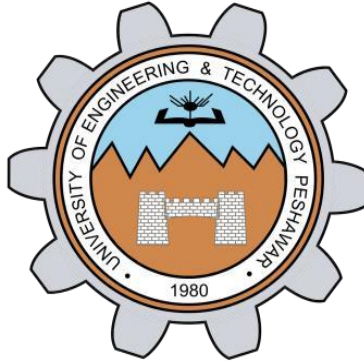


## **Assignment No 2**



### **Communication System**

**Submitted By: Muhammad Ali**

**Registration No: 19pwcse1801**

**Section: A**

**Date: 16/1/2022**

**Submitted To: Sir. Zahid Wadud Mufti**

**“On my honor , as student of University of Engineering and Technology, I have neither given nor received unauthorized assistance on this**

## **Filter: -**

Filter is an electric circuit which is used to block some unwanted frequencies from input signal.

## **Ideal and practical filter: -**

An ideal filter is considered to have a specified, nonzero magnitude for one or more bands of frequencies and is considered to have zero magnitude for one or more bands of frequencies. On the other hand, practical implementation constraints require that a filter be causal.

"An ideal electrical filter should not only completely reject the unwanted frequencies but should also have uniform sensitivity for the wanted frequencies".

Real filters cannot fulfill all the criteria of an ideal filter. In practice, a finite transition band always exists between the passband and the stopband. In the transition band, the gain of the filter changes gradually from one (0 dB) in the passband to zero ( $-\infty$  dB) in the stopband. Practical filters might have passband ripple, and the stopband attenuation of the filter cannot be infinite.

## **Characteristics of an ideal filter: -**

There are many different types of filters based on what we want our frequency response to be. Therefore, the characteristics of each of these types of filters differ. But each of these filters will definitely have a pass-band and a stop-band. Pass-band, as we have discussed, is the frequencies that the filter allows to be kept in the response. Stop-band includes the frequencies that are not in the said limits of the filter response.

## **Low-pass filter: -**

A certain cut-off frequency,  $\omega_c$  radians per second is chosen as the limit, and as the name suggests, the portion with low frequency is allowed to pass. Hence, the frequencies before  $\omega_c$  are what consists of the pass-band and the frequencies after  $\omega_c$  are attenuated as part of the stop-band.

## **High-pass filter: -**

The High Pass Filter allows the frequencies above the cutoff frequency to pass, which will be the passband, and attenuates the frequencies below the cutoff frequency, consisting of the stop-band.

## **Butterworth filter: -**

The Butterworth filter is a type of signal processing filter designed to have a frequency response that is as flat as possible in the passband. It is also referred to as a maximally flat magnitude filter.

## **Classification on the basis of internal circuit: -**

1. A band-pass Butterworth filter is obtained by placing a capacitor in series with each inductor and an inductor in parallel with each capacitor to form resonant circuits.
2. A band-stop Butterworth filter is obtained by placing a capacitor in parallel with each inductor and an inductor in series with each capacitor to form resonant circuits.

## **Mathematical expression of Butterworth magnitude: -**

$$|H(\omega)| = A / (1 + (\omega / \omega_0)^{2n})^{1/2}$$

Where, A is the amplitude,  $\omega(\omega)$  is the frequency,  $\omega_0$  is the cutoff frequency and 'n' is the order of butterworth.

### **MATLAB code: -**

```
clc
clear all
close all

% first order butterworth filter
order=1;
Amplitude=5;
cutoff=Amplitude/1.4142;
freq=0:0.00001:10;
denominator=1+(freq./cutoff).^2*order;
butterworth = Amplitude./sqrt(denominator);
hold on;
plot(freq,butterworth,'g');
text(3,4,' first order butterworth filter');

% second order butterworth filter

order=2;
Amplitude=5;
cutoff=Amplitude/1.4142;
freq=0:0.00001:10;
denominator=1+(freq./cutoff).^2*order;
butterworth = Amplitude./sqrt(denominator);
hold on;
plot(freq,butterworth,'b');
text(2.7,3.5,' second order butterworth filter');
```

```

% third order butterworth filter
order=3;
Amplitude=5;
cutoff=Amplitude/1.4142;
freq=0:0.00001:10;
denominator=1+(freq./cutoff).^2*order;
butterworth = Amplitude./sqrt(denominator);
hold on;
plot(freq,butterworth,'r');
text(0.5,2.3,' third order butterworth filter');
title(' butterworth filter magnitude response ');
ylabel(' | H(wa)| ');
xlabel(' w ');

```

**Plots up to 3rd order of Butterworth filter: -**

