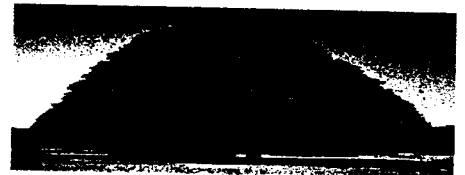


# SRNM Cable DEVELOPMENT

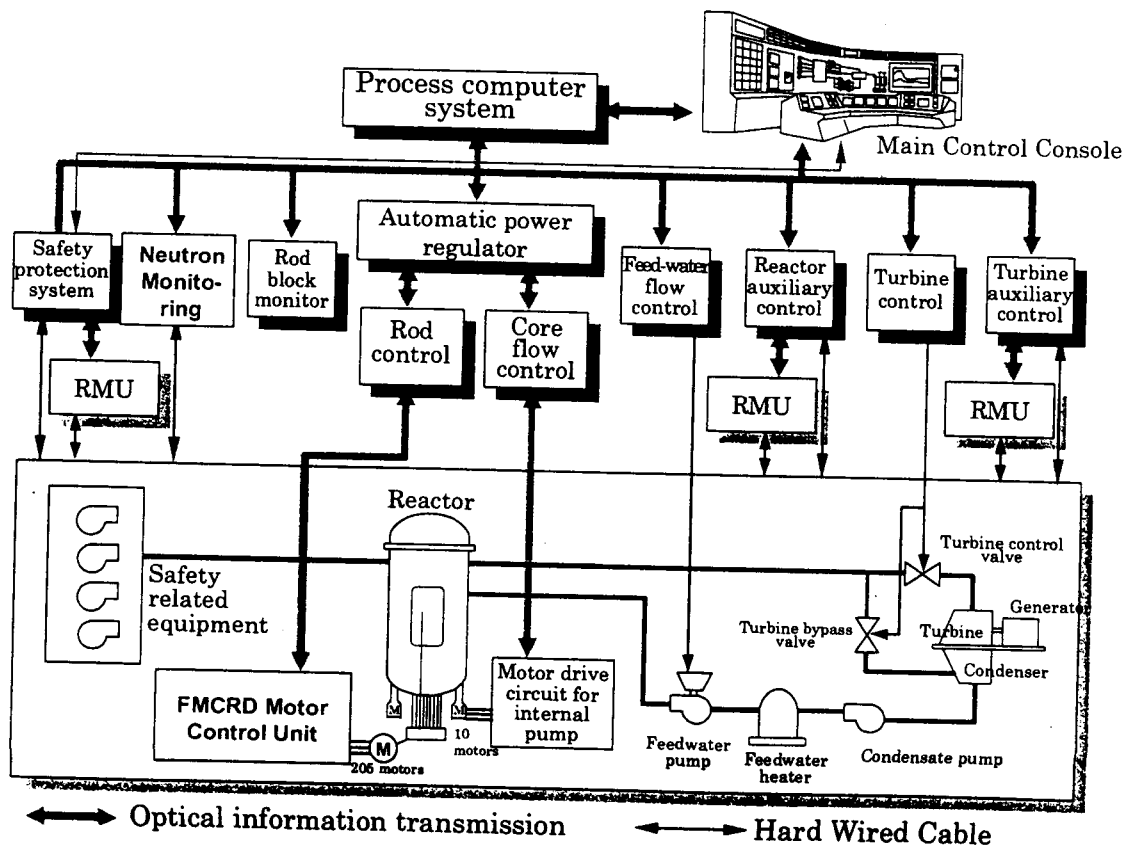
**HITACHI** Inspire the Next



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## ABWR Control and Monitoring System

Page-2

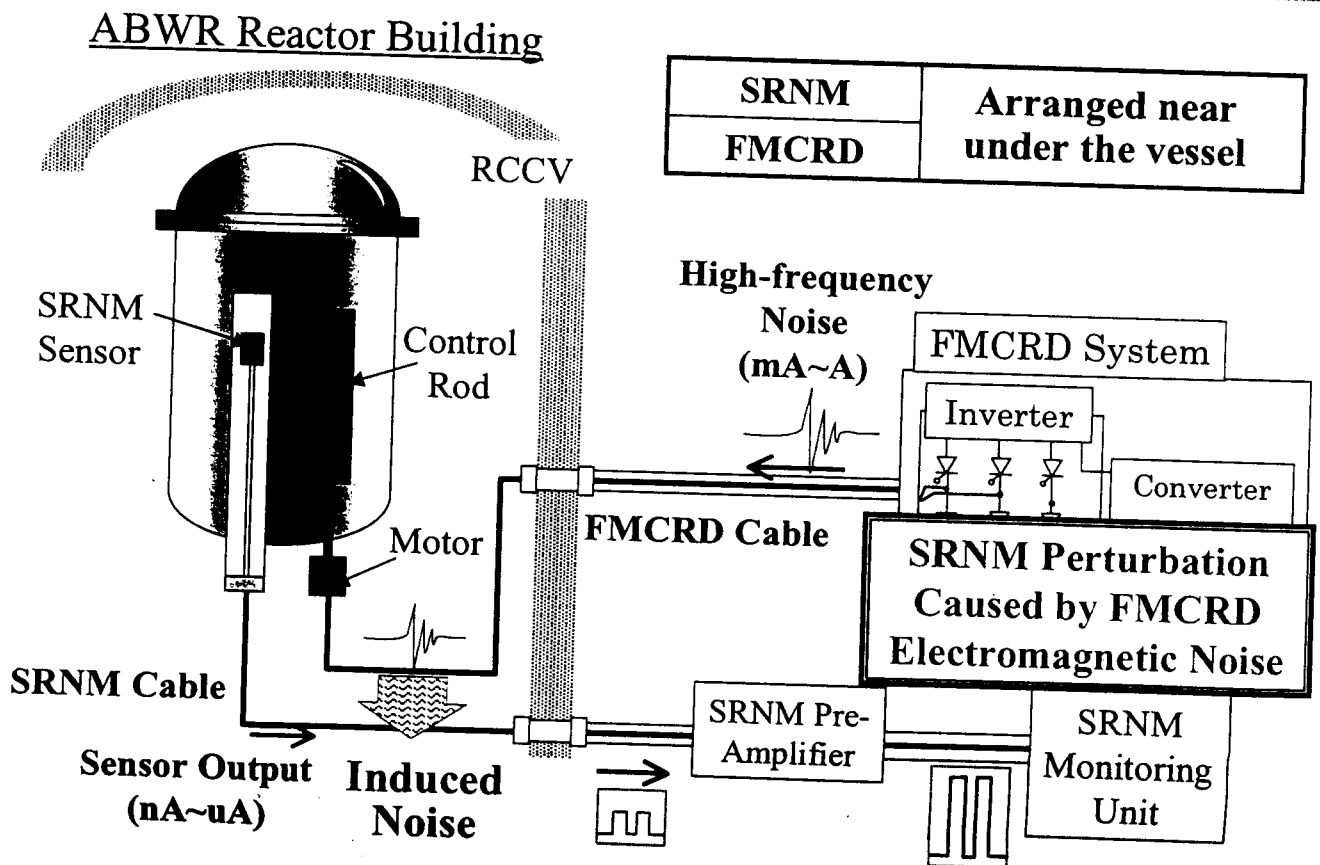


*SRNM and FMCRD both aim to attain high system reliability. Each system have the following features.*

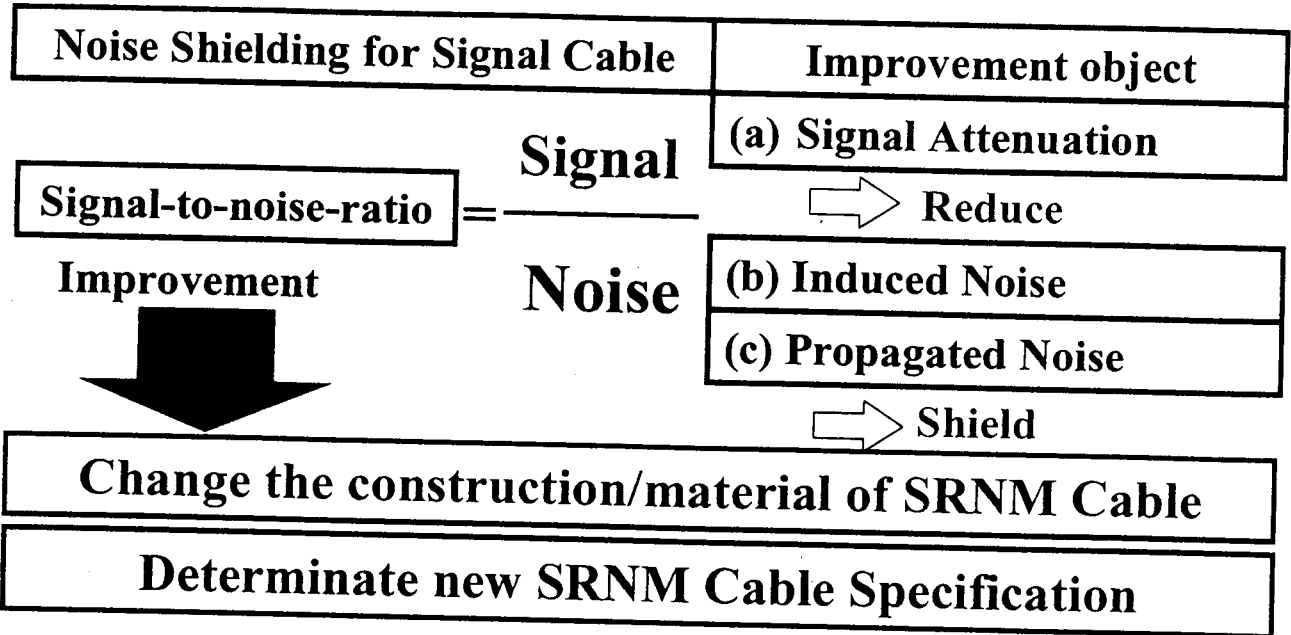
1. SRNM is very sensitive to the High Frequency noise.
  - Transmit the very feeble current. ( $nA \sim \mu A$ )
  - Have long wiring from sensor to monitoring unit.
  - Have amplifier to amplify the sensor output.
2. FMCRD produce the electromagnetic noise.
  - Motor controlled by inverter.
  - FMCRD cable transmits the inverter noise.
3. SRNM and FMCRD arranged very near under the vessel.

➔ It is necessary to consider the effective noise shielding method.

Noise Considering in ABWR



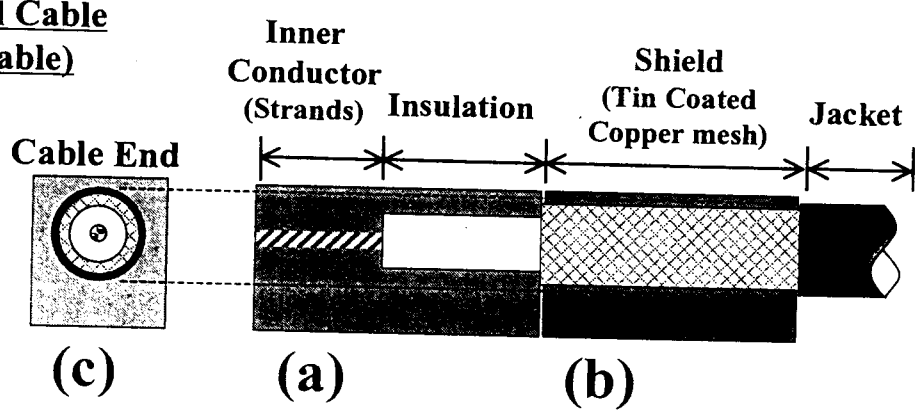




**Target Efficiency**

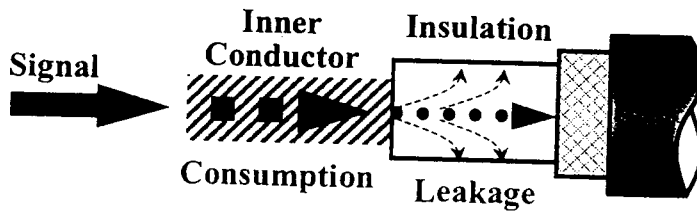
- **50% Reduction** of Noise Level Compared with Existing Cable.
- **Elimination** of the installation work/cost for Shielding-tube.

**SRNM Signal Cable (Existing Cable)**



	Improvement object	Targeted Structure	Development
(a)	Signal Attenuation	(1) Inner Conductor (2) Insulation	(1) Reduce Conductor Resistance (2) Reduce Insulation Permittivity
(b)	Induced Noise	Shield	Increase Shielding Coverage
(c)	Propagated Noise	Cable End	Add Noise Reduction Route within the Cable.

## (a) Signal Attenuation



Signal Attenuation

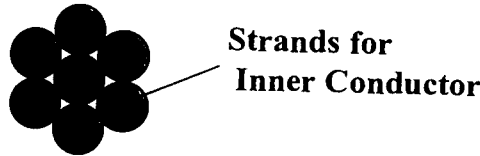
(1) Signal Consumption

+ By Conductor resistance

(2) Signal Leakage

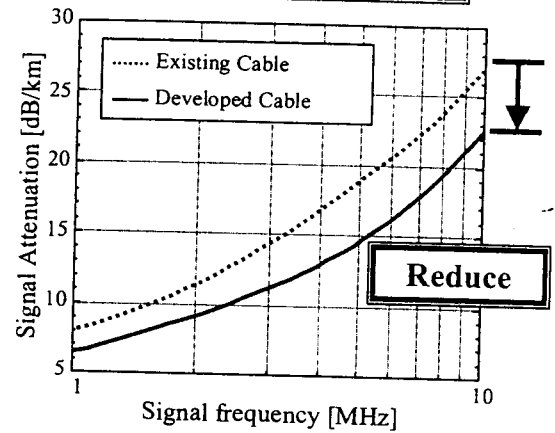
From Insulation

- (1) Signal Consumption reduction  
⇒ Number of Strands are changed



- (2) Signal Leakage reduction  
⇒ Insulation material is changed

Effect of Changes

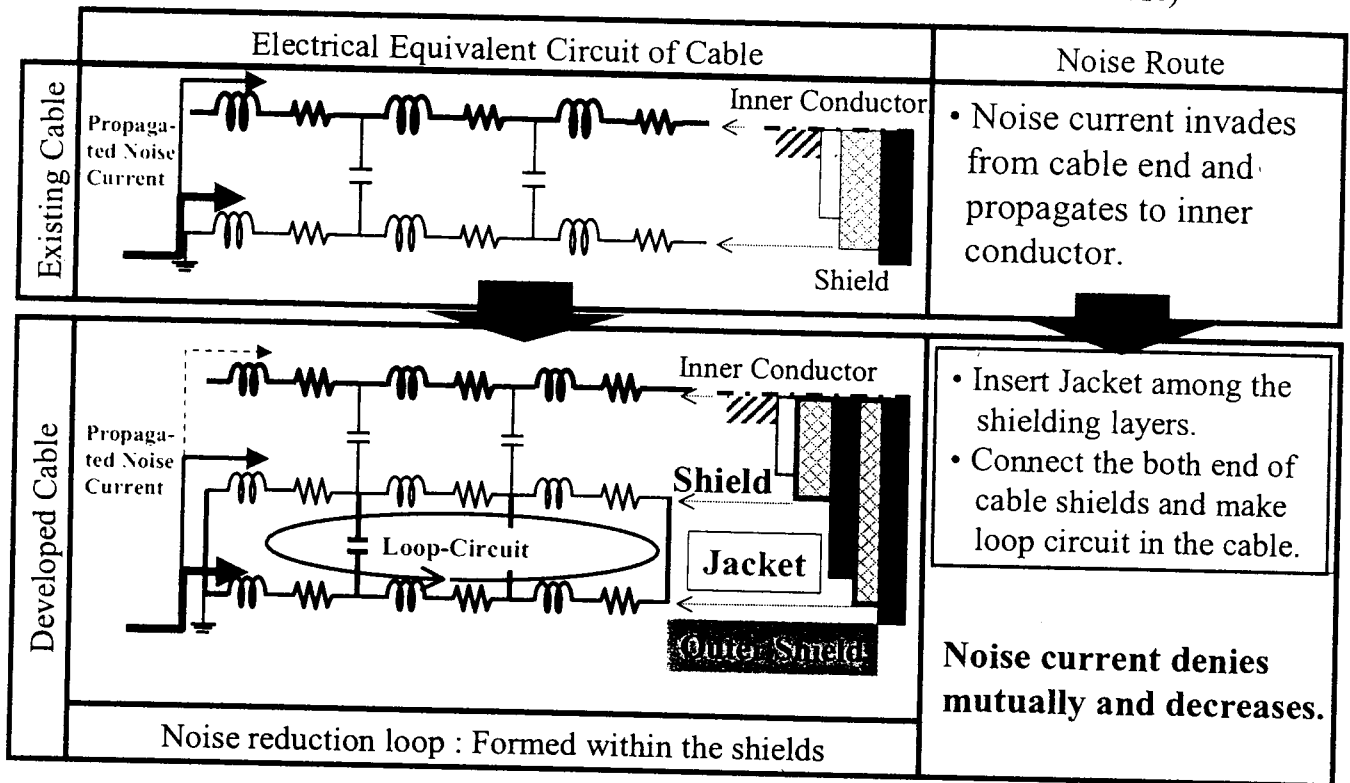


## (b) Induced Noise

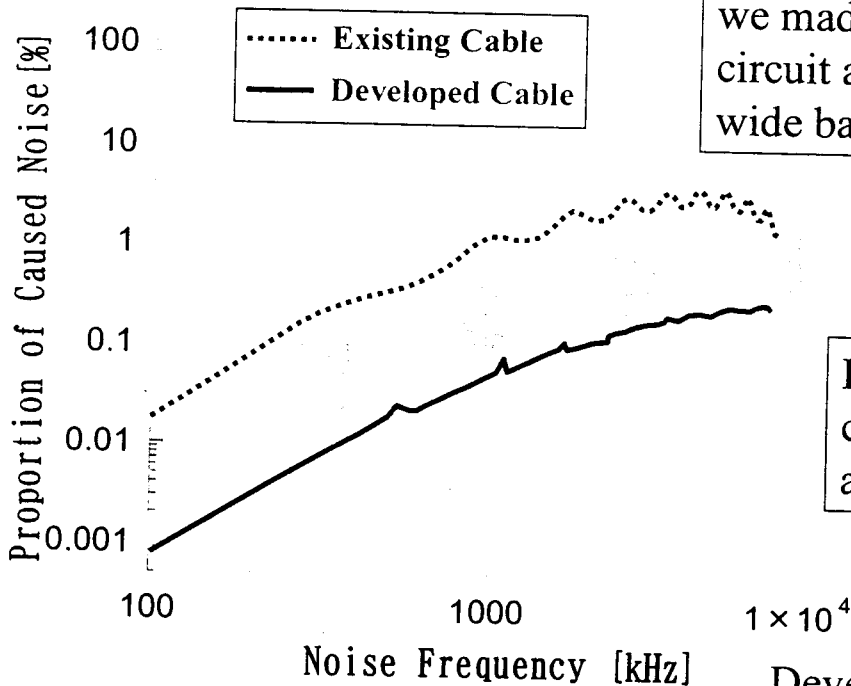
### Shielding Construction

Existing Cable	Ideal Construction	Developing Cable
Induced Noise ⚡ 	Induced Noise ⚡ Metal Pipe	Induced Noise ⚡ 
90% Optical Covered  Electromagnetic Noise can through the opening of shielding braid	Metal Pipe * 100% Optical Coverage * Noise Absorption High Efficiency for Noise Shielding	Increased Optical Coverage Adapted Covering Tape Increased layers High Efficiency for Noise Shielding
	Cable cannot bend under the vessel Installation work is impossible	No Difficulty of Cable Bending. No difficulty for Installation work

## (c) Propagated Noise (Add Noise Reduction Route within the Cable)



## Simulation about the wide band Noise Frequency



For Existing/Developed cable, we made electrical equivalent circuit and evaluated about the wide band noise frequency.

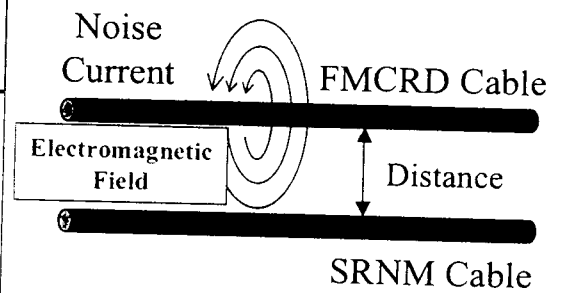
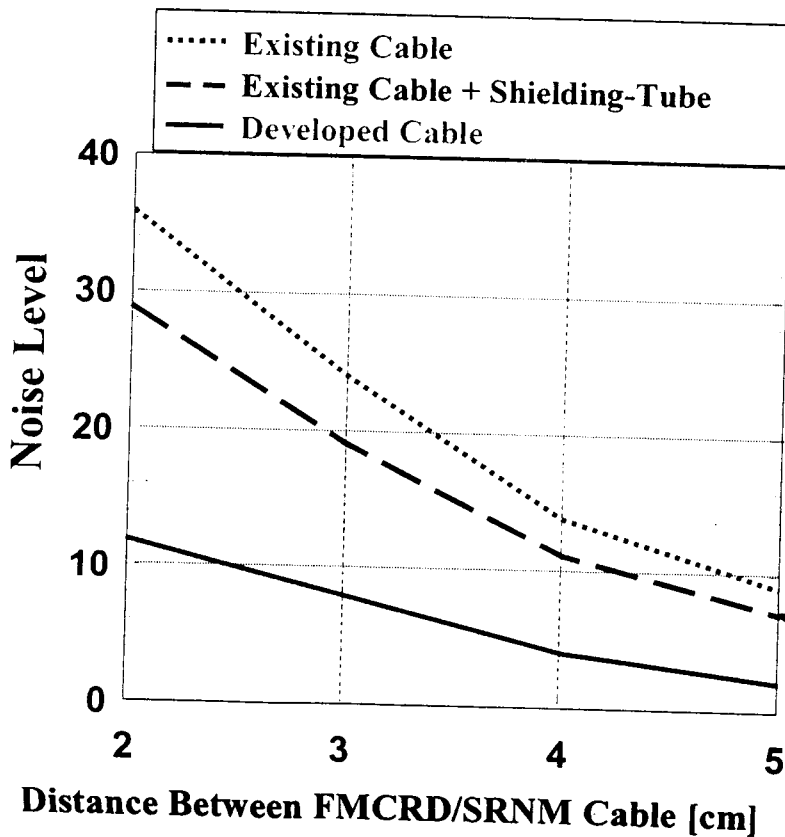
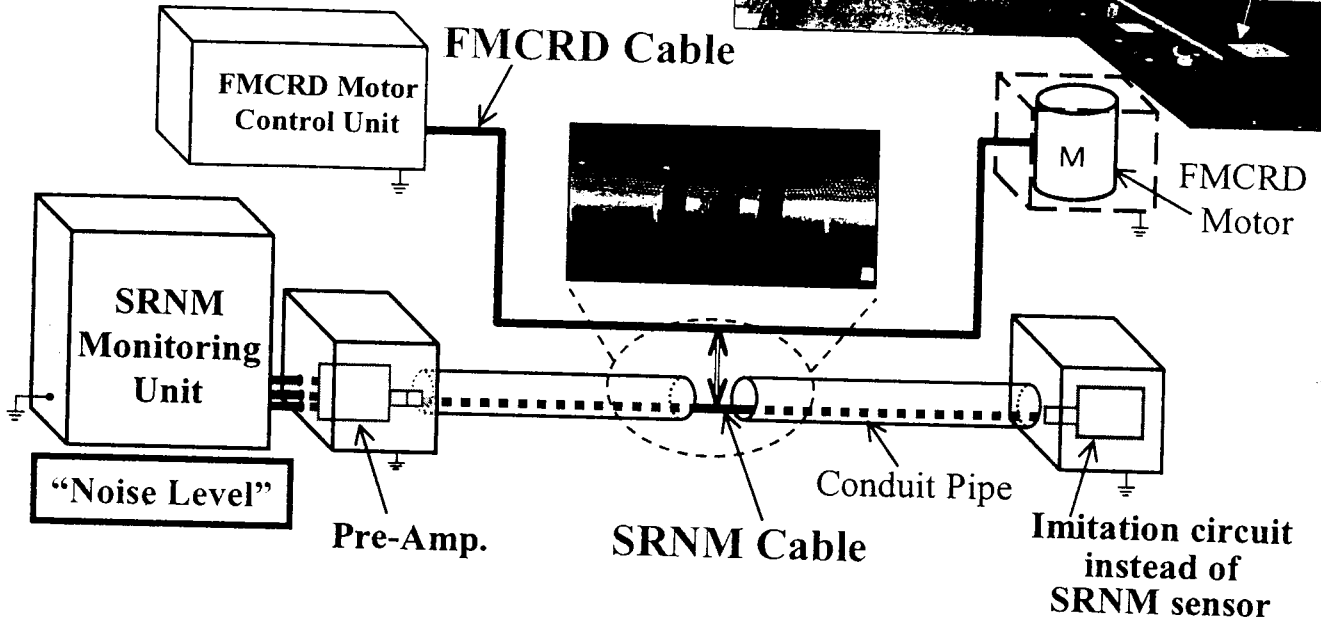
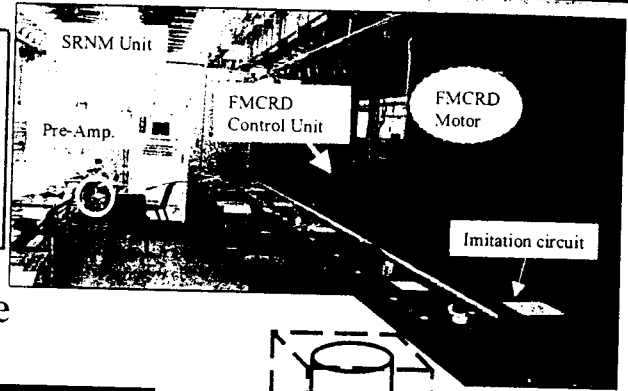
From 100kHz to 10MHz, caused noise is reduced at Developed Cable.



Developed Cable is effective for wide band frequency.

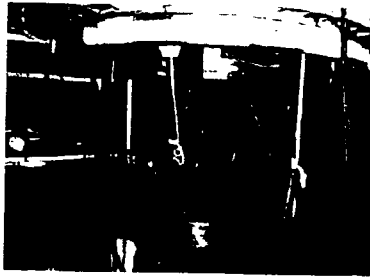
Noise level is measured at the following situation

- Changing the distance between cables
- Changing the SRNM Cable (Old/New)



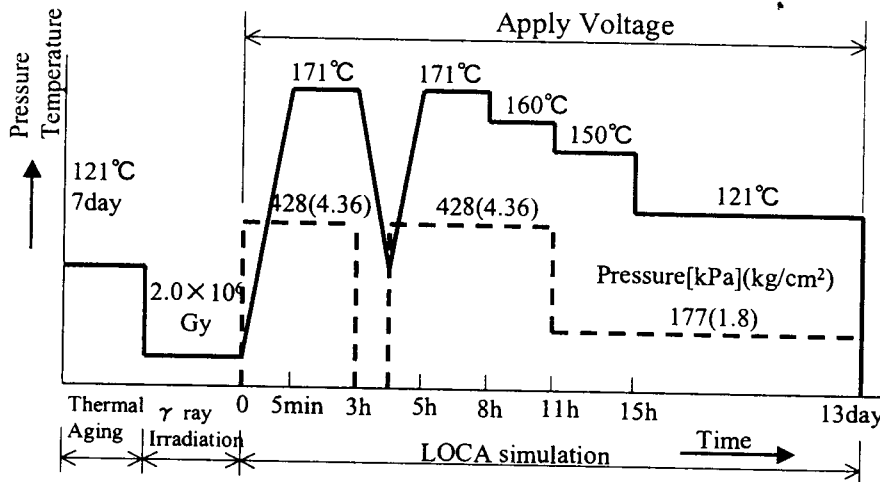
Noise Level Decreases With Increased Distance Between Cables.

Effect of Shielding-tube is Noise Level reduce from Existing Cable



In Accordance with IEEE-383, we evaluated the thermal and radiation resistance of Developed Cable.

After thermal aging test and irradiation test (equal to 40 years life), Developed Cable was tested under the environment simulated LOCA.



under the environment simulated LOCA.



All tests were cleared.

Developed Cable is regarded as Class 1E.

## Conclusion

*Compare with existing SRNM cables, New cable developed by Hitachi has advantages as follows;*

1. *Signal Attenuation reduction;  
Prevent the reduction of SRNM signal.*
2. *Noise shielding;  
Keep high shielding performance in the wide band noise frequency and various type of noise route.*
3. *Shielding-tube is reduced.*

*This cable can be used as Class 1E.*

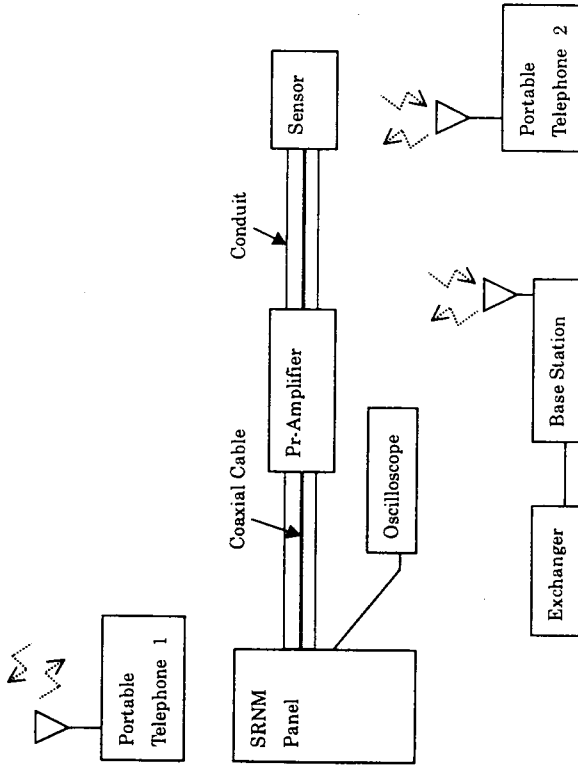
**➡ This cable can be used in BWR3,4,5 and ABWR.**



Noise Test for SRNM\* from Portable Wireless Telephone System  
\*SRNM...Start-up Range Neutron Monitor

- 1. Portable Wireless Telephone:  
Output Power...10mW  
Output Frequency Band...1.9GHz

2. Test Configuration (in factory)



3. Operation of Telephone System

- (1) Exchanger is started up
- (2) Portable Telephone 1 and 2 are started up.
- (3) Portable Telephone 1 and 2 are operated (called and spoken each other).
- (4) Portable Telephone 1 and 2 are shut down.
- (5) Exchanger is shut down.

4. Test Method

- (1) Portable Telephone 1 is close to boards and relays in SRNM Panel (front door or back door is opened) by about 10cm with operating telephone system (above No. 3 (1)-(5)). Portable telephone 2 is located around test equipments.
- (2) Portable Telephone 1 is close to exposed Coaxial Cable between Senior and Pr-Amplifier with operating telephone system (above No. 3 (1)-(5)). Portable telephone 2 is located around test equipments.
- (3) Base station is located by 10~15 cm under Coaxial Cable between Sensor and Pre-amplifier with operating telephone system (above No. 3 (1)-(5)). Portable telephone 2 is located around test equipments.

5. Result

Typical noises by Wireless Telephone system do not appear in SRNM

## Electro-Magnetic Interferences in Plant

Hitachi has experienced Hitachi-made DCS in commercially operated nuclear plants more than 30 years and has been learning lessons about EMI subject which has been gradually critical for both of new construction and refurbishment:

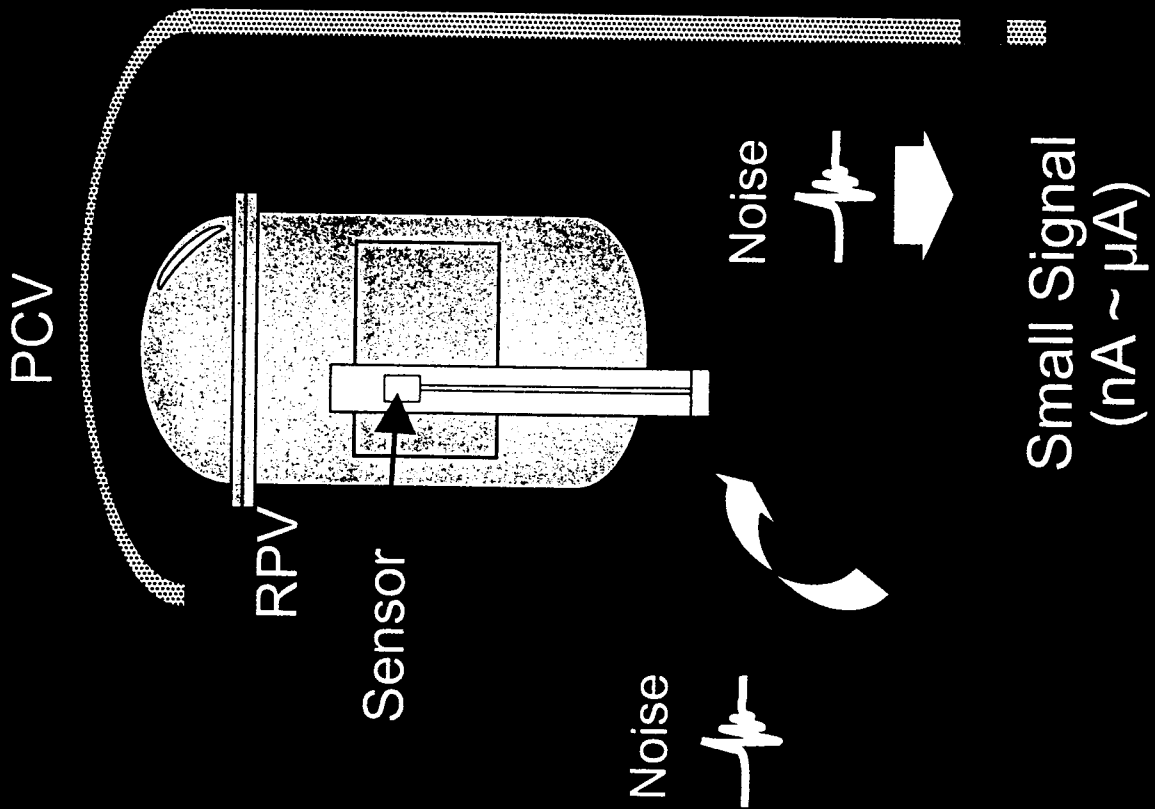
### To Enhance Immunity of Digital Controllers

- Noise from Existing Plant Equipment  
[e.g. Motor Control Drivers, Switching Devices]
- Noise from Other Digital Systems

### To Reduce Emission from Digital Systems

- Influences on Small Signal Processing Systems  
[e.g. Neutron Monitoring System]
- Influences on Other Digital Controllers

# Influences on Neutron Monitoring System



## Subject

Noise Induction to Small Signal Portion  
(from sensor to pre-amplifier)

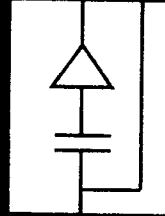
## Noise Source

FMCRD, Motor Valve, Inverter, etc

## Coupling Mechanism

- Electro-Magnetic Coupling
- Capacitive Coupling
- Radiation

Pre-Amplifier



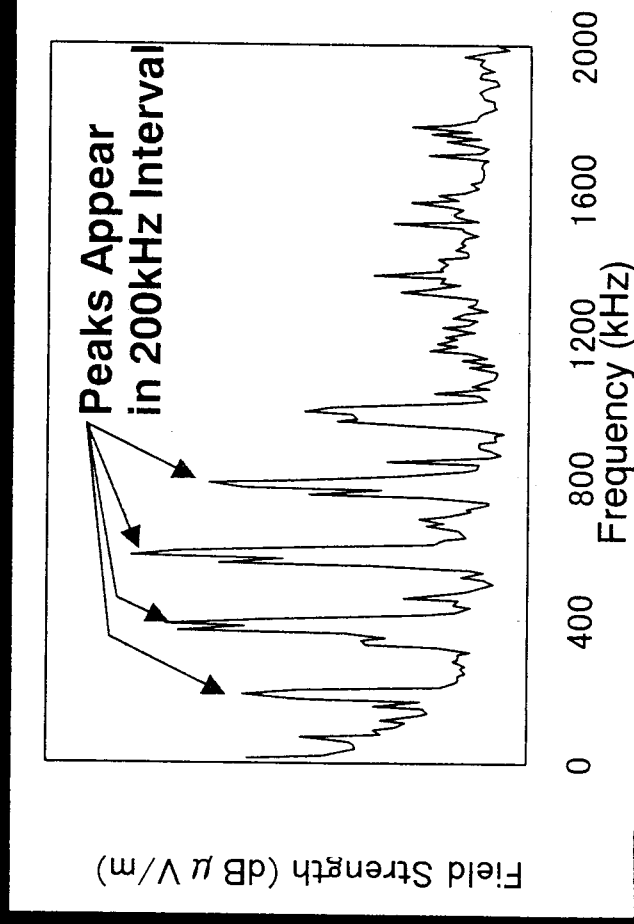
Signal  
Processing  
Unit

( Large Gain:  $10^3 - 10^4$  )

# Electro-Magnetic Noise in existing BWR Plant

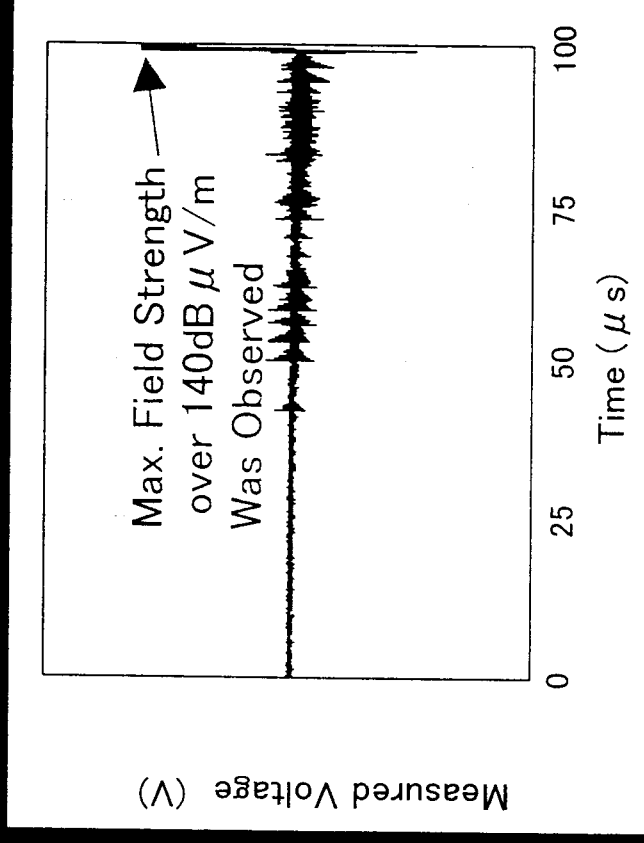
**Conspicuous Peaks  
in Background Noise**

**[ Inverters or Digital Equipments  
may cause these specific noise ]**



**Fig.1 Electro-Magnetic Noise Measured at Reactor Pedestal ( Ordinary Observed in Maintenance Period)**

**Strong Electro-Magnetic  
Noise Was Observed  
When Specific Motor  
Valve Operated**



**Fig.2 Instantaneous Noise Caused by Specific Motor Valve Operation**

# Noise Induction from Motor Driven Equipment to Neutron Monitoring System

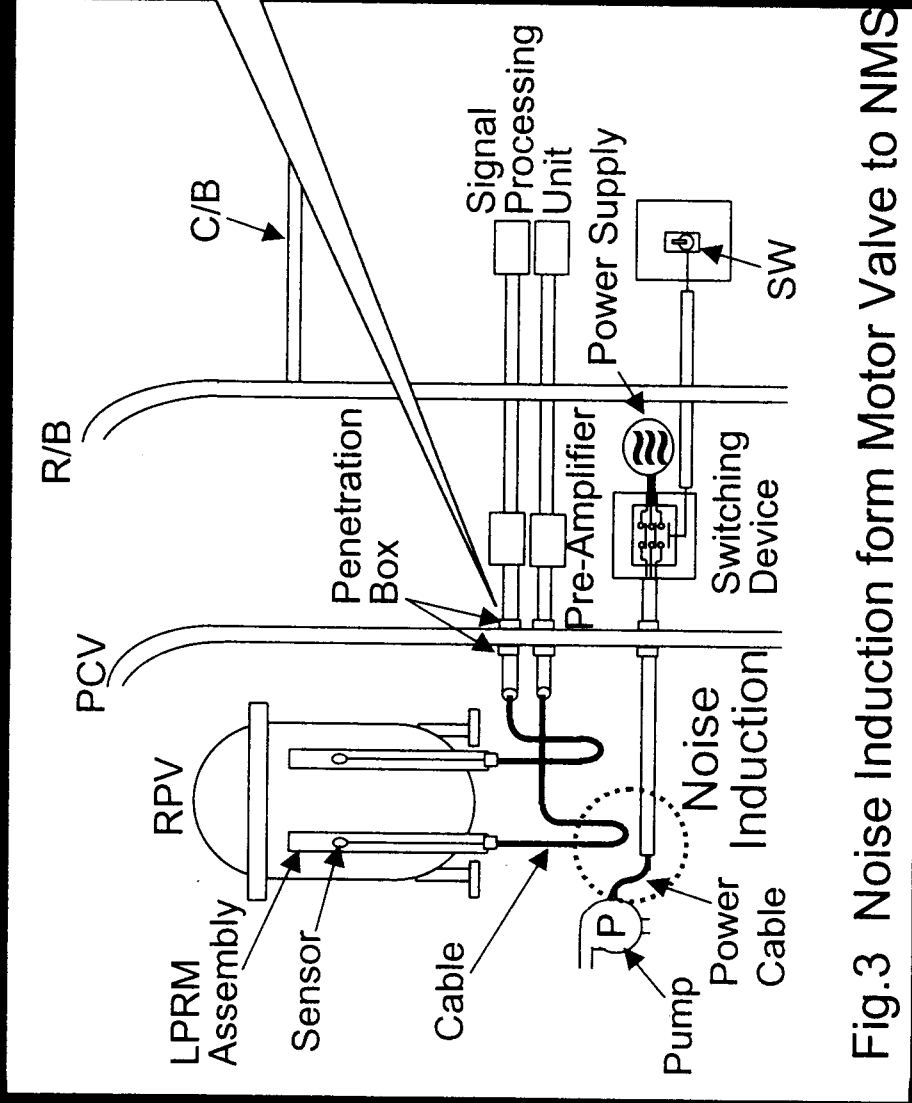


Fig.3 Noise Induction from Motor Valve to NMS

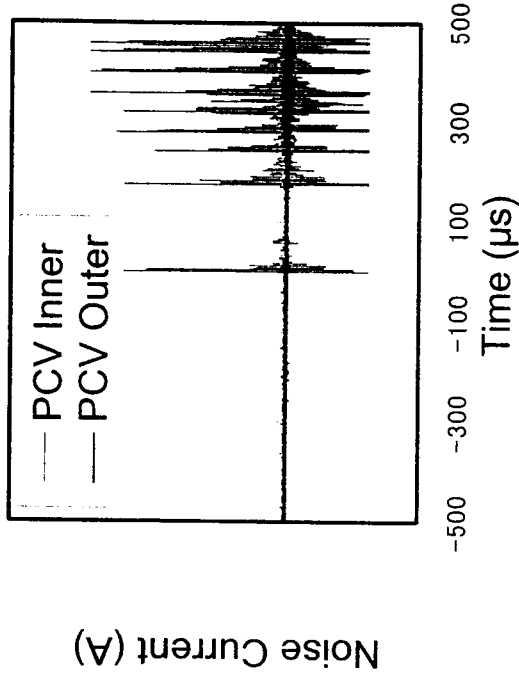
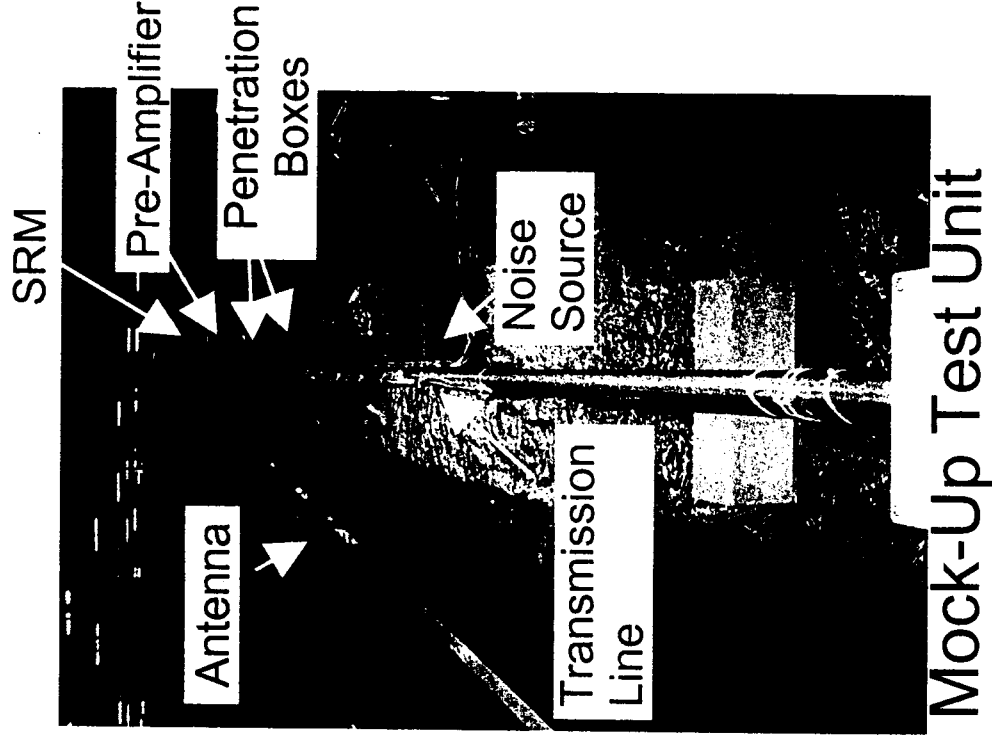


Fig. Noise Current Induced on NMS Penetration Box.

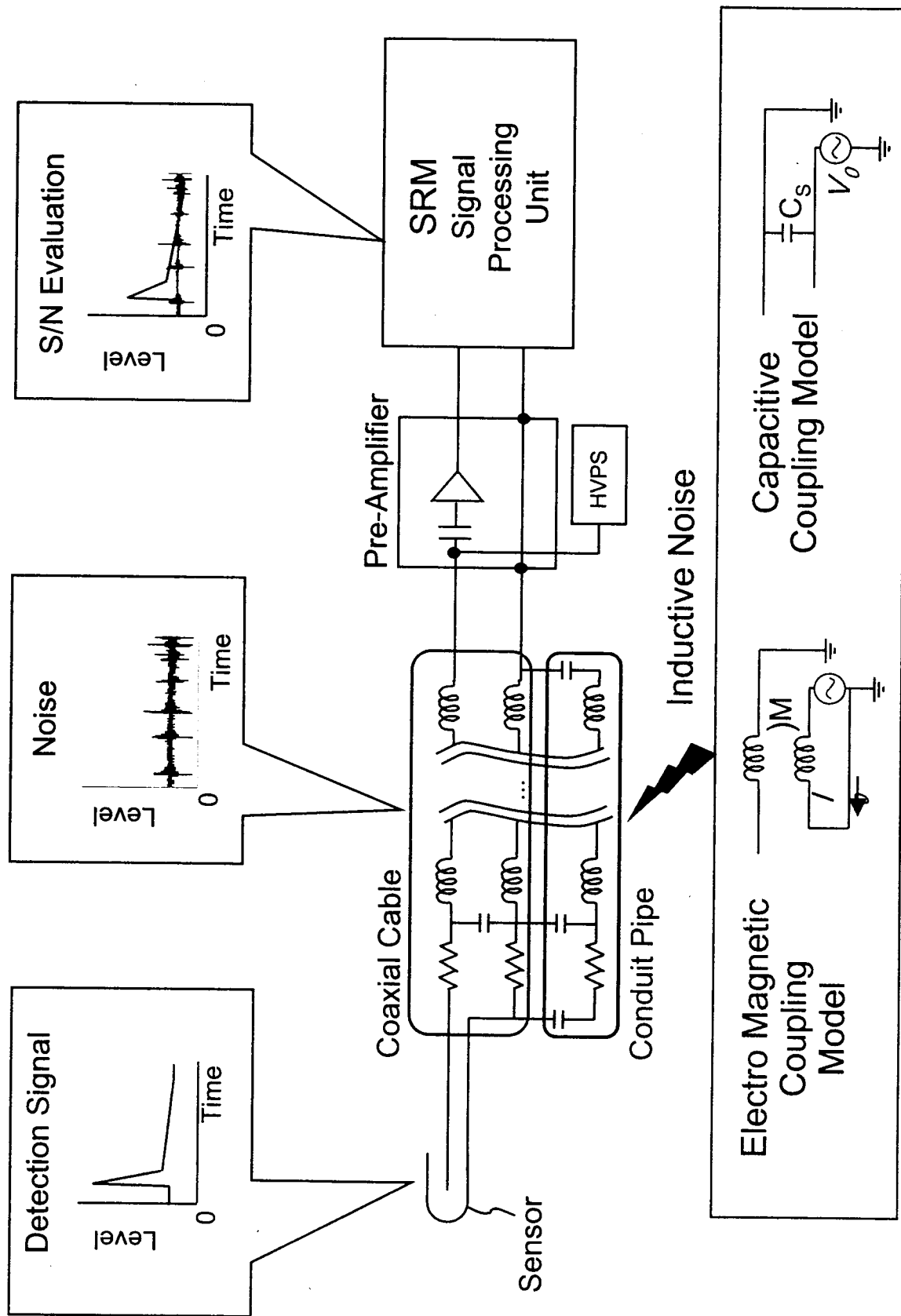
# Noise Evaluation

## Evaluation of Noise Affection

- Measurement of Noise Strength and Indication Level of SRM
- Evaluation of Noise Level to Disturbing Indication of SRM  
→ More than 140dB $\mu$ V/m
- Reflection of Results in Simulation Model



# Simulation Model

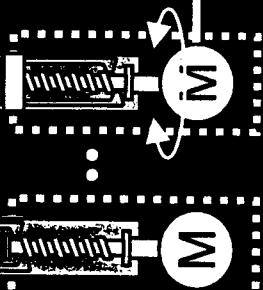
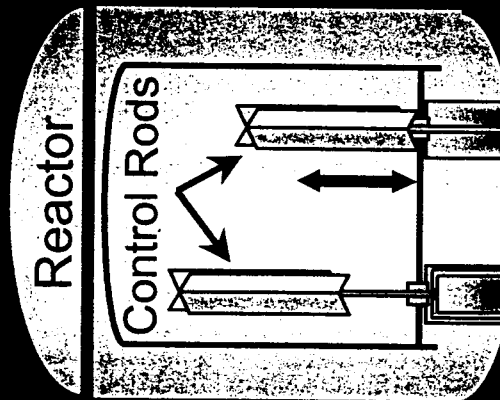
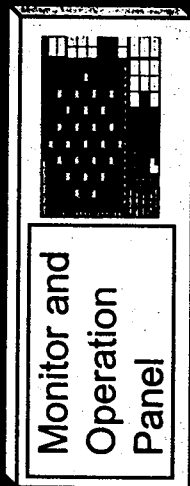


**HITACHI**  
Inspire the Next

# Rod Control and Information System (RC&IS) for ABWR

- Automation of Rod Control with APR and Shortening of Plant Start-up Time
- Reduction of Occupation Space

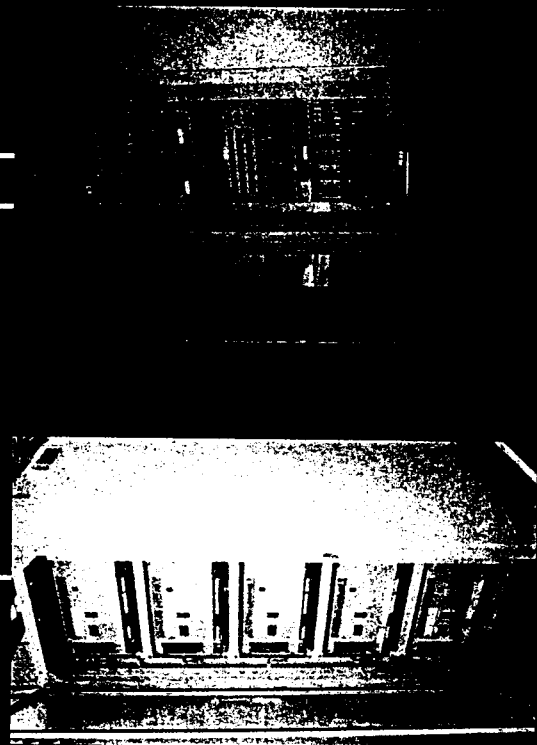
Control Console



205 Motors

Inverter Panel  
( 24 Panels )

Data Transmission Panel  
( 24 Panels )



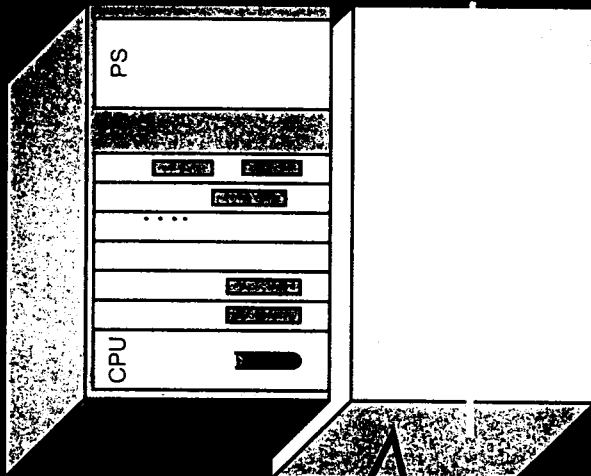
Reduction of Size

- ◆ Space occupied by Conventional Type  
• 55.6 m<sup>2</sup>
- ◆ Reduction Rate  
• 73%

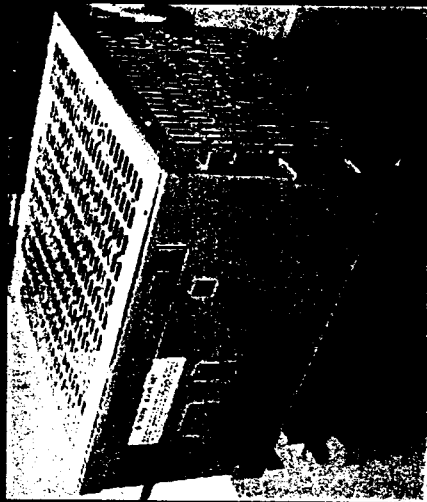


# Compact Inverter and Noise Immunity

Conventional Type



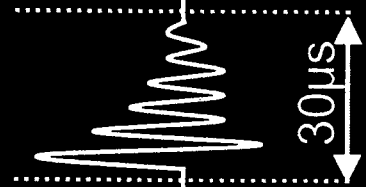
Advanced Type



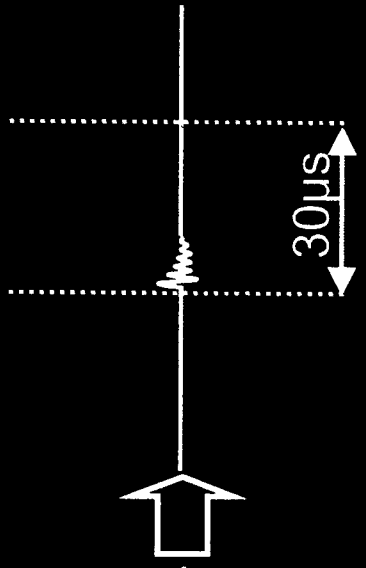
## Compact Inverter

- ◆ Development of LSI for One Board
- ◆ Compact Body by minimizing Circuit Parts ( Adoption of IGBT )

Noise Current



Current



## Suppression of Noise Current

- ◆ PAM
- ◆ EMI Noise Filter