DTMF Based Robot Assisted Tele Surgery

Vikas Pandey, T. L. Joshy, Vyshak Vijayan, N. Babu

Abstract—A new and cost effective robotic device was designed for remote tele surgery using dual tone multi frequency technology (DTMF). Tele system with Dual Tone Multiple Frequency has a large capability in sending and receiving of data in hardware and software. The robot consists of DC motors for arm movements and it is controlled manually through a mobile phone through DTMF Technology. The system enables the surgeon from base station to send commands through mobile phone to the patient's robotic system which includes two robotic arms that translate the input into actual instrument manipulation. A mobile phone attached to the microcontroller 8051 which can activate robot through relays. The Remote robot-assisted tele surgery eliminates geographic constraints for getting surgical expertise where it is needed and allows an expert surgeon to teach or proctor the performance of surgical technique by real-time intervention.

Keywords—Robot, Microcontroller, DTMF, Tele surgery.

I. INTRODUCTION

DUAL-TONE Multi-Frequency Signaling (DTMF) is used for telecommunication between telephone lines in the voice-frequency band between telephone handsets and other communications devices. The DTMF used in push button telephones for tone dialing is known as Touch-Tone. The DTMF technology can also be used in GSM mobile phones. Global System for Communication is an open, digital cellular technology used for transmitting voice and data and is the most widely used accepted standard and is implemented globally. Using the GSM mobile phone with DTMF technology a robotic device can be operated at a distance. Tele operation can also be possible with radio frequency waves. But normal RF has limitation when there is an interference of similar wavelength of another RF. This might affect the quality of the transmission and might leads to receive corrupted or error signal. The evolution of surgical robots has led to a current generation of real-time tele-manipulators. A Robotic system was designed to assist the surgeon by taking control of the laparoscopic camera and responding to voice commands [1], [2]. Early systems required the surgeon to be in the same room as the patient. However, with the use of telecommunications, both tele-monitoring and tele-manipulation were attempted from remote locations [3], [4]. In this work, we developed and present a surgical manipulator which is cost effective a device for performing both minimally invasive surgery (MIS) and open surgery, operating from remote area using DTMF technology.

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II. MATERIALS AND METHODS

A. Block Diagram

Fig. 1 shows the block diagram of the robot assisted tele-surgery. The important components of this robot are DTMF decoder, Microcontroller and motor driver.
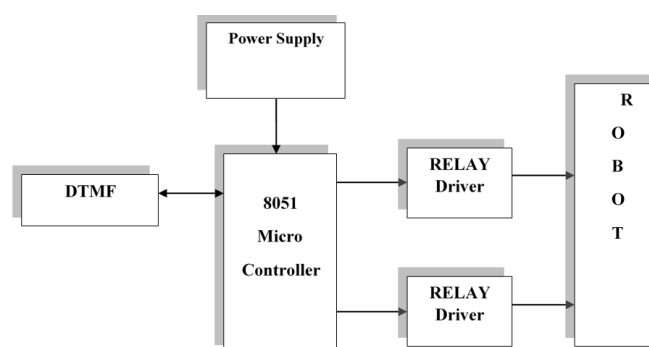

Fig. 1 Block diagram of the robot assisted tele-surgery

B. Power Supply

A step-down transformer is used to step down the supply voltage of 230V ac from mains to lower values, as the various IC's used in this project require reduced voltages. The primary of the transformer is connected to main supply through on/off switch & fuse for protecting from overload and short circuit protection. The secondary is connected to the diodes to convert 12V AC to 12V DC voltage and filtered by the capacitors, which are further regulated to +5V, by using IC 7805. The circuit diagram for power supply is as shown in Fig. 2.
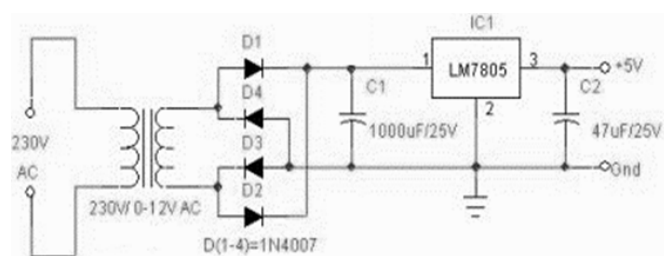

Fig. 2 Circuit diagram for power supply.

C. Dual Tone Multi Frequency (DTMF)

DTMF is one of the common GSM technologies which provide telecommunication signaling over analog telephone lines between communications devices and also applied in the touch-tone (push button) system of mobiles over wireless communications. The basis of using dual tone in DTMF communication is, if two tones were used to represent a digit, the likelihood of a false signal occurring is ruled out. The

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keypad of DTMF is laid out in a 4×4/4x3 matrix, with each row representing a low frequency, and each column representing a high frequency. The low band row frequencies are 697 Hz, 770 Hz, 852 Hz, and 941 Hz and high band column frequencies are 1209 Hz, 1336 Hz, 1477 and 1633 Hz.

Each key pre generates two tons of specific frequencies. One tone is generated from a high frequency group of tones and the other from low frequency group [5]. The DTMF signal is generated whenever a key is pressed from a phone while a call is being made. This signal was utilized to give inputs to a remote via a DTMF decoder and a microcontroller, which in turn controls the movements of the connected actuator. The circuit diagram for decoding the DTMF tones is given in Fig. 3.
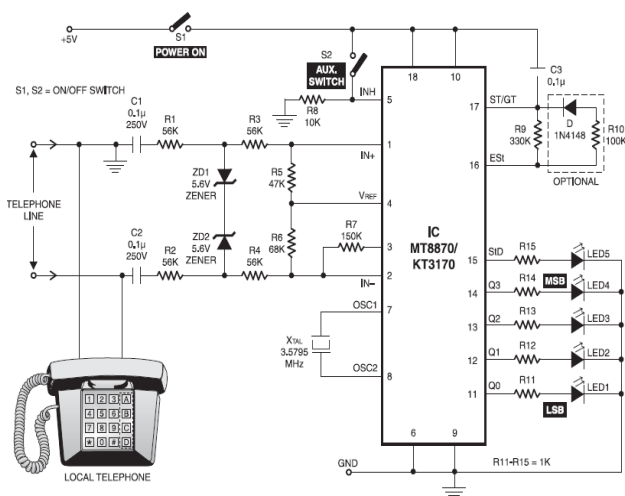

Fig. 3 Circuit diagram for decoding the DTMF tones

Using the DTMF technology, it sends distinct representation of 12/16 common alphanumeric characters 0-9, * and # on the mobile / telephone. The DTMF keypad is arranged such that each row and column will have its own unique tone frequency. A SIM (Subscriber Identity module) was assigned to a receiver mobile and this SIM was called from user mobile which act as transmitter of DTMF tones. The receiver will receive the call and receive the DTMF tones one by one while pressing the keys from the user mobile. For optimum working of mobile /telephone equipment, the DTMF receiver must be designed to recognize a valid tone pair greater than 40 ms in duration and to accept successive digit tone-pairs that are greater than 40 ms apart. However, for other applications like remote controls and radio communications, the tone duration may differ due to noise considerations. Therefore, by adding an extra resistor and steering diode the tone duration can be set to different values. The circuit is configured in balanced line mode. To reject common-mode noise signals, a balanced differential amplifier input is used. To know, which key was pressed in mobile/telephone, there is a set LED arrangements are connected to output of decoder IC. Whenever a key on local telephone keypad was pressed, for example 5, the delayed tearing (Std) output of the IC goes high

on receiving the tone-pair, causing a particular LED (connected to pin 15 of IC via resistor R15) to glow. It will be high for duration depending on the values of capacitor and resistors at pins 16 and 17. Table I shows pressed keys in keypad and glowing of corresponding LEDs (1 - On, 0 - Off). The frequencies generated on phone keys are shown in Table II.

TABLE I
KEYS AND CORRESPONDING LEDS

Key	LED 4	LED 3	LED 2	LED 1
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	1	0	1	0
*	1	0	1	1
#	1	1	0	0

TABLE II
FREQUENCIES GENERATED ON PHONE KEYS

Frequency (Hz)	1209	1336	1477
697	1	2	3
770	4	5	6
852	7	8	9
941	*	0	#

D. Microcontroller and DTMF Detection

The DTMF detection and the control of devise arms for making surgery is integrated by Microcontroller 8051. A microcontroller is a small computer containing a processor core memory and programmable I/O peripherals. Today, most telephone equipment use DTMF receiver IC. One common DTMF receiver IC is the Motorola MT8870 that is widely used in electronic communications circuits. The MT8870 is an 18-pin IC. It is used in telephones and a variety of other applications. In our project also DTMF detection was done by DTMF decoder MT8870 as most of the DTMF based remote control system used. The DTMF detection and control process require some programming and here Keil software is used for this purpose. Keil Software makes C compilers, macro assemblers, real-time kernels, debuggers, simulators, integrated environments, and evaluation boards for the 8051, 251, ARM, and XC16x/C16x/ST10 microcontroller families. Fig. 3 shows the block diagram for DTMF based tele surgery. The DTMF tones produced from mobile touch buttons was decoded and given to microcontroller which sends different output signals to the different relays which are used to activate the robot and robot arms. The relay circuit was given in Fig. 4. The various functions are assigned to move the robot and their arms for every keypads of the mobile/telephone. The functions for the keypads of zero to nine and * are given in Table III.
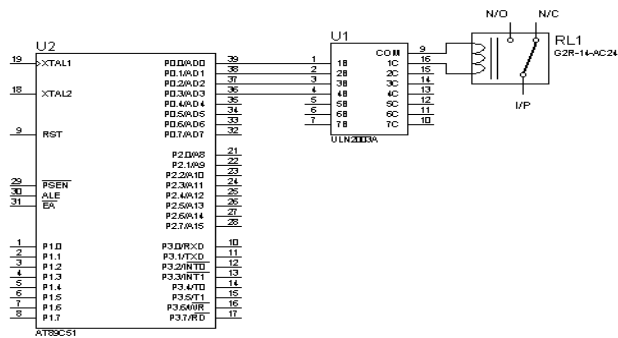
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Fig. 4 Circuit diagram for operating relay.

TABLE III
FUNCTIONS OF KEYPADS

Key	Functions
1	Forward
2	Reverse
3	Right
4	Left
5	Rotate Right
6	Rotate Left
7	Down
8	Up
9	Place
0	Pick
*	Stop

Figs. 5 and 6 show the photo copy of wired circuit board and Robot for tele surgery.

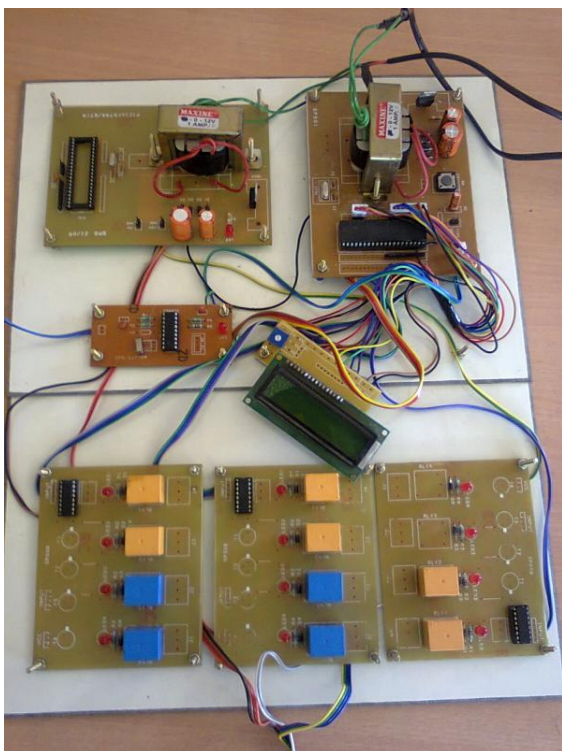Fig. 5 Photograph of wired circuit board

Fig. 6 Photograph of Robot for telesurgery

III. DISCUSSION

Number of communicating techniques such as GPRS, Bluetooth, infra-red and RF transmission etc. are already available for two way data transfer. Normal RF communication has limitation when there is an interference of similar wavelength of another RF also it will be blocked by walls or obstacles. For reliable communication DTMF was used for its low cost, simplicity, reliability, good audibility and accuracy. Dual Tone Multi Frequency encoding scheme as a method for communicating simple messages to operate the arms of the robot for surgery was designed and implemented. The possibility of performing complex manipulations from remote locations allows an expert surgeon to teach or proctor the performance of an advanced or new technique by real-time intervention and actually eliminates geographic constraints for obtaining high surgical expertise where this is required [6].

Robotic and computer technologies have the potential to enhance precision and dexterity [7]-[9] and to allow performance of surgical procedures from a remote distance [10]. This robotic system is more suitable for stationary sender and receiver as communication breaks down between the sender and receiver, or both when they are in motion. This technique also has some disadvantages; lack of face to face contact between patient and doctor, delays in transmission, equipment failure in robot side etc. But the technique of DTMF was used for its simplicity, cost effective, popularity and used with already existing mobile and telephone industry.

IV. CONCLUSION

DTMF communication technique is a highly reliable and cost effective for robotic tele-surgery. This project has described the design and implementation of feasible Dual Tone Multi Frequency encoding scheme as a method for doing remote tele surgery. This method eliminates geographic constraints for obtaining high surgical expertise where it is required and allows an expert surgeon to teach or examine the new techniques by real-time intervention. In addition to enhancing the human performance, robotic systems provides the unique ability to perform surgery in remote locations.

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