MITSUBISHI
ELECTRIC DIRECT
AIR CONDITIONING SYSTEMS

Information Guide

Guide to Building Energy Management Systems

CPD CERTIFIED
Construction CPD Certification Service

Issue **Five**

MITSUBISHI ELECTRIC DIRECT
AIR CONDITIONING SYSTEMS

Guide to Building Energy Management Systems

Information Guide

This is an independent guide produced by Mitsubishi Electric to enhance the knowledge of its customers and provide a view of the key issues facing our industry today. The guide accompanies a series of seminars, all of which are CPD accredited. The changing face of construction in the 21st Century demands that designers, specifiers and suppliers work as teams to create better buildings - for occupants and the environment. Mitsubishi Electric aims to be a part of this by encouraging employees and customers to work together to increase their knowledge of the latest technology, legislation and markets.

Contents

Controls at the heart

Developments in cooling technology by leading air conditioning and other manufacturers have made the building services plant of today the most efficient ever. However, it is building controls which can really make or break the energy efficiency of a commercial building. Even the new Part L of the Building Regulations recognises this fact, emphasising the crucial role that building control systems have to play in ensuring that all building services equipment operates at optimum levels.

The effective control of any type of building plant depends on real-time knowledge of the environment in which the building services plant is operating. Tracking of energy use across many areas of the building, and pieces of equipment is vital. The most advanced building controls systems also monitor external environmental conditions, to make the most of specialised building features such as natural ventilation, in a mixed-mode cooling system.

Because of the constant stream of data into and out of building control systems, they can appear very complex, but at the heart of most types of control is the 'control loop'. This consists of three connected elements: a sensor, a controller and the controlled device, such as an air conditioning unit, or boiler.

The simplest form of control is on/off or 'two-position' control. This system uses a thermostat or temperature sensor to switch the plant on or off, according to a pre-programmed temperature, or 'set point'. For some purposes, such as lighting, this form of control is entirely adequate. A good example of on/off control is the room thermostat found in wet central heating systems for the home. With a relatively small space to heat and short pipe lengths, on/off control will be reasonably effective.

However for the more complex HVAC plant in large commercial buildings, on/off control is limited in its effectiveness. In practice, there is always a time lag between turning the controlled device on or off which has an effect on the controlled space - there will be either an undershoot or overshoot before the setpoint is reached, leaving the space too hot or too cold for occupants.

Control is often therefore enhanced by including an accelerator heater within the thermostat, so that the thermostat switches off before the setpoint temperature in the room is reached, reducing the overshoot. A timed programme of heating periods can also be added to the control.

There are therefore a number of types of control, which can be used by building designers, depending on the building itself, or the requirements of occupants. These include proportional control, proportional integral control and digital control.

Proportional control (P)

Proportional control enables greater accuracy in achieving the setpoint temperature, or any other environmental measure such as as humidity or CO_2 levels in an occupied space. The control system produces an output which is directly proportional to the difference between the setpoint and the actual value. For example, in a heating system, the further the actual room temperature falls below the setpoint temperature, the greater the heating output.

Proportional integral control (PI)

This combines proportional control with integral control. It changes the output proportionately in relation to the rate of deviation from the setpoint. This form of control therefore introduces time as a function of control.

Intelligent controls

Many buildings are now described as 'intelligent' suggesting high levels of control, with all aspects of the building services and other elements working in harmony to create the perfect indoor environment. In particular, intelligent building controls have some kind of learning capability, using control algorithms. The two main types of intelligence used in building controls are fuzzy logic and neural networks. Both of these techniques have been designed to echo the way that humans make decisions. In fuzzy logic there are 'degrees' of truth in the same way that we might describe a room as 'very cold', 'a bit cold', 'about right' or 'a little bit too warm' – a long way from simple on or off mechanisms. This type of control logic is particularly useful for HVAC.

Neural networks are useful for making sense out of large amounts of disconnected and non-linear data. Suitable applications include plant condition monitoring and energy management.

Building Energy Management System (BEMS)

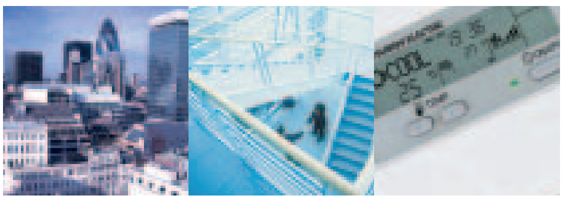
The modern BEMS uses the basics of control to provide a single supervisory system for a whole building or large complex. As well as the mainstream HVAC function, the BEMS can supervise all the automated systems such as lighting control, fire protection, lifts, intruder detection and access control. Early systems used dumb sensors and actuators with all decisions made by a central computer or control unit. In the modern BEMS, intelligence is distributed via local DDC outstations which carry out all the programmed functions, even if communication with the central supervisory computer is broken. Hand-held technology can also be used, enabling maintenance teams to work remotely.

Energy efficiency

Where energy management is concerned, if it can't be measured it can't be managed. A well designed BEMS gives a range of options which can improve energy efficiency without compromising the comfort of the occupants in the building. Monitoring and targeting enables building operators to know where energy is being used and where this can be improved. For sites spending up to £100,000 in energy it will normally be best to analyse energy usage manually or with a simple spreadsheet. For larger, more complex sites a complete M&T software package will probably be the best option. The new revisions to Part L of Building Regulations (and their equivalents in Scotland and Northern Ireland) cover the conservation of energy and emphasise the need for energy metering and sub-metering. The BEMS lends itself to collecting the data automatically from the meters in larger buildings.

The BEMS can also provide information on the running time and condition monitoring of the building plant. This information can be incorporated into a scheduled maintenance programme suited to the individual building. For example the BEMS sensors can measure the pressure drop across the air filters and indicate when they need to be replaced.

Overall, a BEMS can sit at the heart of a modern commercial building, ensuring smooth operation, long-term energy efficiency and enhance the understanding of its functions by giving building operators a clear view of what is happening where.



Talking the talk

The BEMS can incorporate hundreds, or even thousands, of control points – sensors, detectors, damper actuators, valves, fans, pumps, etc, linked to intelligent outstations and a supervisory computer. As with all computer technology, the amount of data generated has increased over time as systems become more sophisticated and complex in their capability. Components, often manufactured by different suppliers, must be able to communicate. For the system to work properly, the flow of signals must not interfere with each other.

The complexity of today's BEMS means that the amount of cabling for the system has become an ever more important factor. Clearly, if every control point is connected directly to a single central control unit, the amount of cabling will be unworkable and expensive. This problem is answered by network architecture, topology design and system integration.

System architecture

The standard BEMS architecture as it has developed over the past decade or so, comprises three levels:

Level 1 Management level - supervisory computer(s).
Level 2 Automation level - DDC controllers, intelligent outstations, central plant.
Level 3 Field level - sensors, actuators, unitary controllers (e.g. AHUs, fan coil units, VAV boxes).

Topologies

Networks, particularly at field level, come in a variety of topologies. The topology determines the amount of cabling needed and the flexibility of the network. It can also affect technical characteristics, such as signalling and reliability. The following are the most widely used topologies:

Ring - a ring cable with devices connected directly to the databus.

Simple bus - similar to a ring network but with a linear cable acting as the databus.

Star - each device is directly connected to the central control unit.

Tree - a combination of databus and star topologies.

Protocols

In networking, the term protocol refers to a set of rules that govern communications. Protocols are to computers what languages are to humans. For any two devices on a network to successfully communicate, they must both understand the same protocols. The move from proprietary protocols, developed by each BEMS manufacturer, has moved to open platforms. This has enabled much greater interoperability between devices from different manufacturers. However, instead of a single universal open protocol, several competing open protocols have been developed.

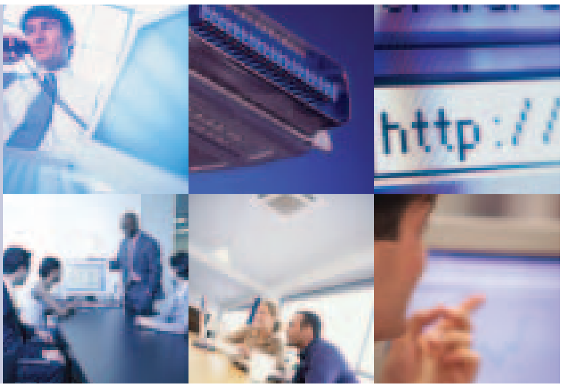
Technology has raced ahead of the technical standards bodies, but the ISO (International Organisation for Standardisation) has developed a design model (ISO 7498) which all protocol development should reference. The European standards body, CEN, is also developing several new standards for network protocols. Effectively, such standards set the 'grammar' for the language, but they haven't prevented a number of BEMS languages springing up. The following are the most important protocols used in building control systems:

Ethernet

This is the starting point of all network technologies. It was first developed as a computer network at the Xerox Palo Alto Research Centre (PARC) in 1973, incorporating a design for the physical cabling and connection of devices plus the communications protocol. Such a network is often called a LAN (Local Area Network). Ethernet today is still the dominant network system for IT networks and as such can be utilised by the BEMS.

LonWorks®

LonWorks®, developed by Echelon as an open platform for networked devices, is based on the LonTalk protocol. One of its main uses is in building controls but it is also widely used in diverse applications such as process control, traffic management



and power stations. Networks can range in size from two to 32,000 devices. LonWorks® is object based. This means that each sensor, detector, actuator, etc is treated as an object with properties that define its purpose. These objects form the building blocks of the system. For example, a sensor object will be able to identify itself, its output (temperature, humidity, etc) and any other optional properties.

Each LonWorks® device has a neuron microchip containing a unique and permanent 48-bit identifier called its physical address. Once the device is connected to a network it is assigned a device address. Device addresses are used instead of physical addresses because they support more efficient routing of messages, and they simplify replacement of failed devices. Although each LonWorks®- compatible device must contain the proprietary neuron chip, the chip can be sourced from different suppliers and competitive pressures keep the price down. Application development of LonWorks® is coordinated by LonMark International, a group comprising manufacturers, end-users and system integrators.

BACnet®

BACnet® (Building Automation and Control Network) was developed through ASHRAE as an open network protocol specifically for building energy management systems. As such, it was tailored for the type of control devices found in buildings. BACnet® is also object based, but it defines a number of standard object types (23 at the moment but this number will increase as new device categories are introduced). Along with LonWorks®, BACnet® is probably the most commonly used protocol used in building controls.

ModBus

Modbus was one of the first network protocols developed to enable communications between devices in industrial automation. It is used to establish master-slave/client-server communication between intelligent devices. The protocol has now been integrated with the TCP/IP protocol, the standard protocol used by Ethernet and the internet. This enables the benefits of simplicity and low cost thanks to the widespread penetration of TCP/IP devices.

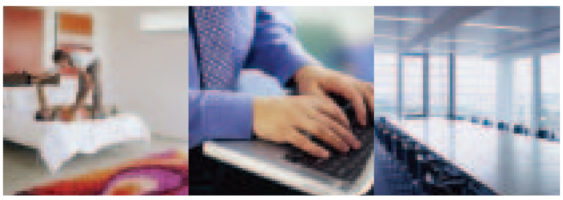
KNX

Three existing European databus protocol standards (Batibus, EIB and EHS) are being harmonised into a new single standard, KNX, for home and building automation. Development is managed by the Konnex Association, which has 95 members and includes major electrical and consumer products manufacturers.

Internet

Whist manufacturers and technical standards committees have spent the best part of 15 years busying themselves with protocol development, the Internet has been created to form the world's information network. Its protocol, TCP/IP, has provided a useful ready-made system for BEMS communications. It is particularly useful for remote monitoring and communication, enabling facilities managers to supervise a BEMS from anywhere as long as they can be connected to the Internet. The use of standard browser software such as MS Internet Explorer makes the whole task even easier.

The large number of competing protocols makes life difficult for manufacturers who want to make devices that can be used with any of the main systems. Network gateways and routers that translate signalling between two different protocols are becoming increasingly important to enable compatibility. It does seem though that the internet will probably become the preferred communication conduit, in that it is a proven technology with almost endless possibilities for development of control tools. Truly, an international language of buildings.



The future

Building controls are closely linked to the wider world of IT, so inevitably developments are similarly fast paced and not always easy to predict. Whilst the basic technology in a boiler or air conditioning unit of today will be little different to one produced 10 years ago, controls technology develops at a much faster rate.

There are however a number of trends which can already be spotted, which point the way for controls in the coming decades.

Wireless communications

The use of RF (Radio Frequency) has already become more common in building automation. Wireless IT networks are now seen in many buildings and the technology is already being adapted to building controls. The advantages are clear: no wiring, which means enormous flexibility in siting devices and simple and quick installation. Since the rooms in commercial buildings are often re-partitioned and have their uses changed at intervals, the benefits of wireless communications are clear.

However, wireless communications will always be more prone to interference than hard wiring, and such devices have to be within range of the wireless transceiver outstation. Development of the standards for wireless communications falls under the IEEE Standards Association. The Association has increased data transfer rates, once a major drawback because they were slow, to 54Mb/s. The IEEE 802.11 standard has been called 'Ethernet without wires'.

Remote monitoring – M to M

One of the main benefits of a BEMS is the ability to monitor all parts of the building from a central base. For example, on large sites this means that the facilities manager can respond to an alarm quickly and efficiently, rather than wait for a phone call complaining that the room's too cold. Machine-to-machine technology takes this benefit a stage further.

Facility managers or other maintenance staff can be alerted wherever they are via mobile phone, handheld organiser or email. Also, machines including this technology can automatically send signals once they detect a potential failure in any component. For example, a message could be automatically sent to a maintenance operative's mobile phone, with a code describing the malfunctioning part. Even before the client realises that the air conditioning isn't working, a repair can be underway.

Plug and play

Any user of a PC will be familiar with the benefits of plug and play devices. For example, when you connect a new scanner your PC automatically recognises the device and takes you through the installation procedure on screen. Plug and play capability for control devices is a facet of inter-operability. Sensors and actuators will become more standardised in the way they integrate with the BEMS giving customers and system designers more choice in selection.

Web-based building controls and the Internet

As already highlighted in this Guide, the Internet has brought about profound changes in control system design.

Two main benefits are clear:

A. Using already developed IT standards like TCP/IP protocol and HTML (and its derivatives) programming language makes life so much simpler for the system designer.

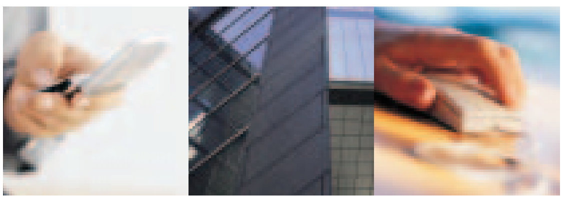
B. Off the shelf PC browser and graphics software is much less expensive and more usable than most custom-designed software packages.

The use of TCP/IP has spread from the management level network of a BEMS down to field level. The very concept of a three level system is changing thanks to the use of IP.

Intelligent buildings

The concept of an intelligent and fully-automated building has been around for many years, but the recent developments in IT make it a far more practicable proposition. Certainly individual devices and items of plant are becoming ever more intelligent asmanufacturers incorporate greater automation. Part of this is driven by the cost benefits of automating tasks previously done by facilities or maintenance staff.

Energy efficiency is another driver in the development of systems that automatically monitor and control energy usage. As well as the reduction of carbon dioxide emissions that are causing climate change, energy efficiency will produce significant cost savings since the fast depletion of fossil fuels will almost certainly increase energy prices long term.



Further information

Glossary

Algorithm
A rule for solving a mathematical problem in a finite number of steps. In BEMS design algorithms are the building blocks of control functions.

Cascade control
An arrangement for larger spaces whereby a slave unit controls the controlled variable and a master unit controls the setpoint of the slave.

Gateway
Device that translates signalling between two networks using different protocols allowing complete interoperability between each of them.

Node
An addressable device connected to a network.

Optimiser
Controller using optimum start algorithm.

Programmable Logic Controller (PLC)
The traditional controller used in intelligent outstations – it is often modular so that different function controls can be added.

Router
Similar to a gateway – a device that enables communication between networks using the same or different protocols.

Setpoint
The set value (e.g. temperature) which the controller seeks to achieve.

TCP/IP
Transmission Control Protocol/Internet Protocol – the standard protocol used in Ethernet and the Internet.

Unitary controller
Field level device that controls a single piece of equipment such as a chiller.

Weather compensation
Heating control incorporating an outdoor sensor so that the flow temperature is adjusted according to the weather.

If you missed the CPD seminar on **Building Energy Management Systems**, you can call your Mitsubishi Electric Regional sales office to arrange an in-house presentation of this information.

Please call one of the numbers below:

East Anglia & London North East	**01707 282480**
London North West	**01707 282480**
London South West	**01707 282480**
London South East	**01707 282480**
Birmingham	**0121 7412800**
Bristol	**01454 202050**
Scotland	**01506 447722**
Leeds	**01924 299875**
Manchester	**0161 8666060**

MITSUBISHI ELECTRICDIRECT
AIR CONDITIONING SYSTEMS

Direct Sales Offices

Birmingham
Tel: 0121 7412800
Fax: 0121 7412801

Bristol
Tel: 01454 202050
Fax: 01454 202900

Leeds
Tel: 01924 299875
Fax: 01924 363639

Scotland
Tel: 01506 447722
Fax: 01506 447755

Manchester
Tel: 0161 8666060
Fax: 0161 8666081

London South Region
Tel: 01707 282480
Fax: 01707 282482

London North Region
Tel: 01707 282480
Fax: 01707 282481

MITSUBISHI ELECTRIC
AIR CONDITIONING SYSTEMS

Telephone: **01707 282880**
email: air.conditioning@meuk.mee.com web: www.mitsubishielectric.co.uk/aircon

UNITED KINGDOM Mitsubishi Electric Europe Air Conditioning Systems Division
Travellers Lane, Hatfield, Hertfordshire, AL10 8XB, England.
General enquiries Telephone: 01707 282880 Fax: 01707 278674

IRELAND Mitsubishi Electric Europe Westgate Business Park, Ballymount, Dublin 24, Ireland.
Telephone: Dublin (01) 419 8800 Fax: Dublin (01) 419 8890 International code: (003531)

Issue 5 (October2005)