Robotic Arm using DTMF Technique

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Abstract *— Humans performing knowledge work today are complemented by technology in increasingly high-value ways. As a result, we are entering a new era of human machine interface for repetitive and rote processes. In current robotics research there is a vast body of work on algorithms and control methods for designing the required target. The purpose of this project is one such attempt to design a –Robotic arm using simple Atmel AT89C2051 (low-power, high-performance 8-bit microcontroller compatible with the MSC-51 instruction set) . The core has to be interfaced with DC motors of robotic arm using L293 D (Dual H-bridge motor Driver) to control the movements of robotic arm. DTMF tone generator is use to provide tone for the interfacing unit of mobile based system to communicate with microcontroller wirelessly using RF module.*

Keywords— *Microcontroller, L293 D, DTMF tone generator, RF Module, robotic arm, DC motor.*

I. INTRODUCTION

Robotics field are increasingly being integrated into working area to replace humans especially to perform the repetitive task. This field are now divided into two areas, industrial and service robotics.

International federation of robotics (IFR) defines a service robot as---- "a robot which operates semi- or fully autonomously to perform services useful to the wellbeing of humans and equipment, excluding manufacturing operations". [3]

The robot institute of America defines a robot as "a programmable multifunctional manipulator designed to move material, parts and tools of specialized device through variable programmed of variety of tasks".[1]

These robots are currently used in many fields of applications including office, military tasks, hospital operations, dangerous environment and agriculture. Besides, it might be difficult or dangerous for humans to do some specific tasks like picking up explosive chemicals, defusing bombs or in worst case scenario to pick and place the bomb somewhere for containment and for repeated pick and place action in industries.

The robotic arm can be fixed or mobile (i.e. wheeled) and can be designed for industrial or home applications. The proposed system constitute of 5 DC Motor drive by 2-- L293 motor drivers, **a Atmel AT89C2051 microcontroller** ,DTMF encoder & decoder, RF Module, 12v battery, 9v cell. Working requires a latest android application "DTMF tone generator". The mobile phone is connected to the electronic circuit which comprises of DTMF encoder, decoder and RF Module. The sound of the keypad tone is received and transmitted to microcontroller. The Mechanical links of this manipulator are designed by connecting joints allowing either rotational motion or axial displacement. Finally, this prototype of the arm may be expected to design a mechanical arm operated by mobile.

II. METHODOLOGY

A self sufficient robotic arm is fabricated by using components like micro-controllers and motors. This increases their speed of operation and reduces the complexity. It also brings about an increase in productivity which makes it easy to shift to hazardous materials. In the implementation process, the necessary components of structure ICs, blocks and power supply are all assembled on the PCB. The main part of the design is AT89C2051 micro-controller which coordinates and controls the product's action.

1. Problem Definition:

DTMF (Dual Tone Multiple Frequency) is a concept used in mobile phones to dial numbers. DTMF Tone is generated by two frequencies (low frequency and high frequency) .The two frequencies are arranged by matrix format and when user presses the keys the two frequencies will get shorted and will generate a tone, that tone is detected by DTMF decoder. DTMF Encoder is used to generate DTMF tones in mobile and will decode the tone and gives a 4 bit binary output and this output is the source of input to the Robot. A DTMF Decoder which gives a 4 bit binary output can perform 16 operations, but as mobiles have only 12 keys only 12 operations can be performed. A mobile phone placed in the Robot will acts as a input device, output signal taken through audio jack and given input to DTMF decoder, the Decoder decodes the analog frequency and give output, which will use to control different movement of the robotic arm.[2]

2. ***Architecture:*** Most of the industrial robots are still programmed using the typical teaching process, through the use of the robot teach pendant. In the proposed project we control the different movements of this robotic arm and gripper using Atmel AT 89C2051 micro controller board through L293D quadruple high-current half-H motor driver board. we interfaced a RF transceiver

module with DTMF tone generator IC MT 8870 to generate digital output.

DTMF produced four digital outputs to the hand movement of the arm. The digital outputs produced by DTMF decoder are converted into signal using RF Transmitter and the transmitted using RF antenna. At the receiver we will have our digital output through the RF receiver Module and forwarded to the microcontroller. Here we are using AT 89C2051 micro controller, which takes the decision of the movement of the arm depending the digital outputs received.

Microcontroller cannot drive motors directly; hence we need to drive the motors through L293D driver circuit. Each L293D can drive maximum of two motors, therefore we add two motors in series and use two L293D ICs to drive five motors of robotic arm.

3. *Transmitter:*

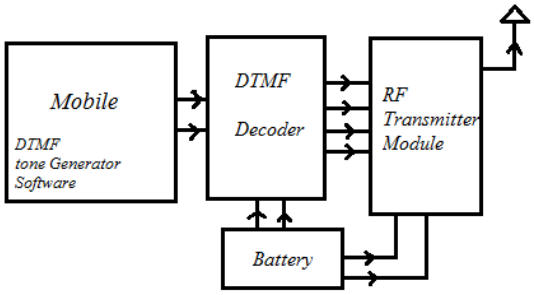


Fig.1: The Transmitter section

The transmitter side has component as mobile, DTMF tone decoder IC, RF encoder and Transmitter unit, antenna.

a. DTMF tone generator Software:

This is a simple android application available on smart phones. DTMF tone generator produces a continuous tone for as long as a key is pressed. This app is ad-supported freeware. DTMF generation is a composite audio signals of two tones between the frequency of 697Hz and 1633Hz. The DTMF keypad is arranged such that each row will have its own unique tone frequency and also each column will have its own unique tone.

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

Table 1: DTMF Keypad logic

Above Table.1 is a representation of the typical DTMF keypad and the associated row/column frequencies. By pressing a key, for example pressing key 5, will generate a dual tone consisting of 770 Hz for the low Group, and 1336 Hz of the high group.

b. DTMF Decoder (IC MT8870DE):

DTMF (Dual Tone Multi Frequency) decoder is a decoder circuit which detects the telephone dial tone and decodes the key .A touch tone decoder IC**,** IC MT8870DE was used for DTMF Signal detection and decodes the signal to 4 digital outputs. The M-8870 DTMF (Dual Tone Multi Frequency) decoder IC was used to determine the frequencies of the limited tones. The decoder identifies the DTMF tone and will generate the binary equivalent of the key pressed. The M-8870 DTMF decoder IC decodes the tone generated by the cell phone. The microphone pin will directly tap the DTMF signals. The red wire of the microphone is DTMF input to the circuit. The microphone wire signals are processed by the DTMF decoder IC and generate binary equivalent sequence D0, D1, D2, and D3 as parallel sequence. The M-8870 decoder IC contains an inbuilt operational amplifier. The signals from the microphone pin are fed in to inverting input of the Op amp through a series of resistance (100kΩ) and capacitance (0.1 µF). The output of Op Amp is passed through the filter network. The filter network contains switched capacitors, which divides the DTMF tones into low and high frequency signals. Filtered frequencies will pass through the frequency detector and code detector circuits and a four digit binary code is latched at the output of M-8870 DTMF decoder IC.

Digit	*Freq Low*	*Freq High*	*D3*	*D2*	*D1*	*D0*	*Movement of ARM Toward*
1	697	1209	0	0	0	1	right side- base
2	697	1336	0	0	1	0	Left side- base
3	697	1477	0	0	1	1	Forward-Shoulder
4	770	1209	0	1	0	0	Backward-Shoulder
5	770	1336	0	1	0	1	Upward-Elbow
6	770	1477	0	1	1	0	Downward-Elbow
7	852	1209	0	1	1	1	Open-Grip
8	852	1336	1	0	0	0	Close- Grip
9	852	1477	1	0	0	1	NOP
0	941	1209	1	0	1	0	NOP
*	941	1336	1	0	1	1	NOP
#	941	1477	1	1	0	0	NOP
A	697	1633	1	1	0	1	NOP
B	770	1633	1	1	1	0	NOP
C	852	1633	1	1	1	1	NOP
D	941	1633	0	0	0	0	NOP

Table 2: DTMF code designing

c. RF Transmitter Module:

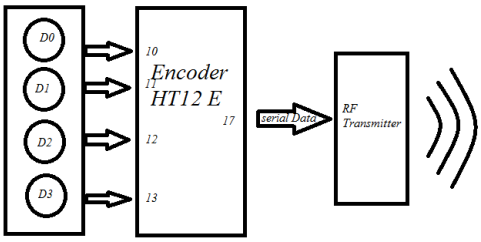


Fig.2: The RF Transmitter Module

RF modules are usually very small in size and operate with voltage range of 3V to 12V. RF transmitter modules are designed to work with 433MHz frequency. If transmitting logic is zero, then no power is drawn by transmitter (consumes very low power if carrier frequency is fully suppressed). For transmitting logic one, it consumes power about 4.5mA with 3V. This system use encoder is HT12 E for the RF transmission purpose. Encoder IC (HT12E) receives parallel data. The control signals along with 8 address bits constitute a set of 12 parallel signals. The encoder HT12E encodes these parallel signals into serial bits. Transmission is enabled by providing ground to pin14 which is active low. The control signals are given at pins 10-13 of HT12E. The serial data is fed to the RF transmitter through pin17 of HT12E. Transmitter, upon receiving serial data from encoder IC (HT12E), transmits it wirelessly to the RF receiver.

4. Receiver:

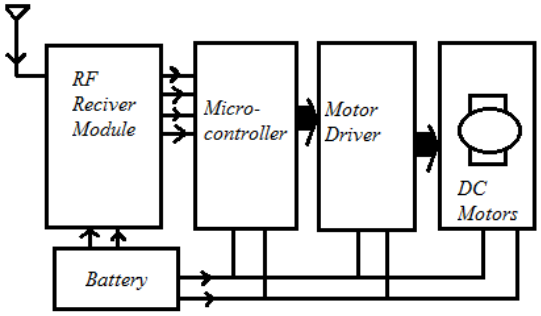


Fig.3: The Receiver

a. *RF receiver Module:*

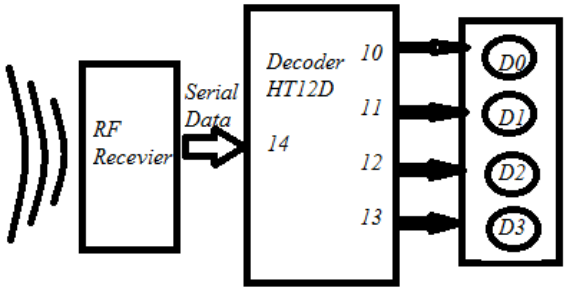


Fig.4: The RF Receiver Module

RF Module comprises of an RF Transmitter and an RF Receiver**.** AS RF receiver we use IC HT 12 D. When no signal is received at data pin of HT12D, it remains in standby mode and consumes very less current (less than 1µA) for a voltage of 5V. When signal is received by receiver, it is given to DIN pin (pin14) of HT12D. On reception of signal, oscillator of HT12D gets activated. IC HT12D then decodes the serial data and checks the address bits three times. If these bits match with the local address pins (pins 1-8) of HT12D, then it puts the data bits on its data pins (pins 10-13) and makes the VT pin high. An LED is connected to VT pin (pin17) of the decoder. This LED works as an indicator to indicate a valid transmission. The corresponding output is thus generated at the data pins of decoder IC.

b. Microcontroller:

The Atmel AT89C2051 is a low-power, high-performance 8-bit microcontroller compatible with the MSC-51 instruction set and object code. The 20-pin AT89C2051, with its many hardware features, is especially attractive to 8051 developers because it is compatible with the 8051 and similar devices, and can reduce board space, components, and cost. In an application comprised of EPROM, address latch, an 8051, and other associated components, for instance, the 8051 offers enough on-chip digital I/O that additional external I/O components may not be required.

The AT89C2051 features:

- 2 KB of on-chip Flash program memory.
- 128 bytes of internal RAM.
- Fully static operation: 0 Hz to 24 MHz.
- Instruction compatible with MCS-51.
- 15 I/O lines.
- Full duplex programmable serial port.
- Two 16-bit programmable timers.
- On-chip analog comparator.
- Low-power and power-down modes.
- Wide operating voltages: 2.7 V to 6 V.
- 20-pin DIP/SOIC package.

c. Motor Drivers: (L293D)

The H-bridge motor driver is the most common method to drive DC motors in two directions with computer control. H-bridges can be built with bi-polar junction transistors (BJT) or with a field effect transistors (FET), or can be even purchased as integrated packages such as the L293. For low current motors the L293 is simplest and inexpensive one while for high current motors, it is easy and inexpensive to make our own H-bridge.

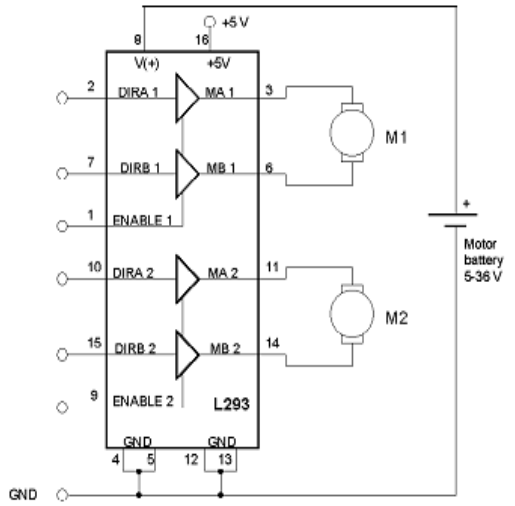


Fig. 7Circuit Diagram of Motor Driver L293

In the propose system we are using 5 DC motor on 2 motor driver Ic L293 D. as figure show that normally L293 D control two motor at a time. Usally it was unadvisable to use three motor on L293 D, but we had try and use three motor at a time on motor driver Ic. We use two motor in series for one of motor Driver as shown below fig.8

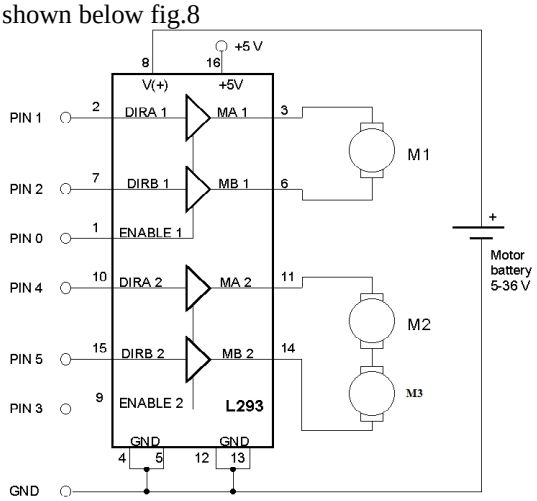


Fig. 7Circuit Diagram of Motor Driver L293 for three motor

Pin 1/9	*Pin2/10*	*Pin7/15*	*Movement*
1	*1*	*0*	*Clockwise direction*
1	*0*	*1*	*Anticlockwise direction*
1	*0*	*0*	*Idle*
1	*1*	*1*	*Idle*
0	*X*	*X*	*X*

Table 3: L293D movement

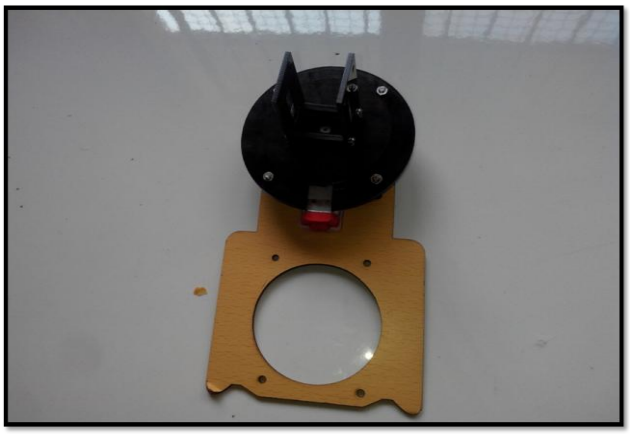
d. DC Motors:

- A DC motor in simple words is a device that converts direct current(electrical energy) into mechanical energy. D.C motors have long been the primary means of electric traction. D.C motor is considered a SISO system having torque/speed characteristics compatible with most mechanical loads. This makes a D.C motor controllable over a wide range of speeds by proper adjustment of its terminal voltage.[4] In addition, they have high efficiency and have a high starting torque versus falling speed characteristics which helps high starting torque and helps to prevent sudden load rise [5].

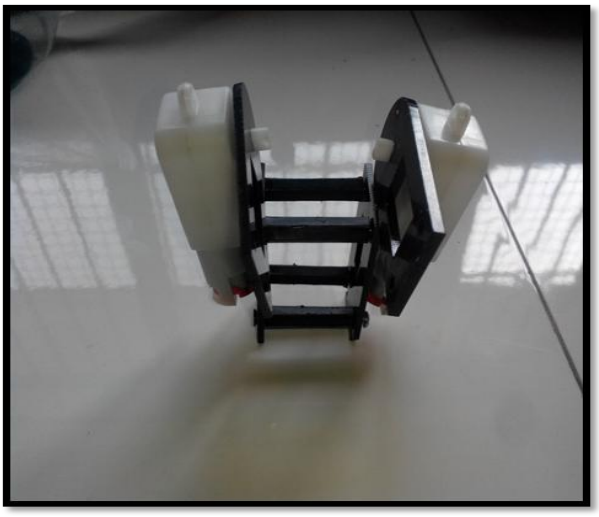
III.MECHANICAL ASSEMBLY

There are different mechanical assemblies on which the device moves. There is a base assembly to move the device right & left. there is axially the shoulder assembly to move device forward and backward, the elbow assembly to move arm up and down. The grip assembly makes the jaws open and close.

1. *Base Assembly:*



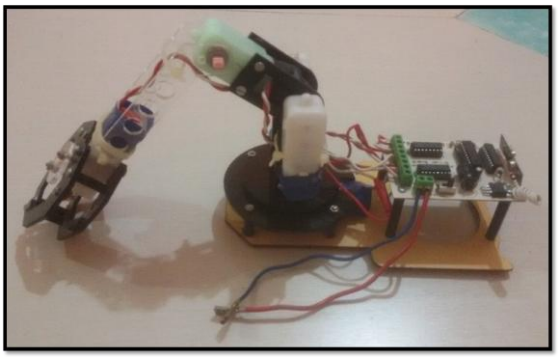
2. Shoulder Assembly



3. *Elbow Assembly*

4. *Grip Assembly*

5. *Assembled ARM*



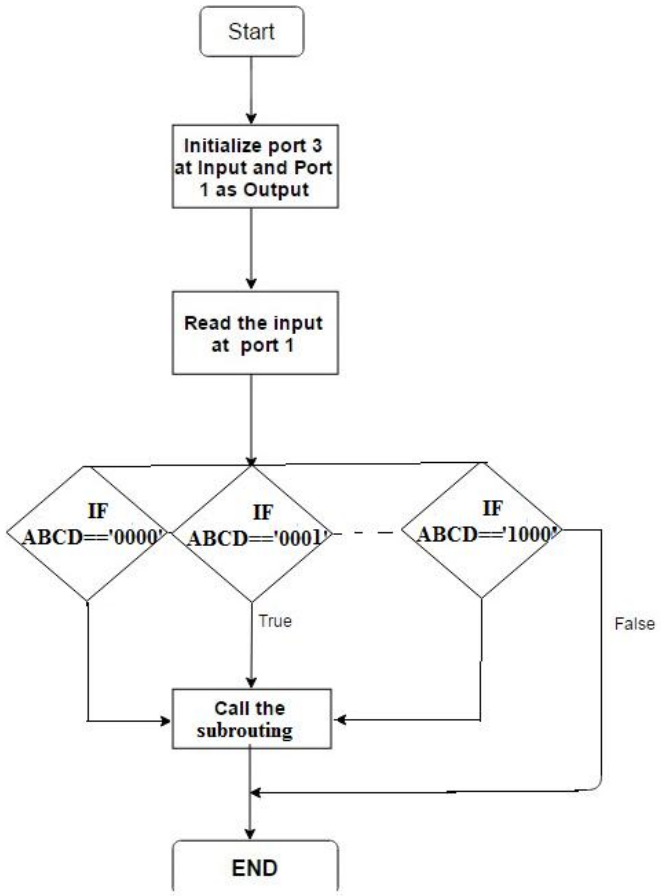
IV. CONTROLLING MECHANISM

The control mechanism is design such that the tone coming from the DTMF software of the mobile is decode and binary data was achevied , is given to the microcontroller through RF module. microcontroller take the decision according to binary data recived. As follows the movement was designed :

D3	D2	D1	D0	Movement of motor
0	0	0	1	Base motor -right side
0	0	1	0	Base motor -Left side
0	0	1	1	Shoulder motor - Forward
0	1	0	0	Shoulder motor – Backward
0	1	0	1	Elbow motor –Upward
0	1	1	0	Elbow motor – Downward
0	1	1	1	Grip Motor-Open
1	0	0	0	Grip Motor-Close

Table 4: movement designed

The flow chart that microcontroller follows is below



V. EXPERIMENTAL RESULT

Our experiments were done mainly in three parts. In the first part, we tested the DTMF decoder receive data from mobile and create the binary code correctly. The second phase we tested the transmitter module. The third phase we test interfacing of the microcontroller and motor driver. Then we tested the complete system with series of event to aim to pick up the object. The system response was very good but the torque and speed of DC motor are problem to control the movement for pick up the object.

VI. CONCLUSION

The robotic arm so far designed is able to lift the objects. In order to extend its capability, more advanced tools and material with the capacity to withhold the heavy weight objects are to be used, which is then applicable in warfront and used as a rescuer at several places where there is a need and also in industrial areas, military, and so on[6].We conclude that the proposed system functions properly as the command is provided. The proposed system operates on Mobile Phone Keypad, as the tone of button is produced the respective part of the arm move. The Electronic Circuit to which the Mobile Phone is connected consist of LED'S which glows as the keypad tone is Received. As we press 1 on keypad the arm moves clockwise with the help of disk, on pressing 2 the arm moves anticlockwise. On pressing particular key on the mobile , we see the resultant movement on the system.The DTMF Tone software is required to operate the Robotic Arm using Mobile Phone Using this system, a non-expert robot programmer can control a robot quickly and in a natural way. The low price and short set-up time are other advantages of the system.[7]

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