MYTHBUSTING Takes on Shielded Cabling

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Brian Davis
Objectives

• Take on myths of shielded cabling and use modern-day science to show what's real and what's fiction - through trial and error actually demonstrate it.
Background

• Shielded is century-old technology (1880)
  – Dating back to early coaxial cabling

• Shielded Twisted-pair Cabling is over 25 years old
  – Dating back to IBM Type I Cabling
Background

- Wide industry experience with IBM Type 1
  - That experience was, admittedly, mostly negative
  - Partly why the industry preference moved to unshielded in North America (‘cheap and easy’ over ‘high performance’)

Bicsi
Background

- Shielded technology has innovated, evolved and developed
  - Evidence of that has not been widely seen in North America due to the limited use of shielded cabling
So, the previous convictions of IBM Type 1 are still applied to all shielded cabling regarding:

- Cable Termination
- The Antenna Effect
- Ground Loops
- The Baked Potato Effect
Cable Termination
Cable Termination

- Myth:
  - Terminating a shielded cable with a shielded connector takes twice as long as terminating an unshielded cable with an unshielded connector.
Research

• IBM Type 1 Cable
  – Two shielded twisted pairs
    • not four pair
  – 22 AWG solid copper conductors
  – Braided shield

• IBM Data Connector
  – Hermaphroditic
  – 4 pole
  – Large
• Data Connector Termination Procedure: 13 steps!

– snip & cut, slide, twist, cut & trim, clamp, slide, insert (x4), pull, align & squeeze, ground, bend, slide, cover & snap (x2) !!
Research

• Today
  – New cable types
    • Without braid
    • Unshielded pairs
    • Four-pair (not 2-pair)
  – New connector types
    • Die-cast (without a “can”)
  – New installation tools
    • Simplify procedure
    • Faster
Experiment - Subjects

- Shielded Termination
  - IBM Type 1
    - 2-pair
    - S/FTP
  - Category 6A
    - 4-pair
    - F/UTP

- Unshielded Termination
  - Category 6
    - 4-pair
    - U/UTP
  - Category 6A
    - 4-pair
    - U/UTP
Experiment - Setup

- Experienced Technicians
- Measure Time For
  - Cable Prep
  - Connector Prep
  - Termination
- Dependent Variables
  - Cabling Type
  - Termination Tool
Termination Tools

- Punchdown Tool
  - Each wire individually

- Installation Tool
  - All wires simultaneously
## Results – Category 6 Unshielded

<table>
<thead>
<tr>
<th>Cable Type</th>
<th>Tool Type</th>
<th>Avg. Install Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat6 U/UTP</td>
<td>Punchdown</td>
<td>2 minutes</td>
</tr>
<tr>
<td>IBM Type 1</td>
<td>Pliers/Snips</td>
<td>3 min 45 sec (2pr)</td>
</tr>
</tbody>
</table>

- Two times myth plausible for IBM Type 1 cable termination
  - Maybe even 4 times
    - four pairs in over 7 minutes!
Results – Category 6A Punchdown

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<tr>
<td>Cat6A U/UTP</td>
<td>Punchdown</td>
<td>3 min 15sec</td>
</tr>
<tr>
<td>Cat6A F/UTP</td>
<td>Punchdown</td>
<td>3 min 20sec</td>
</tr>
</tbody>
</table>

- Two times myth plausible for punchdown cable termination
  - More of a Cat 6A issue than shielded issue
    - Tighter twists, larger wires, more fillers
## Results – Category 6A Installation Tool

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<td>Punchdown</td>
<td>3 min 15 sec</td>
</tr>
<tr>
<td>Cat6A U/UTP</td>
<td>Install Tool</td>
<td>1 min 25 sec</td>
</tr>
<tr>
<td>Cat6A F/UTP</td>
<td>Install Tool</td>
<td>1 min 30 sec</td>
</tr>
</tbody>
</table>

- Even less than Category 6 punchdown!
Result: The Termination Time Myth

BUSTED!!
Additional Considerations

- Field Testing – could make installation time worse for unshielded
  - depends on users choice of ANEXT testing options
- F/UTP vs. SF/FTP (Category 7)
  - Category 7 (SF/FTP) would take longer
- Bonding and Grounding
  - No additional time compared to unshielded
    - Except for pulling back shield foil
The Antenna Effect
The Antenna Effect

• Myth
  – The shield of a shielded cable acts like an antenna and collects radio frequency noise if it isn’t grounded on both ends
Experiment - Subjects

- U/UTP Cable
- F/UTP Cable
Experiment - Setup

- **Noise Source**
  - WAP (2GHz)
  - Laptop PC
- **U/UTP Cable**
- **F/UTP Cable**
- **Network Analyzer**
Results – Noise on Unshielded Cable
Results – Noise on F/UTP Cable with Both Ends Grounded
Results – Noise on F/UTP Cable with Single-ended Ground
Results – Noise on Ungrounded F/UTP Cable
Result: The Antenna Effect

BUSTED!!
Additional Considerations

• All metallic elements act as antennas to some extent – even pairs in an unshielded cable

• The shield dramatically reduces the effects of RFI on the pairs, even if grounded on only one end or if ungrounded!
  – But ground it anyway!

• A shield reduces the effects of induced noise for signals > 30 MHz
  – Shield thickness property
Ground Loops
Ground Loops

• Myth
  – Conductive loops transmit spurious current (noise) if there is any variation in voltage along the loop
Research

• Myth probably outgrowth of “mains hum”
  – Two pieces of audio equipment plugged into different power outlets with different ground potentials
  – This potential difference causes a spurious current to flow through the cables, creating an audible buzz
Experiment - Subjects

• F/UTP Cable
Experiment - Setup

• Apply 60 Hz AC current directly onto shield of F/UTP cable
  – Not an induced current
  – a placed current
• Test signal integrity on balanced twisted-pairs for presence of 60Hz influence
Results

- No influence on signal integrity at 60Hz
Result: Ground Loops

BUSTED!!
Additional Considerations

• Basically proves that balance works, at least for 60Hz (low frequency)
  – Audio cables tend not to be balanced or shielded

• Higher frequency effects reduced by the shield
The Baked Potato Effect
The Baked Potato Effect

• Myth
  – The shield around a shielded cable is just like aluminum foil around a baked potato – it traps generated heat and cooks the cable
Research

• Wrapping the potato in aluminum foil before cooking will help to retain moisture
• When cooking over an open fire or in coals, a jacket of foil prevents burning
• Aluminum foil is designed to keep moisture in the baked potato – not to retain heat
Research

• Power over Ethernet
  – Data cables used for signal and for power
  – Power current creates heat via $I^2R$ losses

• Power over Ethernet Plus
  – More power – more current – more heat
Experiment - Subjects

- U/UTP Cable
- F/UTP Cable
Experiment - Setup

- Cable bundles
  - In insulated conduit, with firestopping
Experiment - Setup

- **Worst case**
  - Place 720 mA current (original PoEP objective)
    - The objective for PoEP is currently only 600mA
  - $57 \text{ V}_{\text{dc}}$ measured at output end of cable (not source)
  - Power on all four pairs
  - Pairs wired in series
Experiment - Setup

- Thermocouple #1
  - Center of Cable Core

- Thermocouple #2
  - Under Cable Jacket

- Thermocouple #3
  - Cable on Inner Layer of Bundle

- Thermocouple #4
  - Cable on Outer Layer of Bundle
Results – F/UTP Shielded Cable

![Graph demonstrating temperature increase over time for different cable sections: core, under jacket, center cable, and outer cable. The graph shows a clear upward trend for all sections as time increases from 0.25 to 3.75 hours.]
Results – F/UTP and U/UTP Cable

**T-Rise measurements**

Ambient Temp. = 22.5 °C

- **Center cable T-Rise**
- **Outer cable T-Rise**

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Ambient Temp. = 21.7 °C

- **Center cable T-Rise**
- **Outer cable T-Rise**

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F/UTP Cable

U/UTP Cable
## Results – 720mA

<table>
<thead>
<tr>
<th>Cable Type</th>
<th>Steady-state Temperature Rise</th>
</tr>
</thead>
<tbody>
<tr>
<td>F/UTP</td>
<td>6°C</td>
</tr>
<tr>
<td>U/UTP</td>
<td>7°C</td>
</tr>
</tbody>
</table>

- Both show increase
- Shielded compares favorably
Result: The Baked Potato Effect

BUSTED!!
Additional Considerations

• Unlikely to see that kind of temperature rise in the field
  – Lower current than POEP objective
  – Violation of fill ratios
  – All four pairs carrying max power
  – Max power measured at device end, not source end
Conclusions
## Review

<table>
<thead>
<tr>
<th>Myth</th>
<th>Conclusion</th>
</tr>
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<tbody>
<tr>
<td>Termination Time = x2</td>
<td>BUSTED !!</td>
</tr>
<tr>
<td>Antenna Effects = Bad</td>
<td>BUSTED !!</td>
</tr>
<tr>
<td>Ground Loops = Bad</td>
<td>BUSTED !!</td>
</tr>
<tr>
<td>Baked Potato Effect = Hot</td>
<td>BUSTED !!</td>
</tr>
</tbody>
</table>
Thank You!

Remember: These are trained professionals – do not try this at home!

No animals (or potatoes) were harmed in this production