White Paper

Benefits of the “Fail Open” Isolation Barrier in onsemi NCID and NCIV Digital Isolator Devices

onsemi.com

June, 2026 − Rev. 0

Publication Order Number:
TND6520/D

Benefits of the “Fail Open” Isolation Barrier in onsemi NCID and NCIV Digital Isolator Devices

Enhancing Safety and Reliability in High Voltage Applications

Introduction

Digital isolator devices are critical components in modern electronic systems, providing robust isolation between high-voltage and low-voltage circuits. **onsemi**’s NCID and NCIV families of digital isolators stand out due to a unique characteristic: their isolation barrier fails open when exposed to local overvoltage or electrical overstress (EOS) conditions. This document outlines the advantages of this feature, supported by test data, and provides a brief overview of the device family.

What are “Fail Open” and “Fail Short” Isolation Characteristics?

A “fail open” isolation barrier is designed so that, when subjected to local overvoltage or fault conditions as shown in Figure 1, the internal structure of the barrier physically separates, preventing any electrical conduction between the high-voltage and low-voltage sides. In contrast, a “fail short” barrier typically results from dielectric breakdown, causing the internal insulation to collapse and create a conductive path that allows hazardous voltages to pass through.

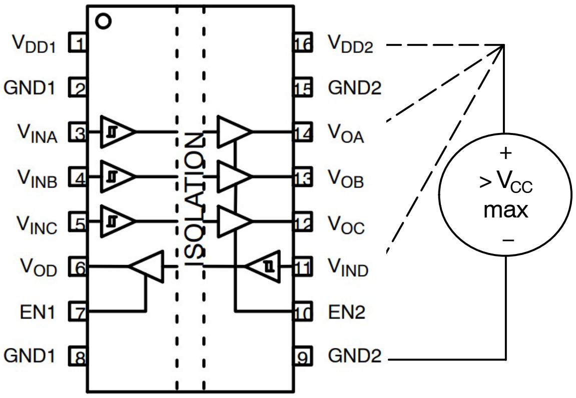

Figure 1. “Same Side” or “Local” Overvoltage Conditions Expose Input, Output, or Power Pins to Excessive Voltages with Respect to the Local GND and Can Damage one Side of a Digital Isolator

The system-level outcome of a “fail short” event is potentially catastrophic, as it can propagate dangerous voltages and currents into sensitive downstream circuits, leading to equipment damage and safety hazards. Conversely, the “fail open” behavior ensures that even during a fault, the isolation remains intact, protecting both the electronics and personnel, and simplifying fault detection and recovery for safer, more reliable system operation.

Which Systems Are Vulnerable to “Fail Short”?

Any system in which the applied voltage can exceed the isolator’s maximum rating is vulnerable to a “fail short” event. For instance, automotive circuits are typically powered by a 12 V battery upstream; if a fault occurs across a low-dropout regulator (LDO) or power supply, it may expose the digital isolation devices connected to this regulated voltage supply to the full 12 V as shown in Figure 2. This can cause immediate electrical-overstress damage to the device and compromise the isolation barrier, ultimately resulting in a short-circuit between the high-voltage and low-voltage sides.

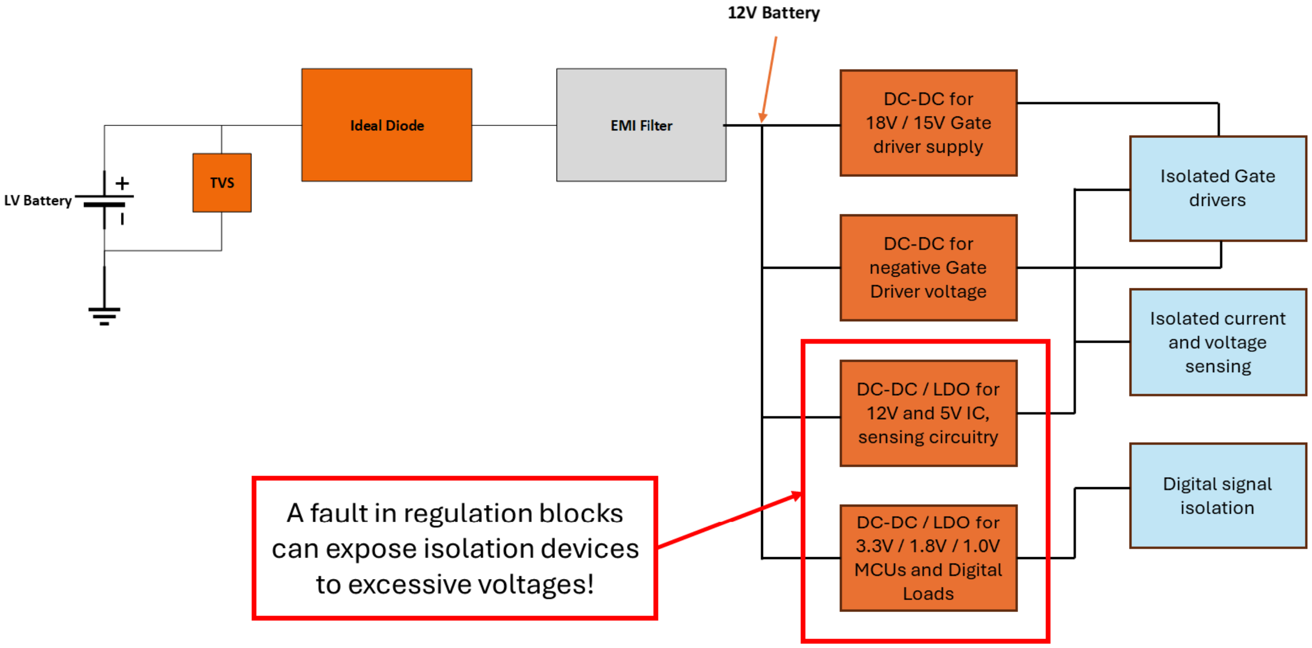

Figure 2. Power Tree of a System Vulnerable to “Fail Short” Damage, an Automotive Traction Inverter

Similarly, in industrial applications such as programmable logic controllers (PLCs), motor drivers, and datacenters, devices are often powered directly by AC mains or a high-voltage backplane. A wiring fault or electrical overstress could expose the digital isolator to dangerous voltage levels well above its rated capacity, potentially causing a “fail short” condition and allowing hazardous voltages to propagate into sensitive control electronics or circuits exposed to human contact. These scenarios highlight the importance of robust isolation, as the consequences of a “fail short” include equipment damage, unsafe operation, and increased risk to personnel.

Benefits of “Fail Open” Behavior for Galvanic Isolators

The ’fail open’ behavior is particularly beneficial in scenarios where circuits are vulnerable to short-circuits or unexpected voltage surges. In automotive applications, for example, a short-circuit to a 12 V or high-voltage (HV) battery rail can occur, potentially causing catastrophic damage if not properly managed. Similarly, in industrial settings, exposure to HV mains or backplane voltages poses a risk to both equipment and personnel. In medical applications, ’fail open’ behavior helps protect patients from unintentional exposure to hazardous voltages, especially in surgical, cardiac, and patient monitoring equipment. By failing open, the isolation barrier prevents the propagation of hazardous voltages to the low-voltage side, thereby safeguarding downstream electronics and reducing the likelihood of secondary failures or safety hazards. This feature also simplifies system-level fault detection and recovery, enabling engineers to design safer, more resilient products.

Distance Through Insulation

Distance through insulation (DTI) is the shortest physical thickness of solid insulating material that separates the two sides of an isolation barrier, making it a key parameter in long-term dielectric robustness and safety certification for optocouplers and digital isolators, with relevant standards including IEC 61010-1, IEC 60601-1, and IEC 62368-1. In practice, reinforced-isolation optocouplers have historically used relatively thick insulation distances, with typical DTI values around 0.4 mm, while many conventional silicon-based digital isolators rely on much thinner on-chip dielectric layers.

A wider DTI generally provides greater margin against insulation defects, dielectric aging, partial discharge, and transient overstress, helping preserve isolation integrity over time and under harsh operating conditions. This is a major advantage of **onsemi**’s NCID9xxx and NCIV9xxx digital isolator families, which use off-chip capacitor isolation in a thick ceramic structure to achieve a DTI greater than 0.5 mm, more than 25x thicker compared to the insulation barrier in competitor digital isolation devices as shown in Table 1. As a result, these **onsemi** devices directly satisfy insulation frameworks that call for 0.4 mm DTI, like those in the industrial and medical standards mentioned above, whereas most competing digital isolators use much thinner insulation barriers and do not meet that structural threshold directly. This combination gives **onsemi** devices the performance benefits of digital isolators together with an insulation barrier that exceeds traditional optocoupler thicknesses, making them a superior isolation solution for demanding industrial, medical, and automotive systems.

Test Data

Extensive laboratory testing of the NCID and NCIV devices demonstrates their reliability under stress conditions compared to other digital isolators on the market. When subjected to local overvoltage events, the isolation barrier consistently fails open, ensuring that no unintended current flows between the isolated domains. Measurements confirm that the devices maintain their isolation integrity up to rated voltages, and when the Maximum Rating power supply and I/O voltages are exceeded, the open-fail mechanism activates without causing damage to the surrounding circuitry. This predictable failure mode enhances both system safety and maintainability compared to competition devices.

“Fail Open” Test Method

The “fail open” behavior of **onsemi** NCID and NCIV devices was tested alongside two competition digital isolator devices by exposing all units to separate overvoltage conditions of 35 V with a 1 A current limit in place for 10 seconds. This type of transient replicates a catastrophic system fault where low voltage regulation components fail and the resulting current draw is not sufficiently high enough to trigger overcurrent protection. In most systems, a continued fault of this nature would cause substantial propagated damage if the isolation barrier is not preserved.

Isolation Barrier Verification

AC ramp to breakdown (RTB) testing is used to verify the strength of the isolation barrier in digital isolation devices. The digital isolator under test is configured so that all pins on each side of the isolation barrier are electrically shorted together, effectively turning the device into a two-terminal component as shown in Figure 3. This setup allows a high voltage stress to be applied directly across the isolation barrier, ensuring that the isolation path is stressed to the maximum extent and to the point that breakdown or failure occurs. By gradually increasing the AC voltage until the barrier fails, as shown in Figure 4, engineers can assess the maximum withstand capability and reliability of the isolation barrier. This method provides a controlled means to evaluate the device’s performance under high voltage conditions, helping to verify that the isolator will provide robust protection against hazardous voltages in real-world applications.

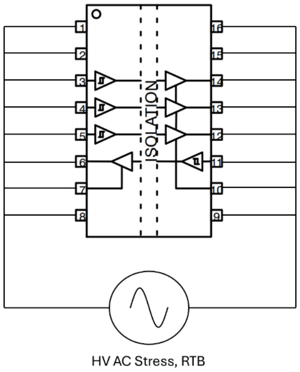

Figure 3. Isolation Barrier Test Configuration for Digital Isolators, Used for RTB

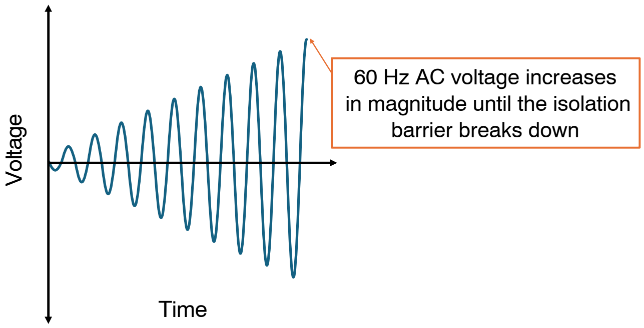

Figure 4. AC Ramp to Breakdown (RTB) Stress Voltage Profile

Results vs. Competition

Table 1 below summarizes the results of pre-overvoltage and post-overvoltage isolation barrier testing for NCID and NCIV digital isolators from **onsemi** compared to two competitor devices. Separate units were tested to assess the pre-EOS and post-EOS capability because RTB is a destructive test.

Table 1. ONSEMI NCID AND NCIV ISOLATION DEVICES DEMONSTRATE ’FAIL OPEN’ BEHAVIOR WHILE BOTH TESTED COMPETITOR DEVICES ’FAIL SHORT’

Device	DTI (μm)	10 kV RTB Capability Pre-EOS	Exposed to Local 35 V, 1 A EOS	10 kV RTB Capability Post-EOS
NCID9411	>500	✓	✓	PASS
NCIV9411	>500	✓	✓	PASS
Competitor 1	>17	✓	✓	FAIL
Competitor 2	>14	✓	✓	FAIL

After 10 seconds of exposure to a local overvoltage event, only the **onsemi** devices successfully tolerated a subsequent 10 kV AC ramp to breakdown (RTB) test, demonstrating their ability to maintain reinforced isolation protection at the system level. In contrast, both competitor devices failed the RTB test after the same stress, indicating a loss of isolation integrity and an inability to provide robust protection against hazardous voltages after a local overvoltage event (EOS). This outcome highlights the superior resilience and reliability of **onsemi**’s digital isolators in demanding safety-critical applications.

onsemi Device Family Overview

onsemi's NCID and NCIV digital isolator families are constructed with off-chip, ceramic capacitor isolation to meet stringent application requirements and enable unique reliability characteristics such as "fail open" behavior. Table 2 shows the devices in the NCID and NCIV product families. These families of parts are available in multiple channel configurations designed for automotive and industrial applications. Their compact form factor, low power consumption, and robust performance make them ideal for many applications, including battery management systems, motor drives, and industrial control units.

Table 2. ONSEMI NCID AND NCIV ISOLATION DEVICE FAMILIES ARE AVAILABLE IN VARIOUS INDUSTRIAL AND AUTOMOTIVE CONFIGURATIONS

Device	Channel Count	VISO Rating	Creepage	Automotive
NCID94xx	4	5000 V	>8 mm	No
NCID93xx	3	5000 V	>8 mm	No
NCID92xx	2	5000 V	>8 mm	No
NCIV94xx	4	5000 V	>8 mm	Yes
NCIV93xx	3	5000 V	>8 mm	Yes
NCIV92xx	2	5000 V	>8 mm	Yes

Conclusion

The "fail open" isolation barrier characteristic of **onsemi**'s NCID and NCIV digital isolator devices provides a significant safety advantage in both automotive and industrial environments. By reliably preventing the transfer of hazardous voltages during fault conditions, these devices help engineers create safer, more dependable systems. Their proven performance and versatile design make them a valuable choice for applications requiring high isolation and fault tolerance.

REVISION HISTORY

Revision	Description of Changes	Date
0	Initial document release.	6/1/2026

onsemi, onsemi, and other names, marks, and brands are registered and/or common law trademarks of Semiconductor Components Industries, LLC dba "**onsemi**" or its affiliates and/or subsidiaries in the United States and/or other countries. **onsemi** owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of **onsemi**'s product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent−Marking.pdf. **onsemi** reserves the right to make changes at any time to any products or information herein, without notice. The information herein is provided "as−is" and **onsemi** makes no warranty, representation or guarantee regarding the accuracy of the information, product features, availability, functionality, or suitability of its products for any particular purpose, nor does **onsemi** assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using **onsemi** products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by **onsemi**. "Typical" parameters which may be provided in **onsemi** data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. **onsemi** does not convey any license under any of its intellectual property rights nor the rights of others. **onsemi** products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use **onsemi** products for any such unintended or unauthorized application, Buyer shall indemnify and hold **onsemi** and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that **onsemi** was negligent regarding the design or manufacture of the part. **onsemi** is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

ADDITIONAL INFORMATION

TECHNICAL PUBLICATIONS:
Technical Library: www.onsemi.com/design/resources/technical−documentation
onsemi Website: www.onsemi.com

ONLINE SUPPORT: www.onsemi.com/support
For additional information, please contact your local Sales Representative at www.onsemi.com/support/sales