Research on Program-controlled Power Source Based on DDS

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Abstract – **Direct Digital Synthesis (DDS) chip was used in the design of program controlled power source in this paper. With the accurate control of Dual DDS chips by Micro Controller Unit (MCU), filter and power amplifier, this power source can generate voltage and current output with variable frequency, amplitude and phase. There are several advantages of this power source such as high power, high accuracy, output stable, light and convenient.**

Key words – ***DDS; phase control; power source; program-controlled***

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1 Introduction[1]

In the development, production, use, testing and maintenance of electronic components, device parts and equipment are needed to provide a standard excitation signal source. This signal source can generate variable-frequency voltage and current signals to put out to the device under test. And then use the other test instruments observing its output response. In this paper, the program-controlled power source is used in electronic measuring as a signal generator. The difference is that it not only generates the waveform signal simply, but also increase in power, make a range of belt containing possible. The program-controlled power source has a major role in the following three points: ①As the excitation source; ②Signal simulation; ③As a standard source.

2 Basic principles of DDS

DDS is the abbreviation of Direct Digital Synthesis. Its basic idea is to search the waveform data in the waveform table, and then synthesize the required waveform directly. The basic structure block diagram of DDS is giving in Fig. 1.

①Large output frequency range. The highest frequency of the output was decided by clock frequency FCLK, usually get 40% of FCLK. The minimum resolution was decided by the bit size of phase accumulator, generally up to 24-23 now, and that the resolution of the FCLK up1/224-1/2.32; ②Fast waveform output response, can achieve microseconds or even nanosecond-level; ③Stable waveform. The waveform strictly controlled by waveform ROM, the frequency depends on the FCW and FCLK.

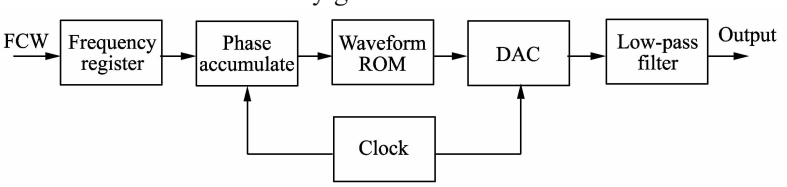

Fig. 1 Basic structure block diagram of DDS

3 Hardware design

3.1 Introduction of AD9832 DDS chip

AD9832 is a DDS chip with complete functions manufactured by Analog Devices. AD9832 was made based on the CMOS process, 3/5 V power supply, receiving data through the serial port, interface and peripheral circuit is simple, low cost. It was composed by the digital control oscillator NCO, phase modulator PA, sinusoidal SIN ROM look-up table and DAC. NCO and PA including two 32-bit frequency register FREQ0 and FREQ1 and 4 12-bit phase register from PHASE0 to PHASE3. FSELECT controls the frequency register, when the rising edge of Fclk, FSELECT port state is read, when FSELECT is low, data in FREQO frequency register is read into PA, on the contrary FREQ1 be read into it. Its basic structure as shown in Fig. 2[2].

There are several main pins as flow: ① FSYNC Data Synchronization Signal, Logic Input. When this input is taken low, the internal logic is informed that a new word is being loaded into the device; ② SCLK Serial Clock, Logic Input. Data is clocked into the AD9832 on each falling SCLK edge; ③ SDATA Serial Data In, Logic Input. The 16-bit serial data word is applied to this input;

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④ I_{OUT} Current Output. This is a high impedance current source. A load resistor should be connected between I_{OUT} and A_{GND}.

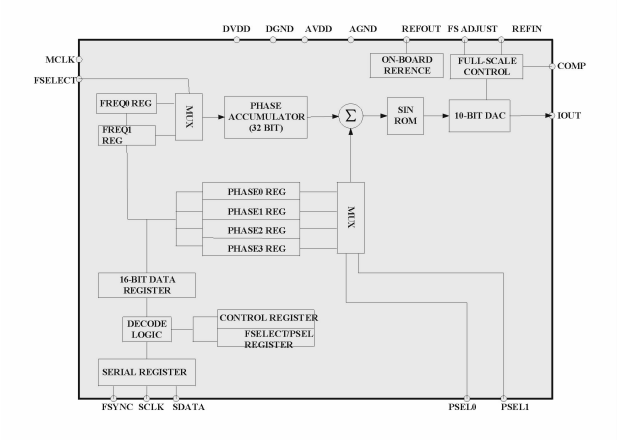

Fig. 2 Basic structure block diagram of AD9832

3.2 Signal power source module design

As a standard device in the field of electronic measuring, the standard power source must generate waveform very accurately. The power source waveform signal used 89C52 MCU to control DDS AD9832 to generate the waveform. The frequency accuracy can be achieved to 0.01HZ and the stability of output waveform is well, and also very easy to adjust. Fig. 3 gives the schematic diagram of the sine wave generated by the circuit of AD9832.

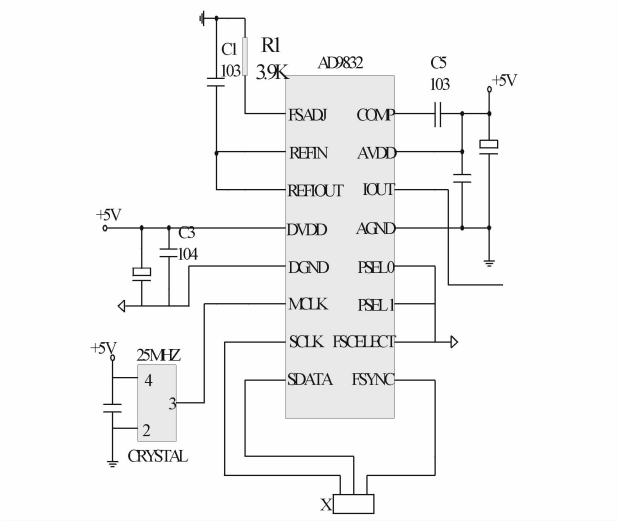

Fig. 3 Schematic diagram of sine wave generation circuit with AD9832

The plug X was connected to MCU, for receiving various control word and the synchronization signals. MCLK was connected to crystal. AD9832 involved as a result of DA conversion, therefore the figures should be noted that with a reasonable simulation to layout to avoid interference.

Since the AD9832 is a current output signal and a standard power source must also have the corresponding voltage signal. The method of voltage and current signal is the same as in the former more of a voltage conversion circuit, the circuit schematic diagram was shown in Fig. 4.

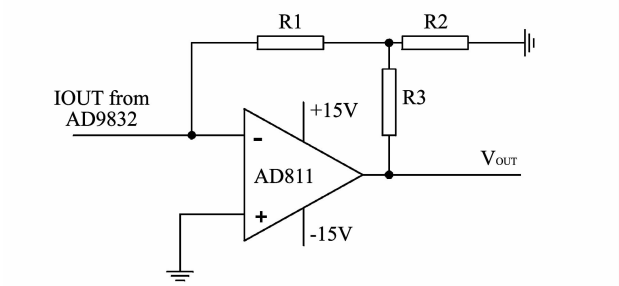

Fig. 4 Schematic diagram of conversion circuit from current to voltage

Set T node voltage, I_{OUT} output current i, output voltage u_{out}, then the node T is the establishment of the following formula:

$$\frac{0-u_t}{R}=\frac{u_t-0}{R_3}+\frac{u_t-u_{out}}{R_{41}}, \tag{1}$$

$$u_t=-iR_1. \tag{2}$$

Eq. (3) can be got from Eq. (1) and (2).

$$u_{out}=-R_3\left(I+\frac{R_1}{R_2}+\frac{R_1}{R_3}\right)i. \tag{3}$$

From the formula (3) we can see, as long as the appropriate adjustments of that can adjust the voltage-current conversion magnification.

3.3 Accurate Phase control of voltage and current

The voltage and current signals which generate by power source were output as single phase signal. As a power source, the phase must be accurate controlled. Through the narrative above we can know, the initial value of PA is just the initial phase of output waveform. We have to control two AD9832, first, we should connected circuit of MCU and AD9832 as shown in Fig. 5[4]. Secondly, two AD9832 should be connected to a common active crystal, the purpose is to maintain the synchronization strictly and reducing the error. Through the analysis of PA, we can see that the phase register and the output waveform initial phase have the following relationship:

$$\varphi = 360 * \Delta\text{Phase} * 1/2^{12}. \tag{4}$$

By setting different values that can adjust the output waveform of the initial phase. Its accuracy can reach around 0.1.

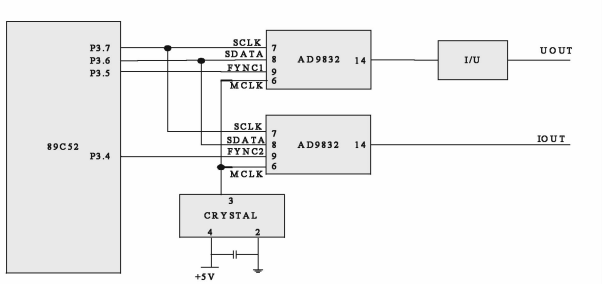

Fig. 5 Interface circuit of mCU and dual AD9832

3.4 Power amplifier design

Because the power source in the electronic measuring device must provide high voltage and high current, the

power amplifier has become an important part of an essential, power amplifier circuit should meet the following three requirements: ① Output power as much as possible; ② The efficiency must high; ③ Nonlinear distortion must small.

For this design, the voltage and current should be taken a different power circuit to enlarged. First of all, the voltage amplification using high-power Darlington complementary tubes Class-AB operational amplifier, where we used OPA502, bridge circuit drove method to increase the load drive capability. The circuit was shown in Fig. 6.

In addition, low-pass filter LPF used the elliptic filters, do not repeat it here because of the article length.

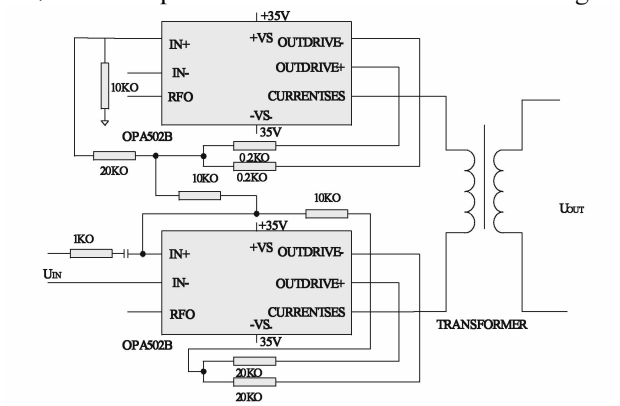

Fig. 6 Power amplifier circuit of voltage

4 Software design

MCU can set FCW by writing the two 32-bit frequency control word register FREQ0 and FREQ1 and by writing the four phase register PHASE0-PHASE3, can set the output initial phase of the signal. In addition, the AD9832 should be corresponding to the initialization of the control register set. Fig. 7 and Fig. 8 gives the flow chart for AD9832 operation and initialization.

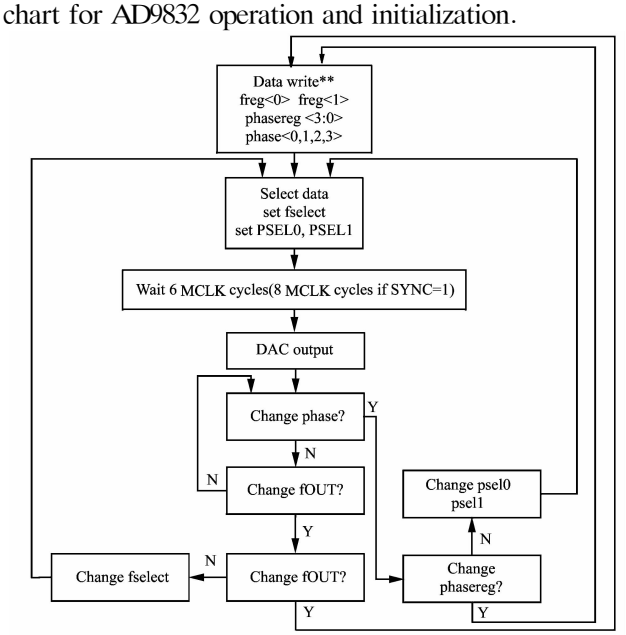

Fig. 7 Flowchart for AD9832 operation

To be notice is, in order to prevent some register value is set to zero when restart the AD9832 components. That may result in simulated output and impact of waveform quality.

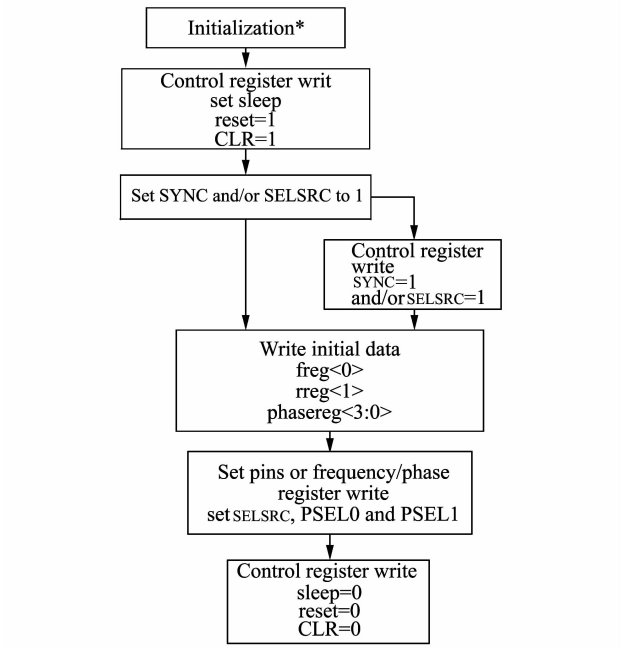

Fig. 8 Flowchart for AD9832 initialization

When initialization begin, set the RESET-bit which from control register to 1 to make no output from AD9832. Till the components can be ready to generate waveform, we set RESET to 0. After 6 clock cycle from MCLK (when SYNC = 1 it is 8), ADC will output sine wave required. In this way, we can guarantee that two AD9832 strictly synchronized, for accurate control of phase to provide a prerequisite and guarantee.

5 Summary and outlook

This AC program-controlled power source can be applied to energy meter calibrator systems, can also calibrate the data acquisition part of reactive power compensation system. It can provide variable frequency and amplitude of single-phase voltage signal and current signal, and simulate the actual power system simulation environment. In addition, in a number of relay protection testers, it can also be used as a standard meter.

I believe in the near future, after the industrialization of the design and production, compared to the traditional power sources, it will have these Advantages as follow: high accuracy, multi-functional, flexible and lightweight and so on.

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