Remote Power: PoE vs. Powered Fiber
Understanding the Difference

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Overview

- Applications for PoE/Powered Fiber
- Basic Terms
- Limitations of PoE/Powered Fiber
- Key Features of PoE Systems
- Planning and Deployment Considerations
- PoE vs. Powered Fiber
Applications for PoE/Powered Fiber

- Wi-Fi Access Points
- 5G Active Antenna Systems
- LED Lighting
- IP Cameras
- IoT Devices

4-Pair Category Cable (PoE)
Powered Fiber (Fiber/Copper Hybrid Cable)
# Basic Terms/Calculations: Electronics 101

<table>
<thead>
<tr>
<th>Unit Name</th>
<th>Unit Symbol</th>
<th>Quantity</th>
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</thead>
<tbody>
<tr>
<td>Ampere (Amp)</td>
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<td>Electric Current (I)</td>
</tr>
<tr>
<td>Volt</td>
<td>V</td>
<td>Voltage (V) Electromotive Force (E)</td>
</tr>
<tr>
<td>Ohm</td>
<td>Ω</td>
<td>Resistance (R)</td>
</tr>
<tr>
<td>Watt</td>
<td>W</td>
<td>Electric Power (P)</td>
</tr>
</tbody>
</table>

**Ohm’s Law Wheel**

- P (Watts) = I (Amperes) x E (Volts)
- E = I x R (Ohms)
- P = E^2 x R
- R = E / I
- E = sqrt(P / R)

**Equations**

\[ P = I \times E \]
\[ E = I \times R \]
\[ P = E^2 / R \]
\[ R = E / I \]
\[ E = \sqrt{P / R} \]
Basic Terms

- **Hybrid Cable**: A cable that contains both copper and optical fiber under one jacket
- **Powered Fiber**: Another term for hybrid cable
- **Remote Power**: A method of powering a device from a centralized location using PoE or hybrid cable, instead of a local AC power source
- **PSE**: Power Sourcing Equipment (ex. Ethernet PoE Switch)
- **PD**: Powered Device (ex. WAP, IP Camera)
Limitations of PoE and Powered Fiber

- DC Voltage Range:
  - Max Voltage: 60 VDC or less (SELV/safety extra low voltage) defined by IEC 60950-1 and NEC Class 2 power source limitations

- Power: 100VA (100 Watts)

- Distance: 100 Meters (PoE Only)

- Bundle Size:
  - TIA TSB-184-A
  - NEC 725.144

NEC Class 2 Power Source Max Rating (60VDC)
- 100VA (100 Watts)
- Max operating current = 100 W/ Vmax
  - Ex.100 W / 60 VDC = 1.66 A
  - Class 2 power supplies generally limited to 57 V max: 1.75 A
- Reference NEC Table 11 (B) Class 2 and Class 3 Direct-Current Power Source Limitations
IEEE 802.3bt PoE Standard Key Features

• Detection
  – Determines whether a valid device capable of receiving PoE is connected before applying power

• Classification
  – Determines how much power the device requires and power availability

• Start-up
• Operation
• Disconnection

Design protocols to ensure safe, orderly operation and to address abnormal events, such as power overload, etc.
What’s New in the Latest PoE Standard?

• More Power at the PSE – Up to 90 Watts
  • 3X previous 802.3at Standard
• Supports Power Delivery Over 4-Pairs
• Intelligence
  • Better power management
• Efficiency – Lower Standby Current
  • Important for applications such as PoE lighting
• Optional Extended Power Mode
  • Up to 90 Watts may be supplied to PD for known channel lengths <100 meters
### IEEE PoE Standards

<table>
<thead>
<tr>
<th>IEEE PoE Standard</th>
<th>TYPE</th>
<th>CLASS</th>
<th>PAIRS</th>
<th>PSE PWR OUT (W)</th>
<th>PD PWR MIN (W)</th>
<th>Imax/Pair</th>
<th>DC Loop Resistance (Ω)</th>
<th>PSE VOUTmin</th>
<th>PD Vin</th>
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<td>2</td>
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</table>
Power Delivery Over 4-Pair Cabling

Ethernet PoE Switch (PSE)

DC Power Superimposed on Center Tap of Transformer

Ex. Wireless Access Point (PD)
DC Loop Resistance

ANSI/TIA-568.2-D Clause 6.3.1
Category 3 through Category 6A DC Loop Resistance

- DC loop resistance for category 3, 5e, 6, and 6A channels shall not exceed 25Ω at any temperature from 20 °C to 60 °C

IEEE 802.3bt Standard
Channel maximum DC pair loop resistance
- Type-1: Max DC loop resistance = 20 Ohms
- Type-2-4: Max DC loop resistance = 12.5 Ohms

Example (Vdrop and Ploss)
600 mA * 12.5Ω = 7.5 V
600 mA² * 12.5Ω = 4.5 W
Power Calculation: Class 8 Example

Voltage Drop and Power Loss

\[ V = 52 \text{ V (MIN)} \times 866 \text{ mA (MAX Current)} = 45.03 \text{ W Per Pair Set} \]

\[ I = 866 \text{ mA} \]

\[ R = 12.5 \Omega \]

\[ E = 10.82 \text{ V} \]

\[ P = 9.37 \text{ W} \]

\[ 45.03 \text{ W} - 9.37 \text{ W} = 35.66 \text{ W} \]

\[ 90.06 \text{ W} - 18.74 \text{ W} = 71.3 \text{ W} \]
Cable Bundle Size Limitations

- National Electrical Code (NEC) 2017 edition introduced section 725.144 with requirements for transmission of power and data.
- NEC 2020 edition provides clarifications:
  - Compliance with Table 725.144 shall not be required for installations where conductors are 24 AWG or larger and the rated current per conductor of the power source does not exceed 0.3 amperes.
**NEC Table 725-144**

<table>
<thead>
<tr>
<th>AWG</th>
<th>1-7</th>
<th>8-19</th>
<th>20-37</th>
<th>38-61</th>
<th>62-91</th>
<th>92-192</th>
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<tbody>
<tr>
<td></td>
<td>Temp Rating (°C)</td>
<td>Temp Rating (°C)</td>
<td>Temp Rating (°C)</td>
<td>Temp Rating (°C)</td>
<td>Temp Rating (°C)</td>
<td>Temp Rating (°C)</td>
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<tr>
<td>26</td>
<td>0.71</td>
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<tr>
<td>23</td>
<td>0.89</td>
<td>1.11</td>
<td>1.28</td>
<td>0.77</td>
<td>0.95</td>
<td>1.10</td>
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<tr>
<td>22</td>
<td>0.94</td>
<td>1.28</td>
<td>1.49</td>
<td>0.77</td>
<td>0.95</td>
<td>1.11</td>
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</table>

Table 725.144 Ampacities of Each Conductor in Amperes in 4-Pair Class 2 or Class 3 Balanced Twisted-Pair Cables Based on Copper Conductors at an Ambient Temperature of 30°C (86°F) with All Conductors in All Cables Carrying Current, 60°C (140°F), 75°C (167°F), and 90°C (194°F) Rated Cables.

Current Values in Table 725-144 are Per Conductor
Current Values in TSB-184A are Per Pair
TIA TSB-184-A, Guidelines for Supporting Power Delivery Over Balanced Twisted-Pair Cabling

<table>
<thead>
<tr>
<th>Current/ pair set</th>
<th>26 AWG</th>
<th>Category 5e (24 AWG)</th>
<th>Category 6 (23 AWG)</th>
<th>Category 6A (23 AWG)</th>
<th>28 AWG</th>
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<tbody>
<tr>
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<td>Air 214</td>
<td>Air 281</td>
<td>Air 349</td>
<td>Air 88</td>
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<td>Air 136</td>
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<td></td>
<td>Conduit 45</td>
<td>Conduit 90</td>
<td>Conduit 128</td>
<td>Conduit 171</td>
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<td>1000mA</td>
<td>Air 33</td>
<td>Air 58</td>
<td>Air 81</td>
<td>Air 101</td>
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<td></td>
<td>Conduit 16</td>
<td>Conduit 36</td>
<td>Conduit 53</td>
<td>Conduit 71</td>
<td>Conduit 21</td>
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## TIA TSB-184-A, Guidelines for Supporting Power Delivery Over Balanced Twisted-Pair Cabling

<table>
<thead>
<tr>
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<th>Category 6 (23 AWG)</th>
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<th>28 AWG</th>
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<tbody>
<tr>
<td>Air Air Air Air</td>
<td>134 74</td>
<td>204 139</td>
<td>269 195</td>
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<td>600mA</td>
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<td>720mA</td>
<td>31 15 55 34 77 50</td>
<td>96 67</td>
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<td>1000mA</td>
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</table>

When planning new installations delivering remote power, category 6A or higher performance 4-pair balanced twisted-pair cabling as specified in ANSI/TIA-568.2-D is recommended.
Installation Guidelines

• Higher categories of cabling with lower dc loop resistance help minimize system losses
• Limit cable temperature rise to 15 °C (27°F) to minimize long term degradation of the cable
• Lower DC resistance will experience less power loss over the cable and will deliver power more efficiently
• Allowing for 15°C temp rise for typical 60°C rated cables, ambient temperature should not exceed 45°C (113°F) for lengths of 1 meter or greater
What is Powered Fiber?

- Fiber/Copper Hybrid Cable
  - Fiber for data
  - At least 2 conductors for DC power
- Not limited to 100 meters
  - Distance limited by voltage drop/conductor size
- Power delivered over separate, larger copper conductors (12-22 AWG)
  - UL 13, Power-Limited Circuit Cables, table 5.1 conductor size (12-30AWG)

### Conductor Resistance @20 °C

<table>
<thead>
<tr>
<th>AWG</th>
<th>Ohms/1000Ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>1.6</td>
</tr>
<tr>
<td>14</td>
<td>2.5</td>
</tr>
<tr>
<td>16</td>
<td>4.0</td>
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<td>18</td>
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<tr>
<td>20</td>
<td>10.1</td>
</tr>
<tr>
<td>22</td>
<td>16.1</td>
</tr>
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</table>
Powered Fiber: Design Considerations

- Powered Device: Power consumption and max current draw (Amps)
- Power Source: Output power (Watts)
- Voltage drop and power loss budget
- Conductor size determined by distance and/or power requirement at PD
Powered Fiber Example
Max Distance for Known Power Level

Supply Voltage: 57 VDC @1.75 A = 99.75 W

Max Current: 1.75 A @48 V = 84 W

Ex. 15.75 W (Power Loss Budget)

Calculate Max Distance for Wire Gauge
(Ex. 20AWG)
20AWG = 10.1 Ω/1000Ft

(5.14 / 10.1) * 1000 = 509Ft
509 / 2 = 254Ft

Note: Must divide distance in half to account for return path
**Powered Fiber Example**

**Max Power for Known Distance**

Supply Voltage: 57 VDC @ 1.75 A = 99.75 W

Max Current: 1.75 A @ 48 V = 84 W

Conductor Size for Known Distance (ex. 328FT)

- Conductor Resistance (including return path) x 1.75A² = Power Loss (Ploss)
- Ambient temp: 20°C

<table>
<thead>
<tr>
<th>AWG</th>
<th>Ohms/1000Ft</th>
<th>Ohms/656Ft</th>
<th>Vdrop</th>
<th>Ploss</th>
<th>PD Max Power Consumption</th>
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</table>
Powered Fiber + PoE: Complementary Solutions
Powered Fiber + PoE Example

Powered Fiber (12AWG Copper)
• 99.75 W – 3.22 W = 96.53 W (to PD)
• PD Power Consumption: 16 W (MAX)
• 80 W Power Available for PoE
• Total Distance: 200m

57 V @ 1.75 A = 99.75 W

Example Device
Power Consumption: 16 W (max)
Summary

• PoE is a standards-based plug and play application, powered fiber is more flexible but requires additional design considerations
• Powered fiber extends the reach of remote power beyond 100 meters
• Powered fiber and PoE can co-exist as complementary solutions
Questions

For more information, please visit

www.occfiber.com