

# Design & Implementation of Universal Digital IC Automatic Test System based on PCI bus

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**Abstract**—The structure and design of hardware and software of automatic testing system for universal digital IC are introduced. The employment of the PCI bus and Complex Programmable Logic Device (CPLD) and the platform C++ Builder are also introduced. It is proved to be good result for precision and reliability.

**Keywords**- IC; PLD; database; PCI bus

## 1. Introduction

Along with the microelectronic technology and the integrated process rapid development, the exploitation, the production and the application of IC have all made unprecedented progress, and become the most important foundation of electronic industrial products and microelectronics technology at the core. Digital circuits can be roughly divided into two categories, universal and special. The universal digital integrated circuit has characteristics of high degree of standardization, strong commonality and widely application, and applies massively in the electronic products development and the production, so researching their testing technology and developing testing equipment have a vital significance.

Domestic IC instruments have already dozens of types, but there is greater disparity in testing technology and craftwork level compared with foreign congener product. In order to remedy the deficiency in domestic integrated testing apparatus, keeping up with the international new situation, we adopt the advanced PCI bus as high-speed communication bridge between microcomputer and test equipment, using the hardware description language (HDL), the complicated programmable logical devices (CPLD) and realization in testing circuit, develop a digital IC automatic testing system with small-scale. On the foundation of logical function tests, we make emphasis on realizing the performance parameter of IC test in alternating AC and DC.

## 2. The System Hardware Design

### 2.1 System Configuration

Testing system hardware is made up of PCI interface card and test case (as shown in Fig. 1).

PCI bus interface card is communication link of information interchange between test *software* and test circuit, installed in the standard PCI expansion slot of microcomputer, and equipped with corresponding hardware device drivers. PCI bus interface card control the work of testing circuits in universal digital IC through the interface card on the large scale programmable logic device programming.

Test case is main component of the systematic hardware circuit of this test, and the control circuit uses CPLD to realize. Each function unit includes PCI9052 local bus, the testing core circuit of digital IC, A/D change circuit, switch matrix, interception management, resetting, three ways of output dc power etc.

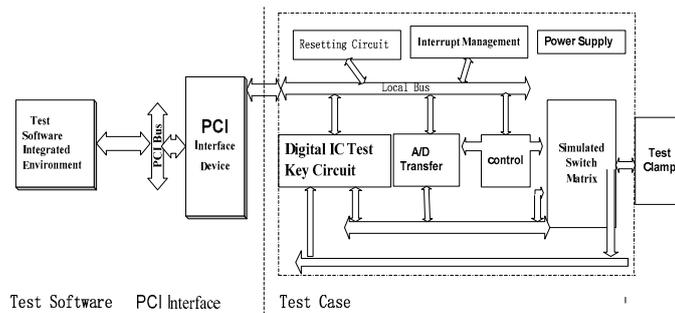


Fig. 1 System structure diagram

## 2.2 Each Section Function and Principle

1) *Logic function test circuits*: Logic function test proves whether the logic functions of the digital IC is qualified or not, which carries on the precondition in parameter tests of dc and ac, and making an essential part to the test system. The test program will take test circuit control code and test vectors to test circuit through PCI9052 local bus, and the realization of logic function test circuits is integrated on CPLD. And its emphases lies in the generation of logic function test code. Algorithm in test code generation is called the G-F binary algorithm.

2) *Dc parameters test circuit*: The test of system parameter test adopts module with precision dc parameters. Working principle: First, according to the needs of the device being exerted the voltage (current), test software give a procedure value. Second, through the local bus of testing case deliver to DAC component and convert into analog voltage to supply four operational amplifiers measuring unit, complete measure current adding the voltage to or measure voltage adding the current, measure resistor and the testing channel through controlling four operational amplifiers measuring unit. Third, enable four operational amplifiers measuring unit, testing channel and the device being tested to be a working return circuit. Lastly, we will need to deliver voltage signal to the ADC component through the range switch, and convert 12 digital signals back to local bus and then achieve the data wire.

3) *Dc parameters test circuits*: There is some difficulty in measuring ac parameter, the circuits including control, frequency division, sampling and counting etc. will realize on CPLD. Working principle: First, test software send one control word through PCI bus, and set up load network corresponding with the device being tested. Then start the universal oscillator and work, control the circuits including frequency division, sampling and counting to work, finally read back count results.

4) *Others controlling circuit*: Controlling of system resetting: The routes which resetting signal of testing system come into being have two kinds: one is the PCI bus of microcomputer system to PCI9052 [76], then produce resetting signal of local bus called LRESET# (/LRESET) from PCI9052, the other resetting signal TRESET/ is produced by the resetting signal of testing circuit (manual button). Two resetting signals are merged into one signal/TRST which making reset to all of the testing circuit through AND door. We stipulate that low electrical level is effective, and low pulse width is not less than local bus work cycle of PCI9052.

*Interrupt management*: There are three interrupt source: "TTL\_INT" is a interrupt that produced by test circuit of digital IC in testing circuits, "OP\_INT" is a interrupt (reservation) that produced by test circuit of simulated integrated circuit, "1674STS" is a interrupt that produced by AD converter (need chip selection signal / OP\_CS to be effective). Considering the system adopts expand card organizing the circuit, it may be unsettled that two former interrupt sources and two chip selection sources, so they are not draw until + 5V by the resistance. We stipulate that low electrical level is effective to interrupt request, and electrical level trigger.

Three interrupt sources connect to /INTi1 interrupt line of local bus in PCI9052 through logic operation, and convert into #INTA interrupt of PCI bus through PCI9052.

## 3. The Software Design

In automatic test system, the software and hardware are inseparable, test system integrated environment develop and finish with object-oriented and visual application program developing platform C++ Builder, and run under Win32 operating system (Win9x/WinNT), adopts object-oriented programming technology, friendly interface, expansibility and maintainability are all better. Test software integration environment is designed to multi-functional module application program, and apply document window for basic skeleton, and

integrated with document editor, parameter database, the test code generation, testing procedures editor and PCI9052 configuration control function module etc. Man-machine interaction interface is very friendly, every part based on this foundation this can be both independent and communication.

### 3.1 Document Editor

Document editor TReports is a key component of testing the integrated environment of the software which encapsulates the general functions in handling file, including font, paragraph, color, saving and printing etc. And it is the key part of the environment, and there are four main uses:

- a) Reporting tools of searching results in IC database.
- b) Offer the detailed report of test result in the IC
- c) Responsible for input and modification to test procedure in IC.
- d) Operate procedure function of compiler, if succeed in compiling, then generate goal code (including the command and test vector), using for testing IC.

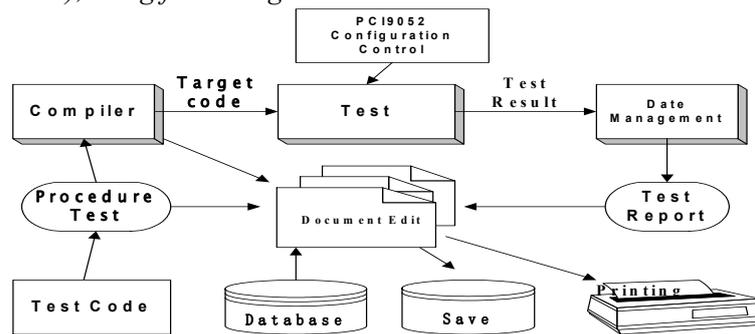


Fig.2 Test software function

### 3.2 Test code Generation

This functional module writes the algorithm procedure based on the theoretical foundation of G-F binary algorithm, which has done more detailed argumentation in the second chapter in the test generation section.

For the assembly logic circuit, G- F binary algorithm can be summed up for six steps:

- a) *The description of line logic signal state:* to describe signal 9 kinds of line logic states with G and F;
- b) *The functional description of constituting basic logical units (functional block or gate circuit):* Adopt the standard of Boolean expressions and preserve in the memory using c cubic form, a product term occupy a unit, a variable occupy two places. It both saves memory and getting operation easier including AND, OR, XOR operation in cube;
- c) *Striving for test code of fault functional block;*
- d) *Seeking sensitization conditions in sensitization function block;*
- e) *Establish test code equations;*
- f) *Solutions.*

### 3.3 Test Procedures and Compiler

It can not make unified test procedure sample due to the diversity of IC, so each sample model of digital IC must be written with the corresponding testing procedures, and then generate goal code of the test procedure after compiler's inspection and errorless check. Test procedure and objective code need to be filed, so that the test for the future can be reused while test operation. The corresponding parts should be compiled again in modification testing procedures when the test requirement changes. In order to reduce the difficulty in writing test procedure and workload, test software integrated environment offer some test procedure with written well and debugged through test; If you need add other types of test procedures, you can write and debug according to the grammar rule. The compiler adopts object-oriented lexical, grammatical and semantic analysis method, and the compiling of test procedure is convenient, striving to come out for simple users from test procedures, and put main attention in focusing on generation of test code.

### 3.4 PCI9052 Configuration Control

Establish PCI9052 on the basis of kernel function and library that driver developing instrument operating system WinDriver offer, form PCI interface configuration function modules, PCI9052 class encapsulates PCI bus configuration, PCI9052 configuration register configuration, EEPROM configuration, two interrupt management and data communication operation etc.that the interface PCI9052 need in normal working, such operation not only can obtain these configuration register current status, but also can set the state of the configuration register according to the need of the makeshift. Such communication operation can be used for debugging, and can transplant to test program function module conveniently also.

### 3.5 Database

Setting up the visual universal digital IC database with stronger function in testing the integrated environment of software, mainly divided into 54 74TTL/IC database and CMOS4000 series IC database which including functional description, pin configuration, dc parameters, ac parameters, dynamic load parameters etc. of IC, and with the functions of adding, deleting searching, browsing etc. to information, easy to handle and manage to scientific. In this database also have function of drawn the IC pin allocation diagram; it is very intuitive and convenient for user to inquire. According to the need of user we can query a certain type of integrated circuits in the database, and provide the information of typical datum about integrated circuit of this type.

Database makes relevant data set together according to certain structural organization. The IC database resource DBF passes the engine of the database (BDE, Borland Database Engine) and visit, and managed by data TTable and data source TDataSource, browsed and edited database by TDBGrid.

The database resources are stored on the database file, including several charts, indexes and other elements. Data visit data resource directly through BDE, and transfer data resource information to controlling data for browsing through data source, then save data information to database file after edit.

## 4. Conclusions

Test system include PCI bus technology, complicated programmable logic device FLEX6000, the internationally advanced technology and devices such as the language AHDL and CMOS analog switch of the low resistance. The development of test software integration environment and the establishment of digital integrated circuit parameters are finished on c + + Builder platform, and run well under Windows9x/NT operating system. This test system has property of stabilization and reliability in real application and strong anti-jamming capability etc.

## 5. References

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