

Stimulation interfacing method in APR1400 simulator

Do Hyun Hwang, Myeong Soo Lee, Jin Hyuk Hong

Korea Electric Power Research Institute Munji-Ro 65, Yuseong-Gu, Daejeon, Korea, 305-380
whitepeach@kepri.re.kr, fiatlux@kepri.re.kr, jhhong@kepri.re.kr

1. Introduction

A project for the localization of nuclear digital I&C system has been carried out on the initiative of Korea Nuclear Instrumentation & Control System (KNICS) for several years. Before a newly developed system is applied to nuclear power plants (NPPs), it should satisfy the proven technology requirements.

EPRI-URD requires the 'proven technology' which should have at least three years experience of documented and satisfactory service as modules of subsystems in the NPP or other plant applications similar to that of NPP [1]. However, it is not easy to satisfy the requirements actually because the newly developed system has some risks for safety and operation rather than the existing system that plant managers are reluctant to introduce it.

Fortunately, as an alternative option, EPRI-URD requires that it should be completed satisfactorily, a 'well defined program of prototype testing' to verify its performance by using the stimulated full scope simulator [2].

Korea Electric Power Research Institute (KEPRI) and Doosan Heavy Industry (DHI) have developed together the KNICS Integrated Performance Validation Facility (IPVF) which could evaluate the performance of the newly developed control and protection system.

There are two methods for applying a system to simulator. One is emulation method which simulates the system virtually in computer, and the other is stimulation one which simulates it using real device and Input/Output (I/O) points connecting the simulator and the device.

In this paper, stimulation interfacing method is introduced by stimulating a system in APR1400 simulator which is modeled by 3KeyMasterTM, a simulation tool of Western Services Corporation.

2. Stimulation interfacing method

2.1 Interfacing System Structure

A Simulator Sever loaded with simulator model connects to Master Node which exchanges I/O signals with I/O system and delivers them to Clients. Simulator Sever and Master Node share mutual memories through a connector in Master Node. Master Node communicates with I/O system through Hub which accommodates all connections to I/O modules in the stimulated system. The Master Node and the Hub also share memories through a connector in Master Node. All communications use TCP/IP networking protocol.

I/O system is developed with Compact Field Point (CFP) system of National Instrument. CFP system is highly expandable programmable automation controller composed of rugged I/O modules and intelligent communication interfaces.

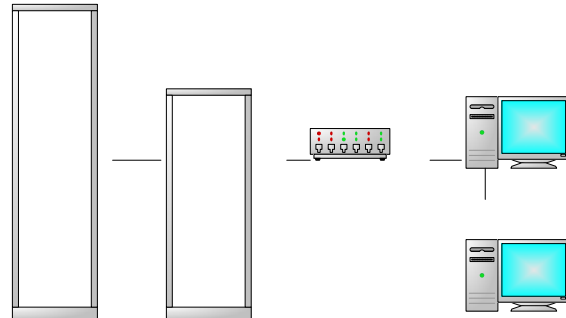


Figure 1. Interfacing system outline

2.2 Work procedure in simulator model for interfacing

Before interfacing simulator model and stimulated system, the procedure should be done in the simulator model as follows.

- 1) List up 4 types I/O variables which consist of analog and digital I/O for stimulation. The input variables in simulator model correspond to the output variables of stimulated system and vice versa.
- 2) Make a mapping table for interfacing. At this stage, the unit and range of interfacing variables should be checked for matching. In case of different unit or range, the conversion of unit or range should be done.

ID	IDType	ControlName	DevName	Channel	Slot	Channel	Tag	VarName_Sin	VarName_Sin_2	VarName_DCS	ID
1	DI	FP # 992_168_1_2	CFP-DI-208A 01	1	1	1	0	RPSC_Cha_Input	zknkics101	RP	RP
2	DI	FP # 992_168_1_2	CFP-DI-208A 01	1	1	1	1	RPSC_Cha_Input	zknkics111	RP	RP
3	DI	FP # 992_168_1_2	CFP-DI-208A 01	1	1	1	2	SIAC_Cha_Input	zknkics121	SI	SI
4	DI	FP # 992_168_1_2	CFP-DI-208A 01	1	1	1	3	CIAC_Cha_Input	zknkics131	CI	CI
5	DI	FP # 992_168_1_2	CFP-DI-208A 01	1	1	1	4	CSAC_Cha_Input	zknkics141	CS	CS
6	DI	FP # 992_168_1_2	CFP-DI-208A 01	1	1	1	5	MSIC_Cha_Input	zknkics151	MS	MS
7	DI	FP # 992_168_1_2	CFP-DI-208A 01	1	1	1	6	RFAS1_Cha_Input	zknkics161	RF	RF
8	DI	FP # 992_168_1_2	CFP-DI-208A 01	1	1	1	7	RFAS2_Cha_Input	zknkics171	RF	RF
9	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	3	0	0	ALP000001_01_output	zknkics101	AL	AL
10	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	3	1	0	ALP000001_02_output	zknkics111	AL	AL
11	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	3	2	0	ALP000001_03_output	zknkics121	AL	AL
12	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	3	3	0	ALP000001_04_output	zknkics131	AL	AL
13	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	3	4	0	ALP000001_05_output	zknkics141	AL	AL
14	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	3	5	0	ALP000001_06_output	zknkics151	AL	AL
15	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	3	6	0	ALP000001_07_output	zknkics161	AL	AL
16	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	3	7	0	ALP000001_08_output	zknkics171	AL	AL
17	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	4	0	0	SGP1_Cha_RST_INCH_output	zknkics101	SG	SG
18	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	4	1	0	SGP2_Cha_RST_INCH_output	zknkics111	SG	SG
19	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	4	2	0	SGP3_Cha_RST_INCH_output	zknkics121	SG	SG
20	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	4	3	0	SGP4_Cha_RST_INCH_output	zknkics131	SG	SG
21	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	4	4	0	SGP5_Cha_RST_INCH_output	zknkics141	SG	SG
22	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	4	5	0	SGP6_Cha_RST_INCH_output	zknkics151	SG	SG
23	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	4	6	0	SGP7_Cha_RST_INCH_output	zknkics161	SG	SG
24	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	4	7	0	SGP8_Cha_RST_INCH_output	zknkics171	SG	SG
25	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	5	0	0	SGP9_Cha_RST_INCH_output	zknkics101	SG	SG
26	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	5	1	0	SGP10_Cha_RST_INCH_output	zknkics111	SG	SG
27	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	5	2	0	SGP11_Cha_RST_INCH_output	zknkics121	SG	SG
28	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	5	3	0	SGP12_Cha_RST_INCH_output	zknkics131	SG	SG
29	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	5	4	0	SGP13_Cha_RST_INCH_output	zknkics141	SG	SG
30	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	5	5	0	SGP14_Cha_RST_INCH_output	zknkics151	SG	SG
31	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	5	6	0	SGP15_Cha_RST_INCH_output	zknkics161	SG	SG
32	DO	FP # 992_168_1_2	CFP-RLV-421 00	1	5	7	0	SGP16_Cha_RST_INCH_output	zknkics171	SG	SG
33	DO	FP # 992_168_1_2	CFP-AB-210 07	1	2	0	0	ARC_L1PW000_Output	zknkics101	AR	AR
34	DO	FP # 992_168_1_2	CFP-AB-210 07	1	2	1	0	ARC_L1PW001_Output	zknkics111	AR	AR
35	DO	FP # 992_168_1_2	CFP-AB-210 07	1	2	2	0	ARC_L1PW002_Output	zknkics121	AR	AR
36	DO	FP # 992_168_1_2	CFP-AB-210 07	1	2	3	0	ARC_L1PW003_Output	zknkics131	AR	AR
37	DO	FP # 992_168_1_2	CFP-AB-210 07	1	2	4	0	ARC_L1PW004_Output	zknkics141	AR	AR
38	DO	FP # 992_168_1_2	CFP-AB-210 07	1	2	5	0	ARC_L1PW005_Output	zknkics151	AR	AR
39	DO	FP # 992_168_1_2	CFP-AB-210 07	1	2	6	0	ARC_L1PW006_Output	zknkics161	AR	AR
40	DO	FP # 992_168_1_2	CFP-AB-210 07	1	2	7	0	ARC_L1PW007_Output	zknkics171	AR	AR
41	DO	FP # 992_168_1_2	CFP-AB-210 07	1	3	0	0	ARC_L1PW008_Output	zknkics101	AR	AR
42	DO	FP # 992_168_1_2	CFP-AB-210 07	1	3	1	0	ARC_L1PW009_Output	zknkics111	AR	AR
43	DO	FP # 992_168_1_2	CFP-AB-210 07	1	3	2	0	ARC_L1PW010_Output	zknkics121	AR	AR
44	DO	FP # 992_168_1_2	CFP-AB-210 07	1	3	3	0	ARC_L1PW011_Output	zknkics131	AR	AR
45	DO	FP # 992_168_1_2	CFP-AB-210 07	1	3	4	0	ARC_L1PW012_Output	zknkics141	AR	AR
46	DO	FP # 992_168_1_2	CFP-AB-210 07	1	3	5	0	ARC_L1PW013_Output	zknkics151	AR	AR
47	DO	FP # 992_168_1_2	CFP-AB-210 07	1	3	6	0	ARC_L1PW014_Output	zknkics161	AR	AR
48	DO	FP # 992_168_1_2	CFP-AB-210 07	1	3	7	0	ARC_L1PW015_Output	zknkics171	AR	AR
49	DO	FP # 992_168_1_2	CFP-AB-210 07	1	4	0	0	ARC_L1PW016_Output	zknkics101	AR	AR
50	DO	FP # 992_168_1_2	CFP-AB-210 07	1	4	1	0	ARC_L1PW017_Output	zknkics111	AR	AR
51	DO	FP # 992_168_1_2	CFP-AB-210 07	1	4	2	0	ARC_L1PW018_Output	zknkics121	AR	AR
52	DO	FP # 992_168_1_2	CFP-AB-210 07	1	4	3	0	ARC_L1PW019_Output	zknkics131	AR	AR
53	DO	FP # 992_168_1_2	CFP-AB-210 07	1	4	4	0	ARC_L1PW020_Output	zknkics141	AR	AR
54	DO	FP # 992_168_1_2	CFP-AB-210 07	1	4	5	0	ARC_L1PW021_Output	zknkics151	AR	AR
55	DO	FP # 992_168_1_2	CFP-AB-210 07	1	4	6	0	ARC_L1PW022_Output	zknkics161	AR	AR
56	DO	FP # 992_168_1_2	CFP-AB-210 07	1	4	7	0	ARC_L1PW023_Output	zknkics171	AR	AR
57	DO	FP # 992_168_1_2	CFP-AB-210 07	1	5	0	0	ARC_L1PW024_Output	zknkics101	AR	AR
58	DO	FP # 992_168_1_2	CFP-AB-210 07	1	5	1	0	ARC_L1PW025_Output	zknkics111	AR	AR
59	DO	FP # 992_168_1_2	CFP-AB-210 07	1	5	2	0	ARC_L1PW026_Output	zknkics121	AR	AR
60	DO	FP # 992_168_1_2	CFP-AB-210 07	1	5	3	0	ARC_L1PW027_Output	zknkics131	AR	AR
61	DO	FP # 992_168_1_2	CFP-AB-210 07	1	5	4	0	ARC_L1PW028_Output	zknkics141	AR	AR
62	DO	FP # 992_168_1_2	CFP-AB-210 07	1	5	5	0	ARC_L1PW029_Output	zknkics151	AR	AR
63	DO	FP # 992_168_1_2	CFP-AB-210 07	1	5	6	0	ARC_L1PW030_Output	zknkics161	AR	AR
64	DO	FP # 992_168_1_2	CFP-AB-210 07	1	5	7	0	ARC_L1PW031_Output	zknkics171	AR	AR
65	DO	FP # 992_168_1_2	CFP-AB-210 07	1	6	0	0	ARC_L1PW032_Output	zknkics101	AR	AR
66	DO	FP # 992_168_1_2	CFP-AB-210 07	1	6	1	0	ARC_L1PW033_Output	zknkics111	AR	AR
67	DO	FP # 992_168_1_2	CFP-AB-210 07	1	6	2	0	ARC_L1PW034_Output	zknkics121	AR	AR
68	DO	FP # 992_168_1_2	CFP-AB-210 07	1	6	3	0	ARC_L1PW035_Output	zknkics131	AR	AR
69	DO	FP # 992_168_1_2	CFP-AB-210 07	1	6	4	0	ARC_L1PW036_Output	zknkics141	AR	AR
70	DO	FP # 992_168_1_2	CFP-AB-210 07	1	6	5	0	ARC_L1PW037_Output	zknkics151	AR	AR
71	DO	FP # 992_168_1_2	CFP-AB-210 07	1	6	6	0	ARC_L1PW038_Output	zknkics161	AR	AR
72	DO	FP # 992_168_1_2	CFP-AB-210 07	1	6	7	0	ARC_L1PW039_Output	zknkics171	AR	AR
73	DO	FP # 992_168_1_2	CFP-AB-210 07	1	7	0	0	ARC_L1PW040_Output	zknkics101	AR	AR
74	DO	FP # 992_168_1_2	CFP-AB-210 07	1	7	1	0	ARC_L1PW041_Output	zknkics111	AR	AR
75	DO	FP # 992_168_1_2	CFP-AB-210 07	1	7	2	0	ARC_L1PW042_Output	zknkics121	AR	AR
76	DO	FP # 992_168_1_2	CFP-AB-210 07	1	7	3	0	ARC_L1PW043_Output	zknkics131	AR	AR
77	DO	FP # 992_168_1_2	CFP-AB-210 07	1	7	4	0	ARC_L1PW044_Output	zknkics141	AR	AR
78	DO	FP # 992_168_1_2	CFP-AB-210 07	1	7	5	0	ARC_L1PW045_Output	zknkics151	AR	AR
79	DO	FP # 992_168_1_2	CFP-AB-210 07	1	7	6	0	ARC_L1PW046_Output	zknkics161	AR	AR
80	DO	FP # 992_168_1_2	CFP-AB-210 07	1	7	7	0	ARC_L1PW047_Output	zknkics171	AR	AR
81	DO	FP # 992_168_1_2	CFP-AB-210 07	1	8	0	0	ARC_L1PW048_Output	zknkics101	AR	AR
82	DO	FP # 992_168_1_2	CFP-AB-210 07	1	8	1	0	ARC_L1PW049_Output	zknkics111	AR	AR
83	DO	FP # 992_168_1_2	CFP-AB-210 07	1	8	2	0	ARC_L1PW050_Output	zknkics121	AR	AR
84	DO	FP # 992_168_1_2	CFP-AB-210 07	1	8	3	0	ARC_L1PW051_Output	zknkics131	AR	AR
85	DO	FP # 992_168_1_2	CFP-AB-210 07	1	8	4	0	ARC_L1PW052_Output	zknkics141	AR	AR
86	DO	FP # 992_168_1_2	CFP-AB-210 07	1	8	5	0	ARC_L1PW053_Output	zknkics151	AR	AR
87	DO	FP # 992_168_1_2	CFP-AB-210 07	1	8	6	0	ARC_L1PW054_Output	zknkics161	AR	AR
88	DO	FP # 992_168_1_2	CFP-AB-210 07	1	8	7	0	ARC_L1PW055_Output	zknkics171	AR	AR
89	DO	FP # 992_168_1_2	CFP-AB-210 07	1	9	0	0	ARC_L1PW056_Output	zknkics101	AR	AR
90	DO	FP # 992_168_1_2	CFP-AB-210 07	1	9	1	0	ARC_L1PW057_Output	zknkics111	AR	AR
91	DO	FP # 992_168_1_2	CFP-AB-210 07	1	9	2	0	ARC_L1PW058_Output	zknkics121	AR	AR

Figure 2. Mapping table for interfacing

Mapping tables with the same name in Simulator Server and Master Node should keep consistency.

- 3) Remove input nodes which are selected to get values from stimulated system in simulator model.

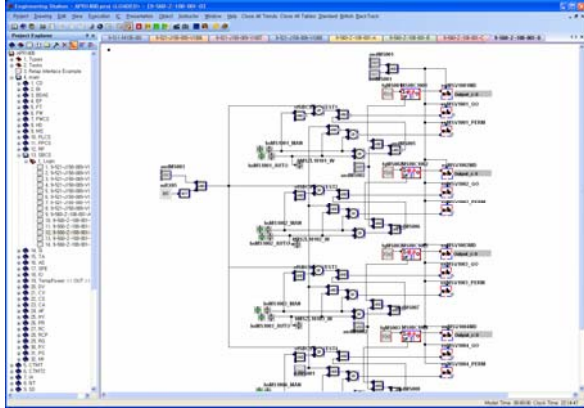


Figure 3. APR1400 simulator model

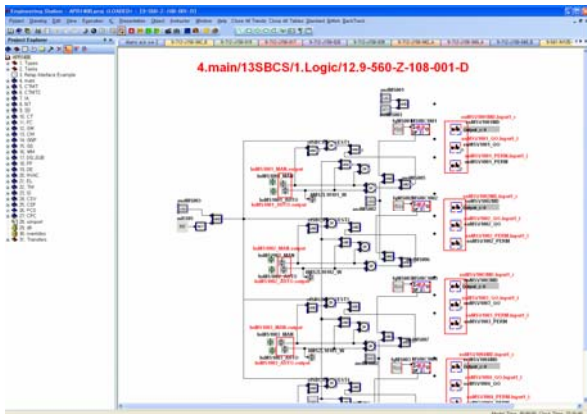


Figure 4. APR1400 simulator model after removing input nodes for interfacing with stimulated system

- 4) Check whether the simulator model maintains the steady-state using 100% Initial condition (IC). If not, check the input variables of which the connecting nodes were removed for interfacing with stimulated system whether they have values at 100% steady-state. In case that they don't have values at 100% steady-state, insert 100% values using overriding function.

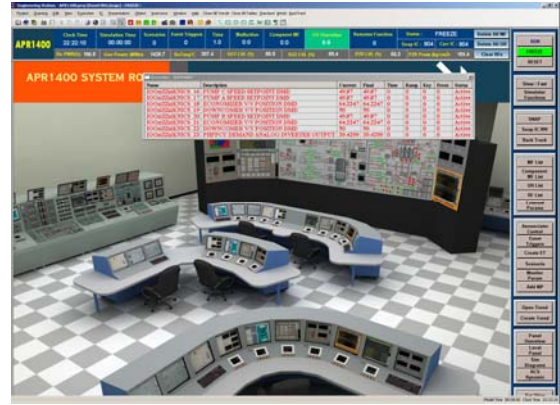


Figure 5. Overriding function

2.3 Interfacing with stimulated system

The steady-state is checked in simulator after the work described in [2.2], then the interfacing between simulator and stimulated system is performed. The interfacing between simulator and stimulated system should be done one I/O point by one I/O point connected each other for the convenience of checking errors. It should be also considered that the response time about RESET function in stimulated system is much longer than in simulator model.

3. Conclusions

It is in progress an interfacing between simulator model developed by KEPRI and proto type system for stimulation developed by DHI [3]. As DHI develops a system, KEPRI revises simulator model for stimulation and integrates with the system. The stimulated scope will be expanded into a full-scale integration test. It is important to get know-how about full-scale stimulation integration because it may cause problems as the scope of stimulation becomes broader, although it is right at each unit test

The stimulation interfacing method will be useful for the Verification & Validation (V&V) of domestically developed systems to satisfy the proven technology requirements before applying to NPPs.

REFERENCES

- [1] EPRI-URD Chapter 11-10-3. 2. 1, Criteria for Proven Technology.
- [2] Dong-Gyun Kim et al., "Integrated Performance Validation Facility for KNICS", Proceedings of the ANS Winter Meeting, pp1164-1169, ANS, DC 2006.
- [3] Myeong-Soo Lee et al., "Integrated Performance Validation Facility for KNICS MMIS, the Korean Nuclear Society Spring Meeting, 2007