Design of microwave frequency hopping source and point frequency source

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Abstract

Frequency synthesizer is one of the key components in modern electronic system.And its performance will directly affect the performance of the entire system.With the rapid development of electronic technology, all kinds of electronic systems are becoming more and more requirements for the performance of the frequency synthesizer.Small step, low stray, low phase noise, frequency agility, ultra wideband has become the inevitable trend of the development of the frequency synthesizer.In this paper, we mainly study the design of microwave frequency synthesizer. Also this paper briefly introduces the development of frequency synthesis at home and abroad, and then combined with the frequency of the subject will be used.In this paper, the basic theory of phase locked loop and some commonly used schemes are described in this paper,At last, the paper introduces the design of X band frequency hopping source and microwave point frequency source, including the analysis and demonstration of the scheme, the selection of the device, the design of the circuit structure, the test results of the experiment and so on.

Keywords

Frequency synthesizer, phase locked loop, mixing, phase noise, spurious.

1. Introduction

Along with the rapid development of all kinds of electronic fields,the electronic system puts forward higher requirements for the frequency synthesizer in a timely manner.In demand driven development, and now the frequency synthesizer is moving towards ultra wideband, low phase noise, low spurious, fast frequency of the direction of development.Especially in today's military field, a variety of radar, missile, electronic countermeasure and other equipment of the RF front-end circuit needs the above high precision, high stability of the microwave millimeter wave frequency source.In addition, the country is now vigorously developing space technology, remote communication, electromagnetic compatibility and other requirements more.Harsh, frequency source is to ensure that well done.Of course, the production of a number of precision instruments and meters is inseparable from the high level of frequency.Direct frequency synthesis (DS), phase locked method (PLL), DDS cyclization synthesis constitute the basic elements offrequency synthesis technology.The four frequency synthesizer is realized by a single phase locked loop.The experimental results show that the phase noise, spurious suppression and power of the four frequency synthesizer are better than those of the given index.[1]

Integrating PLL together is now a hot direction.The advantage of phase locked loop is that phase noise and spurious can be relatively low,but the frequency conversion speed is relatively not very fast.Even now some chips inside bring fast lock function,it was worse than DDS.

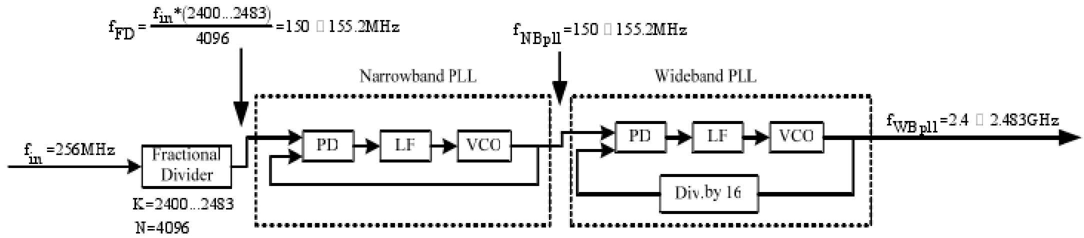

Figure.1 Schematic diagram of double PLL structure

2. The basic theory of frequency synthesizer and common programme

In the first chapter, it has been discussed that the phase locked loop, DDS, mixer, frequency multiplier, frequency divider and so on are the most basic circuit of frequency synthesizer.

This chapter will explain the basic theory of phase locked loop, including phase noise and spurious performance analysis, and introduce some common frequency synthesizer.

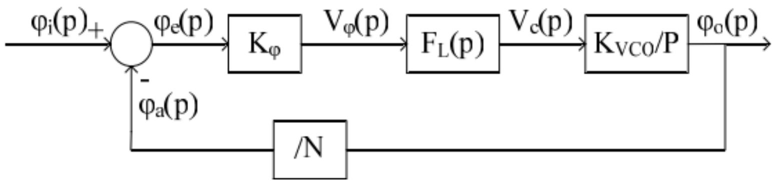

Figure.2 Linear phase model of phase locked loop

The expression from the linear phase model above can draw the phase-locked loop transfer function[2],the forward transfer function (positive loop gain):

$$H(P)=\frac{\varphi_o(P)}{\varphi_i(P)}=\frac{K_\varphi F_L(P)\frac{K_{VCO}}{P}}{1+K_\varphi F_L(P)\frac{K_{VCO}}{NP}} \tag{2-1}$$

Error transfer function:

$$H_e(P)=\frac{\varphi_e(P)}{\varphi_i(P)}=1-\frac{H(P)}{N}=\frac{1}{1+K_\varphi F_L(P)\frac{K_{VCO}}{NP}} \tag{2-2}$$

3. Design of X band frequency hopping source

This chapter will discuss in detail the design of X band frequency hopping frequency source. The module requires that the output frequency range is 9.8 GHz to 10.8 GHz. The specific technical indicators are as follows:

Frequency step: 5MHz

Output power: more than 7dBm

Phase noise: less than -8sdBc/Hz@1 kHz, less than a 88dBc/Hz@10 kHz

Proximal spurious suppression: better than 60 dBc

Finally we use the phase locked ring scheme

The whole system can be divided into main phase locked loop (variable local oscillator) and sub phase locked loop (radio frequency).The main loop VCO output signal is amplified by the amplifier and is divided into two parts:one is the directional coupler through the output end, the other part of the directional coupler is end coupled to the mixer circuit, signal coupling after the amplifier into the mixer Lo end, and vice ring VCO RF signal down conversion produces intermediate frequency signal, intermediate frequency signal again filtered evacuation to enlarge into the phase detector and the crystal phase phase.[3]By using the mode of the lower frequency mixing, we should make the necessary intermediate frequency output signal and the local oscillator signal, the radio frequency signal and the isolation of all kinds of mixing signals.

The main ring oscillator and the phase detector of system phase noise contribution, as shown in table 1.

Table.1 main ring phase noise estimation

Device type	Device self phase noise		Contribution to output phase noise	
	dBC/Hz@1KHz	dBC/Hz@10KHz	dBC/Hz@1KHz	dBC/Hz@10KHz
Crystal oscillator	-154	-164	-113.3	-123.3
phase detector	-152	-152	-93.3	-93.3

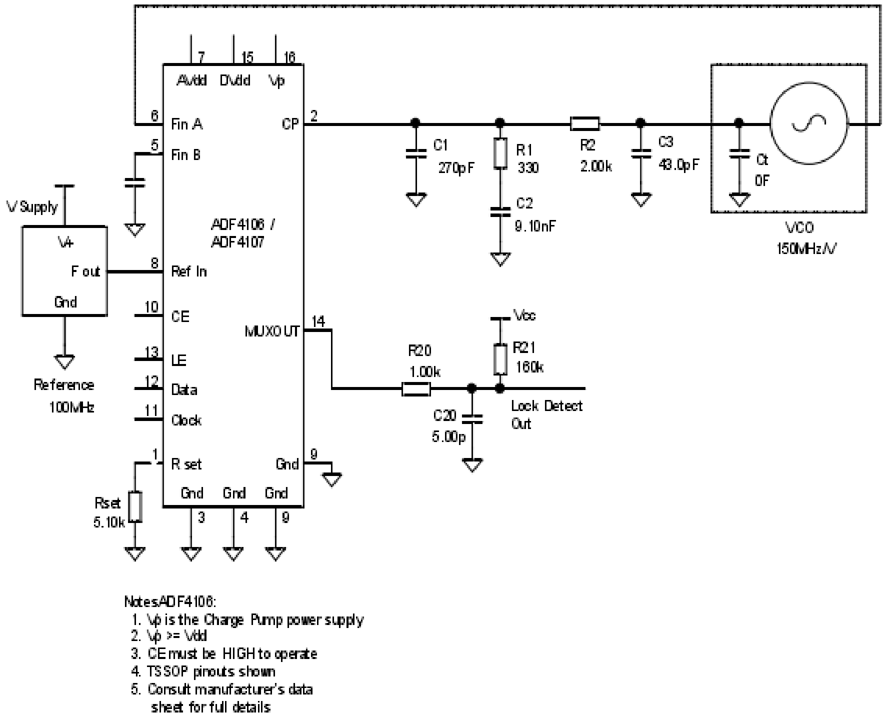

Figure. 3-2 simulation circuit model

In the actual circuit debugging, in accordance with the production of the initial value of the PLL may not be locked loop or can not reach the system indicators and other issues.In order to make the loop locked or reach the optimal state, the parameters are adjusted repeatedly.[4]

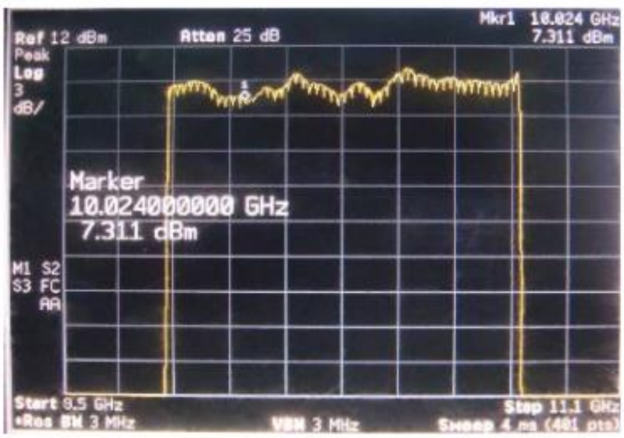

Figure.3-2 The power of the test results as shown in the drawing.

4. Design of microwave point frequency source

A Ku band transceiver includes four modules, Ku band frequency conversion module, the Ku band received payment mode:Block, RFID middleware and crystal oscillator module. All modules are connected by SMA coaxial cable.The designed frequency source includes S band frequency synthesizer, 820MHz frequency synthesizer, 1GHz frequency synthesizer, 280MHz frequency synthesizer.[5]They are mainly for the Ku band frequency conversion module, the RF middleware module to provide the local oscillator signal; and to provide a signal processing board for the baseband signal.

Each frequency synthesizer is designed as an independent module to facilitate debugging.Because the frequency of all the frequency synthesizer is not too high, the performance can be achieved by using phase locked loop.[6]

5. Conclusion

This paper briefly introduces the development of the frequency synthesizer at home and abroad, and then combined with the frequency of the use of the subject,briefly discusses the basic theory of phase locked loop (PLL) and some commonly used frequency synthesizer scheme. At last, the paper introduces the design of X-band frequency source and a microwave frequency source, including the scheme analysis and demonstration, device selection, circuit structure design and experimental results of the test.

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