Power over Ethernet

Fixed Network Foundation Layer for 21st Century Smart Buildings

Delivering power and data in Intelligent Digital Buildings

PANDUIT™

Introduction

This paper is for technologists, architectural, engineering and building operations professionals who wish to explore the development of intelligent buildings. It examines the digital infrastructure technologies available to the building industry as it seeks to reduce energy consumption while hosting billions of connected devices.

It details how the use of Ethernet cable infrastructure for combined power and data communications solves smart building connectivity, power delivery, network topology and thermal management issues.

It shows how this will streamline processes and improve building performance, while creating fully connected and environmentally sustainable 21st century spaces.

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PART 1: The Built Environment Goes Digital using PoE

This section covers: Digital Building Developments – How New Intelligent Building paradigms are changing the game for construction professionals, architects, design engineers and interior design organisations. How Ethernet and PoE is an integral part of Building Information Modelling (BIM) and Building Management Systems (BMS) in changing building construction, operations and occupancy.

The Digital Future of Buildings

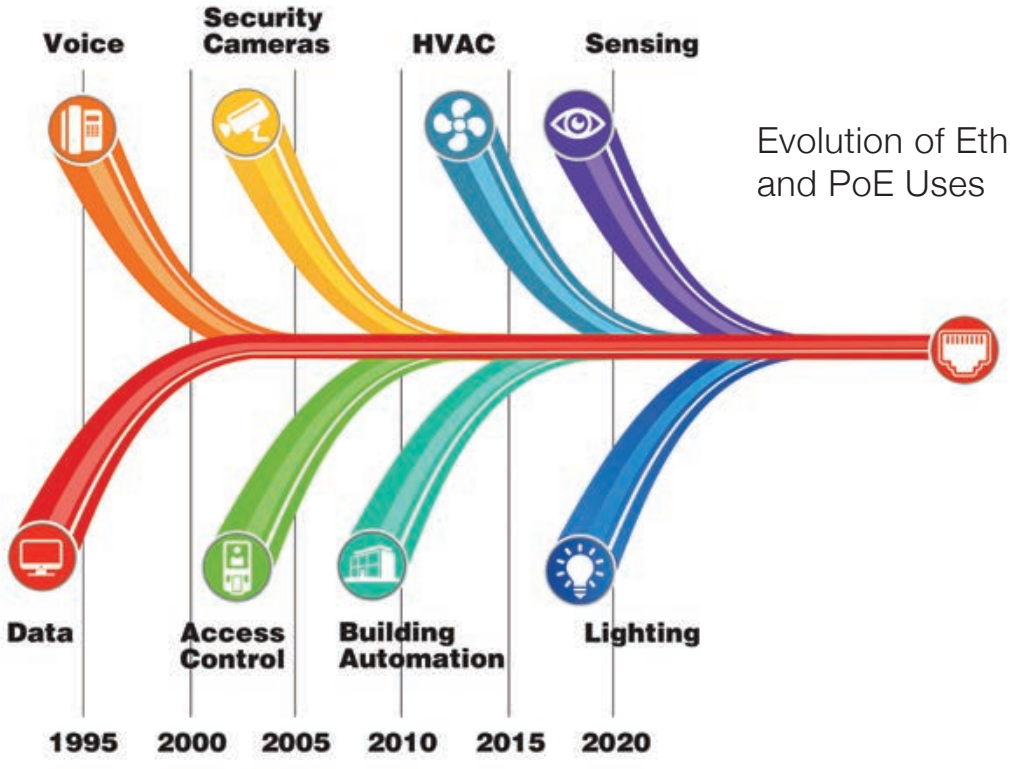
THE MAIN PHASES IN THE LIFE CYCLE OF A BUILDING ARE CONSTRUCTION, OPERATIONS AND OCCUPANCY. EACH IS UNDERGOING A TECHNOLOGICAL REVOLUTION AS BUILDINGS BECOME DIGITAL ENVIRONMENTS.

More than half the world's wealth is locked up in what is known as the Built Environment.

Across the vast property value chain of investors, architecture, design, construction and operations, there is a recognition that digital infrastructure must be embraced to improve sustainability while providing the types of intelligent connected buildings that people, businesses and communities require.

This is in part due to changes in how the property sector views the whole of life building cycle from construction to occupancy to sustainability. Architects, engineers, surveyors and building firms now make data driven decisions.

New standards are being developed as digital becomes a new value proposition for the building sector. Ethernet and specifically Power over Ethernet (PoE) infrastructure, which combines data communications and power delivery over a single Ethernet cable, looks set to become a dominant technology.



Evolution of Ethernet and PoE Uses

Being Digital

Digital technology is now everywhere in buildings. Whether a building is private or public, new or existing, construction projects in hospitals, schools, shopping centres, data centres, hotels, sports stadiums, office buildings and transport terminals are using PoE infrastructure. PoE is already powering traditional applications such as VoIP telephones and security cameras, as well as newer applications like smart lighting and heating controls.

Although historically, property is a very conservative industry, the construction and building management sectors are undergoing rapid, digital change, in order to meet the challenges of creating sustainable, connected buildings.

Professionals are turning to digital infrastructure to reduce energy use and lower greenhouse gas emissions. New generations of digitally native architects and designers are leading the efforts to attain net zero emission buildings. They recognise that any technology which promises to reduce installation costs and drives operational efficiency will be welcomed by suppliers and occupants alike.

Property investors like capital efficiency. This extends to reducing the space needed for infrastructure. Less infrastructure increases valuable occupancy space - while making buildings attractive to tenants. In terms of property management, efficiency extends to the deployment of millions (or billions) of energy efficient connected sensors and devices which are cheap to install, and cheap to power, connect and operate on future-proof network infrastructure.

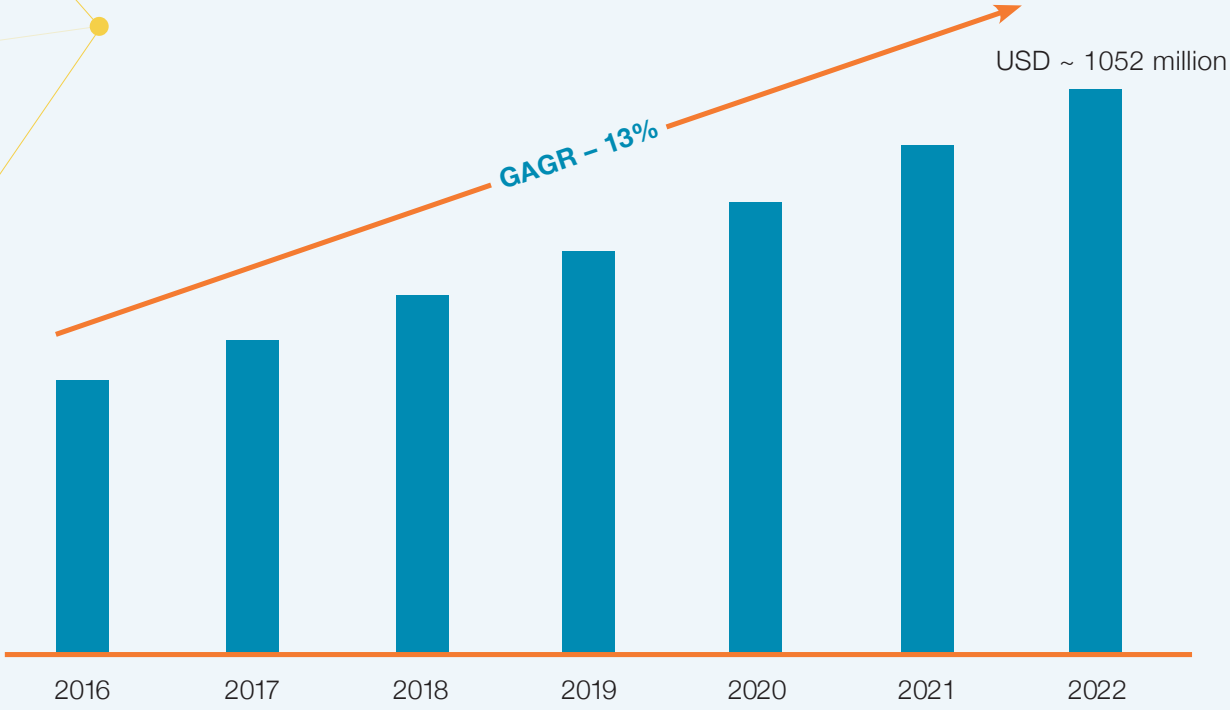
At the infrastructure layer, a single network technology that can provide high performance connectivity for data is PoE. It also meets the power transmission needs of the growing number of integrated and mobile devices being used in buildings and is delivered over twisted pair copper cable. (See Section 3 PoE Technology, page 14).

"The buildings and buildings construction sectors combined are responsible for 36% of global final energy consumption and nearly 40% of total direct and indirect CO2 emissions Energy demand from buildings and buildings construction continues to rise, driven by improved access to energy in developing countries, greater ownership and use of energy-consuming devices, and rapid growth in global buildings floor area, at nearly 3% per year.

The International Energy Agency
https://www.iea.org/topics/energyefficiency/buildings/

More data, more power, more space

Global Power over Ethernet Market



"Devices will be a combination of high power or low power, and high data or low data.

Already designers recognise that in order to have a hope of running all of these devices while operating sustainably, much of the energy need will need to be fulfilled on the data plane infrastructure – i.e. delivering power over high quality, high performance PoE cable infrastructure.

Source: Panduit

Phase 1: PoE and Construction

The construction industry has worked hard on modernising its processes to eradicate duplication of effort and resource waste.

The drivers are both economic and environmental. Capital efficiency and property management efficiency are vital. This has spurred the adoption of Building Information Models (BIM) and Building Management Systems (BMS) which are now familiar to everyone in building construction and operations.

Other considerations are more stringent regulation and compliance requirements. The industry knows it must adhere to tougher regulations by using standards-based digital technologies as the tools for the sector to comply on safety and sustainability.

Building design is becoming all about interoperability between the different participants and about making the building itself interoperable.

"buildingSMART is an international organisation which aims to improve the exchange of information between software applications used in the construction industry. It has developed categories called Industry Foundation Classes (IFCs) as a neutral and open specification for Building Information Models (BIM)."

https://blog.exponential-e.com/bim-the-evolution-of-smart-buildings/

https://www.buildingsmart.org/

As BIM models advance and become interoperable this is driving ever more technology integration into building construction and operation. Ultimately the goal is to develop interoperability between BIM, BMS, IT, IoT and manufacturing based on open standards. As this evolves, one estimate points to more than one billion sensors and connected devices being deployed globally in buildings by 2021. (This does not include the billions of mobile connected devices brought into buildings by tenants, workers and visitors. See below: Users need Apps – Apps need Infrastructure on page 9).

This integration of devices into buildings will require cabling infrastructure which meets or exceeds the latest communications, power and thermal standards, and which does not add to network complexity and cost. This is driving the adoption of PoE for integrated communications and power as the network standard in new builds and the replacement networks in refurbishments.

Phase 2: PoE and Operations Management

In traditional construction, the absence of communications infrastructure for monitoring the state of the building meant it was virtually impossible for architects and engineers to know if a building was used effectively in the manner for which it was designed. Even building operators, usually property management firms, found this difficult. Today the deployment of almost every type of sensor and monitoring system is providing new data sources meaning issues that arise can now be traced back to their origin. These new sensors are being used to inform operators exactly what is happening inside the building based on use and environmental conditions.

As noted above, the goal of zero emissions buildings are creating new challenges. Tougher regulations are the likely product of today's environmentally conscious times meaning sustainability is a vital deliverable of smart building technology. Sustainability is not just about energy use but extends to the entire environment. To this end, it is vital that the base communications infrastructure layer is both future proof and that its deployment has the lowest possible impact. According to KPMG's Emerging Trends in Infrastructure report, sustainability goals include, "operational sustainability, [such as] whether assets have the right technologies and efficiencies to optimize performance" and provide "technological sustainability." This means any base technology must be considered in the context of "viability and potential obsolescence."

As a future proof technology with low environmental impact the use of PoE on copper cable as the base communication infrastructure layer addresses all of these concerns.

What is driving digital buildings?

Typical Office Building	Utilities	Rent	Payroll
Cost per Sq Foot/Year	$3	$30	$300
Potential Savings/Benefit	**$0.30**	**$3**	**$30**
10% improvement			

Jones Lang LaSalle 3-30-300 Rule of Thumb. Source: JLL

Phase 3: PoE and Occupancy

Big changes in how buildings and occupants interact are being enabled by PoE cable infrastructure.

The Royal Institution of Chartered Surveyors says "By combining BIM with the Internet of Things (sensors embedded in everything within the building), we can start to gain a living picture of our buildings. For the first time in history, the planning of the architects and designers can be verified and compared with the use of the building, with tracking over time as the use of the space and its occupiers' changes. Bringing together all this data, we can gain new and better understanding of how our buildings actually work."

https://www.rics.org/globalassets/rics-website/media/knowledge/research/insights/big-data-smart-cities-intelligent-buildings-surveying-in-a-digital-world-rics.pdf

In fact, property management firm JLL points to the benefits of going digital based on cost of square foot per year. It estimated average operational savings in a digital building at 10% across utilities, rent and human capital costs. (Based on utilities costing $3 per square foot per year, rent $30 and $300 for people savings would amount to 30c, $3 and $30 per square foot respectively). See above graphic.

Ethernet represents the core infrastructure standard for combined communications and power which will provide plug and play connectivity for easy deployment of app-based sensors and devices which will make up a digital building.

The World Green Building Council, and the Green Building Councils participating in the Advancing Net Zero project, are dedicated to supporting market transformation towards 100% net zero carbon buildings by 2050.

www.worldgbc.org/advancing-net-zero/what-net-zero

PART 2: PoE Use Cases and Benefits

This section covers: Why resiliance, high performance power and data cable infrastructure is vital as the base layer for digital building operations. From managing the building itself, to how people will interact with their environment through apps and digital devices, it is the data that determines how successful a building will be. It covers the application use cases in kiosks, wireless access points, digital display and signage.

Building a power and data network infrastructure for the long term

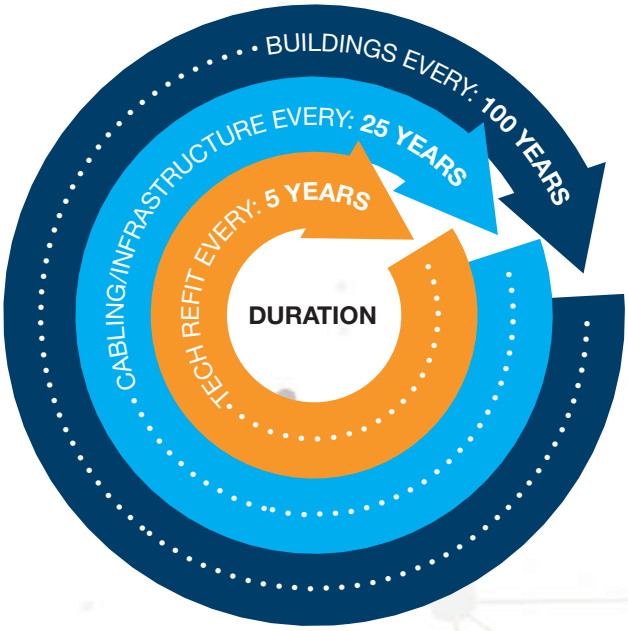
HOW PoE ON COPPER CABLE FITS THE REQUIREMENTS FOR DIGITAL BUILDINGS

When it comes to digital infrastructure in the built environment, there are three timeframes at play. The first is that the building itself may have a 'whole of life' operation of over a century. Secondly, networking and cable infrastructure has a life span of decades and may be considered a minimum 25-year investment. The third time factor is the rapid digital technology changes we are experiencing every three-to-five years. The pace of change in consumer technology and endpoint IT continues to accelerate. So, it is vital to choose a standards-based technology with a clear roadmap. Ethernet is the local area network communications de facto standard for data. PoE runs over the same copper cable as the LAN, providing decades of stable, high performance network infrastructure.

Another major trend in the property sector is that buildings need to become evolvable. They need to be able to adapt to changing technologies, to the growing number of different digital devices and uses. More importantly, they need to be sustainable.

The benefits of digital cannot carry an environmental or additional expenditure cost, so operational efficiency must evolve in line with the needs of owners and occupants. PoE-based networks are optimised for these different demands.

Buildings Evolve Over Time



Users need Apps – Apps need Infrastructure

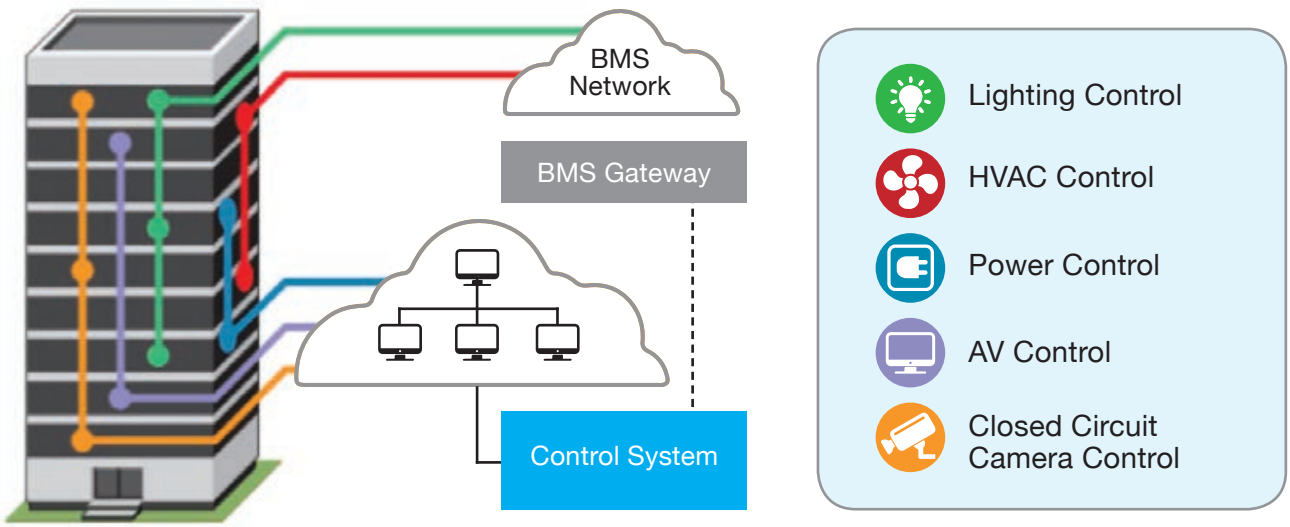
Buildings are becoming digital structures with an infrastructure that supports all of the various applications to optimise operations. Building Management Systems are becoming more advanced. Applications which run and manage HVAC, water, lighting and security are constantly developing, becoming more responsive and smarter.

This property tech layer is categorised as ‘Proptech’. According to Professor Andrew Baum, of the SAID Business School at Oxford University and author of “Proptech 3.0, the future of real estate’: “a smart building is an asset which optimizes the system design and automation to run efficiently.”

Source: https://www.sbs.ox.ac.uk/sites/default/files/2018-07/PropTech3.0.pdf

“When occupied, high velocity data collection establishes whether a building is performing as intended under different occupancy, climatic or environmental conditions”, says the Royal Institute of Chartered Surveyors. At the same time, applications will and do directly interact with the occupiers. When sensors in the lighting detect building or room occupancy, the BMS controls the lighting and alerts air handlers and chillers to adjust pre-set air flow and temperature and possibly other requirements within the space. The benefits extend to wellbeing for people – smart lighting is shown to speed recovery and convalescence in patients in hospital when luminescence tracks the sun and reflects natural ambient outside light. Smart lighting in schools has been shown to make pupils more receptive to learning by stimulating them in the morning and calming them in the afternoons.

In a security context, public and private multiple and single use buildings require ever more security and access control. For example, schools, hospitals, government and other public buildings must balance the needs for accessibility and security by ensuring a building’s physical security at access points and through the expansion of video monitoring. Another change is that the future direction of buildings in urban environments is upwards. That means major changes to modern buildings as multi-use and shared environments become ever more common. It is forecast that future city dwellers will live, work,



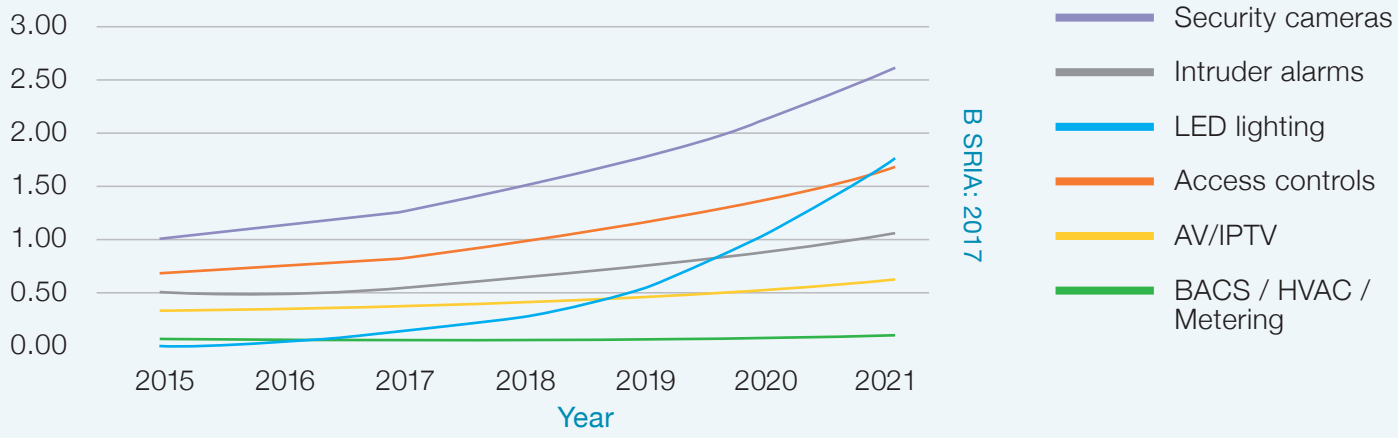
"Instead of choosing fixed and inflexible systems inside, which do not communicate with each other, [buildings] need to move towards utilising a single open-source technology platform into which all the services connect. This enables the building to connect with its operators and tenants and allows new technologies or applications to be plugged in, making the building increasingly responsive to the changing demands of occupants," says smart building consultancy Memoori.

Source: https://www.memoori.com/smart-building-future-proofing-opportunity/

learn and find leisure within single complexes. This will fundamentally change the number of data sources and data patterns managed by the infrastructure. Single use environments will also see more need for robust, secure, low energy digital infrastructure.

These trends all point towards ever increasing numbers and variety of connected nodes, and the necessity to maintain energy use with optimised parameters for buildings. BSRIA's (Building Services Research and Information Association) Convergence and Digitalisation of Commercial Buildings in the US, predicts substantial growth for PoE-powered devices across the business environment, as illustrated below:

Distributed Building Services, million/outlets in commercial buildings by type of products, 2015-2021



Device use cases

Infrastructure operations, interactivity and interoperability have been evolving towards PoE over time. Use of PoE started with VoIP in the 1990s, moved on to CCTV around 2000 and onto HVAC controls and lighting. This expansion of capabilities meant the control of these applications being transferred onto the data infrastructure plane. Now PoE is extending to powering and communicating with an ever-growing variety of physical devices.

Low voltage cameras, embedded sensors, kiosks, wireless access points, physical access points, digital signage and displays are being deployed in ever greater numbers. Market forecasts show an explosion in the number of devices about to enter buildings. Wireless access point numbers alone are forecast to expand by 30% per year until 2027. Kiosks and digital screens will become ubiquitous in multi-use environments. According to a report on the Global Kiosk Market, published by KBV research, the global kiosk market will reach $5.4 billion by 2024, at a growth rate of 26.4% CAGR. The demand for self-service machines and automated devices, wireless communication, technology advancements and remote management are some of the notable factors driving the global kiosk market.

High performance cable infrastructure is the base layer for these smart technologies. All these different devices need to run over a single network which provides power and data. With lower installation costs, fewer hazards and more flexibility, PoE is a proven, viable, cost-effective solution.

Since 1995, history tells us that connected devices are moving to PoE for power. For example, the latest standards show PoE delivering up to 99w over twisted pair cables – this is easily enough to power the latest lighting, wireless access points, kiosks and more.

- Voice and data
- Lighting
- HVAC/Building Automation System
- Sensors
- Wireless
- Security
- A/V
- Supporting Infrastructure

Part 3: Panduit leadership in PoE technology

This section covers: The benefits of Panduit cable and connector technologies in thermal management, connectivity, power delivery, physical footprint, installation ease and deployment options. How Panduit expertise leads in the development of converged PoE infrastructure from physical network topologies, cables, and connectors, covering standards, connectivity, power, thermal management and regulations.

The Benefits of PoE Infrastructure

HOW THE RIGHT PHYSICAL INFRASTRUCTURE SOLUTIONS SAVE SPACE, OPTIMISE INSTALLATION AND OPERATION AND FUTURE PROOF THE PoE NETWORK

Through environmental and sustainability standards such as BREEAM and LEED, owners and operators are incentivised to make their buildings digital. Yet they also need to carefully manage the costs of creating and operating digital infrastructure.

As PoE standards advance, it is opening the possibility to run a single integrated power and communications network for more and more devices – even those considered power hungry.

A single network has positive implications for ease of installation, lower maintenance and better performance and interoperability between different building elements. PoE is a simple means to power digital building management infrastructure devices over the same network network.

Factors affecting cable infrastructure cost and operations include locations, runs, distances, connections and cable fill. They are key factors in performance and Opex management in digital buildings.

New topologies for network infrastructure for digital buildings will see direct connections from Telecom Rooms (TR) to the device. From the TR the switch directly controls the power to the device and data delivery and collection. Common challenges within the TR are crowded cable pathways. Bulk is a big issue as more cables are run in and access is becoming a serious concern as the number of connections increases cable and port densities.

Solutions such as smaller cable diameters, angled connectors, and high-density patching help address these issues. These innovative solutions free up space that would otherwise be used for cable management, to make room for active gear or switches.

Panduit's Category 6A cable with MaTriX technology features an integrated tape that gives the cable advanced thermal properties for handling the heat rise within cable, which is caused by PoE.

A digital building calls for running copper cables for PoE into new physical environments in ceiling voids and under floor spaces. To operate effectively at scale cable infrastructure flexibility becomes ever more important.

Communication and Power Standards

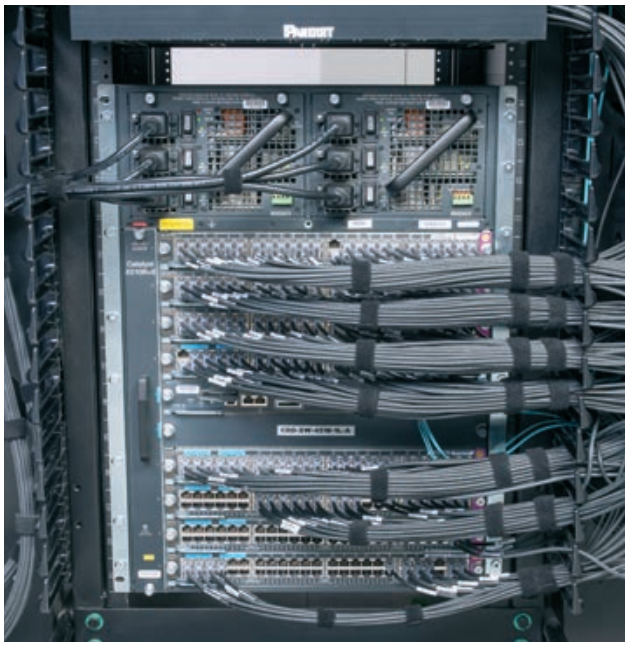
Power over Ethernet Standards are constantly evolving. The latest standards from the IEEE, known as PoE++, are IEEE 802.3bt TYPE 3 and IEEE 802.3bt TYPE 4.

IEEE 802.3bt TYPE 3 provides for 600 mA current, over 4 energised pairs. Power at source equals 60w with power at device of 51w. Delivering 10GBASE-T speeds.

IEEE 802.3bt TYPE 4 provides for 960mA current, over 4 energised pairs. Power at source 99w with power at device 71w. Delivering 10GBASE-T.

Connectivity and thermal management

Power over Ethernet TSB-184A, "Guidelines for Supporting Power Delivery Over Balanced Twisted-Pair Cabling" is a technical service bulletin published by TIA. TSB-184A recommends a maximum temperature increase of 15 degrees Celsius over the ambient temperature for the centre cable in a cable bundle operating at full PoE, PoE+ or PoE++ power. All Panduit cables are designed to efficiently deliver PoE, PoE+ or PoE++ power.



Panduit PoE Switch Rack

Connectivity – When running PoE, two different occurrences can impact RJ45 jacks: heat and arcing. Panduit has mitigated both impacts within its jacks.

Arcing - In a channel running PoE, when a plug is removed from a jack, an arc occurs between the plug contacts and the jack contacts, at the point where the contacts disengage from each other. Over time, this can result in carbon build up on the contacts, impacting channel performance. Panduit has designed its jacks so that arcing point is away from the jack mating region. In addition, the 100g normal force of Panduit jacks, which refers to the amount of force the jack contacts push on the plug as it is inserted, provides sufficient abrasion to remove any carbon scoring.

Heat – Just as heat rise can impact cable performance, temperature testing on jacks has shown that heat rise can also impact jack performance. In response, Panduit jacks have been tested and are now rated to 65°C, and are the only jacks in the market with this temperature rating.

PoE and the New Regulatory Environments

As of August 2017 The Construction Product Regulations mandate that all products used in construction must adhere to strict regulations and all cable infrastructure deployed for integrated comms and power must operate within strict thermal limits. All Panduit offerings adhere to all construction product regulations and to PoE standards.

Conclusion

In the built environment, too many networks remain siloed and separate. This approach is no longer suitable for the new era of intelligent buildings. The new generation of architects and engineers are those with responsibility for delivery of the next generation of smart digital buildings. Understanding the power and benefits of future-proofed PoE cable infrastructure is at the core of physical, economic and digital innovation.

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