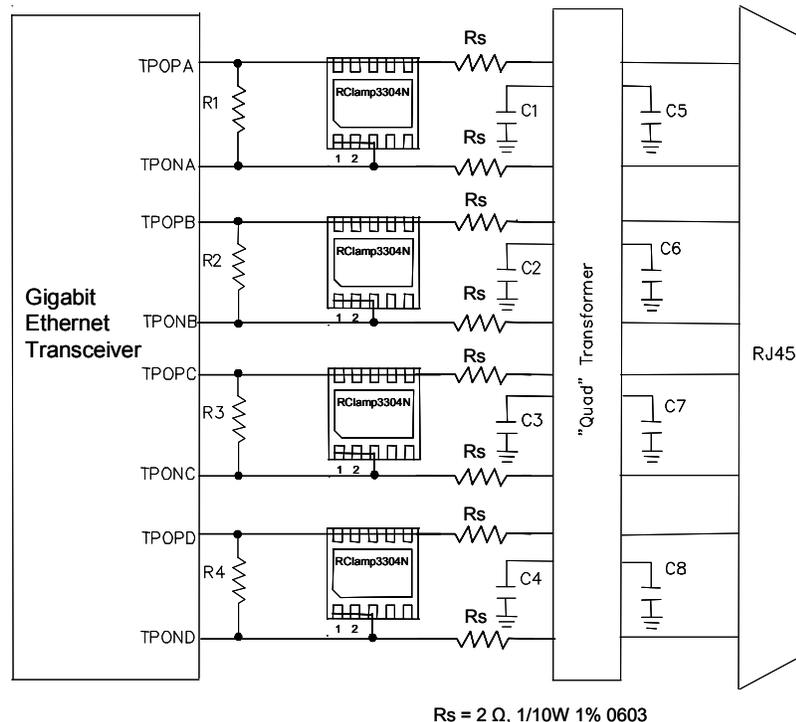


GR-1089 Intra-building Protection for Marvell 88E111x Family

Ethernet systems with connections external to the building are subject to high-level lightning threats. This type of equipment will generally need to meet the surge immunity requirements of Telcordia GR-1089. Reliable protection of the Ethernet transceiver requires a device that can absorb the expected transient energy, clamp the incoming surge to a safe level, and yet remain transparent to the system under normal operation. Additionally, each new generation of Ethernet deployment yields higher-density boards that demand protection solutions that occupy less board space. Exacerbating the problem, Gigabit Ethernet systems must be rated to operate at temperatures as high as 65°C, making application of external protection even more challenging. This application note will present the solution for reliable protection of GbE systems. This solution is designed to meet the surge requirements of GR-1089. If designed properly, this solution can be used without causing transmission errors.

Transient Threats

The small geometries of GbE transceivers make them particularly susceptible to upset or damage from transient events. One of the most common threats is a Cable Discharge Event (CDE). A CDE occurs when an Ethernet cable becomes charged (due to its environment) and subsequently discharges into the circuit when the cable is plugged into the connector. In general, the waveforms last for a few hundred nanoseconds with rapid polarity changes. Electrostatic discharges (ESD) that originate from the user are also common. These types of waveforms last for approximately 60ns and are consistent with the human body model as defined by immunity standards such as IEC 61000-4-2. For outside connections, lightning can also induce high voltage onto the lines that can be transferred to the Ethernet PHY IC. These events are high energy pulses, lasting several microseconds. The Telcordia Technologies GR-1089-CORE specification defines a set of requirements for lightning and ESD immunity for intra-building equipment. The lightning tests are applied as metallic (line-to-line) or longitudinal (line-to-ground) waveforms. The waveforms are


Figure 1 - GbE Protection to GR-1089 Using RClamp3304N

defined with a rise time of 2µs and a decay time of 10µs with an open circuit (metallic) voltage of 800 volts short circuit current of 100A. Positive and negative polarity surges are applied. To pass, the equipment must continue to operate after the test.

Ethernet Magnetics

An Ethernet port includes transformers and common mode chokes for connecting the PHY to the outside world. Transformers and chokes can be discrete components, but integrated solutions that include the RJ-45 connector, resistors and capacitors are becoming increasingly popular. In either case, the transformer will provide a high level of common mode isolation to external voltages, but no protection for metallic surges. For a metallic (Line-to-Line) surge, current will flow into one line, through the transformer and back to the source. As the current flows, it charges the secondary windings of the transformer. Once the surge is removed, the secondary winding will stop charging and will transfer its stored energy to the primary side where the PHY IC is located. The magnitude and duration of the surge is attenuated by the inductance of the magnetics. The amount of attenuation will vary by vendor and configuration (i.e. with or without CM choke) of the

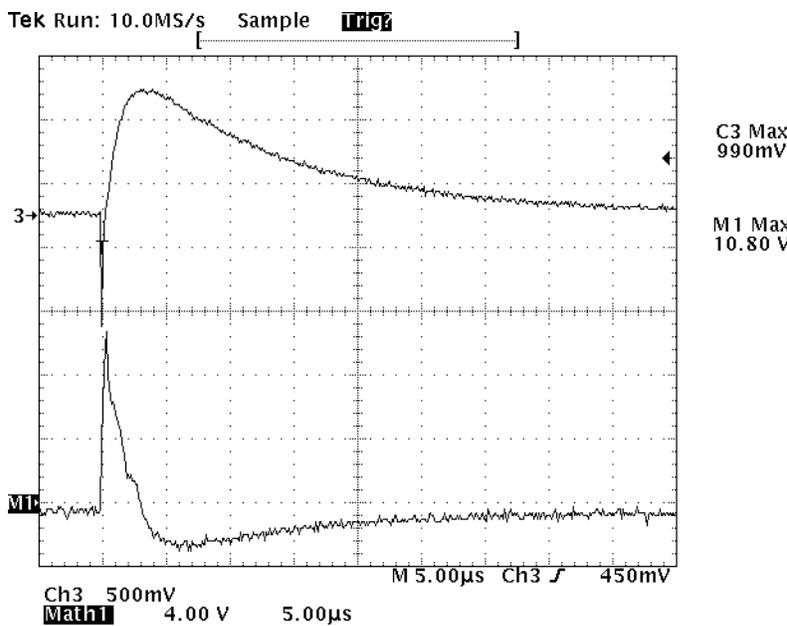
magnetics. Regardless, the pulse will most certainly be destructive to the PHY chip.

Operation Over Temperature

GbE ports must be able to operate at elevated temperatures without symbol or CRC (Cyclical Redundancy Check) errors. Most manufacturers require operation up to 65°C with a 100m cable attached to the port. This presents several challenges. First, the high temperature means the margin of operation of the PHY will be reduced. Also, the 100m cable will degrade the signal at the receiving end. Finally, the protection component will present non-linear impedance over temperature. The GbE PHY can account for some impedance variations or discontinuities on the line by performing a forward error correction (FEC). However, large non-linear impedance changes across the differential pair can not always be accounted for. The amount of variation in the protection device will depend on leakage current and capacitance; factors dictated primarily by the junction area of the device.

Protection Solutions

Semtech’s RClamp3304N is a low capacitance, transient voltage suppressor (TVS) designed to protect Gigabit



Channel 3:

Input surge - 100A 2x10us per GR 1089

Channel M1:

Clamping voltage of the RClamp3304N in the configuration shown in Figure 1.

Figure 2 - Input Surge Voltage vs. Clamping Voltage

Ethernet ports while maintaining traffic performance over temperature. The RClamp3304N may be used on the PHY side of the transformer to meet the intra-building lightning surge requirements of Telcordia GR-1089 (Ipp=100A, tp=2/10us). The RClamp3304N is constructed using Semtech’s EPD process technology to achieve a working voltage of 3.3 volts. As a result, clamping voltage is minimized for maximum protection of the GbE PHY. The device is in a leadless, RoHS compliant package measuring 2.6 x 2.6 x 0.6mm.

Figure 1 illustrates how to connect the RClamp3304N with a 2 Ohm resistor on each line for protecting the Marvell 88E111x Gigabit Ethernet family to GR-1089 (intra-building). Each line pair is protected using one device connected in differential mode (Line-to-Line) configuration on the PHY side of the transformer. For best results, parasitic inductance should be minimized by placing the device as close to the magnetics as possible, on the same side of the board as the PHY and transformer. All pins should be connected and traces can be run through each side of the device as shown. Figure 2. shows that the protection scheme shown in

Figure 1 takes the 800V (100A) surge per GR-1089 to a clamping the voltage of approximately 10.8V. This protection scheme provides the necessary protection required to prevent stress and damage to the GbE PHY while maintaining signal integrity at elevated temperature.

Test Results Over Temperature

Traffic testing using the protection scheme shown in Figure 1 was performed over a temperature range of 25°C to 85°C. The test was accomplished using two Ethernet evaluation boards, one to transmit, and one to receive, connected by 100 meters of cat 5e cable. The protection devices were connected on the receiver board. GbE traffic test results are summarized in Table 1. As shown, the GbE traffic operation was without CRC or symbol errors across the given temperature. Testing per the IEEE template was also performed with passing results.

Test	Circuit Configuration	@ 25 °C		@ 40 °C		@ 65 °C		@ 85 °C	
		CRC/Symbol Error		CRC/Symbol Error		CRC/Symbol Error		CRC/Symbol Error	
Traffic Test	Figure 1	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
IEEE Template	Figure 1	PASS							