Simulation of small signal resonant amplifier based on Multisim

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Abstract. In this paper, using the Multisim software for small signal resonance amplifier circuit virtual simulation experiment was carried out. This paper studies the small signal resonance amplifier circuit of voltage gain, frequency characteristic and the stability of the circuit and noise factor, and so on and so forth. By constantly changing the parameters of the circuit element comparing observation, virtual simulation results and the theoretical analysis and calculation results are consistent. Practice has proved that the application of Multisim in high frequency electronic circuit simulation experiment teaching, parameters are accurate and reliable. It can improve the efficiency of circuit design and analysis, at the same time also can improve the teaching quality and teaching effect.

Keywords: Multisim, small signal tuned amplifier, simulation analysis.

1. Introduction

In radio communication, transmission and reception of the signals is through modulation of the high-frequency signal, in the long distance transmission, signal through the attenuation and interference, arrived at the device receives the signal is very weak high-frequency narrowband signal, prior to further processing must be after amplification and to limit the interference of processing, which requires high frequency small signal amplifier to complete.

High frequency and small signal amplifier is widely used in broadcasting, TV, communications, measuring instruments and other equipment. Main function is from received numerous telecommunication number, select the useful signal and to be amplified, and the useless signal, interference signal and noise signal to inhibit, to increase the received signal quality and ability to resist interference [1].

The theoretical knowledge of high frequency small signal amplifier focuses on the derivation and calculation of the formula, and is dull and boring. In this paper, the characteristics of high frequency electronic technology course, from teaching practice and students interest and ability to accept consideration in an attempt to reduce the theoretical knowledge of the boring of, organic combination of simulation technology and high frequency electronic circuit teaching, on small signal resonant frequency amplification circuit, the output signal and the frequency characteristics of the simulation analysis, at the same time, the parameter sweep and temperature sweep and noise analysis of the influence of various circuit parameters on the frequency characteristics and the simulation results and the theoretical calculation results are compared with [2-7].

2. Design and analysis of simulation circuit

2.1 High frequency small signal resonant amplifier circuit design.

High frequency small signal resonant amplifier is the essential function circuit of the radio communication equipment. In the process of the traditional analysis, the computation is complicated and complicated. The students have difficulty in learning. The use of Multisim software for simulation analysis, you can get rid of the complex formula puzzle, learning more easily. It can also provide a new platform for the analysis, design and optimization of the circuit in the future.

Considering the simulation circuit is mainly used in auxiliary teaching, the circuit is designed for the resonant circuit as the load of the resonant amplifier (Fig.1).

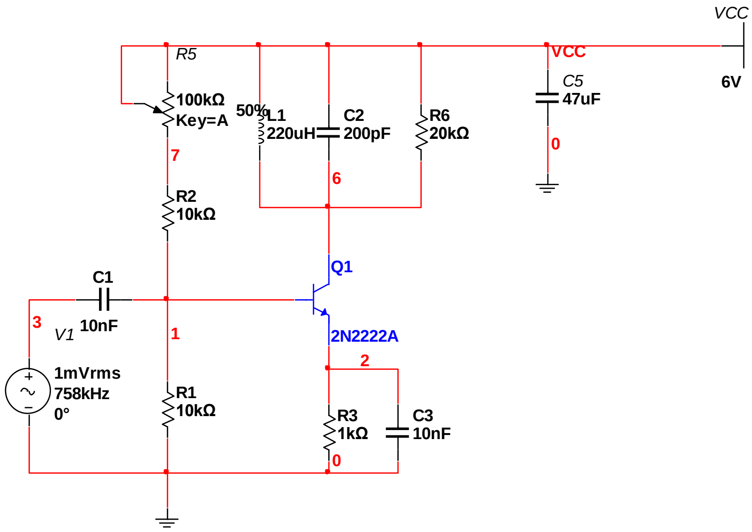

Fig. 1 Small signal resonant amplifier circuit

2.2 High frequency small signal resonant amplifier working principle analysis.

Figure 1 shows circuit for single stage single tuned amplifying circuit and collector load LC parallel resonant circuit, its role is to input frequency for the resonant frequency of the signal to distortion free amplification, and filter the interference frequency. The main performance of the loop is voltage gain, pass band, selectivity (rectangular factor), stability and noise figure, and the specific formula of the index is as follows:

Voltage gain: $\dot{A}_u = -\frac{p_1 p_2 y_{fe}}{g_\Sigma + j\omega c_\Sigma + \frac{1}{j\omega L_1}}$ (1)

Resonance frequency: $f_0 = \frac{1}{2\pi\sqrt{L_1 C_\Sigma}}$ (2)

The circuit has the quality factor: $Q_e = \frac{1}{2\pi f_0 L_1 g_\Sigma}$ (3)

Resonant time voltage gain: $\dot{A}_{u0} = -\frac{p_1 p_2 y_{fe}}{g_\Sigma}$ (4)

Pass band: $BW_{0.7} = 2\Delta f_{0.7} = \frac{f_0}{Q_e}$ (5)

Rectangular factor: $K_{r0.1} = \frac{2\Delta f_{0.1}}{2\Delta f_{0.7}} = \frac{\sqrt{99}\frac{f_0}{Q_e}}{\frac{f_0}{Q_e}} \approx 9.95$ (6)

The gain of the single stage amplifier is not high, the product of the voltage gain and the pass band is a certain value, the wider the pass band is, and the smaller the voltage gain is. The quality factor is small, the frequency band of the quality factor is decreased and the quality factor is smaller, the resonance curve is more and more smooth. The resonance curve is far from the ideal rectangle, and the rectangular coefficient is far greater than 1 and the loop selectivity is poor.

3. Simulation and analysis of results

3.1 Frequency characteristic analysis.

High frequency small signal amplifier is also called frequency amplifier, frequency characteristic is the main technical indicators. Frequency characteristics in the traditional experimental circuit measurement is more complicated, need to adjust the input signal frequency, find the maximum value of the LC resonance circuit output voltage, record at the resonant frequency and the output voltage, and then the input frequency in turn to high or low to the regulation, every 10 kHz and recorded a corresponding output voltage, draw of voltage and frequency curves corresponding to amplitude frequency characteristic curve. The use of Multisim simulation experiments, the simulation instrument Potter can get the amplitude frequency characteristic curve (Fig. 2) and the phase frequency characteristic curve (Fig. 3).

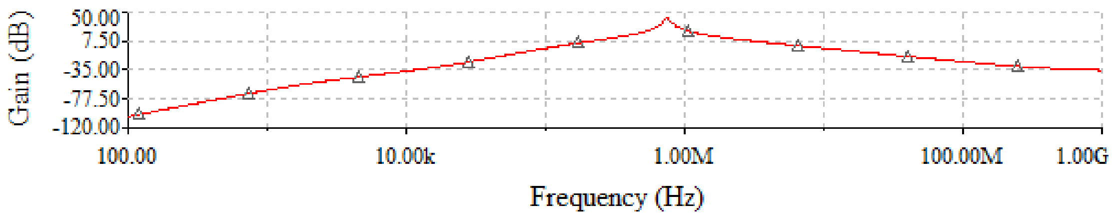

Fig. 2 Amplitude frequency characteristic curve

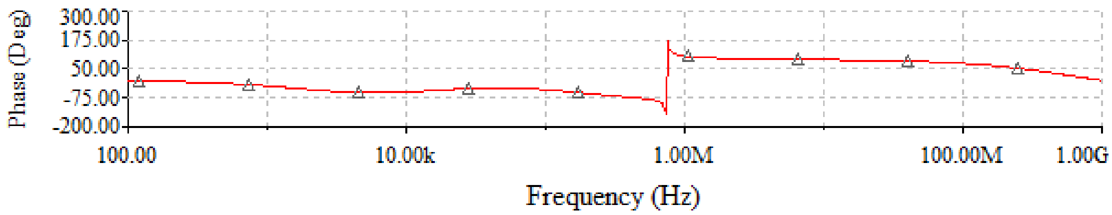

Fig. 3 Phase frequency characteristic curve

In Figure 2 the reading pointer is dragged to the maximum of the amplitude, then the resonance frequency is read, the resonant frequency of the circuit is 758 KHz, the voltage gain is 69. When the gain of the amplifier is reduced to 0.707 times, the corresponding frequency range is 721 KHz~779 KHz, namely the pass band is 58 KHz. When the gain of the amplifier is reduced to 0.1 times, the corresponding frequency range is 528 kHz ~1078 KHz, namely the pass band is 550 KHz, and the rectangle coefficient is 9.48. Amplitude frequency characteristic data is shown in Table 1. In Figure 3, when the frequency is 738 KHz ~756 KHz the phase mutation from -150 ° to 178 °, when the frequency is 758 KHz the phase is 0 °.

Table 1 Frequency characteristic data

	resonant frequency(KHz)	$BW_{0.7}$ (KHz)	$BW_{0.1}$ (KHz)	rectangle coefficient	quality factor	voltage gain
simulation value	758	58	550	9.48	13	69
theoretical value	759	42	418	9.95	19	64
error	-1	16	132	0.47	-6	5

From the above analysis can see:

Simulations are very easy to get small-signal circuit resonant circuit of resonant frequency, frequency band, rectangular figure, voltage gain, and quality factors such as performance, simplifies the process of complex calculations.

Simulations with the theoretical values of each parameter error is small, this simulation circuit parameters description is accurate and reliable, better suited to circuit analysis, design and optimization.

Circuit when the frequency is equal to the resonant frequency of the input signal is a pure resistive circuit, maximum voltage gain; when the frequency lower than the resonance frequency of the input signal circuit for inductive circuits, voltage gain is reduced when the frequency is higher than the resonance frequency of the input signal circuit for capacitive circuits, voltage gain is reduced.

3.2 Output signal and magnification analysis.

The input signal is 50mV, the frequency is 758 KHz, and the waveform of the output signal is analyzed by using the oscilloscope of Multisim. Figure 4 is the waveform of the input signal, the vertical coordinates of the right coordinates, the signal amplitude is 50mV; Figure 5 is the waveform of the output signal, the longitudinal coordinates of the left coordinates, the signal amplitude is 3453mv. From the graph, the output signal is reversed with the input signal. Magnification factor 69 times.

3.3 The influence of static operating point on frequency characteristic.

Change the potentiometer R5 resistance, which makes 1K change to 100K, quiescent operating point change. Using the parametric scanning, the amplitude frequency characteristic and the phase frequency characteristic, and the corresponding curve and data are analyzed, and the data are shown in figure 6~7. From the data of the graph, the static working point is changed; the amplitude frequency characteristic and the phase frequency characteristic curve coincide with the same data. Can see that the change of static working point has no effect on the amplitude and frequency of the.

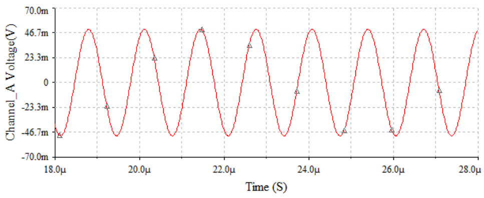

Fig. 4 Input signal waveform

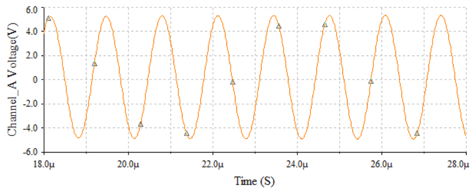

Fig. 5 Output signal waveform chart

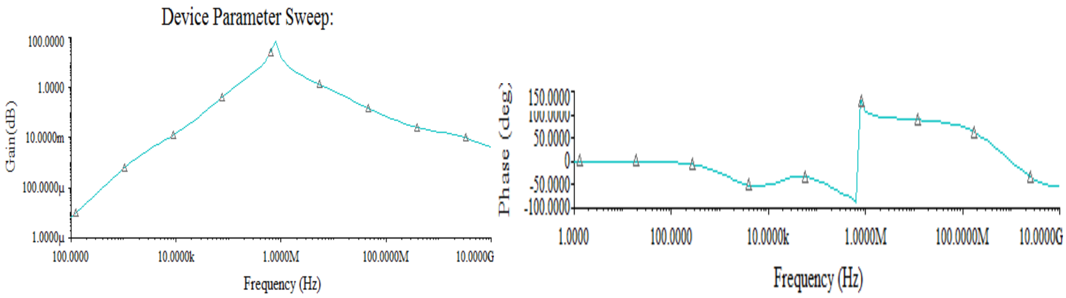

Fig. 6 Time amplitude frequency characteristic and phase frequency characteristic curve of static working point

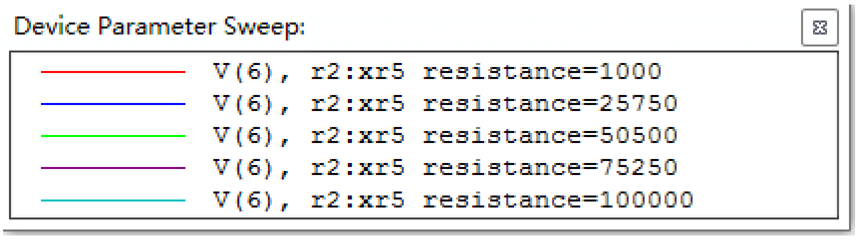

Fig. 7 The resistance change parameters of potentiometer R5

3.4 Temperature change on the circuit performance.

The effect of temperature change on the performance of the circuit can be detected by temperature scan analysis. The analysis is equivalent to the performance of the circuit under the different operating temperatures. For the components of the model and temperature, the equivalent of each time of the element with different temperature values for many times simulation. When the temperature varies from -10 °to 150 °, the output signal waveform (Fig.8) and frequency characteristic of the circuit are analyzed (Fig.9).

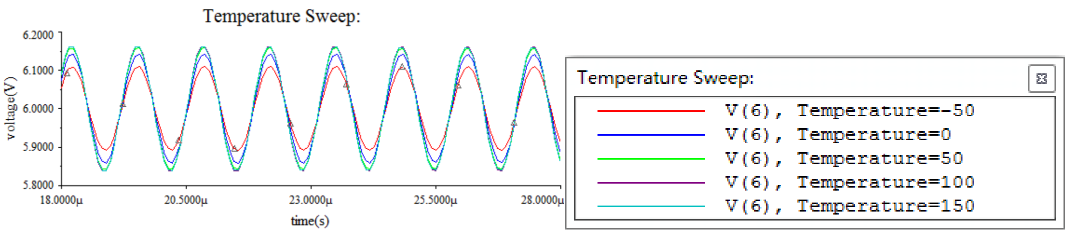

Fig. 8 Output signal curve when temperature change

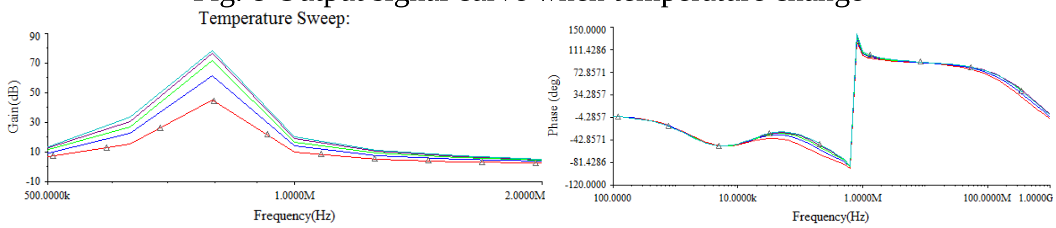

Fig. 9 Time characteristic curve of temperature variation

The graph data shows that:

1. The output of this circuit has a positive temperature coefficient of frequency characteristics is changing, high temperature, voltage gain, circuit performance.

2. When the temperature exceeds 50 degrees when the output signal amplitude is essentially the same.

3. Frequency characteristic curves temperature had no effect on resonant frequency can be seen.

4. Temperature increase affects the voltage gain of the circuit, which increases with temperature.

5. The phase has small fluctuations only at a frequency of 100 KHz~700 KHz and 100 MHz~1GHz with temperature increase.

3.5 Analysis of the stability of the resonance amplifier.

Ideally, the electronic device is a one way amplification device, but in fact, there is internal feedback in the transistor, the formation of the feedback role of the output to the input. When the feedback voltage and the input voltage inverting amplifier can stably work; when the feedback voltage in phase with the input voltage, the self-excited oscillation of possible, at least make the amplitude frequency characteristic distortion. The amplifier is not stable.

When the collector load is reduced that the resistor R6 is changed from 20KΩ to 1KΩ, the amplitude frequency characteristic of the circuit is shown in Fig.10.

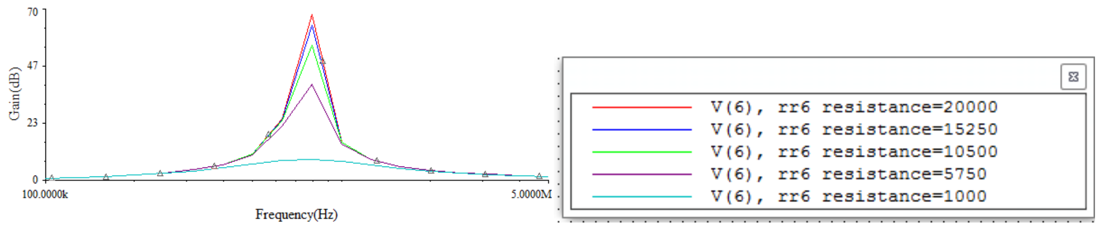

Fig.10 Amplitude frequency characteristic curve when load changes

The graph data shows that:

1. The load, the resonance curve flattening, voltage gain is reduced.

2. Load reduction, and bandwidth, amplifier stability.

3. Pass band wider, loaded quality factor reduced, the resonance curve flattening.

3.6 Noise analysis of resonance amplifier.

When the amplifier works, the components in the circuit internal will generate noise, the amplifier itself will produce noise, while the amplified signal also amplified the noise, so that the signal quality is affected. The effect of noise on the signal can be expressed by the noise figure. The ratio of the signal power to the noise power of a certain point in the circuit is called the signal-to-noise ratio, or the signal to noise ratio. The noise figure is the ratio of the signal to noise ratio and the SNR of the input signal [1].

Multisim provides thermal noise, shot noise and flicker noise and other 3 kinds of different noise models. Noise voltage curves and noise figure (Fig.11) can be obtained by using noise analysis of Multisim. The noise voltage of the curve is the input noise voltage, the longitudinal coordinates of the left coordinates; the other is the output noise voltage, the longitudinal coordinates for the right coordinates.

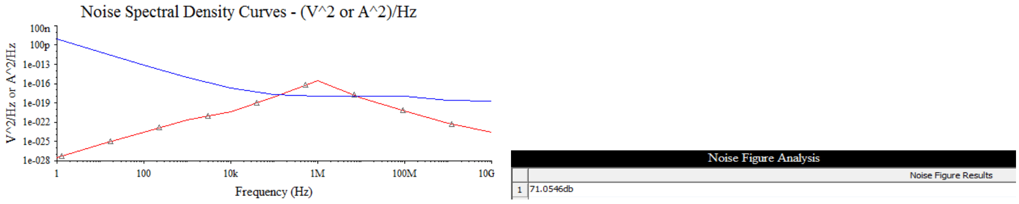

Fig. 11 Input and output noise voltage curves and noise figure

Visible by Figure 11:

1. Enter the noise power decreases with the increase of operating frequency, resonance frequency reaches a minimum.

2. The output noise power in the frequency is less than 10KHz is essentially the same, at the resonance frequency reaches the maximum value, maximum voltage gain, maximum output power, output noise power is also the largest when the operating frequency to continue to rise, voltage gain is reduced, the output signal power decreases, the output noise power decreases.

3. The noise figure is 71dB.

4. conclusions

In this paper, the Multisim software is used for the design of small signal resonant amplifier, and the performance of the small signal amplifier is analyzed. The simulation results show that the performance of the amplifier is consistent with the theoretical analysis and simplify the calculation of the parameters. The simulation software is gradually becoming the indispensable part of the theory teaching and experiment teaching.

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