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Design LC oscillator for MF, HF& VHF using both ideal and practical operation amplifier

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ABSTRACT

In general, the oscillator is a device that used in most circuits and system of electronics, electrical, and telecommunications. There are several kinds of oscillator contingent on frequency band use in a submission such as microwave, audio, and radio frequency. LC oscillator is one of the greatest mutual categories of oscillators, the applications of this oscillator was seemed to be increasing in modern devices, for actual high and very high frequencies to meet the speedy growth of progressive knowledge. That can be secondhand for radio frequency (RF), its productivity signal is frequently applied at the basis of radio communication classification in furthermost applications. In this paper, a designed Colpitts oscillator is covered from voltage amplifier with LC container. This strategy is done by two approaches. Primarily, is approved out exploitation hypothetical scheming. The subordinate is supported out exploitation imitation (Multisim 13). There are two proposal types of circuits the first for generate signal frequencies 0.5MHz,1MHZ,10MHz,20MHz,50MHz &100MHz, the second for generate signal frequencies 4.963MHZ, 5.031MHZ, and 5.756MHz respectively. The consequence is realized to be very hopeful.

Keywords: OP-AMP; LC OSC; RF

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1. Introduction

Frequency oscillator is one of the straightforward strategies that can be custom in furthermost electronics and telecommunications routes and classifications. There are various forms of oscillators contingent on frequency variety usage in a tender. All the attained outcome from this method is reasonable and it is seen to be very encouraging. The software required is Multisim simulation program equipped with multiple blocks of electronic devices and measurement equipment's to be used throughout the performance oscillator electronic circuit design along with the suggested supporting technique of our proposal design. The frequency oscillator container be well-thought-out as an automatic oscillator, that it is yield a monotonous signal by altering DC source voltage to AC indication. It is intermittent motion of sinusoidal and non-sinusoidal outline at confident frequency and firm amplitude deprived of any outside contribution signal [1,2,3]. Automated oscillator can be designated as two foremost categories, non- linear oscillator and inside layer oscillator. Nonlinear oscillator or relaxation oscillator yield a non-sinusoidal waveform. Linear oscillator is electronic circuit can yield sinusoidal waveforms. In this search, the design is done by approaches. Primarily, is approved obtainable exploitation hypothetical scheming. The other approach is carried out using two types of circuits the first for generate signal frequencies 0.5MHz,1MHZ,10MHz,20MHz,50MHz &100MHz, the second for generate signal frequencies 4.963MHZ, 5.031MHZ, and 5.756MHz respectively (Multisim 13). There are numerous categories of response oscillator course, such as and crystal oscillator. Three type of phase shift oscillator, that produces sinusoidal productivity for example Wien connection oscillator, phase modification oscillator and twin T oscillators. Mostly phase modification oscillators are castoff for frequency up to about 1MHz. This oscillator can be castoff in several submissions such as timer group for numerical electronics, converting wave form for adjustment style power source [4]. LC oscillator container be castoff for from top to bottom frequency or radio frequency

submissions. There are different types of these oscillators, the most important are Colpitts oscillator, crystal-controlled oscillator, slap oscillator, Armstrong oscillator and Hartley oscillators [5,6,7].
There are several categories of oscillators but they container be classified into four foremost collections: inductance capacitance oscillators, integrated circuit oscillators, crystal oscillators and resistance capacitance oscillators, among all of these types LC oscillator has specific application [8,9,10]. The aim of our proposal design is to understand and design multi range high & very high frequency Colpitts oscillator using operation amplifier. Also, to simulate this design by Multisim simulation program for different high frequency range with discussion the results of these frequencies. In this paper, the generated optical carriers with high data rate can provide meaningful sources in telecommunication systems such as 4G LTE, 5G Massive MIMO, and UAVs [10-14]. Furthermore, it can also use as numerical oscillator in digital signal generator [15].

2. Methodology and mathematical model

In this proposal the Colpitts oscillator is designed and simulated using Multisim 13 firstly the Colpitts oscillator is designed using theoretical information technology. It is designed using operational amplifier type that can be used for high frequency with using LC tank attenuation circuit in the loop of the feedback as shown in Figure (1). In this design the op-amp is used as noninverting amplifier ($A=1+R_f/R_i$) with LC FB network to obtain the zero-degree phase shift and forward gain slightly greater than one to fulfill the two conditions of Barkhausen to start oscillations in the circuit. Figure (1) demonstrations the circuit illustration of our proposal strategy. As revealed in figure the productivity voltage signal assignment to the LC tank over the condenser Cc. The productivity voltage (Vo) of the tour is formed at C_O of the LC tank. Correspondingly, the response voltage signal is formed at C_f of the LC tank. The proportion of V_f/V_o is less than one so that the value of C_f must be less than or equal to half of Co.

$$B = \frac{Vf}{V0} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

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at resonance frequency them is circulating current between C_o, C_f &L. The inductor discharges the magnetic energy (1/2 LI^2) as voltage through C_o & C_f, then at another time the capacitors charging and then discharge electric energy (1/2 C V^2), through inductance and the op-amp has effect to the operation of charging & discharging condition so that the oscillator frequency is happen an continuous

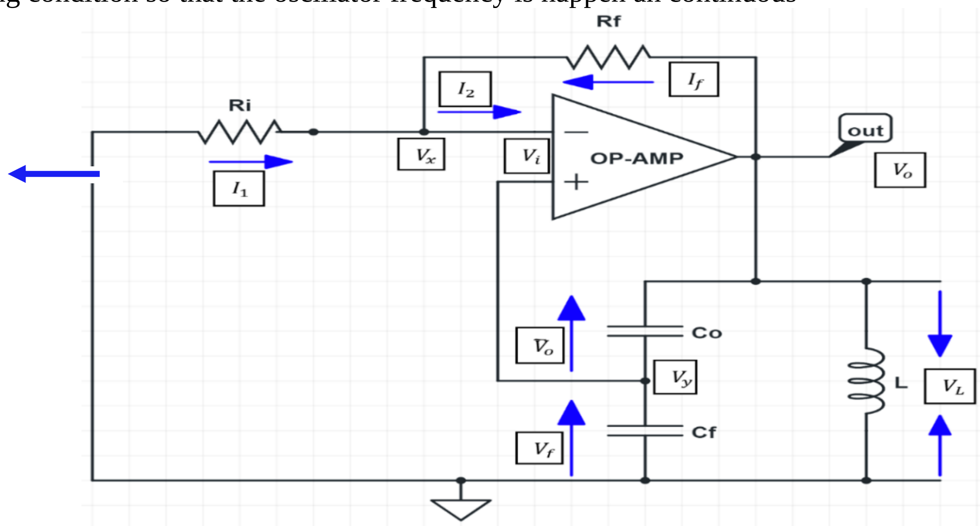


Figure 1. circuit diagram of proposal design

For Figure (1) at oscillation

$$V_i = 0 \;; \qquad V_i = V_y - V_x \;; \qquad \rightarrow \quad V_y = V_x$$

$$V_x = \frac{V_o}{R_f + R_i} * R_i \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$V_y = \frac{V_o}{X_{Co} + X_{Cf}} * X_{Cf} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$\frac{V_o}{R_f + R_i} * R_i = \frac{V_o}{X_{Co} + X_{Cf}} * X_{Cf} \quad \rightarrow \quad \frac{R_f + R_i}{R_i} = \frac{X_{Co} + X_{Cf}}{X_{Cf}}$$

$$\frac{R_f}{R_i} + 1 = \frac{X_{Co}}{X_{Cf}} + 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$\frac{R_f}{R_i} = \frac{\frac{1}{W_{Co}}}{\frac{1}{W_{Cf}}}$$

$$\frac{R_f}{R_i} = \frac{C_f}{C_o} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

From above statement, the absolute value of AB is unity and there is no phase shift between the input and output signal. At oscillation the LC tank in circuit of Figure (1) work as a resonant circuit so that the resonant frequency can be derived after apply KVL &KCL as shown:

$$V_o + V_f - V_L = 0$$

$$F_r = \frac{1}{2\pi}\sqrt{\frac{3}{2LC_f}} \quad \rightarrow \quad F_r = \sqrt{\frac{3}{8\pi^2 LC}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

From Equation (1)

$$B = \frac{Vf}{v0}$$

$$= \frac{IXCo}{IXCf} = \frac{I\frac{1}{WCo}}{I\frac{1}{WCf}} = \frac{Co}{Cf} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

The positive logo resources that there is no segment shift

$$B = \frac{Cf}{Co}$$

The reaction influence (B) which acquire since LC tank requirement be confirm the supplies of criteria Barkhausen for oscillator these requirements are the circle gain necessity be equivalent one as resulting

$$|AB| = 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Nevertheless, B=1/A so that, B can be calculated as done in the above step from Figure (1) which shows the circuit diagram of LC tank that used for positive feedback.

The desired frequency of the output voltage of the proposal design is the resonance frequency in equation (6) above is the approximation and nearly is accurate because in our case the contribution input impedance of the op-amp amplifier is very high so the performance of it act as a load on the resounding response route and increase the quality factor Q of the circuit.

3. Simulation results

3. 1. The first proposal circuit

The first proposal circuit diagram of our proposal design for high frequency Colpitts oscillator is shown in Figure (2) it is achieved also all the parameters required are calculated. This design is simulated using Multisim 13, which, is one of the most popular simulate technique used for mostly to simulate of electronic circuits. Figure (2) demonstrations the circuit drawing of the strategy that simulated with output voltage signal variable different value of R_{in} , R_f, C_o , C_f , and the output desired frequency from the simulated of the design , there are several production voltage signal found with dissimilar frequency as absolute by selecting the rate of C_o ,C_f ,L with the constraint of the rate of A and B.

It is indistinct that beginning the outcomes attained as revealed in Table (1) that these since the principles intended in hypothetical scheming are completed using appearance value. There is similarly the consequence of dependent fundamentals this outcome to decrease the oscillating regularity. Table (1) shows all the parameters for the theoretical calculations and simulation resonance frequencies.

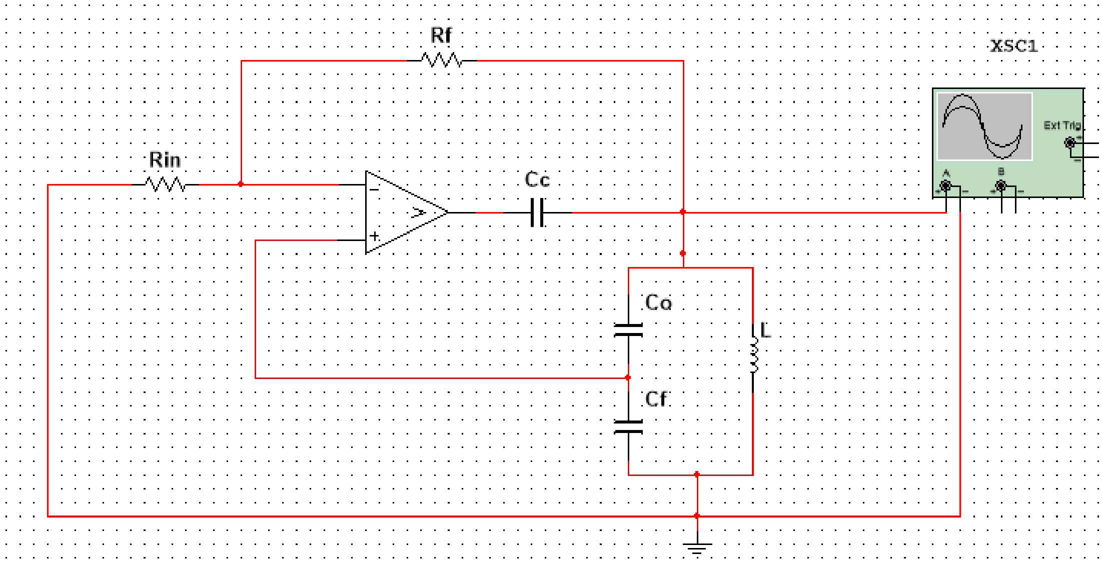


Figure 2. First proposal circuit diagram

Table 1. First proposal circuit calculations & simulation parameters

C Pico farad	C_f Pico farad	Co Pico farad	L micro hennery	Resonance frequency (MHZ) Theoretical Frequency	 Simulation Frequency	proposal circuit with o/p signal shape
18.99	18.99	37.99	2	1	0.958	Figure (3)
190.05	190.05	380.1	2	10	9.703	Figure (4)
47.6	47.6	95.2	2	20	19..207	Figure (5)
7.599	7.599	15.198	0.6	50	44.812	Figure (6)
25.33	25.33	50.66	0.15	100	90.691	Figure (7)

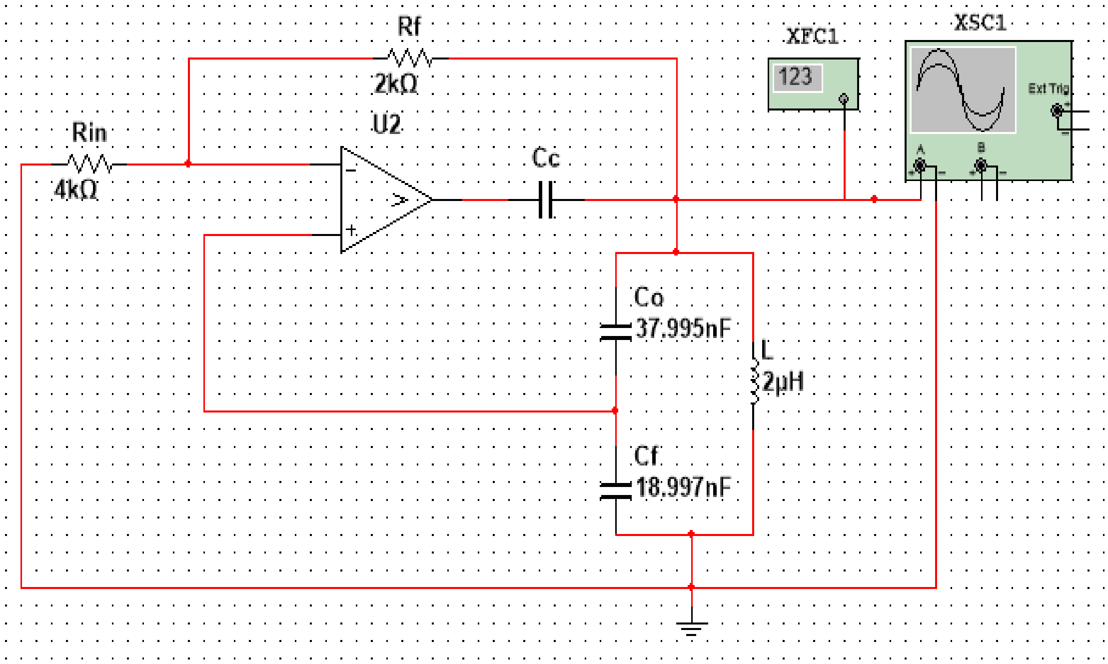
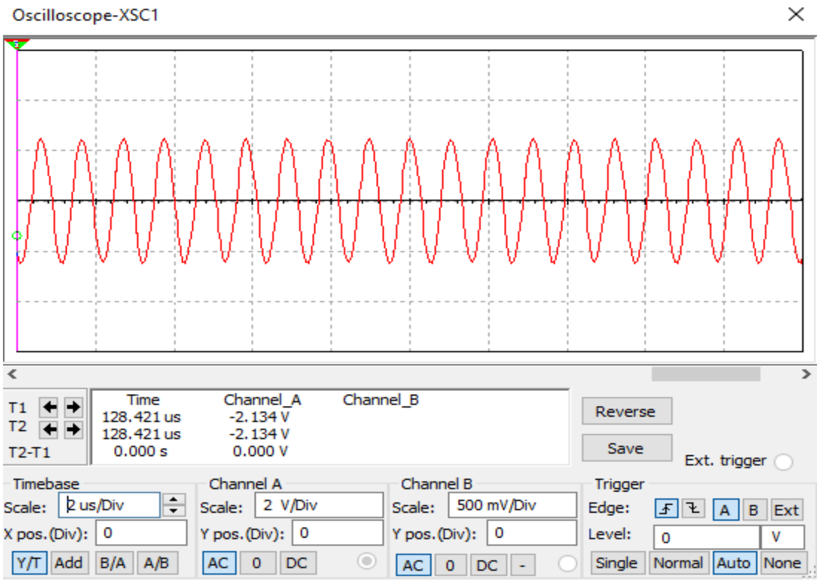
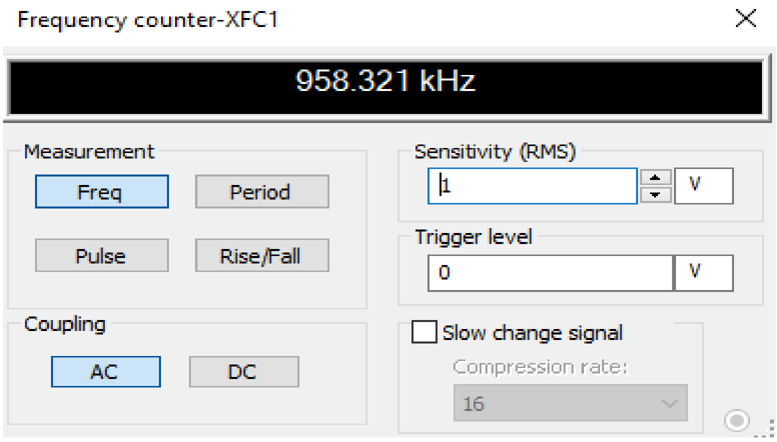


Figure 3. First proposal circuit design of 1MHZ, a. Circuit diagram



b. Shape of o/p voltage



c. The value of frequency

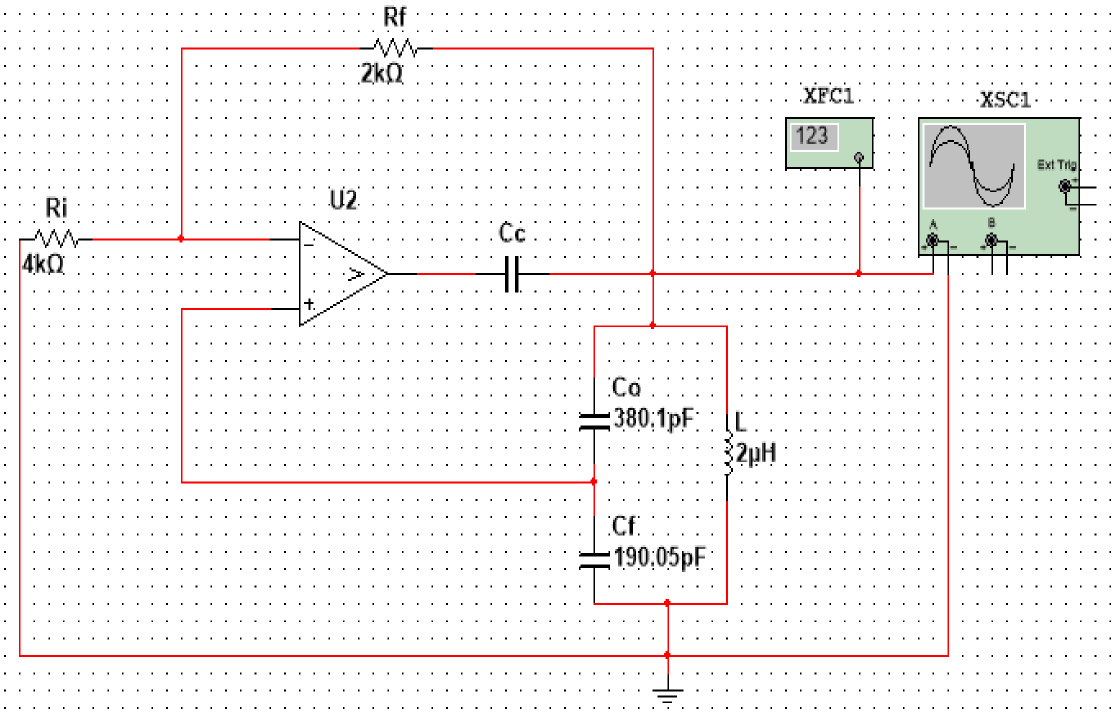
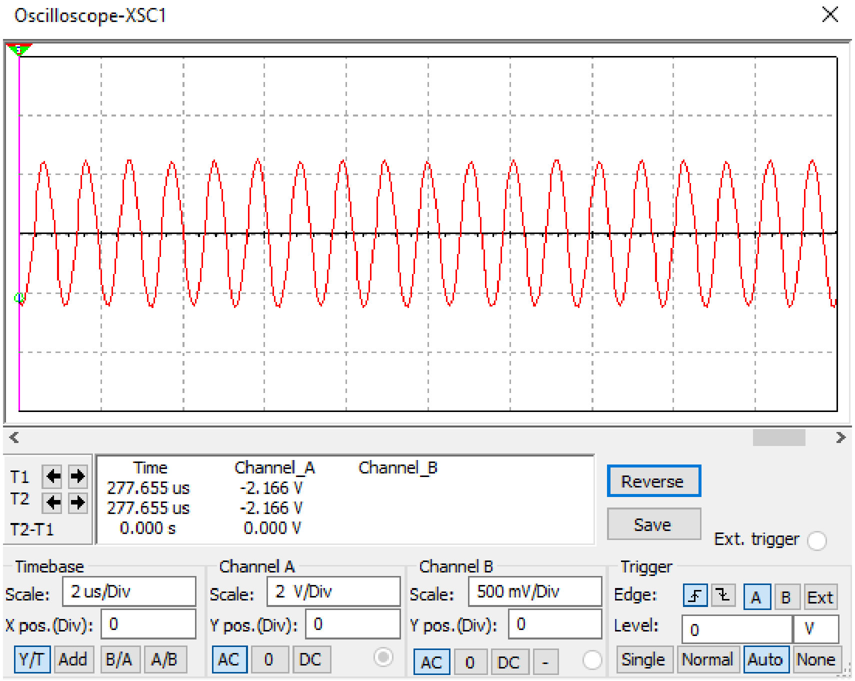
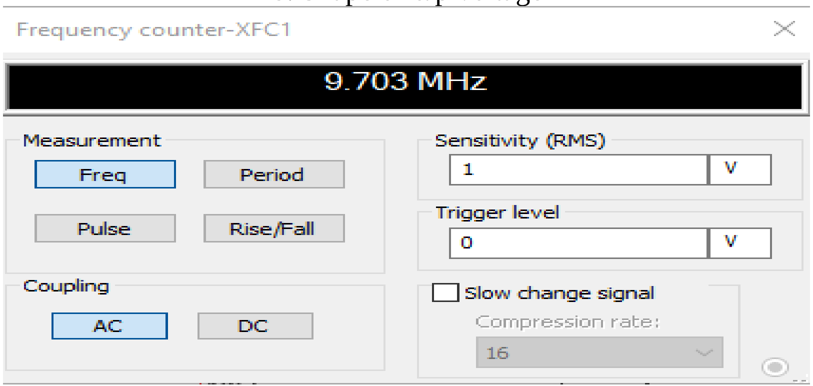


Figure 4. First proposal circuit design of 10MHZ, a. Circuit diagram



b. Shape of o/p voltage



c. The value of frequency

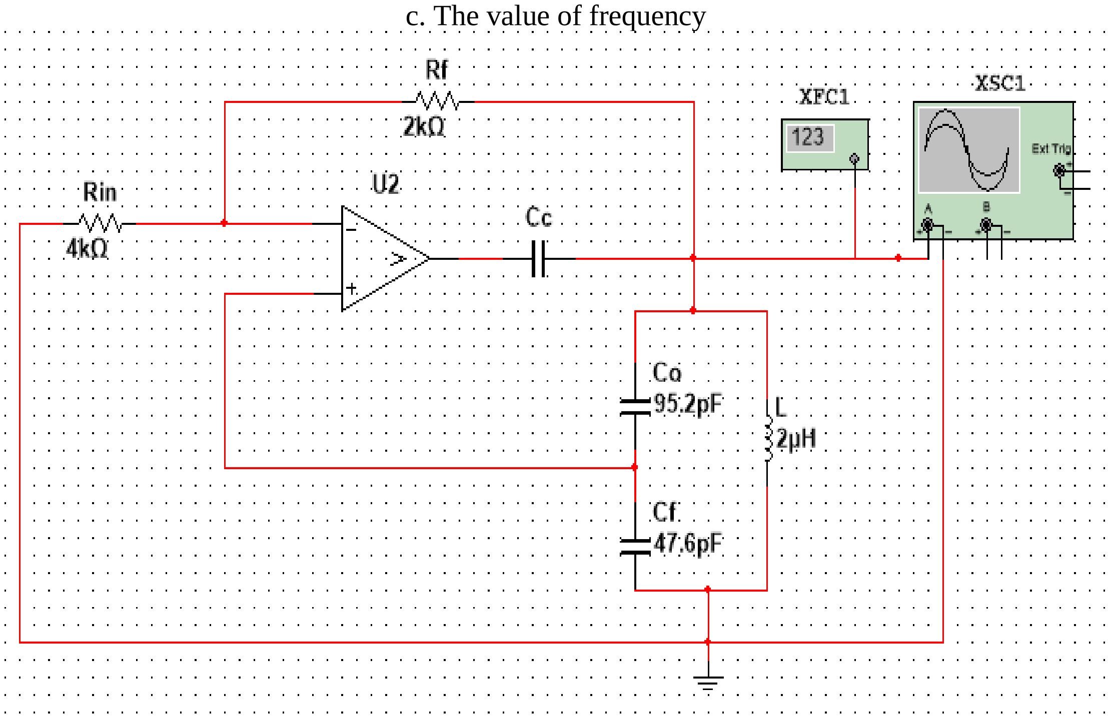
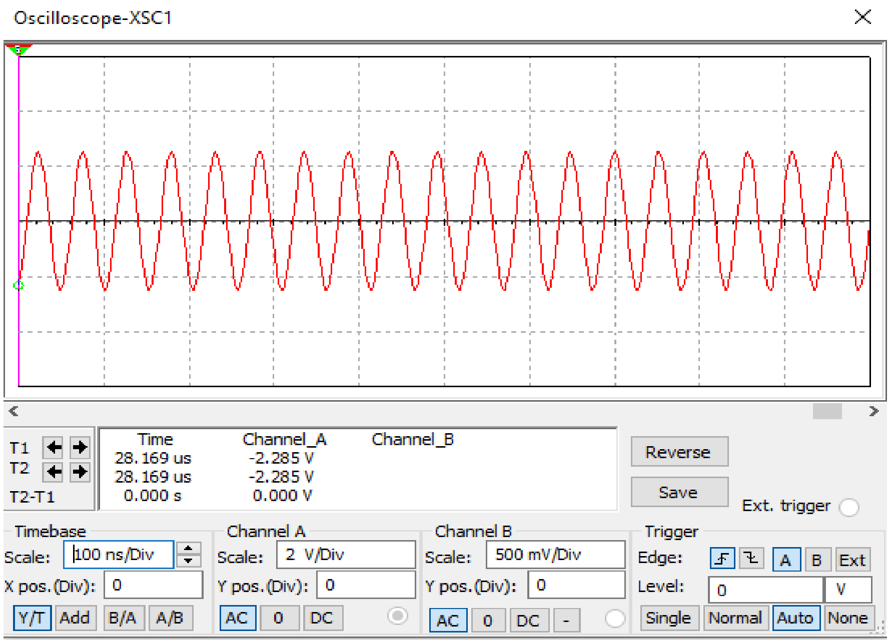
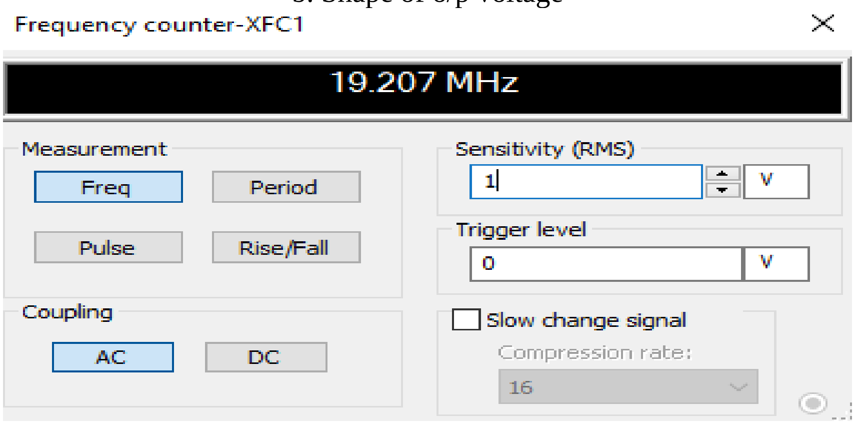


Figure 5. First proposal circuit design of 20MHZ, a. Circuit diagram



b. Shape of o/p voltage



c. The value of frequency

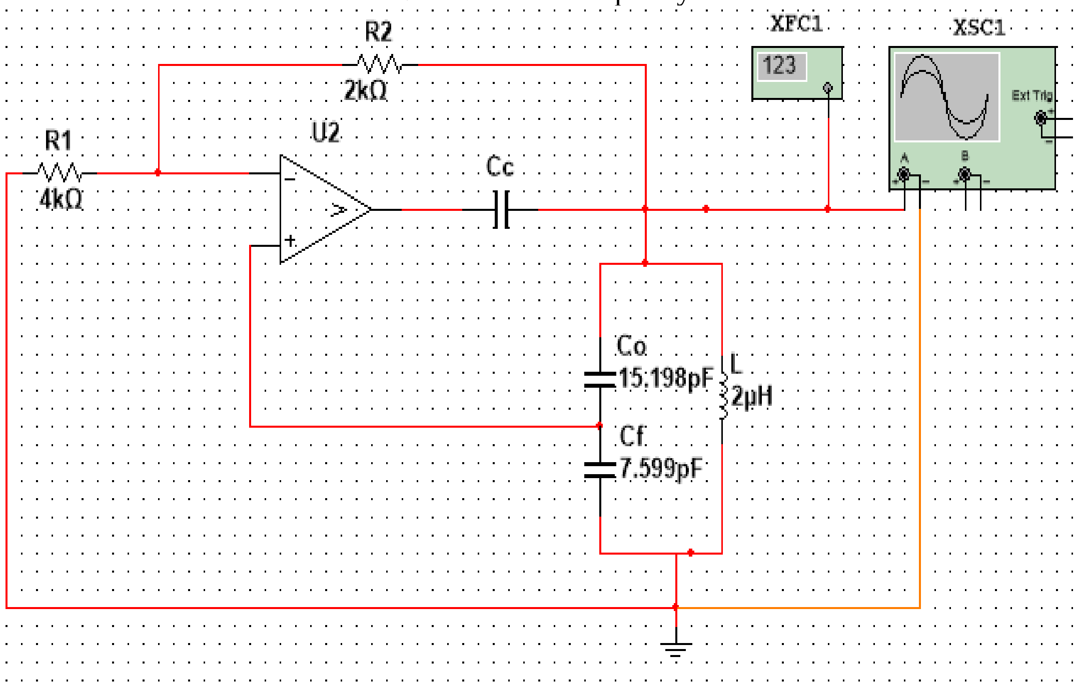
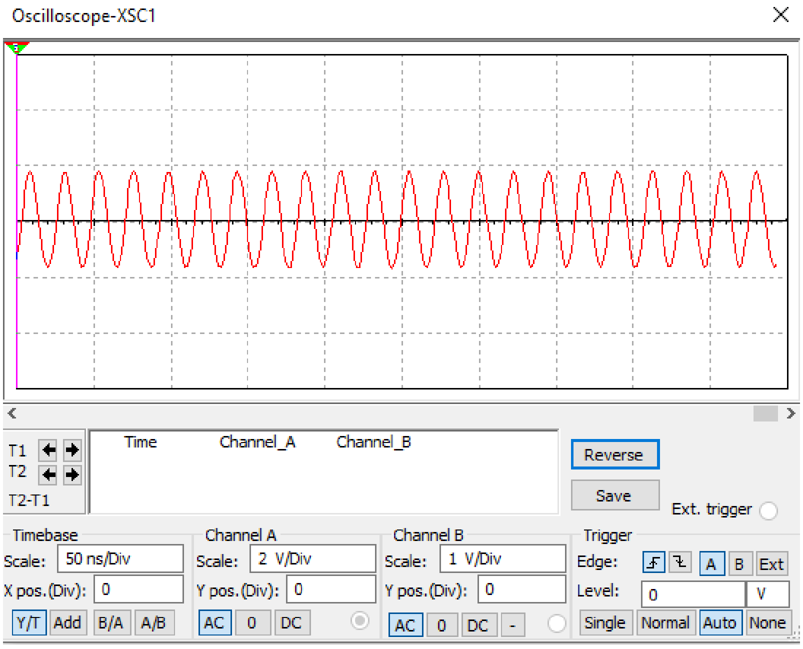
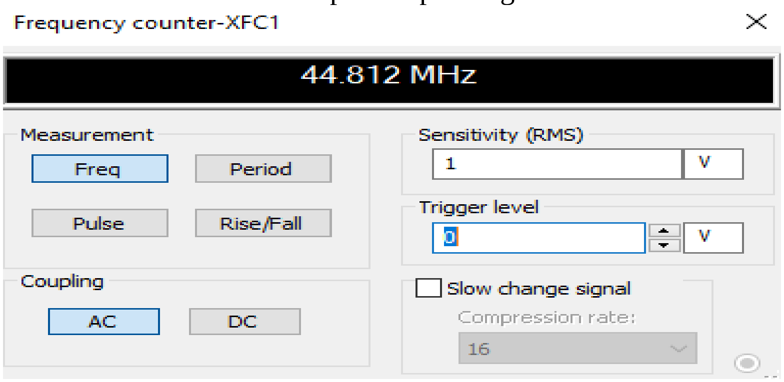


Figure 6. First proposal circuit design of 50MHZ, a. Circuit diagram



b. Shape of o/p voltage



c. The value of frequency

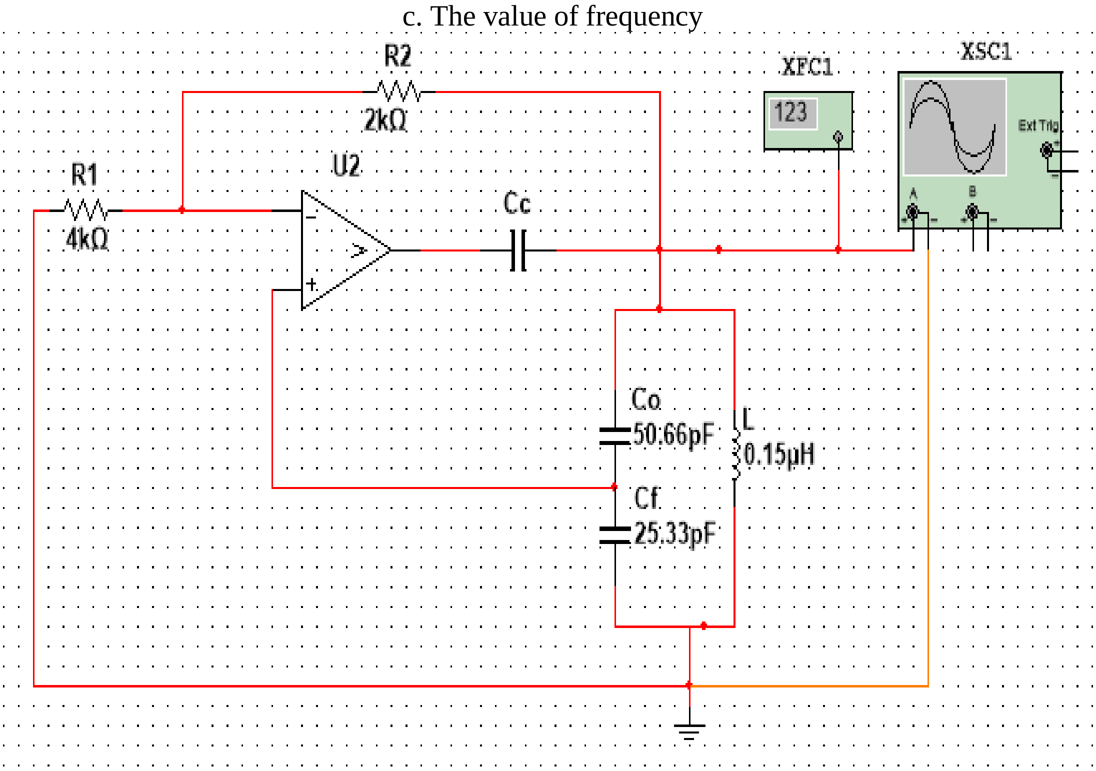
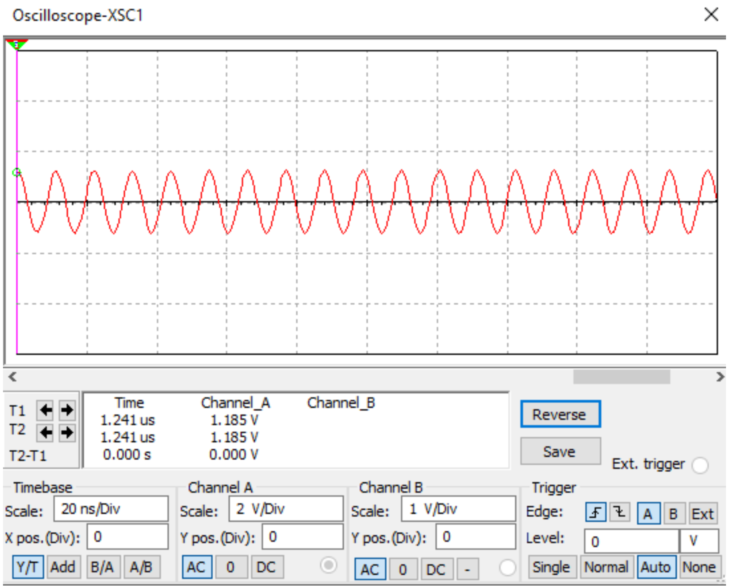
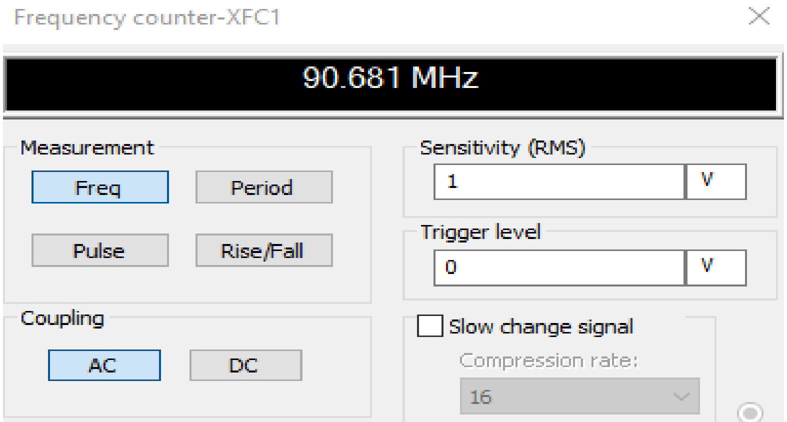


Figure 7. First proposal circuit design of 100MHZ, a. Circuit diagram



b. Shape of o/p voltage



c. The value of frequency

3.2. The second proposal circuit

The second proposal circuit diagram of our proposed design for high frequency Colpitts oscillator is shows in Figure (8). This design is simulated using Multisim 13. Figure (8) shows the circuits diagram of the design that simulated. Table (2) shows the different values of circuit parameters and simulated resonance frequency for the second proposed circuit design.

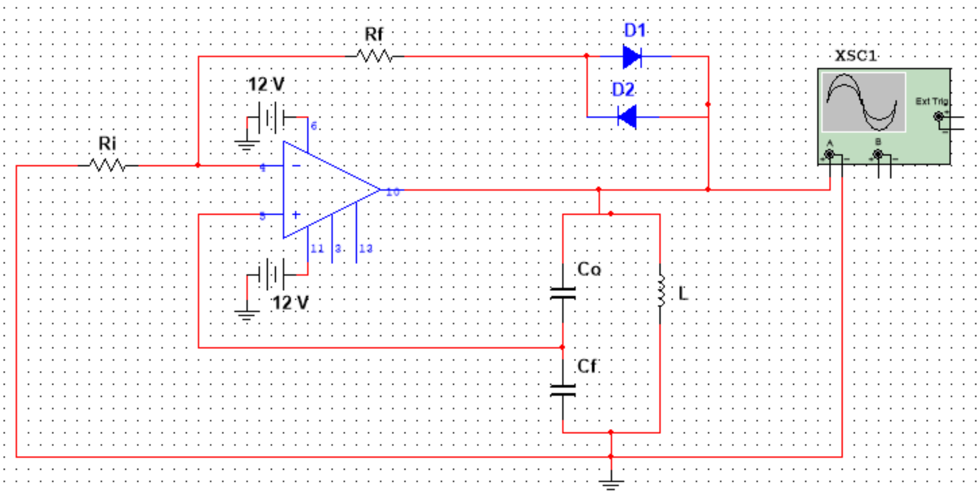


Figure 8. second proposal circuit diagram

Table 2. second proposal circuit calculations & simulation parameters

C pico farad	C_f pico farad	C_o pico farad	L micro hennery	Simulation of resonance frequency (MHZ)	proposal circuit design with o/p signal shape
0.125	0.125	0.5	0.058mH	4.693	Figure (9)
0.25	0.25	0.5	0.058mH	5.031	Figure (10)
0.1	0.1	0.2	0.013mH	5.756	Figure (11)

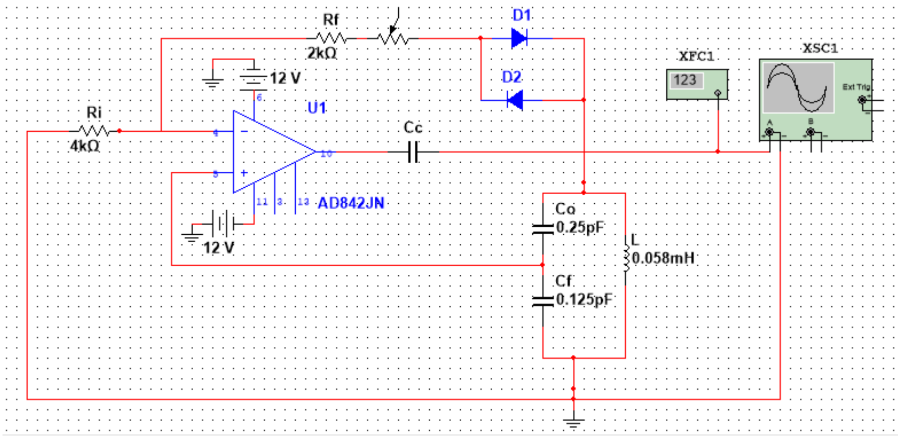
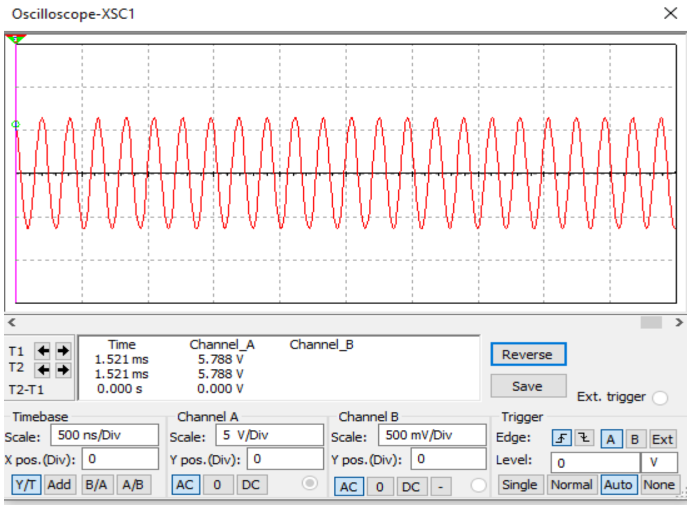
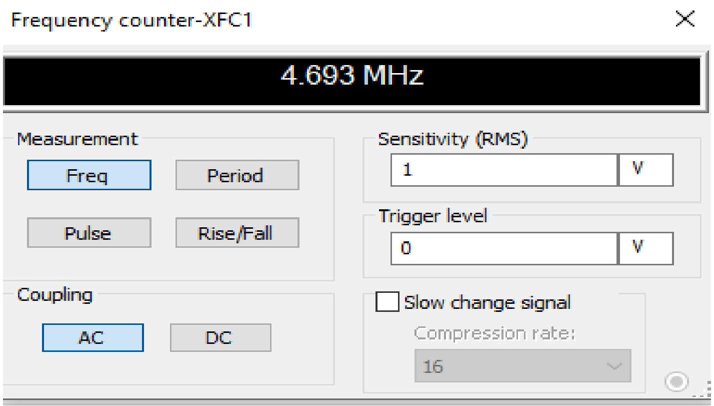


Figure 9. Second proposal circuit design of 4.69MHZ, a. Circuit diagram



b. Shape of o/p voltage



c. The value of frequency

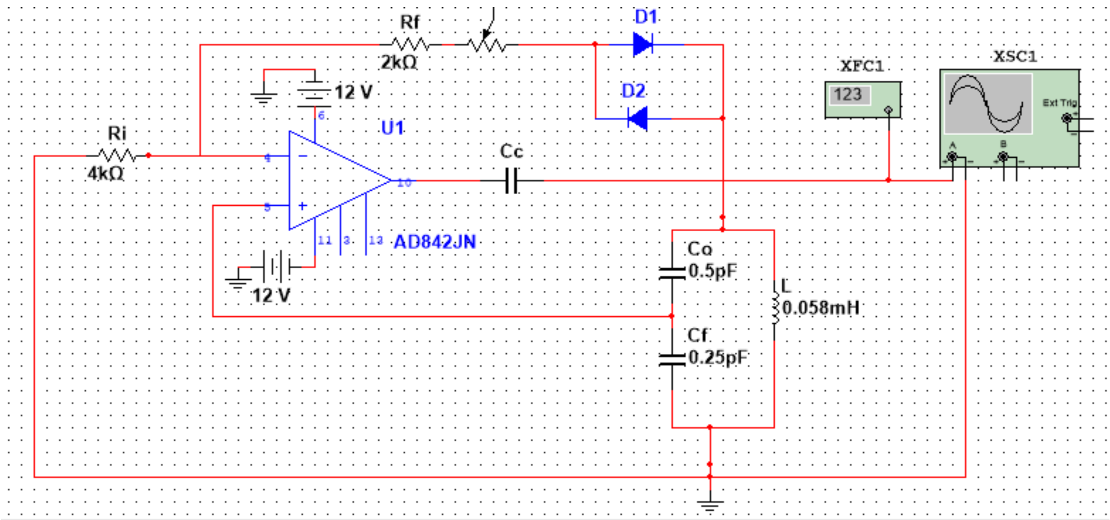
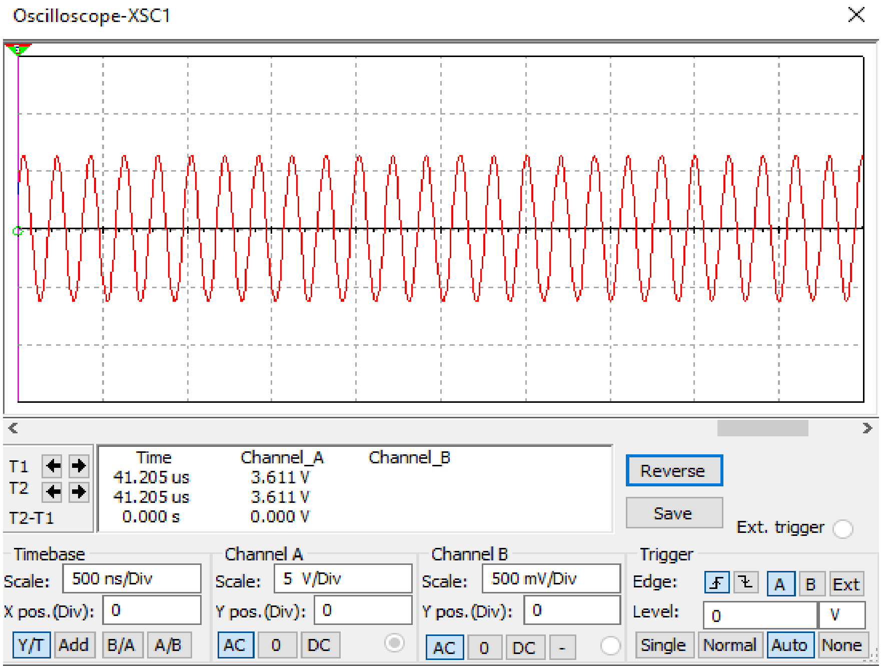
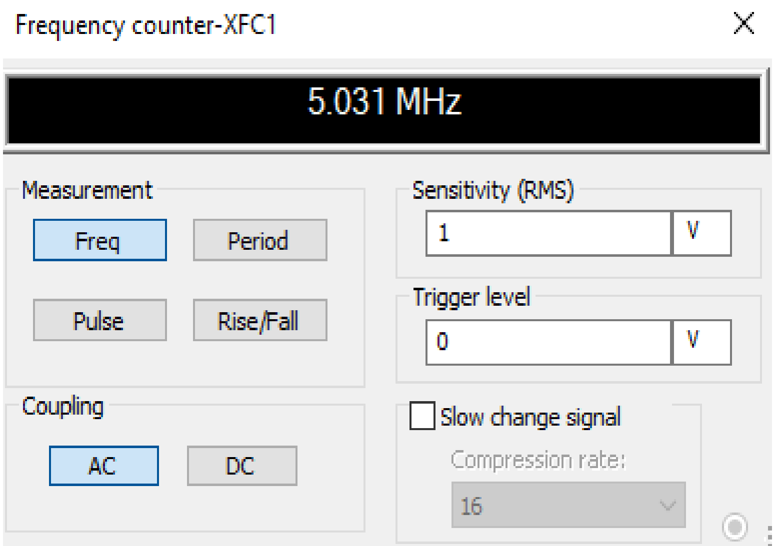


Figure 10. Second proposal circuit design of 5.031MHZ, a. Circuit diagram



b. Shape of o/p voltage



c. The value of frequency

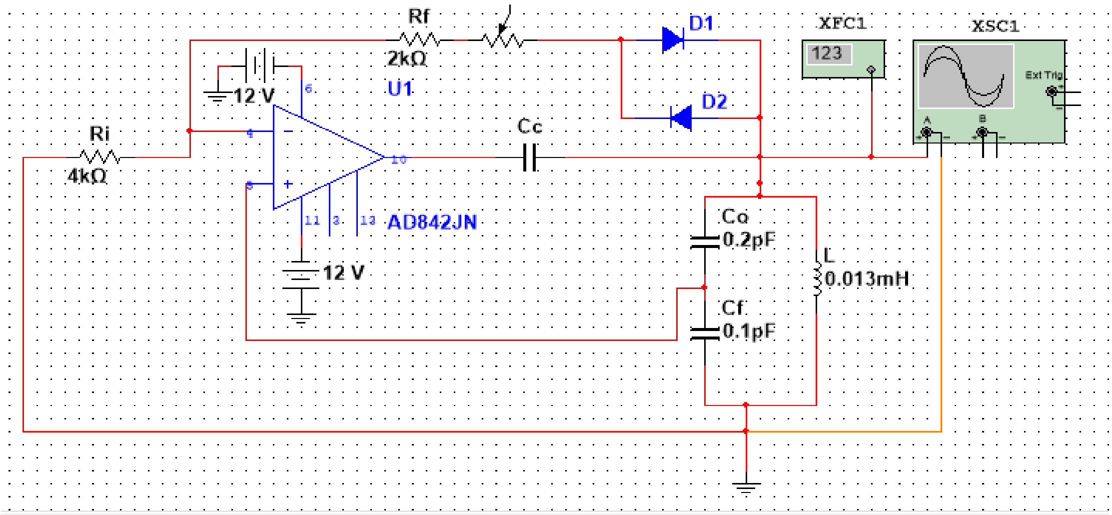
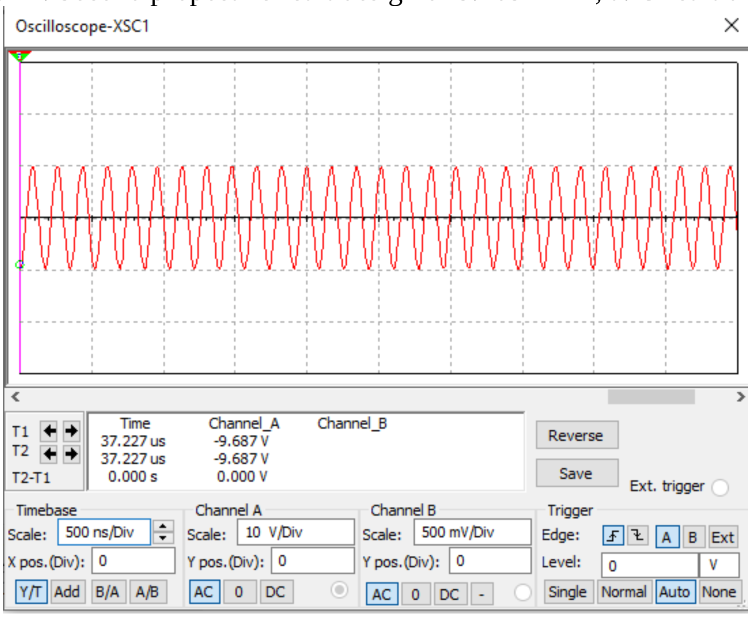
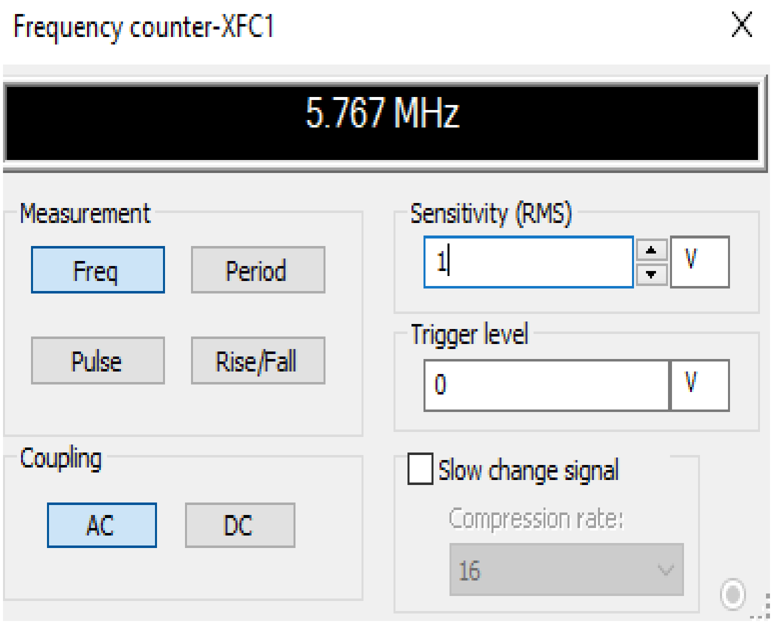


Figure 11. Second proposal circuit design of 5.765 MHZ, a. Circuit diagram



b. Shape of o/p voltage



c. The value of frequency

4. Conclusion

In the beginning of starting the simulation of the circuit of the proposal design the output signal appears as gone increasing in amplitude gradually and after some time become state to fixed amplitude and frequently. According to that is the loop gain initially larger than one slightly and become the effect of value passive element due to many factors become equal one so that the condition of Barkhausen criteria is verified. Many results obtained when choosing the value of Co, Cf & L with the change in the ratio of Co/Cf so that the loop gain equal one or more slightly larger than one. The circuit diagram of this design is comprising after from operational amplifier with LC. This operation amplifier has an improved characteristic, this characteristic made it suitable to be made in the practical design of this high frequency Oscillator Circuit.
The output results of the first proposal circuit design are shown in Figures (3-7) and Table (1). And the output result of second proposal circuit design is shown in Figures (9,10,11) and Table (2). From These results it is indistinct that these are substantial alteration amid theoretical calculations and simulated measuring values. This is appearing since of the loading consequence of which resistivity of the operation amplifier which has large input impedance. There for quality factor is increasing to large than 10. Whereas the theoretical calculated done with consider that quality factor very large so that equation (6) represent the exact and approximate formula of resonant frequency.

References

[1] Kh. A. Humood, W. Qaism And F. Hammed, “Design Analog RC- Active 2nd Order Audio Low Pass Filter (LPF)”, First engineering scientific conference college of engineering- university of diyala, pp.485-498, 2010 .
[2] K. R. Brennan, " Silicon Carbide Technology For Extreme Environments ", A thesis submitted to the faculty of science ,agriculture and engineering for the degree of doctor of philosophy, Msc ,School Of Electrical And Electronic Engineering, Newcastle University , United Kingdom , 2015.
[3] A. S.Seedra And Kenneth C.Smith "Micro Electronic " Newyork Oxford, Oxford University Press , 2015.
[4] Kh. A. Humood, A. H. Saleh, W. Q. Mohamed, “Design And Implementation Of Op-Amp-Rc Sine Wave Oscillator”, Diyala Journal of Engineering Sciences, Vol. 08, No. 01, pp. 89-901, 2015.
[5] G. Gonzalez, " Foundations of Oscillator Circuit Design", Artech House, Inc., 2007.
[6] R. Reha,"Oscillator Design and Computer Simulation", Noble Publishing Corporation Atlanta ,2nd Edition ,1995.
[7] R. Senani, "On equivalent forms of single op-amp sinusoidal RC oscillators", *IEEE Transactions on Circuits and Systems I: Fundamental Theory and Applications*, vol. 41, no. 10, pp. 617-624, 1994.
[8] J. L. Mata-Machuca, R. Martinez-Guerra, “Asymptotic Synchronization of the Colpitts Oscillator “, Computer and Mathematics with Applications , vol.63, pp.1072-1078, 2012.
[9] Q.K. Omran, M.T. Islam, N. Misran, M.R.I. Faruque, “ An efficient ROM compression technique for linear-interpolated direct digital frequency synthesizer “ , IEEE International Conference on Semiconductor Electronics ICSE, 2014.
[10] Kh. A. Humood, O. A. Imran, A. M. Taha, “Design and Simulation of High Frequency Colpitts Oscillator Based on BJT Amplifier” International Journal of Electrical and Computer Engineering (IJECE), Vol. 10, No. 1, pp. 160-170, 2020.
[11] Kh. A. Humood, A. H. Saleh, W. A. H. Hadi “Theoretical Design of MIMO Transceiver &Implementation Its Transmitter Using FPGA “Diyala Journal of Engineering Sciences, Vol. 07, No. 04, pp. 115-131, December 2014.
[12] Kh. A. Humood, S. M. Saleh, W. N. Abed,” Design of 2 ×4 Alamouti Transceiver Using FPGA,” International Journal of Engineering Research & Technology (IJERT), Vol. 3, No. 11, 2014.
[13] Kh. A. Humood, A. H. Saleh, W. A. H. Hadi “Theoretical Design of MIMO Transceiver &Implementation Its Transmitter Using FPGA “Diyala Journal of Engineering Sciences, Vol. 07, No. 04, pp. 115-131, December 2014.
[14] T. Mahmood, O. A. Mahmood & Kh. A. Humood. An efficient technique to PAPR reduction for LTE uplink using Lonzo’s resampling technique in both SC-LFDMA and SC-DFDMA systems. Applied Nanoscience,vol.14, 2021.

[15] H. Kh. AL-Qaysi, T. Mahmood, Kh. A. Humood, "Evaluation of different quantization resolution levels on the BER performance of massive MIMO systems under different operating scenarios", Indonesian Journal of Electrical Engineering and Computer Science Vol. 23, No. 3, pp. 1493-1500, 2021.
[16] Q. Kh. Omran, M. T. Islam, N. Misran, “Design and Simulation of High Spectral Purity Numerically Controlled Oscillator”, Applied Mechanics and Materials Vols. 229-231, pp 2117-2121, 2012.