www.knx.org

Consultants Guide

Contents

KNX, the world's only open standard for building control and automation.

Introduction

This guide is aimed at Consultants and Specifiers working within the Electrical and Mechanical industry who are actively involved with the design of intelligent, sustainable low energy buildings. This subject features at the top of every Building Service's Engineer's agenda today and will remain there in the future as we all take up the challenge and social responsibility of protecting our environment.

With any 21st century development, design for energy conservation is paramount if the demands of regulations, industry targets and Client requirements are to be achieved. This is where building controls play their part within the Electrical and Mechanical design process by providing the operating parameters, strategy, measurement and monitoring by which all systems are operated to.

So why are building controls so important?

If you consider all of the plant, equipment and components that would normally be specified by the Building Services Engineer to achieve the optimum energy performance against the Client's requirements such as luminaires, central battery units, fans, chiller plant, boiler plant, pumps, HVAC terminal units and very many other items that have to be specified, then imagine not having control systems to set these items to work. Add to this the ever changing climate / times of day and the human comfort factor and you should start to see the critical role for building control systems.

Without a functional, well designed and commissioned building control system, achieving optimum efficiency would be very difficult. This is only the start of the story as the control system should evolve and change as the building does overtime. Intelligent building control systems should be designed to cater for the changing needs of the building and offer suitable upgrade paths and expansion capability for the future.

This guide will introduce the concept of Open Protocol Integrated Building Control as opposed to the older traditional approach of many standalone separate systems. We will also show why lifecycle costing must be considered at specification stage and form an integral part of the tender process if we are going to achieve the carbon reduction targets set by Government and associated advisory bodies.

Challenges faced by the Consultant

In the past few years we have seen major shifts within the industry which has led to new challenges and opportunities for the M & E Consulting Engineer. The need to deliver sustainable design and to optimise the energy consumption from our buildings is now top of the agenda and possibly the single most important aspect of the design process. This topic has been highlighted by CIBSE (Chartered Institute of Building Services Engineers) as the industry's most important area of national focus and has been subject to many incentives and working groups.

New training courses and associated qualifications are now available for Consultants to allow them to address the key issues of sustainability, with many practices now offering their services as Low Carbon Energy Assessors. With the mandatory requirements for Energy Performance Certificates and Display Energy Certificates (EPCs & DECs), the Building Services Engineer is possibly now the most important figure within the construction industry when it comes to reducing CO_2 emissions.

Recent studies have been conducted by a number of bodies to discover where our CO_2 emissions are coming from. One such study by the Greater London Assembly concluded that around 62% of the CO_2 emissions in London originated from heating and lighting. These are the two key areas of building services that the Building Services Consultant would normally be responsible for. This amplifies the role of the Building Services Engineer and gives him the challenge of finding smarter ways to control this sector.

End Clients are now becoming aware of the CRCEES (Carbon Reduction Commitment Energy Efficiency Scheme) that will change the way many large energy users control and manage their real estate. The aim of CRCEES is to cut CO_2 emissions by 3.2 million tonnes by 2020, and forms part of the Government's target of an 80% reduction in emissions by 2050 from a baseline set at 1990 levels.

This will give M&E Consultants additional work with end Clients reviewing and offering ways to improve their overall carbon footprint. We believe that building control systems can have the largest effect and offer sensible energy payback periods on an annual basis. This is another good reason to consider KNX control as a key part of your energy strategy.

The Sustainable Approach

Sustainability has many meanings to many people and covers a very wide scope for interoperation. Within our industry the quote below has generally been adopted to define its meaning, and is all about considering the balance of energy and associated carbon emissions. It generally would not be considered sustainable to specify a low energy item that has been manufactured in conditions that fall below acceptable standards and, by the nature of the manufacturing process, any energy savings made after manufacture would be outweighed.

> *"Meeting the needs of the present without compromising the ability of future generations to meet their own needs"*

From this example you can see that sustainability starts at the very beginning with any product or system and having a good understanding of the manufacturing process and origins of the product is important when considering the environmental impact of your design. Coupled with this, the installation phase should be examined to see if environmental savings can equally be made. It is not uncommon for traditional electrical systems to be installed by a number of different companies with many different sets of cables, materials, components, plant / tools and associated transportation. In many cases this is found not to be cost effective or sustainable when there are smarter alternatives to specify.

Using the traditional model as described above can lead to higher site wastage as cable off-cuts, leftover containment and packaging will all add to the overall carbon cost of the construction process.

Using the lifecycle approach to consider any system must take into account the operation and maintenance phase. Will the systems be easy to maintain, reliable / robust with an upgrade path and spares available in the future? If for example a proprietary system was installed and after a short period of operating, needed to be repaired or parts replaced and the end user found that the manufacturer had now moved on to the new system with very little support for the old product, what would you do? At this stage it may be time to start thinking about replacing the whole system. This is a dilemma that many end users face and one that is clearly not sustainable and should be avoided during the design phase.

This guide should illustrate a smarter more sustainable way to the design and management of intelligent integrated building control systems.

Steps to Good Design Practice

The requirements for intelligent building control systems has never been in more demand than now due to more stringent regulations, increasing cost of energy, our awareness to save carbon emissions and the requirements to enhance human environmental comfort within buildings.

With the above criteria we have listed the following key points as the basis to good design practice:

- Start by considering the mechanical design with the electrical design and don't separate the two as there are many cross over points and many aspects that could be designed together. Very often one part of the controls system could be covered within the mechanical specification and another part within the electrical specification, both separated by strict works packages.

- Have an open mind to integration or one system for all. With today's open protocol systems we do not have to have many standalone separate systems. This approach can also lead to more efficient building control as many elements under control will interact with each other to give better human comfort.

- Allow flexibility within the project contractual documentation, works packages and budgets to promote good sustainable design. Get the cost consultants (QS) to buy-in to what you are trying to achieve. More often than not the Client will be on your side as the cheaper upfront cost of the alternative product or system will be the more expensive over a short period of time.

- Introduce lifecycle costing to the tender process and review energy payback calculations. You will be surprised how short payback periods can be with integrated building control systems.

- Design to save installation / cabling. Promote the use of a site-wide IP network for all systems to use. A CAT5e data network installed by a data cabling company throughout a building is now a standard feature. Let's all use this network for communication around the building and save on installation, labour and materials. The structured cabling network will prove to be very reliable and is a single asset to maintain. With most control systems very little bandwidth is required so don't worry about overloading the network.

- Consider using the electrical contractor for all of the cabling installation (you may have a separate data cabling company). Why have different companies installing different cabling systems?

Modern integrated systems promote this approach as their design is intended to be simple and logical to understand. This approach, if managed well, will prove to be beneficial in terms of cost saving and the overall sustainability of the project.

- Consider at design stage the upgrade path and supply of spare parts for the future. Many end Clients are faced with the problem of non-maintainable systems after a very short service life.

- Early engagement of the Systems Integrator is always a good idea for advice and design input. Many problems can be solved early on with the specialists onboard.

- Don't consider building controls as a 'black art'. Make the effort to understand what is being offered as there can be major differences between systems.

- Specify energy metering and monitoring systems to allow system performance checks and targeting. If you can measure the building's performance then you stand a far better chance to improve the overall energy performance.

- Form an understanding of the current Government led energy incentives / legislations such as CRCEES and translate to your Clients in practical terms, the measures that should be taken.

Why Open Protocol?

To start with it is probably worth defining exactly what open protocol means. In the world of controls this can very often have a wide interpretation. Open protocol refers to a bus system based around a known international standard, not manufacturer specific with one software tool used for programming and open to all to purchase.

One of the key benefits of an open protocol bus system is that it is supported by more than one manufacturer and a truly open protocol system will allow products from many manufacturers to be seamlessly connected together on the same network without the need for special application programmes or drivers etc.

The advantages of open protocol bus networks are vast and will give benefit to designer and end client alike.

Key Advantages of Open Protocol:

- Multi vendor products and support.
- Wide range of applications available on one network.
- You will never be tied into any one company.
- No expensive maintenance contracts to be locked into.
- Common software platform not manufacturer owned.
- Select from a wide range of products, mix and match the best in class.
- Standardised training open to all.
- The full system including software can be handed over to the end-user for ongoing maintenance.

With the open protocol approach you will find that your system will never date as there is an upgrade path to follow and in particular with KNX based systems there is a guaranteed forwards and backwards compatibility of products that could be used on the existing bus network.

The open protocol KNX system is very easy to extend at any later date as new bus lines can simply be added to the existing network. The approach is a bit like Lego for building controls.

About KNX – The world's only truly open standard

KNX is possibly the world's only truly open protocol system endorsed by worldwide standards. Formally known as EIB (European Installation Bus), and regulated by the KNX Association of Brussels. KNX is supported by some of the world's leading manufacturers within the electrical industry.

There are over 2000 approved KNX products from more than 150 manufacturers to select from covering all aspects of building control and automation. All KNX products are guaranteed to be interoperable between each other regardless of the manufacturer and product type. This is one of the unique features of KNX; unlike any other bus system the products are totally interoperable allowing you to mix and match without special software drivers or special applications.

One standard piece of software is used by all to commission the system and this is produced and sold by the KNX Association of Brussels. The ETS software (Engineering Tool Software) is manufacturer independent and is used all over the world by many System Integrators for engineering and commissioning of the KNX system. Regulated training is also given in many countries by approved training schools to allow Engineers to obtain the KNX Partner status. This qualification is also regulated by the KNX Association of Brussels who keeps a list of the approved Partners on the international website:

International website: www.knx.org

KNX UK website: www.knxuk.org

All approved KNX products show the KNX logo and are recorded by Brussels. There are other set procedures and design standards laid down on how to design the bus topology and how a system is set out. These standards are set out later within this guide.

Along with the standardised bus communication, products and software, KNX also has its own approved bus cable. The cable is manufactured by KNX approved companies to the same specification, guaranteeing quality and performance.

A typical KNX bus cable specification is shown over the page.

KNX – A Worldwide Standard

KNX is approved as:

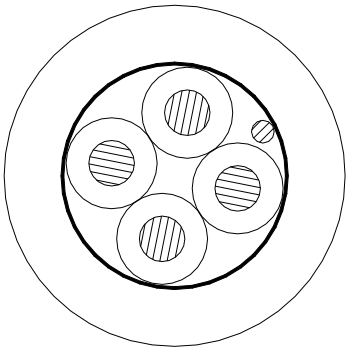
- International Standard (ISO/IEC14543-3)
- European Standard (CENELEC EN50090 and CEN EN 13321-1 and 13321-2)
- Chinese Standard (GB/Z 20965)
- ANSI/ASHRAE Standard (ANSI/ASHRAE 135)

Standard KNX Bus Cable Specification (2pr cable shown)

- Cores
  ***Conductor*..... plain annealed copper, circular solid, 0.8 mm**
  ***Insulation* ..... zero halogen polymer**
  ***Colour code* ..... red, white, black, yellow**

- Further Construction
  ***Laying up*..... Cores twisted to quad**
  ***Screen* ..... ALU / PETP-tape over tinned copper drain wire**
  ***Outer sheath* ..... zero halogen, flame retardancy polymer, green (RAL 6018)**

- Cable marking
  Printing* ..... EIB-Buskabelhalogenfrei and *Manufacturer's id thread



Technical Data

- *Flame retardancy:* **IEC 60332-1**
- *Amount of halogen gas acid:* **IEC 60754-1**
- *Degree of acidity of gases:* **IEC 60754-2**
- *Min. Bending radius:* **8 x Cable-∅ *(Installation)*** **4 x Cable-∅ *(Operation)***

- *Temperature range:*
  +5 °C up to +50 °C *(Installation)*
  -30 °C up to +70 °C *(Operation)*

Geometrical Data

Size	*Conductor size (nom.) n/mm*	*Overall-∅ (approx.) mm*	*Weight (approx.) kg/km*	*Calorific value (approx.) MJ/m*	
2 x 2 x 0.8 mm	**1 / 0.8**	**5.9**	**50**	**0.64**	

Electrical Data at 20 °C

	Character	*Unit*	*Values*	
Conductor size			0.8 mm	
Conductor resistance	***max.***	**Ω / km**	**36.6**	
Insulation resistance	***min.***	**MΩ x km**	**5000**	
Mutal capacitance	***nom.***	**pF / m**	**65**	
Characteristic impedance at 0.1 / 1 / 5 upto 100 MHz	***nom.***	**Ω**	**110 / 85 / 75**	
Attenuation at 0.1 / 10 / 100 kHz 1 / 16 / 20 / 31.25 / 62.5 / 100 MHz	***nom.*** ***nom.***	**dB / 100 m** **dB / 100 m**	**— / 0.46 / 1.16** **4.1 / 10.5 / 11.3 / 12.8 / 17 / 20.3**	
Crosstalk attenuation at			***nominal***	***min. request at EIB***
1 / 10 / 100 kHz		**dB / 100 m**	**90 / 80 / 78**	**80 / 70 / 60**
1 / 16 / 20 / 31.25 / 62.5 / 100 MHz		**dB / 100 m**	**73/61/60/54/52/48**	**nicht definiert**
Test voltage *(Core / Core)* ***(Core + Screen / Water)***	U_{rms} U_{rms}	**V** **V**	**800** **4000**	
Max. operating voltage	U_{SS}	**V**	**350**	
Operating voltage	U_0 / U	**V**	**250 / 250**	

Overview of Applications

The KNX bus system can be used for a very wide range of building control and automation applications across all market sectors from industrial / commercial through to residential projects. It is typical for the system to be used for many different applications on any one project.

Typical KNX applications:

- Lighting control applications
- Blind and solar control
- Window control / natural ventilation
- Field control of HVAC
- Underfloor heating control
- Metering and energy management
- Security applications
- Monitoring systems
- AV Control and interfacing
- Smart home automation systems
- Touch screen control & visualisation packages
- IP connectivity & remote access systems
- Interfaces with many third party systems
- Many other forms of control & automation.

There is no limit to the size and scale of the KNX system as the technology is equally well suited to large-scale projects and small residential projects alike. There are many reference projects to demonstrate the strength of the system; some are shown in later sections of this guide.

In terms of device limits you will see that one KNX line can support up to 64 devices using a single power supply. These lines can be repeated and cascaded to include many lines of 64 and when using IP and the backbone the system is virtually limitless.

KNX is very powerful when it comes to interfacing with other systems or bus networks as there are many well established gateways into a large number of systems. This also includes an OPC Server (OLE for process control) for SCADA type interfaces. These interfaces and gateways are commonly used all over the world and have been tried and tested and are now ‘off the shelf’ solutions.

A list of KNX interfaces is detailed over the page.

Schedule of KNX interfaces to third party systems and other bus networks:

BACnet
LON
Modbus
RS232
M-BUS
DALI
DSI
DMX
1-10V Analogue systems
Crestron
AMX
EnOcean
Bluetooth
Infrared interfaces
RadioBus Wireless systems
IP Interfaces
USB Interfaces
Serial Interfaces
Commercial boiler plant
Air conditioning equipment
Domestic appliances
Access control / locking system interfaces

Systems Layout & Installation Details

The topology of a KNX bus system is design around a simple logical set of rules making it easy to install and understand. The bus network is wired using one type of cable for all parts of the bus and connections to devices. The bus cable is recognised by its green outer sheath and will always have the KNX or EIB logo stamped at regular intervals. The cable is generally a single twisted pair 2 x 0.8mm^2, red and black insulated conductors of solid copper construction. However, it is very common for a 2 pair version to be used with the yellow and white insulated conductors being spare or used for auxiliary power for devices.

Whether the single or two pair cable is used, the specification and properties of the cable will always be the same and should be manufactured by one of the KNX Association approved suppliers. The bus cable is designed to be installed with mains 230V cabling, very often using the same containment and routing. The outer sheath offers insulation resistance to 600V and the communication protocol is immune to mains borne noise from surrounding cables. This is an advantage during the installation as the KNX bus cabling can be installed by the Electrical Contractor at the same time as the mains cabling is installed using the same methods. KNX bus cables are suited to most forms of wiring systems including traditional tray, trunking and conduit or modern pre-fabricated wiring systems.

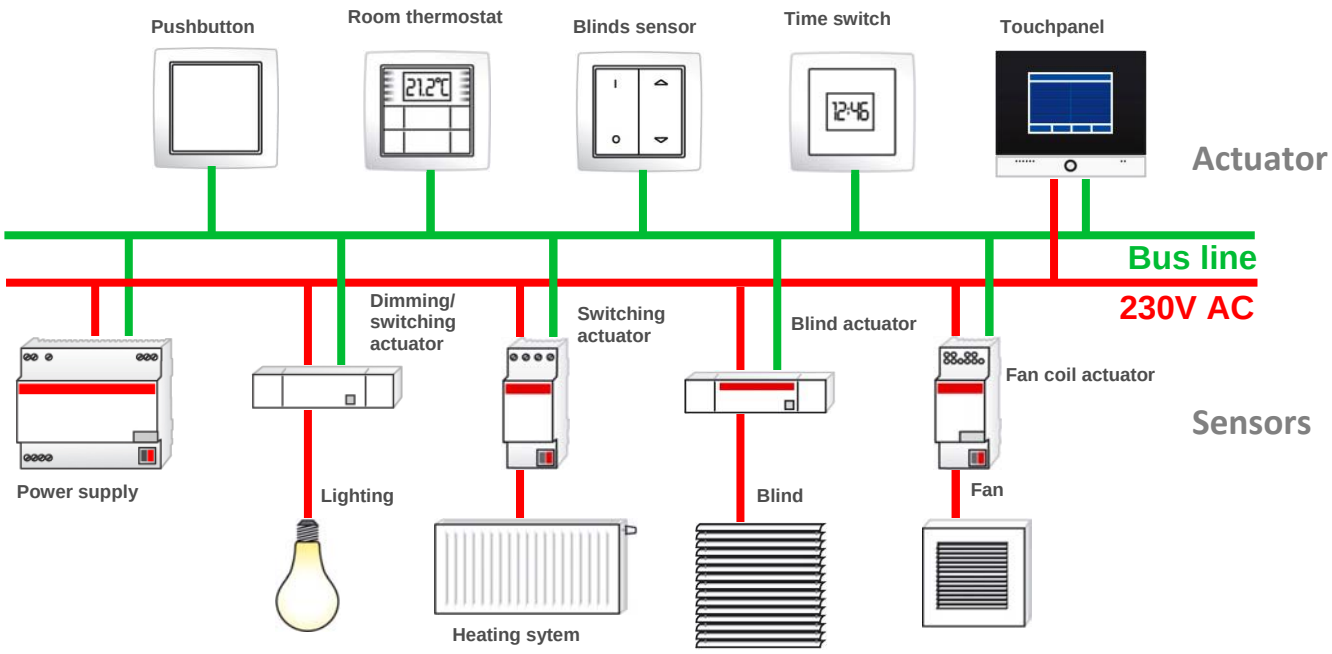
There are many suitable plug and connector systems available for KNX bus wiring (Wieland & Wago for example) which offer simple fast installation methods that can form part of larger pre-fabricated wiring systems, and again can all be installed by the one Electrical Contractor and not a specialist controls cabling company.

The end terminations of the bus cable have been designed to be simple and trouble free and generally the same connection method is used for all terminations.

Typical bus connector & cable details

A typical KNX installation will normally consist of a control panel designed to house the KNX power supply(s) and other DIN rail mounted devices. The control panel will be sized to suite the project as KNX is a modular system whereby components are selected depending upon the requirements of the project i.e. you can be provided with a system tailored to meet your design specification, not stuck with standard fixed equipment.

This modular design approach gives maximum flexibility without compromising functionality as the system can be designed to overcome many of the well-known site issues such as limited riser space and or ceiling void space. One other key point to note is that the control panel could form part of the electrical distribution board, saving site labour and space. A KNX system can also be designed without any central control panels and be completely distributed in the field.



A typical KNX Bus network with mixed devices

The Integrated Approach

KNX has always been at the forefront of integrated building controls as the underlining philosophy of KNX is to bring different manufacturers' products together on one bus network and to be completely interoperable with each other. This has been achieved and will always be one of the core principles of KNX. With this in mind you can start to understand why KNX is now one of the world's widest used bus technologies with international standards recognition. So when we refer to integration we mean not only is KNX fully interoperable between manufacturers and their associated products, but KNX is at the heart of building-wide integration of control applications.

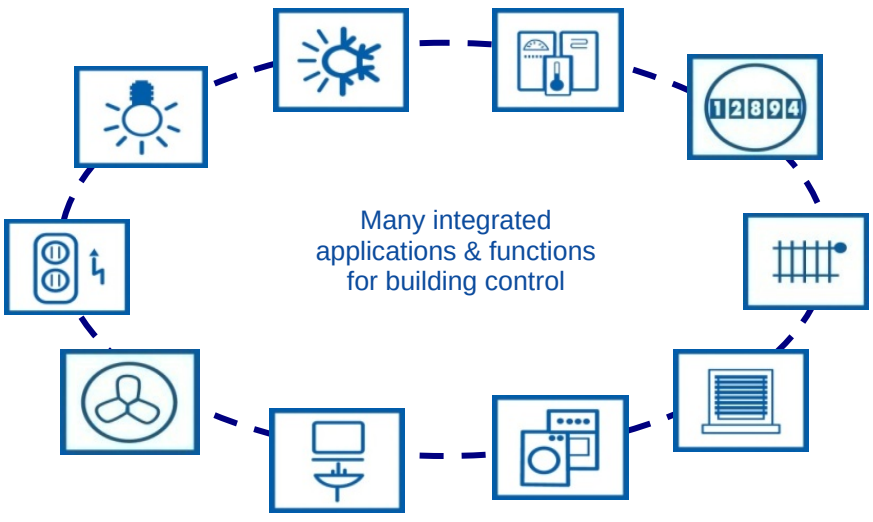
The traditional approach of considering every single control application as a standalone system can now be reconsidered to think of different applications working together on one single bus network. KNX can be designed building wide as the underlying bus technology for many control applications such as lighting control, façade control, underfloor heating and radiator zone control all operating together on the same bus network. This example may consist of a number of different manufacturers' products but the bus network will be common to them all. Integration is all about bringing control applications together and allowing them to operate together sharing information about the space being controlled. If you consider a small office with lighting control, fan coil unit heating / cooling, automatic blind control and perimeter low level heating all being controlled by a single KNX bus network with one wall mounted KNX device for the room temperature control, lighting scene set control and blind override along with a single ceiling mounted KNX presence detector, then you will be able to understand the savings.

The example above illustrates the saving in terms of installation and energy efficiency as the presence detector will set the room to occupied mode taking the fan coil unit to setpoint from the standby temperature, activate the lighting and daylight dimming strategy, set the blinds to the correct position based on external LUX and solar radiation. Along with the KNX wall mounted temperature controller the space will be controlled to achieve optimum efficiency and comfort with some manual override if needed. All of this is simply controlled by the various KNX devices communicating together within the space and not via some central PC or outstation.

When this form of integrated control is implemented across a large site you can really see how major saving can be made over and above the traditional approach while sill maintaining a solid robust system.

Advantages of Integration with KNX:

- Reduced site installation
- Less cabling, containment and wastage
- Efficient installation - one contractor – one system
- Increased levels of control and functionality
- Increased energy efficiency – more sustainable
- Improved environmental comfort
- Enhanced user experience
- Reduced number of devices on the wall
- Wider range of products to select from
- Not locked into any one company or manufacturer
- Data can be passed from one application to another
- Applications can share devices
- Standard commissioning procedures
- Open protocol – end client has full access
- Flexible and fully upgradeable
- Forwards compatibility
- Reduced maintenance



Practical Example 1 – Lighting Control

Practical example 1 – Lighting control

KNX is well suited for lighting control applications and is fully scalable to deal with small and very large projects alike. The KNX bus system has products to support all forms of control including:

DALI
DSI
Analogue 1-10V
Universal phase cut dimming
Switch actuator control
DMX interface

A typical installation may consist of any one of the above forms of control or a mix of the above. KNX is all about selecting the necessary products for the application and not being restricted by the restraints of traditional lighting control systems. Most products are DIN rail mountable allowing a system to be provided with the components you need for your project.

KNX lighting control schemes can be applied across a wide range of buildings from residential to large commercial / industrial projects controlling many different forms of luminaires. Architectural along with general functional lighting can be controlled using the same system as there are many field KNX devices to complement the system.

Touch screens, scene set push button, presence detectors and remote control devices can all be provided by the KNX system in a wide range of finishes and styles. There are off-the-shelf gateways available to many AV systems including Crestron and AMX allowing seamless integration into third party systems.

A typical installation may include central KNX control panels housing the DIN rail equipment (central components) including the systems power supplies. The 230V lighting load circuits would normally be wired back to this panel as part of the general electrical installation for traditional switch control or phase dimming. For DALI systems only a two core cable is needed to link up to 64 DALI ballasts / devices together from the central control panel.

The green KNX bus cable would be run from the control panel linking together up to 64 KNX bus devices in the field (push buttons, presence detectors etc). If there are more than 64 KNX devices in the field a number of KNX bus lines can be run from the panel. Control panels located on different floors or zones can be linked together using KNX bus cable or via an IP network.

The design concept for KNX is very modular and flexible to allow scalability and future upgrades.

If there is no space for central control panels or due to wiring problems you cannot wire back to a central location, then there are many KNX distributed products that can be located in the field. For example the DALI gateway or dimming modules can be distributed and sited by each circuit under control removing the need for any central control panels.

Within the KNX product basket there is a KNX wireless solution that can be used with the normal bus connected devices or as a standalone system. The wireless devices are excellent where you cannot get cables to a device or if installing bus cable is too expensive such as refurbishment projects in old buildings.

Within the KNX range of products there are many headend visualisation options and touch screens that could be incorporated within a system. There is also a tried and tested OPC KNX solution that could be used to connect a KNX network to a common SCADA system.

The key points to note with KNX lighting control is the flexibility of mixing and matching products. This allows you to specify exactly what you need for a project.

In terms of energy saving, lighting is considered to be one of the main energy consuming components within a building. Up to 45% of the total energy used within a typical commercial building could be attributed to the lighting load. Using a well designed KNX lighting control solution over conventional control you could save up to 60% of the energy that would normally be consumed. Presence control with daylight linked dimming using the KNX / DALI solution would generally offer the best overall savings.

For further detailed information on KNX lighting control systems, please contact one of the Manufacturers or System Integrator Partners. A full list can be found at the KNX UK Website: www.knxuk.org

Practical Example 2 – Blind Control

Automatic electric blind control systems are now considered to be part of the dynamic façade management solution for a building. If you can control the glare and solar radiation entering the building, you can make major saving on the internal cooling energy. The saving on mechanical cooling could be up to 40% by reducing the solar gain within the internal space.

Glare control improves the internal environment for all occupants and increases the comfort within the occupied space. With everybody at work now using PCs and visual display screens optical comfort must be considered at design stage. This is a key factor now that many buildings have a 90% glass façade.

KNX blind control solutions are modular and fully scalable, similar to the lighting control systems. There are products that can control 230V and 24V blinds along with other more specialist encoder motor systems. A typical KNX blind motor controller or shutter actuator, as it is sometimes called in central Europe, can be DIN rail mounted or field mounted. There are many different manufacturer products to select depending upon the application and wiring configuration.

One of the key benefits with KNX blind control is that it can sit on the same KNX bus network as the lighting control or any other KNX network that may be planned. No one KNX application should be considered as a separate standalone system as all KNX devices can sit side-by-side on the same bus network. Once you have your blinds connected to the motor controller you can use any KNX sensor or group of sensors to control the blinds.

Within the KNX product range there are weather stations, LUX sensors, temperature sensors, solar radiation sensors, wind sensors, rain sensors along with the normal internal sensors such as presence detectors and push buttons for override control that can all be used as part for the overall blind control strategy. Savings can be made when you have a KNX lighting and blind control system together as they share the network and associated sensors.

KNX can be interfaced with many other systems including AV systems and building management systems (BMS) such as the BACnet based systems or via OPC. If needed, a headend package can be provided for central control and monitoring.

For further detailed information on KNX blind control systems, please contact one of the Manufacturers or System Integrator Partners. A full list can be found at the KNX UK Website: www.knxuk.org

KNX Reference Projects

The British Library, London

Heathrow T5, London

Oundle School, Peterborough

Media City, Salford

KNX Reference Projects

Bridgewater Place, Leeds

Bird's Nest Stadium, Beijing

Networked City, Flensburg

For further information on any subject within this guide, please visit the KNX UK website where you will find information about our members and our technology.

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KNX - the world's only open standard for building control and automation