%load the ecg file

clc

load('112m.mat');

ecg=(val-1024)/200;

fs=360;

N=length(ecg);

t=((0:length(ecg)-1)/fs);

figure(1)

plot(t,ecg)

title('Corrupted ECG Signal')

xlabel('Time[sec]')

ylabel('Amplitude')

grid on

%high pass filter to remove baseline noise

[b2,a2]=butter(2,.5/fs,'high');

m=filtfilt(b2,a2,ecg);

figure(2)

plot(t,m)

title('Filtered ECG signal with baseline removed')

xlabel('Time[sec]')

ylabel('Amplitude')

%legend('unfiltered','filtered')

% m = designfilt('bandstopiir','FilterOrder',2, ...

% 'HalfPowerFrequency1',0.1,'HalfPowerFrequency2',0.5, ...

% 'DesignMethod','butter','SampleRate',fs);

% fvtool(m,'fs',fs)

%to check freq response of orignal signal

Ys=fft(ecg);

Ys=fftshift(Ys);

equal\_space=linspace(0,0.5,N/2); %adjusting freq range interval

freq=(fs/2)\*equal\_space;

Ys=Ys(1:ceil(N)/2);

figure(3)

plot(freq,2\*abs(Ys))

title('ECG signal in freq Domain(original)')

xlabel('Frequency(Hz)')

ylabel('|Y(f)|')

%designing of low pass notch filter

w=60/(360/2);

bw=w;

[d,c]=iirnotch(w,bw); % notch filter implementation

ecg\_notch=filter(d,c,m);

figure(4)

N1=length(ecg\_notch);

t1=(0:N1-1)/fs;

y1 = sgolayfilt(ecg\_notch,0,5);

plot(t1,ecg,t1,y1);

legend('unfiltered','filtered')

title('Filtered ECG signal with powerline removed ')

xlabel('time')

ylabel('amplitude')

%To check freq response of filtered signal

Ys=fft(y1);

Ys=fftshift(Ys);

equal\_space=linspace(0,0.5,N/2); %adjusting freq range interval

freq=(fs/2)\*equal\_space;

Ys=Ys(1:ceil(N)/2);

figure(5),

plot(freq,2\*abs(Ys))

title('ECG signal in freq Domain(Powerline noise free')

xlabel('Frequency(Hz)')

ylabel('|Y(f)|')

1.1 Baseline Wander

Baseline wander or baseline drift is the effect where the base axis (x-axis) of a signal appears to ‘wander’ or move up and down rather than be straight. This causes the entire signal to shift from its normal base. In ECG signal, the baseline wander is caused due to improper electrodes (electrode-skin impedance), patient’s movement and breathing (respiration).

The frequency content of the baseline wander is in the range of 0.5 Hz. However, increased movement of the body during exercise or stress test increase the frequency content of baseline wander. Since the baseline signal is a low frequency signal therefore Finite Impulse Response (FIR) high-pass zero phase forward-backward filtering with a cut-off frequency of 0.5 Hz to estimate and remove the baseline in the ECG signal can be used

**1.2 Powerline Interference**

Electromagnetic fields caused by a powerline represent a common noise source in the ECG, as well as to any other bioelectrical signal recorded from the body surface. Such noise is characterized by 50 or 60 Hz sinusoidal interference, possibly accompanied by a number of harmonics. Such narrowband noise renders the analysis and interpretation of the ECG more difficult, since the delineation of low-amplitude waveforms becomes unreliable and spurious waveforms may be introduced. It is necessary to remove powerline interference from ECG signals as it completely superimposes the low frequency ECG waves like P wave and T wave

1.3 EMG Noise

The presence of muscle noise represents a major problem in many ECG applications, especially in recordings acquired during exercise, since low amplitude waveforms may become completely obscured. Muscle noise is, in contrast to baseline wander and 50/60 Hz interference, not removed by narrowband filtering, but presents a much more difficult filtering problem since the spectral content of muscle activity considerably overlaps that of the PQRST complex. Since the ECG is a repetitive signal, techniques can be used to reduce muscle noise in a way similar to the processing of evoked potentials. Successful noise reduction by ensemble averaging is, however, restricted to one particular QRS morphology at a time and requires that several beats be available. Hence, there is still a need to develop signal processing techniques which can reduce the influence of muscle noise