The Real Impact of High-Power PoE on Your IP Network

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Agenda

• PoE Drivers

• Relevant Standards

• What to know to ask the right questions
  • Cabling considerations
  • Component considerations
  • Channel considerations

• Case studies
  • Calculating power efficiency
  • Justifying capital expenditure
What is Power-over-Ethernet?

Traditional Way
What is Power-over-Ethernet?

Using PoE
Technology Has Changed Buildings

Yesterday

HVAC

HVAC

Network

Automated Elevators

Security Cameras

Fire Alarm System

Lighting

Sensors

Today

New customer experiences and innovation demand improved efficiencies
### PoE Digital Building Endpoint Examples

#### Communications
- IP Call Tower
- IP Call Stations
- WAP

#### Physical Security
- Badge Readers
- Cameras
- Facial Recognition
- Entry Barriers & Turnstiles
- Biometric Door Locks
- Horns & Sirens

#### Sustainability & Wellness
- Environmental Sensor Hubs
- Power Meters
- Status Signs
- Temperature Sensors

#### Tenant Improvements
- Curtain & Blind Motors
- Ceiling Fans
- Meeting Room Nameplate
- Touchscreen PC’s
- Power over Ethernet Displays

#### Electrical
- HVAC VAV’s
- Light Fixtures

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**Sustainability & Wellness**

| Environmental Sensor Hubs | Power Meters | Status Signs | Temperature Sensors |

**Tenant Improvements**

| Curtain & Blind Motors | Ceiling Fans | Meeting Room Nameplate |

**Electrical**

| HVAC VAV’s | Light Fixtures |
Digital Building: Power & Data

- **HIGH DATA, LOW POWER**: Ex: Security Cameras, VoIP
- **LOW DATA, LOW POWER**: Ex: A/V, Environmental Sensors
- **HIGH DATA, HIGH POWER**: Ex: WiFi, AP, Video Conferencing
- **LOW DATA, HIGH POWER**: Ex: LED Lighting, A/V, Shade Controls
## PoE - Commercial Building Applications

### PoE Infrastructure

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED Lighting</td>
<td>389</td>
</tr>
<tr>
<td>Phone, Client, Monitor</td>
<td>192</td>
</tr>
<tr>
<td>Display</td>
<td>15</td>
</tr>
<tr>
<td>Occupancy Sensors</td>
<td>89</td>
</tr>
<tr>
<td>WAP</td>
<td>10</td>
</tr>
<tr>
<td>Shade Control</td>
<td>40</td>
</tr>
<tr>
<td>Security Camera</td>
<td>12</td>
</tr>
<tr>
<td>Access Controls</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>755</strong></td>
</tr>
</tbody>
</table>

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**25,000 SQ Feet**

- **222'-10'**
- **112'-9'**

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**LEGRAND**

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**Superior Essex**

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**2018 BICSI Fall Conference & Exhibition**

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**BICSI**
Power-over-Ethernet
Standards & Codes

Applications

• IEEE 802.3

Cabling, performance, premises & best practices

TIA / TSB 184-A

Codes

• NEC 2017

• BICSI 005--2013
• BICSI 007--2017
## Power-over-Ethernet (IEEE802.3)

<table>
<thead>
<tr>
<th>Standard</th>
<th>IEEE 802.3af</th>
<th>IEEE 802.3at</th>
<th>IEEE 802.3bt</th>
<th>HDBaseT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PoE</td>
<td>PoE+</td>
<td>PoE++</td>
<td>4PPoE</td>
</tr>
<tr>
<td><strong>Type</strong></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>Status</strong></td>
<td>2003</td>
<td>2009</td>
<td>Expected end of 2018</td>
<td>Exists today</td>
</tr>
<tr>
<td>Maximum number of energized pairs</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Maximum DC current per pair</td>
<td>350 mA</td>
<td>600 mA</td>
<td>600 mA</td>
<td>960 mA</td>
</tr>
<tr>
<td>Maximum power delivered by the Power Sourcing Equipment (PSE)</td>
<td>15.4 watt</td>
<td>30.0 Watt</td>
<td>60.0 Watt</td>
<td>99.9 Watt</td>
</tr>
<tr>
<td>Minimum required power at the Powered Device (PD)</td>
<td>12.95 Watt</td>
<td>25.5 Watt</td>
<td>51.0 Watt</td>
<td>71.0 Watt</td>
</tr>
<tr>
<td>Maximum Data Rate</td>
<td>1000BASE-T</td>
<td>1000BASE-T</td>
<td>10GBASE-T</td>
<td>Varies</td>
</tr>
</tbody>
</table>
TIA
What is TSB-184?

- Technical Service Bulletin
- Provides guidelines for supporting power delivery over twisted-pair cabling simultaneously with data
  - Twisted-pair cabling defined in ANSI/TIA-568 series
  - Safety Extra Low Voltage (SELV) limited power source (LPS) power
  - Focus on temperature de-rating of cable
  - Comprehensive approach
  - Defines bundle sizes
  - Includes 26 AWG
  - Installation recommendations
- Describes methods to help manage temperature rise (≤15º)
  - Reduce long term cable degradation
  - Minimize negative effect on transmission performance
  - Reduce the amount of heat added to surrounding environment
TIA TSB-184-A
Guidelines for Supporting Power Delivery over Balanced Twisted-Pair Cabling

- Current has been increased to up to 1000 mA/pair.
- Models have been refined to include additional cable properties and installation conditions.
- Temperature rise tables include temperature rise in open air and sealed conduit.
- Bundling recommendations and installation recommendations have been added.
- Measurement procedures to develop models have been refined and included in the document.
- Includes additional specifications for *pair-to-pair dc resistance unbalance*. 

Driven by high-power PoE
TSB-184-A DC requirements

Energy consumption is related to the loop dc resistance -- heating in cabling will be related to the local dc resistance per unit length.

### DC Loop Resistance of Channels at 60°C

<table>
<thead>
<tr>
<th></th>
<th>Cat 5e 100m</th>
<th>Cat 6 100m</th>
<th>Cat 6A 100m</th>
<th>Cat 8 100m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max dc loop resistance</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>7.22</td>
</tr>
<tr>
<td>Nominal dc loop resistance</td>
<td>24.38</td>
<td>20.09</td>
<td>20.09</td>
<td>6.81</td>
</tr>
</tbody>
</table>

**Notes:**
1. Dc loop resistance applies only to pairs that provide dc continuity end-to-end
2. All values are at or adjusted to 60°C.
3. Max values from ANSI/TIA-568.2-D

Larger conductor size reduces dc loop resistance improving power delivery efficiency & minimize heating.
TSB-184-A DC requirements

<table>
<thead>
<tr>
<th>AWG table</th>
<th>Ohms per 100m solid</th>
<th>Ohms per 100m stranded</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>7.32</td>
<td>6.92</td>
</tr>
<tr>
<td>24</td>
<td>9.38</td>
<td>8.76</td>
</tr>
<tr>
<td>26</td>
<td>14.8</td>
<td>14</td>
</tr>
</tbody>
</table>

Assumptions:
- Category 5e horizontal cable is assumed to be 24AWG solid conductor cable
- Category 6 horizontal cable is assumed to be 23AWG solid conductor cable
- Category 8 horizontal cable is assumed to be 23AWG solid conductor cable
- All categories of cord cable are represented by 26AWG stranded cable

Heating in cabling related to dc resistance per unit length.
TSB-184-A DC requirements

Table A.9 - Nominal power loss per meter of different cable types.

<table>
<thead>
<tr>
<th>Current per pair</th>
<th>Number of Pairs</th>
<th>Category 5e</th>
<th>Category 6</th>
<th>Category 6A</th>
<th>Category 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>600 mA</td>
<td>2</td>
<td>39.08 mW</td>
<td>30.49 mW</td>
<td>30.49 mW</td>
<td>30.49 mW</td>
</tr>
<tr>
<td>600 mA</td>
<td>4</td>
<td>78.15 mW</td>
<td>60.99 mW</td>
<td>60.99 mW</td>
<td>60.99 mW</td>
</tr>
<tr>
<td>720 mA</td>
<td>4</td>
<td>112.54 mW</td>
<td>87.82 mW</td>
<td>87.82 mW</td>
<td>87.82 mW</td>
</tr>
<tr>
<td>1000 mA</td>
<td>4</td>
<td>217.09 mW</td>
<td>169.41 mW</td>
<td>169.41 mW</td>
<td>169.41 mW</td>
</tr>
</tbody>
</table>
BICSI Standards
BICSI 005-2013  Electronic Safety & Security

- Inclusion of IP based architecture
- Support for PoE
- Recommends Category 6 or better
BICSI Standards

BICSI 007-2017  Intelligent Buildings

- Equipment cords and coverage area cables used for data and power transmission should have conductors with a minimum size of 0.205 mm² (24 AWG).

- For new installations, consider using cabling with 0.326 mm² (22 AWG) conductors if:
  - The specific building system (e.g., audio systems, video displays) is expected to require power exceeding 50W during the life cycle of the building
  - Future flexibility is desired in the types of systems that could be supported.
NFPA – NEC 2017 code
NEC is for SAFETY -- not application, power usage or performance

➤ Section 840.160
  • Nothing required if less than 60 watts is used
  • If more than 60 watts is used
    • Comply to section 725.144 or OPTIONALLY comply to UL LP-Listing
UL LP Listing.....
UL LP Listing

New UL Limited Power (LP) certification:

1. CMP burn test

2. Cable Heating test
   • Create a bundle of 192 cables
   • Place in a 6ft long non-metallic conduit
   • Inject power
   • Check if the temperature increase is not higher than the cable rating
   • For 75°C rated cable and 45°C ambient temperature / no more than 30°C
UL LP Listing

Issues

➤ Based on UL test results only

➤ Inconsistent with TIA / IEEE
  • Bundle size different
  • Not same ampacity
  • Temperature reference different
    • UL is vs temperature rating
    • IEEE is temperature rating minus 10°C
    • TIA is ambient temperature + 15°C
UL LP Listing

ISSUE

• Temperature rating
  • Min 60°C for insulation and jacket
  • 75°C marking:
    ? 75°C insulation and jacket
    ? 75°C insulation and 60°C jacket
  • 90°C marking:
    ? 90°C insulation and jacket
    ? 90°C insulation and 75°C jacket
  • 105°C marking:
    ? 105°C insulation and jacket
    ? 105°C insulation and 90°C jacket

What happens if the cable is at 87°C?
The insulation is good but how is the jacket impacted during the time when it is rated for 75°C...
UL LP Listing
What you need to remember
• LP simplifies cable choice by pre-testing
  • Large bundle sizes
  • Accounting for temperature rating
  • Accounts for cable design performance
  • Reasonable worst case environmental conditions
• However...
  • The listing is not being enforced by code or any standard
  • The listing is not aligned with current IEEE or TIA standards development
  • Only compares temperature of cable bundle under power to cable temperature rating
  • Does not include aging affects of operation at elevated temperatures
  • Does not consider cable performance verification at elevated temperatures
  • Confusion about who is allowed to install and how to install (the local authority has the final word)
Component Considerations
Cable: Twisted Pair Cable Factors for PoE

- **Gauge Size**
  Larger copper gauge = less heat and is better at mitigating heat rise

- **Cable Size**
  Larger cables better dissipate heat

- **Temperature rating**
  - Cables with a higher temp rating = better ability to mitigate heat rise
  - 100% FEP (Plenum) insulation will have a higher rating than partial FEP or polyolefin insulation (Riser)

- **Other elements of cable construction**
  Shielded products dissipate heat down the length of the cable so improve capability
Cable: Power Efficiency

- Think about the application
  - High-speed Data vs. High power vs. Mix
  - AWG more important than performance category?
- If main application is high power, high-performance category may not provide best ROI
Cable: Temperature Rise

Higher Temp = Higher Attenuation

Higher Attenuation = Signal loss

Signal Loss = Shorter Channel Distance
## Cable: Temperature Rise

<table>
<thead>
<tr>
<th></th>
<th>Cat 5E</th>
<th>Cat 5E+</th>
<th>Cat 6A</th>
<th>Cat 6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AWG</strong></td>
<td>22</td>
<td>22</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td><strong>Design</strong></td>
<td>UTP</td>
<td>UTP</td>
<td>F/UTP</td>
<td>UTP</td>
</tr>
<tr>
<td><strong>Energy Savings (W)</strong></td>
<td>300</td>
<td>300</td>
<td>90</td>
<td>0</td>
</tr>
<tr>
<td><strong>Temperature Increase (°F)</strong></td>
<td>+13</td>
<td>+10</td>
<td>+13</td>
<td>+20</td>
</tr>
</tbody>
</table>

- 100 cables in bundle
- 100 meters
- 100W for 5 days
Cable: Temperature Rise

- Energized cable has an impact on lifespan of cable materials
- FEP insulation yields longest system lifespan
- Promotes longest life for powered devices

Top Challenges of Implementing Cost-Efficient 4PPoE (IEEE 802.3bt) Cable Solutions
Connectivity: Design Considerations for PoE

- **Interface contact displacement (spark gap)**
  - Prevent arc damage

- **Increase electrical area for power**
  - Support higher current

- **Improved housing cavity**
  - Withstand usage, extended life cycle, improved electrical performance

- **Improved cavity air flow**
  - Heat dissipation

- **Power transfer heat dissipation**
  - Support higher current
Connectivity Design Considerations

Spark Gap Concerns

Spark Gap Concerns When Un-mating Under PoE Load

• Connectivity designs that locate the last point of contact away from the fully mated connection protected area of the mated connection from any arch damage.
Connectivity Design Considerations

- IEC 60512-99 recommendations support 1 amp on each circuit path
  - 802.3af supports a max of 350mA
  - 802.3at supports a max of 600mA
  - 802.3bt projected max of 960mA

- 960mA is dangerously close to 1 amp
  - Connectivity should be designed to support more than 1A

- Pick connectivity ready for emerging devices & designed to withstand the stressors usage and extended life cycles.
Impact on Channel
Challenges for the network

- Delivering up to 100 watts of power while......
  - Maximizing energy efficiency
  - Maintaining data integrity
  - Maximizing life span of cabling
- New Pair to Pair Unbalanced DCR limits required in the standard
- Justifying Capex & ROI
Power will impact data transmission
High power impact on data transmission

Cabling Performance Margins under Power Load

<table>
<thead>
<tr>
<th>Test</th>
<th>Power Source (W)</th>
<th>Power Received (W)</th>
<th>Power Efficiency (%)</th>
<th>NEXT (dB)</th>
<th>RL (dB)</th>
<th>IL (dB) @100 MHz</th>
<th>ACR (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>NA</td>
<td>NA</td>
<td>10.09</td>
<td>5.54</td>
<td>6.68</td>
<td>11.62</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
<td>90.24</td>
<td>90.24</td>
<td>10.27</td>
<td>5.6</td>
<td>7.02</td>
<td>12.41</td>
</tr>
</tbody>
</table>

Margin Differences: 0.18, 0.06, 0.34, 0.79

<table>
<thead>
<tr>
<th>Test</th>
<th>Power Source (W)</th>
<th>Power Received (W)</th>
<th>Power Efficiency (%)</th>
<th>NEXT (dB)</th>
<th>RL (dB)</th>
<th>IL (dB) @100 MHz</th>
<th>ACR (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0</td>
<td>NA</td>
<td>NA</td>
<td>10.64</td>
<td>6.88</td>
<td>5.82</td>
<td>12.34</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
<td>89.22</td>
<td>89.22</td>
<td>10.63</td>
<td>6.35</td>
<td>4.92</td>
<td>12.32</td>
</tr>
</tbody>
</table>

Margin Differences: 0.01, 0.53, 0.9, 0.02
Verify Components and Test Channels
Case Studies
Example based on 10,000 sq. ft

## Connected Lighting TCO with controls

<table>
<thead>
<tr>
<th>Total CAPEX</th>
<th>PoE-LED</th>
<th>PoE-LED (De-central/Ceiling)</th>
<th>AC-LED</th>
<th>AC-FL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Central/Closet</td>
<td></td>
<td>Ceilings</td>
<td></td>
</tr>
<tr>
<td>Total CAPEX</td>
<td>$193,132</td>
<td>$219,304</td>
<td>$236,967</td>
<td>$188,477</td>
</tr>
<tr>
<td>Per Square Foot</td>
<td>$7.73</td>
<td>$8.77</td>
<td>$9.48</td>
<td>$7.54</td>
</tr>
<tr>
<td>Cost Delta (relative to AC-LED)</td>
<td>-18.5%</td>
<td>-7.5%</td>
<td>0.0%</td>
<td>-20.5%</td>
</tr>
<tr>
<td>Total OPEX</td>
<td>$88,177</td>
<td>$86,284</td>
<td>$88,046</td>
<td>$190,369</td>
</tr>
<tr>
<td>Per Square Foot</td>
<td>$3.53</td>
<td>$3.45</td>
<td>$3.52</td>
<td>$7.61</td>
</tr>
<tr>
<td>Per Square Foot (per year)</td>
<td>$0.35</td>
<td>$0.35</td>
<td>$0.35</td>
<td>$0.76</td>
</tr>
<tr>
<td>Cost Delta (relative to AC-LED)</td>
<td>0.1%</td>
<td>-2.0%</td>
<td>0.0%</td>
<td>116.2%</td>
</tr>
<tr>
<td>Total INVESTMENT</td>
<td>$281,309</td>
<td>$305,588</td>
<td>$325,012</td>
<td>$378,846</td>
</tr>
<tr>
<td>Per Square Foot</td>
<td>$11.25</td>
<td>$12.22</td>
<td>$13.00</td>
<td>$15.15</td>
</tr>
<tr>
<td>Per Square Foot (per year)</td>
<td>$1.13</td>
<td>$1.22</td>
<td>$1.30</td>
<td>$1.52</td>
</tr>
<tr>
<td>Cost Delta (relative to AC-LED)</td>
<td>-13.4%</td>
<td>-6.0%</td>
<td>0.0%</td>
<td>16.6%</td>
</tr>
</tbody>
</table>
Case Study: The Sinclair Office Building
## Case Study: The Sinclair Office Building

<table>
<thead>
<tr>
<th></th>
<th>YE 2016</th>
<th>YE 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>jan</td>
<td>316,866</td>
<td>286,861</td>
</tr>
<tr>
<td>feb</td>
<td>272,376</td>
<td>248,146</td>
</tr>
<tr>
<td>mar</td>
<td>268,707</td>
<td>253,063</td>
</tr>
<tr>
<td>apr</td>
<td>291,208</td>
<td>272,666</td>
</tr>
<tr>
<td>may</td>
<td>259,108</td>
<td>238,546</td>
</tr>
<tr>
<td>jun</td>
<td>280,267</td>
<td>262,491</td>
</tr>
<tr>
<td>jul</td>
<td>328,715</td>
<td>312,005</td>
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<tr>
<td>aug</td>
<td>326,295</td>
<td>272,527</td>
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<tr>
<td>sep</td>
<td>316,320</td>
<td>300,119</td>
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<tr>
<td>oct</td>
<td>310,155</td>
<td>189,925</td>
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<tr>
<td>nov</td>
<td>274,787</td>
<td>172,121</td>
</tr>
<tr>
<td>dec</td>
<td>266,411</td>
<td>154,825</td>
</tr>
</tbody>
</table>
Conclusions

• Think differently

  • What performance do you actually need?

• 1G vs. 10G

• CAPEX / ROI
Conclusions

• Know Application

• Work with manufacturing partner
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