

A Design and Analysis of Op Amp Twin-T Band Reject Notch Filter

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Abstract: - In present days the design of filters in the transceivers plays an important role in wireless LAN. In this paper the main focus is to design and analyze the Op Amp Twin T Band Reject Notch filter in order to reject the single or narrow band frequency within the supplied frequency band and to remove the unwanted noise hum. Here the proposed work involves the circuit construction of Dual op-amp Twin T notch filter circuit design in 180nm technology with the 1.8V input power supply. By considering the band rejection twin T notch filter when an input frequency to the filter circuit is allowed with any band frequency range and if there is disturbance in between this band then that particular single frequency is avoided by stopping the unwanted frequency. In this work tried rejecting the frequency of 2.5GHz. This work also includes the addition of voltage to current converter connected after the notch filter circuit design at the-output end in order-to avoid the neutral current in a circuit and thereby measuring parameters results of the circuit i.e gain, power consumption, power quality factor and measure of current is simulated.

Key-Words: - Op amp, LAN, transceiver, Twin T Notch filter, Narrow stopband frequency, Converter.
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1 Introduction

The transceivers play an important role in both wired and wireless network environment. Generally, this Network transceivers are used in specific networks like LAN to transmit and receive signals. A block diagram of wireless LAN is as shown in Fig 1.

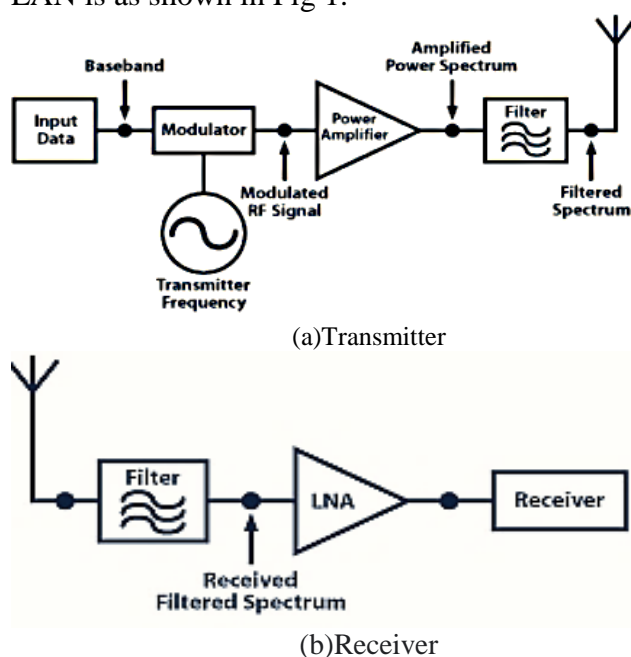


Fig.1. A Block diagram of wireless LAN

The Filters are essential building blocks of any Electronics circuit that is design to pass specified band of frequency. In filter classification notch filter is one of the most commonly used filters at the transceivers. This is capable of rejecting very narrow or single frequency bandwidth with the greater narrow depth, good quality factor, and with the single narrow band rejected characterize of this filter.

A notch filter, it is a kind of simple circuit, is used to remove a specific disturbing frequency. Filters are usually utilized at receiver side so that there are capable of avoiding unwanted noise specific frequency and allow the required frequency signal only.

In a various notch filter classification type a twin T notch filter design is most commonly implemented. This is commonly used at various applications when there is a need for the separation of signal and to avoid the noise disturbance in supplied frequency of a circuit, having narrow reject frequencies it

effectively cut down noise and produce clear signal so that improves quality in frequency signal.

2 Design Methodology

2.1 Twin T Notch Filter

A Notch filter statement is given as a device of a filter which rejects or blocks the single or narrow frequency within a supplied specific frequency range and passes the frequencies outside that range which is needed. The block diagram of op amp twin T notch filter is as showed in fig 2. They are used when there is a required for the separation of signal and to avoid the noise disturbance in circuit. In the filter classification notch filter is one of the most commonly used filters in transceiver for most of the wired and wireless WLAN applications, where this filter is also stated as a stop band filter can reject exactly very single frequency band, here the circuit design of 180nm technology is as shown in Fig 3.

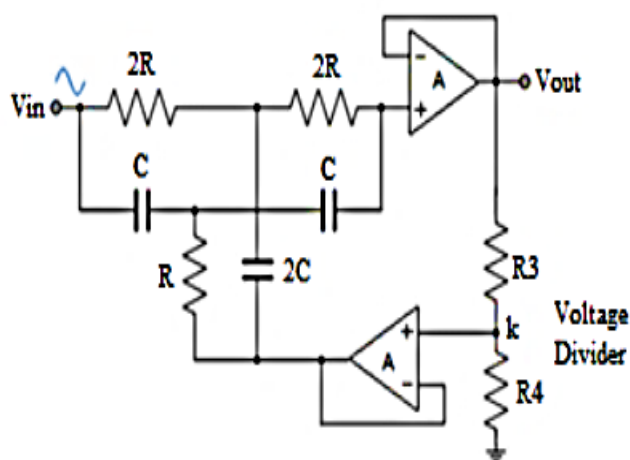


Fig.2. A Block diagram of Op amp twin T active notch filter.

Since the filter is designed to reject one particular frequency, we can expect narrow band frequency by stopping only particular disturbed frequency and by allowing the below and above frequencies which is as shown in the Fig 4.

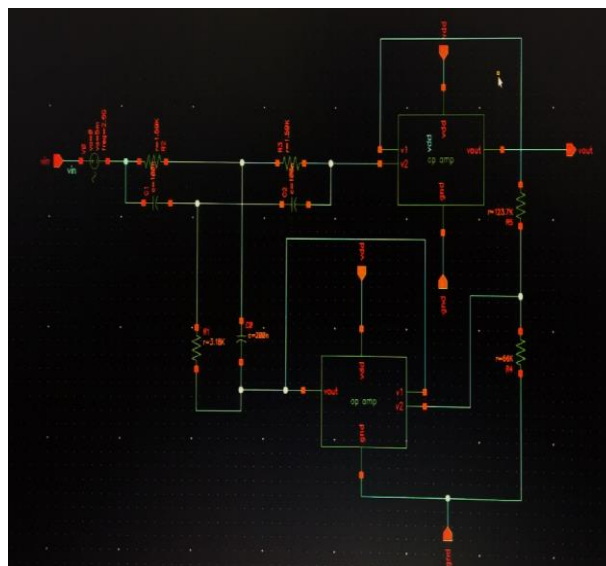


Fig.3. A circuit of dual op amp twin T notch filter

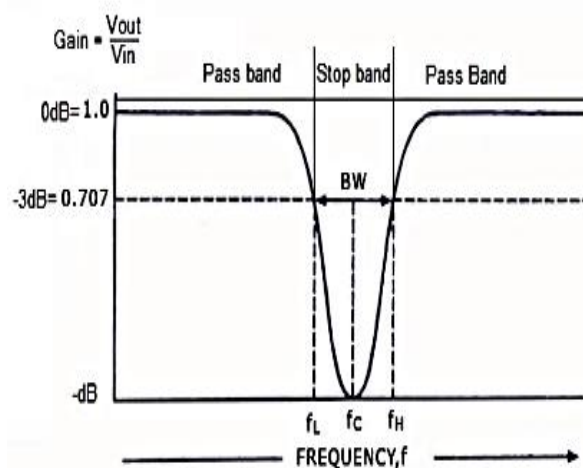


Fig.4. The Notch Frequency of the filter

2.2 Design and Implementation of Twin T Notch filter

The notch filter circuit design of Twin T, RC network can be start with the equation of frequency formula. The complete design of entire circuit will be mainly dependent on stop frequency.

The calculation of unwanted frequency can be rejected using below steps that is formulated as:

$$f_N = \frac{1}{4\pi RC} \tag{1}$$

Step 1: Firstly, need to calculate the R1 value for the assumed capacitance value of 0.1uF.

$$R = \frac{1}{4\pi f_N C} \tag{2}$$

Next to evaluate R2, R3 where R1 should be divided R1 / 2, (where R2=R3).

Step 2: Calculate the value of quality factor Q equation can be formulated as.

$$Q = \frac{f_N}{BW} \tag{3}$$

Step 3: Then the value of feedback fraction K is calculated.

$$k = 1 - \frac{1}{4Q} \tag{4}$$

$$R4 = R1 / (R1 + R2) * 100 \tag{5}$$

Step 4: Then to find R5 resistor value,

$$R5 = R4 - K \tag{6}$$

Step 5: Lastly the notch depth in dB is calculated as:

$$\frac{1}{Q} \text{ (in DB)} \tag{7}$$

2.3 A design of converter from voltage to current

The first stage of notch filter is further extended by serially connecting voltage to current converter. An op amp Twin T band reject notch filter with grid side current converter is proposed in order to avoid neutral current throughout the circuit by converting AC input voltage into the AC current.

For converter design note that the resistors value for circuit will be R4 is parallel to R1 and R3 is parallel to R2, (R1=R4 & R2=R3). Then calculate the Load resistor value of the circuit design, where, $R_L = V_{in} / R_2$.

A junction at n0de A is marked at inverting terminal of the amplifier and junction at node B is at the terminal of non-inverting side. The potential at n0de-B is V_{IN} where input is supplied to the circuit so it is mentioned as the virtual short, where V_A is equal V_B . where $V_{IN} = 1.8mV$.

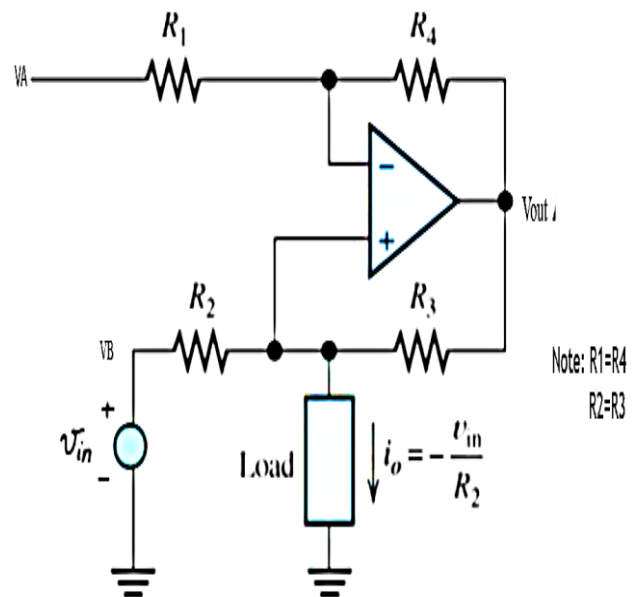


Fig 5 The block diagram of voltage to current converter

The Fig 5 shows the grounded load of converter circuit by connecting to the notch filter at the output side, it starts converting the output voltage obtained from the notch filter to an amount of flow of current in circuit in order to avoid the neutral current in a circuit.

3 Results and Analysis

3.1 Transient analysis

The transient analysis of proposed filter is shown in Fig.6. In this op amp twin T notch filter transient analysis of output voltage and power consumption is observed.

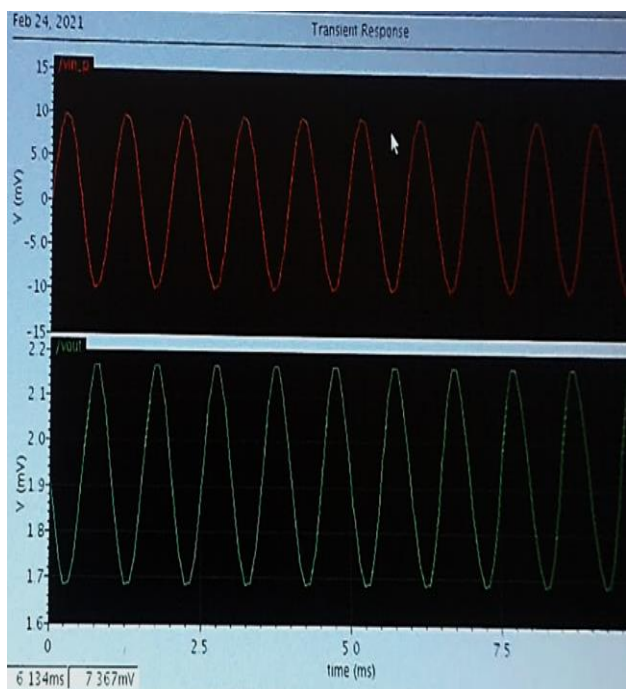


Fig.6. The transient analysis of notch filter

Input is set as $V_{in} = 1.8\text{mV}$ by providing the input amplitude as 10mV for the stop frequency $f = 2.5\text{GHz}$ and obtained output voltage results is $V_{out}: 1.8\text{mV}$ also the power consumption is observed 20.5mW.

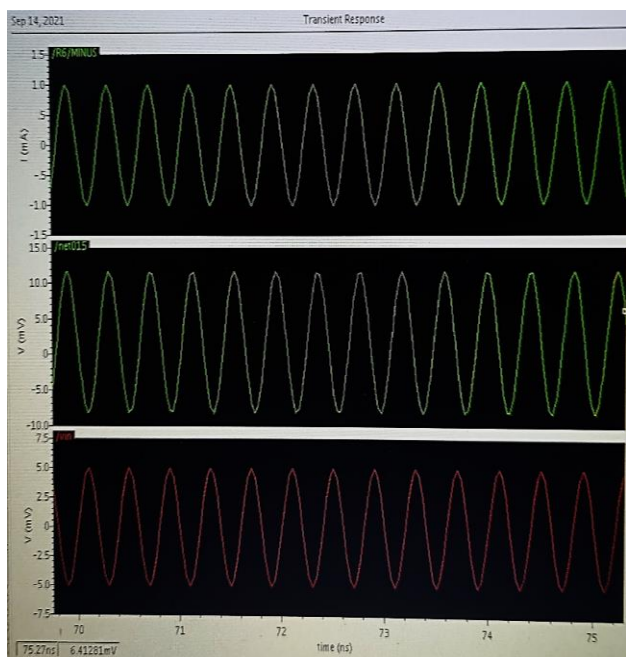


Fig.7 The transient analysis of the proposed filter

The Fig 7 shows the transient analysis of proposed filter with voltage to current converter is observed. Input to the circuit is given by $v_{in} = 1.8\text{mV}$ with stopped frequency $f = 2.5\text{GHz}$ and obtained output voltage $v_{out} = 1.8\text{mV}$ also for the measure of current grid connected converter is attached for converting voltage into the measure of current, the obtained $I_{out} = 1.53\text{mA}$, power consumption = 37.85mW. The Fig 8 shows the power factor $pf = 0.885\text{mW}$ is also observed for the filter.

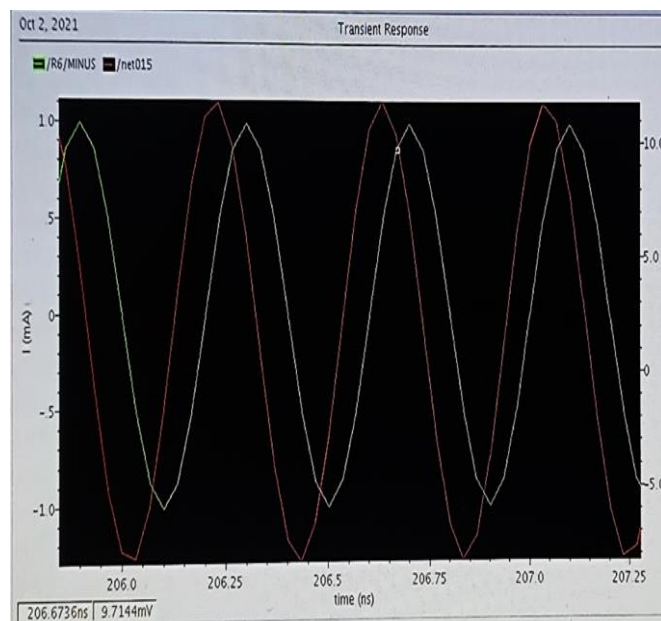


Fig.8. The power factor of the proposed filter.

3.2 AC Response

The AC Response of the notch filter is observed for the disturbed notch frequency of 2.5GHz is rejected. Here the frequency is inversely proposed to the gain of the filter, as the particular disturbed frequency is rejected shapely within the any supplied frequency band range then the rest of all the above and below frequencies will be allowed only by rejecting exactly the unwanted frequency as there will be better frequency signal supply by increase in the gain. The phase is 89.95deg and the gain is 119.9dB is observed by stopping the selected frequency of 2.5GHz as shown in Fig.9.

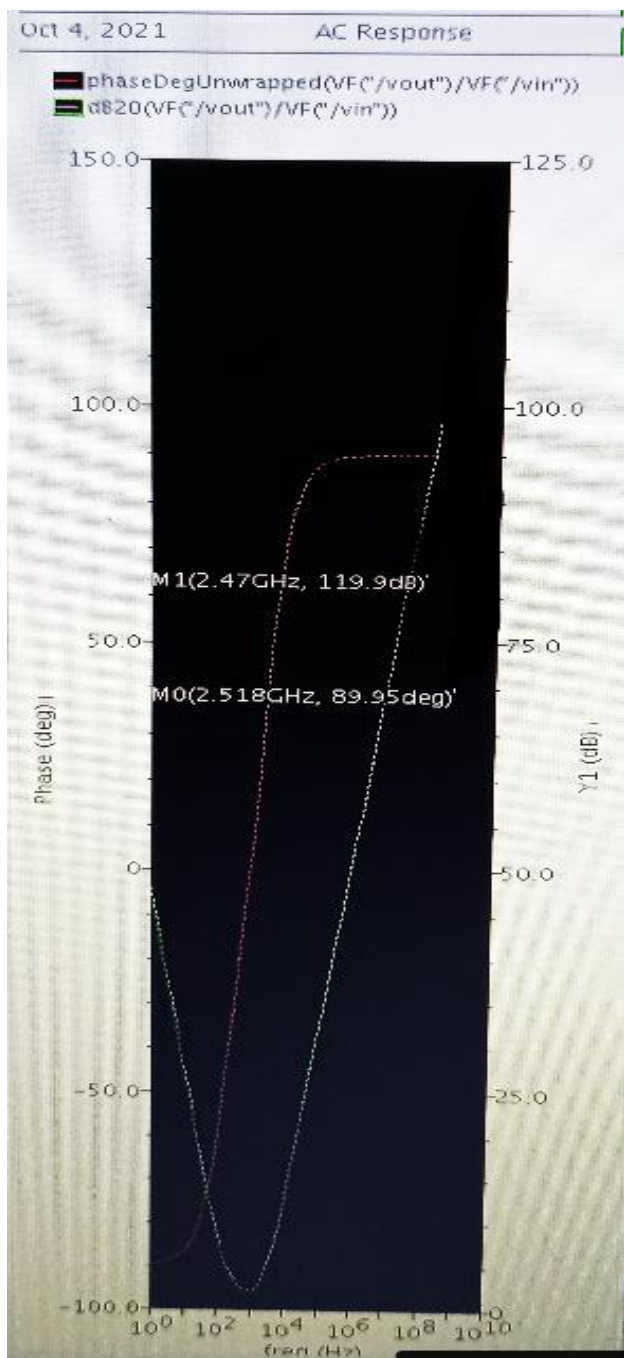


Fig.9. The AC response of proposed filter.

3.3 Summary of Twin T Notch Filter

A summary of Op Amp twin T band reject notch filter gives the simulated value of proposed circuit filter. In proposed circuit the supply voltage is given by 1.8 V with the band rejection frequency is stopped at 2.5GHz. Here in the Table.1 shows the parameters measured for the op amp Twin T notch filter.

Table 1: Summary of Notch Op Amp Twin T Band Reject filter

REFERENCES	[1] 2011	[2] 2012	[3] 2013	[4] 2015	[5] 2016	[6] 2017	[7] 2018	[8] 2019	[9] 2020	Result
TECHNOLOGY	180nm	180nm	90nm	-	180nm	130nm	180nm	-	90nm	180nm
FREQUENCY STOP BAND	2.5 GHz	2.5 GHz	2.4GHz	2.5 GHz	2.4 GHz	2.5 GHz	2.5 GHz	2.5GHz	2.5GHz	2.5 GHz
ATTENUATION	7dB	12dB	20dB	20dB	6dB	6dB	20dB	18dB	20dB	29.61dB
POWER SUPPLY	1.8 v	1.8 v	1.8 v	-	1.8 v	2V	1.8 v	-	1.2 v	1.8 v
POWER CONSUMPTION	-	-	-	-	7.59mw	-	-	-	32mw	20.5mw
GAIN	12dB	44dB	20dB	17.75dB	55.6db	1.8dB	50dB	15dB	110dB	119dB
CURRENT CONSUMPTION	-	-	-	-	-	14mA	-	-	-	-

3.3 summary of notch filter with converter

Table2: Summary of Notch Op Amp Twin T Band Reject filter with converter

References	[10] 2010	[11] 2013	[12] 2016	[13] 2017	[14] 2018	[15] 2019	[16] 2020	Result
Technology	180 nm	180 nm	180 nm	180 nm	180 nm	180 nm	180 nm	180 nm
Input Frequency	2.4 GHz	2.5 GHz	2.4 GHz	2.45 GHz	2.5 GHz	2.5 GHz	2.5 GHz	2.5 GHz
Input voltage range	2v	2.3v	1v	2v	13.2mv	2.25v	5.25v	1.8v
Power Consumption	250mW	2.2mW	100mv	-	0.54mW	14mV	-	37.85mW
Simulated output current	1.23mA	1.3mA	2mA	1.2mA	1.28mA	1.3mA	1.45mA	1.53mA
Gain	40dB	36.79dB	20dB	-	-	32dB	116dB	120dB
Power Factor			-	-	-	-	-	0.885mW

4 Conclusion

Finally, the design of a Notch Op Amp-Twin T Band Reject Filter is simulated with technology of 180 nm and with $V_{in}=1.8v$ input voltage supply is given for band rejecting the frequency of 2.5GHz where output voltage $V_o= 1.8mv$ is obtained also power consumption $pwr =20.5mW$ and gain is achieved as 119dB. The Notch Filter with converter is further extended by connecting grounded load converter in order to reduce the neutral current and avoid AC voltage ripples in the circuit where $I_{out}=1.53mA$, gain = 120dB then with the better power consumption of 37.85mW achieved and also the power factor $pf=0.885mw$ is observed. Future work would be to design the layout for this Circuit and also concentrate in reducing the area occupied by the circuit. Try to design this circuit in lower nano meter technologies.

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