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INDOOR CLIMATE CONTROL IN EIB SYSTEM

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Abstract. The present article refers to the designing of an intelligent electric installation in the European Installation Bus (EIB) system. Its purpose is to present the problems associated with the assurance of human friendly indoor climate with particular emphasis on the implementation of EIB TP system.

Key words: indoor climate, HVAC systems, building management systems, intelligent buildings, electric systems.

I. INTRODUCTION

The idea of intelligent building was created in the 70-ies of the 20^{th} century in the USA. The concept was applied in the next decade in the scope of systems designed to control the watering in greenhouses and in residential gardens. Together with the development of aforesaid systems, other installations were being automatized and connected together to form a centralized and integrated system in the building– Building Management System (BMS). The largest part of energy generated in the European Union i.e. about 40% of its total consumption is used by the buildings. The energy saving and application of renewable energy sources is considered as one of the most important methods of natural environment protection, undoubtfully contributing to the reduction of carbon compounds emissions released to the atmosphere. The building operation costs and environment cleanness are affected by properly programmed climate in the rooms. The energy consumption in the building depends on the designed system and its maintenance.

The climate in the rooms is essential for comfort, health and productivity of their occupants and increases our living standards. We spend most part of the day and night in various rooms.

When designing an intelligent building, we have to pay particular attention to the balance to be maintained between our comfort and economical operation. The latter is affected by several elements established to achieve the same goal: to decrease energy consumption, to reduce maintenance costs, to ensure a simplified and elastic service.

The fact of diversified perception of the climate i.e. as comfortable or optimal is important in the framework of designing intelligent systems ensuring indoor climate parameters control and constitutes the background of the present article.

II. DEFINITION OF VALUES DETERMING THE PARAMETERS OF INDOOR CLIMATE

Indoor microclimate is one of most important elements included in the scope of building quality, because it is closely associated with human health and comfort. The Sick Building Syndrome term is connected with microclimate analysis. As a result of SBS (Sick Building Syndrome), some symptoms of sickness are possible e.g. headache, watery eyes, deteriorated concentration, breathing disorders. Many years of research in the scope of human work environment quality contributed to the creation of the so called intelligent buildings. Their principal goal is the reduction of SBS effects and improvement of living comfort. The level of comfort perceived by an occupant is essentially affected by the following factors:

- Air quality,
- Thermal comfort,
- Noise level,
- Conditions associated with ergonomics (lighting, windows, height of rooms etc.).

As a result of the research in the scope of Sick Building Syndrome – SBS, it appears that poor quality of indoor air is the main principle of illnesses in occupants of such type of buildings.

It is defined as a complex of factors negatively influencing the occupants of the room under consideration. SBS induces typical allergic reactions like conjunctivitis, chronic inflammation of larynx, bronchitis, asthma as well as some other non-allergic symptoms such as headaches, irritation, concentration disorders, humidifier fever as well as cancer diseases as the consequence of an effect of carcinogen substances e.g. tobacco smoke, asbestos or radon.

The Sick Building Syndrome is continually getting intensified, particularly in Western Europe and the USA. Therefore, detailed investigations have been carried out by many companies and scientists.

The following factors causing SBS have been indicated:

- Improper air temperature and humidity,
- Improper lighting,
- Poor air quality,
- Noise.

The air quality is affected by several factors i.e.: ventilation of buildings, air temperature and its relative humidity, variations of pollutions originating of endogen sources, ambient air quality in direct vicinity of a building.

The natural air exchange is often minimized as a result of new technologies and use of energy saving solutions in case of significant number of the buildings being erected actually in Poland.

The perception of comfort and the definition of comfort level are affected by subjectively perceived human impressions, but as a result of many years of scientific research and studies, the standardization of indoor climate parameters was possible [PN-78/B-03421 – Ventilation and air-conditioning. Indoor air design parameters for the rooms designed for permanent human occupation].

The optimal indoor climate is characterized by air temperature in the range between 16 up to 20°C and relative air humidity between 40 and 60%. However, frequently, owing to diversified likes and likes of the occupants, the values of indoor air temperature and relative air humidity are different.

Every designer responsible for the designing of indoor climate control system has to resolve the problem associated with the determination of design inputs and preliminary assumptions to determine the purpose of the design and to enable its verification after the completion of the installation.

However, we have to remember that the indoor climate, except of the ventilation and air-conditioning parameters, also encompasses the interior design including, among others, the dimensions (height, width, length, height and type of windows, interior features, lighting).

In the connection with entry of EPBD Directive issued in the European Union into force, it is ordered to ensure the correct energetic performance of the installation and, consequently, to consider the costs of object operation. The aforesaid Directive was prepared in order to promote an improvement of energetic performance in buildings in the European Community. First of all, the outdoor and indoor conditions of a building as well as projects rentability are considered therein.

Room overheating occurs frequently, and in overdried air it is difficult to maintain the negative ionisation which is favourable for occupants.

The presence of electronic equipment, particularly the screens of TV sets and computers, floor linings made of improper materials, tobacco smoke and even dogs' hair – contribute to the generation of climate with unfavourable ionisation.

III. CONTROL OF INDOOR CLIMATE FORMING INSTALLATIONS

An application of technical solutions offering the individualization of indoor environment parameters is the most effective method contributing to an increased number of occupants positively evaluating the indoor microclimate.

It refers to:

- Indoor heating control with consideration of rooms occupancy,
- Immediate shut-off of the heater valve in case of window opening,
- Elimination of manual screwing in and out of the heaters valves and their replacement by the automatic temperature control vs. time and in accordance with individual preferences,
- Application of heating types ensuring a uniform heat supply (floor heating systems),
- Heating only the rooms where it is needed,
- Application of low temperature heating systems. A smooth heat exchange is possible as a result of low temperature on the feeding side. Thanks to the lack of continuous air circulation occurring in the vicinity of convection radiators, the amount of dust circulating in the rooms is significantly reduced. The heated floor creates less favourable conditions for mites and fungi spores living in dust.

The savings are also associated with the intelligent heating of the building. The conventional systems maintain constant temperature without considering any functions of the rooms and their occupancy periods. However, our intelligent system performs temperature measurements in individual rooms and maintains it at a desirable level. In the standby mode, the temperature is reduced by several degrees when it is recorded that the occupants left the building; in night operation mode - the temperature is reduced to the level preferred by the occupants.

In comfort mode, the optimal temperature is restored before the inhabitants come back after work at the programmed time. It may seem insignificant, but as a result of heating control by means of individual temperature control in each room, more that 30% of energy can be saved.

In many studies on indoor climate, only HVAC installations are considered but it should be emphasized that it is also associated with the interior arrangement and design or with correct lighting.

The analogue signals (mainly on sensors side) as well as digital signals (Fig.1) are used in EIB/KNX system. They convert analogue signals e.g. temperature into electric signals.

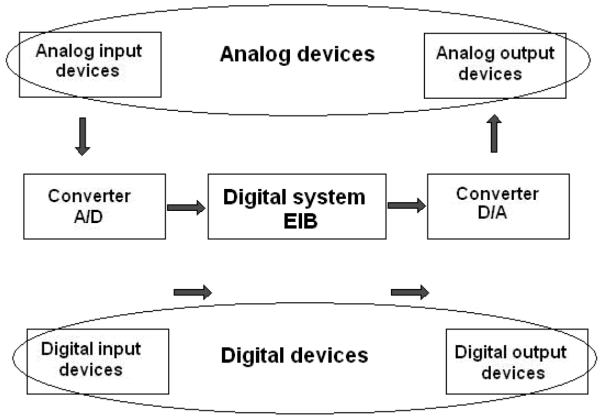

Fig. 1. Use of signals in EIB system 8]

Furthermore, there are many other possibilities ensured for the users by indoor climate control:

- Temperature control enabling diversified temperature settings in a building e.g. reduced temperature setting at night during sleep and increased temperature setting at the time of getting up and other activities before going out to work.

In buildings with an integrated anti-burglary system and HVAC installations control, the remote control of aforesaid systems is also possible.

- The control system installed in an intelligent building also prevents any unreasonable ventilation and air-conditioning, particularly owing to the fact that it frequently happens in the rooms which are not used at a given moment. Therefore, additional costs of unnecessary electric energy consumption are avoided. Thanks to the use of occupancy sensors, the information about necessity or lack of necessity to provide comfortable climate condition in an area is continuously supplied to the system.

The impact of light is also extremely important for indoor climate. The scope of main reasons of the sick building syndrome encompasses improper lighting including too low or excessive illumination, its improper direction, dazzling, incorrect colour of light, strobe effect. The rooms with improper lighting make bad impression and are unfavourable for effective work or rest.

In order to ensure an efficient control of integrated systems, numerous requirements have to be met in all the phases i.e. designing throughout implementation, commissioning and, finally, the commercial operation. It is one of the most important prerequisites contributing to the control systems development including lighting control systems.

The automatic lighting control by means of KNX/EIB system encompasses the following:

– Control vs. time for switching off the light sources during work breaks and weekends,

- Adaptation of the rooms lighting to optimal working conditions by means of the function maintaining constant illumination and depending on natural lighting changes (Fig. 2). Therefore, in combination with intelligent heating control, it is possible to reduce the costs of energy consumption even by 30%,

- Automatic lighting control in the corridors, staircases and rarely used rooms by means of movement sensors.

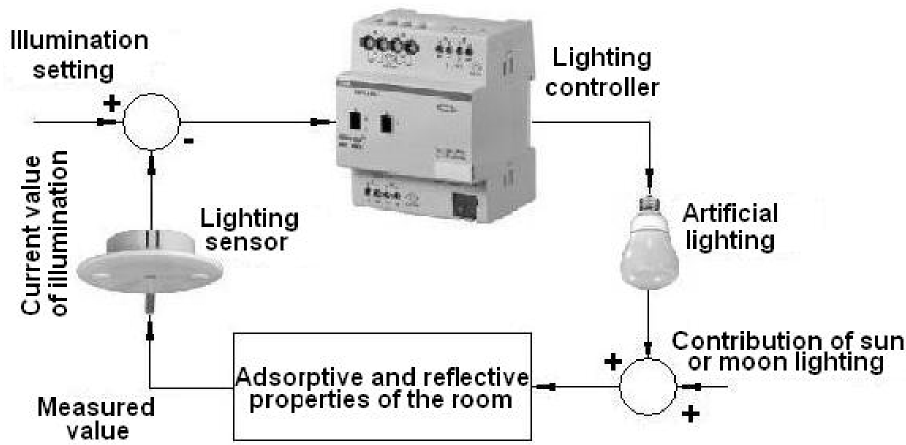

Fig. 2. Devices incorporated in EIB TP system and required to perform the function maintaining constant illumination [7]

The lighting controller and light sensor are used in order to maintain the constant illumination in the room. This sensor is installed on the roof in order to enable the measurement of the surface lighting within its detection range. The measured value is compared with the setting thereafter. As a result of this comparison, the difference between the setting and actual illumination value is minimized. An influence of the sensor's surrounding is also important. If its surrounding is lighter, the contribution of artificial lighting is limited and increased in the case of darker surrounding. The setting is established by means of the illumination meter, which is incorporated under the light sensor for this purpose.

The essential advantages resulting from the use of the control systems are:

- Flexibility – enabling the reconfigurations of circuits being controlled in case of any changes in interior arrangement, without any necessity of physical intervention into the installations,
- Energy saving – enabling reduced consumption of energy for lighting purposes even up to 70%,
- Improved visual conditions for work and possibility of user's intervention into lighting intervention,
- Possibility of lighting scenarios realization.

The lighting must meet several conditions, and the most important ones are:

- The value of average illumination within the surface under consideration conformed to the standard
- Lighting uniformity in space and time
- Correct luminance distribution
- Light colour adapted to needs.

The average illumination E is determined as the ratio of total luminous flux onto the surface area under consideration and the size of this surface area. The lowest permissible values of average illumination in all types of rooms are included in the standard PN-84/E 02033.

The uniformity of lighting ε on the surface consists in the maintenance of average illumination in various points of illuminated surface area of the room.

The ratio of the lowest value of illumination to its average value should not be lower than 0.65 within the room, on the working plane.

The light colour is a very important parameter of lighting, because it may affect the human mental comfort as well as ability to perform work efficiently. The most favourable are the sources generating light with the colour similar to daylight.

The lighting efficiency method as well as point method and computerized programs e.g. Dialux, Calculux, Relux are most frequently used for lighting calculations

Lighting efficiency method

The lighting efficiency method is based upon the general lighting efficiency and the luminaire efficiency. The lighting efficiency $\eta_{oś}$ is defined as the ratio of useful luminous flux onto the surface area of the plane being illuminated to the luminous flux emitted by the light sources in the luminaire.

The reflection indices for the walls and ceiling are assumed from the calculation table containing the general lighting efficiency. The distance "h" between the light sources and working plane and the room index are calculated thereafter by:

$$h = H - H_b - L_{zw}, \tag{1}$$

where:

h – distance between the light sources and working plane,

H – height of the room,

H_b – height of the work field,

$L_{zw.}$ – length of luminaire suspension.

$$w = \frac{0.2a + 0.8b}{h}. \tag{2}$$

The calculation of total luminous flux required to generate the illumination $E_{śr}$ in the room is performed after transformation of the following equation:

$$E_{śr} = \frac{n\Phi K\eta}{ab}\frac{\eta_{op}^{'}}{\eta_{op}}, \tag{3}$$

where:

$E_{śr}$- average illumination within working plane under consideration,

n – number of luminaries,

Φ - summarized luminous flux,

η_{op} – luminaire efficiency,

η'_{op} – actual luminaire efficiency,

η - lighting efficiency, considering the reflection indices of the ceiling, walls and floor, luminaire efficiency and index of use,

a – length of the room,

b – width of the room,

$k = 1/K$ – reserve ratio considering the reduction of illumination level parallel to the period of use, closely associated with an efficient maintenance system; included in the table. The reserve ratio depends on the type of lighting, its class luminaire efficiency, room index as well as reflection indices of the ceiling and walls.

Having calculated the summarized luminous flux Φ for light sources, we can select the light sources ensuring the required values of summarized luminous flux and average illumination as recommended by standards. Then the power required for lighting and actual average illumination are calculated:

$$P = nP_n , \tag{4}$$

where:
n – number of light sources,
P_n – power of single light source.

$$E^*_{śr.} = E_{śr.} \frac{\Phi^*}{\Phi}, \tag{5}$$

where:
Φ - summarized designed luminous flux of light sources,
Φ^* - summarized actual luminous flux of light sources.

The lighting scenes system applied in intelligent installations, makes it possible to program even several lighting scenarios in the same room, lamps dimming, maintenance of constant lighting level.

Point method

In the framework of the point method, the horizontal and vertical component of the illumination in a design point are calculated:

$$E_{hA} = \frac{I}{r^2} \cos\alpha, \tag{6}$$

$$E_{vA} = \frac{I}{r^2} \sin\alpha, \tag{7}$$

$$E = \sqrt{E_{hA}^2 + E_{vA}^2}, \tag{8}$$

where:
I – candle power of the lamp read from the candle power transmission curve,
α – angle used for the determination of candle power (Fig. 3.).

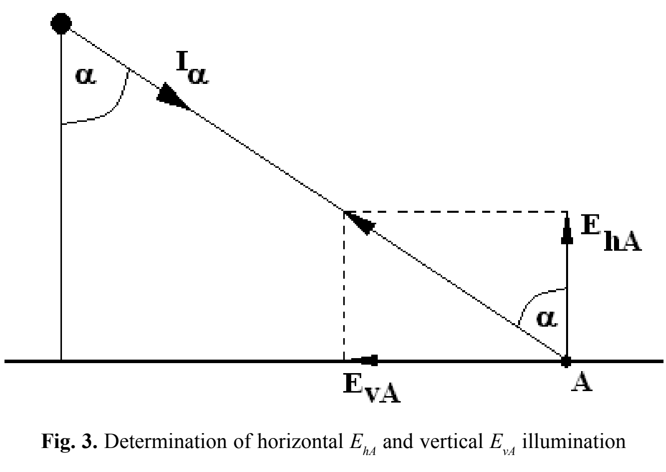

Fig. 3. Determination of horizontal E_{hA} and vertical E_{vA} illumination

IV. CONCLUSION

The requirements associated with indoor environment have been continuously increased in recent years. As a result of the experience gained in the past, it is obvious, that the future of intelligent buildings installations is very optimistic. The dynamic development of electronic sector and its progressing miniaturization contribute to the construction of more and more modern automatic systems including building management systems. Sick Building Syndrome and indoor climate are the essential issues associated with the modern building systems. They demonstrate the fact that the modernization of human life brings also some dangers to be continuously monitored in order to avoid or at least reduce their negative impacts.

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STEROWANIE KLIMATEM POMIESZCZEŃ W SYSTEMIE EIB

Streszczenie. Artykuł dotyczy projektowania inteligentnej instalacji elektrycznej w systemie Europejskiej Magistrali Instalacyjnej (EIB). Poruszono w nim zagadnienia związane z zapewnieniem przyjaznego dla człowieka klimatu pomieszczeń. Szczególną uwagę zwrócono na implementację do tego celu systemu EIB TP.

Słowa kluczowe: klimat pomieszczeń, systemy HVAC, systemy zarządzające budynkiem, budynek inteligentny, instalacje elektryczne.