Overcoming Resistance Unbalance

The key to successful PoE implementation

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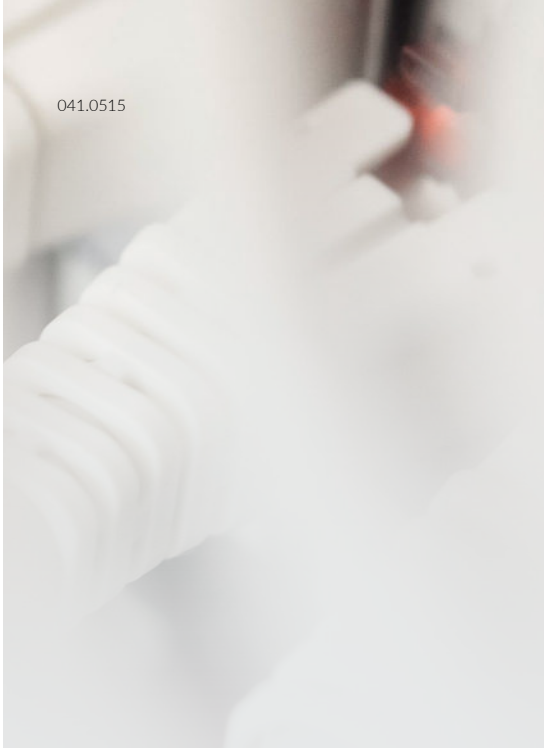
R&M

Is the structured cabling ready for Power over Ethernet?



Power over Ethernet (PoE) technology has revolutionized the way network devices are powered and connected. It enables power and data to be transmitted over a single Ethernet cable, reducing the need for separate power and data outlets near the devices. This technology has made it possible for devices such as cameras, phones, and wireless access points to be powered remotely from the floor distributor.

The possible power that can be delivered by PoE increased constantly over time. The **original PoE standard** (IEEE802.3af) supported up to 13 watts (Type 1). The successor, **PoE+** (IEEE802.3at) supported up to 25 watts (type2). **4PPoE** (IEEE802.3bt), ratified in 2018, available in Type 3 and Type 4, offers even higher power up to 90W on each PoE port. This allows support of devices such as laptops or TVs.

Data is transmitted through a cable pair by sending differential signals down that pair's dual conductors. This approach helps reduce electrical disturbances and improves EMC. Power, however, is sent as common-mode voltage between 2 or 4 pairs of the cable. The same DC voltage is applied to both conductors of the pair. The data signals and the power are mixed or separated in a balun (balanced to unbalanced transformer), an electrical device in the active equipment that allows balanced signals and common mode voltage to be interfaced without disturbing each other. The power is tapped off leaving the data to pass through the magnetic transformer.

Overlooked challenges

One of the so far mostly overlooked challenges of PoE technology is the issue of DC resistance unbalance. In a PoE system, 50V DC is transmitted as phantom power over the two wires of selected pairs in an Ethernet cable. I.e. the DC power supply voltage will be fed into the center tap of the signal transformers and the current is traveling equally on the two wires of the pair. If the two DC currents in the pair are equal, the magnetic flux created in the respective coils of the signal transformers cancel each other out, resulting in no net magnetic flux in the balun.

However, if there is an unbalance in the resistance between the wires in a pair, the currents on the two wires will not split equal. Are the two DC currents not the same, the magnetic flux generated by each current in its part of the coil will not cancel each other out. One flux will dominate and may saturate the ferrites of the transformer. This leads to increased attenuation loss and the system won't be able to transmit data signals anymore, resulting in interruptions in the data communication.

Consequently, when using remote power supply (PoE), reducing resistance unbalance is an absolute precondition. It is therefore vital to control the resistance unbalance throughout the complete channel – including any patch cords.

In this White Paper, we will examine the Resistance Unbalance parameter and its causes, how it relates to remote power standards like PoE and available solutions.

Recent experiences have brought to light, that differences in resistance between wires in pairs are widespread in LAN cabling. This will result in considerable negative effects on the operation of PoE powered devices.

Meeting the component standards isn't enough, as these standards aren't fully keeping up with the current reality of remote power installations. The only way to be sure that structured cabling supports remote power safely and reliable is to test thoroughly and use only prequalified patch cords.

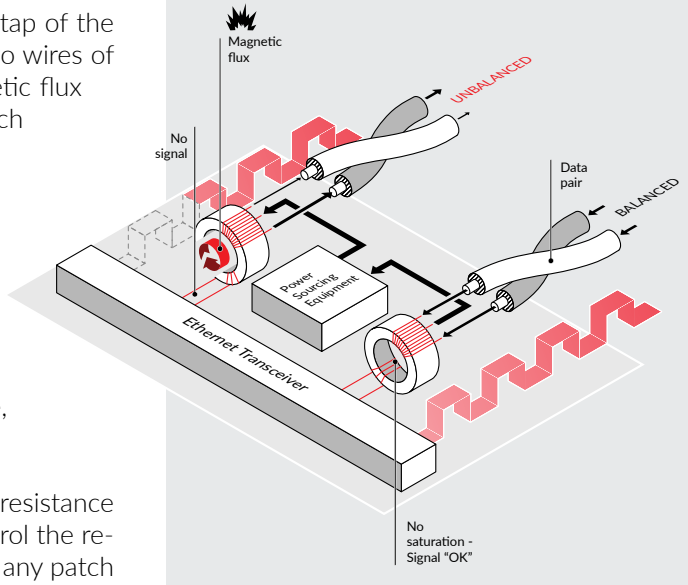


Fig 1: Magnetic saturation effects in the baluns

What is DC Resistance Unbalance (DCRU)?

DC Resistance Unbalance expresses, how much the DC resistances of the two conductors of a pair differ from each other. This is not the same as the "Resistance" or "DC Loop Resistance" commonly seen in usual field measurements. Figure 2 explains the difference between the two measurements.

ISO/IEC 11801-1 (6.3.3.7. Direct current resistance unbalance) defines maximum resistance unbalance limits: "The DC resistance unbalance between the two conductors within a pair of a channel shall not exceed 3% or 0.2 Ω, whichever is greater." The %-value is calculated by dividing the difference of the two wires by the sum of them (i.e. dividing the resistance unbalance value by the loop resistance value). Therefore, depending on channel length, the maximum allowable DC resistance unbalance for Class D – EA would be between 200 – 750 mΩ.

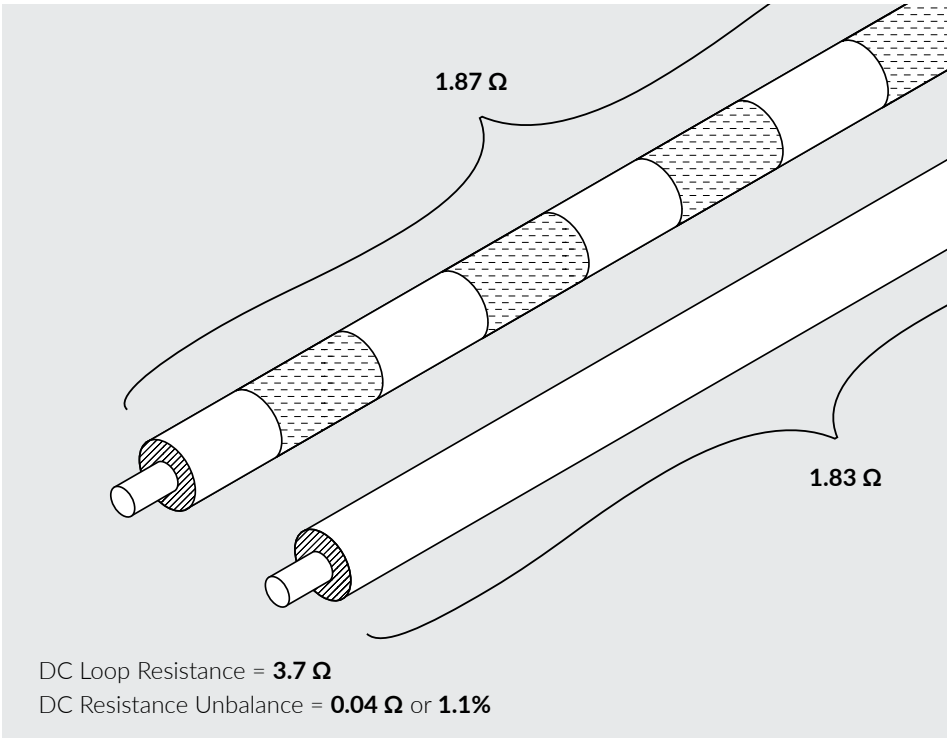


Fig 2: Different resistance measurements in a wire pair

However, in ISO/IEC 11801-1 Annex A (Table A.1.) DC resistance unbalance within a pair is defined as an optional parameter to be tested during Installation Conformance Testing.

In essence this means, that while the DCRU is specified within the standards, there is no requirement to test for this parameter, yet. Considering the magnitude of the problem in the support of PoE, this may change in future revisions of the standards, but for the moment it is up to the end user to specify that DCRU shall be tested to ensure PoE compatibility.

Watch video

Potential causes of DCRU

Unbalance resistance in a cable pair, may be caused by substandard cable and connector manufacturing, poor installation practices or unreliable termination technology that degrades over time.

Manufacturing mistakes

Cable and connector manufacturing mistakes that would result in resistance unbalance, are typically resulting in fails in other parameters as well. They are most likely recognized in normal quality assurance measurements and should therefore not reach the market in the first place.

Installation practices

Poor installation practice unfortunately could occur any time. Properly trained installers (QPP partners) however know how to handle the products properly. Visual inspections mostly allow to evaluate, whether an installation has been done properly. Generally, if increased DCRU is recognized it is good practice to re-terminate the affected connectivity to eliminate the possibility of termination mistakes.

Unreliable wire termination

The last reason, an unreliable termination, unfortunately is very hard to find. If an unreliable wire termination ages, it is very likely that the uncoordinated increase in resistance will cause DCRU. Very often, resistance unbalance develops over time and is the first indication of something wrong. Transmission parameters often remain within acceptable limits, while resistance unbalance already reaches prohibiting levels. With unreliable termination technology resistance unbalance can occur unpredictable and suddenly in a previously properly working link.

To prevent time consuming and annoying search for the cause of transmission failures, the use of cabling components with reliable and stable long term termination quality is the best way to prevent this kind of problems.

Potential effects of DCRU

Magnetic saturation

If the resistance between the two conductors of a pair is different, the split of the DC current in these conductors will not be the same (see fig.1). This, in turn, could lead to magnetic saturation effects in the baluns and to heating differences in the two conductors. In the most common case, the unbalanced current will cause signal transmission failures due to induced insertion loss in saturated transceivers, as described above.

Additional heating

Another issue (albeit less serious) is the additional heating of the cabling. The heating in the wires is proportional to the square of the DC current. Based on the binomial theorem, unbalanced current is producing more heat than balanced current. In such a case, the cable heating will be higher than expected and the attenuation of the cabling slightly higher.

Overall efficiency

Higher operating temperatures can reduce equipment lifetime and reduce the overall efficiency of the installation. Furthermore, the additional heating of an unbalanced pair could render the planning for RP3 (Remote Power Category) obsolete. For 4PPoE devices, operating on all four pairs, the situation could be even worse, if the resistance between one pair and another is not identical, resulting in an even more uneven current split.

«In short: PoE equipment will not send/receive data on cabling that has excess resistance unbalance.»

Testing the entire channel and the role of patch cords

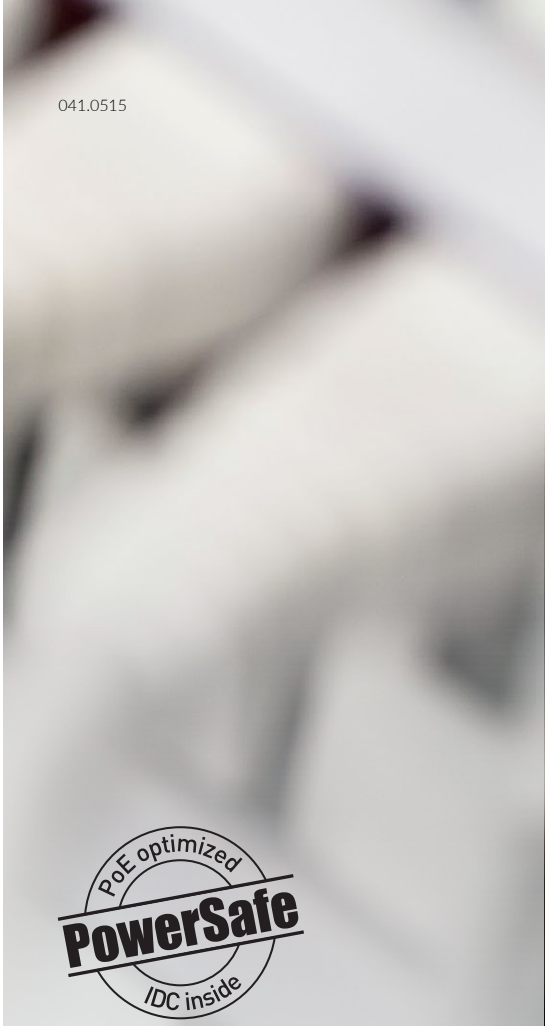
Low resistance unbalance is an essential precondition for using PoE. This requires that each complete channel meets the specified DCRU requirements – including any patch cords. Current testing guidance has always been to test the permanent link and then attach standards compliant patch cords. However, this may present problems for PoE applications, if the patch cords and their connectors introduce undue resistance unbalance.

Therefore, R&M strongly recommends testing the complete channel, with patch cords in place or in the case of Permanent Link testing, **the use of specific "PowerSafe" patch cords.**

Reliability and performace

The more high-performance devices (both in data transmission and in PoE) are connected to the network, the more important patch cords become. Patch cords often are the critical component in ensuring the functionality of the entire channel. Reliability criteria as well as performance should be considered for the optimal selection of a patch cord, since failing to take these into consideration can lead to rework and complicated, costly fault-finding and repairs.

In many use cases patch cords are exposed to harsh environmental conditions such as heat, dust, sunlight or moisture. Where PoE is added, cables and connectors are additionally thermally stressed by the current flow. Patch cords age quickly, yet they should still guarantee interference-free transmission. At the same time, they should be as thin and flexible as possible in order to achieve a high density and good handling. A LAN is only as strong as its weakest link, which in many cases are the patch cords.



PoE optimized PowerSafe IDC inside

«Wherever PoE is used, only patch cords that can guarantee reliable transmission over the entire life cycle should be used.»

More about POWERSAFE

Reliable termination technology for Patch Cords

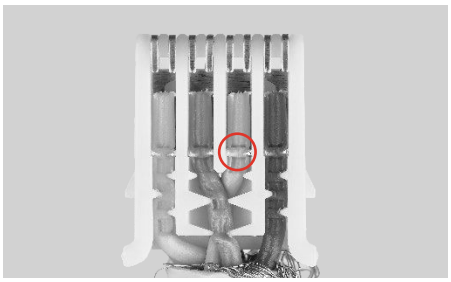
To use tested permanent links without surprises, patch cords need to be designed and specified to prevent resistance unbalance. Patch cords with IDC termination, for example, will ensure a reliable, low resistance wire termination over their entire operational lifetime. IDCs provide the optimal foundation for continuous high-level PoE operation. The widely used IPC termination technology on the other hand, does only give good initial contact resistance, but contact reliability will deteriorate quickly over time.

R&M is marking connectivity products that are exclusively using reliable IDC termination technology with the “PowerSafe” label. “PowerSafe” products are covered by the R&Mfreenet warranty to support PoE applications of every level over the whole intended lifetime of the cabling. With a “PowerSafe” product, DCRU is no problem.

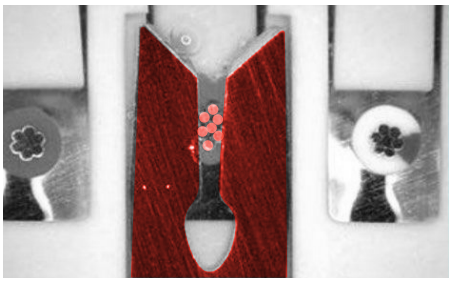
How IDC (Insulation Displacement Contact) works

The wire is clamped between two legs of a forked spring contact. The contact halves cut through the insulation, press the stranded wire resiliently and thus establish the contact.

Contact resistance and transmission properties of an IDC connection remain permanently low and stable.



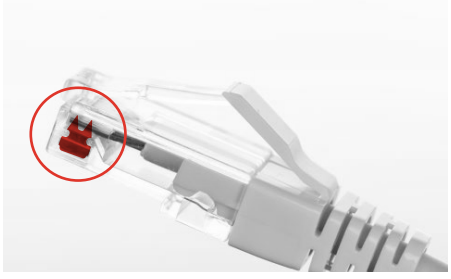
R&M IDC Wiring Block - Top view



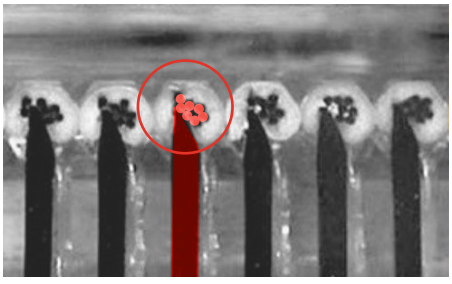
IDC microsection R&M wiring - Front view

How IPC (Insulation Piercing Contact) works

A metal tip pierces the wire insulation and makes the connection to the stranded wire. Although this state-of-the art method is cost-effective, it does have the disadvantage, that contact resistance deteriorates uncontrollably over time due to aging and environmental influences. While this is acceptable for pure data transmission, piercing technology cables are not recommended for PoE transmission over long periods of time and at higher power levels.



Piercing connector (IPC) - Side view



Microsection piercing contacts - Front view

Summary DC Resistance Unbalance

PoE is becoming increasingly widespread, supported by developments in systems convergence and 'All over IP'. When using remote power supply (PoE), ensuring a low resistance unbalance is a precondition. Resistance unbalance testing ensures, that an installation supports PoE without introducing data transmission issues or unaccounted heating. Field testing is more important than ever to ensure low DC Resistance Unbalance. Patch cords should be included to the testing scheme, by performing channel testing.

PowerSafe solutions

R&M's PowerSafe range of patch cords, cable assemblies, connection modules, couplers and field-mountable connectors with insulation displacement contact (IDC) technology offer optimal low resistance wire termination. PowerSafe solutions guarantee stable, reliable transmission of interference-free data and power up to 4PPoE.

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