Design of Data Acquisition Card Based on Microwave Auto-measurement System

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ABSTRACT: This paper provides a brief introduction to the hardware configuration and the measuring principle of microwave auto-measurement system, and gives more details on the design of the data acquisition card based on the system. The card has a high accuracy which is owed to 12-bit high sampling AD converter and 12-bit multi-channel DA converter being applied, and it takes CPLD as the control core, USB as the interface, which achieves the speedy and reliable data transmission between the data acquisition card and the PC.

KEYWORDS: Microwave auto-measurement CPLD AD

1 INTRODUCTION

Nowadays, many people adopt the traditional measuring method which depends on people to move a probe to measure every standing-wave amplitude in the waveguide. It has shortcomings as follow: low speed, low precision, easily to be interrupted by people. Now the traditional measuring method has been changed. The microwave scalar network analyzer, shown in Fig 1, is an apparatus based on auto-measurement system made by our laboratorial members. It adopts the auto-measurement method, and greatly improves the measuring speed and precision, of which the data acquisition card has played an important role in the system. It connects the computer and network analyzer, which makes them enable to communicate with each other. Taking CPLD (Complex Programmable Logic Device) as the control core, USB (Universal Serial Bus) as the interface, we design a data acquisition card based on the microwave auto-measurement system.

2 THE HARDWARE CONFIGURATION AND THE MEASURING PRINCIPLE

As shown in the Fig2, we can see that the system consists of three parts. They are microwave system, network analyzer and microcomputer system.

Fig 1 Photograph of the microwave network analyzer

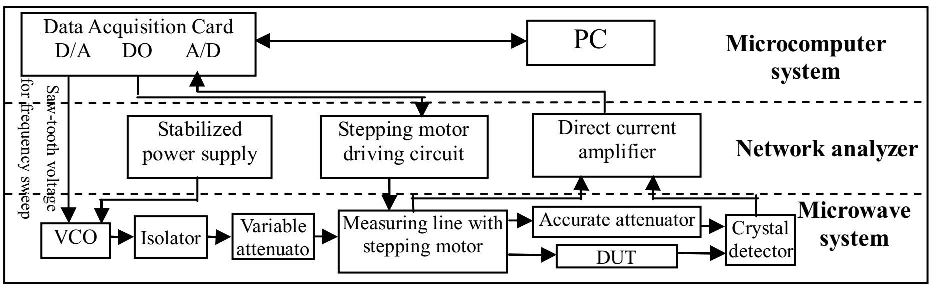

Fig 2 the auto-measurement system

During the sweep-frequency state, the D/A port of the data acquisition card sends the saw-tooth wave voltage to the VCO, then we can get the transmission characteristics、frequency bias、resonant Q value of the sweep-frequency state after the output signals are dealt with by PC.

During the dot-frequency state, the DO port sends the four pulses to the stepping motor driving circuit which drive the stepping motor and the probe connecting to it to run together. Then the probe sends the detected standing wave voltage to the A/D port of the data acquisition card via the direct current amplifier. Finally, we can get the reflection parameter of the dot -frequency state after the conversion results are dealt with by PC.

3 THE HARDWARE DESIGN OF THE DATA ACQUISITION CARD

The data acquisition card is made up of five modules as shown in the Fig2. They are USB control module, CPLD control module, AD conversion module, DA conversion module, and DO module. Owing to the limitation of the space, we will give more details on CPLD and AD modules, and the other modules will be provided a brief introduction.

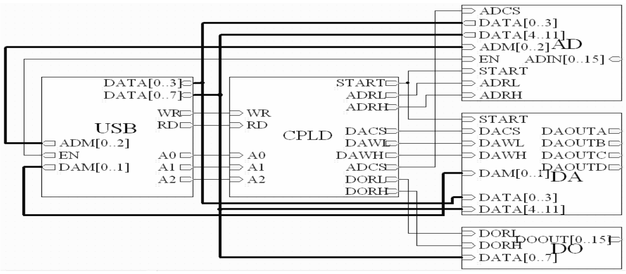

Fig 3 block diagram of data acquisition card

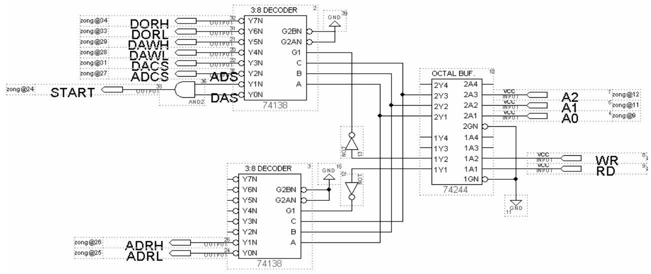

Fig 4 the control chart for CPLD

3.1 CPLD Control Module

The module mainly consists of a CPLD (EPM7064) chip and a monostabillity trigger (74121).CPLD is the core of the acquisition card. It decodes the three address lines from USB, to produce some logic control signals which play a controlling function on every module. The control circuit diagram is shown in the FIG 4.

As is shown in the diagram, the write strobe signal WR and the read strobe signal RD coming from USB connect to the input ports of two 3:8 encoder respectively. When PC sends out the order to write which starts the corresponding encoder, then CPLD will export eight control signals: starting AD and DA conversion and CS signals; writing the high 8-bit and low 4-bit of DA signals; writing the low 8-bit and high 8-bit of DO signals; Similarly, when PC sends out the signals to read, it will also start the corresponding encoder and export two controlling signals to read the high 8-bit and low 4-bit of the AD converter respectively.

3.2 AD Conversion Module

The module is mainly made up of an AD conversion chip, two single 8-channel analog multiplexers and two flip-latches. ADS774 which is made by the BB Company of the USA is a 12-bit successive approximation analog-to-digital (AD) converter. It has four optional voltage output and two working modules. We choose the independent working module

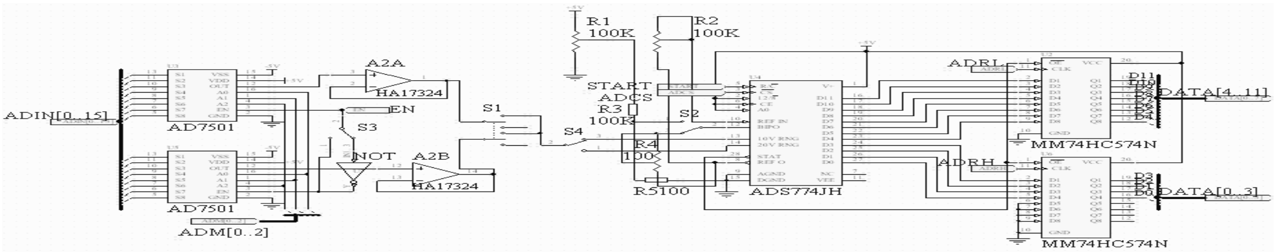

Fig 5 schematic diagram of the AD conversion

with the 0~10V of output range. The schematic diagram of the AD conversion is shown below.

First of all, in order to start the A/D conversion, an impulse about 500ns is sent by the CPLD module to the R/C port of the ADS774. During the conversion, the STAT port is high, and it restrains the data output of two flip-latch as it has been linked to the CLK port of them; After conversion is done, the STAT port jump to low, making the two flip-latch start to work, and then under the control of CPLD, the 12-bit data which is divided into high 8-bit and low 4-bit is exported from two flip-latch output ports. As there are two analog variable inputs which come from the crystal detector and measuring line, we adopt two 8-channel chips called AD7501 which are controlled by the USB. Thus we can sample analog variable inputs of 16 single channels or 8 dual channels.

3.3 The Other Module

USB Control Module is mainly made up of a USB control chip and a voltage conversion chip. AN2131QC is a special USB interface control chip whose rate of transmission can reach 12Mb/s.It is connected with PC and is responsible for the communication with the PC. Thus PC can transfer to CPLD via USB interface some orders such as starting the AD and DA conversion, which makes it enable to control the AD, DA and DO modules utilizing CPLD.

DA Conversion Module mainly consists of a 4-channel, 12-bit quad voltage output DA converter named DAC7625, two flip-latches and some voltage operational amplifiers. It begins to digital-to-analog conversion as soon as the CPLD module sends an impulse about 500ns to the R/W port of it. And its output voltage is given by the following equation:

$$V_{OUT} = V_{REFL} + \frac{(V_{REFH} - V_{REFL}) \bullet N}{4096}$$

So if the reference inputs V_{REFL}=0V, and V_{REFH} plus a 2.5V reference voltage, we can get a voltage output ranged from 0V to 2.5V. Then it will be magnified four diameters via an OP07 amplifier. Finally, we will get a voltage of saw-tooth wave ranged from 0V to 10V which will be provided for the VCO source.

Two flip-latches 74HC273 are adopted in the DO Module. Their CLK ports connect to the output of CPLD and their input ports connect to eight data lines of the USB respectively. Under the control of the CPLD, 8-channel signals can be sent out from the flip-latches twice, which constitute the 16-channel DO. Then 4-channel of them is sent to the driving circuit for stepping motor to produce 4-phase-8-time signals for driving the stepping motor.

4 MEASUREMENT RESULTS AND PERFORMANCE EVALUATION

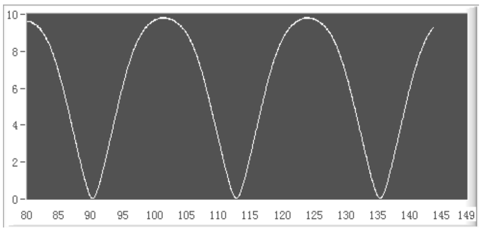

Fig 6 the standing wave

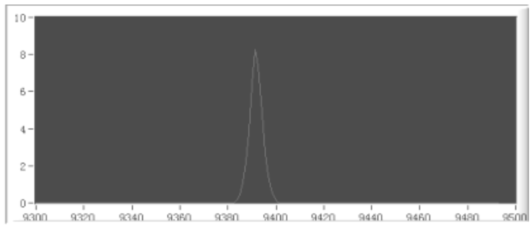

Fig 7 the resonance peak

The experiment result shows that during the dot-frequency state, the stepping motor can move along the slotted line when 4-phase-8-time signals are given, then we can get the standing wave shown in the Fig6. The wave is smooth and has little glitch, and its peak to peak value ranges from 0V to 10V, which measures up to the requirement of our experiment.

During the sweep-frequency state, when the VCO sends out the sweep-frequency signals, we can get the peak of the resonant cavity. As shown in the Fig 7, the maximum voltage of the resonance peak is 8.238V, and its corresponding frequency is 9375MHz which ranges from 9300MHz to 9400MHz. So it also measures up to the requirement of our experiment.

5 CONCLUSIONS

With our designed software and the microwave auto-measurement system, the design goal to measure automatically the microwave parameter in the dot-frequency and sweep-frequency states has been achieved. Its advantages of stable performance, high measuring accuracy, and convenience are beyond the reach of the manual method. My designed data acquisition card, which is established in the auto-measurement system, plays an important role in the system. It can not only collect variable analog variable, but also export the voltage of saw-tooth wave to the VCO source and 4-phase-8-time signals to the stepping motor. So a 12-bit data acquisition card of multi-channel and high precision which takes the CPLD as a core and the USB as an interface has been developed. Furthermore, the card can be performed in many data acquisition situations, thus it can be brought into wide use.

6 REFERENCES

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