Electronic Current Limiter Solutions

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Ethernet is the most pervasive interface technology used in Local Area Networking (LAN). There are several variations of Ethernet; the most common types are the 10BaseT at 10 Mbps data rate, Fast Ethernet at 100 Mbps and a growing trend toward Gigabit Ethernet (GbE). The use of Ethernet is expected to grow over the next 10 years. In this timeframe, GbE is expected to adhere to the IEEE 802.3 standard, which will lead to faster and simplified deployment while delivering higher bandwidth LAN performance.

As communications networks increase in presence both inside and outside of the home and office, there is an increasing likelihood that Ethernet cabling and ports will be exposed to electrical overstress due to lightning surge, power line induction and power cross. This can result in damaged network interface components and increased system costs due to hardware problems. An electronic current limiter (ECL) is a type of circuit protection technology solution that effectively protects Ethernet ports within nanoseconds of a power threat and is resettable.

This article discusses the various protection standards for Ethernet ports and examines ECLs as a design solution for effective circuit protection. It provides additional details on how to implement the technology features of ECL devices to serve as a fast-acting circuit protection solution for Ethernet port protection. The supplementary lightning surge and power fault protection characteristics of electronic current limiter technology will be examined, and benchmark test results are included that demonstrate the robust capabilities of ECLs for secure and reliable circuit protection in Ethernet ports.

Protection Standards

Ethernet was not originally intended to be used in the broad array of applications in which it is used today. Customers recognize the need for protection on these ports. Thus protection standards generally, and Telcordia and ITU-T standards and recommendations specifically, are now in “catch up” mode. In the interim, engineers are adapting telecom standards and applying them, sometimes with customization, to their Ethernet port protection. One such adaptation that customers are implementing is Telcordia GR-1089-CORE.

The protection standard GR-1089-CORE Issue 4, Section 4.6 defines the criteria for equipment interfacing with telecommunications ports and requires that “telecommunications ports be tested regardless of the type of traffic they carry or what function they perform. For example, 10BaseT and 100BaseT Ethernet and other similar ports are considered telecommunications ports and shall be tested.” Engineers take these requirements, sometimes modifying the configuration, and use them as a guide to determine the resilience of their protection schemes against faults.

Lightning surge and AC power fault surge tests for Ethernet applications are

categorized based by port types in GR-1089-CORE Issue 4. Depending on the exposure level and resistibility level, engineers chose between Port Type groups 1, 3, and 5 and Port Type groups 2 and 4. In the protection standard GR-1089, criteria for equipment interfacing with telecommunications ports is referred to as first-level or second-level criteria. First-level compliance requires that the equipment under test (EUT) “shall not be damaged and continue to operate after the application of the tests.” This is typically the goal engineers strive to achieve in their design.

GR-1089 defines second-level criteria as more destructive than first-level criteria. Second-level criteria ensures that the EUT will not become a fire, fragmentation hazard, or electrical safety hazard as a result of the applied test. However, the EUT may be damaged during the test.

The other large standards group addressing Ethernet protection is the ITU-T. Currently, the recommendations of ITU-T do not cover the need for Ethernet protection. Working groups are discussing these at the moment. In general, for equipment with ports or cables that are exposed to more than just ESD threats, the basic and enhanced requirements of ITU-T K.45 are applied. A summary of the requirements found in the two standards and recommendations includes 800 V, 1500 V, and up to 6000 V surge levels. AC power cross requirements are typically 120 Vac and 230 Vac.

ECL Protection

Electronic current limiters are an effective method for protecting Ethernet transmit and receive pairs for 10Base-T, Fast Ethernet, and Gigabit Ethernet. The ECL device is placed in the circuit to block the fault current when a line is surged. An ECL is a normally low resistance semiconductor device that is triggered to a high impedance state when the current flowing through it reaches a preset trigger level.

In normal operation, the ECL device appears as a resistor in the circuit. It is a two terminal device, and requires no connection to a supply or ground. Hence, the only capacitance it introduces into the circuit is that of stray capacitance to surrounding traces, which is no more than a typical surface mount resistor. The ECL device is extremely fast to react to transients -- typically limiting current within 500 ns.

ECL Device Protection Solution

Ethernet applications include an isolation transformer between the drivers/receivers and the line interface. Depending on the level of protection, available PCB area, and other factors, the ECL device is used either in front of or behind the transformer.

In gigabit applications, bandwidth measurements are often analyzed. During normal operation, the ECL device appears as an equivalent series resistor with approximately 500 pF in parallel, translating to a slight insertion loss at low frequencies. Around 100 MHz will rise due to the bypass effect of the capacitance. This is typically the case up to around 2 GHz, at which point circuit layout will have the most effect on bandwidth.

Bench Measurements

The following test results demonstrate the protection capabilities of some of the

circuits described through this point. The ECL device used in the tests below has an impulse voltage rating of 850 V, which means that peak surge voltages lower than 850 V are blocked by the device and the circuit will pass the surge requirements described in the standards section of this report. For voltages higher than 850 V, a gas discharge tube (GDT) is used in conjunction with the ECL. This combination provides the fast blocking protection of the ECL device and the high voltage surge protection (up to 6 kV) of a GDT.

The Ethernet line transformer provides high voltage isolation between the line and the protected side of the transformer. Primary to secondary voltage isolation is typically rated for 1500 V or higher. The termination capacitor is rated to withstand longitudinal mode voltage conditions. The center-tapped virtual AC ground capacitor is present on the primary side of the Ethernet transformer to reduce emission levels due to electromagnetic interference (EMI). The capacitor value is 220 pF, 2 kV.

800 V Lightning Surge Testing

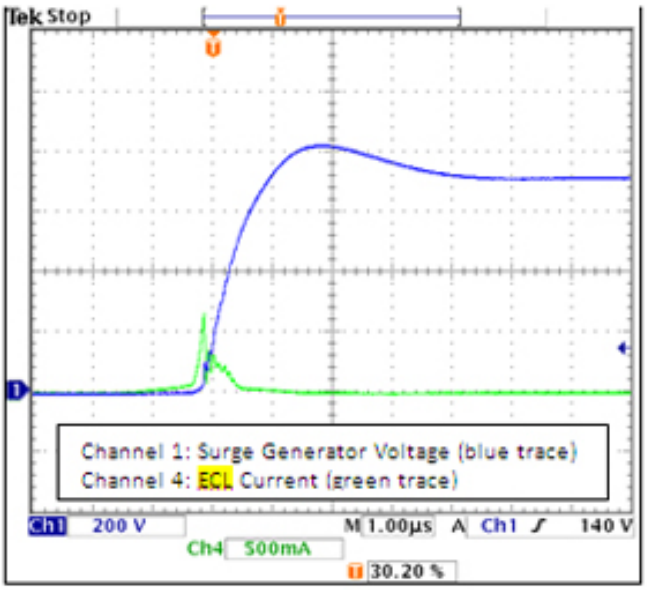

Figure 1. Rx Pair

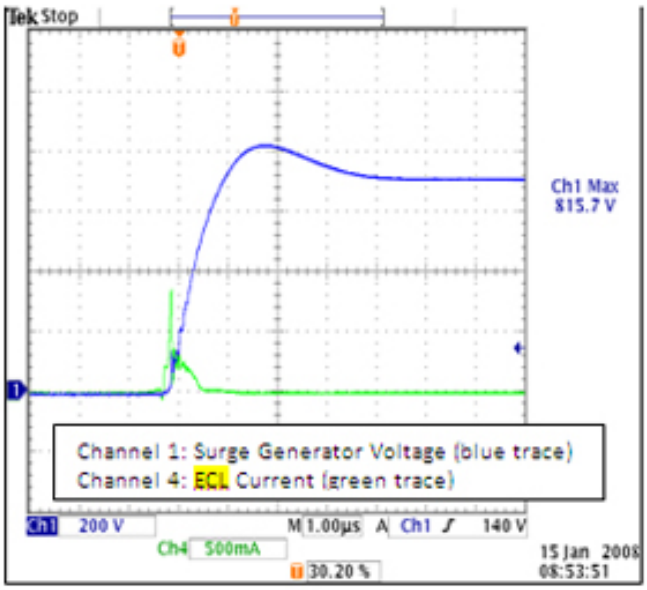

Figure 2. Tx Pair

In Figures 1 and 2, the generator voltage increased and the current through the ECL device caused the device to trigger. The port is protected and no damage or stress occurred to the Ethernet and protection circuits. The port remains functional after the test.

120 Vrms Power Fault Test

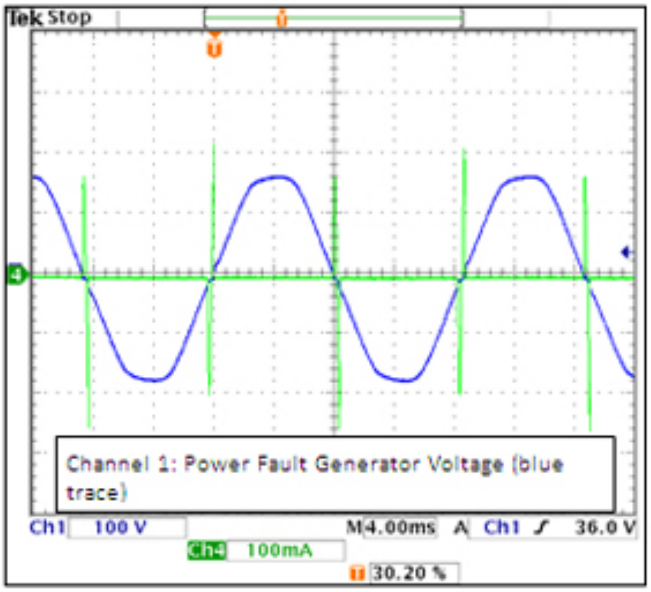

Figure 3. Rx Pair

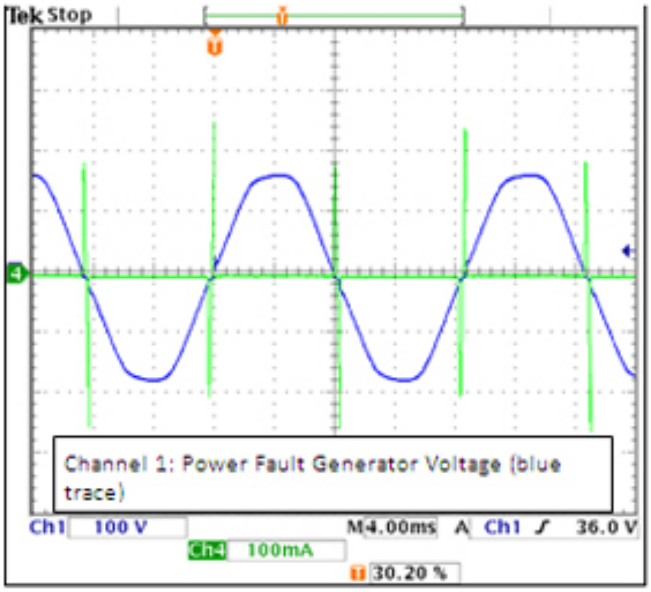

Figure 4. Tx Pair

Figures 3 and 4 show the ECL triggering during the power fault test. When the ECL device triggers due to a positive-going AC power fault, it protects the Ethernet port. Once the surge voltage reduces, the device resets until it triggers and protects against the negative-going AC power fault. This cycle repeats for the duration of the fifteen minute test. No damage or stress occurs to the circuits. The port remains functional after the test.

Conclusion

ECL devices are designed to provide superior protection for Ethernet applications and their bandwidth allows for very high data rates to pass without interference to the signals. Since no damage or stress is made to the Ethernet circuit or the protection devices, the circuit is fully functional after the surge tests within rated limits. When implemented correctly, an ECL device solution provides fast-acting Ethernet port protection and meets the Telcordia GR-1089 and ITU-T protection standards and recommendations. For more information about ECL devices, a white paper is available at www.bourns.com/data/global/pdfs/Bourns_tbu_white_paper.pdf [1].

Links:

[1] http://www.bourns.com/data/global/pdfs/Bourns_tbu_white_paper.pdf