Laboratory stand for designing industrial KNX networks on Siemens logo! Communication modules

Aleksandr Kartuzov^{1,*}, Tatyana Kartuzova¹, and Lyudmila Seliverstova¹

¹Chuvash State University named after Ulyanova, Cheboksary, Russian Federation

Abstract. Industrial automation networks based on the EIB / KNX protocol are very popular among European companies in the construction of intelligent buildings, but they are of little interest in high school education and currently professional specialists are not trained to use them. Developing the KNX-based automation system simulator for the training of engineering students is required. We have designed and installed a KNX simulator for engineering students training on smart systems. The presented stand was developed on Siemens LOGO! Basic with CM KNX communication modules. The modules of simulator and KNX software programming tool ETS are explained. Besides, sample scenarios for engineering students to enhance and implement their projects are given.

1 Introduction

When building smart energy systems, it is necessary to choose a method of data exchange between control and executive elements (controllers, relays, etc.). In this case, AS-i, ProfiNet, ModBus [1], KNX / EIB, LonWorks [2] and other protocols are usually used. Among these protocols, the KNX protocol is preferred thanks to its some specifications such as easy and fast installation, user-friendly software, and adaptation to the existing system.

In high school education, little attention is paid to building industrial networks based on these modern protocols [3]. An intelligent building management system typically includes [4]:

- lighting control - by motion sensors, light level or timers;
- adjustment of illumination (dimming) [5];
- heating by temperature, time or occupancy sensors;
- ventilation by indicators of air sensors or the presence of gas [6];
- automatic gates, shutters, electric pumps;
- perimeter security in the house and intrusion detection [7];
- alarm (sound, light) in case of alarm;
- power outlets;
- fire protection by the presence of smoke or fire;
- protection against water leaks;
- information board for indication and management;
- weather data;
- energy saving due to electricity and water metering.

The EIB / KNX system assumes the fulfillment of all the above functions [8]. This simplifies the cable systems of the building, their design and installation. The EIB system has great flexibility: expansion and change of functions are achieved by rearrangement, addition or reprogramming of components [9].

Selection of Siemens LOGO! Basic is determined by their availability, a wide range of functions and the availability of communication capabilities.

2 Methods

The KNX standard based on EIB has been actively developed over the past years and is approved by the international organization «KNX Association» as ISO / IEC 14543 [10]. Its advantages [11] are expressed in a distributed decentralized architecture that does not require a central control device / computer, the use of different topologies (common bus - a two-pair low-current cable, star, tree), distance ranges (up to 1000 m), support for various data transmission media (twisted pair, power line, radio channel), baud rate (9600 baud), event control (the master sends a telegram - the slave makes an acknowledgment) and speed (20 ms) [12]. Some disadvantage of KNX is its low fault tolerance - in the absence of acknowledgment (confirmation), data transfer is stopped and must to be repeated, i.e. it cannot be used in applications related to danger to people.

Siemens LOGO! Controllers are industrial and meet all electrical safety standards. Logo! Basic 24RCE has an output relay capable of controlling power devices up to 10A. 38 built-in functions are programmed using the Siemens Soft Comfort software with visual simulation.

* Corresponding author: kartuzovaleksandr@yandex.ru

LOGO! Communication Module CM EIB / KNX has 24 virtual digital inputs and 16 outputs, as well as 8 analog water and 2 outputs. CM modules can operate as master and slave devices.

Parameterization of the modules is carried out using the KNX ETS software (Engineering Tool Software). The software allows to organize centralized equipment management throughout the entire building automation project. While almost all smart home systems are tied to the manufacturer [13], KNX ETS is an open and extensible system that allows to combine a wide range of devices from different suppliers, adding new sensors and actuators as needed. ETS5 software contains a built-in database of KNX equipment from leading manufacturers ABB [14], Gira, Schneider Electric, Zennio and others, which allows you to build real projects. About 10 thousand KNX devices include: relays (including control of curtains, blinds, gates), dimmers (dimmer), buttons and switches, binary and analog inputs and outputs, sensors (movement, light, temperature, power consumption, weather, water, smoke, gas leaks), climate control (heating, ventilation, air conditioning), touch panels, bridges to other systems (IP, DALI, SMS, phone, email, intercom, security systems), system components (power supplies, bridges, programming interfaces, controllers) [15, 16].

Structurally, the stand (Fig. 1) is a stand mounted on a laboratory bench. The stand is portable and can be mounted on any suitable laboratory table. Corresponding holes are provided at the base of the rack for attaching to the table. On the table there is a laptop with an adapter, which is an integral part of the stand, as well as, if necessary, an addressing and diagnostic device for network modules, a multimeter and an oscilloscope.

A metal panel is mounted on the front side of the rack, with the equipment of the network under study installed on it. On the panel there are located:

- block of programmable controller LOGO! Basic, which includes a PS-300 power supply unit, a CPU314C-2DP processor module with I / O modules for discrete and analog signals, as well as a communication module for communication with the EIB / KNX network;
- field to indicate module output signals (2 digital voltmeters);
- field to set input signals to the module (2 potentiometers);
- repeater (extension cord) of the KNX network;
- field to set input (buttons and toggle switches) and indication (LEDs) of signals;
- input / output module of discrete network signals (2 inputs / 2 outputs);
- field to set the input (toggle switches) and indication (LEDs) of the module signals;
- field to set input signals (buttons, toggle switches, potentiometers) and output signals (LEDs, voltmeters) to the LOGO! Basic
- stand power switch.

The rack has a drawer with a lock for storing a laptop, addressing and diagnostic device, multimeter and

technical documentation, and also provides a compartment with a partition for papers, literature, etc.

Fig. 1. KNX laboratory stand at Siemens LOGO!

Building design and parameterization of KNX devices is done in ETS software. The demo version allows you to program up to 5 devices, Lite - up to 20.

Project development is carried out in a few simple steps [17]:

- import of the KNX device catalog (as it is constantly updated). For programming, it is mandatory to have a configuration file appropriate for the device;
- creating a new project (you can use the wizard - a building or an apartment);
- breakdown of the project into floors (rooms);
- adding devices from the catalog;
- address selection (usually performed automatically by the ETS program);
- setting parameters of sensors;
- specification of actuator actions: switching, drive control (enable motion, stop, step), dimming (relative, stop, absolute value), transfer of physical quantities (eg temperature).
- creation of a group address structure (if necessary), distribution of devices to group addresses (can have a logical structure different from the building and topology);
- downloading firmware (settings) to devices;
- performance check, diagnostics.

An example of a task performed by students. Automate a room with 5 rooms on a common KNX bus. Functional requirements for each individual room:

- lighting circuits with adjustable brightness, switching on manually or automatically;
- shutters, proportionally adjustable, can be controlled manually or automatically;
- 1 radiator with proportional control and corresponding heating controller;
- window contacts that lower the temperature when opening windows;

Fig. 2. Project in KNX ETS

- 1 information control panel displaying functions and values temperature controller (set and current temperature, night / day operation),
- wind indication and display of the condition of the blinds for lighting control (manual / automatic);
- buttons that implement the central function: basic lighting (2 of 3 streaks of light), blinds;
- wind sensor: raising the blinds in case of a storm;
- light sensor: when exceeding a certain brightness limit, closing the blinds, lifting the blinds in the dark.
- a timer that weekly centrally controls the temperature profile of the room, turning off the lighting at night.

3 Results

As a result of solving the test example, we obtain the following configuration. For each room:

- 1 x 3x dimmer / dimmer with integrated dimmer
- 0.25 x 8-fold shutter drive
- 1 valve actuator with 2 integrated contact inputs
- 1 heating controller with integrated 2x button
- 1 x 4x button
- 1 display with at least 8 display and control functions
- 1 logic module for converting analog thresholds to binary signals (gate)
- 1 logic module for all binary connections for group signals
- 1 weather control unit
- 1 time master (since the functions of the clock can also be detected by an analog threshold generator when it receives time on a regular basis).

4 Conclusions

To document the project, ETS creates a series of reports [18]:

1. Building construction with dedicated devices
2. Parts List
3. Overview of bus topology
4. Detailed device lists

5. Group addresses

6. Commissioning status

View Building View, in principle, was already enough in theory. However, it is difficult to find information quickly, for example, about the equipment of the bus line, about the entire structure of the topology about the number and structure of group addresses used. Information about which devices were loaded and with what result cannot be deduced from this either. Information about the device, that is, the configuration of flags, flags of objects, comments and assigned addresses, should not be printed out in the form of a building, but in the form of a detailed line.

The commissioning of the KNX installation does not necessarily require a complete setup of the shared bus installation with all devices. Since the complete data set is not absolutely loaded onto the bus coupler at the commissioning stage, it may be useful to load only the individual addresses into the bus couplers and the remaining relevant data. Regardless of whether commissioning is carried out on a breadboard or on a construction site, flush-mounted application modules must not yet be installed, so that the programming button and programming LED remain accessible. In switchboards, it is necessary to remove the covers so that for these KNX devices the programming button and LEDs remain accessible. In the case of built-in devices in suspended ceilings or fixtures, it is advisable to assign them their individual address before installation, since such devices are usually available only with great effort after installation.

The goals of commissioning and diagnostics are as follows:

- Download - opens the download menu for individual addresses and programs;
- Download individual address - download an individual address;
- Download the application - downloads the application program;
- Reset - sends a restart command to the bus device;
- Unload - resets the device that has already been commissioned to its original state;
- Information - reads information about the device;
- Diagnostics by individual address - checking existing bus devices in the installation for compliance with the project.

After testing the project on the basis of a laboratory stand, students receive the necessary amount of knowledge and practical skills in the design of industrial KNX networks. Further development of the project is seen in the use of mobile devices on Android / iOS [19] and in Internet Of Things (IOT) [20] to control smart energy systems.

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