

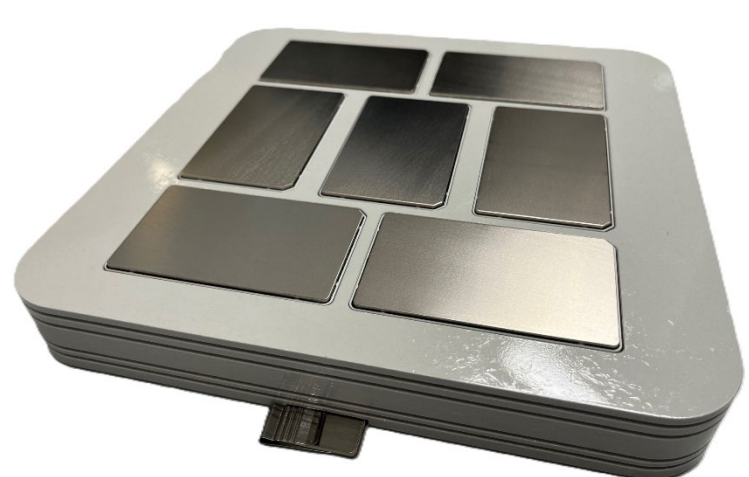
New generation Ultra high-power semiconductors for VSC-HVDC applications

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Hitachi Energy Semiconductors Ltd. www.hitachienergy.com/semiconductors



VSC-HVDC bulk power transmission plays an essential role in achieving Carbon Neutrality and, in turn, calls for more powerful power semiconductors with higher current capability. Such power devices need to fulfill higher current, higher operating temperature, higher short circuit capability, higher surge current capability, lower losses and even higher reliability to ensure power availability. To address these challenging demands, we have further optimized chip design, leading to successful development of IGBT rated at 6250A accompanied by discrete Fast Recovery Diode (FRD) with unprecedented area.



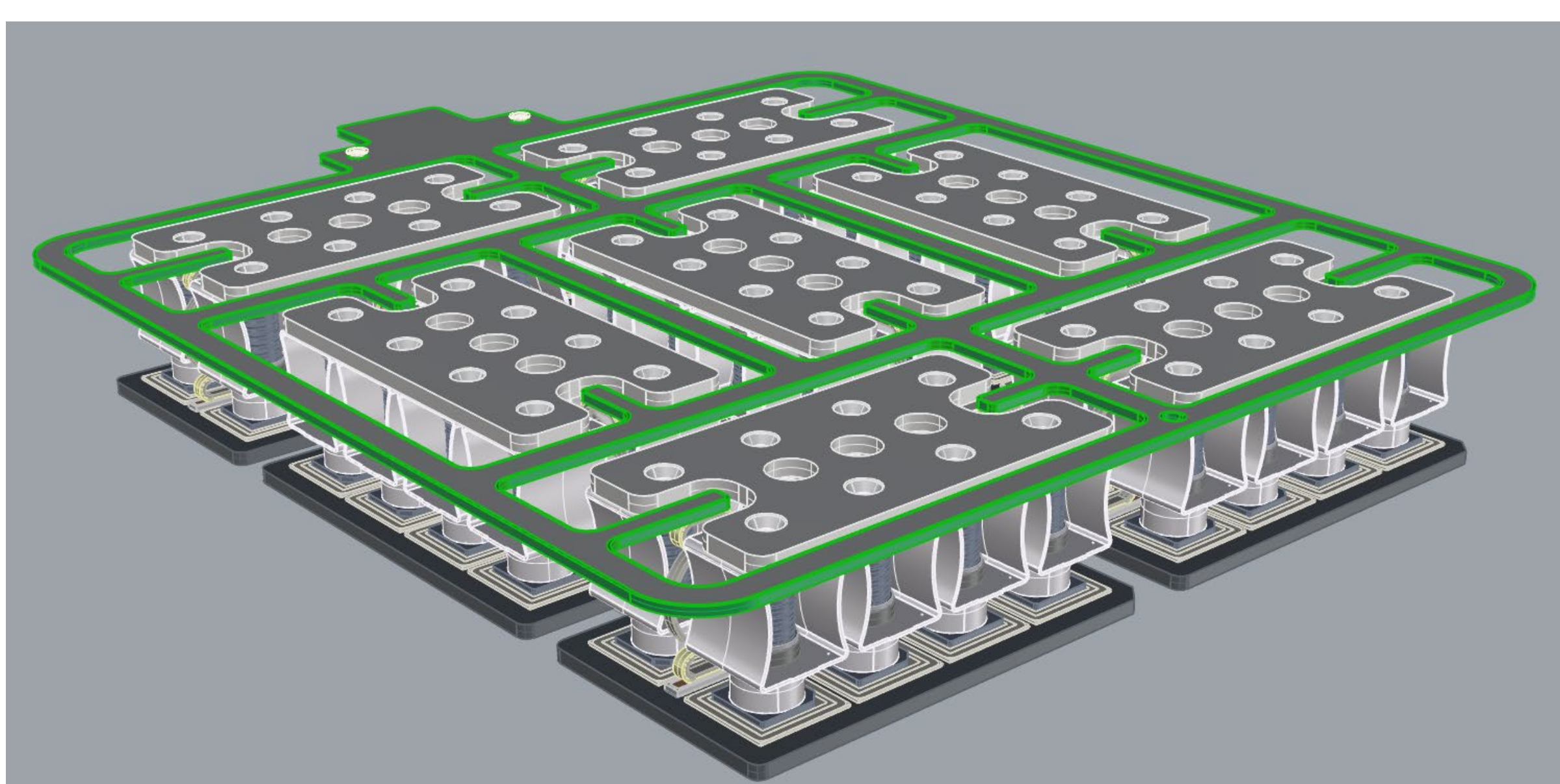
The IGBT StakPak



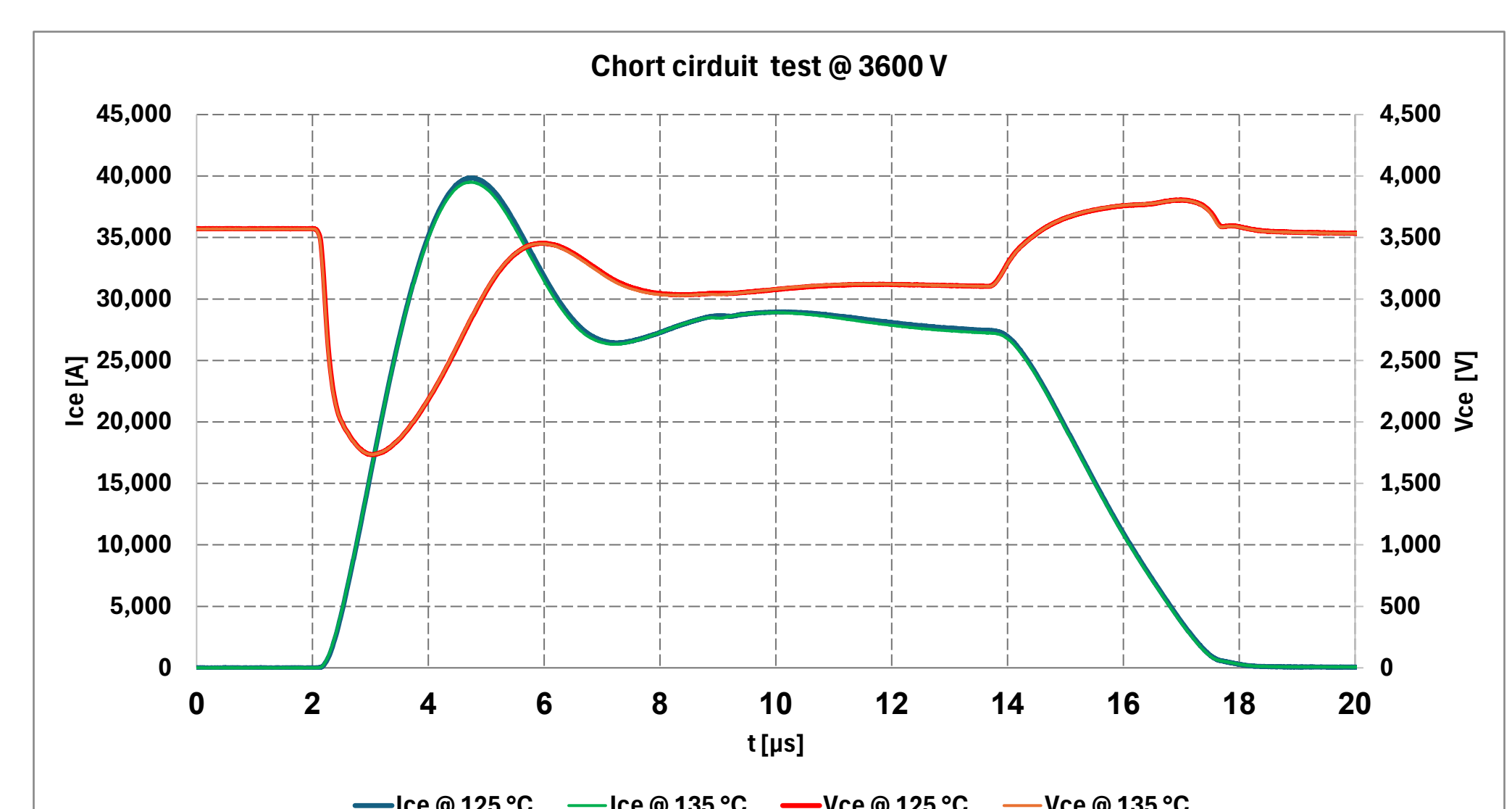
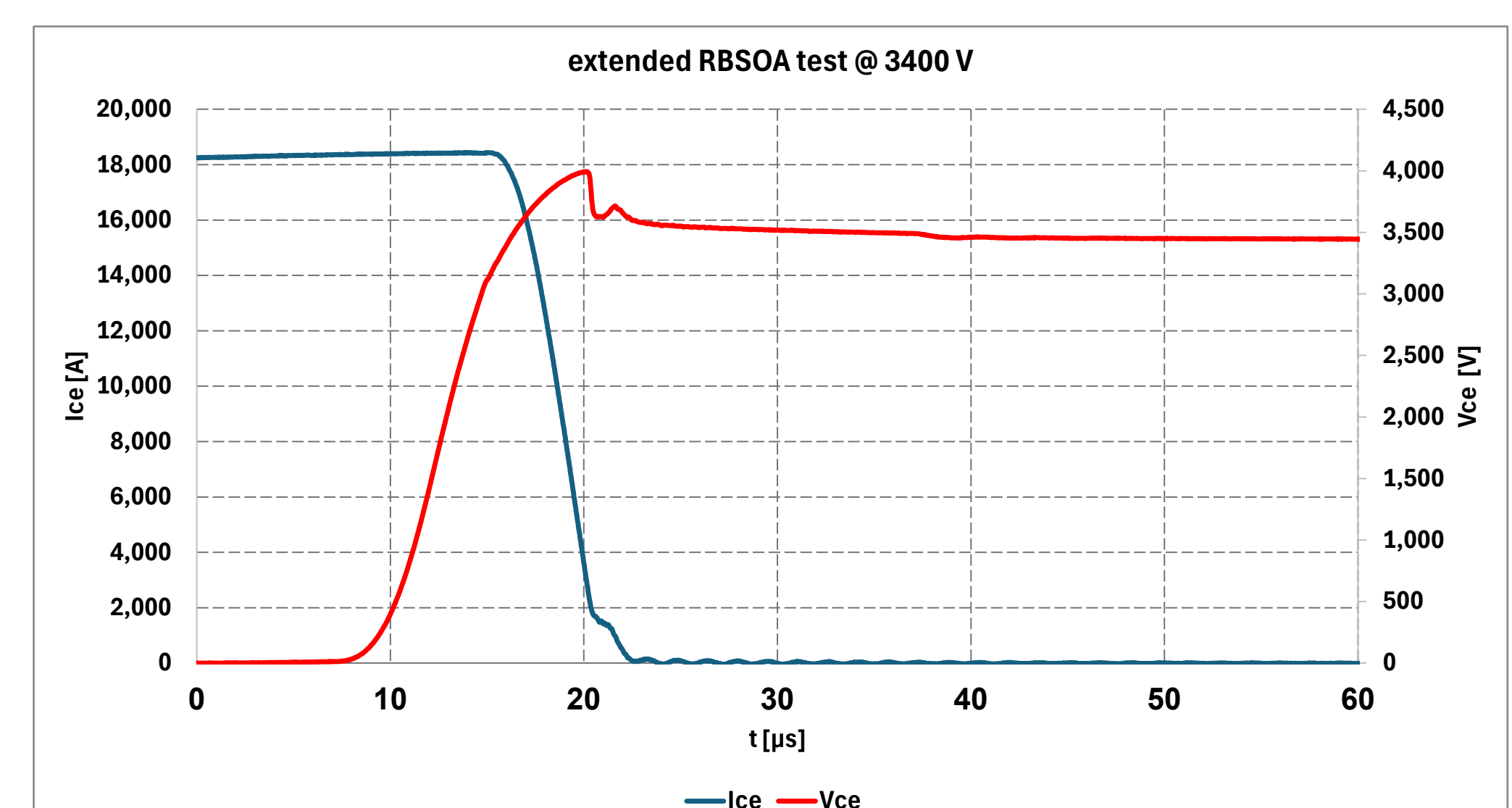
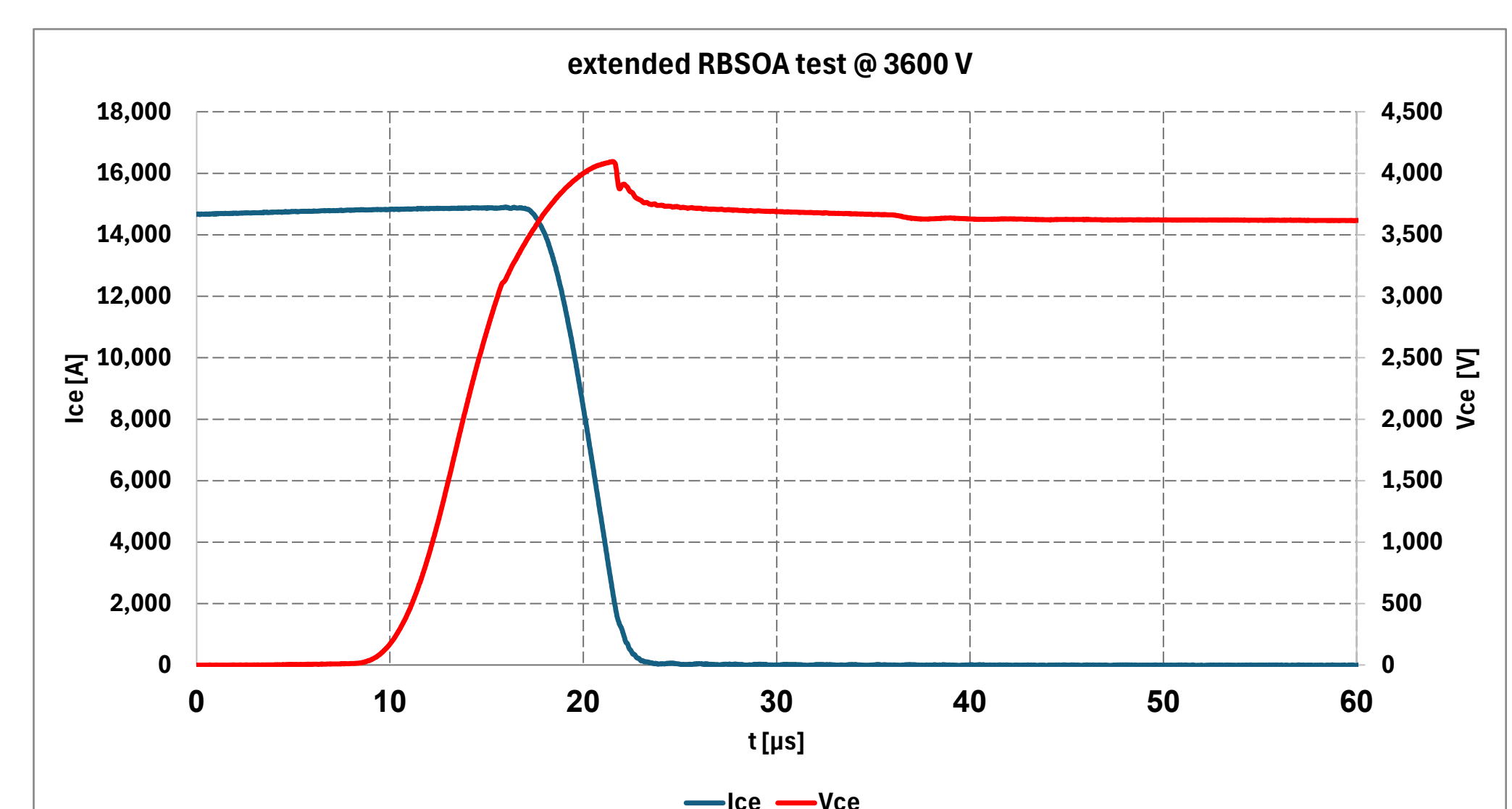
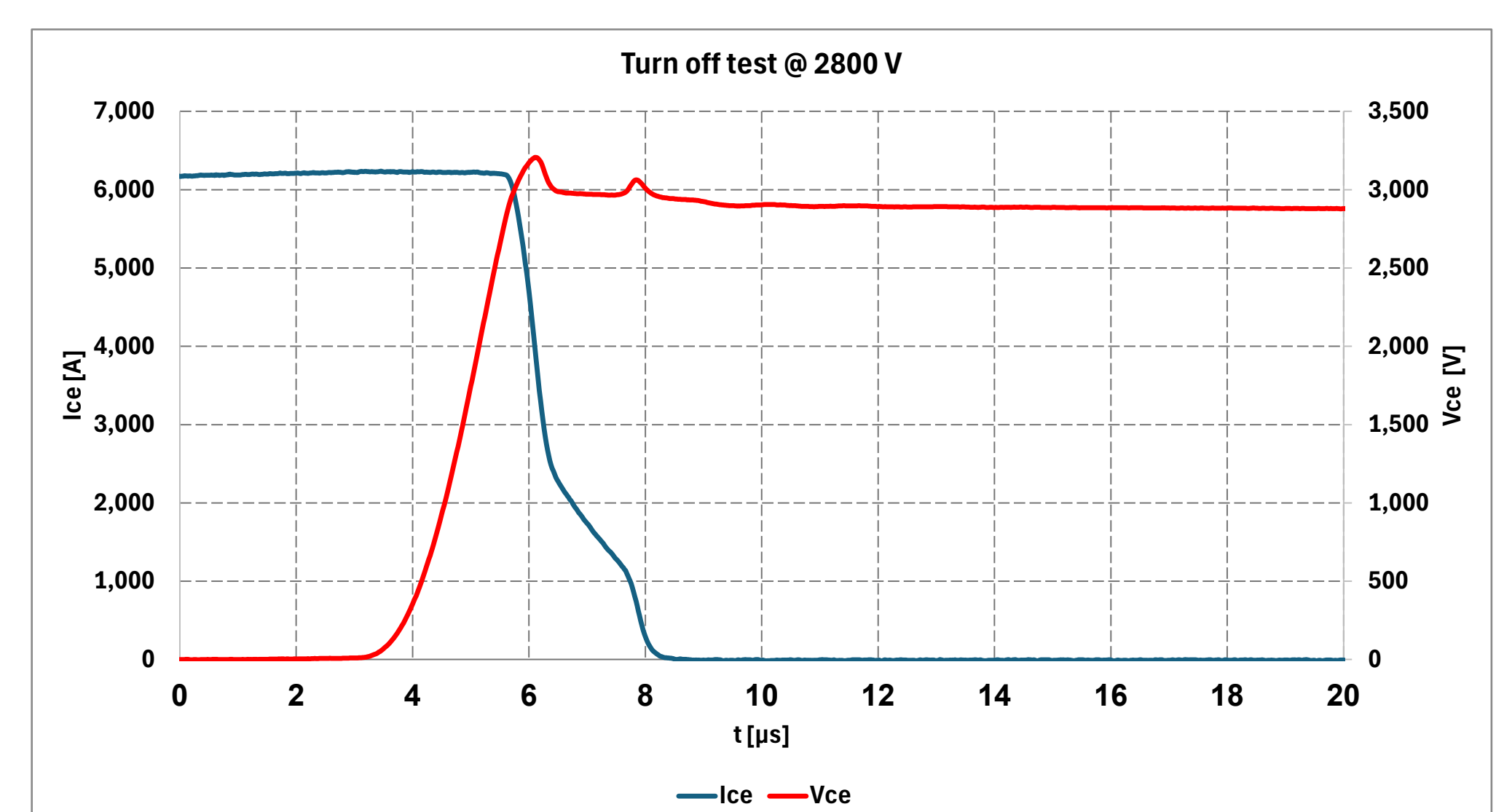
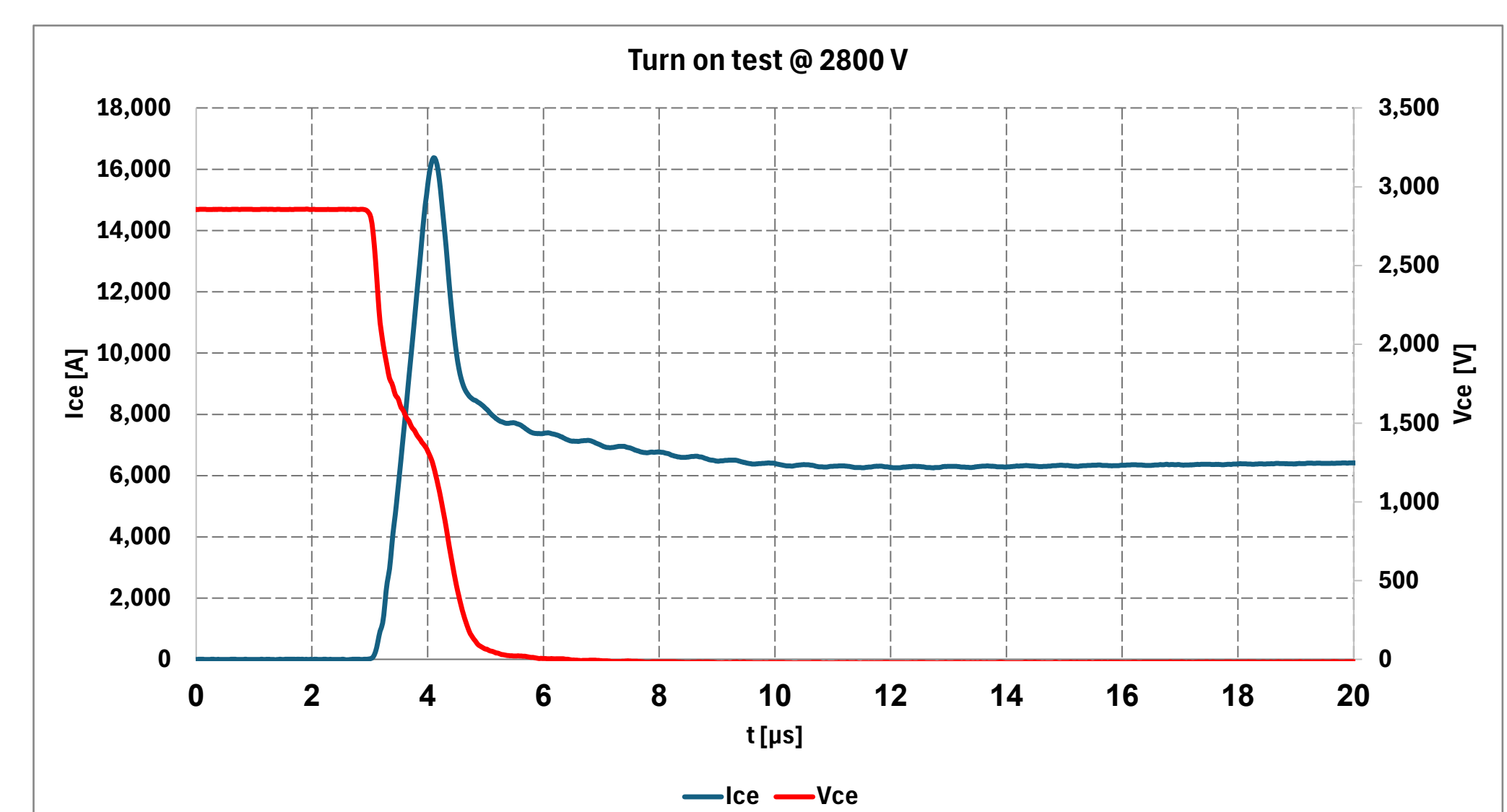
Discrete Bipolar diode

Module design with Optimized electromagnetic

A balanced current sharing between sub-modules parallel connected in an IGBT module is a fundamental requirement to upscale current rating and to maximize the performance, efficiency, and reliability of the product [2]. To this end, sub-modules are rigorously evaluated individually to verify their performance and reliability standards. Following individual testing, the sub-modules are then assessed in parallel on module level to ensure they can work together harmoniously, sharing the current evenly under various operating conditions.



Internal details of exemplary 7-sub StakPak module used for EM simulation.



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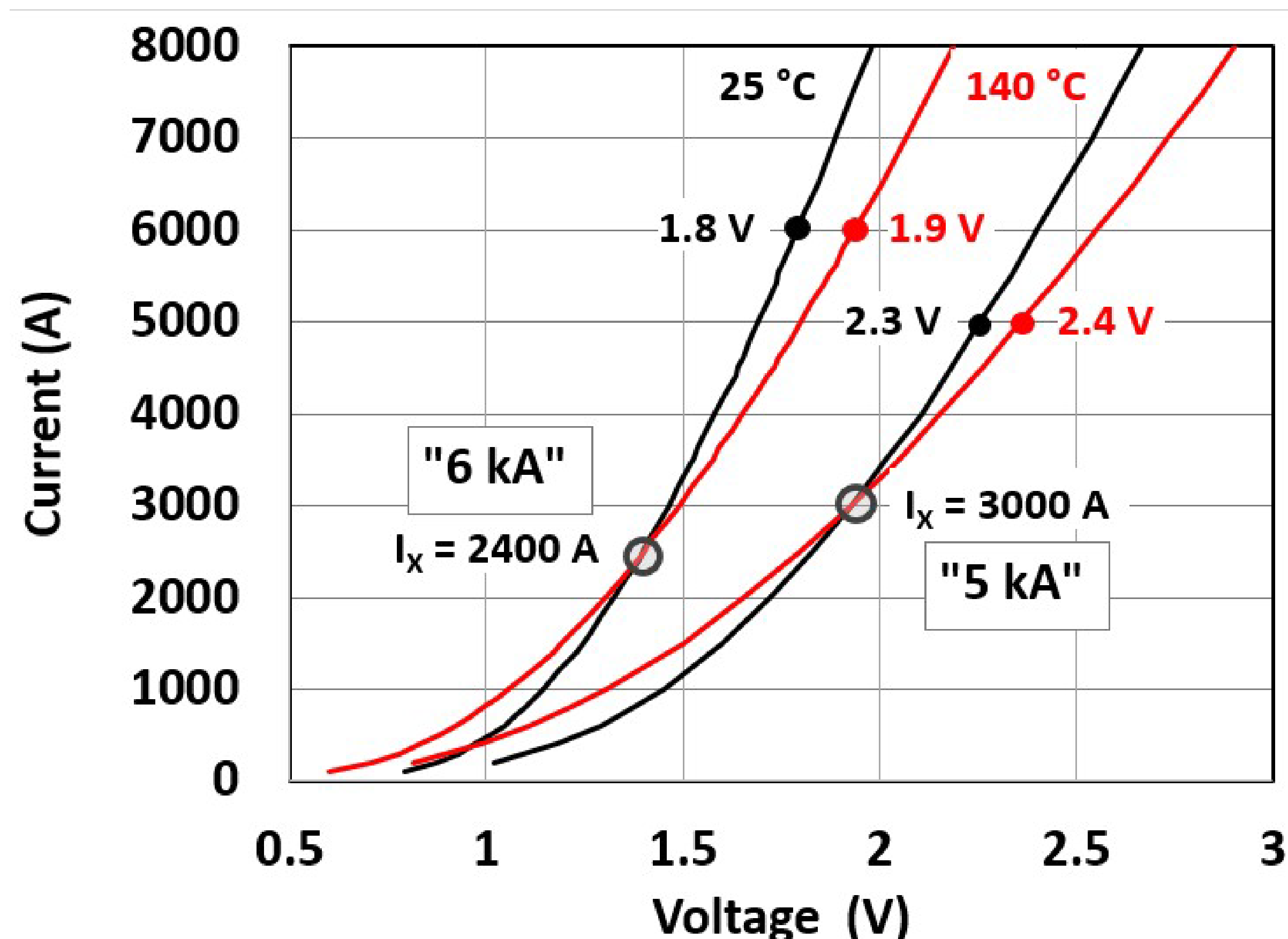
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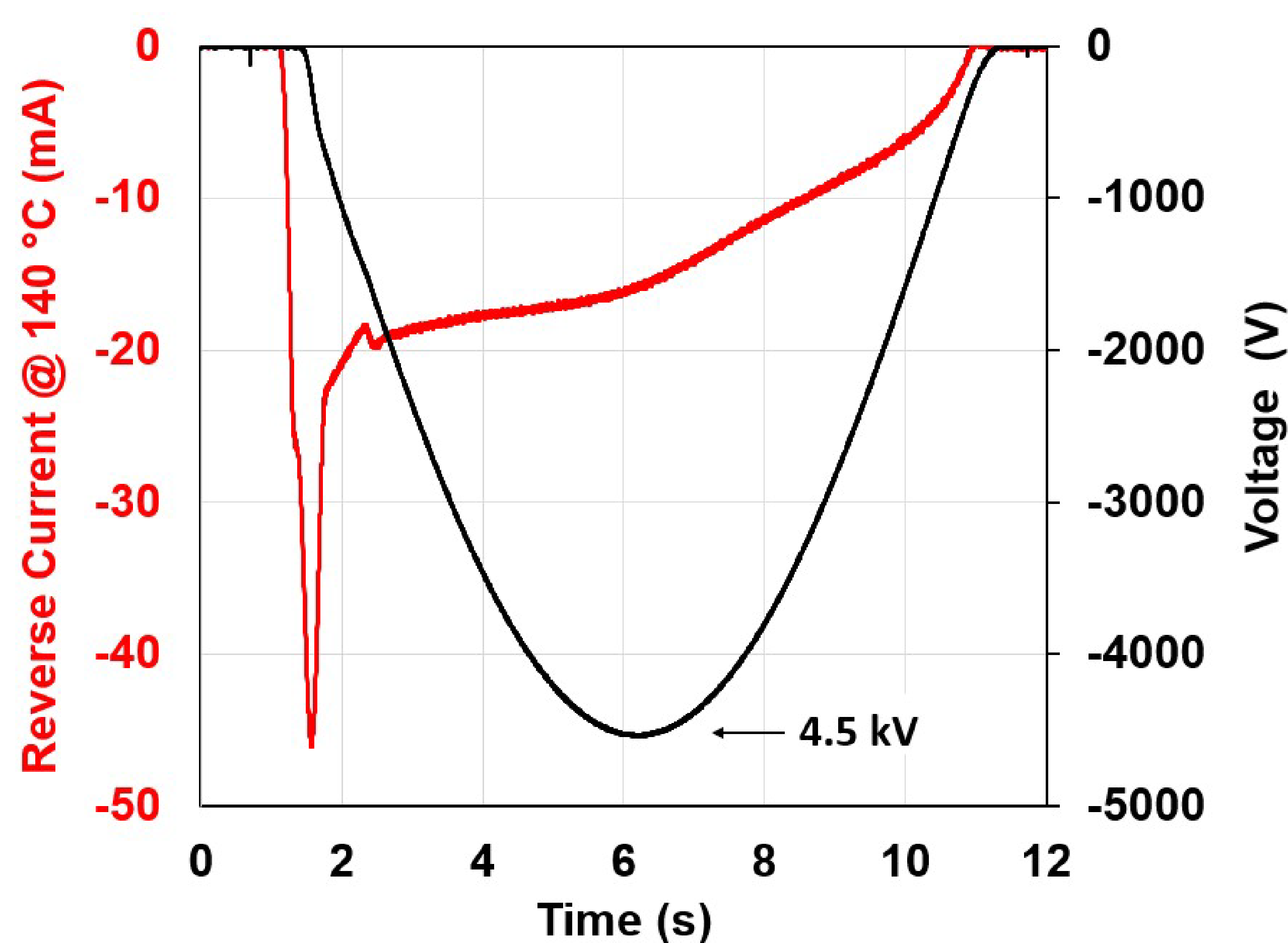


The 6 kA Fast Recovery Diode

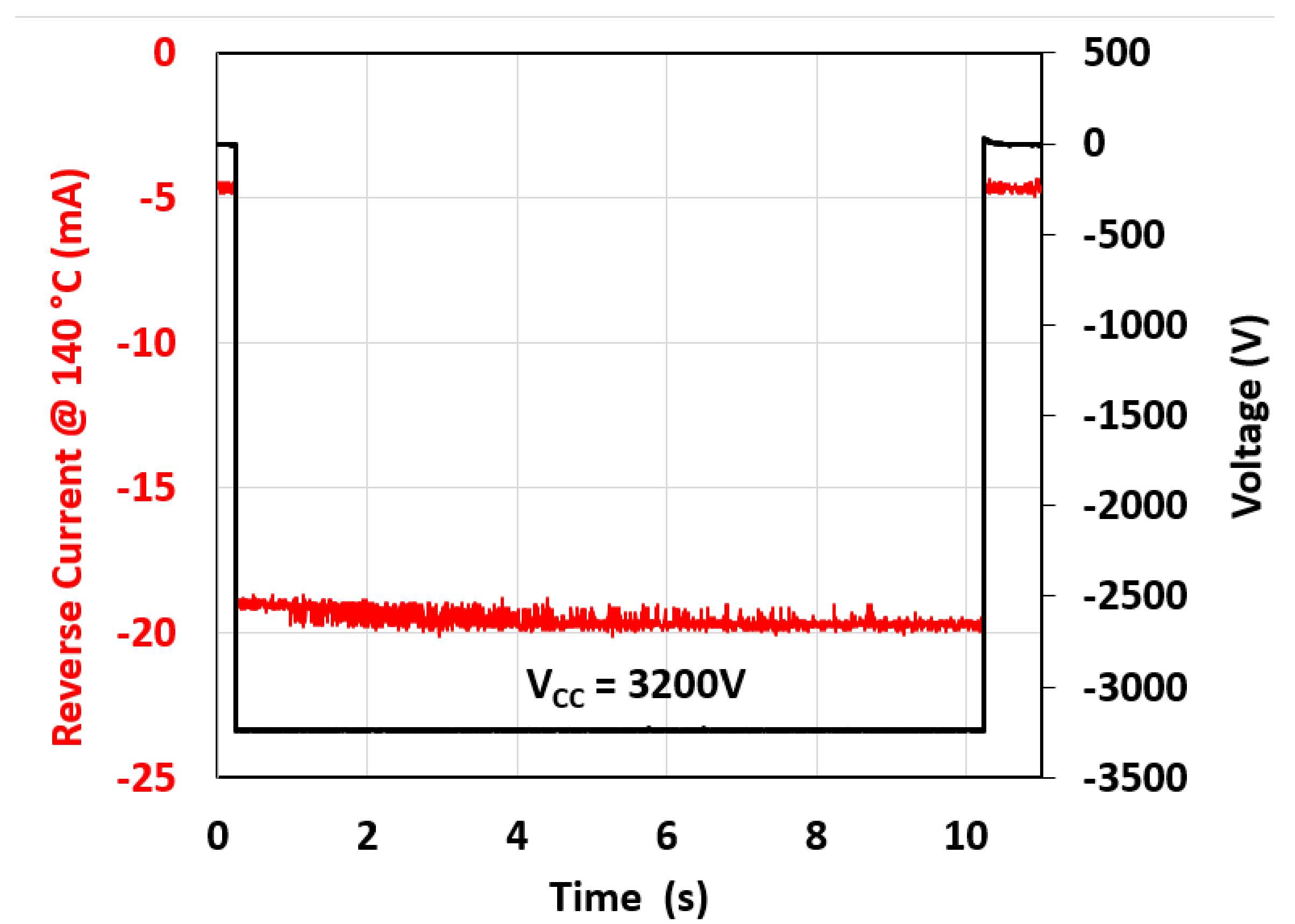
The new diode with 6 kA rating is the follower of the existing discrete 4.5 kV FRD 5SDF 45U4521 in ceramic housing with the pole piece of 119 mm, up to this time the largest FRD in the product portfolio of the Hitachi Energy. The device consists of classical P-i-N diode wafer with typical on-state voltage drop $V_F = 2.4$ V at $I_F = 5$ kA.



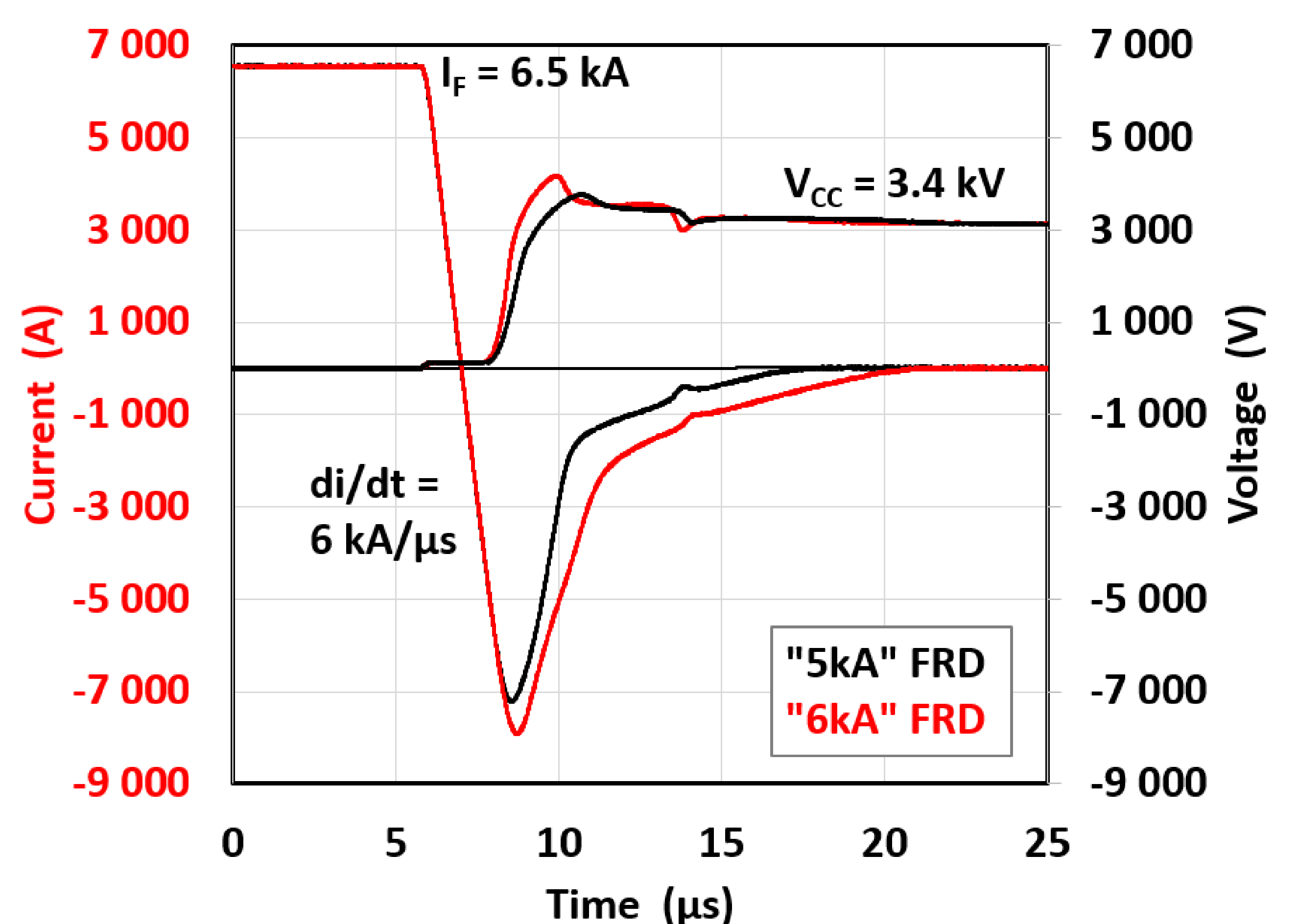
Forward I-V curves of 5SDF 45U4500 ('5kA') and new '6 kA' FRD.



AC blocking stability of 6 kA diode measured for half sine wave up to $V_{RRM} = 4.5$ kV at $T_{jmax} = 140$ °C.



DC blocking stability of 6 kA diode at DC link voltage $V_{CC} = 3.2$ kV measured at $T_{jmax} = 140$ °C.



Reverse recovery at 3.4 kV DC link voltage

FRD	I_F (kA)	I_{rr} (kA)	di/dt (kA/μs)	V_{DC} (kV)	Q_{rr} (mC)	E_{rec} (J)	P_{prec} (MW)
5 kA	6.5	7.2	5.8	3.4	19.8	52.7	22.8
6 kA	6.5	7.9	5.8	3.4	28.8	73.0	20.3

Parameters of reverse recovery from picture above