

Remotely and Locally Administrable Access Control System

Group No: B04

T V Praneeth (04007032) <praneethtv@ee.iitb.ac.in>

B. Sudhir (04007033) <bs@ee.iitb.ac.in>

Shashank Neelam (04007034) <shashank@ee.iitb.ac.in>

Vivek Subramanian (04007035) <viveks@ee.iitb.ac.in>

Supervisors: Prof H Narayanan, Prof D K Sharma

Course Instructor: Prof H Narayanan

Abstract

The report discusses the design of a system that allows for remote and local control and administration over a locking system. The local control consists of a keypad with LCD readout that is mounted on the door itself. The remote control consists of a DTMF-based circuit that allows users to control the lock via the telephone. We have attempted to design a robust and versatile circuit which meets the above requirements.

1. Problem Statement

To design an electronic circuit that can be mounted on existing infrastructure such as doors and cabinets with minor changes to the basic frame, to effectively control access to it. Specifications of the major hardware we are using:

- Locking mechanism from automobiles – 12 V DC Motor
- L298 Motor Driver
- AT89C52 Microcontroller
- CM8870 DTMF Decoder
- 5 V Goodsky Relay
- Max232 Transceivers

Working voltage: 5 V DC and 12 V DC for Motor

2. Introduction

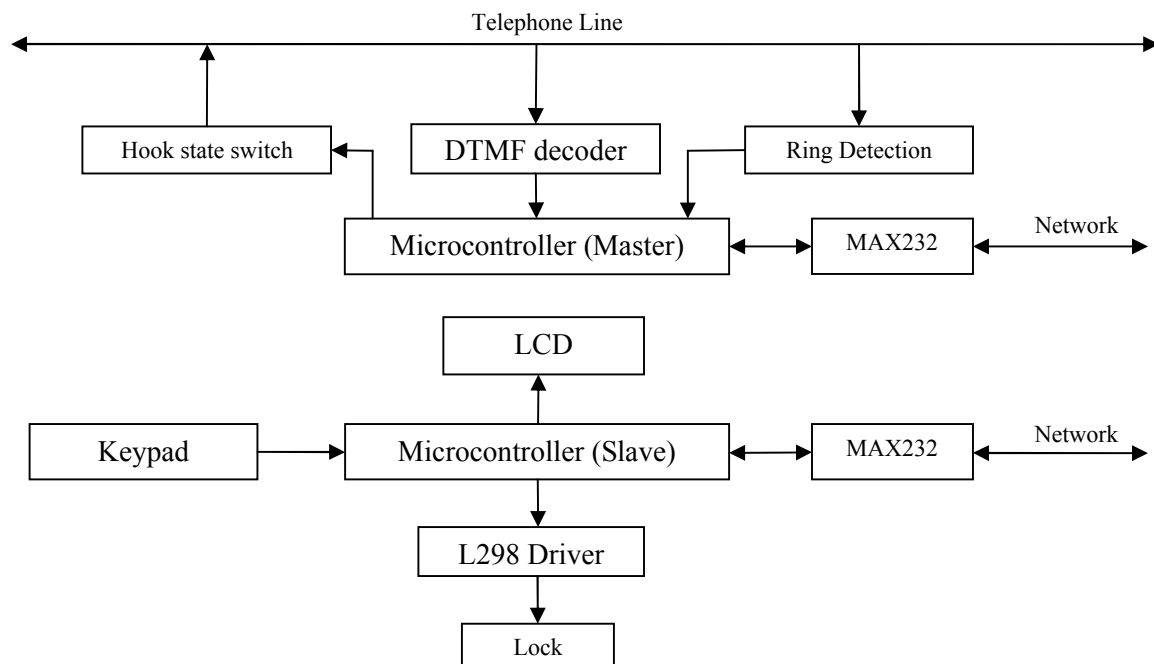
It is a well known fact that several offices (in IIT say) have limited keys but need to give access to several people. Various keyless access systems exist, but they either require the user to be physically present or require fingerprint recognition and other advanced technologies. The current system proposes to allow or disallow access to the lock based on a phone call. Thus, the lock can be operated remotely. Also, for users who are physically present but do not have immediate access to a phone, the system also provides a keypad through which access codes can

be entered. Also, various administrative functions can be performed using the same keypad like updating the access code.

3. System Design

The hardware consists of the following major parts:

1. The lock itself, and its associated control circuitry – we have used a standard electrical locking mechanism that is used in automobiles, driven by a 12 V motor. The motor driving circuit consists of an L298 driver (circuit diagram is attached).
2. The Master DTMF circuit – this consists of an AT89C52 microcontroller and a CM8870 DTMF decoder which handles the telephone interface, and associated circuitry, to communicate with the slave circuits, and to hook the telephone line.
3. The Slave Microcontroller circuit – this is based around an AT89C52 microcontroller which gives control signals to the L298. This is also controls an LCD display and keypad, which fulfil the function of being the local access control system.
4. The communication between the master and the slaves follows the RS485 protocol. This protocol allows a multidrop broadcast network where each slave is connected to the master through a common twisted cable. (for the purpose of the demo in the lab, RS232 protocol was used)



Block Diagram of the Entire System (Master & Slave)

The software is designed in two separate modules, for the master and the slave circuits. The software for the master circuit is primarily designed to receive a call, handle the DTMF signals, decode them, and provide control signals to the slave circuit.

The software for the slave circuit is designed to accept control instructions from the master circuit, and translate them into actions upon the lock. The software also handles the keypad and LCD interface.

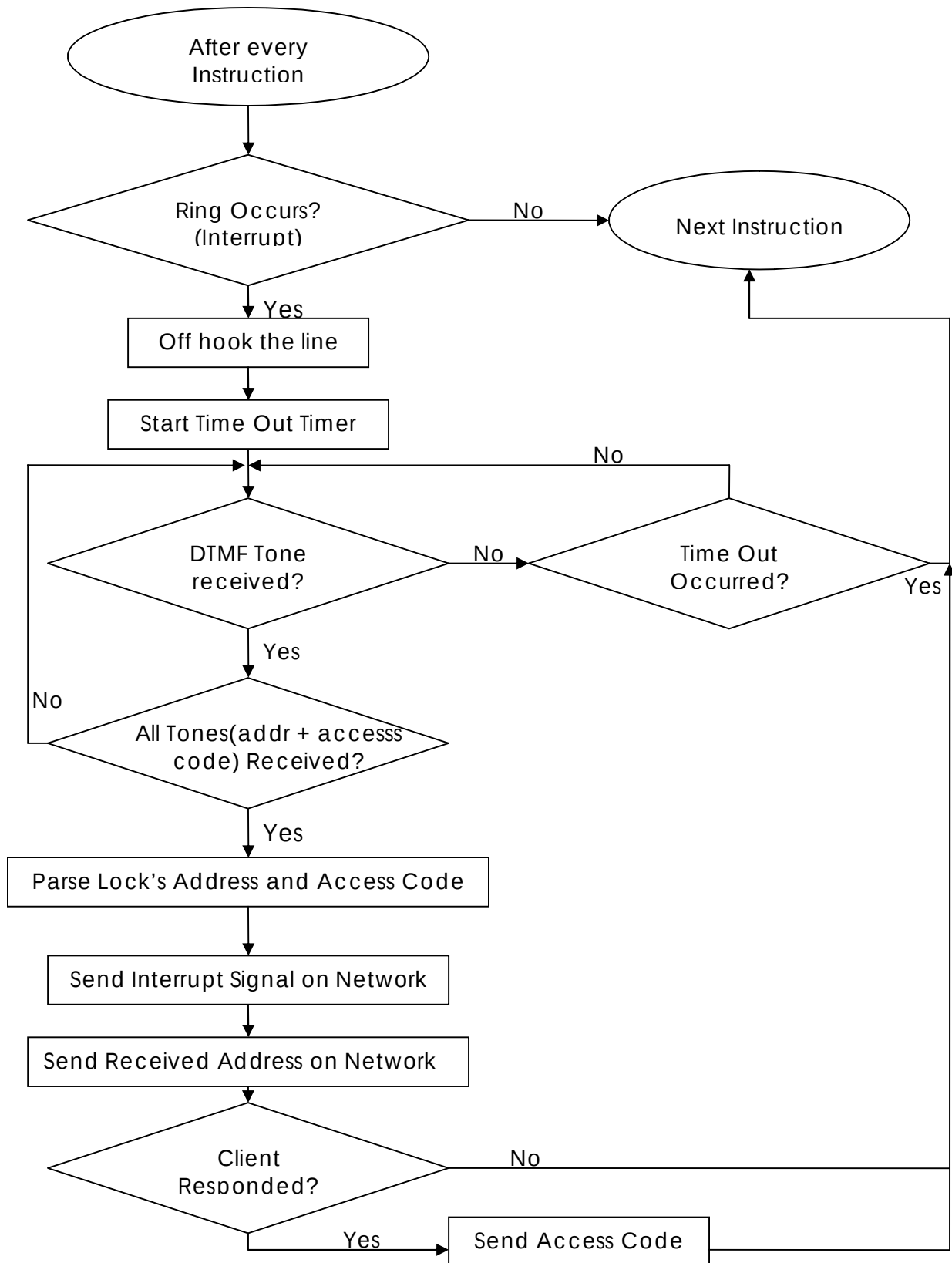
How this would work is as follows:

- When the system is in normal default state, there is 50 V DC on the telephone line, and all other circuits are in idle mode.
- Let us say a user tries to open the lock remotely using the telephone. When a call is made, a 90 V RMS AC signal is superimposed on the line.
- From the signal on the telephone line, DC is removed, and the AC signal is used to generate a negative edge, which triggers an interrupt on the microcontroller.
- The telephone line is made off-hook (voltage across the line brought down to 10V) by the microcontroller, which then waits for the DTMF codes to be entered by the remote user.
- The address data is then parsed and an interrupt is broadcasted to the slaves.
- The slave with the matching address responds and the master then transmits the access code entered by the remote user.
- After this, the master returns to the wait state.
- Upon receiving the data, the slave checks if the access code matches.
- If it is valid, the state of the lock is changed as specified by the user.
- After this, the slave returns to wait state.
- A keypad/LCD based menu interface is provided for each of the slaves using which one could change the state of the lock and also perform administrative functions.

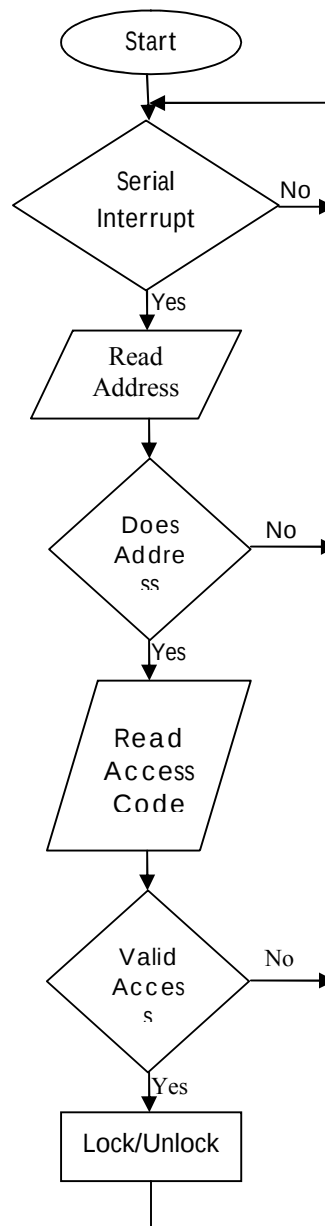
Menu Interface

The menu consists of three options:

- Open/ Close the Lock: This option may be used to open or close the lock based on the current state. The local user is required to enter the access code on invoking this option. The state of the lock is changed if the access code is valid.
- Access Codes: There are 10 unique access codes which can be changed using this menu option. On selecting this option the user can scroll down and view all the access codes. The currently displayed access code may be changed.
- Address: This option allows the user to enter a new address for the slave in question. The address is a 4-digit binary number lying between 0000 and 1001.



Flowchart for the Master



Flowchart for the slave

4. Circuit Explanation

The circuit can be broken down into two broad parts:

- Master circuit – the DTMF Decoder and Microcontroller
- Slave circuit – the L298 with motor and Microcontroller

Master Circuit

In the on-hook state a 50V DC voltage exists on the telephone line. When a ring occurs, a 90V (r.m.s) AC signal is superimposed on this DC voltage. Two 400 V, 22 nF decoupling capacitors are used to remove the DC component. Because of this there is a differential AC signal on the two input pins of the DTMF decoder. These pins of the DTMF decoder are clamped between 0V and 5V using 1N4007 diodes to protect the chip. The differential AC voltage is then differentially amplified, and then compared with a fixed value of 0.5 V using an LM324 OpAmp, which generates the negative edge for triggering the microcontroller on the INT0 pin.

Once the interrupt has been generated, the microcontroller switches on a 5V relay through a BC107 transistor, which in turn places a 220 Ω resistor across the telephone line to force the telephone line into the off-hook state. On this the voltage across the telephone line changes to 10V.

DTMF (Dual Tone Multi Frequency) tones consist of two voltage signals of different frequencies in the range of 600-1600 Hz superimposed on each other. The DTMF decoder circuit consists of a CM8870 DTMF receiver (decoder) chip. The pin layout of the CM8870 is as given in Figure 1 below.

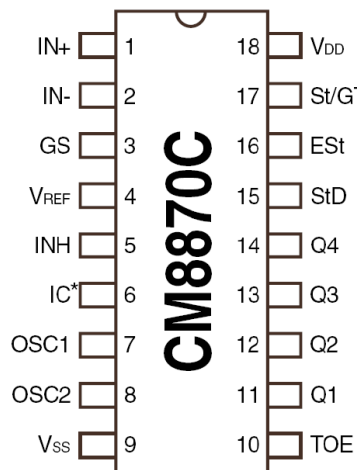


Figure 1: Pin Layout of DTMF Decoder CM8870 1

The input to the DTMF decoder is the DTMF signal, which is given to the pins IN+ and IN-. The gain of the signals can be adjusted by varying either the series resistance for the DTMF signal or the feedback resistance from pin3 (GS). The chip needs a crystal of frequency 3.579545 kHz. The decoder will decode the DTMF signal and present the output as four bits on Q1, Q2, Q3, and Q4. Logic high on the pin TOE (Three-state output enable) will enable the outputs Q1-Q4. The steering circuit using the pins 18 (Est) and 19 (St/GT) will control the minimum time for which a DTMF signal should be present on the line for it to be detected. This can be controlled by varying the resistance and capacitance connected to these pins. The Est pin presents a logic high

when a valid pair is detected and any change in the signal causes it go low. The StD pin presents a logic high when a valid tone-pair has been registered and the output is latched. It then returns to logic low when the voltage on the pin St/GT falls below a threshold. When a key is released the signal goes o(r) and hence, ESt will go low and St/GT pin voltage falls to zero. Thus, after a small time StD pin goes low. The StD output of the DTMF decoder is connected the microcontroller to notify the microcontroleer whenever a DTMF tone has been latched. The output corresponding to each of the keys pressed is given in Table 1.

Table 1

Digit	TOE	INH	ESt	Q ₄	Q ₃	Q ₂	Q ₁
ANY	L	X	H	Z	Z	Z	Z
1	H	X	H	0	0	0	1
2	H	X	H	0	0	1	0
3	H	X	H	0	0	1	1
4	H	X	H	0	1	0	0
5	H	X	H	0	1	0	1
6	H	X	H	0	1	1	0
7	H	X	H	0	1	1	1
8	H	X	H	1	0	0	0
9	H	X	H	1	0	0	1
0	H	X	H	1	0	1	0
*	H	X	H	1	0	1	1
#	H	X	H	1	1	0	0
A	H	L	H	1	1	0	1
B	H	L	H	1	1	1	0
C	H	L	H	1	1	1	1
D	H	L	H	0	0	0	0
A	H	H	L	undetected, the output code will remain the same as the previous detected code			
B	H	H	L				
C	H	H	L				
D	H	H	L				

Slave Circuit

This consists of an LCD display, a keypad, and the lock with its L298 driver, all controlled by an AT89C52 microcontroller. This arrangement can receive an interrupt from two possible sources. One source is the master and the other is the keypad. If the interrupt is generated by the master, it is handled as described above. The slave receives the access code from the master. It then compares the access code with the stored access codes. If there is a match, the state of the lock is changed accordingly.

The other source of interrupt is from the keypad. This is an 8-line 4x4 16 key keypad. Inputs to the keypad are made depending on the display on the LCD. The LCD displays a menu, with various choices including administrative options such as changing the access codes and the

normal functions of operating the lock itself. The command words for the LCD screen are shown below in Table 2. Based on the choices inputted, the microcontroller then sends the signal to lock or unlock to the L298. The L298 is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive a DC motor (lock). An enable input is provided to enable or disable the device independently of the input signals. Based on the state of the two other inputs from the microcontroller to the L298, we are able to control the direction of movement of the motor driven by the L298.

Network

In practice, when this apparatus would be implemented, we would need to implement the RS485 protocol using MAX485 transceivers. However, for demonstrative purposes, we have used RS232 protocol using MAX232 transceivers. The RS485 protocol gives us the following features:

- Master-slave operation, eg communication is initiated by the master only and slaves respond
- Multiple nodes on one bus
- Larger distances and higher speeds
- Uses differential voltages (hence eliminates the need for a common ground reference)

The MAX232 transceiver is intended for all EIA/TIA-232E and V.28/V.24 communications interfaces, particularly applications where $\pm 12\text{V}$ is not available. Its job is mainly that of amplification; it converts +5 Volts to -10 Volts, and 0 Volts to +10 Volts. It is the simplest of all serial communication protocols.

The communication protocol between the master and the slave is as follows:

- It consists of two lines, a transmitter and a receiver with respect to the master, henceforth referred to as TxD and RxD respectively. (assumes the ground reference is common for both)
- The bit period is 768 μs .
- The serial transfer starts with a -ve edge on the TxD line, the start bit being a zero.
- This is followed by 4 bits which denote the address of the slave.
- The slave with the matching address acknowledges with a zero on the RxD line.
- Once the master receives the acknowledgement, it starts transmitting 14 bits of the access code.
- The slave receives the 14 bits and the communication is closed.

5. Current Status

The circuit was assembled and found to be completely working on a breadboard. The circuit is ready on PCB, but complete testing of the PCB is yet to be done. The testing of the circuit was done using a telephone product tester (BK Precision Model 1054B) and a telephone instrument. The telephone product tester also simulates a ring on the telephone line. It also simulates a telephone line between the telephone instrument and the circuit.

6. Conclusions and Suggestions

A fully functional product could have the following extra features:

- An EEPROM can be included to store the access codes and the address and also to save the logs.
- An Interactive Voice Response System for users using the remote access facility.
- Packet encryption during data transmission between master and slave.
- Logging of all access to the system. These logs should be exportable to a computer system.
- Self contained power supply to convert from commonly available 230 V AC Mains, with emergency backup feature.

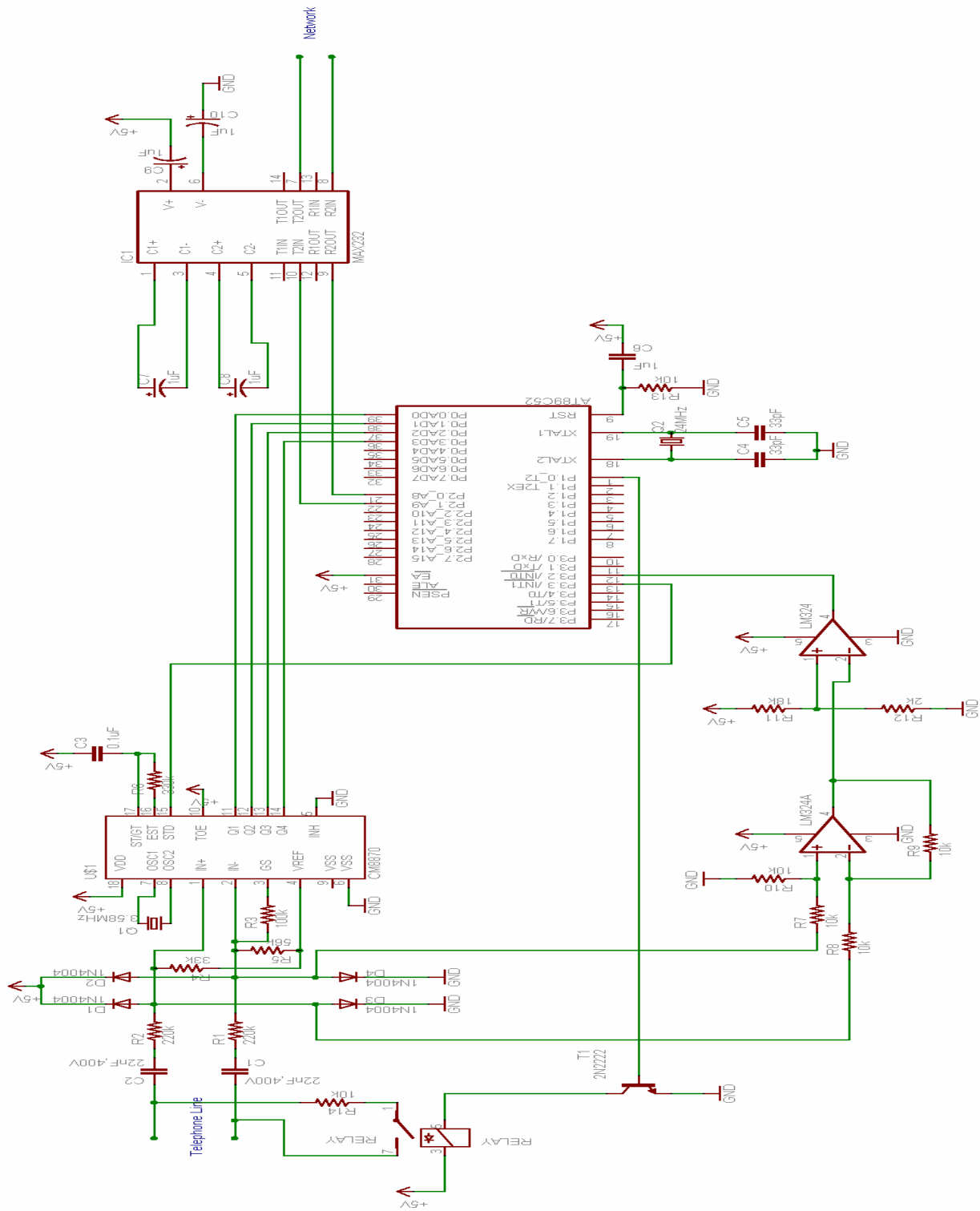
7. References

1. Datasheet of IC CM 8870, <http://www.datasheet.org.uk/datasheet-mac.html>
2. "Telephone circuits", <http://www.epanorama.net/links/telephone.html>, by Tomi Engdahl
3. DTMF Generator/Decoder", <http://www.boondog.com/tutorials/dtmf/dtmf.htm>, by Paul Oh
4. Datasheet of IC AT 89C52, www.datsi.fi.upm.es/docencia/Micro_C/atmel/doc0313.pdf
5. Datasheet of IC L298, www.st.com/stonline/products/literature/ds/1773.pdf
6. Datasheet of IC MAX232, www.ortodoxism.ro/datasheets/texasinstruments/max232.pdf
7. "The 8051 Microcontroller and Embedded Systems", by Muhammed Ali Mazidi and Janice Gillispie Mazidi

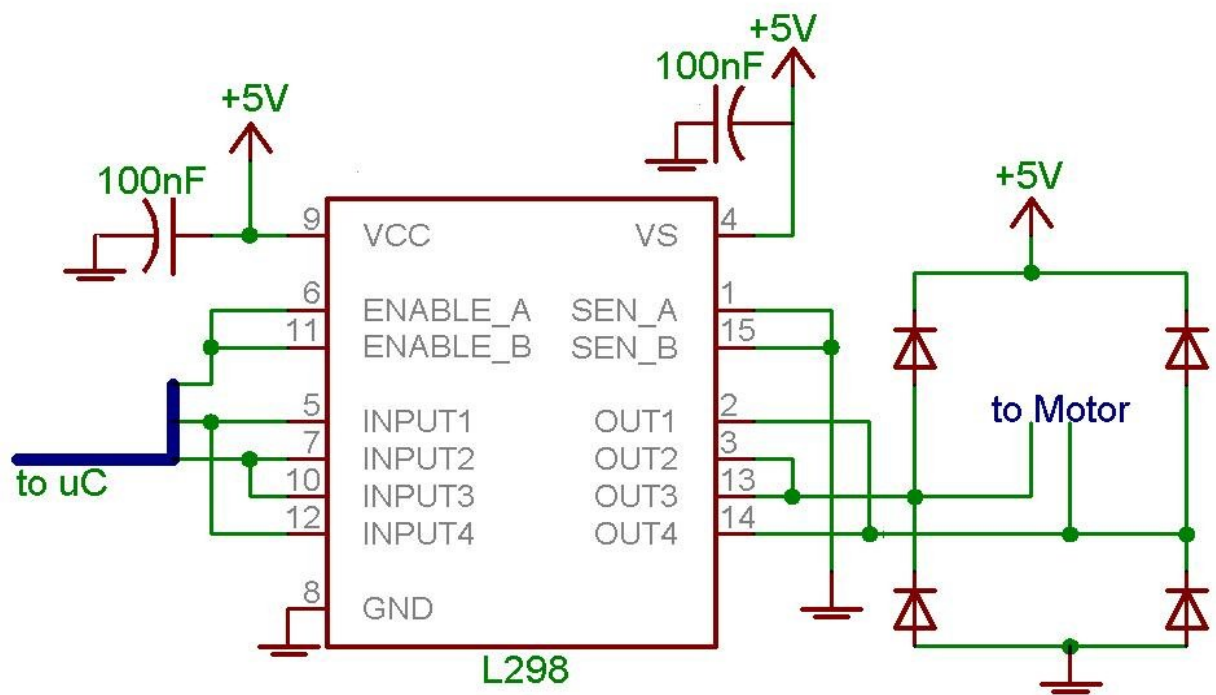
8. Acknowledgement

We are grateful to our project supervisors, who helped us whenever the need arose.

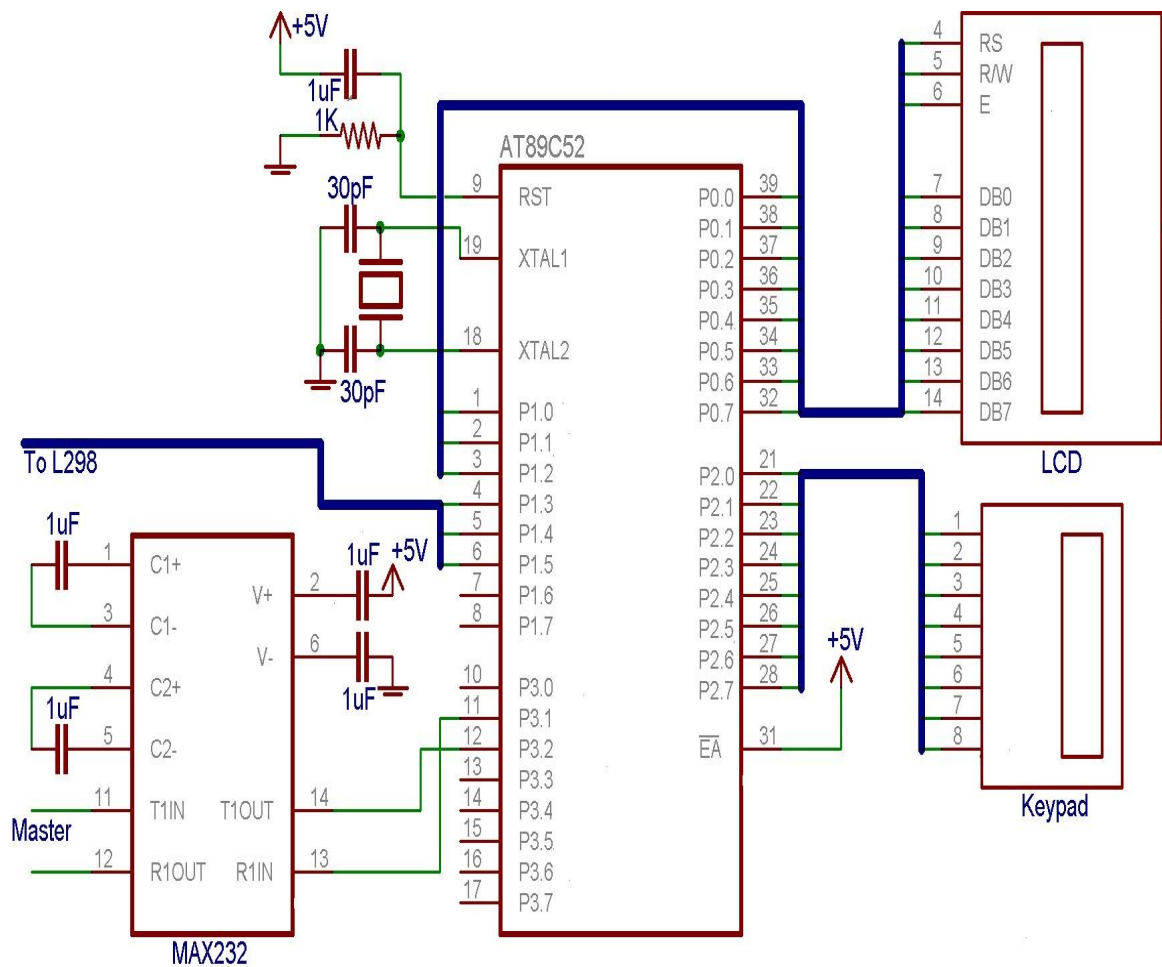
10. Circuit Diagrams



Master Circuit



L298 Circuit



Slave Circuit