REMOTE ALARM AND COMMAND SYSTEM FOR RESIDENTIAL DOMOTICS TROUGH GSM - SMS

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ABSTRACT

The conception of an electronic system for alarm monitoring and remote command devices, through GSM mobile net using short messages (SMS) is described.
It was developed as a low cost solution based on a common mobile phone and an Intel 8751 microcontroller. A prototype was built with a versatile configuration for residential domotics, including 6 binary inputs and 6 binary outputs, allowing to be associated to 4 different users (mobiles phones). The main characteristics of the hardware and protocol used for communication are described. The system was conceived in order to get an adequate performance, which came to be confirmed with the prototype. Reference is also made to other known systems for similar functions.

KEYWORDS: alarm monitoring, home domotics, mobile phone, SMS.

1. INTRODUCTION

The evolution of micro-electronics and communications technologies, brought many innovations in different automation areas, in particular in Domotics, where the technology of industrial processes was adapted to routine domestic tasks.

Domotics is the technology for integrating automated process in buildings, at comfort level, safety, energy saving and communications.

An increase of receptivity to residential domotic solutions is being noticed lately, reflecting the users wakening for the need and utility of personalized management solutions for the devices and equipment already available in the majority of homes [1].

New technological opportunities are appearing that can contribute to simpler forms of implementation of domotic scope functions, namely, the wireless nets, the detectors and sensors and the mobile communication systems. This last aspect is important because part or all home users usually move to sometimes great distances, and eventually for long periods, thus motivating the investment in the present study.

The proposed system is intended for device state monitoring in a residence, for sending alarms, and also for remote command of equipment, by using simple messages in a mobile, trough GSM ("Global System for Mobile Communications") net, using the Short Message Service (SMS) [2,3].

The mobile phone is a natural choice, since it is a communication resource generally available by people, which makes them practically always contactable and capable to send commands to operate home systems.

SMS is a globally accepted wireless service that enables the transmission of alphanumeric messages up to the limit of 160 characters between mobile subscribers via SMS Center (SMSC). All GSM operators provide the Short Message Service.

It is low cost, easy to use and a relatively safe media, with sufficient message dimension and rhythms of transaction for the normal functions in residential domotics; it may also assure late deliverance in case of momentary communication breaks.

The most important limitation on this type of solution results from the need of signal coverture by the mobile operator at the installation place.

2. CURRENT SOLUCTIONS FOR LONG-DISTANCE COMMUNICATION BY GSM

Some devices of this type can be already found in the market, which, although not very diverse, is quite interesting in terms of functionalities and application potentials. Some commercial assignments are referred: Spider Sms, Auto Bleep, Anino Sms, Comsat.

Such devices have, in general, inputs to which external alarm systems are connected and outputs through which

house equipment can be commanded. The inputs are cyclically checked; the occurrence of a change of state triggers the sending of one or more messages by SMS with the event information.

The interface with the command devices is guaranteed, normally, with electromechanical relays, operated by the reception of a specific SMS message.

One common characteristic of the studied equipment is its manufacturers' concern with actualisations, referring to new functionalities, which suggests that this type of solutions is still in an active phase of research and technological development.

Two types of solutions for communication may be found in the local (fixed) command unit: one is based on the incorporation of an ordinary mobile phone, through a data cable, while the other one uses a specific modem (modulator-demodulator) for this type of communication. The use of a modem has advantages in terms of data handling and the use of protocols defined by the user; it is usually a good solution for large scale data transfer, normally using GPRS (General Packet Radio Service), but having a high cost for typical residential automation applications.

The advantage of using a mobile phone in this type of system is its low cost, due to large-scale production, and general availability. It also assures automatic reconnection mechanisms to the cellular net, even after service or transmission occasional interruptions. However they require the knowledge of serial communication protocols established by the manufacturers that, in general, are not freely available.

Regarding the analysed systems it was decided to work on the development of a low cost system that fits the typical needs of an urban residence with medium level functionalities.

3. SYSTEM DESIGN

The developed system consists of a home unit with: on one hand, 6 binary inputs for equipment monitoring (e.g. intrusion, fire detection, etc.) which triggers the delivery of warning or alarm SMS messages to specified mobile phones; on the other hand, 6 output binary (relay) devices (e.g. for air conditioning, light control, irrigation, etc.), to be actuated by remote command, through coded SMS messages by authorised mobile phones. The system block structure is presented in fig. 1.

An ordinary mobile phone, in this case the NOKIA 3310 model, was chosen as the dedicated (fixed) device to perform the communication tasks. However, the user's mobile phones can be from different manufacturers.

The interpretation and elaboration of messages is done by a microcontroller. It manages the information bi-directional flow between the mobile phone and the microcontroller (namely the detection of arrival messages, the delivery of other messages, the removal of read messages, etc.).

The inputs are connected to external alarm systems, through optocouplers and the outputs are connected to external devices by relays for better disturbance rejection.

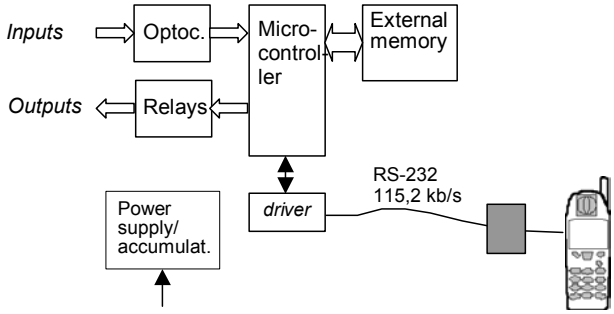

Figure 1 – General structure of the home (fixed) unit

A. System Functions

When a change of state occurs in one of these inputs a protocol byte sequence is transmitted through the serial port to the fixed mobile phone, corresponding to a command of sending an SMS to a specific number of mobile phone with a previously defined warning text. Similar messages are sent to other specific mobiles, up to a total of 4.

When a communication of this type takes place, the microcontroller waits until the mobile acknowledges the command reception. If an acknowledgement is not received the command is sent again up to three attempts.

Conversely, an SMS reception by the dedicated mobile causes a byte sequence transmission trough the serial interface. This sequence is analysed by the microcontroller and, if valid, it actuates the corresponding output relay to turn on/off the device to which is connected.

By sending a specific enquiry SMS message, from an authorised mobile number, the user can get the overall input and output state as a reply message in his/hers phone.

Any mobile allows a limited number of messages to remain in memory, beyond which it does not accept new messages. In order to avoid that, every message is automatically deleted from the memory card, preventing a memory overflow.

An MSWindows application was elaborated to allow an easy configuration of up to four accepted numbers of mobile phones, making possible to specify, for each number, which input (warning) messages are to be sent and which outputs are authorized to be operated.

This is the only situation when a computer should be connected to the unit, in order to initialize the system. A RS232 serial cable is used to make the connection. The main configuration window is shown in figure 2.

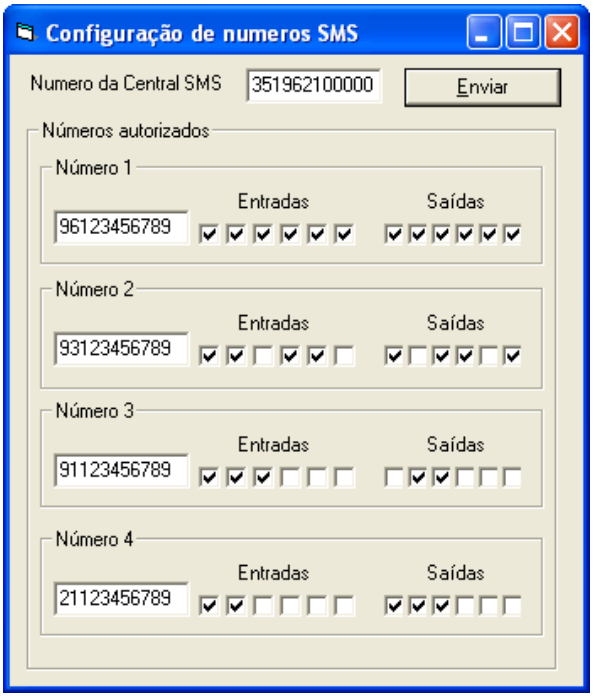

Figure 2– Main window of the configuration program

Alarm messages as well as the remote command messages that allow operating the external devices, are previously defined and may not be changed.

B. Communication Protocols

To establish the connection between mobile and SMSC a communication protocol based on ETSI rules, is used [4].

However to establish the connection between the microcontroller and the dedicated mobile phone the used protocol is an ETSI adaptation, the F-Bus protocol, from the manufacturer NOKIA [5].

The signal elaboration is NRZ type, with asynchronous serial full-duplex data transmission, organized in octets. The baud rate is 115,2 kbit/s, using 8 data bits, 1 stop bit and no parity bit.

In general terms the communication sequence established between the dedicated mobile and the microcontroller is processed in the following way:

- microcontroller sends a command package
- mobile sends an acknowledge command
- mobile sends a reply package, reporting successfully delivery
- microcontroller sends an acknowledge command.

When this last acknowledge command does not arrive at the mobile, the protocol interprets this situation as a communication fail and retransmits the reply package up to three times.

C. System Hardware

The system is based in a single Intel 87C51FA microcontroller [6], appropriately configured to work at 115,2 Kbits/s, using a 14.7456 MHz oscillator.

The considerable amount of data from messages being processed requires the use of an external memory, since the microcontroller only has 256 bytes data space.

A data cable that contains electronic processing to convert the mobile phone 3V signals into RS-232 type signals completes the mobile phone and microcontroller connection.

Electrical connections between output relays and input optocouplers and external devices are schematically shown in figure 3.

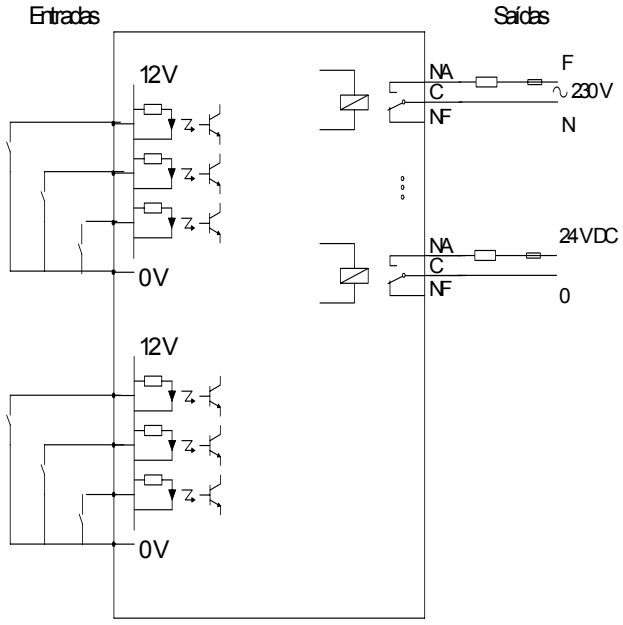

Figure 3– External interface schematics

D. System Firmware

Details of the microcontroller program developed for this system are described on the flowcharts of figure 4 and figure 5.

Its broad structure consists of two main routines, one for sending the sms messages and another for reading and processing the incoming messages.

The firmware is stored in the 8 Kbyte internal EPROM program memory of the microcontroller.

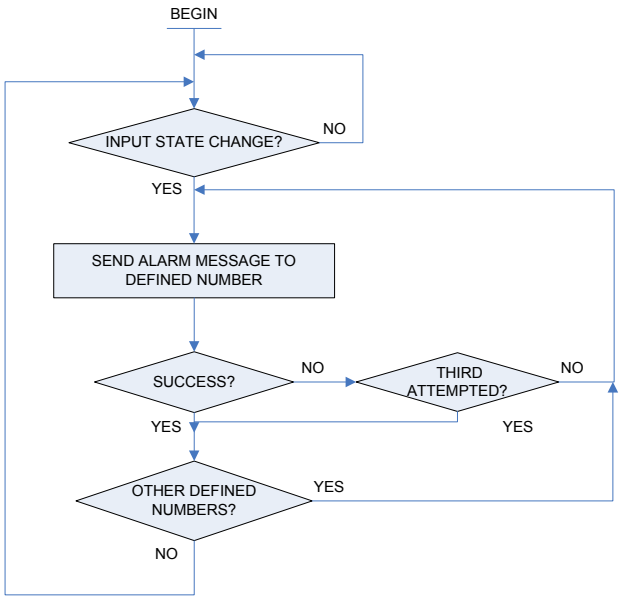

Fig. 4– Alarm monitoring/sending routine

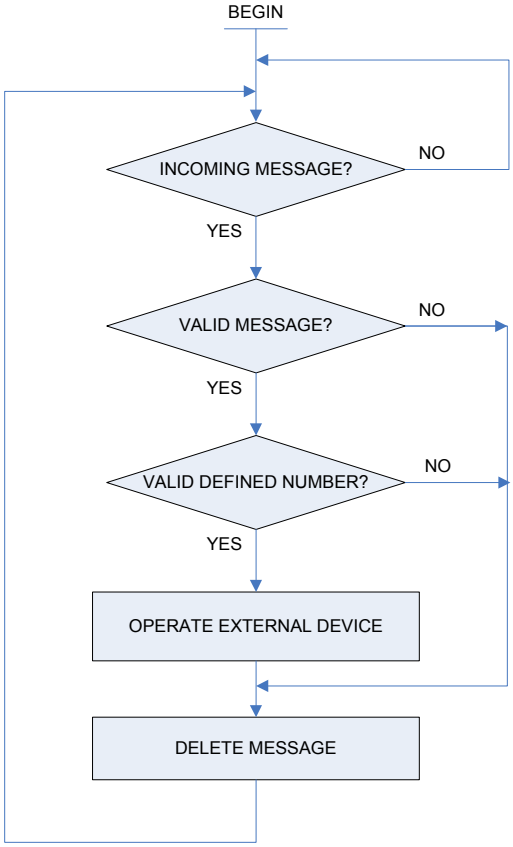

Fig. 5– Remote command routine

E. Developed System

The developed prototype board, connected to the dedicated mobile, is shown in figure 6. Experimental tests carried out with the system confirm the expected performance.

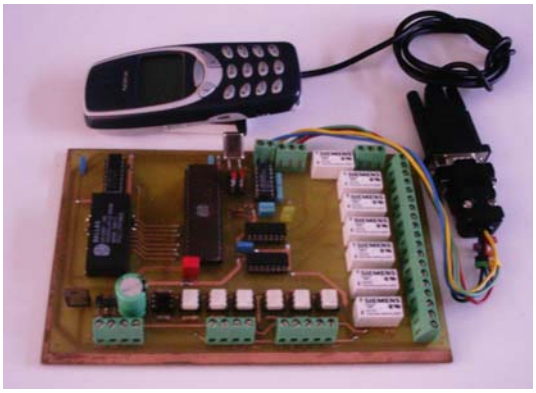

Fig. 6– Developed system photo

4. CONCLUSIONS

The developed system accomplishes the objective of good performance and low cost, as intended, as well as showing good immunity against the interference of strange agents, given the strict recognition made to the authorized numbers of mobile phones.

Major limitations consist of the reduced number of users, unchangeable message contents and need of signal coverture by mobile net operator.

This type of solution brings an important contribution for security and comfort aspects in residential domotics. However it still has potential for other applications in industry and services requiring a moderate debit of message transactions.

Looking at other commercial systems some interesting solutions were found, capable of performing similar functions, although with different characteristics, and in general with relatively high cost.

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