“ANALYSIS OF WINDOW LENGTH VARIATION OF SHORT-TIME FOURIER TRANSFORM IN VARIOUS APPLICATIONS”

Project report submitted in partial fulfillment of the requirement

for the degree of

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

By

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UNDER THE GUIDANCE OF

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MAY 2019

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DECLARATION

I hereby declare that the work reported in the B-Tech thesis entitled **"ANALYSIS OF WINDOW LENGTH VARIATION OF SHORT-TIME FOURIER TRANSFORM IN VARIOUS APPLICATIONS"** submitted at **Jaypee University of Information Technology, Waknaghat , India ,** is an authentic record of my work carried out under the supervision of **Mr. Pardeep Garg.** I have not submitted this work elsewhere for any other degree or diploma.

Name **Signature**

Akriti Gupta, 151024

Department of Electronics and Communication Engineering

Jaypee University of Information Technology, Waknaghat, India

Date:

CERTIFICATE

This is to certify that the project entitled "**ANALYSIS OF WINDOW LENGTH VARIATION OF SHORT-TIME FOURIER TRANSFORM IN VARIOUS APPLICATIONS**" submitted by **Akriti Gupta** to the Department of Department of Electronics and Communication Engineering for the fulfilment for the award of **B.Tech** degree from **Jaypee University of Information Technology, Waknaghat, India,** is a record of student's own work carried out under my supervision.

Mr. Pardeep Garg

Assistant Professor

Department of Electronics and Communication Engineering

Dated:

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to all those who supported me throughout the entire course of this B. Tech project and without whose guidance it would have been quite a difficult task. I am highly thankful to **Mr. Pardeep Garg, Project Supervisor,** for his valuable supervision in this project, whose constant support and motivation encouraged me to do the project efficiently. I am also thankful to my parents and friends for their support. I gratefully acknowledge each one of them.

Akriti Gupta, 151024

Date:

LIST OF ABBREVIATIONS

1. STFT: Short Time Fourier Transform
2. FFT: Fast Fourier Transform
3. N: Window Length
4. VF: Voice Frequency
5. PSD: Power Spectral Density
6. PQ: Power Quality
7. PQD: Power Quality Disturbance

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ABSTRACT

In this project, I have applied Short-Time Fourier Transform (STFT) on various signals and analyzed the effect of various windows taking into consideration different parameters like window length, spectral leakage. I have compared distinct processing techniques such as Fourier Transform to STFT, contrasting different window to determine the quality of overall results and then monitoring the effect of window length based on the desired application. On underlying aim in this project is visualize the effect of variations of window length, so will be encountering different techniques through which the purpose can be accomplished. Designing techniques and algorithms that can be used in real time application is challenging domain in the project. Another application is to observe and study power quality disturbances on which the window length variations can be used for better visualization. Referring to the research papers that are pre - existing, we will be reviewing the algorithms and will purist it the idea into creating an adaptive algorithm for spectrogram visualization. Highlighting the real life problems, frequency resolution and time resolution have stood as demanding concerns. Taking these problems into account, this project is an initiative to discover the appropriate and desired solution. Also this will look forward to the problems that have not been encountered yet.

LITERATURE REVIEW

1. **AUTHORS: Utkarsh Singh ,Shyam Narain Singh [1]**

Title: Time–frequency–scale transform for analysis of PQ disturbances [2017]

This paper focused on research in power quality disturbances. It tells us the basic need of signal processing tools which can give us higher resolution and immunity to noise. The transform matches short time Fourier transform with extra scaling feature. Application of windows is used for truncated signal because of aptness of cosine, sine wave, higher resolution and less spectral leakage.

2. **AUTHORS: P. L. Chithra1 and R. Aparna2 [2]**

Title: Performance analysis of widowing techniques in automatic signal speech segmentation [2001]

Work done in this paper was they analyzed the performance of windowing techniques in speech signal. Window function is applied to input signal and apply Discrete Fourier Transform. The outcomes created by the windowing and Filtering systems in division process are plotted. The proposed strategy out performs well and the execution of various windowing and filtering systems is used. The number peaks found is organized.

3. **AUTHORS: Aparna R. and Dr.PL.Chithra [3]**

Title: A study on impact of various windowing techniques in continous speech signal segmentation [2005]

In this we got to know that speech is the most widely recognized method for human communication. The investigation of speech signs and its processing strategies is known as processing of speech. Speech division is critical to different automated speech processing algorithms. The process through which language of digitalized speech is identified by computer is known as Automatic language identification.

4. **AUTHORS: Mohamed A. Tolba Dr. Vladimir N. Tulsky [4]**

Title: Study and analysis of power quality for an electric power distribution system [2016]

The reason for this undertaking is that we can improve the power nature of a significant distribution system and after that taking care of the issues of intensity quality in that system. This paper demonstrates the practical estimation and examination of the distribution system has significant loads with high power quality disturbance signal. In this paper we study about voltage profile disturbances considering over and under voltage has been given as power quality disturbances and the voltage is dropped and losses of power are determined during simulation.

5. **AUTHORS: R . K. Aggarwal, M. Weinhold and R. Zurowski [5]**

Title: Power quality improvement in distribution systems [1997]

The utilization of power electronic equipment,electronic weights, renewable of sustainable power source frameworks, un-interrupted with power supply, and so forth., pollute the power nature of the electrical distribution framework. The power quality issues like sounds in the system, diminish the limit of distribution things like conductor, transformers, gears, and so on., and furthermore increment the loss. In this paper, the effect of power quality issues on electrical distribution framework is talked about.

6. **AUTHORS: Cho, S.H., Jang, G., Kwon, S.H [6]**

Title: Time–frequency analysis of power-quality disturbances via the Gabor–Wigner transform [2010]

There are signal-processing systems, for example, Fast Fourier Transform, Short Time Fourier Transform have been connected to distinguish, recognize, and arrange power quality (PQ) For example the different Power quality disturbances that includes voltage swell, voltage sags, harmonics, Transient, voltage changes with different frequencies and variation of voltage, or flicker, will be altogether explored with the helpof time-frequency analysis technique.

7. AUTHORS: Ozgonenel, O., Yalcin, T., Guney [7]

Title: A new classification for power quality events in distribution systems [2013]

The expanded utilization of non-linear loads and the event of flaults on the power systems have brought about crumbling in the nature of quality provided to the end clients. Power quality (PQ) events and disturbances lead to either breaking down or complete disappointment of electrical/electronic hardware. Voltage sag, voltage swell, voltage transient and harmonic disturbances among others are the most widely recognized kinds of power quality (PQ) events. Precise and accurate recognition of these PQ events is extremely basic for satisfactory restorative measures to be taken. This paper explores such events by utilizing the utilization of Short Time Fourier Transform (STFT) for PQ events identification on an real time voltage waveform.

8. AUTHORS: Montano, J.C., Bravo, J.C., Borras [8]

Title: Joint time–frequency analysis of the electrical signal', in Moreno-Munoz [2007]

The issues related with the existence of instability in power distribution system are the power quality issues as well as influence the efficiency of energy of the plant. To the extent energy effectiveness is worried in a building power dispersion system where the two dominant variables in power quality are its uneven deformation and harmonic disturbances.

9. AUTHORS: E.Jacoben and R.L yon [9]

Title: Sliding DFT, signal processing Magazine [2003]

The Fourier Transform is a significant figure processing apparatus which is utilized to decay a figure into its sine and cosine parts. The yield of the conversion represents to the figure in the Fourier.

CHAPTER 1

SHORT TIME FOURIER TRANSFORM

1.1 INTRODUCTION

In signal analysis there is a fundamental problem is to obtain a spectrum elements present in a precise signal plus to obtain information about the time intervals at which assured frequencies prevail. The Fourier analysis solves the issue partially, because it doesn't allow an assignment or spectral components with respect to time. Therefore there is a need of transforms that give a detailed approaching into the signal characteristics in a unique manner. The short time Fourier transform is a transform that includes time and frequency and also provides frequency time analysis, and to be more specific signal description in the time frequency domain. The short time Fourier transform (STFT) is a transform that is used to decide sinusoidal frequency and face satisfied of local components of a signal that usually changes overtime.in general the method for determining STFT is to break a longer time signal into shorter segments of identical length and then determine the Fourier transform distinctively on each shorter segment this reveals the Fourier spectrum on every shorter segment and then the varying spectra is plotted a function of time .the STFT depicts a trade of between frequency and time based approach of a signal. It provides particular about when and at what frequencies a signal prevails. This information can only be acquired with limited precision and accuracy which is determined by the range of the window. The spectral representations is time varying with two dimensions that is time on the horizontal axis and frequency on the vertical axis. The 3rd dimension is represented by the darkness of each point in the image which indicates the amplitude of a vibration with a specific frequency at a specific time. Linear and logarithmic frequency scales are used to demonstrate harmonic relationship and melodic relationships respectively.

1.2 CONTINUOUS TIME STFT

In the continuous time domain, a non- zero window function is multiplied by the function to be transformed for a short period of time. The window is slide along the Fourier transform (a one dimensional function) of the resulting in a 2D representation of the signal [10].

Mathematical equation [1]

STFT{x(t)}(τ,w)=X(τ,w)≡ $\int_{\infty}^{\infty} x(t)w(t-\tau)$ e^{-jwt} dt

Where

w(t) is window function

x(t) is signal to be transformed

x(τ,w) is Fourier transform of x(t) w(t-τ)

1.3 DISCRETE TIME STFT

In the discrete time domain, the data to be transformed is fragmented into chunks or frames (which usually overlap each other) to reduce artifacts at the boundary. The magnitude of the phase is recorded and observed for each at every peak in time and frequency by doing the Fourier transform of every chunk and the result is usually stored in a matrix.

Mathematical equation [2]

STFT{x[n]}(m,w) ≡ X(m,w) = $\sum_{n=-\infty}^{\infty}$ x[n]w[n − m]e^{-jwn}

Where

w[n] is window function

x[n] is signal to be transformed

x(m,ω) is Fourier Transform of x[n]w[n-m]

1.4 METHOD TO COMPUTE STFT

The method to compute STFT is mentioned below-

STFT COMPUTATION USING FFT:

1. We will section the information signal into covering squares. The covered will be half and each square will be" windowed" by a smooth raised – cosine work .The window will be picked with the goal that unique sign can be remade consummately if no sign change is finished.

2. For each windowed hinder, the FFT will be determined. This gives an otherworldly "preview" of what is happening amid that short square of the info signal.
3. We can't do some adjustment of the FFT information such an increasing by spectral shape (filter)or some other kind of recurrence space preparing .accepting that we had a genuine just yield sign and we need a genuine just yield signal, we have to ensure that whatever a control is connected completes such that will keep the complex DTFT information in conjugate symmetric structure .that is , on the off chance that we change anything in the DFT receptacles ,among 0 and n/2 , a similar change needs to apply to the perfect representation containers n-1 down to n/2,and the subsequent altering DFT information must stay conjugate symmetric.
4. After the spectralIFFT (alters FFT) is determined. The subsequent square is then covered added to the yield output, accordingly reproducing the ideal sign. The graphical portrayal of STFT is known as spectrogram.

CHAPTER 2

WINDOW FUNCTIONS AND WINDOW SIZE

2.1 INTRODUCTION

The window measure speaks to various examples and its span. It is the primary parameter of the examination of a sign. The window estimate relies upon the recurrence, power and changes of the sign. The FFT measure is an outcomes of the standards of the Fourier series: it communicates in what number of recurrence groups the analysis window will be sliced to set the recurrence goals of the window. The window estimate impacts the worldly or recurrence goals of the analysis.

Windowing is a process that considers small sets of the original data on which operations can be performed such as analysis and processing. There occur a change in the spectral properties of the signal due to processing that reduces the signal level and redistributes it over a wide frequency range. Due to change in the properties of the signal there occurs spectral leakage. To prevent this we take help of window function that limits the waveform to a particular window. Window reduces the sharp transients and smoothen the signal.

Windowing decreases the plentifulness of the discontinuities at the limits of each limited groupings obtained by the digitizer. Windowing comprises of duplicating the time record by a limited length window with an adequacy that changes easily and step by step towards zero at the edges. This makes the end purposes of the waveform meet and subsequently, results in a constant waveform without sharp advances.

2.2 TYPES OF WINDOWS

1. FIXED WINDOWS

The shape of these windows in time domain remains fixed and hence MSLL and SLFOR of these windows also remain constant. Only HMLW can be varied by varying window length. Rectangular, Triangular, Hanning and Blackman windows are the examples of this category.

2. VARIABLE WINDOWS

These window have an addition parameter known as shape parameter. Therefore, the shape of these windows in time domain can be made variable by varying shape parameter. Thus, all analysis parameters remain variable in these windows. Kaiser windows is one of the example of this type of windows.

2.2 WINDOW FUNCTIONS

There are various sorts of window works that we can apply contingent upon the properties of a sign. To see how a window influences The recurrence range , we have to see progressively about the recurrence attributes of a window and real plot of a window demonstrates that the recurrence qualities of a window is constant range with a primary projection and a few side hurls .The fundamental flap is focused at every recurrence part of the time area signal, and the side throws approaches zero .The tallness of the side heave shows the impacts of the windowing capacity has possess frequencies around principle throws . The side throws reaction of a solid sinusoidal can overpower the principle projection reaction of a close-by frail sinusoidal flag typically, lower side heaves decreases spillage in the major FFT yet builds the data transfer capacity of the real flap. The side heave job of rate is asymptotic rot rate of the side projection crests [11]. By expanding the side throws job of rate, we can decrease the phantom spillage. Choosing a window work isn't a simple errand.

Every window work has its very own qualities and appropriateness for various applications to pick a window. Work, we should evaluate the recurrence substance of the sign.

- If our signal contain tough interfering frequencies components isolated from the frequency of interest we have to choose a smoothening window with a high side lob role of-rate.
- If the signal contains strong interfering signal near the frequency if interest we will be choosing window function that as a low maximum side lobe level.
- If the off chance that the frequency of the interest contains at least 2 signal exceptionally close to one another, otherworldly goals is significant. for this situation it is ideal to pick a smoothing window with a thin primary projection

- On the off chance that the plentifulness precision of a solitary recurrence part could easily compare to the careful area of the segment in a given recurrence canister, we pick a window with a wide primary projection.
- On the off chance that the sign range if fairly level of brood and in recurrence content we utilize the uniform window or no window.

In general the the hanning window has very good frequency resolution and reduced a spectral leakage. Either nature of that signal is not known but we want to apply an smoothing window and when to start with the hanning window, we use no window the the signal is convollved with a rectangular shaped window of a uniform height by the nature of taking an snapshot in time of the input signals and working with discrete signals. This convolution contains a sine function characteristics of spectrum. No window is often call the uniform or the rectangular window as there is still windowing effect.

The hamming as well as hanning window functions mutually have a sinusoidal shape. Bothe windows results with a large peak excluding low side lobs. Though the hanning window that touches 0 at both ends eliminate all the discontinuitiess. The hamming window doesn't rather reach 0 in totaling to a minor discontinuity in the signals. because of the difference the hamming window does a healthier job of cancelling the adjoining side lobe excluding poorer job of cancelling any additional. These window functions are helpful for noise size where improved frequency resolution in so as to case some other windows is necessary but moderate side lobs doesn't recent a problem.

The blackman harris window is as good as to hamming plus hanning. the ensuing has a wide peak but good side lobe compression. There are two most important types of this window. The fourth term black man harris is a high quality general point window have side lobe refusal in the high 90's db and a rather wide main lobe. The seven term blackman harris windows funcction has all the active range we be supposed to ever need but it come with a wide main lobe.

A Kaiser-bassel window strike a balance among the a variety of conflicting goals of amplitude correctness side lobe distance an side lobe height. It compare around to the blackman harris window functions but for the similar main lobe width the near side lobe be likely to be higher but the extra outer side lobes are lower. However the uncertainty principle applies, given a lower bound for the area of window. Choosing a short time window leads to a good time resolution and on the contrary a poor frequency resolution. On the other hand, along time window yields poor time resolution but better frequency resolution.

2.4 WINDOW LENGTH (SIZE)

The optimum window length will depend on application. If our application is such that we need frequency domain information to be more specific, then we increase the size of the window. If our application is such that we need time domain information to be more specific then we decrease the size of the window.

2.4.1 WINDOW SIZE AND TIME-FREQUENCY RESOLUTION

1. Frequency Resolution: how well two spikes in time can be separated from each other in the frequency domain.
2. Time Resolution: how well two spectral components can be separated from each other in the time domain we need frequency domain information and resolution to be more specific.

CHAPTER 3

ANALYSIS OF WINDOW LENGTH

3.1 INTRODUCTION

Window functions are extensively used in different applications of signal processiing and communication engineering. In signal processing, designing of a digital FIR filters and spectral analysis are the most important applications of the window function. In both of this applications the choice of a window functions plays an key role in determining the quality of generally result.

3.2 SPECTRAL PARAMETERS

1. Maximum side-lobe level (MSLL): it is the peak ripple value of side lobes this must be low to overcome Gibb's phenomena efficiently.

2. Half main lobe width (HMLW) : it is the frequency at which first null off |W(f)| exists lower value of HMLW makes less width of main lobe and hence better resolution .

3. Side lobe fall off-rate (SLFOR): this is an asymptotic decay rate of side lobes.Higher decay rates makes better encounter of gibb's.

3.3 ANALYSIS OF VARIOUS FUNCTIONS

3.3.1 RECTANGULAR WINDOW (w[n] =1)

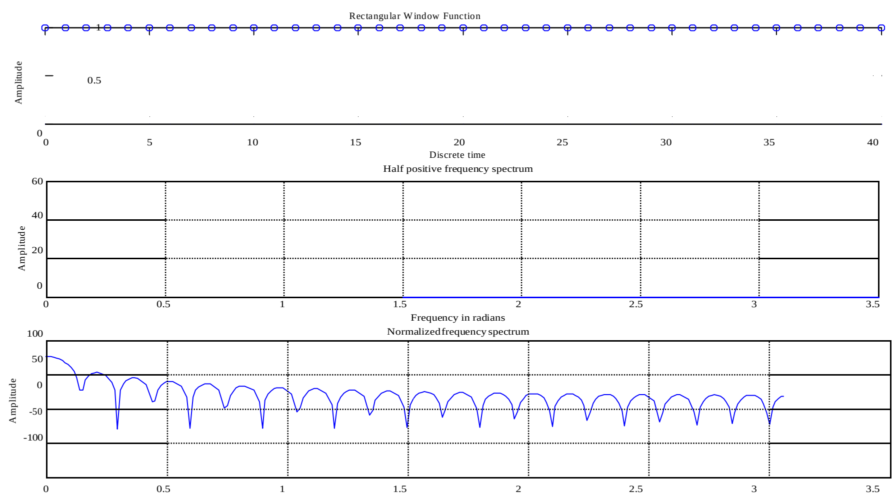

Figure 3.1: Rectangular Window Function

3.3.2 TRIANGULAR WINDOW (w=1-(2* abs (n-((N-1)/2)))/(N-1))

Where n=0:N-1 and N=41

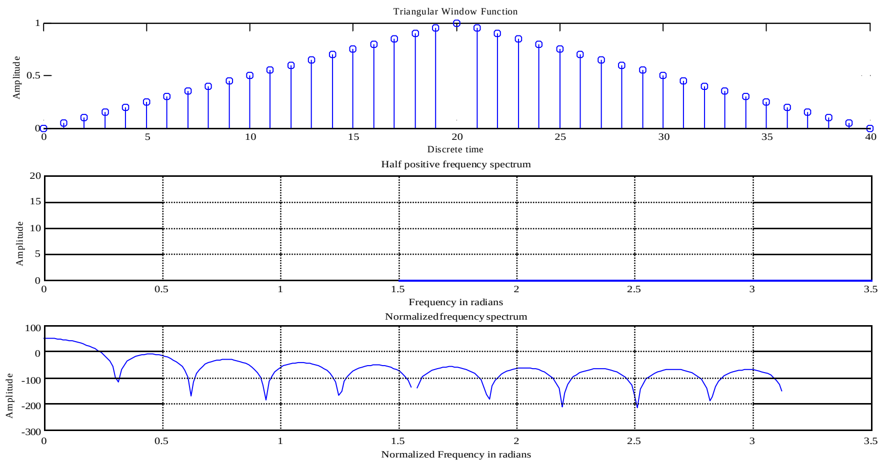

Figure 3.2: Triangular Window Function

F
i
g

3.3.3 HANNING WINDOW (w=0.5(1- cos (2*pi*n/(N-1))))

Where n=0:N-1 and N=41

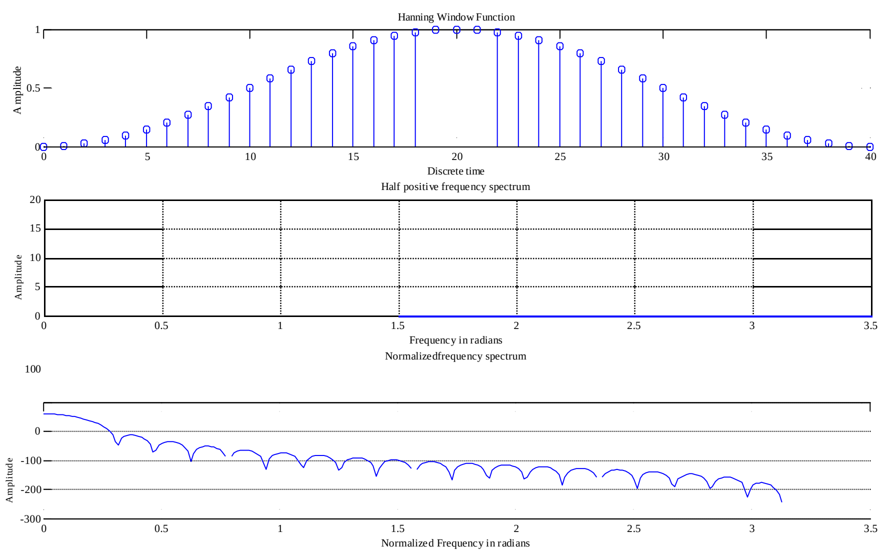

Figure 3.3: Hanning Window Function

3.3.4 HAMMING WINDOW (w=0.54-0.46*(cos (2*pi*n/(N-1))))

Where n=0:N-1 and N=41

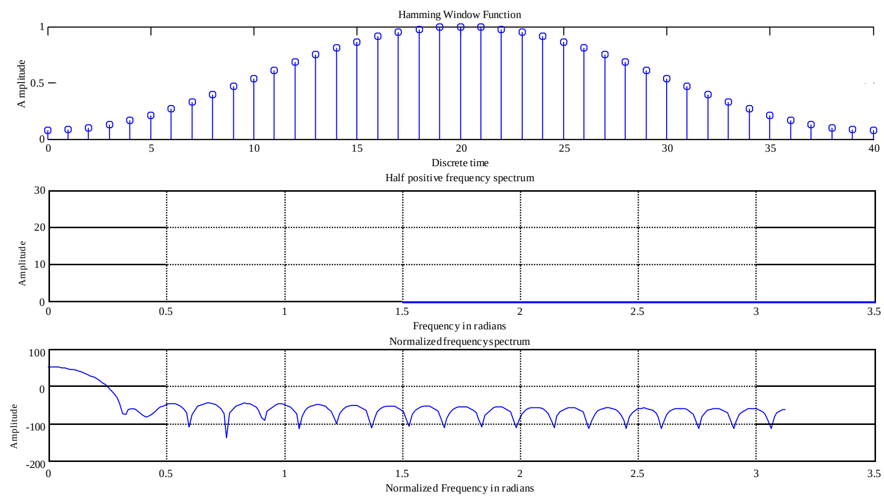

Figure 3.4: Hamming Window Function

3.3.5 BLACKMAN WINDOW (w=0.42-(0.5*cos(2*pi*n/N-1))))+(0.8(cos(4*pi*n/(N-1)))))

Where n=0:N-1 and N=41

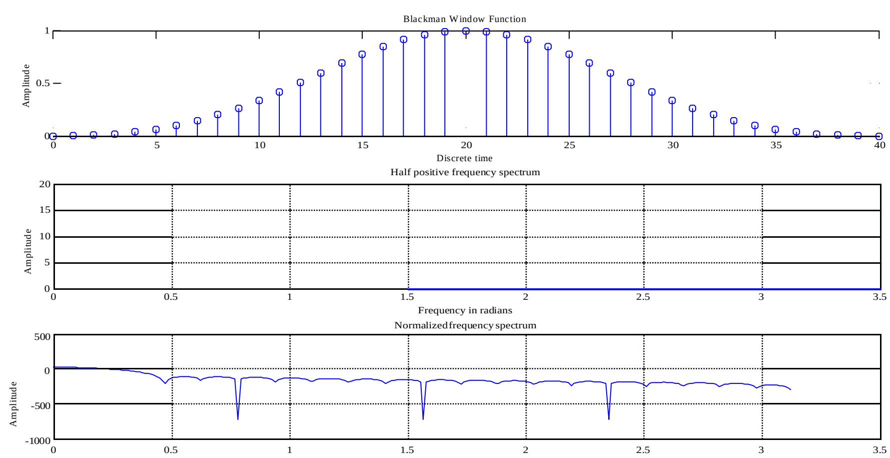

Figure 3.5: Blackman Window Function

DISCUSSION

- Rectangular window is used to truncate a signal within a finite time interval. It has the highest amount of spectral leakage. The rectangular window used for transient analysis that have a less duration than that of window. Transients are signals that exists simply for a short time period.

- The Hanning window has a shape similar to that of half a cycle of a cosine wave. The Hanning window is helpful to transient analysis longer than the time period of the window and for all-purpose applications.
- The Hamming window is a customized version of the Hanning window. The form of the Hamming window is as similar to as of a cosine wave. The Hanning plus Hamming windows are alike as shown in the earlier two figures though in the time domain the Hamming window does not acquire as close to zero next to the edges as does the Hanning window.
- The Blackman window is helpful for single tone dimensions as it has a low highest side lobe level plus a high side lobe roll-off rate.Windows with a additional gradual transition to zero contain lower side-lobe level are valuable for spectral display plus a variety of signal processing application base on FFT methods.

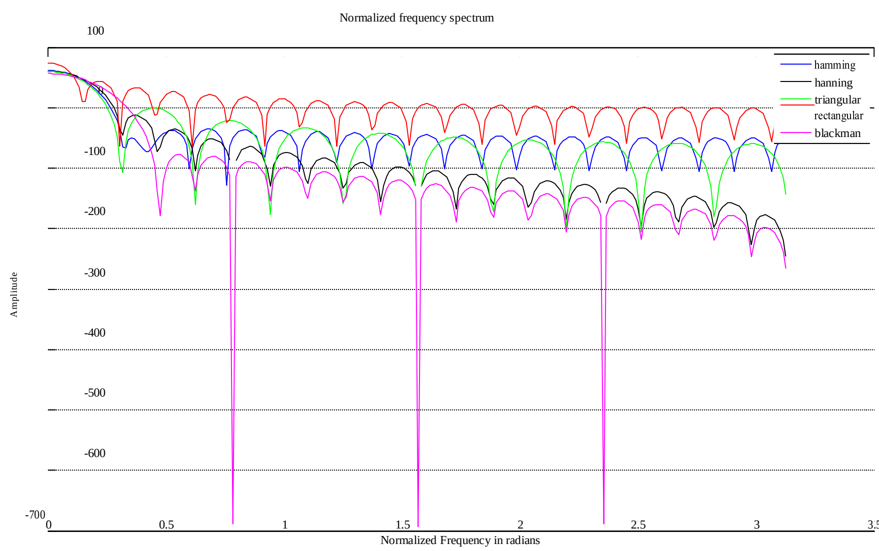

Figure 3.6: Comparison of windows

3.4 WINDOW LENGTH VARIATION

Output analysis where I have varied window length using hanning window (w=0.5(1- cos (2*pi*n/(N-1))))

Where n=0:N-1

- N=11

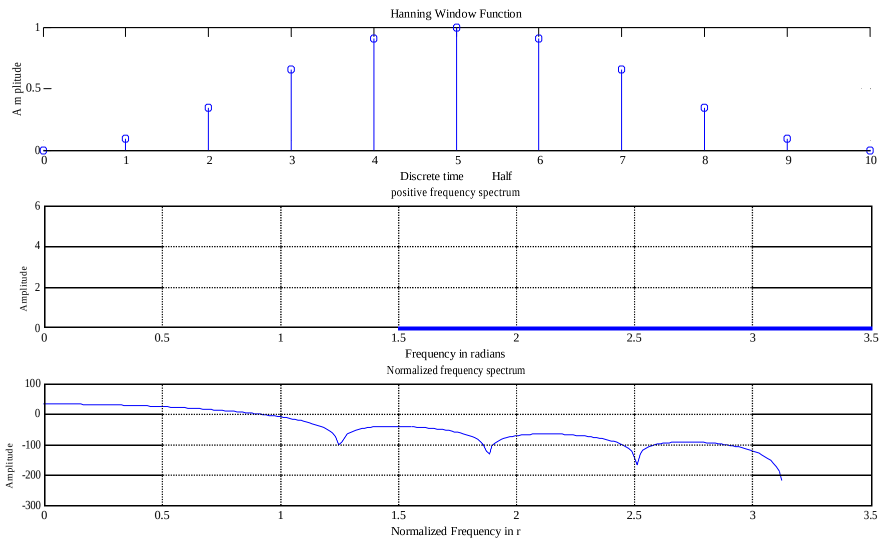

Figure 3.7: Hanning Window Function N=11

- N=41

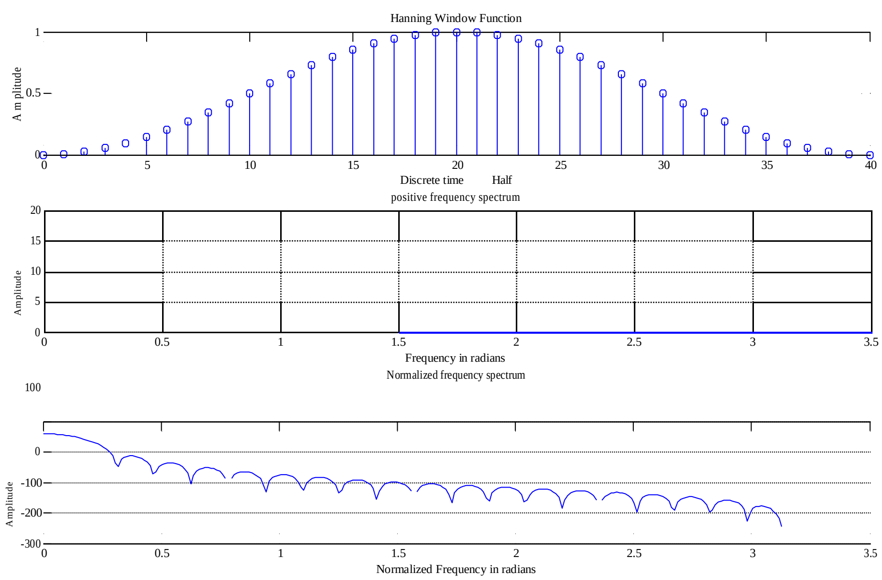

Figure 3.8: Hanning Window Function N=41

- N=91

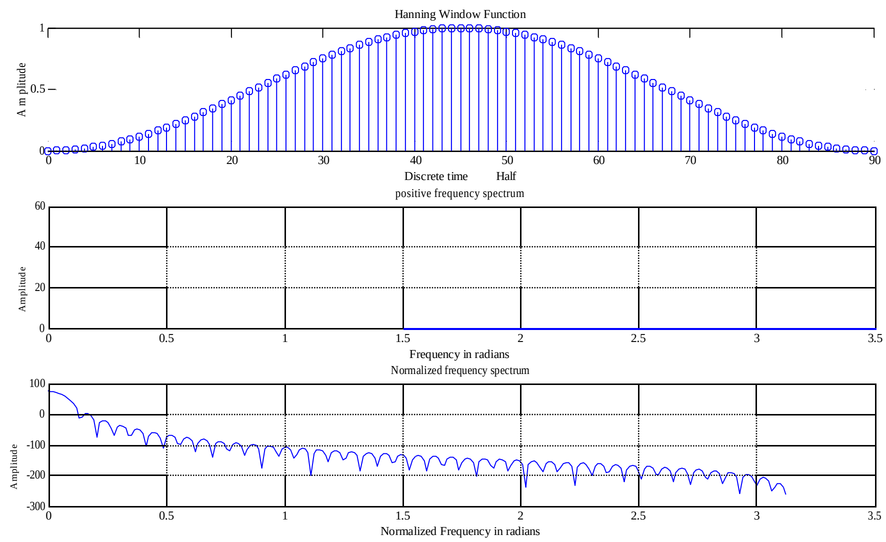

Figure 3.9: Hanning Window Function N=91

- N=201

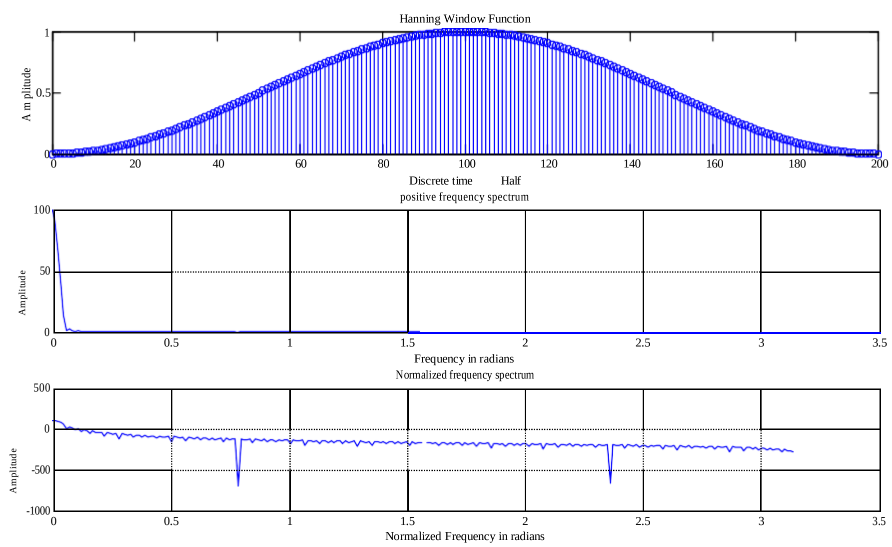

Figure 3.10: Hanning Window Function N=201

- N=501

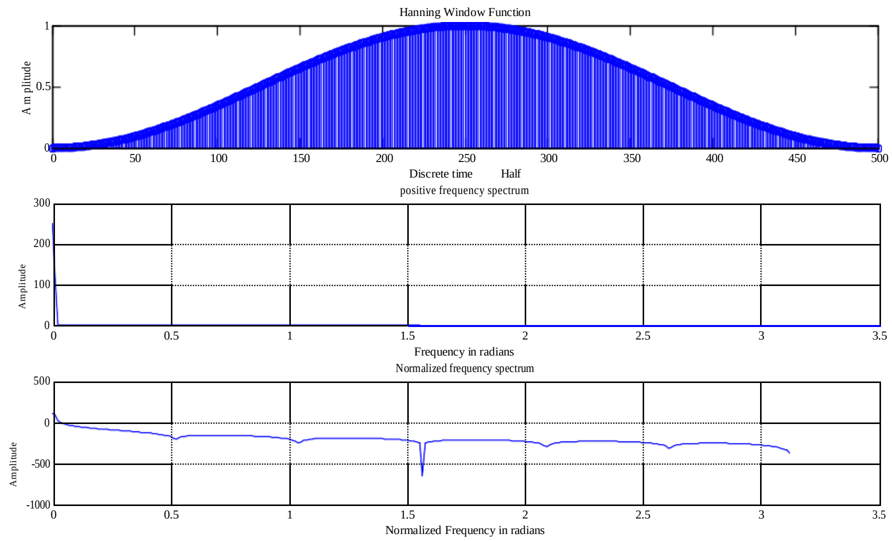

Figure 3.11: Hanning Window Function N=501

- N=2000

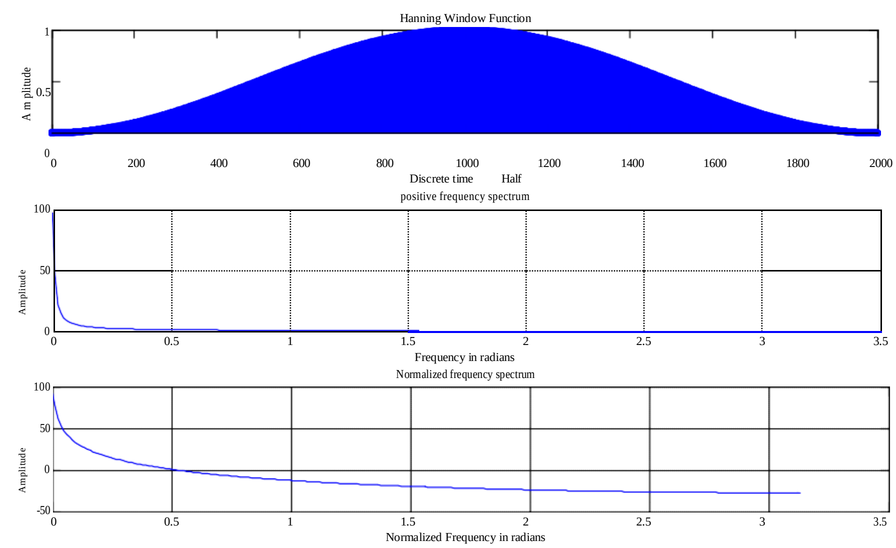

Figure 3.12: Hamming Window Function N=2000

DISCUSSION

The frequency resolution of an spectrum analysis window is firm by it main-lobe size in the frequency domain. As the window size increases, the main lobe width narrows down i.e. decrease giving better frequency resolution (spectral resolution). A better size will result in higher spectral resolution, but lower temporal resolution, Whereas the opposite will result in a minor spectral resolution, but superior temporal resolution.

CHAPTER 4
VOICE ENCAPSULATION AND WINDOWING

4.1 INTRODUCTION

A voice frequency (VF) is one of the frequencies, inside piece of the sound range, That is being utilized for the transmission of speech. In communication, the usable voice recurrence band ranges from around 300 Hz to 3400 Hz. The human vocal string is similar to time fluctuating examples at unpredictable interims of time and are non- occasional in nature. Non periodicity reflects in "band of frequencies". Furthermore, that band of frequency are restricted to less vibrations every second which are generated from vocal rope vibrations. Be that as it may, in sound signal a signal can be vibrated from most minimal of 1Hz to 100 kHz including infra, audible& ultrasonic sounds and those sounds can't be delivered from human voice [15].

The voiced speech of a commonplace grown-up male will have an essential recurrence from 85 to 180 Hz, and that of grown-up female from 165 to 255 Hz." ... That is, those phone amplifiers never got the fundamental frequency, just 300 Hz and higher.

Audio signal is a portrayal of sound, ordinarily utilizing a dimension of electrical voltage for simple signs and has a sense of binary numbers. Voice signals have frequencies in the voice frequency s of approximately 20 to 20,000 Hz, which relates to the lower and maximum cut off points of human hearing. Voice signals might be orchestrated legitimately, or may begin at a transducer, for example, a receiver, melodic instrument pickup, phonograph cartridge, or tape head. Amplifiers or earphones convert an electrical voice signal once again into sound.

4.2 POWER SPECTRAL ANALYSIS

A Power Spectral Density (PSD) is a graph of frequency versus power of signal. A PSD is commonly used to describe broadband random signs. PSD’s amplitude can be normalized with the help of spectral resolution employed to digitize a signal. PSD is the extent squared of the Fourier Transform of a continuous time and finite power signal. It is the amount of intensity for every frequency part: in this manner, PSD integral is the total sign power. PSD is a kind of frequency domain analysis in which a structure is exposed to a probabilistic spectrum of harmonic to get probabilistic distribution for dynamic measures. PSD cannot be negative for any signal and if it is then particular frequency are complex numbers. It is the frequency spectrum of energies and eigen values. The way of generating power spectrum is by discrete Fourier transform.

4.3 WINDOWING AUDIO SIGNAL

Windowing is mostly utilized in spectral analysis, to see a brief span section of a more extended signal and analyze signal’s frequency content [16]. Windows are additionally used to make short sound segments of a couple of milliseconds' term called "grains", which can be consolidated into granular sound clouds for interesting sorts of union. When all is said in done, one can think about any limited sound that has a beginning point and a end point just like a windowed section in time. For instance, a cycle object is continually delivering a signal, however we can window it with a *~ object, keeping its amplitude at 0 aside from when we need to hear it. Be that as it may, a rectangular window — all of a sudden changing from 0 to 1 and after that again from 1 to 0 — will as a rule make a click so other window shapes are normally increasingly desirable.This kind of windowing system is helpful for forming the amplitude envelope of sampled sounds or some other sound signs, so as to keep away from clicks and to make the kind of attack regardless of whether it be a short grain or a more extended extract as shown in figure 4.1.

SIMULATED RESULTS

The goal of the task is to create techniques for spectral envelope estimation, control, and application for sound synthesis, and to characterize an adaptable and effective portrayal of the information both for permanent and internal storage.

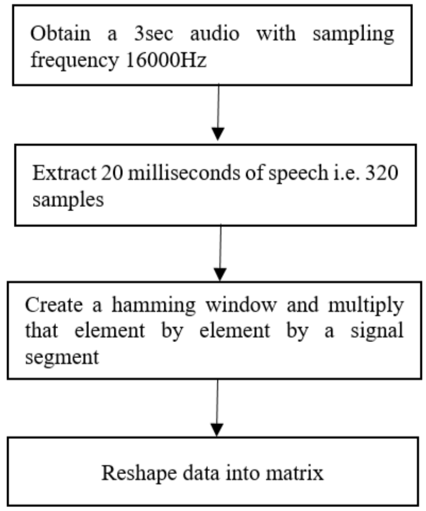

Figure 4.1: Flow chart of voice encapsulation

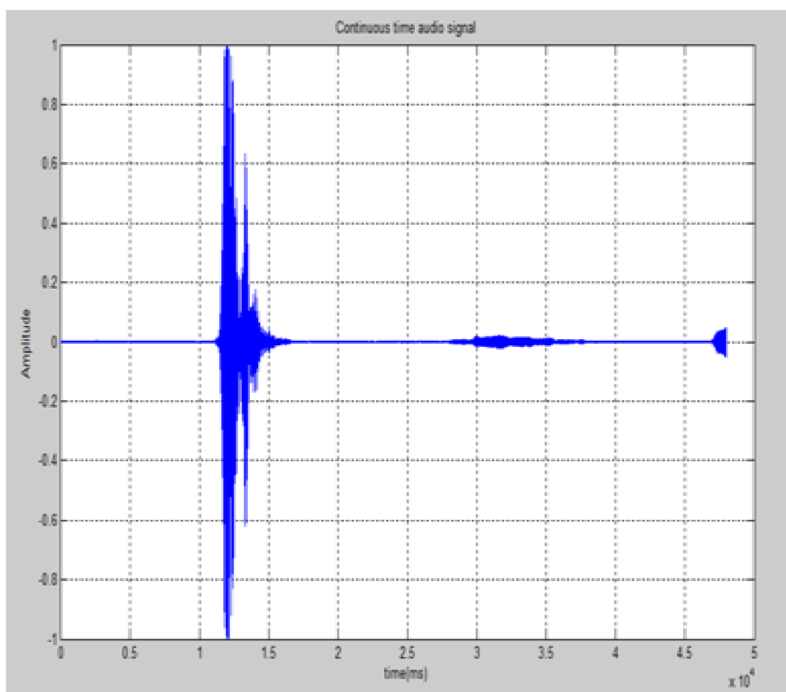

Figure 4.2: Continous time audio signal

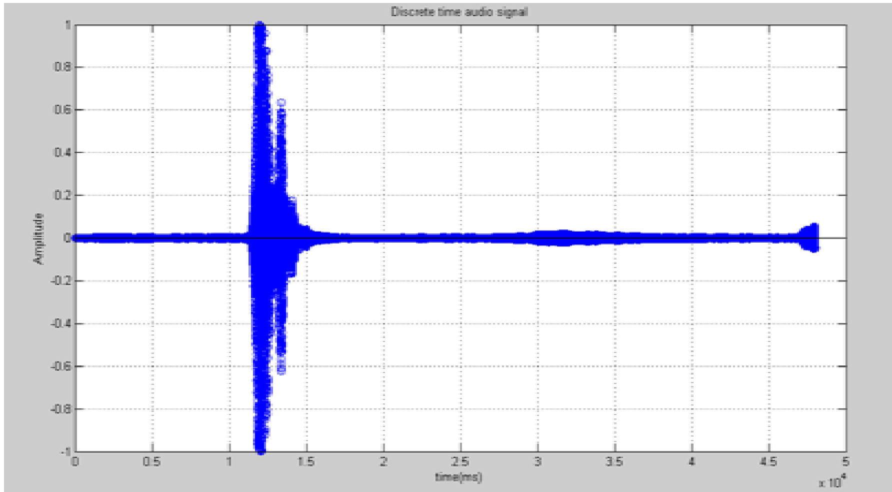

Figure 4.3: Discrete time audio signal

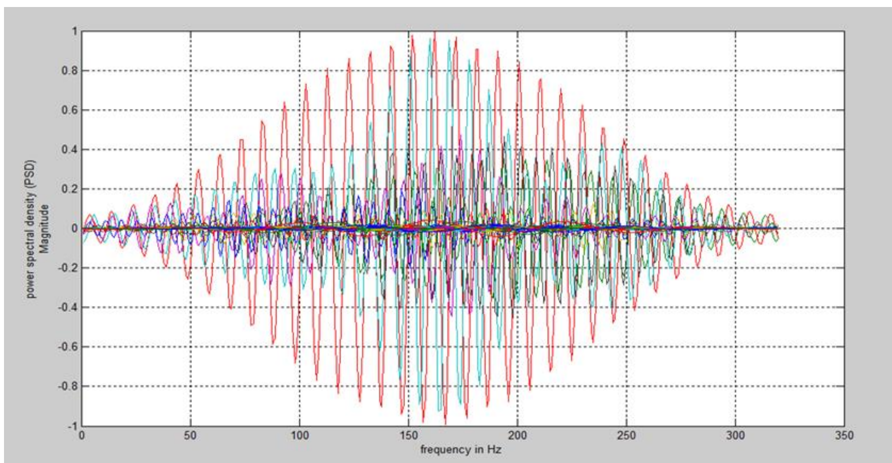

Figure 4.4: PSD of audio signal

DISCUSSION

We have extracted 20 millisecond audio speech and applied specific window length and have plotted power spectral density of audio signal. It explains power present in the signal and have also plotted discrete time audio signal and continuous time audio signals.

CHAPTER 5
ANLAYSIS OF POWER QUALITY DISTRUBANCES

5.1 INTRODUCTION

The electric power is produced in huge power stations at a moderately tiny number of areas. This power is then transmitted and supplied to the end clients, normally essentially known as "loads. Electrical power system mostly deliver undistorted sinusoidal appraised current and voltage persistently at rated frequency to the purchasers. Lately, network clients have distinguished an expanding number of disadvantages brought about by electric power quality (PQ) varieties and PQ issues have honed in light of the expanded number of burdens delicate to PQ and is difficult to solve as load is also an important cause for the degradation of quality. Therefore, nowadays, clients request more elevated amounts of PQ to guarantee the correct and proceeded with sensitive equipments.

PQ is basically a customer problem nowadays. Power quality can be characterized as any issue showed in voltage, flow, or frequency deviation that outcomes in disappointment or maloperation of electric hardware. The electric power quality is likewise characterized as a term that helps to keeping up the power system voltages and current at rated frequency and magnitude [1]. Along these lines electric power quality is mostly used to express voltage quality, current quality. Power quality issue is additionally significant for the service organizations. They are obliged to supply buyers with electrical intensity of worthy quality. The power quality unsettling influences rely upon amplitude or frequency or on both amplitude and amplitude. Power quality is the idea of controlling and grounding sensitive hardware in an issue that is reasonable to the activity of that equipment.

Power quality is basically the blend of voltage quality in addition to current quality. Voltage quality is disturbed with deviation of the real voltage from the ideal voltage. A dialog on what is perfect voltage might take many pages, a comparative talk on the current much more.

A basic and straight forward arrangement is to define the the ideal voltage as a sinusoidal voltage waveform with consistent adequacy and steady frequency where both amplitude and frequency are equivalent to their nominal values. The perfect current is likewise of consistent amplitude and frequency, however furthermore the present frequency and phase are the equivalent frequency and period of the voltage.

There are various explanations for increase interest in PQ.

The main reasons are:

- Equipment has turned out to be less tolerant of voltage quality disturbances, production processes have turned out to be less tolerant of erroneous activity of hardware, and companies have turned out to be less tolerant of creation stoppages.
- Equipment delivers more present unsettling influences than it use to do. Both low-and high-control equipment is increasingly more controlled by straight ahead power electronic converters which make a wide range of distortion. There are signs that harmonic deformation in the power framework is rising, but no decisive outcomes are accessible because of the absence of extensive scale surveys.
- The deregulation (advancement, privatization) of the power business has led to an expanded requirement for quality markers. Clients are hard and getting more data on the voltage quality they can anticipate.

5.2 POWER QUALITY ISSUES

Any kind of difference of voltage or current from the ideal voltage or current is a power quality disturbances (PQD). Disturbances can be a voltage or a current disturbance yet usually unrealistic to recognize the two. Any change in current gives an adjustment in voltage and in a different way. Where we make use of a qualification among voltage and current disturbances. We utilize the reason as a criterion to recognize them: Voltage unsettling influences start in the power network originates voltage disturbances and possibly influence the clients while customer originates current disturbances. PQD can be caused by non- linear loads, electronics equipment and natural disruption. A few instances of issues that happen because of quality issues are: Automatic Resets,

Circuit Board Failure, Memory Loss, UPS Alarms, Software Corruption.

The issue of electric power quality is picking up significance as a result of a few reasons:

1. The general public is winding up progressively reliant on the electrical supply.
2. A little power blackout has an incredible efficient effect on the modern purchasers. Modern society can be harmed with longer interruption.
3. Nowadays, equipments are likely to be more sensitive to power quality variations.

4. Due to new power devices like speed drives has led to new disturbances in the system.

5.3 DISTURBANCES IN PQD

Due to involvement of heavy loads, reactive power equipments modern power system is affected. This can result in multiple steady state or single steady state [1].

Disturbances in PQD can be classified as:

- VOLTAGE SAG
- VOLTAGE SWELL
- INTERRUPTION
- TRANSIENT
- HARMONICS
- FLICKER

Type	Equation	Parameters
Sag	$(t) = [1-\alpha(u(t-t_1)-u(t-t_2))]\sin(2\pi ft)$	$\alpha= 0.6, t_1=4T, t_2=7T$
swell	$(t) = [1+\alpha(u(t-t_1)-u(t-t_2))]\sin(2\pi ft)$	$\alpha= 0.4, t_1=5T, t_2=8T$
Interruption	$(t) = [1-\alpha(u(t-t_1)-u(t-t_2))]\sin(2\pi ft)$	$\alpha= 0.98, t_1=4T, t_2=9T$
Transient	$(t) = [1-\alpha(u(t-t_1)-u(t-t_2))]\sin(2\pi ft)$	$= 2.9, t_1=4T, t_2- t_1=0.001$
Harmonics	$= \sin(2\pi ft)+a_h\sin(2\pi f_h t)+a_i\sin(2\pi f_i t)$	$0.3, f_h =150, a_i =0.1 f_i =125$
flicker	$x(t) = [1+ a\sin(2\pi\beta t)]\sin(2\pi ft)$	$A=0.1, \beta=20$

Table 5.1 PQD Simulation mode [1]

1. VOLTAGE SAG:

A decline of the ordinary voltage height somewhere in the range of 10% and 90% of the rms voltage at the power frequency, for spans of 0,5 cycle to 1 minute as shown in figure 5.2. Blames on the distribution or transmission network (a large portion of the occasions on parallel feeders). Blames in customer's establishment. Association of overwhelming burdens and start-up of expansive engines.

Factors affecting voltage sag:

1. Abrupt changes in loads or excessive burdens can cause a voltage sag.

2. Energizing of transformers is another reason behind voltage sag.

3. Electric motor can also be a factor in voltage sag.

4. Refrigerators or air conditioner leads to voltage dip.

In industrial areas there are various industrial sites located there which can cause voltage sag. Distribution of voltage can affect the other industries.

The consequences of malfunctioning of data innovation hardware, in particular microchip based control frameworks that may prompt a process stoppage. Stumbling of contactors and electromechanical transfers. Detachment and loss of productivity in electric rotating machines. Typical voltage value of sag is 0.1-0.9 Pu

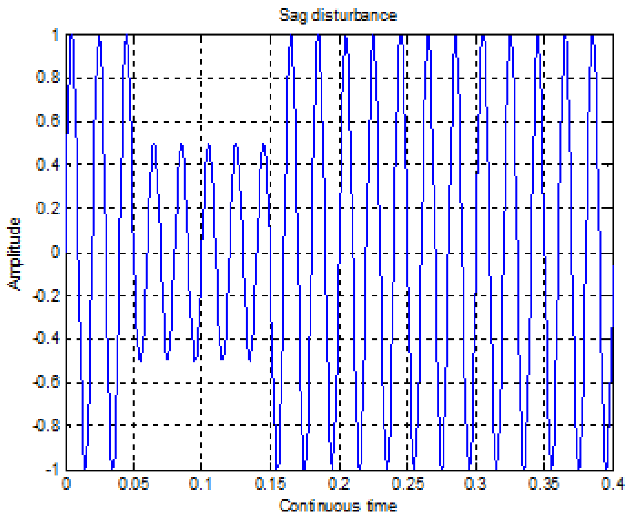

Figure 5.2: Sag disturbance

2. VOLTAGE SWELLS

Transitory increment of the voltage in the power frequency outside the ordinary tolerance with term of extra than one cycle and commonly not exactly a couple of seconds. Voltage swell is just opposite of voltage sag which is increase in voltage if heavy loads turn off.

An increase in the ordinary voltage level somewhere in the range of 10% and 90% of the rms voltage at the power frequency, for spans of 0.5 cycle to 1 minute as shown in figure 5.3. Voltage swell mostly occur less the voltage dip and is due to fault of system. Voltage swell causes are when large loads are turned off or on or there are bad condition in regulation of transformers.

Voltage swells can likewise be brought about by the denergization of a huge burden. The unexpected interruption of current can produce an expansive voltage per the formula: V = L di/dt, where L is the inductance in the line and di/dt is the adjustment in current flow. In addition, the stimulation of a large capacitor can likewise cause a voltage swell though it all the more frequently causes an oscillatory transient.

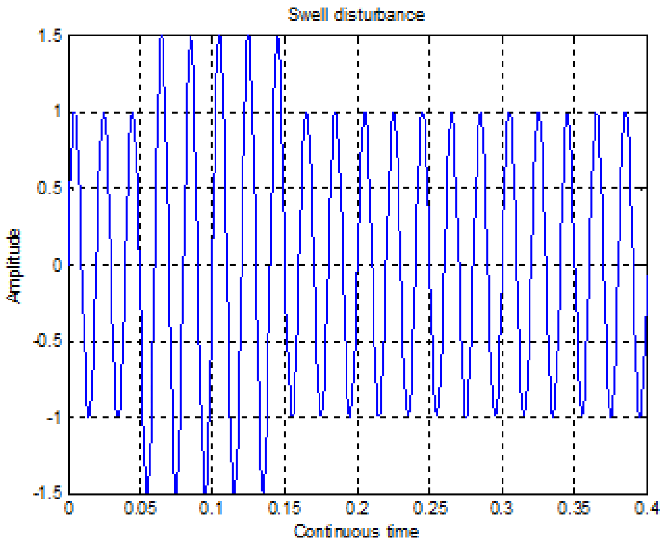

Figure 5.3: Swell disturbance

3. INTERRUPTION:

Interferences are grouped by IEEE 1159 into either a brief length or long-length variety. In any case, the expression "interference" is frequently used to allude to brief term interruption while the later is gone before by sustained to demonstrate a long-span. They are estimated and depicted by their term duration since the voltage extent is in every case under 10% of nominal as shown in figure 5.4.

Interruptions generally come about because of reclosing circuit breakers or recloses endeavoring to apparent temporary issues, first opening and afterward reclosing a little short time delay. The gadgets are ordinarily on the distribution framework, yet at certain areas, flashing interferences additionally happen for flaws on the sub transmission framework. The degree of interference will rely upon the reclosing capacity of the protective gadget. For instance, quick reclosing will restrict the interruption brought about by a temporary flaw to under 30 cycles. Then again, time delayed reclosing of the protective gadget may cause a transitory or brief interference. It is classified as a long duration voltage variation phenomena.

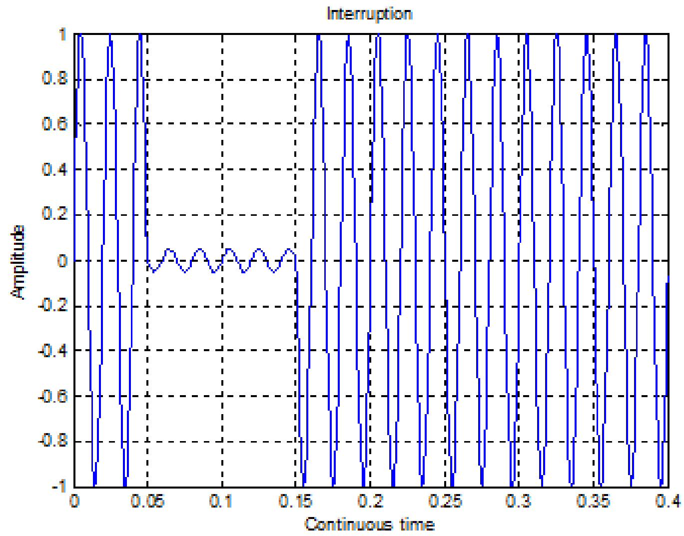

Figure 5.4*:* Interruption

4. TRANSIENT:

Transients are the disturbances in power that include damaging high ranges of current and voltage or even both. It might attain a huge figure of volts and amps even in low voltage frameworks. In any case, such phenomenon just exist in a brief duration from under 50 nanoseconds to up to 50 milliseconds as shown in figure 5.5. This is the most limited among PQ issues, consequently its name. Transients include strange frequencies which could reach to as high as 5 MHz.

EFFECTS OF TRANSIENT

1. Electronic Equipment
2. Motors
3. Lights

4. Circuit breakers

5. Fluorescent bulbs

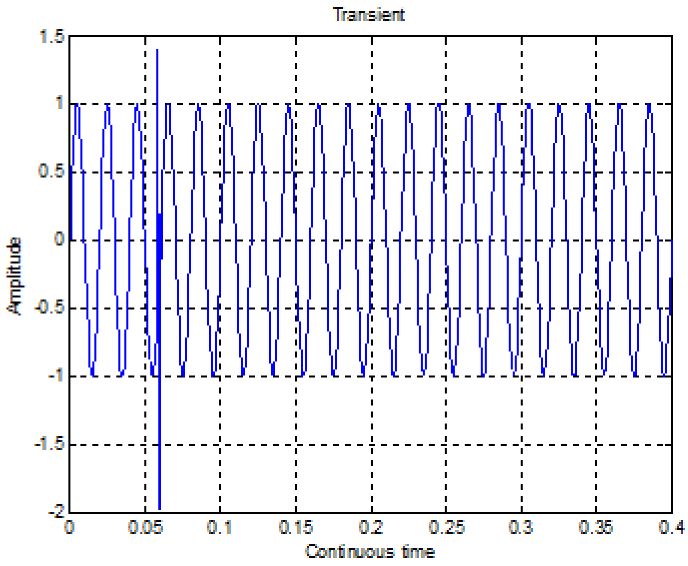

Figure 5.5: Transient

5. HARMONICS

Voltage or current waveforms expect non-sinusoidal shape. The waveform compare to the complete of a range of sine-waves with various size and phases having frequencies that are yield of intensity of power system frequency. It means voltage and current are distorted and much deviated from the basic signal as shown in 5.6.

If we take sine wave as an input the measurements will be the ratio of sum of higher harmonic frequency.

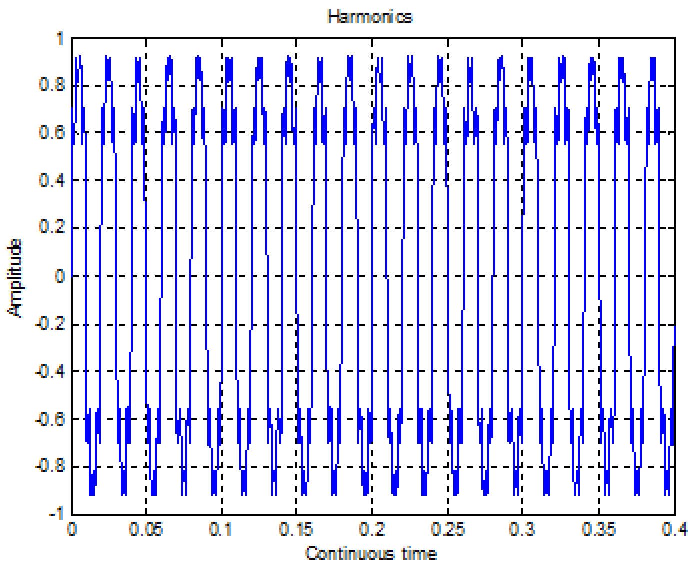

Figure 5.6: Harmonics

6. FLICKER

Free wiring is the most basic purpose behind flickering lights and basic cause of house fires. Shut off the light at the electrical switch before evacuating the fixture to check the wiring as shown in figure5.7. In the event that the apparatus appears as though it may be free or insecure, it's a great opportunity to call a circuit repairmam. This is the thought of unreliable of the visual sensation realized by a light stimulus, whose luminance varies with time. Flicker is basically the response of changing loads of power system.

Flicker is view as the most critical crash of voltage change since it can power the creation condition by causing personal fault and inferior work focus levels. What's more, voltage variances may expose electrical and electronic equipment to adverse impacts that may disturb creation forms with extensive financial expenses.

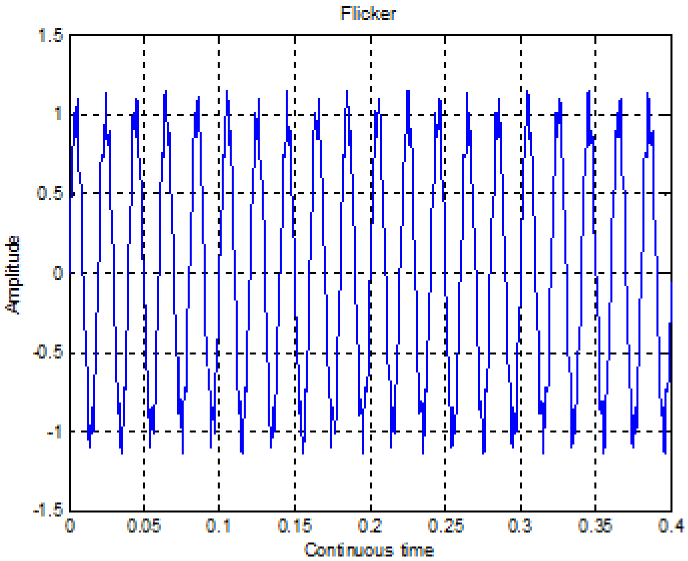

Figure 5.7: Flicker

5.4 EFFECT OF WINDOW LENGTH

A decrease in window length compares to increment in time resolution plus vice a versa. The reason for window length difference is simply to improve the visualization of PQDs. Accordingly, the length is picked with a least trade-off among the time and frequency resolution.

After applying window length on these disturbances we get following results:

- When we applied hamming window on sag disturbance, following output (fig 5.8) was obtained:

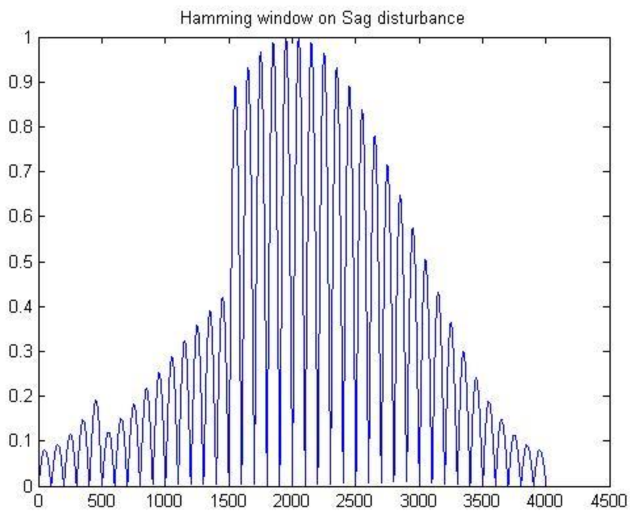

Figure 5.8: Hamming window on sag disturbance

- When we applied hamming window on swell disturbance following output (fig 5.9) was obtained:

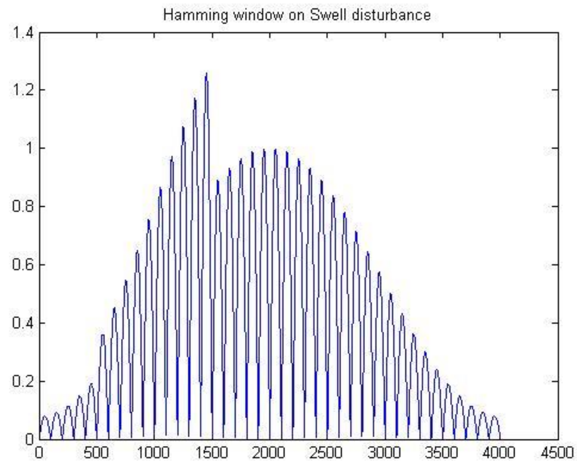

Figure 5.9: Hamming window on swell disturbance

- When we applied hamming window on Interruption following output (fig 5.10) was obtained:

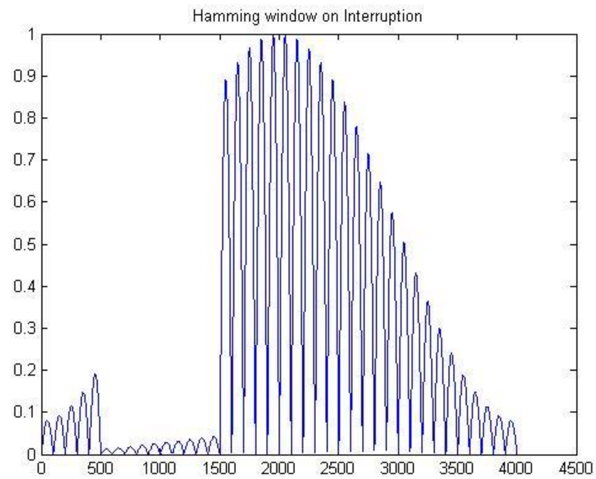

Figure 5.10: Hamming window on Interruption

- When we applied hamming window on Transient following output (fig 5.11) was obtained:

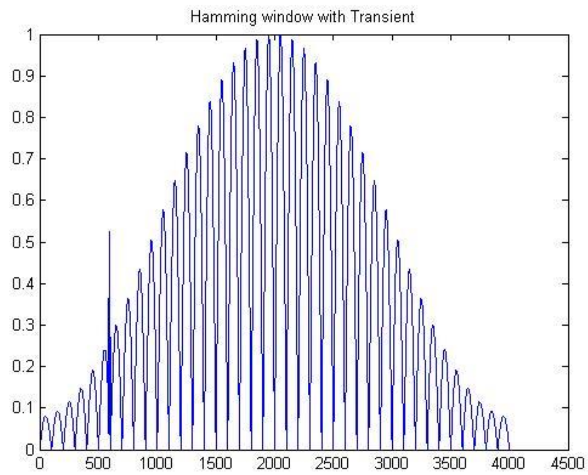

Figure 5.11: Hamming window Transient

- When we applied hamming window on Harmonics following output (fig 5.12) was obtained:

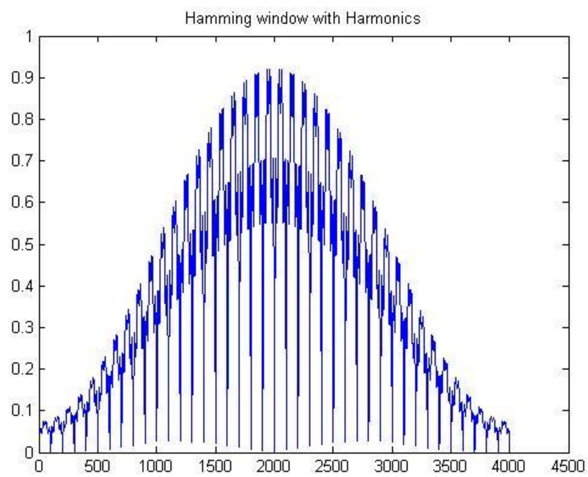

Figure 5.12: Hamming window with harmonics

- When we applied hamming window on Flicker following output (fig 5.13) was obtained:

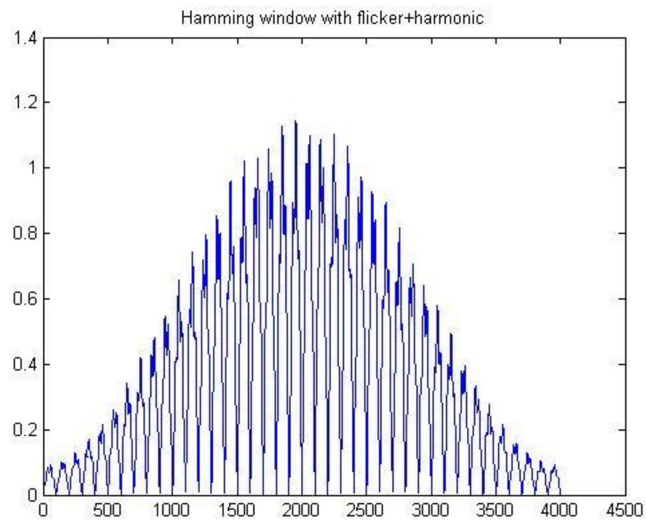

Figure 5.13: Hamming window with flicker

- When we applied hanning window on sag disturbance following output (fig 5.14) was obtained:

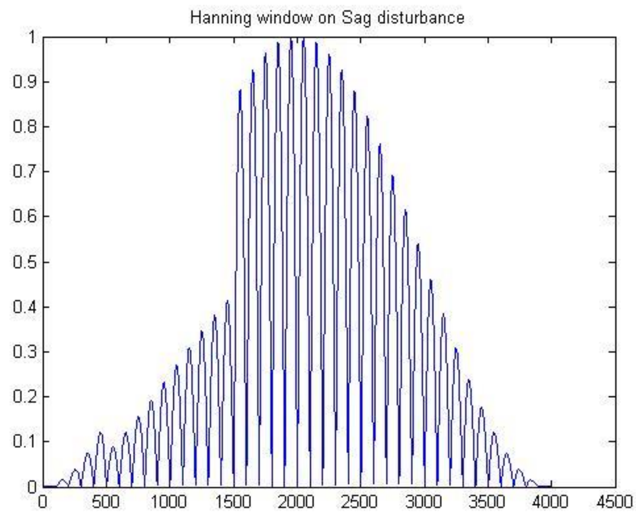

Figure 5.14: Hanning window on sag disturbance

- When we applied hanning window on swell disturbance following output (fig 5.15) was obtained:

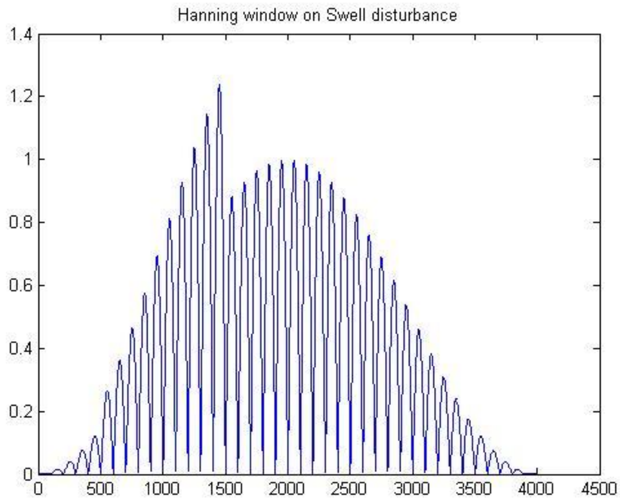

Figure 5.15: Hanning window on swell disturbance

- When we applied hanning window on Interruption following output (fig 5.16) was obtained:

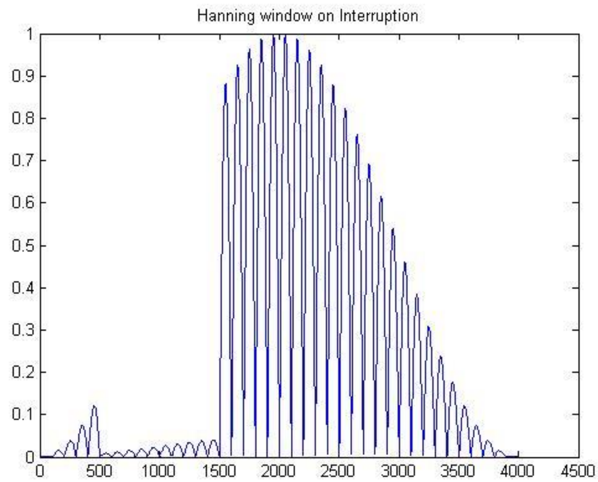

Figure 5.16: Hanning window on interruption

- When we applied hanning window on Transient following output (fig 5.17) was obtained:

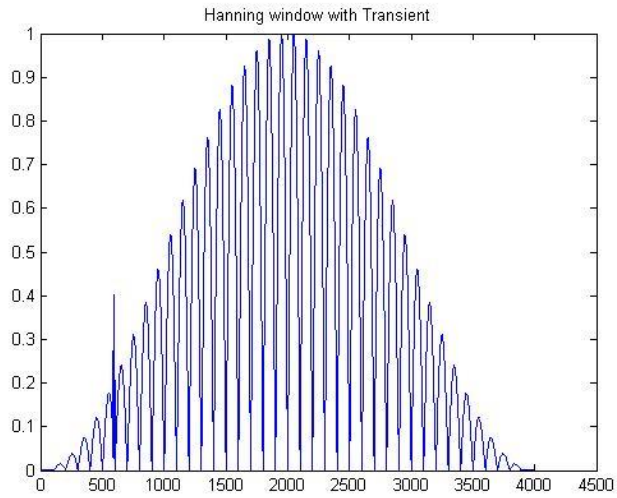

Figure 5.17 Hanning window on transient

- When we applied hanning window on Harmonics following output (fig 5.18) was obtained:

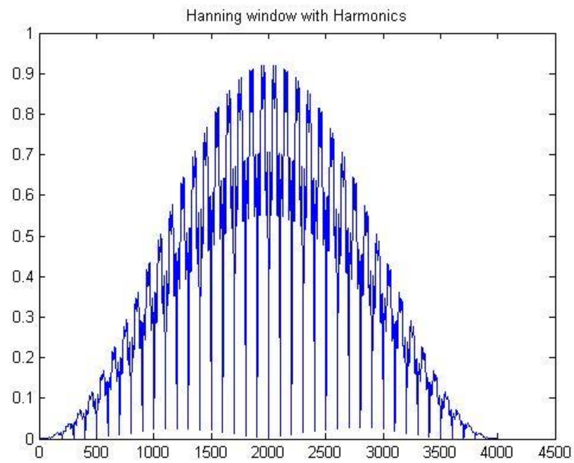

Figure 5.18 Hanning window on harmonics

- When we applied hanning window on Flicker following output (fig 5.19) was obtained:

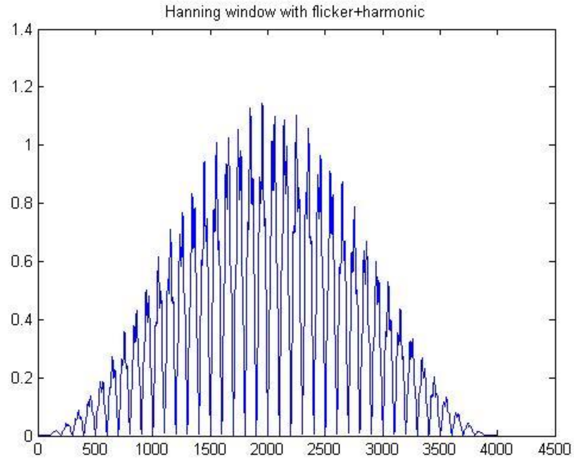

Figure 5.19: Hanning window on flicker

DISCUSSION

In these diagrams hanning and hamming window on power quality disturbances have been applied and have seen time resolution and frequency resolution. There is better visualization of PQD and trying to resolve amplitude that are lower in range. Hanning and Hamming window have sinusoidal shape and Hamming window gives better idea of frequency spectrum by reducing ripple while Hanning window removes discontinuity of signal as it touches zero at ends.

CONCLUSION

As the window size increases, the main lobe width narrows down i.e. decrease giving better frequency resolution (spectral resolution). A decrease in window length compares to increment in time resolution and vice-versa. The reason for window length difference is simply to improve the visualization of PQDs. Windowing is very important to get precise and useful data. It also helps to minimize spectral leakage. Signals are smoother after window is applied and it removes discontinuity. Windowing give us more precise idea of original signal frequency spectrum. Window is applied to disturbances so that we can get better idea of noise so it will be easy to remove from the signal.

FUTURE SCOPE

We will be optimizing window length by encountering different techniques through which the purpose can be accomplished. Designing techniques and algorithms that can be used in real time applications is a challenging domain. A protocol will be created which when applied to a signal helps it to adapt the efficient window size and trains it to produce the desired output.

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APPENDIX

SOURCE CODE

The MATLAB codes of various windows have been mentioned below-

```
EFFECT OF WINDOW ON DISTRUBING SIGNALS
clear all;
close all;
clc;
Sine Signal
t=[0 :0.0001:0.4];
y1=sin(314*t);
figure(1)
plot(t,y1)
title('Pure 50 Hz Sine wave')
winvec = hamming(length(y1)); % hann(length(x));
xdft = (y1'.*winvec);
figure(2)
plot(abs(xdft))
title('Hamming window on input Signal')

Sag Disturbance
%alpha ranges 0.1 to 0.9
t=[0 :0.0001:0.4];
alpha=0.5;
y2=(1-alpha*((heaviside(t-0.05)-heaviside(t-0.15)))).*sin(314*t);
figure(3)
plot(t,y2);
title('Sag disturbance');
winvec = hamming(length(y2)); % hann(length(x));
xdft = (y2'.*winvec);
```

```
figure(4)
plot(abs(xdft))
title('Hamming window on Sag disturbance')

swell wave
%alpha ranges 0.1 to 0.8
t=[0 :0.0001:0.4];
alpha=0.5;
y3=(1+ alpha*((heaviside(t-0.05)-heaviside(t-0.15)))).*sin(314*t);
figure(5)
plot(t,y3);
title('Swell disturbance');
winvec = hamming(length(y3)); % hann(length(x));
xdft = (y3'.*winvec);
figure(6)
plot(abs(xdft))
title('Hamming window on Swell disturbance')


Interruption
alpha ranges 0.9 to 1
t=[0 :0.0001:0.4];
alpha=0.95;
y4=(1-alpha*((heaviside(t-0.05)-heaviside(t-0.15)))).*sin(314*t);
figure(7)
plot(t,y4);
title('Interruption');
winvec = hamming(length(y4)); % hann(length(x));
xdft = (y4'.*winvec);
figure(8)
plot(abs(xdft))
```

title('Hamming window on Interruption')

Harmonics

alpha3,aplha5, alpha7 range from 0.05 to 0.15

```
t=[0 :0.0001:0.4];
alpha3=0.15;
alpha5=0.15;
alpha7=0.15;
alpha1= sqrt(1- alpha3^2-alpha5^2-alpha7^2);
y5= alpha1* sin(314*t)+ alpha3*sin(3*314*t)+ alpha5*sin(5*314*t)+ alpha7*sin(7*314*t) ;
figure(9)
plot(t,y5)
title('Harmonics');
winvec = hamming(length(y5)); % hann(length(x));
xdft = (y5'.*winvec);
figure(10)
plot(abs(xdft))
title('Hamming window with Harmonics')
```

Transient

```
%1 start duration
%t2 end duration
%ampllitude
%fn goes from 300 to 900
fn=500;
amp= 1;
t1=0.06; t2=0.058;
ty= (t1+t2)/2;
t=[0 :0.0001:0.4];
amp= 5;
t1=0.06; t2=0.058;
```

```
ty= (t1+t2)/2;
t=[0 :0.0001:0.4];
y6= sin(2*pi*50*t)+ amp*(heaviside(t-t2)-heaviside(t-t1)).*exp(-t/ty).*sin(2*3.14*fn*t);
figure(11)
plot(t,y6)
title('Transient');
winvec = hamming(length(y6)); % hann(length(x));
xdft = (y6'.*winvec);
figure(12)
plot(abs(xdft))
title('Hamming window with Transient')
```

Flicker

```
%alpha ranges 0.1 to 2
%beta ranges 5 to 10
t=[0 :0.0001:0.4];
alpha=0.15;
beta=7.5;
y9=(1+alpha*sin(beta*314*t)).*sin(314*t);
figure(17)
plot(t,y9)
title('Flicker');
winvec = hamming(length(y9)); % hann(length(x));
xdft = (y9'.*winvec);
figure(18)
plot(abs(xdft))
title('Hamming window with flicker+harmonic')
```

WINDOWING AUDIO SIGNAL

```
fs = 16000;
r = audiorecorder(fs,16, 1);%fs is the sample rate and 16 bits with 1 channel
```

```
recordblocking(r,3);
x = getaudiodata(r, 'double');
p=play(r);
figure(1)
stem(x);
grid on
figure(2)
plot(x);
t = [1/fs: 1/fs: length(x)/fs ];
grid on
figure(3)
y = x(1:160);
y = x(1:320).*hamming(480);%audio signal multiplied with the hamming window of length 320
s=fft(y,480)
s1=abs(s)
s2=s1/max(s1)
grid on
plot(s2)
y = reshape(x,[320 150]);
y = y.*repmat(hamming(320),1,150);
%plot(y))
```