Contents

1. ABSTRACT

- DTMF Encoder Decoder is a very easy to use program to decode DTMF dial tones found on telephone lines with touch tone phones.
- DTMF is the global standard for audible tones that represent the digits on a phone keypad.
- DTMF Decoder is also used for receiving data transmissions over the air in amateur radio frequency bands.
- The signal is encoded as a pair of sinusoidal (sine wave) tones from the table below which are mixed with each other.

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

- Each DTMF tone is actually two tones – a low frequency tone and a high frequency tone combined, that's why it is dual tone multi frequency.
- Looking at the standard phone keypad as a grid, the low tone corresponds to the row, while the high tone corresponds to the column.
- DTMF was known throughout the Bell System by the trademark TouchTone. The term was first used by AT&T on July 5, 1960 and was introduced to the public on November 18, 1963.

2. INTRODUCTION

- Dual tone multi frequency or DTMF as it is popularly known as is the technical term for the sound frequencies produced when a telephonic key is pressed.

- DTMF also known as touch tone was primarily used for telephone signalling to and from the local exchange though today it finds several applications in the field of tele-communications and call centres.

- A different frequency is assigned to each key in the telephone and there are two tones – One Low frequency and One High frequency that are played simultaneously when a key is pressed. This combination of two tones makes it nearly impossible to reproduce by the human voice.

- Each of the four rows of keys in a telephone is assigned a low frequency tone and each of the three columns is assigned a high frequency tone. A fourth column of keys labelled as A, B, C & D is optional and is mostly used in Military networks.

- DTMF can be transmitted over telephone lines as well as over the internet. The tones are decoded on the receiving end and used for practical applications such as interacting with computer systems and answering machines. The interaction with a computer system is achieved using an IVR system.

- Over a regular landline, DTMF is sent as audio signals. DTMF tones are transmitted through the same wires that carry the voice signals. In the case of mobile phones, DTMF tones can be generated only after the connection is established.

3. PRINCIPLE

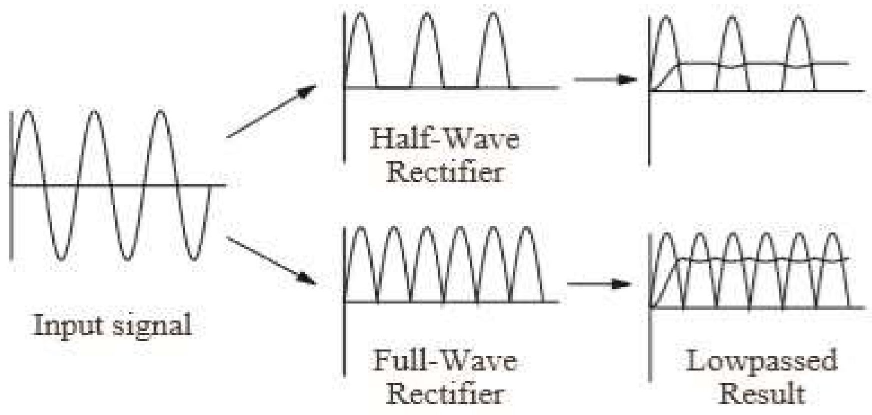
- There are sixteen DTMF signals, each of which is made up of two tones from eight different frequency signals. Twelve of these are commonly used by consumers with four being reserved for military use or use by exchanges (Usually the keys A, B, C and D).
- These keys are system tones used for configuring telephone exchanges and to carry out special functions. The DTMF keypad for consumer use is designed in a four-row by three-column matrix. Each dial row is represented by a low tone frequency and each column by a high tone frequency.
- The frequencies used are 697 Hz, 770 Hz, 852 Hz, 941 Hz, 1209 Hz, 1336 Hz, 1477Hz, and 1633 Hz. The frequencies were carefully chosen in such a way as to prevent harmonics. Thus, one can notice that no frequency is a multiple of another and the difference or sum between any two frequencies is not equal to any other frequency.
- Additionally, the frequencies generated have to be within an error tolerance of 1.5% and the higher frequency is transmitted at 3 dB louder to compensate for any high frequency roll-off. The pair of signals represents the digit or symbol at the intersection of the row and column. For example, if the digit 5 has to be sent, the frequencies transmitted are 1336 Hz and 770 Hz in a sinusoidal combination.
- There a number of steps to perform when decoding DTMF signals. The first two steps allow us to determine the strength of the signal at each of the DTMF frequencies. We first employ a bank of bandpass filters with center frequencies at each of the DTMF frequencies. Then, we process the output of each bandpass filter to give us an indication of the strength of each filter's output. The third step is to "detect and decode." From the filter output strengths, we detect whether or not a DTMF signal is present.

- If it is not, we refrain from decoding the signal until a tone is detected. Otherwise, we select the two filters with the largest output strengths and use this information to determine which key was pressed.

- When performing DTMF decoding, we want filters that pass only one of the DTMF frequencies and reject all of the rest. We can make use of the correlation idea above to develop such a bandpass filter. We want our impulse response to be similar to a signal with the frequency that we wish to pass; this is the filter's centre frequency.

- In order to measure the strength of the filter's output, we actually want to measure (or follow) the envelope of the filter outputs. To follow just the positive envelope of the signal, we first need to eliminate the negative portions of the signal. If we simply truncate all parts of the signal below zero, we have applied a half-wave rectifier. Alternately, we can simply take the absolute value of the signal, in which case we have applied a full-wave rectifier.

- Once we have processed the outputs of the bandpass filters, we can now detect whether or not a DTMF tone is present and, if it is, determine which key was pressed to produce it. Ultimately, we want to convert our signal into a sequence of keys pressed to produce this sequence.



4. PROBLEM FORMULATION

- Each key on the Dialpad is a combination of a high frequency and a low frequency.

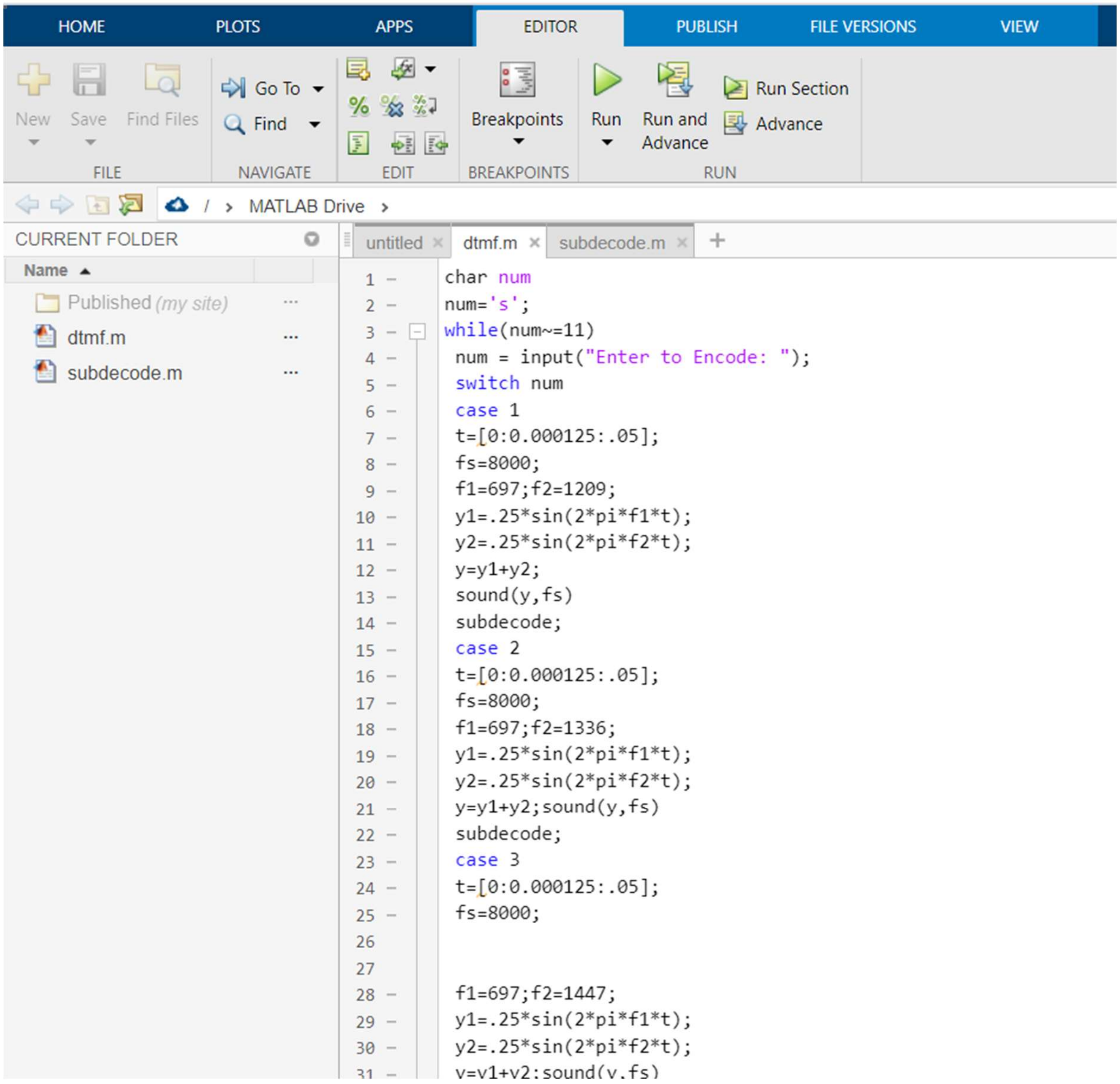
- Whenever any key is pressed, a low frequency and a high frequency combine together to produce a dial tone which is unique for every key.

- For example, the 1 key produces a superimposition of a 697 Hz low tone and a 1209 Hz high tone. Initial pushbutton designs employed levers, enabling each button to activate one row and one column contact. The tones are decoded by the switching centre to determine the keys pressed by the user.

- So the problem of the project is to decode that signal and represent the higher and lower frequency which makes up the dial tone for the particular key that is pressed.

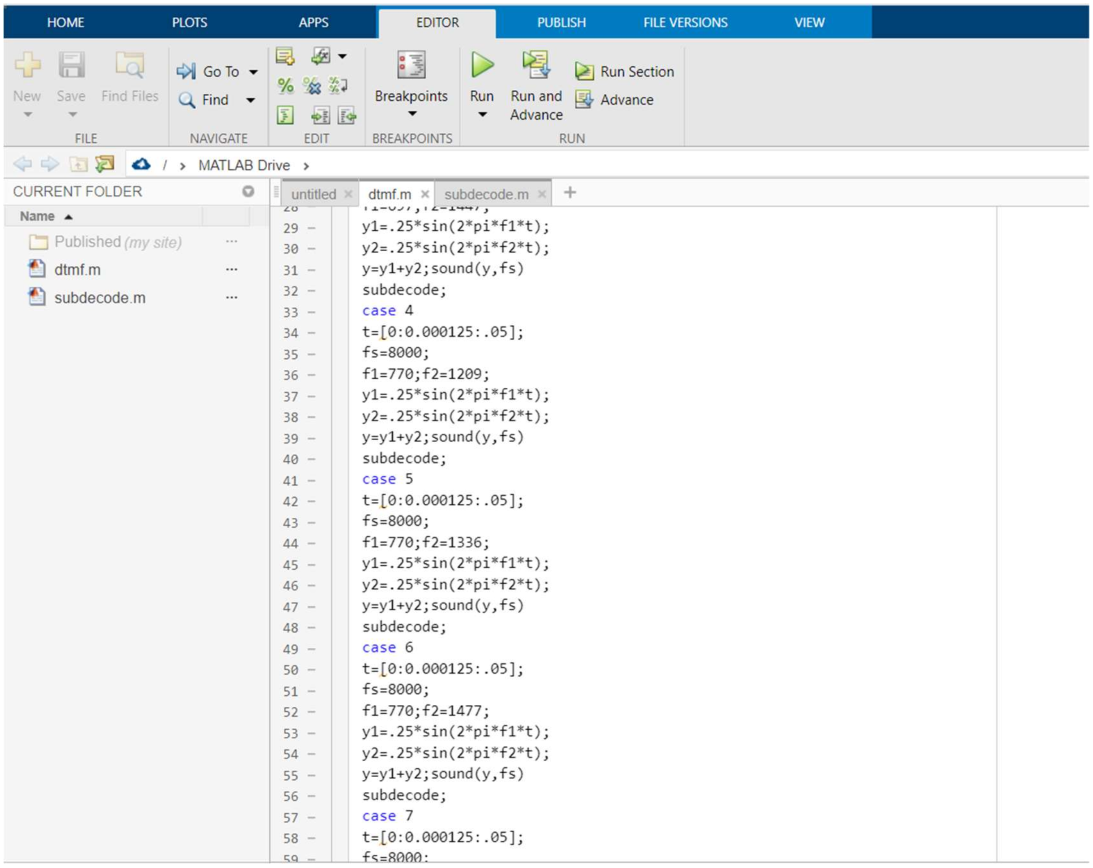
5. MATLAB CODE:

DECODE:

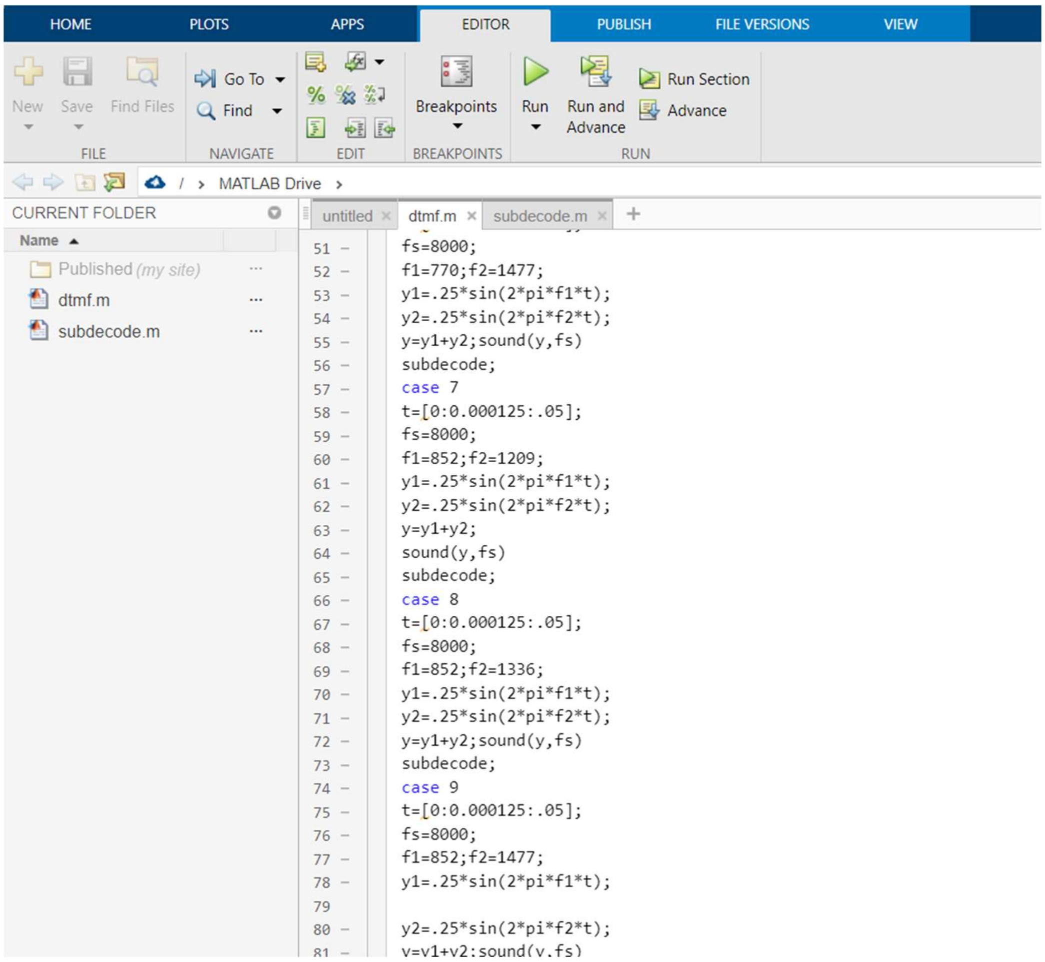


```
char num
num='s';
while(num~=11)
 num = input("Enter to Encode: ");
 switch num
 case 1
 t=[0:0.000125:.05];
 fs=8000;
 f1=697;f2=1209;
 y1=.25*sin(2*pi*f1*t);
 y2=.25*sin(2*pi*f2*t);
 y=y1+y2;
 sound(y,fs)
 subdecode;
 case 2
 t=[0:0.000125:.05];
 fs=8000;
 f1=697;f2=1336;
 y1=.25*sin(2*pi*f1*t);
 y2=.25*sin(2*pi*f2*t);
 y=y1+y2;sound(y,fs)
 subdecode;
 case 3
 t=[0:0.000125:.05];
 fs=8000;


 f1=697;f2=1447;
 y1=.25*sin(2*pi*f1*t);
 y2=.25*sin(2*pi*f2*t);
 y=y1+y2;sound(y,fs)
```

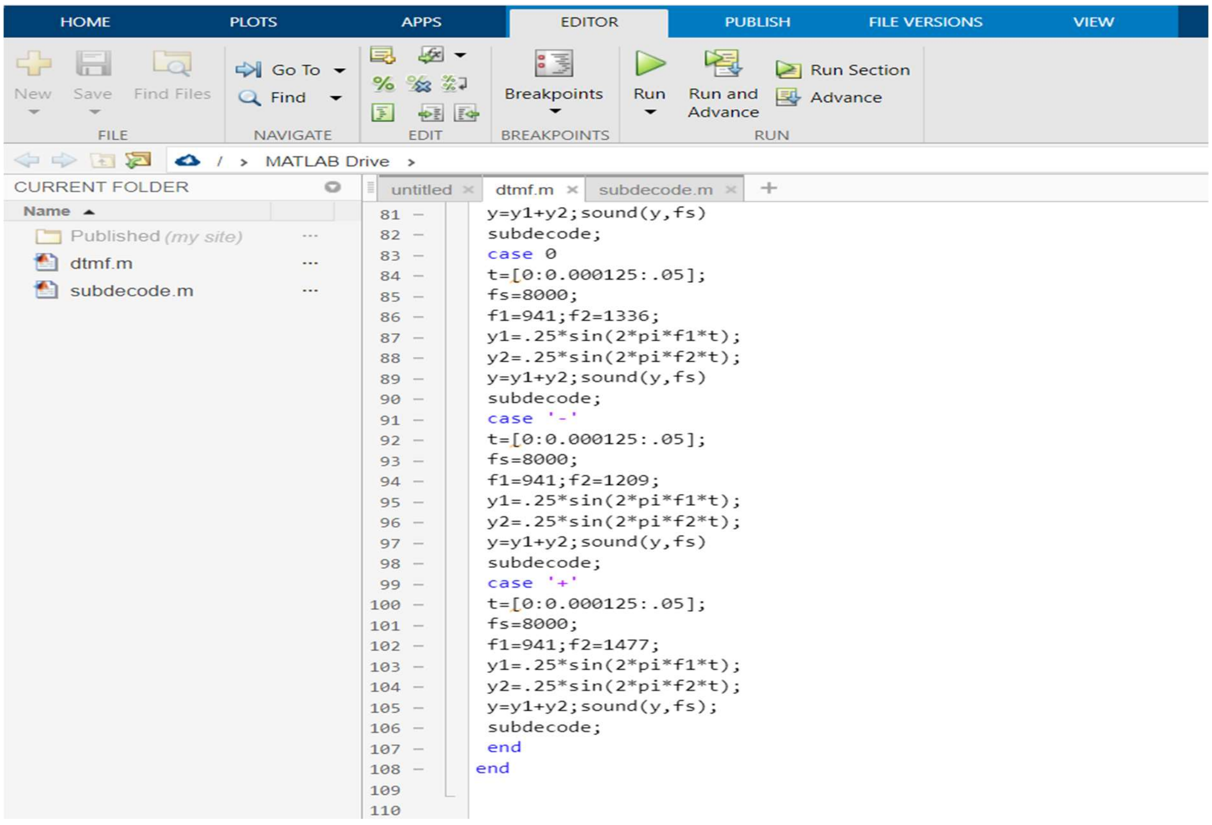


```
y1=.25*sin(2*pi*f1*t);
y2=.25*sin(2*pi*f2*t);
y=y1+y2;sound(y,fs)
subdecode;
case 4
t=[0:0.000125:.05];
fs=8000;
f1=770;f2=1209;
y1=.25*sin(2*pi*f1*t);
y2=.25*sin(2*pi*f2*t);
y=y1+y2;sound(y,fs)
subdecode;
case 5
t=[0:0.000125:.05];
fs=8000;
f1=770;f2=1336;
y1=.25*sin(2*pi*f1*t);
y2=.25*sin(2*pi*f2*t);
y=y1+y2;sound(y,fs)
subdecode;
case 6
t=[0:0.000125:.05];
fs=8000;
f1=770;f2=1477;
y1=.25*sin(2*pi*f1*t);
y2=.25*sin(2*pi*f2*t);
y=y1+y2;sound(y,fs)
subdecode;
case 7
t=[0:0.000125:.05];
fs=8000;
```



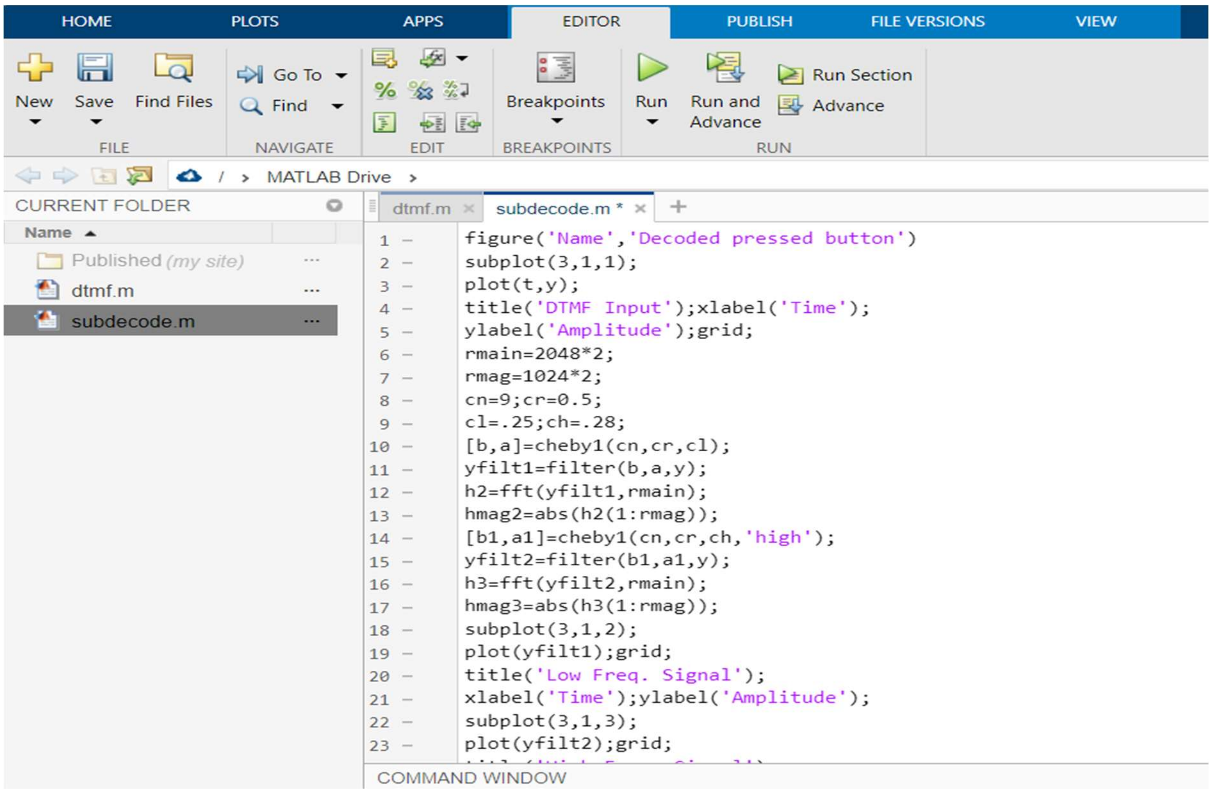
```
fs=8000;
f1=770;f2=1477;
y1=.25*sin(2*pi*f1*t);
y2=.25*sin(2*pi*f2*t);
y=y1+y2;sound(y,fs)
subdecode;
case 7
t=[0:0.000125:.05];
fs=8000;
f1=852;f2=1209;
y1=.25*sin(2*pi*f1*t);
y2=.25*sin(2*pi*f2*t);
y=y1+y2;
sound(y,fs)
subdecode;
case 8
t=[0:0.000125:.05];
fs=8000;
f1=852;f2=1336;
y1=.25*sin(2*pi*f1*t);
y2=.25*sin(2*pi*f2*t);
y=y1+y2;sound(y,fs)
subdecode;
case 9
t=[0:0.000125:.05];
fs=8000;
f1=852;f2=1477;
y1=.25*sin(2*pi*f1*t);

y2=.25*sin(2*pi*f2*t);
y=y1+y2;sound(y,fs)
```

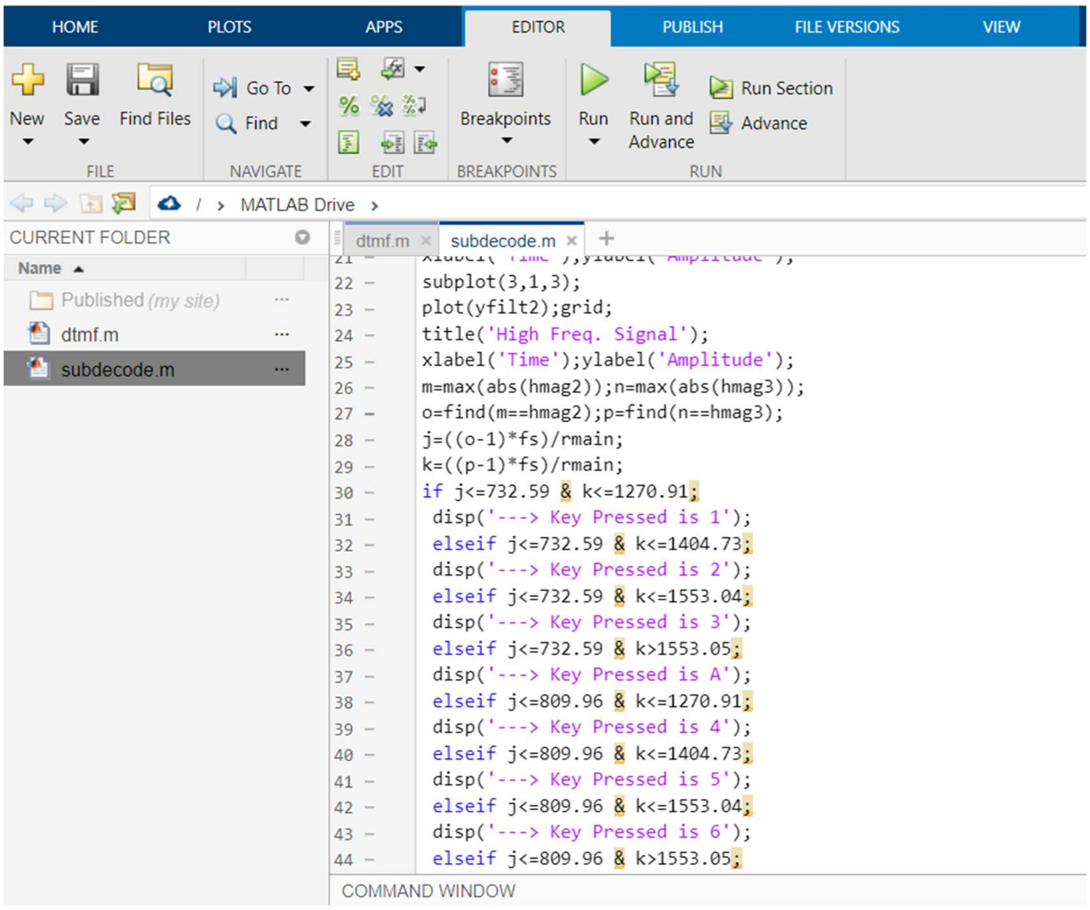


```
     y=y1+y2;sound(y,fs)
     subdecode;
     case 0
     t=[0:0.000125:.05];
     fs=8000;
     f1=941;f2=1336;
     y1=.25*sin(2*pi*f1*t);
     y2=.25*sin(2*pi*f2*t);
     y=y1+y2;sound(y,fs)
     subdecode;
     case '-'
     t=[0:0.000125:.05];
     fs=8000;
     f1=941;f2=1209;
     y1=.25*sin(2*pi*f1*t);
     y2=.25*sin(2*pi*f2*t);
     y=y1+y2;sound(y,fs)
     subdecode;
     case '+'
     t=[0:0.000125:.05];
     fs=8000;
     f1=941;f2=1477;
     y1=.25*sin(2*pi*f1*t);
     y2=.25*sin(2*pi*f2*t);
     y=y1+y2;sound(y,fs);
     subdecode;
     end
    end
```

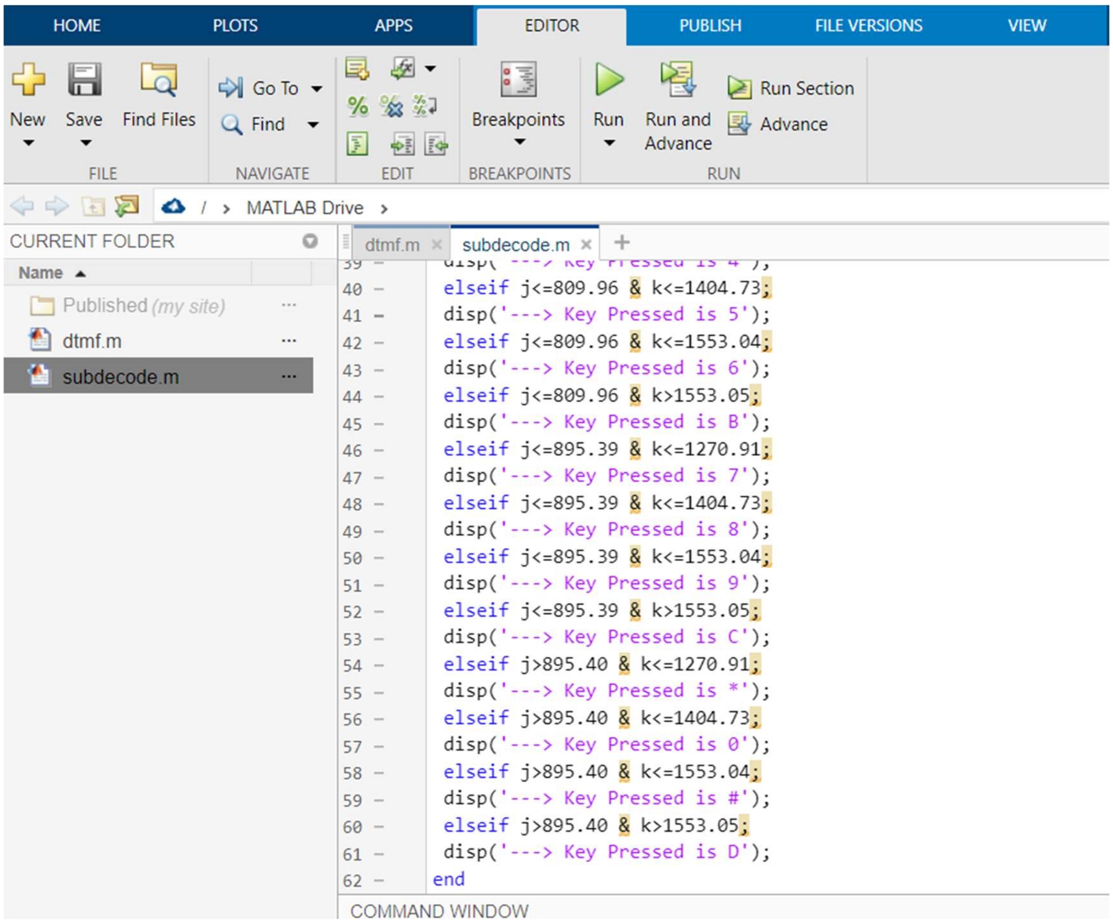
Sub decode:



```
figure('Name','Decoded pressed button')
subplot(3,1,1);
plot(t,y);
title('DTMF Input');xlabel('Time');
ylabel('Amplitude');grid;
rmain=2048*2;
rmag=1024*2;
cn=9;cr=0.5;
cl=.25;ch=.28;
[b,a]=cheby1(cn,cr,cl);
yfilt1=filter(b,a,y);
h2=fft(yfilt1,rmain);
hmag2=abs(h2(1:rmag));
[b1,a1]=cheby1(cn,cr,ch,'high');
yfilt2=filter(b1,a1,y);
h3=fft(yfilt2,rmain);
hmag3=abs(h3(1:rmag));
subplot(3,1,2);
plot(yfilt1);grid;
title('Low Freq. Signal');
xlabel('Time');ylabel('Amplitude');
subplot(3,1,3);
plot(yfilt2);grid;
```



```
xlabel('Time');ylabel('Amplitude');
subplot(3,1,3);
plot(yfilt2);grid;
title('High Freq. Signal');
xlabel('Time');ylabel('Amplitude');
m=max(abs(hmag2));n=max(abs(hmag3));
o=find(m==hmag2);p=find(n==hmag3);
j=((o-1)*fs)/rmain;
k=((p-1)*fs)/rmain;
if j<=732.59 & k<=1270.91;
 disp('---> Key Pressed is 1');
 elseif j<=732.59 & k<=1404.73;
 disp('---> Key Pressed is 2');
 elseif j<=732.59 & k<=1553.04;
 disp('---> Key Pressed is 3');
 elseif j<=732.59 & k>1553.05;
 disp('---> Key Pressed is A');
 elseif j<=809.96 & k<=1270.91;
 disp('---> Key Pressed is 4');
 elseif j<=809.96 & k<=1404.73;
 disp('---> Key Pressed is 5');
 elseif j<=809.96 & k<=1553.04;
 disp('---> Key Pressed is 6');
 elseif j<=809.96 & k>1553.05;
```

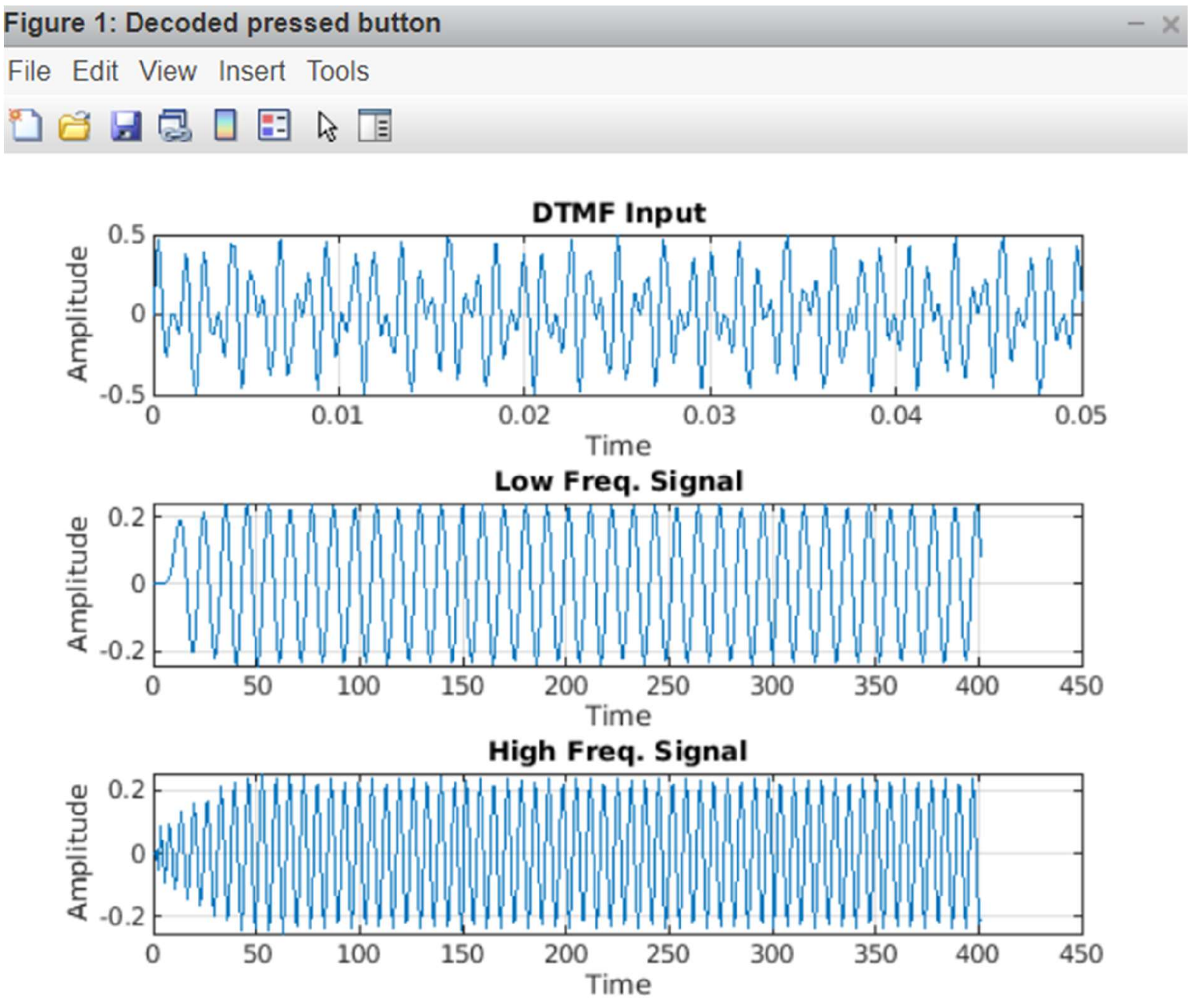


```
 disp('---> Key Pressed is 4');
 elseif j<=809.96 & k<=1404.73;
 disp('---> Key Pressed is 5');
 elseif j<=809.96 & k<=1553.04;
 disp('---> Key Pressed is 6');
 elseif j<=809.96 & k>1553.05;
 disp('---> Key Pressed is B');
 elseif j<=895.39 & k<=1270.91;
 disp('---> Key Pressed is 7');
 elseif j<=895.39 & k<=1404.73;
 disp('---> Key Pressed is 8');
 elseif j<=895.39 & k<=1553.04;
 disp('---> Key Pressed is 9');
 elseif j<=895.39 & k>1553.05;
 disp('---> Key Pressed is C');
 elseif j>895.40 & k<=1270.91;
 disp('---> Key Pressed is *');
 elseif j>895.40 & k<=1404.73;
 disp('---> Key Pressed is 0');
 elseif j>895.40 & k<=1553.04;
 disp('---> Key Pressed is #');
 elseif j>895.40 & k>1553.05;
 disp('---> Key Pressed is D');
end
```

Functions used are:

1. **sound(y,Fs) :** sends the signal in vector y (with sample frequency Fs) to the speaker on PC.
2. **plot(X,Y) :** creates a 2-D line plot of the data in Y versus the corresponding values in X.

Output:



6. CONCLUSION

DTMF was originally designed to use the frequencies in the normal human voice range. As a result, it can easily pass over normal two-way radio channels, narrow band, and wide band. DTMF is a straight forward technology that is easy to understand, and is compatible with most equipment and can be used to provide the most cost effective and flexible features. It does not require expensive equipment or special channels for transmitting the frequencies.

As pulse dialling has nearly reached the end of its lifespan and voice recognition engines still have a long way to go, DTMF solutions seem to be the answer for call centres for at least the next couple of decades. Even when call centres move to voice recognition systems, it is a good idea to offer the customer the choice of whether he would prefer DTMF or voice inputs.

From the above information finally, we can conclude that the frequencies of DTMF tones are very beneficial as they permit telephones for indicating which digit is being pushed by the operator. These are very useful as well as less expensive for executing compare with the earlier signalling technique utilized by rotary dialled telephones.

7. SCOPE FOR WORK

- The DTMF is used to identify the dialled numbers in the telephone switching centres
- These are used to operate the remote transmitters in the terrestrial stations
- DTMF is applicable in-home automation, call centres, security systems, as well as industrial applications.
- IVR (Interactive Voice Response) systems also use dual-tone multifrequency signals as a line of communication between a phone and a computer. The computer uses a telephony board or card to understand DTMF signals.

8. REFERENCES

- https://www.phonescoop.com/glossary/term.php?gid=206
- http://www.polar-electric.com/DTMF/Index.html
- https://en.wikipedia.org/wiki/Dual-tone_multi-frequency_signaling