How IEC 60512-99-001 Compliance Ensures Power over Ethernet Plus (PoE+) Network Reliability

White Paper 236

Revision 0

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Executive summary

Power over Ethernet (PoE) Plus allows for the delivery of additional power via a single common power / data RJ45 connector-equipped Ethernet cable. This translates into cost savings, greater freedom regarding the location and variety of connected devices, and improved energy efficiency management. However, in this environment, lack of compliance with IEC 60512-99-001 standards can result in downtime. This paper describes proper steps to take when upgrading building infrastructure to PoE Plus.

Introduction

Ethernet TCP/IP protocol is a staple in control room, network backbone, and access link environments. The installation of technologies such as IP phones, wireless access points, security cameras, and LED lighting has grown exponentially. In fact, this Ethernet connectivity boom is expected to reach 14 billion devices worldwide by the end of 2022[1]. As a result, the rapid growth of connected IP devices has driven the need for Ethernet-based services in LAN environments inside offices, hospitals, apartments, and other buildings. Research shows that overall cabling in LAN environments is expected to increase from $4.9 billion in 2012 to $6.7 billion in 2020 (see **Figure 1**)[2].

Building facility owners and operators now need to consider and assess the impact of this projected growth on existing networks. Mistakes made in configuring network upgrades could result in avoidable cost. "Passive" network infrastructures (that is to say, network infrastructure within floors, walls, and ceilings like cables and RJ45 connectors that reside in buildings for an average of 7 years before requiring an upgrade) need to be able to support the "active" network infrastructure (equipment like servers and switches that evolve quickly and that are replaced / upgraded much more frequently).

Fortunately, Power over Ethernet (PoE) technologies can power devices such as IP phones, wireless access points, security cameras, and LED lighting via structured cabling systems infrastructure. Structured cabling systems (SCS) consist of panels, twisted-pair cables, RJ45 connectors, cords, and enclosures. Existing investments in current passive network infrastructure may in some cases be preserved. However, certain precautions need to be taken in order to ensure that any potential cost savings entitlement can be leveraged.

Figure 1
Forecast of structured cabling growth in LAN environments from 2006 to 2020, in millions of US dollars

The PoE approach uses one cable for both power and data. The transmission of data and power are dealt with in a separate manner. Current enters an Ethernet cable through what is known as an injector. This prevents the electrical current from interfering with data transmission. PoE technology benefits include cost savings and freedom regarding the location of connected devices.

An advanced version of this technology, PoE Plus, which has been standardized and ratified by the Institute of Electrical and Electronics Engineers (IEEE 802.3at), can provide up to 30 watts of DC power capacity (compared to 15W DC for standard PoE) on the same data / power cable. This additional power capacity enlarges the

[1] BSRIA, "Long term View of the Structured Cabling Market World Overview, September 2013

[2] Cabling Installation and Maintenance, "BSRIA: Global structured cabling market will exceed $8B by 2020", September 2013

scope for those future devices and applications that require additional power (for example, new-generation wireless access points which meet the IEEE 802.11ac standard, recent pan-tilt-zoom motorized cameras, and new versions of building LED lighting systems).

Deployment considerations

In order to proactively anticipate and support future PoE Plus technology deployments, the structured cabling systems of LAN networks should be sized to support the higher voltage and current requirements of PoE Plus.

The use of PoE Plus on cabling infrastructure can create an electrical arc between the plug contact of the patch cord and the contact of the RJ45 connector during the disconnection phase (see **Figure 2**)[3].

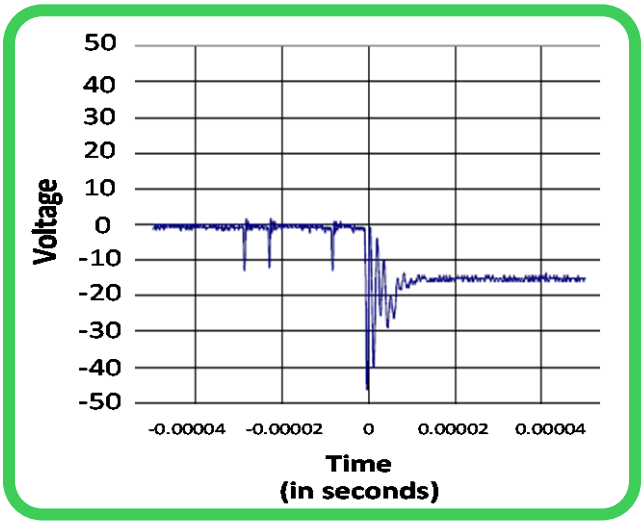


Figure 2
Measured voltage on a RJ45 connector contact during circuit break (disconnection phase) Source: Delta

To guard against this possibility, a standard (IEC 60512-99-001) has been created for cabling infrastructure. The objective of this standard is to test RJ45 connectors. Tests are conducted that simulate both real-life PoE Plus capacity loads and the aging process (using a corrosive gas). If the connectors pass all the tests, they are deemed compliant (meaning that their transmission performance is not impacted by the use of PoE Plus, that is, no corrosion appears on the surface of the contact used for transmission – see **Figure 3**).

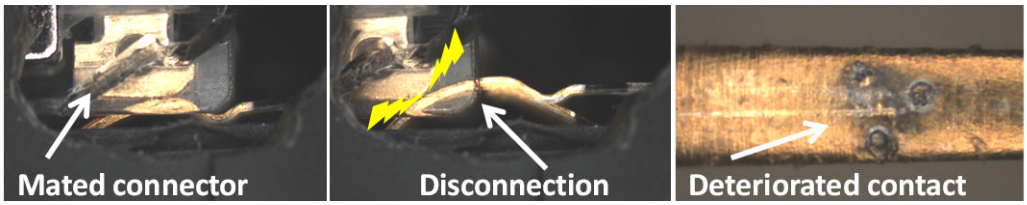


Figure 3
The impact of frequent connect / disconnect sequences along with additional power through the wire can result in rapid deterioration.

Connection and disconnection of devices such as servers, laptops, switches, IP phones, wireless access points, and cameras to and from the network is performed manually. An IT manager or user of the connected device removes the patch cord (male plug) from the RJ45 connector (female receptacle) of the device (see **Figure 4**). In situations where the IEC 60512-99-001 standard has not been enforced, an electric arc appears during the disconnection process and can damage and corrode

[3] Delta, "Testing of connecting hardware for ability to deliver power over Ethernet," March 2012

the contact (see **Figure 3**). The contact may not be able to be used anymore after one or several disconnections. As a result, the connector will need to be replaced, and this will drive up maintenance and installation costs.

Figure 4
Areas where the contacts of the RJ45 connectors could be damaged under the PoE Plus load.

Benefits of embracing the standard

When designing structured cabling systems infrastructure for new or refurbished buildings, the connecting hardware being used should conform to the IEC 60512-99-001 standard and be validated by a qualified third-party laboratory. The risk of ignoring such compliance activities is that some of the RJ45 connectors will no longer operate at the right levels of performance because damaged connector contacts will result from the added PoE Plus loads. Adherence to the standard eliminates this risk and increases the overall reliability of the network (see **Table 1**).

Table 1
IEC 60512-99-001 standards, if correctly interpreted, can result in multiple business efficiency benefits

Benefit	Description
Improved network reliability	• IEC 60512-99-001 compliance guarantees that the levels of current and voltage used to carry the power over the network (in the case of PoE Plus) will not impact / deteriorate the key passive components (RJ45 connectors) of the network infrastructure and degrade transmission performance. Connectors will remain functional after supporting PoE Plus loads, with no functional area contact corrosion.
Extended return on investment	• IEC 60512-99-001 compliance ensures that the RJ45 connector portions of the cabling infrastructure are ready to support PoE Plus technologies when they are deployed. There will be no need to upgrade the passive infrastructure when deploying PoE Plus. This extends the cabling infrastructure lifecycle.
Increased cost savings	• IEC 60512-99-001 compliance avoids additional costs to the passive network infrastructure when upgrading. • No need to replace out of order connectors that will deteriorate due to electrical spark/arc/flash when PoE Plus power levels are added to the network • Since only one cable is required to transmit both data and power to connected devices, the overall quantity of cabling to be purchased will be reduced. • PoE Plus technology enables the monitoring of connected component electrical consumption data. This opens the door to increased energy savings, thereby reducing electrical costs. • The upgraded system will allow connected devices to be visible to building management system administrators, which can help to further control energy consumption costs.
Improved quality	• IEC 60512-99-001 certification is delivered by an external / 3rd party company (neutral view). This reinforces the warranty of quality and proof of quality.
Enhanced maintenance flexibility	• IEC 60512-99-001 compliance guarantees that connection and disconnection of devices will not deteriorate the RJ45 connectors. Maintenance operations (moves, adds, and changes) in buildings requiring connection and disconnection can be performed without specialized personnel or experts. • PoE Plus load compliance means that fewer calls will be made to maintenance personnel for network-related diagnostic issues.

Facts about RJ45 connectors

RJ45 connectors (see **Figure 5**) are one of the principal standardized components of structured cabling systems and support Ethernet services across all building types. All RJ45 connectors, regardless of vendor, are governed by the same ISO/IEC 11801:2011 Ed.2.2 standard (front face dimension and transmission performance standards).

This standardization ensures a minimal number of connection / disconnection occurrences and ensures that the cable medium has the proper construction to carry data. However, this standard does not address RJ45 connector behavior when subjected to the additional power of PoE Plus. The double use of the cable was not accounted for in the current standard. As a result, there are potential risks when connecting and disconnecting network components. To address this situation, the IEC 60512-99-001 standard came into being.

Figure 5
An example of RJ45 connector with visible contacts

It should be understood that compliance to the current IEEE 802.3at standard (PoE Plus) standard is NOT sufficient for buildings that choose to migrate to PoE Plus. In order to leverage the new technology, the IEC 60512-99-001 standard needs to be embraced. As buildings get "smarter" the future usage of network infrastructure will involve the increased convergence of data and power.

"As buildings get "smarter" the future usage of network infrastructure will involve the increased convergence of data and power."

All RJ45 connector contacts are manufactured with the same material to ensure compliance with the minimal requirements of transmission performance. However, the quantity of each material used to manufacture an RJ45 connector is proprietary and can vary depending upon the manufacturer (the quantity of gold used, for instance, can vary).

The connector has eight contacts to ensure a good connection. Materials used to manufacture a contact include:

- Inside layer: bronze alloy (tin, copper, and phosphorus)
- Middle layer: nickel (to ensure hardness)
- Outside layer: gold (to make contact more malleable)

The quantity of gold on a contact is minimal (~0,5µm) but is very important to ensure proper behavior when the contacts are under the pressure of load.

The IEC 60512-99-001 standard details

Some manufacturers have made the decision to be compliant with the IEC 60512-99-001 standard. The future reliability of networks is a key consideration because passive networks are expensive to upgrade and rapid technology obsolescence is to be avoided, particularly in the buildings industry. These manufacturers will contract with an external laboratory to certify its connectors. This helps to validate that the test results are objective.

This independent third party measures the resistance of contacts before and after the tests. If the resistance is the same (with a tolerance of 20mΩ) before and after the testing, then the connector passes the test. The result means that the contact is suitable for PoE Plus use. This certification is a warranty of quality for the customers. As a result, end users avoid the cost of having to independently certify their installations.

Testing standards require a minimum of eight specimens (connectors). The eight contacts of each RJ45 connector are subjected to the tests. All of the specimens (100%) must pass the test to be validated as conforming to the IEC 60512-99-001 standard.

Testing to validate compliance with the IEC 60512-99-001 standard can be broken down into six important steps (see **Figure 6**) which are detailed in the following pages.

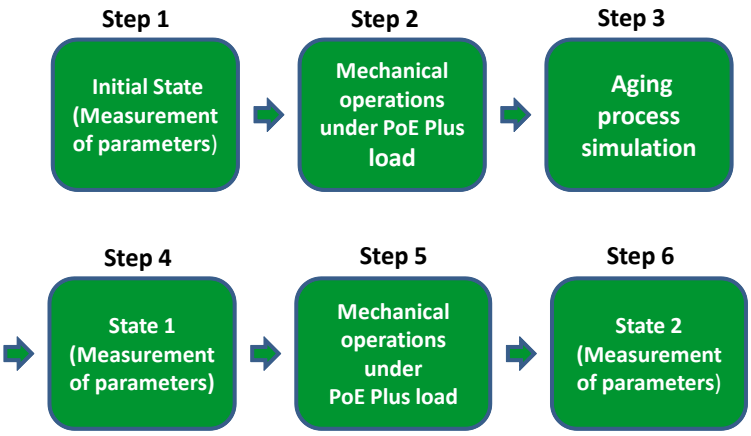


Figure 6
The six steps to test for IEC 60512-99-001 standard compliance

Step 1: Initial state (state 0)

Although the key parameter being measured for each RJ45 connector sample is contact resistance, two additional tests are performed on RJ45 connectors. One measures insulation resistance; the other, voltage verification (see **Figure 7**).

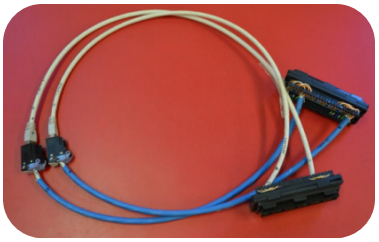
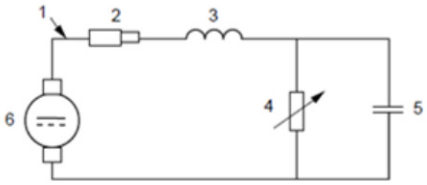


Figure 7
Samples of RJ45 connectors prepared for testing

For voltage verification, the defined parameter is set above 1000 volts DC at step 1 (before modification) and at step 6 (after modification). This test is more demanding than the IEEE 802.3at testing (which specifies a maximum current of 0.3 amps per contact and 55 volts DC). The IEC 60512-99-001 standard requires a doubling of the current, to a maximum of 0.6 amps (see **Figure 8**).



1	Cables in accordance with 4.1
2	Connector under test
3	Inductor 100 µH
4	Variable resistor (e.g. 50 Ω to 300 Ω)
5	Capacitor 5 µF
6	Power source

Figure 8
Electric circuit representing one contact for measuring contact resistance

The idea is to test by simulating real-life situations encountered in the field. Since there is a high probability that one contact will disconnect before the other in the same pair, the second contact will be required to support twice the power (~33W).

Step 2: Mechanical operation under PoE Plus load

Once the samples' initial state is defined, they are subjected to mechanical operation under a PoE Plus load. The mechanical system (see **Figure 9**) separates the connector from the plug a certain number of times under the load. This includes 25 mating cycles for one polarity of the current, and 25 mating cycles for the other polarity. The current load is applied only during separations.

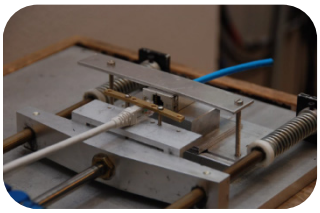
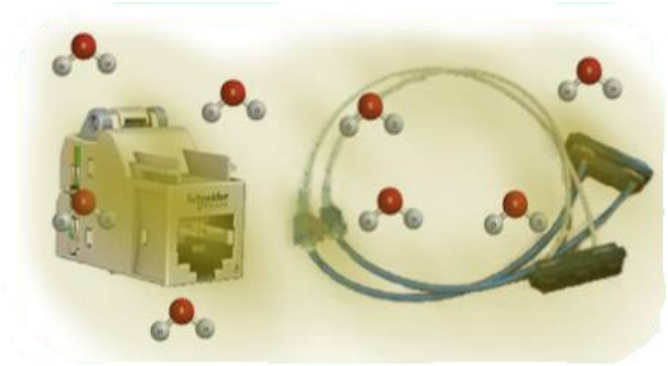


Figure9
System prepared for simulated real-life mechanical operations

The connection / disconnection phase is performed manually in both steps 2 and 5. In these steps, the patch cord (male plug) is removed from the RJ45 connector (female) which is located in a device such as a computer, laptop, switch, IP phone, access point, or camera (see **Figure 11**). The test measures the difference in contact resistance after 100 cycles (connection without load and disconnection under load). This occurs 50 times during both step 2 and step 5.

Step 3: Aging process simulation

After the mechanical operations and to simulate the aging process, the samples are next exposed to flowing mixed gas. Half of the samples are mated during exposure, and half are unmated during the exposure (see **Figure 10**).



Unmated samples **Mated samples**

Figure 10
Mated and unmated samples are exposed to flowing mixed gas to simulate the aging process

The electrical arc caused by the PoE Plus load creates corrosion on the gold portions of the connector contact. Over time, the corrosion increases due to harsh environmental conditions. To simulate this phenomenon, RJ45 connectors are subjected to corrosive H_2S and SO_2 gases. These gases impact several materials, including copper (Cu), nickel (Ni), steel, and zinc (Zn). This particular test simulates milder environments (clean surroundings) such as what is encountered in a typical office building. The connectors are placed into a special tank for four days to simulate this aging process.

Step 4: Modified initial state (state 1)

After the mechanical operations (step 2) and exposure to flowing mixed gas (step 3), the initial state of the samples has been modified. That is why a new round of measurements of key parameters (insulation resistance, contact resistance, voltage

verification) is necessary to validate that samples have not been impacted by the previous actions.

Those (state 1) measurements are compared with the initial-state (state 0) measurements. The test sanctions that the gap between the contact resistance of state 0 and state 1 should not exceed 20 mΩ. If not, the test has failed and the samples are not compliant with the IEC 60512-99-001 standard.

Step 5: Mechanical operation under PoE Plus load

If the samples have passed step 4, they are again subjected to the same mechanical operations under the PoE Plus load as done during step 2. This includes 25 mating cycles for one polarity of the current and 25 mating cycles for the other polarity.

As done during step 2, the connection/disconnection phase is performed manually in both steps 2 and 5. This occurs 50 times during both step 2 and step 4 (see **Figure 11**).

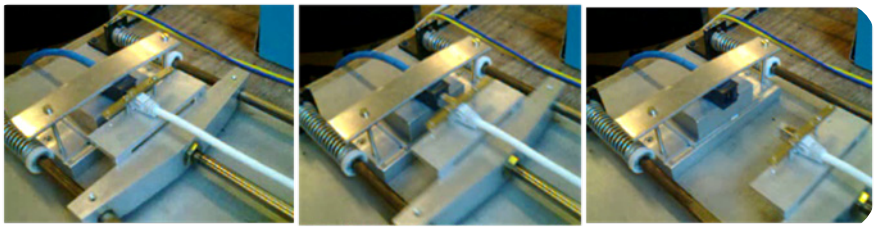


Figure 11
The RJ45 is connected (left) and disconnected (right) to a mechanical system 50 times

Step 6: Modified state 1 (state 2)

After the second mechanical operations test, a final round of measuring key parameters (insulation resistance, contact resistance, voltage verification) is performed to ensure that the samples have kept the same level of performances as previous states (state 0 and state 1).

The results of those (state 2) measurements are compared with the results obtained at initial state (state 0) and modified state (state 1). The test sanctions that the gap between the contact resistance of state 0, state 1, and state 2 should not exceed 20 mΩ. If not, the test has failed and the samples are not compliant with the IEC 60512-99-001 standard.

Conclusion of the test

In order to successfully pass the test, the components being tested must reach a performance range within the measured target parameters of each of these steps. The purpose of this test schedule is to reflect an accurate lifecycle performance of RJ45 connectors in LAN environments.

The IEC 60512-99-001 standard compliance is more rigorous than IEEE 802.3at (PoE Plus) compliance. The IEEE 802.3at standard as it is written today is not sufficient to avoid the risk of deterioration in both PoE Plus environments and in future 4-pair PoE environments (new IEEE 802.3bt standard). Compliance with the IEC 60512-99-001 standard lowers risk and ensures higher reliability within networks. Since the IEC 60512-99-001 standard testing is performed on each of the eight RJ45 connector contacts, the testing results will be relevant to future 4-pair PoE standard deployments in which 4-pair wires are used instead of 2-pair in order to deliver twice the power (60W). Therefore compliance with the IEC 60512-99-001 standard helps to “future-proof” the impacted network.

Conclusion

Compliance with the IEC 60512-99-001 standard as it applies to RJ45 connectors protects LAN networks from PoE Plus upgrade-related damages that can result from the increased power capacity. A compliant approach will strengthen the reliability of the installation and "future-proof" the network for when the next generation of PoE technology (such as 4-pair Power over Ethernet with up to 60W capacity) is rolled out.

When transitioning to or upgrading an existing PoE network, the following steps should be considered:

Step 1: Determine which new applications (e.g., access points, lighting) are most critical for supporting the business. Benchmark available technologies to establish which are the best fit for addressing short- and long-term business issues.

Step 2: Consider whether PoE Plus can help to optimize the network infrastructure. Determine which physical infrastructure components (such as cables and connectors) are robust enough to support the demands of the implementation.

Step 3: Calculate the payback of the upgrade project, and make sure that compliance with the IEC 60512-99-001 standard is part of the present and future vision.

About the authors

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