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Discussion on the Experiment Teaching Reform for Electronic Measurement Technology

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Abstract
Targeting at the existing problems in current electronic measurement course practice teaching, a teaching method of implementing comprehensive experiment practice program is proposed to better develop students' problem analysis ability and independent innovation capability. Through progressive practice, the students are required to construct a complete digital signal generator step by step: welding and debugging single chip processor's minimum system and AD9850 module, checking its circuit functions, testing the waveforms and parameters of AD9850 module, and assembling and debugging the entire digital signal generator. This teaching method not only mobilizes students' learning enthusiasm and achieves good teaching effect, but also cultivates their practical engineering application ability and improves their measuring skills and innovation capabilities, fully satisfying the needs of the enterprises.
Key words: ELECTRONIC MEASUREMENT TECHNOLOGY, EXPERIMENT TEACHING, PRACTICE ABILITY

1. Introduction

Electronic measurement is an electronic technology-based measuring technique. The development of effectively promotes the application of electronic measurement and allows it to play a vital role in people's production and living activities. As a specialized course for students majoring in Electronic Information Engineering Technology, Electrical Engineering and Automation, Telecommunications Engineering Technology, Measuring and Controlling Technology, electronic measurement is a highly practical course that develops students' production practice ability, comprehensive application competence and adaptive capability.

The following problems can be found in the practice teaching of electronic measurement in many colleges and universities at home and abroad:

(1) The experimental teaching instruments are backward and worn-out and update slowly, failing to keep up with the industry's development.

(2) The experimental practice links mostly involve fundamental replication experiments and lack com-

prehensive experiments.

(3) The students only have an understanding of the instruments' functions but not their working principles after the completion of the experiments.

(4) The experimental teaching is not highly valued by most colleges and universities, and professional experimental teaching faculty is inadequate.

The experimental practice links of electronic measurement technology mostly involve fundamental replication experiments. Following the experimental instructions, the students can easily complete the experiments, so they cannot systematically integrate what they have learned into a comprehensive practical project, which is not conducive to the cultivation of students' practice ability and independent innovation capability. Given the limitations of practice contents of current electronic measurement technology, the experiment contents must be reformed and perfected, namely, offering students more practice and training opportunities in a limited time to improve their problem analysis ability and independent innovation capability. The construction and implementation of comprehensive experiment practice program for electronic measurement technology proposed in this paper has achieved good effect among students.

2. Construction of digital signal generator system

2.1. Overall structure of the system

Digital signal generator system mainly consists of single-chip microcomputer minimum system, AD9850 module, low-pass filter and sinusoidal signal & square signal output. The single-chip microcomputer, as the core of the whole digital signal generator, controls AD9850A to output sinusoidal and square signals[1]. Overall structure of the system is as shown in Figure 1.

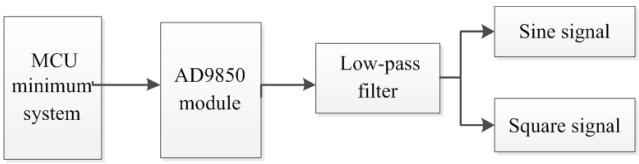

Figure 1. Overall Structure of Digital Signal Generator System

2.2 Single-chip microcomputer minimum system and DDS module

Single-chip microcomputer minimum system, or minimum application system, refers to the system of single-chip microcomputer which is made up of minimum elements for operation. As to 51 series of single-chip microcomputer, minimum system generally consists of single-chip microcomputer, crystal oscillation circuit and reset circuit[2]. The minimum system mainly provides various sequence signals for AD9850 module and transmits frequency & phase control words to make AD9850 module output sinusoidal and square signals with certain frequency and phase.

Along with rapid development of digital technology, the technology of generating multi-frequency from a reference frequency source by virtue of digital control method, namely, direct digital synthesizer (DDS) technology, rises suddenly. The frequency synthesizer AD9850 with high integration promoted by American AD Company adopts the DDS technology. AD9850 has 40-bit control words, 32 of which are used for frequency control and 5 of which are used for phase control. The 32-bit frequency control words can enable the output frequency resolution of AD9850 to reach 0.0291Hz[3]. It is easy to obtain sinusoidal and square signals through controlling AD9850 module by single-chip microcomputer. Besides, pure waveform can be obtained through low-pass filtering and the frequency range can reach 1Hz-60MHz. This module is very suitable for comprehensive experiment of the course of Electronic Measurement Technology.

3. Teaching implementation

3.1. Module assembly

The fabrication of digital signal generator can be divided into two modules, namely, minimum system module and AD9850 module. PCB and necessary elements of the two modules are provided by school, and the students only need to weld and assemble them according to schematic diagram. Before the assembly, operating principle of the whole system, function of each element and key welding points will be explained in detail. Students are extremely interested in this link since they can not only enhance the electronic assembling and welding skills they learned previously, but also have relatively profound understanding on the digital signal generator. However, AD9850 chip is the micro-miniature chip package of SSOP28[4] and the students have never welded such device before. Therefore, the key welding points of the device shall be explained especially, for example, controlling the temperature of soldering iron well; the electric soldering iron shall be welded by 20W internal heating method and each welding spot shall be welded well for about 2s to the greatest extent; instead of welding the pins one by one like plug-ins welded previously, it is required to adopt drag soldering method; in addition, after the welding is completed, the cotton yarn with ethyl alcohol of defined amount is used to clean the soldering flux remained in the welding point[5]. As to polar capacitor and LED,

drag soldering method shall be employed. It is required to emphasize that positive pole, and the negative pole of the pin shall not be welded reversely for both straight cutting type and SMD type. As to the element of straight cutting type, the welding spot shall be aesthetic and smooth on appearance without any burr or pin after the welding, and the whole soldering pad shall be filled with soldering tin. Welding sequence of the whole plate shall be from low point to high point, from easy point to difficult point and from internal point to external point. Minimum system plate and AD9850 module assembled well shall be shown as Figure 2 and Figure 3.

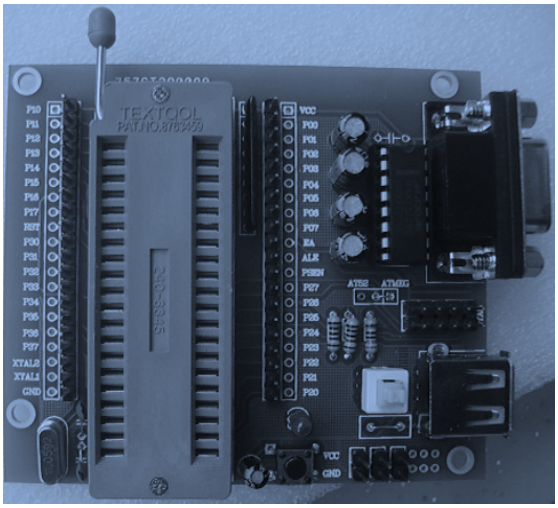

Figure 2. The Minimum System

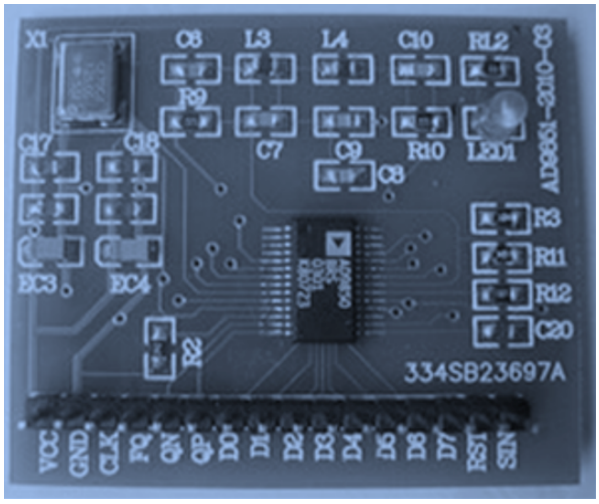

Figure 3. AD9850 Module

3.2. Assembly and testing of the complete machine

After the minimum system module and AD9850 module plates are completed, it is required to carry out assembly of the complete machine and it is only required to connect the two modules by Dupont line. Connect P12, P13 & P14 of the single-chip microcomputer with RESET, FQ_UD & W_CLK of AD9850 as the control pin. P2 port shall be connected with D0-D7 of AD9850 as the data line. It is able to test the signal on AD9850 through oscilloscope after the successful assembly. Sinusoidal wave will be output for SINA and SINB, while square wave will be output for QN and QP.

3.2.1. Circuit function inspection of minimum system module and AD9850 module

It is worth noting that before hardware circuit functions are confirmed to be normal completely, it is forbidden to plug the chip of single-chip microcomputer, so as to prevent the burning caused by circuit fault. Above all, check whether the power supply can work normally and whether power lights on the two plates can be lit. In case that the power lights can not be lit, cut off the power supply immediately and check the power circuit; otherwise, connect the Dupont line and use oscilloscope to test the sinusoidal signal. In case that the oscilloscope can not display correctly, check whether the single-chip microcomputer starts oscillation at first and measure whether the pin connected to crystal oscillator has waveform. In case that there is any waveform, it indicates that the single-chip microcomputer works; otherwise, it fails to work, and it is able to replace the single-chip microcomputer or find out other reasons related to the hardware circuit. After the debugging of minimum system module is completed, the circuit debugging of AD9850 module (of course, the debugging program shall be correct) will be carried out. In case that there is still no waveform, there must be something wrong with the welding of SMD element on the module, especially AD9850 element. Then check whether each pin has been welded well due to the small probability that the general element is damaged.

3.2.2. Testing of waveform and parameters on AD9850 module

How to test the wave signal on AD9850? Use oscilloscope to measure different signals and master the data processing after measurement. Specific testing steps are as follows:

(1)Above all, test the calibrating signal with the frequency of 1kHz and voltage of 3V provided by oscilloscope itself. In this way, it can not only detect if the probe of oscilloscope is intact, but also test if the measurement of oscilloscope itself is correct.

(2)Test the sinusoidal wave signal. Connect the probe of oscilloscope with SINA or SINB signal on the circuit of AD9850 module to measure the cycle of the signal T and peak-peak value of the voltage Upp.

In case that the result measured is as shown in Figure 4, we know from Figure 4 that peak-peak value of the voltage Upp = grid number from peak to valley × range scale of the base scale during scanning. U is the effective value of the voltage. The cycle T=grid number of a single cycle × base scale during scanning.

$$U_{pp} = 2 \times 500\text{mV} = 1\text{V} \quad (1)$$

$$U = \frac{\sqrt{2}\times 1}{2} = 0.3535V \quad (2)$$

$$T = 1\text{ms} \times 2 = 2\text{ms} \quad (3)$$

And the value is the same with T value obtained according to f=500 Hz in Figure 4. After several tests, we can obtain the result that the higher frequency of the sinusoidal wave is, the smaller the peak-peak value will be.

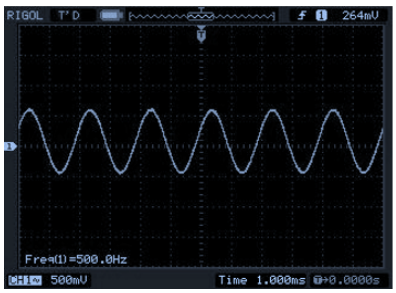

Figure 4. Sinusoidal wave signal

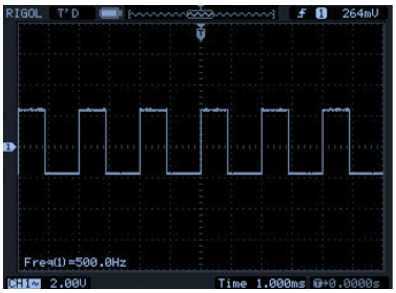

Figure 5. Square signal 1

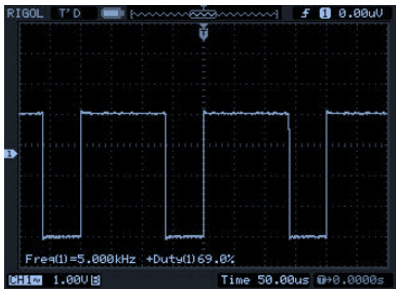

Figure6. Square signal 2

(3)Test the square signal. Connect the probe of oscilloscope with QA or QB signal on the circuit of AD9850 module to measure the cycle of the signal T, amplitude U and duty ratio (the ratio of high level within a frequency cycle). In case that the result measured is as shown in Figure 5, we know from Figure 5 that amplitude U of the square wave is 4V, the duty ratio is 50% and the cycle T is 2ms. The duty ratio of square wave can be adjusted through potentiometer button on the module. The figure of square wave after adjustment is as shown in Figure 6 and amplitude of the square wave in Figure 6 is still 4V, but the duty ratio changes into 69% and cycle T is 0.2ms. During the waveform test, many students discover that waveform is not displayed stably at the beginning, but such case can be avoided effectively through adjusting trigger source, coupled mode of the trigger and trigger level successively.

It is discovered that learning enthusiasm of students is improved greatly through the teaching of assembly since they have learned what 51 single-chip microcomputer minimum system is. They have especially learned much and put forward many questions as to the welding of AD9850, for example, how to debug output frequency of the signal? How to measure the output waveform? How can AD9850, such a small chip, realize the sinusoidal and square signals within the wide output frequency range? Learning interest of the students has been enhanced greatly, which can hardly be seen in previous course of Electronic Measurement Technology.

3.3. Debugging of digital signal generator

The debugging of digital signal generator is the basic target of comprehensive experimental training of Electronic Measurement Technology, and the most important means to train the practical operating ability and improve the creative thinking ability[6] of students. The minimum system module and AD9850 module are welded and assembled by students themselves, so there must be many problems, such as cold solder joint, short circuit, false welding, false connection of wire, etc. The purpose of debugging is to enable students to use various conventional instruments flexibly and measurement technology they have learned comprehensively, and to remove various problems until correct results are obtained finally. To realize the purpose mentioned above, the following guiding steps of debugging are formulated for refe- rence:

(1) After the welding and assembly are completed, the students shall carry out inspection seriously according to the sample drawing to remove various obvious faults, and then each two students shall carry out cross inspection mutually to find out more mistakes to the greatest extent. Since the ability and the degree of mastering knowledge of each student are different, mutual exchange is extremely favorable for improving their practical operating ability and thinking.

(2) Before and after the power supply for the system assembled, multimeter can be used to measure if the system can work normally preliminarily. Digital multimeter can measure the resistance, voltage, current, etc. Students can judge which parts can work normally and which parts cannot work normally roughly & preliminarily through measuring these pa-

rameters. Besides, students can learn to think deeply, for example, resistance, current and voltage of which parts can be measured, how to analyze working condition of the circuit, etc.

(3) To confirm the working conditions of the system further, the students are guided to measure various key signals by virtue of oscilloscope, such as crystal oscillator & reset signal of the single-chip microcomputer, sinusoidal & square wave output signals of AD9850. Frequency and amplitude of these signals are different considerably. By measuring these signals, the students can deepen their understanding on the principle of digital signal generator. On the other hand, their ability of debugging the circuit by virtue of oscilloscope can also be improved. Since there are various problems of the circuit assembled by students itself, it is relatively difficult to measure various waveforms and display them graphically. It is required to consider both the problem of circuit and the use & operation of oscilloscope.

In order to measure the characteristics of output signals of digital signal generator, the frequency meter can also be employed to measure the frequency, cycle, etc. The students can analyze the performance indexes of digital signal generator and deepen their understanding on general knowledge of the signal generator according to the results measured.

4. Conclusions

With the implementation of the comprehensive experiment practice program of digital signal generator, the teachers has led the students to independently complete the project, and the students have had enough time for discussions and practice and taken the initiative to complete the program, effectively mobilizing their learning enthusiasm and creativity. This program has covered most chapters of the course of electronic measurement technology, deepened the students' understanding of the knowledge acquired, allowed them a flexible use of various instruments, effectively enhanced the teaching quality and level of electronic measurement technology, improved their practice ability and innovation capability, thereby having achieved the desired goals. Yet, the practice teaching reform of electronic measurement technology is a trial-and-error process of continuous improvement. In the future, the real enterprise programs should be introduced to the classroom and an open experiment model should be established for further reforms.

Acknowledgements

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