

# ***Power Network Control by HVDC in Japan***

***The 8<sup>th</sup> EPCC Workshop***

***June 2005***

***Toshiba Corporation  
Tokyo Japan***

Courtesy of N. Fukushima

# ***Power Network Control by HVDC in Japan***

***Islands are connected by HVDC.***

***The 50Hz system and the 60Hz  
system are connected by HVDC as  
frequency converter.***

***Specially designed controls are  
utilized in addition to normal power  
control on HVDC.***

# HVDC Projects in Japan

**AFC : Automatic Frequency Control**

**FC : Frequency Converter**

**EPPS : Emergency Power Pre-Set**

**PM : Power Modulation**

**Minami - Fukumitsu  
BTB 300MW – 1999  
(AFC)**

**Hokkaido-Honshu HVDC  
Link 600MW – 1993  
(AFC)**

**Shin-Shinano FC  
600MW - 1992**

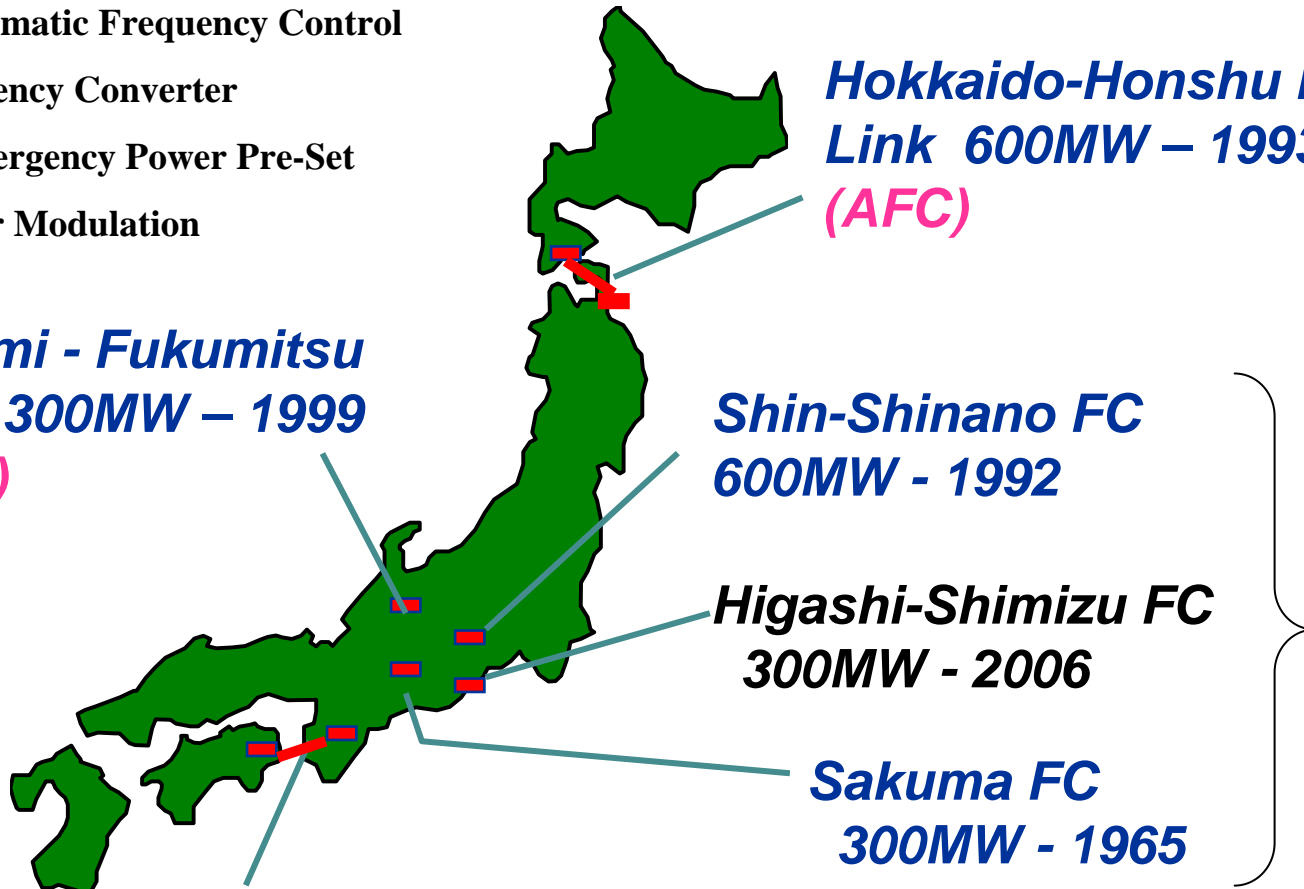
**Higashi-Shimizu FC  
300MW - 2006**

**Sakuma FC  
300MW - 1965**

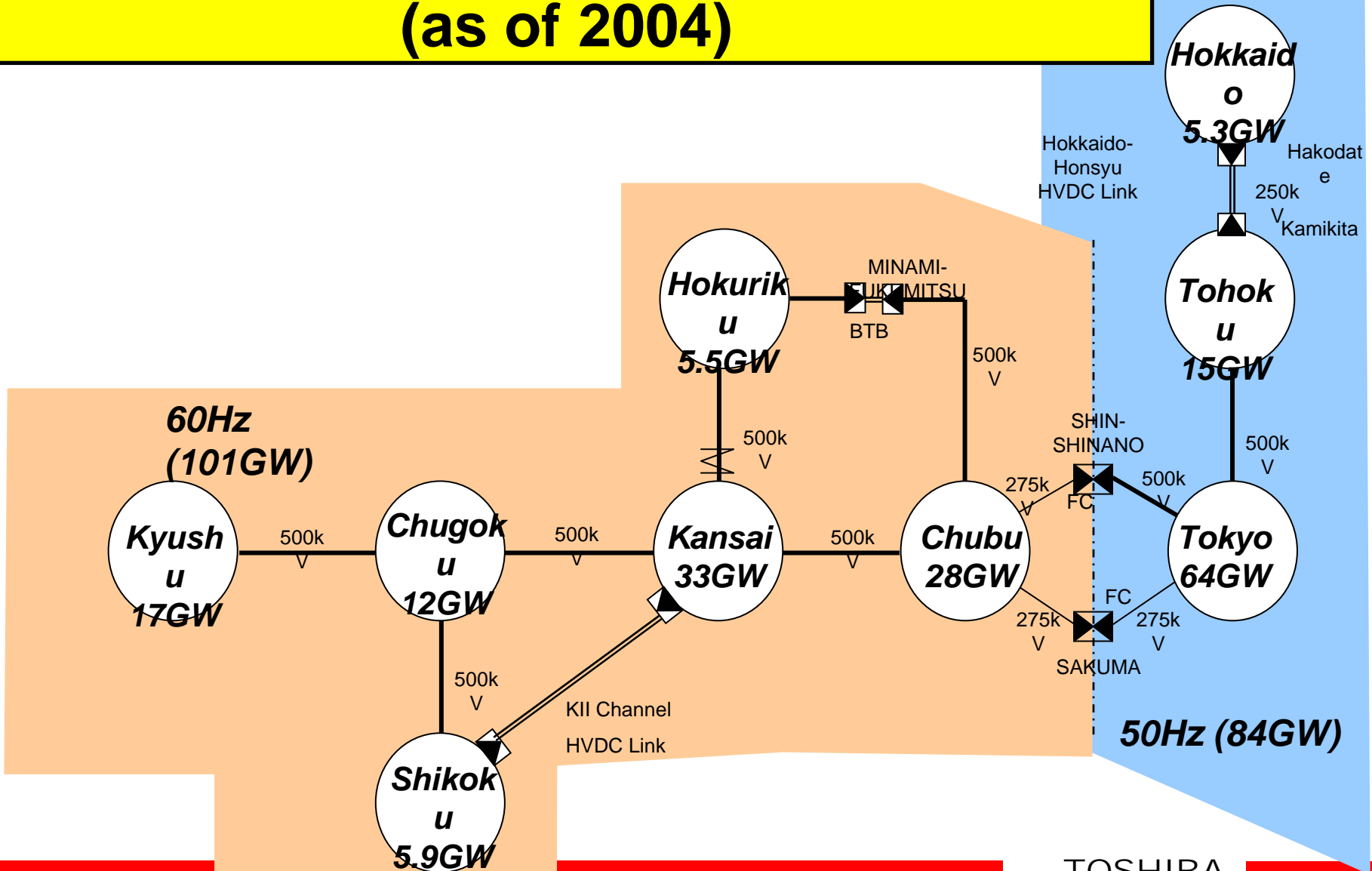
**(EPPS)**

**Kii Channel HVDC Link**

**1400MW – 2000 (PM, Fast power recovery, AFC)**



# Inter-Regional Interconnection in Japan (as of 2004)

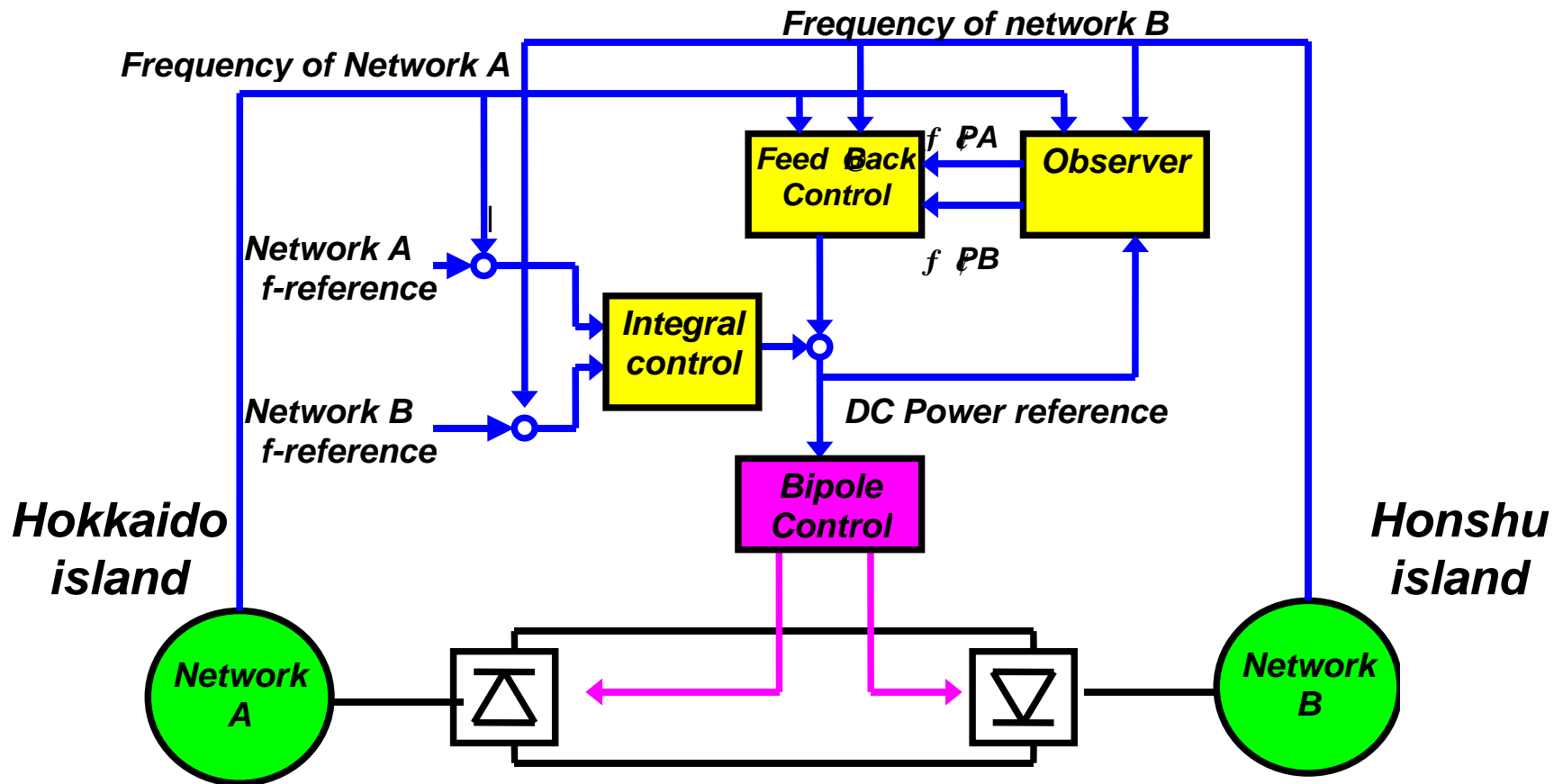


# EPPS

- EPPS is for emergency cases where one of the two frequencies (50 or 60 Hz) exceeds some limits.
- In such an emergency case EPPS immediately sends the pre-set power to the abnormal frequency power system to recover the frequency.
- EPPS has long been successfully operated with many actual operations in Japan.

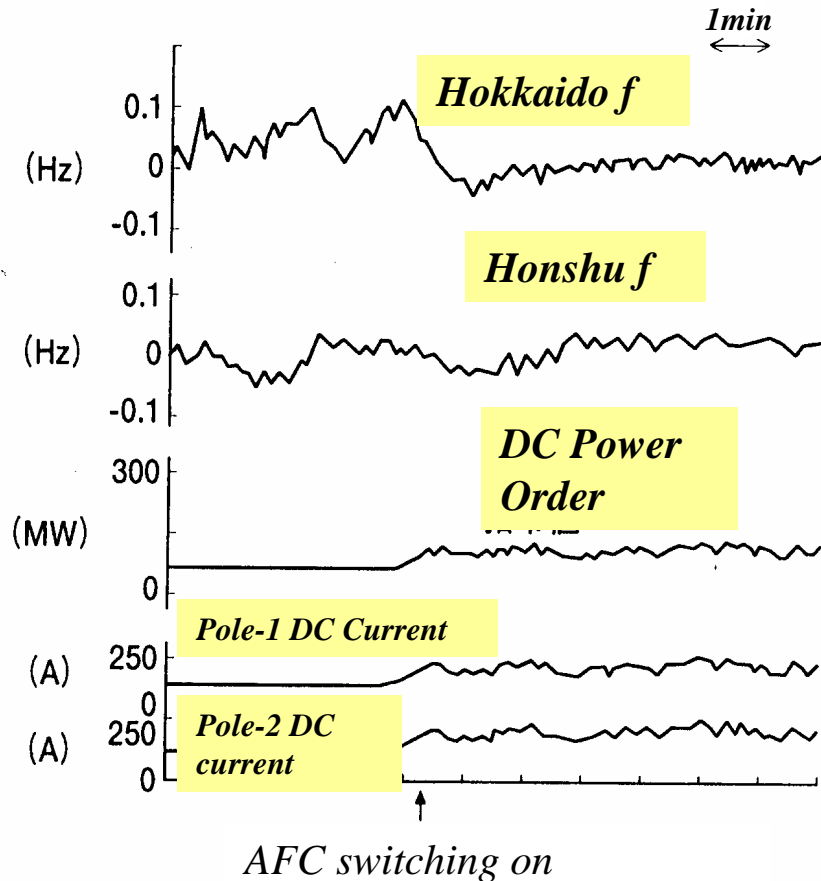
# Multi-variable AFC Control

(Hokkaido-Honsyu HVDC)

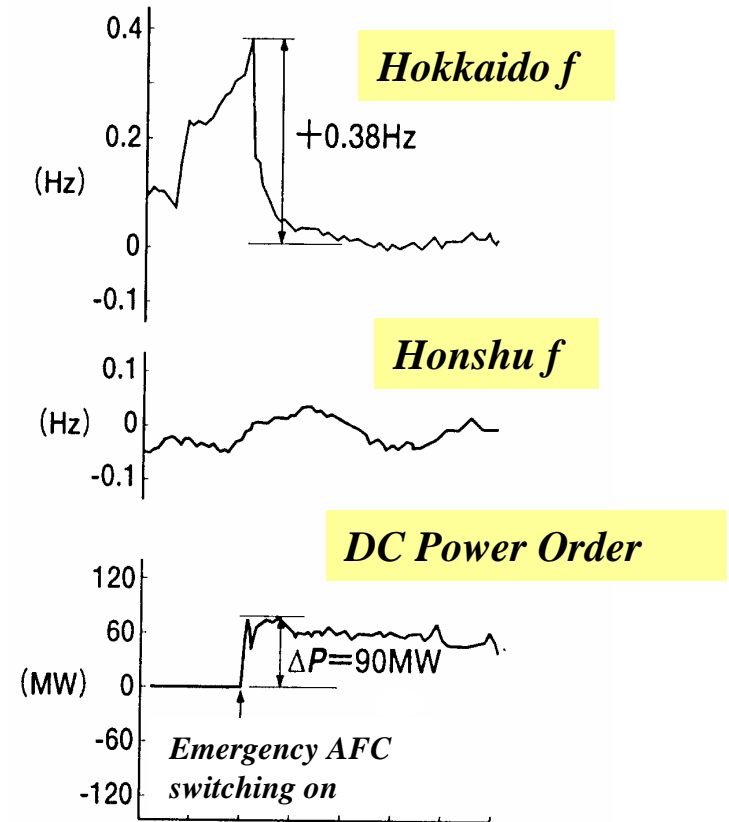


# Effects of AFC (Hokkaido-Honsyu HVDC)

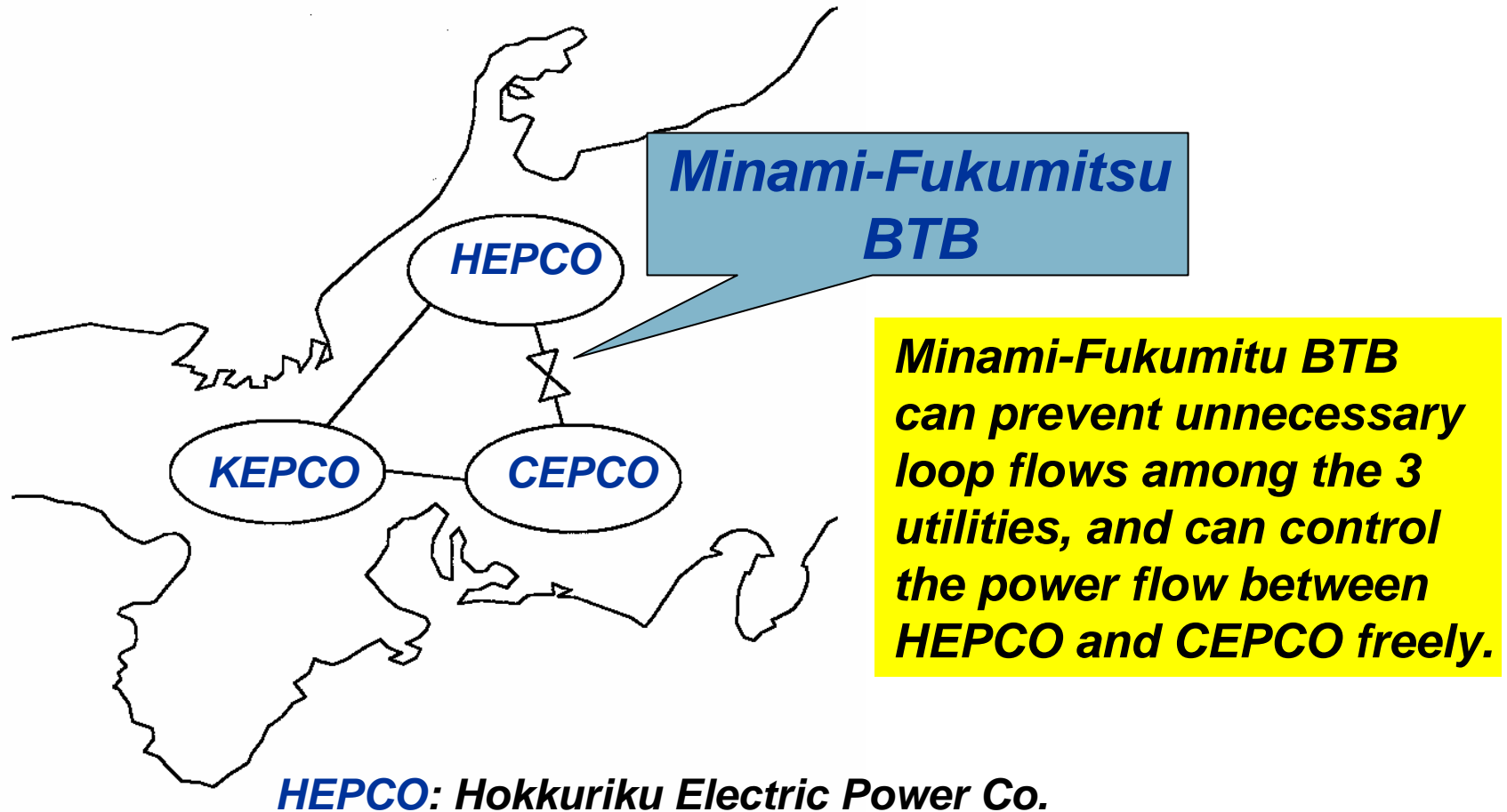
## Ordinary AFC



## Emergency AFC



# Minami-Fukumitsu BTB C/S

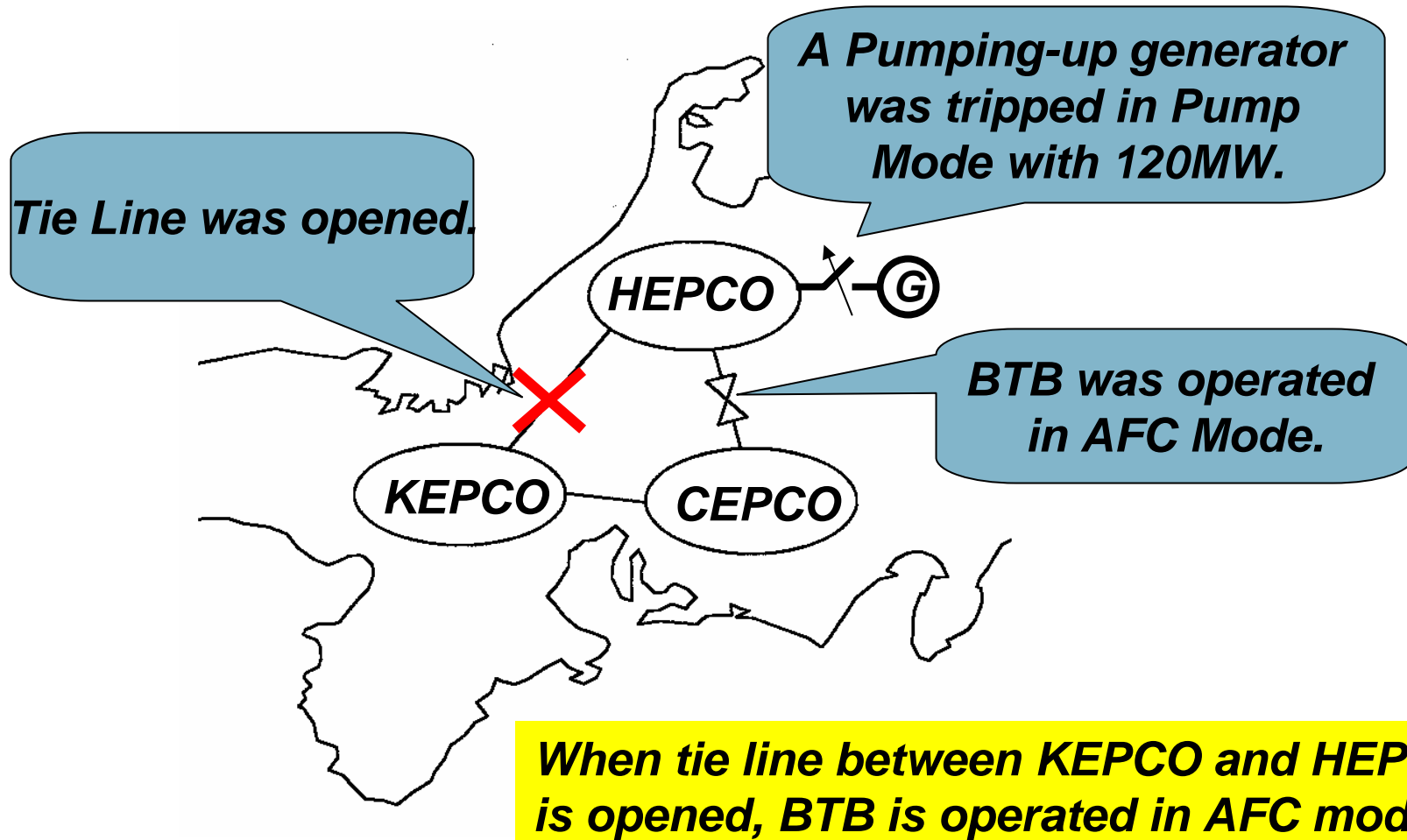


**HEPCO:** Hokkuriku Electric Power Co.

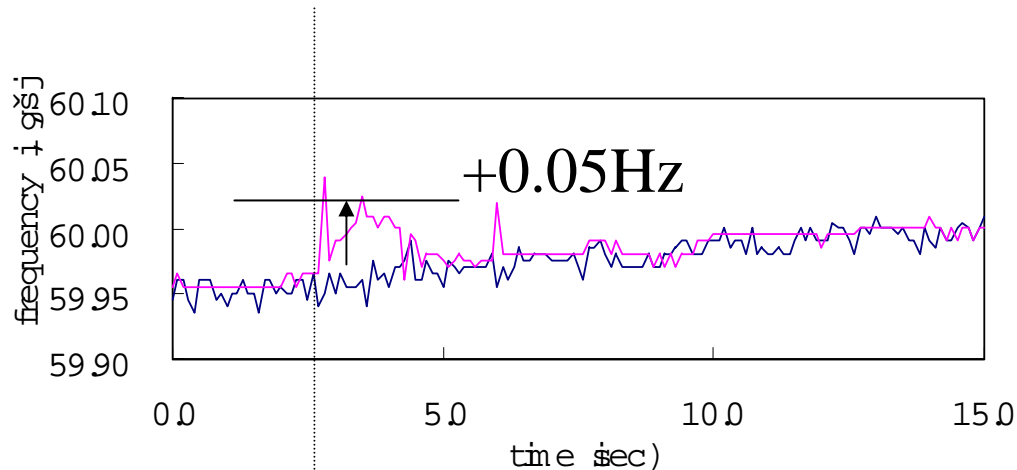
**KEPCO:** Kansai Electric Power Co., **CEPCO:** Chubu Electric Power Co.



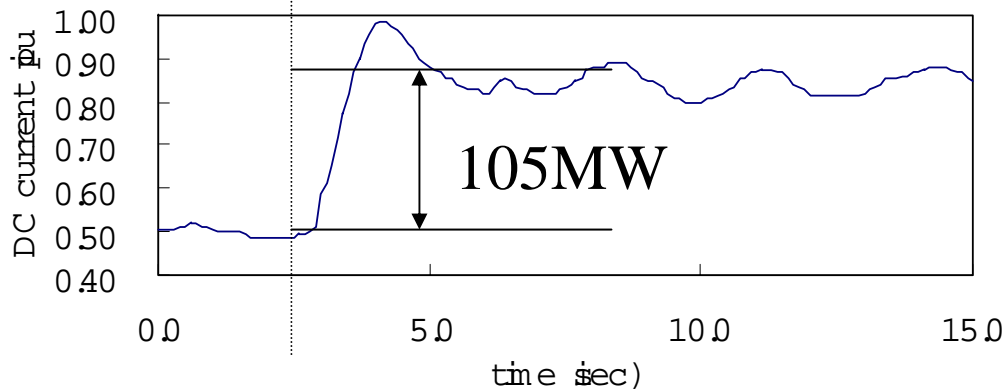
# Actual Power System Test



# Actual Power System Test



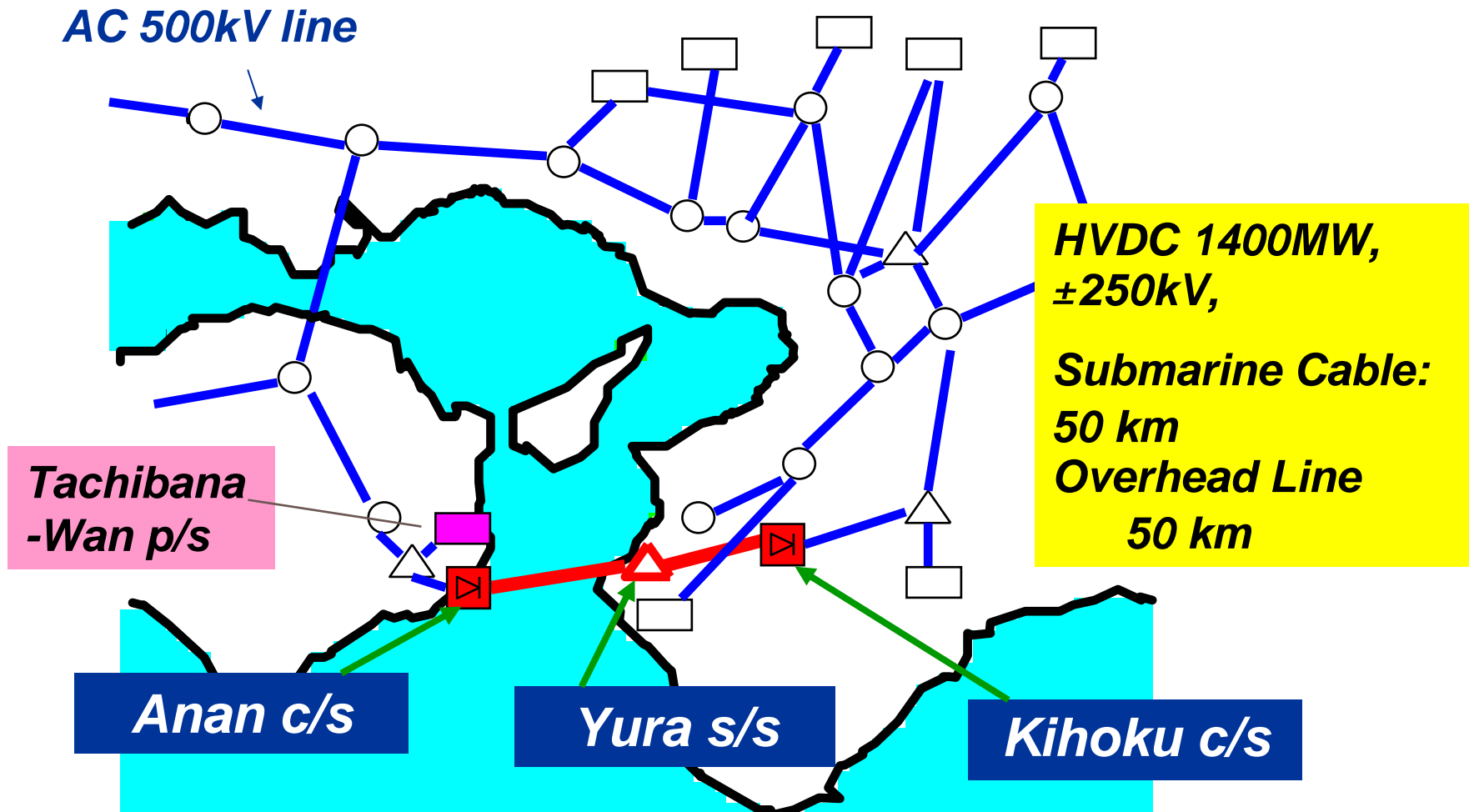
**magenta: HEPCO**  
**blue : CEPCO**



**By increasing the DC power from HEPCO to CEPCO by 105 MW, the maximum frequency changes are suppressed to less than 0.04 Hz.**

**Pump rejected**

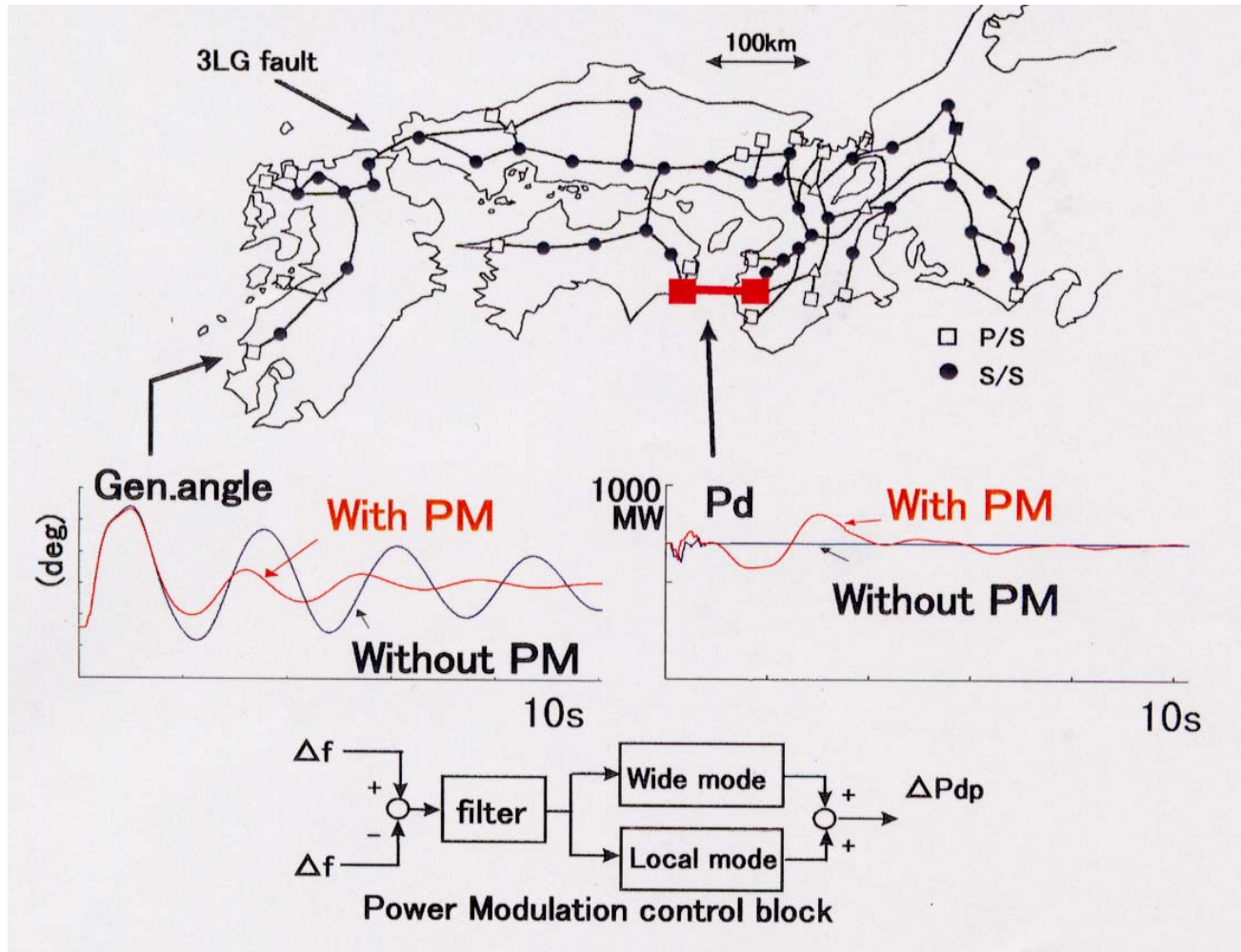
# Kii Channel HVDC Link



Note: P/S=Power Station, S/S=Switching Station, C/S=Converter Station

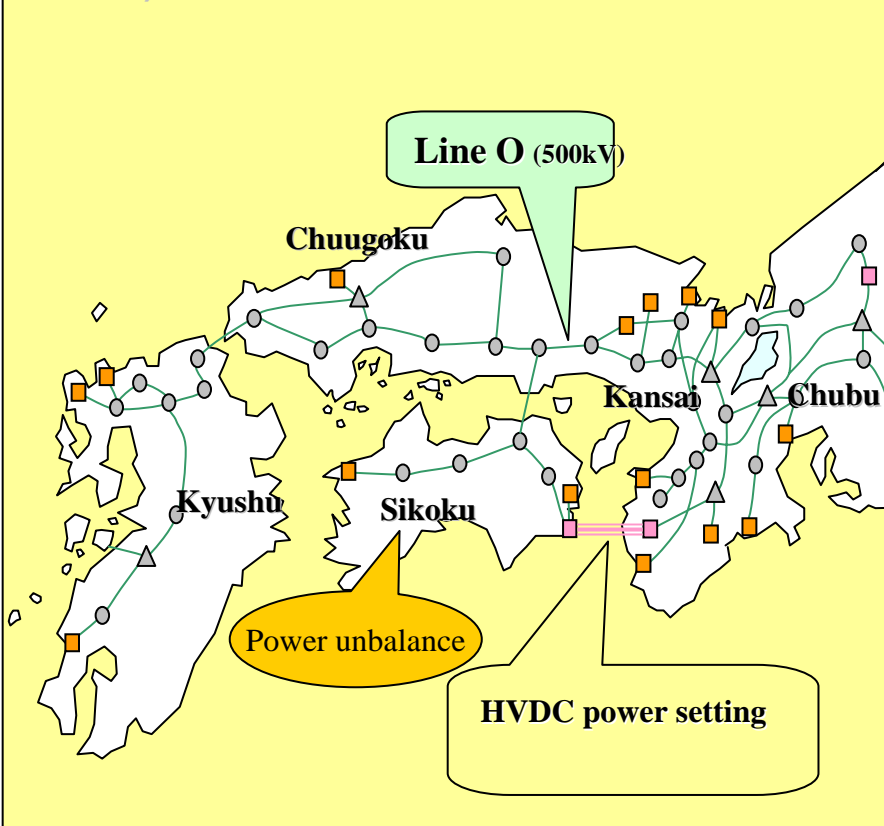
TOSHIBA

# Power Modulation study

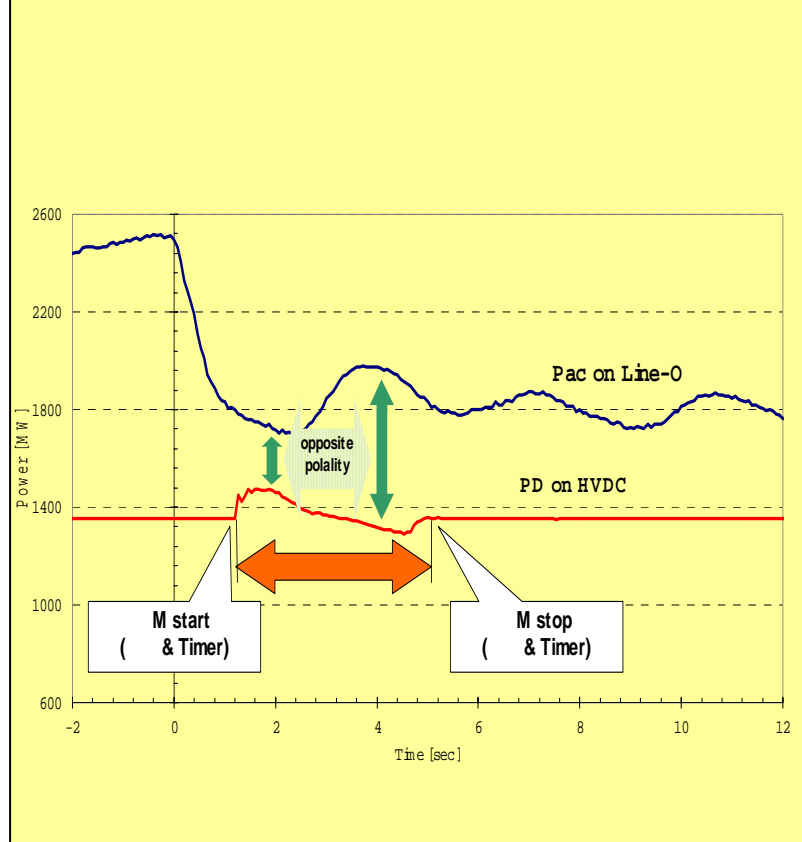


# Record of Power Modulation

HVDC 1400MW (from Sikoku to Kansai)



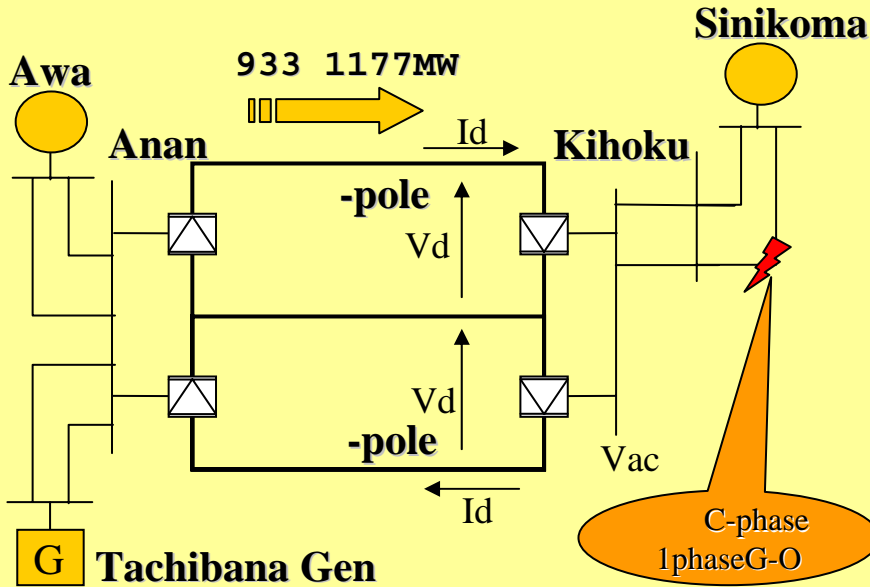
Power of AC line and HVDC



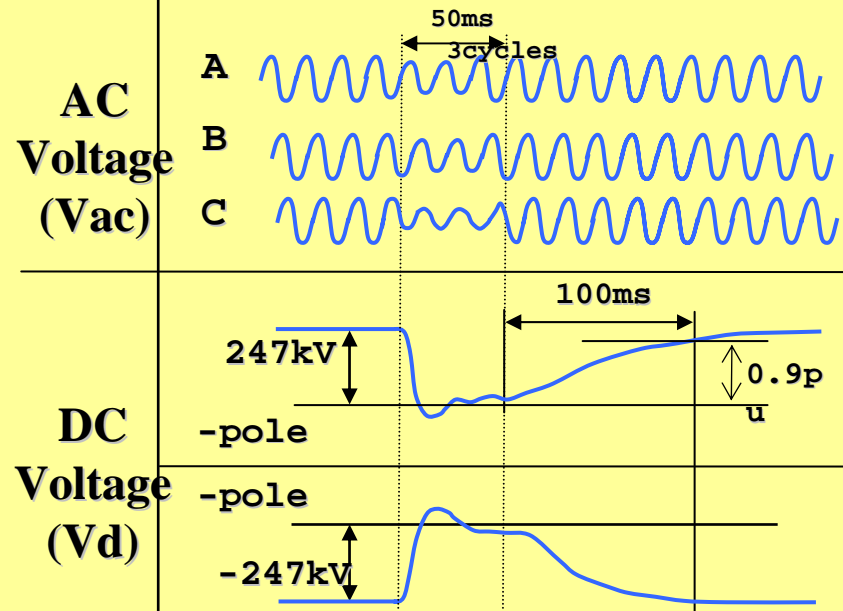
Power swing is well suppressed by PM controller

# Records of Fast Power Recovery after AC fault

## Power flow at 1-phase fault



## Recorded chart



**Pdc was recovered within 100ms after fault clearing**  
**Lightning attacked 11times during 2 months after commission,**  
**fast power recovery was completed successfully for all cases**

# Japan Electric Power Exchange (JEPX; Started from April 2005)

- JEPX is private and voluntary
- It accepts only physical transactions
- Wholesale power exchanges are treated
- It is the single market for the whole Japan as long as all the ATCs are not violated
- ATCs are checked to facilitate each power exchange between players
- It is to supplement bilateral transactions

# ATC of Each Inter-Tie Line

- $ATC = TTC - \text{Margin} - \text{Scheduled Flow}$
- ATC; Available Transfer Capability
- Margin; Reserved for some risks
- TTC; The most severe constraint among thermal, stability, voltage stability, and frequency limit. It is equipment limits for HVDC, BTB, FC links.
- Scheduled Flow; Reserved for bilateral contracts for long time