TEKA. COMMISSION OF MOTORIZATION AND ENERGETICS IN AGRICULTURE – 2013, Vol. 13, No. 1, 57–64

Intelligent control for HVAC devices in LCN system

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Received January 26.2013; accepted March 14.2013

Summary: The present paper describes the components of intelligent electric systems used in the building automation systems for HVAC installations control as well as methodology for designing said installations using LCN – Local Control Network system as an example combining the tasks performed by a conventional system and introducing multiple new functionalities making it possible to control individual systems in the building, including HVAC installation.

Key words: heating, control, intelligent, designing, integration, installation.

INTRODUCTION

Electric energy is the most cost-consuming element generating the highest financial burdens in the housing sector [21]. Therefore, newly erected objects are equipped with the systems enabling energy minimization through the cognizant energy management i.e. the systems controlling the devices operation in a manner imposed by operating personnel in order to minimize energy losses [3, 4, 5, 6, 12, 18].

Due to technological development, the contemporary buildings should ensure proper and effective working conditions for their users [14]. It is possible to achieve this goal by means of the state of art, integrated and automated electric installation systems. Therefore, the designers are required to perform a completely new task as a result of such approach to the designing and completion of electrical installations on the basis of technical novelties. In recent years, increased requirements have been observed in the scope of forming a microclimate in rooms. The assurance of proper air quality (described by means of temperature and humidity) becomes an essential task to be performed by an intelligent building. Aforesaid requirements can be met by introduction of modern HVAC systems (Heating, Ventilation, Air Condition), i.e. the heating, ventilation and air – conditioning in the rooms [1, 2, 7, 16, 19, 20].

LCN system has been created and introduced to the market by a German company – ISSENDORFF Mikroelektronik GmbH. The system can be installed in small objects as well as in large buildings, like in case of Main Tower in Frankfurt or F1 racing track in Germany [13].

LCN belongs to leading intelligent control systems worldwide and to the most popular solutions in the scope of buildings automation in global scale. The features of an intelligent building are demonstrated by the degree of integration of installations provided therein. HVAC systems constitute an important element of a modern and fully automated building. The present paper describes the basic elements of LCN system applied in HVAC installation with particular consideration of their programming by means of LCN Pro utility program.

The technological progress in the scope of building sector contributed to the use of more and more new and complex systems dedicated for devices controlling. Due to such complexity and diversity of installations, it was necessary to introduce a system enabling the management of the whole system with all the devices in an integral mode. Another important factor consists in the fact that it is impossible to manage the building energy resources by means of old type installations.

In practice, an intelligent building makes it possible to save 20 up to 30 % of energy; these calculations are realistic even in case of reduced stability of daily and monthly distribution. With increasing speed of our life, we are more interested in the comfort of buildings and in their convenient use. Routine everyday activities can be performed by the building management system to be controlled properly by all of us as the users.

LEGAL AND NORMATIVE REQUIREMENTS IN THE SCOPE OF VENTILATION

Pursuant to building law, the designers of ventilation systems are required to meet determined requirements to ensure proper conditions in the scope of hygiene and energy consumption. Air change intensity in the building should be modified depending on concentration of the emissions caused by the persons occupying a room and by the devices installed therein.

The amount of air to be removed within one hour from various types of rooms is specified in case of residential buildings. In public utility buildings, the requirements can be met on the basis of fresh air supplied to each person staying in such room.

The issues associated with thermal comfort perceived by the employees in office rooms are governed by PN-EN ISO 7730:2006(U) standard: "Thermal environment ergonomics. Analytical determination of thermal comfort and its interpretation applying the calculation of PMV and PPD indicators and local thermal comfort criterion" and the draft of prEN 15251 standard: "Criteria of indoor environment, encompassing thermal conditions, inside air quality, lighting and noise" [22, 23]. The indicators presented in both documents are used to describe thermal comfort. PMV indicator (Predicted Mean Vote) depends on: activity of an individual, insulation of his / her clothing, air flow velocity as well as its temperature and humidity. The indicator determines the mean vote for thermal environment in the rooms (for a group of persons) in seven step scale: – 3 (cool), 0 (neutral), +3 (hot).

PPD indicator (Predicted Percentage of Dissatisfied (people)) is the next thermal comfort indicator, closely associated with thermal comfort. It must be recognized that owing to individual perception, it is impossible to achieve identical thermal comfort that can satisfy everyone in the same room.

Three basic categories of office rooms are specified in the draft of prEN 15251 standard [7]:
- Class A – PPD < 6%,
- Class B – PPD < 10%,
- Class C – PPD < 15%.

Therefore, it can be concluded that the requirements applicable to class C are met by the majority of objects in Poland and that only a small number can be classified in class B.

REDUCED CONSUMPTION OF ELECTRIC ENERGY AND COMFORT OF USE AS ONE OF ESSENTIAL GOALS OF LCN

We live in times where significant attention is paid to saving of natural resources due to their decreasing amounts and increasing prices. The majority of object resources in the form of thermal and electric energy originates from natural resources processing. Therefore, rational use of electric energy or thermal energy generation became a priority.

Currently, the scope of two principal fields of systems integration encompasses the integration of object security systems as well as building automation systems. The purpose of the first field is to integrate the following systems together: burglary and attack alarm system (SSWN), access control and closed loop control television system (CCTV) in order to enable proper building safety management and to accelerate the support of alarm, emergency and fire signals. The building automation system encompasses the control functions in the scope of heating, ventilation and air-conditioning as well as the control functions in the scope of shutters, lighting, lifts, doors and their power supply system (including holdup systems).

The purpose of the building automation systems integration is the eagerness to achieve savings. A structural network is often used for this task. Simultaneously with increasing prices of electric energy, the reduction of energy consumption in the building causes more and more problems.

Each system makes it possible to reduce the operation costs. For example, the cooperation of systems with each other in the scope of temperature comfort and ventilation in determined room of the building can be commenced at the time of logging in to the system by means of employee's identification card and the temperature will be maintained on an economic level after its logging out. The heating, ventilation and air-conditioning control in the office rooms occupied by several employees increases the comfort of work and is possible by means of simple logical functions AND and OR. The level of saving and safety increase are significantly affected by the number of integrated systems in the building. There are many examples and manners of correct energy management, for instance the heating planning system in the room. Regular working hours for the personnel employed in the specified office are between 8.00AM and 4.00PM. Using the heating electro-valves and temperature sensors connected to LCN network, temperature can be controlled in advance. In order to achieve the temperature of 21ºC in the room at 8.00AM, the heating is turned on at 7.00AM and turned out at 3.00PM by the system maintaining the temperature of 15ºC. It does not make any big difference but, according to an energy balance, the savings on room heating for the employees are possible. This solution is also comfortable because none of the employees is responsible for heating control [13].

THE EFFECTS OF POOR VENTILATION

Respiratory tract diseases (for instance asthma) are possible as a result of non-compliance with applicable standards and regulations (and consequently poor ventilation and breathing contaminated air) and prolonged stay in the rooms with poor ventilation leads even to cancer cases. The use of gas fired heating equipment in the rooms with inefficient ventilation may lead to carbon monoxide generation.

Carbon monoxide poisoning is most dangerous for humans due to colourless and odourless character of this chemical compound and may lead even to death.

Apart from adverse health consequences for the personnel, the impact of poor ventilation on the building (its structure and appearance) is also unfavourable and leads to heat losses, as shown in Table 1.

Table 1. The effects of poor ventilation (prepared on the basis of [16])

THE EFFECTS OF POOR VENTILATION	
VISIBLE	INVISIBLE
Mildew and mould presence on the lintels, windows framing, under window stools, in the corners of the rooms and behind furniture.	Bad mood, headache and vertigo, tiredness, irritation, irritations of the nasal mucosa, irritations of throat, skin irritation, allergic reactions.
Glasses mist over in windows.	Destruction of building structure, humidity penetration into walls and their gradual reaction.
Condensed water vapour on cool surfaces of walls and objects.	
Air supply through air exhaust grilles in gravity ventilation system.	

THE HEATING, VENTILATION AND AIR-CONDITIONING IN LCN SYSTEM

The central control becomes a necessity in case of lighting, shutters and security system but first of all in case of heating, ventilation and air-conditioning system in many public utility buildings. The main focus is on maintaining the air quality parameters conforming with applicable laws and EU directives in the scope of work conditions. LCN system is selected by many companies in order to meet these expectations. The sensors, actuators and panels are supplied by various manufacturers and selected in a manner ensuring optimal functioning of the whole control system and its economy with consideration of selected transmission medium.

Indoor air quality is measured by means of temperature sensors (thermostats), humidity sensors and carbon dioxide concentration sensors. These values are transmitted to air – conditioning controller ensuring the air – conditioning devices control and to KNX controller ensuring the heating control.

The required data for the system i.e.: wind direction and velocity, daylight intensity are supplied by KNX weather station installed outdoors. KNX/EIB system gives the possibility of remote control and information receiving by means of mobile telephones and the Internet. The settings of heating, ventilation and air-conditioning can be selected automatically, in accordance with the schedule.

It is possible to set „standby" or „comfort" operation mode on the basis of signal informing about open or closed status of the doors locks in a room [8, 9, 10, 11].

LCN system demonstrates its advantages particularly in case of complex control systems, like the heating, ventilation and air-conditioning system. The system simplifies the complex installation enabling the system modifications as well as remote access to the object and measuring data archiving.

SELECTED ELEMENTS AND SENSORS OF LCN SYSTEM VICINITY PARAMETERS

LCN-TSA TEMPERATURE SENSOR

An outdoor temperature sensor equipped with own processor and able to support all modules provided with connection I. The measurement values are directly affected by the installation place. The following factors should be taken into consideration: air flow, solar radiation incidence on the sensor as well as the height of its installation and distance from adjacent heat sources (lamps, ventilation openings). Maximum length of the conductor connecting the sensor with module is equal to 100 m (by means of LCN-IV). After its connection to module, the sensor is identified automatically and its indications are displayed after status checking for the module currently connected with the sensor. Temperature value is specified in the form of four values: LCN value, Kelvin degrees, Celsius or Fahrenheit degrees. After activation, the sensor should be set to determined value of hysteresis associated with its reaction but not exceeding the sensor accuracy. It is also possible to program proper response of module for threshold values contained in the program.

Fig. 1. LCN-TSA sensor [13]

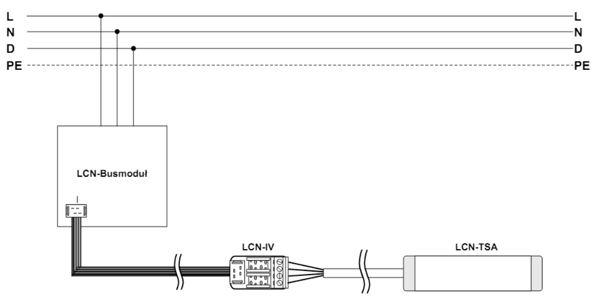

Fig. 2. Sensor connection method [13]

LCN-TS TEMPERATURE SENSOR

Indoor sensor with miniature dimensions enabling its installations. Exactly like outdoor sensor described above, LCN-TS temperature sensor is provided with its own processor establishing gradient dependent noise free values and sending them via port I to specified module. Furthermore, the impact of environment on potentially occurring measurement errors should be taken in account at its installation. The programming is identical to the method applied in case of LCN-TSA sensor.

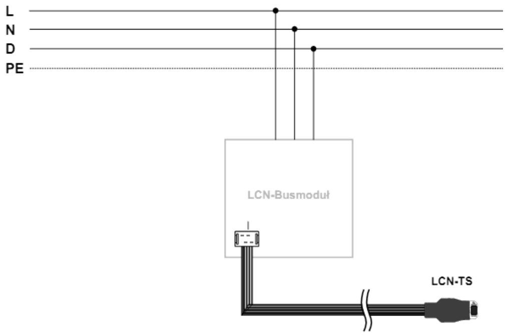

Fig. 3. Sensor connection method [13]

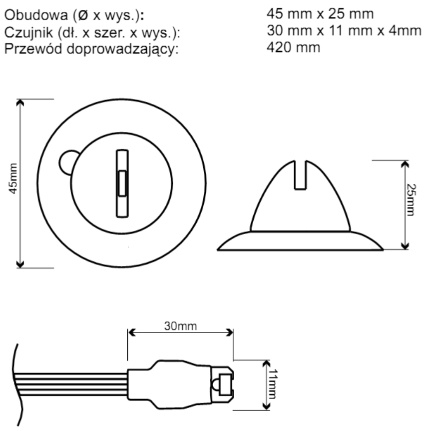

Fig. 4. Sensor dimensions [13]

The sensor is supplied with special holder enabling its installation in any location without excessive jumping out.

LCN-AVC ELECTRO-VALVE FOR HEATING AND AIR – CONDITIONING CONTROL

LCN-AVC is an electronic actuator dedicated for valves setting on central heating radiators. The device is provided with opening angle electronic meter and used for heating control in the rooms instead of conventional radiator shutoff knob. It is possible to connect maximum 5 actuators to one output in the module.

The transparent cover installed on the housing is also used as the lever in order to dismantle the valve from its fastening holder. The flap can be removed in order to prevent any unauthorized flow rate adjustments.

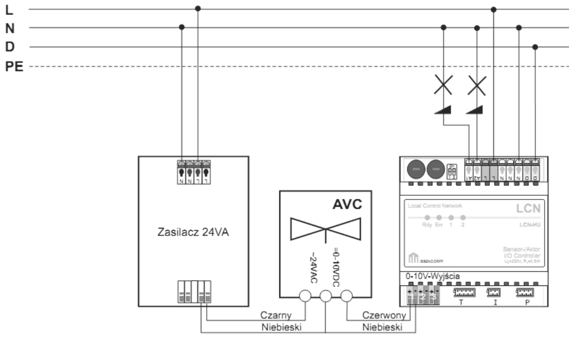

Fig. 5. Sensor connection method [13]

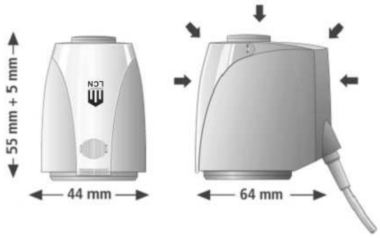

Fig. 6. Sensor dimensions [13]

Fig. 7. LCN-AVC sensor [13]

LCN-WRL65 WEATHER STATION

Weather station consisting of light sensor, rain sensor and wind intensity meter including proper cables. The whole set is contained in two protective boxes which can be installed on the wall or mast. Proper parameters are set by means of appropriate software supplied by the manufacturer. It is possible to change the sensitivity of rain sensor by means of built – in potentiometer. This sensor is subjected to maintenance consisting in contacts cleaning after determined period of use.

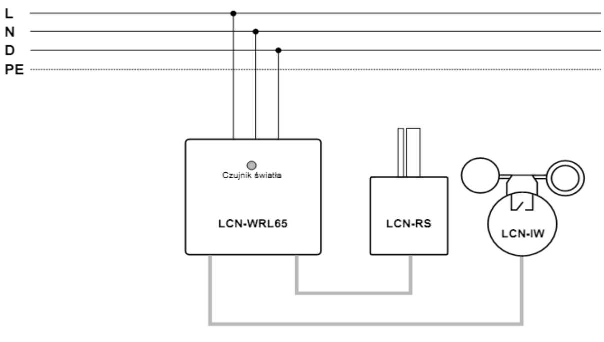

Fig. 8. Sensor connection method [13]

SELECTION OF INTELLIGENT INSTALLATION ELEMENTS

The designing of an intelligent building encompasses the following basic phases:

– Identification of client's needs and presentation of object management system concept.
– Design.
– System installation and programming.
– As-built documentation.
– Warranty and post-warranty service.

In case of incorrect identification of client's needs it is impossible to fully utilize system capabilities. Therefore an audit is necessary to eliminate the differences between client's expectations and system capabilities. Each sensor is less or more necessary, depending on types of objects. It is not required that an object should be provided with all types of specified sensors. All solutions depend on users' needs [16].

An additional data wire and conventional zero wire is used in LCN system for communication. The modules can be provided with 230V power supply or 12 V/ 24 V if required [13].

In designing phase, it is necessary to consider the presence of other systems in the building and to answer the question whether the intelligent network will be integrated with said system and to determine the degree of integration. Furthermore the designer is required to consider the functions which will be performed by the system and to anticipate the use of alternative energy sources.

The models are often created in order to enable the analysis of building installations and to establish the assumptions for energy saving buildings control. The model illustrated in Fig. 8 has been used for testing of installations in an energy saving building.

DESIGN DESCRIPTION

The object has been designed for office functions. The thermostats integrated with electro – valves have been installed in each designed office room in order to ensure the possibility to control and to maintain the temperature in the room on preset level. Windows opening sensors have been installed additionally in order to reduce heat losses and to directly improve rooms heating effectiveness.

Various types of air supply and exhaust elements have been installed in order to ensure proper ventilation in the rooms. Slot diffusers have been mounted in walls or close to the ceiling as well as air supply and exhaust elements i.e. the diffusers mounted in ceiling have been applied in the project in the form of square diffusers. Except of typical gravity ventilation elements, the devices enabling air change control and air temperature control for the air supplied to the rooms have also been installed. Air curtains have also been designed. The principal purpose of an air curtain is to create a visible barrier between the rooms being heated or air – conditioned and its surroundings. These devices are applied in order to improve thermal insulation properties of

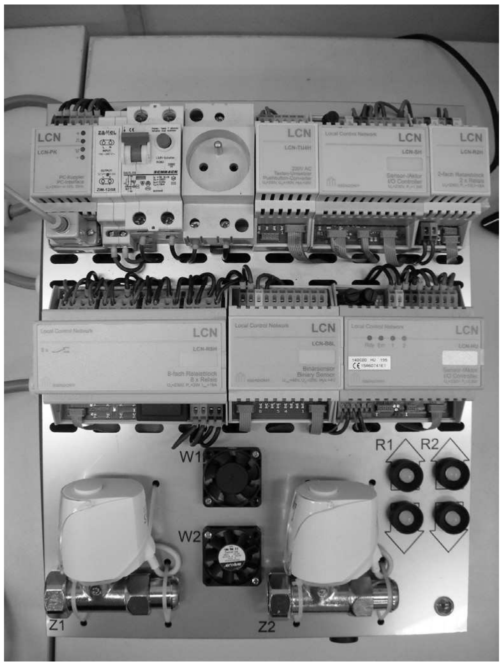

Fig. 9. Switchgear model

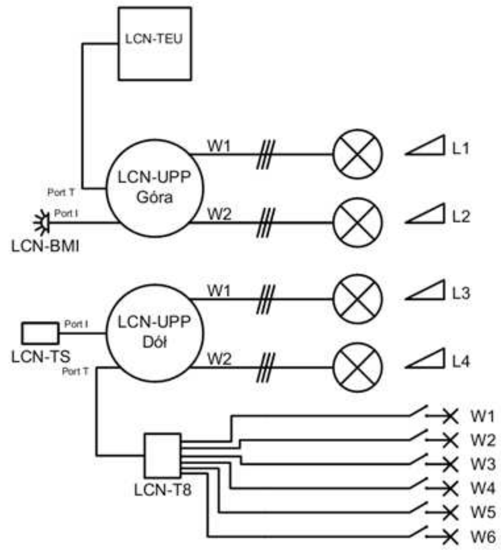

Fig. 10. Electric connection diagram for building modules

the room where they are installed. Therefore, they are usually installed in the areas in vicinity of windows and doors characterized by the highest heat loss. One of the rooms in the building (kitchenette) has been equipped with kitchen extractor hood. This device is usually operated during short period of time but its output is high and air extracted from the rooms contains high amounts of contaminants (mainly fats). Therefore, any connections of kitchen extractor hood with the main ventilation system are avoided.

CONCLUSIONS

The purpose of the present study was to present and analyse HVAC systems integration issue in an intelligent building and to elaborate the installation design for an office object. In order to achieve this goal, the categories of building automation systems and the concept of intelligent systems integration were first presented. The structure of intelligent installation in LCN system as well as devices contained in these systems, their intercommunication and programming were described thereafter.

The following general conclusions are drawn from the considerations presented in this study:

1. The integration and central control solutions are necessary in many public utility buildings owing to large number of installed building automation systems in case of the following systems: lighting, shutters, safety system but first of all in case of heating, air-conditioning and ventilation system. The main focus is on maintaining the environment quality parameters (e.g. air temperature and humidity) conforming with applicable laws and EU directives in the scope of work conditions.
2. Heat losses and unfavourable impact on the building (its structure and appearance) are possible as a result of non-compliance with applicable standards and regulations. Breathing contaminated air may cause unfavourable health consequences for personnel (e.g. respiratory tract diseases, asthma) and prolonged stay in the rooms with poor ventilation leads even to cancer cases.
3. It is impossible to find one perfectly integrated building automation system meeting all the requirements. All systems, regardless of their capabilities, have their own advantages and disadvantages. Future users of intelligent systems have diversified requirements and needs. Therefore, they will try to find a suitable system in the market; i.e. the system which could attempt to meet their individual needs in the most complete manner.
4. An intelligent installation installed in the building makes it possible to create a place with high comfort, convenience and safety for its users and to improve electric energy quality and its saving. The saving level and safety increase are significantly affected by the number of integrated systems in the building. The tasks associated with LCN system use in an intelligent building are completed in the scope of system operation reliability and its flexible self – adaptation to continuously varying requirements in work and rest environment.
5. Due to low additional expenditures incurred for systems integration, the intelligent building systems become more and more profitable. The investment return period is very short, particularly in case of objects with high energy consumption (e.g.: machine shops, trade and office objects, educational objects). From an economic point of view, the best solution consists in control systems installation in the object already in its construction phase. In such a case, the cost of control systems is equal to only 1-2% of total costs incurred during its whole service life. On the other hand, these systems make it possible to reduce the costs associated with later operation and maintenance of the building by about 75%.
6. Increasingly often, application of intelligent systems in the buildings can bring positive effects in micro scale (residential building, enterprise etc.) as well as in macro scale (whole economy).

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23. Projekt normy prEN 15251: „Kryteria środowiska wewnętrznego, obejmujące warunki cieplne, jakość powietrza wewnętrznego, oświetlenie i hałas".

Streszczenie: Niniejszy artykuł omawia elementy inteligentnych systemów elektrycznych stosowanych w automatyce budynków, w instalacji HVAC. Opisuje również metodykę projektowania tych instalacji w systemie LCN – Local Control Network System, jako przykład łączący zadania wykonywane w ramach tradycyjnej instalacji i systemu inteligentnego budynku.
Słowa kluczowe: ogrzewanie, sterowanie, inteligentne, projektowanie, integracja, instalacja