Amphenol ICC

Connecting to the Future of Intelligent Buildings

1. General Introduction

In recent years, the design of virtually all types of buildings, commercial and residential, has been evolving away from having separate, unconnected systems for HVAC, lighting, security, and communications functions toward a more networked approach that integrates these functions with an increasing degree of automation, in such a way that it enables the building's occupants to more seamlessly control these systems, and eventually, for the building itself to manage most, if not all, of these functions automatically. This increasingly integrated approach to buildings follows the converging dynamics of several technology and societal trends – the integration of networked computers into virtually all aspects of daily life, the ubiquitous presence of wireless connectivity, the need for energy efficiency, and an increasing focus on comfort and safety features that have become the standard for modern society.

The evolution of computers from large standalone machines wired to a network to pocket-sized handheld devices with wireless connectivity, together with increasingly sophisticated sensor technology, has made the automation and integration of building systems possible, paving the way for the rise of "intelligent buildings." These intelligent buildings are designed to provide comfort and safety for the occupants, energy-efficient operation, lower costs, increased communications, as well as monitoring of the building systems to provide proactive maintenance alerts.

Although many of the intelligent building systems will be wirelessly interfaced with sensors and user devices, virtually all of the subsystems within the buildings networks will require connectors to integrate sensors and feedback, provide power, and deliver data, audio and video signals throughout the building. These connectors will form an integral part of the intelligent building's flexibility, sustainability and cusomization for specific uses.

2. Intelligent Buildings Defined

The initial concept of an "intelligent building" became common in the early 1980s, and was primarily used to describe an increased level of building automation that was enabled by the advances in electronic and information technologies that made the first steps toward integration of the separate systems used in buildings, including heating, ventilation and air conditioning (HVAC), plumbing, electrical distribution, lighting, elevators, security/building access, and communications. With the rise of the Internet and universally-connected computing in the 1990s, followed the by "Internet of Things" (IoT) in the 2000s, these two technology trends merged to advance the state-of-the-art in intelligent buildings.

A more comprehensive definition was proposed by the Intelligent Building Institute in 1985, describing an intelligent building as "providing a productive and cost-effective environment through optimization of four basic elements: structure, systems, services, and management, as well as the inter-relationship between them."[1] This definition

would be realized by optimally matching these four elements to the needs of the user through the use of technology to integrate them into the building design. Thus, an intelligent building would be designed to provide building owners, property managers, and occupants with lower cost, ebergy efficiency, increased comfort, safety, and convenience, as well as long-term flexibility.

While there will be a range of both open-source and proprietary wireless protocols implemented by different builders, interconnection hardware for integration of intelligent building systems and interface with the users will be required as well, and for the most part will be the same whichever chipset or communications protocol is implemented.

3. Market Projections and Trends

According to research firm MarketsAndMarkets estimates[2], the intelligent building market is expected to grow from an estimated US $7.42 billion in 2017 to US $31.74 billion by 2022, at a compound annual growth rate (CAGR) of 33.7% over that period. This market is primarily driven by the growing demand for integrated security and safety systems, as well as increasing government initiatives for intelligent building projects.

The key enabling technology that is already starting to transform today's automated buildings into intelligent buildings is the widespread adoption of Internet of Things (IoT) applications to develop truly integrated building management systems (BMS), especially in commercial buildings. The deployment of sensors to detect motion, air pressure, light levels, temperature, and water flow enable an integrated BMS to not only monitor and communicate this sensor data, but also to analyze and autonomously react and adjust different systems. According to a recent study by Deloitte[3], sensor deployment in commercial buildings is projected to grow at a CAGR of 78.8% between 2015 and 2018. Virtually all of these sensors will require interconnect hardware at some point in their link back to the integrated BMS.

This level of IoT-enabled integration delivers building owners a value proposition that goes beyond energy efficiency and operations control to include higher-level cost savings, productivity gains (through the elimination of manual controls), as well as an enhanced user experience for the building occupants, and the potential for increased revenue opportunities from data analytics. A recent report from Gartner, Inc.[4] estimates that large commercial sites, such as industrial parks, office campuses, shopping malls, and airports could realize a 30% reduction in energy costs and building maintenance through the use of a fully integrated BMS.

4. Types of Intelligent Buildings

Common benefits for all types of intelligent buildings

There are universal benefits for any type of building that implements an intellgent building design empowered by IoT technology. One of the primary benefits of any well-designed intelligent building is lower operating costs, achieved through energy efficiency. Also, an intelligent building will improve the heath and well-being of its occupants, with an increase in productivity. Finally, an intelligent building will incorporate surveillance and security systems to enhance safety and facilitate faster emergency reponse.

Manufacturing facilities

In addition to the universal benefits of controlling building HVAC systems, lighting, communications, and security, an intelligent manufacturing facility requires integrated control and monitoring of the machines and robots used in manufacturing, as well as tracking systems for incoming materials, assembly line progress, inventory of finished products, and shipping/delivery schedules.

Multifamily residential facilities

While there will be an increasing adoption of “smart home” technology for single-family dwellings, the potential for intelligent building designs in multifamily residential facilities represents an important market. By installing and connecting an array of sensors to measure temperature, motion, humidity, lights, and water flow in each room of an apartment building, a smart system can track the preferences and habits each resident, so that owners can use the data collected to improve their space utilization and enhance the tenant experience. Tenants are able to develop personal settings for a customizable experience in which they can remotely access, control, and monitor their environment.

Office buildings

By creating an office environment where employees can control and customize lighting and temperature in their individual workspaces, an intelligent building design can enhance both workplace efficiency and employee productivity; and integrated sensors monitoring indoor air quality and humidity levels to create a healthier work environment. Potential benefits for management include the abilty to gain insights into employee’s behavior, with the ability to monitor and automate redundant tasks and motivate employees to enhance productivity.

Retail facilities

Intelligent building systems specific to the retail environment include a host of applicatinos designed to enhance the shopping experience, including automatic recognition of customers, personalized shopping suggestions, parking availability alerts, and automatic payment systems.

Educational facilities

From individual elementary school buildings to multiple buildings of a university campus, educational facilities represent an opportunity for the application of intelligent building design to enhance security through access control, as well as to create customizable classroom environments for healthier learning.

Healthcare facilities

Hospitals, nursing homes, and other healthcare facilities have unique requirements for intelligent building design beyond the standard building systems control, including patient monitoring, location tracking for medical personnel and equipment, and specialized environmental and lighting controls for ICU and operating rooms.

Types of building subsystems

Intelligent building designs will integrate these subsystems as part of their overall architecture:

Environmental systems: Heating, ventialting, & air conditioning (HVAC); building energy management systems (BEMS) that optimize for energy efficiency and resource conservation; plumbing and sanitary systems; lighting (including optimizing natural light)

Safety & security systems: Building access controls; security cameras; fire detection, alarm, and suppression systems; emergency lighting & call boxes

Building systems: Elevators & escalators; electrical power distribution; utility metering & controls; structured cabling for data, voice, and video signals; lighting controls

Communications systems: Enterprise Resource Planning (ERP) implemented over IP-enabled networks (including wired LAN, WiFi, in-building wireless network & location services, telecommunications service) that monitors, analyzes, controls, and manages business processes and occupant needs autonomously; digital signage, audio speakers for public address

Personnel systems: Employee monitoring; motion detection; parking access; vending machines

Exterior systems: Perimeter monitoring & protection; vehicle parking management; irrigation systems; landscape lighting and exterior building lighting; weather monitoring

5. Amphenol ICC product application areas

As a world leader in interconnect technology, Amphenol ICC provides interconnect products for the information, communications, and commercial electronics markets. The company is especially well positioned to deliver a wide range of innovative connectors and cable assemblies for intelligent building systems from its portfolio of diverse interconnect application areas, including server, storage, data center, networking, industrial, and business equipment markets.

Several families of Amphenol interconnect products deliver a number of advantages for the specific application areas within the intelligent building system infrastructure, with several product families covering multiple application areas. The table below shows a sample of some of Amphenol's product families and their primary application areas within the intelligent building system.

Amphenol ICC Products for Intelligent Building Applications

Application	Access Control	Elevator Cab Panel	Down lights	Fire Detection	Building Control Network	Security Camera	Vending Machine
Bergstak® 0.5	☐	☐	☐	☐	☐	✔	☐
Bergstak® 0.8	☐	☐	☐	☐	☐	✔	☐
Bergstik®	✔	✔	☐	✔	✔	☐	☐
Cable Assemblies	☐	☐	☐	☐	☐	☐	✔
D-Sub	☐	☐	☐	☐	☐	☐	✔
Dubox®	✔	✔	☐	✔	✔	☐	☐
Econostik®	✔	✔	☐	✔	✔	☐	☐
FFC/FPC Connectors	☐	✔	☐	☐	☐	☐	☐
Griplet™	☐	☐	✔	☐	☐	☐	☐
Mezzostak™ 0.5	☐	☐	☐	☐	☐	✔	☐
Minitek PWR™	☐	☐	✔	☐	☐	☐	✔
Minitek™ 1.27	☐	☐	☐	☐	☐	✔	✔
Minitek™ 2.0	✔	✔	☐	✔	✔	✔	✔
Modular Jack	☐	✔	☐	✔	✔	✔	✔
Modular Jack Slim Line	☐	✔	☐	✔	✔	✔	✔
RotaConnect™ BTB	☐	☐	✔	☐	☐	☐	☐
Universal Contact	☐	☐	✔	☐	☐	☐	☐
USB Solutions	☐	✔	☐	✔	✔	☐	☐
WTB 1.20	☐	☐	☐	☐	☐	✔	☐
WTB 1.25	☐	☐	☐	☐	☐	✔	☐

6. Amphenol ICC product descriptions

Following are overviews of the Amphenol interconnect products for intelligent building systems:

Bergstak® 0.5mm mezzanine connectors: A versatile board-to-board high-speed, high-density interconnect system with 10 to 60 positions in 0.5mm pitch double-row contacts and stack heights from 3mm to 6mm, the Bergstak® 0.5mm mezzanine connectors support 25Gb/s data transfer rates, making them ideal for digital video cameras in security systems, portable measurement equipment, handheld medical devices, and point of sales terminals.

Bergstak® 0.8mm mezzanine connectors: A flexible high-density parallel board-to-board connector system with 0.8mm double-row contacts with 40 to 200 positions in stack heights from 5mm to 20mm, the Bergstak® 0.8mm mezzanine connectors feature a “vertical vs. vertical” mating profile and deliver data transfer rates up to 12Gb/s for telecommunications and router applications, board interconnects inside servers, office machines, instrumentation, test & measurement equpiment, and medical diagnostics systems.

Bergstik® 2.54mm unshrouded headers: These flexible board-to-board and wire-to-board connectors come in single or double row configurations, and are available in surface mount (SMT), through-hole (THT), press-fit, stacking, and pin-in-paste (PIP), in straight or right-angle versions from 2 to 72 positions. They feature a “breakway” design, enabling designers to adjust each connector to an exact length for specific circuits. Designed to mate with Duobox® receptacles, the Bergstik® headers are used in a wide range of intelligent building application areas, including entry access controls, elevator control panels, fire alarms, communications and data servers, displays, instrumentation, and industrial electronic systems.

Amphenol cable assemblies: With the ability to integrate a wide variety of power and signal connectors, Amphenol’s cable assemblies provide highly flexible, customized interconnect solutions that can be applied to the internal connections within communications equipment and servers, industrial equipment, energy meters, lighting systems, displays, security systems, medical monitoring devices, and vending machines.

D-subminiature connectors: Part of a long-established industry standard for reliable and rugged I/O connectivity, Amphenol’s proven D-sub connectors are pin-and-socket devices that employ contacts encased in a dielelectric insert surrounded by a D-shaped polarized metal shell. These versatile connectors are available in five shell sizes with 9 tp 50 positions (standard density), and 15 to 78 positions (high density); plus they offer the broadest range of contact styles and mounting options to meet a variety of design requirements. D-sub connectors are used extensively in telecommunications and data servers, office machines, medical equipment, and industrial electronics.

Duobox® connectors: The Duobox® product family is a comprehensive series of connectors available in surface mount or through-hole versions in single-row or double-row configurations with 2 to 50 positions. Their pre-stressed contacts feature a dual-beam design and a four-wall design to ensure signal integrity. Designed to mate with Amphenol’s Bergstik® headers, the Duobox® connectors are ideal for a wide variety of applications within intelligent building systems that require a parallel, planar, or perpendicular board-to-board, wire-to-board, or flat cable interconnect, including building access panels, elevator controls, fire detection systems, and building communications network equipment.

Econostik® connectors: An economical series of 2.54mm unshrouded headers, the Econostik® connectors are available in single-row configurations form 1 to 36 positions, and double-row confiurations from 4 to 72 positions, with vertical surface mount, vertical through-hole, and vertical right angle versions. They are ideal for board-to-board connections in industrial controls, elevator controls, security alarms, utility meters, and vending machines.

FFC/FPC connectors: Amphenol is a leading supplier of flat flexible cable (FFC) / flexible printed circuit (FPC) connectors with the broadest product range in the industry. These connectors provide compact, high-density interconnect solutions where high data trasfer rates up to 10GB/s are required. With a range of contact pitches

from 1mm to 0.2mm, a variety of LIF (low insertion force) and ZIF (zero insertion force) styles, and vertical, right angle, through-hole and surface mount configurations, these connectors provide low-profile, high-density, high-speed connections for high-definition displays used in monitors for control panels in elevators, building control systems, and industrial equipment.

Griplet® miniature IDC connectors: An innovative and ruggedly-designed miniature connector series featuring a proven insulation displacement contact (IDC) design, the Griplet® series devices deliver economical and robust wire-to-board connections for single wires from 30 to 20 AWG. The compact, low-profile design provides four points of contact per wire, plus strain relief to ensure highly reliable and vibration-resistant connections even under harsh environmental conditions. Available in continuous “break-away” strips, the Griplet® connectors can be customized to fit any number of wires connecting to a PC board. The secure, easy-to-install single-wire connections make the Griplet® series ideal for a wide range of inteligent building applications, including smart meters, thermostat controls, sensors, LED lighting, and building automation controls.

Mezzostak® 0.5mm mezzanine connectors: A robust fine-pitch mezzanine connector series available in stack heights from 4mm to 7mm with 20 to 90 positions, the Mezzostak® connectors feature an innovative “hermaphroditic” design that enables each connector to securely “mate-to-itself” for simplified installation, with polarized guidance “scoops” to prevent mis-mating. The connectors are ideal for use in security cameras, access control panels, portable instrumentation, handheld monitors, medical devices, and point-of-sale terminals.

Minitek™ PWR connectors: A flexible and comprehensive series of connectors specifically designed for power applications, the Minitek™ PWR series devices are available with 2 to 24 positions, in contact pitches from 2.5mm to 5.7mm, and current ratings from 5A to 23A. Complementary to the MiniTek™ wire-to-board signal connectors, the Minitek™ PWR connectors feature a positive locking mechanism to ensure secure mating and wire retention. These connectors are suited for wire-to-board, wire-to-wire, and wire-to-panel power connections in HVAC systems, industrial equipment, telecom and datacom servers, medical devices, and security monitors.

Minitek™ 1.27 connectors: These compact fine-pitch (1.27mm) modular board-to-board / wire-to-board connectors are available stack heights from 5.8mm to 6.9mm, with 4 to 100 positions, in vertical and right-angle / surface mount and through-hole configurations. These versatile connectors are used in a wide range of intelligent building applcations, including industrial control panels, medical equipment, data and telecommunications systems, and security systems.

Minitek™ 2.0 connectors: A fully modular series of board-to-board / wire-to-board connectors in 2.0mm contact pitch, the Minitek™ connectors are available in vertical and horizontal configurations and single- and double-row styles from 2 to 25 positions per row. The 2mm contacts enable a 38% space savings compared to conventional modular connectrs, making these connectors ideal for connections between PC boards, wires, and flat cables in

access control systems, elevator control panels, fire detection systems, building controls, security camera controls, and vending machines.

Modular Jack RJ45 connectors: The proven RJ45 modular jack is widely used for communications connections in telecom, datacom, and LAN networking applications. Amphenol's RJ45 Modular Jacks are available in a wide range of options, including right-angle or vertical styles, surface mount or through-hole configurations, shielded and unshielded, and from 1 to 16 positions in single or stacked designs in both standard and low profile versions. The Cat3 version of the Modular Jack supports data transmissin rates of 16Mbps for phones, modems and point-of-sale terminals, while the Cat5 version supports high-speed signals at 100Mbps for data switches, routhers, and hubs. Their versatility make them suitable for a wide range of inteelligent building applications, including computer and communications networks (servers, hubs, routers, and Ethernet switches); telecommunications equipment (PBX systems, security phone lines, and fax machines); plus interface connections in point-of-sale terminals, vending machines, security systems, and medical equipment.

Slimline Modular Jack RJ45 connectors: Amphenol's Slimline version of the RJ45 Modular Jack features a 7mm centerline port spacing, and occupies just 50% of the board space required for a conventional RJ45 modular connector, effectively doubling the density of connections to the PC board. Available in an 8-position stacked configuration, the shielded Slimline Modular Jacks support Cat5e data transmission rates, and can be used in similar applications to the standard RJ45 Modular Jacks where board space is at a premium.

RotaConnect® rotatable connectors: Available in 2- and 4-position surface mount designs, these innovative board-to-board connectors feature a unique rotatable design that allows them to mate at any angle between 90° and -60°, enabling the connectors to be placed anywhere on the PC board. A 'hermaphroditic" contact design incorporates both male and female contacts, enabing the parts to "mate-to-itself," simplifying both inventory and design. The RotaConnect® rotatable connectors are ideal for many types of LED lighting applications used in intelligent buildings, including luminaires, and rigid LED strip lighting, as well as for sensors, acutuators, control panels, and digital signage.

Universal Contact connectors: Amphenol's single-position spring contact is designed without a housing to save cost and space on the PC board. The metal dome-formed contact area provides excellent connection retention and low contact resistance. With no fixed mating interface, the Universal Contact connectors can be placed anywhere on the PC board to deliver maximum design flexibility for single-wire connections. The Universal Contact connectors are ideal for LED light fixtures, sensor connections, and switches.

Universal Serial Bus (USB) connectors: As one of the earliest adopters of the latest USB connector design standard, Amphenol provides one of the industry's broadest range of USB connectors. The latest generation design, the USB 3.1, Type C provides multi-function single-cable transmission for up to 100W of power, as well as

data transfer rates up to 10Gb/s for data, audio, or video signals. In addition, Amphenol offers previous designs (USB 3.0/2.0, Mini/Micro/Standard) in straight, right angle, surface mount or through-hole configurations, with stacked versions and ruggedized connector designs for harsh environments. The USB connectors are widely used in many data communications applications for intelligent buildings, including control panel displays, security camera systems, fire detection systems, and network control interfaces.

Wire-to-board connectors: Amphenol offers a comprehensive family of 1.25mm pitch wire-to-board terminals, crimp housings, and PC board headers in straight, right angle, surface mount and through-hole configurations in single-row designs from 2 to 15 positions. For space-constrained applications, a 1.2mm contact pitch low profile wire-to-board connector series is available in 3, 4, and 6 positions. Unlike many other wire-to-board connectors, Amphenol's products are made with halogen-free materials to comply with EU Industry Safety Standards and feature an operating temperature range from -40°C to +105°C. These connectors are used for sensors, acutators, security systems, and fire detection systems, or wherever individual wires need to be connected to a PC board.

7. Conclusion – the future of intelligent building design

The era of intelligent building design is just beginning, with the potential of the Internet of Things (IoT) technology to provide near-univeral connectivity into all the systems that impact our homes, our workspaces, and our daily lives. IoT technology will enable a increasing level of integration for all types of building systems, enabling more connectivity, collaboration, and productivity, as well as lower cost of operations, more energy efficiency, and more sustainability, ultimate leading to buildings with net zero energy consumption as a standard practice.

One of the key factors in achieving the level of integration required for a truly intelligent building design is for architects and building systems designers to take a holistic and human-centric approach to the design process for these systems, and to then optimize them to enhance the human experience by prioritizing the occupants' needs such as comfort, productivity, connectivity, space optimization, and safety.

Delivering the level of connectivity between all the systems needed for integrating all the elements that go into an intelligent building design requires a technology partner to provide the comprehensive interconnect solutions needed to make these designs a reality. Amphenol has the breadth of connector technologies, technical support, applications experience, and sales network to be your trusted partner for intellignet building designs.