TELECONTROL PLATFORM
Telecontrol Platform for Industrial Installations

Eduardo J. Moya, Oscar Calvo, José María Pérez, José Ramón Janeiro and David García
Fundación CARTIF, Parque Tecnológico de Boecillo, Parcela 205, 47151 Boecillo, Valladolid, Spain

Keywords: GSM modem, analogical modem, PLC, SCADA, monitoring, Industrial Process.

Abstract: This article explains the telecontrol platform for industrial installations developed by CARTIF Foundation. Using this system it will be able to send control orders and receive notification of alarms from the PLC thanks to SMS (Short Messages System) messages which use GSM technology. In case of requiring a greater flow of data it will use telephone line combined with MODBUS protocol. All this will enable us to monitor and control any industrial installation with a very low cost. *Copyright © 2007.*

1 INTRODUCTION

The possibility of remote connections with industrial processes can represent significant savings of time and money for companies. In fact, you can control and monitor equipments, update the software or locate faults regardless of equipment location with a simple remote connection.

These monitoring tasks can be carried out with conventional technologies, as GSM network or switched telephone network, (International Engineering Consortium, 2007) which have been installed for many years. These systems are reappearing in industrial applications thanks to its low cost and the broad range of possibilities offered

By using of these technologies (GeneralLynx, 2007), CARTIF Foundation has developed a monitoring system based on GSM modems and analogical ones that allow us to monitor and modify variables of processes controlled by SIEMENS S7-200 automatisms.

The article is organized as follows. In Section 2 we explain the first part of this project that consisted in creating a system capable of controlling and monitoring a process through SMS messaging. In Section 3 we expose the second part of this project. In this case we use an analogical modem to link PLC and SCADA. In Section 4 we will explain a practical case of the combined use of the library SMS and communication via RTC modem. Finally conclusions and open issues for future research are discussed in Section 5.

2 MONITORING OF PROCESSES USING GSM TECHNOLOGY

In the case we're dealing with we'll use the GSM network, which will allow us to send simple control commands between a cellular and a PLC from any place as long as we have enough coverage; this system requires only a GSM modem and a SIM card which are very cheap.

In this section we'll explain the library called SMS developed by CARTIF Foundation. This library has been developed to be used with a programmable Siemens PLC although similar developments can be performed to be used with other brands as Telemecanique, Omron or Allen-Bradley.

2.1 Elements of the System

CARTIF Foundation uses mainly programmable PLCs of Siemens or Telemecanique. We decided to develop SMS library to be used with a low-mid range Siemens PLC. In this way, the automatism that has been selected is a S7-200. Developing this library for the S7-200, subsequent developments in other PLC´s will be able to be conducted in a very similar way.

Besides that it will be needed a RS 232/PPI Multi-Master cable because the ports of Siemens S7-200 series are RS-485 and GSM modems usually have RS-232.

The third item of the system is a GSM modem.

J. Moya E., Calvo O., María Pérez J., Ramón Janeiro J. and García D. (2008).
TELECONTROL PLATFORM - Telecontrol Platform for Industrial Installations.
In *Proceedings of the Fifth International Conference on Informatics in Control, Automation and Robotics - RA*, pages 81-86
DOI: 10.5220/0001491300810086

At first it was wanted to develop a library that would be independent of the brand and model of GSM modem, but it wasn't possible because each brand have different responses to the commands that are sent to it. In order to simplify the design of the library it will be used a generic one, GSM/GPRS Wavecom Fastrack (Fastrack Modem M1306B, 2007).

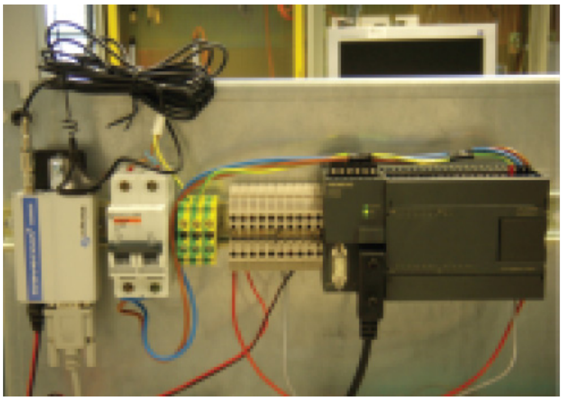


Figure 1: PLC & GSM modem.

2.2 Characteristics of SMS Library

SMS library has as basic functions the reception and sending SMS messages, always besides their treatment. The great advantage is that communication with modems is standardized through the use of AT commands (AT Commands Interface Guide, 2007). AT commands are just coded instructions for communication between a device and a modem. As we said before although the instructions that are sent to modems are standardized through the AT commands, the modems responses are not. This causes the library not to be valid for all GSM modems, although its adaptation to other models is very simple.

2.2.1 AT Commands

The commands AT used in the library are: ATE0, AT+CPIN ?, AT+CPIN = "Nº PIN", AT+CMGF = 1, AT+CSMP = 17,167,0,0, AT+CREG ?, AT+CPMS = "SM", AT+CMGS = "PHONE NUMBER", AT+CMGR = X, AT+CMGD = X.

2.2.2 Library Functions

The library functions are:

- Sending SMS.
- Periodical control of coverage.
- Output of error.
- Automatic blocking in case of entering a wrong PIN.
- Reception of SMS
- Elimination SPAM.
- Automatic Clearing of the read SMS.
- Permits of access.
- Treatment automatic SMS.
- Treatment of SMS by the user.
- Size in program memory: 4.5Kb
- Size in data memory: 490 bytes.

2.3 Compatible SMS

For the use of library SMS is only necessary to have a mobile phone (Moya, 2007). You can send SMS of two types:

2.3.1 SPECIFIC Messages

These messages are customized for an installation in concrete. In this case, the library SMS returns the text message received and is the programmer of PLC who is responsible to deal with it. These messages have the following format:

```
"PERS" "STOP MOTOR 1"
```

In addition, the programmer of PLC can send SMS of notification of alarms or as a response or acknowledgement to an SMS received, being the format of these messages to choice of the controller.

2.3.2 STANDARD Messages

These messages are called standard because they are not specific of an installation. They are treated directly by the library SMS and in the event that it will have configured, send an acknowledgement of receipt.

This kind of message has the following format in the case of messages of modification of variables:

```
"ESTA""SYMBOL""ADDRESS""OPERATION"
```

or in case of messages of consultation

```
"ESTA" "SYMBOL" "ADDRESS" "?"
```

Once received a message of consultation, the response is sent automatically, and in the case of modifications of variables is sent an acknowledgement if it has been configured.

In this kind of messages, "SYMBOL" corresponds with the type of variable (V, VB, VW, VD and VR). The "ADDRESS" corresponds with the memory address (1000.1). The "OPERATION" field corresponds with the value to write in the direction of memory and in the case of "?" means that it is a consultation of the value of the data located in this address.

Table 1: Operations performed by SMS.

DATA	OPERATION	DESCRIPTION
V	1	Force a bit to be ON
	0	Force a bit to be OFF
	?	Ask about a bit status
VB	VALUE	Change a byte
	?	Ask about a byte value
VW	VALUE	Change a word
	?	Ask about a word value
VD	VALUE	Change a integer
	?	Ask about a integer value
VR	VALUE	Change a real
	?	Ask about a real value

2.4 Program Flow

As is shown in the flow diagram (figure 2), firstly a start stage is done in which, among other things, it's checked whether the PIN code is entered (if it's not, it will be entered) and the existence of coverage is verified.

The following step is to check if there are messages in the SIM card. In the case that there are any, the message is downloaded from the SIM card to a reserved area in the PLC. In the case that there are not, it would go to the stage for sending SMS from which it would send a message in the case that the user program required so. In the next step it's checked whether the SMS sender's telephone has permission to access to the control and modification of variables. This eliminates directly SPAM and telephones without access permission.

In the next step it's verified that the text message has not been read in previous cycles. In the case that the telephone does not have permission to access or the SMS has been read, the message is deleted. In the case that the SMS has not been deleted in the previous stage, it is checked whether the type of message is: "ESTANDAR", "SPECIFIC" or none of the two types. In the last case it is removed.

When it is received a "ESTA" SMS, it is dealed by the library SMS whether it is a monitoring message or if it is a control message.

If it's a message "PERS" type it is returned by the subroutine SMS to the main programme and it is the programmer the responsible for its dealing.

Then, once dealed, the SMS is removed from the GSM modem's SIM memory. In the next step SMS's are sent both of the acknowledgement, responses to consultations or notification of alarms.

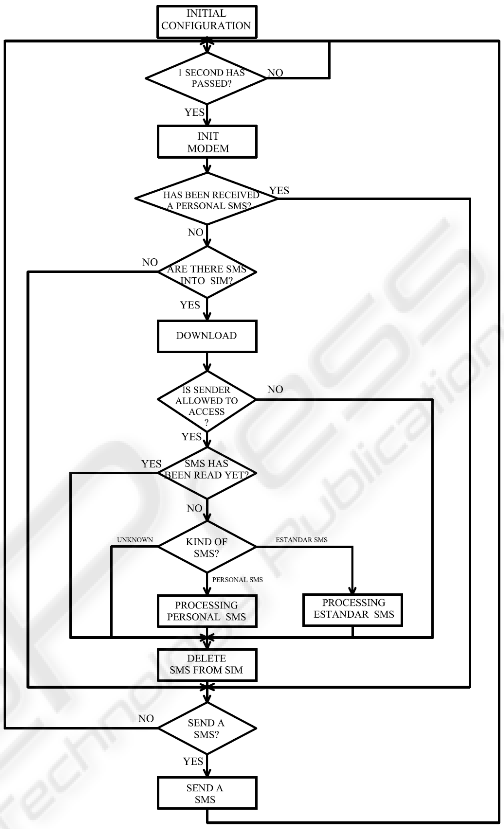


Figure 2: SMS program flow.

3 SUPERVISION & CONTROL OF PROCESS THROUGH ANALOGICAL MODEMS

In recent decades, the improvement of communication systems has caused a change in the form that the society sees the world. These improvements have narrowed the gap between the different points of the planet so any event can be known anywhere almost instantaneously.

Communications via telephone line and its application to computer systems through the modems have largely contributed to this.

The great coverage of the conventional telephone network enables an almost immediate connection between two computers if modems are used, and if it's extended to the industrial area it will provide us a cheap and effective method of controlling a process without the need for large disbursements.

3.1 Items of the System

3.1.1 PLC

Like for communication via GSM the PLC that we'll use will be a S7-200, although once set the foundations of the system, it can be carried out in other brands's PLC by introducing small changes.

3.1.2 Analogical MODEM

The Modem chosen is a module for expansion of S7-200. It does not need any library and its configuration is very simple, thanks to the assistant of the PLC's programming tool. It works in slave mode, and it uses MODBUS protocol to communicate with the PC, which will play a master role in our supervision system (Jiménez, 2007).

3.1.3 Personal Computer

The master of the system is a PC. This has a Modem to communicate with the Modem EM241 via the telephone line. To treat the data being received, a software application in Visual Basic has been scheduled, which transforms the MODBUS strings characters in data that can be displayed in a SCADA also scheduled in Visual Basic (Janeiro, 2006).

3.2 System Characteristics

3.2.1 Description of Modbus RTU Protocol

Once the connection between the modem local modem and remote modem connected to the PLC is established, we must choose a protocol that helps us to exchange data between the PC (MASTER) and the PLC that controls our process (SLAVE).

In our case the protocol which we'll use will be MODBUS RTU, very used in the industry for communications via modem.

The controllers communicate by means of a master-slave technique, in which only one device (master) may start transactions. The other devices (slaves) respond by supplying the master the data requested, or carrying out the action requested in the petition. Among the master devices typical central processors and programming panels are included. Typical slaves are the PLC's.

3.2.2 The Query-Response Cycle

Query: The function code in the petition indicates the slave device directing the type of action to perform. The bytes of data contain any additional information that the slave will need to carry out the function. The data field must contain the information to indicate the slave in what registration it should begin and how many has to read. The error verification field provides a method for the slave to validate the integrity of the contents of the received message.

Response: If the slave develops a normal response, the function code content in the response is a replica of the function code sent in the petition. The bytes of data contain data collected by the slave, such as values of registers or states. If an error occurs, the function code content in the answer is different from the function code sent in the petition, to indicate that the answer is a response of error and the bytes of data contain a code that describes the error. The verification of error field allows the master to confirm that the contents of the message are valid.

3.2.3 Queries Implemented by the Application

Modbus is a protocol developed by Modicon for its range of PLCs. Siemens, particularly S7-200, has implemented libraries, which introduced in the program code, allow to use it. In our case, the EM241 module has them included, for what it's not necessary to modify anything in the PLC's programme.

Table 2: Modbus operations implemented by SIEMENS.

FUNCTION	DESCRIPTION
1	Read coil status
2	Read input status
3	Read holding registers
4	Read input registers
5	Force single coil
6	Preset single register
15	Force multiple coils
16	Preset multiple registers

Despite that Modbus incorporates a wide variety of functions, SIEMENS only has 8 implemented which are those indicated in the table 2.

These operations act on bits in the case of inputs and outputs, or in words if it is variables in PLC memory. In the case of desiring to use different variable sizes, as double words, bits of PLC memory, etc, it must be done from these functions.

The application which has been developed, has taken into account this problem and has been programmed to allow the following requests:

- Read and write digital outputs.
- Read analogical inputs.

- Read and write integers.
- Read and write double integers.
- Read and write real numbers.
- Read and write bits from V memory.

The PLC responds by strings MODBUS RTU in hexadecimal that must be decoded.

3.2.4 AT Commands used

As in the case of communication using a GSM link, it has been needed AT commandsm: AT, ATE0, ATS30=time (s), ATDnumber, ATH.

3.2.5 Application Flow

Before establishing any communication it must be verified that the configuration of PC-Modem is correct. If this is so it can proceed to dial the telephone number of the modem connected to the PLC. In the case of being the line occupied or not to establish the connection it will generate a message informing about what is happening.

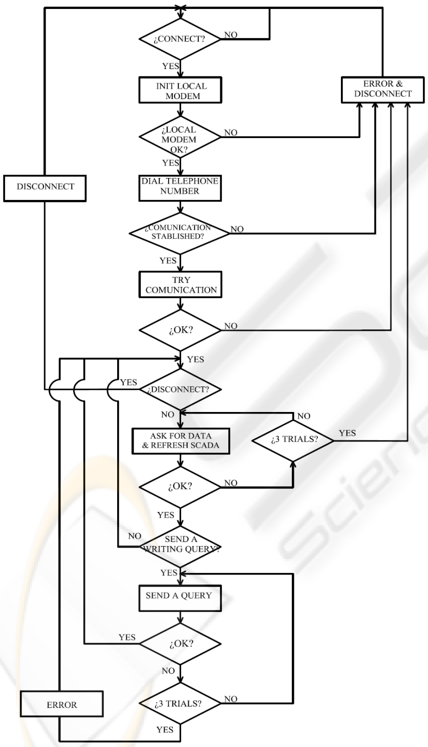


Figure 3: Program flow.

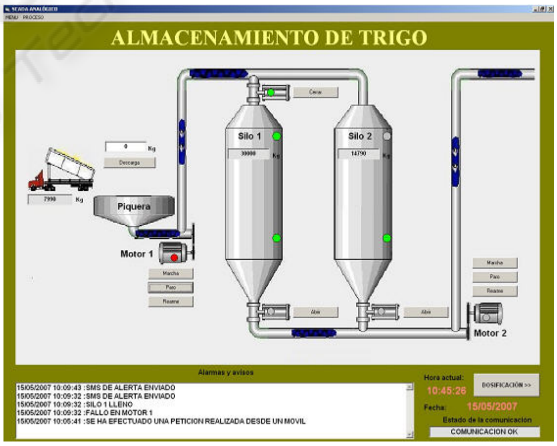
After connecting with the PLC test strings will be sent to see check that the communication is good. If everything is OK application will send petitions to the PLC with the frequency of refresh assigned by the user. The times of refresh can vary, from 2 seconds. Application must send petitions to the PLC, receive the responses from it, decode them and display in a screen through the SCADA. In addition to this, it will have to detect the communication errors that may occur.

On the other hand, it also takes into account the possible delays that may result from a wrong function of the modem, temporary disconnections of the line, etc. If these failure times are excessive, as in the previous case, the Modem gets disconnect and the cause is notified. In the case of wanting to change a variable of the PLC, the SCADA refreshing cycle is interrupted and the petition sent. If the operation is carried out successfully it returns to the routine of variable reading.

4 PRACTICAL APPLICATION

Now we will explain a practical case of the combined use of the library SMS and communication via RTC modem.

The case that we explain is a wheat storage and dosage plan. The process is divided into two parts: the part storage of wheat (Figure 4) consists of the bunghole and the first of two silos, while the part dosage of wheat (Figure 5) includes the last five silos and a weight scale.



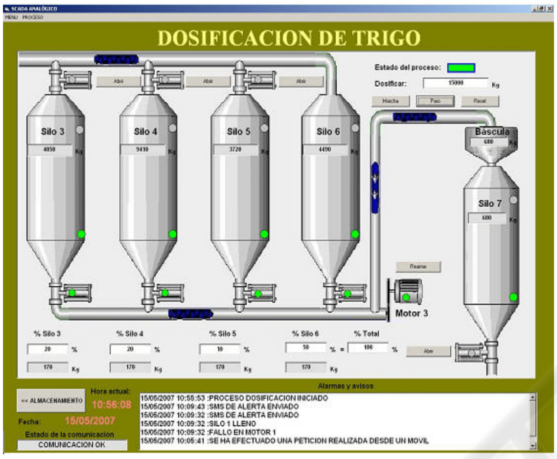
```
15/05/2007 10:09:43 :SMS DE ALERTA ENVIADO
15/05/2007 10:09:32 :SMS DE ALERTA ENVIADO
15/05/2007 10:09:32 :SILO 1 LLENO
15/05/2007 10:09:32 :FALLO EN MOTOR 1
15/05/2007 10:05:41 :SE HA EFECTUADO UNA PETICION REALIZADA DESDE UN MOVIL
```

Figure 4: Storage of wheat.

The download of wheat from the truck is carried out in the bunghole. To transfer the burden of wheat from the entry deposit to one of the two storage silos (Silo 1 or 2) the engine on the left must be on to activate the endless screw and the buckets elevators (horizontal and vertical displacement of wheat).

The wheat shall be deposited in Silo 1 or Silo 2, depending on whether the upper chopping block in Silo 1, is open or not. The wheat flow considered when this transfer performed is 10 kg/s.

The process of dosage consists on four silos (Silo 3, 4, 5 or 6) where different types of wheat are stored and on silo 7, where the mixture composed by wheats form Silos 3, 4, 5 or 6 is obtained. The maximum capacity of all these silos is 10.000 Kg. The flow of endless screws and the buckets elevators is as maximum 50 kg/s. The wheat supply in Silos 3, 4, 5 or 6 comes from storage Silos 1 and 2 of. The operator will be responsible for selecting the destination of wheat from Silos 1 and 2 by opening/closing the different upper chopping blocks of Silos 3, 4, 5 or 6.



```
15/05/2007 10:55:53 :PROCESO DOSIFICACION INICIADO
15/05/2007 10:09:43 :SMS DE ALERTA ENVIADO
15/05/2007 10:09:32 :SMS DE ALERTA ENVIADO
15/05/2007 10:09:32 :SILO 1 LLENO
15/05/2007 10:09:32 :FALLO EN MOTOR 1
15/05/2007 10:05:41 :SE HA EFECTUADO UNA PETICION REALIZADA DESDE UN MOVIL
```

Figure 5: Dosage of wheat.

Apart from "ESTANDAR" SMS configured for this installation, the following "SPECIFIC" messages have been programmed:

Control: It can activate the dosage and stop it.

Consultations: It can make consultations such as the weight of different silos, of the bunghole or of the dosage. It can ask about the state of the engines, as well as the state of the chopping blocks.

Maintenance: The alarm notifications have been programmed: unloading a truck in the bunghole, failure of any of the engines, filling of silos, and failure in the dosage and notices that the dosage has been completed.

To display the status of the process and the changes that we are doing via SMS we use the SCADA scheduled in Visual Basic, which uses the RTC line to establish the communication with the PLC.

5 CONCLUSIONS

The aim of this project was to make a system for supervising processes that allowed remote control of any installation in a simple and safe way but without incurring big costs.

This platform has been focused to be used in mid-range automatons such as the S7-200, because this PLC is the most indicated to control the processes that can be supervised by this system.

It has been tried to deal with the issue from two fronts, through a wireless communication by GSM Modems and on the other hand, a communication through telephone line. The choice of one or another depends on different factors such as: the location and accessibility of the plant, means of communication, level of automation, process complexity, etc.

In general, it can be said that for all activities that require an important exchange of data or/and a constant supervision, it would be advisable the implementation of an analogical modem communication system.

In the future is planned to develop this platform with other PLC brands like Telemecanique and Omron.

ACKNOWLEDGEMENTS

This work was supported in part by “Programa de Fomento de la Investigación Técnica para los Centros Tecnológicos”, (PROFIT grant FIT 330220-2005-138) from the Spanish Education and Culture Ministry.

REFERENCES

AT Commands Interface Guide, *<http://www.rfsolutions.co.uk>,* (in June 6, 2007).

Fastrack Modem M1306B User Guide, *<http://www.omniinstruments.co.uk>*, (in June 6, 2007)

GeneraLynx. *Remote supervision and control by WAP, <http://www.euroines.com/down/DemoDoc/WapScada%20DD.pdf>*, (in January 10, 2007)

International Engineering Consortium. Global System for Mobile Communication, *<http:www.iec.org/online/tutorials/gsm/>*, (in January 10, 2007)

Janeiro, J. R., 2006. *Supervisión remota de procesos industriales controlados por Autómatas Programables*, University of Valladolid. Spain, 1nd edition.

Jiménez, M., *Comunicaciones Industriales, Protocolo Modbus*, *<http:www.dte.upct.es>*, (in June 6, 2007).

Moya, E., 2007. *Control y mantenimiento de instalaciones remotas*. Wireless. Automática e Instrumentación, 384, pp. 44-47.