Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 10-11, 2007

Field Application Tests of a Domestic CAR Interface Device

Young-San Choi, Sang-Hoon Bae, Seung-do Baek, Young-Ki Kim, Hoan-Sung Jung.
yschoe@kaeri.re.kr

1.0 Introduction

An interface device that controls a CAR with a reactor used to be manufactured and supplied by the AECL, but its production has discontinued causing a problem of securing spare parts. In order to avoid relying on foreign technology and to secure stable supply of spare parts and technical support, an interface device was designed and manufactured by domestic technology and its production has been completed.

From when a sample was developed, field application tests were performed for several years to resolve both software and hardware problems, and as a result, its performance has been advanced as good as the previous device and through systematic tests, it is now concluded that a domestically-manufactured interface device can be a sufficient substitute of the previous device.

2.0 Composition and Signal of the Interface Device

The roles of the interface device is to convert the digital signals received from the MLC to controllable signals, and it is composed of Main Interface Card (J4001), Indexer Card (IMD015), and Motor Driver Card(PDM502). J4001 card receives binary signals from MLC and outputs the ASCII signals to the Indexer Card. This signal is transformed to a pulse form in the number of steps that received commands to be sent to the Motor Driver Card, and the Drive Card controls a motor by making 48V step pulse for actual motor operation. These three cards are the objects to be domestically manufactured and they are shown in Figure 1.

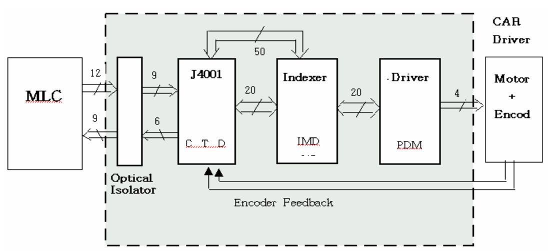

Figure 1. Circuit Diagram of the CAR Interface Device

In Figure 1, the signals that the interface device sends and receives between MLC and Motor are total 4 including 4 MLC and 2 Motors. The interface device receives the binary number of driving steps computed by MLC. 8 out of 9 data bits are the CAR motor driving signals and the remaining 1 signal is for reset. MLC receives the rotating state of the CAR motor driven according to these signals with 6 signals. 4 out of 6 signals are related to CAR problems including Encoder Failure, Time Out, Invalid, and Error, while the other 2 signals are about the driving state of the CAR motor. These signals are all in the form of 24V Discrete Input/Output.

The interface device produces 48V Step Pulse to drive the CAR motor. The Rotary Encoder rotated by these commands estimate the number of steps of the driving CAR motor and send feedback to the interface device, and by using this, the break down state of CAR shall be determined. The mechanical composition for this process is described in Figure 2.

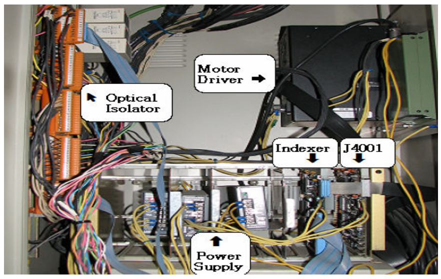

Figure 2. Composition of the Previous CAR Interface Device

3.0 Field Application Tests of the Domestic Interface Device

The domestic interface device is to control the CAR Stepping Motor, and it should be proved that the performance is this device is same as that of the previous product. Main focuses include the accuracy in processing command signals and signal compatibility between the previous interface device and MLC. [1] In the initial testing stage, the performance of the sample had been confirmed before manufacturing the actual product; when the actual domestic product was manufactured, it was replaced the previous interface device to verify if its performance is same as that of the previous one. Both tests were carried out with three levels.[3]

Level 1 Test was the initial test after completing the manufacturing of sample and it was to identify the problems while operating normal command steps and limited command steps. From the tests continued for three months, about 10 cases were identified. After changing the design, the manufacturer solved these problems. Main problems found in Level 1 were as follows.

* Discordant rotating directions of the CAR Motor
* Occurrence of "Invalid" in normal step commands
* Disagreement in the number of feedback steps of the Encoder
* Break down of the Motor Driver while testing

Level II Test was performed with a load that has the same weight as the actual CAR by repeating the normal command steps from Step 1 to Step 15 for a certain number of times. In this test, no abnormal events occurred. Also, a program that automatically produces CAR driving signals was developed so a test was performed by using PLC. Produced command steps and driving directions are arbitrarily determined by PLC and the test was continued for more than 72 hours without any abnormal events.

Level III Test was performed by temporarily installing the sample instead of the previous interface device in the actual CAR in order to test signal compatibility. Under the normal condition with a pump operating, the normal command steps from Step 1 to Step 15 were sent by using MLC. It was found that the CAR driving state and the Error state all normally operated.

After completing the tests using the sample, the products actually manufactured for use were total 6 sets including 2 sets of spare. Software installed in hardware is the same version used in Level III. Considering outside noise cover, a special case was made to house hardware. [2] This is shown in Figure 3.

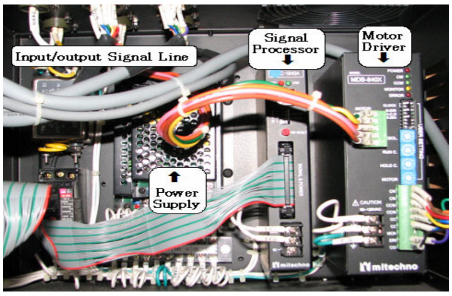

Figure 3. Composition of the New CAR Interface Device

Performance tests for the actual produce for use were carried out in the same way as those for the sample. It was initially assumed that no problems would occur since the sample test was successfully completed. However, some minor problems were found in Level 1 and Level II tests. These problems were solved after the manufacturer continued testing, and they are:

* Several occurrences of "Invalid" at #001 and #003
* Operating -60 step in reverse at all cases
* Occurrence of Motor Driver Breakdown at #004

In Level III Test, signal compatibility was examined by sending normal command steps from Step 1 to Step 15 using MLC. Several problems were found in this test and they are: First, an occurrence of Encoder Error due to intermittent Step 1 error; Second, unclear flashing of Reset S/W in case of withdrawing CAR #4; and, third, no Reset S/W operation in descending the CAR after stopping RRS.

The first problem was solved by setting the Error Range to 2 Pulses, which is shown in Figure 4.

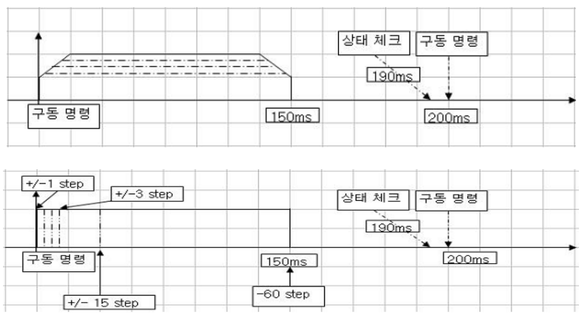

Figure 4. Before and After Changing the Pattern of Motor Driving

The second problem was found only in # 4 but in no other CARs, so it was suspected that the problem was with Reset s/w of #4 and the machine operating device was disassembled and replaced. The third problem indicates that the CAR is well inserted into a reactor and is a signal to get ready for resuming an operation, so it is a significant issue in terms of safety of a reactor. Through tests with many steps, the program was modified to solve the causes.

* Occurrence of Encoder Error due to Step 1 error
* Flashing of Reset S/W in CAR #4
* Unable to operate Reset S/W with RRS stopped

Ultimately, the whole process of designing, purchasing, manufacturing and testing the CAR interface device for domestic manufacturing was successfully performed.

4.0 Conclusion

This paper describes the process of field application tests of the CAR interface device. With successful domestic manufacturing, it now is possible to reduce the dependency on foreign technology and instead to secure spare parts and provide technical support domestically. The next step now would be to apply the device to an automatic driving test of a reactor to see if it is possible to support the normal operation. Considering the hitherto test results, it is expected that a future test will be carried out successfully as well.

REFERENCES

[1] C. Papas, "Design Manual - Reactor Regulation System" Rev. 3, DM-37-63700-001, 1993. 7. 29
[2] Mi-techno, "Interface Device for HANARO Control Rad, "End of Examination Report " , 2001. 12. 6
[3] Y. K. Kim, "Performance Test Procedure for HANARO Control Rad ", Test Procedure, HAN-RS-OP-IT-637-02-001, Rev. 0, 2002. 9. 12