# Advantages and Circuit Configuration of a DC Microgrid

**Toshifumi ISE**
**（Osaka University, JAPAN）**
ise@eei.eng.osaka-u.ac.jp

# Problems on Microgrids

1) Synchronization of distributed generators

2) Inrush current

(transformers, Induction motors, Induction generators)

3) Three-Phase Unbalance

(single-phase loads, single-phase generators such as photovoltaic)

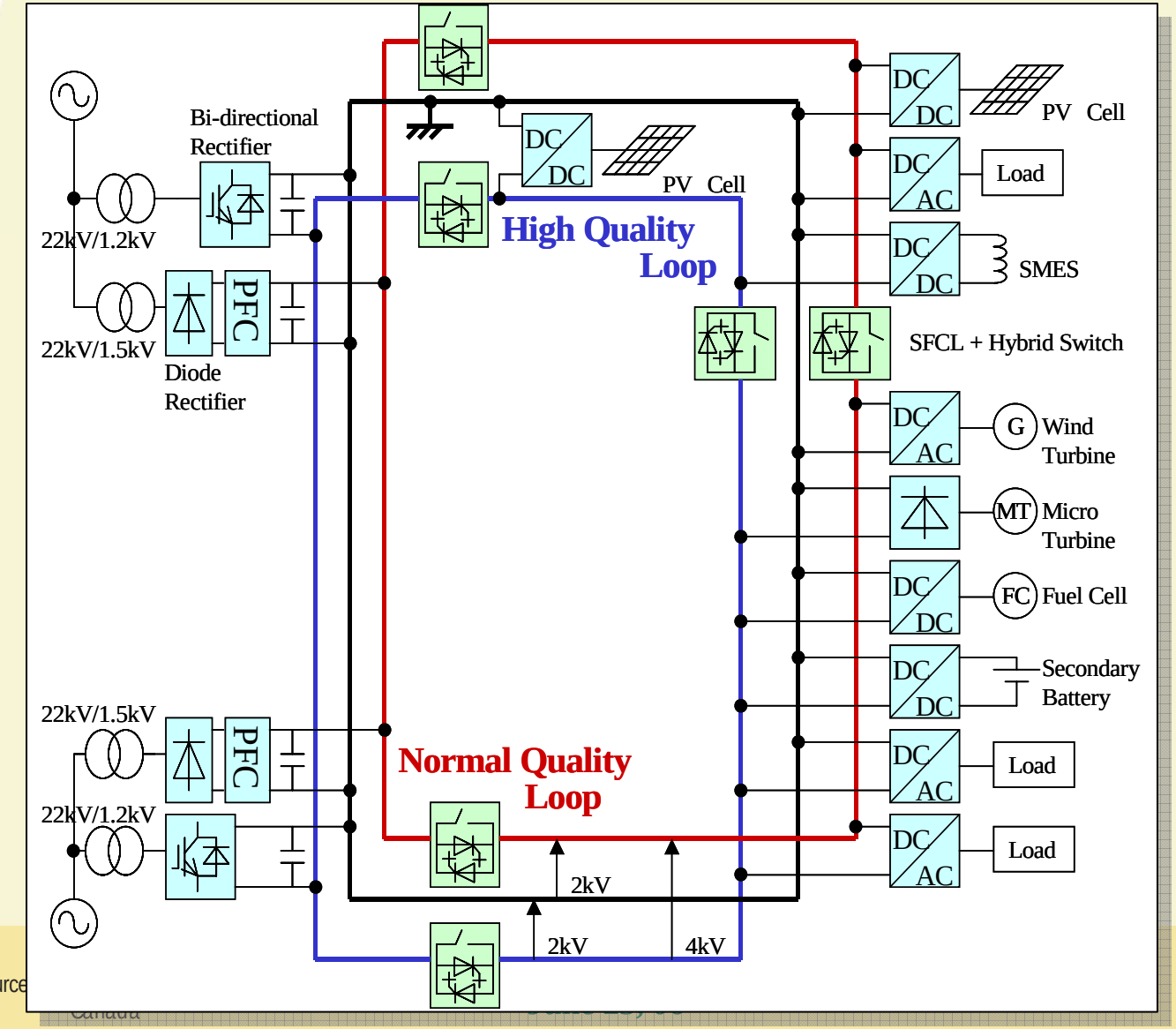
# Recent Trends

1) Introduction of many Inverter loads (AC/DC and DC/AC conversions are included)

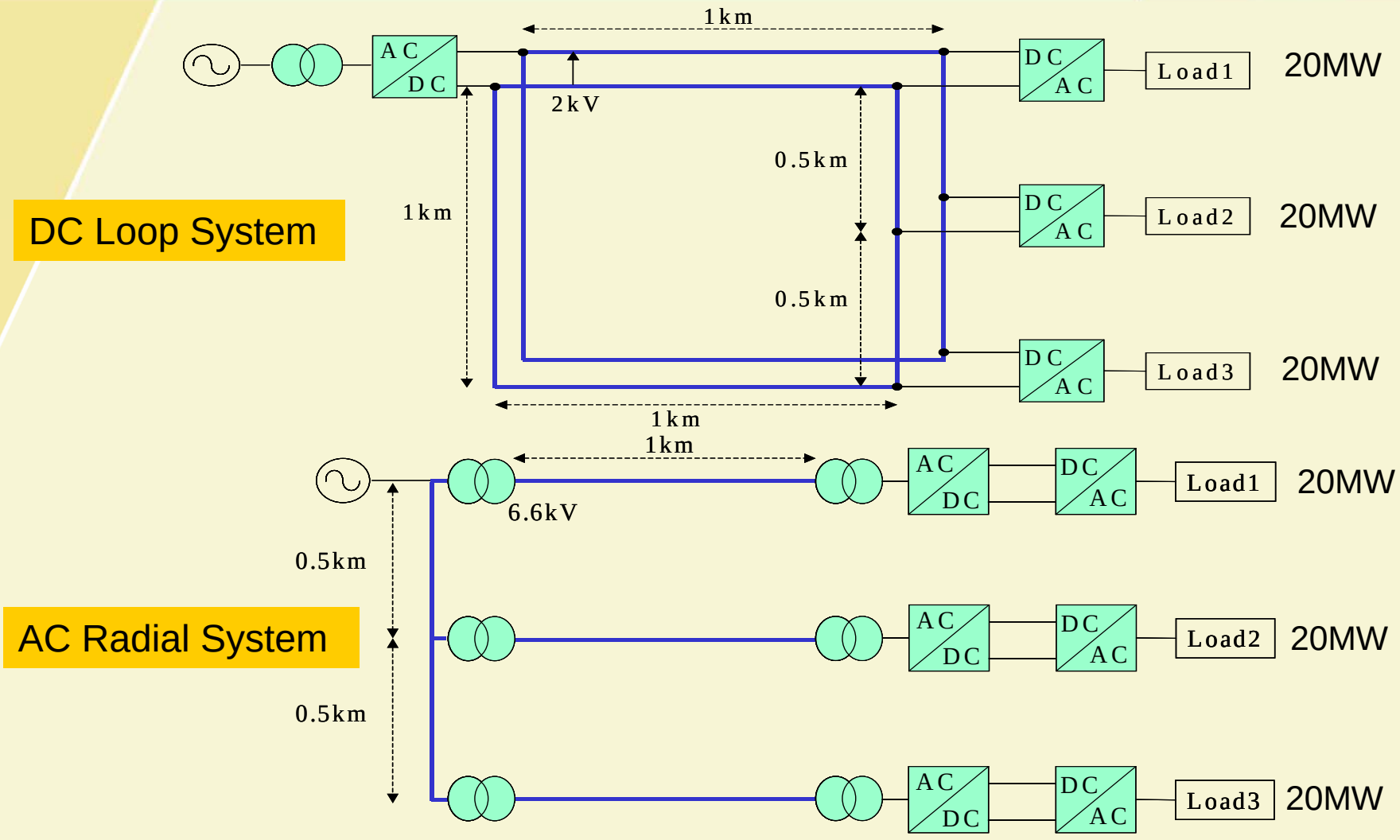
2) Introduction of distributed generations with DC output (photovoltaic, fuel cell, variable speed type wind turbine, micro turbine, gas engine)

3) Needs for higher quality power

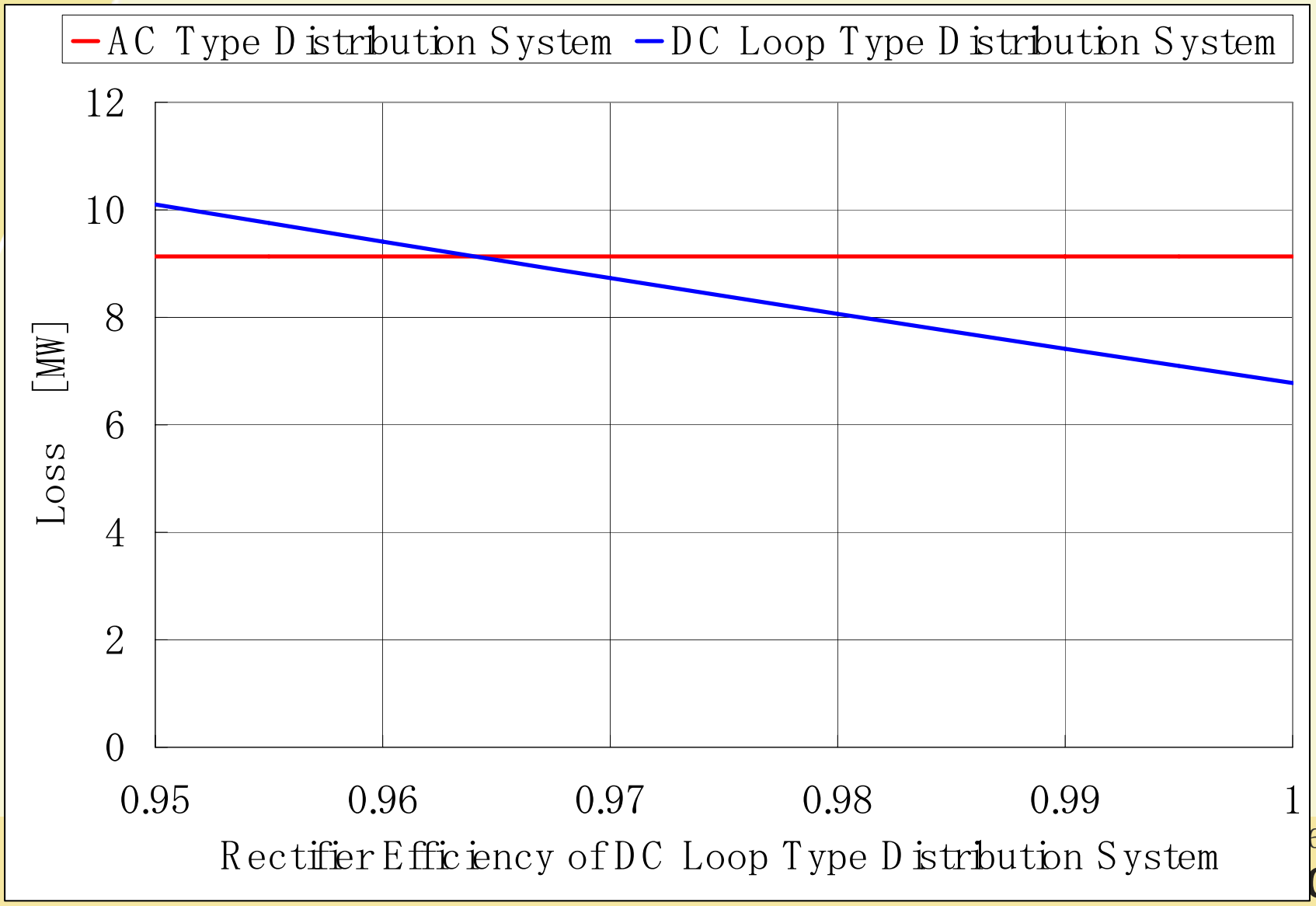
# DC Loop Type Configuration



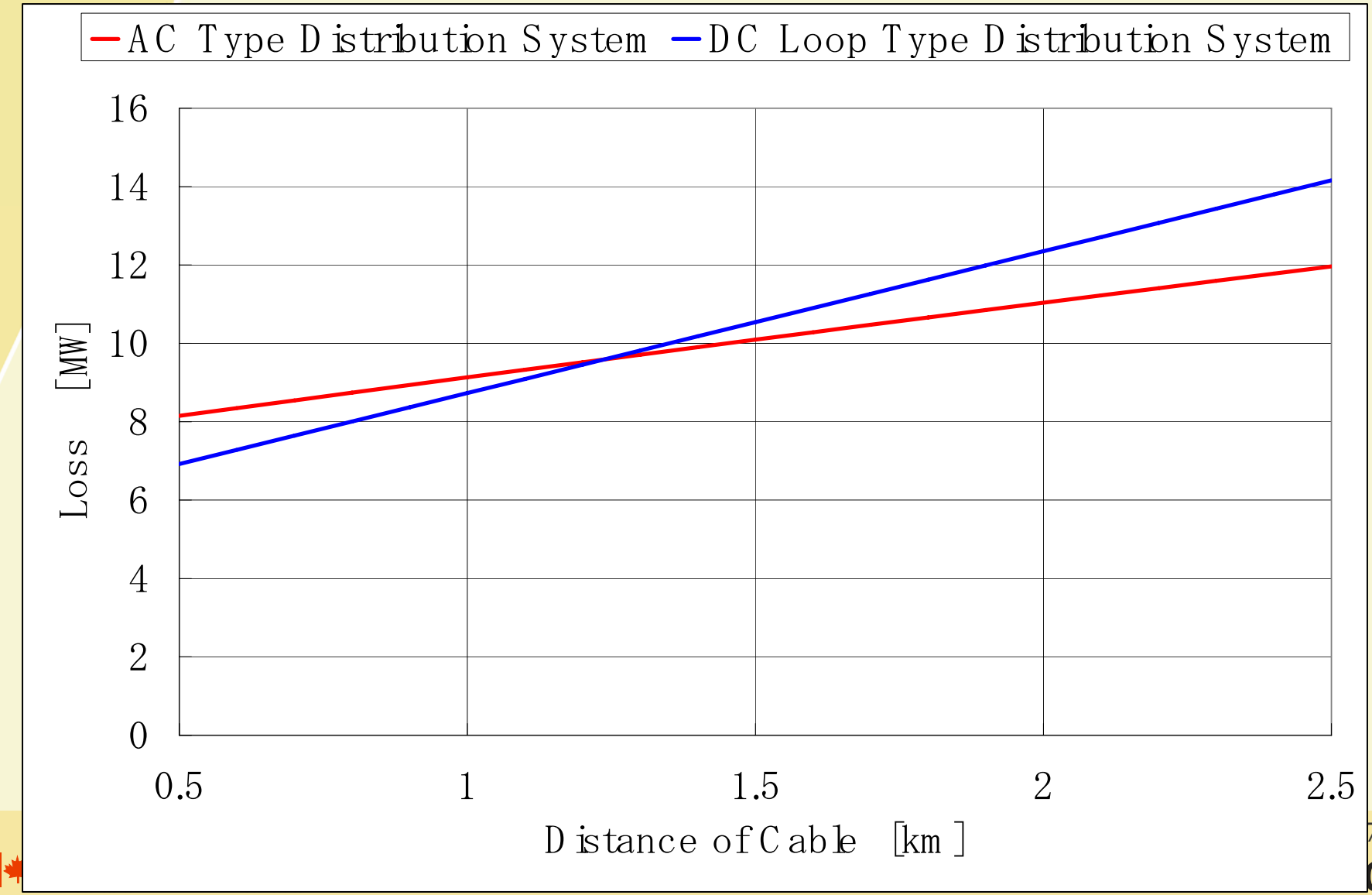
# Circuits for Loss Comparison



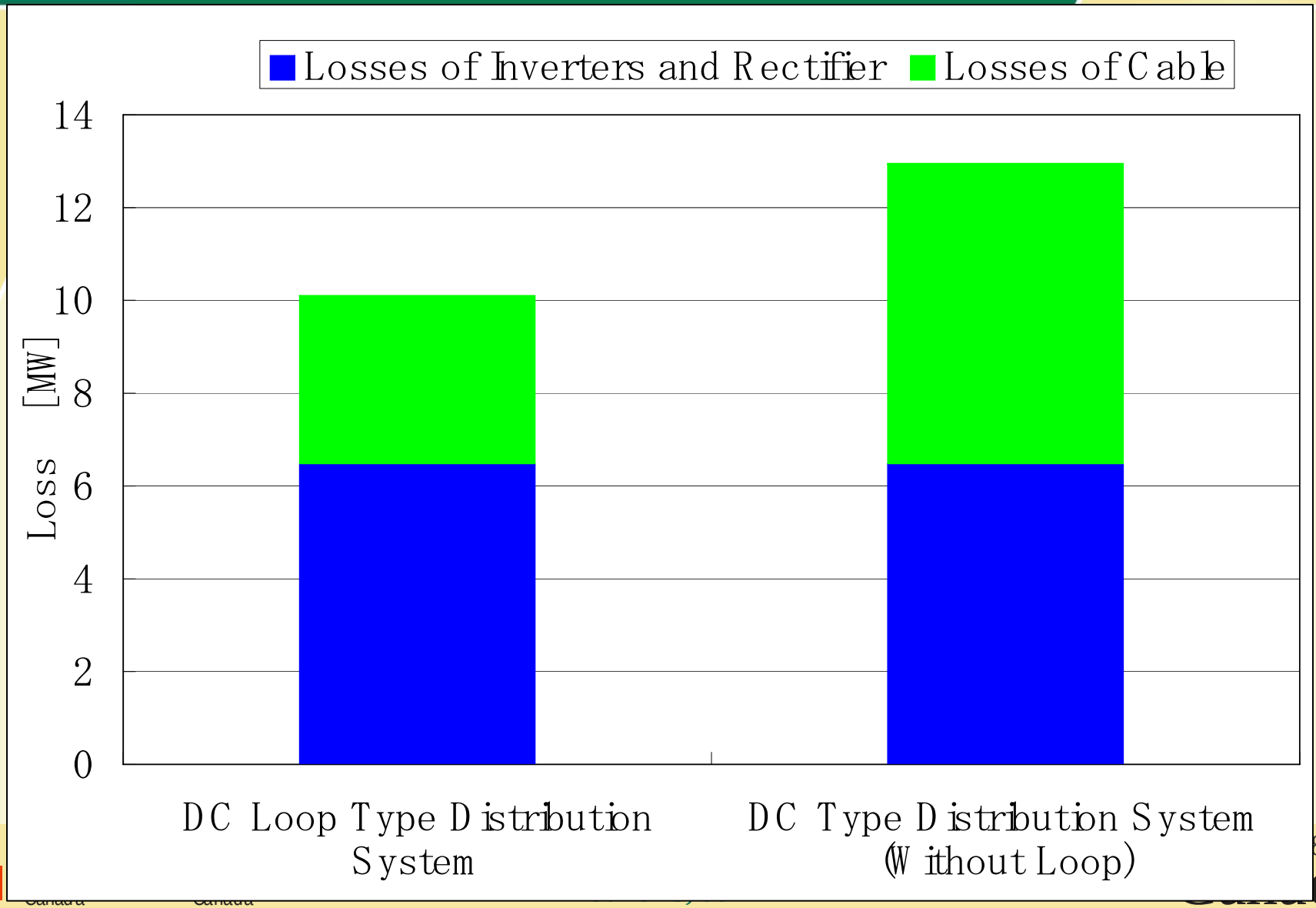
# Reduction of Rectifier Losses



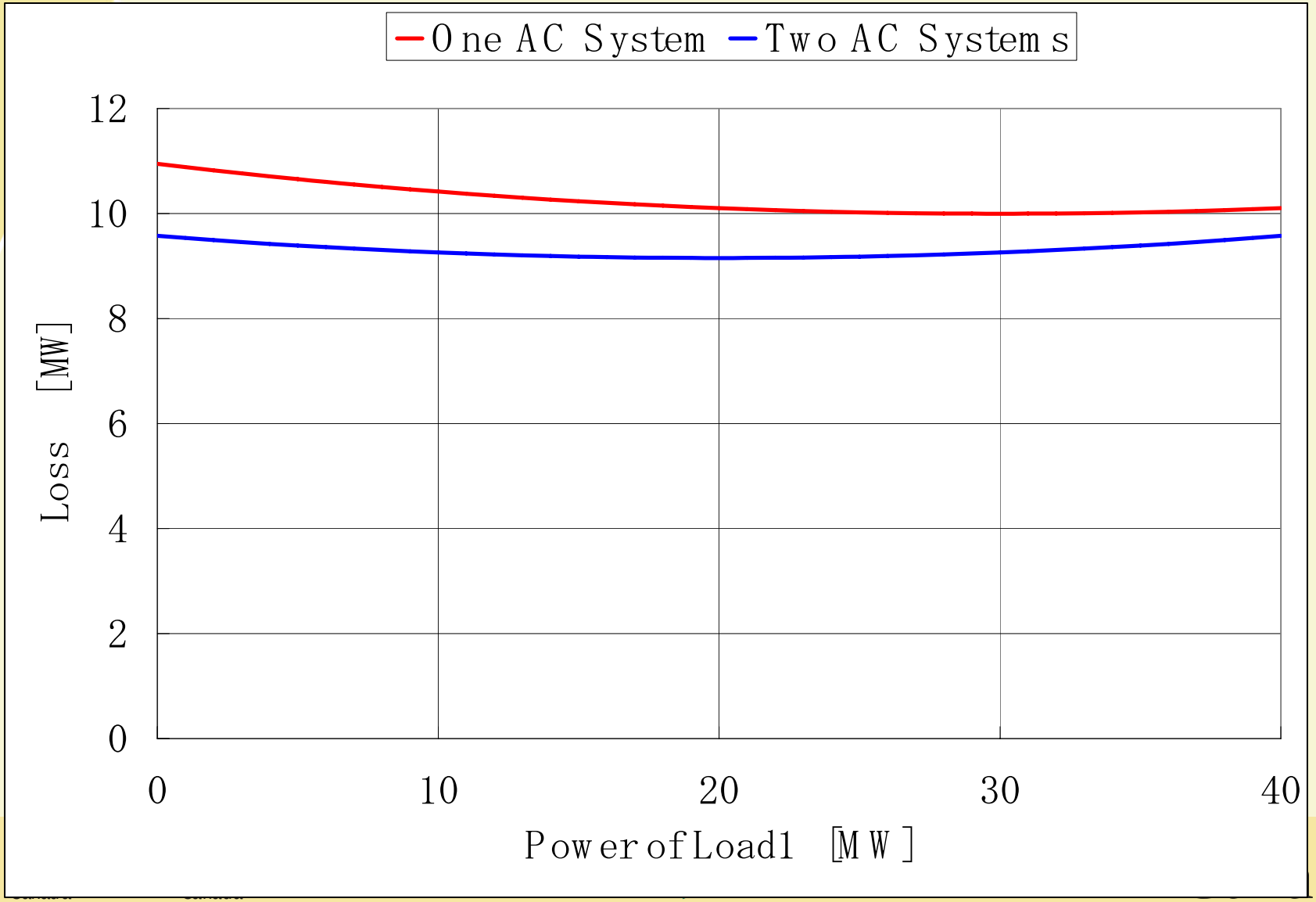
# Distance of Cable and Losses



# Loss Reduction due to Loop System

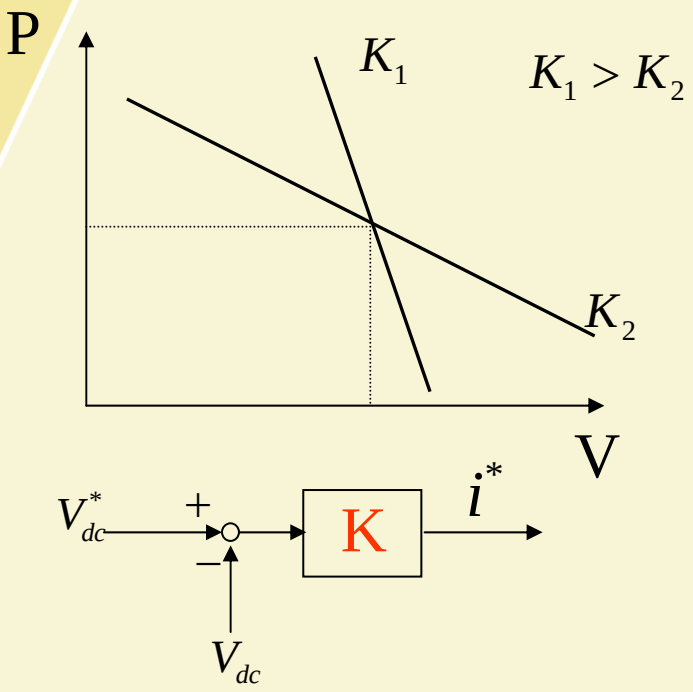


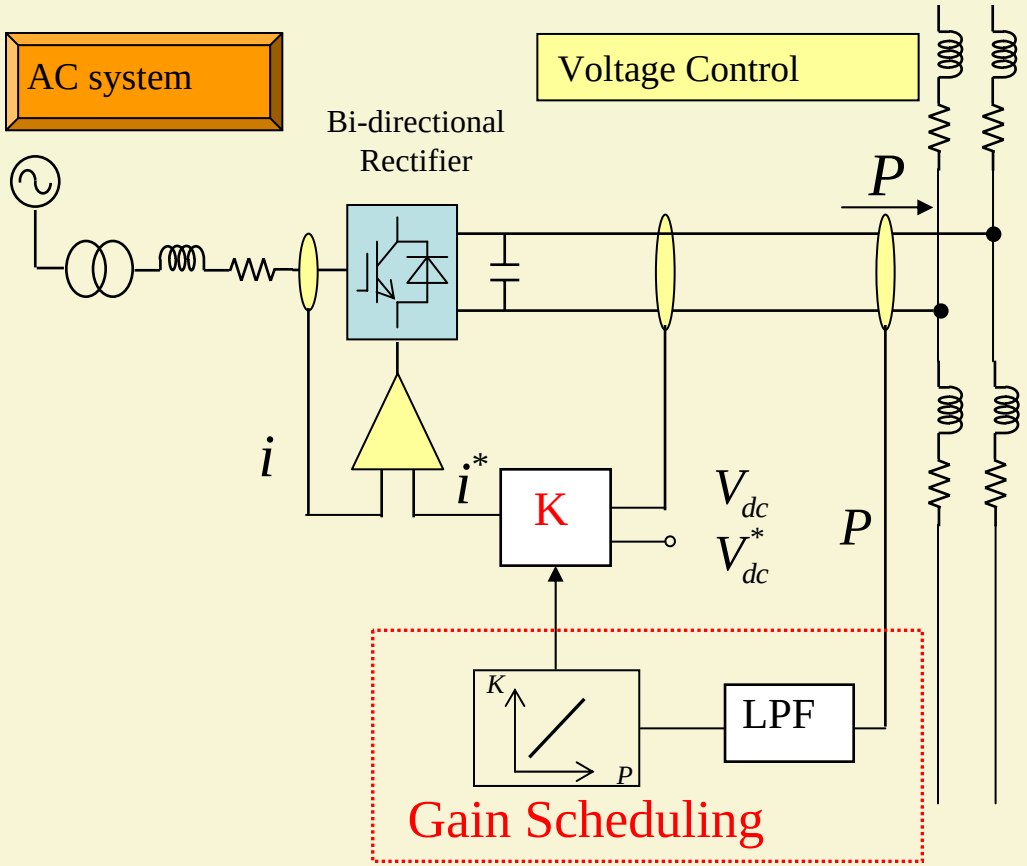
# Loss Reduction by Feeding from Two AC Systems



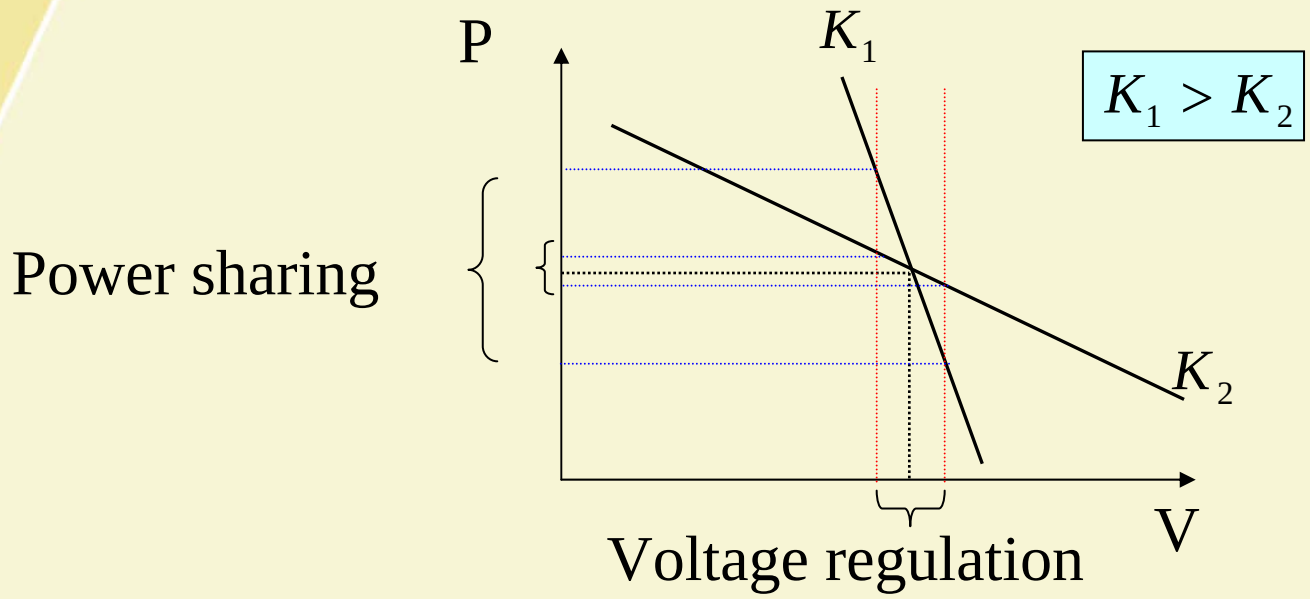
# Control Method of Rectifiers Using Gain-Scheduling Method

**Controlled Characteristics with Proportional Controller**



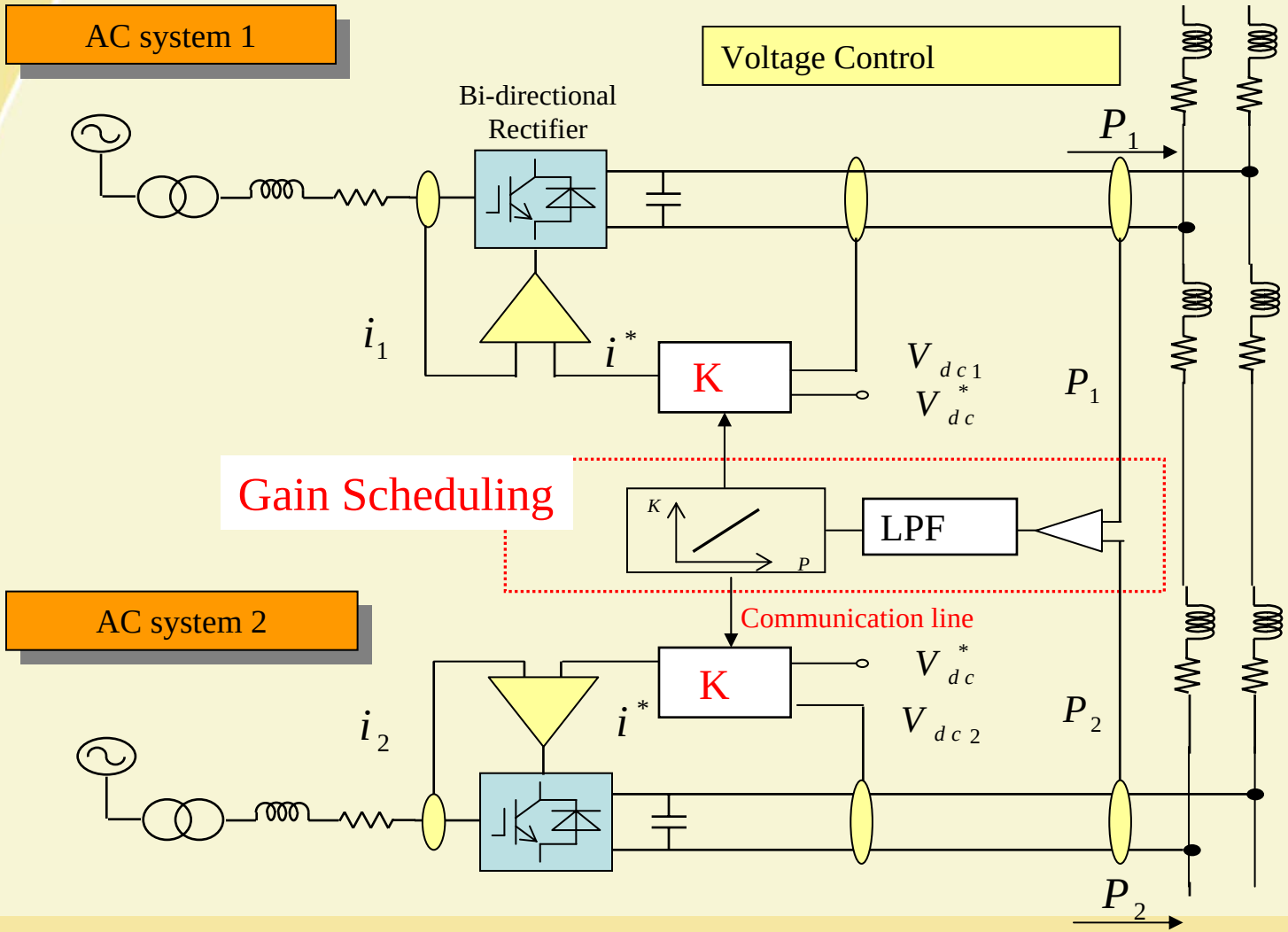



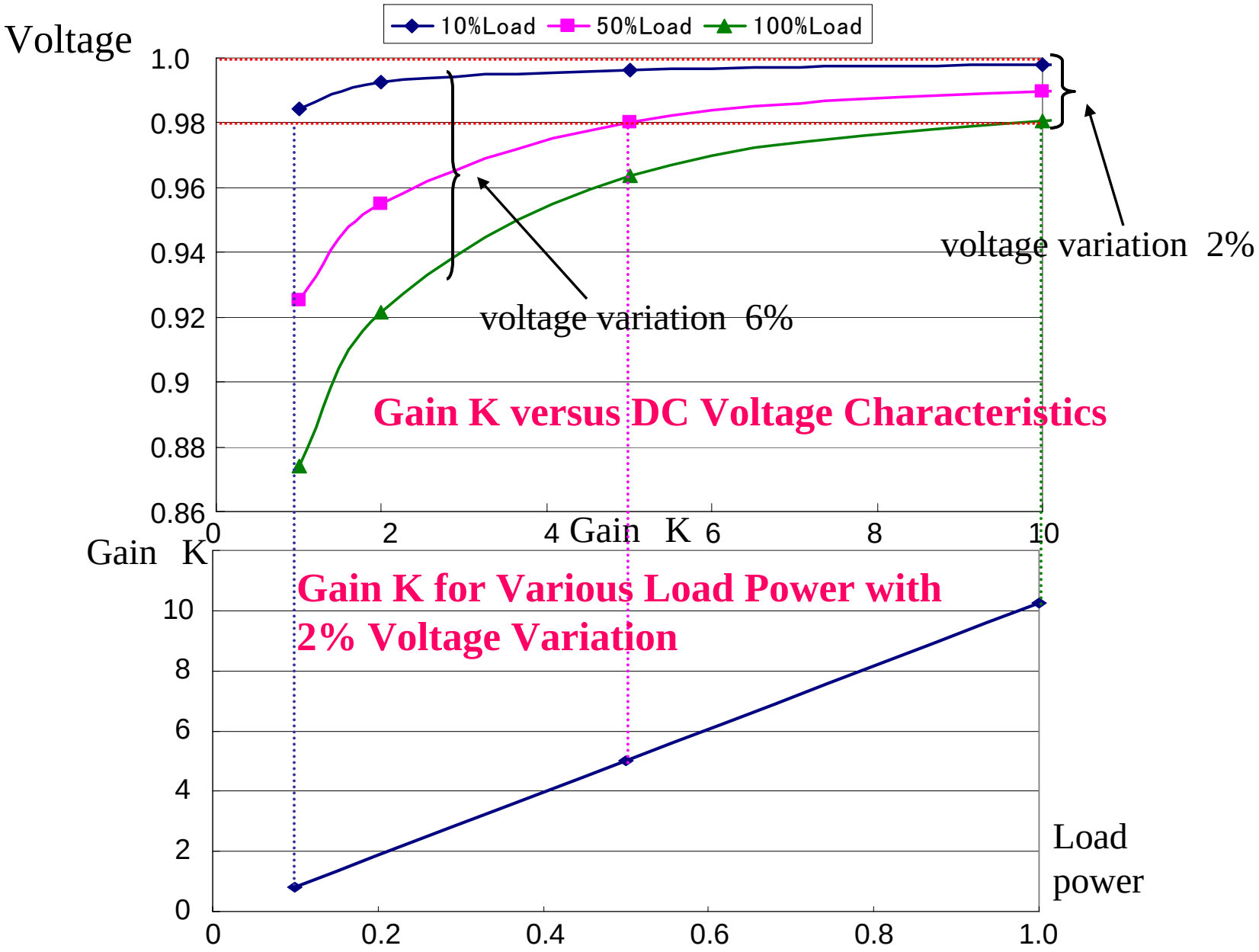
# Effect of Gain Scheduling



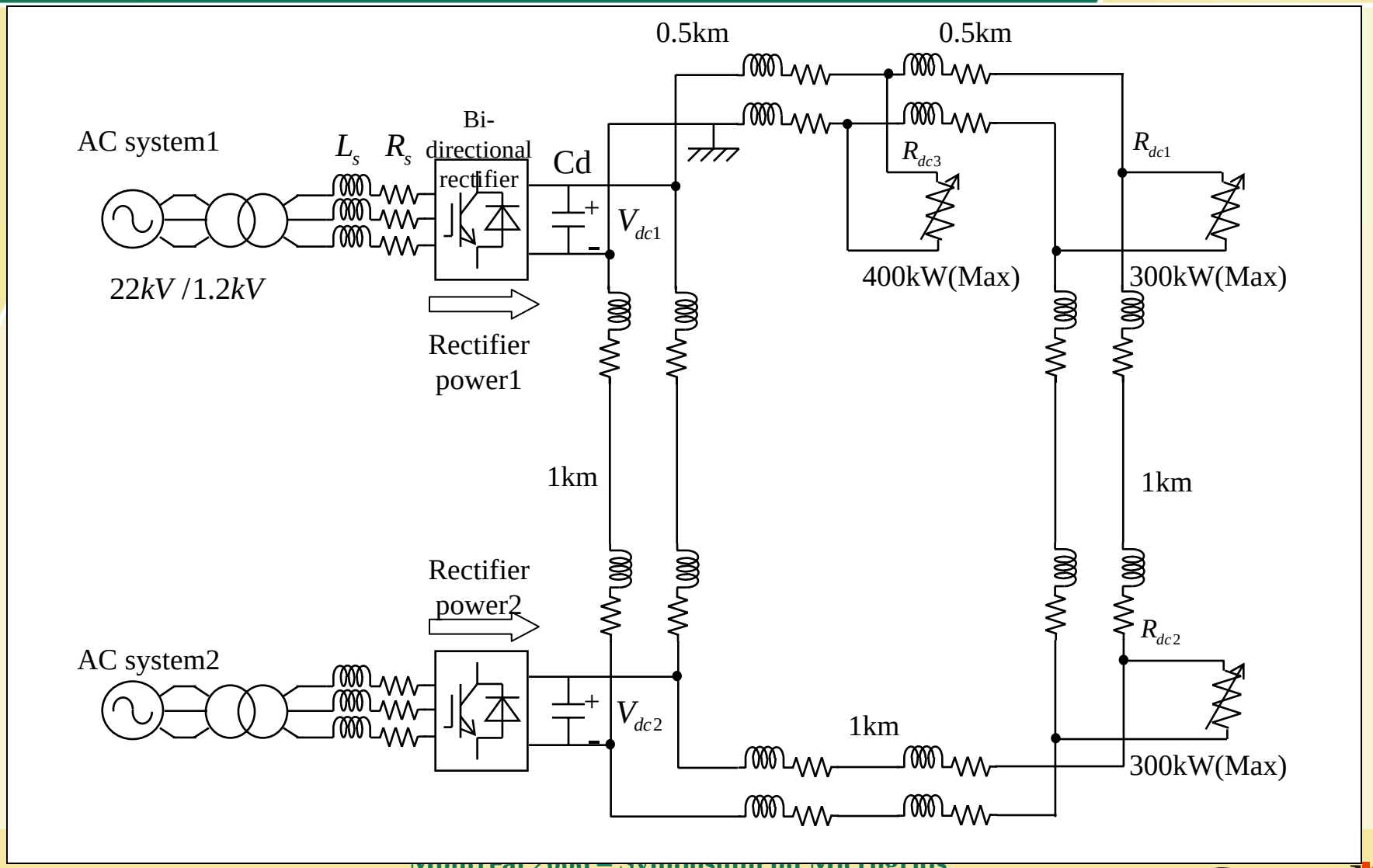

| | Voltage Regulation | Power Sharing |
|---|---|---|
| Large Gain K | **Excellent** | **Fair** |
| Small Gain K | **Fair** | **Excellent** |
| Gain Scheduling | **Good** | **Good** |

# Control of Multiple Rectifiers

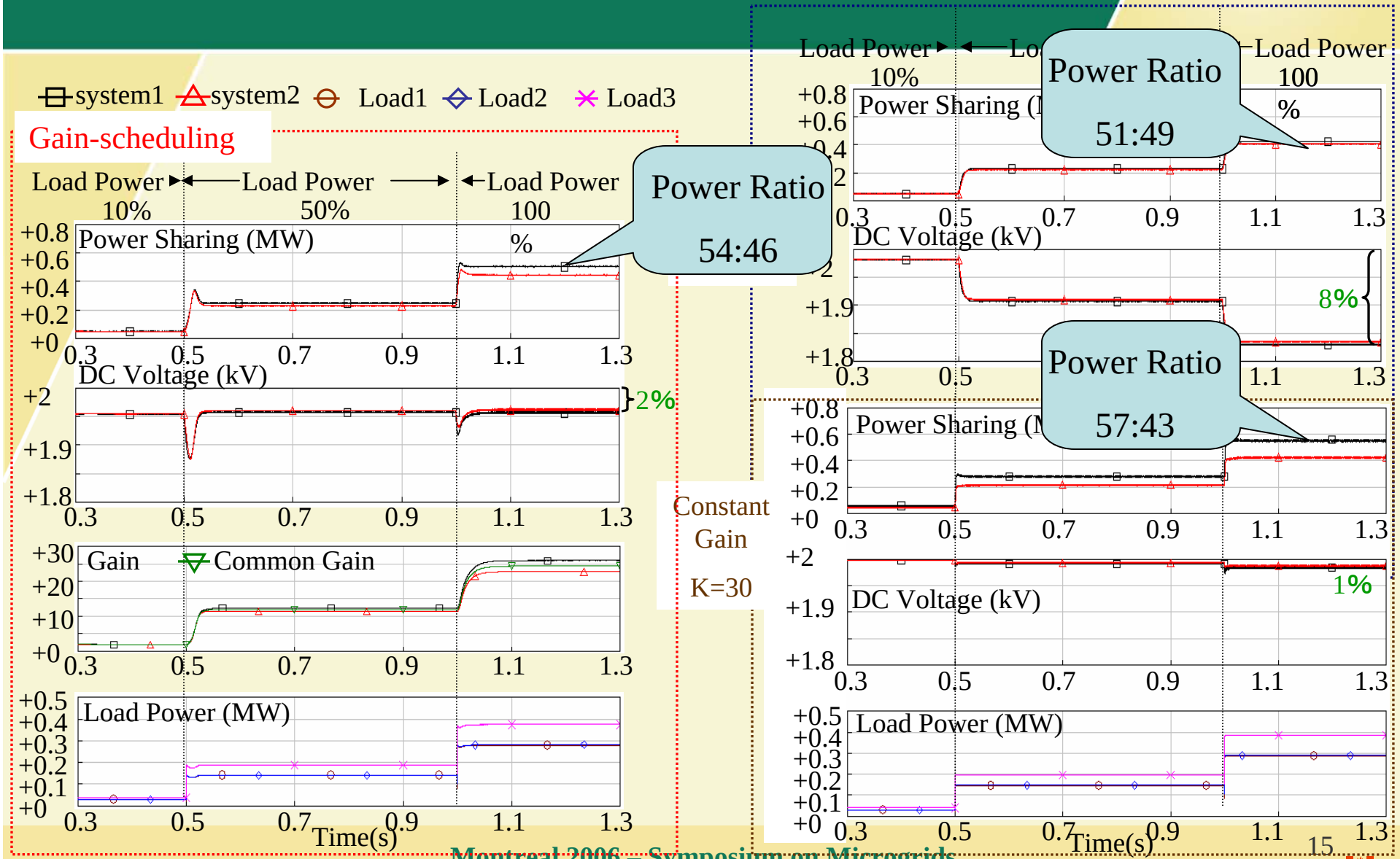



Voltage
10%Load
50%Load
100%Load
1.0
0.98
0.96
0.94
0.92
0.9
0.88
0.86
voltage variation 2%
voltage variation 6%
Gain K versus DC Voltage Characteristics
0
2
4
Gain K
6
8
10
Gain K
Gain K for Various Load Power with
2% Voltage Variation
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1.0
Load
power

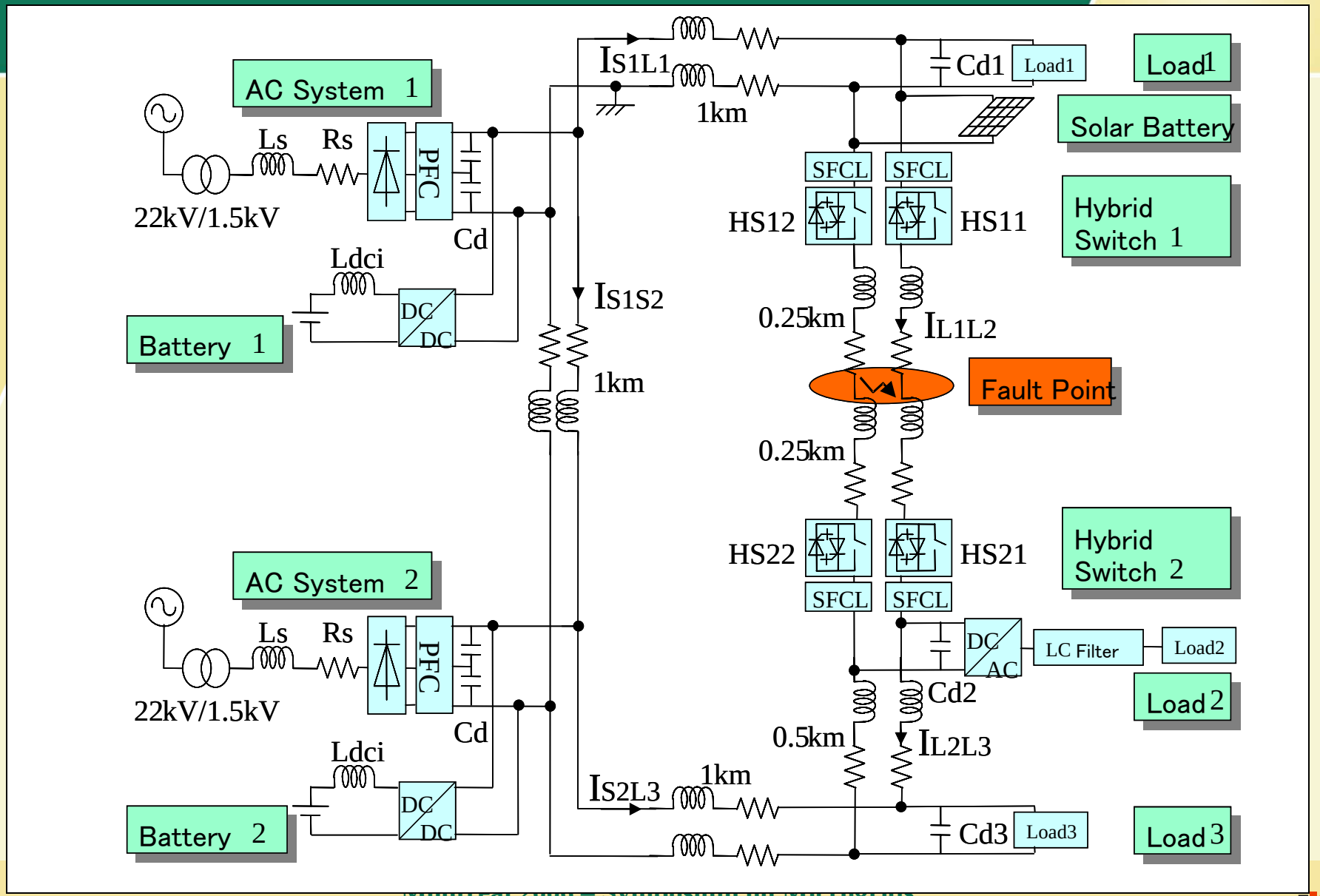
# Simulation Circuit



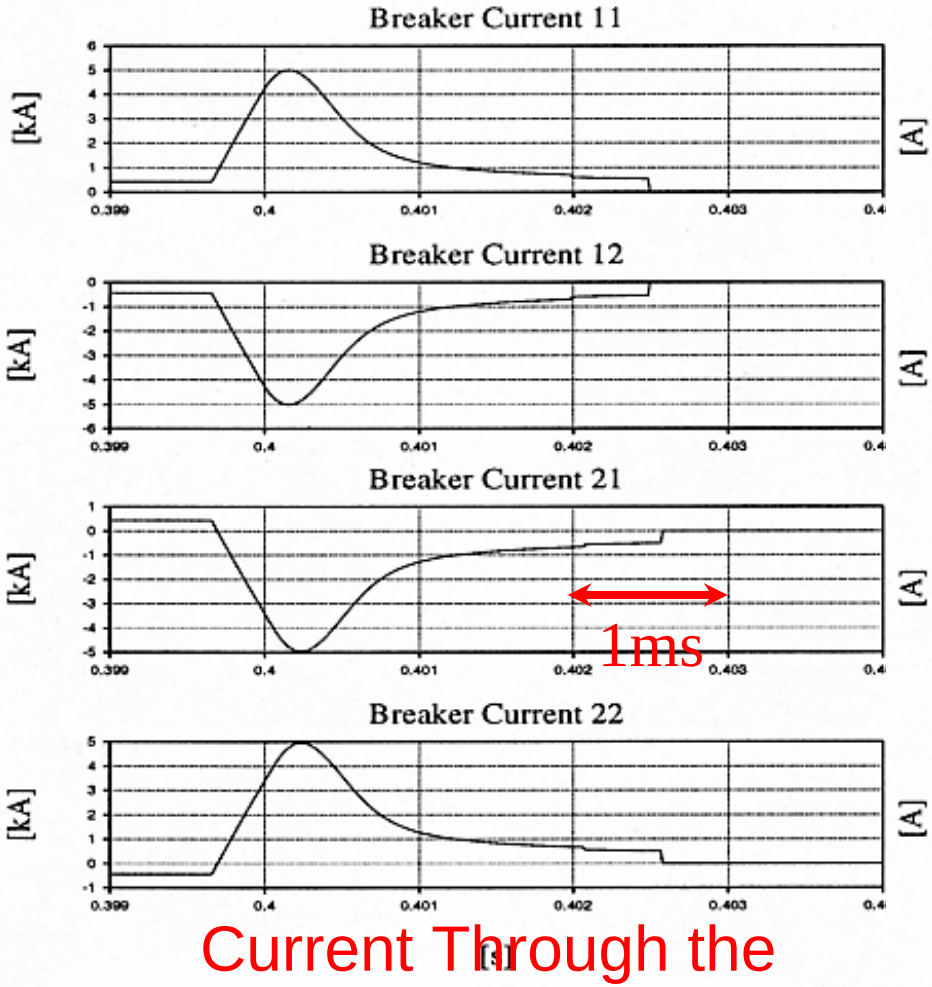
# Simulation Results of Power Sharing



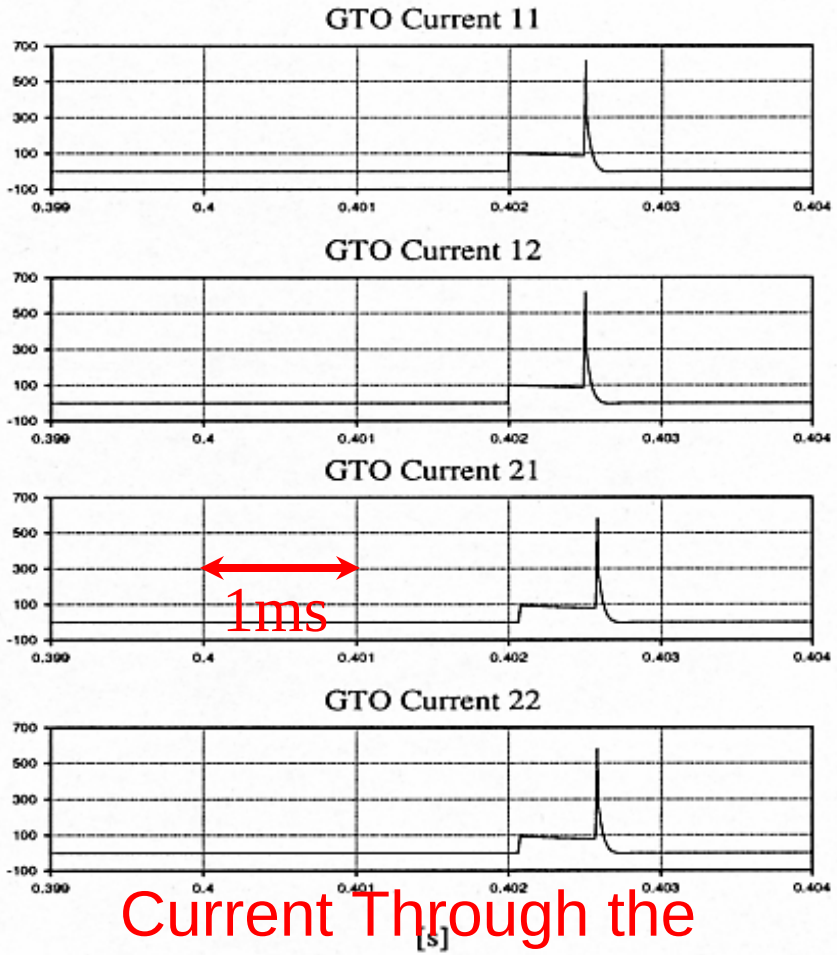
# Simulation Circuit for Protecting Operation



# Simulation of Protecting Operation

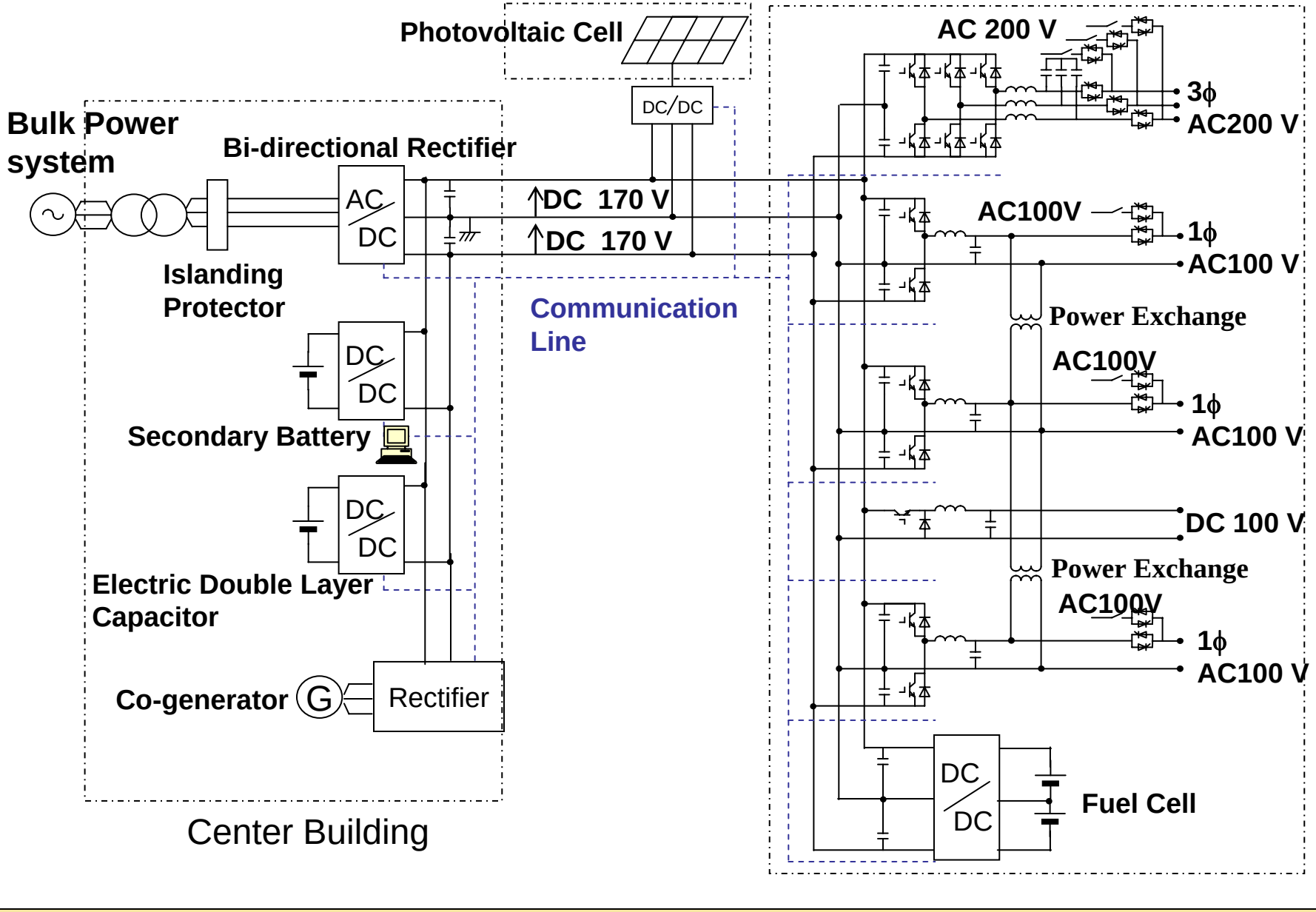



Current Through the Mechanical Switch




Current Through the Semiconductor Switch

# Low Voltage Type DC Microgrid



# Features of Low Voltage Type DC Microgrid

- Distributed scheme of load side converters contributes to provide a super high quality power supplying.
- Various forms of electric power like single phase 100V, three phase 200V, DC 100V can be obtained without using transformers.
- If power consumption become more than a power production during a long term isolation, DC micro-grid can stop supplying power for some loads intentionally by load side converters in order to continue supplying power for more important loads.
- When a temporary overload occurs at one load, electric power can be shared by using additional electric power lines between load side converters.

# Features of DC Microgrid

- Synchronization of distributed generators are not necessary.
- Fluctuation of generated power of distributed generators and load power can be compensated in the dc line by using energy storage devices.
- Loads are not affected by voltage sag, voltage swell, three-phase voltage unbalance, and voltage harmonics.
- Power quality is not affected by Inrush current, single-phase loads and single-phase generators.
- Higher efficiency than AC microgrid is expected.