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Controlling Automobile Functions by the Phone as an Embedded System

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Abstract: This paper presents a full demonstration to use a mobile phone as a control tool to specifically most important automobiles function which can provide safety, saving time and even provide comfort to the individual owner. The door locks, locking or unlocking, opening and closing the driver window, starting and stopping the engine, and finally turning the air conditioning on and off. By using two regular mobile phones, the code is sent by a DTMF (Dual Tone Multi Frequency) from the owner mobile to the automobile's mobile, in each phone there's a 12 separated keys, each has a specific tone, which analyzed by the DTMF regulator, the controller then sends its commands to the different necessary parts to do the specific function required.

Key words:

INTRODUCTION

Since modern automobiles are equipped with the most luxurious and advanced technology systems to provide the user with comfort. Due to this achievement in technology this study is presented to provide all of the previous features including safety. This model enables the user to perform many tasks from his mobile and abandon the keys, the user can start the engine by pressing number one to warm it up in winter while resting at home, and he can turn it off by pressing number five. Pressing number two to open the window, letting the passenger cabinet to freshen up in the summer heat, and pressing number six if the user was some where away and worried if the windows are open or not, pressing number three and seven to lock and unlock the central lock of the automobile and to protect the automobile from theft, finally pressing number four to turn on the air conditioning to either cool or warm up the passenger cabinet without having to worry about either sweating or freezing before going for a ride.

Second part of the system, is sending a message when a automobile accident happens, over speed driving and when the door is opened by any other way than the mobile phone. The automotive industry is responding to the new technical challenges by implementing more computer based applications,

therefore Autotronics has grown to become a necessity and it is put into practice through the use of computers, sensors and actuators to control particular processes in the vehicle.

To make a tracing survey for the development of such system, Brad A. Myers, (2002), exploring, as part of the Pebbles research project, the many ways that mobile devices such as Palm OS Organizers or Pocket PC / Windows CE devices, can serve as useful adjuncts to the “fixed” computers in the user’s vicinity. This brought up many interesting research questions, such as how to provide a user interface that spans multiple devices that are in use at the same time? How will users and systems decided which functions should be presented and in what manner on what device? How can the user’s mobile device be effectively used as a “Personal Universal Controller” to provide an easy-to-use and familiar interface to all of the complex appliances available to a user? How can communicating mobile devices enhance the effectiveness of meetings and classroom lectures?

Christian S. et al. (2000). Discussed the characteristics of Service Discovery Protocol (SDP), its requirements and its limitations. Furthermore, it describes the implementation of system architecture for the complete Service Discovery Application which includes client and server, a user interface, the SDP protocol itself and a control module for the Bluetooth links.

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The present work aims to use the mobile in controlling many automobiles functions, it consists of many parts. See the block diagram below.

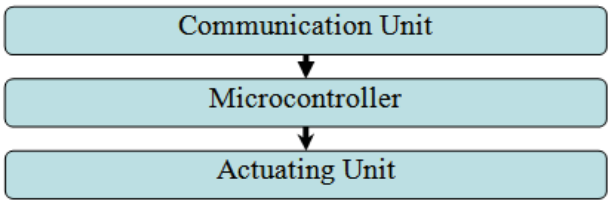

Fig. 1: General block diagram

Components Description and working Principles:

1. Communications units:

It consists of the following parts:

a-Transmitters and Receivers-Mobile phones:

Nowadays, mobile phones is a well known technique to all and almost available to every one, in this system two regular mobile phones had been used. One of them is used as transmitter, and the other one used as receiver. The transmitter phone which controls the automobile can be either mobile phone or land phone, but the receiver phone which is connected with the system core (CPU – UNIT) system is a mobile phone.

b-Data communication protocol:

Controlling signals is transferred as DTMF tones when any number button in the phone is pressed; DTMF tone is generated, these tones can be considered as the controlling input signal to the system. In addition to this, the receiver mobile can send an SMS *by using AT Commands*

c-DTMF (Dual-Tone-Multi-Frequency) Decoder or Receiver:

Dual-tone multi-frequency (DTMF) signaling is used for telephone signaling over the line in the voice-frequency band to the call switching signal (DTMF decoder). The version of DTMF used for telephone tone dial is known by the trademarked term touch tone. Table (1) shows the frequencies used for the DTMF system, which is also referred to as tone dialing. The signal is encoded as a pair of sinusoidal (sine wave) tones from the table below which are mixed with each other.Pressing a single key (such as '1') will send a sinusoidal tone of the two frequencies (697 and 1209 hertz (Hz)). The original keypads had levers inside, so each button activated two contacts. The multiple tones are the reason for calling the system multi frequency. These tones are then decoded by the DTMF decoder to determine which key was pressed.

Table 1: mobile tones

Symbol		Tone B [Hz]			
		1209	1336	1477	1633
Tone A [Hz]	697	1	2	3	A
	770	4	5	6	B
	852	7	8	9	C
	941	0	0	#	D

The tone frequencies, are selected such that harmonics and inter-modulation products will not cause an unreliable signal. No frequency is a multiple of another, the difference between any two frequencies does not equal any of the frequencies, and the sum of any two frequencies does not equal any of the frequencies. The frequencies were initially designed with a ratio of 21/19, which is slightly less than a whole tone. The frequencies may not vary more than ±1.5% from their nominal frequency, or the switching center will ignore the signal. The high frequencies may be the same volume or louder as the low frequencies when sent across the line. The loudness difference between the high and low frequencies can be as large as 3 decibels (dB) and is referred to as "twist". The minimum duration of the tone should be at least 70 m sec., although in some countries and applications DTMF receivers must be able to reliably detect DTMF tones as short as 45ms. DTMF decoder used in this system as an integrated circuit (IC) which use to decode DTMF dial tones found on telephone lines with touch tone phones and convert the tone to binary coded decimal BCD referred to the dialed number. It is also used for receiving data transmissions over the air in amateur radio frequency bands.

- Attention Commands:

The Hayes command set, is a specific command-language originally developed for the Hayes Smart modem 300 baud modem. The command set consists of a series of short strings which combine together to produce complete commands for operations such as dialing, hanging up, and changing the parameters of the connection. Most dialup modems follow the specifications of the Hayes command set. The following text lists part of the Hayes command set (also called the AT commands). The Hayes command set can subdivide into four groups:

1. Basic command set - A capital character followed by a digit. For example, M1.
2. Extended command set - An "&" (ampersand) and a capital character followed by a digit. This extends the basic command set. For example, &M1. Note that M1 is different from &M1.
3. Proprietary command set - Usually starting either with a backslash ("\") or with a percent sign ("%"); these commands vary widely among modem-manufacturers.
4. Register commands - Sr=n where r is the number of the register to be changed, and n is the new value that is assigned. A *register* represents a specific physical location in memory. Modems have small amounts of memory onboard. The fourth set of commands serves for entering values into a particular register (memory location). The register will store a particular variable (alpha-numeric information) which the modem and the communications software can utilize. For example, *S7=60* instructs the computer to "Set register #7 to the value 60". Although the command-set syntax defines most commands by a letter-number combination (L0, L1 etc.), the use of a zero is optional. In this example, "L0" equates to a plain "L". Keep this in mind when reading the table below. Some of the most important characters that may appear in the modem initialization string follow. Normally one should not change these characters:

1. AT - "Attention": tells the modem that modem-commands follow. This must begin each line of commands.
2. Z - Resets the modem to its default state.
3. ,(a comma) - Makes the software pause for a second. More than one comma can appear in succession: for example, ",,,," tells the software to pause four seconds. (The setting of register S8 governs the duration of the pause.)
4. ^M - Sends the terminating carriage Return character to the modem. This is a control code that most communication software translates as a carriage return. (Note, when this is sent to the modem, it is sent as a single byte, ASCII CR (0x0D), or "Control-M" not the two characters ^ and M.)
5. ; (a semi-colon) - Return to command mode immediately after dialing. This makes it possible, for example, to dial more than 45 digits numbers, or to walk through interactive menus.
6. W - Wait for dial tone. The modem will wait for a dial tone before dialing numbers following the W. For this to work, waiting must not exceed a timeout, generally configured in the S7 register.
7. ! - Flash hook - Put quickly the modem on/off hook.

The normal escape sequence is three plus signs ("+++"), and to disambiguate it from possible real data, a guard timer is used: it must be preceded by a pause, not have any pauses between the plus signs, and be followed by a pause; by default a "pause" is one second and "no pause" is anything less.

2- the Microcontroller Unit:

A microcontroller (also MCU or μC) is a computer-on-a-chip. It is a type of microprocessor emphasizing high integration, low power consumption, self sufficiency and cost-effectiveness, in contrast to a general-purpose microprocessor In addition to the usual arithmetic and logic elements of a general purpose microprocessor, the microcontroller typically integrates additional elements such as read-write memory for data storage, read-only memory, such as flash for code storage, EEPROM for permanent data storage, peripheral devices, and input/output interfaces. At clock speeds of as little as a few MHz or even lower, microcontrollers often operate at very low speed compared to modern day microprocessors, but this is adequate for typical applications. They consume relatively little power (mill watts), and will generally have the ability to sleep while waiting for an interesting peripheral event such as a button press to wake them up again to do something. Power consumption while sleeping may be just Nano-watts, making them ideal for low power and long lasting battery applications. The PIC microcontroller was the optimum choice regarding its low cost a high functionality. Unlike most other CPUs, there is no distinction between "memory" and "register" space because the RAM serves the job of both memory and registers, and the RAM is usually just referred to as the register file or simply as the registers.

3- Actuating Units:

The actuators in this system are relays, each relay connected with a specific circuit in the automobile (output circuit) to perform the required function.

A relay is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts. Because a relay is able to control an output circuit of higher power than the input circuit, it can be considered to be, in a broad sense, a form of an electrical amplifier.

System Functionality:

As explained before all the inputs and outputs are described, this section explains how every function is done in details, and how the output pin of the PIC is connected.

Making a phone call is just as easy as pressing single key, so when calling the receiver phone of the system, the receiver as adjusted answers it automatically after almost two seconds, and to access to the system a pass code should be entered for protection, so when pressing any key the transmitter sends its signal as a tone has dual frequency, then the receiver hear it and the DTMF also, so now the signal get analyzed and transferred to the PIC, the PIC is programmed to act differently for each code it receives from the DTMF.

After the pass code is entered, the PIC starts a buzzer two times to confirm the code is right to start the system, and when is wrong the buzzer starts one time, and if the password is entered wrongly four times, the siren alarm system starts for 15 seconds. For starting the engine, key number one is pressed the PIC receives it in BCD as 0001, now the PIC sends a high voltage as 1 from the port B to the 50 A relay that connect the power to the whole automobile, after this relay is activated and the power is supplied to the whole automobile including ignition starter and fuel pump and so on, a second 50 A relay receives ON signal from the PIC after 5 sec from the first signal to activate the relay and start the self starter and turn the engine on, then the PIC stops the ON signal for the second relay after 2 second so that the self starter wouldn't be damaged

When pressing key number two another signal is sent to the PIC, then the PIC outputs ON signal to the relay connected within two wires to the central lock system, when the relay is activated, the central lock locks the doors.

For opening the window, pressing key number 3 the PIC receives the signal from the DTMF decoder then the PIC makes ON output for 3 seconds to activate the relay connected with the window switch to open the window for just three seconds and stops. Turning the air conditioning on, starts by pressing key number 4. the PIC then outputs a signal always ON to activate the relay directly, and keeps it activated to keep connecting the wires of the AC with the power supply. For now its clear how every function is started by pressing the first four key, and now for controlling the opposite function of what is described above, for turning the engine off, key number 5 has the code for this function, so pressing key number 5 make the PIC low voltage signal received on the relay that is connected to the power circuit of the automobile, and the engine will automatically turns off. Also the same for the AC, pressing key 8, will cut off the power of the AC by the relay connected, and turns the AC off. As for pressing key number 6 the PIC sends a voltage to activate the second relay connected with unlocking the central lock circuit, to get the doors unlocked and same for closing the window, the PIC sends a voltage to a second relay connected with the closing window switch. The first part of controlling the automobile is done, and for the second part which includes the anti stealth alarm message sending and for automobile accident and speeding over 120 km/hr. First is how the anti stealth door alarm functions:

Since any system is more preferred if it's made of the same component of an automobile, which can save money and parts, here the door light switch was used that turn the passenger cabinet light on when the door is open, then a two wires connected from this switch to a relay ,then directly to PIC, then the PIC recognize the signal and sends a signal via the serial port including the code to send a message for the user to inform about the automobile condition, which includes "the automobile is being opened".

Second is the crashing accident switch: Using switches at different locations in the automobile, which can send a signal immediately to the PIC when the switch is pressed if an accident happens, and then the PIC sends a different signal with a different code to send a message include "the automobile had a accident". Third is over speed recognizer: Adding a contact switch in the speed meter basically will do the recognition of the speed, so when the pointer of the speed meter reach the speed of 120 km/hr the contact attached to it will directly touch the other contact on the speed meter board, and the two contact are connected directly to the PIC, and the PIC do as described before with a message including "the is over speeding than 120 Km/Hr, and followed in details to explain how every signal makes the function needed .General block diagram, see figure 2.

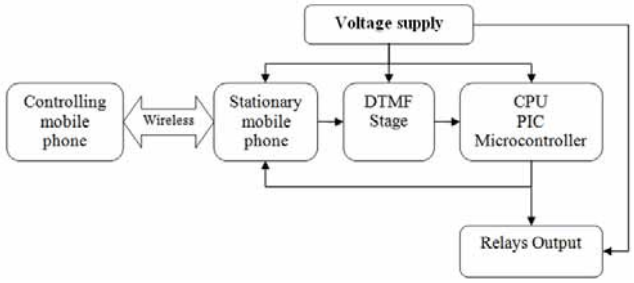

Fig. 2: Block diagram

RESULTS AND DISCUSSION

Entering Password:

When entering a password, buzzer is activated as shown in fig. 3.

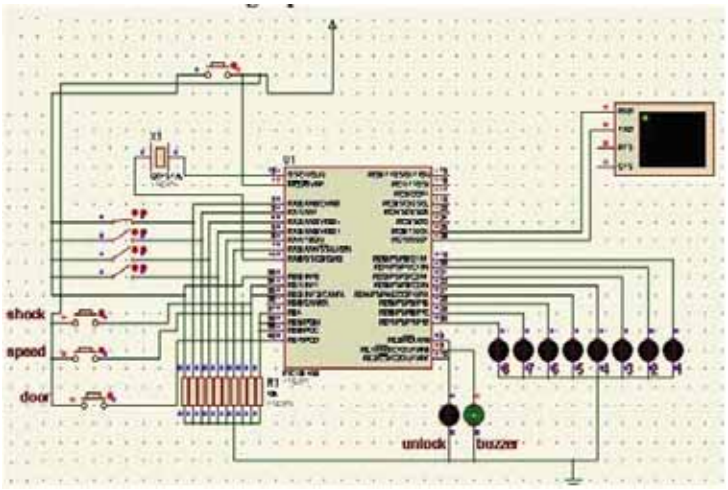

Fig. 3: Entering password

Turn Engine On:

When pressing number one on the phone keypad, led number one (which represents the ignition switch) activated and after five seconds led number two (which represents the starter) activated for 1.3 second, as shown in fig. 4.

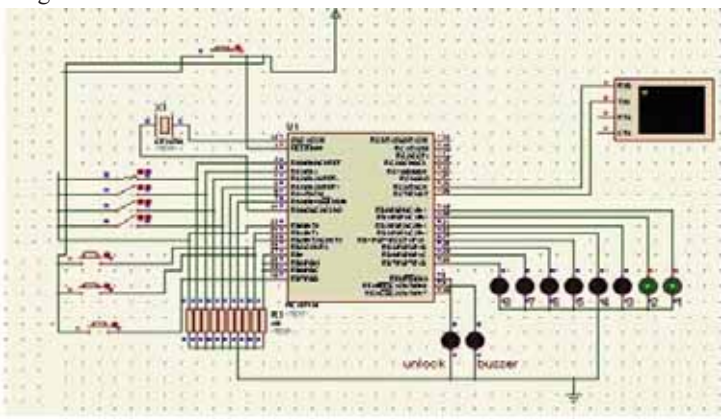

Fig. 4: Engine ON

Locking central:

When pressing number two, LED number 3 (which represents central lock module) is activated as shown in fig. 5.

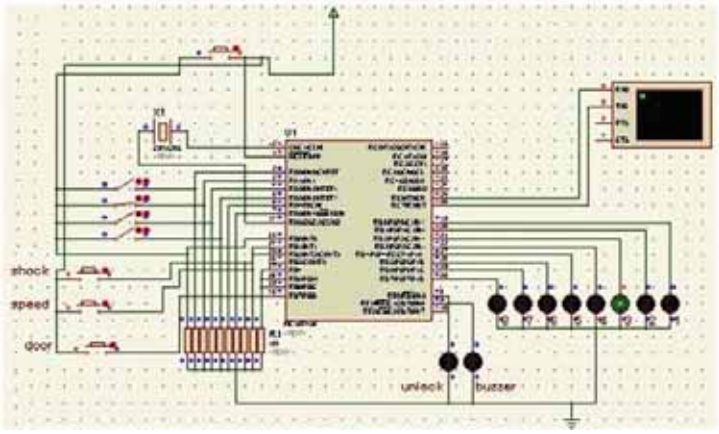

Fig. 5: Central locking

Opening Window:

When pressing number three, the LED number 5(which represents the window motor) is activated as shown in fig. 6

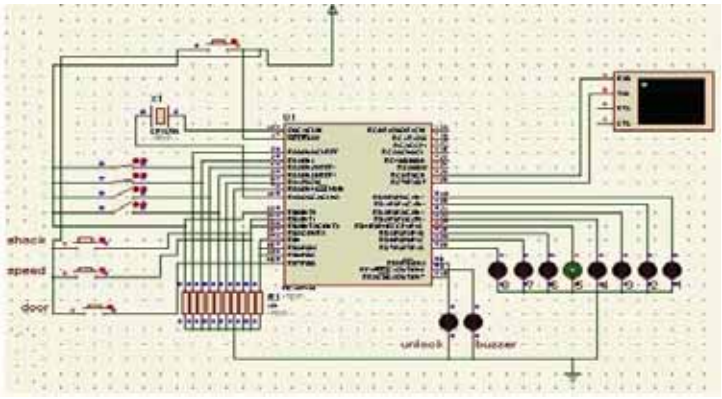

Fig. 6: Opening window

Turn Air Conditioning On:

When pressing number four, the LED number 7 (which represents the A/C compressor) is activated as shown in fig. 7

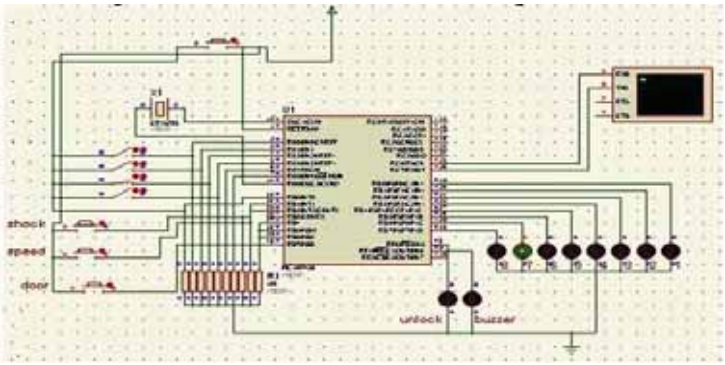

Fig. 7: Turn A/C on

Unlocking Central Lock:

When pressing number six, the LED number 4 (which represents central lock module) is activated as shown in fig. 8

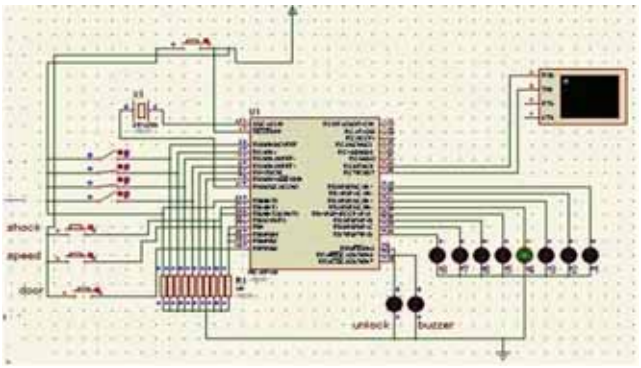

Fig. 8: Unlocking central lock

Closing Window:

When pressing number seven, the LED number 6 (which represents the window motor) is activated as shown in fig. 9.

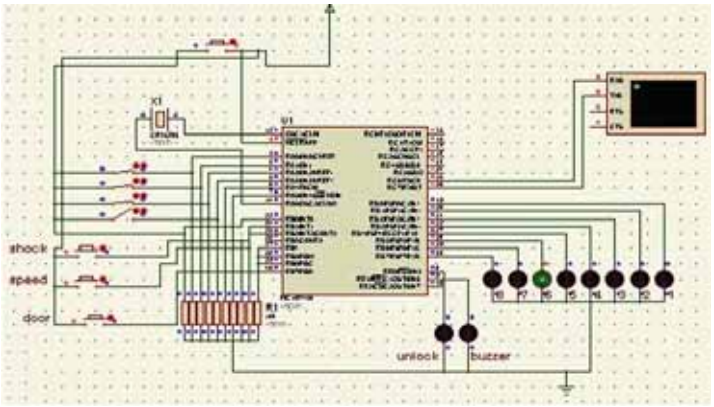

Fig. 9: Closing window

Alarm System:

When the door opens by any way other than this system, the LED number 8 (which represents the alarm system) is activated and the serial port also activated to send an SMS which contains this text " SOME ONE OPENS MY DOOR!!! " as shown in fig. 10

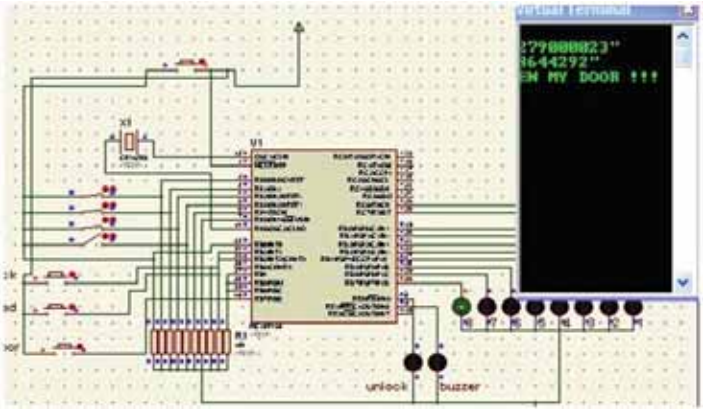

Fig. 10: Alarm System

Accident:

When the automobile faced an accident the serial port is activated and sends this massage "ACCIDENT" to 2 mobile phones, as shown in fig. 11

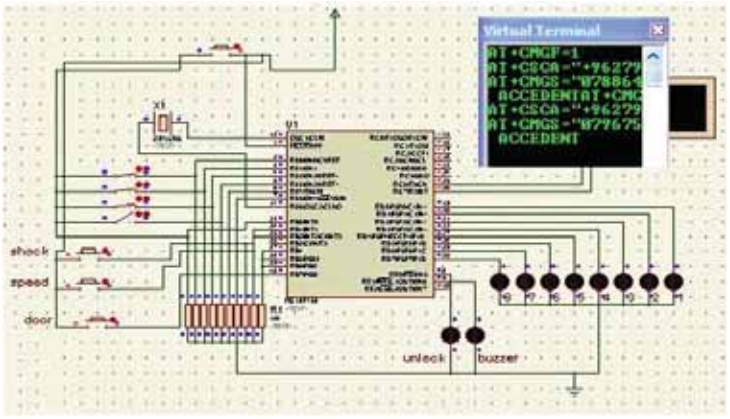

Fig. 11: Accident

High Speed:

When automobile speed exceeds 130 km/h, serial port is activated and sends an SMS to the police contains the identification number of the automobile. See fig. 12

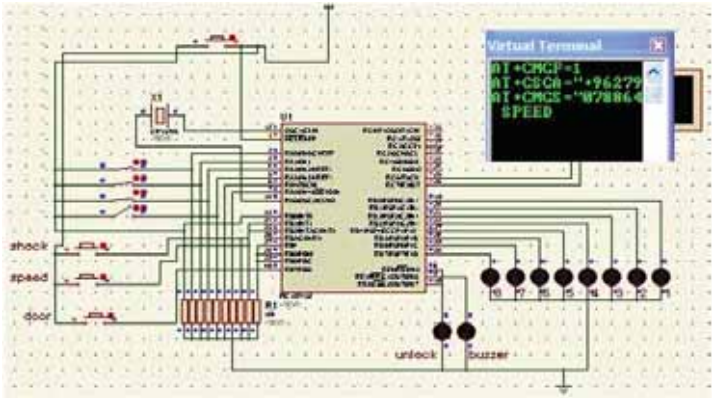

Fig. 12: High speed

Conclusion:

It is obvious that controlling the automobiles functions are look like to be easier using mobile as a controller. No need to hold any keys, or readiness for starting or stopping the automobiles, as a whole conclusion the automobiles functions controlling becomes more comfort and reliable.

Recommendations:

In the future many additional options can be added to the system like:

1. Changing the password of the system easily by connecting a computer directly to the device, and changing it for trading purposes.
2. Adding more functions.
3. Make the system works by voice commands without using the number keys.
4. And for the long term the GSM network can be replaced by the satellite or GPS.

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