# Assuring Infrastructure Readiness Across Smart Building Technologies

Presented by:
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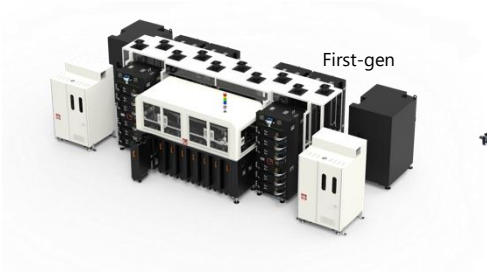
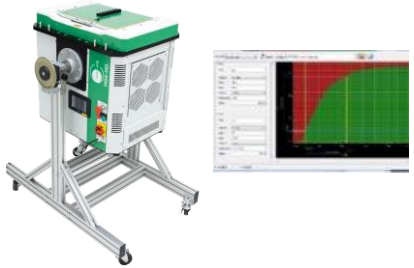
## TEST CELL SOLUTIONS




System Level Test Solutions

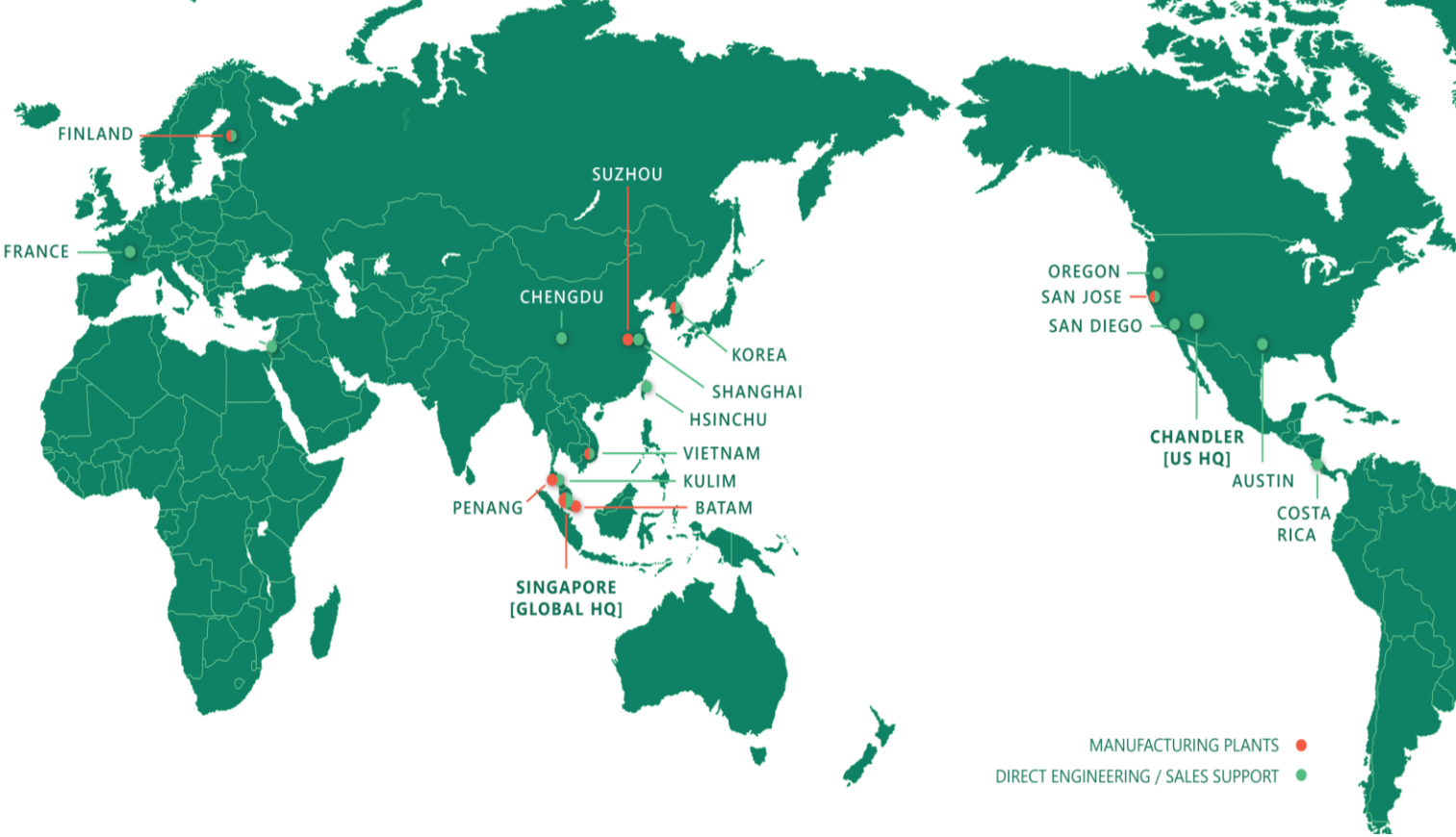
Wafer Test Solutions

## INSTRUMENTATION



ATE Solutions

Precision Cable Test




**AEM's mission is to provide the most comprehensive semiconductor and electronics test solutions based on the best-in-class technologies, processes and customer support.**

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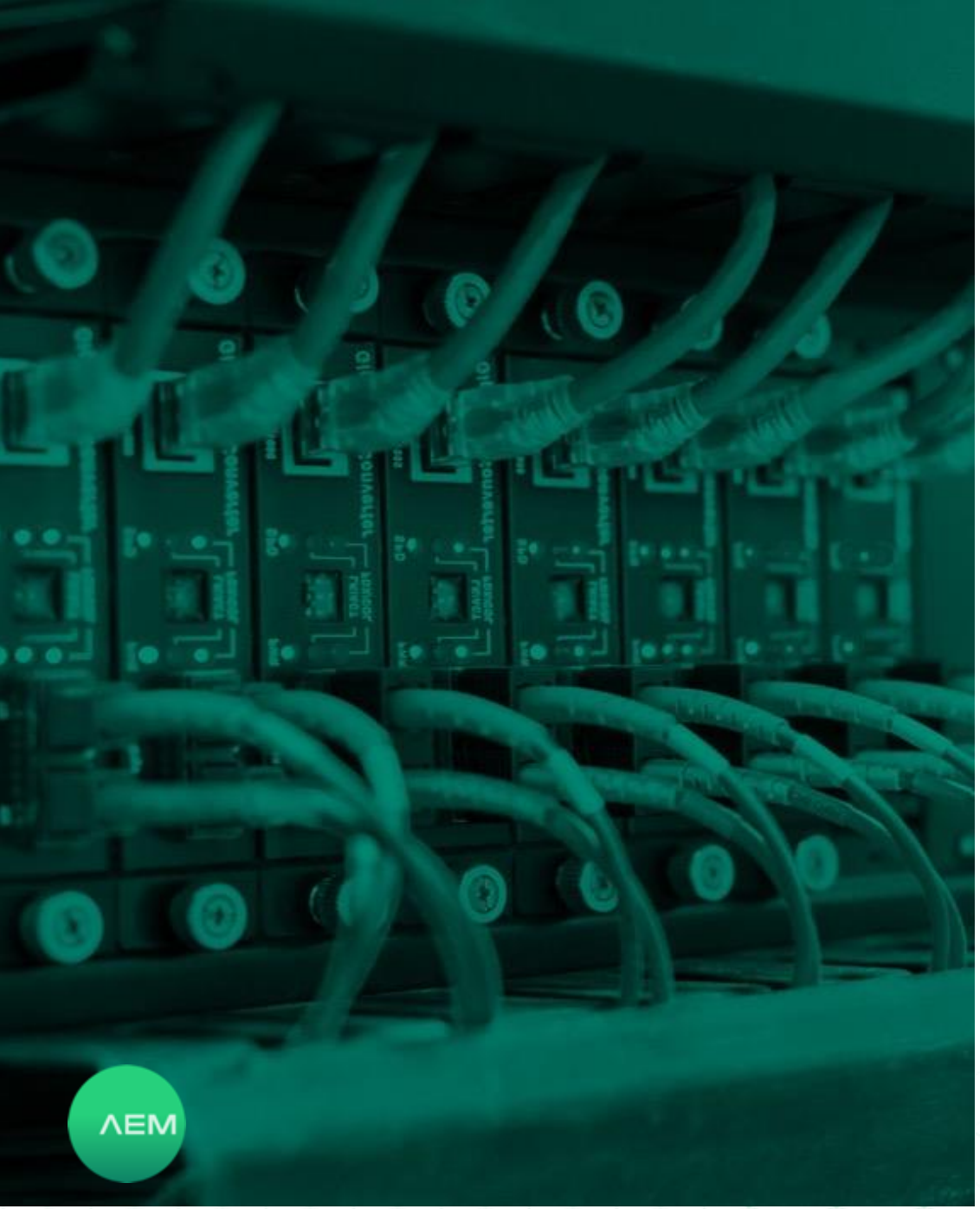

## Presentation Agenda

- Key Drivers for Smart Building Systems
- Internet of Things
- Test Parameter Considerations
- Communication Technologies Testing
  - Four Pair Ethernet
  - Multi-Gigabit
  - Single Pair Ethernet
  - Fiber Optic
  - Network Connectivity Wired/Wireless
- Alternative Powering Technologies and Testing
- Smart Building Reporting
- Wrap Up

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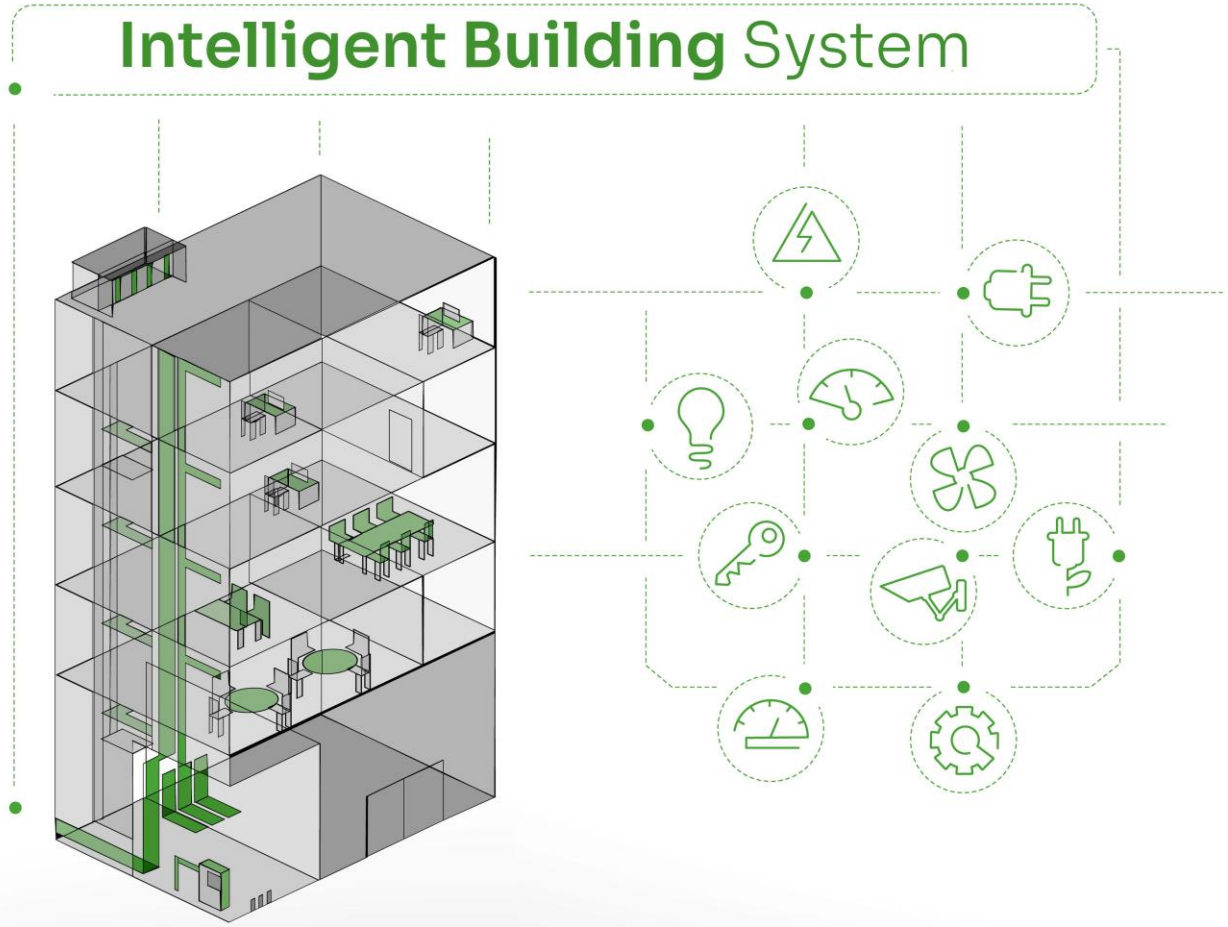


## Key Drivers for Smart Building Systems

- ✓ Combine many disparate building systems into a single platform
- ✓ Optimize operations, maintenance and overall cost

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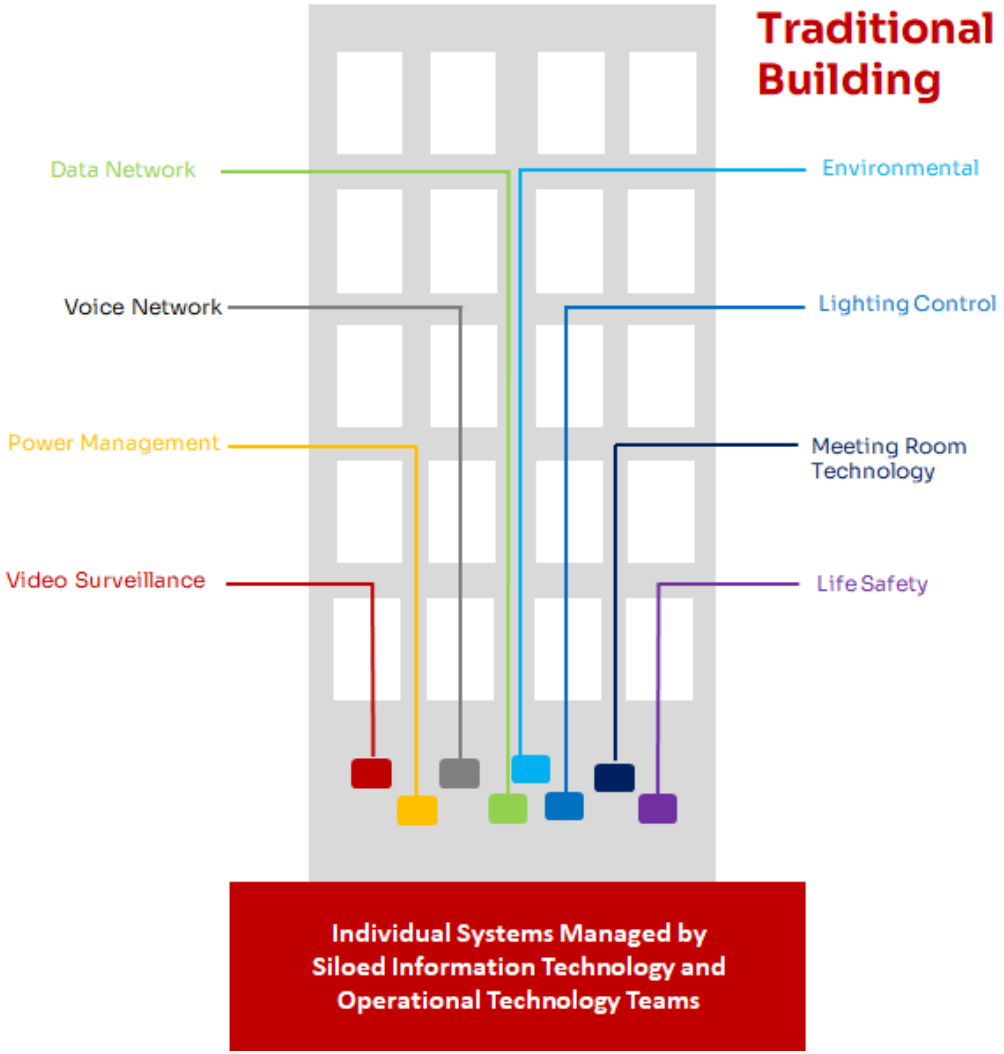
## Internet of Things (IoT)

# The Enabling Technology

**IoT Technology Means** | Many Different Things to Many Different Industries

# Back in the day….

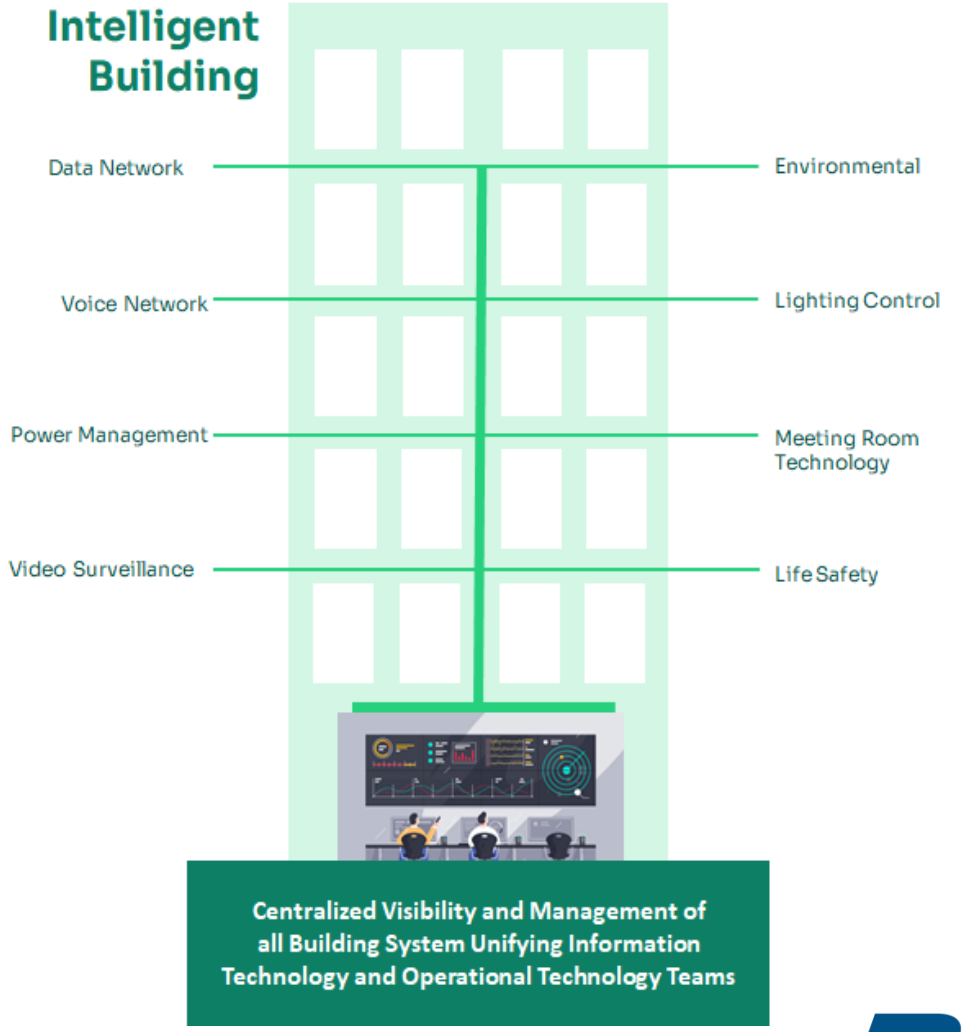



- Building systems were separately deployed and managed

- Cat 3 - 10Mbps
- Cat 5 - 10/100Mbps
- *Cat 4 came and went*

# Times have changed…

- Building systems are deployed in a unified manner and centrally managed
- Many more technologies to oversee
- Power and Data running on the same wire requires more testing

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# Test Parameter Considerations for Smart Buildings

- Times have changed….
- Could noise on the link affect overall network performance?
- Will this link support the multiple link speeds required ?
- Is this link capable of supporting power over the same wire as that the network data needs to run on?

Testing needs have evolved just as the modern network infrastructures of today has evolved

# Test Parameter Considerations

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# A Lot to Think About

- ✓ What's the deployment objectives?
- ✓ What's the network environment?
- ✓ How will the "Things" be connected?
- ✓ How will the "Things" be powered?
- ✓ What network speed do the "Things" require?

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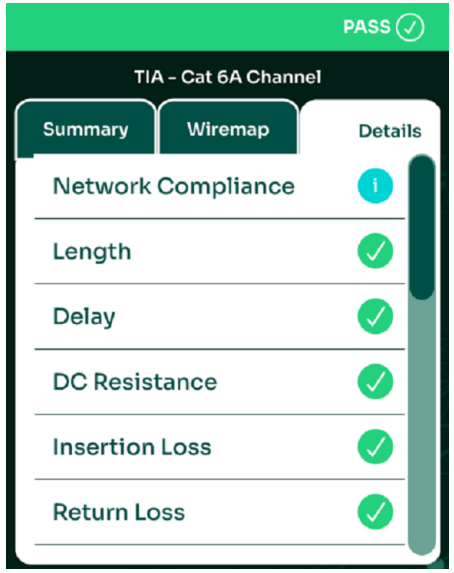
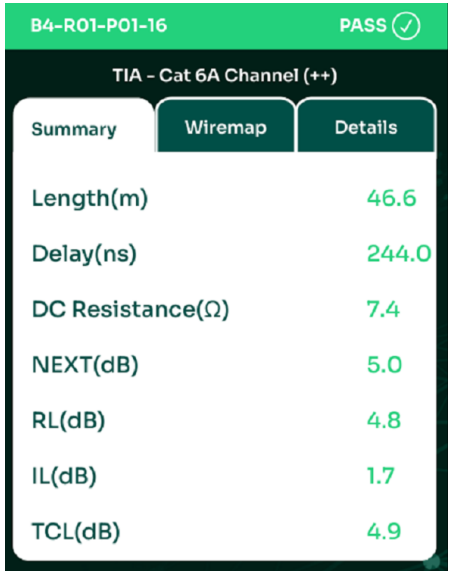
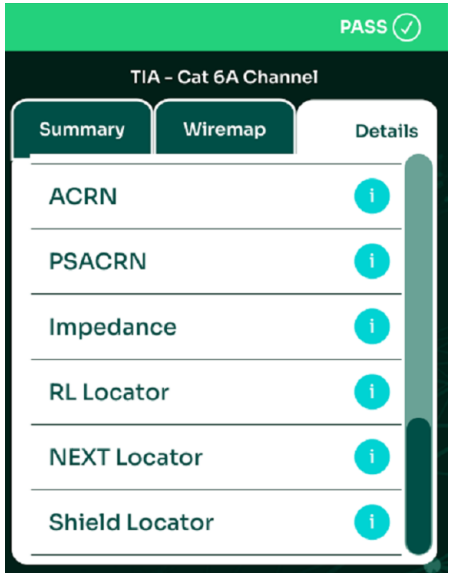
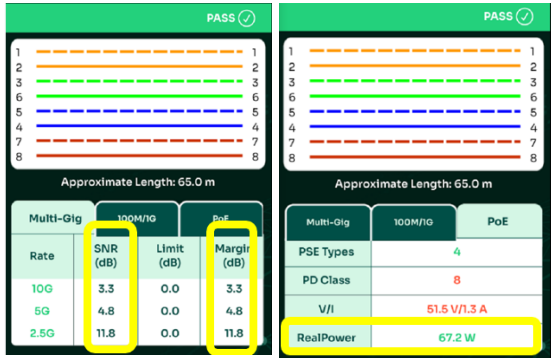
# Overview of Testing Needs

| | ANSI/TIA 1152.A/IEC 61935-1<br>TIA-568/ISO 11801<br>Pass/Fail | ANSI/TIA 1152.A/IEC 61935-1<br>TIA-568/ISO 11801<br>Optional Parameters (++) or(+)<br>Pass/Fail | TIA 1152.A/IEC 61935-1<br>TIA-568/ISO 11801<br>Additional Parameters<br>Informational Only | Additional Testing for IB Support |
|---|---|---|---|---|
| Configurations | Channel, Permanent Link, MPTL | | | |
| Test Parameters | Length, Delay, DC Loop Resistance, Insertion Loss, Return Loss, NEXT, PSNEXT, ACRF, PSACRF | TCL, ELTCTL<br>DC Resistance Unbalance:<br>(in Pair & Pair to Pair) | TDR to Fault Location for RL, NEXT, Shield.<br>ACRN, PSACRN, Impedance | 2.5/5/10GBASE-T<br>PoE 802.3 af/at/bt, UPoE<br>Hybrid Powered Fiber |



# Resistance Requirements for Channels to be compliant for PoE delivery

- As specified in ISO 11801, ANSI/TIA-568.2-D and TIA TSB-184A D3.0

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- DC Loop Resistance for Cat3/5e/6/6A shall not exceed 25 Ohms
  - ✓ Required for certification

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- DC Resistance Unbalance <200mOhms or <3% of Unbalance in pair (750mOhms)
  - ✓ Optional with certification as a pre-qualifier for PoE support

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- DC Resistance Unbalance between pairs <200mOhms or <7% of unbalance between pairs
  - ✓ Optional with certification as a pre-qualifier for PoE support

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- ***DC Resistance Unbalance tests are NOT a PoE test***

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# Why Resistance Matters - $I^2R$ Power Loss

- In an ideal circuit, the power applied to the link would be delivered to the endpoint (load) with no energy wasted or dissipated in the wiring or components along the path.

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- Real circuits, however, have resistance. Even a small amount can cause electrical losses dissipated as heat.

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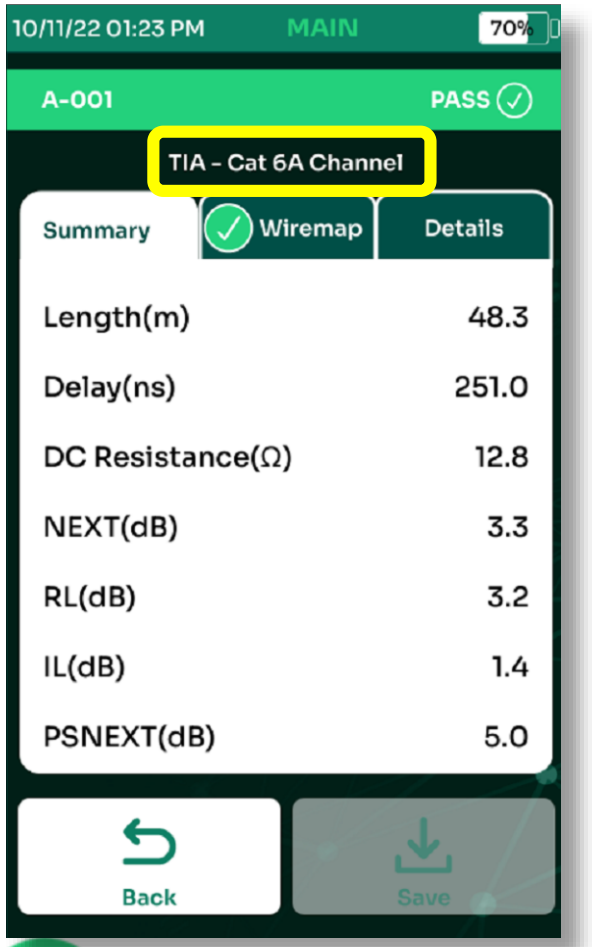
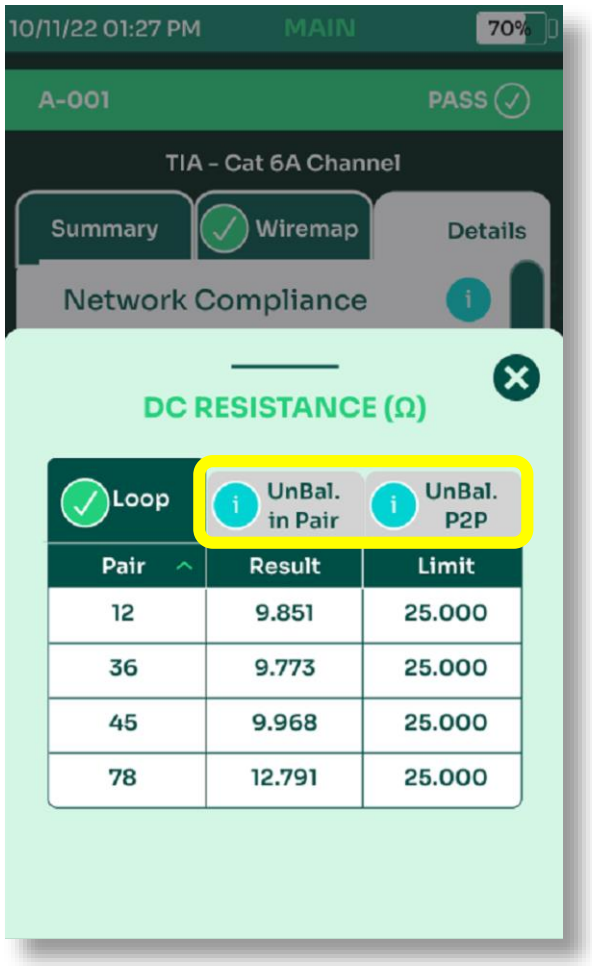
- These losses can be calculated by using the current squared multiplied by the resistance ($I^2R$).
  - Example:
    - I - Measured Current under load is 1.73A
    - R - Resistance is 6.25 ohms
    - $I^2$ - Current squared: 1.73 x 1.73 = 2.99
    - 6.25 (ohms) x 2.99 (current squared)= 18.7W power loss (71.3 delivered on 90W PoE)

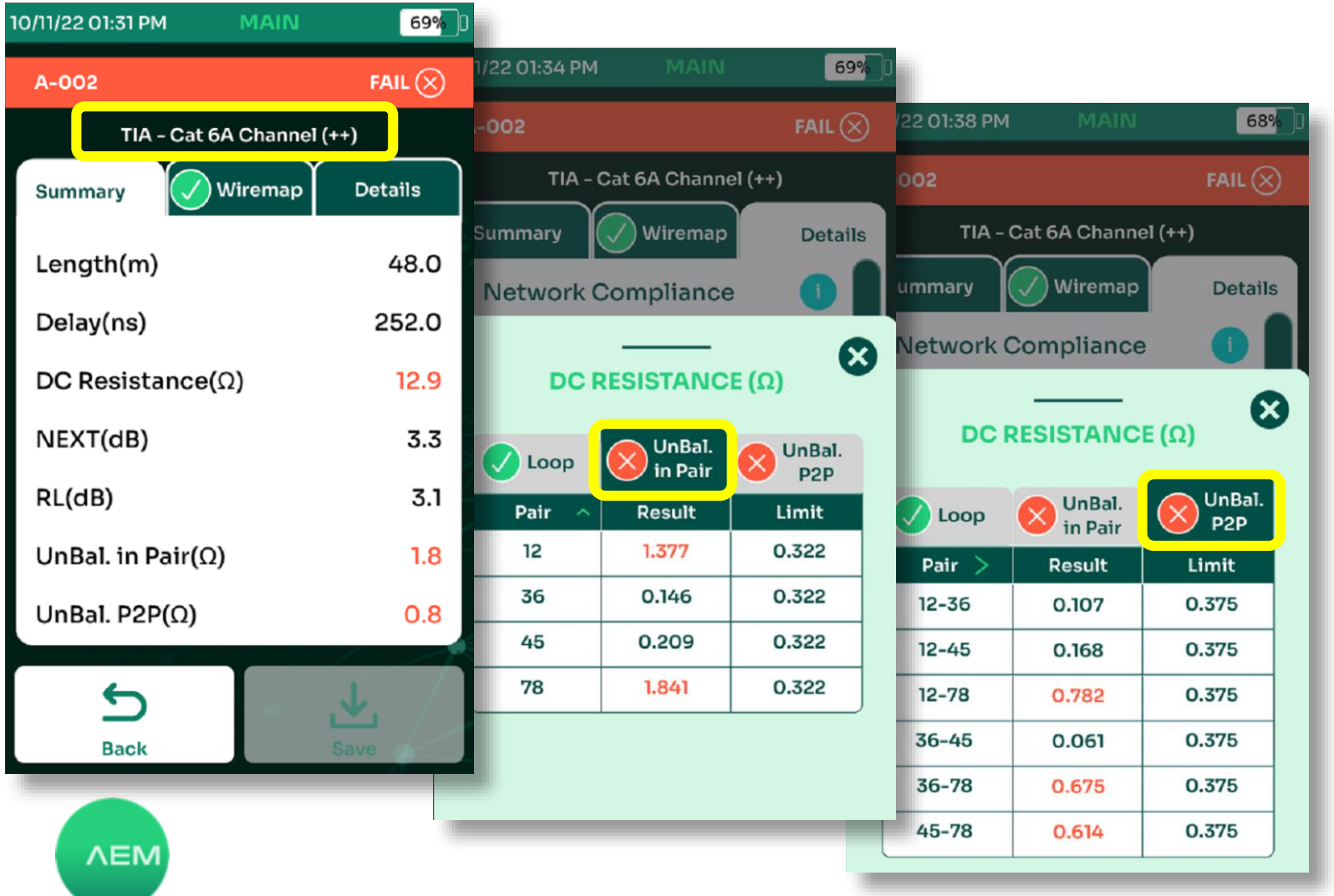
# Importance of Testing for Smart Building Needs




- Remember those optional tests we just talked about?
- A cable that passed a "standard" autotest …….

# Importance of Testing for Smart Building Needs




- May fail an autotest with the optional parameters
- This underscores the importance of complete testing to ensure support of the IoT technologies that will be deployed to avoid problems during device install
- Note: Patch cords play a big role in resistance/resistance unbalance

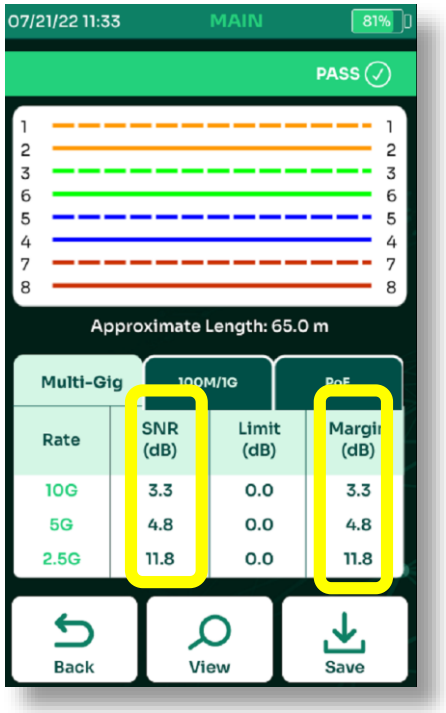
# Category Cabling Factors

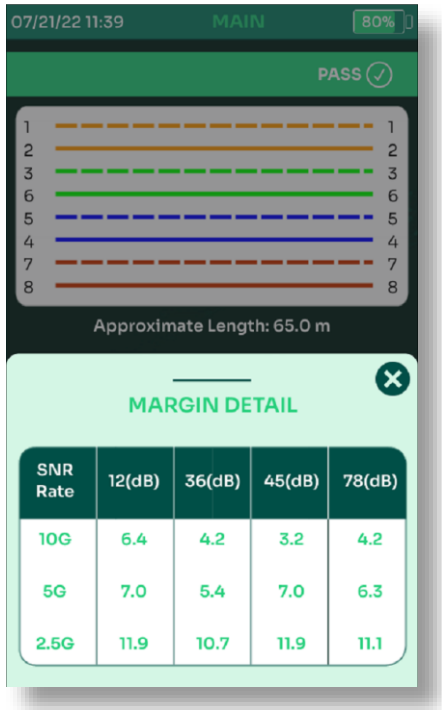
- Installing IoT connected devices on a legacy system?
  - ✓ >1.5B Cat5e/Cat6 Outlets
  - ✓ >70B meters of Cat5e/Cat6 Installed cable

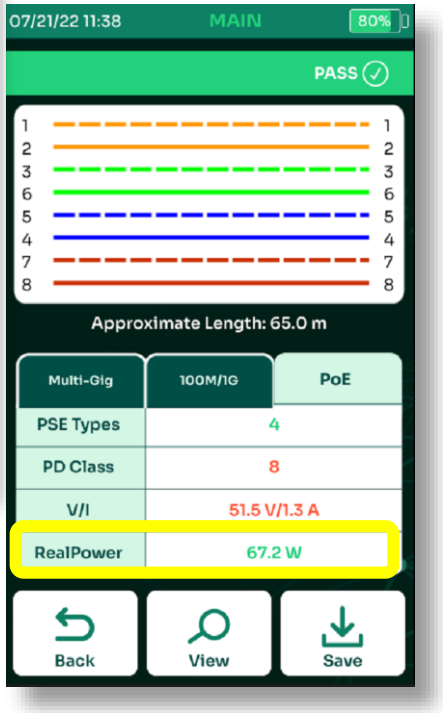
| Bundled Cable Length 0m to 55m | CAT5e | CAT6 | CAT6A |
|---|---|---|---|
| 2.5GBASE-T | | | Assured |
| 5GBASE-T | | | Assured |
| 10GBASE-T | NA | Subject to Alien Crosstalk Testing | Assured |
| **Bundled Cable Length 55m to 100m** | **CAT5e** | **CAT6** | **CAT6A** |
| 2.5GBASE-T | | | Assured |
| 5GBASE-T | | | Assured |
| 10GBASE-T | | | Assured |

- ✓ Cat6A was designed such that it is assured to support all GBASE-T link speeds up to 100m

# Ensuring Multi-Gigabit Link Speed

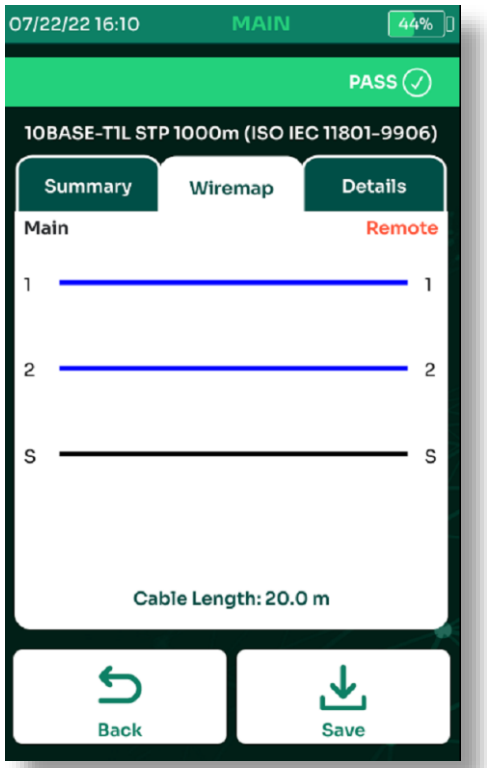


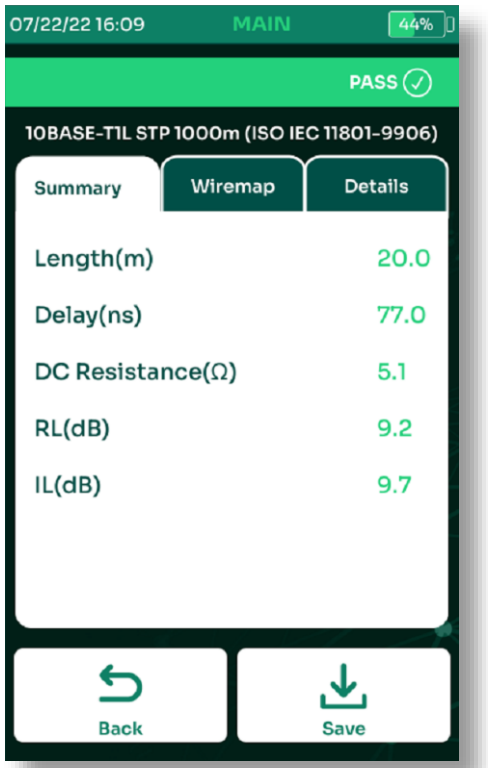




- Many IoT connected devices require a specific level link speed in order to operate efficiently
- Safeguard you're getting the best performance possible with your investment by testing
- Signal to Noise Ratio (SNR) is an important test to provide you with visibility into headroom
- SNR based testing, means you are testing under load to simulate as much of a real world environment as possible
- If PoE will be deployed, it's a good idea to test with BOTH traffic and power running on the wire simultaneously

# Single-Pair Ethernet (SPE) for Smart Buildings




SPE

- SPE technology has been used in automotive applications for many years, due to the reduce weight, volume and low cost
- In enterprise building and factory deployments, SPE is an attractive option
  - Lighter
  - Lower cost
  - Longer distance (1k meters)
- Supports Power over Data Line (PoDL) power delivery method
  - Follows 802.3cg = SPoE

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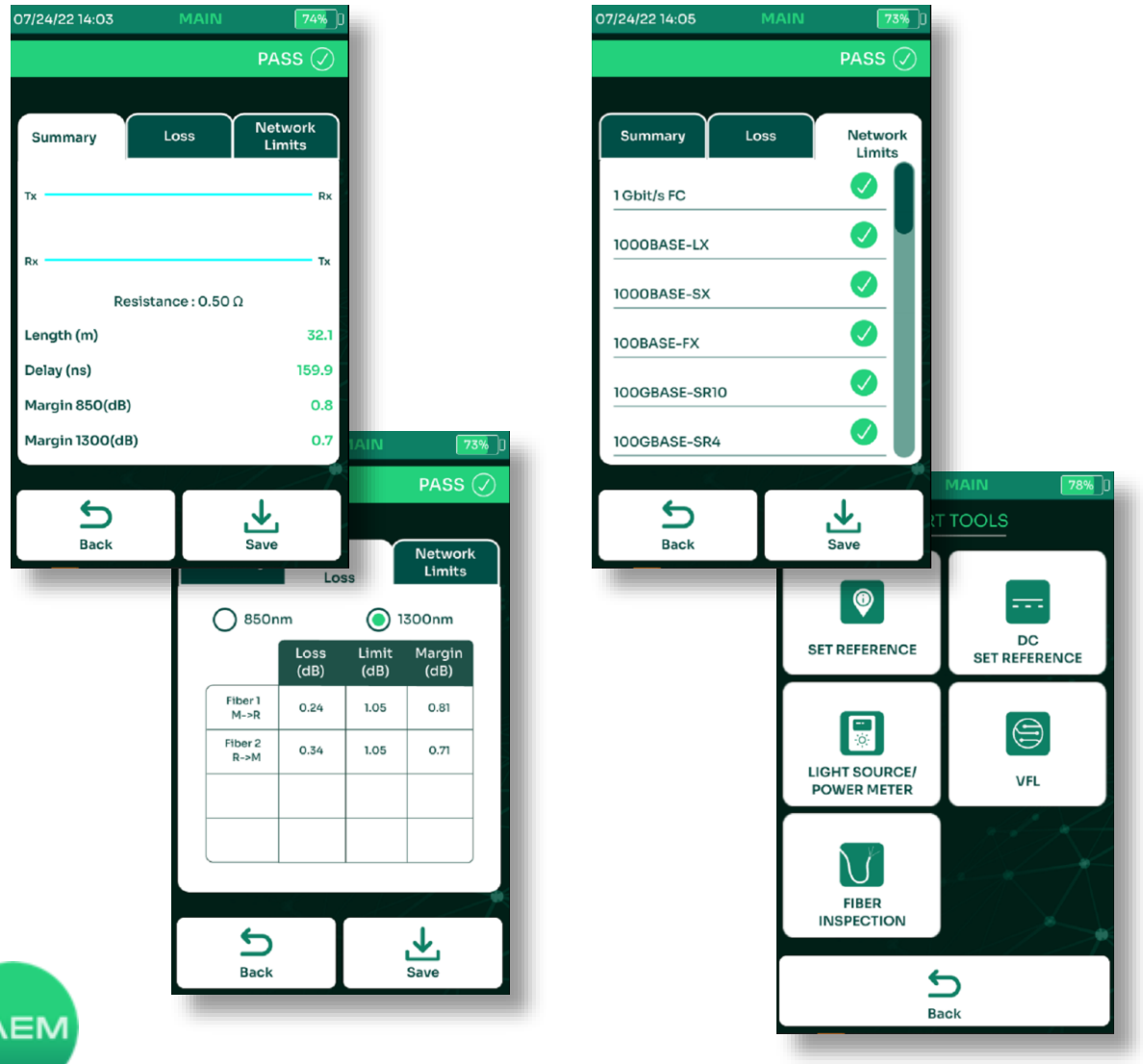
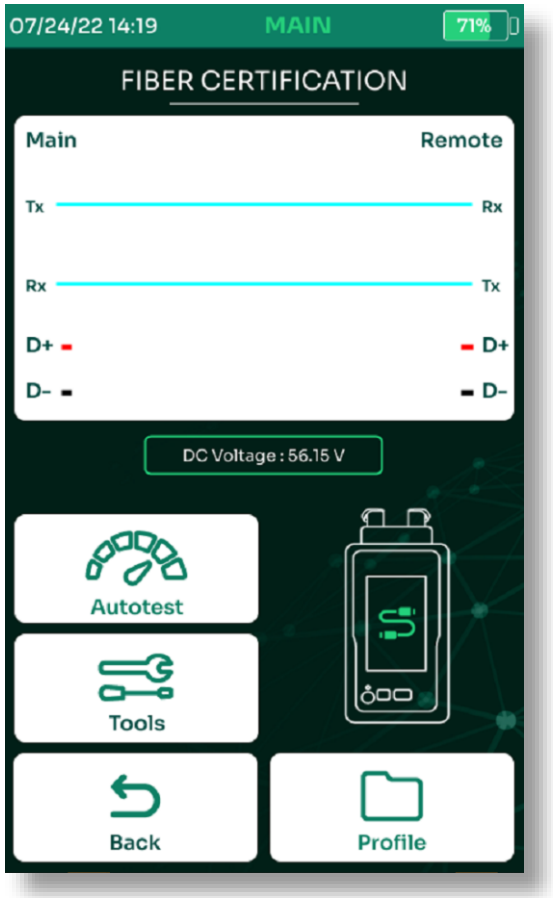
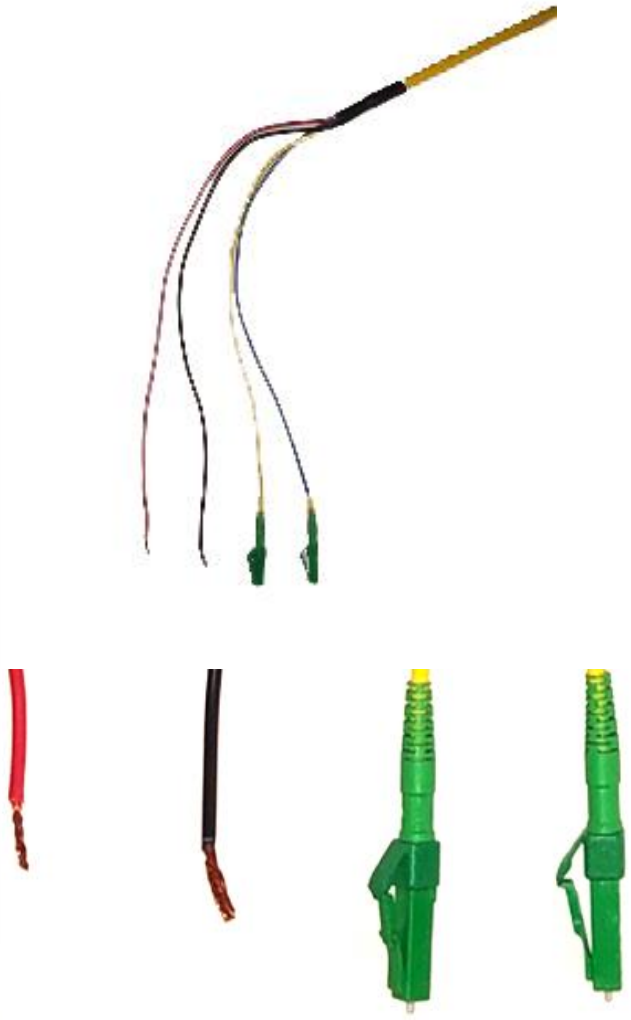
# Ensuring Fiber Optic Links




- Tier-1 certification (Multimode and Singlemode)
- Length and propagation delay
- Dual ended loss
- Single ended loopback loss
- Hybrid Powered Optical Fiber Testing
  - Integrated loop resistance testing
  - Voltage measurement

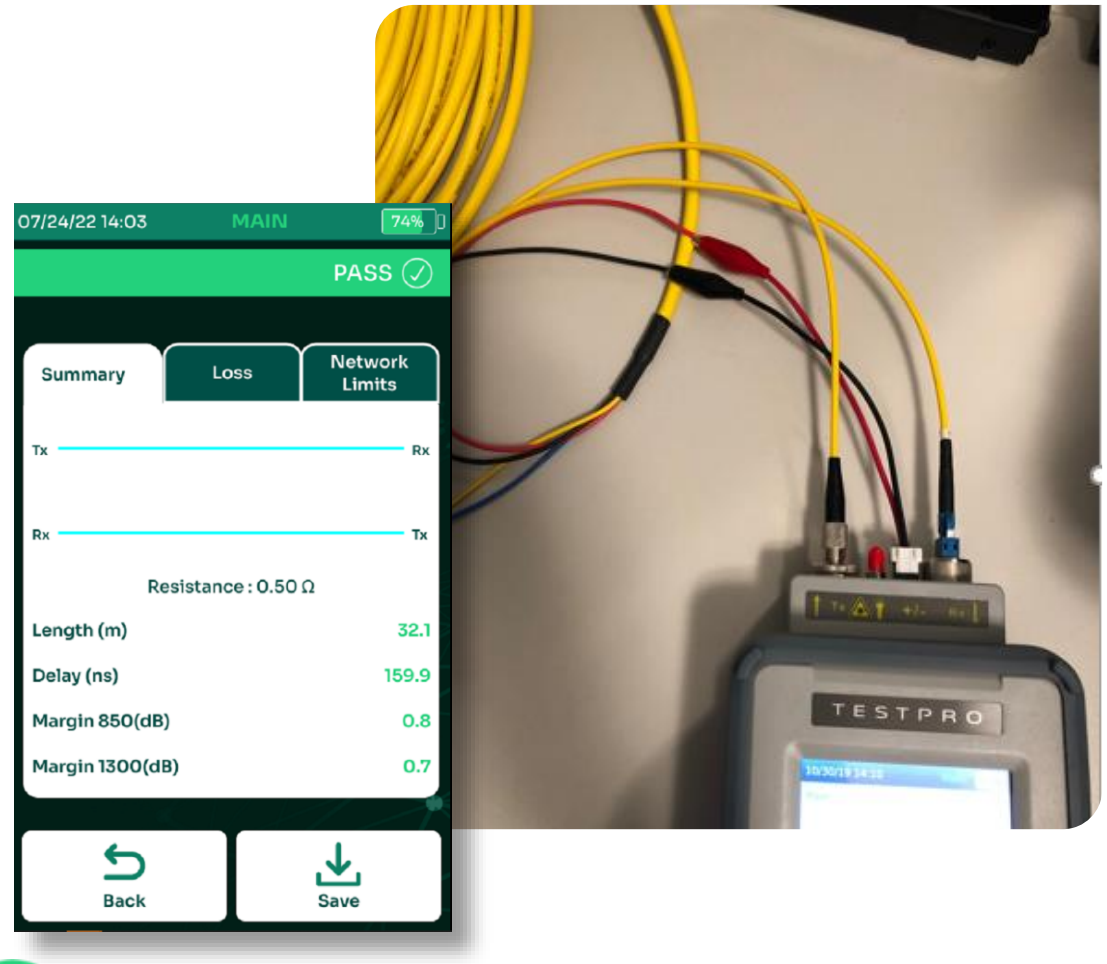
# Hybrid Powered Optical Fiber



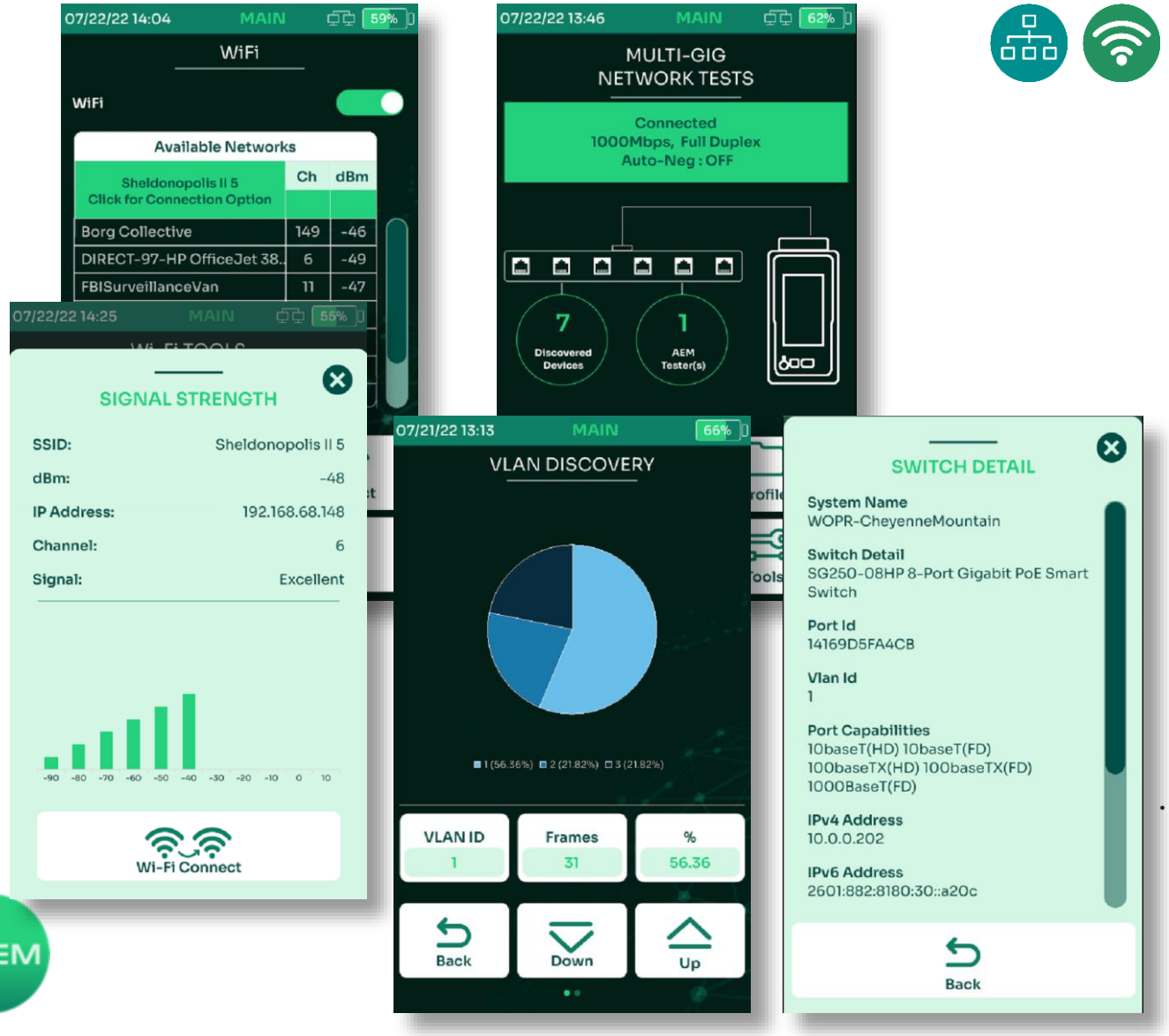
- Fiber cable with a copper pair under same jacket
- Copper pair is used to provide power to remote device or PoE extender

# Hybrid Powered Optical Fiber - resistance measurement of copper pair




- Provides assurance of the copper pair that will carry the power
- Time savings in testing the fiber and copper wire simultaneously

# Ensuring Network Connectivity




- ✓ Physical infrastructure installed and tested
- ✓ Network components installed and tested
  - PSE, "regular" Switch, PDs (WAPs, Cameras, etc.)
- ✓ What's next on the testing check list?

.....Wired and Wireless network connectivity testing

# PoE Deployment Types

| PoE Method | Pairs Used | Advertised Power Delivery at PSE | Allocated Power Available at PD* |
|---|---|---|---|
| IEEE 802.3af Type 1 | 2-Pair Only | 15.40W | 12.95W |
| IEEE 802.3at Type 2 PoE+ | 2-Pair Only | 30.0W | 25.5W |
| IEEE802.3bt Type 3 PoE++ | 2-Pair or 4-Pair | 60.0W | 51.0W |
| IEEE802.3bt Type 4 PoE++ | 4-Pair Only | 90.0W | 71.3W |
| Cisco UPoE | 4-Pair Only | 60.0W | 54.4W |

PSE = Power Source Equipment a.k.a. the switch

PD = Powered Device i.e. Camera, WAP, Light Fixture

*Allocated Power assumes a good 100m channel. Delivered power (a.k.a. "Real Power") depends on length and resistance and requires PoE Load Test to determine.

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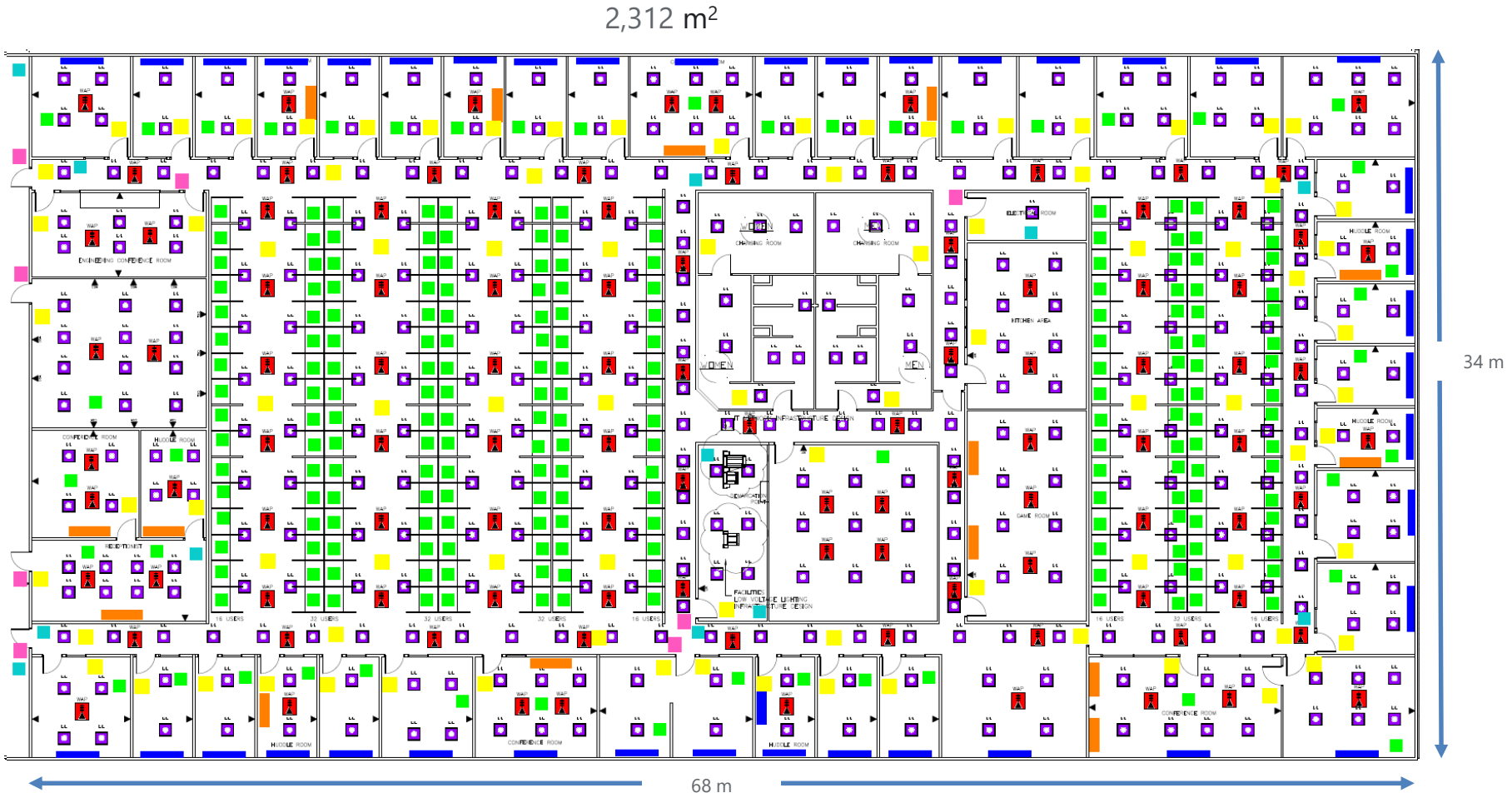
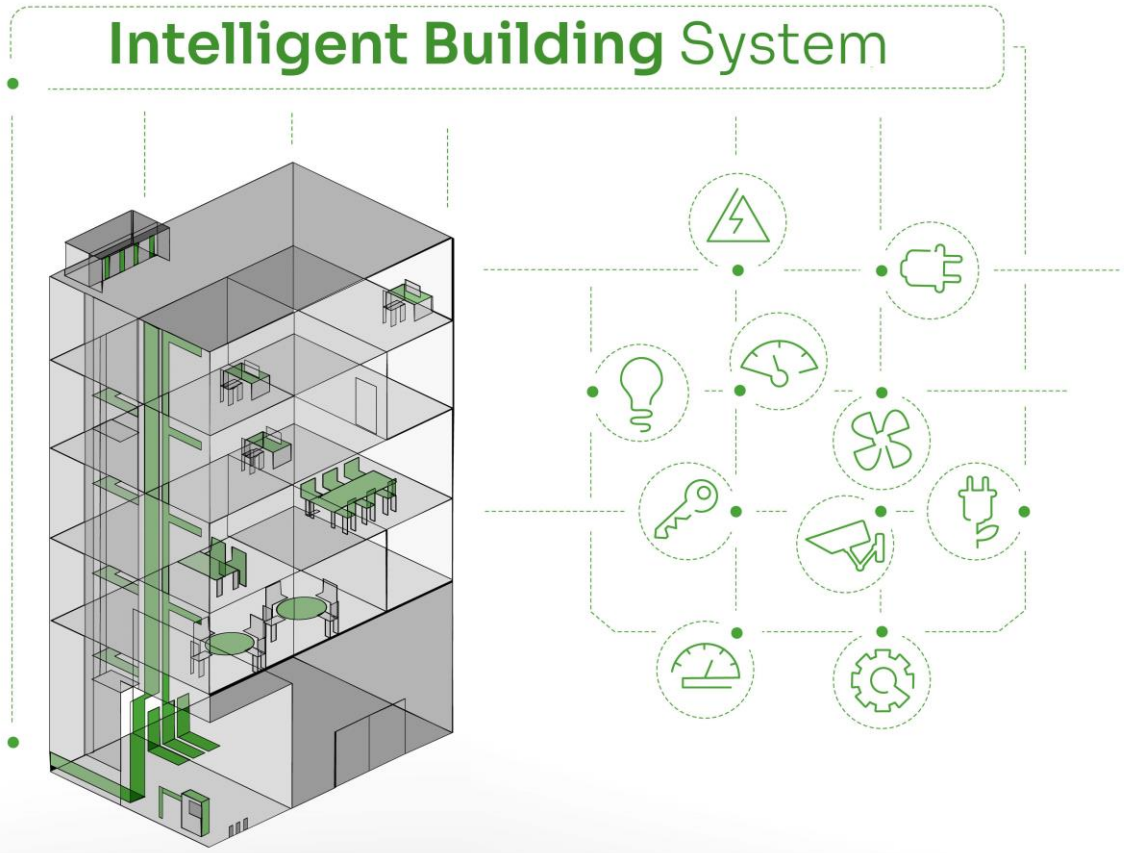
# Demanding More from the Network Infrastructure

| PoE Infrastructure | |
|---|---|
| LED Lighting | 389 |
| Phone, Client Monitor | 192 |
| Display | 15 |
| Occupancy Sensors | 89 |
| WAP | 10 |
| Shade Control | 40 |
| Security Camera | 12 |
| Access Controls | 8 |
| **Total** | 755 |

Thousands of metres of cable that must support data and power



# Ability to Perform PoE Load Testing is Critical




- Things can go wrong
  - PSE misconfiguration
  - PSE overprovisioning
  - Not enough power at the PD
- And, there's always the blame game to deal with when something doesn't work
  - When something doesn't turn up, who's likely to get the phone call…
- Ability to perform load testing is critical
  - Exonerate the cable infrastructure
  - Be the hero and find problem domain

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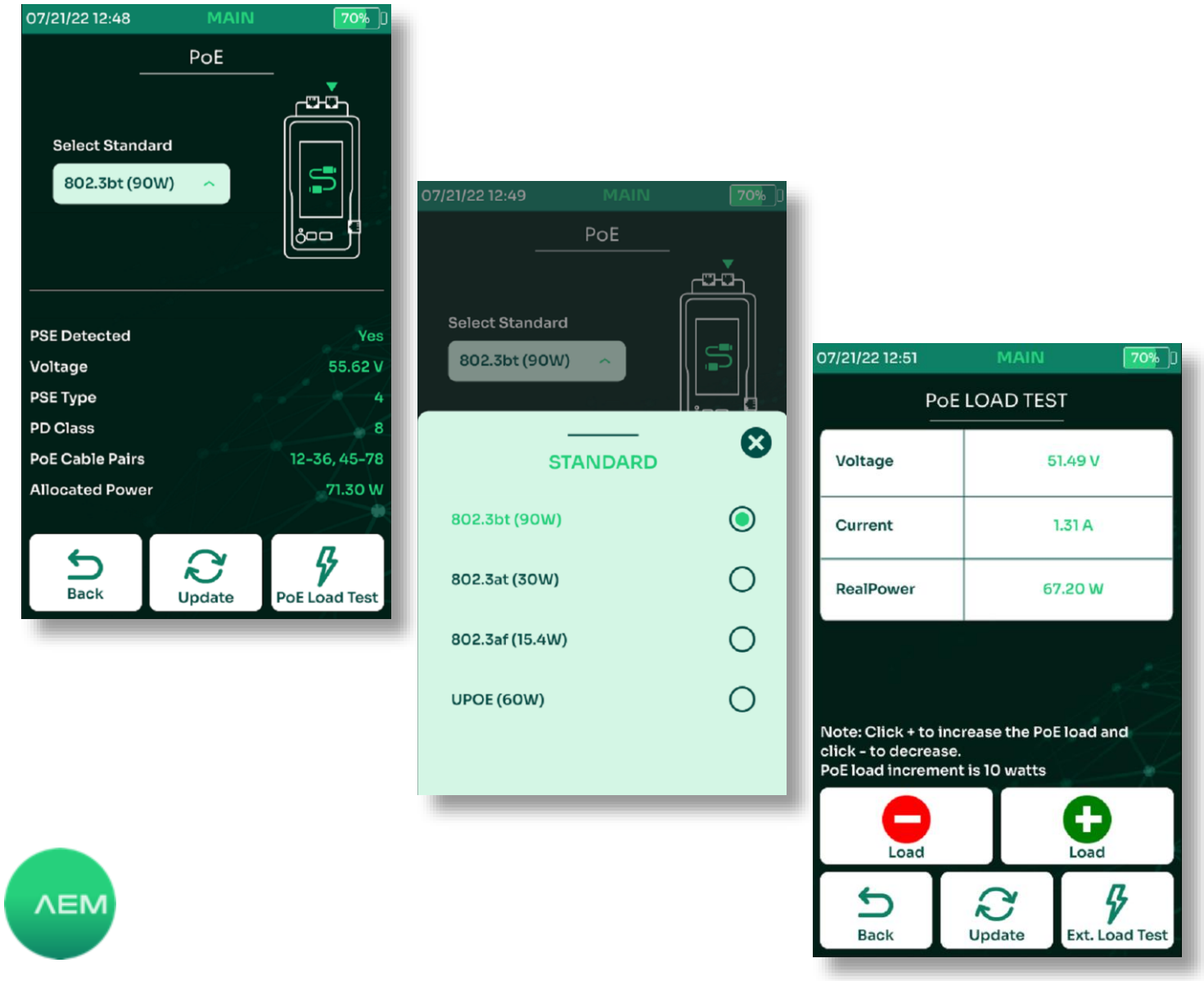
# Load Testing




PoE Load Test validates the **Real Power received at end point device**

# Documentation

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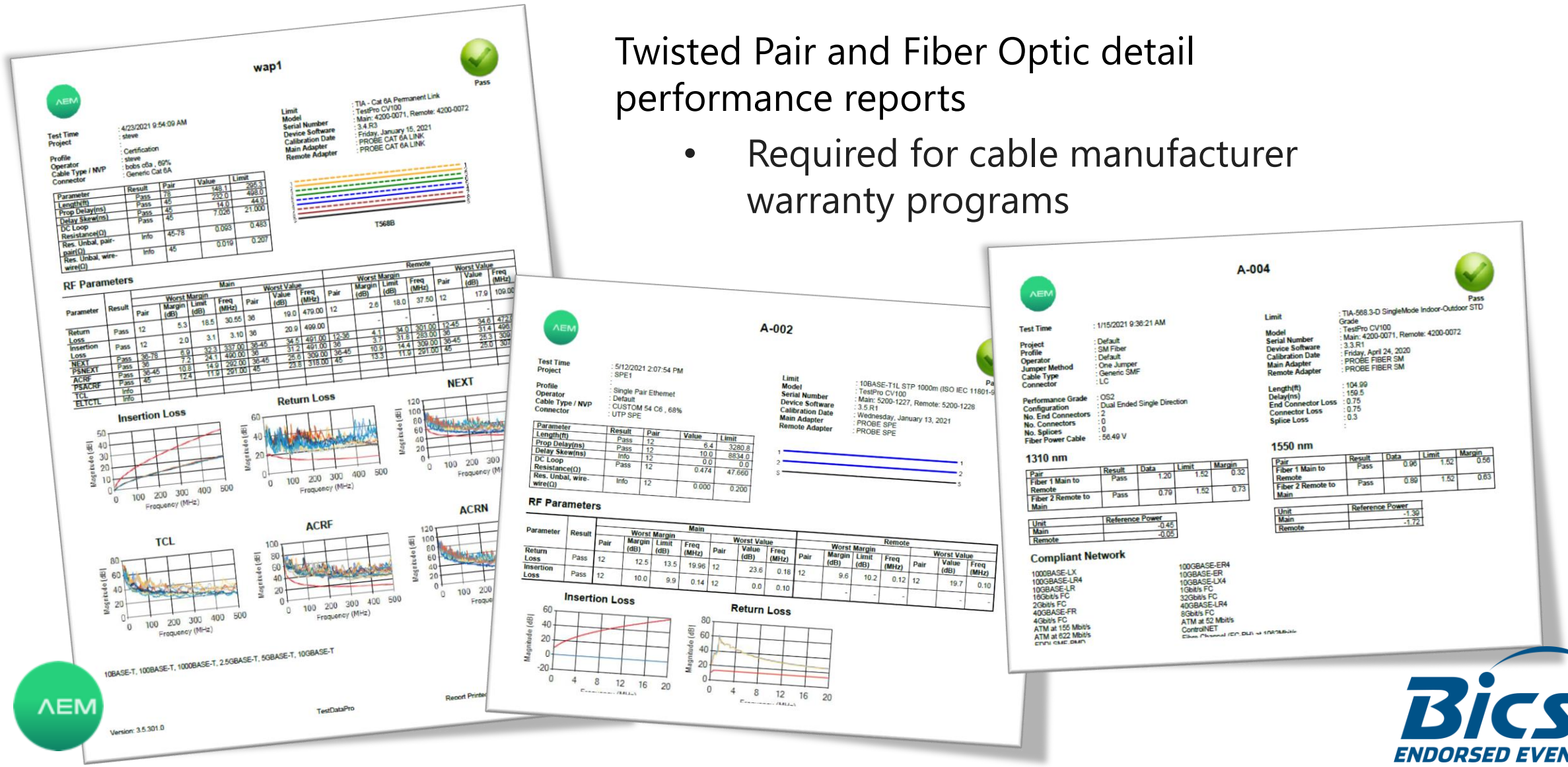
# Complete Smart Building Reporting




Twisted Pair and Fiber Optic detail performance reports

- Required for cable manufacturer warranty programs

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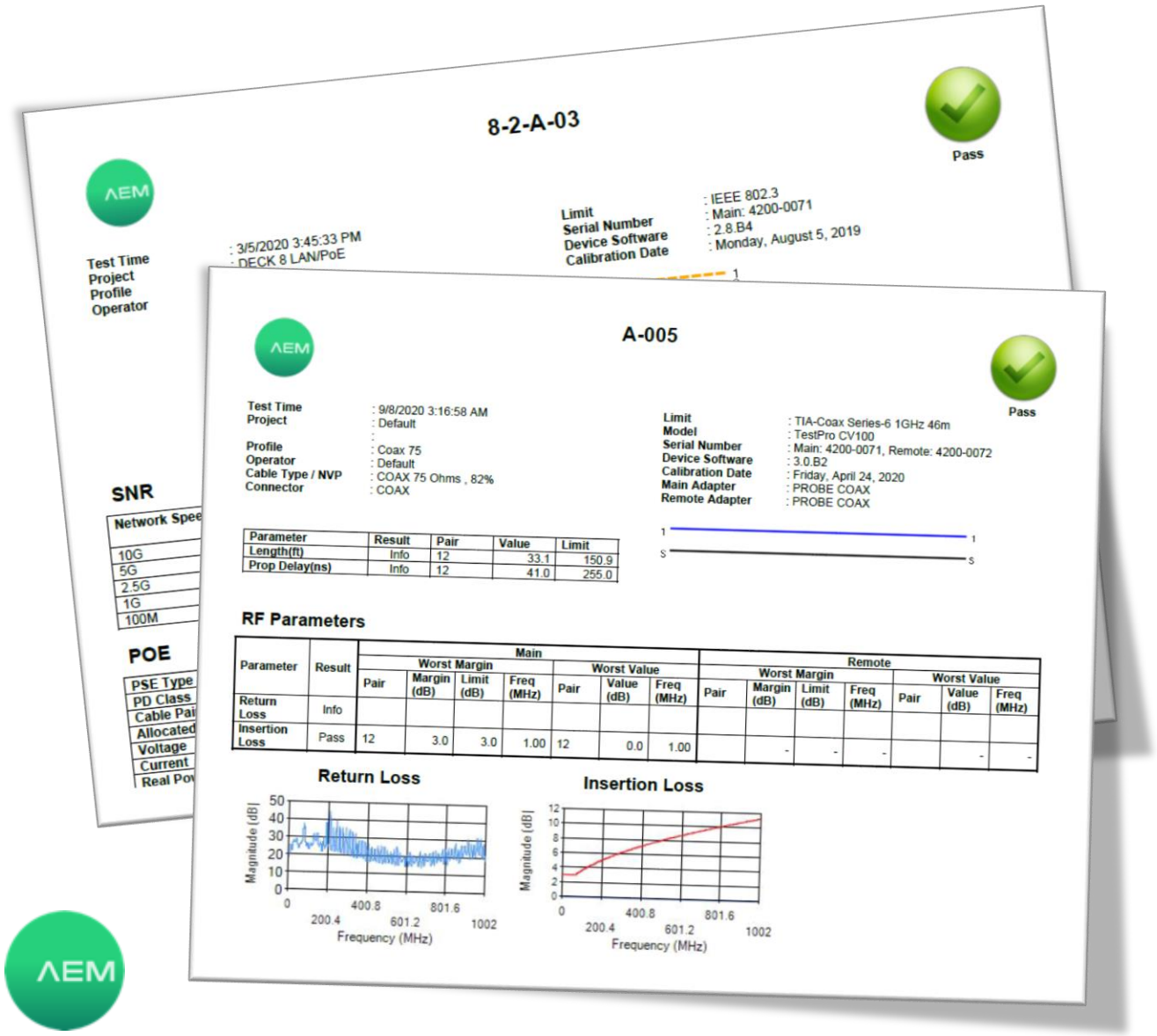
# Complete Smart Building Reporting




## Multi-Gigabit link speed reporting

- Provides Pass/Fail indication at each required link speed include available margin/headroom

## PoE Load

- Document PSE configuration and RealPower at the jack where PD will be deployed

## Coax

- Document Coax link performance

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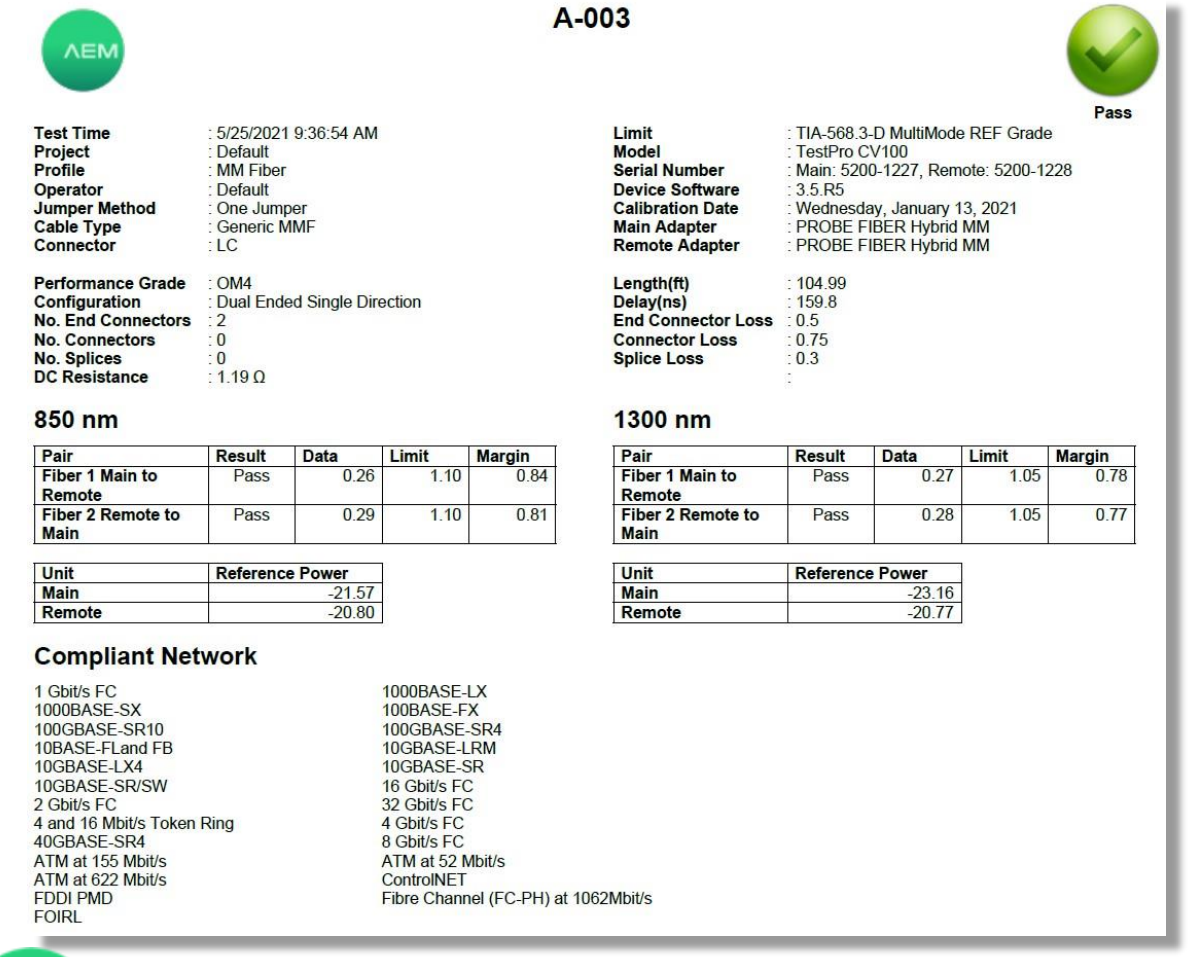
# Complete Smart Building Reporting Benefits



**A-003**

Pass

| | | | |
|---|---|---|---|
| **Test Time** | : 5/25/2021 9:36:54 AM | **Limit** | : TIA-568.3-D MultiMode REF Grade |
| **Project** | : Default | **Model** | : TestPro CV100 |
| **Profile** | : MM Fiber | **Serial Number** | : Main: 5200-1227, Remote: 5200-1228 |
| **Operator** | : Default | **Device Software** | : 3.5.R5 |
| **Jumper Method** | : One Jumper | **Calibration Date** | : Wednesday, January 13, 2021 |
| **Cable Type** | : Generic MMF | **Main Adapter** | : PROBE FIBER Hybrid MM |
| **Connector** | : LC | **Remote Adapter** | : PROBE FIBER Hybrid MM |
| **Performance Grade** | : OM4 | **Length(ft)** | : 104.99 |
| **Configuration** | : Dual Ended Single Direction | **Delay(ns)** | : 159.8 |
| **No. End Connectors** | : 2 | **End Connector Loss** | : 0.5 |
| **No. Connectors** | : 0 | **Connector Loss** | : 0.75 |
| **No. Splices** | : 0 | **Splice Loss** | : 0.3 |
| **DC Resistance** | : 1.19 Ω | | : |

**850 nm**

| Pair | Result | Data | Limit | Margin |
|---|---|---|---|---|
| Fiber 1 Main to Remote | Pass | 0.26 | 1.10 | 0.84 |
| Fiber 2 Remote to Main | Pass | 0.29 | 1.10 | 0.81 |

| Unit | Reference Power |
|---|---|
| Main | -21.57 |
| Remote | -20.80 |

**1300 nm**

| Pair | Result | Data | Limit | Margin |
|---|---|---|---|---|
| Fiber 1 Main to Remote | Pass | 0.27 | 1.05 | 0.78 |
| Fiber 2 Remote to Main | Pass | 0.28 | 1.05 | 0.77 |

| Unit | Reference Power |
|---|---|
| Main | -23.16 |
| Remote | -20.77 |

**Compliant Network**

1 Gbit/s FC
1000BASE-SX
100GBASE-SR10
10BASE-FLand FB
10GBASE-LX4
10GBASE-SR/SW
2 Gbit/s FC
4 and 16 Mbit/s Token Ring
40GBASE-SR4
ATM at 155 Mbit/s
ATM at 622 Mbit/s
FDDI PMD
FOIRL
1000BASE-LX
100BASE-FX
100GBASE-SR4
10GBASE-LRM
10GBASE-SR
16 Gbit/s FC
32 Gbit/s FC
4 Gbit/s FC
8 Gbit/s FC
ATM at 52 Mbit/s
ControlNET
Fibre Channel (FC-PH) at 1062Mbit/s

- Provides end customer a proof of quality
- Protects the installer
- Supports manufacturer's system warranty
- Includes complete test results, details about the equipment used, test configuration and application compatibility

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# Wrap Up

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## Summary

**Smart/Digital Buildings offer organizations**

- ✓ Alignment between IT and OT
- ✓ Lower infrastructure costs
- ✓ Deployment flexibility
- ✓ Centralized control
- ✓ Simplified installation
- ✓ Cost savings
  - Electric bill
  - Cable re-use

# Subsequent Cable System Re-Testing

- Moves/Adds/Changes can have an impact on cable system performance over time

- Replacement of patch cords (user cords & equipment cords)
  - ✓ Lower quality or different category can cause issues

- Unplugging/Plugging cycle (plug/jack mating)
  - ✓ Moving/changing out a PoE device and unplugging the patch cord from a live PoE connection and plugging in again can result in arcing between the plug and jack, causing degradation of contacts

- Re-testing of the cabling system over time can help ensure performance is still at acceptable level to provide

# Thank You

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