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Anti-Intrusion Security System based on Microcontroller with Local Host Android and SMS Alert via Cellular Network

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***Abstract*—**This electronic and software project is aimed to control an home intrusion alarm system using wireless HC-06 interface, ultrasonic ranging module HC-SR04, local host android device and remote mobile device with available cellular network. The ATMEGA328P microcontroller is used as control device of the electronic system. The microcontroller can be interfaced to the Wireless -Bluetooth module through UART protocol and communicates with the local host. The local host device sends automatically a text message to remote phone of the user via cellular network, to warn the user about the intrusion in a closed environment, anywhere the user is.

Keywords*—ATMEGA328P Microcontroller, Android Applications, Gui (Graphical user interface), C++ Control Software, Smartphone, Bluetooth, Ultrasonic Sensors, Cellular Network*

I. INTRODUCTION

Android system is an open-source platform using an operating system for mobile device, middleware layer and key applications [1]. Android includes Wifi, Bluetooth and wireless data over a cellular connection. Also Android consists of full set of tools that have been made from the ground up alongside the platform providing developers with high productivity and deep insight into their applications. Bluetooth is a wireless technology for exchanging data over short distances from fixed and mobile device, where the distance range is approximately 10 meters (30 Feet) [2]. The microcontroller ATMEGA328P on the Arduino UNO is an open source platform based on easy-to-use hardware and software. Sriskanthan in [3] proposed a home automation system that can control home appliances from a PC using Bluetooth. However, the system cannot be controlled by smartphone or cellular. In [4] and [5] security systems that interface with an Android mobile device, have been developed. However the systems communicates via Bluetooth because a short range only communication system was desired. In [6] an home automation system which consists of two main hardware components, the cell phone and the Arduino BT board, has been made. The cell phone hosts the Python script which enables the user to access the home appliances and also the control commands for the appliances. This Python script communicates with the Arduino BT board and sets up an ad-hoc communication protocol between the two devices, which allows controlling the behaviour of the Arduino BT board. The disadvantage of this method is that the mobile phone works with Symbian. Symbian is an old operating system that currently does not exist anymore in commercial devices. A method to merge Bluetooth and Arduino UNO technologies for mobile robot control has been shown in [7], [8].

In this paper a new experimental home system security intrusion alarm is developed where an alert text message can be sent to a remote mobile device of a user, anywhere the user is. A local host Android smartphone has a bidirectional wireless communication with the microcontroller ATMEGA328P via bluetooth interface and also communicates with the remote mobile device via cellular network. With respect to platform like iOS, android platform as local host is an active research field with development of several applications and the open source system allows to interface the smartphone easily with other components. The advantages of this system with respect to works proposed in [3], [4], [5], [6] are the following:

1. modern technologies have been used and are economically available in the marketing;
2. the microcontroller ATMEGA328P on the Arduino Uno is an open source device which can be programmed through any operating system like Windows, Mac, Linux;
3. the used language for Arduino is understandable and easy;
4. shields bluetooth are available in market and it can be managed easily with Arduino and android systems;
5. the android system is an open source software and can run many applications, where the software may be reviewed and improved;
6. android local host, allows you to have a touchscreen GUI (Graphical User Interface) with which the user can easily interact to customize the functionality of the security system;
7. android smartphone local host has very low costs, and it is easily integrated in the security system;
8. the alert text message can be sent to remote distance via cellular network.

In particular, in Section II the block scheme and the circuit diagram are shown. Section III presents the hardware of the security system. Section IV presents the software description and functionality of the proposed system.

II. PROJECT DIAGRAMS OF THE PROPOSED SYSTEM

A. Block Scheme

With difference to the projects [4], [5] and [6], the alarm security system of this paper guarantees sending of alert text messages to remote distances and uses modern smartphones with android system as local host. The blocks scheme is sketched in Fig. 1.

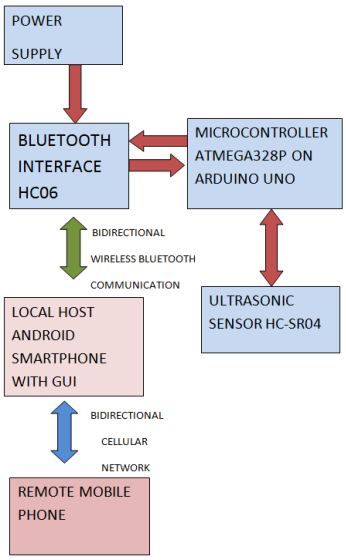

Fig. 1 Block scheme of the alarm security system

The components of the proposed system are the followings:

Microcontroller ATMEGA328P on Arduino Uno Board: it has 14 I/O digital pins, a 16 Mhz quartz crystal. Two of the digital inputs are used for data acquisition by the ultrasonic sensor. Major details of the microcontroller are in Section III.A

HC-06 Bluetooth Interface: the Bluetooth serial module converts the serial port to Bluetooth. The module is treated in Section III.B.

Ultrasonic Sensor HC-SR04: the sensor can be used for security alarm, invisible fence with alarm or distance measurement (cm). In our project the sensor has been used for alarm based on the distance between the sensor and the intruder. The HC-SR04 module works under the principle of ultrasonic wave transmission and ultrasonic wave reflection (echo). The time difference between transmitter wave to echo wave is calculated through the software to find the distance between the sensor and the intruder. Major electric details have been shown in Section III.C.

Power supply: it is an electronic component that supplies electric energy to a load. In our project the MB102 power supply of Ywrobot has been used to supply energy to the HC06 bluetooth interface. The power supply (5V DC) of the HC-SR04 sensor is made available by the voltage regulator of the microcontroller. Two different power supplies with common ground are needed to avoid interference between the sensor and the wireless module. The features of the MB102 power supply are in section III.D.

B. Circuit Diagram

The circuit diagram is sketched in Fig. 2

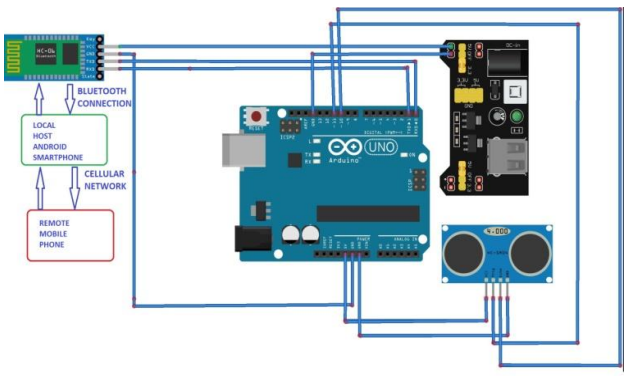

Fig. 2 Circuit diagram

III. HARDWARE PROJECT

A. Microcontroller ATMEGA328P

Main features of the microcontroller are the following:

- Advanced RISC Architecture: 131 Powerful Instructions; most Single Clock Cycle Execution; 32 x 8 General Purpose Working Registers.
- High Endurance Non-volatile Memory Segments: 32KBytes of In-System Self-Programmable Flash program Memory; 1KBytes EEPROM; 2KBytes Internal SRAM; Write/Erase Cycles: 10,000 Flash/100,000 EEPROM; Data Retention: 20 years at 85°C, 100 years at 25°C; Optional Boot Code Section with Independent Lock Bits.
- Peripheral Features: two 8-bit Timer/Counters with Separate Prescaler and Compare Mode; One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode; Real Time Counter with Separate Oscillator; Six PWM Channels; 8-channel 10-bit ADC; Two Master/Slave SPI Serial Interface; One Programmable Serial USART; One Byte-oriented 2-wire Serial Interface (Philips I2C compatible); Programmable Watchdog Timer with Separate On-chip Oscillator; One On-chip Analog Comparator; Interrupt and Wake-up on Pin Change
- Operating Voltage: 1.8V - 5.5V.

B. HC-06 Interface

The HC-06 interface module is shown in Fig. 3. It is a wireless serial Bluetooth port [8]. User can connect 3.3V to 5V D.C. and connect UART-TXD and UART-RXD to control serial I/O ports of the microcontroller. Serial port is qualified Bluetooth V2.0+EDR (Enhanced Data Rate), 3Mbps modulation with complete 2.4Ghz radio transceiver and baseband [6]. It uses BlueCore 4-external Single chip Bluetooth with CMOS and AFH (Adaptive Frequency Hopping Feature).

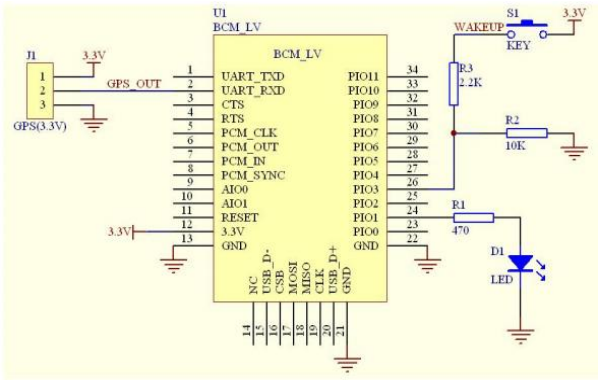

Fig. 3 HC-06 Bluetooth Interface

C. HC-SR04 Ultrasonic sensor

The HC-SR04 sends a ping as a submarine does and measure the time between sending and receiving anything back when an intruder is in front of the sensor. Because using sound for its measurements we can reach up to 4 meters [9]. The module has a 4 pin connection. Two pins are needed to power the module with 5 Volts. The working current is about 15 mA. One pin is the trigger ping and the last one is used to read the result of the measurements, the echo pin. The measuring angle from the HC-SR04 is 15 degree. At 4 meter distance this should be a beam of about 1 meter. At 1 meter this is 26 cm so we have to keep this in mind when using this information. One ping of the HC-SR04 actually exists of 8 pulses at 40 kHz to

do the measurement. To start a ping you need to provide a 10ns start pulse on the trigger input (see Fig.3)

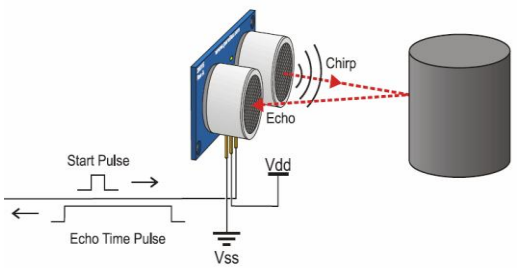

Fig. 4 HC-SR04 start pulse and Echo Time Pulse

When the distance is measured by the 8 pulses the HC-SR04 puts a pulse on the echo pin. The distance with the length of the echo pulse and the speed of sound can be calculated. The speed of sound is 340 m/s or 2.9 micro seconds per mm. We have to divide the length of the pulse by 2.9 to get the result in mm. The ping is traveling towards an object and back to the sensor again. Because of this we need to divide the result by two. Between two pings we need to keep a 60ms measurement cycle.

D. MB102 Ywrobot Power supply

The main features of the component are the following:

- Input Voltage: 6.5V to 12V DC or USB power supply;
- Output Voltage: 3.3V/5V can switch over;
- Maximum Output current: <700mA;
- Fluctuation to road independent control, can switch over to 0V, 3.3V, 5V;
- On board two groups of 3.3V , 5V DC, output plug pin, convenient external lead use.

IV. Flow Charts, Software and Project Functionality

A. ATMEGA328P Microcontroller software for HC-SR04 ultrasonic sensor control

In Fig. 5 there is the flow-chart which represents the acquisition by the microcontroller of the distance between the intruder and the ultrasonic sensor. The microcontroller ATMEGA328P executes a loop of software instructions to evaluate the distance and it sends the information to the local host Android device using HC-06 interface.

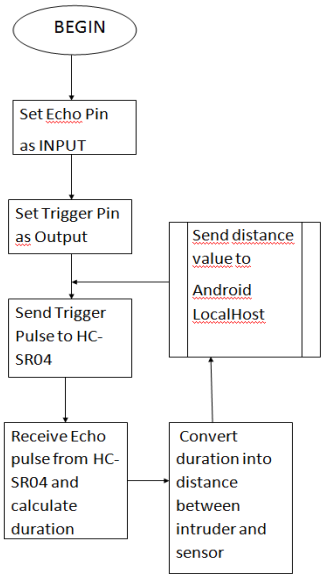

Fig. 5 Flow Chart for acquisition of the distance between intruder and ultrasonic sensor

In Fig. 6 code C++ is sketched.

```
#include "SR04.h"
SR04::SR04(int echoPin, int triggerPin) {
  _echoPin = echoPin;
  _triggerPin = triggerPin;
  pinMode(_echoPin, INPUT);
  pinMode(_triggerPin, OUTPUT);
    }
  long SR04::Distance() {
  long d = 0;
  duration = 0;
  digitalWrite(triggerPin, LOW);
  delayMicroseconds(2);
  digitalWrite(triggerPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(triggerPin, LOW);
  delayMicroseconds(2);
  _duration = pulseIn(echoPin, HIGH,
PULSE_TIMEOUT);
  d = MicrosecondsToCentimeter(_duration);
  delay(25);
  return d;
}
```

Fig. 6 Example of part of code C++ to calculate the distance between the intruder and the sensor HC-SR04

B. Procedure for wireless sending of the distance between sensor and intruder to the local host Android and sms to mobile phone of the user

Now the information of the sensor may be sent to the android local host device via wireless connection. Fig. 7 shows the touchscreen GUI to activate the wireless connection with the ATMEGA328P microcontroller via HC-06 interface.

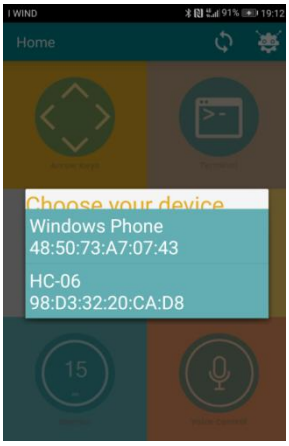

Fig. 7 Touchscreen GUI for activation of Wireless connection between local host android and Microcontroller

Once launched and connected to the local host, this tool is optimized to receive the distance between the intruder and the HC-SR04 sensor via the println() function of the microcontroller ATMEGA328P on The Arduino Uno, which allows special processing of the data received. Fig. 8 shows the flow chart which represents the procedure to send the above distance to the local host.

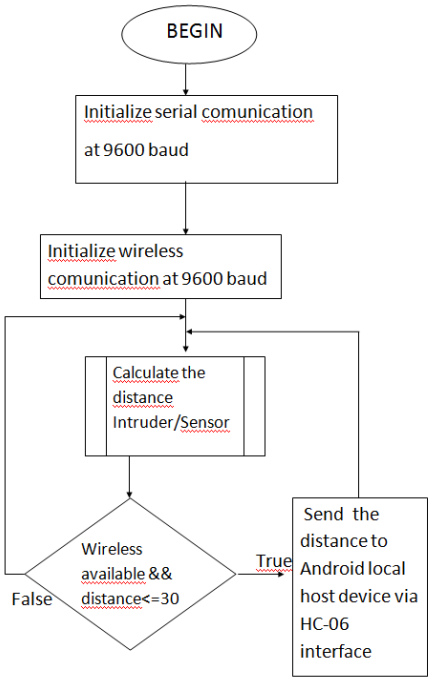

Fig. 8 Flow chart for sending distance to local host android device

Fig. 9 shows an example of pseudocode in C++ language which implements the flow-chart of Fig. 8.

```
SoftwareSerial bluetooth(rxPin, txPin);

long d ; // distance value between sensor and
intruder

void setup()
{
  Serial.begin(9600); //set baud rate
  bluetooth.begin(9600); //set baud rate
}

void loop()
{" RUN SUB-ROUTINE FOR DATA
ACQUISITION FROM HC-SR04 SENSOR";
}
 while(bluetooth.available()&&d<=30){
      Serial.println(d); //show the distance d
between sensor and intruder  in smartphone
local host
        }
  }
  delay(2000); //delay
}
```

Fig. 9 Example of pseudocode for sending the distance between the intruder and the sensor HC-SR04 to local host android smartphone

Now the application allows to receive only numbers and fix alarms to get notified about the variation of the value received, either by classical notifications or by sms to another phone via cellular network. Fig. 10 shows the GUI touchscreen interface. By setting "Alarm value" the user will need to specify only a number. The number above is the minimum value of the distance between intruder and ultrasonic sensor that allows the activation of the alarm and sending the text alert message to the mobile device of the user. Also, by using the GUI, the user can disable the sms sending or the sonar alarm of the local host. The mobile phone number to send SMS is customizable. The user can choose either his mobile or police number if the service is available.

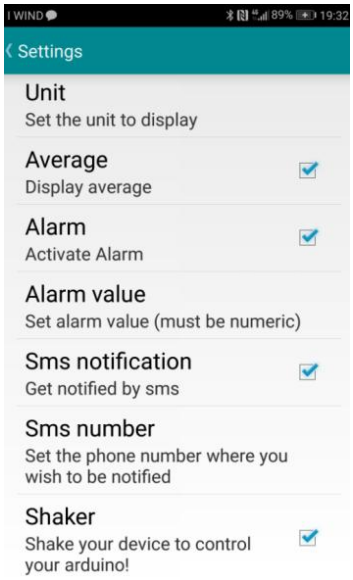

Fig. 10 GUI for setting options of the security system

Fig. 11 shows the GUI of the alarm where the distance between intruder and sensor is shown. Once the alarm triggered, a stop button shows up, allowing the user to stop it.

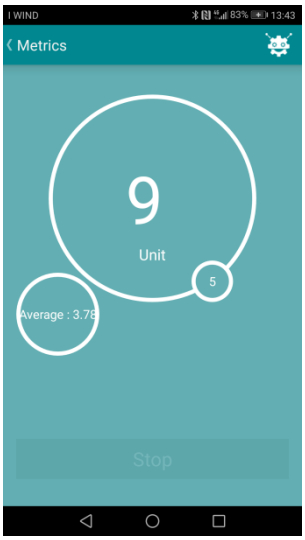

Fig. 11 GUI of the android local host to visualize distance between intruder and sensor

Fig. 12 shows the sms in the mobile device of the user. The text message indicates the alarm and the distance above.

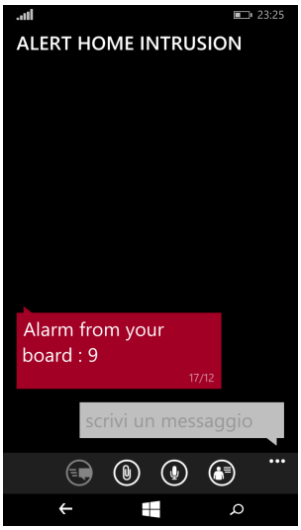

Fig. 12 SMS in the mobile device of the user

CONCLUSIONS

In this paper an experimental system to control intrusion in closed environment based on microcontroller ATMEGA328P, local host Android device, HC-SR04 sensor and HC-06 wireless interface has been presented. The system sends an alert sms to a mobile device of the user via cellular network with very low time response. The project has been called "MELPLAT Security System" and it is constantly evolving. Further development may be the integration of an infrared remote control to help a disable person to easily call emergency assistance.

Acknowledgment

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