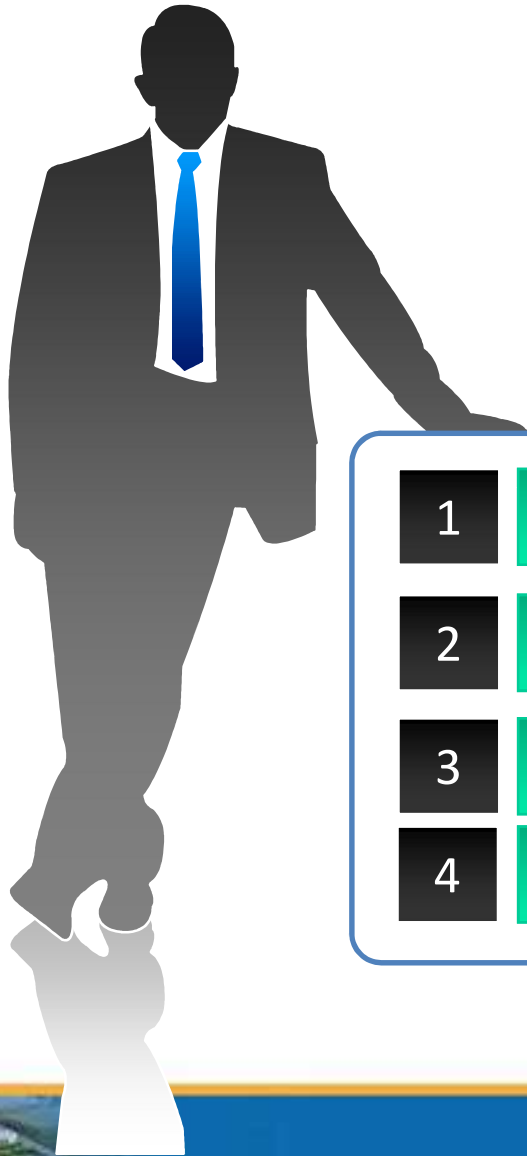


# Establishment and Application of ATE for FPGA-based RPS

**Kang Lihong**

康礼鸿

**China Nuclear Control System Engineering Co., Ltd**



## OUTLINE

1

Background

2

RPS Testing methodology of FPGA

3

Automatic Test Equipment

4

Applications

# 1. Background

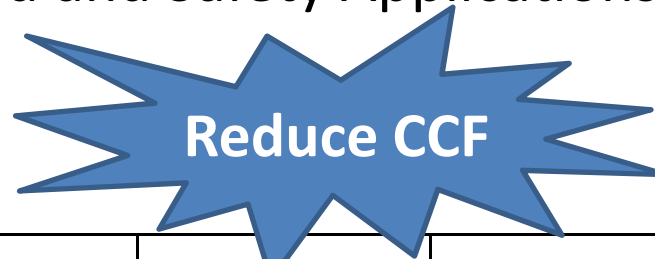
➤ Nuclear I&C system are usually based on Microprocessor

✓ Based on Microprocessor

<b>FOXBORO</b>	<b>AREVA</b>	<b>WESTINGHOUSE</b>	<b>MITSUBISHI</b>	<b>CTEC</b>	.....
TRICON	TXS	Common Q	Meltac	Firmsys	.....

➤ Platforms are being developed and Safety Applications are starting to use FPGA-based Platforms

✓ Based on FPGA



<b>DOOSAN</b>	<b>RADIY</b>	<b>CNCS</b>	<b>SNPTC</b>	<b>CSI</b>	.....
HFC-FPGA	RADICS	NicSys®8000N	NuPAC	ALS	.....

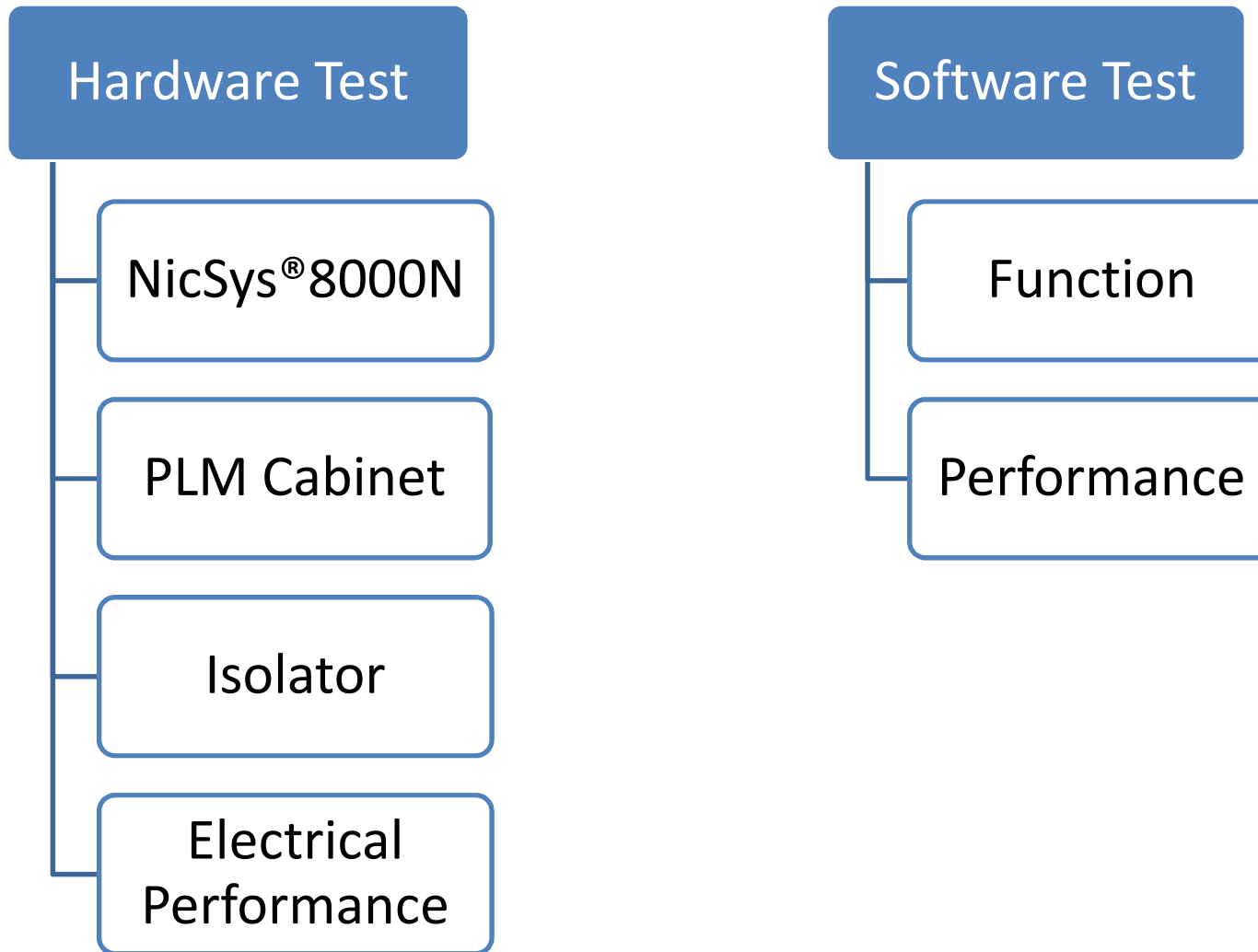
**Simplified Structure**

**Reliable performance**

**Safe and efficient**



## ➤ Reactor Protection System- Pre-FAT Test



## ➤ Reactor Protection System- Pre-FAT Test

### Hardware Part

#### NicSys® 8000N

Test Items	TP Num.
Power-up Test	40
Diagnostic Test	40
System network test	14
Standby module test	6
Precision test	13
<b>SVDU</b> diagnostic test	8
Scanning cycle test	2
I/O Test	3

126

#### PLM Cabinet

Test Items	TP Num.
Power-up Test	10
Diagnostic Test	10
PLM logic Test	10
ECP logic test	10
Isolator Test	10
PLM module RTT	10
ECP hardware logic RTT	10

70

## ➤ Reactor Protection System- Pre-FAT Test

# Software Test

## Function Test

Test Items	TP Items
RTS function Test	80
ESFAS functions Test	33
LHA/B Function test	76
Voting logic test	99
Periodic Test	10
SVDU function test	26
Train Server Test	194

## Performance Test

Test Items	TP Num.
RTT	79
HFT	79

158

1. Complex system;
2. Lots of Tests need high test consume;
3. Low efficiency without automatic test tools;

618

## ➤ Tool selection

### Need Tools

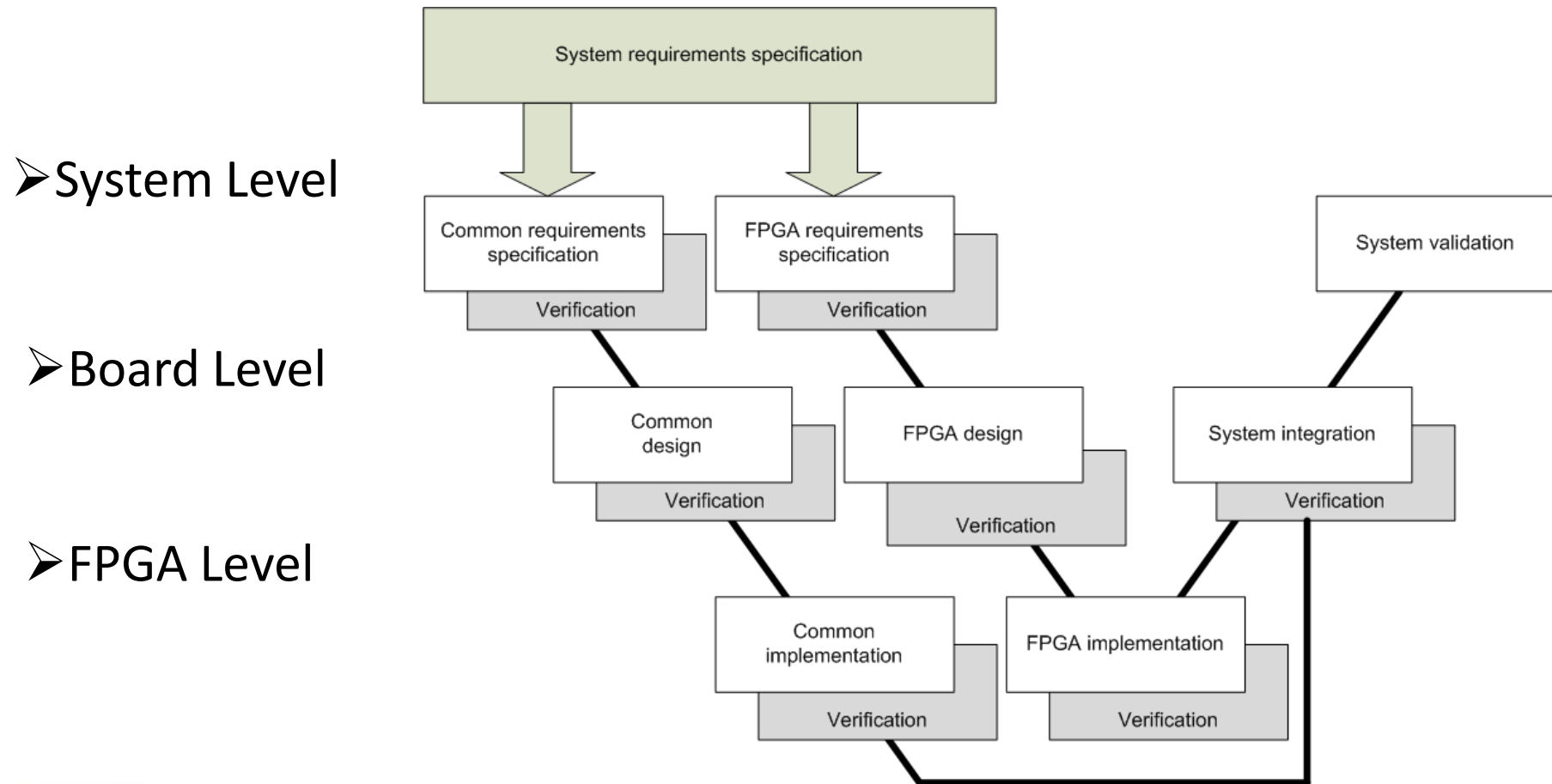
- ✓ The use of appropriate software tools **can increase the integrity of the software development process** and hence software product **reliability**, by reducing the risk of introducing faults in the process.
- ✓ The use of tools can also have **economic benefits** as they can reduce the time and human effort required to produce software.
- ✓ Tools can also reduce the effort required for testing and to maintain automated logs.



The standard of **IEC60880** describes the selection of tools

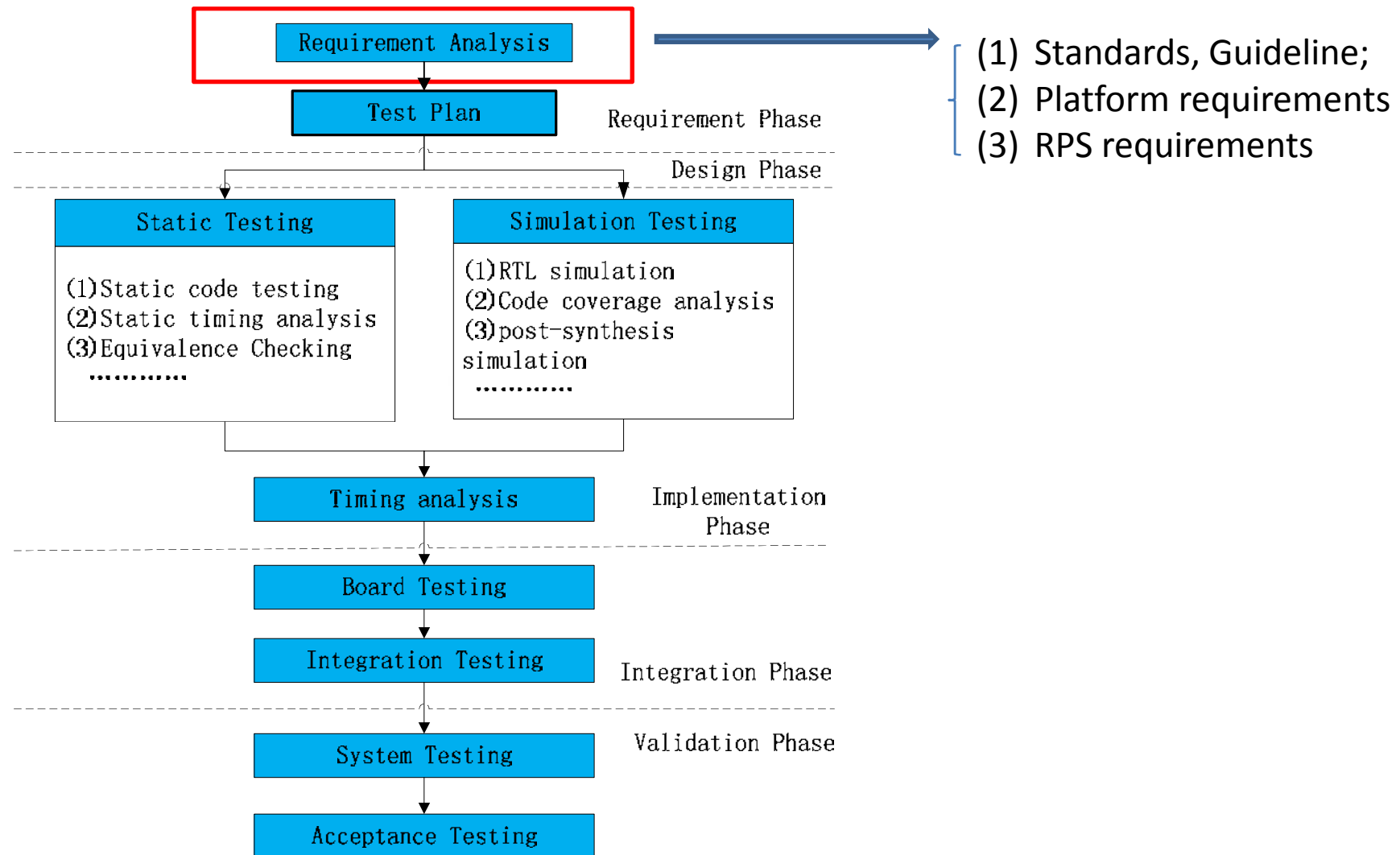
## 2. RPS Testing methodology of FPGA

The test will be practice into three **Test levels** according to the life-cycle by IEC62566.

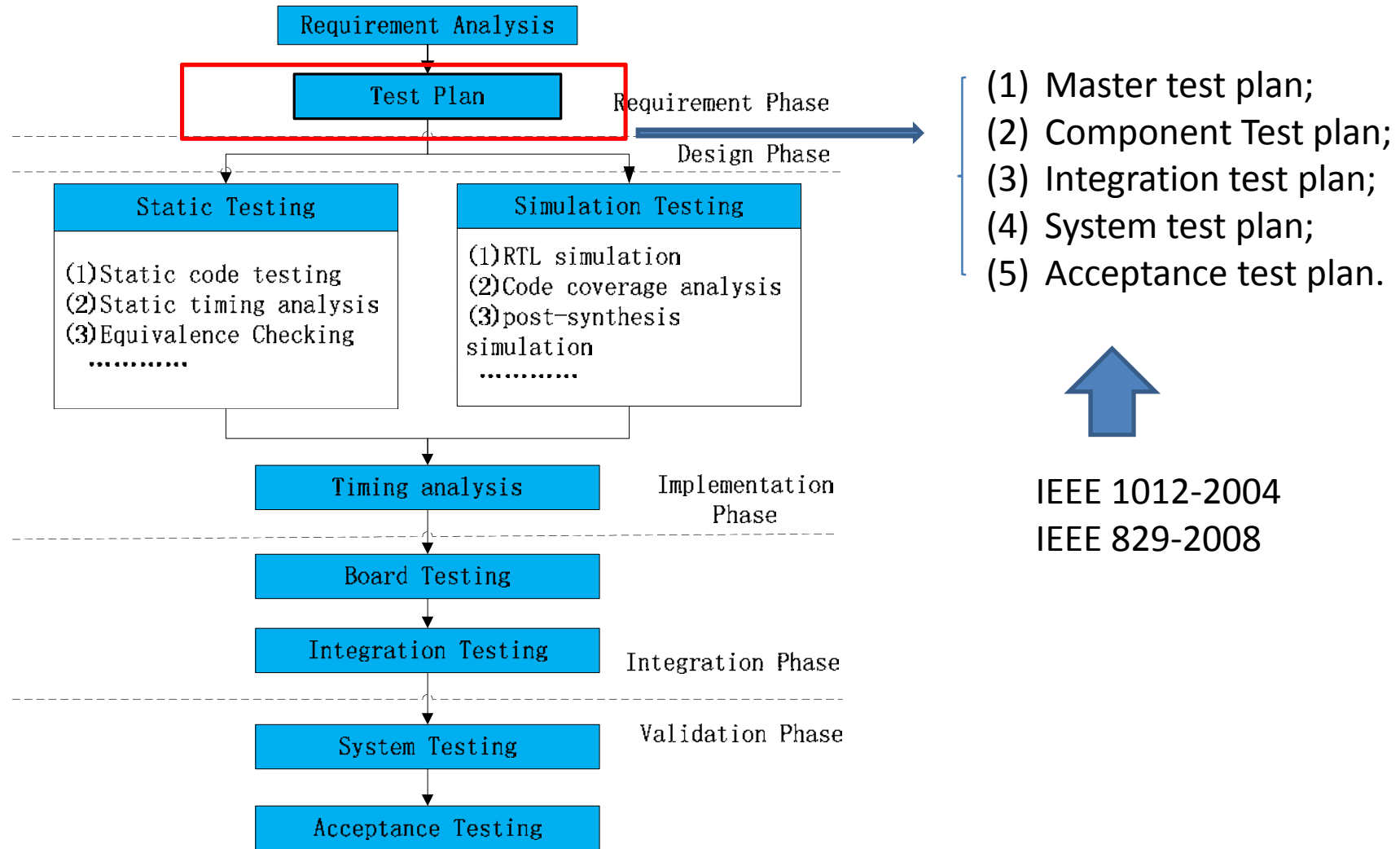




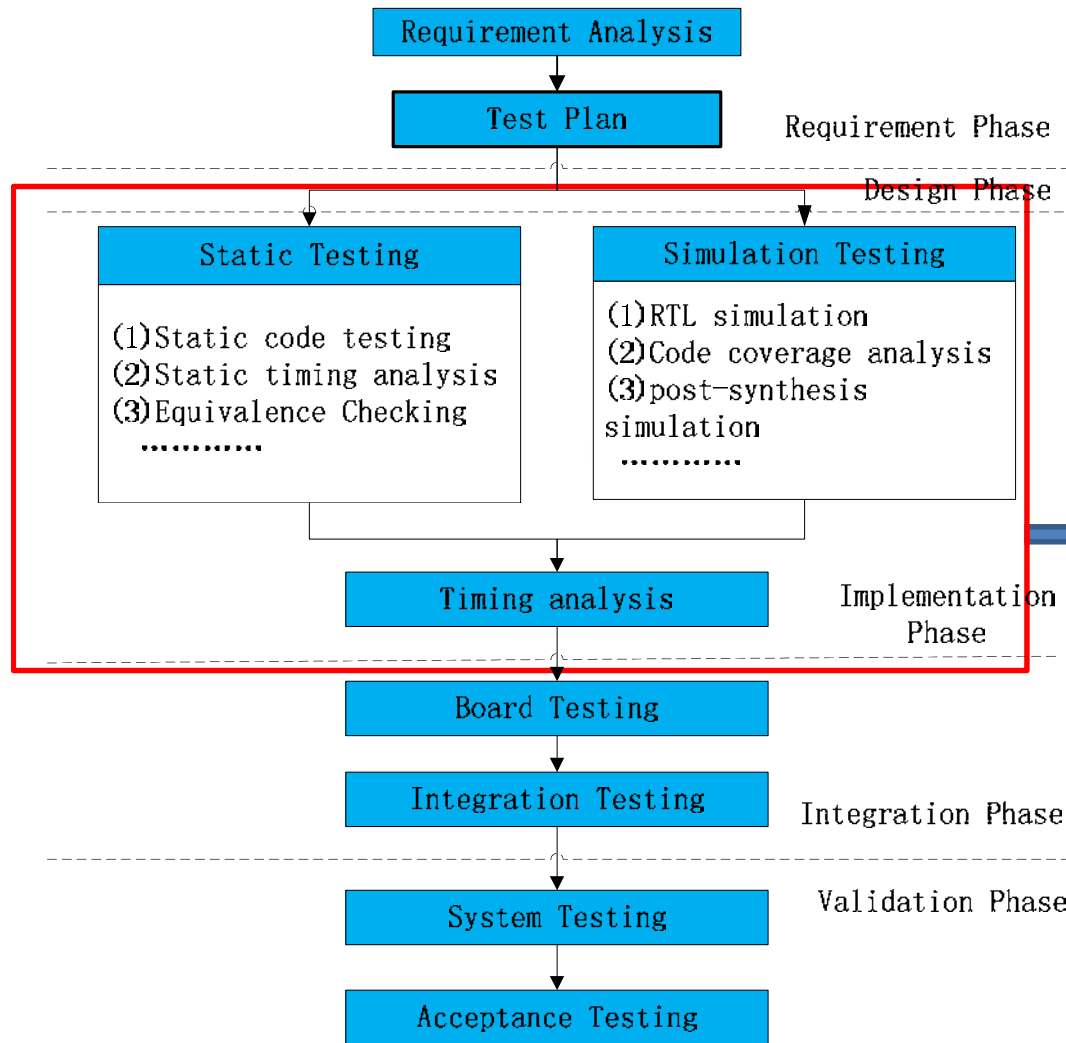
## 2. RPS Testing methodology of FPGA



## 2. RPS Testing methodology of FPGA



### 3. RPS Testing methodology of FPGA

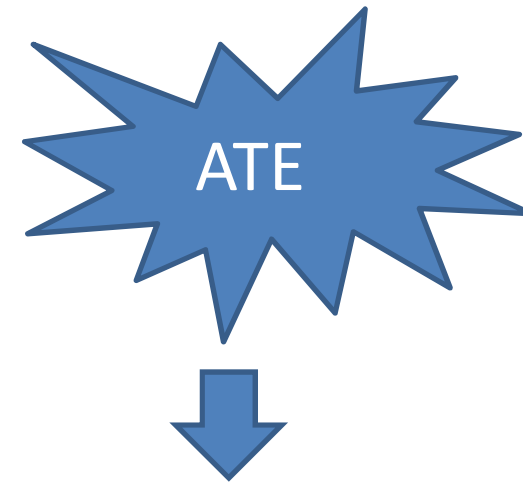
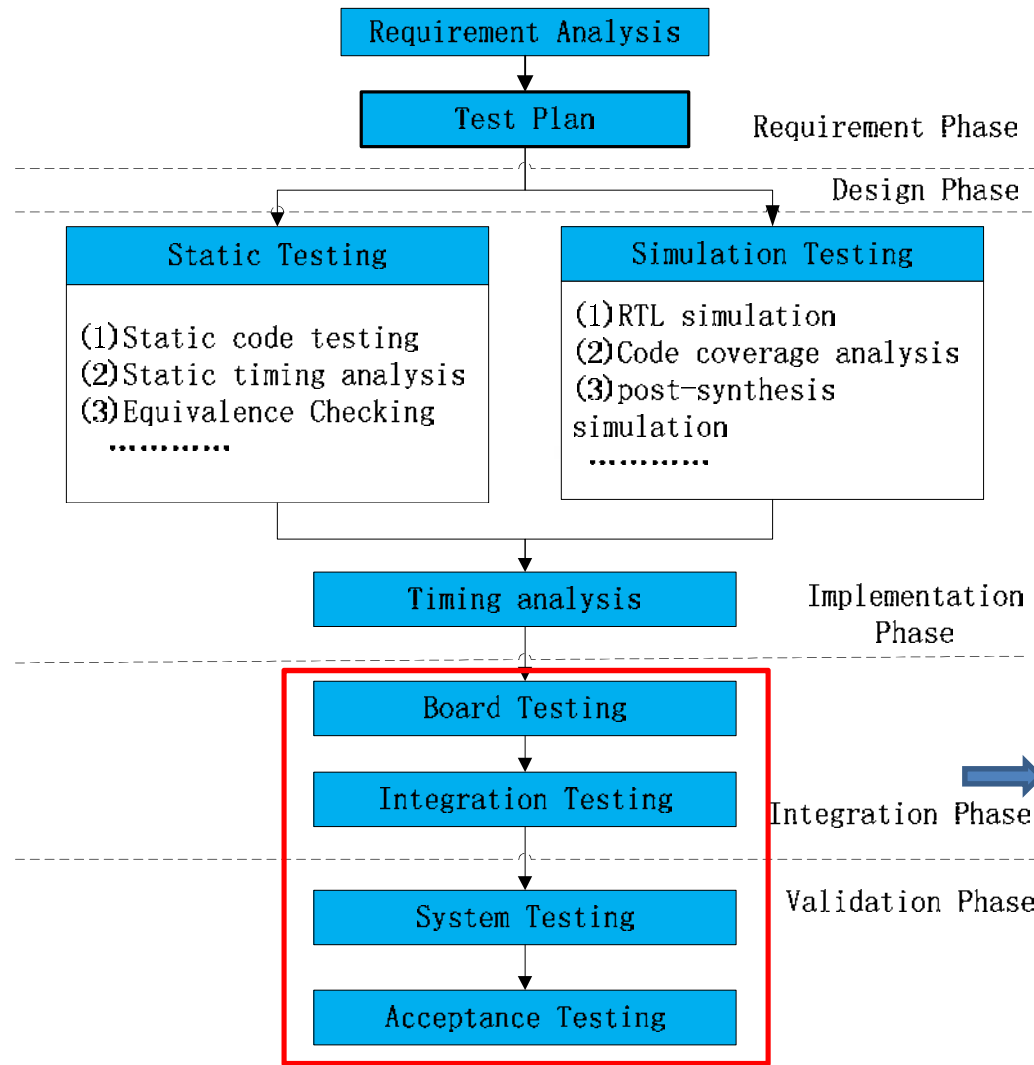


#### FPGA Level Test

- (1) RTL coding rules checking;
- (2) Source codes inspection;
- (3) RTL functional simulation;
- (4) Post-Synthesis / Post-Layout simulation
- (5) Equivalence checking
- (6) Static Timing Analysis
- .....



### 3. RPS Testing methodology of FPGA



- Board Level Test
  - Hardware simulation
- System Level Test
  - integration test(HPD aspect)
    - FPGA&board level
    - Hw&Sw level
  - validation test



### 3. Automatic Test Equipment -- ATE

---

- FPGA Testing for V&V comply with IEEE1012、 IEC62566
  - ✓ Independent requirement (IV&V)  
-- independent of Technology, management and financial.
  - ✓ The personal should have the ability and qualification of performing V&V tasks.
  - ✓ V&V Tools should be independent from the development tools.
  - ✓ Integrity Level determined by analysis and V&V tasks performed.
  
- **Application:** aerospace, defense, energy, automobile, medicine, meteorology and consumption areas.
  
- **Features:** Modularization, Seriation, standardization, small, generalization, etc.



## ➤ Test Requirements Analysis

---

- (1) the engineering design for test requirements;
- (2) the engineering assembly integration for test requirements;
- (3) Engineering verification and validation for test requirements;
- (4) the contract demand of the system itself, and customer demand for the test requirements;
- (5) the laws and regulations, standards, policies, and regulator for test requirements.



## ➤ ATE requirements:

---

### 1. **Hardware overall requirements**

Modular structure and flexible expansibility , The standard of input and output ports , reliability , High-performance control unit and high precision of I/O unit , high performance PC

### 2. **Software overall requirements**

The configuration of control algorithm , HMI configuration , Data Interface.

### 3. **Performance requirements**

the ability of range, precision, speed and protection ,etc.

### 4. **Function requirements**

Refer to RPS function requirements, such as RTS and ESFAS logic test , IO test .

### 5. **Interface requirements**

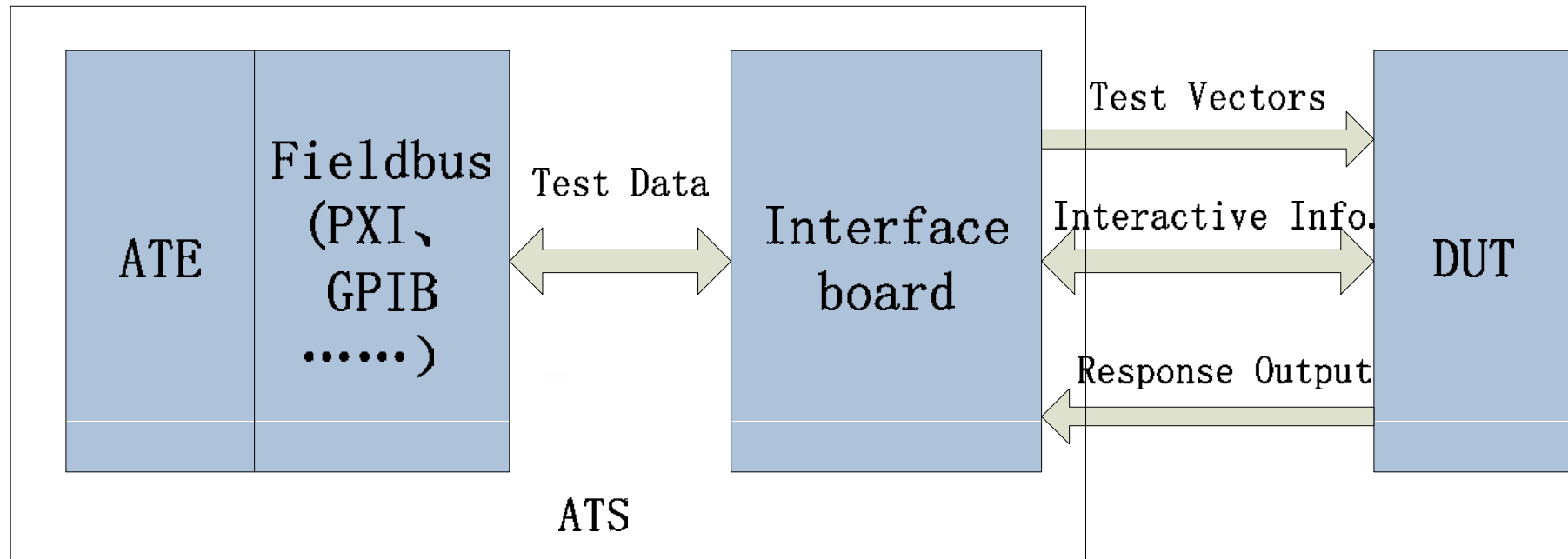
Hardware interface, software interface, communication interface ,etc.

### 6. **Structure requirements**

ATE platform main part size.



## ➤ ATE System Structure

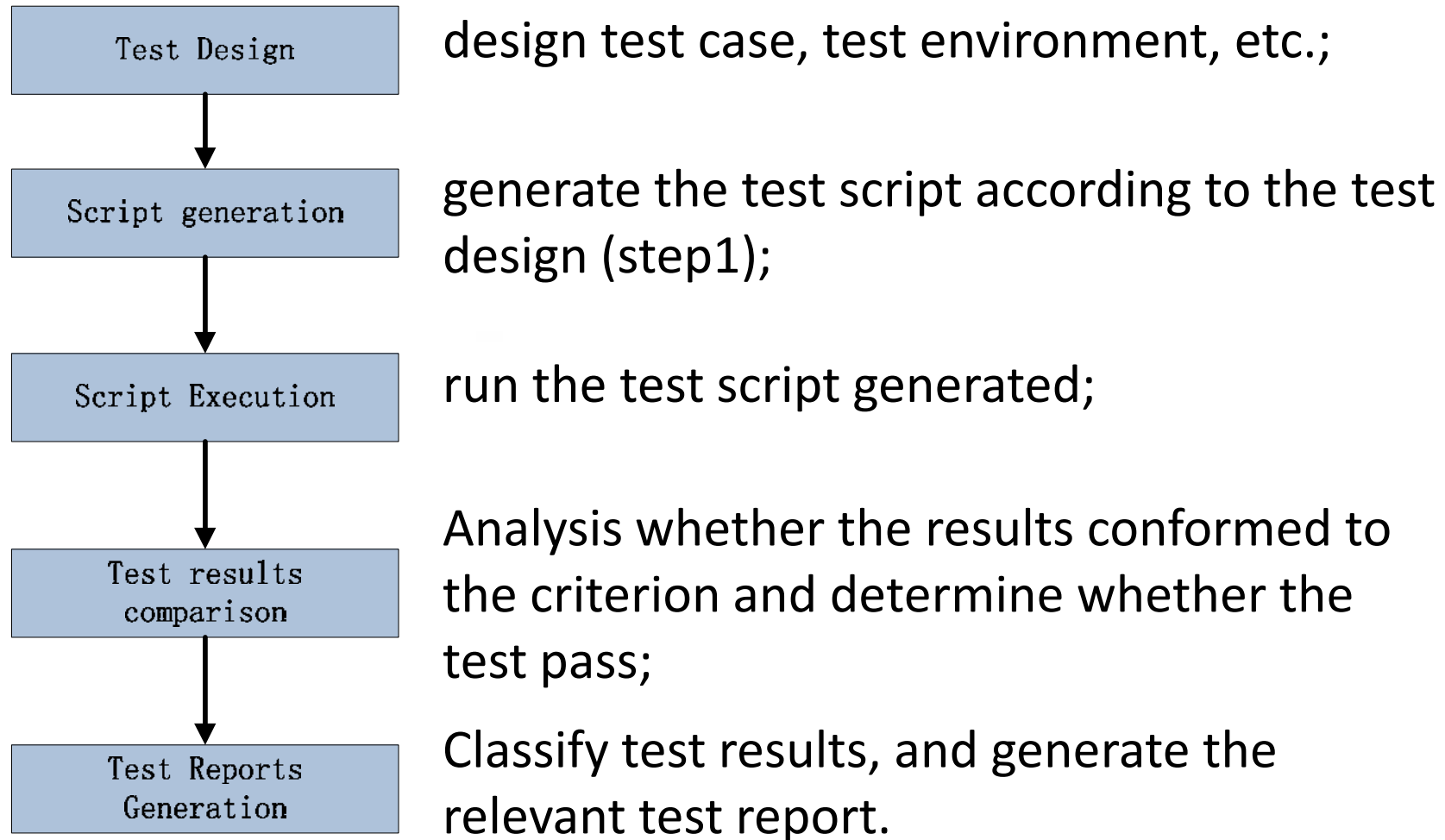


ATS is composed of common ATE , Interface board . Common ATE software configuration test basic processes, Interface board is developed according specific FPGA model, its function is connecting ATE and DUT (Device Under Test) to realize the transmission of signals.

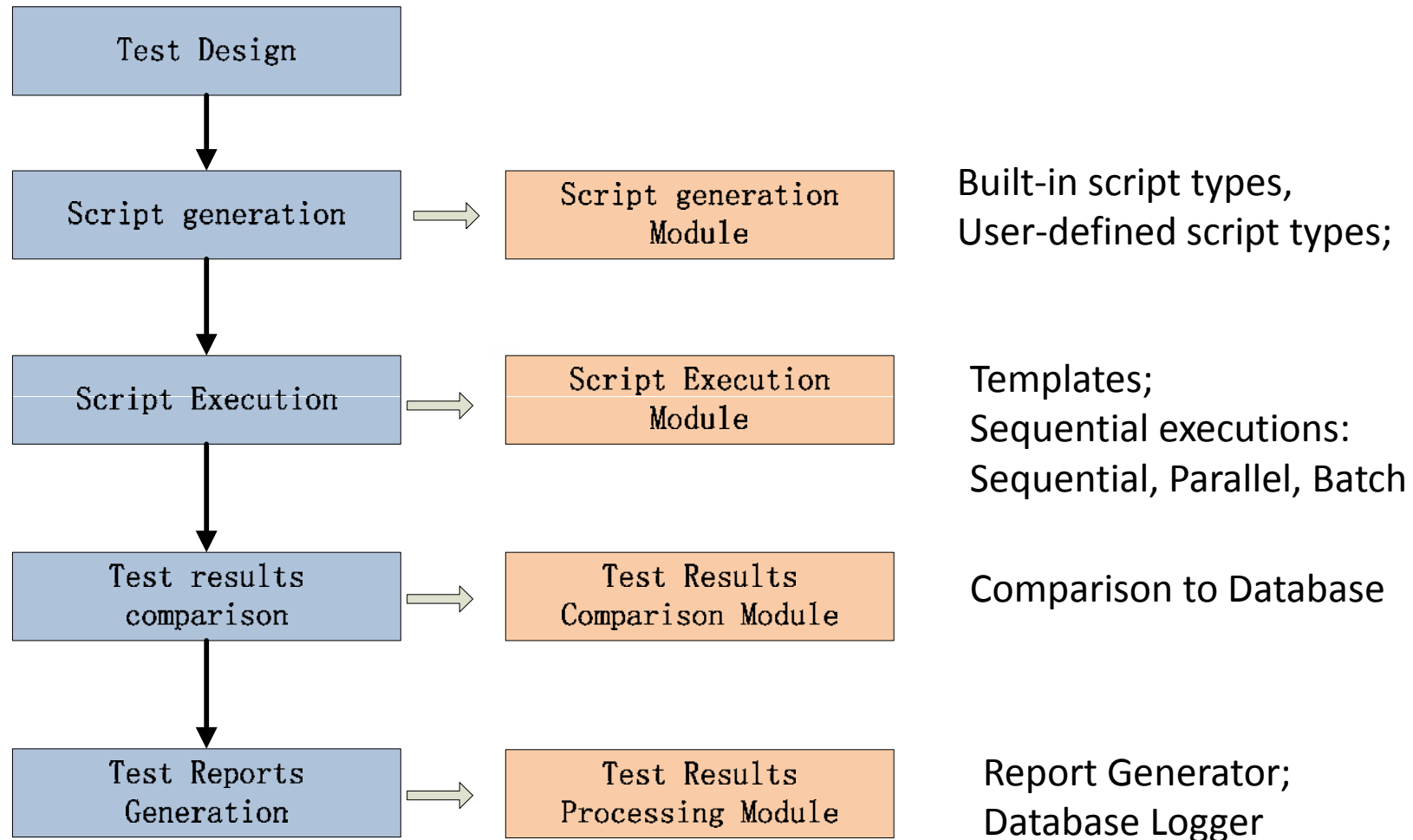


## ➤ Automation Test Basic Processes

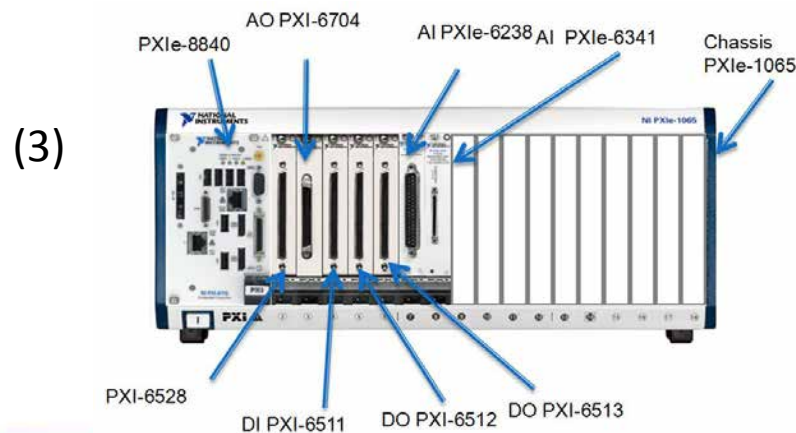
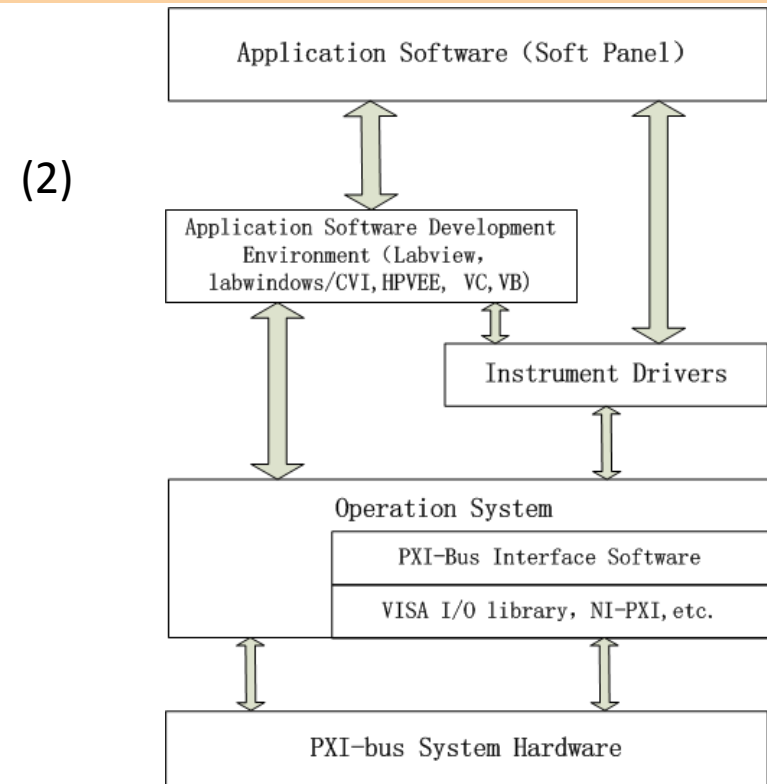
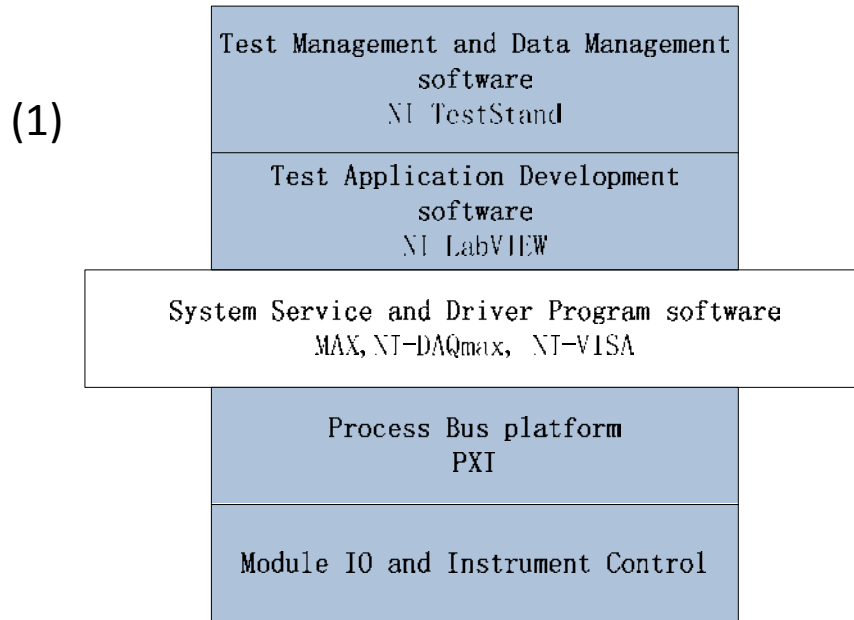
---



# ATE Module Design

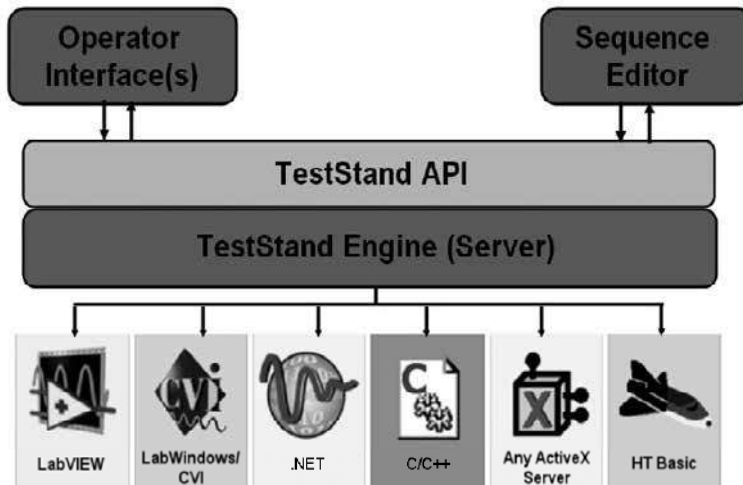


# Application1 : ATE- Based on PXI bus Virtual Instrument

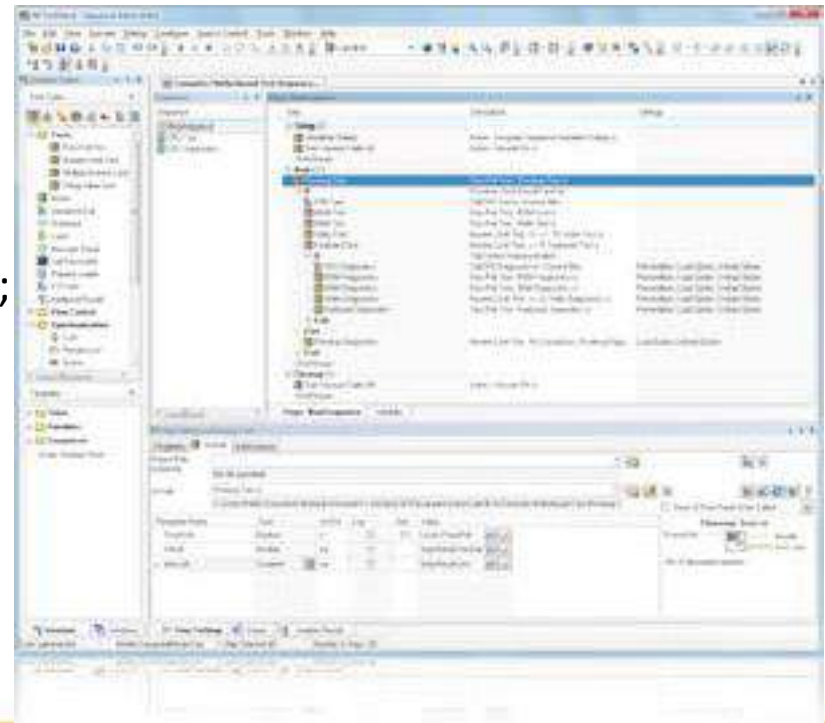


# Application1: ATE- TestStand

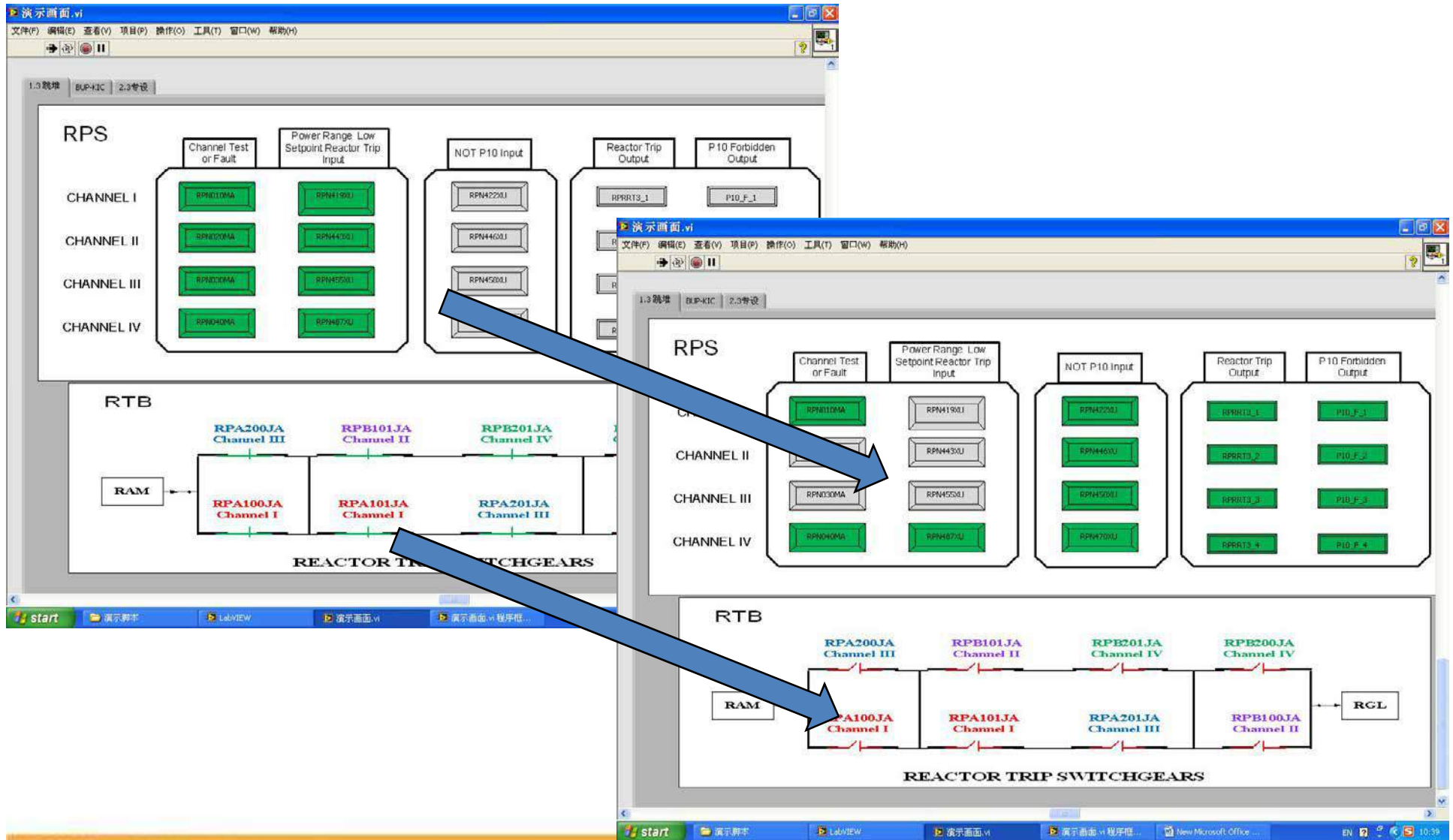
## TestStand Architecture



- (1) Graphic programming environment;
- (2) call any programming language test sequence;
- (3) using breakpoints and tracking tools, fast debugging sequence;
- (4) Sequential, parallel or batch mode to run the test sequence;
- (5) Record the results to a file or Access, SQL database, custom reports such as HTML, XML;

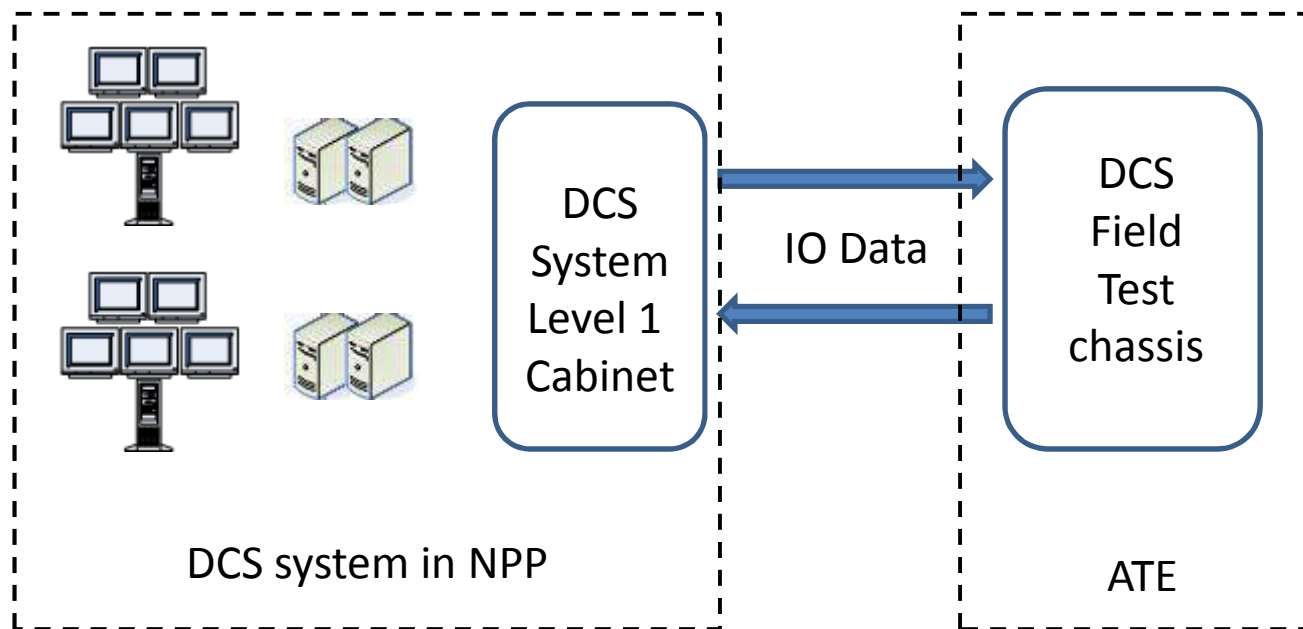


# Application1: RPS Test



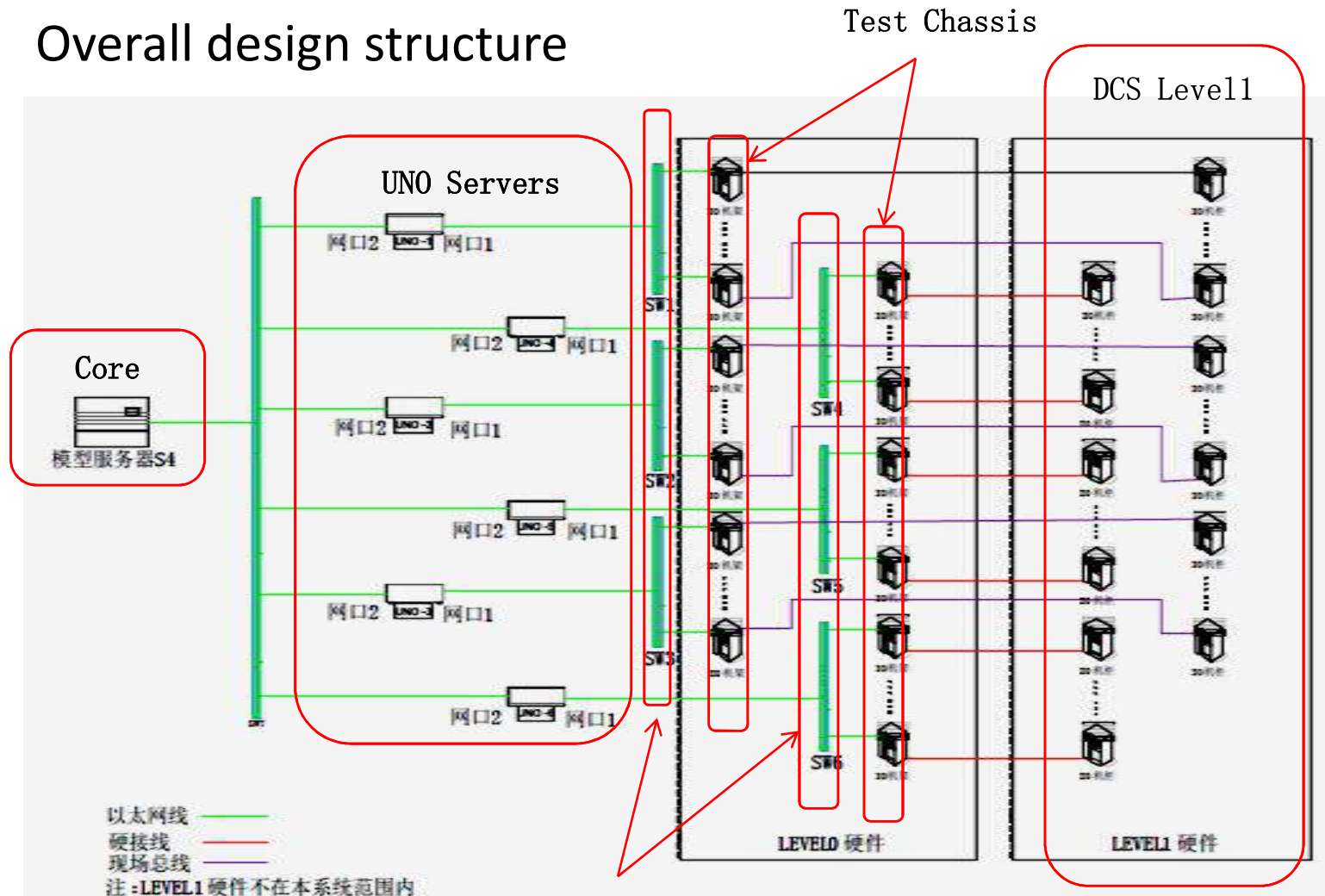
## Application2:ATE based on Nicsys2000

- DCS field test system is a kind of ATE by simulating the main craft system of reference unit , and using in nuclear power plant DCS functions and performance verification.



# Application2: ATE based on Nicsys2000

## Overall design structure



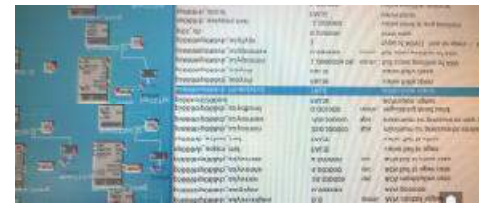
communication Servers



# Application2: ATE based on Nicsys2000

## Structure and principle

1. Hardware part-Nicsys2000 Series Board.
2. Software Part-Core: CNPO Nuclear power unit test simulation system .
3. Interior Communication: Sent the signal of CNPO test simulation system to NicSys2000 series chassis through communication program in the UNO server .
4. Communication with DCS Level 1 : Sent IO signal to DCS Level 1 through the way of hardware lines or DP communication.





## Application2: ATE based on Nicsys2000

### ➤ Product Figure



# Conclusion

---

1. FPGA-based RPS is more reliability and stability than CPU-based RPS because the former reduces the possibility of CCF.
2. It is necessary to perform V&V tools requirements analysis especially standards applicability analysis.
3. ATE is suitable for FPGA-based RPS test, by using the ATE, it will reduce the consume of development time and human effects. It will improve the efficiency of the test. And ATE solutions based on virtual instrument and NicSys2000 are given.



---

# Thank you for your attention



kanglihong@cncs.bj.cn

Website : [www.cncs.bj.cn](http://www.cncs.bj.cn)



**CNCS**