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The Method of System Test using I/O Stimulator

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1. Introduction

The paper describes the method of system test using input and output stimulator for the application of safety-critical systems. It mainly describes the establishment of test method, test case design, test procedures, and test execution using the Input/Output(I/O) stimulator. In general, the software development lifecycle consists of the requirement phase, design phase, implementation phase, testing phase, integration phase (software-software integration, software-hardware integration), installation phase, and operation and maintenance phase. The fundamental parts to the testing phase are component test, software integration test, software-hardware integration test, and system test. Among these tests, we focused in particular on system test using I/O stimulator. The system test operates the functionality, performance, and interface because system testing falls within the scope of black box testing, which should not require knowledge of the inner design of the code or logic. The purpose of developing a system test using a I/O stimulator is to save time and effort from the functionality and performance tests. We developed an I/O stimulator for the burning system test based on the operational scenario. The hardware, software, and man-machine-interface (MMI) are fundamental parts to the I/O stimulator. Signal sources from the I/O stimulator contain analog input, analog output, digital input, digital output, a Programmable Power Supply, an RS232C Serial interface and a dual port Ethernet interface. Using LabVIEW programming instead of test scripts, we established a stimulator Man Machine Interface(MMI) control station that can generate signal sources such as a tri-angle wave, sign wave, and step-wise wave. The I/O stimulator can provide a solution for the time discrepancy between the input signal source and result value during the real-time synchronization process. It was successfully implemented on a prototype I/O stimulator setup. While automation cannot reproduce everything that a software engineer can do, it can be extremely useful for the system test.

2. Design Specification of I/O Stimulator

The detailed input/output specification of the I/O stimulator in System Test is as follows.

o Analog I/O

- Voltage Source (-10V~10V) : 64 Channels
- Voltage Source (-0V~10V) : 48 Channels
- Current Source (-20mA~20mA) : 8 Channels

o Digital I/O

- Digital Input (30V max) : 64 Channel

o 60V Programmable Power Supply

o RS232C Serial interface

o Dual port Ethernet interface

The above are the input and output specifications of the I/O stimulator. It has a total of 184 channels. Among these, Analog I/O takes up 120 channels, and Digital I/O takes up the remaining 64. In addition, the 60V Power Supply is provided. For a weighted signal test, a power supply above 48V is required, and we enhanced it using 60V. Other than this, there are an RS232C and Ethernet interface for testing the target and communication. The test results can be obtained through these communication ports. We also added the USB interface device. The concept design of an I/O stimulator is a target for a system test, as shown in Figure 1. Figure 1 is a signal generator for system test. The image in Figure 1 shows the cabinet design. We put the wheels on the bottom of this device to make it easier for moving not only in the laboratory, but also in the on-site fields. Figure 2 is the MMI design for an I/O stimulator. The type of input, output channel, test range, and starting condition are the settings. In particular, it was designed to find the status monitoring information about the progress of the ongoing test.

Fig. 1. Cabinet Design for Signal Generator

Fig. 2. MMI Design for I/O Stimulator

2.1 Establishment of I/O Stimulator

Figure 3 shows the testing hierarchy as the test process. The upper part shows the factory acceptance test and manufacturing test, and the bottom parts are requirement-based, structure-based, and code-coverage based tests. This paper is related to the system testing. According to the test process, after making a test plan, a test suite/test case was generated. All results from the testing were documented and reported as a test summary report.

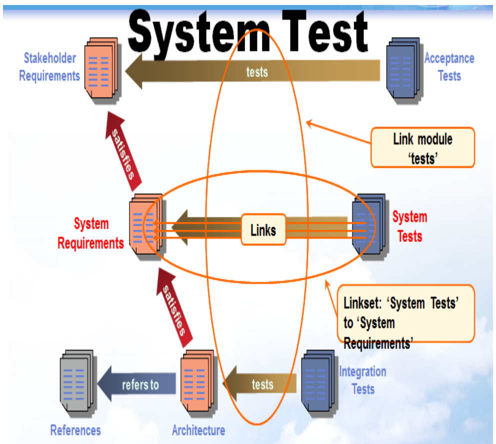


Fig. 3. Hierarchical structure of test process

The following items describe the system test environment and system test configuration.

However, in order to establish of an I/O stimulator system, five items are to be considered.

a) System configuration
b) Environment variable setup
c) LabVIEW Programming
d) Making an automatic testing scenario
e) Time synchronization between input value and result value (i.e., returning the output value)

The prototype system configuration is shown in Figure 4.

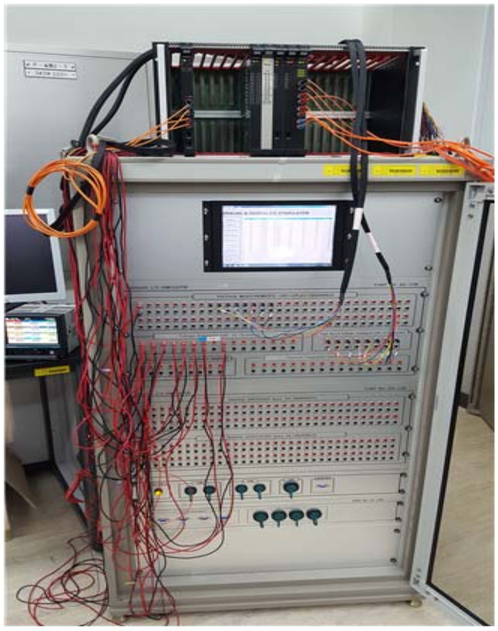


Fig. 4. System Configuration of I/O Stimulator

2.2 Test Case Design

The test case generation form is as shown in Table 1, which are the Test case ID, Input Range, Sequence NO, Voltage, Current, Input Value, and Expected Value. The expectation value is calculated using the Engineering Unit Conversion (EUC) formula. The rest are the Result Value, Error Tolerance Range, TRUE/FALSE (which means Pass or Fail), and Comments. The generation form of the following test cases can be written before the actual tests. Test case IDs are unique numbers for test items. The input range is either 0–10Volts or 4–20mA. For all input data, several sequence numbers can be assigned. The current value is mapping to the volt value using the Ohm formal equation. The input value is for testing the input data. The expected value is calculated by the Engineering Unit Conversion (EUC) Formula in advance. The result value is an actual output value. The tolerance range is acceptable values between the actual input value and expected output value assuming ±0.1%. TRUE or FALSE indicates PASS or FAIL, respectively. More detailed information is shown in Table 1.

Table 1 Test case generation form for test result measurements

Test case ID	Input Range	Seq. NO	Volt	Current	Input Value	Expected Value (EUC :MATH Formula)	Result Value (%)	Tolerance Range		TRUE / FALSE	Comments
								(Low)	(High)		

2.3 Software Design

There is software that is core and integrated to the I/O stimulator. We created this software using

LabVIEW graphic language, as shown in Figure 5. It consists of 40 modules. There are two types of test modes. Both manual test mode and automatic test mode can be conducted based on need.

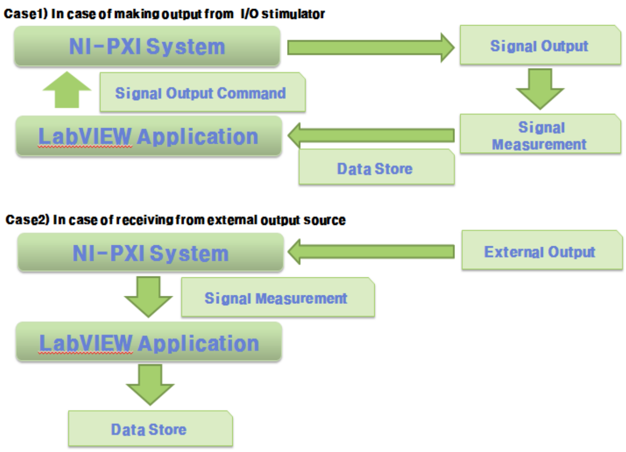
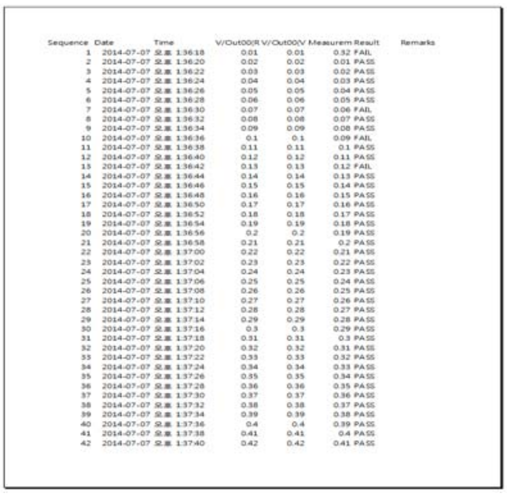


Fig. 5. Software Design for LabVIEW Programming

2.4 Test Results

The test case of Table 1 is executed under the I/O stimulator in Figure 4. The I/O stimulator we developed is fully automated and covers virtually all of the range of the system testing. It was time saving and cost efficient in comparison to the manual testing. Based on our I/O stimulator, here, an example of the results from an automatic test is shown in Figure 6. We made sure that the results from an automatic test matched the results from a manual test. We rechecked this using Fluke-755 manually.



Sequence	Date	Time	V/Out00(R	V/Out00(V	Measurem	Result	Remarks
1	2014-07-07	오후 1:36:18	0.01	0.01	0.32	FAIL	
2	2014-07-07	오후 1:36:20	0.02	0.02	0.01	PASS	
3	2014-07-07	오후 1:36:22	0.03	0.03	0.02	PASS	
4	2014-07-07	오후 1:36:24	0.04	0.04	0.03	PASS	
5	2014-07-07	오후 1:36:26	0.05	0.05	0.04	PASS	
6	2014-07-07	오후 1:36:28	0.06	0.06	0.05	PASS	
7	2014-07-07	오후 1:36:30	0.07	0.07	0.06	FAIL	
8	2014-07-07	오후 1:36:32	0.08	0.08	0.07	PASS	
9	2014-07-07	오후 1:36:34	0.09	0.09	0.08	PASS	
10	2014-07-07	오후 1:36:36	0.1	0.1	0.09	FAIL	
11	2014-07-07	오후 1:36:38	0.11	0.11	0.1	PASS	
12	2014-07-07	오후 1:36:40	0.12	0.12	0.11	PASS	
13	2014-07-07	오후 1:36:42	0.13	0.13	0.12	FAIL	
14	2014-07-07	오후 1:36:44	0.14	0.14	0.13	PASS	
15	2014-07-07	오후 1:36:46	0.15	0.15	0.14	PASS	
16	2014-07-07	오후 1:36:48	0.16	0.16	0.15	PASS	
17	2014-07-07	오후 1:36:50	0.17	0.17	0.16	PASS	
18	2014-07-07	오후 1:36:52	0.18	0.18	0.17	PASS	
19	2014-07-07	오후 1:36:54	0.19	0.19	0.18	PASS	
20	2014-07-07	오후 1:36:56	0.2	0.2	0.19	PASS	
21	2014-07-07	오후 1:36:58	0.21	0.21	0.2	PASS	
22	2014-07-07	오후 1:37:00	0.22	0.22	0.21	PASS	
23	2014-07-07	오후 1:37:02	0.23	0.23	0.22	PASS	
24	2014-07-07	오후 1:37:04	0.24	0.24	0.23	PASS	
25	2014-07-07	오후 1:37:06	0.25	0.25	0.24	PASS	
26	2014-07-07	오후 1:37:08	0.26	0.26	0.25	PASS	
27	2014-07-07	오후 1:37:10	0.27	0.27	0.26	PASS	
28	2014-07-07	오후 1:37:12	0.28	0.28	0.27	PASS	
29	2014-07-07	오후 1:37:14	0.29	0.29	0.28	PASS	
30	2014-07-07	오후 1:37:16	0.3	0.3	0.29	PASS	
31	2014-07-07	오후 1:37:18	0.31	0.31	0.3	PASS	
32	2014-07-07	오후 1:37:20	0.32	0.32	0.31	PASS	
33	2014-07-07	오후 1:37:22	0.33	0.33	0.32	PASS	
34	2014-07-07	오후 1:37:24	0.34	0.34	0.33	PASS	
35	2014-07-07	오후 1:37:26	0.35	0.35	0.34	PASS	
36	2014-07-07	오후 1:37:28	0.36	0.36	0.35	PASS	
37	2014-07-07	오후 1:37:30	0.37	0.37	0.36	PASS	
38	2014-07-07	오후 1:37:32	0.38	0.38	0.37	PASS	
39	2014-07-07	오후 1:37:34	0.39	0.39	0.38	PASS	
40	2014-07-07	오후 1:37:36	0.4	0.4	0.39	PASS	
41	2014-07-07	오후 1:37:38	0.41	0.41	0.4	PASS	
42	2014-07-07	오후 1:37:40	0.42	0.42	0.41	PASS	

Fig. 6. The sample of system test results

3. Conclusions

While automation cannot reproduce everything that a software engineer can do, it can be extremely useful for the system test. However, it does require the test criteria and a well-developed test suite of the testing scripts in order to be useful. In this study, we developed a multipurpose and cost-efficient I/O stimulator using LabVIEW program instead of the testing scripts.

Our study is to improve this I/O stimulator and make it possible to system test such as an FPGA-based controller and CPU-based controller.

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