

A Compact Microstrip Band pass Filter for UWB (Ultra-Wide Band) Harmonic Suppression

Submitted in partial fulfillment of the requirements for the award of Bachelor of
Engineering degree in Electronics and Communication Engineering.

By

K. NOOTHAN (37130180)



**DEPARTMENT OF ELECTRONICS AND COMMUNICATION
ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONICS ENGINEERING
SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade “A” by NAAC | 12B Status by UGC | Approved
by AICTE.**

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

March – 2021



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JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI -600119

www.sathyabama.ac.in

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of K NOOTHAN (37130180), who carried out the project entitled “A Compact Microstrip Band pass Filter for UWB (Ultra-Wide Band) Harmonic Suppression” under our supervision from November 2020 to April 2021.

Internal guide

Dr. B Rajasekar B.E, MTech, Ph.D.

Associate Professor, Department of ECE

Head of the department

Dr. T Ravi, M.E., Ph.D.

Submitted for Viva voce examination held on _____

Internal Examiner

External Examiner

DECLARATION

I **K NOOTHAN (37130180)** here by declare that the project Report entitled “A Compact Micro Strip Bandpass Filter for UWB (Ultra – wide Band) Harmonic Suppression” under the guidance of **Dr. B Rajasekar** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electronics and Communication Engineering.

DATE:

1) K. Noothan

PLACE:

SIGNATURE OF THE CANDIDATE

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Abstract

In addition to the antenna, the front-end part of wireless communication equipment is often consisting of filter and other elements. The main aim of this project is to design an ultra-compact design of filter for Ultra-Wide Band Harmonic Suppression. The size of the filter that is going to be designed is of 1.2 to 1.8 centimetres. It is important to design the micro-strip Band pass filter to full fill the ever-increasing needs in the wireless communication. In this thesis report, a compact micro strip band pass filter is constructed Under ultra-wide band application (i.e., UWB application). Ultra-wide band generally comes under the working frequency range of 3.2GHz to 10.6Ghz.

The filter that is constructed comes under the application of UWB. This means that the working or operating frequency range of this filter is of 3.2 to 10.6 Ghz and, the filter that is going to be implemented is of strip line filter. It is not of Component filter. In component filters the damage of any component will lead to the damage of Complete filter. Here, the filter that is going to be implemented is of Strip line filters. Using a simulation software namely Ansys we are going to design a hair pin bend filter with an operating range of frequencies of (3.32Ghz to 5.78Ghz).

CHAPTER 1

INTRODUCTION TO FILTERS

A filter is a circuit capable of passing (or amplifying) certain frequencies while attenuating other frequencies. Thus, a filter can extract important frequencies from signals that also contain undesirable or irrelevant frequencies.

In the field of electronics, there are many practical applications for filters. Examples include:

- Radio communications: Filters enable radio receivers to only "see" the desired signal while rejecting all other signals (assuming that the other signals have different frequency content).
- DC power supplies: Filters are used to eliminate undesired high frequencies (i.e., noise) that are present on AC input lines. Additionally, filters are used on a power supply's output to reduce ripple.
- Audio electronics: A crossover network is a network of filters used to channel low-frequency audio to woofers, mid-range frequencies to midrange speakers, and high-frequency sounds to tweeters.
- Analog-to-digital conversion: Filters are placed in front of an ADC input to minimize aliasing.

1.1 NEEDS OF Filters

- In signal processing, a filter is a device or process that removes some unwanted components or features from a signal.
- Filters are used in several electronic and telecommunications applications to emphasize signals in a particular frequency range while rejecting or suppressing those in the undesired frequency range.
- Radio frequency filters are also one of the most used application in frequency applications.
- RF Filters are a special type of filters that allows a signal of preference to pass through while attenuating other unwanted signals.

1.2 TYPES OF FILTERS

The Filters are mainly classified into two categories namely Active and Passive filters. And from this Active and Passive filter they are again made into classifications.

1.2.1 Passive Filter:

- ☐ Passive filters include only passive components—resistors, capacitors, and inductors. In contrast, active filters use active components, such as op-amps, in addition to resistors and capacitors, but not inductors.
- ☐ Passive filters are most responsive to a frequency range from roughly 100 Hz to 300 MHz.
- ☐ Passive filters include only passive elements such as resistors, capacitors, inductors. Combination of pure RLC circuits comes under passive devices.
- ☐ In Passive filters, there are again classified as four types of filters. They are.
 - 1)Low pass filter.
 - 2)High pass filter.
 - 3)Band pass filter.
 - 4)Band notch filter.

1.2.2 Active Filter:

- ☐ Active filters use active components such as Op-Amps in addition to the resistors, capacitors, and inductors.
- ☐ Active filters can be used to design high-order filters without the use of inductors; this is important because inductors are problematic in the context of integrated-circuit manufacturing techniques.

1.2.3 Low pass filter

It is a type of Filter which attenuates all the frequencies above the cut-off frequencies. It provides a constant output (gain) from zero to cut-off frequency.

The **cut off frequency** for a **low-pass filter** is that **frequency** at which the output (load) voltage equals 70.7% of the input (source) voltage. Above the **cut off frequency**, the output voltage is **lower** than 70.7% of the input, and vice versa.

Cut-off frequency is also called as corner frequency. Cut-off frequency is the range of frequency up to which system works, after the cut-off frequency the system does not work.

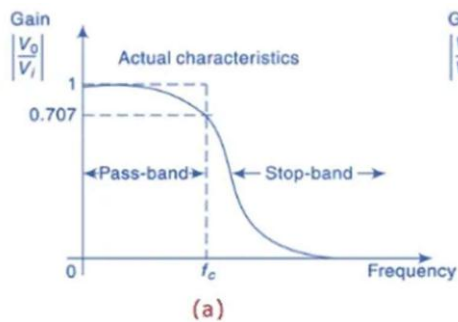


Fig 1 Actual Characteristics

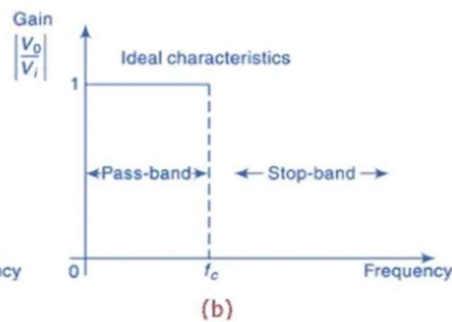


Fig 2 Ideal Characteristics

1.2.4 High pass Filter

It is a type of Filter which attenuates all the frequencies below the cut-off frequencies. It provides a constant output (gain) above the cut-off frequency.

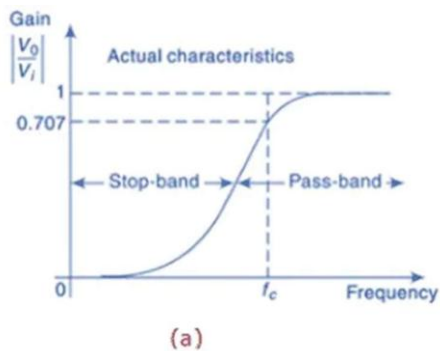


Fig 3 Actual Characteristic

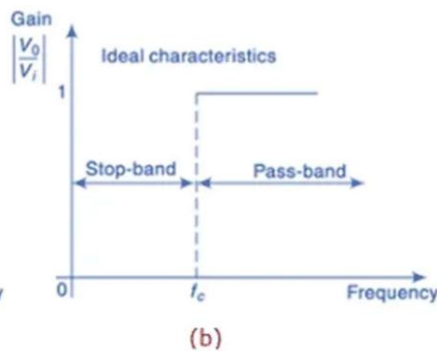


Fig4 Ideal Characteristics

1.2.5 Bandpass Filter

It is a type of filter which allows specific Band of frequencies to pass through and all other frequencies outside the band are attenuated.

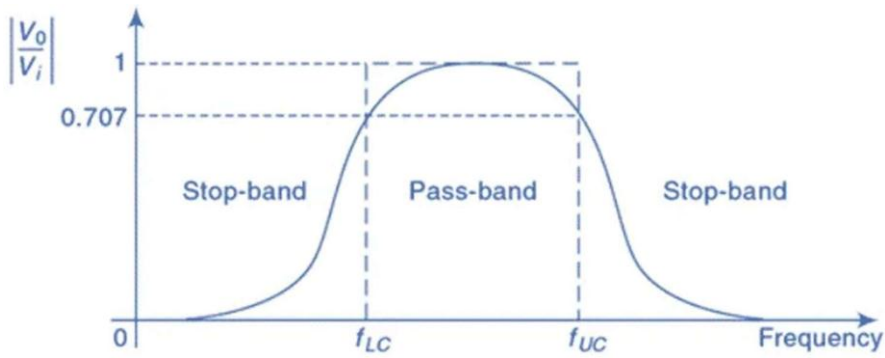


Fig 5 Band Pass Filter

1.2.6 Band Notch Filter

In this type of filter, a specific band of frequencies get rejected and it allows the frequencies passing outside the band.

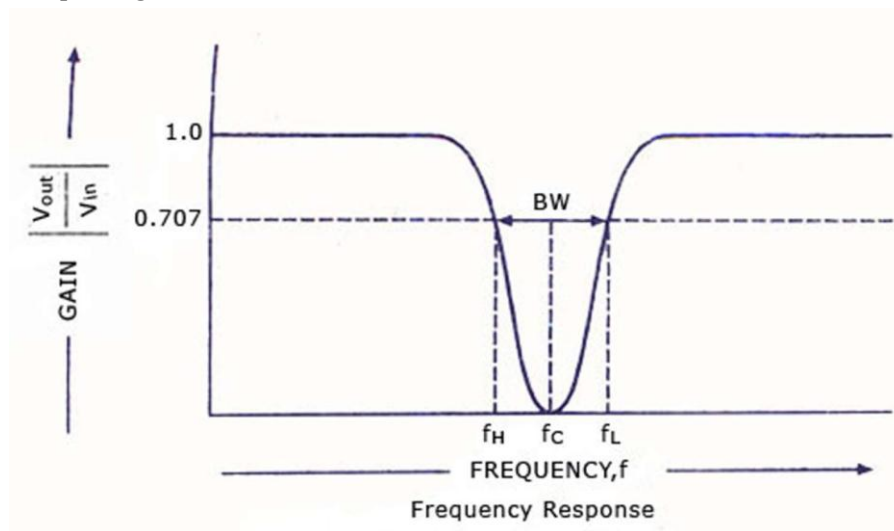


Fig 6 Band Notch Filter

1.3 Filter Parameters

The parameters are the most important phase in testing anything. In order to know the working status of the filter, parameters play an important role. By analysing the parameters, one can know the working condition of a Particular thing. In the same way, to estimate the working

condition of the filter parameters are the most important things that need to be considered. In order to know the proposed model is of efficient one or not these parameters play a very important role.

1.3.1 Notching Parameters

The Notching parameters are the parameters which has Stop band characteristics. Stopband is defined as the range or band of frequencies that are attenuated by the filter. By analysing the notching parameters, one can know the range of frequencies in which the filter is working.

1.3.2 Passing parameters.

The passing parameters are the parameters which has Pass band characteristics. Pass band is defined as the frequency band within which the frequencies are allowed to pass without any attenuation. By analysing the passing parameters, one can know that the particular filter is working in the estimated frequency range or not.

1.3.3 Group Delay.

Group delay in a filter is termed as the delay in the signal through the device under test as function of frequency. Group delay is measured in seconds. For an ideal filter, the group delay value is constant.

1.3.4 Impedance plot.

Impedance is a type of measure of effective resistance. The effective resistance of a particular circuit is called impedance. Through this impedance plot, one can know the characteristics of that model that it is exhibiting. This impedance plot is represented in a smith chart. The middle line of this impedance plot is of resistive line. If the plot is of above resistive line, then it exhibits inductive characteristics. If the plot is of below resistive line, then it exhibits capacitive characteristics.

1.3.5 Accepted power.

Accepted power represents the amount of power that is given to the filter for the operation of the filter.

1.3.6 Radiated power.

Radiated power is a measure by which one can know the amount of power that is radiated by that element.

1.3.7 Radiation efficiency.

Radiation efficiency is the ratio of gain to the directivity. It can be estimated by calculating the ratio of gain to that of the directivity. For the filter applications the radiation efficiency should be of more than 60 percentage.

1.4 APPLICATIONS

Frequency filters have so many applications in our livelihood; some of these applications are given below:

- ☐ The tuner in radio: The bandpass filter in the tuner of the radio allows a fixed frequency to the output speaker.
- ☐ Treble & bass of the speaker: The bass has lower frequencies & treble has higher frequencies. They are separated using high pass & low pass filter and are separately routed to corresponding bass speaker & treble speaker for clear music.
- ☐ Anti-Aliasing: it is a low pass filter that filters out the high-frequency components from a signal before sampling. It prevents the aliasing component from being sampled.
- ☐ Notch Filter: they are band reject filters with a narrow bandwidth that filter out any interfering signal.
- ☐ Power Supply Smoothing: The output of the power supply which is a rectifier has an AC ripple in it. These frequencies are filtered out using a low pass filter which results in smoothing the output signal.
- ☐ Noise suppression: They are used in communication systems for noise removal from the received signals.

The above are some of the general applications of filter that we see in our daily day to day life.

- ☐ The proposed filter is used for all the frequency applications that comes under sub-six (3.4 to 3.6Ghz), sub-seven (4.2 to 4.8Ghz), 5G modem (5.15 to 5.28Ghz) and in advanced vehicular communication.

- Thus, our project is suitable for all the advanced 5G applications. And the real time model of the filter avoids high frequency harmonic distortion by using simplex transmission line method.
- We are using a high heat capable material for our design because of wider fringing losses.

1.5 Introduction to UWB

Ultra-wideband systems use wireless technology capable of transmitting data over a wide spectrum of frequency bands for short distances with very low power and high data rates. They are used for the operation of sending and receiving extremely short bursts of RF energy. The UWB systems have outstanding ability for applications that require precision distance or positioning measurement as well as high-speed wireless connectivity.

The UWB technology delivers high data rates more than 100 Mbps up to 1 Gbps. The UWB waves can penetrate through doors and other obstacles. The key advantages of the UWB systems over narrowband systems are high data rate due to the large bandwidth, low equipment cost, low power, and immunity to multipath.

An UWB transceiver system includes a digital and a RF hardware. The RF hardware, that is basically a RF front end, includes a low noise amplifier (LNA), a microwave filter, an antenna, and matching components with the required bandwidth.

In 2002, the Federal Communications Commission (FCC) approved the use of ultra-wide band (UWB) from 3.1 GHz to 10.6 GHz for commercial communication applications.

1.5.1.UWB RF systems and its applications

The UWB radios typically communicate with short pulses or cycles on the order of nanoseconds, spreading their energy over a wide swath of bandwidth, as opposed to modulated sinusoids whose energy is localized around a single frequency.

UWB signalling has many attributes that make it attractive for a wide range of applications; from ultra-low-power RFID tags & wireless sensors to streaming wireless multimedia & wireless USB at a greater rate than 1Gb/s [2]. The high data rate multimedia home networks or child locator applications are a few to name.

The UWB is seen as the most efficient technology for short range wireless interconnection between computing devices. Many applications in wireless technology have been focused on narrowband implementations. Technology requirements on UWB systems present differences from the narrow band ones. However, silicon and hardware improvements, challenges in software and algorithms for efficient data transmission and network management are the technical challenges that should be taken up by this new technology.

1.5.2 Usage of UWB Filters

A RF front end essentially consists of a low noise amplifier, a filter, and an antenna. This thesis focuses on design of the UWB microstrip filter which can be employed in this UWB RF front end module. To transmit or receive a high-quality signal, an UWB Bandpass filter must have the following specifications: – Typical bandwidth of 20% or 500 MHz or greater – A high selectivity to reject signals from existing systems such as 1.6 GHz global positioning systems (GPS), 1.9 GHz cellular band, and 2.4 GHz ISM band operating systems. In the recent decade, the UWB systems have been developed and applied widely. To meet the FCC specifications, a good selectivity at both lower and higher frequency ends and flat group-delay response over the whole band are required.

Design and Development of an UWB Filter

In this section, a sample ultra-wideband microstrip filter design and development is presented. Filter details including circuit model, simulations, optimizations, layout, creation, manufacturing, testing and troubleshooting are explained.

1.6 Feeding Technique (strip line)

Micro-strip patch antennas can be fed by variety of methods. These methods can be classified in to two categories.

- 1) Conducting
- 2) Non conducting

In the conducting method, the RF power is fed directly to the radiation patch using a connection element such as micro-strip line. In the non-conducting scheme, Electromagnetic field coupling is done to transfer power between the micro-strip line and the radiating patch.

The four most popular feed techniques are,

1. Conducting schemes.

- 1) Micro-strip line
- 2) Coaxial probe

2. Non conducting schemes.

- 1) Aperture coupling
- 2) Proximity coupling

1.6.1 Micro-strip feed line

In this type of feed line technique, a conducting strip is connected directly to the edge of the micro-strip patch. The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure. The purpose of the inset cut in the patch is to match the impedance of the feed line of the patch without the need of any additional matching element. This is achieved by properly controlling the inset position. Hence this is an easy feeding scheme; it provides ease of fabrication and simplicity in modelling as well as for impedance matching.

1.6.2 Coaxial Feed

In this the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is coupled to the ground plane. The major advantage of this is that the feed can be placed at any of the desired locations inside the patch to match with its input impedance. The disadvantage is that it provides narrow bandwidth and is complex to model.

1.6.3 Aperture Coupled Feed

In this technique, the radiating patch and the micro-strip feed line are separated by the ground plane. The patch and the feed line are coupled through a slot in the ground plane. The coupling slot is centred below the patch, leading to low cross polarization due to symmetry of the configuration. Since the ground plane separates the patch and the feed line, spurious radiation is minimized. The main disadvantage of this feed technique is that it is difficult to fabricate due to multiple layers, which also increases the antenna thickness.

1.6.4 Proximity Coupled Feed

This type of feed technique is also called as the electromagnetic coupling scheme. Two dielectric substrates are used, and the feed line is between the two substrates. The radiating patch is on the top of the upper substrate. The main advantage of this feed technique is that it eliminates spurious feed radiation and provides very high bandwidth. The major disadvantage of this feed scheme is that it is difficult to fabricate because of the two dielectric layers which need proper alignment.

1.7 Planar Transmission line

In microwave circuits has taken place through the development of planar transmission lines which are flat, two or multiconductor transmission lines having low profile and light weight. This geometry allows control of the characteristic impedance of the line by defining the line dimension in a single planed and is therefore suitable for microwave integrated circuits. The complete transmission line circuit can be fabricated in one step by thin film technology and photolithography techniques.

There are four basic forms that are widely used.

- 1) Strip lines
- 2) Micro-strip lines
- 3) Slot lines
- 4) Coplanar strip lines

1.7.1 Strip lines.

It consists of central thin conducting strip of width $W \gg$ its thickness 't' placed inside a low loss dielectric substrate thickness between two wide ground plates. The operating bandwidth of a strip line is considerably large for TEM mode of propagation means it's called as higher order strip lines. The strip lines are excited by a coaxial line which interfaces the strip lines by means of a special launcher or connector.

1.7.2 Micro-Strip lines.

It consists of a single ground plane and a thin strip conductor on a low loss dielectric substrate above the ground plate. Since the size of the microwave solid state devices is very small, the techniques of signal input to those devices and extracting output power from them uses micro-strip lines on the surface on which they can easily mounted.

1.7.3 Slot lines.

In this type of the conductor is in one plane on a dielectric substrate. The propagation fields are concentrated in the dielectric regions at the gap between the two adjacent conductors. The characteristics impedance Z_0 of slot lines increases with the increases of width of the slot.

1.7.4 Coplanar lines.

It is a parallel three conductor line consisting of a thin centre strip and two ground strips on a dielectric substrate. Coplanar lines are very convenient for both series and shunt mounting of components across the gap in the centre strip and between the conductors respectively.

1.8 Fabrication.

Design and Development of an UWB Filter: In this section, a sample ultra-wideband microstrip filter design and development is presented. Filter details including circuit model, simulations, optimizations, layout, creation, manufacturing, testing and troubleshooting are explained.

Printed circuit boards are electronic circuits created by mounting electronic components on a nonconductive board and creating conductive connections between them. The creation of circuit patterns is accomplished using both additive and subtractive methods. The conductive circuit is generally copper, although aluminium, nickel, chrome, and other metals are sometimes used. There are three basic varieties of printed circuit boards: single side, double side, and multi-layered. The spatial and density requirement and the circuitry complexity determine the type of board produced. Printed circuit boards are employed in the manufacturing of business machines and computers, as well as communication, control, and home entertainment equipment.

Production of printed circuit boards involves the plating and selective etching of flat circuits of copper supported on a nonconductive sheet of plastic. Production begins with a sheet of plastic laminated with a thin layer of copper foil. Holes are drilled through the board using an automated drilling machine. The holes are used to mount the electronic components on the board to provide a conductive circuit from one layer of board to another. Following drilling, the board is scrubbed to remove fine copper particles left by the drill. The rinse water from a scrubber unit can be significant source of copper waste. In the scrubber, the copper is in a particulate form and can be removed by filtration or centrifuge. Equipment is available to remove this copper particulate, allowing recycle of the rinse water to scrubber.

However, once mixed with other waste streams, the copper can dissolve and contribute to the dissolved copper load on the treatment plant. After being scrubbed, the board is cleaned and etched to promote good adhesion and it plated with an additional layer of copper. Since the holes are not conductive, electroless copper plating is employed to provide a thin continuous conductive layer over the surface of the board and through the holes. Electroless copper plating involves using the chelating agents to keep the copper in solution at an alkaline pH. Plating depletes the metal and alkalinity of the electroless bath. Copper sulphate and caustic are added as solutions, resulting in a growth in volume of the plating solutions. This growth is a significant source of copper-bearing wastewater in the circuit board industry.

Treatment of this stream is complicated by the presence of chelating agents, making simple hydroxide precipitation ineffective. Iron salts can be added to break the chelate, but only at the cost of producing a significant volume of sludge. Ion exchange is used to strip the copper from the chelating agent, typically by using a chelating ion exchange resin. Regeneration of the ion exchange resin with sulfuric acid produces a concentrated copper sulphate solution without the chelate. This regenerate produces a useful product.

Growth from electroless copper plating is typically too concentrated in copper to treat directly by ion exchange. Different methods have been employed to reduce the concentration of copper sufficiently either to discharge the effluent directly to the river or treat it with ion

exchange. One method, reported by Hewlett-Packard, replenish growth with formaldehyde and caustic soda to enhance its automatically plating tendency, and then mixes it with carbon granules on which the copper plates out in a form suitable for reclaiming.

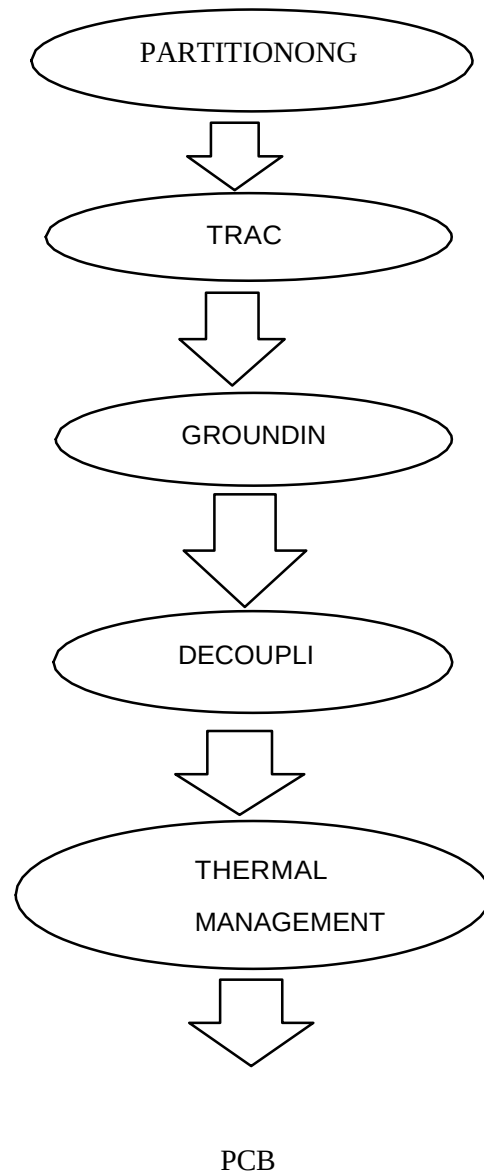


Fig 7 PCB design

General steps to follow before implementing any design:

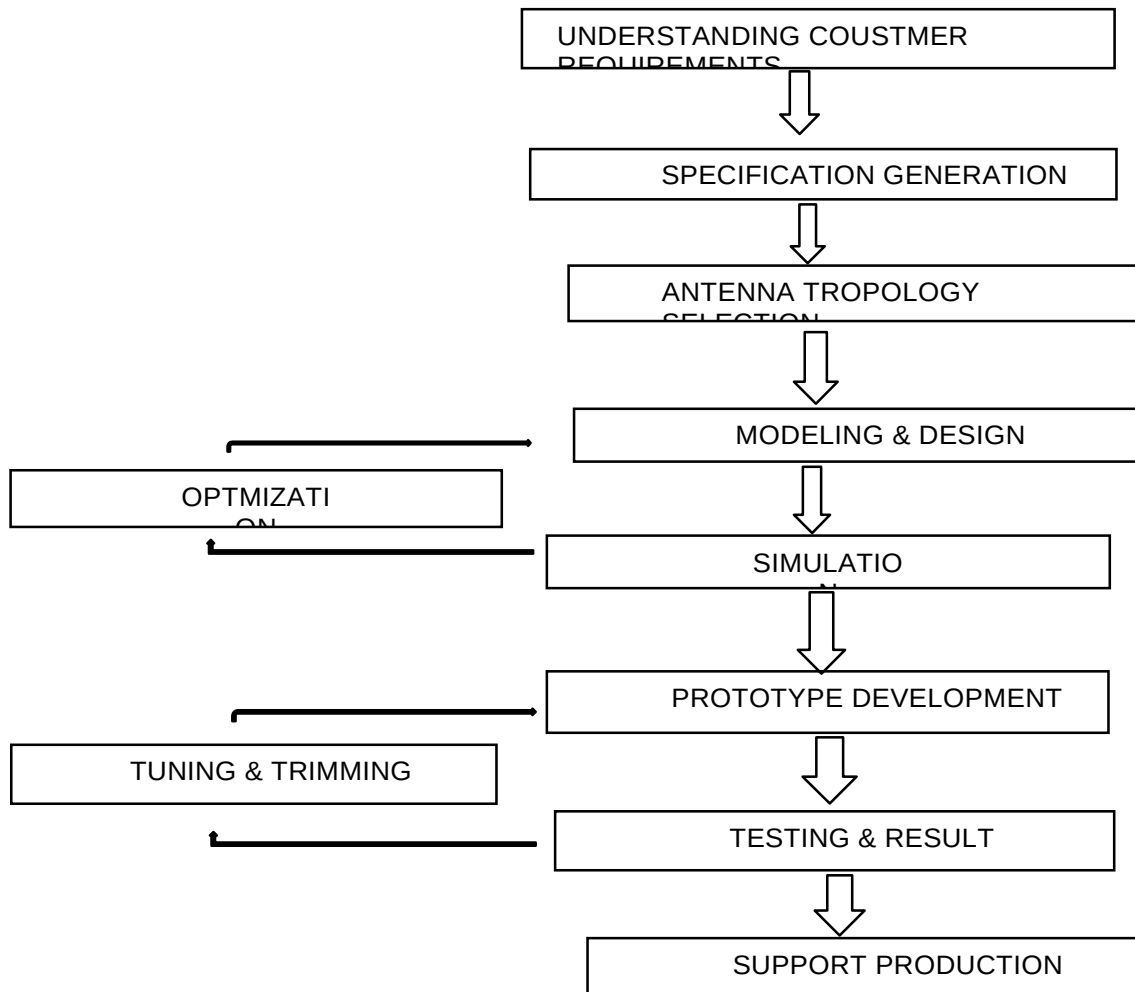


Fig 8 General Steps for Design

The plating resist is then removed to expose the copper not of the part of the financial circuit pattern. The exposed copper removed by etching to removal the circuit pattern. Ammonia-based etching and makes solutions are most widely used. Use of ammonia etching is sulfuric acid/hydrogen peroxide etching solutions. This latter etched is continuously replenished by adding concentrated peroxide, and acid as the copper concentration increases to about 80g/L. At this concentration, the solution is cooled to precipitate out copper sulfate. After replenishing with peroxide and acid, the etched is reduced. Disadvantage of the sulfuric acid-peroxide etching solutions are that it is relatively slow when compared with ammonia and controlling temperature can be difficult.

CHAPTER-2

LITERATURE SURVEY

“Hussie N.Shaman” (2016), their design based on the transmission line concept. They had implemented their design with three short-circuited stubs which are separated by three short-circuited stubs and with two redundant unit elements. Each of the elements that are used in implementing this design is replaced with a lowpass filter to shrink the size of the filter. In this design they had implemented the completed model using full -wave EM simulation software. In this, the filter exhibits a better performance with less losses at mid-band frequency.

In the proposed methodology by Hussie N.Shawman, they had used a GML 1000 substrate with a dielectric constant of 3.05 and thickness of 0.508mm. They had achieved the minimal insertion loss using the proposed model. And in this proposed method, a UWB Band pass filter with 3 shunts short-circuited stubs has been presented. And the connecting lines have been replaced with non-uniform connecting lines in order to suppress the harmonic suppressions that will encounter.

Keren Li, Daisuke Kurita and Toshiaki Matsui, had discussed about UWB Band pass filter using broad side coupled micro strip coplanar waveguide structure. In this proposed methodology they had constructed a filter with microstrip line coupled to coplanar waveguide (CPW) which was fabricated on the ground of the microstrip line. And, while measuring different parameters they had taken group delay also into consideration which is very important in an impulse radio UWB system. They had achieved the group delay of 0.95ns over the whole band. The developed filter has been successfully developed for the UWB pulse generation. And also, the experimental results in the proposed model demonstrate that step like negative pulse with less than 5ps fall time, which is generated from a pulse generator.

In the proposed methodology of Keren Li, Daisuke Kurita, and Toshiaki Matsui they had used a dielectric substrate of ARLON which has dielectric constant of 2.98 and thickness of 0.508. The filter dimensions that they had constructed is of length 7mm and of width 3.8mm.

The key part of this filter structure is that they have implemented a broad side coupled microstrip coplanar wave guide (CPW). The UWB concept that is implemented improves the filter skirt performance both low and high frequency ends as well as the performance out band up to 16 Ghz and also increases the range of attenuation up to 22 db. The filter structure and configuration are very simple and can be very compact, since the CPW is fabricated on the

ground and shares the ground with the microstrip line. The only disadvantages of the proposed methodology are fabrication of coplanar waveguide is very costly and also as gold ribbons are needed to suppress higher order modes at every quarter wavelength. Relative thick substrates are needed in the construction of coplanar waveguide structures.

Zhang-Cheng Hao, in his methodology he had implemented an UWB Band pass filter by cascading High pass and Low pass filters implemented with multilayer liquid crystal polymer technology. The hybrid microstrip and coplanar waveguide resonant structures are proposed to design the UWB bandpass filter in this methodology. However, the proposed methodology will suffer from strong harmonic response. To reduce that stop band need to further developed or improved. Quasi-lumped-element and resonator UWB filters can be designed and implemented using multilayer liquid crystal polymer (LCP) or low-temperature co-fired ceramics (LTCC) circuit technique to achieve a small footprint in terms of the design of the filter.

To develop a UWB Band pass filter, they had taken a low dielectric constant LCP substrate. The cascaded high pass and low pass filters technique would have some of the advantages and these advantages had been used in the construction of this UWB band pass filter. To achieve a small size for the UWB bandpass filter, a miniature low-pass filter must be used in a cascaded high-pass and low-pass filter architecture in this design.

Kai-Rang Xaing and Fu-Chang Chen, in this project an effective and simple method for suppressing the spurious frequency in Bandpass filter is proposed. Quarter- and half-wavelength uniform impedance resonators (UIR) are used to generate the filtering function. Band-pass filter is important for RF/microwave circuit and systems. Parallel microstrip coupled transmission lines are very important for designing bandpass filter, while the drawback is that the inherent presence of spurious passband make it hard to be acquired. In this part, a microstrip bandpass filter with wide stopband will be presented. Aiming to compression the filter size, the fourth-order filter consists of two half-wavelength UIRs and two quarter-wavelength UIRs are implemented in the proposed methodology. To absorb radiation, a layer of absorbing material is attached on the bottom face and top face of the metal box. The stopband rejection is better than 22.9 dB up to over 16 GHz by using a metal box with absorbent material.

Kaliyavarathan Thirumalaivasan and Rangaswamy Nakkeeran, in this paper, they had implemented miniaturized Ultra-wide band (UWB) microstrip bandpass filter with wide pass band. The group delay variation in the proposed filter is of 0.02ns. The overall dimensions of the filter that is proposed by Kaliyavarathan Thirumalaivasan and Rangaswamy Nakkeeran is of length (10.7 mm) $\times$ width (3mm) $\times$ Thickness (1.6mm). The proposed model consists of three pairs of transversely connected stub that is loaded in the center section with two identical couple lines in both left and right sections. Out of three transverse stubs, two of them are folded one. The middle section of the constituted MMR exhibits an excellent lowpass property and it is linked with external feed lines via direct coupled.

The proposed filter is constructed by the combination of high pass and low pass filter using microstrip technology. It is not of transmission line method. In this paper, they had used of the characteristics of low pass and high pass filter. For instance, the low pass filter requires high impedance and that is achieved using strip line method. For the high pass filter section, strong broadside coupling between wide line section and ground substrate is required to increase the inductance value, which results in small size and a wide passband filter response the compact low loss nature is achieved in this method using strip line concept. In this paper, miniaturized UWB bandpass filter with improved passband is designed, developed, and characterized. The developed filter with passband of 7 GHz from 2.5 to 9.5 GHz has insertion loss of -0.5 dB and return loss of around -35 dB.

M.Nedil, T.A.Denidni and A.Djaiz, in their proposed model, ultra-wide band microstrip (CB-CPW) have applied in various wave circuits. In their method they had proposed transmission line concept such as microwave and coplanar waveguide. For instance, multilayer microwave integrated circuits require more flexibility to use both microstrip and CPW circuit technologies. In this paper, a novel ultra-wideband microstrip to CB-CPW transition using slot coupling is proposed. The proposed filter offers a wider out-of-band rejection bandwidth and has good performance in terms of group delay. A new back-to-back microstrip to CB-CPW transition has been designed and implemented.

In this methodology they had used EM simulator IE3D, which actually belongs to the Zealand software package. And also, the top and bottom 50-ohm transmission lines were drawn using HP's Lineal. The main drawback of the CB-CPW technology is the parallel-plate modes, which are considered as unwanted bulk modes. This represents the minimum parasitic parallel modes

of the CB-CPW. Thus, the implemented methodology is of CB-CPW transmission line method based broadband filter.

Chuan Ge and Xiao – Wei Zhu (2014), in their paper they discussed about two – patch mixed coupling tuneable band pass filter with constant band – width. A little bandwidth variation in a large tuning range due to compact configuration. The equivalent circuit of the coupling structure has presented. They derived different formulas for the two – patch mixed coupling structure to determine the initial dimension of the resonator. An additional resonance circuit is introduced in the I/O structure to generate multiple adjustable transmission zeros. A frequency band of 0.78 – 1.35 Ghz is implemented for the verification. The odd and even phase velocity compensation was utilized to maintain the constant band width with good out – of – band rejection. They used a tuneable filter with an overall size around 40mm *40mm fabricated on a Taconic CER – 10substrate, with 1.27mm thickness. A mixed coupling concept was utilized to control the band width variation for the first time. They introduced a dual mode open loop tuneable filter with constant band width.

Girdhari Chaudhary, Yong Chae Jeong and Jongsik Lim (2012) ,they proposed a novel approach to the design of tuneable dual – band band-pass filter with broad band harmonic suppression. The filter proposed by them offers the two tuneable passbands, as well as fixed first pass band and controllable second pass band. The shift of the harmonics occurs with tuneable pass band frequency, which need to be suppressed to improve out-off the pass band characteristics. Defected ground structures are used at input and output feeding lines to suppress the harmonics over a broad band width. It is found that the proposed filter exhibits a first passband centre frequency tuneable range of 34.14% from 0.85 to 1.2 Ghz with almost constant 3 dB fractional band width of 13% and second pass band centre frequency tuneable range of 41.81% from 1.40 to 2.14 Ghz with the 3 dB fractional band width of 11%. The DGS are utilized to reject harmonic. For all the tuning states, transmission zeros are realized near the passband frequencies.

Yiping Zang, Huiqing Zhai, Leixi and Long Li (2019) has proposed a compact micro-strip antenna with enhanced band width and ultrawide band and harmonic suppression. Here they used the U-shaped patch, slender stud and parasitic patch to improve the bandwidth of the harmonic suppression. They achieved a wide harmonic suppression band width 6.62 GHz-26GHz. In their proposed methodology they used 6.62GHz-26GHz. But in our proposed methodology we used 3.32GHz-5.78GHz band width.

Prasan Kumar Mishra, Tapan Kumar Patnik, Bhavani Prasad and Kailash Chandra Rout has proposed an UWB antenna: a design for wide range prospective. Here a micro strip fed is implemented and two L-Shaped metallic slots that are implemented at the top of the design. Inserting the metallic slots improves the resonant frequency and improves the impedance bandwidth. In our proposed methodology we used the Wagon-Well shape and the circular ground used for 5G applications.

In early days Pramod Singh and Dr Rekha Aggarwal ha proposed a comparative study of UWB microstrip antenna with different defected grounds, here they used three ground shapes L-Shaped, U-Shaped and E-Shaped grounds. They compared these grounds based on their bandwidth, gain and radiation properties. Here microstrip patch antenna is designed for UWB applications. They concluded that that L-Shaped is more directive than other two, but it is not suitable for multiband operations. Compared L-Shaped the U-Shaped shows a response which cover entire UWB. Here they used the L, U and E shaped grounds. By considering this we introduced the circular ring-shaped ground with meta material which is used to produce the narrow bandwidth, this ground is used for 5G applications like 5G wi-fi, sub six and sub seven range of frequency, VO5G and Advaned vehicular communication.

Jun-Hui Ou ET.EL has proposed a compact microstrip antenna with extended half power beam width and harmonic suppression. They proposed a half power beam width extended with patch antenna with harmonic suppression. It consists of one driver patch and two parasitic patches. These patches are placed parallel to the adjacent edges of driven patch. By considering this we proposed a filter with wagon well structure with feedback connectivity. The design comprises of circular capacitance parallel with two inductors in the feedback of resistive path, along with this a circular ring structured ground is introduced.

Since the U.S federal communications commission (FCC) released the UWB(Ultra-Wide-Band) spectrum in February 2002 for commercial applications. There is a large demand for this UWB applications. UWB band pass filters are one of the most required one for the existing frequency applications. Implementing this UWB filters with compact size and lower losses will be very helpful many frequency applications that are present in the existing scenario.

But in the Proposed methodology they had used for the lower frequency ranges. But in the existing methodology, we are using the frequency ranges that are suitable for the applications of 5G. The proposed methodology will be suitable for all the 5G, VO5G, advanced vehicular communication purposes. And, in the existing methodology the usage of power is high. In the existing methodology power usage is less. And it is of 1.2 watts to 1.5 watts.

The proposed methodology is to design a hairpin bend filter with less power consumption of real time model. And the value of losses will be very minimized one and it is suitable for all the 5G Frequency applications.

CHAPTER-3

AIM & SCOPE OF PRESENT INVESTIGATION

3.1 EXISTING SYSTEM:

By analysing the previous microstrip Bandpass filter design for sub 6GHz applications. The Microstrip Bandpass filters are designed with various size, structure and different design factors. The designed filter which are used in the existing model is of high heat capable material to avoid wide fringing losses. More complicated structures are used in the design to resonate in a single band frequency which can be achieved in a simple structure also with higher efficiency. In existing antenna designs high-cost materials are used to design and fabricate the filter like Rogers, RT Duroid, Cotton etc.

3.2 DRAWBACKS:

The microstrip Bandpass filter which has been designed for 5G applications and it covers a frequency range from 3.3GHz to 3.6GHz and its a narrow band but in this place if a wide band wide bandwidth is obtained and it's a drawback of the structure. The previously designed filter which we have analysed have higher losses this also affects the efficiency of the antenna and for the 5G application antenna design the efficiency of the designed structure should be more. The usage of power is very high in the previous proposed models.

3.3 PROPOSED SYSTEM:

When compared to other shapes in wagon wheel shape filter wide range of communication is achieved easily due to its shape. And the proposed filter also shows the lower losses and high efficiency in real time this is mainly due to its wagon wheel shape. The design consists of circular capacitance parallel with the two inductors along with the feedback connectivity. Feedback connectivity can be achieved using resistive path. The ground of the filter comprises of rectangular edge in which circular shape of the ground is comprised in it. It represents that, rectangular shape is induced in the inductive effect and circular shape is induced in the capacitive effect. In all the existing systems they had used the combination of low pass and

high pass filters. And the characteristics of both these high pass and low pass are comprised in the design of the filter. But in the proposed model of the filter, we had used the combination of inverse low pass filter with band notch filter which results in the Band pass filter. The main reason of selecting the Bandpass filter is that it will achieve frequency reuse concept. Mainly in construction of frequency applications like filter, frequency reuse concept should be achieved to make error less communication. The frequency reuse concept helps in maintaining error free communication. And the ground structure that is proposed is of tank structure. Tank structure normally forms when two inductors which are in series forms parallel connection with the capacitor. Ground of the filter is of meta material ring. Meta-materials are the type of artificial materials which are basically used in converting pure material into negative indexing material. By the usage of this meta-material, low power will be consumed. And this is the key reason behind the usage of meta-material in the ground structure of the proposed filter.

The main principle of the filter is of “store and reforward alone”. And this is achieved very efficiently in the proposed system. The losses that are obtained in the filter is of very minimized one and the power consumption of the filter is also very less for real time model that we are proposing. To achieve store and reforward principle, the filter should strictly exhibit capacitive characteristics. And these characteristics have been plotted and clearly shown in the impedance plot that had been taken in the Ansys HFSS Software. The proposed filter is suitable for all the sub-six; sub-seven; VO5G; 5G modem and advanced vehicular communications.

3.4ADVANTAGES:

- 1) Efficiency of the filter is above 70%, which is a very good efficiency according to the outside standards.
- 2) The design and structure of the filter is very simple and of very compact size.
- 3) Losses are minimized and the power usage is very less.
- 4) Group delay is of very minimized one.

CHAPTER-4

MATERIAL REQUIREMENT FOR THE EXPERIMENT

4.1 SUBSTRATE MATERIAL

FR4 epoxy glass substrates are the material of choice for most PCB applications. The material is very low cost and has excellent mechanical properties, making it ideal for a wide range of electronic component applications. As more and more microwave systems aimed at consumer markets are developed, there is a considerable interest in minimising the cost of these systems. Substantial cost savings could be realised by using FR4 in place of costly PTFE based substrates for microwave circuits and antennas. This paper describes a programme of work which has been undertaken at ERA Technology, as part of its Membership Research Programme, to evaluate the characteristics of this material at microwave frequencies between 1 GHz and 15 GHz. It is concluded that the use of FR4 is unlikely to be viable for antenna feeding structures due to its high losses. However, for high density microwave circuits where path lengths are short and for broadband antenna elements, where losses and absolute dielectric constant values are less critical, the material could be used in place of more conventional microwave substrate materials, offering significant cost savings. To provide the high-speed network environment to cope with a large volume of data, a multilayer PCB that can transfer digital signals at high speed in the high frequency domain is needed. The FR-4 substrate is applicable to network equipment with low dielectric loss and low permittivity.

4.2 SMA CONNECTOR

The SMA connector is a semi-precision sub-miniature RF and microwave connector that is extensively used, especially for RF connections within electronic systems for frequencies up to 18 GHz and sometimes more.

The SMA connector comes in a variety of formats, male, female, straight, right-angled, bulkhead fitting and many more enabling it to meet most requirements. Its sub-miniature size also enables it to be used, even within relatively small items of electronic equipment.

Although now well established, the SMA connector is likely to see its use extended as many new RF systems see their operating frequencies extending well into the microwave region. SMA connectors are designed to have a constant have a 50-ohm impedance across the connector. The SMA connectors were originally designed and specified for operation up to 18 GHz, although some versions have top frequencies of 12.4 GHz, some less and some are specified up to 24 or 26.5 GHz. The higher frequency top limits may need to operate with a higher return loss. The SMA connector uses a 1/4-inch diameter, 36-thread-per-inch threaded barrel.

4.3 VECTOR NETWORK ANALYSER:

A Vector Network Analyzer contains both a source, used to generate a known stimulus signal, and a set of receivers, used to determine changes to this stimulus caused by the device-under-test or DUT.

The stimulus signal is injected into the DUT and the Vector Network Analyzer measures both the signal that's reflected from the input side, as well as the signal that passes through to the output side of the DUT. The Vector Network Analyzer receivers measure the resulting signals and compare them to the known stimulus signal. The measured results are then processed by either an internal or external PC and sent to a display.

Vector Network Analyzer's perform two types of measurements – transmission and reflection. Transmission measurements pass the Vector Network Analyzer stimulus signal through the device under test, which is then measured by the Vector Network Analyzer receivers on the other side. The most common transmission S-parameter measurements are S₂₁ and S₁₂ (S_{xy} for greater than 2-ports). Swept power measurements are a form of transmission measurement. Some other examples of transmission measurements include gain, insertion loss/phase, electrical length/delay, and group delay. Comparatively, reflection measurements measure the part of the VNA stimulus signal that is incident upon the DUT but does not pass through it. Instead, the reflection measurement measures the signal that travels back towards the source due to reflections.



Fig 9 Vector network analyser

4.4 SOFTWARE:

Ansys HFSS is a 3D electromagnetic (EM) simulation software for designing and simulating high-frequency electronic products such as antennas, antenna arrays, RF or microwave components, high-speed interconnects, filters, connectors, IC packages and printed circuit boards. Engineers worldwide use Ansys HFSS to design high-frequency, high-speed electronics found in communications systems, radar systems, advanced driver assistance systems (ADAS), satellites, internet-of-things (IoT) products and other high-speed RF and digital devices.

HFSS (High Frequency Structure Simulator) employs versatile solvers and an intuitive GUI to give you unparalleled performance plus deep insight into all your 3D EM problems. Through integration with Ansys thermal, structural, and fluid dynamics tools, HFSS provides a powerful and complete Metaphysics analysis of electronic products, ensuring their thermal and structural reliability. HFSS is synonymous with gold standard accuracy and reliability for tackling 3D EM challenges by virtue of its automatic adaptive meshing technique and sophisticated solvers, which can be accelerated through high performance computing (HPC) technology.

The proposed wearable microstrip patch antenna is simulated using the ANSYS EM suite version 20 which is described above in detail and in the next part the simulated WMSPA is place and given some destabilization on the design and done analysis in the proposed design.

4.5 FILTER DESIGN

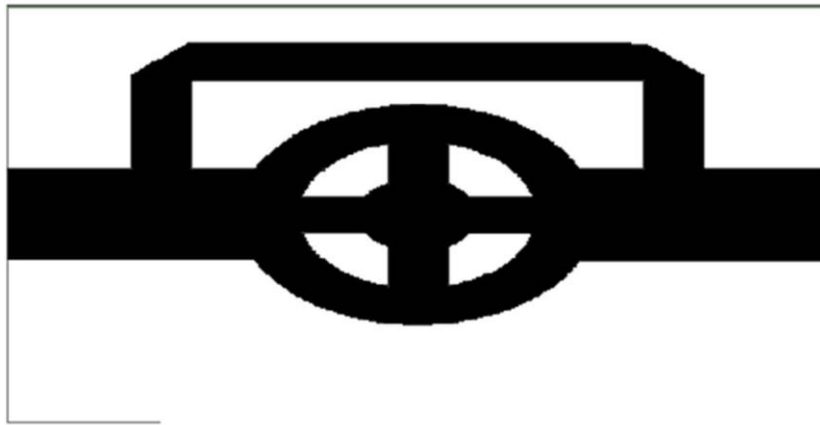
- Our filter design is of wagon wheel structure with feedback connectivity.

Filter design comprises of circular capacitance parallel with two inductors in the feedback of resistive path.

- In our design, circular shape is induced in the capacitive effect whereas rectangular shape is induced in the inductive effect.
- Ground of the filter is of metamaterial. Generally, metamaterial produces narrow bandwidth.
- But, in filters to get wide bandwidth we proposed a design of rectangular ring integrated with circular ring.

Now, metamaterial is also of combinational like structure.

- The proposed model of filter consists of landing edges. This landing edges produces resistive effect.
- In the existing methodology, two inductors are in series with one capacitance and parallel with one resistance.
- The resistance acts as a feedback loop, thus by producing the filter feedback effect.



27.6 x 22.6 mm

FR4 1.6 mm

Fig 10 Wagon wheel shaped Band pass filter



Fig 11 Ground of the filter

The construction of the filter does not consist of any passive elements like resistors, capacitors, inductors. The filter is not a Component model filter. It is a Strip line model filter. It does not contain any components like resistors, capacitors, inductors in it. The only component that is present in this is of copper. The copper that is present in this filter is of 0.2 ounces density. Copper is the only element that is present in this filter. Due to this copper only, filter acts as a

conductive element. After making the design on the printed circuit board, etching process will be done. To make the portion to be conductive at particular places this etching process will be done. After this process a wagon wheel shaped band pass filter is ready for testing all the frequency applications.

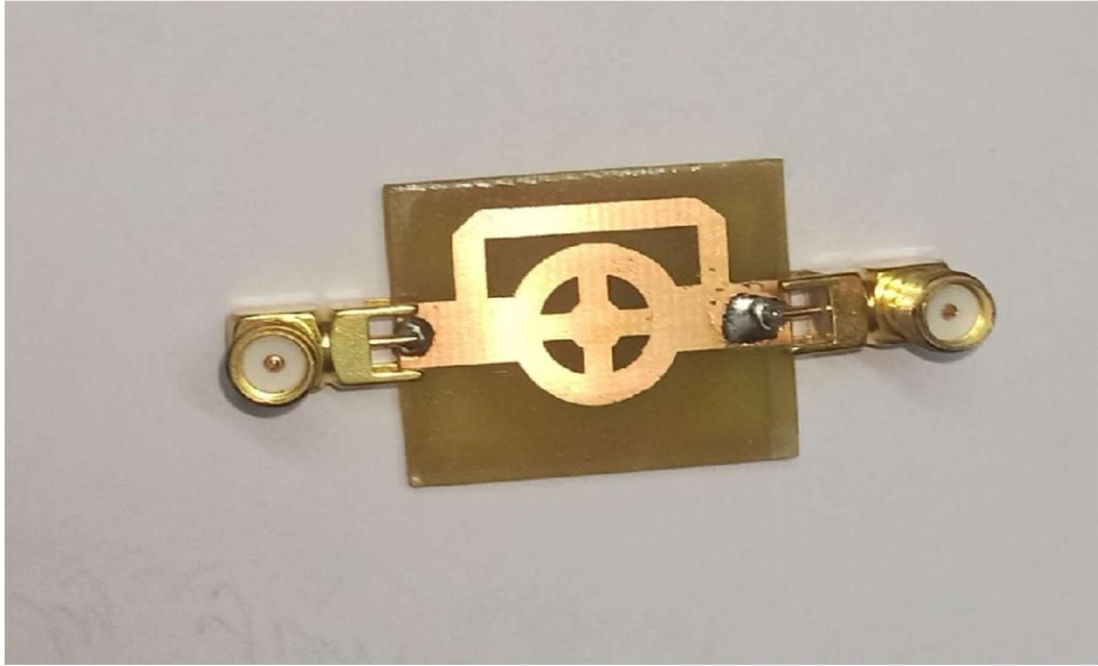


Fig 12 Real time model of the filter.



Fig 13 Real Time Ground of the filter.

The figure 1 represents the proposed design of wagon wheel shaped bandpass filter. It is built using the substrate material called FR4 epoxy with dielectric constant of 4.4. In this proposed Filter design the shape of the filter is of wagon wheel to achieve wide range of communication. And the proposed filter is of bandpass filter. The main reason in selecting the bandpass filter is that in filter applications one must achieve frequency reuse concept. Frequency reuse concept is best achieved using bandpass filter. The frequency of this filter resonates at the 3.5 GHz so the application of this proposed wagon wheel shaped Band pass filter is 5G and operating in Sub-6-GHz band with high performance efficiency in real time. The novel wagon wheel shaped Band pass filter is analysed in full ground using the HFSS software which shows the high accurate results in simulation. This obtained value shows the great accuracy where it is discussed in upcoming literature sections.

CHAPTER 5

RESULT ANALYSIS

In this section various parameters of wagon wheel shaped bandpass filter is discussed & analysed by simulating it with the help of HFSS software so this literature section will give the detail analysis in results with very high accuracy.

5.1 Notching and Passing parameters

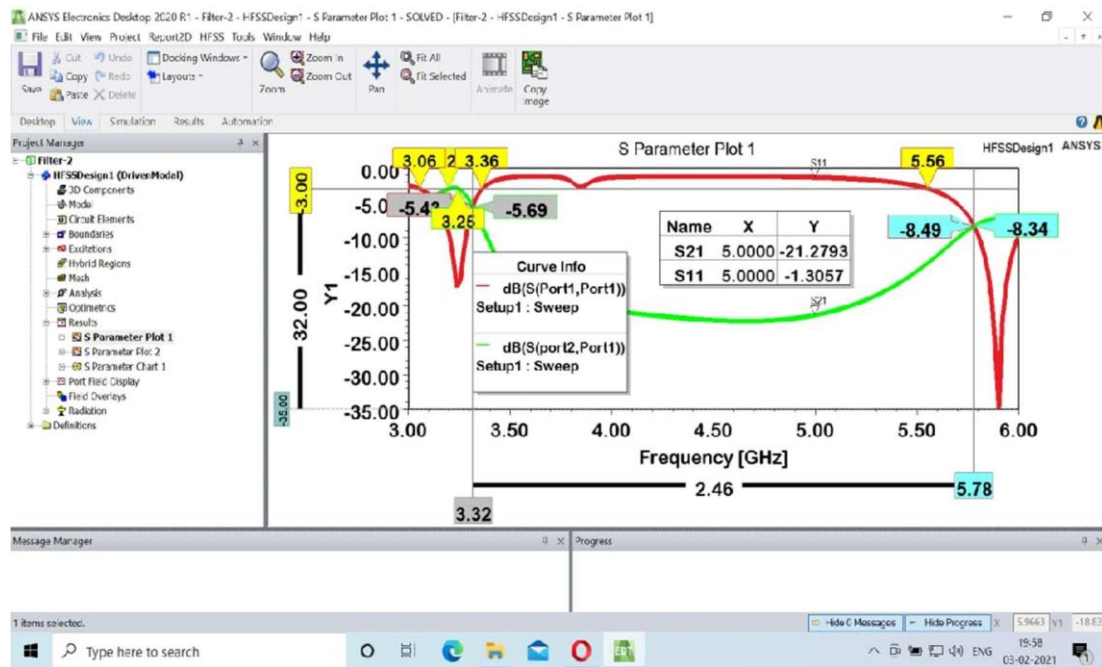


Fig 14 Notching and passing parameters of the filter.

- ☐ The above graph represents the passing parameters as well as the notching parameters.
- ☐ In the above graph it is clearly visible that in the frequency range of (3.36 to 5.56GHz), it shows pass band characteristics.
- ☐ Other than the operating frequency range (3.36 to 5.56GHz), the filter will possess stop band characteristics. And it is clear in the above notching and passing parameters.

5.2 Group Delay Plot



Fig 15 Group delay Representation

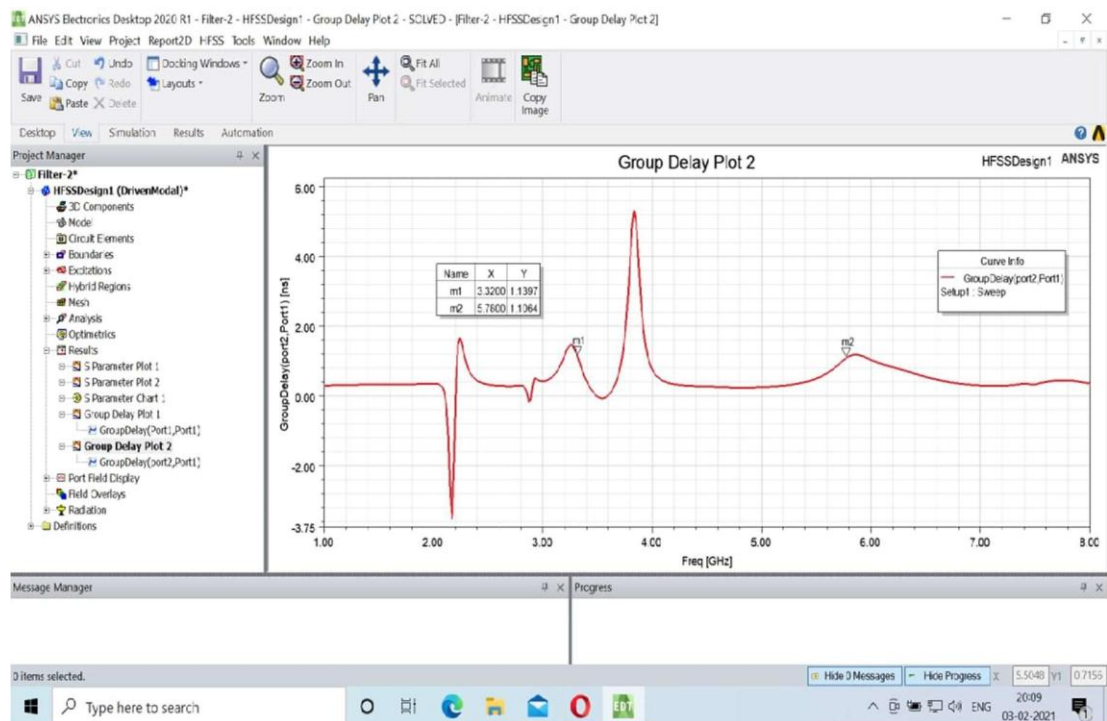


Fig 16 Group delay representation

Group delay in a filter is the time delay of the signal through the device under test as a function of frequency. Group delay represents the loss of frequency that has been attained when the frequency is sent from source to destination. The first group delay plot represents the stop band, and second plot represents the pass band. They are exactly opposite to each other. For general rf circuits, the group delay value should be below 1.27ns. If it satisfies that particular group delay value, then that particular design is of efficient one.

5.3 Impedance Plot

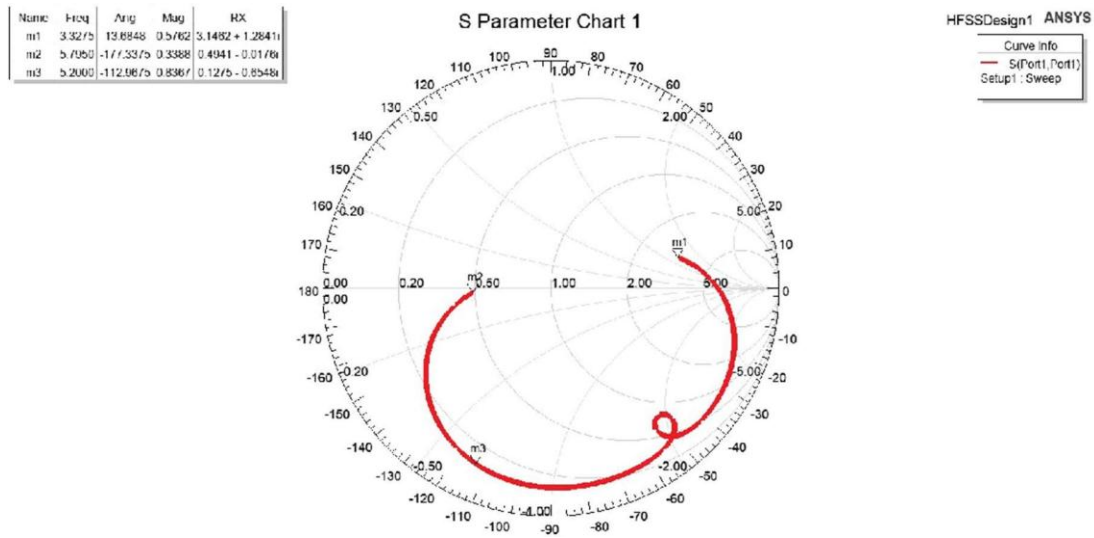


Fig 17 Impedance plot.

The above plot is the impedance plot. And it is represented using smith chart representation. In the above smith chart representation, the middle line is of resistive line. The line above the resistive line represents inductive characteristics, whereas the line below the resistive line represents capacitive characteristics. It is evident that Our Filter design exhibits capacitive characteristics from the above smith chart representation. The main principle of Filter is Store and Reforward the value. It can be achieved only by capacitive characteristics. Thus, the proposed model is efficient filter which is exhibiting proper capacitive characteristics.

5.4 Accepted power

Accepted power represents the power that is required for the operation of the filter. It is the power that is expressed in decibels which is used for the operation of the proposed filter.

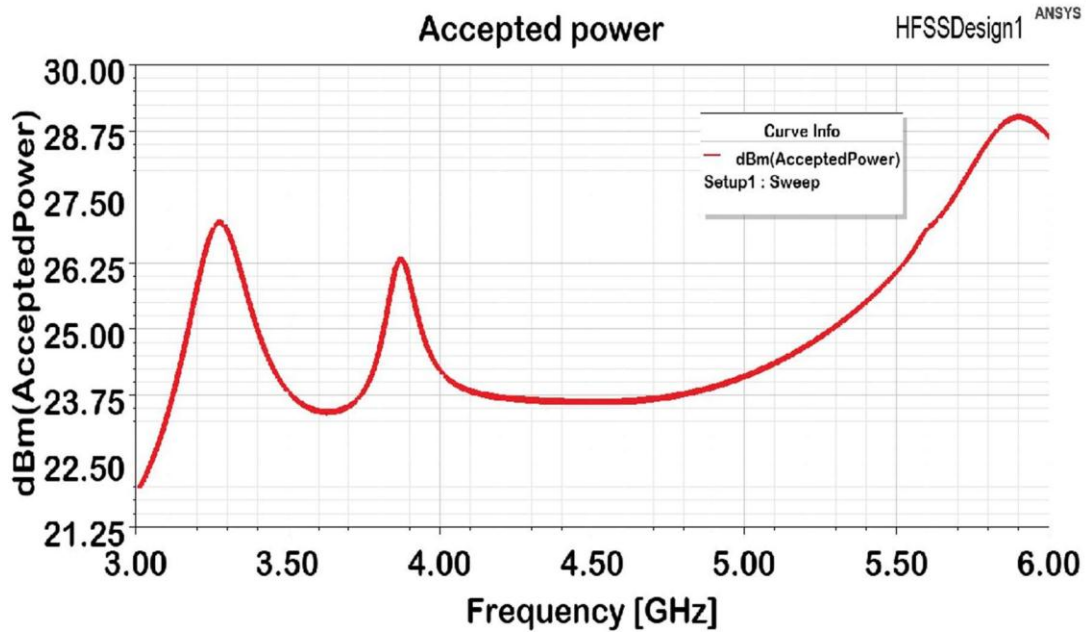


Fig 18 Accepted power of the filter

5.5 Radiated power

Radiated power is a measure by which one can know the amount of power that is radiated by that element.

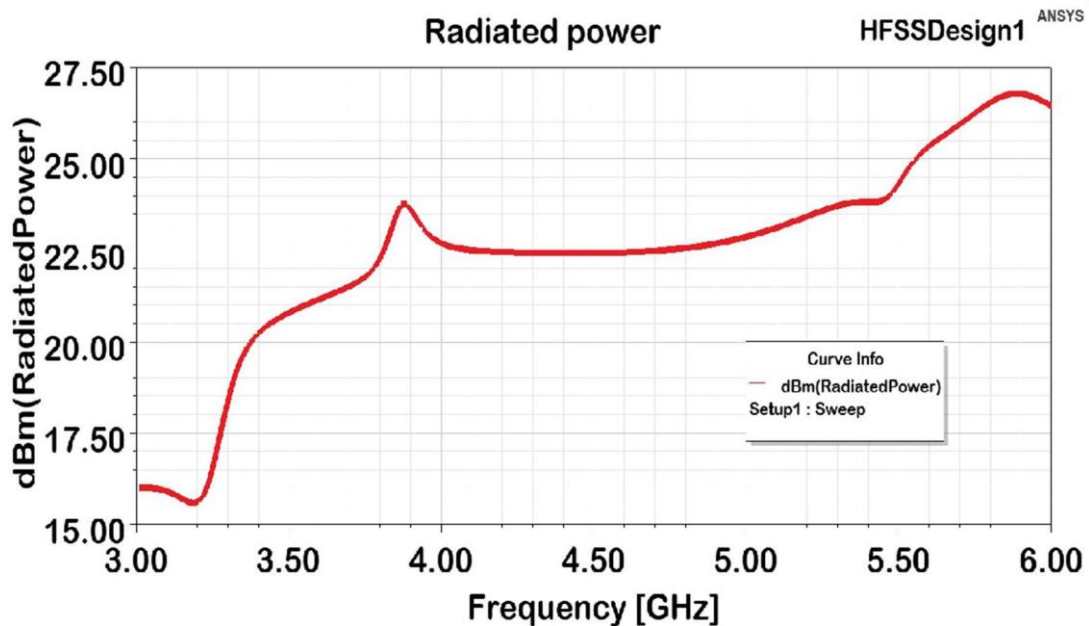


Fig 19 Radiated power of the filter

5.6 Radiation efficiency

Radiation efficiency is the ratio of gain to the directivity. It can be estimated by calculating the ratio of gain to that of the directivity. For the filter applications the radiation efficiency should be of more than 60 percent.

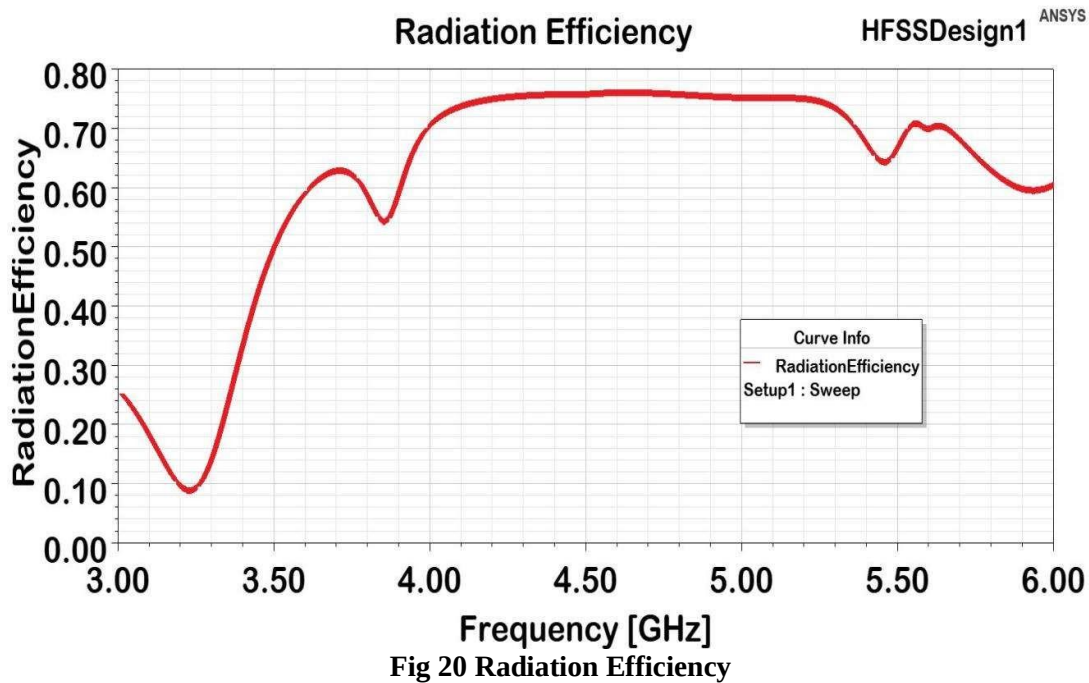


Fig 20 Radiation Efficiency

5.7 Results to be considered:

In the analysis of filter, mainly we must consider four type of losses. They are of:

- 1)Return loss.
- 2)Reflection loss.
- 3)Insertion loss.
- 4)Attenuation loss.

All these losses will be considered while constructing a filter. The reflection coefficient value will be calculated to estimate the working condition of the filter. The accepted power and radiated power will also be considered in the design of a filter.

There are some formulas that need to be considered in estimating the various losses that have been discussed above.

Formulas required:

- Reflection coefficient (dB) = $20 \log (1 / S_{11})$
- Reflection loss, Rf L (dB) = $10 \log [1 / (1 - S_{11}^2)]$
- Insertion loss, IL (dB) = $20 \log [1 / S_{12}]$
- Attenuation loss, AL (dB) = $10 \log ([1 - S_{11}^2] / [S_{12}^2])$

Tabulation for Losses Obtained:

S.NO	LOSSESS	VALUES OBTAINED
1.	Return loss	-1.3057 dB
2.	Reflection coefficient	-2.316 dB
3.	Insertion loss	-26.559 dB
4.	Attenuation loss	-28.078dB
5.	Reflection loss	-1.3dB

Table 1 Losses Obtained

The above are the values that need to consider in designing the filter. And as return loss value is equal to reflection loss, cross polarisation will be avoided, such that filter acts as efficient one.

5.8 FABRICATED FILTER DESIGN IMAGES**Fig 21 Front side of the fabricated design**



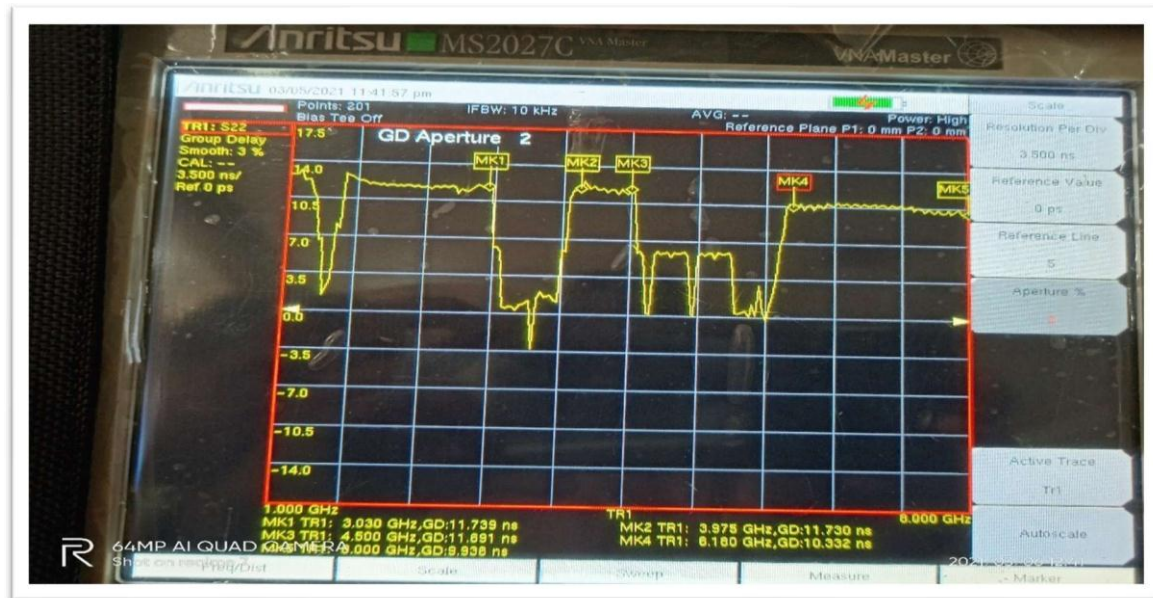
Fig 22 Back side of the fabricated design

Wagon wheel shaped bandpass filter have been designed and simulated. Compared to normal filter the efficiency is high and Power usage is less, so we fabricated the Wagon wheel shaped Bandpass filter as shown in the below figure.

5.9 TESTED RESULT

These are the results obtained by our real time model during the testing with the vector network analyser.

Fig 23 GROUP DELAY at S22



The above Fig 5.10 represents the group delay at S22 with the help of vector network analyser.

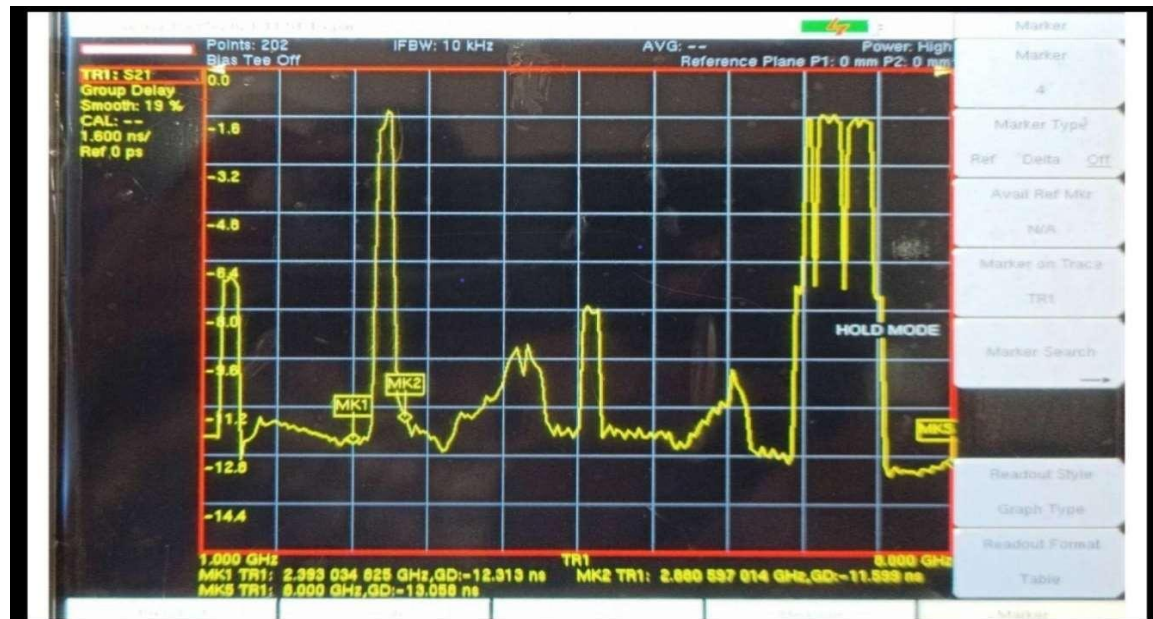


Fig 24 GROUP DELAY at S21

The above graph represents the group delay at S21 with the help of vector network analyser.

Notching Parameters and Passing Parameters:

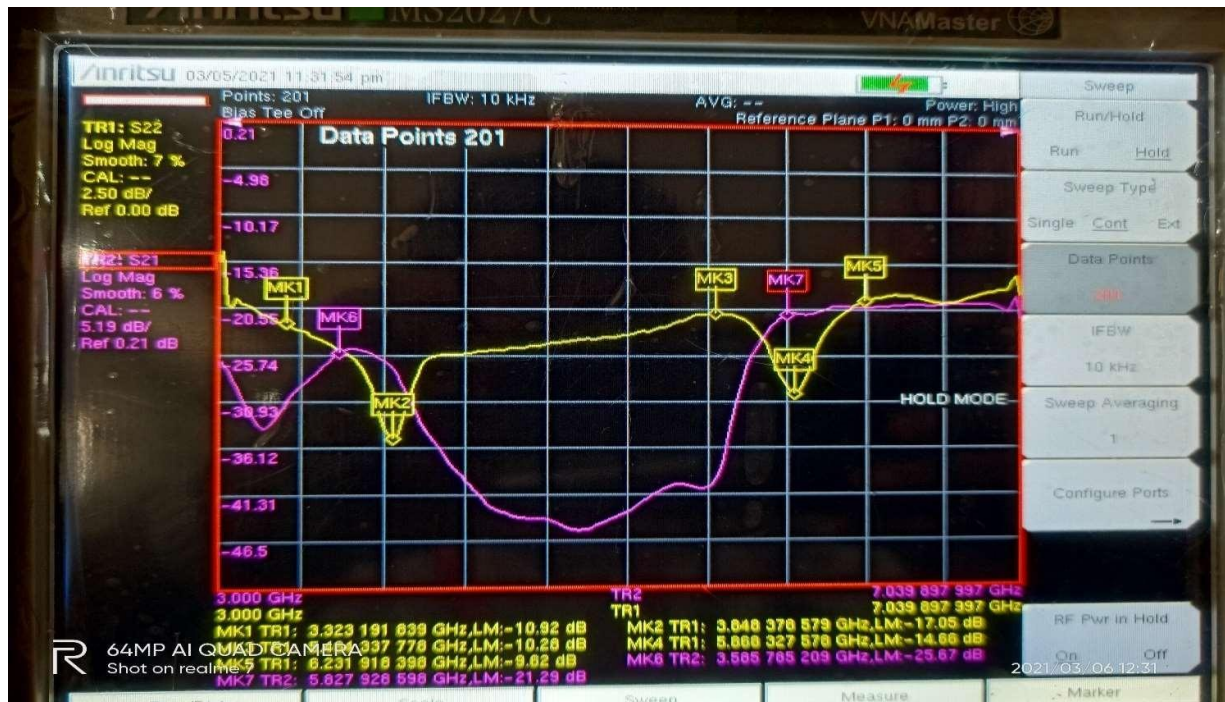


Fig 25 Notching and passing parameter at S21.



Fig 26 Notching and passing parameter at S22.

Above two graphs represent the notching parameters and passing parameters at S22 and S21 with the help of vector network analyser. From the above graph we can determine the return loss of the real time model. And Notching and passing parameters should be exactly opposite to each other. And this is clearly achieved in the above Fig 5.9.3.

PHASE PARAMETERS:

These three graphs represent the phase at S21, S12 and S22 measured in the vector network analyser.

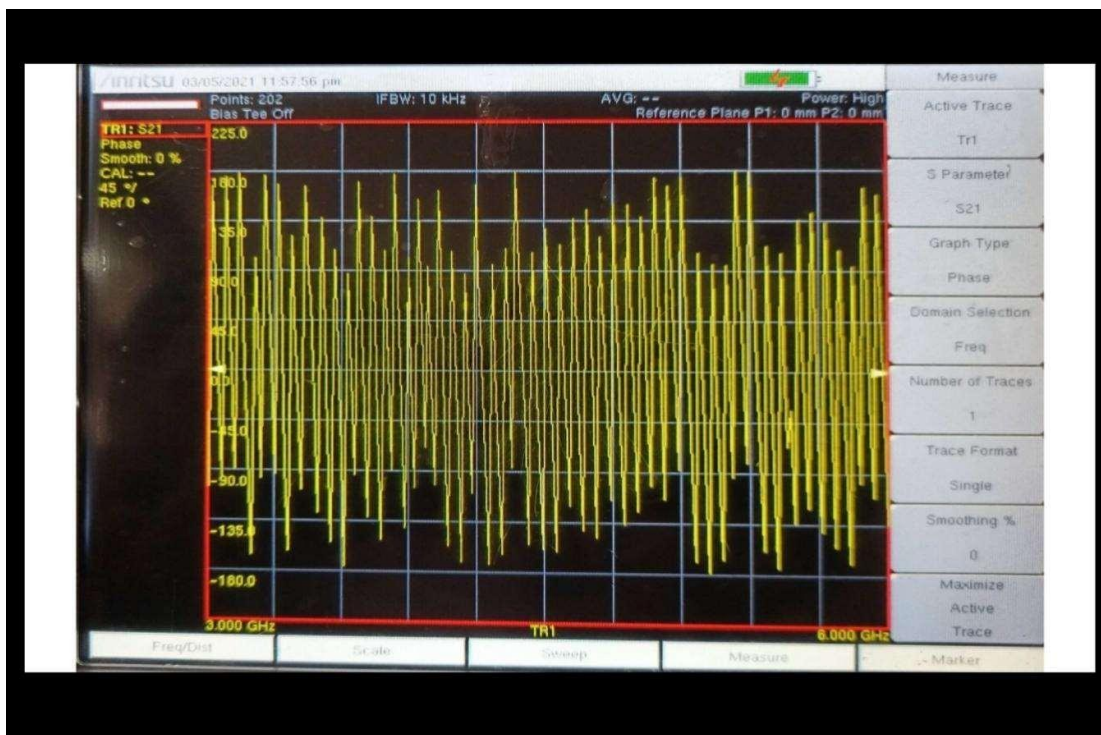


Fig 27 Phase plot at S21

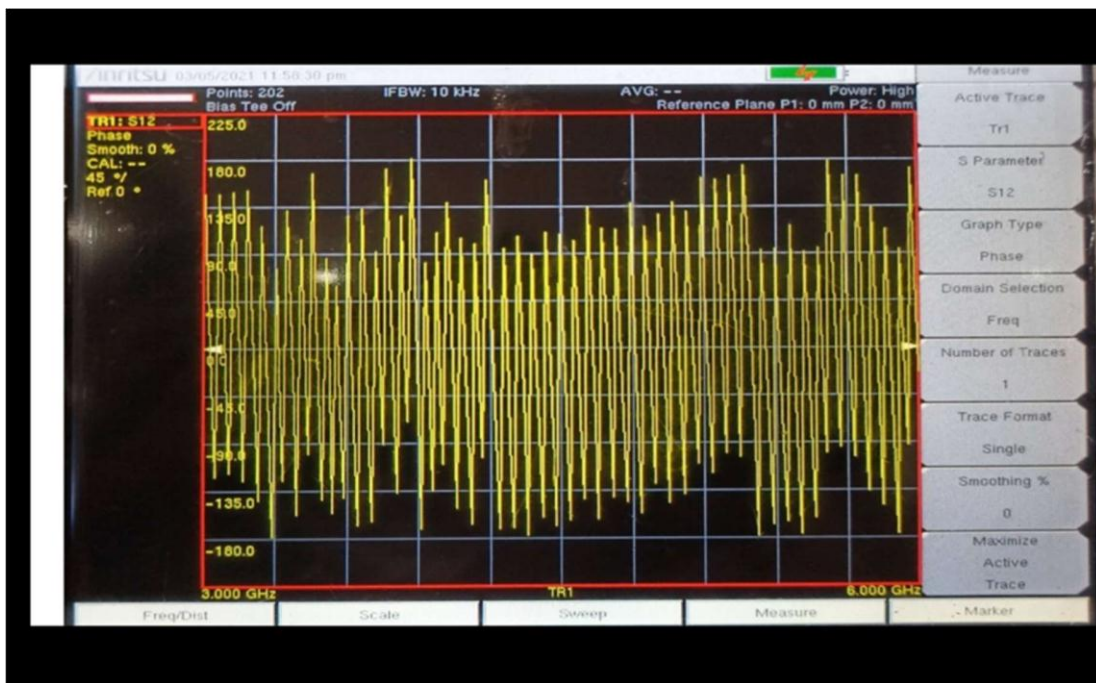


Fig 28 Phase plot at S12



Fig 29 Phase plot at S22

6.CONCLUSION

The proposed micro-strip Band pass filter was plotted using the substrate material such as FR4 with wagon shape and achieved to work in 5G applications in sub-6GHz band with low losses. The performance parameters such as Notching and passing parameters, Group delay, Impedance plot, Accepted power, Radiated Power, Radiation efficiency were noted and analysed using the HFSS simulation tool and took a detail study in the above literature.

The proposed methodology revealed better performance rate from the analysis. The presented fabricated wagon wheel shaped ultracompact bandpass filter will show's a great performance in real time with the high efficiency of above 70% in 5G applications operating in Sub-6GHz band.

REFERENCES

[1]

Almorqi S ET. EL, "Parallel-coupled stub-loaded resonator bandpass filter with ultra-wideband passband on multilayer liquid crystal polymer substrates," International Journal of Microwave and Wireless Technologies., pp.1-4, Jul. 2015.

[2]

Ge, Chuan; Zhu, Xiao-Wei (2014). Highly Selective Tuneable Bandpass Filter With Two-Path Mixed Coupling. IEEE Microwave and Wireless Components Letters, 24(7), 451–453. doi:10.1109/lmwc.2014.2316218

[3]

Girdhari Chaudhary, ET. EL, "Harmonic Suppressed Dual – Band Band-Pass Filters with Tuneable Passband". IEEE Transactions on Microwave theory and Techniques. Doi: 10.1109/TMTT.2012.2197020

[4]

Hussein N. Shaman; National Centre for Sensors and defence Systems Technologies (NCS DST), "Compact Ultra-wideband (UWB) Bandpass Filter with Wideband Harmonic Suppression". doi.org/10.1109/MIKON.2016.7492045.

[5]

Kaliyavarathan Thirumalaivasan, Rangaswamy Nakkeeran; "Development of Compact Ultra-Wideband (UWB) Microstrip Bandpass Filter"; Journal of Electromagnetic Analysis and Applications. doi:10.4236/jemaa.2011.38053.

[6]

Kai-Ran Xiang, and Fu-Chang Chen, Member, IEEE. "Compact Microstrip Bandpass Filter with Multiparous Suppression Using Quarter-wavelength and Half-wavelength Uniform Impedance Resonators". doi.org/10.1109/ACCESS.2018.2822262.

[7]

Keren Li, Daisuke Kurita, and Toshiaki Matsui; "A Novel UWB Band pass filter and its application to UWB pulse generation"; National Institute of Information and Communication Technology (NICT). doi.org/10.1109/ICU.2005.1570029.

[8]

Nedil E ET. EL "Ultra-wideband microstrip to CB-CPW transition applied to broadband filter"doi:10.1049/eI:20070693.

[9]

Prasan Kumar Mishra, ET. EL "Compact ultra-wideband bandpass filter using broadside coupled hairpin structures on multilayer liquid crystal polymer substrate," Electron. Lett., vol.44, pp. 1197–1198, 2008. J.S.

[10]

Shaman H, ET. EL "Ultra-wideband (UWB) bandpass filter with cascaded lowpass filter on multilayer liquid crystal polymer (LCP) substrate," IETE Journal of Research., pp.1-4, Jan. 2015.

[11]

Yiping Zang, ET. EL has proposed "A Compact Micro-Strip Antenna with Enhanced Band width and Ultrawide band and Harmonic suppression" in March 2019.

[12]

Zhang-Cheng Hao and Jia-Sheng Hong, "UWB Bandpass Filter Using Cascaded Miniature High-Pass and Low-Pass Filters with Multilayer Liquid Crystal Polymer Technology". doi.org/10.1109/ICU.2005.1570029.

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Impedance Resonators", IEEE Access,
2018

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1

3

Chaudhary, Girdhari, Yongchae Jeong,
and Jongsik Lim. "Harmonic
Suppressed Dual-
Band Bandpass Filters With Tunable
Passbands", IEEE Transactions on
Microwave Theory and Techniques,
2012.

Publication

1

4

Hussein N. Shaman, Abdulrahman M.
Almughamis, Ali M. Alamro, Yahya S.
Alharthi.
"Compact Ultra-wideband (UWB)

1

bandpass filter with wideband harmonic suppression", 2016 21st International Conference on

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K. Li. "UWB Bandpass Filter: Structure, Performance and Application to UWB Pulse Generation", 2005 Asia-Pacific Microwave Conference Proceedings, 2005

Publication

14

Submitted to American University of Kuwait

15

Student Paper

Y. Horii. "A Compact Multi-Layered Bandpass Filter with Transmission Zeros for UWB Applications", 2005 Asia-Pacific Microwave Conference Proceedings, 2005

16

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17

res.mdpi.com

Internet Source

Othman, M.A., M.S. Ishak, M.Z.A. Abd Aziz, M.M. Ismail, H.A. Sulaiman, M.H. Misran, M.A. Meor Said, and R.A. Ramlee. "UWB Chebyshev band pass filter for UWB communication", 2013 International

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Publication

31 Zhang-Cheng Hao. "Ultra-Wideband Bandpass Filter Using Multilayer Liquid-Crystal-Polymer Technology", IEEE Transactions on Microwave Theory and Techniques, 2008
Publication

32 docplayer.net
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34 K. LI. "Notch-Band Implemented UWB Bandpass Filter", IEICE Transactions on Electronics, 12/01/2007

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