Experimental Design of C-class High Frequency Power Amplifier

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Abstract: This research presented an experiment on C-class high frequency power amplifier, in which the preamplifier stage under A class linear conditions was used to fit the smaller input signals, and the postamplifier stage under C class linear conditions was adopted to determine the current pulse shape under the conditions of undervoltage, critical voltage, overvoltage, respectively. Through the control of switches and potentiometer, we observe the influences of excitation voltage, supply voltage and load change upon the working condition of the C-class high frequency power amplifier. The proposed design gave a further understanding on the basic working principles of the C-class high frequency power amplifier so as to grasp the designing method of such power amplifier.

Keywords: High Frequency; Pulse Shape; C-class High Frequency Power Amplifier

1. Introduction

High frequency power amplifier is an important part of the transmitting equipment in communication system, which can convert current power to the high frequency alternating power and output it. Its main function is to provide a large enough high frequency output frequency to radiate the signal out by the antenna [1]. The common features of the high frequency power amplifier and low frequency power amplifier are the large output power and high efficiency, but the operating frequency and relative frequency bandwidth of the both are very different from each other, which determine the fundamental difference between the two: the operating frequency of low frequency power amplifier is low, but the relative frequency bandwidth is very wide; the operating frequency of high frequency power amplifier is high, from several hundreds kHz up to hundreds, thousands even ten thousands MHz, but the relative frequency bandwidth is narrow. Therefore, generally, the high frequency power amplifier uses the frequency selective networks as the load circuit, working in the C-class state [2].

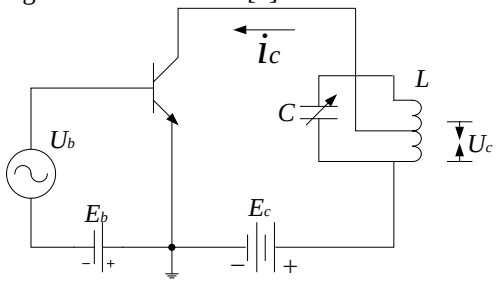

Figure 1. The circuit schematic diagram of high frequency power amplifier

The high frequency power amplifier consists of transistor, LC tuned circuit, DC voltage, E_c and E_b, and U_b is the high frequency excitation voltage supplied by the prelevel. The circuit schematic diagram of high frequency power amplifier is shown in Figure 1.

2. The Basic Principles of C-class C Tuned Power Amplifier

C-class tuned power amplifier adopts the reverse bias, in static state, the tube is in the cut-off state. Only when the excitation signal U_b is large enough, exceeding the sum of reverse bias voltage E_b and the starting on-state voltage of transistor u_i, the tube can be turned on. Thus, the tube is turned on only in a small part time in one-cycle. So, the collector current is periodic cosine pulse. The waveform is shown in Figure 2.

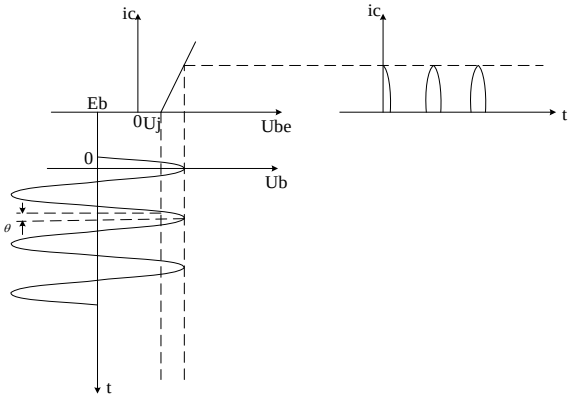

Figure 2. Analyze nonlinear circuit current waveform with fold line method

According to whether the operation of tuned power amplifier enters into the saturation area, the amplifier can be divided into undervoltage, overvoltage and the critical voltage three operation states. In the entire cycle, if the operation of the transistor does not enter into the saturation area, that is at any time it works in the enlarged area, which is called that the operation of the amplifier is in the undervoltage state; if it just enters the edge of the saturation area, which is called the operation of the amplifier is in the critical condition; if the operation of the transistor gets into the saturation area in a part time, which is called that the operation of the amplifier is in an overvoltage state. The three operation states of the amplifier depend on the supply voltage E_c, the bias voltage E_b, the excitation voltage amplitude U_{bm} and collector equivalent load resistance R_c.

3. Experimental Circuit of High Frequency Power Amplifier

The design takes the RZ8653 type "high-frequency electronic circuit experiment platform" of Nanjing Runzhong Technology Co., Ltd. for instance, and the experimental circuit of high frequency power amplifier is shown in Figure 3.

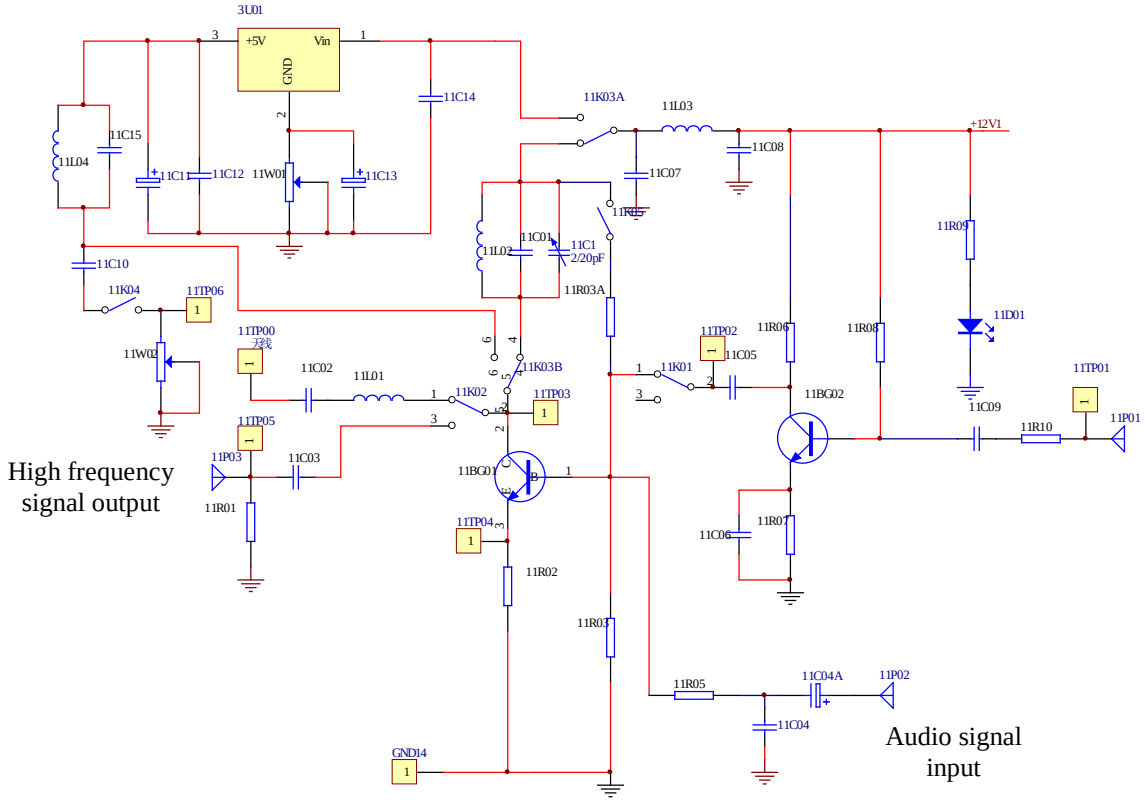

Figure 3. The experimental circuit diagram of high frequency power amplifier

In this experiment unit, the high frequency signal is input by the rivet holes 11P01, via 11R10 and 11C09, added to the base electrode of 11BG02. 11TP01and 11TP02 are the input and output measuring points for the level. 11BG02 is the preamplifier stage, which works in Group A linear state to fit the smaller input signal level. Since the load of the level is a resistance which has no filtering and tuning effect on the input signal, so it can be used as AM amplification, also as FM amplification. When 11K05 jumper is removed, the 11BG01 is C-class high frequency power amplifying circuit which base electrode bias voltage is zero, constituting reverse bias by the voltage on the emitter. Therefore, only in the positive half cycle of the carrier and the amplitude is large enough, the power tube can be turned on. Its collector load is the LC selected frequency resonance circuit, and the resonance has selected the basic wave at the carrier frequency, so greater power output can be obtained. This experimental amplifier has two selected circuits, which are decided by the 11K03. When 11K03 is put on the left (1, 2, 4, 5 are turned on), the selected resonance route consists of 11L02 and 11C01 and 11C1, whose resonance frequency is about 6.3MHZ, and the amplifier can be used to form a wireless transceiver system at this time. When 11K03 is put on the right (2, 3, 5, 6 are turned on), the resonance circuit consists of 11L04 and 11C15, whose resonance frequency of resonance circuit is about 2MHZ. At this point, it can be used to measure the current pulse wave-

forms under the three states (undervoltage, critical, overvoltage), because a lower frequency is better for measurement. 11K04 is used to control the switch or not of the load resistor. 11W02 potentiometer is used to change the large or not of the load resistor. 11W01 is used to adjust the large or not of the amplifier collector supply voltage (the resonance circuit frequency is about 2MHZ). When the amplifier constitutes the system, 11K02 controls the amplifier is output by the antenna or directly through the rivet holes. When 11K02 is put on the above, the amplifier output is launched by antenna and 11TP00 is the antenna access point. When 11K02 is put on the below, the amplifier is output by 11P03. 11P02 is input port of audio signal, which can carry out base electrode amplitude modulation for the amplifier when adding the audio signal. 11TP03 is the test point of the amplifier collector. 11TP04 is the test point of the emitter, in which current pulses waveform can be measured. 11TP06 is used to measure the large or not of the load resistor. When the input signal is amplitude-modulated wave, 11BG01 can not work in the C-class state, because the amplitude is small when the amplitude-modulated wave at the trough, the 11BG01 may not be turned on, causing serious distortion of the output waveform. Thus, the input signal is amplitude-modulated wave, 11K05 jumper must be connected so that 11BG01 work in the A-class state.

4. Characteristic Test of Preamplifier Stage

The frequency set of frequency signal source is about 6.3MHz; the amplitude peak is about 300mV. Connect to 11P01 with rivet holes, turn the switch 11K01 to "OFF" on the module, use oscilloscope to measure the waveform amplitude of 11P01 and 11TP02 and calculate its magnification times. As the collector load of this class is resistor, so it set a selected frequency effect.

The input and output waveform of test preamplifier stage and the amplitude are shown in Figure 4.

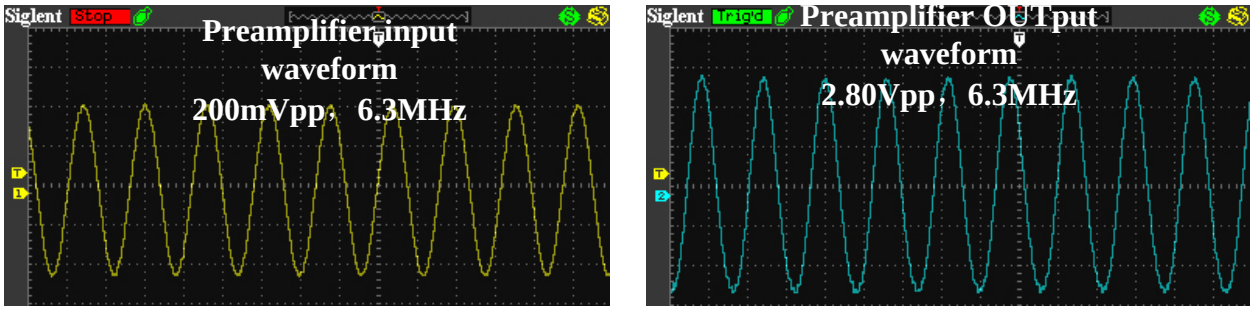

Figure 4. The input and output waveform of test preamplifier stage and the amplitude

The magnification times of the preamplifier stage is: $2.80Vpp \big/ 200mVpp = 14$ times.

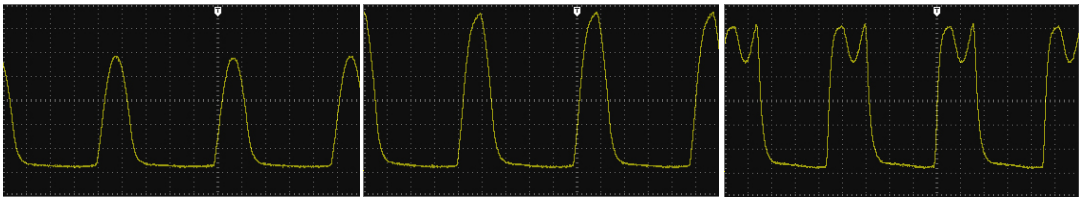

Figure 5. Influence of excitation voltage U_b on the working condition of C-class frequency power (undervoltage, critical, overvoltage waveform)

5. The Working Condition of C-class Frequency Power Amplifier

5.1. Influence of Excitation Voltage U_b on the Working Condition of C-class Frequency Power Amplifier

Set the switch 11K01 on "on", 11K03 to "right side", 11K02 to below. Keeping collector supply voltage E_c = 6V (measure DC voltage of 11TP03 with a multimeter, tune 11W01 equal to 6V), the load resistance $R_L = 8k\Omega$ (set 11K04 on "off", measure 11TP06 resistance with a multimeter, tune 11W02 equal to $8k\Omega$, then 11K04 is set on "on") is not change.

High frequency signal source frequency is about 1.9MHZ, amplitude is 200mv (peak – peak value) and connect to the input of amplifier module (11P01). Oscilloscope CH1 connects to 11TP03 and CH2 connects to11TP04. Adjust the frequency of the high frequency signal source to make the amplifier output that is amplitude resonance reaches the (11TP03) maximum. Change the amplitude of the signal source, that is change the excitation signal voltage U_b, and observe 11TP04 voltage waveform.

When the signal source amplitude varies, the undervoltage, critical, overvoltage pulse waveform should be observed, which is shown in Figure 5.

5.2. Influence of Collector Supply Voltage E_c on the Working Condition of the Amplifier

Hold the excitation voltage U_b (11TP01 voltage is 200mv peak – peak value), not change the load resistance $R_L = 8k\Omega$, change the collector voltage amplifier E_c (adjust11W01 potentiometer, make the change of E_c is 5-10V), observe 11TP04 voltage waveform. When adjusting the voltage E_c, the voltage, critical, overvoltage pulse waveform should be observed, which is shown in Figure 6.

5.3. Influence of the Change of Load Resistance R_L on the Working Condition of the Amplifier

Keep amplifier collector voltage = 6V, the excitation voltage (11TP01 point voltage, 150mv peak – peak value) unchanged, change the load resistor R_L (adjust 11W02 potentiometer, pay attention to the 11K04 to "ON"), observe 11TP04 voltage waveform, the voltage, critical, overvoltage pulse waveform should be observed, which is shown in Figure 7.

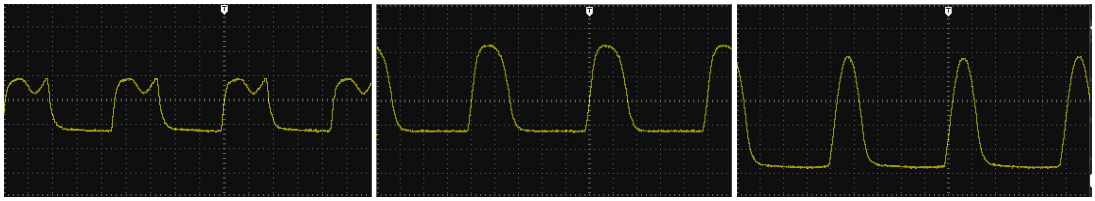

Figure 6. Influence of excitation voltage E_c on the working condition of C-class frequency power (undervoltage, critical, overvoltage waveform)

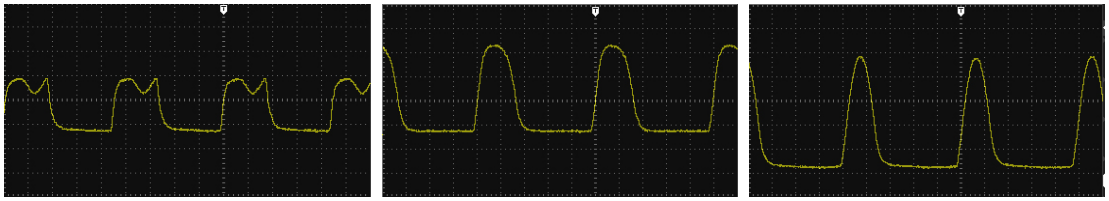

Figure 7. Influence of the change of load resistance R_L on the working condition of the amplifier (voltage, critical, overvoltage waveform)

6. Experimental Summaries

The experiment on C-class high frequency power amplifier adopts the preamplifier stage high frequency signal under A class linear conditions, uses the post C-class high frequency power amplifier which takes the selective network as load circuit, and observes the influences of excitation voltage U_b, supply voltage E_c and load circuit R_L on the working condition of the C-class high frequency power amplifier. The proposed design gave a further understanding on the basic working principles of the C-class high frequency power amplifier so as to grasp the designing method of such power amplifier.

7. Acknowledgement

Project of university-level education and teaching reform in Tianjin Polytechnic University in 2014: Construction of high frequency electronic technology network course and experimental teaching materials (No. 2014-3-13).

References

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