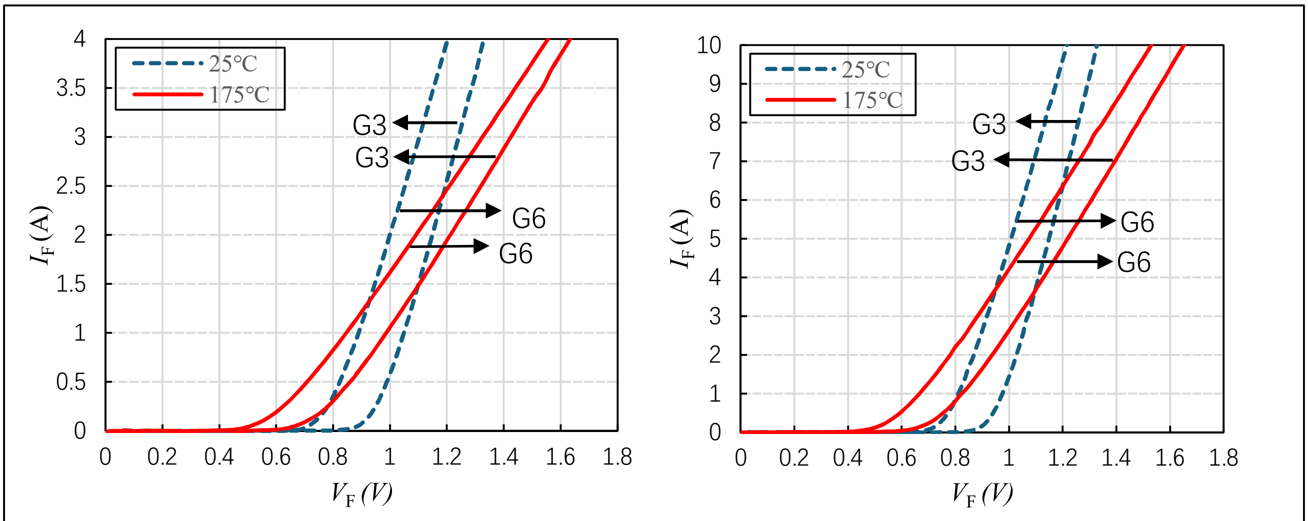

Figure 1: Forward Characteristics comparison at I_F= 4A (left) and 10A (right)

As seen from the curves, G6 devices have lower V_F compared to the G3 devices, both at 25°C and 175°C. It is also observed that the forward drop of the SiC SBDs has a positive temperature coefficient, which means that a positive change in junction temperature causes a positive change in the V_F for the same I_F. As compared to Si diodes, which have a negative temperature coefficient, the positive temperature coefficient is advantageous when used at higher operating temperatures or in parallel configurations. Considering the scenario where a branch of the paralleled Si diodes experiences an increase in current due to an abnormal operating condition, causing the device temperature of the branch to increase, the current sharing between the branches is affected. The increased current causes further increases the ohmic losses, leading to a further junction temperature rise, eventually causing thermal runaway, and destroying the diode. As a result, the other branches are forced to bear more current, leading to thermal runaway, and finally destroying all the paralleled diodes. This situation is avoided in SiC SBDs due to the positive temperature coefficient of the V_F. Under similar abnormal conditions, if the temperature of the SiC SBD increases, the current in the branch reduces to maintain a constant voltage across the device thereby avoiding a catastrophic failure of the devices.

Further analysis on the 650V 6th Gen SiC SBD has been carried out and the thermal performance in terms of temperature rise and heat dissipation has been compared with the previous generations, namely Gen 3 (G3) and Gen 4 (G4). The diodes used in the comparison were packaged in a standard TO220 package, and tested at an ambient temperature of 23°C. The 650V/4A diodes (all generations) were subjected to a test current I_{DC}=2A, and the 650V/10A diodes (all generations) were tested at I_{DC}=5A. The maximum hotspot temperature on the surface of molding compound of the TO220 package was measured and plotted. The results are shown in Figure 2.

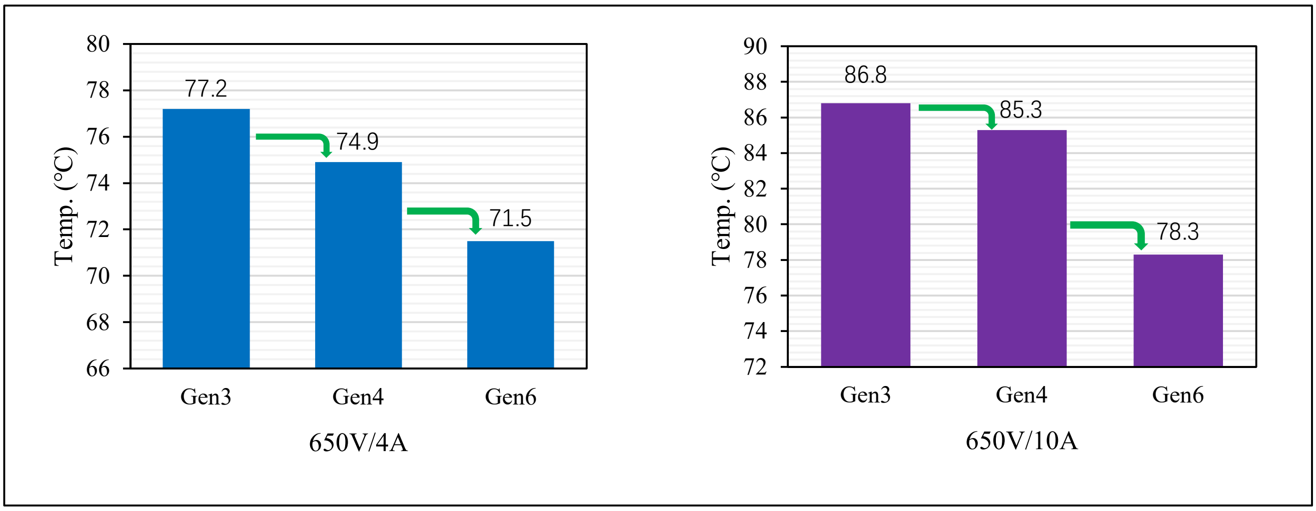

Figure 2: Temperature Rise Comparison of Sanan's G3, G4, and G6 650V/4A SiC SBD (left) and 650V/10A SiC SBD (right)

Figure 2 shows that the temperature rise of the 650V/4A G6 SiC SBD is 7.4% lower than its G3 counterpart, whereas the 650V/10A G6 SiC SBD is 9.8% lower than its G3 counterpart. These are significant figures that translate to improvement in system efficiency and thermal performance. This is demonstrated through the system-level performance evaluation of a 100W Off-Line Power supply/LED driver supplied from the Mains. Figure 3 shows the schematic of the LED power supply. The SiC SBD has been used in the PFC conversion stage, clearly marked in Figure 3. The device used is the 650V/4A G6 SiC SBD, the SDS0650J004C6. The power supply adopt PFC as front-stage and double-transistor forward topology as second stage.

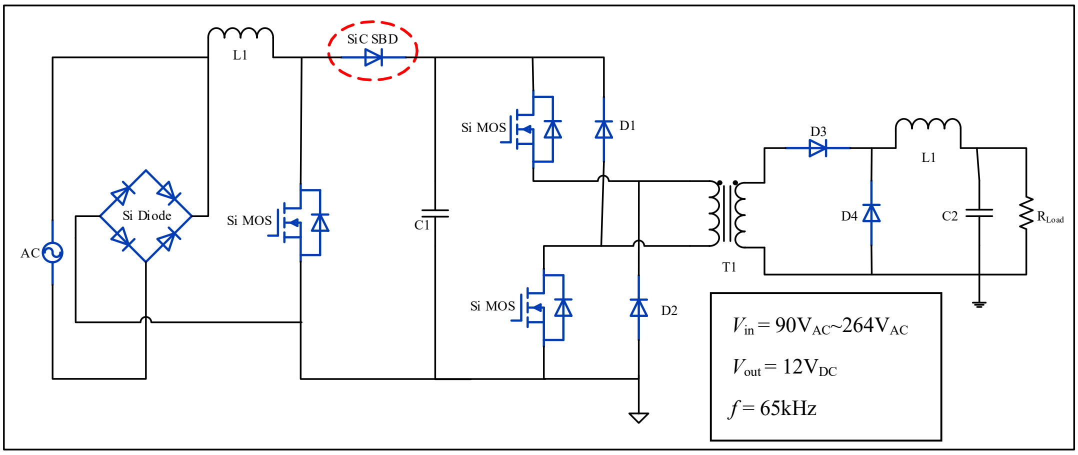

Figure 3: 100W LED Power Supply

The thermal performance of the SDS0650J004C6 is measured and compared with a 650V/10A Si Fast Recovery Diode (FRD). For both cases, the system efficiency is also measured at various loads and different input conditions and compared.

As shown in Figure 4 and Figure 5, this is the comparison of load-carrying efficiency between SDS0650J004C6 and the 650V/10A Si fast recovery diode (FRD) in the LED power supply system under different input voltages and other conditions when the ambient temperature T_{amb} = 25°C.

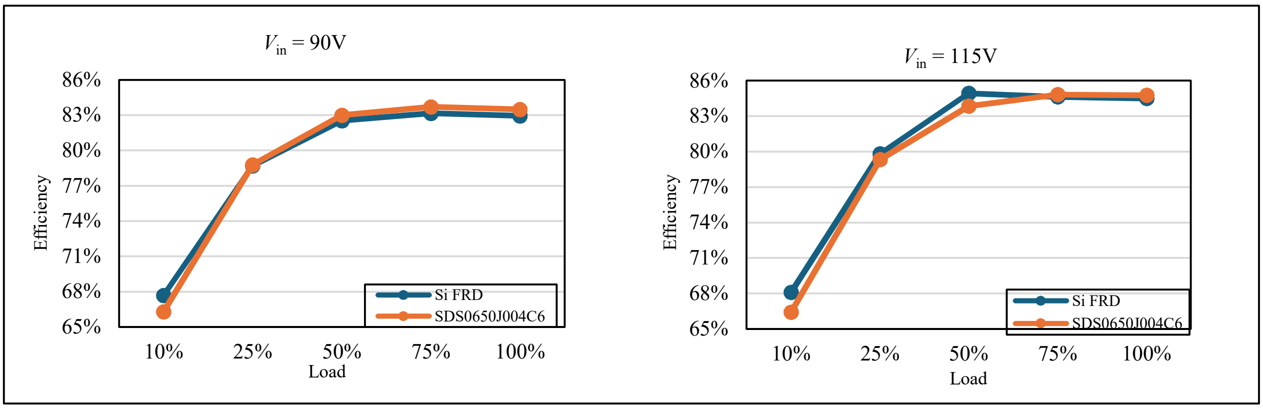

Figure 4: SDS0650J004C6 compared to 10A Si-FRD on Efficiency for V_{IN} = 90VAC (left) and 115VAC (right)

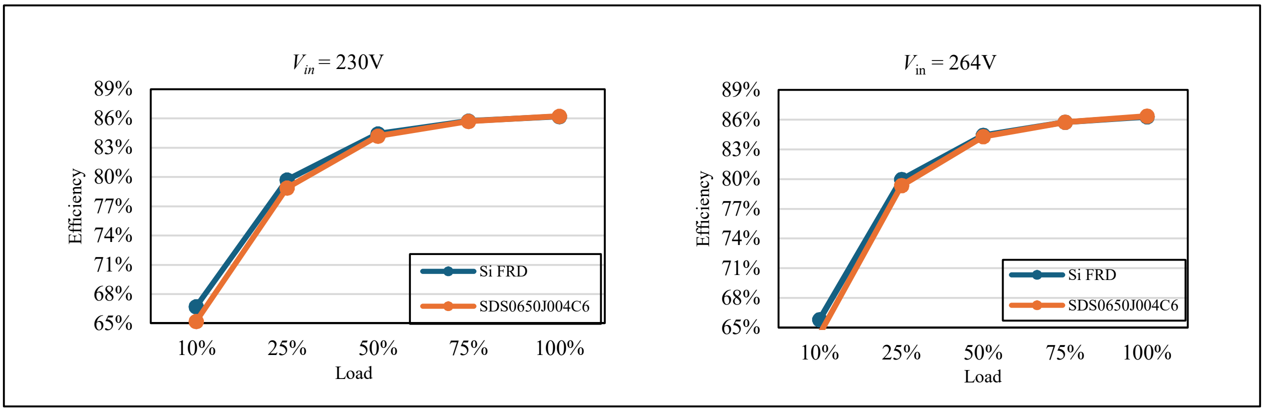

Figure 5: SDS0650J004C6 compared to 10A Si-FRD on Efficiency for V_{IN} = 230VAC (left) and 264VAC (right)

Figure 6 shows the thermal images taken from an IR camera at full load of 100W, and an input of 90VAC. The temperature of the metal clip that straps the Diode to the heatsink is measured.

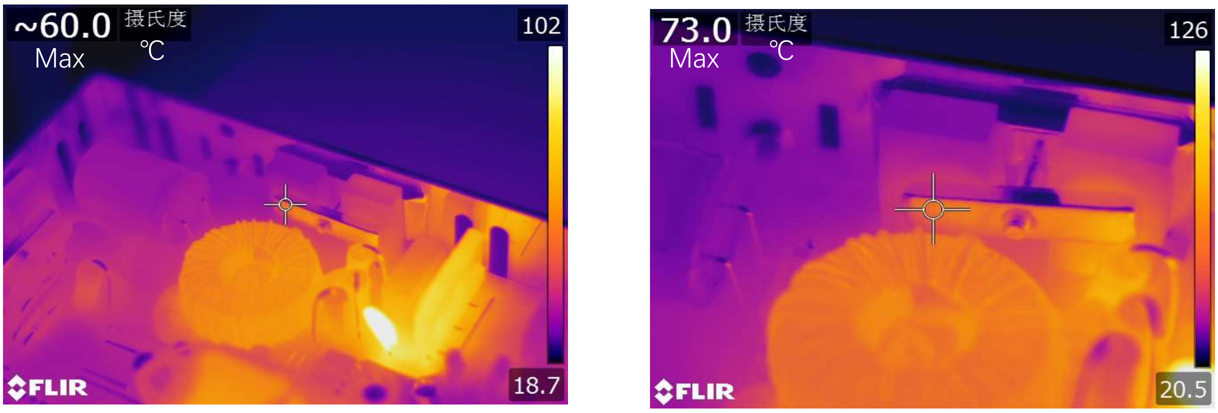

Figure 6: Metal Clip Temperature of SDS0650J004C6 (left) and 650V/10A Si FRD (right)

Test data show that, although the surface temperature of the SDS0650J004C6 is around 60°C, the maximum system efficiency is 86.48%, despite the harsh operating conditions. This is equivalent to system efficiency when a 650V/10A Si-FRD is used. Under the same conditions, the surface temperature of the Si-FRD is 73°C, which is 13°C higher than SDS0650J004C6. This can be attributed to the fact that the conduction loss is lower in SiC devices, which reduces the temperature rise of the diode itself, thereby reducing the temperature rise of the surrounding components. Also, the reverse recovery current (I_{rr}) of the SiC SBD is almost zero, which is caused by the oscillation of the parasitic inductance with the junction capacitance. On the other hand, Si FRD has a higher I_{rr}, and is prone to voltage spikes and oscillations (hard recovery) during the reverse recovery process, leading to higher energy loss and higher temperature rise in addition to causing EMI problems. When designing power supplies with higher switching frequencies and higher power densities, the limitations and hidden risks associated with Si FRD will only amplify, making the benefits of SiC SBDs more obvious.

In summary, the low on-voltage (V_F) of San'an's 6th Generation SiC SBD, the SDS0650J004C6, allows cooler operation due to lower conduction losses, which can help power supply engineers to simplify the design of heatsink and thermal management, paving the way for lighter, more compact power supplies with higher power density, effectively controlling costs, and extending the service life of the device without the risk of thermal runaway.

San'an's 6th Generation 650V SiC SBD

I_F (A)	TO220-2L	TO220N-2L	TO252-2L	SMA	SMB	Bare die
View						
2A					SDS26E6	SDS065J002B6
4A	SDS065J004C6		SDS065J004D6	SDS46A6	SDS46E6	SDS065J004B6
6A			SDS065J006D6			SDS065J006B6
10A	SDS065J010C6	SDS065J010N6	SDS065J010D6			SDS065J010B6

(THE LATEST PRODUCTS CAN BE FOUND ON THE OFFICIAL WEBSITE OR CONTACT SALES.)

Industry application