Application Note: IPAN1005

Single-Phase AC Tripping Evaluation Using a B-TRAN®-Based Solid-State Circuit Breaker (SSCB) Evaluation Board

1. Purpose and Scope

This application note is intended for customers developing three-phase AC Static Transfer Switches (STS) who wish to evaluate single-phase AC tripping performance using Ideal Power's B-TRAN®-based SSCB evaluation board.

The document provides:

- A clear description of how a single-phase AC test maps to three-phase STS requirements.
- Practical guidance on configuring and executing AC tripping tests using the SSCB evaluation board.
- A framework for defining customer-facing AC test specifications that can be used to validate performance.

This document is written to be used directly by customers during early-stage validation and feasibility testing, specifically for pre-design validation prior to three-phase STS hardware development.

2. Background: STS Requirements and Relevance of Single-Phase Testing

- **Static Transfer Switch Operating Context**

  A three-phase AC Static Transfer Switch typically consists of:

  - Two independent AC sources (e.g., utility and backup)
  - Semiconductor-based bidirectional switches per phase
  - Fast fault detection and source transfer logic

  Each phase leg must independently:

  - Conduct bidirectional AC current
  - Block line voltage when open
  - Interrupt current during abnormal or fault conditions

- **Why Single-Phase AC Testing Is Sufficient at Early Stages**

Single-phase AC testing is a necessary and representative subset of a full three-phase STS validation because:

- Each phase in a three-phase STS is electrically equivalent from a device stress perspective
- AC current zero-crossing, bidirectional conduction, and voltage blocking are exercised identically
- Protection response time and tripping behavior can be validated per phase

Therefore, successful single-phase AC breaking tests provide direct confidence in the applicability of the B-TRAN® device to multi-phase STS systems.

3. Overview of the B-TRAN®-Based SSCB Evaluation Board

- **Functional Description**

The SSCB evaluation board integrates:

- A B-TRAN® bidirectional power device as the main switching element
- Base drive circuitry
- Current sensing and protection logic
- Voltage transient mitigation and protection components

The board is designed to:

- Conduct AC current in both polarities
- Interrupt current via protection-threshold-based operation
- Allow direct observation of voltage and current waveforms

The SSCB evaluation board supports operation at both 50 Hz and 60 Hz AC line frequencies.

Figure 1: B-TRAN®-based SSCB evaluation board

- **Relevance to STS Applications**

Key characteristics of the B-TRAN® device that align with STS needs include:

- True bidirectional current conduction
- Symmetric blocking capability
- Controlled turn-off independent of AC polarity

These attributes allow the SSCB board to serve as a functional phase-leg for STS evaluation. The SSCB evaluation board is not a drop-in replacement for a production STS phase module and should not be interpreted as such.

4. Single-Phase AC Test Configuration

- **Electrical Test Topology**

The recommended test configuration uses:

- A single-phase AC source operating at 50 Hz or 60 Hz
- A controllable load to set RMS current
- The SSCB evaluation board placed in series with the load

The board is operated as a series interrupting element, electrically representative of one phase leg of an STS, but without transfer or multi-source coordination functionality.

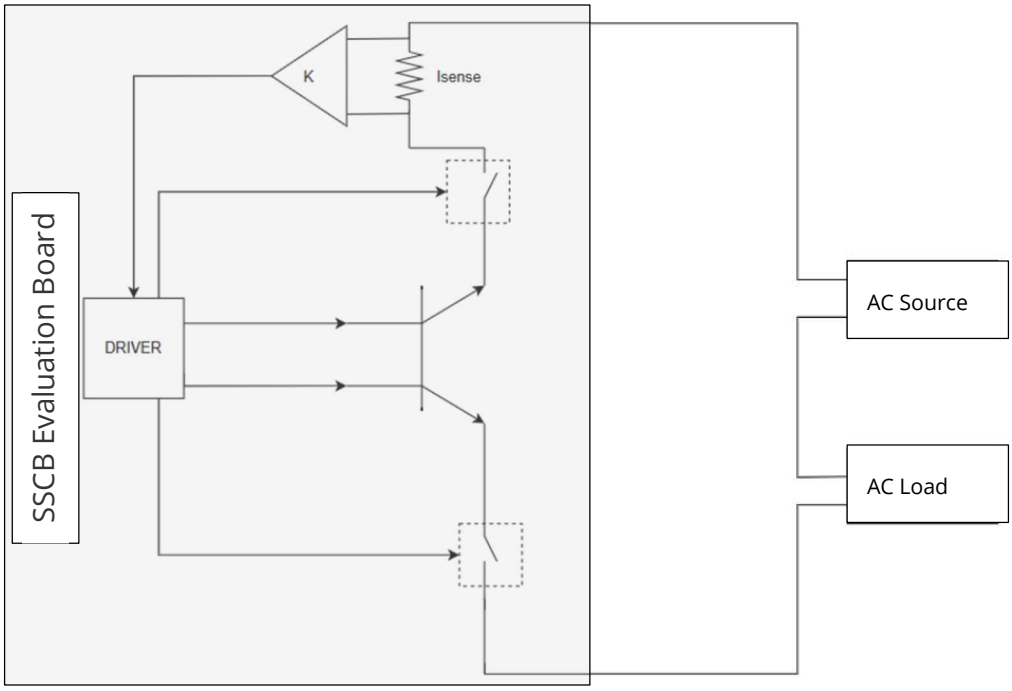

Figure 2: Single-phase AC test topology using SSCB evaluation board

- **Instrumentation**

Typical instrumentation includes:

- True RMS current measurement
- Differential voltage measurement across the SSCB
- Oscilloscope capture of time-aligned voltage and current

Instrumentation accuracy directly impacts interpretation of trip behavior and interruption timing.

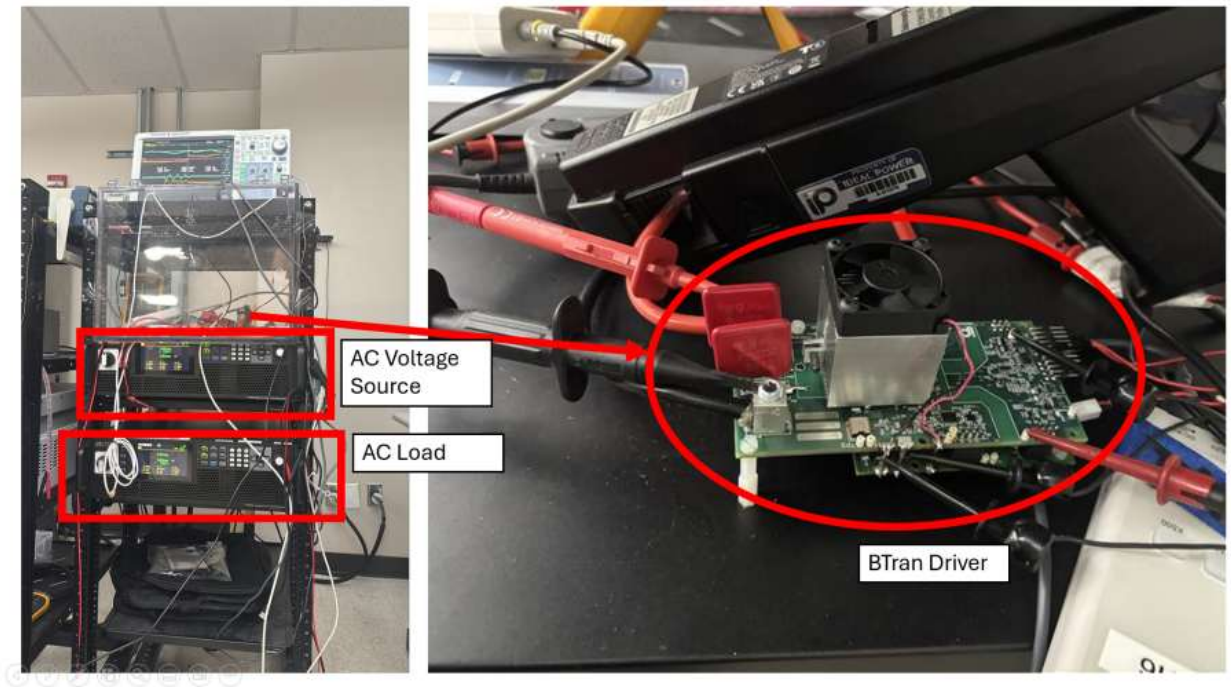

Figure 3: Experimental test setup to test for B-TRAN based SSCB AC tripping event

- **Typical Evaluation Limits for B-TRAN based SSCB Evaluation Board**

The SSCB evaluation board is intended for controlled laboratory evaluation of single-phase AC tripping behavior. Testing should be performed only within the board's documented electrical limits and using appropriate protective equipment. Typical evaluation conditions include:

- AC Line Frequency: 50 Hz / 60 Hz operation
- AC RMS Voltage Range: Up to the maximum RMS voltage of 300 Vrms
- RMS Load Current Range: Up to the maximum continuous RMS current rating of 50Arms

Ideal Power recommends starting at low voltage/current conditions and incrementally increasing stress while monitoring device temperature, trip timing, and transient response.

5. Test Methodology for AC Breaking Evaluation

- **General Test Sequence**

A typical AC breaking test proceeds as follows:

1. Configure the AC source to the desired RMS voltage and frequency (50 Hz or 60 Hz).
2. Apply load such that current flows through the SSCB.
3. Verify steady-state conduction and waveform symmetry.
4. Increase current until the configured protection threshold is reached and the SSCB interrupts conduction.
5. Capture voltage and current waveforms before, during, and after interruption.

Interruption on the SSCB evaluation board is triggered by the internal protection threshold.

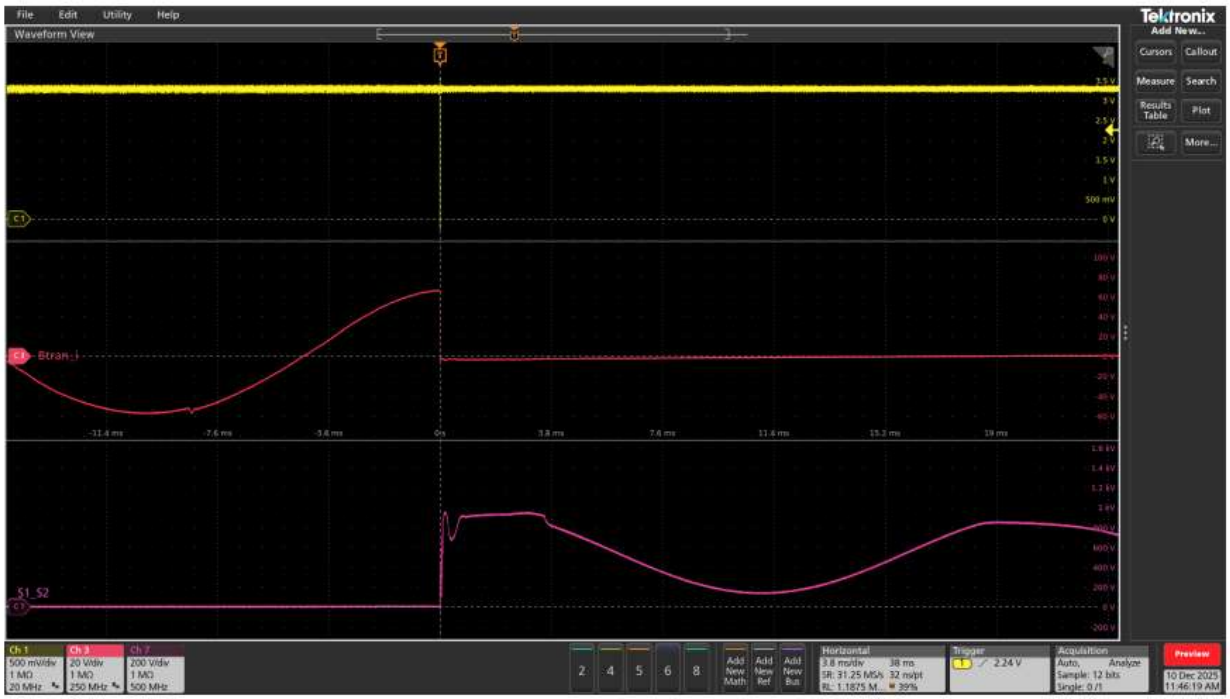

Figure 4: Example timing diagram showing AC tripping event at 300Vrms and 50A

- **Observations of Interest**

During testing, customers should focus on:

- Current at the instant of interruption
- Voltage blocking behavior immediately after turn-off
- Presence of voltage overshoot or ringing
- Repeatability across multiple AC cycles and polarities

6. Mapping Results to STS Phase-Level Requirements

Single-phase AC results can be mapped to STS requirements as follows:

STS Requirement	Single-Phase SSCB Test Observation
Bidirectional conduction	Symmetric current waveform
Fast fault isolation	Interruption timing
Voltage blocking	Post-trip voltage waveform
Phase independence	Repeatability across tests

This mapping allows customers to build confidence before moving to multi-phase hardware.

7. AC Test Specification Framework

Based on the SSCB evaluation board and this test methodology, customers may define internal validation specifications such as:

- Nominal AC RMS voltage used for testing
- RMS current range exercised
- Tripping trigger method (protection-based or commanded)
- Measurement bandwidth and sampling rate
- Pass/fail criteria for tripping and blocking

8. Practical Considerations and Limitations

- The SSCB evaluation board is intended for pre-design validation and does not represent a complete STS phase assembly
- Single-phase testing does not capture inter-phase interactions, transfer logic, or common-mode effects
- Thermal behavior under continuous three-phase operation must be evaluated separately
- Mechanical integration, redundancy requirements, and certification considerations are outside the scope of this document

9. Summary

This application note demonstrates how Ideal Power's B-TRAN®-based SSCB evaluation board can be used as a practical and representative platform for single-phase AC tripping evaluation relevant to three-phase Static Transfer Switch development.

By following the outlined test configuration and methodology, customers can:

- Validate bidirectional AC tripping behavior
- Gain early confidence in B-TRAN® suitability for STS applications
- Establish internal AC test specifications aligned with their system needs

10. Next Steps

Customers progressing beyond single-phase evaluation are encouraged to:

- Replicate tests across multiple phase legs
- Evaluate coordinated control and transfer logic
- Engage with Ideal Power for system-level guidance and device optimization

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