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OUTER GATE AUTOMATION USING MICROCONTROLLERS AND RADIO FREQUENCY COMMUNICATION

BY

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Abstract. This paper aims to improve the external automated gate systems using all the advantages offered by microcontrollers and radio frequency systems. The system uses a radio communication channel for controlling remotely a DC motor. To achieve this communication system it was used a PIC microcontroller and the speed of DC motor can be controlled by setting some microcontroller's registers.

Key words: automation system; microcontroller; radio transmitting channels; outer gate.

1. Introduction

1.1. Radio Frequency Communication

Radio communication system realizes the transmission of signals by modulation of electromagnetic waves with frequencies below those of visible light. Each system contains a transmitter and a receiver.

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The transmitter consists of a source of electrical energy, producing alternating current having a desired frequency. The transmitter contains a system to modulate (change) some properties of the energy produced to impress a signal on it. This modulation might be as simple as turning the energy on and off, or altering more subtle properties such as amplitude, frequency, phase, or combinations of these properties. The transmitter sends the modulated electrical energy to a tuned resonant antenna; this structure converts the rapidly-changing alternating current into an electromagnetic wave that can move through free space (sometimes with a particular polarization) waves.

Electromagnetic waves travel through space either directly, or have their path altered by reflection, refraction or diffraction. The intensity of the waves diminishes due to geometric dispersion (the inverse-square law); some energy may also be absorbed by the intervening medium in some cases. Noise will generally alter the desired signal; this electromagnetic interference is produced by natural sources, as well as by artificial sources such as other transmitters and accidental radiators. Noise is also produced at every step due to the inherent properties of the devices used. If the magnitude of the noise is large enough, the desired signal will no longer be discernible. This is the fundamental limit to the range of radio communications.

The electromagnetic wave is intercepted by a tuned receiving antenna. This structure captures some of the wave's energy and returns it in the form of oscillating electrical currents. At the receiver these currents are demodulated, representing a conversion to a usable signal form by a detector sub-system. The receiver is "tuned" to respond preferentially to the desired signals, and reject undesired signals (Hariton *et al*., 2010).

The present practicable limits of radio frequency are roughly 10 kHz to 100 GHz. Wireless system at present commonly operate in hundreds MHz or a few GHz frequency. Electromagnetic waves with a frequency in these limits have a propagation distance with an acceptable attenuation and a good penetrating capability through buildings and vehicles and are able to carry wide-band signals (Gu, 2005).

Today, the external automated gate systems are improving by detailed studies such as a microprocessor based automatic gate. This system monitors two gates – the entrance and exit. The automatic gate senses any vehicle approaching it. It automatically opens, waits for a specified time and closes after the time has elapsed (Shoewu & Baruwa, 2006).

Another analysed project is presented in the paper DC Motor Speed Control using Microcontroller PIC 16F877A of EA AI Choon. This project is mainly concerned on DC motor speed control system by using microcontroller PIC 16F877A. It is a closed-loop real time control system. This system will be able to control the DC motor speed at desired speed regardless of load (Choon, 2005).

This paper intends to improve the automation systems for sliding gates. The sliding gates slowly replace the swing gates in most industrial and business premises. This is due to space and operational credibility. With a swing gate installed it usually needs a lot of space to operate. A sliding gate is very convenient at a point whereby a number of vehicles can fit in and out at the same time during motion.

The system developed in this paper is equipped with a radio-frequency opening system and the main advantage of this one is that the gate continues the route when it detect small obstacles and stop only at a double order.

It ignore the small obstacles and the end of the race will be when the time required route ended.

Another advantage of this system is to use a single button for closing and opening the gate because the program always check the previous state of the gate, and so the user does not have to watch what is the gate position.

1.2. The Operation of Radio Communication System

Radio communication system includes a two channels RF codelock transmitter and a two channels RF receiver. The RF transmitter sends a command to control a remote system. It must be compiled into a pre-arranged format (which may follow a standard structure), modulated onto a carrier wave which is then transmitted with adequate power to the remote system. The remote system will then demodulate the digital signal from the carrier and execute it. Transmission of the carrier wave occurs at radio frequencies.

The radio communication system uses the PIC12F629 microcontroller (Hariton *et al*., 2010). The RF receiver will be connected to the control board of DC motor which uses the PIC18F2480 microcontroller.

Radio frequency receiver will send the signal to the control board by one of the two channels.

2. DC Motor Control Board

Before using microcontrollers, radio communication systems were large and disturbed by noise. Microcontrollers brought flexibility in making these systems and an easy handling.

2.1. The Control Board Structure

The control board of this automation system will order two relays which will control a DC motor.

In the Fig. 1 is presented the control board scheme, where the micro-controller embedding in the system is observed.

Depending on the order received from RF transmitter, the RF receiver will open one of two electromechanical relays that will control the motor movement.

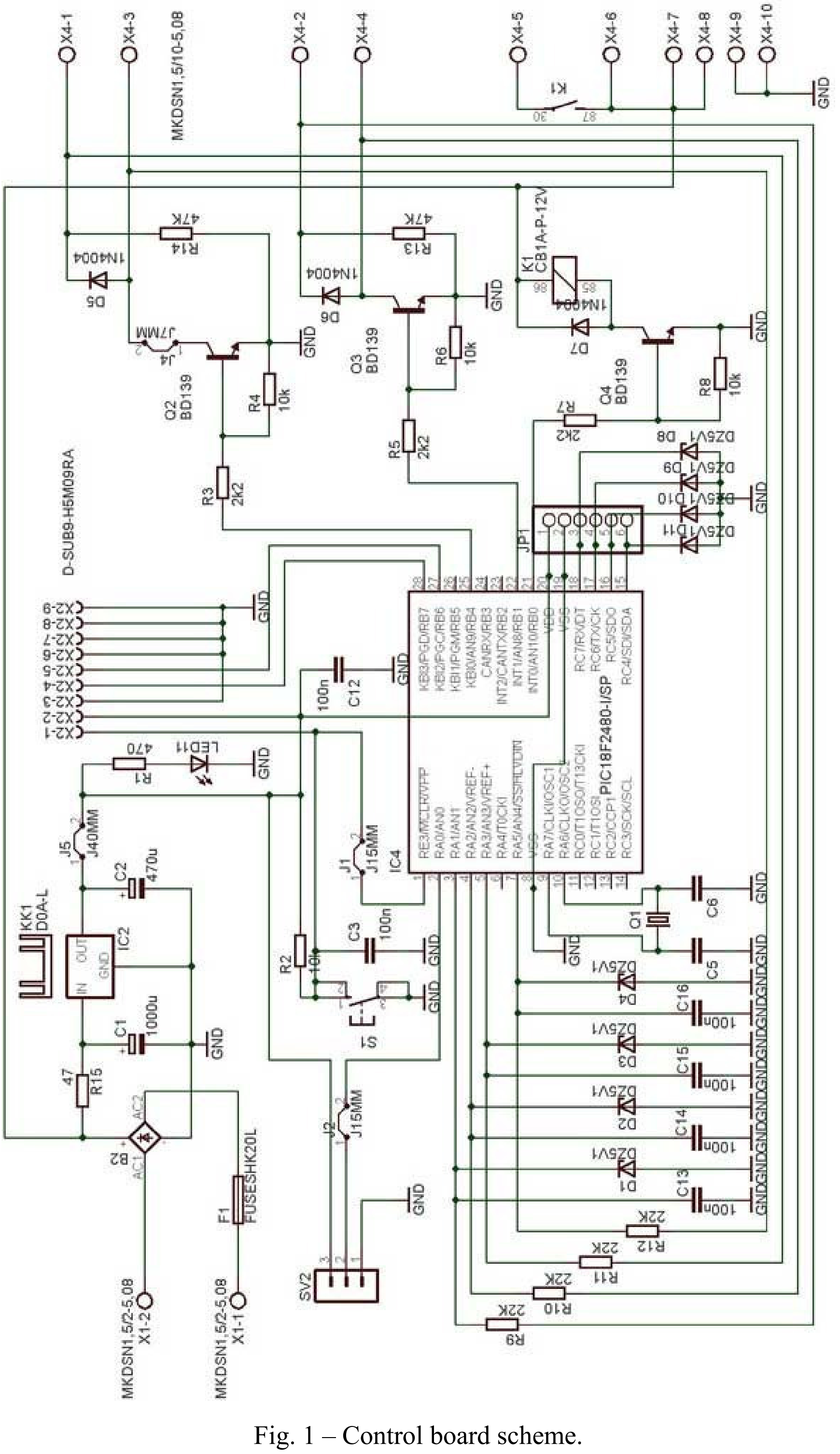

Fig. 1 – Control board scheme.

The relay is an electromechanical device that converts an electrical signal into a mechanical movement. When a voltage is applied across a coil, the current flows and will produce a magnetic field that moves the armature to close one set of contacts and/or to open another set. When the relay is not powered, the magnetic flux from the coil stops and produces a high voltage in the opposite direction. This voltage can damage the driver transistor and that is why a diode with reverse polarity is connected across the coil to make short circuit between the voltage peaks when they appear. Many microcontrollers can not drive a relay directly and so it is necessary to be connected a control transistor.

Electromechanical relays are switching devices typically used to control high power devices.

The PIC18F2480 microcontroller offers the advantages of all PIC18 microcontrollers namely, high computational performance at an economical price, with the addition of high-endurance, Enhanced Flash program memory. This device incorporate a range of features that can significantly reduce power consumption during operation and offer ten different oscillator options, allowing to users a wide range of choices in developing application hardware (four Crystal modes, using crystals or ceramic resonators, two External Clock modes, offering the option of using two pins (oscillator input and a divide-by-4 clock output) or one pin (oscillator input, with the second pin reassigned as general I/O), two External RC Oscillator modes with the same pin options as the External Clock modes, an internal oscillator block which provides an 8 MHz clock (±2% accuracy) and an INTRC source (approximately 31 kHz, stable as temperature and Voltage Drain Drain), as well as a range of six user-selectable clock frequencies, between 125 kHz to 4 MHz, for a total of eight clock frequencies).

2.2. The Control Board Operation

Before final assembly of the automated system for outer gates a functioning board test was made. So, in Fig. 2 the test operation can be observed.

After RF receiver will receive one command from the transmitter, it will activate the control board that mean one of two available pins of the microcontroller PIC18F2480. This pin will control the rotation direction of motor by activating the corresponding relay.

DC motor uses a maximum current of 15 A and the control board uses the PIC microcontroller.

Pulse width modulation (*PWM*) is an effective method for adjusting the amount of power delivered to an electrical load. A simple circuit containing an inverter chip, diodes, trimpot and capacitor creates the variable duty-cycle

PWM. By changing the width of the pulse applied to the DC motor we can increase or decrease the motor speed (Hariton *et al*., 2010).

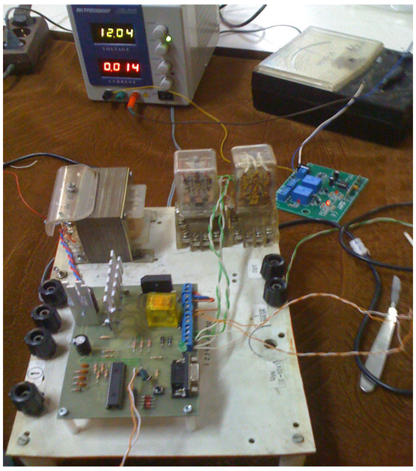

Fig. 2 – Testing scheme of control board operation.

2.3. Automation Program of the System

The automation program loaded on the PIC18F2480 establishes the rules of operation and the possibilities of opening the outer gate. The practical test of the automation program was done to a sliding gate. All the controlled by the program delays were carefully analysed and synchronized for optimal functioning of the gate.

The initial state of the gate is closed .

If the order to open the gate is given the program check the previous status of the gate and, if it is allowed to open, it will command the corresponding relay. Each command generates an alarm which consists of lighting and extinguishing a bulb. The light signal is a periodical one and it is individualized for each type of possible command. After a closing or an opening order it is expected for the end position detection. Once acted the race limiter the gate is completely open or closed.

The program begins with initialization of ports used by the micro-controller so that the PORTB has been set as an output port (turn on and off the bulb light) and the PORTA as input port.

```
void InitPorts()
{
TRISB = 0x00; // setting PORTB as outputs
PORTB = 0x00;// all orders are inactive
ADCON1 = 0x06;//A port  is digital port
TRISA = 0xcf;//setting PORTA as inputs
}
```

After this initialization the input is read and depending on the result will be set the race ends.

For filtering the noise from the buttons used to generate orders it has been applied a delay of 200 ms with DelayMs(200) function.

In this program all possible states that can find the gate at a certain time were treated. These states are the followings: when it is founded an end to the race, either at opening or at closing the gate and when it is detected a command from the remote button. When the gate receives a command it is necessary to check both the current state of the gate and its previous status.

In the Fig. 3 it is shown flow chart to implement the function of activation and deactivation of the order sent to the gate.

In the program it was used a set of variables like

```
byte end_opening_race = false; // gate opening has not been completed
byte end_close_race = true; // initial gate state is closed
byte gate_opening_coupled = false; // opening relay is activated
byte gate_close_coupled = false; // close relay is activated
byte command_button = false; // if the command button is pressed then
command_button = true
alert current_alert = none_alert; // current_alert is set by default
gate_state current_state = stop, previous_state = stop; // when the program start
current_state and previous_state are set on stop
```

To facilitate the flow chart building, for the gate command function, it has made the following notations:

open_state = os, close_state =cs, stop_state = ss.

For this program we have used the MPLAB IDE programming environment. MPLAB Integrated Development Environment (IDE) is a free, integrated toolset for the development of embedded applications employing Microchip's PIC microcontrollers.

MPLAB IDE runs as a 32-bit application on MS Windows, is easy to use and includes a host of free software components for fast application development and super-charged debugging.

MPLAB IDE also serves as a single, unified graphical user interface for additional Microchip and third party software and hardware development tools.

The simulation was performed using PROTEUS VSM as shown in the Fig. 4.

Virtual System Modelling (VSM) combines mixed mode SPICE circuit simulation, animated components and microprocessor models to facilitate co-simulation of complete microcontroller based designs.

It is possible to develop and test such designs before a physical prototype is realized. This is possible because we can interact with the design using on screen indicators such as LED and LCD displays and actuators such as switches and buttons.

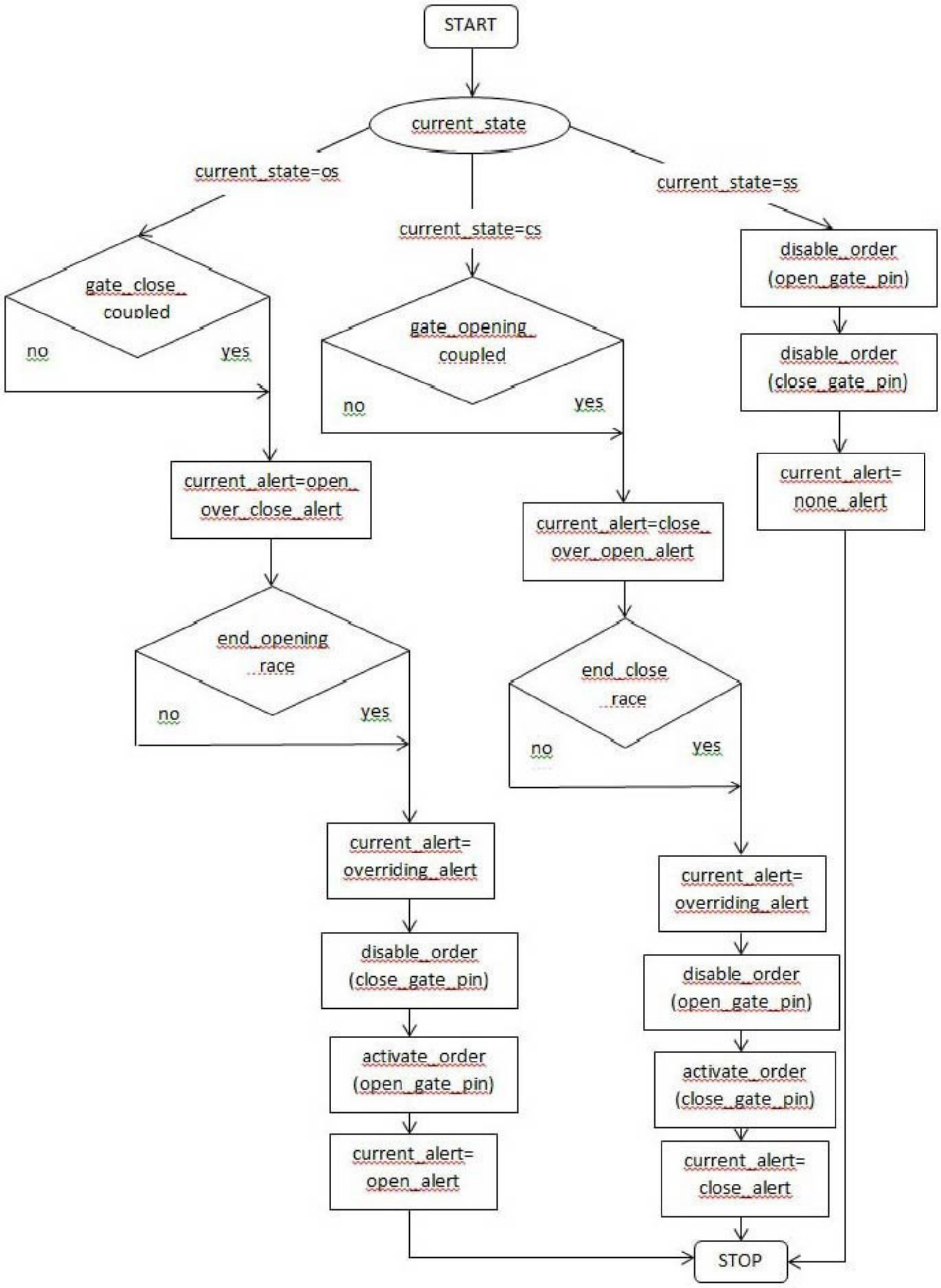

Fig. 3 – Flow chart illustrating the function of activation and deactivation of the order.

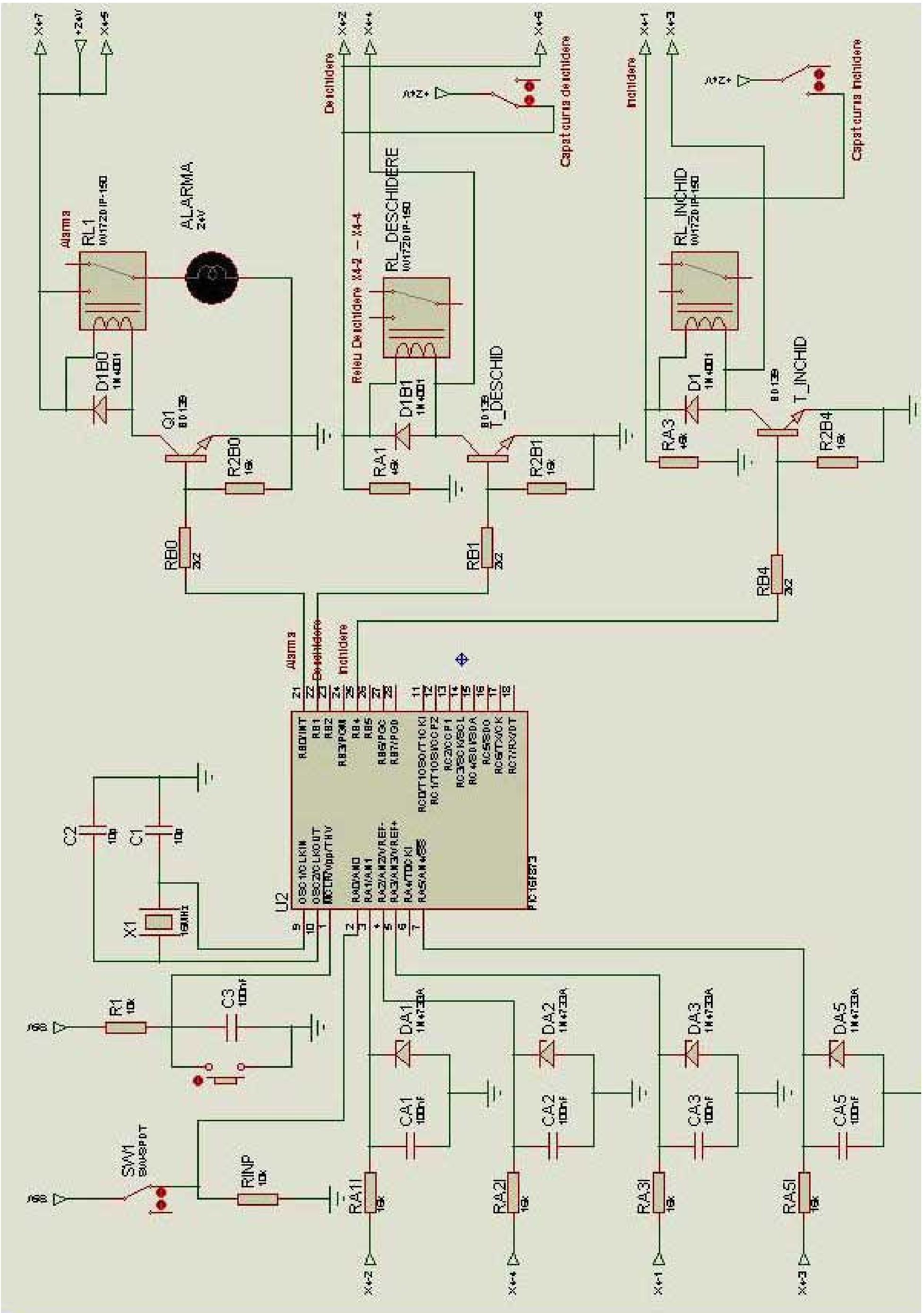

Fig. 4 – Proteus simulation.

3. Conclusions

Unlike the other automation systems used for outer gates the proposed system has a very precise operation, treating in detail the possible situations which may cause command errors and can block the opening or the closing of the gate.

The delays, provided in the program, are carefully calculated to be more useful in the practical operation of these systems.

Benefits of the microcontroller PIC18F2480 are used efficiently and the simplicity of the structure makes this system be easily modified and improved.

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AUTOMATIZAREA PORȚILOR DE EXTERIOR CU AJUTORUL MICRO-CONTROLERELOR ŞI A COMUNICAȚIEI PRIN RADIOFRECVENȚĂ

(Rezumat)

Se aduc argumente pentru îmbunătățirea sistemelor automate ale porților de exterior prin folosirea optimă a tuturor avantajelor oferite de către un microcontroler şi de către sistemele de radiofrecvență. Sistemul foloseşte un canal de comunicație radio pentru generarea, respectiv captarea comenzilor specifice deschiderii şi închiderii unei porți glisante dar şi un microcontroler PIC pentru controlul la distanță a unui motor de curent continuu care execută efectiv fiecare comandă.