CENTRAL STATION OF INTELLIGENT HOUSE

Zdeněk Kaňa
Doctoral Degree Programme (1), FEEC BUT
E-mail: xkanaz00@stud.feec.vutbr.cz

Supervised by: Zdeněk Bradáč
E-mail: bradac@feec.vutbr.cz

ABSTRACT

This paper is aimed at design of hardware and software for the central station of intelligent house (CSoIH). The CSoIH was developed for automatic and energy saving regulation of given heating/cooling system for low-energy house. The main part of CSoIH is the RCM3200 RabbitCore module with integrated 10/100Base-T Ethernet port.

1. INTRODUCTION

The CSoIH was developed for certain application, with special emphasis on low price. The main objective of CSoIH is regulation of heating, cooling and ventilation system of low energy intelligent house.

The controlled system is placed in double-deck family house and consist of: heat pump (with heating and cooling function), ventilation unit, solar thermal collector(-s) (will be installed in the future), 300-litres water tank with 3 immersion heaters and two tubular exchanger circuits (domestic hot water and hot water from solar collector(-s)), fireplace with water heating and two heating circuits (radiators upstairs and coil heating downstairs). There's a need to measure 6 binary values, 6 temperatures and to set 16 binary process values (heat pump, circulating-water pumps, immersion heaters). The CSoIH should be set up and monitored by GSM and HTML.

2. CSOIH DESCRIPTION

Requirements of regulated system have resulted in this configuration of interfaces of the CSoIH:

- 16 relay outputs
- 8 digital inputs
- 6 temperature inputs
- RS-232C asynchronous serial port
- 10Mbit Ethernet port

The CSoIH is based on RabbitCore RCM3200 module, which incorporates the powerful Rabbit 3000 microprocessor, flash memory, static RAM, digital I/O ports, and a

10/100Base-T Ethernet port [1]. This module is programmable in Dynamic C development environment [2] (firm version of ANSI C language for embedded systems with many useful libraries) and will provide services of MicroC/OS-II real-time operating system, http server and control algorithm.

The RCM3200 is mounted directly on a motherboard with subsequent circuits creating interfaces to another instrumentation needed in process. Ethernet port is used to establish http server, which satisfies function for monitoring and setting-up the CSoIH. Asynchronous serial port RS-232C should be in the future used for connecting the GSM modem, which should enable to control the CSoIH by SMS. Figure 1 shows block diagram of connected CSoIH.

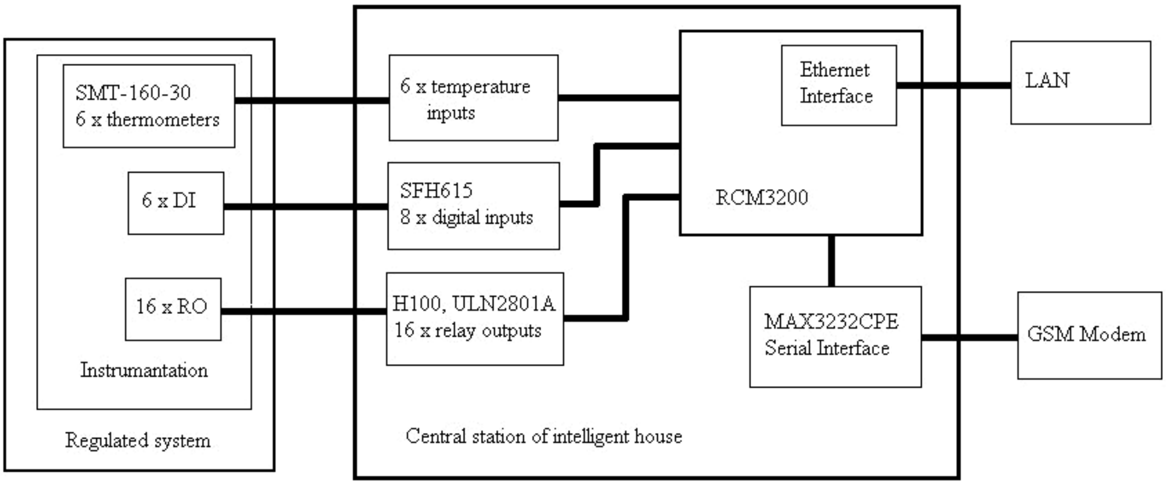

Figure 1: Block diagram of CSoIH

2.1. HARDWARE

As mentioned before, the "heard" of CSoIH is RCM3200. Further circuitry placed on motherboard and needed for respective interfaces is described now. Relay outputs are realized by H100 relays which are connected to the microprocessor by transistors arrays ULN2801A. Digital inputs are galvanic isolated by optocouplers SFH615 and equipped with 5 ms lag unit and protective diode against inverse voltage on input. Both relay outputs and digital inputs are connected to indicative LEDs. There's also needed to measure temperatures in the process. I decided to use converter temperature/duty SMT-160-30. This element needs 5 V TTL logic levels, therefore it is used Zener diode to lower this voltage on 3.3 V needed by Rabbit 3000. Part MAX3232CPE is used as level converter for RS-232C.

Rabbit needs regulated 3.3 V power source and relays need 5 V power source. I decided to use linear three-terminal voltage regulator to obtain wide range of supply voltage connected to the motherboard. The disadvantage of linear voltage regulators is a need of heat sink; this should be solved easily in our application. Figure 2 shows designed printed circuit board.

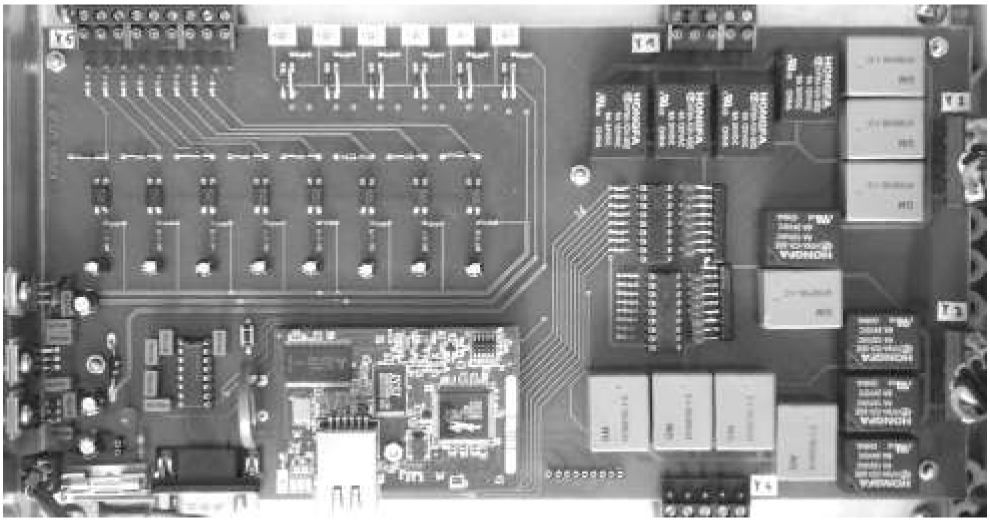

Figure 2: Central station of intelligent house

As shown on the Figure 3 the CSoIH has been put into consumer unit together with power sources (one for powering the CSoIH and one for galvanic isolated digital inputs), circuit breakers and terminals.

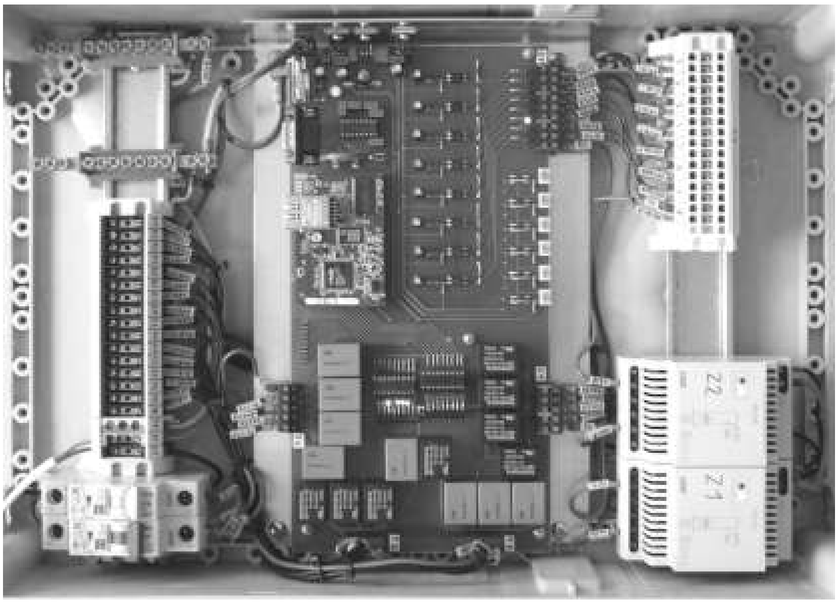

Figure 3: CSoIH in consumer unit

2.2. SOFTWARE

The software for Rabbit 3000 was developed and debbuged in design environment Dynamic C 8.61. Whole application is written in C language and is running on Real-Time Kernel MicroC/OS-II, created by Jean J. Labrosse [3]. MicroC/OS-II is a preemptive, prioritized kernel, which permits 63 user-definable tasks controlled by semaphores, mutex semaphores, queues, event flags and mail boxes.

There were created 3 tasks. The first one measures temperatures (it is periodically sampling SMT-160-30 inputs) and has the highest priority. The second one ensures the main control algorithm. There was developed 5 heating/cooling programs (summer, transitional, winter, economical-winter and manual program) and 4 ventilation programs (off, on without air-condition, on with air-condition, automatic). The last task, with lowest priority, secures services of a HTTP server. Web pages provided by the HTTP server uses forms and SSI (Server Side Inclusive) for setting up parameters of control algorithm and visualization.

3. CONTROL ALGORITHM

I'd like to mention only two most important heating/cooling programs – winter and summer program and to highlight control fundamentals. I'll describe the winter program initially. The house is divided into two heating sections (upstairs and downstairs) with individually adjustable desired temperatures. The first upstairs section with radiators use nonlinear feedback loop turning on/off two circular pumps. Downstairs section with coil heating is regulated due to the ekvi-term curve representing relationship between outdoor temperature and desired temperature of warm water entering coil heating. The water temperature is regulated by centre valve controlled by servo, which is connected to two relay outputs (one for closing and one for opening the valve) of CSoIH. There is also measured the temperature of this heating water.

During the summer program the domestic hot water is being prepared by solar collector(-s) and the temperature in house is regulated by air-condition constituted by ventilation unit and heat pump in cooling function.

4. CONCLUSION

There was developed low-cost control system suitable for building control. This system is considered to be used in family house with installed given heating/cooling system, but due to the use of standard interfaces can fit many other applications.

The whole system is right now (February 2006) being finished and putting in action. There should be installed solar thermal collectors this summer and bought and installed GSM modem for setting up and monitoring the CSoIH by SMS.

ACKNOWLEDGEMENTS

This work has been supported by Ministry of Education, Youth and Sports of the Czech Republic (Research Intent MSM0021630503 MIKROSYN New Trends in Microelectronic Systems and Nanotechnologies).

REFERENCES

[1] RabbitCore RCM3200 User's Manual, U.S.A., Rabbit Semiconductor Inc. 2004, 019-0118

[2] Dynamic C User's Manual, U.S.A., Rabbit Semiconductor Inc. 2004, 019-0125

[3] Labrosse, J.: MicroC/OS-II, The Real-Time Kernel, San Francisco, CCMP Books 2002, ISBN 1-57820-103-9