B-TRAN® Solid-State Circuit Breaker (SSCB) Reference Design Kit (RDK) Specification

1. Purpose

This document defines the electrical, protection, control, thermal, mechanical, and laboratory evaluation specifications for the B-TRAN® based Solid-State Circuit Breaker (SSCB) Reference Design Kit (RDK). The document is intended to establish a common engineering reference for customer laboratory evaluation.

The RDK is intended to accelerate customer understanding of SSCB application feasibility under defined operating conditions. It is therefore written to answer three practical questions: what the RDK is intended to evaluate, under what boundary conditions it may be used, and what customer system information is required before meaningful evaluation can begin.

2. Scope

The RDK is intended for controlled laboratory use as an engineering evaluation platform. It supports proof-of-concept testing, customer-side application learning, and early system architecture assessment for B-TRAN® based DC solid-state circuit breaker use cases.

The RDK is not intended for direct field deployment, safety-certified installation, unattended operation, or use as a production-equivalent product. Any use beyond the stated evaluation boundary shall require explicit engineering review.

3. Functional Description

The RDK implements a B-TRAN® based DC switching and interruption platform intended to evaluate SSCB behavior in representative DC protection scenarios. The platform is structured to support bidirectional conduction, commanded interruption, and observation of switching, thermal, and fault-related behavior at the system level.

The RDK is intended to help move the customer discussion beyond device-level interest and toward application-level feasibility. It shall therefore be used as a platform for evaluating interruption performance, conduction behavior, and integration constraints under a defined customer test plan.

Key device attributes:

- Continuous current conduction behavior and on-state loss characterization
- Overcurrent and short-circuit interruption under defined source and loop conditions
- Overshoot and transient behavior during fault clearing
- Thermal response under continuous or pulsed operating conditions
- System integration considerations for SSCB architectures in customer applications

4. System Overview

At a functional level, the RDK shall be understood as a controlled interruption stage inserted between a DC source and a representative load or fault point. The platform includes the B-TRAN® power stage together with the associated control and drive functions needed for engineering evaluation.

The actual customer laboratory setup may include source impedance, cable inductance, fixture inductance, and externally imposed fault conditions that materially influence observed performance. The RDK shall therefore be evaluated only with clear documentation of the test setup.

5. Electrical Specifications

5.1. Voltage Ratings

DC Bus Operating Envelope Parameter	Minimum	Typical	Maximum	Unit
Nominal DC bus voltage	0	400	440	VDC

5.2. Current Ratings

Parameter	Minimum	Typical	Maximum	Unit	Notes
Continuous current capability	—	—	80	A	Subject to stated cooling condition and ambient temperature.

Short circuit (SC) current under defined conditions	—	180	200	A	Must be tied to bus voltage, loop inductance.

6. Interruption Performance

Parameter	Minimum	Typical	Maximum	Unit	Notes
Fault detection to trip command delay	—	130	—	ns	SC detection to turn off corresponding cascode FET
Semiconductor interruption interval	—	2.4	—	µs	Cascode turn off till BTRAN's current reaches 10% of the peak current. Refer to Fig. 4
Total clearing time	—	11	—	µs	Refer to Fig. 4. System inductance = 20uH
Peak transient overshoot voltage	—	—	850	V	Refer to Fig. 4
Maximum supported current slew rate during fault interruption	—	—	50	A/µs	Must be tied to bus voltage, loop inductance.

7. Conduction Performance

Parameter	Minimum	Typical	Maximum	Unit	Notes
On-state voltage drop at stated current and temperature	—	0.53	0.57	V	Includes two shunts, two cascode FETs, and BTRAN at 80A.
On-state driving base voltage at stated current and temperature		1.1		V	Beta = 4 at 80A load current.
On-state driving base current at stated current and temperature		20		A	Beta = 4 at 80A load current.
On-state conduction loss at stated operating point	—	42.4	45.6	W	BTRAN_temp = 77degC at 80A load current.
Bidirectional conduction capability	Yes	—	—	—	As implemented in the evaluated configuration.
Bidirectional blocking capability	Yes	—	—	—	As implemented in the evaluated configuration.

8. External Energy and Bus Capacitance Conditions

Parameter	Minimum	Typical	Maximum	Unit	Notes
Validated external bus capacitance range for stated tests	—	22	—	μF	
Validated stored bus energy for interruption cases	—	1.76	—	J	At 400V

9. Protection and Control Specifications

This section shall describe the functional protection features and operating interfaces implemented in the RDK.

9.1. Protection Functions

Function	Availability	Engineering Notes
Manual trip command	Turn on/off rocker switch on primary side	
Overcurrent trip	[To be defined]	Will be implemented in firmware
Short-circuit trip	Implemented by analog circuit	
Fault indication / reporting	[To be defined]	LED indication

9.2. Control functions

Parameter	Value	Notes
Control supply requirement	20V – 28V, 2A	Nominal operating voltage is 24V.
Trip reset method	Power cycle	24V supply needs to be power-cycled.

10. Thermal Specifications

Thermal performance shall be stated together with the cooling condition under which it was measured. Continuous current or conduction-loss claims without explicit cooling and ambient boundary conditions shall not be used in this document.

10.1. Thermal Operating Envelope

Parameter	Minimum	Typical	Maximum	Unit	Notes
Ambient operating temperature range for evaluation	—	25	—	°C	
Case or heatsink temperature at full load	—	—	80	°C	
Estimated maximum allowable junction temperature basis	—	—	150	°C	
Continuous current under stated cooling condition	—	—	80	A	

10.2. Cooling Requirements

Parameter	Value	Notes
Cooling method	12V Fan	Forced air

11. Mechanical Specifications

The mechanical section shall define the physical evaluation hardware sufficiently for safe handling, correct connection, and reproducible bench setup. It should be specific enough for customer lab use without implying product-level packaging definition.

11.1. Physical and Interface Definition

Parameter	Value	Notes
Board dimensions	60mm×100mm	
Assembly envelope including heatsink and fan	60mm×100mm×72.5mm	
Approximate weight	176g	
Input / output terminal type	Screw terminal	HEX socket screw
Connection rating basis	100A	B2A-PCB-HEX
Mounting method for evaluation	2 legs (.24X.05”) with a 0.16" (4mm) PCB penetration	

12. Measurement and Test Access

For customer laboratory use, the RDK should expose or identify the measurement points needed to capture meaningful switching and fault waveforms. This section shall list the available access points and any precautions associated with their use.

12.1. Measurement Access Features

Measurement Item	Availability	Notes
Bus voltage measurement access	Differential prob	Vs1s2
Current measurement access or recommended insertion point	Current prob	S1/S2 current
Control or trip signal observation point	Test point	Ggs1/Ggs2
Temperature measurement point or sensor access	BTRAN’s case temperature	Thermal Camera

13. Recommended Evaluation Use Cases

The RDK should be used to answer specific customer application questions, not merely to demonstrate that switching hardware exists. Recommended evaluation use cases should therefore be framed around measurable SSCB behavior under realistic customer-relevant conditions.

- Continuous conduction and thermal baseline characterization
- Overcurrent interruption under defined bus and loop conditions
- Short-circuit interruption under reviewed fault conditions
- Capacitive bus fault or stored-energy interruption studies where applicable
- Repetitive operation studies within reviewed energy and thermal limits
- Architecture learning for customer SSCB implementation and scaling decisions

14. Safety and Handling Precautions

High-voltage and high-current SSCB testing presents significant electrical and thermal hazard. Customer evaluations shall be conducted only by qualified personnel using appropriate laboratory practice and protection.

- Use only qualified personnel familiar with high-energy DC testing.
- Verify bus discharge before handling the hardware after each energized test.
- Use appropriate insulated fixtures, probes, and personal protective equipment.
- Do not touch the assembly during energized operation or immediately after high-energy testing.
- Inspect interconnects, terminations, and thermal hardware before each test sequence.
- Observe stated repetition and cooldown limits once defined.

15. Documented Validation Cases

15.1. Validated Internal Test Cases

The driver architecture is shown in Fig. 1. It consists of a flyback power stage which converts the input voltage of 24Vdc to two isolated 12V channels. This 12V then supplies regulated current to the base of BTRAN® through a buck converter. The amount of current injected to the base is a function of load current which is known as beta. The load current is constantly measured through Shunt1 and Shunt2, depending on the current direction.

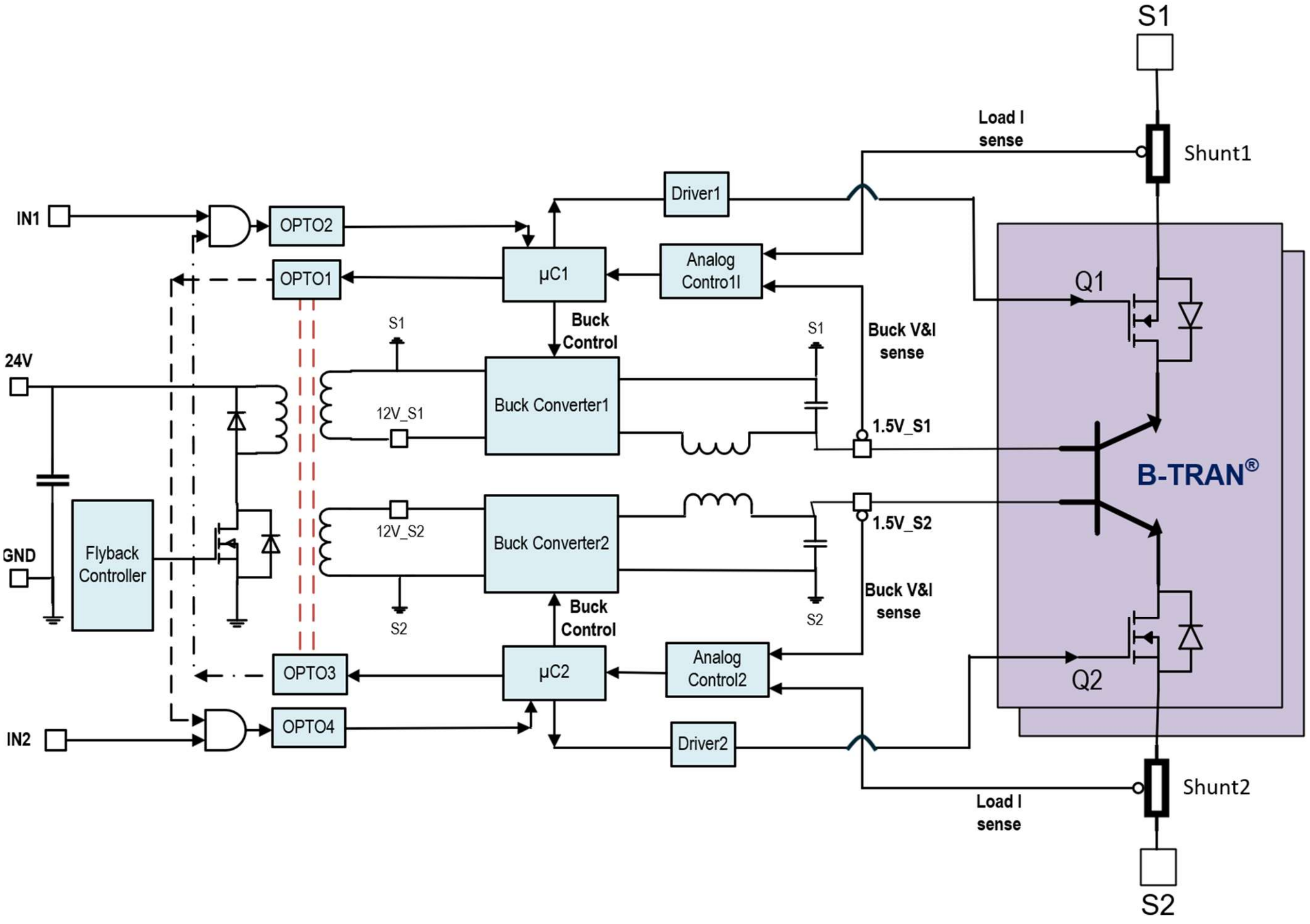


Fig. 1: Driver Architecture

Fig. 2 shows the 400V, 80A SSCB RDK board.

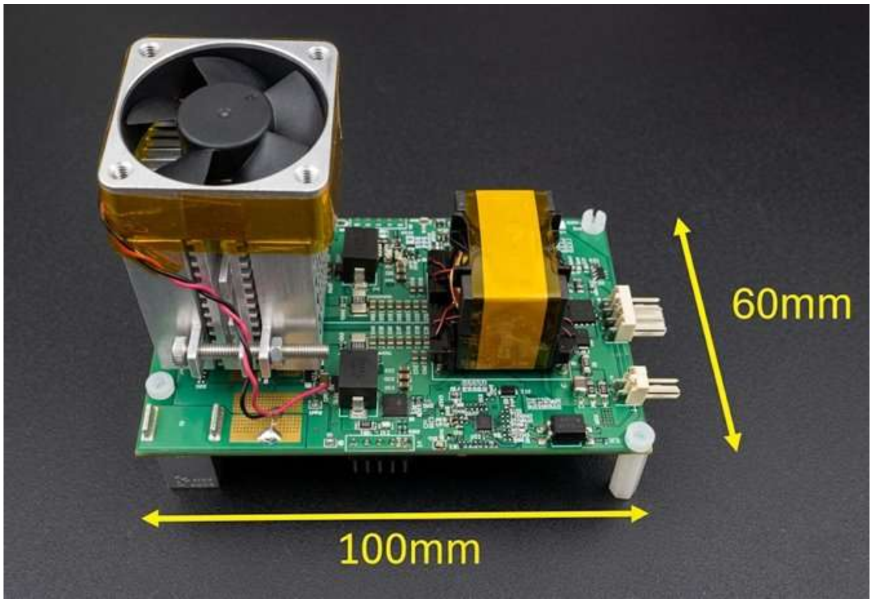
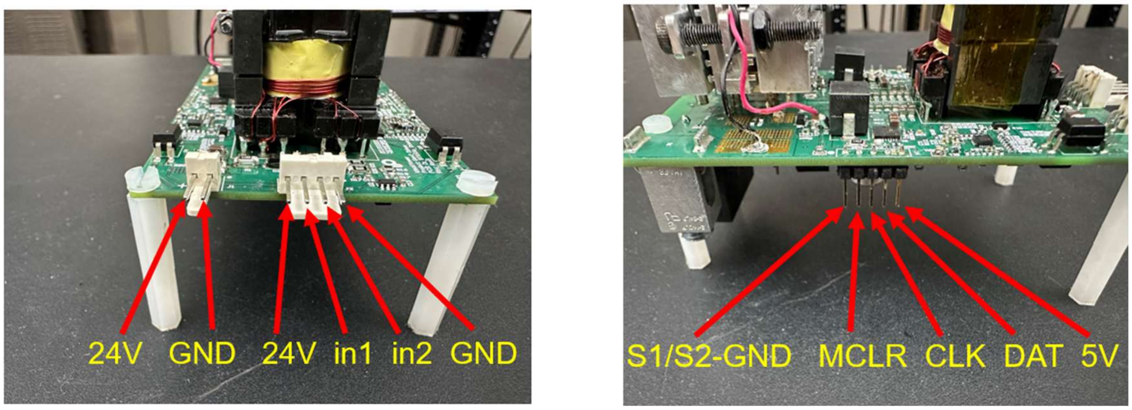


Fig. 2: BTRAN's 80A SSCB RDK

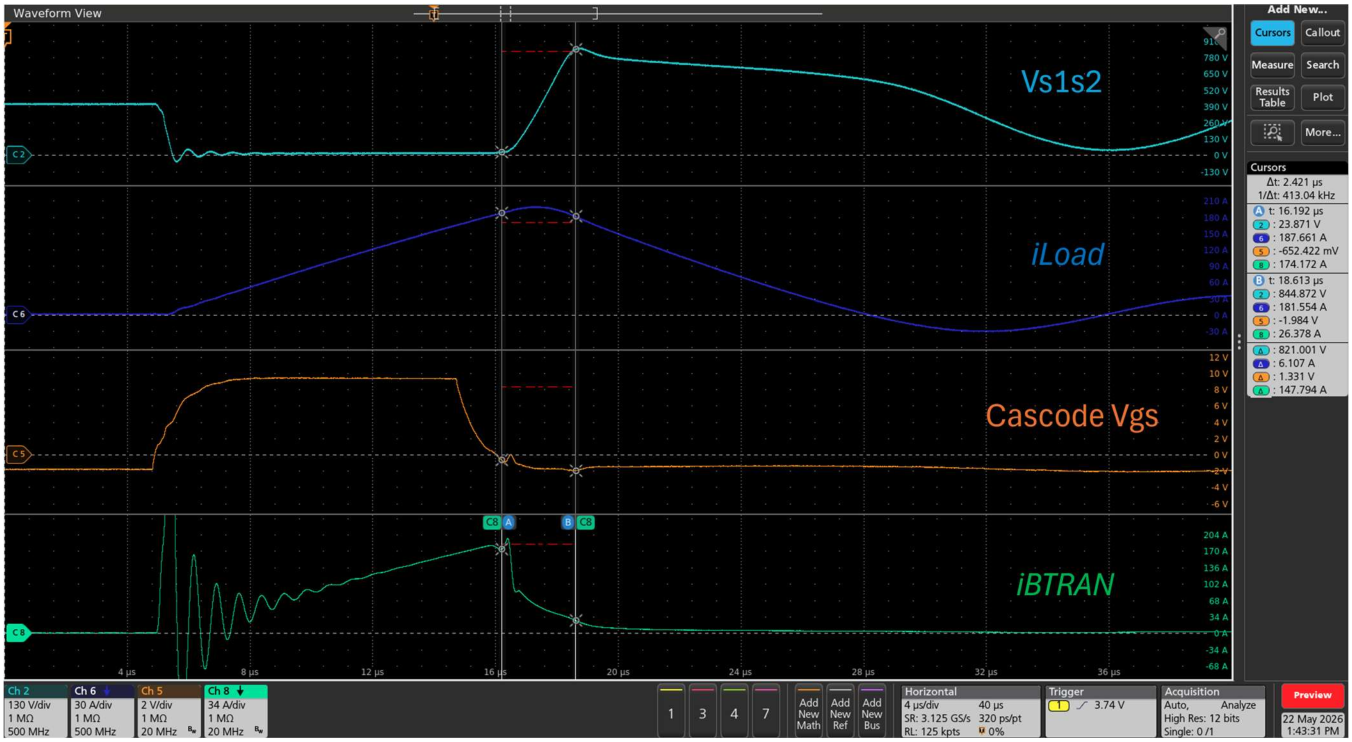
The SSCB's input connectors, and programming header are shown in Fig. 3.



(a) (b)

Fig. 3: (a) Input Terminals, and (b) Programming Header.

Fig. 4 shows short circuit test at 400V with a 20uH inductor.



Cursors
Δt: 2.421 µs
1/Δt: 413.04 kHz
A t: 16.192 µs
2 : 23.871 V
6 : 187.661 A
5 : -652.422 mV
8 : 174.172 A
B t: 18.613 µs
2 : 844.872 V
6 : 181.554 A
5 : -1.984 V
8 : 26.378 A
Δ : 821.001 V
Δ : 6.107 A
Δ : 1.331 V
Δ : 147.794 A

Ch 2: 130 V/div, 1 MΩ, 500 MHz
Ch 6: 30 A/div, 1 MΩ, 500 MHz
Ch 5: 2 V/div, 1 MΩ, 20 MHz
Ch 8: 34 A/div, 1 MΩ, 20 MHz
Horizontal: 4 µs/div, 40 µs, SR: 3.125 GS/s, 320 ps/pt, RL: 125 kpts, 0%
Trigger: 1, 3.74 V
Acquisition: Auto, Analyze, High Res: 12 bits, Single: 0 /1
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Fig. 4: Short circuit test waveforms at 400V, 180A.

80A DC continuous test is shown below.

@80A
Conduction Loss = **0.535V * 80A = 42.8W**
Driver’s Power Consumption = **35.6W**
Total Power Loss/Consumption= **78.4W**

BTRAN®s’ Temperature was measured at 77degC after one hour in steady state, and is shown in Fig. 5.

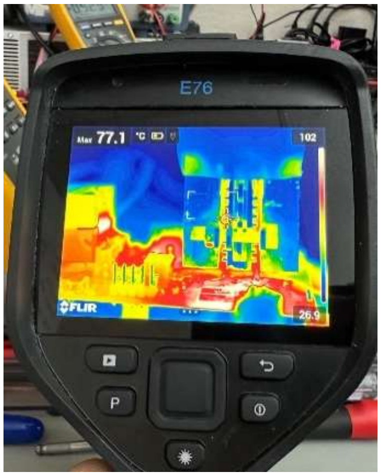

Fig. 5: BTRAN®s’ case temperature after 1hr.

16. Closing Statement

This RDK specification is intended to accelerate customer understanding and supervised evaluation of B-TRAN® based SSCB architectures under controlled laboratory conditions. Application feasibility for a specific customer system shall be determined using the customer’s actual voltage, current, fault energy, bus capacitance, thermal constraints, and interruption requirements, together with the validated operating envelope defined in this document.

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