DTMF (Dual Tone Multi-frequency or Touch-Tone) coder/ decoder

AIM:

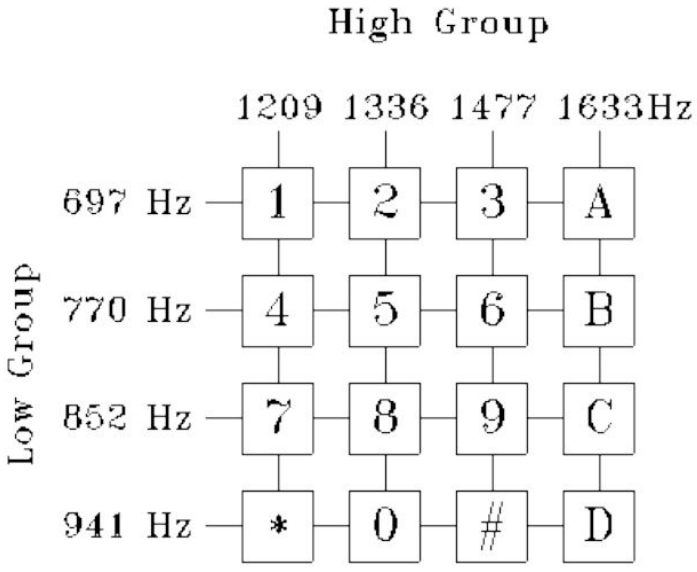
To study and analyze DTMF (Dual Tone Multi-frequency, or Touch-Tone) coder/decoder using FIR Filter in MATLAB.

THEORY:

DTMF stands for Dual Tone - Multi Frequency and it is the basis for your telephone system. DTMF is actually the generic term for Touch-Tone (touch-tone is a registered trademark of AT&T). Your touch-tone phone is technically a DTMF generator that produces DTMF tones as you press the buttons.

When you press the buttons on the keypad, a connection is made that generates two tones at the same time. A "Row" tone and a "Column" tone. The sinusoids of the corresponding row and column frequencies are generated and summed producing two simultaneous or dual tones. Tones representing a single key press on a telephone device, consists of two summed frequencies that have been chosen so that no harmonics occur.

These two tones identify the key you pressed to any equipment you are controlling. If the keypad is on your phone, the telephone company's "Central Office" equipment knows what numbers you are dialing by these tones, and will switch your call accordingly. If you are using a DTMF keypad to remotely control equipment, the tones can identify what unit you want to control, as well as which unique function you want it to perform.

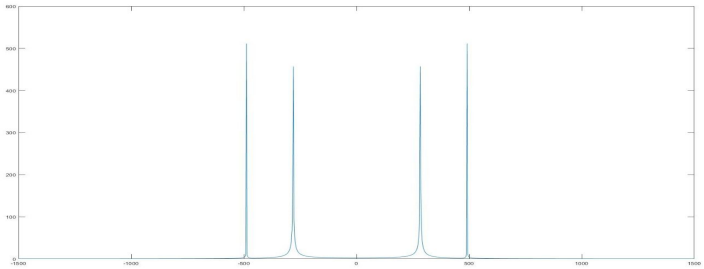


When you press the digit 1 on the keypad, you generate the tones 1209 Hz and 697 Hz. Pressing the digit 2 will generate the tones 1336 Hz and 697 Hz. Sure, the tone 697 is the same for both digits, but it takes two tones to make a digit and the decoding equipment knows the difference between the 1209 Hz that would complete the digit 1, and a 1336 Hz that completes a digit 2.

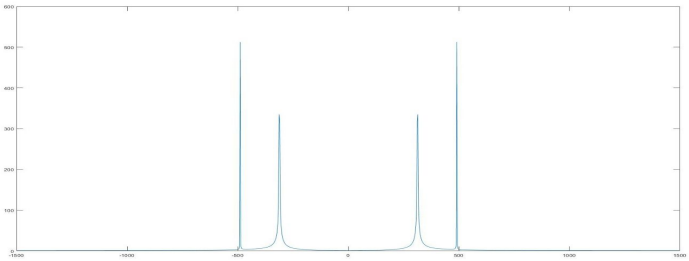
As with other multi-frequency receivers, DTMF was originally decoded by tuned filter banks. Late in the 20th century most were replaced with digital signal processors. Although DTMF can be decoded using any frequency domain transform (such as the popular Fast Fourier transform).

SOURCE CODE AND RESULTS:

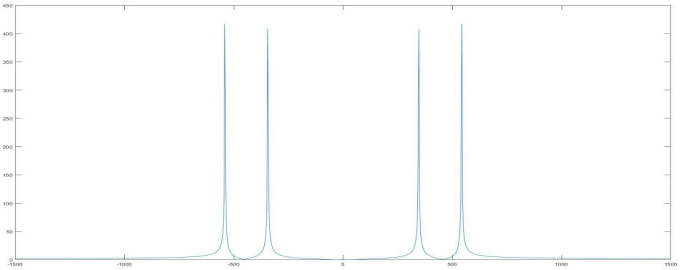
```
num = input("Enter a number ", 's');
num = strtrim(num);

omega1 = 0; omega2 = 0;

if(num=='1' || num=='2' || num=='3' || num=='A')
    omega1=697;
end
if(num=='4' || num=='5' || num=='6' || num=='B')
    omega1=770;
end
if(num=='7' || num=='8' || num=='9' || num=='C')
    omega1=852;
end
if(num=='*' || num=='0' || num=='#' || num=='D')
    omega1=941;
end

if(num=='1' || num=='4' || num=='7' || num=='*')
    omega2=1209;
end
if(num=='2' || num=='5' || num=='8' || num=='0')
    omega2=1336;
end
if(num=='3' || num=='6' || num=='9' || num=='#')
    omega2=1477;
end
if(num=='A' || num=='B' || num=='C' || num=='D')
    omega2=1633;
end

t = linspace(0,1,8192);
signal=cos(2*pi*omega1*t)+cos(2*pi*omega2*t);

signal_fft = fftshift(abs(fft(signal,1024)));
f = linspace(-1500, 1500, length(signal_fft));
plot(f, signal_fft);

row_freq = [697 770 852 941];
col_freq = [1209 1336 1477 1633];

i_row = 0; i_col = 0;
x_row_max = 0;
x_col_max = 0;

% t = 0 : 1000;
for i = 1:4
    h_row = cos(2*pi*row_freq(i)*t);
    h_col = cos(2*pi*col_freq(i)*t);

    x_row = rms(conv(h_row, signal));
    x_col = rms(conv(h_col, signal));

    if(x_row > x_row_max)
        x_row_max = x_row;
        i_row = i;
    end
```



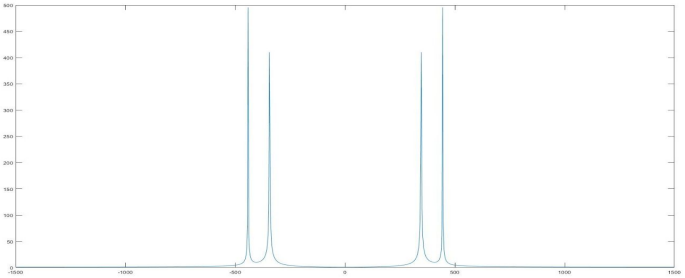
Key - 5



Key - 8



Key - #



Key - *

DISCUSSION:

- DTMF is a signalling system for identifying the keys or better say the number dialed on pushbutton or DTMF keypad. The early telephone systems used pulse dialing or loop disconnect signalling. This was replaced by multi frequency (MF) dialing. DTMF is a multi-frequency tone dialing system used by the push button keypads in telephone and mobile sets to convey the number or key dialed by the caller.
- DTMF has enabled the long distance signalling of dialed numbers in voice frequency range over telephone lines. This has eliminated the need of telecom operator between the caller and the cal lee and evolved automated dialing in the telephone switching centers.
- DTMF (Dual tone multi frequency) as the name suggests uses a combination of two sine wave tones to represent a key. These tones are called row and column frequencies as they correspond to the layout of a telephone keypad.
- A DTMF keypad (generator or encoder) generates a sinusoidal tone which is mixture of the row and column frequencies. The row frequencies are low group frequencies. The column frequencies belong to high group frequencies. This prevents misinterpretation of the harmonics. Also, the frequencies for DTMF are so chosen that none have a harmonic relationship with the others and that mixing the frequencies would not produce sum or product frequencies that could mimic another valid tone.
- DTMF tones are able to represent one of the 16 different states or symbols on the keypad. This is equivalent to 4 bits of data, also known as nibble.
- National telephone systems define other tones that indicate the status of lines, equipment, or the result of calls. Such call-progress tones are often also composed of multiple frequencies and are standardized in each country. The Bell System defines them in the Precise Tone Plan. However, such signalling systems are not considered belonging to the DTMF system.