Design of Signal Source without External Reference for Fiber Optical Comb System

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Abstract— Femtosecond frequency comb is a great invention in the field of metrology at the end of the last century. It can simply and effectively synchronize the phases for optical signals of different wavelengths or RF signals. Erbium doped fiber optical comb has many advantages. The National Time Service Center of Chinese Academy of Sciences has launched a project on the new type erbium-doped fiber femtosecond optical comb research. This paper introduces the signal source which is designed for this project. DDS chip AD9854 is used as the signal source. The signal source output has a wideband from 1–80 MHz. Test result for the signal source is discussed.

1. INTRODUCTION

Femtosecond frequency comb is a great invention in the field of metrology at the end of the last century [1, 2]. It can simply and effectively synchronize the phases for optical signals of different wavelengths or RF signals. Direct synchronous frequency difference can be up to 100,000 times or more. It solves the problems of comparison between different optical frequency signals [3, 4]. There are many kinds of femtosecond frequency comb. The spectrum center of erbium doped fiber optical comb is located at 1.55 μm communication wavelength. Accordingly, erbium doped fiber optical comb has more advantages in component selection, price, and application. This makes the erbium doped fiber optical comb has many characteristics, such as high stability, small volume, low power consumption, flexible operation, and good robustness. In addition, by using the commercial nonlinear fiber crystal, it can be more convenient to extend the operation wavelength of erbium doped optical comb to that of several other optical combs.

A lot of time frequency laboratory are carrying on the research about doped femtosecond comb technology. At present, the National Time Service Center of Chinese Academy of Sciences has launched a project on the new type erbium-doped fiber femtosecond optical comb research. This paper introduces the signal source which is designed for this project.

Nearly almost all of the electric control system needs signal source. Many methods can be used to generate the signal. In the field of low frequency, it can be achieved with single-chip, and in the field of high frequency, it can be achieved by FPGA or DDS chip. Because of the stability of the DDS chip, usually in the RF and microwave bands, it is a good design by using DDS chip as the signal source [5]. In the next part, the authors will introduce the signal source that designed for this optical fiber frequency comb system. In the third part, the test results of the signal source will be introduced.

2. DESIGN OF SIGNAL SOURCE

The system's signal source use a DDS chip AD9854. When without an external reference source, sine wave, square wave and triangular wave of arbitrary frequency from 1 to 80 MHz can be generated by this signal source. DDS is a new kind of method of frequency synthesis. The reference clock is directly sampled, digitalized, and then use the digital computing technology to generate a frequency. The AD9854 is a type of high performance DDS chip produced by AD Company. The operation principle diagram of AD9854 is shown in Figure 1. It integrates 48-bit frequency accumulator, 48-bit phase accumulator, sine and cosine waveform table, 12-bit orthogonal digital-to-analog converter, and modulation and control circuit.

Its operating voltage is 3.3 V. The highest working frequency is 300 MHz. The output frequency ranges from 0 to 120 MHz. It can export FSK, PSK, BPSK, AM, and CHIRP signal. AD9854 has five kinds of work mode: Single-tone, Unramped FSK, Ramped FSK, Chirp, and BPSK. In the above five modes, Single-tone is one of the most flexible model. This model can be used to set the output signal's frequency, amplitude and phase characteristics.

In the design, we use AVR ATMEGA32 MCU to control the AD9854. Usually, the serial RS232 is used to communicate with MCU. The use of USB communication is a technology direction in recent years. This design uses the USB to serial RS232 chip CH340G. As to the system software

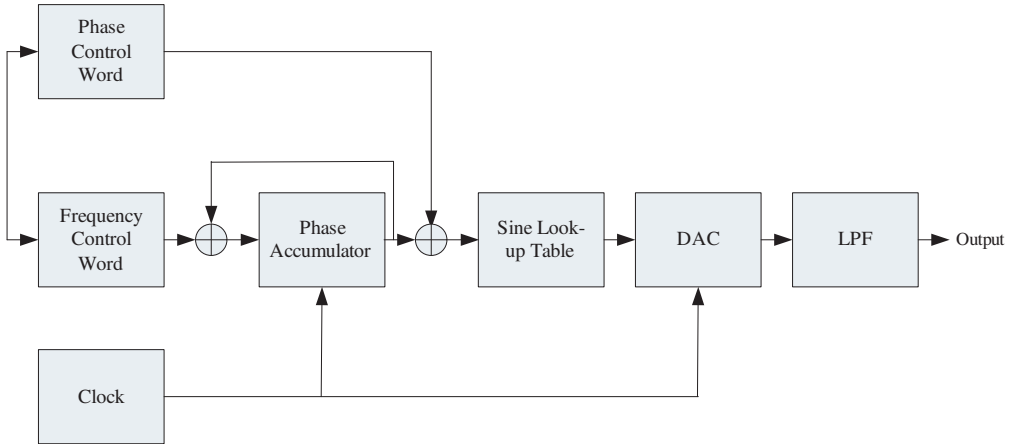

Figure 1: Operation principle of AD9854.

control part, first of all, set up the I/O update signal of AD9854. Whether the control signal is correct decides whether the AD9854 works correctly. Next, the internal 40 registers of AD9854 are set up. The control registers that have addresses from 1D-20 are 32 bits. They control the working mode, the comparator, the output amplitude, the system clock. After we have set up the control register, we set up the frequency registers amplitude registers, and phase registers. A chip has two frequency registers and two phase registers. Phase Adjust registers are used to control the waveform phase. Their addresses are 00 and 01. They are 14-bit registers. So the waveform phase generated has a 14-bit precision. Frequency tuning word register is used to control the waveform frequency. Their addresses are 04 and 09. They have a 48-bit precision. Output Shape Key I and Output Shape Key Q are amplitude registers. Their addresses are 21 and 24. They are 12-bit registers.

Figure 2 is the signal source software control interface that we design.

Figure 3 is the hardware circuit of signal source.

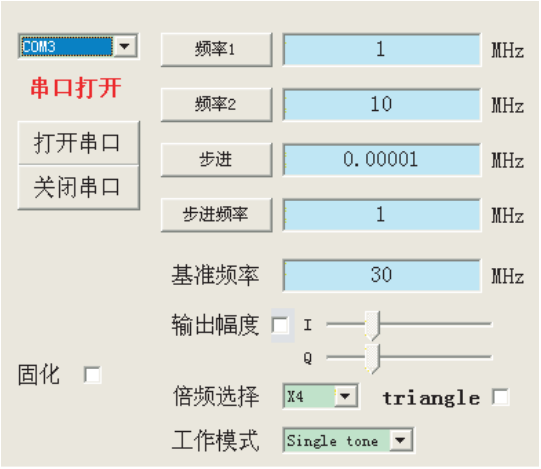

Figure 2: Signal source software control interface.

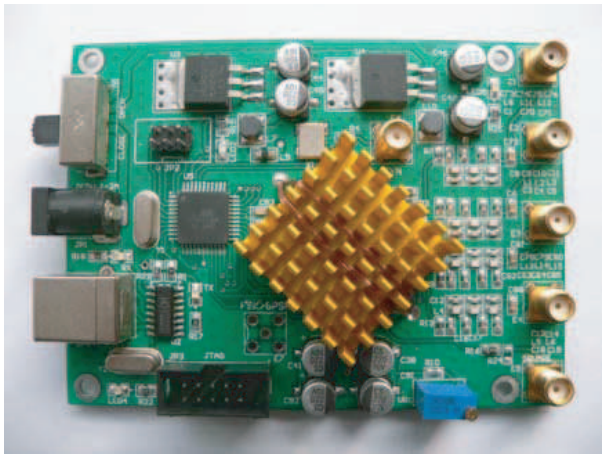

Figure 3: Hardware circuit of signal source.

We test the properties of the signal source. Test results are shown in Figure 4.

In Figure 4, a signal is generated by the circuit that we designed. Its frequency is 10 MHz. It is displayed by the oscilloscope. Signal with frequency from 1–80 MHz can be easily generated by the signal source.

3. DISCUSSIONS

From Figure 4, we can fully realize the circuit with expected function. AD9854 can be used to accurately generate different frequency sine wave and square wave. This paper is related to the issue that there is no outer reference input source. As to the next step research we will develop

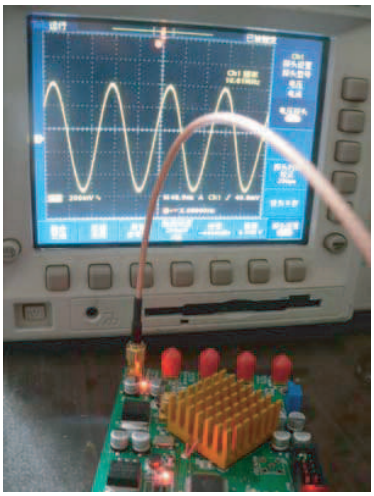

Figure 4: Test results of the signal source.

signal source with external reference input. Usually some high-frequency microwave signal is used as external reference input.

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