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Construction of Telephone Operable Message System

H H E. Jayaweera and R Lelwala
Department of Physics, University of Colombo, Colombo 03, Sri Lanka

ABSTRACT

A password protected, dynamic LCD (Liquid Crystal Display) messaging board is developed to use with ordinary telephone is discussed in this publication. The device should be connected in parallel to a fixed-line telephone (called host telephone) and can be operated via host telephone itself or any other fixed-line or mobile telephone.
After authentication, user can feed a message by using the built in standard message list or by typing each character via telephone keypad. There are 9 standard messages and a standard message can be extended up to 250 characters and any of the ASCII characters can be used but only capital English letters, 0 to 9 and space are allowed when user feeding his own message through a telephone keypad.

System comprises of a Microchip™ PIC 16F877A microcontroller and a MT-8870D DTMF receiver, a Hitachi HD44780-based 20×2 LCD panel, a Ring Detection Unit, an Off-Hook Emulation Unit and a Customizing Unit. System runs with 6 V DC supply and it was successfully tested with the internal PABX system of the University of Colombo as well as with the national telephone grid.

1. INTRODUCTION

There are a large number of message boards used for different purposes in different places. Messages are displayed with symbols, pictures and letters. Some of the message boards are considered as static, while some others are considered as dynamic by considering the way of displaying the message on it. Dynamic message boards can be automatically or manually operable. For example, road sings, and boards indicating the name of a city can be considered as static message boards and the score boards in basketball courts can be consider as manually operated dynamic boards since the scores are changed frequently. Also the notice boards in the stock market are good example for automated dynamic message boards.

Displaying via a static message board is good when the space available for the board is sufficient, and message changing time is considerably large. When the situation of message meets all the requirements of a static board except the valid time, which is very low, it has to move to a dynamic board. For example, a Basketball score board. Since Basketball score boards have few parameters to change rapidly, manually operated boards are more suitable when considering the cost. But when more parameters are to be changed, automated message boards have to be used. But if the emphasis of a message is considered only, an

automated dynamic board is the best solution. By using those boards messages can be represented attractively using animations. In most cases dynamic message boards are too expensive and difficult to maintain because of high power consumption and requirement of expert knowledge to handle.

1.1 Requirements to be satisfied by a Message Board

Message boards should be of low cost. Also the cost of maintenance should be low. The expert knowledge required operating the message board, and the power consumption should be less. The readability of the message should be high. The message on the message board should be in control of the customer. Also the message should be protected from unauthorized users.

2. METHODOLOGY

2.1 Telephone Line States and Signaling

The telephone network uses one copper twisted wire for one telephone. The two wires are named as “Ring” and “Tip”. There is a switch in the telephone to connect and disconnect the phone from the network. This switch is generally called the hook switch. When the handset is lifted, the hook switch goes to switch on state, and the telephone line becomes “off-hook” state. Otherwise it stays “on-hook” state. Those two states are the basic states of the telephone line.

When a telephone is in on-hook state the Tip is at about 0 V, while Ring is about -48 V with respect to earth ground. When it is in off hook state, current is drawn, Tip goes negative and Ring goes positive. A typical off hook condition is Tip at about -20 V and ring at about -28 V. This means that there is about 8 V voltage between the wires going to the telephone in normal operation condition. When the telephone is ringing there will be an extra AC ringing voltage around 90 V of frequencies in 20 to 40 Hz range.

2.2 DTMF

DTMF is a tone composed of two sinusoidal waves of given frequencies. It was not intended for data transfer, but it is designed to control signals only. The one common element and most important of all phone connections is the voice. The bandwidth necessary for legible voice communication is in the range of 300 to 3000 Hz. A single tone or frequency could have been used providing that no voice was present. If voice is present, it could certainly at times conflict with the control tones. In addition, it would have required ten different tones, one for each digit. The engineers choose instead two tones or frequencies for each number. Generating two separate tones, not related harmonically to each other, will eliminate a voice accidentally producing a valid pair. The table 1 resembles

a matrix keyboard, and shows how to compose any DTMF code which consists of two simultaneous frequencies mixed together (added amplitudes)

Table 1 - DTMF Frequency table

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

2.3 Alphanumeric Keypad

Although a typical telephone keypad contains only twelve keys. One key has been assigned to more than one character. There are several ways of assignments of characters to telephone keypads. According to the International Telecommunication Union (ITU) Recommendation E.161 [2] and The European Telecommunications Standards Institute (ETSI) standard ES 202 130 [1] one alphanumeric keypad layout is defined. In the Nokia, Sony, Ericson and Motorola mobile phones use this standard.

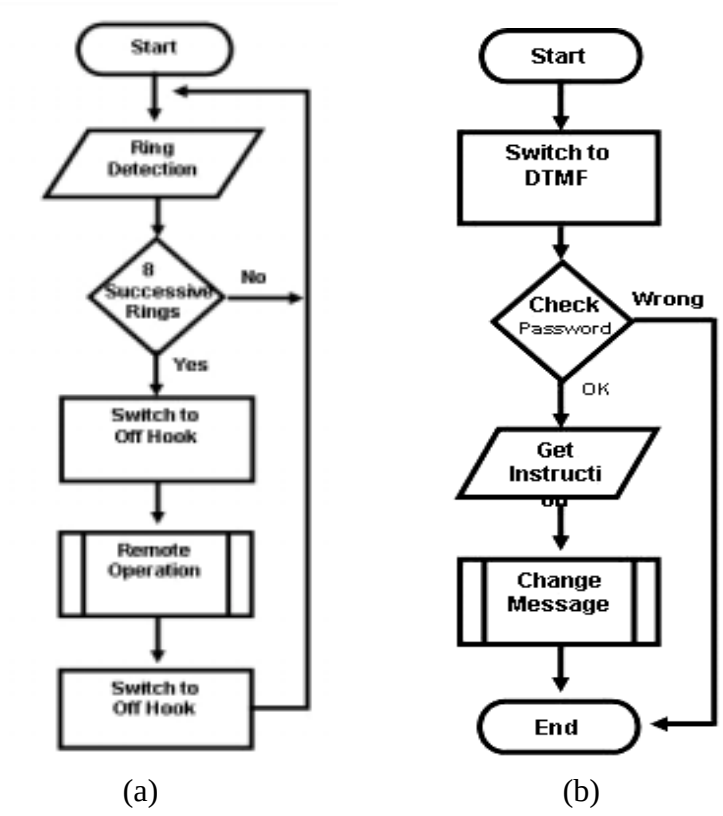
Figure 1: TDU compatible alphanumeric keypad layout

3. DISCUSSION

3.1 Basic Functionality

Tele Display Unit (TDU) is connected in parallel to the telephone named as host telephone. The Tele Display Unit can be remote operated by using the telephone number of the host telephone. When a ring comes to the host telephone TDU also detects that ring. If the phone is not answered till the number of continuous rings equal to the user predefined number (user can change this), then the TDU is connected to the telephone at the other end called the remote telephone which made the ring to the host telephone. Actually at this time telephone line is sent to the off hook state and is connected to the DTMF decoding unit. Then through the key pad of the remote user's telephone, remote user can send signals to the TDU. The main process flow of TDU has been sketched below.

For operation of TDU, user has to enter the password in order to logon to the TDU. If the password is incorrect, remote user is not allowed to change the message on TDU and telephone line is sent to on hook state. Otherwise the user is allowed to change the message on the TDU. Password can be customized by the user at the host end.

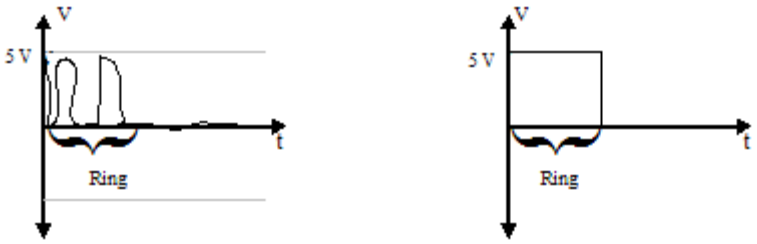


(a) (b)

Figure 2 (a): Main Process Flow of the TDU, (b) - Remote operating routine

3.2 Construction and Testing

Ring signal detection was done by capturing high volt AC signal at 25 Hz. Discriminator output for one signal is a train of pulses, so integrating circuit was introduced to make it one pulse. Since integrating circuit average the voltage a level shifter was inserted to push up the output into Transistor-Transistor Logic TTL compatible level. The ring detection unit produces one pulse for one ring and it does not draw enough current from the phone line to pick up the phone. For further protection of electronics from high voltages an optical isolator was used.



(a) (b)

Figure 3: Output signal of ring detection (a)- without integrating circuit, (b)- with integrating circuit

To get rid of decoding of voices which seem almost DTMF signals by the DTMF decoder valid signal duration is checked by external RC time constant of 100 nF capacitor and 300 K resistor (30 ms). Any signal not consistent with the time of RC time constant will not be taken into the account.

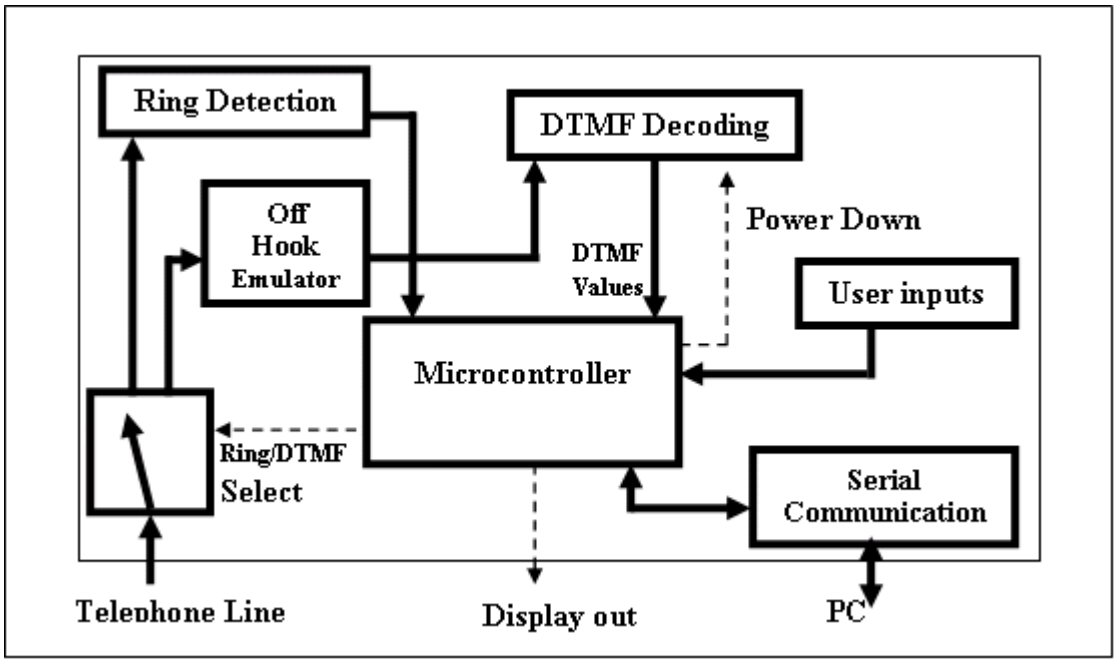


Figure 4: Basic functionality of diagram of final circuit

When a ring signal comes through the telephone line there is a high voltage and large noise signals present, but when a connection is established between two telephones there are no such shocking signals coming through the telephone line. Hence DTMF decoding circuits cannot be connected directly parallel to the telephone line since it is much sensitive circuit, since ring detection part consists of optical isolation system it can be connected directly parallel to the telephone. Therefore switching system was used to switch the telephone line between DTMF decoding circuit and ring detection circuit.

The phone line has to be sent off hook state to transmit DTMF signals from one phone to another. Hence off hook state has to be emulated inside the Tele Display Unit to receive DTMF signals from the remote telephone. This was achieved by giving that 300 Ω input impedance to the telephone line, similarly as the telephone does by using 300 Ω 0.5 W resistor.

The display unit was constructed using a Hitachi HD44780U compatible 5×8 dot-matrix 40×2 character liquid crystal display (LCD). 4-bit data transferring protocol was used to save the ports of the microcontroller. Since only the write function of the LCD is used, only additional 2 control lines were required.

User has to construct the message to be displayed on the TDU, using 12 keys on the telephone keypad. Therefore each key on the telephone keypad has been assigned several alphanumeric characters. Consequently the data send as DTMF signal have to be decoded to alpha numeric characters. The keys representing 0 to 9 on the telephone keypad have been used to represent alphanumeric characters. The keys representing the symbols '*' and '#' have been assigned as 'Clear' and 'Enter' control keys. Since a data key have been assigned several alphanumeric symbols pressing a data key once, twice, thrice or four times will result distinct alphanumeric symbol. The protocol is to first enter the data by pressing data key successively and press # (Enter) key to accept it. When pressing a data key, if that key is pressed three times as an accident but wanted is only two times, then * key can be used for clear the last press. E.g. :Sending "AE2" using this protocol

Table 2 - Steps of sending data "AE2"

Key Pressed	**Current data**	**Decoded Data**
2	A	
#	Enter	A
3	D	
3	E	
#	Enter	E
2	A	
2	B	
2	C	
2	2	
#	Enter	2

DTMF signal detection was done by using Motorola MT8870D chip and it is always kept standby to reduce power consumption [3]. The major draw back of TDU is there is no feedback to the remote user. Hence he does not know whether the data is uploaded to the display panel. The only way to make sure whether it is sent or not is hearing the DTMF signals while typing. As the solution for this drawback a text to speech engine can be installed on the TDU and it can send user the feedback by saying the received letter. The

standard inbuilt messages cannot be customized by the user. But for distinct users require different messages. As a solution for this, customizing software can be developed by using serial communication capability of the microcontroller.

Another drawback is that when typing a message on the display the remote telephone has to be online. But this drawback cannot be eliminated since the remote end only has a telephone. By adding a small gadget, offline typing mode can be developed but when considering the requirement of TDU this is not possible, because TDU to use only a telephone in the remote end.

4. CONCLUSIONS

One of the built-in standard messages stored in the device memory or custom message constructed using the keypad of the telephone can be uploaded through any telephone to the Tele Display Unit (TDU). Standard message can consist of any ASCII character and custom message can only include capital letter of English alphabet, 0 to 9 numbers and a few symbols. The device is protected from unauthorized access by user customizable password. TDU has been developed by using low cost devices and it consumes very low power. Major drawback of the TDU is there is no proper acknowledge to the remote user. Hence the remote user does not know whether the message is launch to the TDU or not. TDU is developed for the PABX systems as well as for the national telephone grid without changing anything.

REFERENCES

Websites and datasheet:

1. http://www.etsi.org/pressroom/previous/2003/alphanumeric%20keypads.htm
2. http://www.itu.int/rec/T-REC-E.161-200102-I/en
3. Motorola MT-8870 DE DTMF receiver datasheet