ACTIVE UWB ANTENNA PROJECT REPORT

by

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A comprehensive project report has been submitted in partial fulfillment of the requirements for the degree of

Bachelor of Technology

in

ELECTRONICS & COMMUNICATION ENGINEERING

Under the supervision of

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MAY,2018

CERTIFICATE OF APPROVAL

This is to certify that the project titled "**ACTIVE UWB ANTENNA**" carried out by

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for the partial fulfillment of the requirements for B.Tech degree in **Electronics and Communication Engineering** from **Maulana Abul Kalam Azad University of Technology, West Bengal**is absolutely based on his own work under the supervision of **Mr. NANDAN BHATTACHARYYA**. The contents of this thesis, in full or in parts, have not been submitted to any other Institute or University for the award of any degree or diploma.

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DECLARATION

"We Do hereby declare that this submission is our own work conformed to the norms and guidelines given in the Ethical Code of Conduct of the Institute and that, to the best of our knowledge and belief, it contains no material previously written by another neither person nor material (data, theoretical analysis, figures, and text) which has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgement has been made in the text."

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is hereby recommended to be accepted for the partial fulfillment of the requirements for B.Tech degree in **Electronics and Communication Engineering** from **Maulana Abul Kalam Azad University of Technology, West Bengal**

Name of the Examiner Signature with Date

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ABSTRACT

Aim of this project is to make UWB Antenna which operates within a large bandwidth from 3.1 to 10.6 GHZ. At first the short pulses were generated Using Advance Design System Software where we observed the output pulses for a certain input pulse. The drawbacks of that circuit was - 1. It was made in low frequency range.2.we were getting the output pulses for both the rising and falling edges. The above mentioned circuit was based on HEMT (High ElectronMobility Transistor) and was tested at low frequencies. The L of 800nH and C of 1nF were connected to the drain. For the input pulse train VLow = −2.5V, VHigh =−0.15V, pulse rate was at 5kHz,VDC = 2.5V was used for biasing the UWB circuit. To eliminate the effect of rising pulses another circuit was implemented whereSchottky diode with wire leads, a resistance of 100kΩ,coupling and bypass capacitors of 1UF values were added in the circuit.But the main drawback of that circuit was that it was not following the wide range of UWB pulses as proposed by FCC.For that some modifications were done in the above mentioned circuit where The values of coupling and bypass capacitors were being changed into 10nF,10uF and 1pF respectively. The value of the Inductor was also changed into 1nH. Next part was to check the bandwidth limit of the circuit using MATLAB. We imported the designed file from ADS and load it into MATLAB by using 'LOAD' command such that it could read the ASCII values of the output file.After simulating inMATLAB we got the output range nearly to the required range of bandwidth.The next part was to implement the antenna with HFSS software (High Frequency Structure Simulator).In this part our main aim was to design the UWB planar micro strip fed slot antenna and simulate it.

CONTENTS

LIST OF FIGURES

LITRATURE SURVEY

Numerous ultra-wideband, ultra-short-pulse transmitters have been developed [1]. Most of the circuits are quite sophisticated, employing high-performance components and sub-systems.The simplest circuit that has been described in [2] is the simplest circuit proposed for generating UWB pulses from a digital input, employing one FET, one optional diode and a few passive components.UWB signals have been usually generated using two techniques. One is to generate a narrow pulse using a differentiator-type circuit, and then modify the shape by filters [3] to fit the FCC spectral mask. The other way is to generate a precise UWB pulse whose frequency spectrum satisfies the FCC regulation [4, 5].A new scheme is proposed in [6] for the generation of short pulse using a FET (use of a BJT is also possible).

Chapter 1

INTRODUCTION

Wireless communication technology has changed our lives during the past two decades. In homes and once everywhere the technology is being used. Wireless local area network (WLAN) technology provides us access to the internet without sobering from managing cables.Large number of new services are being implemented like The first-generation (1G) mobile communication technology only allowed analogue voice communication, the second-generation (2G) technology realized digital voice communication, the third-generation (3G) technology can provide video telephony, internet access, video/music download services as well as digital voice services, the fourth-generation (4G) technology will be able to provide on-demand high quality audio and video services, and other advanced services .Whereas, now we are looking for new technology named (5G),the fifth-generation technology.

Now the uses of (WPAN) technology worldwide changing the dimension of technology. The future WPAN aims to provide reliable wireless connectionsbetweencomputers, portabledevicesandconsumerelectronicswithina short range, fast data storage and exchange between these devices will also be accomplished. The maximum achievable data rate or capacity for the ideal band-limited signal can be calculated by Shannon-Nyquist criterion as shown in Equation.

In the 2002 on 14th February, the Federal Communications Commission (FCC) of the United States adopted and permitted the commercial operation of ultra wideband (UWB) technology. Since then, UWB technology has been regarded as one of the most promising wireless technologies that provide high data rate transmission.

WHAT IS ANTENNA:

The purpose of antenna is to convert the Radio Frequency (RF) into Alternating Frequency (AC) and vice versa. Antenna can be named as transducer. Two type of antennas are being used -1.Receiving Antenna 2.Transmitting Antenna

In Receiving Antenna, RF energy is intercepted and delivered AC to electronic equipment. In Transmitting Antenna, fed with AC from electronic equipment and produces RF Field.

UWB ANTENNA:

Ultra –Wideband is considered as Radio Technology. At very low energy level and for very short range the utilities of UWB Antenna can be found. The main purpose of UWB Antenna is for high bandwidth communications and over a large portion of Radio Spectrum. For Non-cooperative radar imaging UWB is used. Another application we can obtain is for precision location or tracking application etc.

A certain frequency has been assigned by (FCC) for the UWB Antenna is from 3.1 to 10.6GHz for commercial communication applications in February 2002. A feasible UWB antenna should possess a good performance in both the time and frequency domain and small , compact appearance is also necessary .So undoubtedly designing of UWB Antenna is a kind of challenge.

Ultra-wideband is a technology for transmitting information spread over a large bandwidth (>500 MHz); such that it can be able to share spectrum with other users. Regulatory settings by the Federal Communications Commission (FCC) in the United States intend to provide an efficient use of radio bandwidth while enabling high-data-rate personal area network (PAN) wireless connectivity; longer-range, low-data-rate applications; and radar and imaging systems etc. Personal Area Network is considered to have the connectivity within the range on an individual person (say within a range of 10 meters).For an example we can consider that we can connect printers to our personal computers without using wires and this can be done with some wireless technologies.

Though earlier UWB was referred as pulse radio(the frequency range is from $1*10^4$ to $3*10^{11}$), but the InternationalTelecommunication Union Radio communication Sector currently define UWB as an antenna transmission for which emitted signal bandwidth exceeds the lesser of 500 MHz or 20% of the arithmetic center frequency.

A significant difference between conventional radio transmissions and UWB is that conventional systems transmit information by varying the power level, frequency, and/or phase of a sinusoidal wave. UWB transmissions transmit information by generating radio energy at specific time intervals and occupying a large bandwidth, thus enabling pulse-position or time modulation. The information can also be modulated on UWB signals (pulses) by encoding the polarity of the pulse, its amplitude and/or by using orthogonal pulses. UWB pulses can be sent sporadically at relatively low pulse rates to support time or position modulation, but can also be sent at rates up to the inverse of the UWB pulse bandwidth.

Another feature of pulse-based UWB is that the pulses are very short (less than 60 cm for a 500 MHz-wide pulse, less than 23 cm for a 1.3 GHz-bandwidth pulse)—so most signal reflections do not overlap the original pulse, and there is no multipath fading of narrowband signal.

DEVELOPMENT:

The development of UWB technology started by the US military in the year of 1962. Traditionally networks had been characterized according to the parameters such as amplitude and phase with respect to frequency. Then the concept of Ultra Wide band had risen.

But the equipments were not available at that time to make an antenna of such large bandwidth. Then and then the research has started to make all the possible equipments to produce such antenna.

After the microwave networks to impulses, the next major step forward occurred when the techniques were applied to radiating systems. Since in the year of 1968 it became obvious that for the communication purpose applying of UWB technology will be advantageous.

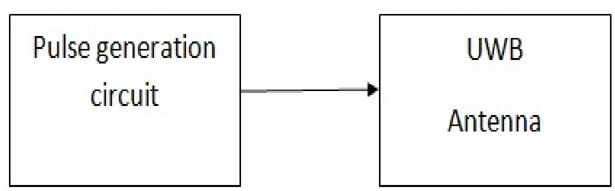
The rate of producing equipments was increased after that year and during this period it was termed carrier free or impulse technology. Though the technology had been produced in a larger rate but was only limited to military use.

In the years following 2000, commercial wireless communications became established. Technologies such as 802.11 (Wi-Fi), Bluetooth and others were established. Development of such technologies made a revolutionary change in the world of digital technologies. The rate of uses of digital technologies increased in a larger way.

One of the major limitations to the speed at which UWB could enter the commercial marketplace was legislation. In view of the fact that UWB occupies a wide bandwidth, even though at a low power level, it has to exist alongside traditional transmissions without causing any undue interference. Accordingly the legislative bodies and in particular the FCC in the USA have been proceeding with caution. Any changes in direction required will be far more difficult to address in later years once UWB technology is firmly established. Despite this UWB transmissions are allowed, provided that they remain within a given power density and frequency profile. This ensures that the allowed transmission levels do not cause any noticeable interference to existing transmissions.

ACTIVE ANTENNA :

An active antenna, by definition, integrates the active microwave circuits and the radiating element on the same substrate, thereby reducing transition and transmission losses.



Advantages of Active Antenna :-

It is more important to minor impedance mismatch or cable length than passive antenna and It helps to keep the receiver noise figure low.

Disadvantages of Active Antenna :-

It needs more power (about 10 to 60 mw) to compare to passive antenna.

DIFFERENCE BETWEEN UWB AND SPREAD SPECTRUM:

According to "Introduction to Ultra-Wideband Radar Systems" by James D. Taylor, ultra wideband was called by a number of names before 1990 such as impulse, video pulse, super wideband, carrier less signals, non sinusoidal and baseband. The common term ultra wide band can simply be seen as "wider than wide band".

Though through operation point there are similarities between UWB and Spread Spectrum but there is little dissimilarity also to distinguish. Spread spectrum sends a signal over a frequency range wider than the minimum required to actually send the signal, but its baseband signal is only a few kilohertz wide before being encoded and sent over a wider frequency bandwidth. Spread spectrum has a fractional bandwidth but not as low as UWB. Ultra-wideband signals differ from spread spectrum in that their fractional bandwidth is less than 25%, typically far less. The broader frequency range and lower power requirements are why UWB antennas are increasingly used in indoor wireless networks relative to spread spectrum.

IMPORTANCE OF UWB ANTENNA:

Importance of UWB Antenna as follows:

1) Large Bandwidth –

The bandwidth allotted more than 500MHz to 7.5GHz which is from 20% to 110 % fractional of center frequency.

2) Very Short Duration Pulses –

UWB pulses are of typically mono second or nanosecond order.

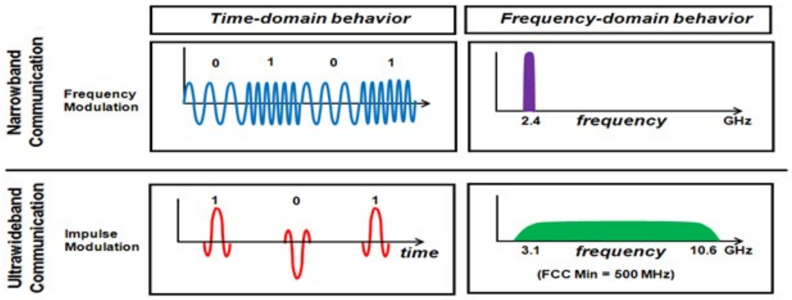


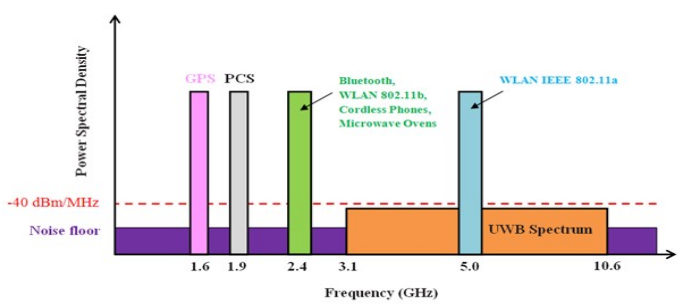
Fig 1.1 Time and Frequency domain behavior of narrowband vs UWB Antenna

3) High Data Rates with Fast Speed -

One of those advantages of UWB transmission for communications is the ability of UWB system to achieve high data rates in future wireless communication which requires increasing the bandwidth of the communication system. Another advantage of UWB systems is the ability to effectively reduce fading and interference problems in different wireless propagation channel environments because of the limited power transmitted power of UWB Systems.

4) Low Power Consumption –

When signals are sent over ultra-wide band antennas, a low level of signal over a wide frequency band, less power is needed because it suffers from less interference. The means UWB antennas need less energy to provide internet access, digital voice services and video telephony. UWB antennas also don't interfere with carrier wave transmissions and narrowband signals. The lower power output reduces the risk of eavesdropping, and when communications are key, the fact that UWB is very hard to jam is attractive.



Due to spreading the energy of the UWB signals over a large frequency band, the maximum power available to the antenna – as part of UWB system- will be as small as in order of 0.5mW according to the FCC Spectral mask.

5) Small size and low cost:-

The main arguments for the small size of UWB transmitters and receivers are due to the reduction of passive components. Antenna size and shape is always an important factor .Low system complexity and low cost are the important parameters of designing an antenna.

Another valuable aspect of UWB technology is the ability for a UWB radio system to determine the "time of flight" of the transmission at various frequencies. This helps overcome multipath propagation.

Ultra wide band has reduced fading from multipath but can suffer from inter symbol interference.

APPLICATION:

Ultra-wideband characteristics are well-suited to short-distance applications, such as PC peripherals. Due to low emission levels permitted by regulatory agencies, UWB systems tend to be short-range indoor applications. Due to the short duration of UWB pulses, it is easier to engineer high data rates; data rate may be exchanged for range by aggregating pulse energy per data bit (with integration or coding techniques). Conventional orthogonal frequency-division multiplexing (OFDM) technology may also be used, subject to minimum-bandwidth requirements. High-data-rate UWB may enable wirelessmonitors, the efficient transfer of data from digital camcorders, wireless printing of digital pictures from a camera without the need for a personalcomputer and file transfers between cell-phone handsets and handheld devices such as portable media players. UWB is used for real-time location systems; its precision capabilities and low power make it well-suited for radio-frequency-sensitive environments, such as hospitals. Another feature of UWB is its short broadcast time.

Ultra-wideband is also used in "see-through-the-wall" precision radar-imaging technology, precision locating and tracking (using distance measurements between radios), and precision time-of-arrival-based localization approaches. It is efficient, with a spatial capacity of approximately 10^{13} bit/s/m². UWB radar has been proposed as the active sensor component in an Automatic Target Recognition application, designed to detect humans or objects that have fallen onto subway tracks.

UWB has been a proposed technology for use in personal area networks, and appeared in the IEEE 802.15.3a draft PAN standard. However, after several years of deadlock, the IEEE 802.15.3a task groupwas dissolved in 2006. The work was completed by the WiMedia Alliance and the USB Implementer Forum. Slow progress in UWB standards development, the cost of initial implementation, and performance significantly lower than initially expected are several reasons for the limited use of UWB in consumer products (which caused several UWB vendors to cease operations in 2008 and 2009).

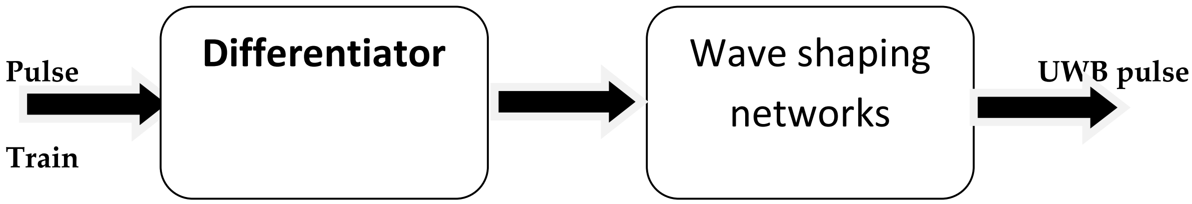
Chapter 2

PROJECT STATEMENT: DESIGN OF ACTIVE UWB ANTENNA

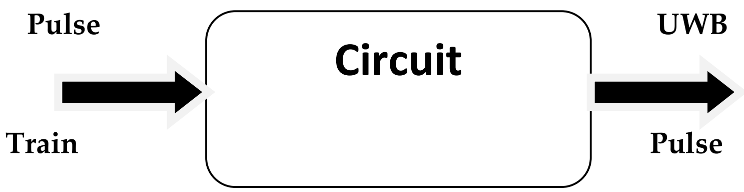
PULSE GENERATION CIRCUIT DESIGN:

Here is the block diagram of two methods of generation UWB signals. UWB signals have been usually generated using **two techniques:**

- Generate a narrow pulse using a differentiator-type circuit, and then modify the shape by filters or an up-converter to fit the FCC spectral mask.



Generate a precise UWB pulse whose frequency spectrum satisfies the FCC regulation.



We have implemented the short pulse generation circuit using a FET as an active device.

COMPONENTS USED:

According to our previously described method here list of the components that are used for the circuit simulation.

COMPONENTS NAME	QUANTITY
DC voltage source(Vdc)	1
Capacitor	3
Inductor	1
FET	1
Diode	1
Voltage Source	1
Resistor	3

SOFTWARE USED FOR SIMULATION:

1. Advanced Design System(ADS) 2008 software.
2. High Frequency Structure Simulator 13.0(HFSS 13.0) software.

VERIFICATION OF CIRCUIT AT LOW FREQUENCY USING FET:

The circuit is based on HEMT (High Electron Mobility Transistor) and tested at low frequencies. The L of 800nH and C of 1nF were connected to the drain. For the input pulse train VLow = −2.5V, VHigh = −0.15V, pulse rate is at 5kHz,VDC = 2.5V was used for biasing the UWB circuit. In this case, we get output pulses corresponding to the rising as well as falling edges of input pulse train.

But to get an output pulse on at the falling edge of the input pulse train Schottky diode with wire leads, a resistance of 100kΩ and capacitor of 470pF were used in the input side of the transistor. The same input pulse is given to the circuit in the simulator and correspondingly we get the simulated output pulses. The action of the diode is as follows: for the falling edge, the gate of the FET is rapidly pulled through the ON diode to the negative input voltage (−2.5V). This causes an abrupt turn-off of the FET, thus abruptly diverting the drain current into the L-C at the output, which generates the UWB pulse. For the rising edge, the gate and the 470pF capacitor have to discharge through the resistor R, the diode being OFF. This slows the turn-on of the FET, and the drain current rises gradually as shown in Fig. This gradual turn-on leads to a negligibly weak output pulse generated by the L-C network at the rising edge of the input.

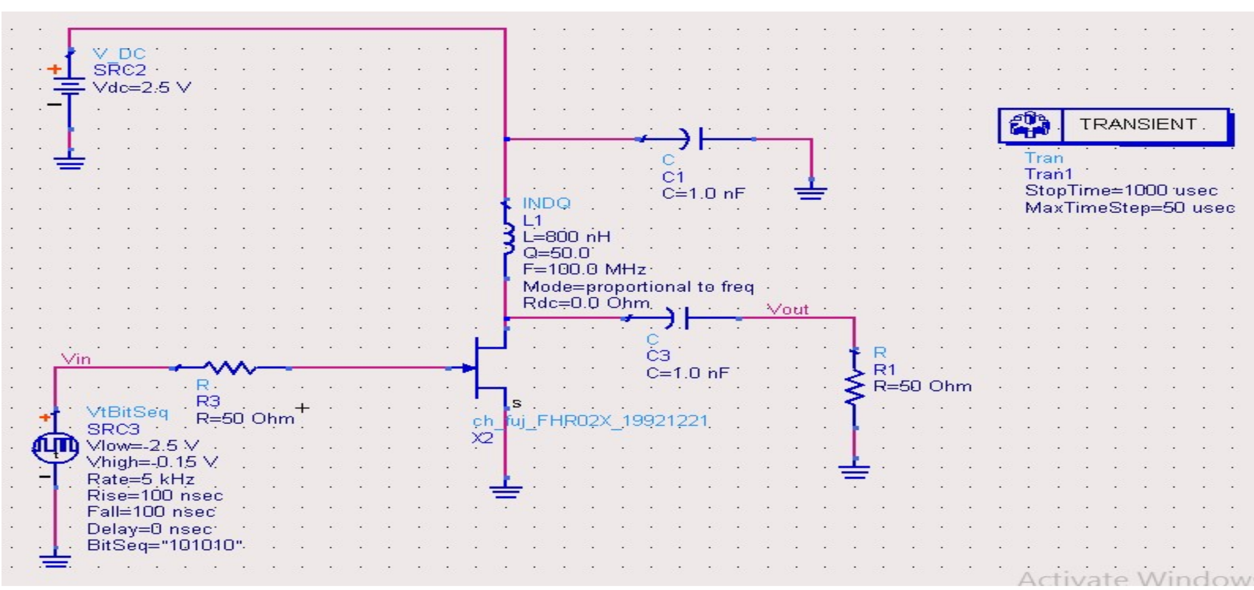


Fig 2.1: Basic short-pulse generation circuit at low frequency

OUTPUT:

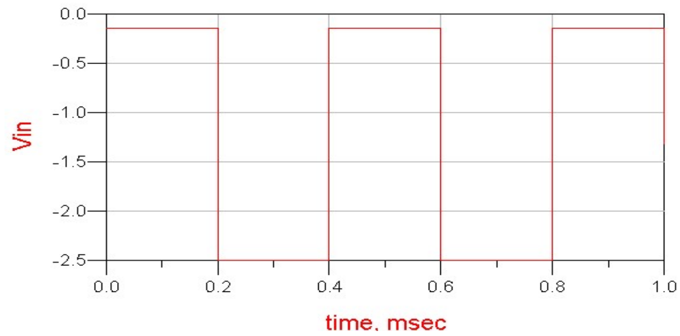


Fig 2.2: Input Pulse

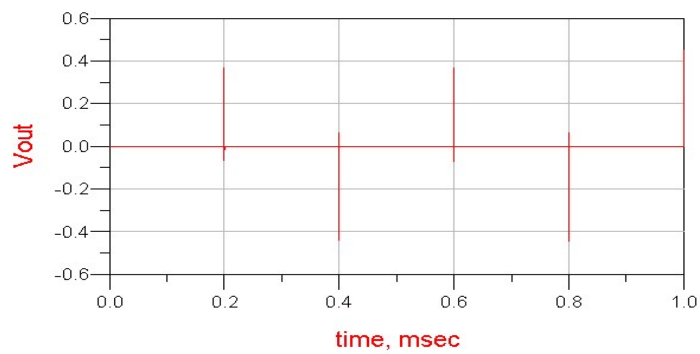


Fig 2.3: Output Short Pulse

ZOOMED VIEW OF OUTPUT :

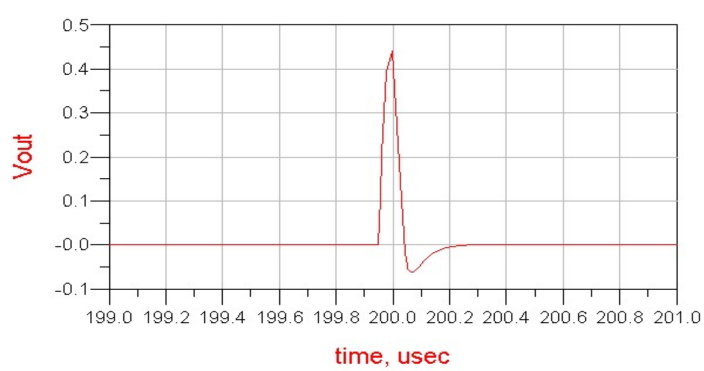


Fig 2.4:At the Time of Rising Edge of Input Pulse

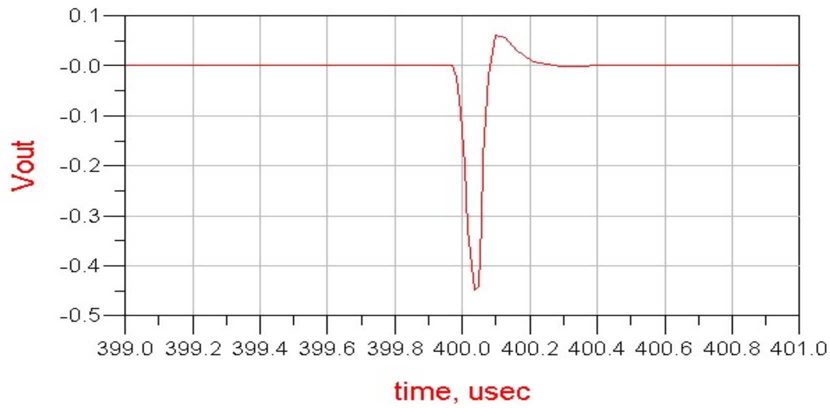


Fig 2.5: At the Time of Falling Edge of Input Pulse

<u>**CIRCUIT TO ELIMINATE THE SHORT PULSE GENERATED FOR THE RISING EDGE OF INPUT PULSE:**</u>

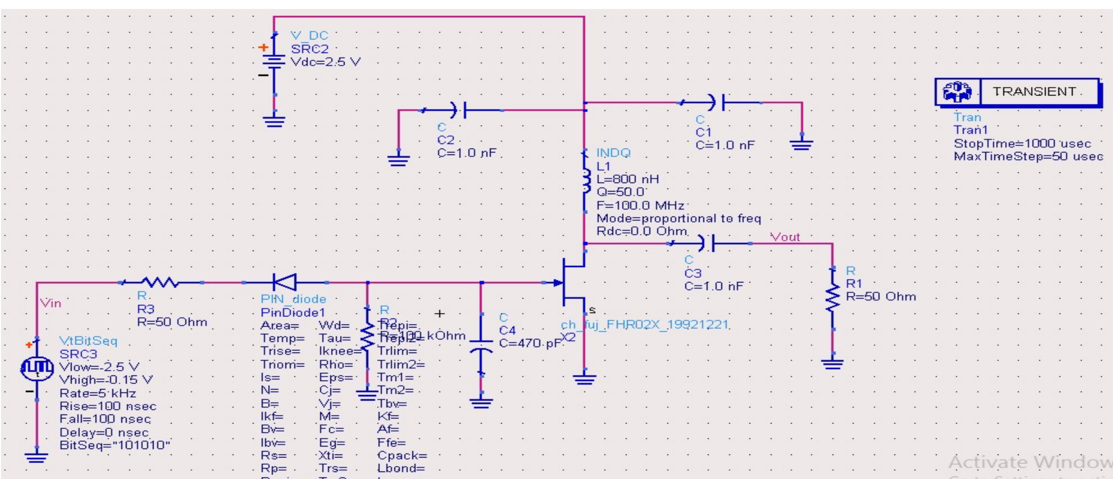


Fig 2.6: Circuit to eliminate the short pulse generated for the rising edge of input pulse

In this circuit the MIC capacitor, the d.c. decoupling capacitor of 1UF value has been used but that capacitor is being unable to remove the sub-nanosecond ripples from the voltage at the d.c input point. Though it is quite excepted in case of UWB antenna design. For the output wave of short pulse generation circuit we can observe that the output is being generated for both the rising edge and falling edge of the input curve. Nowin this circuit we want to eliminate the effect of rising and to check the output at the falling edge only.

In this circuit PN junction diode, coupling and bypass capacitors of value 1.0nF are added to get the desired result of the output.

<u>SIMULATION RESULT</u>:

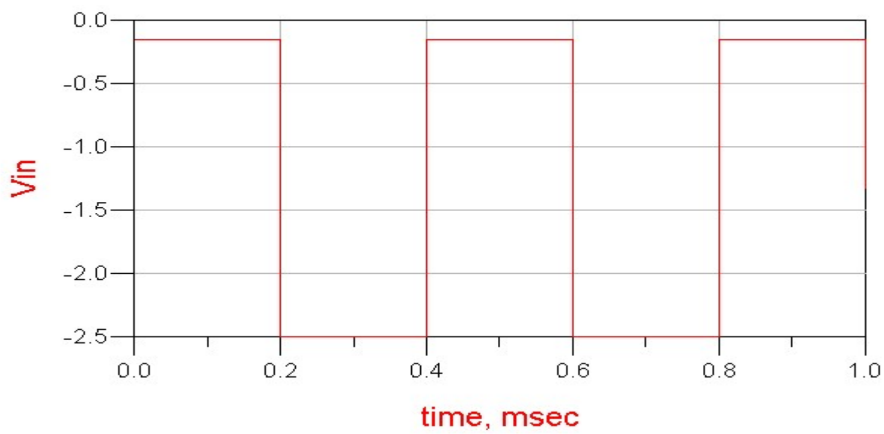


Fig 2.7: Input pulse

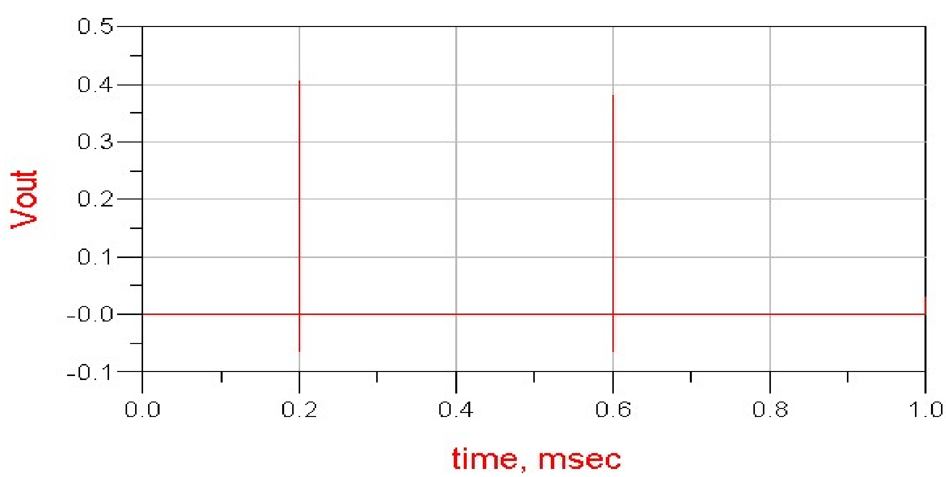


Fig 2.8: Output pulse

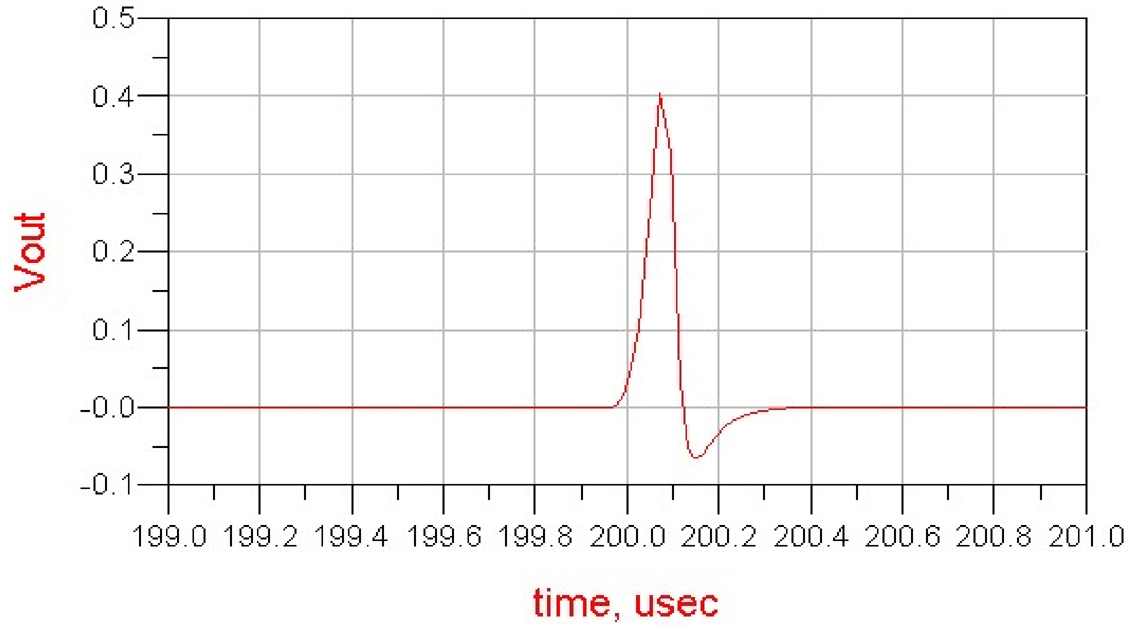


Fig 2.9: Zoomed view of output

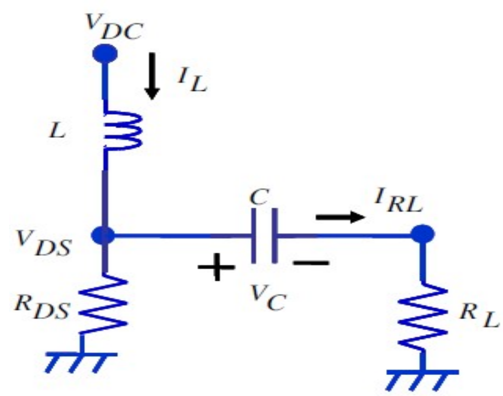
ANALYSIS OF CIRCUIT:

As per the brief analysis of the circuit For a rising edge at the input, we can assume that the device is initially in OFF state but still there is some voltage across the capacitor, and at t = 0 it abruptly turns ON (with a low but finite RDS). Standard transient circuit analysis is used then to calculate the resultant waveform, which also predicts the final current in the inductor. This is used as an initial condition for analyzing the turn-OFF. When the device is turned OFF by the input going low, the output waveform can be calculated by analyzing the L-C-R circuit (At this case RDS and CDS have to be ignored).

(i) **FET in Turn-on State**

When transistor is working in the turn-on state, the equivalent circuit is shown in below . The on-state resistance (RDS)or drain to source resistance of the FET is calculated using a data sheet and for this case the value of RDS is 10 ohm. The load resistance RL is 50Ω.

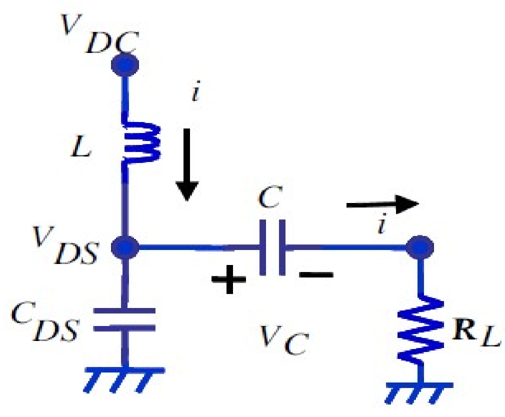
Initially capacitor C is charged upto the voltage VDS(Drain to Source Voltage) when the transistor remains in OFF condition and current flowing through the inductor is zero.



The equivalent circuit for FET turn-on

<u>FET in Turn-off State</u>

When transistor is working in the turn-off state, The value of capacitance (CDS) of the FET is 0.12pF and it can be neglected for simplification.



The equivalent circuit in the turn-off condition of FET

We know that the initial current i(t = 0+) present in the inductor due to turn-on condition of the transistor. i.e., i(t = 0+) = I0 = 0.25A (the first initial condition) and VC(t = 0) = VDC.

Let loop current be *i* °owing in the circuit. In the time domain application of KVL to the circuit gives:

Combining the turn-ON and turn-OFF, with an input pulse-width of 10ns, we get the final load current waveform which may be compared to the simulated result. We can observe the changes that happen during the high frequency than low frequency.

CIRCUIT FOR GENERATION OF UWB PULSES FOR 3.1–10.6 GHZ RANGE:

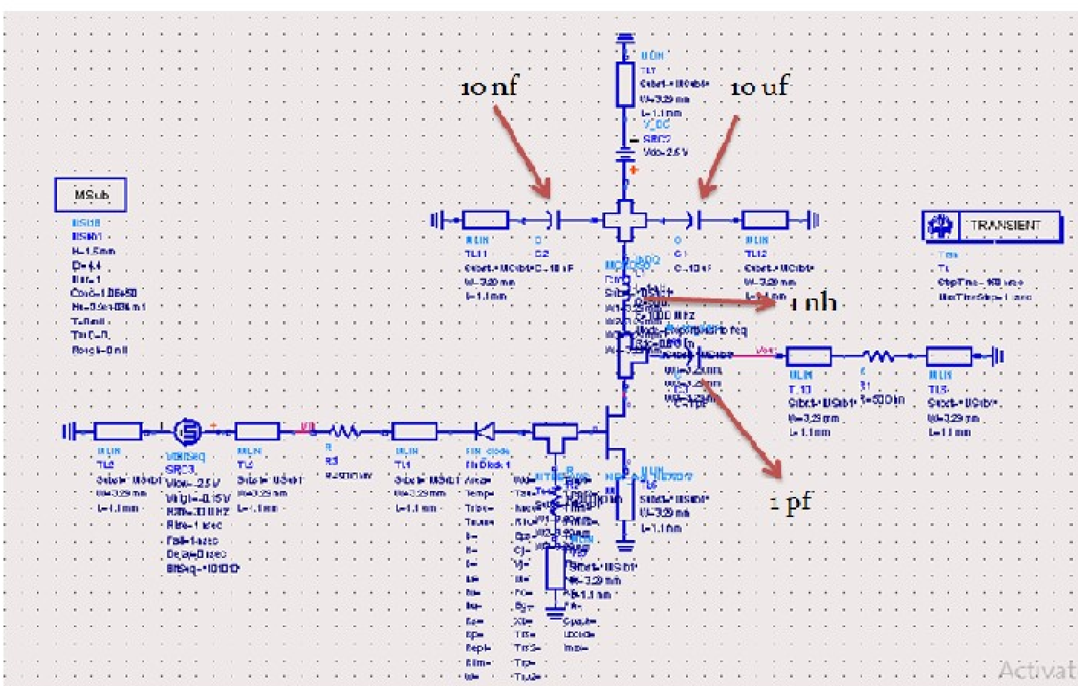


Fig 2.10: Circuit for generation of UWB pulses for 3.1–10.6 GHz range

In the above modified circuit though we had produced the output curve for the falling edge only but the frequency range was very low. To produce UWB pulses we need the required range of bandwidth i.e. from 3.1 to 10.6 GHz. To obtain the required results we have modified the values of the components. We have added several micro strip lines within the components where length of those strips is put manually and width is being calculated for 50 ohm impedance. Where the components that are being used in the previous modified circuit of short pulse generation are kept same in this circuit generation. The values of the components are modified. After modification we have done fft of the output signal using MATLAB to check the frequency range of that signal whether it is in between 3.1 to 10.6 GHz or not. Doing this process (i.e. component value modification and corresponding frequency range checking) for several times we could able to get the optimized result.

SIMULATION RESULT:

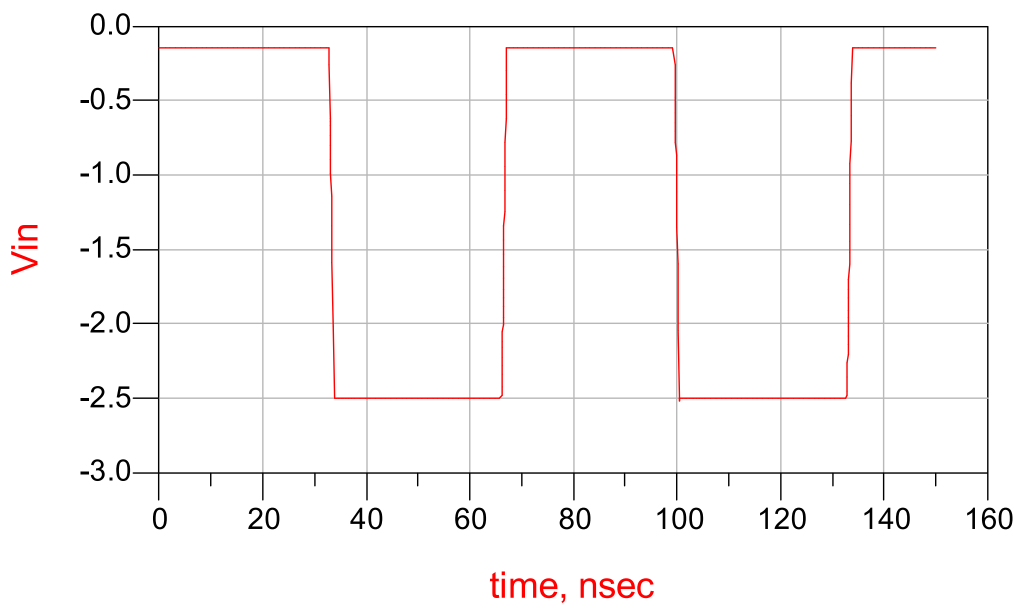


Fig 2.11: Input Pulse

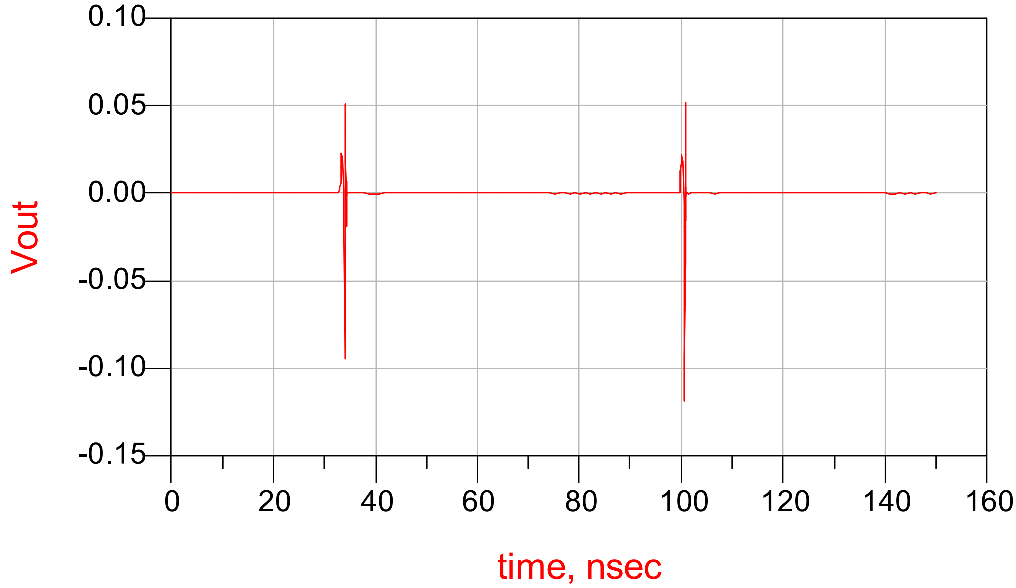


Fig 2.12: Output Pulse

The optimized values of coupling and bypass capacitors are 10nF, 10uF and 1pF respectively. The value of the Inductor is also changed into 1nH.

MATLAB SIMULATION PROCEDURE:

Firstly, the data of the output graph which is obtained from ADS (Advance Design Systems) software is exported and is converted to ASCII value. Then the obtaining data file is loaded to MATLAB. At the next step FFT transform is needed to see the range of the signal at frequency domain. Repeatedly changing the component value of the circuit at ADS software we get some different data file of output signal. These components are Bypass capacitor, coupling capacitor and inductor. Then the data files are loaded in MATLAB and after doing FFT transform we observed the range in the frequency domain. Through this process we tried to take the optimum value of circuit component and to keep it between the frequency range 3.1 GHz 10.6 GHz. But we could not be able to keep the output signal within the given range of 3.1 GHz 10.6 GHz. So we tried to keep it within the nearest range.

The MATLAB code is in below:

```
clc
clear all
formatlongeng
vout = dlmread('C:\Users\admin\Desktop\ads.txt','\t','A1..A662');
t = dlmread('C:\Users\admin\Desktop\ads.txt','\t','B1..B662');
t = t*10^9;
plot(t,vout);
xlabel('Time (ns)');
ylabel('Normalised Amplitude (V)');
Fs = 1/(t(2)-t(1));                 % Sampling frequency
n = 2048;
VOUT = fft(vout,n);
P = abs(VOUT);
A = angle(VOUT);
F = Fs*(0 : n - 1)/n;
figure(2)
plot(F,P);
P1 = P(1:n/2);
A1 = A(1:n/2);
F1 = Fs*(0 : n/2 - 1)/n;
figure(3)
plot(F1,P1);
xlabel('Frequency in GHz')
ylabel('|P(f)|')
```

MATLAB SIMULATION RESULT:

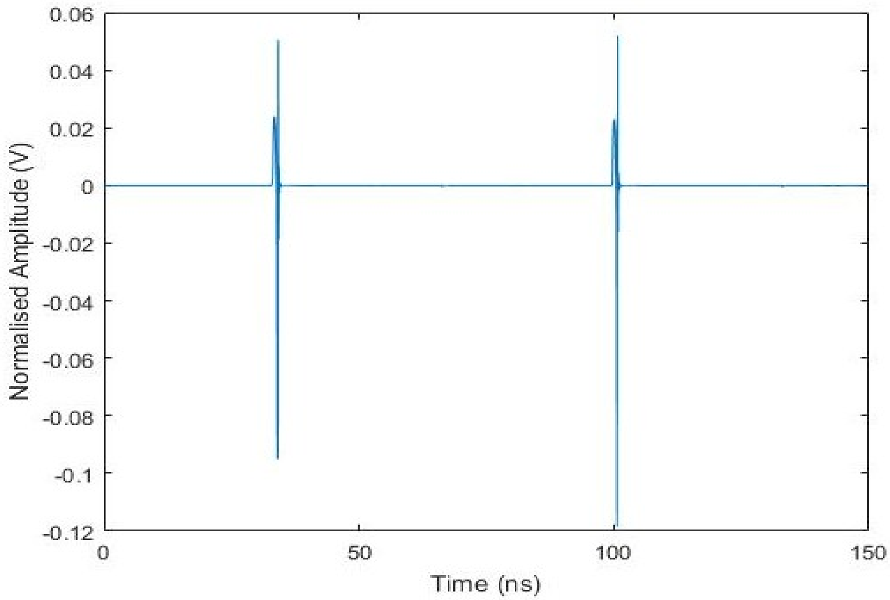


Fig 2.13: Time Domain

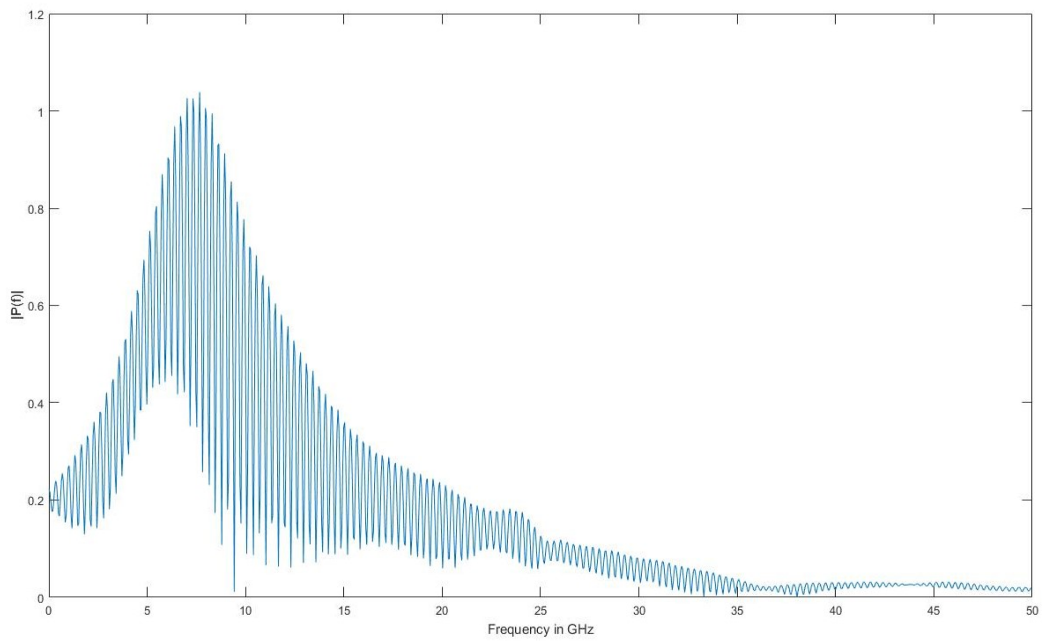
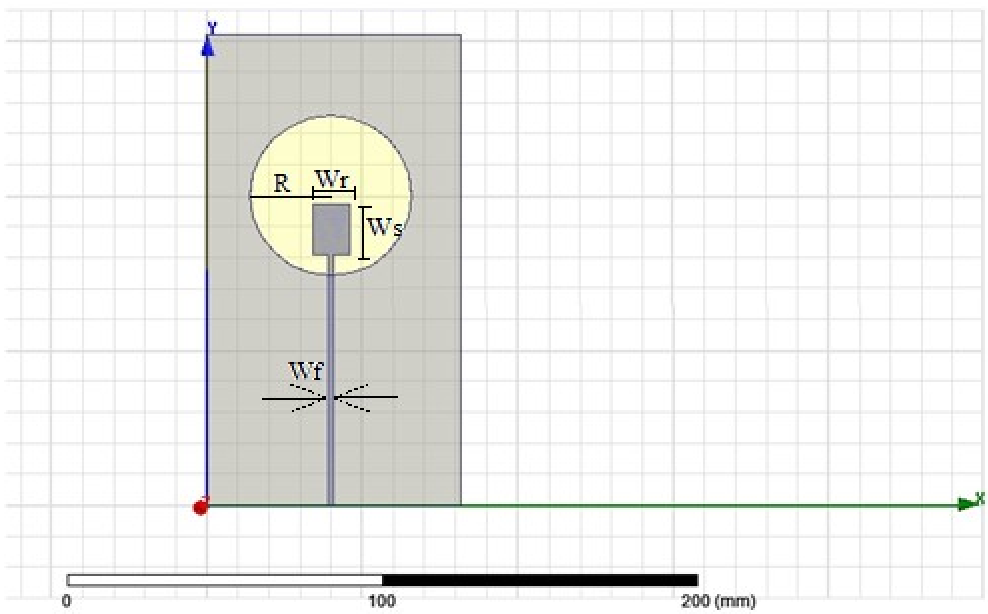


Fig 2.14: Frequency Domain

CIRCULAR SLOT ANTENNA DESIGN:

A **slot antenna** is made of a metal surface which is usually a flat plate, with one or more **slots** cut out. When the plate is driven by a driving frequency, the **slot** radiates electromagnetic waves.

Slot antenna is used at frequencies between 300 MHz and 24 GHz. Slot antennas have a roughly omni-directional radiation patterns. It has linear polarization.



Wr =12mm

Ws =16mm

R =26mm

Wf=1.94 mm

Fig 2.15: Circular Slot Antenna Design

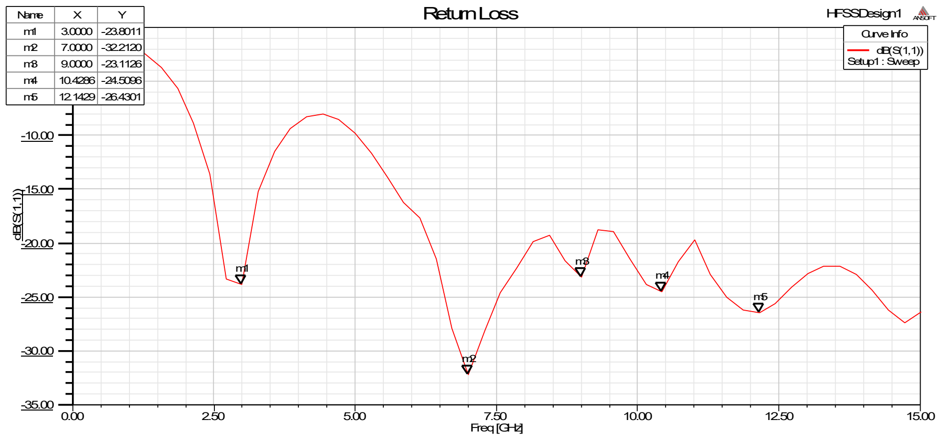


Fig 2.16: Simulation of Circular Slot Antenna

CONCLUSION:

Output short pulse is generated by designing the circuit in **A**DS software. This is the simplest circuit for generation of UWB pulse. We have got low frequency pulse. To obtain UWB pulses for 3.1-10.6 GHz range we have modified values of some components like coupling capacitor, bypass capacitor, and inductor. Then the output file is exported from ADS software and loaded into MATLAB software. We have used the load command to read the ASCII values of output file. After that we have checked that the frequency range of the output pulse is approximately between 3.1-10.6 GHz. We have designed and simulatedcircular slot antenna using HFSS (High Frequency Structure Simulator)software.

FUTURE WORK:

In this project till now we have differently designed and simulated short pulse and UWB pulse generation circuit using ADS software and implemented circular slot antenna in HFSS. The integration between circuit and slot antenna is to be completed and to design receiver to check whether the transmitted and received power are equal or not . Based on the output of receiver end we have to design active UWB antenna practically.

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