# LAB BASED PROJECT REPORT

**On**

# Design and implementation of

# 'Anti-aliasing filter'.

Submitted in partial fulfilment of the

Requirements for the award of degree

**Bachelor of Technology**

In

**Electronics and Communication Engineering**

Submitted

By

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Under the guidance of

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**DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING**

**KONERU LAKSHMAIAH EDUCATIONAL FOUNDATION**

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# CERTIFICATE

This is to certify that the mini project entitled **"Design and implementation of 'Anti-aliasing filter'."**, being submitted by **" N. Satish – 180040132 "** in partial fulfillment for the award of degree of **Bachelor of Technology (B. Tech)** in Electronics and Communications Engineering is a record of confide work carried out by them under our guidance during the academic year **2019-2020**and it has been found worthy of acceptance according to the requirements of the university.

**Signature of the Project Guide**

**Signature of Head of Department**

**Department of ECE**

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

## *DECLARATION*

we here by declare that this project based lab report entitled "**Design and implementation of 'Anti-aliasing filter'**" has been prepared by us in partial fulfillment of the requirement for the award of degree **"BACHELOR OF TECHNOLOGY IN ELECTRONICS AND COMMUNICATIONS OF ENGINEERING"** during the academic year 2019-2020.

we also declare that this project based lab report is of our own effort and it has not been submitted to any other university for the award of any degree.

# Acknowledgement

We are greatly indebted to our KL University that has provided a healthy environment to drive us to achieve our ambitions and goals. We would like to express our sincere thanks to our project in charge Dr. Madhukar Deshmuk (Assoc. professor) sir for the guidance, support and assistance they have provided in completing this project.

With immense pleasure, we would like to thank the Head of the Department, **Dr. SUMAN MALOJI** sir for his valuable suggestions and guidance for the timely completion of this project.

We are very much glad for having the support given by our principal**, N.Venkata Ram** sir who inspired us with his words filled with dedication and discipline towards work.

We believe that "**Practical Leads A Man Towards Performance**".

Last but not the least, a special thanks goes to the Parents, staff and classmates who are helpful either directly or indirectly in completion of the Lab Based project

# CONTENTS

Project Title:

- “**Design and implementation of ‘Anti-aliasing filter’**”

# ABSTRACT

In this project, it was aimed to get rid of aliasing problem for an image using an anti-aliasing filter before sampling procedure. To implement this filter, aliasing is generated in MATLAB software which will be discussed in this report. Different types of filters are applied to the image and the best one is determined after some experiments. These filters are also discussed in this report in terms of their advantages and disadvantages.

## Aliasing in General

To be able to understand the concept of aliasing, sampling procedure should be analyzed before discussing this concept. During sampling procedure, samples are taken from an analog signal with a sampling rate. Aliasing concept is totally depends on this sampling rate. If the sampling rate is not sufficient, aliasing problem occurs during the reconstruction of the sampled signal while converting the digital signal into the analog signal.

## Aliasing:-

- Aliasing is a common problem in digital media processing applications. Many readers have heard of "anti-aliasing" features in high-quality video cards.
- This page will explain what Aliasing is, and how it can be avoided.
- Aliasing is an effect of violating the Nyquist-Shannon sampling theory.
- During sampling the base band spectrum of the sampled signal is mirrored to every multifold of the sampling frequency. These mirrored spectra are called alias.
- If the signal spectrum reaches farther than half the sampling frequency base band spectrum and aliases touch each other and the base band spectrum gets superimposed by the first alias spectrum.
- The easiest way to prevent aliasing is the application of a steep sloped low-pass filter with half the sampling frequency before the conversion.
- Aliasing can be avoided by keeping Fs>2Fmax.

According to Nyquist's sampling theorem, sampling rate must be at least twice of the bandwidth of the analog signal at the beginning of sampling procedure to be able to reconstruct the sampled signal. In other words, if the analog signal is a periodic signal, at least two points must be sampled in one period.

## Nyquist Sampling Rate:-

- The Nyquist Sampling Rate is the lowest sampling rate that can be used without having aliasing. The sampling rate for an analog signal must be at least two times the bandwidth of the signal.
- So, for example, an audio signal with a bandwidth of 20 kHz must be sampled at least at 40 kHz to avoid aliasing. In audio CD's, the sampling rate is 44.1 kHz, which is about 10% higher than the Nyquist Sampling Rate to allow cheaper reconstruction filters to be used.
- The Nyquist Sampling Rate is the lowest sampling rate that can be used without having aliasing.

**Aliasing Problem in General:-**

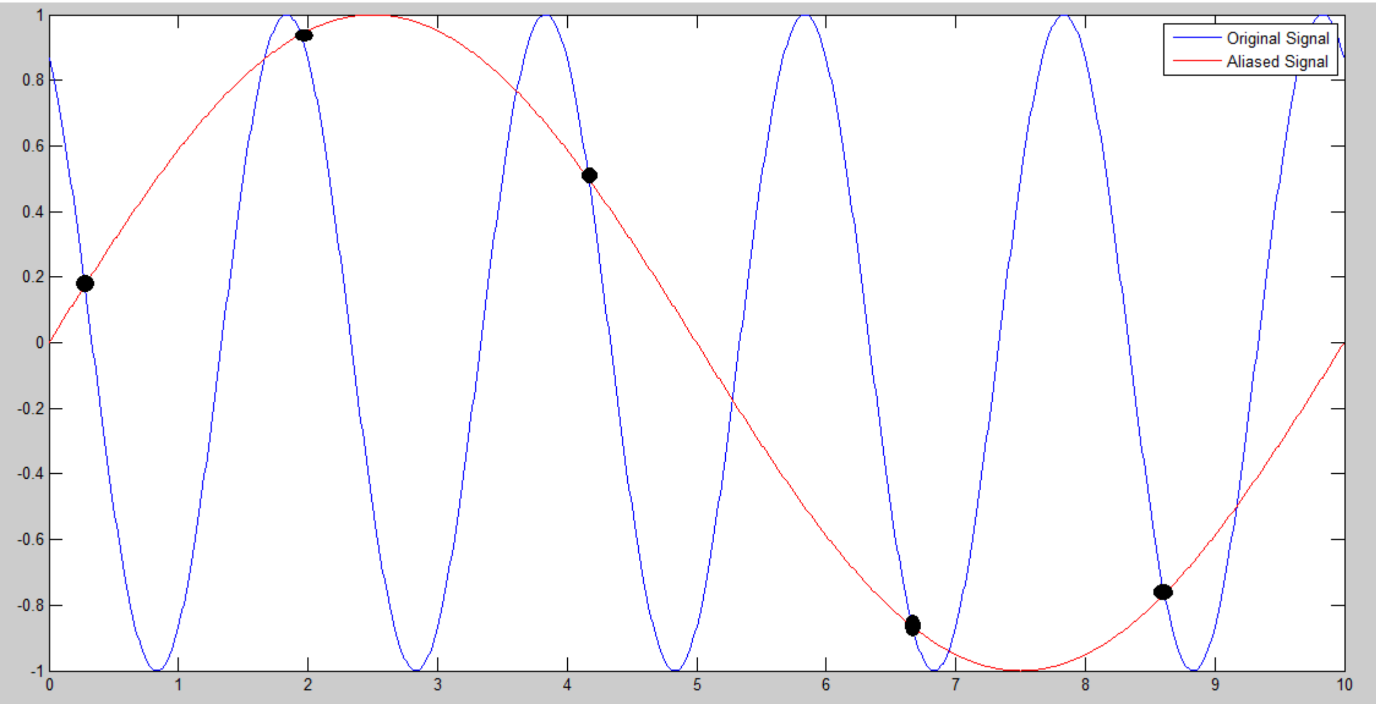



**Figure 2.1 . Aliasing Problem in General:-**

In figure 2.1, aliasing problem for a periodic signal is illustrated. As seen in this figure, there  are not taken two sample points in one period which causes the aliasing problem during reconstruction.

If the original signal is not periodic, its frequency spectrum should be analyzed. In figure 2.2, this case is examined. As seen in figure 2.2, if the sampling rate is smaller than the Nyquist frequency, high frequency components in the original signal could not be reconstructed as they crosses the low frequency components of its replicas which are created during sampling procedure. For this situation not to happen, sampling rate must be at least Nyquist frequency.

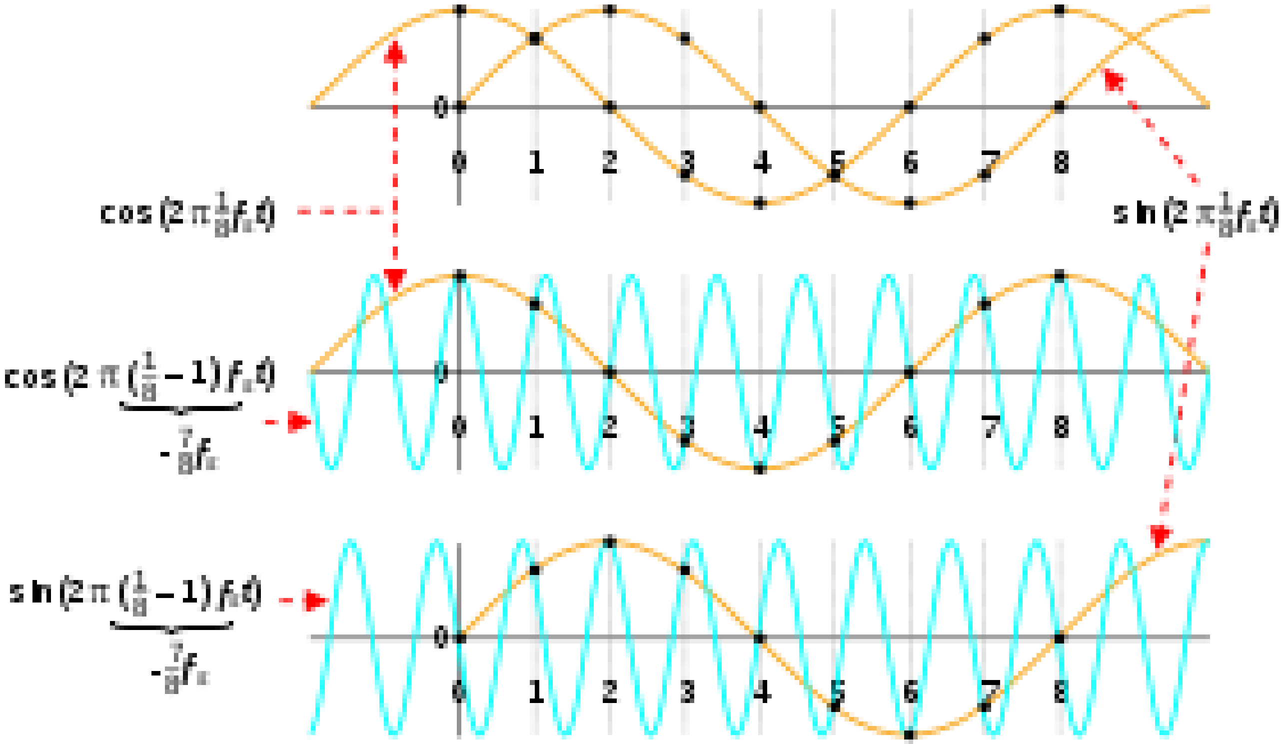
**Figure 2.2.Frequency Spectrum Analysis of Aliasing**



**Figure 2.2. Frequency Spectrum Analysis of Aliasing**

**Spatial Aliasing in Signals :-**

**Aliasing** occurs whenever the use of discrete elements to capture or produce a continuous **signal** causes frequency ambiguity. **Spatial aliasing**, particular of angular frequency, can occur when reproducing a light field or sound field with discrete elements, as in 3D displays or wave field synthesis of sound.



## 1. Spatial Aliasing in Images

Spatial aliasing in images is not much different from the aliasing concept in general. An analog image has a frequency spectrum as well but there are two frequency axes because an image simply has two dimensions. During sampling of an analog image, the spatial frequency spectrum of the image is duplicated at the spatial sampling frequencies of the axes. This situation is illustrated in figure 3.1.

**Figure 3.1.Spatial Frequency Spectrum of an Image after Sampling**

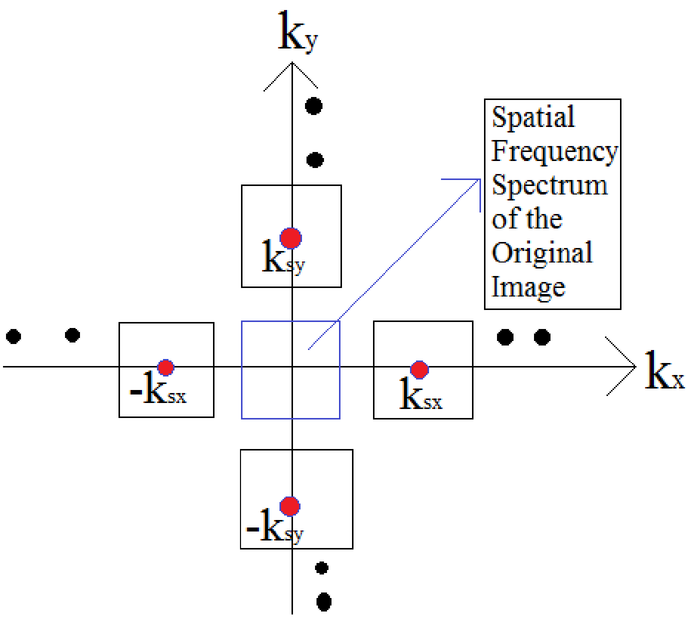
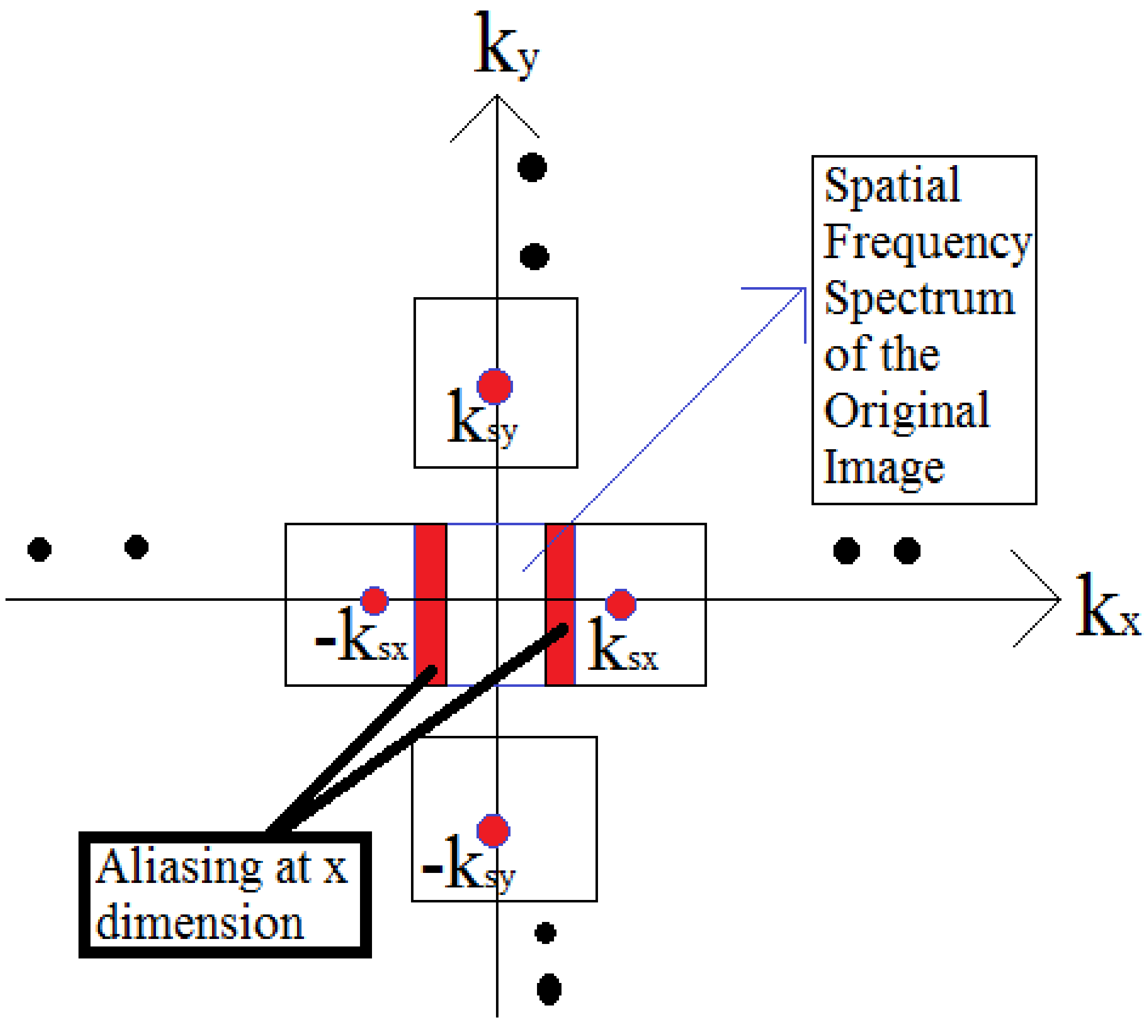



**Figure 3.1.Spatial Frequency Spectrum of an Image after Sampling**

If the spatial sampling frequency rate of a dimension is not sufficient, aliasing occurs in this dimension of the image because the spatial frequency spectrum of the original signal crosses its replicas at higher spatial frequencies of this dimension. The mentioned situation is illustrated in figure 3.2 where sampling spatial frequency at x dimension is not enough to prevent aliasing.

**Figure 3.2.Spatial Frequency Spectrum Analysis of Aliasing in an Image after Sampling**

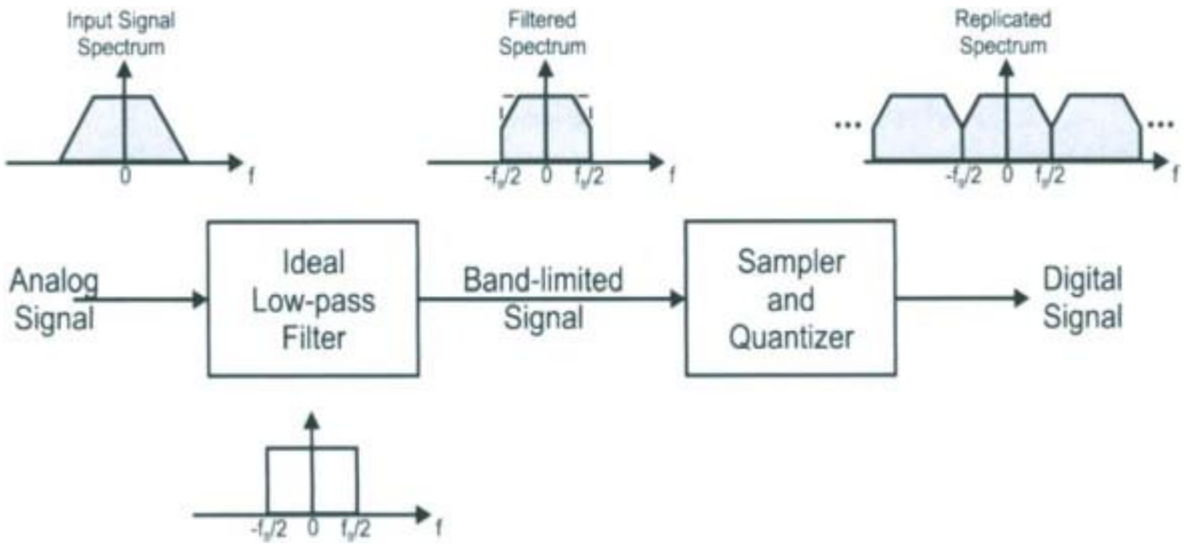


## Anti-aliasing :-

- The sampling rate for an analog signal must be at least two times as high as the highest frequency in the analog signal in order to avoid aliasing. Conversely, for a fixed sampling rate, the highest frequency in the analog signal can be no higher than a half of the sampling rate.
- Any part of the signal or noise that is higher than a half of the sampling rate will cause aliasing. In order to avoid this problem, the analog signal is usually filtered by a low pass filter prior to being sampled, and this filter is called an anti-aliasing filter.
- Sometimes the reconstruction filter after a digital-to-analog converter is also called an anti-aliasing filter.

## Anti-aliasing Filter Design

- Since the aliasing is caused by high spatial frequency components as discussed in the previous sections, the bandwidth of the image should be limited in low spatial frequency components by using low pass filters.
- Thus, the type of the anti-aliasing filter should be a low pass filter.
- The type of low pass filter is to be determined after trying them for the same anti-aliased image oe signal .


Input Signal Spectrum
Filtered Spectrum
Replicated Spectrum
Analog Signal
Ideal Low-pass Filter
Band-limited Signal
Sampler and Quantizer
Digital Signal

**Execution:-**

**Matlab code:-**

```
img=imread('D:\Education\EE562\PROJECT\Fig0807(a)(Random).tif');
img=imresize(img,0.2);
ft=fft2(img);
[pft,mft]= cart2pol(real(ft),imag(ft));
[sy,sx]=size(img);
rows= sx;
cols = sy;
x = (ones(rows,1) * [1:cols] - (fix(cols/2)+1))/cols;
y = ([1:rows]' * ones(1,cols) - (fix(rows/2)+1))/rows;
radius = sqrt(x.^2 + y.^2);
 f = 1 ./ (1.0 + (radius ./ (0.1)).^(2*1));
figure;mesh(f);
mft1=f.*fftshift(mft);
mft1=ifftshift(mft1);
[re,im]=pol2cart(pft,mft1);
ft1=re+i*im;img1=abs(ifft2(ft1));
figure;subplot(1,2,1);
imshow(img,[]);
subplot(1,2,2);
imshow(img1,[]);
 f = 1 ./ (1.0 + (radius ./ (0.2)).^(2*1));
figure;mesh(f);
mft1=f.*fftshift(mft);
mft1=ifftshift(mft1);
[re,im]=pol2cart(pft,mft1);
ft1=re+i*im;
img1=abs(ifft2(ft1));figure;
subplot(1,2,1);
imshow(img,[]);
subplot(1,2,2);
imshow(img1,[]);
f = 1 ./ (1.0 + (radius ./ (0.3)).^(2*1));
figure;mesh(f);
mft1=f.*fftshift(mft);
mft1=ifftshift(mft1);
[re,im]=pol2cart(pft,mft1);
ft1=re+i*im;
img1=abs(ifft2(ft1));
figure;subplot(1,2,1);
imshow(img,[]);
subplot(1,2,2);
```

```
imshow(img1,[]);
f = 1 ./ (1.0 + (radius ./ (0.4)).^(2*1));
figure;mesh(f);
mft1=f.*fftshift(mft);
mft1=ifftshift(mft1);
[re,im]=pol2cart(pft,mft1);
ft1=re+i*im;img1=abs(ifft2(ft1));
figure;subplot(1,2,1);
imshow(img,[]);
subplot(1,2,2);
imshow(img1,[]);
 f = 1 ./ (1.0 + (radius ./ (0.5)).^(2*1)) ;
figure;mesh(f);
mft1=f.*fftshift(mft);
mft1=ifftshift(mft1);
[re,im]=pol2cart(pft,mft1);
ft1=re+i*im;
img1=abs(ifft2(ft1));
figure;subplot(1,2,1);
imshow(img,[]);
subplot(1,2,2);
imshow(img1,[]);
```

## Advantages:-

- Anti-aliasing filters are applied so that when a set of sample points is inspected, the input frequency components that are present are uniquely related to the input data.
- Otherwise, there are many possible input frequencies (the aliases), all of which can produce the same data points.
- No depth quantization error

## Disadvantages:-

- Over rendering

## CONCLUSION

As a result, aliasing affects the high spatial frequency components. Because of that, the bandwidth of the image should be limited before sampling procedure by using a low pass filter. Two types of low pass filters and median filter, which also smooths the image, are examined in this project to be used as the anti-aliasing filter. After applying some tests, Butterworth low pass filter is determined to be used to limit the bandwidth of the image.

# REFERENCES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