Mobile Controlled Crane using DTMF Technology Via PLC System for Industrial Application & Security

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ABSTRACT
We here by present controlling of cranes, using Dual Tone Multi Frequency (DTMF) technology. The crane is controlled by a mobile phone that makes a call to another mobile phone attached to the crane's control panel. During the call, if any button is pressed, tone corresponding to that button is heard at the other end of the call. This tone is received through headset which is subsequently used to relay the commands to a Programmable Logic Controller (PLC) that would perform switching action of motors, connected to the moving parts of the crane. With advantages of simplicity, audibility, cost effectiveness & unlimited range the hypothesis is that DTMF could replace Radio Frequency (RF) in simple communications. This paper proposes other application areas, such as Industrial environments, where DTMF is feasible and would be advantageous over RF. In this fashion, direction of motion of the crane can be remotely controlled by a mobile phone by DTMF technology via Global System for Mobile communication (GSM).

General Terms
Electronics**.**

Keywords
GSM, DTMF, PLC.

1. INTRODUCTION
The aim of the proposed system is to develop a cost effective solution that will provide controlling of industrial equipment's remotely and enable Industrial security against intrusion in the absence of industrial owner.

The system not only does the same work in twenty times less capital but also provides an unlimited range of control unlike contemporary remotes based on radio frequency (RF) control. These remotes have a range of around 200 meters. However devices connected also consume electrical power. As a result, it is crucial to control these devices by turning on/off whenever required. Since now it is a necessity to control devices more effectively and efficiently at anytime from anywhere. In this system, we are going to develop a cellular phone based industrial equipment controller via PLC.

To activate the cellular phone unit on the system a call is to be made and as the call is answered, in response the user would enter a two/three digit password to access the system to control devices. As the caller press the specific password, it results in turning ON or OFF specific device. The device Switching is achieved by Relays. Security is preserved because these dedicated passwords owned and known by selected persons only. For instance, our system contains an alarm unit giving the user a remote on/off mechanism, which is capable of informing up to five different numbers over telephony network about the nature of the event.

2. PROCESS
There is mobile at the user end which calls to the mobile embedded in our system.

The latter is in auto answering mode and a headset is connected to the phone which is fixed to our circuit.

These signals are received by KT9170 IC as input, and 4 bit digital output is generated from output pins.

Since we need to have at least 10 switching, as a result we have to put a 4:16 decoder (IC 74154) after KT9170.

This output is connected to the input of PLC which has a program written in its memory; the coding decides the action to be taken and accordingly relays are picked up.

Relays are connected to the motors which move the parts of the crane.

3. DTMF GENERATION & DECODING
A DTMF signal is the algebraic sum of two different audio frequencies, and can be expressed as follows:

$$f(t) = A0\sin(2*\Pi*fa*t) + B0\sin(2*\Pi*fb*t) + \ldots \quad \text{------->(1)}$$

Where fa and fb are two different audio frequencies with A and B as their peak amplitudes and f as the resultant DTMF signal. fa belongs to the low frequency group and fb belongs to the high frequency group.

Each of the low and high frequency groups comprise four frequencies from the various keys present on the telephone keypad; two different frequencies, one from the high frequency group and another from the low frequency group are used to produce a DTMF signal to represent the pressed key.

The amplitudes of the two sine waves should be such that

$$(0.7 < (A/B) < 0.9)V \qquad \text{--------(2)}$$

The frequencies are chosen such that they are not the harmonics of each other. The frequencies associated with various keys on the keypad are shown in figure:

Fig 1: Keypad

4. WAVEFORM

When you press the digit 1 in the keypad it generates a resultant tone signal which is made up of frequencies 697Hz and 1209Hz. Pressing digit 7 will produce the tone taken from tones 852Hz and 1336Hz. In both the cases, the column frequency 1209 Hz is the same.

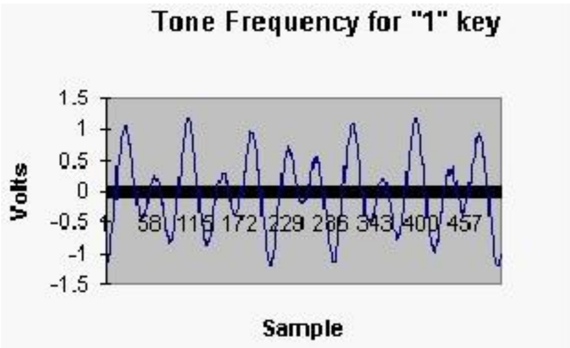


Fig 2: Sample

These signals are digital signals which are symmetrical with the sinusoidal wave.

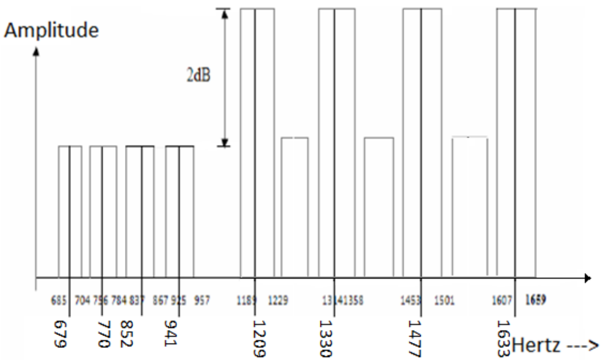


Fig 3: Dual Tone Multi Frequency (DTMF) spectrum

As the above frequency spectrum demonstrates, each & every tone must fall within the proper band pass before a valid decoding takes place. If one tone falls outside the band pass spectrum, the decoder will not operate at all. The purpose of DTMF decoding is to detect sinusoidal signals in the presence of noise. The DTMF decoder IC interfaces with a controller. In addition, the signal processing associated with the decoding is usually beyond the scope of the microcontroller's capabilities. So the designer is forced to use the devoted IC or advance controller to perhaps a more costly digital signal processor. The theory is quite similar to the "classical" signal processing technique. To detect DTMF signals it is digitized w.r.t. the incoming signal and 8 DFT's (discrete Fourier transforms) are computed centered on the 8 DTMF composite frequencies. DFT's are preferred over FFT's because the frequencies are not equally spaced (in fact, they are logarithmically spaced). In its simplest form, the DFT can be written as:

$$DFT(x) = \sum^{N} x(k)\, W(k) \quad \ldots\ldots(1)$$

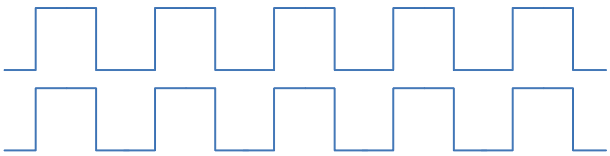
Where x (k) are the time samples and W (k) is the famous kernel function:

$$W(k) = e^{(j2\pi fk/N)} = \cos(2\pi fk/N) + j \sin(2\pi fk/N) \quad \ldots\ldots(2)$$

It means that multiplying the samples by sine waves and cosine waves and adding them together the W(k) can be found. This will give up eight complex numbers. The magnitudes of these numbers give an idea about how much energy is present for each frequency of the input signal. In other words, we have computed the frequency spectrum at the 8 DTMF composite frequencies. The reason why this works so well is because of the "orthogonality" of the sine waves. In other words, this happens if the DFT is performed on two sine waves as shown in the following equation:

$$DFT = \sum [\sin(f1t)\sin(f2t)] \quad \ldots\ldots(3)$$

From equation (3), it is clear that we will get the result as a "large" number if the two frequencies are the same and a "small" number or zero if they're different. "DFT" With Square waves



1+1+1+1+1+1+1+1+1+1+1+1+1+1+1+1+1+1+1+1+1+1+1+1+1+1+1+1+1=20

Fig 4: Sample of Waveform

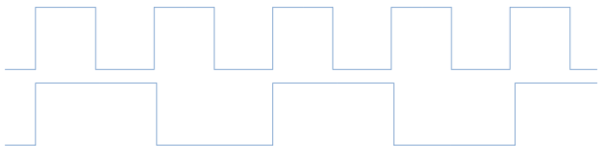
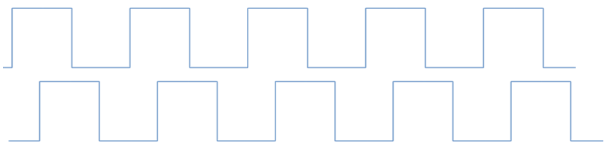


Fig 5: Sample of Waveform



+1-1-1+1+1-1+1-1-1+1+1-1+1-1-1+1+1-1+1-1-1+1+1-1+1-1-1+1+1 = 0

Fig 6: Quadrature form of Wave

The orthogonally concept applies equally well to square waves too. In fact, it's even easy to illustrate with ASCII art. Let us consider the two examples as given below: In the first example (figure5), the two square waves have the same frequency and phase. When the individual samples are "multiplied" andSummed together, we get a large number: 20.

In the second case (figure6), the square waves differ in frequency by a factor of two. Again as expected, when we

"Multiply" the individual samples and add them up, we get a small number: 2. If we look closely, we'll notice that the multiplication is really an exclusive OR operation. DFT in Quadrature Form In the DFT, both the sine and cosine waves are used. The two types of wave are obviously related by 90 degree phase shift. An analogously shifted square wave is needed for the DTMF decoding too. The reason is that it's possible to end up with a small sum-of-products even if the two waveforms have the same frequency. This idea can be cleared with the example of figure-9.On the other hand, the DFT operation is a dot product operation also. We can imagine the signal and the kernals as vectors whose indices are the sample number. The vectors could be very large, e.g. 4096 samples.

i) Signal Strength of DFT:

If the DFT's are computed with sine and cosines, then the signal strength of a particular frequency is easily ascertained with help of following equation:

Strength ≡√(real(DFT)2 + imaginary(DFT)2) …………..(4)

In other words, the result of a DFT is a complex number when the complex kernel is used. And the magnitude of a complex number is the square root of the sum of the real part squared plus the imaginary part squared. This is a cumbersome operation that we would rather avoid. The square root of the sum of the squares normalization is called the "square norm". It is a subset of the general class of normed linear spaces called the "p-norm". In our case, the linear space consists of two components: the real and imaginary parts of the DFT.

The p-norm for our case is strength≡ P√(abs(real(DFT))p + abs(imaginary(DFT))p) …(5)

And this is the same as the square norm when p is 2. Now if p is 1, we end up with an extremely simple formula, the 1-norm:

Strength ≡√abs (real (DFT)) + abs (imaginary (DFT))……….(6)

ii) Digitization process:

Digitization process of +1 and -1 OR +1 and 0 have to be done, until now we've been digitizing to +1 and -1. However, in a real program we'll probably want to digitize to +1 and 0 since these are the numbers which are most comfortable for microcontroller operation. The next point is how this impacts the DFT calculations. Suppose we have two square waves that are digitized to +1 and - 1. What will happen to their dot product if we digitize them to +1 and 0 instead? Let f1 and f2 be the two square waves as like below:

f1 = -1 or +1 and f2 = -1 or +1

For the conversion from +1 and – 1 to 1's and 0's:

q1 = (f1 + 1)/2 => f1 = 2q1 – 1……………………………….(7)

q2 = (f2 + 1)/2 => f2 = 2q2 – 1……………………………….(8)

So, q1 and q2 represent the re-digitized f1 and f2 square waves. Now the dot product:

DFT = Σ f1.f2 ≡Σ (2q1 - 1).(2q2 - 1)

= (4q1q2 - 2q2 - 2q1 + 1)

= 4 Σq1q2 - 2 Σq2 - 2 Σq1 + Σ 1………………..(9)

The last term evaluates N. In other words, 1+1+1+ ... +1 = N.

The middle two terms requires a closer examination. Assume that f1 and f2 contain no DC component:

N

Σ f1 = 0……………………………………………… (10)

0

Then the sum of q1 is:

Σq1 = Σ (f1 + 1)/2

= 0 + N/2 = N/2…………………………………(11)

Similarly, the sum of q2 is N/2. Combining these results it can be shown that:

f1.f2 = 4 Σ q1.q2 - Σ2N/2 - Σ2N/2 + N

= Σ4 (q1.q2) - N………….………………………….(12)

Therefore, in conclusion, we can say that the digitization with 0's and 1's is essentially the same as digitizing with +1's and -1's. But a new "DC" term of N has been introduced and the dot product has been scaled which are the only differences.

iii) Decoding Process:

In DTMF there are 16 distinct tones. Each tone is the sum of two frequencies: one from a low and one from a high frequency group. There are four different frequencies in each group. Most of our phones only use 12 of the possible 16 tones. If we observe our phone, there are only 4 rows (R1, R2, R3 and R4) and 3 columns (C1, C2 and C3). In case of some mobile phones, it may be varying. The rows and column select frequencies from the low and high frequency group respectively. Each key is specified by its row and column locations. For example, the "2" key has row 0 (R1) and column 1 (C2). Thus, "2" has a frequency of 697 + 1336 = 2033 Hz. The "9" is row 2 (R3) and column 2 (C3) and has a frequency of 852 + 1477 = 2329 Hz.

5. SYSTEM DEVELOPMENT

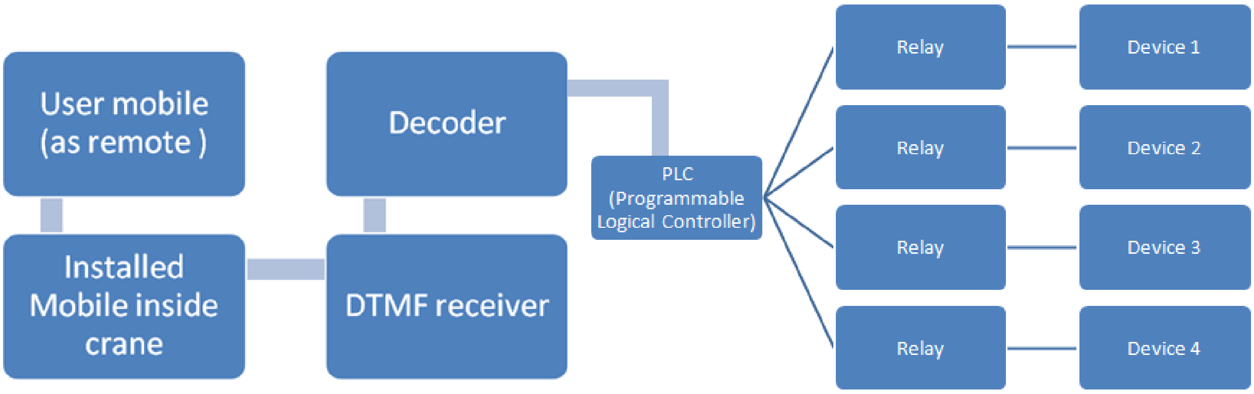


Fig 7: System Block Diagram

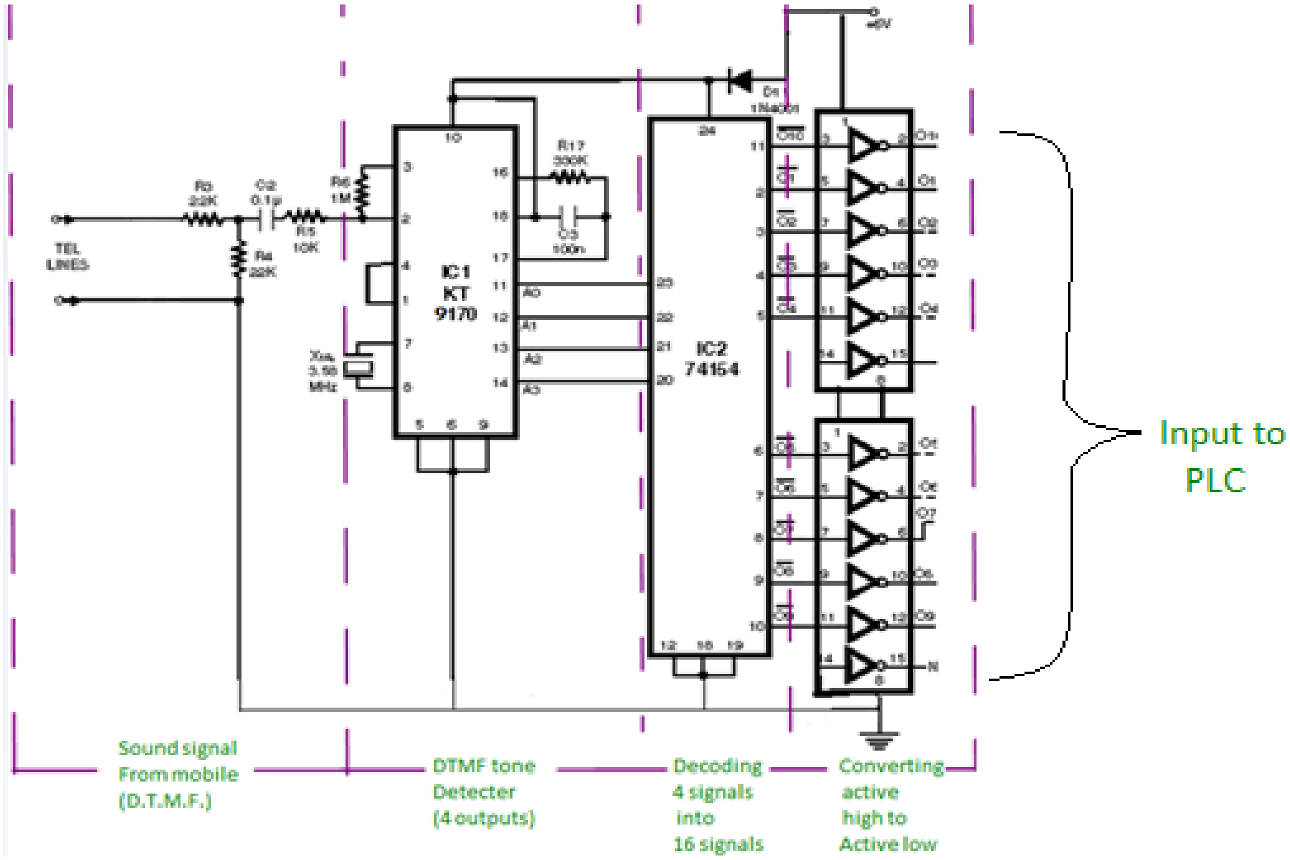


Fig 1: Circuit Diagram

6. FACTORS TO BE CONSIDERED WHILE IMPLEMENTING THE SYSTEM

1) The receiver must reside in a location where a signal with sufficient strength can be obtained.

2) The only person who can communicate with the control module is the person who will be successfully authenticated.

3) Only devices with electrical controlling input ports will be possible targets for controlling.

4) The receiver must have a power source (12V) attached at all times.

5) Operation of the controlling unit is only possible through a cell phone with DTMF capabilities and voicemessage.

7. FURTHER STUDY

1) Possibility of confirming the devices initial condition (status) using short messaging system (SMS)

2) Though mobile in the control panel required to be charged, therefore charging system should be automated which meant a timer can be implemented so that mobile can be charged after a certain period and disconnected from the charger when not required.

3) The system can be expanded to provide such control over the GPRS. In this way, the capabilities of the internet can be combined with the capabilities of our physical line free communication system. Furthermore, by adding a closed loop control facility, the system capabilities can be improved.

8. ACKNOWLEDGMENTS

We feel proud to present our project on remote controlling of mega structure cranes using DTMF technology which includes learning all the mechanical systems, electrical equipment's & electronic instruments required to control a typical EOT crane

This project wouldn't have been feasible without the proper and rigorous guidance of Mr. Mahesh Gupta, Professor OPJIT Raigarh, Mr. Avinash, OPJIT Raigarh who guided us at all times.

Thereby, we would like to thank them for guiding us on a step by step basis and ensuring that they don't even miss a single drop of knowledge unshared

Rigorous hard work has been put in this project to ensure that it proves to be the best project ever made & it is hoped that this project will prove to be a breeding ground for the next generation of students and will guide them in every possible way.

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