GSM Based Remote Control for Distributed Systems

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***Abstract**: In this paper are presented the results regarding the implementation and testing of a novel type of remote control based on the data transmission facilities offered by the GSM network infrastructure and the processing power achieved by new generation of microcontrollers. The system is intended to be used in the development of complex distributed control applications that are specific to various automated industrial processes, including the manufacturing of printed circuit boards and electronic modules. The proposed control system was designed using a prototype board equipped with Atmega 328 microcontroller. For implementation of data communication between the remote modules that compose the distributed control system a Quectel M10 quad-band GSM/GPRS radio modem was used. The quality of the proposed design was evaluated through extended performances analysis focused on the delay time, maximum transfer rate, failure tolerance and reliability. The system allows versatile configuration of command's structure and can operate with an extended set of commands for the remote modules. Also, compared with other implementation solutions the proposed design can be used almost in any location due to the large availability of the GSM infrastructure.*

1. INTRODUCTION

The distributed control appeared initially in the industrial domain and had an evolution that begun with the development of microcomputers and communication networks, but in our days the concept is extending also in home automation and embedded systems. Also, the implementation of complex manufacturing processes that are located in wide areas requires dedicated equipments organized in distributed control and monitoring systems. Such control systems for distributed applications imply the integration of some basic components such: sensors, actuators, controllers, communication buses and dedicated user interfaces for human-machine interaction or machine-machine communication. The communication method used for data transmission between the modules of a distributed control system represents an essential aspect. In the latest designs, wireless communication is increasingly used due to the inherently advantages such as: mobility, easy setup of the system, reduced costs. In addition, the advent of mobile terminals and embedded servers increased the attractiveness of distributed control approach but also generated new security threats.

In this context, in our paper we present the results regarding the implementation and testing of a novel remote control system based on the data transmission facilities offered by the GSM network infrastructure combined with the processing power of a performing microcontroller [1].

2. THE IMPLEMENTATION OF THE GSM BASED REMOTE CONTROL SYSTEM

The design of the remote control system is realized around an Arduino Uno development board. The main element of this board is the Atmega 328 microcontroller. This microcontroller is a high-performance device operating on 8 bits and having a set of 131 instructions that are mostly executed in one clock cycle. The relatively reduced instruction set combined with a 20MHz maximum clock frequency lead to an increased operation speed of microcontroller that reflects also into the operation speed of the development board and the system.

On the peripheral side, the module offers 14 digital input/output terminals, six of them been configurable as PWM outputs (Pulse Width Modulation). Also the

development board has the possibility to acquire six analog input signals from various sensors. The internal analog-to-digital converter used for implementing the analog inputs of the system operates with a 10 bits resolution.

The initial programming of the Atmega 328 microcontroller is realized through onboard ICSP interface (In-Circuit Serial Programming). This allows the programming of the Atmega 328 microcontroller while it is mounted on the board.

The communication interface of the Atmega 328 is represented by a programmable serial Universal synchronous/asynchronous receiver/transmitter (USART). For connecting the development board to the PC using the USB interface, it was necessary to be used an interface circuit implemented with the second microcontroller Atmega 16U2. This device operates also with 8 bits and has and reduced instruction set computing architecture (RISC) based on 131 instructions. The general parameters of the Atmega 16U2 microcontroller are similar to that specific to the main microcontroller represented by Atmega 328.

In our approach the communication with the remote module is achieved through GSM network infrastructure. A mobile phone is used for monitor and control the remote module that is directly connected to the process through actuators and sensors [1], [2].

For ensuring the bidirectional communication with the user terminal from which are sent the commands, the Arduino Uno development board is directly connected to a GSM shield implemented with Quectel M10 quad-band GSM/GPRS radio modem [3].

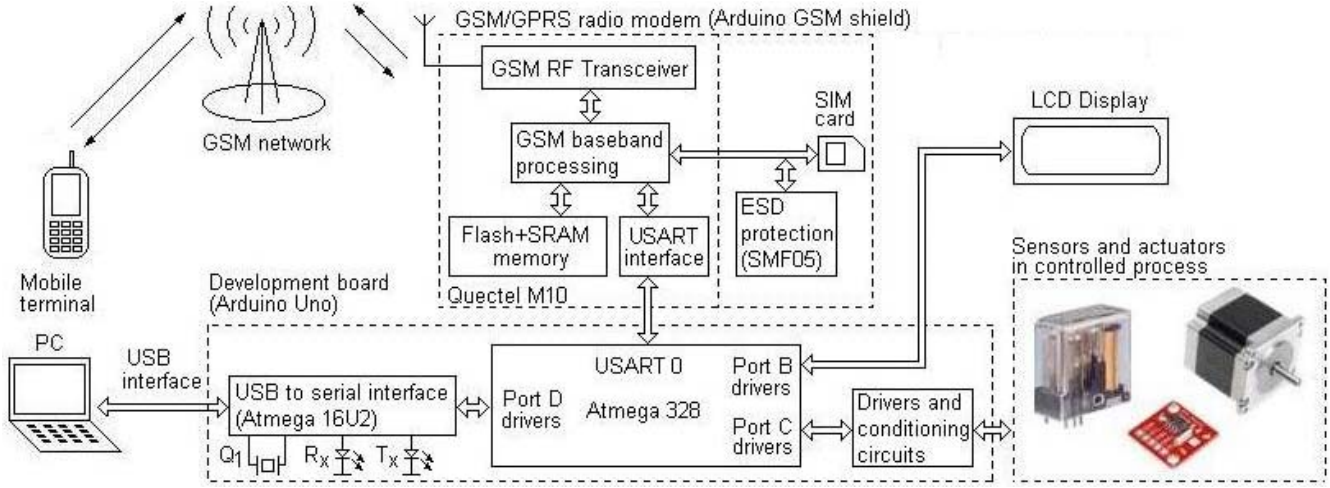

Fig. 1. The main elements of the GSM based remote control system.

The GSM/GPRS radio modem is capable to communicate using all standard frequencies: 850, 900, 1800 and 1900Mhz respectively. Also, the modem allows automatic searching and selection of the desired frequency bands through common AT commands implemented is software routines. The AT commands are sent to the radio module as short text strings and represents a common method of control for modem applications. The transmission power used in our application is imposed by the radio modem which can operate in two modes: Class 4 with 2W in GSM 850 and 900MHz and Class 2 with 2W in DCS 1800 and 1900 MHz bands. Also, the maximum achievable data transfer rates with the GSM module included in the proposed design of the remote control system is limited to 85,6kb/s for both downlink and uplink directions. It is used an general packet radio service (GPRS) with multislot connectivity and a configurable class from 1 to 12 [4], [5].

The Quectel M10 quad-band GSM/GPRS radio modem is connected to the Atmega 328 microcontroller from the Arduino Uno development board through a standard serial interface (USART) with controlled speed in the range of 4800 to 115200 bit/s. As can be observed form the block diagram presented in Fig. 1, the SIM card that is necessary to be inserted in the GSM/GPRS radio modem is protected against electrostatic discharges by an dedicate circuit SMF 05.

4. THE SOFTWARE APPLICATION

The software program for the GSM based remote control system presented in this paper was written in the Arduio's specific software development platform. The created application was uploaded into the memories of the microcontrollers using a serial connection and a specific bootloader that is previously stored in the system. The procedure imposes that after resetting the development board to wait few seconds for activating this small software bootloader which allows the initial programming of the microcontrollers.

Regarding the operation of the program for the GSM based remote control system, as can be observed from the main state diagram represented Fig. 2, the first module of the application contain an initialization of the specific parameters of the hardware module, including communication parameters, followed by an procedure for connecting the system to the GSM network. From our practical tests resulted that this connection procedure and initial parameters setting is realized in less than 4 seconds, which represents an acceptable value for the purpose of the proposed design.In the second module of the software application is implemented a procedure for receiving and verifying the validity of a command text message using the short message service (SMS) facility of the GSM network. The SMS communication is realized with the Quectel M10 quad-band GSM/GPRS radio modem whose operation is controlled in our case by the software routines based on AT commands. The AT commands set represents a versatile language specific to mobile and other transceiver units.

After receiving an SMS message the application verifies the content and extracts the sender phone number. If the sender number is not found in the internally stored list containing the valid numbers, then the application send and locally displays a specific message, "Invalid number", followed by the operation of deleting the received message. But if the sender's number is in the stored list with accepted users, then is analyzed the password. In the content of the received SMS, the password is placed at the beginning of the text string and consists in five characters. If the validity of the received password is not confirmed then, as in previous case, the whole message is deleted and after a short delay (100ms) the system is entering in the procedure of waiting the apparition of a new received message.

In case that the password is validated then the application activates a special routine that read and execute the received command. The message containing the executed command is temporary stored in the microcontrollers memory and will be read sequentially. At the level of the development board are stored a list with accepted commands. If the received command is not found in the internal list than an error message is sent back to the sender.

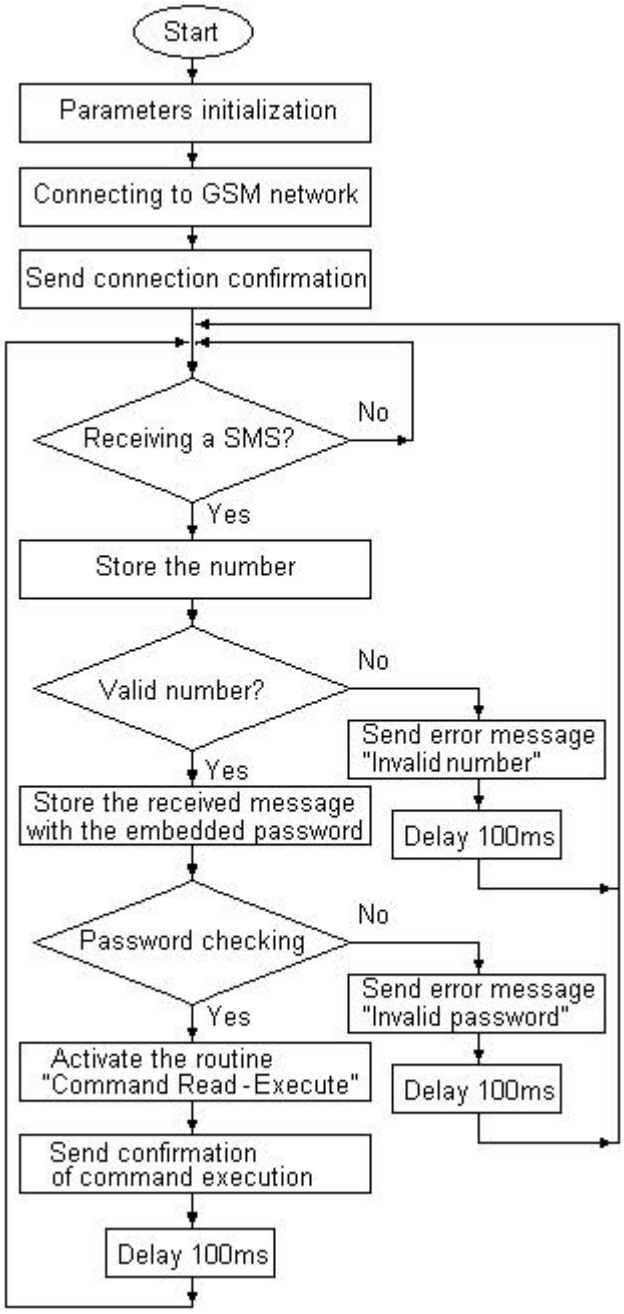

Fig. 2. The main state diagram of the software application for the GSM based remote control system.

5. RESULTS

As vas mentioned before, for verifying the quality of the proposed design we implemented an experimental module. The prototype system contains as main element an Arduino Uno development board equipped with ATmega 328 microcontroller.In Fig. 3 and Fig. 4 are illustrated the prototype modules that represents the first variant of the proposed system. Although the remote module has a dedicated LCD for locally displaying the state of the control system, the information is also transmitted to a PC using the USB interface of the Arduino Uno development board.

The results obtained in the experimental tests focused on system's performances. The delay time in command execution was monitored and resulted and maximum value of 5 seconds, depending mainly of the GSM network state and receiving condition of radio signal. The maximum transfer rate of 85,6kb/s was limited by the used GSM/GPRS radio modem Quectel M10. The failure tolerance and reliability of the system was dictated by the used development board and the extension module. Because the initial design was a prototype system these parameters can be improved significantly by special hardware design of the mounting case and used connectors [6].

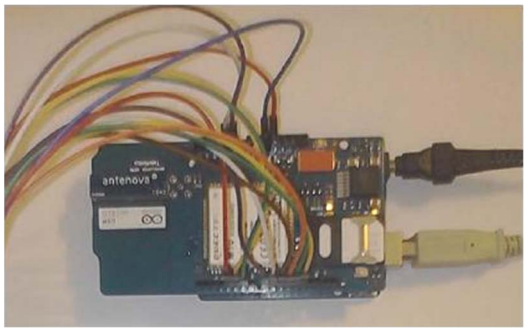

Fig. 3. The development board directly connected to the GSM shield implemented with Quectel M10 quad-band GSM/GPRS radio modem.

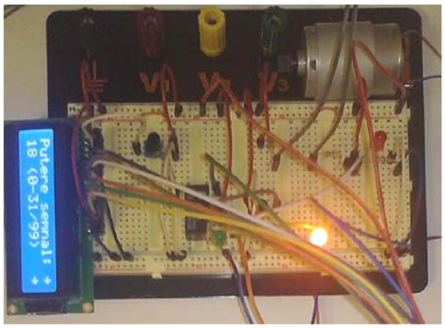

Fig. 4. The remote control system executing a command received from the user terminal.

6. CONCLUSIONS

The proposed remote control system based on GSM communication represents a versatile platform for developing distributed control systems with very wide spectrum of applications, beginning from complex industrial manufacturing processes that are located in wide areas and extending also in home automation. Due to the global availability of the GSM network, the proposed implementation solution can be used almost in any location. The system can be extended to operate with a more complex set of commands and with a larger number of mobile terminals or even embedded servers.

REFERENCES

[1] Vini Madan, S.R.N Reddy, "GSM-Bluetooth based Remote Monitoring and Control System with Automatic Light Controller", *Int. Journal of Computer Applications*,vol. 46, no.1, pp. 20-28, 2012.

[2] I. Coskun, H. Ardam, "A remote controller for home and office appliances by telephone", *IEEE Trans. on Consumer Electronics*, vol. 44, pp. 1291-1297, 2002.

[3] Adrian Tulbure, Hans-Peter Beck, Mircea Risteiu, "Variable motor operating point by integration of power electronic device into rotor", *European Power 13th Electronics and Motion Control Conference, 2008, EPE-PEMC 2008.*, pag. 1243-1248, 2008.

[4] Gerardo Aranguren, Lopez Nozal, Carola Blazquez, and Jose Arias, "Remote control of Sensors and actuators by GSM", *IEEE 2002 28th Annual Conf. of the Ind. Electronics Soc. IECON 02*, vol. 3, 5-8 Nov. 2002, pp.2306 - 2310.

[5] Alin Mazare, Laurentiu-Mihai Ionescu, Adrian-Ioan Lita, Gheorghe Serban, "Real Time System for Image Acquisition and Pattern Recognition Using Boolean Neural Network", *38th International Spring Seminar on Electronics Technology*, *ISSE* 2015, pp. 292-295.

[6] Andrei Drumea, Robert Alexandru Dobre, "Modelling, simulation and testing of an autonomous embedded system supplied by a photovoltaic panel", *20th International Symposium for Design and Technology in Electronic Packaging (SIITME2014)*, pp. 309-312.