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Electric Fast Transient (EFT)

Application Note

Revision History

Document No.	Release Date	Change Description
301ANR00	September 23, 2024	Initial release.

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Introduction

Reliability is crucial for connectivity devices, especially in harsh environments where various disturbances can lead to voltage or current noise issues. Therefore, different standards exist for specific circumstances, such as electrostatic discharge (ESD), electrical fast transients (EFT), and surges.

EFTs are a common disturbance observed in switching systems. The impact of these transients can vary ranging from minor effects such as momentary room light flickering to severe consequences such as device or equipment damage. This application note provides a general overview of EFT and describes how MaxLinear products adhere to the *EFT* standard to safeguard against system damage.

What is EFT

EFTs are rapid bursts of high-frequency pulses typically caused by sparking or arcing. These sparks happen when circuits are connected or disconnected from power supplies, switchgear, or when lines contact with each other. Inductive loads such as relays, switches, or heavy-duty motors can also generate these bursts during transitions. Power line transients may occur when power cords are plugged in or switched off. Figure 1 shows EFT voltage waveforms with a 50Ω termination, as defined by the *IEC* standard. These transients can disrupt system signals, causing glitches that may lead to communication failures, device or interface bus damage, signal integrity loss, or similar issues. EFT occurrences are common in motor control systems, automotive electrical systems, AC power mains, Ethernet and data lines, as well as various other electrical systems.

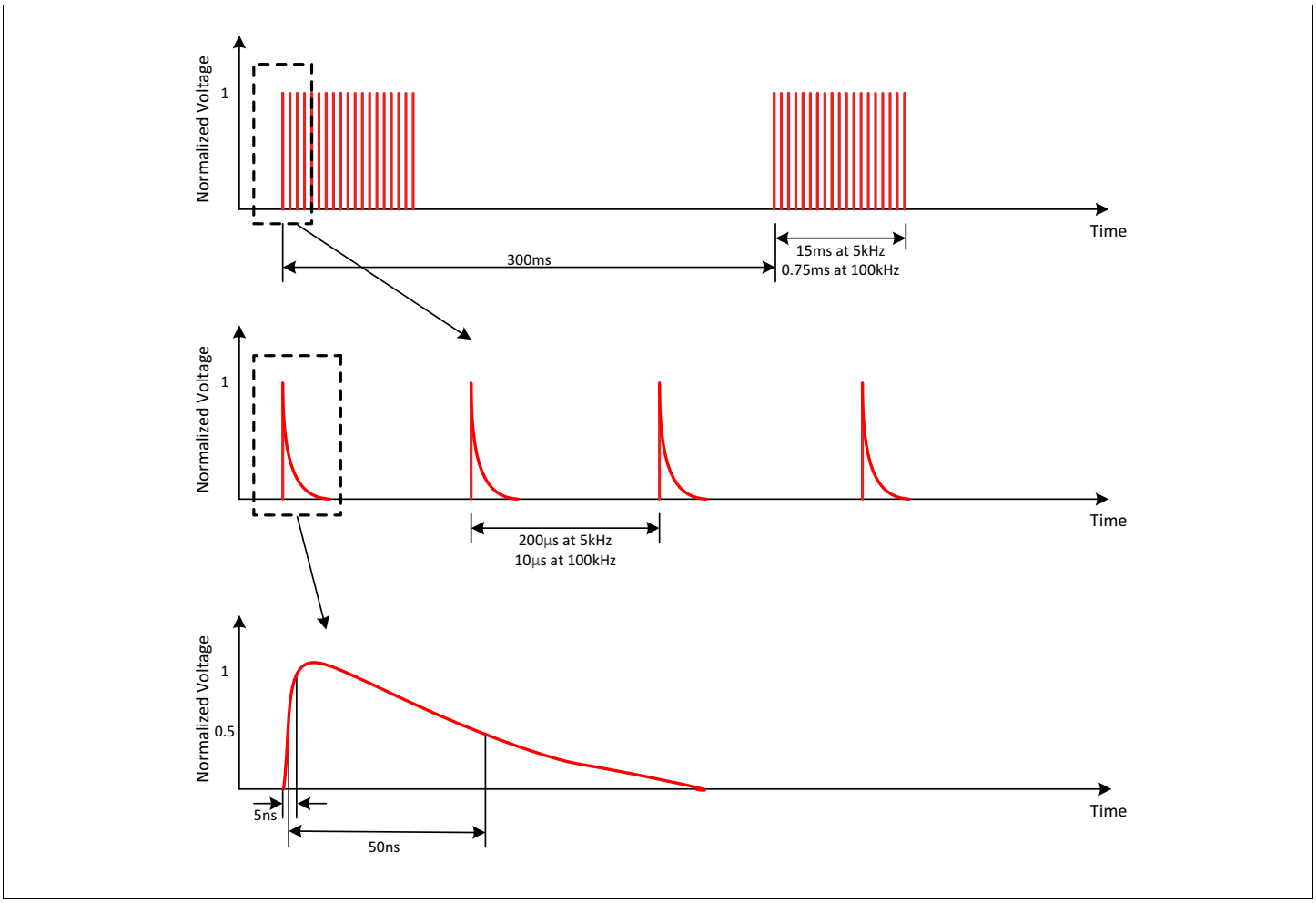

Figure 1: EFT Voltage Waveforms

EFT Tests and Actual Impacts

EFT tests, also known as *IEC 61000-4-4* tests, aim to assess the resilience of electrical and electronic equipment when exposed to repetitive bursts of electrical fast transients on control, supply, signal, and earth ports. These tests simulate the transients produced by switching inductive loads on AC power lines.

Figure 2 shows a straightforward setup for an EFT bench test. Two devices under test (DUTs) are linked through an EFT clamp. Data generated from a function generator is transmitted from one end to the other. The EFT input is produced by the EFT tester. Subsequently, the signal affected by EFT is monitored and observed using the oscillator.

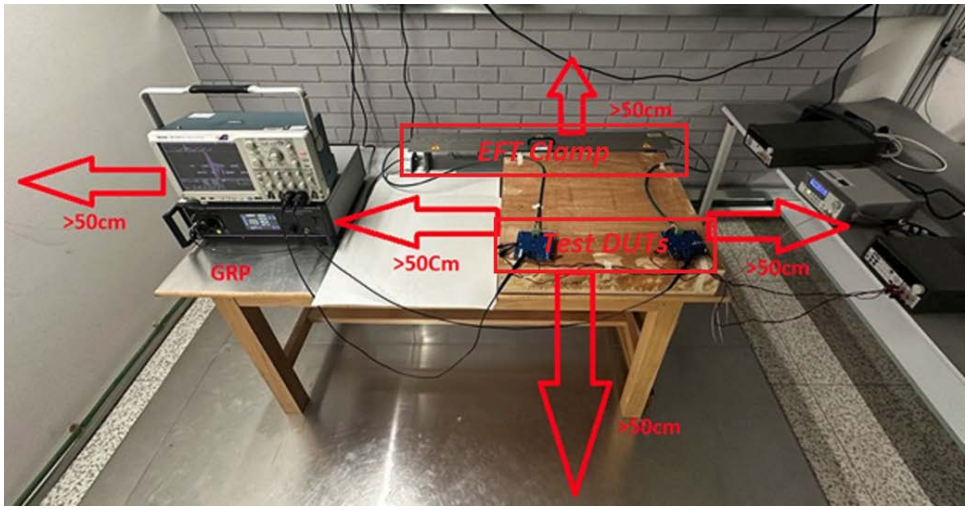

Figure 2: EFT Bench Setup

EFT disturbances have the potential to disrupt critical data transmission or even damage devices, leading to system failures and costly downtime. Consider the consequences of sending undefined or incorrect control messages to equipment in an automated factory. This disruption can result in production line downtime or unexpected damage. Similarly, disturbances in a servomotor factory can lead to incorrect data transmission, causing the motor to receive the wrong commands and potentially lose control altogether.

Note that completely eliminating EFT from a system is not always possible. Therefore, implementing EFT protection is crucial for designs or environments sensitive to noise. You should mitigate or reduce the impact of EFT to prevent it from compromising performance within the application limits. Besides adding external components on the PCB for protection and filtering, or implementing software error-check mechanisms, one effective approach is to select devices that come with built-in EFT protection. MaxLinear offers several RS-485 serial transceivers with built-in EFT protection.

Figure 3 shows a waveform capturing the impact of a 4kV EFT burst on the data pins (DI of the driver side and RO of the receiver side) of an RS-485 transceiver with EFT protection. While the EFT burst does affect the RS-485 data, the transceiver not only reduces the EFT impact but more importantly quickly self-recovers to full functionality, ensuring system reliability and stability.

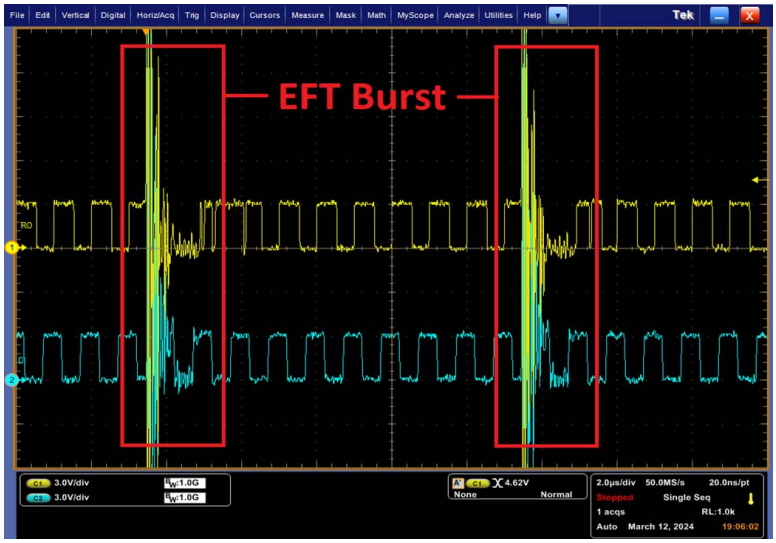

Figure 3: EFT Burst Sample

EFT Test Levels and Passing Criteria

The *IEC 61000-4-4* standard categorizes EFT tests into four levels based on the device's operating environment. Various voltage levels are applied depending on the type of device being tested. Table 1 lists the environment and corresponding test voltage levels for each level.

MaxLinear offers transceivers with ±2kV EFT (or higher) rating on their IO ports and are therefore capable of supporting level 4 EFT or applications in severe industrial environments. For further information about MaxLinear products with EFT protection, see Table 3 on page 5.

Table 1: IEC 61000-4-4 EFT Test Voltage Levels and Environments

Levels	Test Voltage (kV) for Signal, Control, IO Ports	Test Voltage (kV) for Power Ports	Environment Type
Level 1	0.25	0.5	Well protected environment
Level 2	0.5	1	Protected environment
Level 3	1	2	Typical industrial environment
Level 4	2	4	Severe industrial environment

The test results can be categorized based on loss of function or degradation of performance exhibited by the DUT. Per I*EC 61000-4-4*, the performance criteria are listed in Table 2.

Table 2: Performance Criteria

Performance Criteria	Description
Criteria A	Normal performance within the specification limits.
Criteria B	Temporary loss of function or degradation of performance which is self-recoverable.
Criteria C	Temporary loss of function or degradation of performance which requires operator intervention or system reset.
Criteria D	Loss of function or degradation of performance which is not recoverable due to damage of equipment (components) or software, or loss of data.

However, end application requirements dictates whether the criteria are considered passing or failing.

If an EFT event occurs with a device compliant with criteria D or with no EFT protection capability, the resulting unrecoverable data loss or device failure can render the entire system inoperable or even cause damage. Conversely, if a device compliant with criteria C experiences an EFT event, it may require manual intervention from a system operator to recover the device or system, which is not ideal and may necessitate unnecessary resources in settings such as automated factories.

MaxLinear's devices are tested to meet or exceed criteria B, which means that even in the event of temporary data loss due to EFT, the device at the very least can self-recover. This eliminates the need for additional efforts to restore the entire system to normal operation.

MaxLinear Devices and EFT

MaxLinear employs a robust test procedure designed to ensure reliable and repeatable *IEC 61000-4-4* EFT tests. These tests are conducted to assess the immunity of electrical and electronic equipment when exposed to repetitive bursts of electrical fast transients on supply, signal, control, and earth ports.

MaxLinear's test procedures adhere to the guidelines outlined in the *IEC 61000-4-4 International Standard, Electromagnetic Compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test. Edition 3.0, 2012-04*, providing a comprehensive framework for accurate evaluation and assessment.

MaxLinear Transceivers with EFT Support

MaxLinear's transceiver products are equipped with Electrostatic Discharge (ESD) and EFT protection mechanisms, ensuring stable performance even in noisy environments.

Table 3: MaxLinear Devices with EFT Protection

MaxLinear Part Number	ESD and EFT Ratings	
	ESD Ratings	**EFT Ratings**
MxL83101	±15kV (HBM ESD) ±8kV (IEC 61000-4-2 Contact)	±2kV
MxL83102	±15kV (HBM ESD) ±8kV (IEC 61000-4-2 Contact)	±2kV
MxL83111	±15kV (HBM ESD) ±8kV (IEC 61000-4-2 Contact)	±2kV
MxL83112	±15kV (HBM ESD) ±8kV (IEC 61000-4-2 Contact)	±2kV
MxL83121	±15kV (HBM ESD) ±12kV (IEC 61000-4-2 Contact)	±2kV
MxL83122	±15kV (HBM ESD) ±12kV (IEC 61000-4-2 Contact)	±2kV
MxL83211	±15kV (HBM ESD) ±12kV (IEC 61000-4-2 Contact)	±4kV
MxL83212	±15kV (HBM ESD) ±12kV (IEC 61000-4-2 Contact)	±4kV
MxL83214	±15kV (HBM ESD) ±12kV (IEC 61000-4-2 Contact)	±4kV
MxL83411	±15kV (HBM ESD) ±8kV (IEC 61000-4-2 Contact)	±2kV
MxL83433	±15kV (HBM ESD) ±12kV (IEC 61000-4-2 Contact)	±4kV
MxL83434	±15kV (HBM ESD) ±12kV (IEC 61000-4-2 Contact)	±4kV

Conclusion

To minimize potential damage and enhance reliability, it is essential to always consider EFT protection when designing systems that interface with high voltage or high current sources, or incorporate inductive loads such as motors, relays, and switches. Without adequate EFT protection, the risks can range from data inaccuracies to system damage, necessitating additional costs for repairs or recovery. MaxLinear's devices, compliant with Performance Criteria B, not only bolster the reliability of the device and the overall system but also mitigate potential risks and associated costs.

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