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The Verification of ESF-CCS Integration Test procedure by utilizing Labview

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1. Introduction

Man-Machine Interface System (MMIS) developed by local R&D is applied to ShinUlChin nuclear power plant unit 1 & 2 for the first time. So far MMIS technology has been depending on the oversea. Since the Fukushima event, especially it is considered to be important to guarantee the safety of plant by mitigating the major accident. ESF-CCS (Engineered Safety Feature-Component Control System) is monitoring all the plant variables and generates the ESF-CCS actuation signals when the plant variables violate the setpoint.

Taking a look at the classic design, ESF-CCS is composed of the sub-components such as Minimum Inventory (MI), ESCM (ESF-CCS Soft Control Module), CPM, ITP, Group Controller (GC), Loop Controller (LC), CCG (Control Channel Gate), MTP, CIM (Component Interface Module), as indicated in Fig. 1.

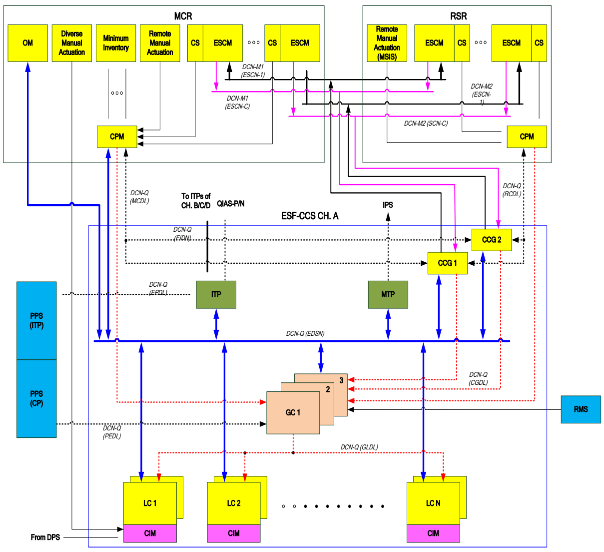

Fig. 1 ESF-CCS configuration

2. The Preparation of ESF-CCS Integration Test

The category of integration test for ESF-CCS is like the followings; analog input/output test, alarm indication and interface test, cabinet status and indication test, system actuation functionality test, component actuation functionality test, diesel load sequence test, diverse manual initiation test, diverse protection functionality test, MCR/RSR control transfer test, MTP/OM functionality test, system response time test, and abnormal state test. Among these category, component actuation functionality test generates the 600 of ESF and safety-grade actuation output signals for CIM control of field devices, and the control logic is implemented on LC according to the Control Logic Diagram (CLD). It takes upto 50% of time in preparation of the total integration test procedure

2.1 Component actuation functionality test [2]

2.1.1. Control Logic Diagram (CLD) Analysis

It is to verify the component actuation status based on the inputs designed in the CLD that is containing component features, and identify the actuation status that is going to other relevant systems through communication and/or hardwired connection.

2.1.2. Labview Coding[1]

When preparing the test cases as a part of integration test procedure, the Labview code that is developed to simulate the CLD is utilized to generate the "expected result value" for the combination of inputs as design in CLD. The part of the Labview code is indicated in Fig. 4.

2.2 Component Actuation Test Case design

Here it addresses the activity explaining how to prepare the test case with "expected result" for pump start/ stop testing by utilizing the Labview.

2.2.1. Pump Start/Stop CLD

In Fig 2, the left side of (red box, line) box indicates the inputs for pump start and stop, and the right side of (red box, line) box indicates the final output signal for pump stop and start. As input combination described in the Fig 2, appropriate test cases as many as reasonable is required for test reliability.

2.2.2. Pump Start/Stop Labview Coding

According to the logic typically indicated in Fig. 2, test case generation using Labview is conducted by specifying the input combination and analyzed expected output.

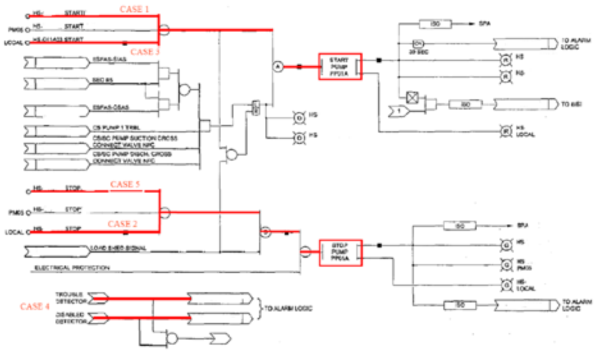

Fig. 2 Control Logic Diagram (CLD)

For test case simulation, GUI (Graphical User Interface) in Fig 3 is implemented, enabling test procedure preparer to test case generation efficiently and systematically. By simulating the ESCM or MI switch actuation inputs and local inputs, it is possible to monitor the component actuation status, and to provide the field inputs to monitor the component status like TROUBLE/DISABLE. This is advantageous to save time in test procedure generation and its verification. Fig. 3 is a typical test UI (User Interface), and Fig. 4 is atypical Labview code implementing the CLD logic. Labview code itself is verified and validated for reliability. Then Validated Laview code is utilized to prepare the integration test procedure.

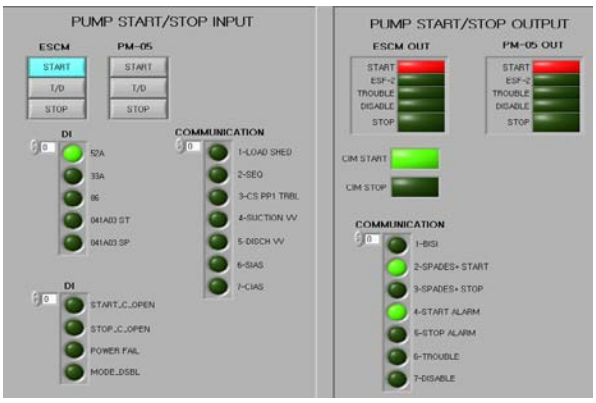

Fig. 3 Labview User Interface

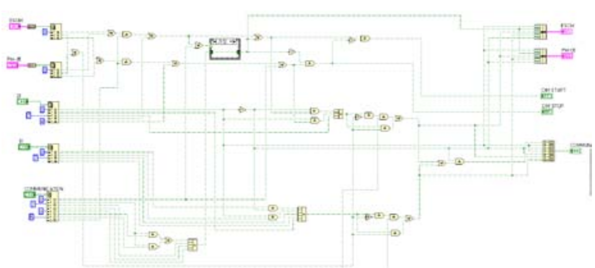

Fig. 4 Labview CLD Code

2.2.3. Pump Start/Stop test data sheet

Test data sheet is prepared by specifying the inputs of "and", "or" logic as in Fig2 into "PUMP START/STOP INPUT" UI in the Fig. 3, then preparer records the input values such as *HS-start, stop, contact signal, and* simulated expected results such as actuation status*(Color), "ON", "OFF"* in the TDS (Test Data Sheet). Relatively input combination and field feedback signal are complicated for component actuation. However it is easier to prepare the TDS and its verification by using Labview simulation code.

Fig. 5 and 6 are the typical TDS for input and output result. Component status and input are recorded in "Input Sheet", and expected result with pass/fail is recorded in "Output Sheet" without description of textual procedure. The method shall meet IEEE 829[1].

Test Input Sheet

Test Doc.: XXXX Test Procedure-Component Actuation Function Test											
Component	9-XXX-X-PPXXA	System: SI	Detail Test Item: Shutdown Cooling Pump								
Test summary & Note *Generate Sim I/O input within 0.5 seconds											
Input			CASE								
Description	Location/Display	Action	Initial	1	2	3	4		5	6	7
HS-Start	Soft Contrller	ST		ST						…	…
HS-T/D	Soft Contrller	T/D						T/D		…	…
HS-Stop	Soft Contrller	SP	SP						SP	…	…
Started	I/O SIM	0/1	0	1*	0	1*	0			…	…
Local-Start	I/O SIM	0/1				1				…	…
Local-Stop	I/O SIM	0/1			1	0				…	…
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

Fig. 5 Test Input Sheet

Test Output Sheet

Test Doc.: XXXX Test Procedure-Component Actuation Function Test											
Component	9-XXX-X-PPXXA	System: SI	Detail Test Item: Shutdown Cooling Pump								
Test summary & Note *Confirm "DISABLE" after 10 seconds.											
Input			CASE								
Description	Location/Display	Action	Initial	1	2	3	4		5	6	7
HS-Start	Soft Contrller	R	OFF	R	OFF	R	OFF			…	…
HS-T/D	Soft Contrller	F/Y	OFF				F	Y	OFF	…	…
HS-T/D	Soft Contrller	F/Y	OFF				F	Y	OFF	…	…
HS-Stop	Soft Contrller	G	G	OFF	G	OFF	G			…	…
CIM	I/O SIM	ON/ OFF	OFF	ON	OFF	ON			OFF	…	…
CIM	I/O SIM	ON/ OFF	ON	OFF	ON	OFF			ON	…	…
PP01A_INOP _STOP	BISI (SI)	0/1	0				1			…	…
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

Fig. 6 Test Output Sheet

3. Conclusions

By help of Labview simulation in integration test procedure preparation, the following benefits are attained;

- Control logic and design evaluation by Labview
- Eliminating the time-consuming test case design, and determining the "expected result" with design validation
- The reliability upgrade of integration test quality

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REFERENCES

[1] National Instrument "Labview fundamental", 2007
[2] IEEE Std 829 " IEEE Standard for Software Test Documentation", 1998