

## CEDM Controller for a Linear Pulse Motor by using Pulse Width Modulation Method in Integral Reactor

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### 1. Introduction

Integral Reactor SMART is under development at KAERI. The design characteristics of SMART are radically different from those employed in currently operating loop type PWR in Korea.

The reliability and accuracy of Control Rod Drive Mechanism are very important to the reactor safety and the design of the Plant Protection System.

The SMART CEDM designed for fine-step movement consists of a linear pulse motor, reed switch type sensor with top and bottom limit switches which also act as Control Element Assembly(CEA) Position indicator. The linear pulse motor is a four phase synchronous DC electric machine with inner stator and output stator in coolant medium inside a strong housing. The objective of this paper is to introduce and to explain the CEDM controller. CEDM Controller is being developed with a new design concept and digital technology to reduce the Operating Error and improve the systems' reliability and availability. And Switched Mode Power Supply is also being developed with digital hardware technology. This paper involves the test details and result.

### 2. Characteristics of CEDM Controller

#### 2.1 Main difference between Conventional NPP & SMART CEDM Controller

Conventional CEDM controller is magnetic-jack type driver using SMPS which is composed of thyristor module whereas developed CEDM controller is based on Microprocessor system and IGBT Module which is easily controlled than thyristor module

It is possible for Developed controller to be precisely controlled and accurate position calculation and also reliability & availability is improved

Table 2. Main difference between Conventional & New developed CEDM Controller

|              | Conventional CEDM Controller | New Developed CEDM Controller |
|--------------|------------------------------|-------------------------------|
| Accuracy(cm) | 30cm                         | 0.25mm                        |
| H/W & S/W    | PLC                          | Industrial                    |

Computer,  
C language,  
viewing Tool

#### 2.2 Advantages & Characteristics of CEDM Controller

##### 1) Reduction of Position Deviation among Individual CEAs

Controller is designed to automatically adjust CEA movement when Position Deviation among the CEAs is above 5mm. Thus CEA position deviation is restricted by 5mm. Automatic as well as manual control is acceptable to CEDM Controller.

- Deviation Limitation among the individual CEA position : below 5mm
- Automatic/Manual adjustment in case that position : deviation is above 5mm

##### 2) Improvement of Control Accuracy

In normal operation, CEDM controller generates four(4) trimmed pulse power per one(1) second for driving the Linear Pulse Motor and drive the 0.25mm/second for linear pulse motor

These detail movements are compared than 30cm. this control method is very high accurate

- CEA movement speed by new developed controller
 

|                     |                 |
|---------------------|-----------------|
| Normal Operation    | : 0.25mm/second |
| Emergency Operation | : 2mm/second    |

##### 3) Precise CEA position Calculation

Precise CEA position calculation is very important for monitoring the CEA position and controlling precisely CEA control.

CEA Position is calculated by using following input signals ; two(2) ultrasonic sensor, two(2) upper & two(2) lower limit switch, four(4) pulse counting for driving the linear pulse motor.

Control accuracy is below 0.25m and is lower than that of conventional CEDM controller.

- Position calculation input
 

|                            |        |
|----------------------------|--------|
| Upper & Lower Limit Switch | : 2, 2 |
|----------------------------|--------|

Ultrasonic Sensor : 2  
Pulse Counting Sensor : 4

**3. Conclusion**

The reliability and accuracy of Control Rod Drive Mechanism Control System are very important to the reactor safety and the design of the core protection system. The SMART CEDM designed for fine-step movement consists of a linear pulse motor, reed switch type sensor with top and bottom limit switches which also act as Control Element Assembly(CEA) Position indicator, The linear pulse motor is a four phase synchronous DC electric machine

CEDM Controller is being developed with a new design concept and digital technology to reduce the operating error and improve the systems' reliability and availability. Also, Switched Mode Power Supply is also being developed with a new design concept and digital hardware technology

In this paper, CEDM Controller is introduced and compared as conventional CEDM controller. Advantage s of the controller are the following

- Reduction of position deviation among individual CEAs
- Improvement of Control Accuracy
- Precise CEA position calculation technique

**REFERENCES**

[1] M. H. Jang, G. W. Yeo, Basic Design Report of SMART, KAERI/TR-2142/2002, p. 507-527, 2002.

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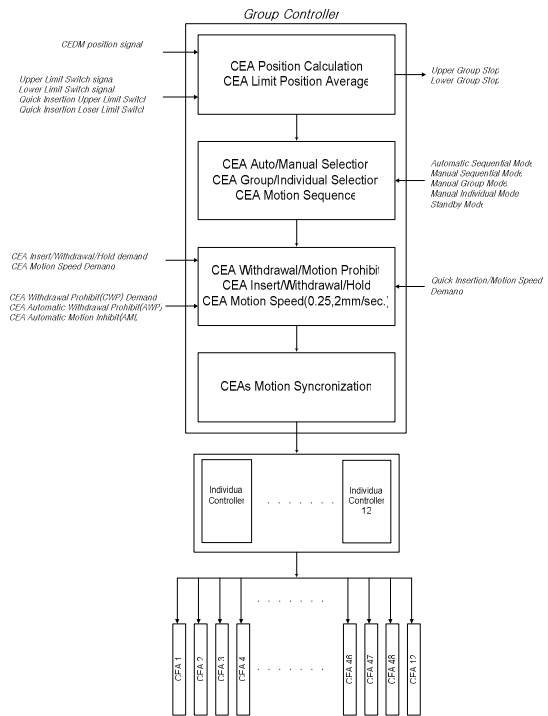


Figure 1. Simplified Block Diagram of developed CEDMCS.

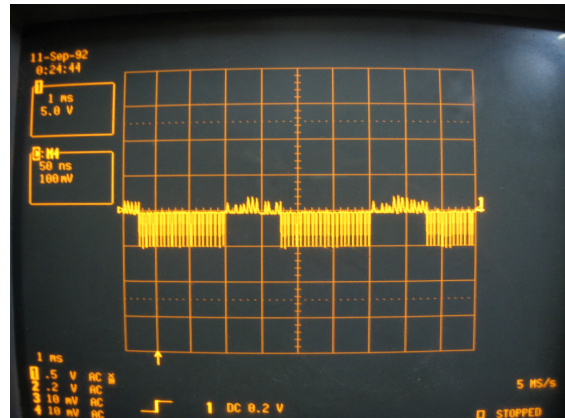


Figure 2. PWM signal (Phase A) for operating Linear Pulse Motor