# A Feasibility Study to Prevent Unnecessary CEA Movement due to RCS Hot-leg Thermal Stratification

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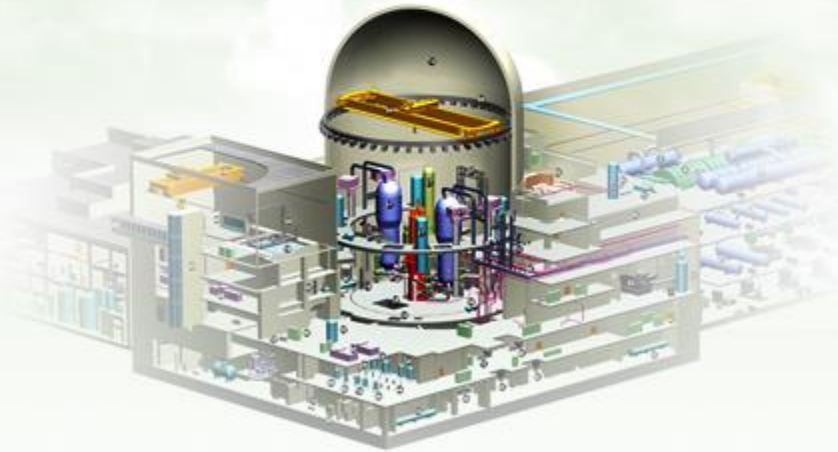

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# Contents

# Introduction



## - Reason

- Low Leakage Loading Pattern in OPR1000
- Power Deviation between Inner and Outer Parts of Reactor Core
- Thermal Stratification
- Reactor Coolant System (RCS) Hot-legTemperature Hunting Phenomenon

## - Solution

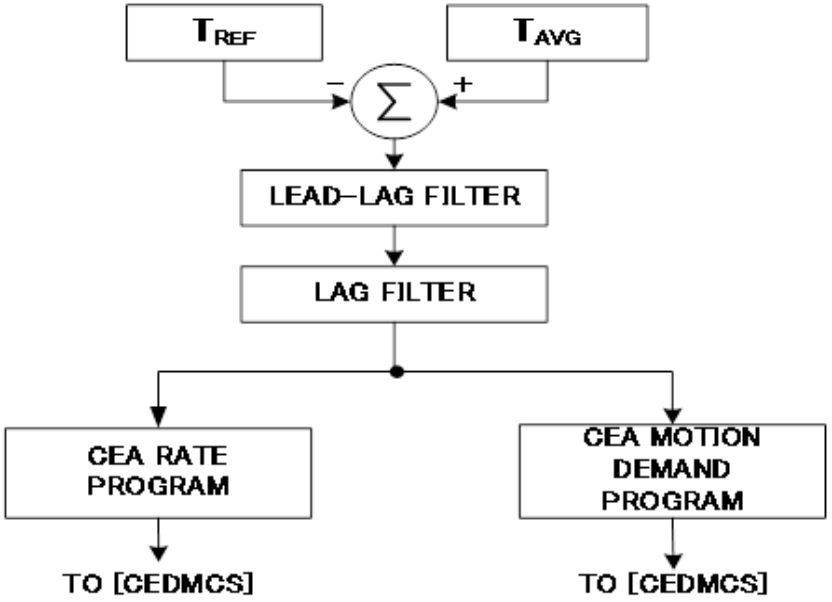
- Sensitivity Study by Adjusting Control System Constant
- Feasibility Study on Adjusted Constant

# Control Function of RRS



## - Reactor Regulating System (RRS)

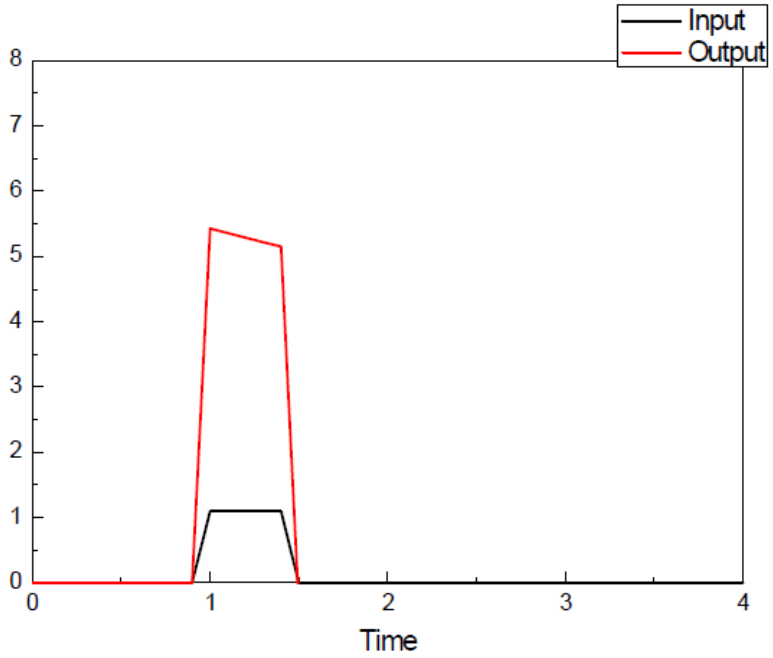
- Control the Control Element Assembly (CEA) Movements to Maintain the Average Coolant Temperature ($T_{AVG}$) Matching with Reference Temperature ($T_{REF}$)
- Compensation of Temperature Deviation to Adjust Performance by Changing Time Constant

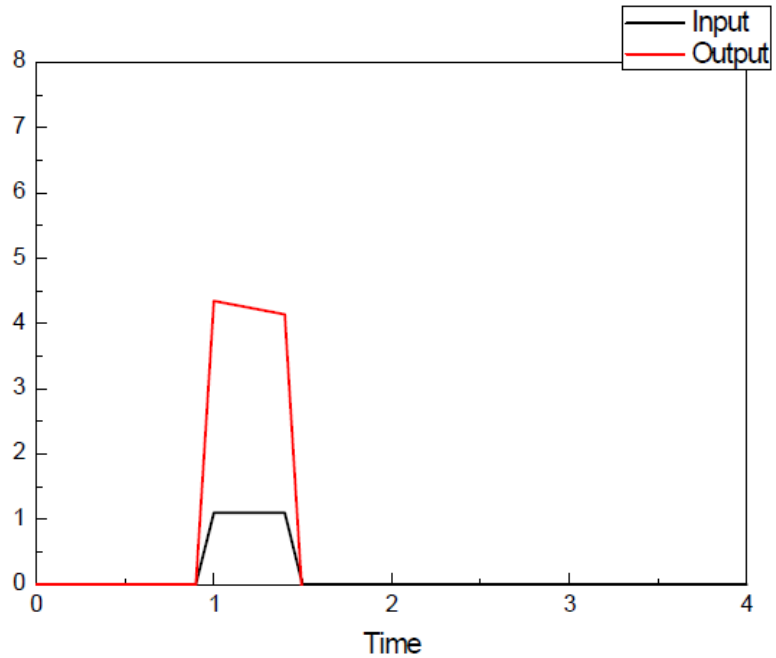


# Control Function of RRS



- RRS Time Constant Change




Prevent Unnecessary CEA Movement
by
Lead Time Constant Change

## - Method

- KEPCO E&C Integrated System Performance Analysis Code (KISPAC)

## - Initial Condition & Assumption

- Reactor Power : Full Power
- Maximum Temperature Deviation : 2.53 ℃
- Burnup Compensation : 10%
- RCS Cold-leg Temperature : Constant

## - Hunting Simulation

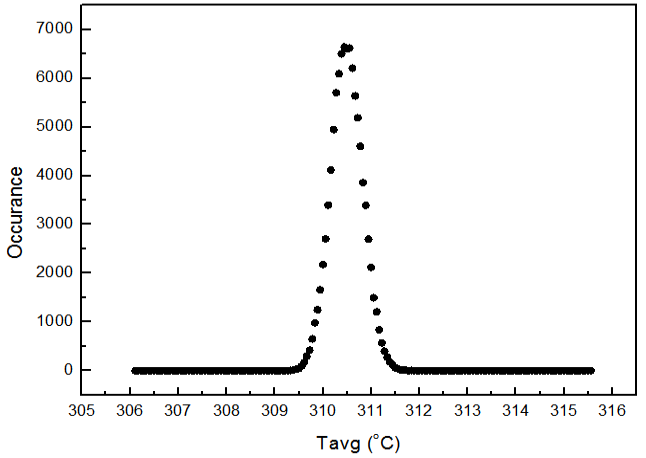
Gaussian Random Number

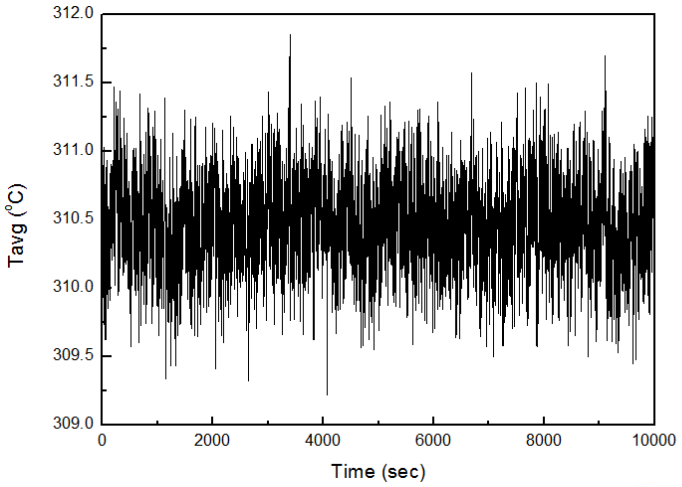
↓

Add to $T_{AVG}$

↓

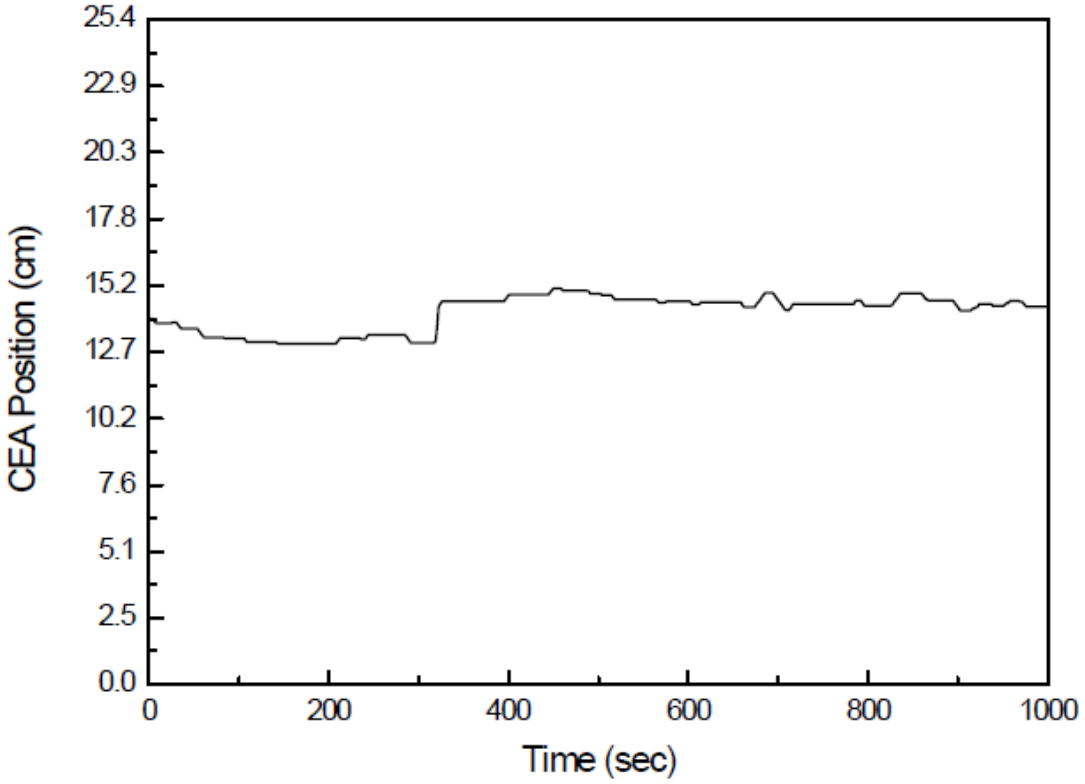
$T_{AVG}$ Hunting



## - Hunting Simulation

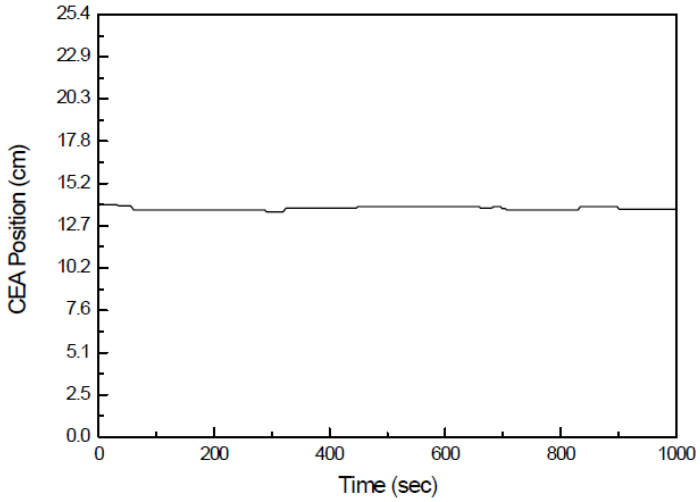
- Unnecessary CEA Movement with Hunting Simulation



# - Determination of Time Constant

- Sensitivity Study on Lead Time Constant

| Case | T1t | Max Amplitude of CEA Movement (cm) | Remark |
|---|---|---|---|
| 01 | 30 | 4.52 | Present |
| 02 | 28 | 4.29 | |
| 03 | 26 | 3.94 | |
| 04 | 25 | 3.02 | |
| 05 | 24 | 3.15 | Optimized |
| 06 | 22 | 2.44 | |
| 07 | 20 | 2.01 | |
| 08 | 18 | 1.60 | Minimum |




Minimum Case

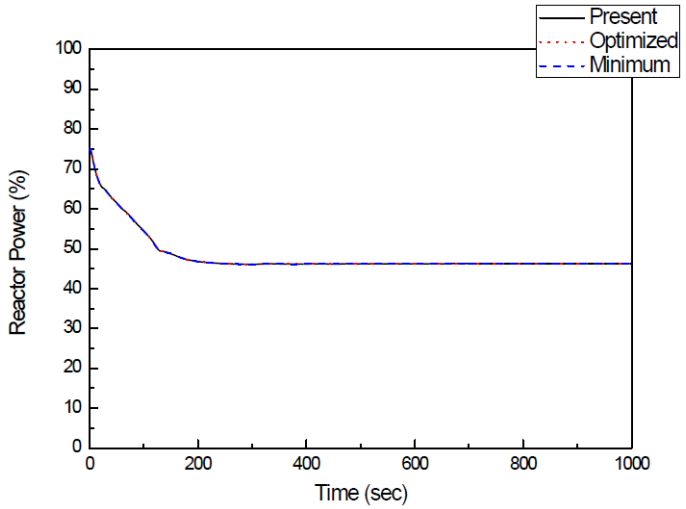
## - Feasibility Study on Time Constant Adjustment

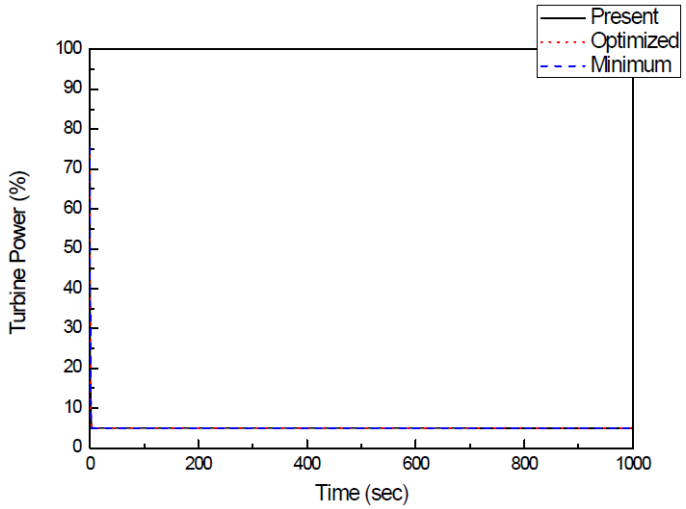
- Effect on the Response of CEA Movement
- The Most Limiting Performance Related Transient Events Analysis
  - ✓ Load Rejection at 75% Power
  - ✓ Loss of a Main Feedwater Pump at 100% Power
- Three (3) cases study
  - ✓ Present
  - ✓ Optimized
  - ✓ Minimum

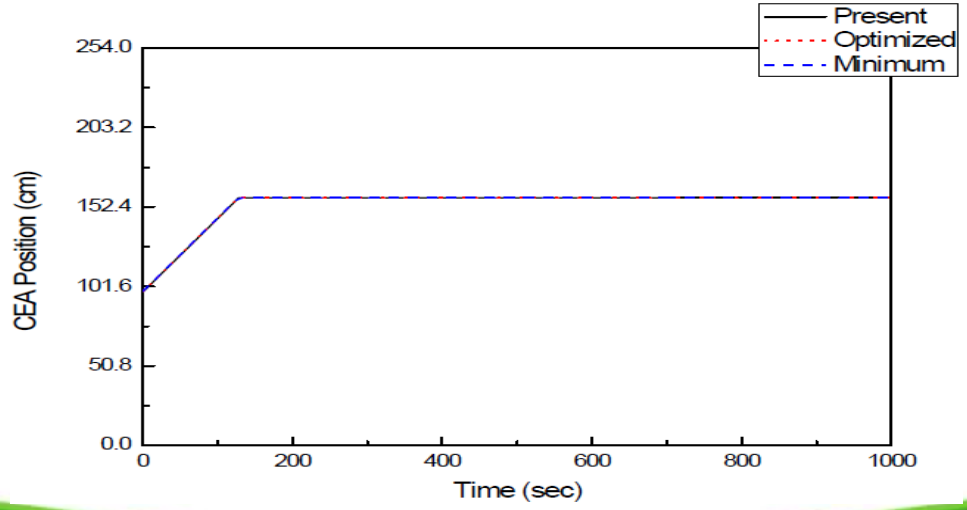
# Transient Analysis



- Load Rejection at 75% Power



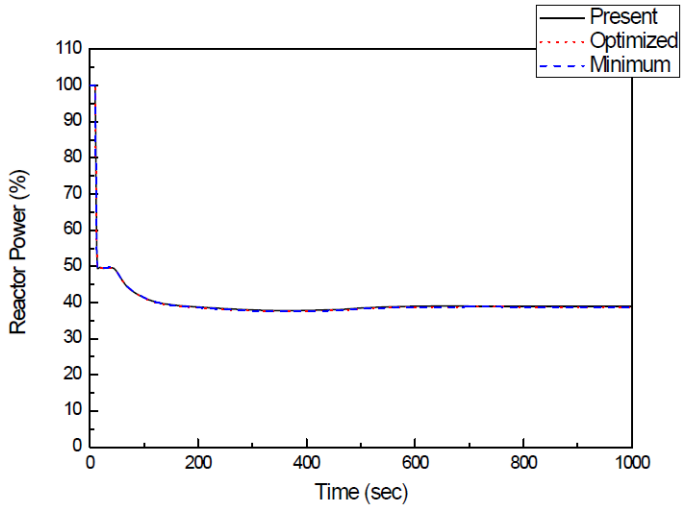



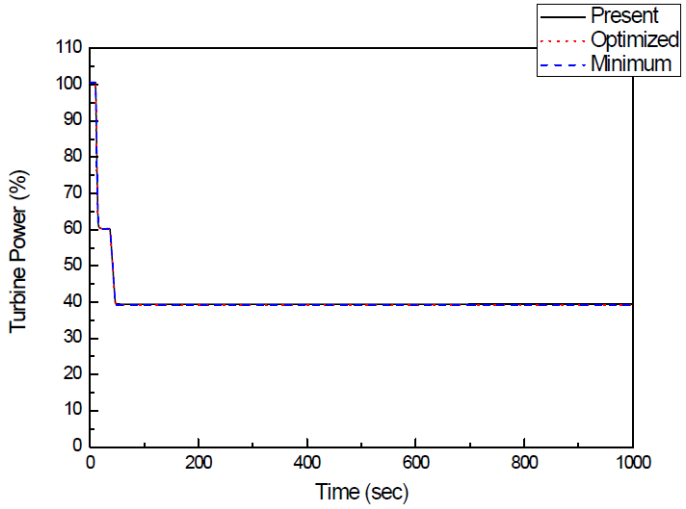



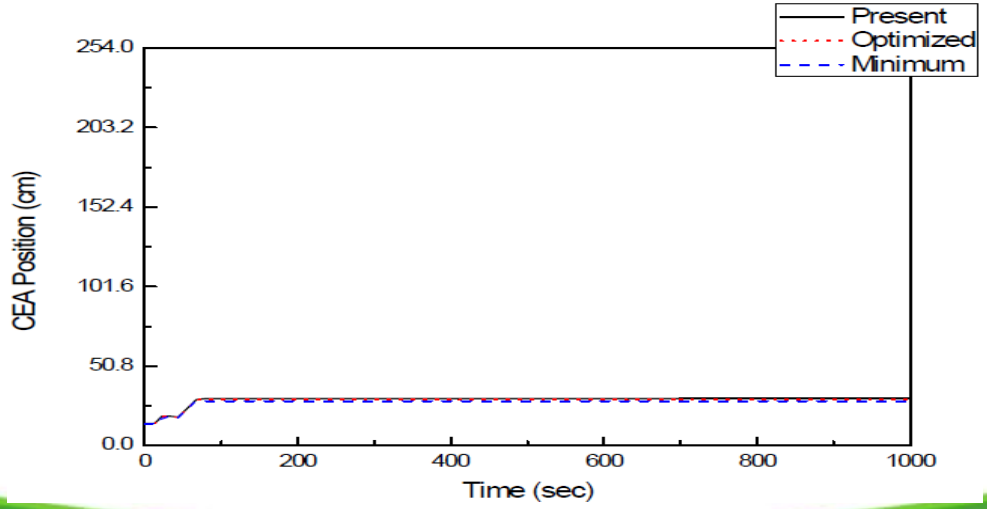
# Transient Analysis



- Loss of a Main Feedwater Pump at 100% Power



# Conclusion



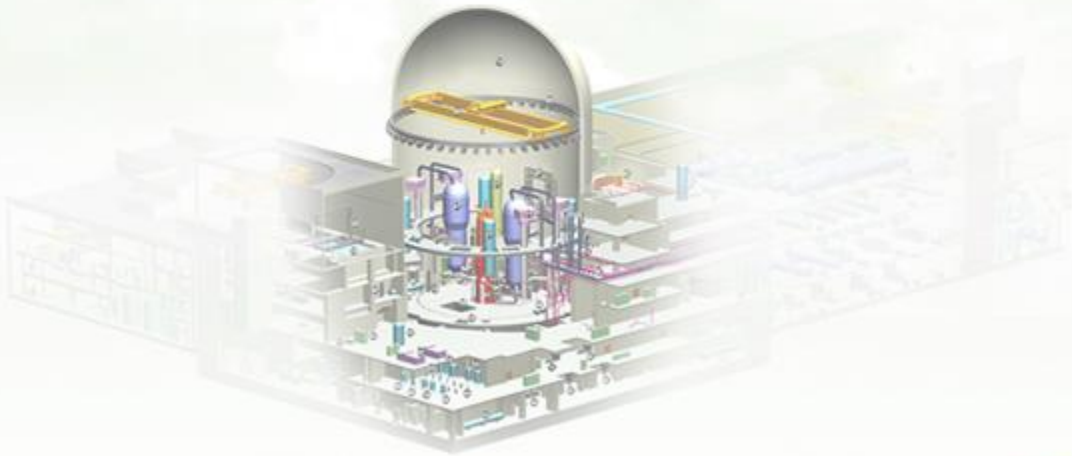
- Unnecessary CEA Movement due to Thermal Stratification

- Sensitivity Study of Lead Time Constant in RRS

- Feasibility Study for Response of CEA

**Unnecessary CEA Movement Can be Prevented with Acceptable Performance by Changing Lead Time Constant in RRS**

# *Thank You!*



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