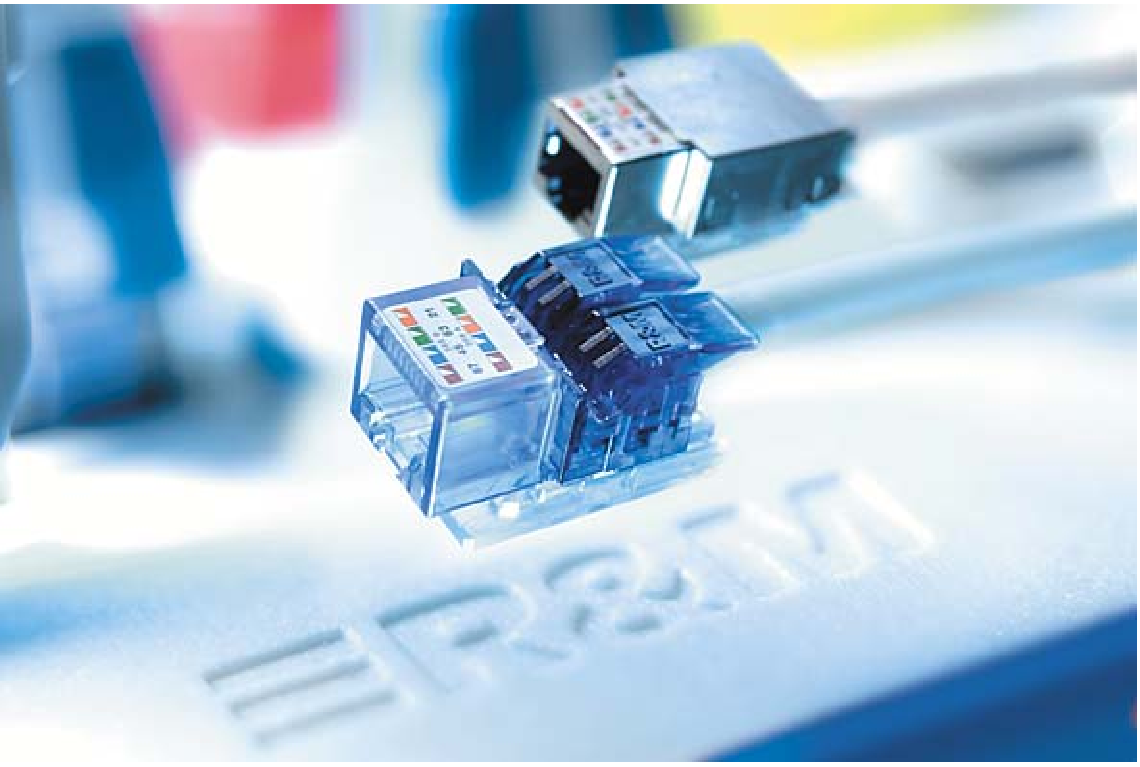
White Paper



Power over Ethernet Plus – Update and Cabling Considerations

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Power over Ethernet Plus – Update and Cabling Considerations

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PoE and PoEplus: To increase power, plan with greater care

Power over Ethernet (PoE) – bundling power and data transfer in one cable – is becoming increasingly common on the market. Application options increase if higher power can be provided. This is why PoEplus will be launched in 2009. More electrical energy in the data cable automatically means that the wires will heat up more, which is a risk factor. Those planning data networks that will use PoEplus must be particularly careful when selecting the cabling system and, in some cases, observe some limitations. However, the problem of wire heating can be managed through consistent observation of existing and future standards and will not result in any disadvantages for data transfer. Another risk factor, however, must be noted: the danger of contact degradation if devices are plugged/ unplugged while under voltage. Tests by R&M show that high-quality, stable solutions ensure lasting contact quality. This white paper will provide you with assistance in planning data networks with PoEplus applications and indicate any questions that have not yet been answered in the course of the current standardization process.

Application:	Enterprise cabling
Technology:	Copper cabling, Power over Ethernet (PoE), IP applications
Format:	White paper
Topics:	Update and further development of Power over Ethernet to Power over Ethernet plus, IEEE 802.3af, IEEE 802.3at, application of PoEplus, cable heating, layout of link lengths, selection of cabling system and wire cross-section, contact quality, prevention of contact degradation, etc.
Target:	Orientation for planning, procurement, integration of copper cabling for data networks with PoEplus applications such as monitoring, security, Voice over IP, wireless LAN, RFID, POS, etc.
Target groups:	System integrators, planners, installers, users
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1. Introduction

The use of data cables as a transmission medium for information and electrical energy is no longer a vision, but based on the IEEE 802.3af standard known by the name “Power over Ethernet” (PoE). It is often used over a generic cabling system to provide remote power to end devices such as:

- Wireless Access Points
- VOIP-telephones
- IP-cameras, etc.

Since its introduction in 2003, PoE has grown into a thriving market and is forecast to continue to grow significantly in the future. Market research group Dell’Oro predicts that in 2011 there will be 100M PoE enabled devices sold, as well as over 140M PoE ports in sourcing equipment, such as switches (Figure 1).

VDC’s (Venture Development Corporation, Natick, Massachusetts) recently completed market study, Power over Ethernet: Global Market Opportunity Analysis, discusses the adoption drivers of leading PoE applications. IP phones and wireless access points (WAPs), and the leading vendors of these devices. According to the research, the demand for enterprise WAPs will increase by nearly 50% per year through 2012.

Today a maximum power of 12.95W at the powered device (PD) is defined by the standard. Since the introduction of Power over Ethernet, demand for higher power has grown in order to supply devices such as:

- IP-cameras with PAN/Tilt/Zoom functions
- VOIP Video phones
- POS Terminals
- Multiband Wireless Access Points (IEEE 802.11n)
- RFID-Reader, etc.

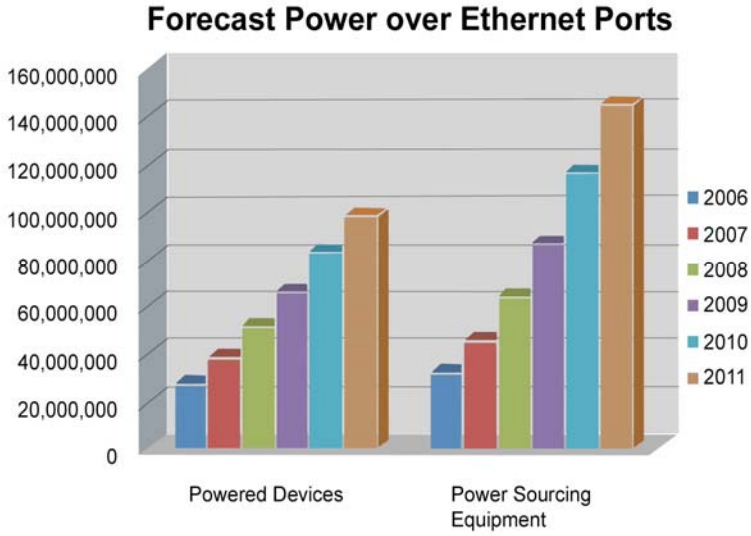


Figure 1: Dell'Oro 2007 Forecast Report and IDC's 2007 Forecast for Network Cameras predict an increase in using Power over Ethernet.

Therefore work is in progress on a new standard which will define support for a minimum power of 24W at the PD.

- Status today **IEEE 802.3af**: Power over Ethernet (POE) = 12.95W power
- Status tomorrow **IEEE 802.3at**: Power over Ethernet (POEplus) = min. 24.00W power

The new standard, IEEE 802.3at, is planned to be released in 2009.

Note: The definition of powered devices (PD) and power sourcing equipment (PSE) is the same as defined by the PoE IEEE 802.3af standard. Below one end span option is pictured. For more information, see our white paper "Power over Ethernet".

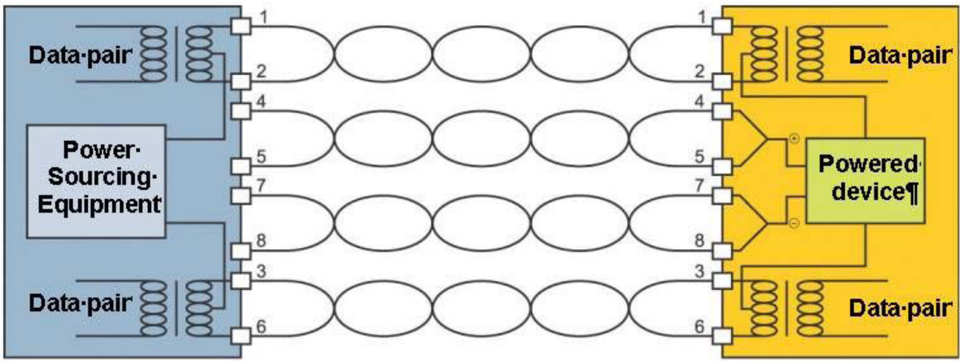


Figure 2: One possible end span option as defined by the PoE IEEE 802.3af standard.

2. Application Objectives

The current objectives of the IEEE standards group are as follows:

1. PoEplus will enhance 802.3af and work within its defined framework.
2. The target infrastructure for PoEplus will be ISO/IEC 11801-1995 Class D / ANSI/TIA/EIA-568.B-2 category 5 (or better) systems with a DC loop resistance no greater than 25 Ohms.
3. IEEE STD 802.3 will continue to comply with the limited power source and SELV requirements as defined in ISO/IEC 60950.
4. The PoEplus power sourcing equipment (PSE) will operate in modes compatible with the existing requirements of IEEE STD 802.3af as well as enhanced modes (Table 1).
5. PoEplus will support a minimum of 24 Watts of power at the Powered Device (PD).
6. PoEplus PDs, which require a PoEPlus PSE, will provide the user with an active indication when connected to a legacy 802.3af PSE. This indication is in addition to any optional management indication that may be provided.
7. The standard will not preclude the ability to meet FCC / CISPR / EN Class A, Class B, Performance Criteria A and B with data for all supported PHYs.
8. Extend power classification to support PoEplus modes.
9. Support the operation of midspan PSEs for 1000BASE-T.
10. PoEplus PDs within the power range of 802.3af will work properly with 802.3af PSEs.

The initial goal was to provide 30W of power at the PD over two pairs, but this was revised down to 24W. Also, the goal of doubling this power by transmitting over 4 pairs has been removed, but could be revisited in a new version at a later date.

PD Operation based on PSE Version		
	PoE PSE	**PoEP PSE**
PoE PD	Operates	Operates
PoEP PD < 12.95W	Operates	Operates[Note 1]
PoEP PD > 12.95W	PD will provide user active indication	Operates[Note 1]
PD = Powered Devices, PSE = Power Sourcing Equipment *Note 1: Operates with extended power classification*		

Table 1: Compatibility between PoE and PoEP versions of the PD and PSE.

Great care was taken to be backward compatible and continue support for legacy PoE, or low power devices. The following terminology was thus introduced to differentiate between low power and the new higher power devices:

- Type 1: low power
- Type 2: high power

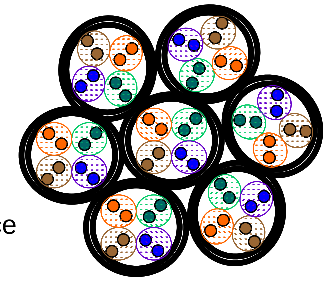
Table 2 summarizes some of the differences between PoE and PoEplus.

With the higher currents flowing through the cabling, heating was an important consideration. Some vendors have recommended using higher category cabling to reduce these effects. Below we look at this issue in detail.

	PoE	**PoEplus**
Cable requirement	Cat. 3 or better	Type 1: Cat 3 or better Type 2: Cat 5 or better
PSE current (A)	0.35 A	Type 1: 0.35 A Type 2: 0.6 A
PSE voltage (Vdc)	44-57 Vdc	Type 1: 44-57 Vdc Type 2: 50-57 Vdc
PD current (A)	0.35 A	Type 1: 0.35 A Type 2: 0.6 A
PD voltage (Vdc)	37-57 Vdc	Type 1: 37-57 Vdc Type 1: 47-57 Vdc

Table 2: Differences between PoE and PoEplus.
Source: Ethernet Alliance, August 2008

3. Heat Considerations for Cabling



The transmission of power over generic cabling will result in some temperature rise in the cabling depending on the amount of power transferred and the conductor size. The cable in the middle of a bundle will naturally be somewhat warmer due to the inability of heat to dissipate. As heat increases in the cable (ambient + temperature increase), insertion loss also increases which can reduce the maximum allowed cable length.

In addition, the maximum temperature (ambient + increase) is limited to 60°C according to standards.

Therefore, two limiting factors are given:

- Reduction of the maximum allowed cable length due to higher cable insertion loss from higher temperatures
- Maximum specified temperature of 60°C given in the standard

The temperature rise for various cable types has been determined through tests performed by the IEEE 802.3at PoEplus working group (measured in bundles of 100 cables, Table 3).

Cable Type	Profile	Approx. Temp. Rise
Cat. 5e / u	AWG 24	10°C
Cat. 5e / s	AWG 24	8°C
Cat. 6 / u	AWG 24+	8°C
Cat. 6A / u	AWG 23	6°C
Cat. 6A / s	AWG 23	5°C
Cat. 7	AWG 22	4°C

Table 3: Temperature rise operating PoEplus

4. Calculating the maximum cable length at higher temperatures

For simplicity, this summary only uses the Interconnect-TO cabling model as defined in the standards (see figure 2, model A). Similar results could be expected with the other reference cabling models. For better comparison between the different cabling types, one analysis uses the Class D formula for all cabling types.

Model	Class D Channel with Cat. 5e Components	Class E Channel with Cat. 6 Components	Class F Channel with Cat. 7 Components
Interconnect-TO	H = 109-FX	H = 107 – 3* - FX	H = 107 – 2* - FX

- ***H*** = *Maximum length of the fixed horizontal cable (m)*
- ***F*** = *Combined length of patch cords/jumpers, equipment and work area cords (m)*
- ***X*** = *the ratio of cord cable insertion loss (dB/m) to fixed horizontal cable insertion loss (dB/m) (normally 1.5)*
- ***** = *This length reduction is to provide an allocated margin to accommodate insertion loss deviation*

At operating temperatures above 20°C, the maximum link length H must be reduced as follows:

- Shielded cabling: 0.2% per °C
- Unshielded cabling: 0.4% from > 20°C – 40°C
  and 0.6% from > 40°C – 60°C per degree

Note: heat can be better dissipated over the shield with shielded installations.

Table 4 calculates the impact on the maximum link length with PoEplus with different cable types and at various ambient temperatures.

4.1. Class D Calculation Example with a Cat. 5e/s Cable

Calculation of the theoretical maximum length:

Starting length for Class D: 109
Patch cable length (F): 10m
Factor (X): 1.5

H = 109-FX
H = 109-(10*1.5)
H = 109-15= 94m

Calculating the effects of PoEplus and ambient temperature of 30°C

Temperature increase in cable bundle due to PoEplus (from Table 3): 8°C

30°C + 8°C = 38°C in cable bundle

Calculating the length reduction due to higher temperature >20°C

38°C -20°C = 18°C
94 – (18°C*0.2%)
94 – 3.6% = 90.62m

According to the standards, the maximum length is 90m, thus 90.62m is reduced down to 90m.

Clarification of table:

Cable Type	Starting Channel Length (Class D standard)	Length Factor Cat. 6, Cat. 7 Cables	Length of both Patchcords	Patchcords incl. Insertion Loss Factor (1.5) Standard	Theoretical max. Link Length	Ambient Temp. °C	Temp. Rise in Cable °C operating PoEplus	Total Temp. °C	Temp. Reduction Factor (% per °C)	Max. Link Length (Link Length minus Temp. Reduct. Factor) Class D Formula *	Max. Link Length (Link Length minus Temp. Reduct. Factor) Class E / F Formulas **	Max. ambient Temp. °C (60 °C minus Cable Temp. Rise)
Cat. 5e / u (AWG 24)	109	1	10	15	94.00	20	10	30	0.4	90		50
						30	10	40	0.4	86		50
						40	10	50	0.4	83		50
						50	10	60	0.4 -0.6	74		50
Cat. 5e / s (AWG 24)	109	1	10	15	94.00	20	8	28	0.2	90 (92)		52
						30	8	38	0.2	90 (91)		52
						40	8	48	0.2	89		52
						50	8	58	0.2	87		52

Class D with a Cat. 5e/s cable
H=109-FX = 109-15=94m

PoEplus at 30°C ambient temperature (30°C + 8°C)
94 – (18°C*0.2%)
94-3.6% = 90.62m

Maximum ambient temperature
60°C – cable temperature increase
60°C – 8°C = 52°C

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Cable Type	Starting Channel Length (Class D standard)	Length Factor Cat. 6, Cat. 7 Cables	Length of both Patchcords	Patchcords incl. Insertion Loss Factor (1.5) Standard	Theoretical max. Link Length	Ambient Temp. °C	Temp. Rise in Cable °C operating PoEplus	Total Temp. °C	Temp. Reduction Factor (% per °C)	Max. Link Length (Link Length minus Temp. Reduct. Factor) Class D Formula *	Max. Link Length (Link Length minus Temp. Reduct. Factor) Class E / F Formulas **	Max. ambient Temp. °C (60 °C minus Cable Temp. Rise)
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Cat. 5e / s (AWG 24)	109	1	10	15	94.00	20	8	28	0.2	90 (92)		52
						30	8	38	0.2	90 (91)		52
						40	8	48	0.2	89		52
						50	8	58	0.2	87		52
Cat. 6A / s (AWG 23)	109	1.1	10	15	103.00	20	6	26	0.2	90 (102)	89 (88)	54
						30	6	36	0.2	90 (100)	87 (86)	54
						40	6	46	0.2	90 (98)	85 (84)	54
						50	6	56	0.2	90 (96)	84 (83)	54
Cat. 7 (AWG 22)	109	1.15	10	15	108.00	20	5	25	0.2	90 (107)	90 (89)	55
						30	5	35	0.2	90 (105)	88 (87)	55
						40	5	45	0.2	90 (103)	86 (85)	55
						50	5	55	0.2	90 (100)	85 (84)	55

Table 4: Calculating the impact on the maximum link length with PoEplus with different cable types and at various ambient temperatures (u = unshielded, s = shielded (using Class D formula for all cabling types for comparison purposes).

***** *If the calculated maximum fixed cabling length is >90m, it must be reduced to standard-conform 90m. The values in brackets are the theoretical length for PoEplus based on the Class D formula for comparison purposes.*

****** *The first value is the maximum link length based on the Class E and F formulas respectively without taking PoEplus into account. The values in brackets represent the maximum link length including the impact of PoEplus.*

5. Discussion of Analysis

As can be seen from the table, the use of AWG23 and AWG22 cable for PoEplus is not absolutely necessary at room temperature. The problem of increased cable temperatures with PoEplus should be considered with long cable lengths, or long patch cords, and with high ambient temperatures such as those found in tropical environments.

With an unshielded Cat. 5e/u cable, an additional temperature increase of 10°C from PoEplus with an ambient temperature of 40°C would mean a reduction in the allowed permanent link length of approximately 7m. This reduction with a shielded Cat 5e/s cable and an ambient temperature of 40°C would only be approximately 1 m.

This 7m or 1m reduction in the link length could be compensated with a higher category cable with a larger wire diameter. However, a careful review of the cost benefit relationship of such a solution is recommended. It should also be considered that the length restrictions for class E and F are much more severe than those for PoEplus and may limit the applicable permanent link length.

In any case, when planning an installation for PoEplus, extra care must be taken to consider the consequences of heat dissipation, both in the cable and ambient, regardless of which cable is used.

6. Connector Considerations

R&M investigated the effects of PoE on the connector, specifically the damage from sparking that may be caused by unmating a connection under power. In addition, R&M co-authored a technical report on this subject that will be published by IEC SC48B “The effects of engaging and separating under electrical load on connector interfaces used in Power-over-Ethernet (PoE) applications”.

In this paper, the concept of nominal contact area was introduced. During the mating operation, the point of contact between A (plug) and B (module) moves along the surface of the contacts from a point of first contact (the connect/disconnect area) to the point of final rest (the nominal contact area). These two areas are separated by the wiping zone (figure 3).

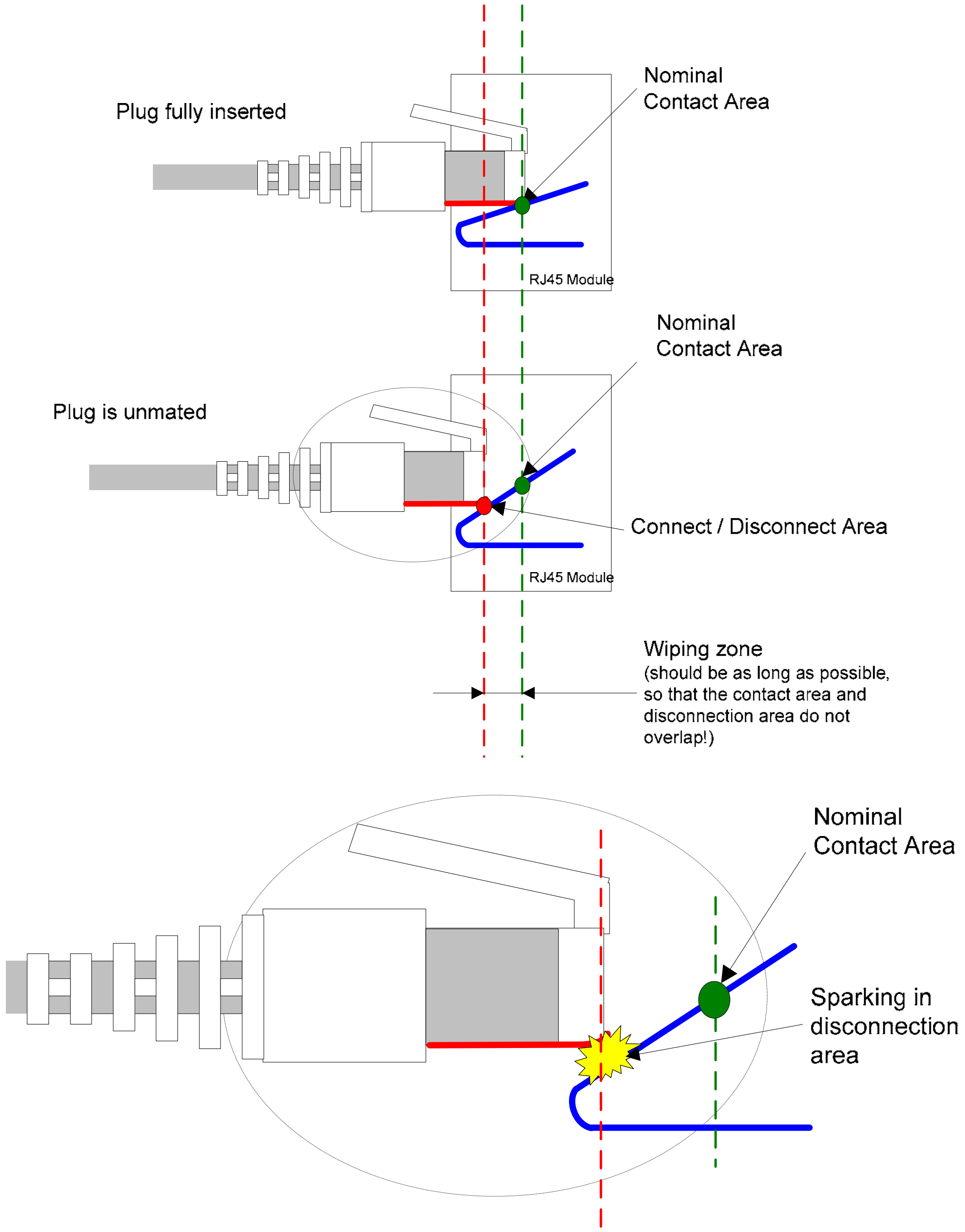

Figure 4: Illustration of the nominal contact area concept.

The investigations showed that traditionally the design of modular connectors described in the IEC 60603 standards ensures that the zone where contact is broken and sparking can occur is separate from the zone where contact between plug and jack is made during normal operation (the nominal contact area).

The picture on the left (figure 5) illustrates the case of a good contact design where damage does not affect the contact zone. The picture on the right (figure 6) shows a bad contact design where the contacts are folded and the damage is in the contact zone (overlap of nominal contact area and connect/disconnect area).

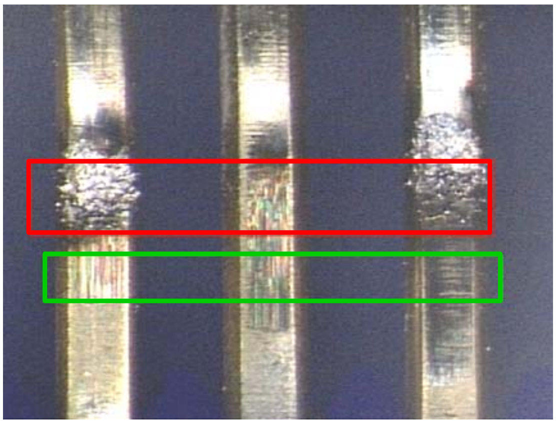

Figure 5: Good contact design. (R&M module)

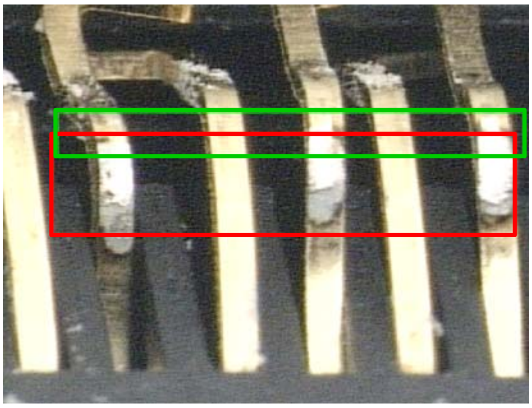

Figure 6: Bad contact design due to overlapping of nominal contact and connect/disconnect areas.

Photos: R&M

Nominal contact area

Connect / disconnect area

The increased power of PoEplus may cause a larger spark upon disconnection which will aggravate this problem. In addition, with new Category 6A, 6_A, 7 and 7_A connecting hardware, the contact design may deviate significantly from more traditional designs and thus be affected by the electrical discharges.

Unfortunately, the standards bodies have not yet fully addressed this concern. Test methods and specifications have not been finalised to ensure that connecting hardware will meet the demands of PoEplus.

Efforts to date in both IEEE and ISO/IEC bodies have focused mainly on establishing the limits in terms of cable heating. Until the connecting hardware is also addressed, a guarantee of PoEplus support for a cabling system is premature.

R&M will continue to push for resolution of this issue in the appropriate cabling standards bodies and will inform our customers as new information becomes available.

7. Conclusions

The success of PoE to date and the demand for PoEplus indicate that this technology has met a need in the market that will continue to grow and expand. There are many issues to take into account when implementing this technology including power sourcing and backup in the rack and dealing with the additional heat produced there by the use of PoEplus-capable switches.

The cabling system also needs to be carefully considered. Much effort has been invested in looking at the effects of increased heat in the cabling. As we have seen, the combination of high ambient heat and the effects of PoEplus can lead to length limitations for all types of cabling. Customers are therefore encouraged to choose the appropriate cabling for their application and requirements after reviewing the specifications and guidelines provided.

The same amount of effort needs to be invested into looking at the effects of unmating connecting hardware under power. Unfortunately, to date, this work has not been undertaken by the standards bodies and thus no specifications or test methods currently exist to ensure compatibility with the upcoming PoEplus standard.

8. Sources and Additional Information

- IEEE 802.3af
- IEEE 802.3at
- For more information on R&M products and solutions, visit our website: www.rdm.com