NSSS Control System Design of Integral Reactor

Joon-Koo Lee, Heui-Youn Park, In-Soo Koo
Man Machine Interface System Development Department, Korea Atomic Energy Research Institute
jklee@kaeri.re.kr
P.O BOX 105, Yuseong, Daejeon, 305-600, Korea

1. Introduction

MMIS(Man Machine Interface System) of Integral reactor is composed of Control Room, Plant Protection System, Control System, Monitoring System which are related with overall plant operation.
MMIS is being developed with new design concept and digital technology to reduce Human Factor Error and improve the system safety, reliability and availability.
Fully digitalized system and design concept are introduced in NSSS control system.

2. NSSS Control Systems

2.1 Reactor Regulating System

Reactor Regulating System(RRS) forms closed control loop to regulate steam generator inlet temperature and reactivity with Control Element Drive Mechanism Control System together. Reactor Regulating System is designed to automatically reduce the temperature difference between steam generator inlet temperature and programmed reference temperature which is determined as function of current feed water flow rate within the temperature margin and also to reduce the power difference between neutron flux power and current feed water flow rate within the power margin. Overall configuration of Reactor Regulating System System is shown in Figure 1.
RRS algorithm for controlling the steam generator inlet temperature and reactivity generates power/temperature error signals and then CEA insertion, withdrawal, motion speed are determined by those error signals. CEA insertion, withdrawal, motion speed demand signal-generated from RRS -are transmitted to CEDMCS.

2.1.1 Main Coolant Pump Power Control System

There are two(2) MCPs vertically installed on the top annular cover of the RPV. Each MCP is an integral unit consisting of a canned asynchronous three phase motor and an axial-flow single-stage pump.
MCP Control equipment are SMPS(Switched Mode Power Supply) for modulating the frequency of power source. Power to MCP motor is controlled by the MCP control equipment.

2.2 CEDM Control System

Control Element Drive Mechanism Control System(CEDMCS) receives CEA insertion, withdrawal, motion speed demand signals from RRS, Prescram CS and CEDMCS can control six(6) CEA group or forty nine(49) CEA in the purpose of regulating a reactivity. Overall configuration of Reactor Regulating System System is shown in Figure 2. There are Regulating CEA group and Shutdown CEA group.
CEAs are moved with low speed or high speed when CEDMCS receives RRS motion demand signal or prescram motion demand signal respectively. CEDMCS shall be designed to accommodate the following CEA control mode.

1) Automatic Sequential
2) Manual Sequential
3) Manual Group
4) Manual Individual
5) Standby

CEDMCS is designed to accommodate following interlock signals. These interlock signals prevent CEA from excessing travel distance and enable CEDMCS to do harmonical operation with Reactor Coolant System during a transient and abnormal condition.

1) CEA Withdrawal Prohibit(CWP)
2) Automatic Withdrawal Prohibit(AWP)
3) Automatic Motion Inhibit(AMI)
4) CEA Upper Limit Switch(ULS)
5) CEA Lower Limit Switch(LLS)
6) CEA Quick Upper Limit Switch(QULS)
7) CEA Quick Lower Limit Switch(QLLS)

2.2.1 CEDM Power Control System

Function of CEDM Power Control Equipment is to provide a modulated/varied .voltage source for stepping

motors which move CEAs up or down. There are total forty nine(49) CEDM Power Control equipment which receive CEA motion signals from CEDMCS. CEDM Power Control equipment are SMPS(Switched Mode Power Supply) for modulating/varying the frequency/the amplitude of the voltage source.

2.3 Reactor Power Cutback Control System

Function of Reactor Power Cutback Control System is to enable Integral Reactor to operate normally in spite of main component malfunction. Reactor Power Cutback Control System is automatically initiated by failure signal of MCP or Main Feed Water Pump without actuation of safety class equipment. Feed water reduction demand signal is transmitted to FWCS and FWCS reduces total feed water flow rate.

2.4 Pre-scram Control System

Pre-scram control system is initiated when instrumentation and control variables reach the set-point. As soon as the generated pre-scram signal is transmitted to CEDMCS, CEAs are inserted quickly by CEDMCS. If the instrumentation and control variables return normal value, pre-scram function is finished.

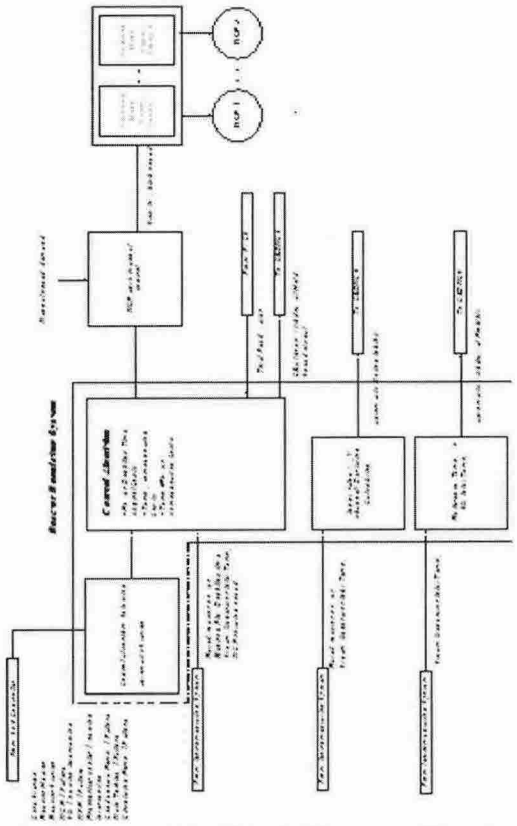

Figure 1. Simplified Block Diagram of Reactor Regulating system

3. Conclusion

MMIS was being developed with new design concept and digital technology to reduce Human Factor Error and improve the system safety, reliability and availability.

NSSS control system is composed of RRS, CEDMCS, RPCS, PrescramCS and other component control system. Each control system was designed with fully digital equipment which were composed of Micro-processor board, memory card, network interface card, system bus and etc.

REFERENCES

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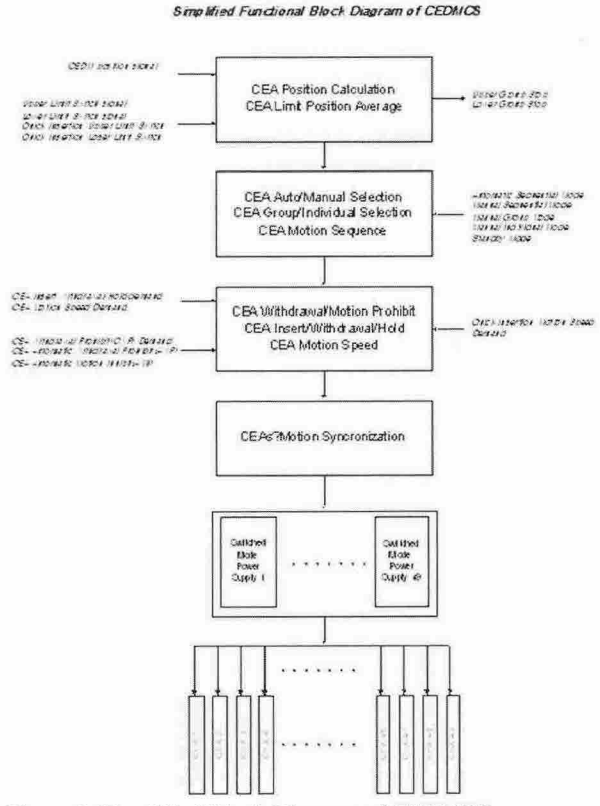

Figure 2. Simplified Block Diagram of CEDMCS.