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Comparative Analysis of Hamming and Kaiser Window Technique for SIRF Based WiMax system

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ABSTRACT: *WiMax(Worldwide Interoperability for Microwave Access) is a trademark for a family of telecommunication protocols that provide fixed and mobile internet access. It has key advantages such as capacity improvement per station, increased data rate, standardization. Multicarrier OFDM system has increased the capability of WiMax system because of its high spectral efficiency, robustness against multipath fading and simple receiver structure. In the OFDM system, orthogonally placed sub – carriers are used to carry the data from the transmitter end to the receiver end.Insertion of cyclic prefix is needed to avoid intersymbol interference. The addition of FIR filters in the SIRF basedWiMax system using window techniques helps us to improve the system performance . The basic idea behind the window design is to choose a proper ideal frequency-selective filter and then truncate (or window) its impulse response to obtain a linear-phase and causal FIR filter. Therefore, the emphasis in this method is on selecting an appropriate windowing function and an appropriate ideal filter. For the given filter specifications, we ought to choose the filter length and a window function for the narrowest main lobe width and the smallest side lobe attenuation possible. Our study will be helpful to characterize FIR filter to be integrated into the WiMax based communication system for addaptive channel equalization. Among various window techniques, we studied only Hamming and Kaiser window techniques.*

KEYWORDS: *WiMax, OFDM, FIR filter, SIRF.*

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I. INTRODUCTION

Wireless communication is the transfer of information over a distance without the use of electrical conductors or wires. The term "Wireless" came into public use to refer to a radio receiver or transceiver (a dual purpose receiver and transmitter device), establishing its usage in the field of wireless telegraphy early on; now the term is used to describe modern wireless connections such as in cellular networks and wireless broadband Internet. The term "wireless" has become a generic and all-encompassing word used to describe communications in which electromagnetic waves or RF carry a signal over part or the entire communication path.

The most basic level of communications is the capability to send a signal from one place to another. It is important to the understanding of how wireless data communications works. Wired Communication are based on mappings of voltage levels to symbols. For example, 5V may indicate the binary symbol “1”, while 0V indicates the symbol “0”. The signaling on wireless communications involves manipulating the characteristics of a sine wave in such a way that messages can be sent on it[1].

Wireless communication may be via: radio frequency communication, microwave communication, for example long-range line-of-sight via highly directional antennas, or short-range communication infrared (IR), short-range communication, for example from remote controls or via IRDA. Applications may involve point-to-point communication, point-to-multipoint communication, broadcasting, cellular networks and other wireless networks[1].

Wireless communications have some special characteristics.Firstly, wireless communications relies on a scarce resource – namely, radio spectrum – the property rights for which were traditionally vested with the state. In order to foster the development of wireless communications (including telephony and broadcasting) those assets were privatized. Secondly, use of spectrum for wireless communications required the development of key complementary technologies; especially those that allowed higher frequencies to be utilized more efficiently. Finally, because of its special nature, the efficient use of spectrum required the coordinated development of standards. Those standards in turn played a critical role in the diffusion of technologies that relied on spectrum use[2].

There are several advantages of using wireless communication like Increased efficiency, Greater flexibility, Mobility, Reduced costs, Neat and easy Installation, More user, and Rarely out of touch[3], [4].

Wireless communication has demonstrated it importance in the past decade as a fundamental driver of economic growth, first in the form of cellllular networks and more recently for computer networks (WiFi, WiMax). The next decade is likely to boring equally dramatic developments, driven by: i)increasing demand for bandwidth-hungry services such as HDTV and access to data files of rapidly increasing size; ii)increasing rates available from fixed networks (DSL at increassed rates, 1000-base-T, FTTH and FTTB), which users will then expect wireless to match; iii)the efficiency gains available from coordinated networks of autonomous devices and sensors, for example for security and surveillance.

The full extent of these developments cannot be predicted, but they are sure to include: i)Coverged broadband services: "triple-play" services (speech, data, video) at rates up to 1 Gbit/s for users in any environment, delivered by standard/system-agonostic means; ii)Ubiquitous computing which is the distributed intelligence in a multitude of devices operating autonomously; iii)Wireless sensor networks for suveillance and environmental sensing.

These applications pose a number of severe challenges for wireless communications. Which are given below:

- Increase in system bandwidth efficiency by around an order of magnitude;
- For Quality of service (QoS) aware networks;
- Coping with new and heterogeneous system architectures, such as mesh networks; multi-hop networks like peer-to-peer communication and multi-standard networks;

Coordination of a multiplicity of autonomous devices using heterogeneous devices using heterogeneous standards which include efficient, timely transmission of very large volumes of short messages.

In the perspective of Bangladesh there are so many probabilities to develop different techniques to establish powerful wireless communication system. Now-a-days we use advanced techniques such as , WiMax, 2G ,3G, 4G .but to keep pace with the developed countries we have to apply these technologies more accurately and improve their performance from the context of the special case of this densly populated under developed country. From international perspective, we find, that technologies are becoming modern as well as advanced. Various models and techniques are improving so fast in order to make the wireless communication system more and more perfect and stronger. The WiMax technique is much more attractive to us because of it's techniques which are becoming applicable very widely now-a-days.In case of OFDM based WiMax system , SIRF filter is used to shorten the impulse response perfectly, because in OFDM system intersymbol interference occurs. So it has motivated us to study SIRF filter and specially the characteristic of FIR filter wich is an integral part of SIRF filter based system.

This paper is organized in different sections. Section one shows the introduction, basic wireless communication is shown in section two, section three demonstrate WiMax technology, section four shows adaptive channel equalization in WiMax, section five shows simulation study of a digital FIR filter and section six shows conclusion.

II. BASIC OF WIRELESS COMMUNICATION

Transfer of information between the transmitting antenna and the receiving antenna is achieved by means of electromagnetic waves in wireless communication system. The mobile radio channel places fundamental limitations on the performance. The transmission path between the transmitter and the receiver most of the time is severely obstructed by buildings, mountains and foliage which causes reduction in the signal strength and also path-loss. Radio channels are extremely random and do not offer easy analysis. Even the speed of motion impacts how rapidly the signal fades as a mobile terminal moves in space[5]. Modeling the radio channel has historically been one of the most difficult parts of mobile radio system design, and is typically done in a statistical fashion, based on measurements made specifically for an intended communication system or spectrum allocation[6].

Models for path loss can be categorized into three types (Fig. 1):i) Empirical Models, ii) Deterministic Models, iii) Stochastic Models.

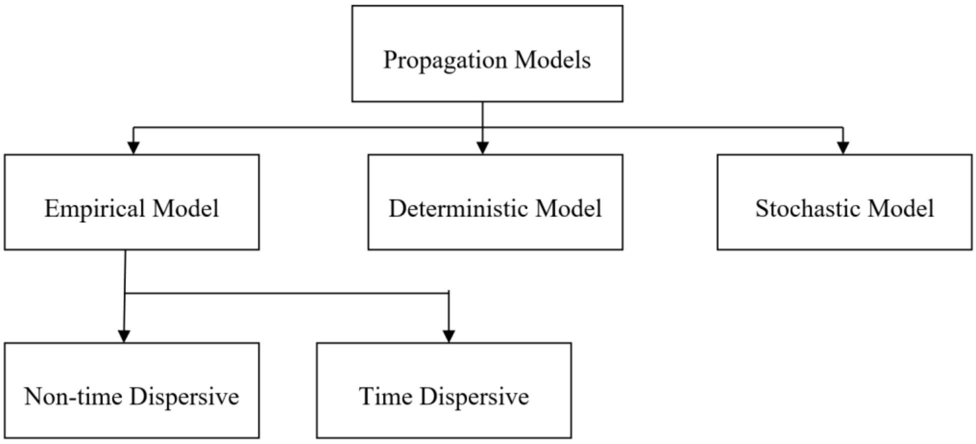


Fig. 1. Different types of Propagation Models.

In wireless communications, fading is deviation of the attenuation that a carrier-modulated telecommunication signal experiences over certain propagation media. The fading may vary with time, geographical position and/or radio frequency, and is often modeled as a random process. A fading channel is a communication channel that experiences fading.

Signal fading is caused by multipath effect. The presence of reflectors in the environment surrounding a transmitter and a receiver creates multiple paths that a transmitted signal can traverse. As a result, the receiver sees the superposition of multiple copies of the transmitted signal, each traversing a different path. Each signal copy will experience differences in attenuation, delay and phase shift while travelling from the source to the receiver. This can result in either constructive or destructive interference, amplifying or attenuating the signal power seen at the receiver.

A common example of multipath fading is the experience of stopping at a traffic light and hearing an FM broadcast degenerate into static, while the signal is re-acquired if the vehicle moves only a fraction of a meter. The loss of the broadcast is caused by the vehicle stopping at a point where the signal experienced severe destructive interference. Cellular phones can also exhibit similar momentary fades.

Wireless communication systems require signal processing techniques that improve the link performance in mobile radio environments. There are three techniques which can be used independently or in tandem to improve received signal quality and link performance over small-scale times and distance[6].Equalization, Diversity and Channel Coding.

In electronics modulation is the process of varying one or more properties of a high-frequency periodic waveform called the carrier signalwith a modulation signal which typically contains information to be transmitted.

In telecommunication modulation is the process of conveying a message signal. For example a digital bit stream or an analog audio signal, inside another signal that can be physically transmitted. A device that performs modulation is known as a modulator and a device that performs the inverse operation of modulation is known as a demodulator (sometimes detector or demod). Now-a-days digital modulations are widely used. The move to digital modulation provides more information capacity, compatibility with digital data services, higher data security, better quality communications and quicker system availability[7].There are various types of digital modulations such as Binary Phase Shift Keying (BPSK),M-ary Phase Shift Keying (MPSK), M-ary Quadrature Amplitude Modulation (QAM),M-ary Frequency Shift Keying (MFSK), Differential Phase Shift Keying (DPSK), Quadrature Phase Shift Keying (QPSK), Offset QPSK,Pi/4 QPSK[8].

III. WIMAX TECHNONOLGY

WiMax is a wireless technology put forth by the WiMax Forum that is one of the technologies which is being used for 4G networks.It can be used in both point to point and the typical WAN type configurations that are also used by 2G and 3G mobile network carriers.Its formal name is IEEE standard 802.16.WiMax (Worldwide Interoperability for Microwave Access) is a trademark for a family of telecommunications protocols that provide fixed and mobile Internet access. In Ref. [9], [10], in 2005 WiMax revision provided bit rates up to 40 Mbit/s where as in 2011 it is updated up to 1 Gbit/s for fixed stations. The name "WiMax" was created by the WiMax Forum, which was formed in June 2001 to promote conformity and interoperability of the standard. The forum describes WiMax as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL" [11].

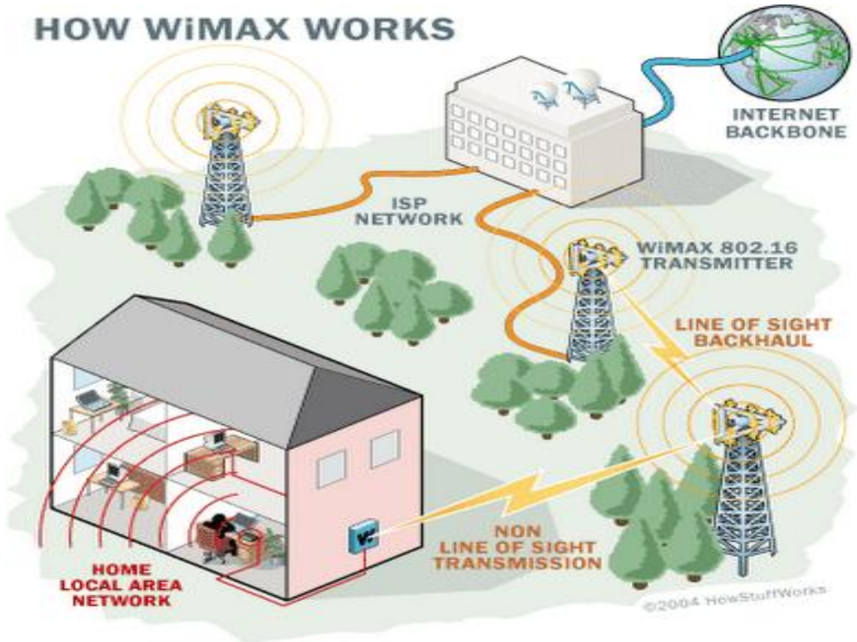


Fig. 2. Working method of WiMax

Table 1 Specifications of WiMax

Parameter	**Value**
Range: Line of Sight(LOS)	~50 km
Range: Non line of sight(NLOS)	~10 km
Maximum Data Speed	~70 Mbps
Licensed Frequency Band	2-11 GHz
Un-licensed Frequency Band	10-66 GHz
Switching	Packet
Multiplexing	SOFDMA
Modulation	BPSK,QPSK,16QAM,64QAM

OFDM is becoming the chosen modulation technique for wireless communications. OFDM can provide large data rates with sufficient robustness to radio channel impairments. Many research centers in the world have specialized teams working in the optimization of OFDM for countless applications.

IV. ADAPTIVE CHANNEL EQUALIZATION IN WIMAX.

4.1 Wireless Channels

An important requirement for assessing technology for Broadband Fixed Wireless Applications is to have an accurate description of the wireless channel. Wireless channels operate through electromagnetic radiation from the transmitter to the receiver. In principle, one could solve the electromagnetic field equations, in conjunction with the transmitted signal, to find the electromagnetic field impinging on the receiver antenna. This would have to be done taking into account the obstructions caused by ground, buildings, vehicles, etc. in the vicinity of this electromagnetic wave[12]. In WiMax communication systems, the effective channel is the convolution of the transmission filter, physical channel, receiver filters and shortening filters.

4.2 Adaptive Channel Equalization

An adaptive equalizer is an equalizer that automatically adapts to time-varying properties of the communication channel. For a reliable digital transmission system, it is crucial to reduce the effects of ISI and it is where the equalizers come on the scene. The purpose of adaptive channel equalization is to compensate for signal distortion in a communication channel. During the transmission process, the signal that contains information might become distorted. To compensate for this distortion, an adaptive filter can be applied to the communication channel. The adaptive filter works as an adaptive channel equalizer. Fig. 3 shows adaptive equalization process. Here, x (n) is the signal that is transmitted through the communication channel, and y (n) is the distorted output signal.

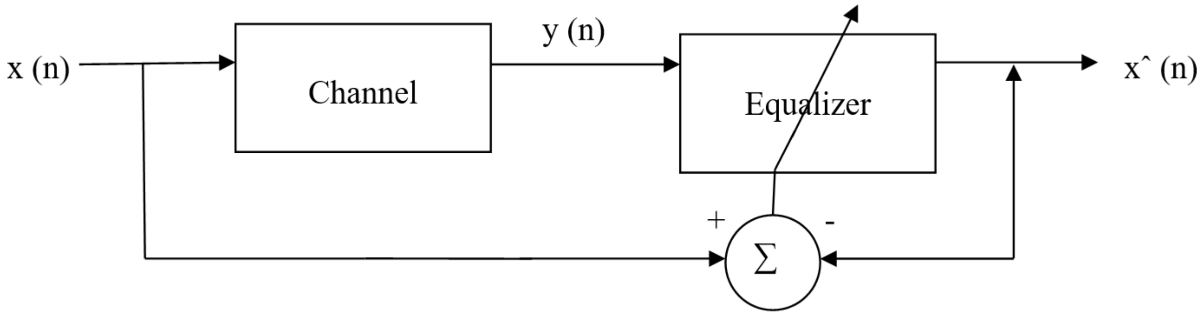


Fig. 3. Adaptive Channel Equalization

4.2.1 Adaptive Channel Equalization in WiMax

WiMax aims to provide broadband wireless access to residential and small business applications, as well as to enable Internet access in countries without any existing wired infrastructure in place. So adaptive channel equalization forWiMax has become an issue of great interest. Orthogonal Frequency Division Multiplexing (OFDM) is widely accepted as an attractive transmission technique in wireless communication system.[41] It is also a very promising technique for delivering high data rate multimedia services. The performance of such systems is limited by the severe effects of multiple delay spread and intersymbolic interference, as is described in the previous sections. For retaining the orthogonality of subcarriers and overcome these effects, a cyclic prefix is inserted instead of simply inserting guard interval. For CP length equal to L, the CP is the last L samples of original symbol. If the maximum delay of the multipath channel does not exceed the CP length, the OFDM system would be ISI free by removing the guarding interval. For WiMax systems, its delay spread is typically over several micro-seconds which is easily longer than the guarding interval. Therefore, it is very challenging to maintain the system BER performance for non-line-of-sight (NLOS) channels at high data rate transmission with high bandwidth (e.g. 20MHz) since high sampling rate is needed and the CP length is often much shorter than the physical channel impulse response (CIR).

For the channel has longer delay spread than the CP length, we can apply a finite impulse response (FIR) shortening filter in the receiver. The purpose of this filter is to shorten the impulse response of the effective channel, which is the convolution of the transmission filter, physical channel, receiver filters, and shortening filters. If the shortened response is less than CP length, the system would be ISI free.

4.3FIR Filter

If the unit impulse response of an LTI(Linear Time Invarient) system is of finite duration, then the system is called a finite-duration impulse response(FIR) filter. For an Fir filter impulse response, h(n)=0 for n < n_1 and for n > n_2 . The following equation describes a causal FIR filter:

$$\mathbf{y(n)} = \sum_{m=0}^{M} \mathbf{b_m\, x(n-m)} \qquad (1)$$

So, h(0) = b_0, h(1) = b_1,…, h(M) = b_m, while otherh(n)'s are 0.

4.3.1 Design of a FIR filter

Before designing a filter, we must have some specifications[13].

The magnitude specifications are given in one of two ways. The first approach is called absolute specifications, which provide a set of requirements on the magnitude response function $|H(e^{j\omega})|$. The second approach is called relative specifications, which provide requirements in decibels (dB), given by

$$\textbf{dB scale} = -20\log_{10}\frac{|H(e^{j\omega})|}{|H(e^{j\omega})|_{max}} \geq 0 \qquad (2)$$

Absolute specifications are as follows:

- Band [0, ω_p] is called the passband, and δ_1 is the tolerance (or ripple) that we are willing to accept in the ideal passband response,
- Band [ω_s , π] is called the stopband, and δ_2 is the corresponding tolerance (or ripple), and

- Band [ω_p, ω_s] is called the transition band, and there are no restrictions on the magnitude response in this band.

Relative specifications are as follows:

- R_p is the passband ripple in dB, and
- As is the stopband attenuation in dB.

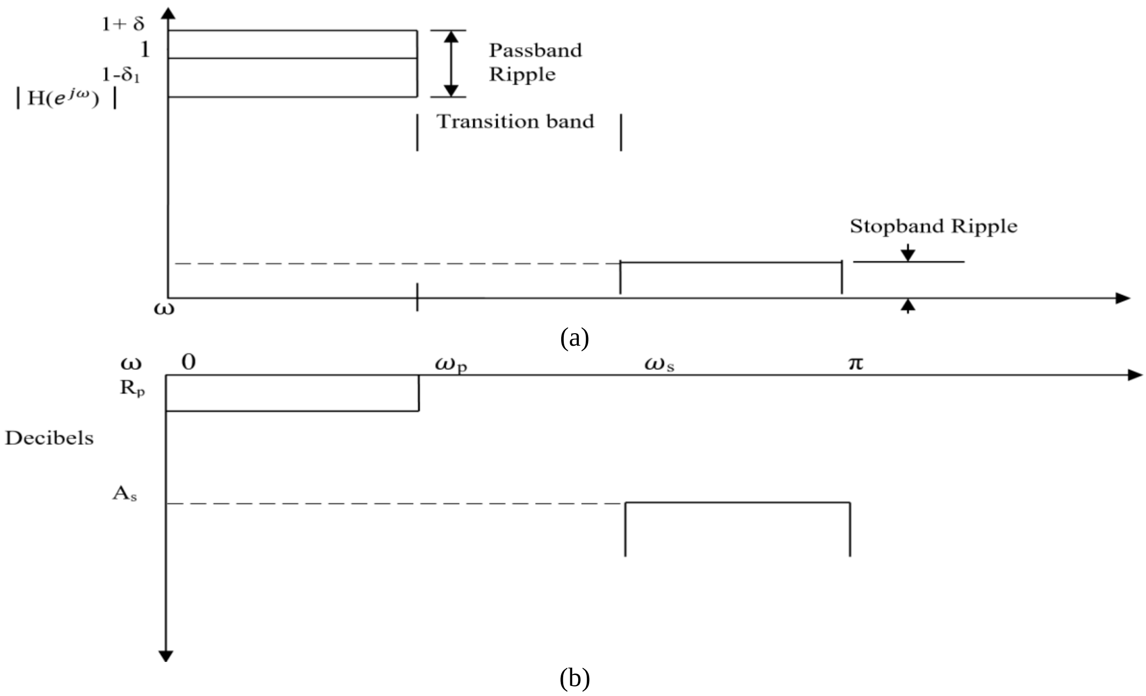


Fig. 4. FIR filter specifications (a) Absolute (b) Relative[13].

The parameters given in the above two specifications are related. Since $|H(e^{j\omega})|_{max}$ in absolute specifications is equal to (1+ δ_1), we have

$$R_p = -20 \log_{10}\frac{1-\delta1}{1+\delta1} > 0 \quad (3)$$

and

$$A_s = -20 \log_{10}\frac{\delta2}{1+\delta1} > 0 \quad (4)$$

4.3.2 Shortening Impulse Response Filter (SIRF)

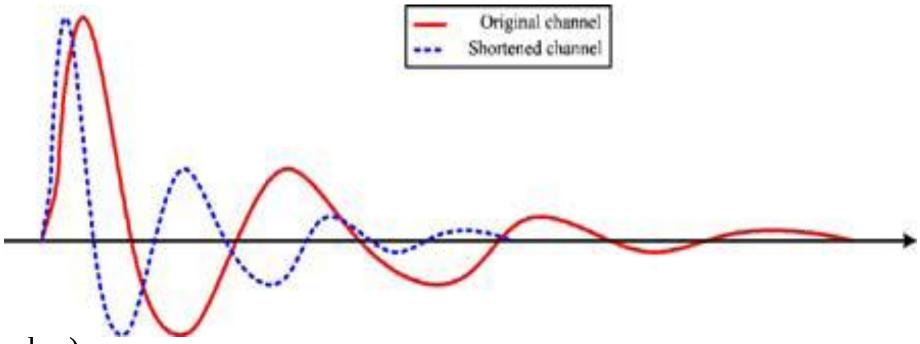
In OFDM system, when the maximum delay is longerthan the CP duration which is at most 1/4 symbol duration,the ISI effect is irreducible from the system. If a shortenedimpulse response filter (SIRF) w(n) with length W isappliedbefore removing CP block in the receiver, which isindicated in Fig. 3.10, the output of the SIRF can beexpressed as,

$y(n) = (h(n)*w(n))*x(n) = heff(n)*x(n)$(5)

Where,

- x(n)= the transmitted data
- * =theconvolution operator$h_{eff}(n)$ = the effective channelimpulse response after shortening.

impulse response



n(sample number)

Fig. 5. The impulse response of original channel andshortened channel.

V. SIMULATION STUDY OF A DIGITAL FIR FILTER USING WINDOW TECHNIQUES

Among various window techniques we will study Hamming and Kaiser window techniques.

5.1 Hamming Window Technique

The Hamming window is one of the most popular and most commonly used windows. The characteristics of this window techniques are-

- A filter designed with the Hamming window has minimum stopband attenuation of 53dB, which is sufficient for most implementations of digital filters.
- The transition region is somewhat wider than that of the Hann and Bartlett-Hanning windows, whereas the stopband attenuation is considerably higher.
- Unlike minimum stopband attenuation, the transition region can be changed by changing the filter order.
- The transition region narrows, whereas the minimum stopband attenuation remains unchanged as the filter order increases[12].

5.2 Kaiser Window Technique

Kaiser window is known as optimal window. An optimal window is a function that has maximum attenuation according to the given width of the main lobe[14]. The characteristics of this window technique are as follows:

- The Kaiser window function has a variable parameter, beta, which trades off-side lobes for main lobe.
- The main disadvantage of the window is that one has to compute Bessel function to get the window coefficients[13], [15].

5.3 Effect of Kaiser Window Technique

To find out the effect of Kaiser window we firstly varied w_s while keeping other parameters like w_p, R_p, A_s constant. Secondly, we varied w_s while choosing another value of w_p and keeping other parameters value as previous. When $w_s < w_p$, the length of the filter M is negative which is not acceptable. So, considering specifications where $w_s > w_p$ we have designed the filters. The results of the simulation studies using Kaiser window technique are given in the figure below-

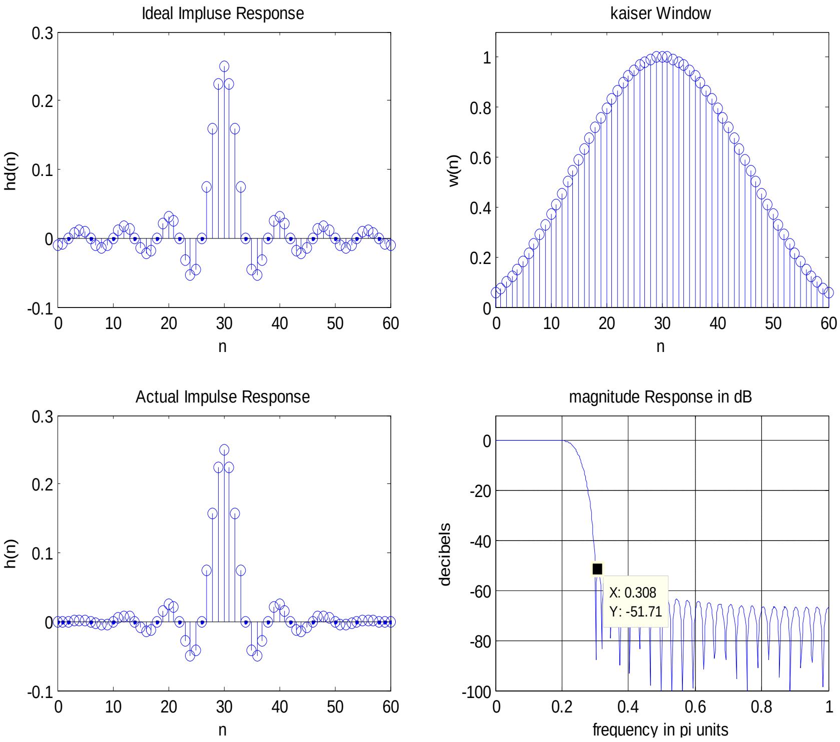


Fig. 6.FIR Filter Characteristic curve for $w_p = 0.2\pi$, $R_p = 0.25\ dB$
$w_s = 0.3\pi$, $A_s = 50\ dB$

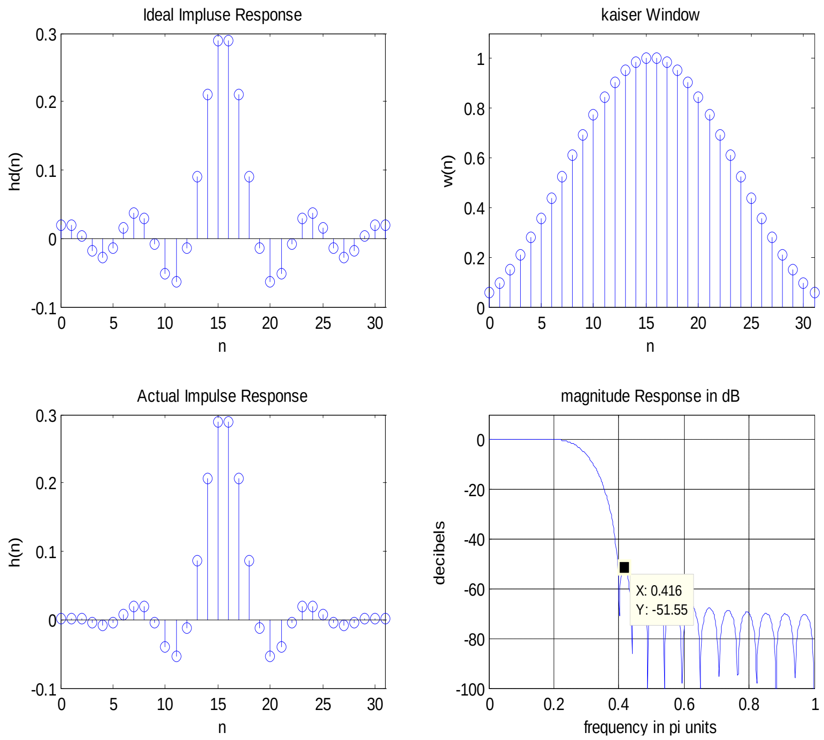


Fig. 7.FIR Filter Characteristic curve for $w_p = 0.2\pi$, $R_p = 0.25\ dB$
$w_s = 0.4\pi$, $A_s = 50\ dB$

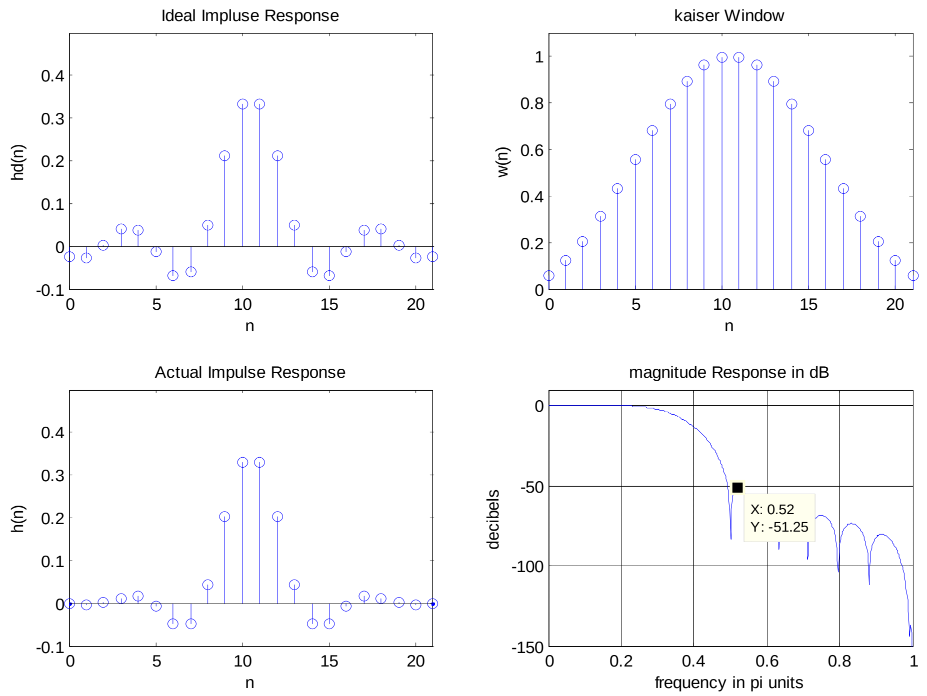


Fig. 8.FIR Filter Characteristic curve for $w_p = 0.2\pi$ **,** $R_p = 0.25\ dB$ $w_s = 0.5\pi$ **,** $A_s = 50\ dB$

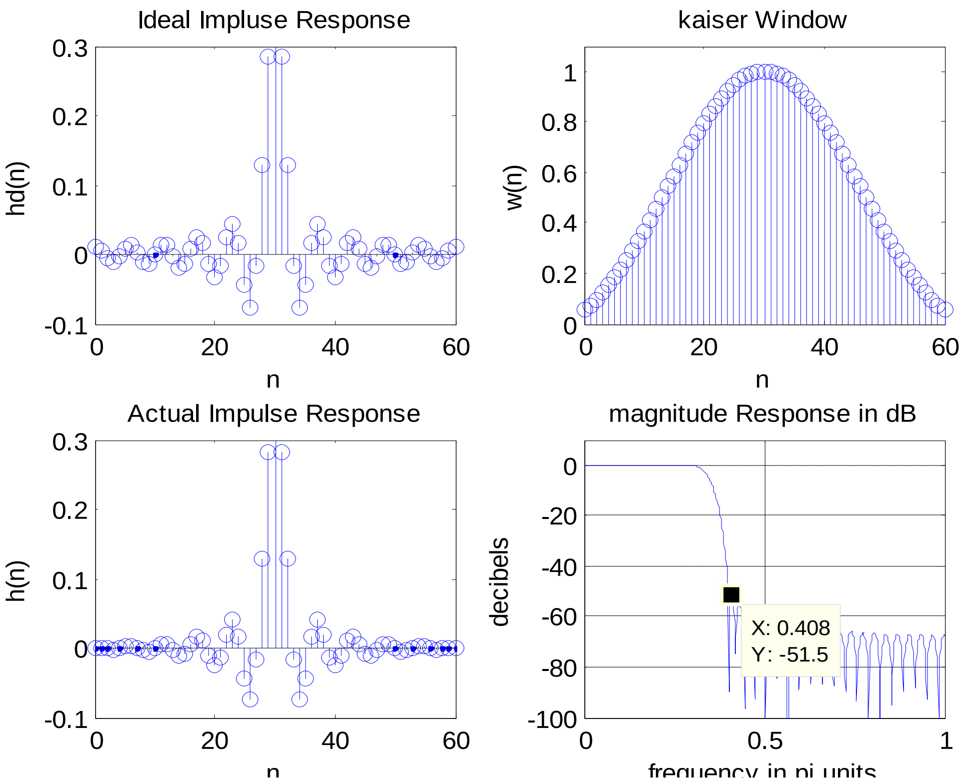


Fig. 9.FIR Filter Characteristic curve for $w_p = 0.3\pi$ **,** $R_p = 0.25\ dB$ $w_s = 0.4\pi$ **,** $A_s = 50\ dB$

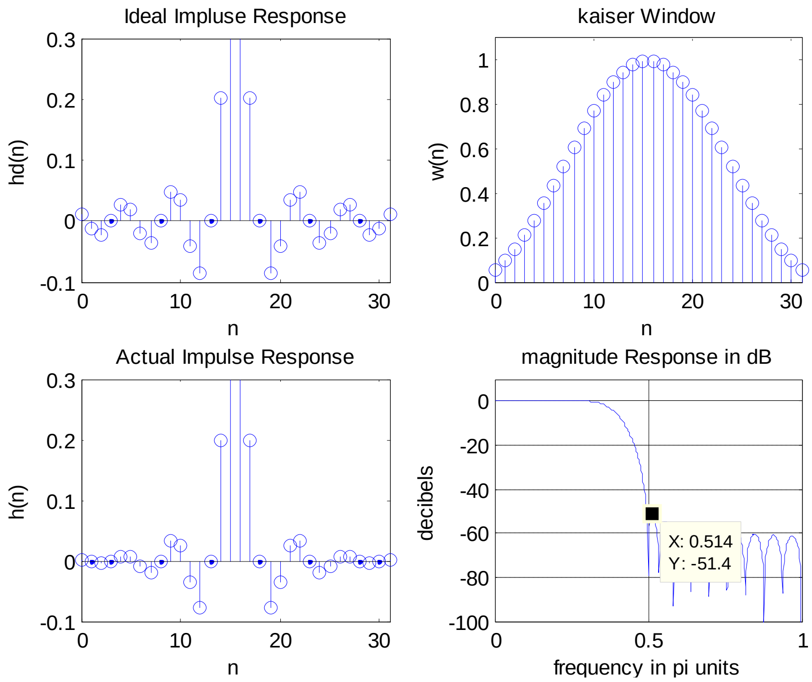


Fig. 10. **FIR Filter Characteristic curve for $w_p = 0.3\pi$, $R_p = 0.25\ dB$ $w_s = 0.5\pi$, $A_s = 50\ dB$**

5.5 Effect of Hamming Window Technique

To find out the effect of Hamming window we firstly varied w_s while keeping other parameters like w_p, R_p, A_s constant. Secondly, we varied w_s while choosing another value of w_p and keeping other parameters value as previous. When $w_s < w_p$, the length of the filter M is negative which is not acceptable. So, considering specifications where $w_s > w_p$ we have designed the filters. The results of the simulation studies using Kaiser window technique are given in the figure below-

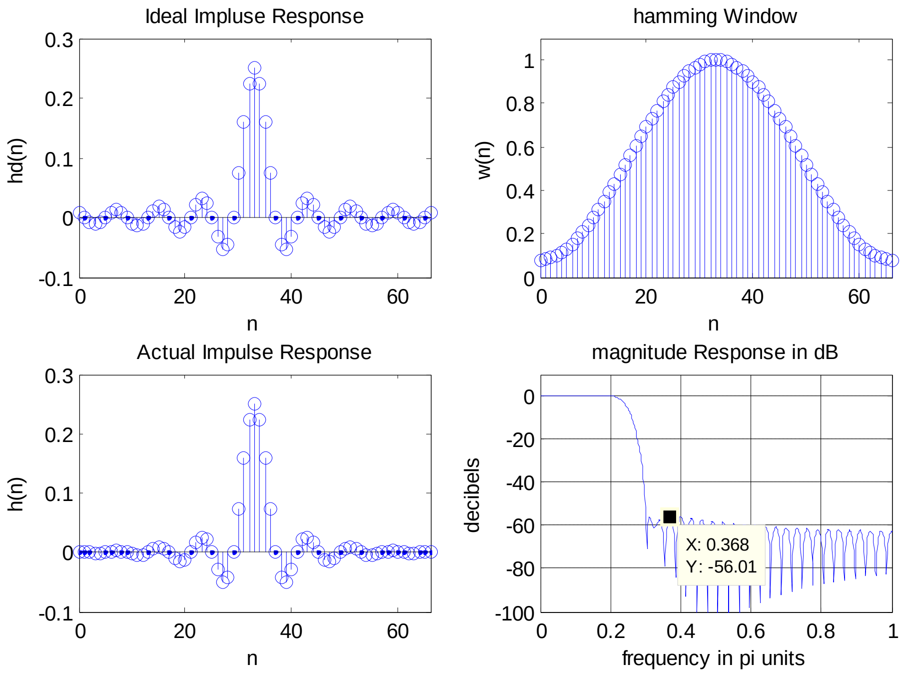


Fig. 11. **FIR Filter Characteristic curve for $w_p = 0.2\pi$, $R_p = 0.25\ dB$ $w_s = 0.3\pi$, $A_s = 50\ dB$**

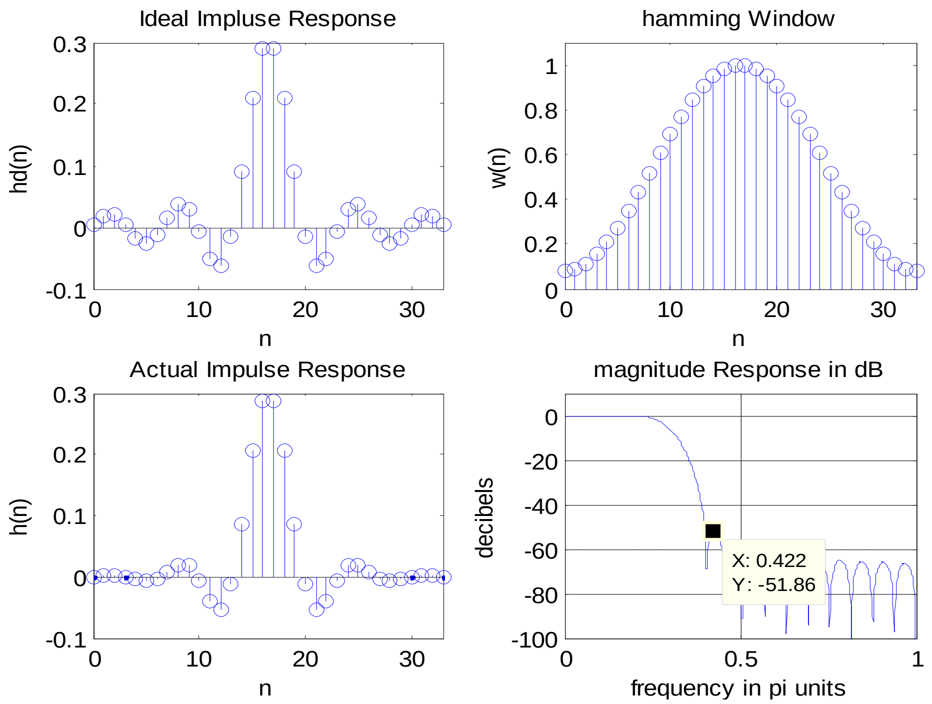


Fig. 12. **FIR Filter Characteristic curve for** $w_p = 0.2\pi$, $R_p = 0.25\ dB$ $w_s = 0.4\pi$, $A_s = 50\ dB$

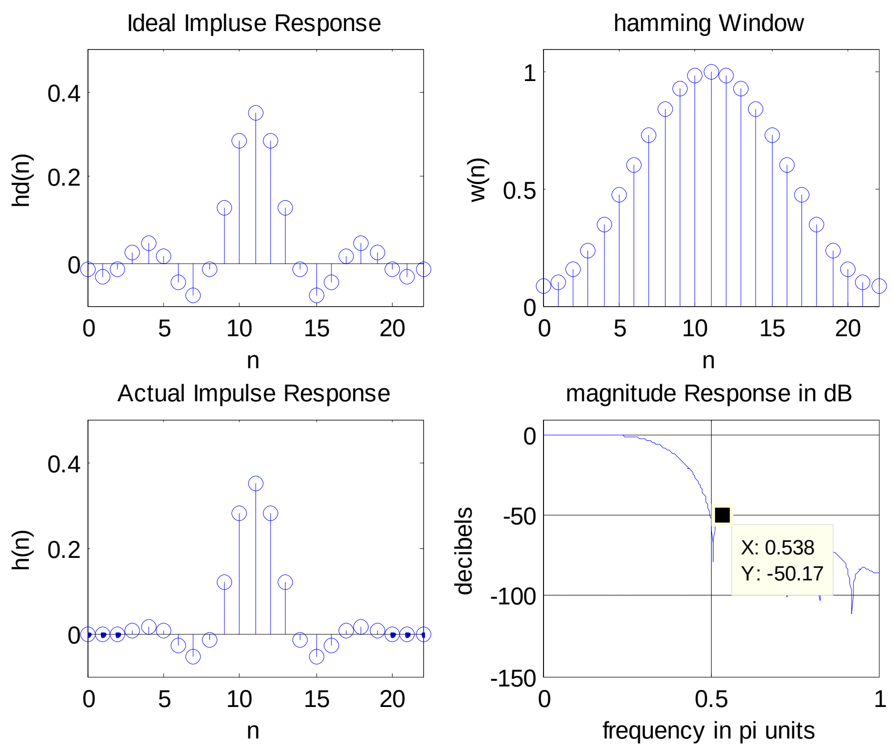


Fig. 13. **FIR Filter Characteristic curve for** $w_p = 0.2\pi$, $R_p = 0.25\ dB$ $w_s = 0.5\pi$, $A_s = 50\ dB$

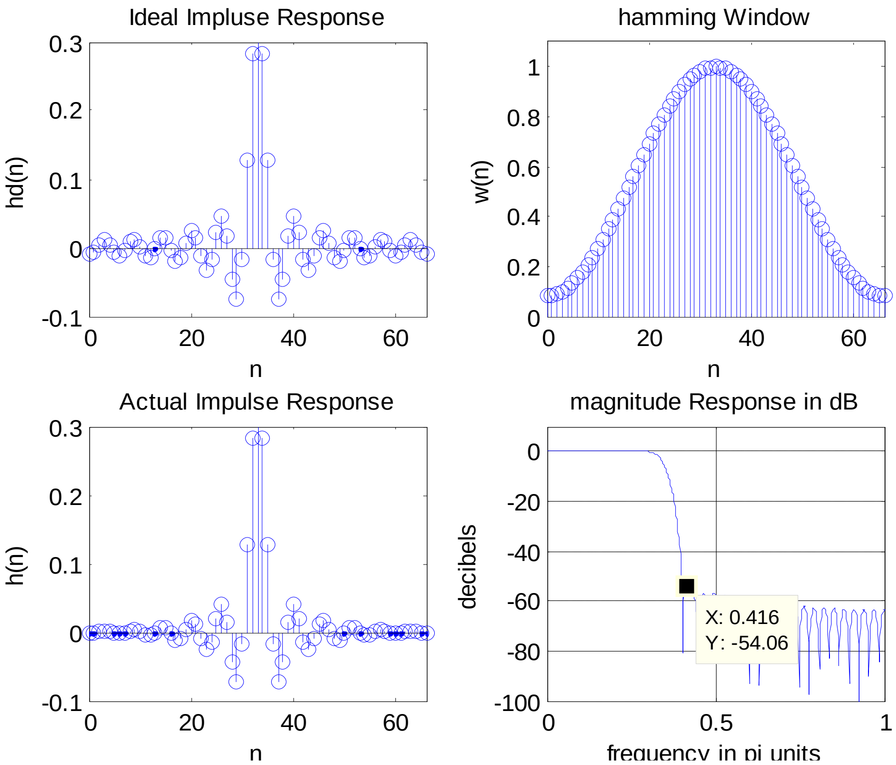


Fig. 14. FIR Filter Characteristic curve for $w_p = 0.3\pi$, $R_p = 0.25\ dB$
$w_s = 0.4\pi$, $A_s = 50\ dB$

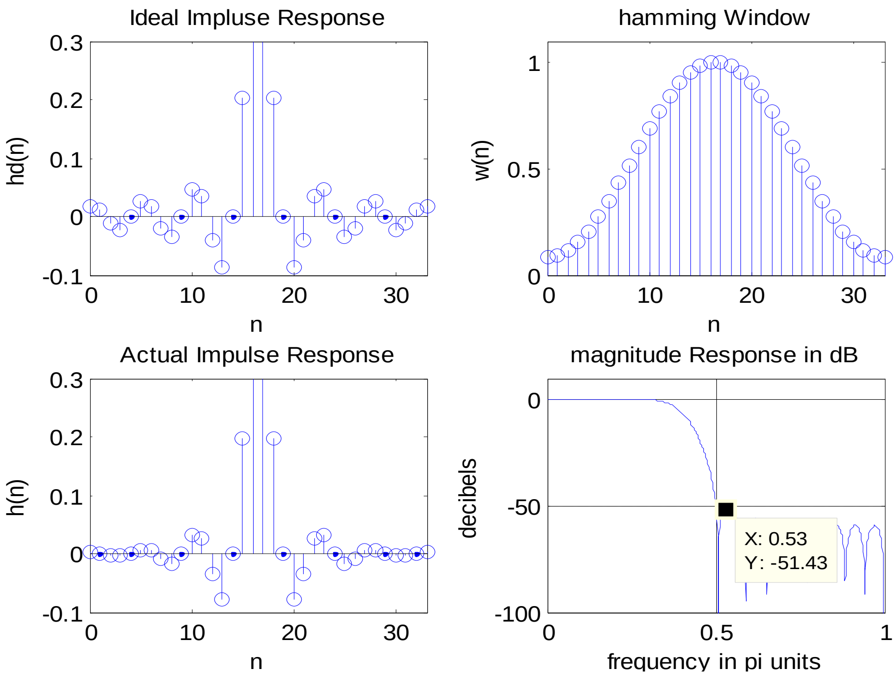


Fig. 15. FIR Filter Characteristic curve for $w_p = 0.3\pi$, $R_p = 0.25\ dB$
$w_s = 0.5\pi$, $A_s = 50\ dB$

5.5Comparison of Hamming & Kaiser Window Techniques

The results obtained from the simulations of the Kaiser and Hamming Window Techniques are listed in the tables below for comparison of the data obtained of the two window techniques –

Table 2 Comparison of Kaiser and Hamming window technique of Fig. 5 &10

Specifications	Kaiser Window	Hamming Window
W_p	0.2π	0.2π
W_s	0.3π	0.3π
R_p	0.0442 dB	0.0394 dB
A_{sc}	52 dB	52 dB

Table 3 Comparison of Kaiser and Hamming window technique of Fig.6&11

Specifications	**Kaiser Window**	**Hamming Window**
W_p	0.2π	0.2π
W_s	0.4π	0.4π
R_p	0.0334 dB	0.0477 dB
A_{sc}	52 dB	52 dB

Table 4 Comparison of Kaiser and Hamming window technique of Fig. 7&12

Specifications	Kaiser Window	Hamming Window
W_p	0.2π	0.2π
W_s	0.5π	0.5π
R_p	0.0312 dB	0.0577 dB
A_{sc}	51 dB	50 dB

Table 5 Comparison of Kaiser and Hamming window technique of Fig. 8&13

Specifications	**Kaiser Window**	**Hamming Window**
W_p	0.3π	0.3π
W_s	0.4π	0.4π
R_p	0.0433 dB	0.0458 dB
A_{sc}	51 dB	50 dB

Table 6 Comparison of Kaiser and Hamming window technique of Fig. 9&14

Specifications	**Kaiser Window**	**Hamming Window**
W_p	0.3π	0.3π
W_s	0.5π	0.5π
R_p	0.0459 dB	0.0550 dB
A_{sc}	51 dB	49 dB

VI.CONCLUSION

WiMax technology enables us the delivery of last mile wireless broadband access as an alternative to cable and DSL. OFDM can provide large data rates with sufficient robustness to radio channel impairments.So, OFDM is becoming the chosen modulation technique for wireless communications.Adaptive channel equalizer is used to minimize the signal distortion in a communication channel. To shorten the impulse response of the effective channel, SIRF filter is used. Here we discussed about Hamming and Kaiser window technique. Using MATLAB, we varied Wp and Ws, and we observed Asc and Rp for five different cases.To design an efficient digital FIR filter, selectivity of the filter should be high enough that is the transition region should be narrower and we need higher suppression of undesirable spectrum which means we need higher stopband attenuation.In both window technique, passband ripples are satisfied by the design. Actual stopband attenuation is higher than the minimum stopband attenuation for first fourth cases in both window techniques. But, at fifth case, Asc is less than as in case of Hamming window.To increase the actual stopband attenuation the filter order needs to be changed in order to satisfy the design.

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