Digital Ceiling Lighting and Cabling Design Challenges

Harry Aller, Innovative Lighting
Frank Straka, Panduit
Agenda

• Digital Lighting Topologies
• Cabling Standards
• Cabling Design for Digital Lighting Topologies
• Recommendations
Digital Lighting Topologies
Digital Lighting Topologies

Why do we need digital lighting? Features!

NOTES

1. Electrical contractor shall verify quantities of all devices. Additional devices may be necessary. Refer to reflected ceiling plans for additional devices.

2. A maximum of 10 sensors shall be energized per power pack. Supplement with additional power packs if over 10 sensors.

3. Auxiliary relay requires sensor power to function. Auxiliary relay changes state when all connected sensors register unoccupied. Grey and brown wires are connected during occupied state. Violet and brown wires are connected during unoccupied state.

4. Low voltage dimmer may be programmed for either vacancy or occupancy mode. Refer to reflected ceiling plans for control type.

Occupancy / Vacancy

Dimming
Digital Lighting Topologies

Why do we need digital lighting? Features!

- Dimming
- Occupancy / Vacancy
- RGB Notification Lighting
- White Light Color Tuning
- Scenes
- Daylight Harvesting
- High / Low Trim
- Power Reporting
- Dimming
- Utilization

2019 BICSI FALL Conference & Exhibition
Digital Lighting Topologies

Why do we need digital lighting? Features! Daylight Harvesting.

July 17, 2019
High End Trim, Occupancy, Vacancy, Daylight Harvesting & Rhythm
Digital Lighting Topologies

Topologies? Fixture vs Node

Fixture Centric

1 : 1
Digital Lighting Topologies

Topologies? Fixture vs Node

Node Centric
1 : N
Digital Lighting Topologies

Node Centric. PoE Power.

- IEEE 802.3af (PoE)
  - 2003
  - 15.4W, 13W

- IEEE 802.3at (PoE+)
  - 2009
  - 30W, 25.5W

- Cisco (UPOE Prestandard)
  - 2012
  - Four-Pair: 60W, 51W

- IEEE 802.3bt (PoE++, 4PPoE)
  - 2018
  - Four-Pair: 60W, 51W
  - Four-Pair: 90W, 71.3W
Digital Lighting Topologies

Node Centric. Fixture capabilities.

1W + 1W + 1W = 3W

8W + 8W + 8W + 8W + 8W + 8W = 48W

51W
Digital Lighting Topologies

Node Centric  Hardware Design Challenges.

- Isolation (DC / DC)
  802.3af, IEC

- Plenum Rating
  NEC, UL 2043

- Multiple Channels

- High Power Input

- Multiple Fixture Options

IEC (International Electrotechnical Commission)  NEC (National Electrical Code)  UL (Underwriters Laboratories)
# Digital Lighting Topologies

*Fixture vs Node Centric. Approximate costs.*

## Fixture Centric

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
<th>Cost per Unit</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSE Port (30W)</td>
<td>7</td>
<td>$100.00</td>
<td>$700.00</td>
</tr>
<tr>
<td>Downlight</td>
<td>6</td>
<td>$150.00</td>
<td>$900.00</td>
</tr>
<tr>
<td>Switch</td>
<td>1</td>
<td>$100.00</td>
<td>$100.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>$1,700.00</strong></td>
</tr>
</tbody>
</table>

## Node Centric

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
<th>Cost per Unit</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSE Port (60W)</td>
<td>1</td>
<td>$150.00</td>
<td>$150.00</td>
</tr>
<tr>
<td>Node</td>
<td>1</td>
<td>$250.00</td>
<td>$250.00</td>
</tr>
<tr>
<td>Downlight</td>
<td>6</td>
<td>$75.00</td>
<td>$450.00</td>
</tr>
<tr>
<td>Switch</td>
<td>1</td>
<td>$75.00</td>
<td>$75.00</td>
</tr>
<tr>
<td>Sensor</td>
<td>1</td>
<td>$75.00</td>
<td>$75.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>$925.00</strong></td>
</tr>
<tr>
<td><strong>Sensor</strong></td>
<td></td>
<td></td>
<td><strong>$1,000.00</strong></td>
</tr>
</tbody>
</table>
Cabling Design for Digital Lighting Topologies

Best Practice.

- Manufacturer Recommended (RS485)
- Manufacturer Recommended (21V @ 1100mA)
- Manufacturer Recommended (21V @ 350mA)
- Standard Practice (60W UPOE)

23AWG CAT6
Digital Lighting Topologies

*Power to the light is everything!*

\[
\begin{align*}
\text{Loss Percentage} &= \left( \frac{P_{\text{Load}}}{V_{\text{Load}}} \times R_{\text{Wire}} \right) / V_{\text{Source}} \\
\text{Where} & \quad V_{\text{Source}} = 50V \\
& \quad P_{\text{Load}} = 25.5W \\
& \quad R_{\text{Wire}} = 12.5\Omega \\
& \quad V_{\text{Load}} = 42.5V
\end{align*}
\]

60W UPOE at PSE = 51W at PD

Loss of 1 Watt every 36ish feet between PSE and PD

Keep the runs short!

Centralized vs Decentralized?
Cabling Standards
NEW INSTALLATION PRACTICES

YESTERDAY
Voice & Data

TODAY
Security
Voice & Data
Digital Signage
Sensors
Wireless
Lighting
Major Cabling Standards

• Power over Ethernet
• TIA TSB-184-A
  • Working on TSB-184-A-1 for 28 AWG
• 2017 National Electric Code
• New ANSI/TIA-568.2-D
• ANSI C137.0-2017
  • American National Standard for Lighting Systems
• Coming Soon! Single Pair Ethernet
## PoE Performance Summary

<table>
<thead>
<tr>
<th>Type</th>
<th>Standards</th>
<th>Maximum Current</th>
<th>Number of Energized Pairs</th>
<th>Power at Source</th>
<th>Power at Device</th>
<th>Maximum Data Rate</th>
<th>Standard Ratified</th>
</tr>
</thead>
<tbody>
<tr>
<td>PoE</td>
<td>IEEE 802.3af (802.3at Type 1)</td>
<td>350 mA</td>
<td>2</td>
<td>15.4 W</td>
<td>13 W</td>
<td>1000BASE-T</td>
<td>2003</td>
</tr>
<tr>
<td>PoE+</td>
<td>IEEE 802.3at Type 2</td>
<td>600 mA</td>
<td>2</td>
<td>30 W</td>
<td>25.5 W</td>
<td>1000BASE-T</td>
<td>2009</td>
</tr>
<tr>
<td>PoE++ (4PPoE)</td>
<td>Proposed IEEE 802.3bt Type 3</td>
<td>600 mA</td>
<td>4</td>
<td>60 W</td>
<td>51 W</td>
<td>10GBASE-T</td>
<td>APPROVED</td>
</tr>
<tr>
<td></td>
<td>Proposed IEEE 802.3bt Type 4</td>
<td>960 mA</td>
<td>4</td>
<td>99 W</td>
<td>71 W</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No IEEE standard</td>
<td>Cisco UPOE</td>
<td>600 mA</td>
<td>4</td>
<td>60 W</td>
<td>51 W</td>
<td>Varies</td>
<td>Exists today – no official ratification</td>
</tr>
<tr>
<td></td>
<td>HDBaseT (<a href="http://www.hdbaset.org">www.hdbaset.org</a>)</td>
<td>1000 mA</td>
<td></td>
<td>100 W</td>
<td>100 W</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Current increase by 1.5X
- Power going from 2 pairs to 4 pairs
- Approximately 3X increase in power
Impact of 2017 National Electric Code

- Recognizes new UL listing for Limited Power (LP) cables
  - LP not required
  - Need at least a 0.5A rating
  - Example: TYPE CMP-LP(0.5A) (UL) 23 AWG 90°C

- LP simplifies installation and inspection
  - With no LP, refer to ampacity table

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<td>2</td>
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<td>960 mA</td>
<td>4</td>
<td>90 W</td>
<td>71.3 W</td>
</tr>
</tbody>
</table>

NEC® 2017 not a concern

NEC® 2017 imposes new requirements
Ampacity Table

<table>
<thead>
<tr>
<th>AWG</th>
<th>Number of 4-Pair Cables in a Bundle</th>
<th>1</th>
<th>2-7</th>
<th>8-19</th>
<th>20-37</th>
<th>38-61</th>
<th>62-91</th>
<th>92-192</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Temp Rating</td>
<td>60°C</td>
<td>75°C</td>
<td>90°C</td>
<td>60°C</td>
<td>75°C</td>
<td>90°C</td>
<td>60°C</td>
</tr>
<tr>
<td>26</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>0.7</td>
<td>0.8</td>
<td>1.0</td>
<td>0.5</td>
</tr>
<tr>
<td>24</td>
<td>2.0</td>
<td>1.0</td>
<td>1.4</td>
<td>1.6</td>
<td>0.8</td>
<td>1.0</td>
<td>1.1</td>
<td>0.6</td>
</tr>
<tr>
<td>23</td>
<td>2.5</td>
<td>1.2</td>
<td>1.5</td>
<td>1.7</td>
<td>0.8</td>
<td>1.1</td>
<td>1.2</td>
<td>0.6</td>
</tr>
<tr>
<td>22</td>
<td>3.0</td>
<td>1.4</td>
<td>1.8</td>
<td>2.1</td>
<td>1.0</td>
<td>1.2</td>
<td>1.4</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Note 1: For bundle sizes over 192 cables, or for conductor sizes smaller than 26 AWG, ampacities shall be permitted to be determined by qualified personnel under engineering supervision.

Note 2: Where only half of the conductors in each cable are carrying current, the values in the table shall be permitted to be increased by a factor of 1.4.

- Cat 5e (24 AWG, 60C): Maximum bundle size of 61
- Cat 6A (23 AWG, 75C): Maximum bundle size of 192
When will the 2017 NEC® Apply to Me?

• Depends on state
• 2017 adoption is up
• Often a lag between code adoption and local awareness
• Code can be interpreted differently at a local level
Cable Type Discussion

• 23 vs 24 AWG
  • 23 AWG less heat loss / power loss
  • 23 AWG needed for LP rating

• Copper Clad Aluminum?
  • NO!
  • Not allowed by standards
  • Not safe
  • Aluminum is ~50% higher resistance

<table>
<thead>
<tr>
<th>Cable</th>
<th>23 AWG</th>
<th>24 AWG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>8.1 W</td>
<td>10.3 W</td>
</tr>
<tr>
<td>Copper Clad Aluminum 10%</td>
<td>12.6 W</td>
<td>15.9 W</td>
</tr>
<tr>
<td>Copper Clad Aluminum 15%</td>
<td>12.2 W</td>
<td>15.4 W</td>
</tr>
</tbody>
</table>

Power Loss over 200 feet of cable @ 20C

Use 23 AWG standard copper cable for horizontal backbone
ANSI/TIA-568.2-D

• Governing copper standard
• Replaces ANSI/TIA-568-C.2
• 28 AWG patch cords now standards compliant
• Recognizes & test method for field terminated plugs
28 AWG Patch Cords

- New change in ANSI/TIA-568.2-D
- Recognizes for patch cords only
  - No horizontal cables
  - 1.95 de-rating
- Working on TSB-184-A-1 addendum
  - 28 AWG supporting PoE++
  - Smaller bundle sizes & bundle spacing
Impact of 28 AWG on Channel Length

100 meter Channel (24 AWG Patch)

- 24 AWG Patch: 5m
- 23 AWG Horizontal Cabling: 90m
- 24 AWG Patch: 5m

Total: 100m

96 meter Channel (28 AWG Patch)

- 28 AWG Patch: 3m
- 23 AWG Horizontal Cabling: 90m
- 28 AWG Patch: 3m

Total: 96m

93 meter Channel (28 AWG Patch)

- 28 AWG Patch: 5m
- 23 AWG Horizontal Cabling: 82.5m
- 28 AWG Patch: 5m

Total: 92.5m
Modular Plug Terminated Links

• Modular Plug Terminated Links = Permanent Link
  • Same test limits
  • Referred to as MPTL

• Why MPTL?
  • Cleaner look
  • Replace components & labor
  • Ensure compliance (plenum)
  • Ensures performance of that plug

• Is terminating a plug in the field standards compliant? YES!
Traditional Methods to Test Links and Channels

**Permanent Link**
- Tester has plug for inserting into jack
- Tester tests both jacks & cable

**Channel**
- Tester has jack for inserting patch cords
- Tester ignores plug inserted into tester (only continuity)
Modular Plug Terminated Links

- Tester uses normal permanent link adapter (cord) to plug into one end
- Tester uses patch cord adapter on other end (could be both)
- Tests performance of ALL components plug, cable, and jack

- Modular Plug Terminated Links = Permanent Link
  - Available on some field testers (called MPTL)
- Ensures plug meets performance requirements
  - Important for wireless access points & cameras
Coming Soon... Single Pair Ethernet

- Panduit World Headquarters
- 600,000 feet of 4-pair
- 500,000 feet of 2-wire
  - HVAC
  - Lighting control
  - Access control
  - Etc.
### Single Pair is Unique

<table>
<thead>
<tr>
<th>Parameter</th>
<th>4-pair</th>
<th>Single Pair</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Rate</td>
<td>Up to 10 Gb/s (10GBASE-T)</td>
<td>10 Mb/s at 1000 m (1 Gb/s at shorter dist.)</td>
</tr>
<tr>
<td>Power Levels</td>
<td>Up to 71 W (PoE++)</td>
<td>Up to 15 W (TBD)</td>
</tr>
<tr>
<td>Reach</td>
<td>Up to 100 m</td>
<td>Up to 1000 m</td>
</tr>
<tr>
<td>Connector Type</td>
<td>RJ45</td>
<td>Modified LC</td>
</tr>
<tr>
<td>RU Density</td>
<td>48 ports in 1 RU</td>
<td>96 ports in 1 RU</td>
</tr>
</tbody>
</table>
Cabling Design for Digital Lighting Topologies
Cabling for Fixture Centric (2 fixtures)

Switch — Jacks in patch panel — Light Fixture

Switch — 28 AWG patch cords — Horizontal Cable — Field Terminable Plug — Light Fixture
Cabling for Node Centric (2 fixtures)

Switch ➔ Node ➔ Light Fixture

- Jacks in patch panel
- 28 AWG patch cords
- Horizontal Cable
- Field Terminable Plug
Cabling Comparison

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Fixture Centric</th>
<th>Node Centric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switch Ports</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Jacks</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Patch Cords</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Field Term Plugs</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Horizontal Cable</td>
<td>2x150 feet = 300 feet</td>
<td>150 feet</td>
</tr>
</tbody>
</table>

100% savings on horizontal cable with Node Centric
Cabling Design for Digital Lighting Topologies

*Centralized vs Decentralized.*

Centralized  

Decentralized  

New smaller, PoE switches allow for installation in plenum spaces; closer to lighting loads.
Summary & Recommendations

• Node Centric provides optical cost structure
  • Hardware savings vs fixture centric
  • Cabling savings vs fixture centric

• New standards important to consider
  • LP ratings for PoE
  • 28 AWG patch cords for space savings
  • Modular plug terminated links

• Test your cables

• Design with flexibility in mind

• Follow manufacturer recommendations