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Analysis of Starting Time and Output Amplitude of RC Wen's Bridge Sine Wave Oscillation Circuit

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Abstract: In this paper, through theoretical analysis and Multisim 12 simulation experiment, the influence of circuit voltage amplification on the stable voltage output amplitude of the RC bridge sine wave oscillator circuit is analyzed. By observing and analyzing multiple different starting and stable whole processes, it is concluded that the change of voltage amplification directly affects the amplitude of the circuit when the circuit is stable. In the linear working range of the circuit, the stable voltage output amplitude is amplified with the voltage that is increased during the start-up. And the larger the start-up voltage amplification factor, the shorter the start-up time. The research results will facilitate the setting of circuit component parameters and systematically study the composition of the circuit.

Keywords: *RC bridge sine wave oscillating circuit; start-up time; output amplitude; Multisim*

I. INTRODUCTION

The RC bridge sine wave oscillating circuit, also known as the Wen's bridge oscillating circuit in the related literature, is a self-excited frequency selective amplifying circuit. The circuit consists of an amplifying circuit, a feedback network, a frequency selective network, and a stable link[1]. Since there are few related literatures on the influence of the oscillation amplification factor on the oscillation time and the amplitude of the stable output voltage, the research results are of great significance for the development of the oscillation circuit. Therefore, this paper analyzes in detail the influence of the starting voltage amplification factor on the magnitude of the voltage output when the circuit is stably oscillated and the starting time of the circuit.

II. RC BRIDGE SINE WAVE OSCILLATOR CIRCUIT COMPOSITION AND MAIN INDICATORS

The composition of the RC bridge sine wave oscillating circuit is shown in Fig. 1. In order to reduce the influence of the amplifying circuit on the frequency selective characteristics, the oscillating frequency is determined only by the frequency selective network, and the voltage series negative feedback amplifying circuit is usually introduced[2]. The main circuit of the circuit uses the same arithmetic circuit as the comparator, and the operational amplifier model is the 741 operational amplifier. The capacitors C_1 and C_2 and the resistors R_1 and R_2 together form a positive feedback frequency selection network. For the convenience of parameter adjustment, the capacitances of capacitors C_1 and C_2 are the same, and the resistances of resistors R_1 and R_2 are the same. In the feedback network, the feedback resistor uses a resistor with adjustable resistance to facilitate parameter conversion. Two diodes of the type 1N4001 are connected in parallel and connected in series with the feedback resistor to add a nonlinear component to form a stable link of the oscillator circuit.

The main technical indicators of the circuit given in most of the literature are oscillation frequency, self-oscillation condition, and starting condition[3].

RC series-parallel frequency selective network, when $C_1 = C_2 = C$ and $R_1 = R_2 = R$, the oscillation frequency is

$$f_o = \frac{1}{2\pi RC} \tag{1}$$

The condition of self-oscillation is

$$\dot{A}\dot{F} = 1 \tag{2}$$

When $f = f_o$, the feedback coefficient of the feedback network is

$$\left|\dot{F}\right| = \frac{U_I}{U_O} = \frac{1}{3} \tag{3}$$

In order to meet the amplitude balance condition of the start-up, $\left|\dot{A}\dot{F}\right| > 1$ is required. Thus, the starting condition of the oscillating circuit that can be obtained at the f_o frequency is

$$\left|\dot{A}\right| > 3 \tag{4}$$

III. RC BRIDGE SINE WAVE OSCILLATOR CIRCUIT OUTPUT AMPLITUDE AND START-UP TIME ANALYSIS

The RC bridge sine wave oscillating circuit composed of the RC series-parallel network and the same comparison circuit is shown in the Fig. 1.

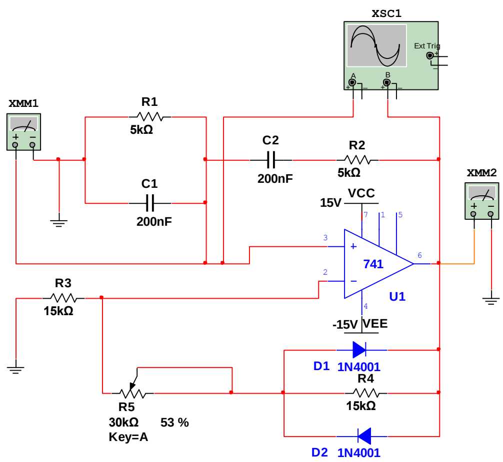

Fig.1 Simulation circuit diagram of RC bridge sine wave oscillation circuit

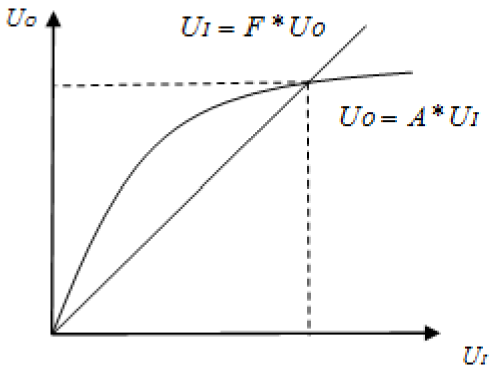

Fig.2 RC bridge sine wave oscillator circuit working process

Under the signal of the specific frequency f_O, the feedback voltage is input as the input voltage from the non-inverting input of the operational amplifier, and the output voltage is gradually increased from zero to the maximum value. When the voltage is amplified, the voltage amplification factor is greater than 3. Due to the characteristics of the nonlinear components, the limitation of the power supply, and the function of the amplitude stabilization section, the voltage amplification factor is equal to 3 when the final circuit is stably oscillated. Since the frequency selection network parameter is a fixed value, the feedback coefficient F is a constant. The working process of the RC bridge sine wave oscillating circuit is shown in Fig. 2 by the formula $U_O = A * U_I$, $U_I = F * U_O$ [4]. Obviously, as the amplification amplification factor increases, the amplitude of the output stable voltage increases continuously, and the circuit reaches a stable oscillation state when the two curves intersect. And the larger the starting amplification factor, the shorter the transition time required for starting the vibration.

IV. RC BRIDGE SINE WAVE OSCILLATION CIRCUIT SIMULATION EXPERIMENT TEST

The simulation experiment circuit of the RC bridge sine wave oscillation circuit created in Muhisim12 is shown in Fig. 1[5]. The value of the feedback resistor determines the magnitude of the starting amplification factor, so the adjustable feedback resistor value is first taken as 53% * 30KΩ. Start the simulation button, the test results are shown in Fig. 3. The waveform can be observed without distortion by the oscilloscope. Since the research object of this paper is the relationship between the dependent variable (magnitude, start-up time) and the independent variable (oscillation magnification), multiple sets of simulation tests are performed. The test results are shown in Table 1. Among them, the oscilloscope is used to observe the input and output waveforms. The smaller the amplitude of the figure is the input waveform, and the larger the amplitude is the output waveform. The multimeter is used to observe the rms value of the input and output voltages.

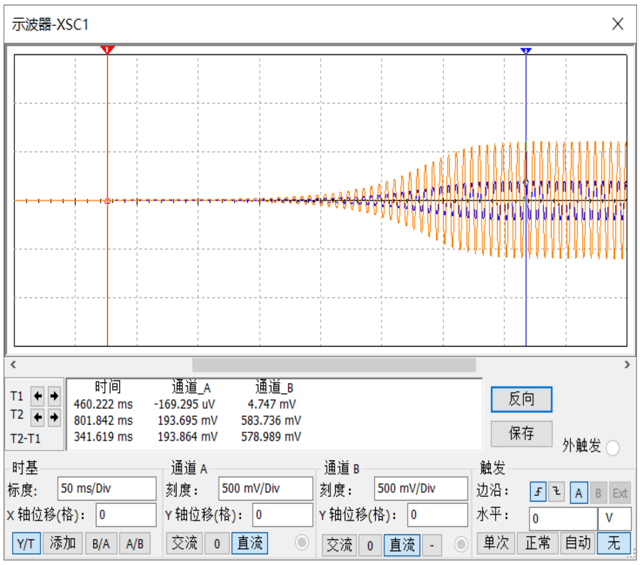

Fig. 3 RC bridge sine wave oscillator circuit oscillating and amplitude stabilization process

The data in the table is used to plot the change of the start-up time with the amplification factor[6], as shown in Fig. 4. It can be seen intuitively that during the process of increasing the starting amplification factor, the starting time is shorter and shorter, but the rate of change is slower and slower.

Table 1 Effect of starting voltage amplification on output voltage amplitude and start-up time

R_5数值/KΩ	53%30	58%30	63%30	68%30	73%30	78%30	83%30	88%30
振荡电压放大倍数$A=\frac{U_O}{U_I}$	3	3	3	3	3	3	3	3
起振放大倍数$A=1+\frac{R_4+R_5}{R_3}$	3.06	3.16	3.26	3.36	3.46	3.56	3.66	3.76
输出电压有效值U/ mV	406.457	687.546	928.875	1209	1573	2097	2935	4509
起振至稳幅时间T/ mS	277.699	112.926	67.472	51.136	42.898	36.506	33.239	32.955

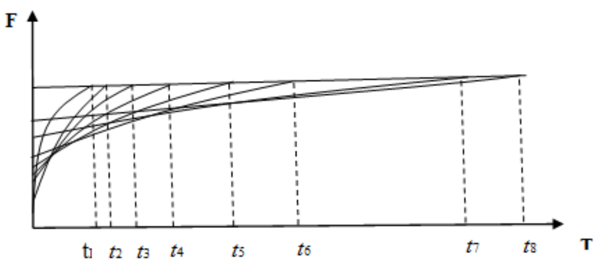

Fig. 4 The variation of the oscillating time of the RC bridge sine wave oscillating circuit with the amplification factor at the time of starting

CONCLUSION

The perspective and starting point of this paper are different from the existing literature, mainly reflected in

1. From the perspective of the effect of the oscillating amplification on the circuit, the variation of the oscillating voltage output amplitude and the oscillating time at different starting amplification factors is studied.
2. Using the conclusions obtained from the study, the starting time can be effectively adjusted, and the starting voltage amplification factor can be accurately set for the required stable oscillation amplitude.

The conclusions obtained in this paper are

1. The oscillating amplification factor of the RC bridge sine wave oscillating circuit directly affects the amplitude of the stable oscillating voltage output. The increase of the oscillating amplification factor will result in an increase in the amplitude of the stable oscillating voltage output.
2. The starting amplification factor determines the length of the starting time. As the starting amplification factor increases, the starting time is shortened. However, when the starting amplification factor increases to a certain value, the starting time changes tend to be saturated, and the reduction is not obvious.

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