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# PoE Design and Installation

## Infrastructure guidelines

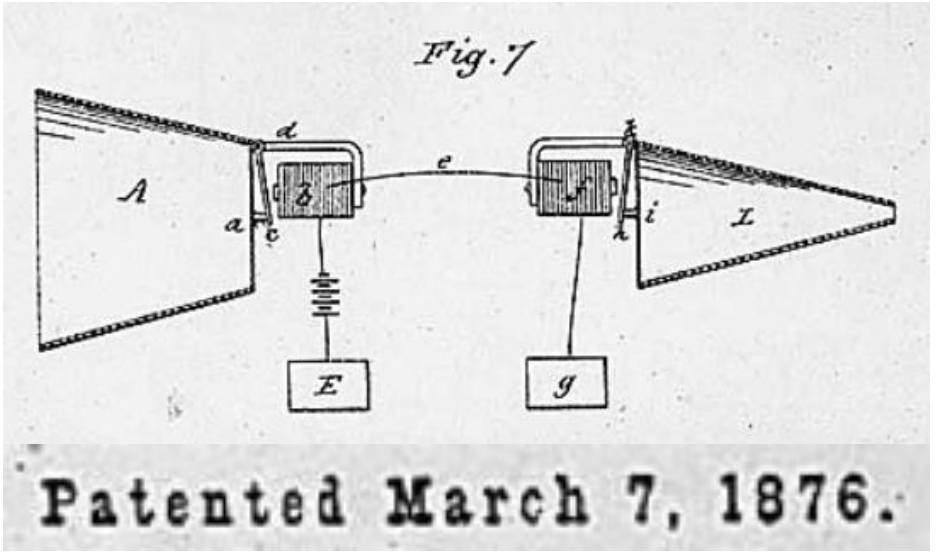
Madrid – November 2019

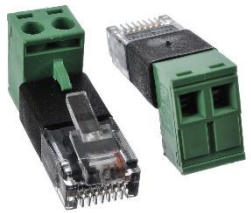


**Arne Keller**

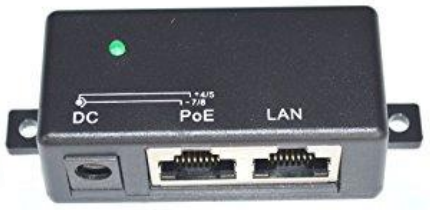
Technology Evangelist
Principal Field Application Engineer
ISO/IEC and CENELEC Cabling standards Expert

- Powering of telecommunication devices over twisted pair cabling is a s old as the telephone
- Power over Ethernet (PoE)
  - PoE, IEEE 802.3af
  - PoE+, IEEE 802.3at (PoE Plus)
  - 4PPoE, IEEE 802.3bt (PoE++, PoE Type 3 and Type 4)
- Something else
  - Cisco Universal Power over Ethernet (UPoE)
  - Microsemi High Power PoE
  - CommScope Enhanced PoE (ION-E)
- Something totally different
  - Passive PoE (often unsafe)
- Remote powering (CENELEC name)
  - Delivery of power to a device using the cable elements of information technology cable








# What is PoE? Comparing Apples and Oranges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| Standard | Type | Class | $V_{PSE(min)}$ | $I_{wire(max)}$ | $P_{PSE(max)}$ | $P_{PD(max)}$ | DCLR | Pair |
|---|---|---|---|---|---|---|---|---|
| 802.3af | Type 1 | Class 1 | 44V | 175mA | 4W | 3.84W | 40Ω | 2 |
| | | Class 2 | 44V | 175mA | 7W | 6.5W | 40Ω | 2 |
| 802.3at | Type 2 | Class 3 | 50V | 300mA | 15.4W | 12.95W | 25Ω | 2 |
| | | Class 4 | 50V | 300mA | 30W | 25.5W | 25Ω | 2 |
| 802.3bt | Type 3 | Class 5 | 50V | 250mA | 45W | 40W | 25Ω | 4 |
| | | Class 6 | 50V | 300mA | 60W | 51W | 25Ω | 4 |
| | Type 4 | Class 7 | 52V | 360mA | 75W | 62W | 25Ω | 4 |
| | | Class 8 | 52V | 430mA | 90W | 72W | 25Ω | 4 |

- The numbers are based on minimum compliant Cat5E cables
- The difference from 90W down to 72W is a loss of 18W or 20%
- Average cable length is less than 50 meters, reducing loss to 10%
- The efficiency of a small linear power supply is normally 40-50%
- The efficiency of a small switch mode supply is normally less than 70%
- High quality switch mode supply's can be more than 90% effective
-

# IEEE Power over Ethernet (PoE)

IEEE 802.3af (type 1) was standardized in 2005

IEEE 802.3af (Type 2) was standardized in 2009

IEEE 802.3bt (Type 3 and 4) was standardized in 2018


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IEC 62368-3

Edition 1.0 2017-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

GROUP SAFETY PUBLICATION
PUBLICATION GROUPÉE DE SÉCURITÉ

Audio/video, information and communication technology equipment –
Part 3: Safety aspects for DC power transfer through communication cables and ports

Équipements des technologies de l'audio/vidéo, de l'information et de la communication –
Partie 3: Aspects liés à la sécurité relatifs au transfert de puissance en courant continu au moyen de câbles et d'accès de communication

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 33.160.01; 35.020

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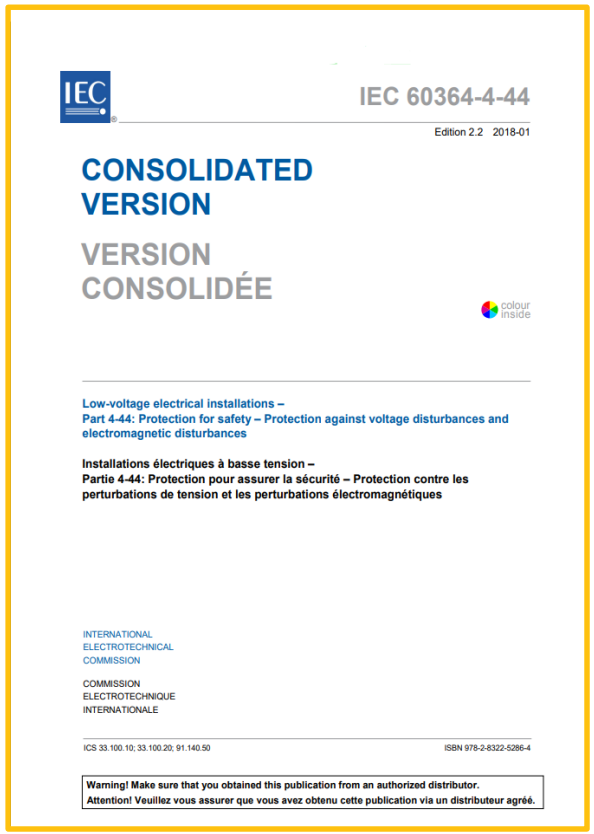
**Equipment**

IEC 62368-3:2017

Audio/video, information and communication technology equipment - Part 3: Safety aspects for DC power transfer through communication cables and ports. Requires that equipment meets safety standards e.g. ES1, ES2, ES3, SELV or PELV


IEC 60364-4-44

Edition 2.2 2018-01

CONSOLIDATED VERSION

VERSION CONSOLIDÉE

colour inside

Low-voltage electrical installations –
Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances

Installations électriques à basse tension –
Partie 4-44: Protection pour assurer la sécurité – Protection contre les perturbations de tension et les perturbations électromagnétiques

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 33.100.10; 33.100.20; 91.140.50

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**Installation**

IEC 60364-4-44 is the base document for Electrical Codes

A new chapter Low-Voltage electrical installations - Part 7-716: Requirements for special installations or locations – DC power distribution over Information Technology Cable Infrastructure (to be published 2020 or later) will require that EN 50174 series or ISO/IEC 14763-2 is followed

# Safety Standards


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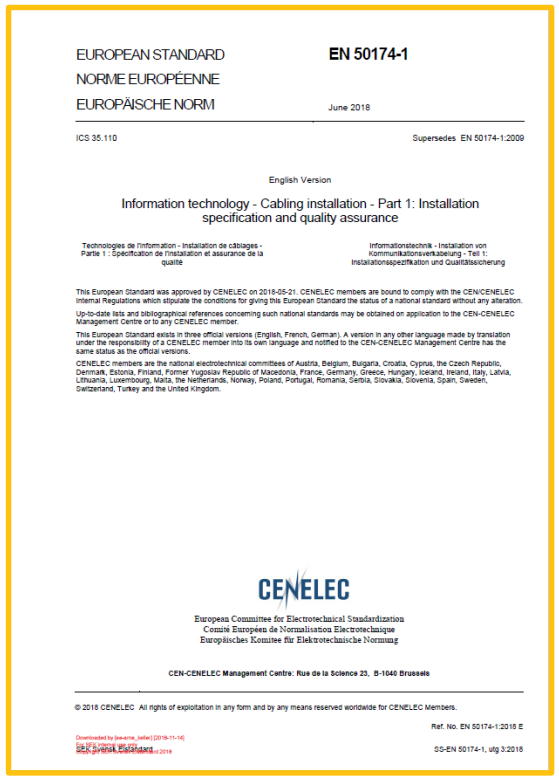

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

**EN 50174-1**

June 2018

ICS 35.110

Supersedes EN 50174-1:2009

English Version

Information technology - Cabling installation - Part 1: Installation specification and quality assurance

Technologies de l'information - Installation de câblages - Partie 1 : Spécification de l'installation et assurance de la qualité

Informationstechnik - Installation von Kommunikationsverkabelung - Teil 1: Installationsspezifikation und Qualitätssicherung

This European Standard was approved by CENELEC on 2018-05-21. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

**CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels**

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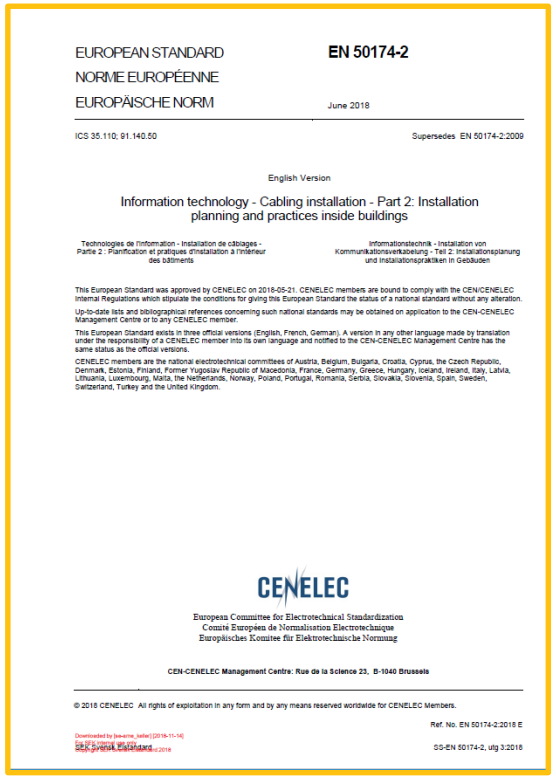

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

**EN 50174-2**

June 2018

ICS 35.110; 91.140.50

Supersedes EN 50174-2:2009

English Version

Information technology - Cabling installation - Part 2: Installation planning and practices inside buildings

Technologies de l'information - Installation de câblages - Partie 2 : Planification et pratiques d'installation à l'intérieur des bâtiments

Informationstechnik - Installation von Kommunikationsverkabelung - Teil 2: Installationsplanung und Installationspraktiken in Gebäuden

This European Standard was approved by CENELEC on 2018-05-21. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
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SS-EN 50174-2, utg 3:2018

## CENELEC EN 50174-1:2018

## CENELEC EN 50174-2:2018

## ISO/IEC 14763-2 (expected 2019)

- Requirements and recommendations for planning and installation of data cabling in support of remote powering up to 100W.
- The technical specification shall detail any remote powering objectives using equipment in accordance with EN 62368-3
- If there are no requirement in the tender the installer can assume there are no need for remote power

# Cabling Installation Standards



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# Remote Powering classes (RPx)

## RP1

PoE and PoE+

- Average current for all conductors not greater than 212 mA
- No planning and installation requirements
- Documentation and administration during the lifetime of cabling

## RP2

- Average current for all conductors between 212 mA and 500 mA
- Require complex planning and installation practices
- Documentation and administration during the lifetime of cabling

## RP3

PoE type4

- Average current for all conductors not greater than 500 mA
- Require planning and installation practices
- No documentation and administration during the lifetime of cabling

RECOMMENDED


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**Initial impact**

- Plan for pathways big enough for separation
- Plan for less than 90 meter permanent link
- Document plans and calculations

**During use**

- Connect any PoE equipment anywhere
- As PoE landscape is growing
- No additional documentation
- When additional cabling are needed
- Plan based on original calculations

# Plan for RP3


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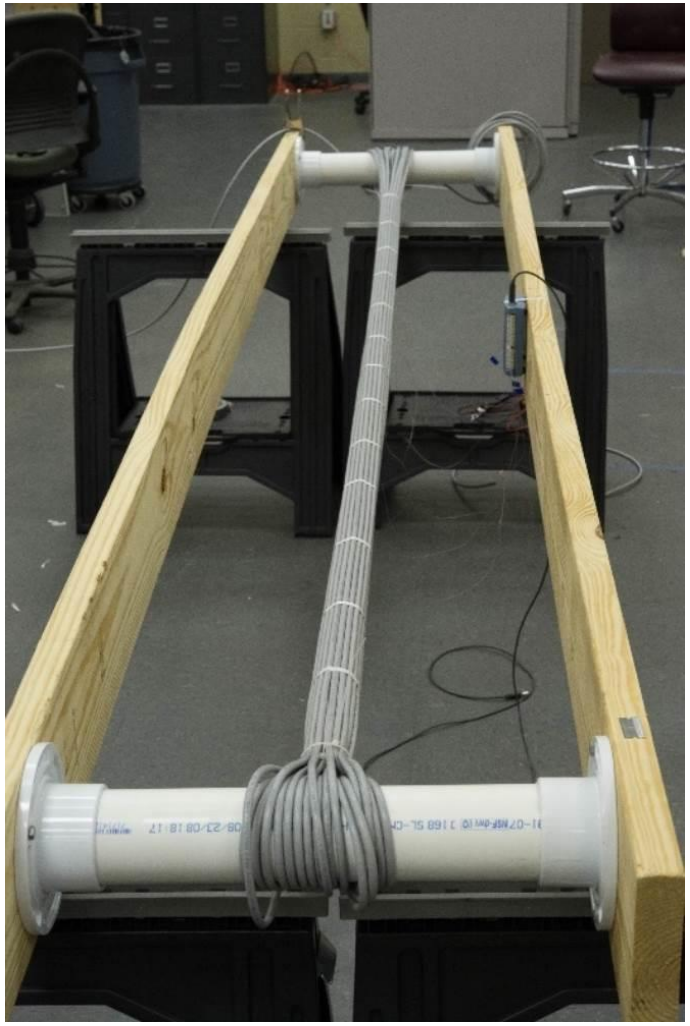
# Establishing A Test Method And Testing

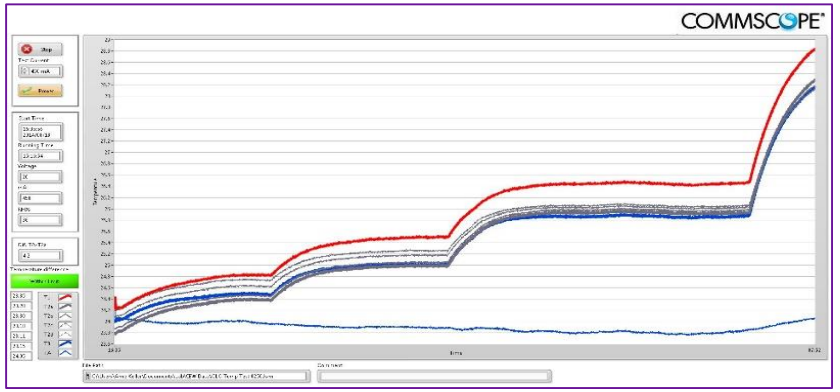
- Bundle size of 37 cables was selected to make a “perfect” bundle with more than 24 cables
- All wires connected in series to maintain equal current level in all wires
- Format for measurement data defined
- Hundreds of test performed by CommScope and shared with Standards bodies



| | |
|---|---|
| Test File ID | 001 |
| Wires used | 8 |
| Conventional test set-up (Y/N) | Y |
| Cable type (U/UTP etc.) | U/UTP |
| Cable diameter | 7,3 mm |
| Average conductor resistance | 0,076 Ω/m at 21 °C (see note) |
| Installation conditions | Free air |
| Relative humidity (at steady state heated condition) | 41 % |
| Images attached | IMG001.JPG |
| NOTE Obtained from a d.c. loop resistance of 15,5 Ω for a physical length of 102 m | |

Test File Data format

| Time (min) | $T_1$ | $T_{2a}$ | $T_{2b}$ | $T_{2c}$ | $T_{2d}$ | $T_3$ | $T_A$ | Voltage (V) | Current (mA) |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 24 | 300 |
| 5 | 22 | 22 | 22 | 21 | 21 | 22 | 21 | 24,2 | 300 |
| 10 | 23 | 23 | 23 | 22 | 22 | 23 | 21 | 24,3 | 300 |
| 15 | 25 | 25 | 24 | 24 | 23 | 25 | 21 | 24,4 | 300 |
| 20 | 27 | 27 | 26 | 25 | 24 | 27 | 21 | 24,5 | 300 |
| ..... | | | | | | | | | |



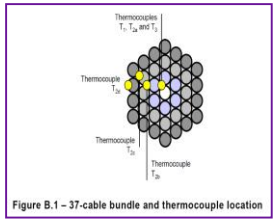




Figure B.1 – 37-cable bundle and thermocouple location

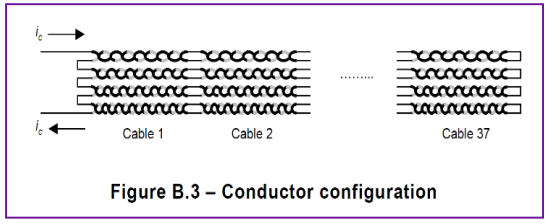
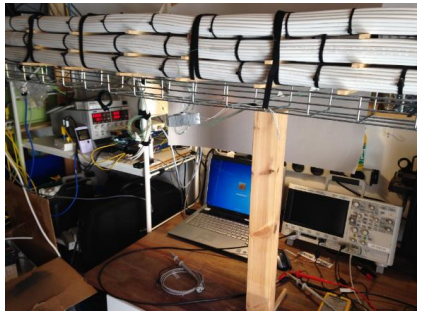
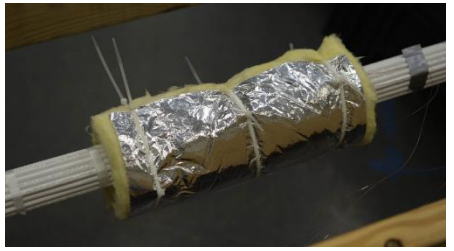
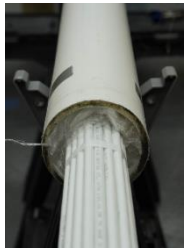



Figure B.3 – Conductor configuration









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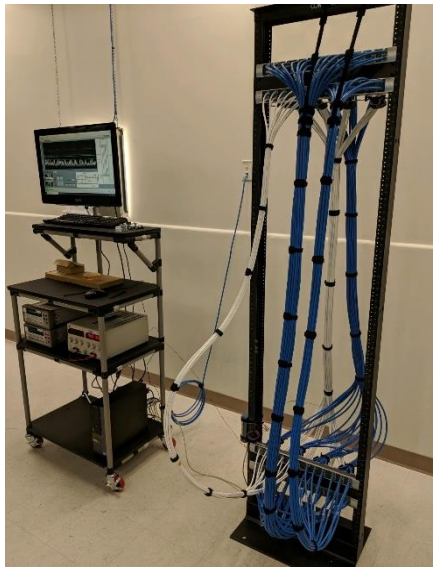
# Greensboro PoE Lab

- Customer facing lab
- Demo of heating and disconnect under load
- Collecting remote powered devices
- Collect real live data











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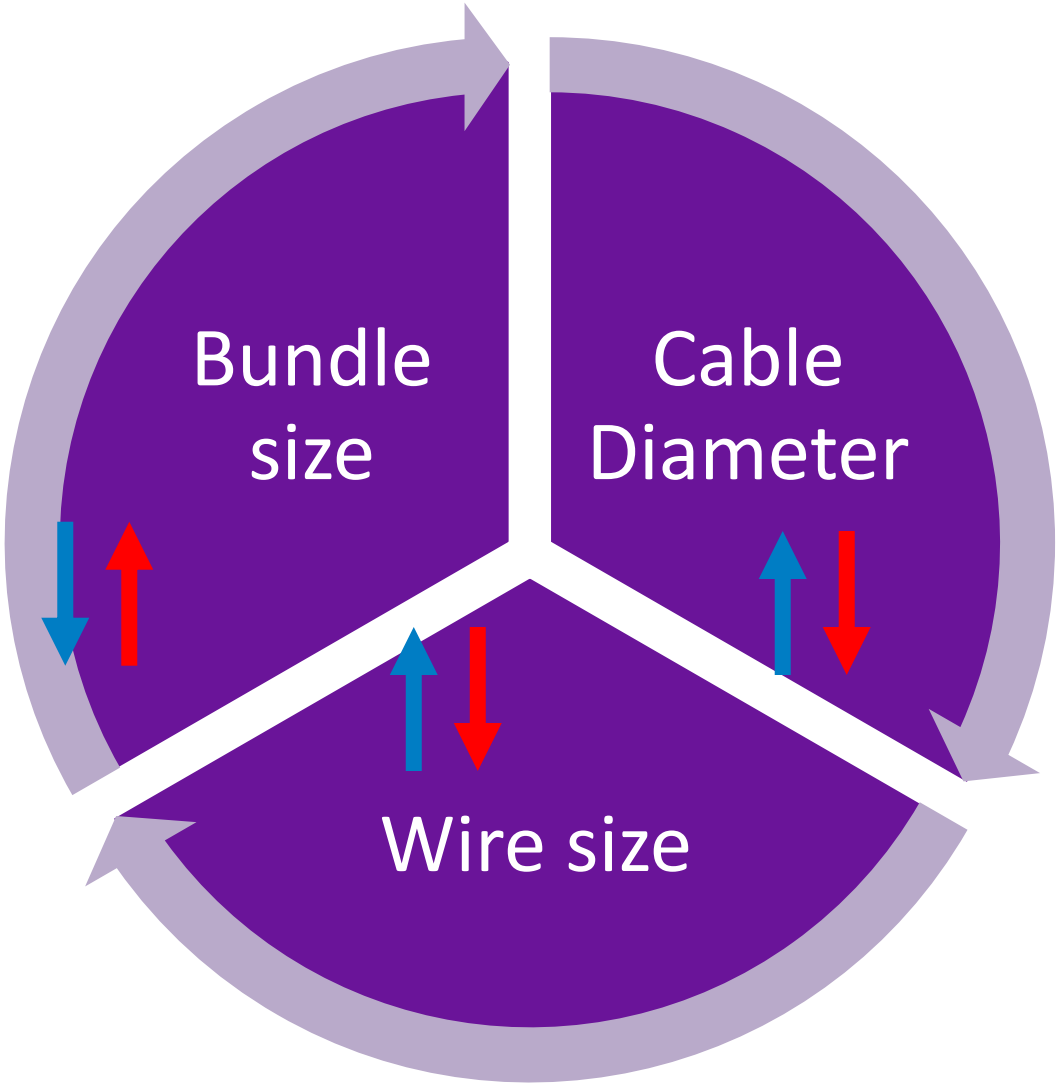
# Remote Power Heating Basics

- Ambient temperature = temperature surrounding the cables
- Heating = the heating caused by the applications including power delivery
- Operating temperature = the combination of the ambient temperature and the heating
- Data cables are normally specified up to 60°C
- Major factors for heating:
  - Ambient temperature
  - Installation conditions
  - Wire size
  - Cable diameter
  - Bundle size





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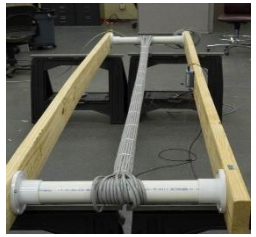
Differet installation conditions influences the cable heating. (naming from HD 60364-5-52)

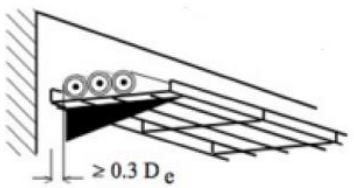
Cables in free air heat less than cables inside a wall with insulation material.

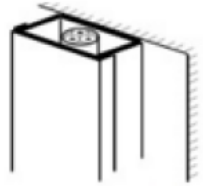
- E/F – Ventilated
- C – Open perforated tray
- B – Trunking conduit
- A - Insulation

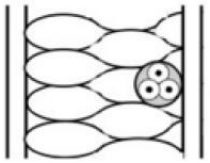


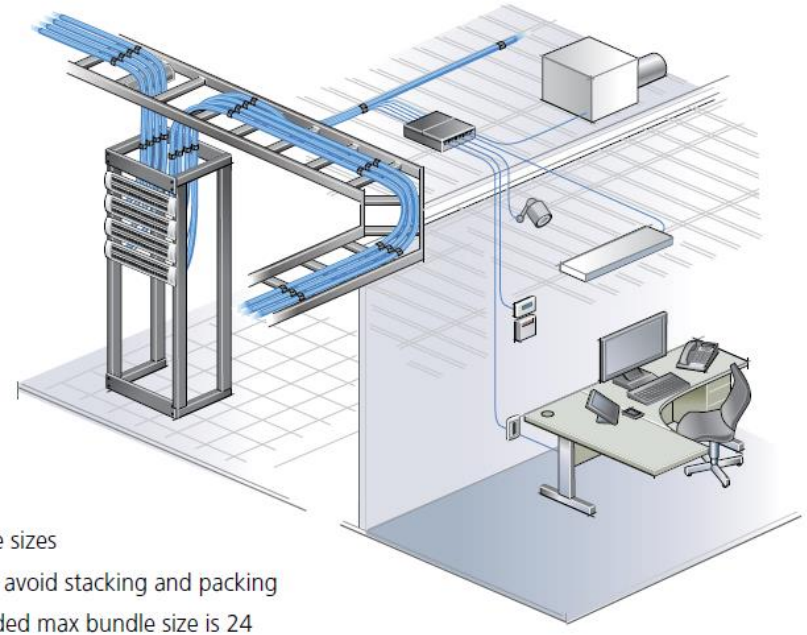










NOTES:

1. Limit bundle sizes
2. Organize to avoid stacking and packing
3. Recommended max bundle size is 24

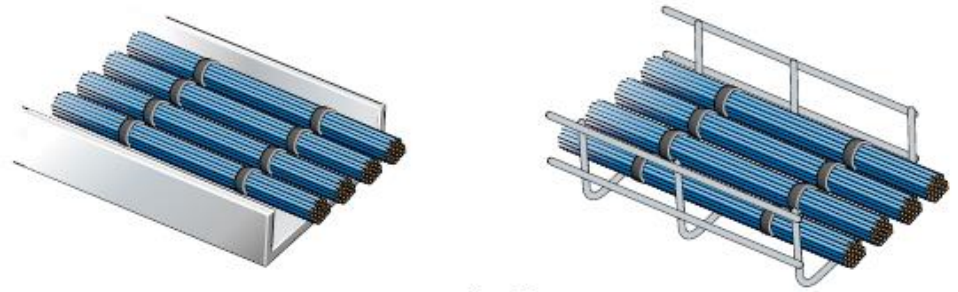


**Figure 7**

Illustration of cable bundles in solid-bottom and wire mesh cable tray

# Installation Conditions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# Length Reduction

Cabling channel performance and reference implementation with 90 meter PL +10 meter cords are based on 20°C operating temperature

- Higher temperature demands a shortening of the channel length
- The table assumes same temperature along the whole length of the cabling
- If needed it can be calculated for each part of the cabling according to the specific ambient temperature and bundle heating and summed up
- Length less than 1 meter are insignificant (e.g. fire barriers)

**Table 4 — Technology-independent channel length vs. temperature**

| | Total length of cords m | | |
|---|---|---|---|
| | 10 | 15 | 20 |
| $T_{global}$ °C | Channel length m | | |
| 20 | 100 | 98 | 95 |
| 25 | 98 | 96 | 93 |
| 30 | 97 | 94 | 91 |
| 35 | 95 | 92 | 89 |
| 40 | 93 | 90 | 87 |
| 45 | 90 | 87 | 85 |
| 50 | 86 | 84 | 82 |
| 55 | 83 | 81 | 79 |
| 60 | 80 | 78 | 76 |

NOTE The channel length values assume the use of cords with an attenuation premium of 50 % and an overall temperature coefficient of 0,4 % per °C up to 40 °C and 0,6 % per °C between 40 °C and 60 °C.


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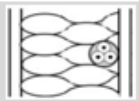
# CommScope cables, CENELEC and ISO/IEC cable heating calculation

According to EN 50174-2: 2018 and draft ISO/IEC 15763-2 fully loaded with 100W type 4 on all cables

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bundlesize | 24 | | | | | | | | | | | | | |
| Ambient °C | 25 | | | | | | | | | | | | | |
| | | | | | | Cord | Cord | | | | | | | |
| | | SYSTIMAX | SYSTIMAX | SYSTIMAX | SYSTIMAX | SYSTIMAX | CommScope | CLC | Netconnect | Netconnect | Netconnect | Netconnect | Netconnect | Netconnect |
| | | Cat5E | Cat6 | Cat6A | Cat7 | Cat6 | Cat6 | Cat6A | Cat6 | Cat6A | Cat6A | Cat7 | Cat7 | Cat7A |
| | | U/UTP | U/UTP | U/UTP | S/FTP | U/UTP | U/UTP | | U/UTP | U/UTP | F/FTP | F/FTP | S/FTP | S/FTP |
| | Cabletype | 3061A | 3071E | 3091B | 3291B | GS8E | MiNo6 | | CS34Z3 | CS44Z3 | CS44ZC | CS54ZC | CS54ZC | 1499101-1 |
| | No. of cables per bundle, N | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| | Cable OD, D (mm) | 5.21 | 5.89 | 7.24 | 7.52 | 6.02 | 3.84 | 7 | 5.72 | 7.24 | 7 | 7.29 | 7.39 | 9 |
| | Cable DCR, R (ohm/m) | 0.0938 | 0.0761 | 0.0761 | 0.08 | 0.0938 | 0.23 | 0.075 | 0.0938 | 0.0761 | 0.0761 | 0.0761 | 0.0761 | 0.07 |
| | Ambient temperature °C | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
|  | Installation condition E/F -Ventilated | | | | | | | | | | | | | |
| | ΔT °C | 6.90 | 5.12 | 4.44 | 4.55 | 6.21 | 21.38 | 4.47 | 6.44 | 4.44 | 4.54 | 4.42 | 4.38 | 3.55 |
| | **Operating temperature** | **31.90** | **30.12** | **29.44** | **29.55** | **31.21** | **46.38** | **29.47** | **31.44** | **29.44** | **29.54** | **29.42** | **29.38** | **28.55** |
|  | Installation condition C - Open perforated tray | | | | | | | | | | | | | |
| | ΔT °C | 8.61 | 6.35 | 5.44 | 5.56 | 7.69 | 27.07 | 5.49 | 8.00 | 5.44 | 5.57 | 5.41 | 5.36 | 4.29 |
| | **Operating temperature** | **33.61** | **31.35** | **30.44** | **30.56** | **32.69** | **52.07** | **30.49** | **33.00** | **30.44** | **30.57** | **30.41** | **30.36** | **29.29** |
|  | Installation conditions B - Trunking/conduit | | | | | | | | | | | | | |
| | ΔT °C | 12.39 | 9.06 | 7.64 | 7.79 | 10.96 | 39.63 | 7.74 | 11.44 | 7.64 | 7.85 | 7.60 | 7.51 | 5.92 |
| | **Operating temperature** | **37.39** | **34.06** | **32.64** | **32.79** | **35.96** | **64.63** | **32.74** | **36.44** | **32.64** | **32.85** | **32.60** | **32.51** | **30.92** |
|  | Installation condition A - Insulation | | | | | | | | | | | | | |
| | ΔT °C | 25.62 | 18.55 | 15.36 | 15.61 | 22.41 | 83.64 | 15.61 | 23.49 | 15.36 | 15.84 | 15.27 | 15.08 | 11.63 |
| | **Operating temperature** | **50.62** | **43.55** | **40.36** | **40.61** | **47.41** | **108.64** | **40.61** | **48.49** | **40.36** | **40.84** | **40.27** | **40.08** | **36.63** |

# Calculate Cable Heating

$$\approx \left(0{,}8 \times N + \frac{0{,}0578 \times \sqrt{N}}{D}\right) \times R$$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# Keeping bundles cold

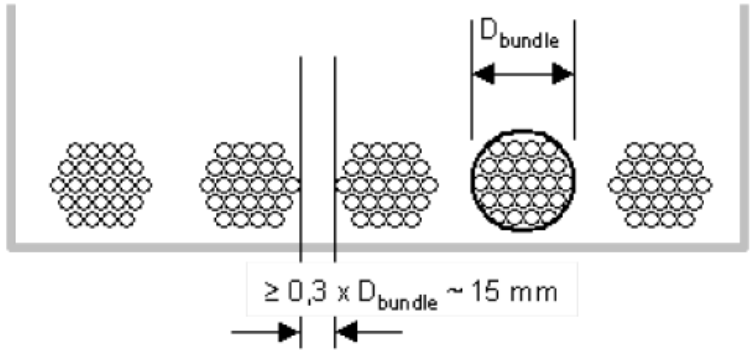
For heating and mechanical reasons, bundle size is limited to 24 cables

If bundles are separated by 0,3x bundle size the heat up like a single bundle. The below examples in wire tray E/F ventilated conditions.

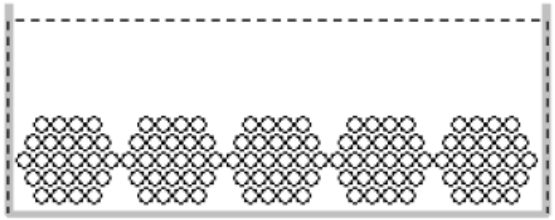
- 1 bundle of 24 SYSTIMAX GigaSPEED X10D heats up 5°C
- 5 bundles of 24 = 120 cables heats up 14°C
- Arranged side by side without air gaps 14°C * 0,66 = 10°C
- 9 bundles of 24 = 216 cables heats up to 22°C
- Arranged side by and on top without air gaps 22°C * 0,84 = 19°C

Ambient 25°C

97 meter




95 meter



90 meter

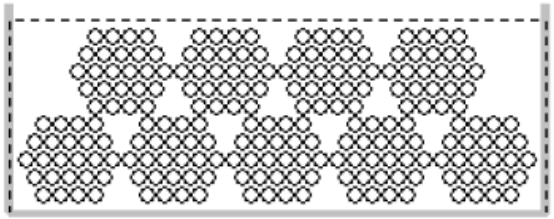


**Table 6 — Reduction factors for rectangular cable groups**

| Width-to-height ratio of cable group | 1:1 | 2:1 | 3:1 | 4:1 | 5:1 | 6:1 | 7:1 | 8:1 | 9:1 | 10:1 |
|---|---|---|---|---|---|---|---|---|---|---|
| $\Delta T$ multiplier | 0,89 | 0,84 | 0,77 | 0,71 | 0,66 | 0,62 | 0,59 | 0,56 | 0,53 | 0,51 |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# Documentation

**RP3**

- Worst case cable temperature at or below 60°C
- Assumed ambient temperature
- Highest bundle temperature
- Resulting Channel reduction

**RP2**

- As RP3 but also including calculations of limiting maximum average power
- Documentation system

**RP1**

- Documentation system

**RP3**

This installation is designed and installed to support up to 90W remote powering (4PPoE/Type4) on all cables according to EN50174. If the installation is extended or changed the responsibility for planning and installation is transferred to the installation owner.

**XYZ Installation, Tel: 123 456 789**
**www.xyzinstallation.com**

Documentation could be done in imVision

**RP1**

No remote powering equipment may be connected without prior written agreement with the IT department that maintains calculations and documentation of cable heating.

**XYZ Installation, Tel: 123 456 789**
**www.xyzinstallation.com**


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# Demating Under Load

- If connectors are disconnected under load arcing will ocour
- That might degrade the communication over the connecting hardware
- EN 60512-99-001 / IEC 60512-99-002 is teststandards for demating under load
- All CommScope connectors and cords have been tested according to these standards
- Here are a example of our MGS600 connector and how the design ensures that the arcing area is far away from the contact area

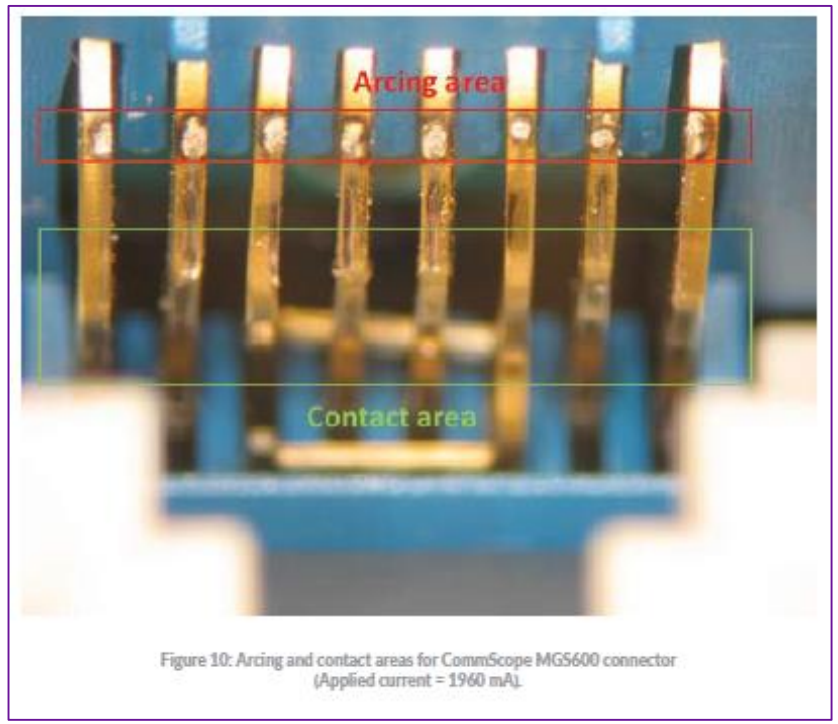
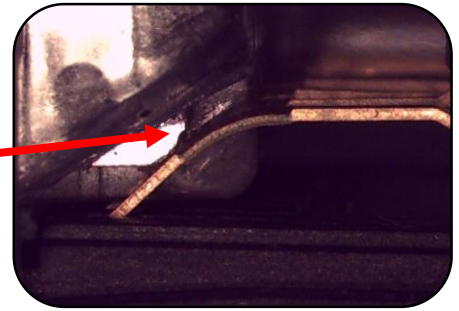
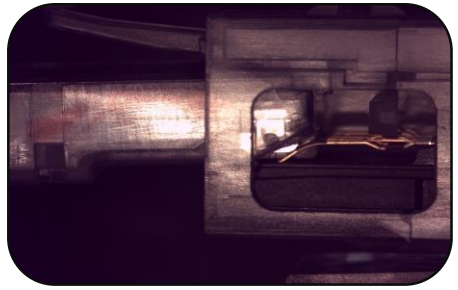


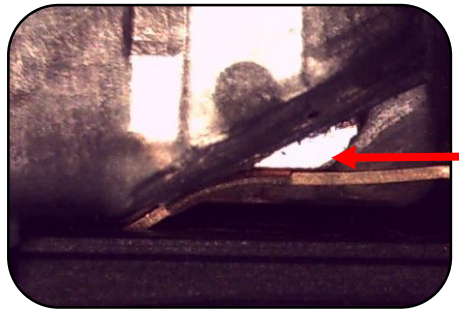

Figure 10: Arcing and contact areas for CommScope MGS600 connector (Applied current = 1960 mA).

**Initial Mated Contact Point**









**Final Mated Contact Point**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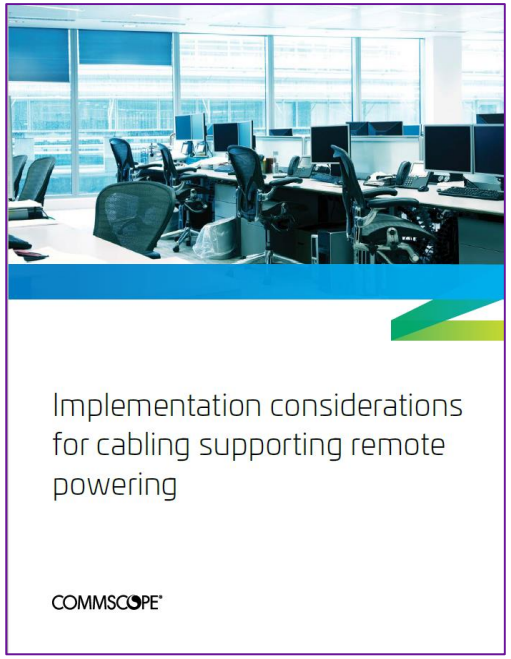
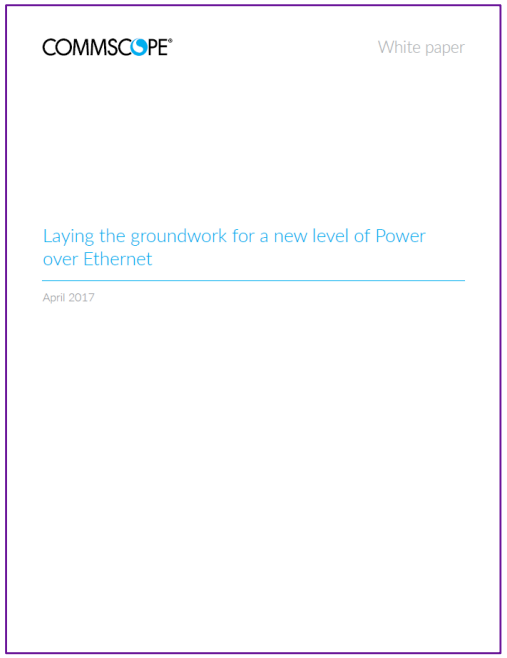
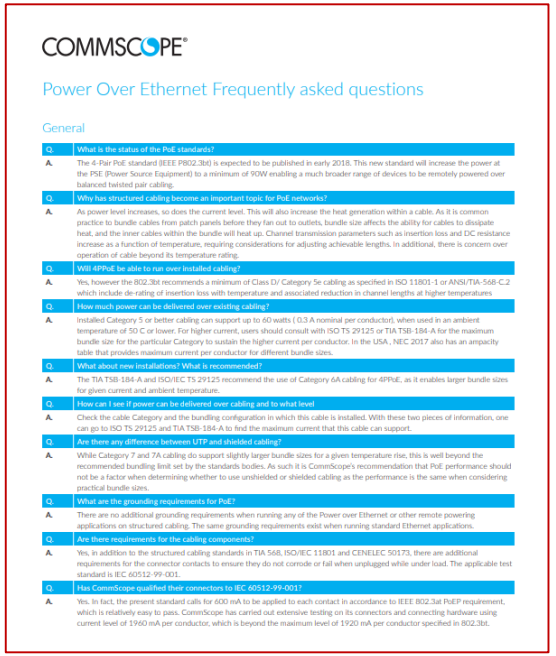
# CommScope Remote Power Resources

- Powered Fiber
- Power over Ethernet
- Powering the tower
- Distributed power and fiber connectivity
- Power over coaxial
- Broadband power

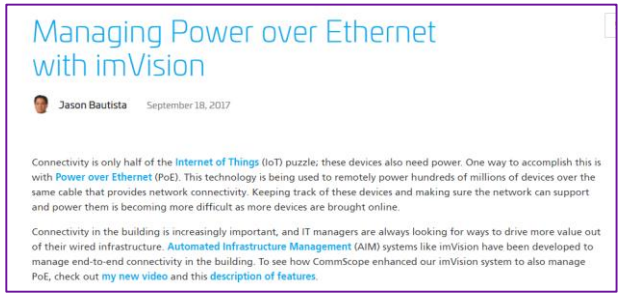


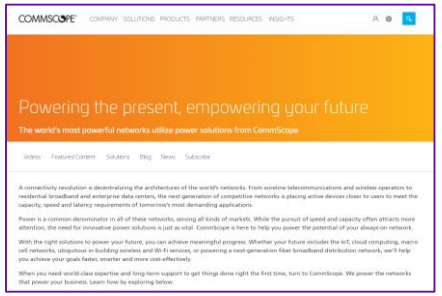










*https://www.commscope.com/power/*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# Summary

- Limit bundles to 24 cables
- Plan pathways so separation is possible (15mm)
- Use Class $E_A$/Cat$6_A$ that will have less heating
- Plan for shorter channel length than 100 meter
- Make pathways in spaces with low temperature
- Plan for universal deployment of Type 4
- If you need help reach out to CommScope


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now meets next

# Thank You

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