Application Note

Magnetic Field Immunity of TI's Isolation Devices: Meeting Class 5 of IEC 61000-4-8 and IEC 61000-4-9

Varun Kumar, Garudadri Vasishta

ABSTRACT

Isolation devices operate at the boundary between a noisy, high-power domain and a quiet, low-voltage control domain. That boundary is typically a few centimeters from a bus bar, a motor winding, a transformer, or a switching device — all of which generate strong magnetic fields. If those fields couple into an isolator which is not robust enough, the result can be a corrupted data bit, a false gate-driver edge, or a corrupted measurement.

This application note explains, in plain language, the two IEC standards that define how magnetic field immunity is tested: *IEC 61000-4-8* (power-frequency fields) and *IEC 61000-4-9* (pulse fields). This document also explains what the test levels and environment classes mean and how TI's isolation devices (Table 8-1) perform against the highest severity level defined by both standards, *Class 5* .

Table of Contents

Trademarks

All trademarks are the property of their respective owners.

1 Introduction

1.1 Why Magnetic Field Immunity Matters for Isolators

Every isolator transmits information across an isolation barrier galvanically (without physical contact or wire). TI's isolators achieve this with the patented silicon dioxide (SiO_2)-based isolation structure, with the data modulated across the isolation barrier as a high-frequency signal.

Any conductive loop in that path, no matter how small, is an antenna for a changing magnetic field. Two things therefore decide whether a changing magnetic field can disrupt communication through an isolator:

1. How big is the loop? - A smaller differential loop picks up less.
2. How fast is the field changing? - A slow 50/60Hz field is less harmful than a lightning-driven pulse with a microsecond rise time, even at the same peak amplitude, due to faster rate of field change.

That is precisely why there are two separate standards.

1. IEC 61000-4-8 covers case (a): a large duration but slowly varying field.
2. IEC 61000-4-9 covers case (b): a shorter duration but very fast field.

Table 1-1. What Failure can Look Like at System Level Operation for Different Isolation Devices

Device type	Consequence of magnetic upset
Digital isolator	Single-bit error, corrupted SPI/UART frame, watchdog trip
Isolator with integrated DC/DC	Disturbance on the isolated supply rail
Isolated CAN / RS-485	Bus error frames, retransmissions, loss of communication
Opto-Emulators	Glitch on output, Switch changing the state on output side

2 Magnetic Field Units at a Glance

The test standards specify test severity in A/m (magnetic field strength, *H*), while the commonly known physics equations typically work in Wb/m^2or Tesla (magnetic flux density, *B*). In air, the equations are directly proportional per Equation 1 and Equation 2:

$$B = \mu 0 \times H \tag{1}$$

$$\mu 0 = 4\pi \times 10^{-7} Wb/(A \times m) \tag{2}$$

Quantity	Conversion
$1Wb/m^2$	= 1T (Tesla)
1A/m	≅ 1.26µT ($1.26 \times 10^{-6} Wb/m^2$)
80A/m	≅ 1G
Earth's magnetic field	≅ 0.5G ≅ 40A/m
100A/m (IEC 61000-4-8 Level 5, continuous)	≅ 126µT
1000A/m (IEC 61000-4-9 Level 5, pulse)	≅ 1.26mT

3 IEC 61000-4-8 — Power Frequency Magnetic Field Immunity

3.1 What IEC 61000-4-8 Test Simulates

This test reproduces the steady magnetic field that surrounds any conductor carrying mains current at 50Hz or 60Hz emulating fields generated by power lines, bus bars, transformers, motor cables. The standard covers residential and commercial locations, industrial installations and power plants, and medium- and high-voltage substations.

The field is applied continuously while the equipment operates normally, at the severity level chosen for the installation environment. The standard specifies only how to test, not whether a given product must pass a test level — the required pass level comes from the applicable end product standard.

3.2 Test Levels for IEC 61000-4-8 Continuous Power Frequency Fields

Level	Continuous magnetic field (A/m)
1	1A/m
2	3A/m
3	10A/m
4	30A/m
5	100A/m
X(1)	Special

(1) "X" is an open level defined in a dedicated product specification. "X" can be above, below or between the listed values.

3.3 Environment Classes — How a Level is Chosen

There's a common point of confusion that can occur during testing, which is: "level" and "class" are not the same thing. The "levels" mentioned in Test Levels for IEC 61000-4-8 Continuous Power Frequency Fields above are the test severities. The "classes" mentioned below describe the installation environment and are given in Annex C of IEC 61000-4-8 as informative guidance for picking a test level.

Equipment is classified based upon the environment in which the equipment is operating, and the corresponding test level is then selected. In practice, Class *n* requires Level *n*.

Class	Environment	Typical examples
1	Environments using electron-beam devices	CRT monitors, electron microscopes
2	Well-protected	Household, office, hospital
3	Protected	Commercial areas, small industrial plants, computer room of an HV substation
4	Industrial	Heavy industrial plants, power plants, control room of an HV substation
5(1)	Severe industrial	Switchyards of heavy industrial plants, MV and HV power stations

(1) Class 5 is explicitly characterized in the standards as environments with conductors, bus bars, or MV/HV lines carrying *tens of kiloamperes*, and ground conductors of lightning-protection systems carrying full lightning current.

3.4 Field Strengths Observed in Actual Installations

IEC 61000-4-8 Annex D contains field strength measurements from real-world installations. These values help in understanding the level of headroom one can have by meeting Class 5 requirements.

Equipment Installation Location	Typical field strength observed
Household appliances, 0.3m from surface	0.03 – 10A/m (max ≅ 20A/m)
Household appliances, 1.5m from surface	< 0.1A/m (max 0.4A/m)
Directly under HV lines	10 – 16A/m per 1000A of line current
30m laterally from HV lines	3 – 5A/m per 1000A of line current
HV substation (220/400kV), near a 500A line	9 – 14A/m
HV substation relay room	1 – 7A/m
HV substation equipment room	≅ 0.7A/m
Power/industrial plant, 0.3–1.5m from a 2200A bus bar	6 – 85A/m
Other industrial plant sources	4 – 30A/m

Since field strength diminishes rapidly with distance, proximity is as critical as current magnitude. Which is why the isolator—positioned directly at the power boundary—is the component that requires the greatest margin and highest level of immunity.

4 IEC 61000-4-9 — Pulse Magnetic Field Immunity

4.1 What IEC 61000-4-9 Test Simulates

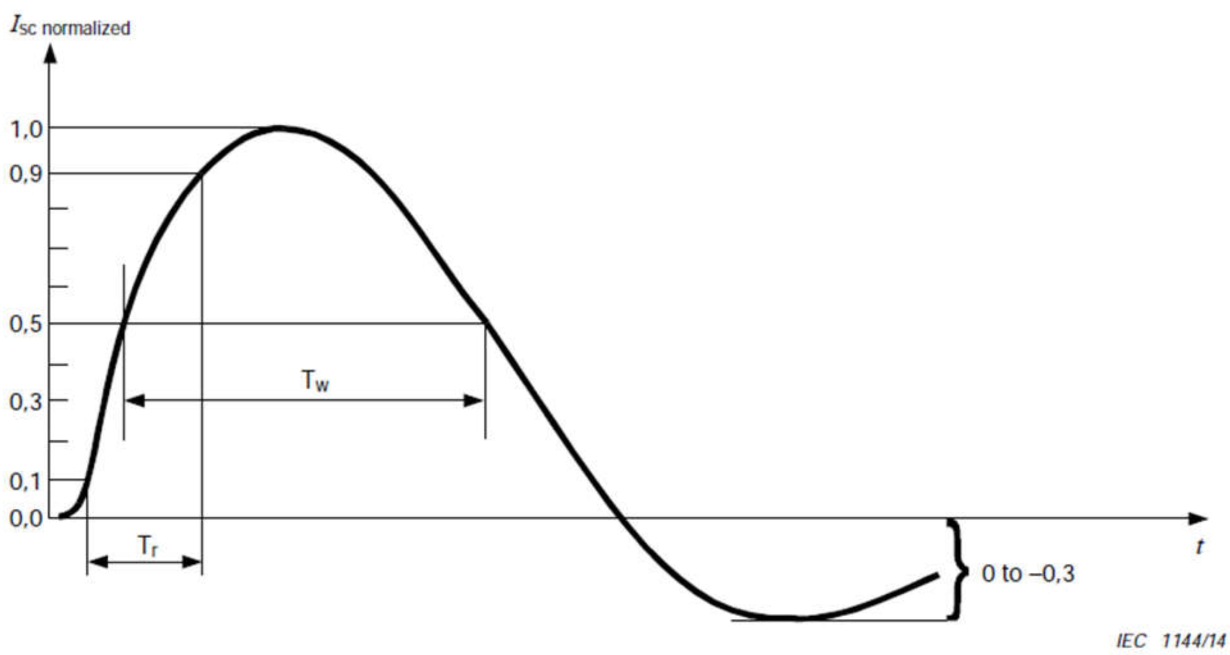
While IEC 61000-4-8 is about steady frequency fields, the IEC 61000-4-9 is about transient ones: the magnetic field produced by a lightning strike on a building, mast, or lightning-protection down-conductor, and by fault currents in low, medium and high-voltage systems. The stated environments are industrial installations, power stations, railway installations, and MV/HV substations.

Because the current rises in microseconds rather than milliseconds, dB/dt is orders of magnitude higher than in the IEC 61000-4-8 test , which means this is the more aggressive test for a data-carrying isolator, even though the field is present only briefly.

4.2 Impulse Current Waveform for Pulse Magnetic Field

The disturbance is generated by driving an induction coil with a combination wave generator (the same generator family used for IEC 61000-4-5 surge testing), producing an 8/20µs short-circuit current waveform as shown in Figure 4-1:

Parameter	Value
Front time, T_f	8µs ± 20% (T_f = 1.25 × T_r)
Duration to half value, T_d	20µs ± 20% (T_d = 1.18 × T_w)
Peak short-circuit current	100A to 1000A
Polarity	Positive and negative
Repetition rate	1 per minute or faster
Number of Impulses	5 positive + 5 negative



Front time: $T_f = 1{,}25 \times T_r = 8\ \mu s \pm 20\ \%$
Duration: $T_d = 1{,}18 \times T_w = 20\ \mu s \pm 20\ \%$

NOTE 1 The value 1,25 is the reciprocal of the difference between the 0,9 and 0,1 thresholds.

NOTE 2 The value 1,18 is derived from empirical data.

Figure 4-1. Waveform of Short-Circuit Current (8/20µs) for Generating Pulsed Magnetic Field as per IEC 61000-4-9

4.3 Test Levels for IEC 61000-4-9 Pulse Magnetic Fields

The IEC 61000-4-9 also has end equipment installation classes given in Annex C as an informative guidance similar to Environment Classes — How a Level is Chosen to select an appropriate test level as described below. Only Class 3, 4 and 5 are applicable for this standard because of the harsh environment where these pulse fields are expected to be encountered.

Level	Pulse magnetic field strength (A/m, peak)
1(1)	Not applicable
2(1)	Not applicable
3	100A/m
4	300A/m
5	1000A/m
X	Special

(1) Levels 1 and 2 are not applicable as per IEC 61000-4-9 — environments which are not harsh enough, in this case Class 1 and Class 2, are not considered to have any significant pulse magnetic field interference.

5 Summary of Class 5 Testing— What We Are Targeting

Standard	Field Type	Class 5 Test Level	Equivalent Magnetic Flux Density
IEC 61000-4-8	Power frequency, continuous	100A/m at 50/60Hz	≅ 126μT
IEC 61000-4-9	Pulse, 8/20μs	1000A/m, peak	≅ 1.26mT

Passing at Class 5 means a device carries no magnetic-field restriction anywhere in the severity range — a system designer doesn't have to derate, shield, or reorient the isolator to satisfy a system-level magnetic immunity requirement.

6 What "PASS" Means — Performance Criteria

Test results are classified into four categories, and the applicable product standard says which category is acceptable:

Category	Description
A	Normal performance within specification limits
B	Temporary degradation or loss of function that is self-recoverable
C	Temporary degradation or loss of function requiring operator intervention or system reset
D	Degradation or loss of function that is not recoverable — damage to hardware, software, or loss of data

For an isolation device, "pass" is defined as Criterion A, evidenced by all the below conditions throughout the time when magnetic field is applied:

- No bit errors on any isolated data channel
- No glitches, missing edges, or extra edges on the isolated outputs
- No Supply fault or UVLO assertion
- Isolated power supply rail (for devices with integrated DC/DC) remains within specified regulation.

7 Test Setup Details

A single, standalone isolation device is not exactly an "EUT" according to IEC 61000-4-8/9 standards — both the standards intend to test end equipment which gets installed in various harsh environments. To verify that TI's isolation devices can withstand Class 5 test levels and perform as per "Criteria A", the standalone devices are tested on the board without any magnetic shielding. This exposes the devices directly to the magnetic fields (per IEC 61000-4-8 and IEC 61000-4-9) generated by the induction coil connected to the test current generator as shown in Figure 7-1.

For monitoring device-level performance during the magnetic field testing, the DUT is mounted on an evaluation board and operated in a representative, continuously monitored functional loop:

1. **DUT board**: A purpose-built characterization board, small enough to sit inside the maximum exposed area of the 1m × 1m coil.
2. **Input Signal**: A known pattern (for example, a fixed-frequency square wave) driven into the input side.
3. **Output Monitoring**: The isolated output signal/power is compared against the input in real time by a pattern checker / error counter, with an oscilloscope capturing any glitch.
4. **Power Supply**: Both sides powered at nominal and at the extremes of the recommended operating range; isolated supply output monitored for devices with integrated DC/DC.
5. **Orientation**: The board is rotated to expose the differential loops of the die to the field in all three axes. This matters because coupling is proportional to the loop area *projected* onto the field direction, so a single orientation is not a valid test.

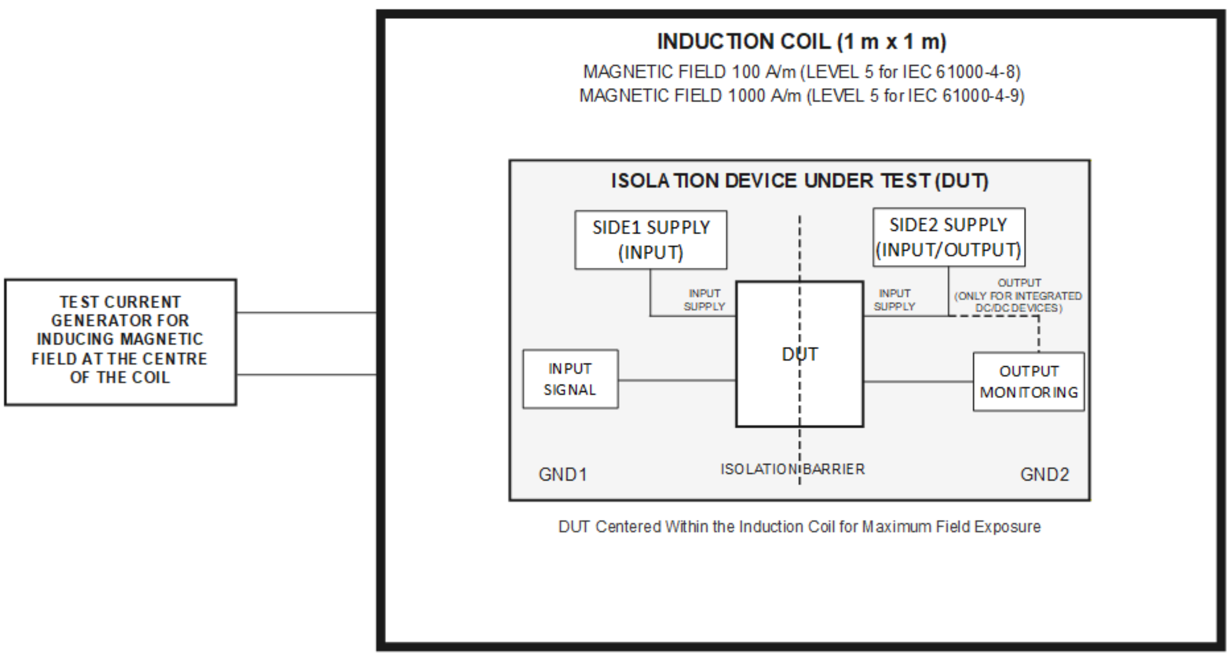


Figure 7-1. Test Setup for Magnetic Field Immunity

8 Test Results and Summary

All the devices listed in Table 8-1 have been tested for and passed the highest severity level (Level 5 / Class 5) of both IEC 61000-4-8 and IEC 61000-4-9 with "Performance Criterion A" in all three orthogonal field orientations. No external shielding, reorientation, or layout restriction was required to achieve this performance.

8.1 Test Conditions for Both Standards:

1. IEC 61000-4-8 (Power Frequency Magnetic Field) –
   a. 50Hz power frequency field
   b. All three orthogonal orientations
   c. 1m × 1m standard induction coil
   d. Continuous field applied for a 180-second duration
2. IEC 61000-4-9 (Pulse Magnetic Field) –
   a. 8/20μs pulse field
   b. All three orthogonal orientations
   c. 1m × 1m standard induction coil
   d. 10 positive + 10 negative impulses per orientation
   e. 10-second repetition rate for each pulse

Table 8-1. Magnetic Field Immunity Test Level and Performance Summary for TI's Isolation Devices

DUT Tested	Device Family Covered with the DUT Results	Device Category	IEC 61000-4-8		IEC 61000-4-9	
			Level 5 (100A/m)	Performance	Level 5 (1000A/m)	Performance
ISOW6441	ISOW64xx	Digital Isolator + Isolated Power	PASS	Criterion A	PASS	Criterion A
ISOW3080	ISOW308x	Isolated RS485 Transceiver + Isolated Power	PASS	Criterion A	PASS	Criterion A
ISOW1050	ISOW1050	Isolated CAN Transceiver + Isolated Power	PASS	Criterion A	PASS	Criterion A
ISO6441	ISO64xx	Digital Isolator	PASS	Criterion A	PASS	Criterion A
ISO6041	ISO60xx	Digital Isolator	PASS	Criterion A	PASS	Criterion A
ISOM8610	ISOM8xxx	Opto-Emulators	PASS	Criterion A	PASS	Criterion A
ISO7241	ISO72xx	Digital Isolator	PASS	Criterion A	PASS	Criterion A
ISO7041	ISO70xx	Digital Isolator	PASS	Criterion A	PASS	Criterion A

The above test results thus demonstrate the fact that TI's isolation devices are robust to magnetic field interferences and are not the limiting factor for immunity performance of end equipment in achieving even Class 5/Level 5 of magnetic field immunity.

9 System Design Considerations for End Equipment Performance

Even with an inherently robust isolator for magnetic fields from TI, the surrounding system design deserves attention, because at board level the loop areas are much larger than inside the isolator package:

1. Minimize loop area on both sides of the barrier. Route signal and return paths as tightly coupled pairs as the induced voltage is directly proportional to enclosed loop area.
2. Keep decoupling capacitors as close to the supply pins as possible. The supply loop is often the largest loop near to the isolator on the board.
3. Avoid running signal traces parallel to and directly beneath high-current conductors.
4. Using differential signaling for anything crossing a noisy region — magnetic coupling into a tight differential pair is largely common-mode and gets rejected at receiver side.
5. Remember that distance is a free margin since field strength falls off rapidly with increasing distance; a few extra centimeters from a strong magnetic field source is often more effective.

10 Summary

TI's isolation products (Table 8-1) achieve Class 5 performance for Magnetic Field Immunity (per IEC 61000-4-8 and IEC 61000-4-9) through several key architectural innovations such as - small differential loop areas, well-matched differential signaling with defined noise margins and an isolation barrier independent of magnetic coupling - which in turn makes sure that TI's isolation device used in the system design is not going to be the limiting factor for end-equipment performance. This is further validated by test results demonstrating successful Class 5/Level 5 performance.

11 References

1. IEC 61000-4-8:2009, *Electromagnetic compatibility (EMC) — Part 4-8: Testing and measurement techniques — Power frequency magnetic field immunity test*, Edition 2.0.
2. IEC 61000-4-9:2016, *Electromagnetic compatibility (EMC) — Part 4-9: Testing and measurement techniques — Impulse magnetic field immunity test*, Edition 2.0.
3. IEC 61000-4-5, *…Surge immunity test* (combination wave generator definition).
4. Agilent Technologies, *Compliance Testing to IEC/EN 61000-4-8*, Application Note 1319, publication 5968-3730E.