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# A model of an energy efficient building automation system

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Abstract. A good building is characterized by structural and installation flexibility. Its another important feature consists in adaptability i.e. in potential subdivisions and modification of the functions owing to the fact that the type of activity conducted in a building object may be changed in course of its service life. There are several market requirements to be met by a building. The basic requirements are: the profit for the owner and developer, effective use of available space, low maintenance costs and possibility to generate profits. It is possible to determine the principles of engineering (POE) for a building on the basis of an assessment of quality of the already existing buildings. The following quality categories are determined in the framework of this method: technical, functional, behavioural, organizational and economic category. The users of the building as well as their needs and location in the building and the needs of this building are further elements to be considered.

The purpose of the present article is to establish a definition of an intelligent building and to present a model of building automation system in this type of building as well as to present the examples illustrating the use of computer in order to reduce electric energy consumption. The issues associated with the designing of energy efficient systems in the scope of building management have also been discussed.

Key words: energy efficiency, programming, building system, intelligent building, electric system.

## INTRODUCTION

The eagerness to increase the comfort of the user and to reduce the maintenance costs was the guiding principle for te development of intelligent building. The construction of a building efficiently responding to human needs has become possible thanks to the development in the scope of information technology and automatic control engineering. The human effort aiming at the improvement of living conditions is one of the factors determining the development of new technologies in the scope of electric systems. Unfortunately there are often new problems caused by more and more advanced technologies in the scope of household appliances facilitating everyday life of their users.

The electric energy demand is increased as a result of new energy receivers occurring in the building system. A building which seemed to be an energy efficient object at its commission, becomes a source of increasing expenditures.

Therefore the versatility of the building and its openness to future changes is extremely important. The varying family situation of its users is another essential factor to be considered owing to changes in the house: children are born, their parents get older and need certain facilitation in the operation of the building systems.

Nowadays, the form of the employment of the users is sometimes changed and it becomes necessary to arrange some new rooms not considered before in the building, e.g. an office, laboratory or a doctor's or dentist's office. The reconstruction or extension of an existing house is often very expensive and arduous. Therefore the decision on the type of electric system to be applied in the building should be made as early as in its designing phase.

Unless this perspective is considered by the designer and/or investor at this moment, increasing energy consumption may become problematic after several years in case of an average functionality of the building.

There is a series of solutions elaborated for electric systems in order to increase the functionality of buildings [2, 3, 4, 5, 6]. Their scope encompasses the approach based upon control engineering solutions in conventional systems as well as upon introduction of intelligent building elements. The state-of-art building systems make it possible to organize the operation of many devices in a better manner and to optimise their power supply. The operation of many devices can be programmed according to the needs and habits of the users. Therefore it is possible to improve the comfort and to achieve potential savings.

The specialized software is often necessary in order to prepare the design and to start the automation systems.

## APPLICATION OF COMPUTER ENGINEERING IN DESIGN

The enterprises have to cope with difficult tasks in the scope of planning and production control to meet the requirements of contemporary market. There are two types of production processes: i.e. continuous production processes and discrete production processes [13].

The continuous production processes are characterized by the manufacturing of a product in a continuous manner, most often by means of chemical, physical or mechanical processes.

The discrete production processes are characterized by the manufacturing of products consisting of elements which are produced individually in accordance with individual process plans (Fig. 1).

There are three basic types of production: mass, series and piece production.

A characteristic feature of the mass production consists in the manufacturing of very large quantities of standard products. The design or technological revisions are insignificant.

The series production is characterized by the medium scale of production and medium number of product variants. These products are manufactured in small lots.

The piece production is characterized by large number of products variants; the products are manufactured in small lots or as pieces.

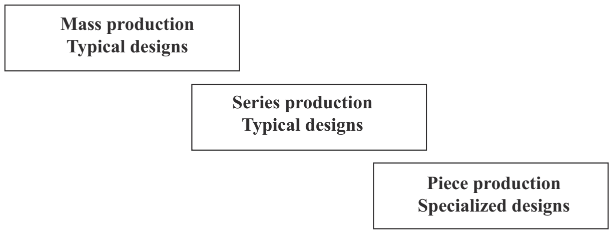



**Fig. 1.** Designing as a discrete production process

Depending on the type of an investment, the design of automatic control of the building can be interpreted as a kind of production. The designing may be associated with the tasks which are applied in very large number of the projects thereafter; which corresponds to mass production. Sometimes it is associated with the issues resembling serial production or the designer creates his/her own solutions. The following groups of functions are performed by the designer of the building automation systems in accordance with the type of solutions being elaborated:

– New systems,
– Modernized systems,
– Variant systems.

The complete design process consists of three phases:

– Concept design,
– Engineering,
– Preparation of documentation.

Depending on the group of systems being considered, certain phases of design process may be completed in limited scope.

The activities performed by the designer in individual design phases are illustrated in Table 1. In case

**Table 1.** The activities performed by the designer in individual phases of building systems designing

| Group of systems | | | Design phase | The activities performed by the designer | Applied programs |
|---|---|---|---|---|---|
| New system | Modernized system | Variant system | Concept design | Preparation of requirements | Text editor, Spreadsheet CAD 2D, |
| | | | | Preparation of concept variants | |
| | | | | Preparation of system topology | |
| | | | | Assessment of solution selection | |
| | | | Engineering | Consultation with investor | Text editor, Spreadsheet, Tools |
| | | | | Preliminary assumptions | |
| | | | | Preliminary calculations | |
| | | | | Optimisation of system topology | |
| | | | | Building permit design | |
| | | | | Detailed engineering | |
| | | | Preparation of documentation | Formal and legal documents | Text editor, Tools, CAD 2D |
| | | | | The scope of works to be performed | |
| | | | | Technical description and calculations | |
| | | | | Bill of quantities and installation tables | |
| | | | | Graphical part | |

of state of art systems, the designer also acts as a person programming and running the building automation system.

The designer of electric systems should use a work station equipped with hardware and appropriate specialized software. The software encompasses a text editor and several programs aiding the calculations carried out in course of design activities.

The important criteria to be considered by the designer in software selection are: possibility to create diagrams, to design systems basing upon architectural blueprints in dwg format as well as to support the selection and calculations of system elements.

A new role of PC appeared with the introduction of the new building systems e.g. KNX. The computer became a tool required to start up the devices. Therefore a portable computer is necessary for the designer/ installer to enable his convenient displacement in the building in course of their starting.

The structure of the designer's work station depends on the functions and tasks to be performed by the designer. The final definition of requirements regarding the size of computer and its configuration depends on installed software and tasks to be performed by the designer. The basic equipment of the station is illustrated in Fig. 2.

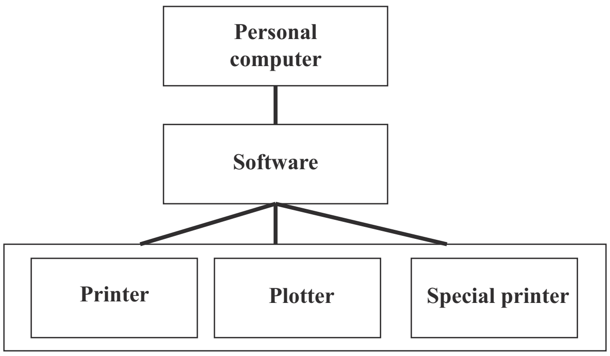



**Fig. 2.** Basic elements of the electric systems designer's work station

A personal computer is the basic element of the station. The computer should be equipped with highly efficient processor as well as high capacity memory and good graphical card. Furthermore the station should be provided with good quality printer, because a colour printout makes it possible to facilitate the localization of the systems in the building and to avoid collisions between them. The use of plotter is required in case of printout of large formats.

## A MODEL OF SYSTEMS IN AN INTELLIGENT BUILDING

The systems integration is an extremely important issue in contemporary buildings [1, 3, 8, 9, 10, 12].

A model of systems in an intelligent building has been designed in order to enable the analysis of the issue associated with devices integration in KNX system. The work at this station consists of the following phases:

- Preparation of system design and creation of schematic connection diagram.
- Connections of selected devices.
- Determination of systems topology in the building.
- Introduction of bus devices and assignment their physical addresses in ETS4 program.
- Systems programming by means of ETS4 program.
- Systems starting.
- Verification of systems functioning for the compliance with preliminary assumptions.

Design of laboratory station is equipped with elements constituting the components of each building system (Fig. 3).

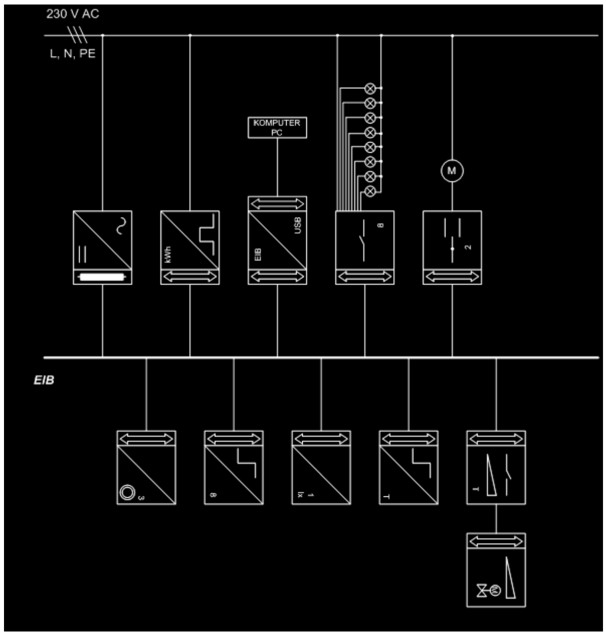
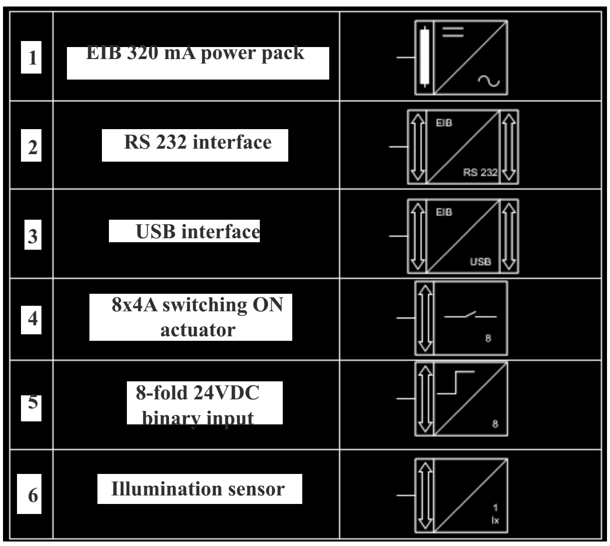
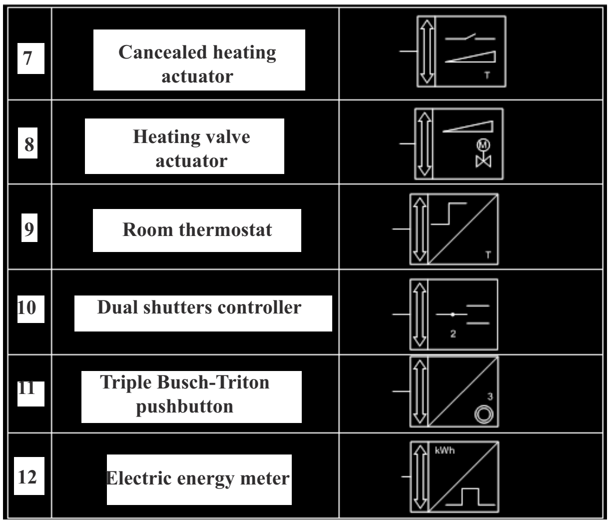



**Fig. 3.** Block diagram of laboratory station design






This station makes it possible to build the systems enabling the lighting, heating and shutters control. Furthermore the station is provided with an electric energy meter to enable the checking and testing of power consumption for individual elements of the system which has been built.

The following system operation simulations are possible by means of created model of the building:

– ***Lighting control***

The design and construction of the system enabling the control of two groups of lamps: the lamps are turned on and off in an independent manner. The illumination sensor should be used to send a telegram switching the corresponding groups of lamps; this telegram is sent to the bus if the preset threshold values of illumination measured in lx are exceeded.

– ***Heating control***

The design and construction of the system enabling the control of heating: the created system should enable the heating control in three modes: comfort, stand by and night operation mode.

– ***Shutters control***

The design and construction of the system enabling the control of shutters: the created system should enable the control of two groups of shutters independent of each other. One of them will be controlled upwards or downwards by prolonged depression of the pushbutton. Another group of the shutters will be provided with possibility to stop their movement time any time by short depression of the pushbutton.

The systems specified above should be provided with an electric energy meter to enable the checking of power consumption for individual devices.

The system makes it also possible to select an interface to be used for PC connection to the system. The connection is possible by means of RS 232 or USB interface.

The computer constituting a component of the station is equipped with ETS4 program to enable the preparation of the building automation system design, the system starting and execution of the building systems operation simulations.

## CONCLUSIONS

The following conclusions can be made on the basis of considerations contained in the present article:

1. The testing of KNX system elements is possible by means of designed model of an intelligent building.
2. Its principal task is to analyse the integration of devices other than elements of this system.
3. Energy saving is the principal goal to be achieved.
4. The simulations of the lighting, heating and shutters control are possible at this station.
5. The electric energy meter enabling the monitoring of energy consumption during the executed experiments is an essential component of the station.
6. An important advantage of this project is the possibility to design and to implement various configurations of bus devices connections, because there are no permanent connections between the station modules. Therefore a wider scope of KNX system testing is possible through the creation of systems combining the lighting, heating and shutters control.
7. Further extension of the station in the form of new bus devices is also possible.
8. In order to enable full representation of possibility of optimised energy consumption in KNX system, this station should be provided with elements of a conventional electric system including energy meter in future. Thanks to created hybrid model, it will be possible to compare both the systems and to demonstrate possible savings in a more complete manner.

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