Application Note: IPAN1006

B-TRAN® Customer FAQ for Solid-State Protection Applications

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1. What is B-TRAN® and what problem does it solve?

B-TRAN® is a **bidirectional low-conduction-loss solid-state switch** designed for static or conduction-dominant power paths, with controllable turn-off for protection and bidirectional blocking at the device level. It solves the core problem you run into with MOSFET-based solutions in these paths: conduction loss and temperature rise scale badly with increasing current, and bidirectional blocking requires **back-to-back devices plus more driver complexity**.

2. Where does B-TRAN® fit best (and where does it not)?

B-TRAN® fits best where the **switch is ON** most of the time and you only switch during transfer or fault isolation [Solid State Circuit Breaker (SSCB), Static Transfer Switch (STS), EV Contactor, Battery Disconnect Unit (BDU) or similar applications]. It is not positioned today as a high-frequency PWM device where switching loss is the dominant term. **Concrete rule of thumb**: If your switch is ON most of the time, and current is high enough that conduction dominates, B-TRAN® is a strong fit.

3. What is B-TRAN® on-state voltage drop? What is the SiC MOSFET equivalent?

B-TRAN® behaves like a **forward voltage drop** device (loss ~ V·I) while a SiC MOSFET/JFET is $R_{ds(on)}$ (loss ~ I^2R and R rises with temperature). For comparison at your operating point, we can express B-TRAN® as an “equivalent R”:

$R_{eq} = V_{drop} / I$ at that current and temperature. That’s a fair apples-to-apples way to compare conduction at one operating point.

4. How do we calculate total power loss for B-TRAN®?

Use this:

- **Conduction**: $P_{cond} \approx V_{drop} \cdot I$
- **Base Drive**: $P_{drive} \approx V_{drive} \cdot (I/\beta)$
- **Cascode Loss:** $P_{cascode} \approx 2 \cdot I^2 \cdot R_{ds(on)}$
- **Events**: add switching energy only for transfer/trip events (E_{on}/E_{off} × events/sec)

5. Does B-TRAN® have a thermal advantage? How is cooling typically done?

B-TRAN® has a thermal advantage for two reasons.

First, in conduction-dominant applications it typically generates less heat because **conduction loss behaves like a low voltage drop** rather than an $R_{ds(on)}$ which rises squarely with current. That allows either higher current in the same cooling envelope or simpler cooling for the same current.

Second, the device structure allows heat removal from both sides, enabling **double-sided cooling**. This reduces effective thermal resistance and improves heat spreading, which is especially beneficial in high-current SSCB and STS applications where continuous conduction is followed by short fault-energy events.

Cooling itself is conventional: heatsink with forced air or cold plate, using steady-state R_{thJC} and transient Z_{thJC} for fault analysis.

6. Voltage rating: is 1200 V a continuous operating voltage?

1200 V is an **off-state blocking rating** of discrete B-TRAN®, not a recommended “operate at 1200 V bus” number.

7. Can B-TRAN® be used in series?

Yes, B-TRAN® can be used in series to achieve higher voltage capability, but series operation must be engineered for both **static and dynamic voltage sharing**. This requires appropriate balancing networks, symmetric layout and parasitics, and coordinated drive and protection behavior so that one device does not experience excessive voltage during switching or fault events. Series connection is therefore a system-level design activity, not simply placing devices in series.

8. Can B-TRAN® devices be paralleled?

Yes, **parallel operation is feasible** if layout and thermal symmetry are handled properly and protection thresholds are aligned. B-TRAN® has Positive Temperature Coefficient (PTC) which allows for safe paralleling of devices for higher power applications. Ideal Power has demonstrated this successfully for customers.

9. What is the current gain (β) of B-TRAN®? Can it be higher?

β is the ratio of emitter current to base current under stated conditions. **Typical values are in the range of 4.5 to 9**. The present generation of devices are intentionally optimized for protection and high-current conduction performance rather than maximizing gain alone. Device improvements are continuously being pursued as part of normal product evolution, but customers should design based on the published characteristics of currently available devices.

10. Does base drive erase conduction advantage?

No, if you're in the conduction-dominant region B-TRAN® is intended for, **base power is part of the budget but does not usually erase the advantage**. The right way to settle this is a one-line comparison at your operating point:
$(P_{cond} + P_{drive} + P_{cascode})$ versus $(I^2 R_{ds(on)})$ for a back-to-back MOSFET solution.

11. Turn-on/turn-off times: why not *ns* numbers?

Because in static protection and transfer applications, the product doesn't win on "*ns*". They win on **Inverse Time Current Characteristic (ITCC)**, **Short Circuit Withstand Time (SCWT), Soft turn-off energy limits**, overshoot voltage managed using snubbers, system designed clearing time and related turn-on/turn-off EMI.

12. Why active turn-off is required (vs. thyristor)?

Thyristors are great when the system naturally commutates and you can wait for a zero crossing. In converter-fed faults and DC systems, you often need **forced interruption and controllable energy handling**. Active turn-off gives you deterministic isolation and coordination.

13. What is the "interrupting capability" of a B-TRAN® based SSCB?

Interrupting capability of a B-TRAN® SSCB defines the **maximum fault current** that can be safely interrupted at a specified system voltage while maintaining device integrity and repeatable operation. This capability depends not only on the SSCB device itself but also on key system design parameters such as DC bus voltage, loop inductance, protection response time, and the selected snubber or clamp network. These parameters determine how quickly fault current rises and how the stored inductive energy is managed during interruption.

As a result, the interrupting capability represents a qualified operating condition, and customers select or confirm their SSCB rating by ensuring their system inductance, protection timing, and energy management approach fall within the specified design range.

14. How does B-TRAN® behave in a short-circuit event (step-by-step)?

When a short circuit occurs, **fault current begins to rise** according to system voltage and wiring inductance. The SSCB **detects abnormal current** within microseconds using electronic protection. The B-TRAN® then **turns off in a controlled manner** while the snubber capacitor and clamp manage stored energy. Current is interrupted without arcing, and the device safely **blocks system voltage**. The process is fast, repeatable, and allows the SSCB to return to service **without mechanical wear or replacement**.

15. Will higher dI/dt cause excessive temperature rise?

Higher dI/dt by itself does not directly cause excessive temperature rise. Temperature rise is primarily determined by how much current flows and for how long. A **higher dI/dt simply means the fault current reaches its peak faster**, which reduces the available time before the protection system must act. The B-TRAN® SSCB is designed to detect and interrupt faults within this allowable time window, ensuring the device remains within safe thermal limits. In practice, system inductance and protection response time are considered during application design so that even fast-rising fault currents are safely managed.

16. What does the B-TRAN® driver look like? Can Ideal Power provide a driver/protection solution?

B-TRAN® is a current-driven device, so the driver architecture is different from a conventional MOSFET gate driver. The drive solution includes controlled base current, appropriate bias and power supplies, and cascode elements to achieve the required normally-off system behavior and controlled turn-off during protection events.

Ideal Power has developed **custom driver and protection implementations** to support evaluation and system development. These include the required base drive control, supporting power supplies, and recommended protection approaches to demonstrate proper device operation and fault handling.

We can support customers with reference design hardware. The final driver architecture, however, must be aligned with the customer's isolation strategy, system topology, sensing method, and safety requirements, since these are system-level decisions rather than device-only choices.

17. The package looks unique-can you support other package forms (e.g., top-side cooling)?

The current B-TRAN® package is **intentionally designed for high-current SSCB and protection applications**, where low parasitic inductance, high current capability, and strong thermal performance are critical. The package supports efficient heat removal and current flow suited to conduction-dominant operation and fault interruption. It enables effective thermal management including **double-sided cooling** approaches when integrated at the system level.

Alternative package forms, including top-side cooling or application-specific mechanical formats, are possible. However, any new package option requires proper thermal, electrical, and reliability qualification to ensure performance is maintained under protection and fault conditions. We typically evaluate alternative packaging together with customers once cooling method, mechanical constraints, creepage/clearance requirements, and expected production volumes are defined.

18. Reliability / qualification status?

B-TRAN® devices are currently undergoing both **automotive and industrial qualification processes**, with the required reliability testing already in progress. These qualification activities include long-term reliability and application-relevant stress testing aligned with protection and high-current operating conditions. The qualification programs are scheduled to be successfully completed by summer 2026.

Qualification scope and documentation are aligned to the customer's target industry requirements, and we continue to work with customers to ensure validation matches their specific system-level reliability expectations.

19. How does cost compare to SiC MOSFET / JFET / IGBT / thyristor solutions?

Cost comparison for B-TRAN® should be evaluated at the system level, not at the individual device level. In many protection and bidirectional applications, overall cost is influenced by total device count (for example back-to-back or cascode arrangements), driver complexity, snubber and clamp requirements, thermal management, and the margin required to meet reliability and protection targets.

In architectures where **bidirectional blocking and controlled protection behavior** simplify the overall implementation, B-TRAN® can **reduce total system cost** by lowering component count and simplifying thermal and protection design.

Device pricing and commercial terms are application and volume dependent. As programs move toward production volumes, we work with customers to align pricing and discuss volume-based cost optimization and pricing as part of the commercial engagement.

20. What are lead times, availability, and sample support?

B-TRAN® discrete engineering samples and SSCB reference design boards are available immediately to support customer evaluation and development work. Typical lead times for devices are approximately 4-8 weeks, depending on order volume and program timing.

For production availability, we align supply planning with customer program requirements and qualification timelines to ensure availability matches the intended deployment schedule.

For additional information, please contact Ideal Power Sales sales@idealpower.com