SC D2 2015 SESSION

ENERGY STORAGE SYSTEMS FOR FREQUENCY REGULATION AT ELECTIRC POWER PLANTS IN KOREA

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INTRODUCTION

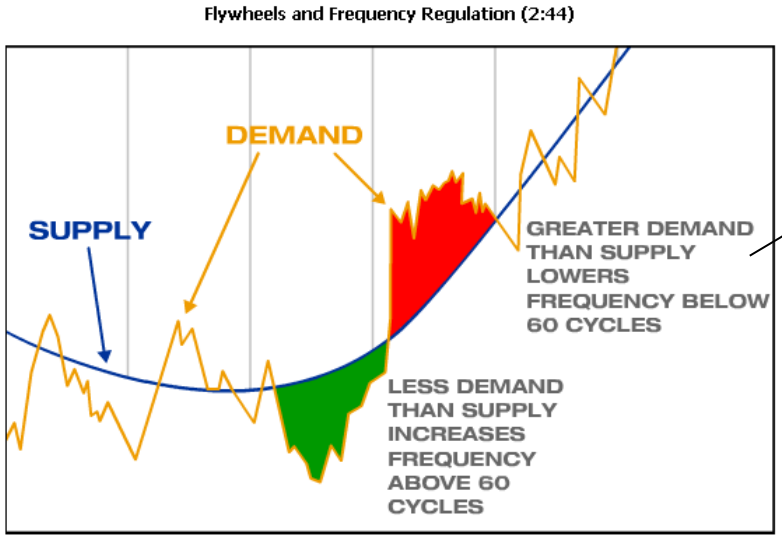
- In this paper,
  - We demonstrate our system architecture of the power management system (PMS) for Frequency Regulation (FR) which is installed in a substation in Korea
  - We explain our methods to support the time-critical data in PMS

INTRODUCTION

- Power Line Frequency (or System Frequency)
  - Power line frequency should be controlled to be stable
    - Appliances may not operate efficiently or even safely if used on anything other than the intended frequency (50 or 60 Hz)
    - Generators can only be interconnected to operate in parallel if they are of the same frequency and wave-shape

INTRODUCTION

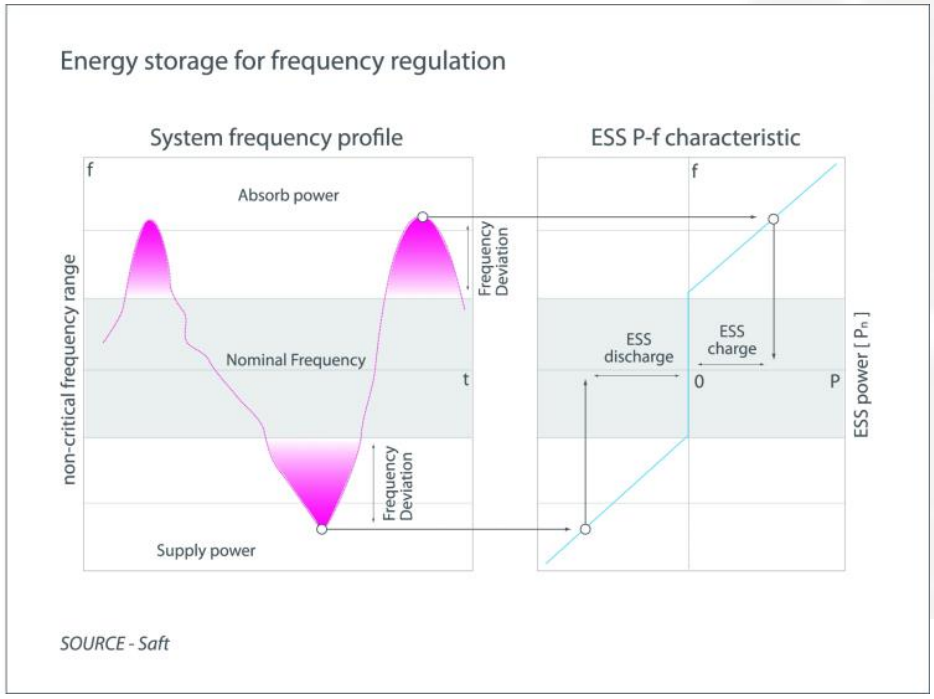
- Frequency Regulation (FR)
  - Power line frequency changes continuously due to the imbalance between generation and load
  - Frequency regulation is one of ancillary services to maintain a stable frequency by balancing generation and load in real time
    - Generators have to reserve a fraction of power capacity for frequency regulation



When demand momentarily exceeds generation, the missing energy is supplied by the kinetic energy of the generators' rotors

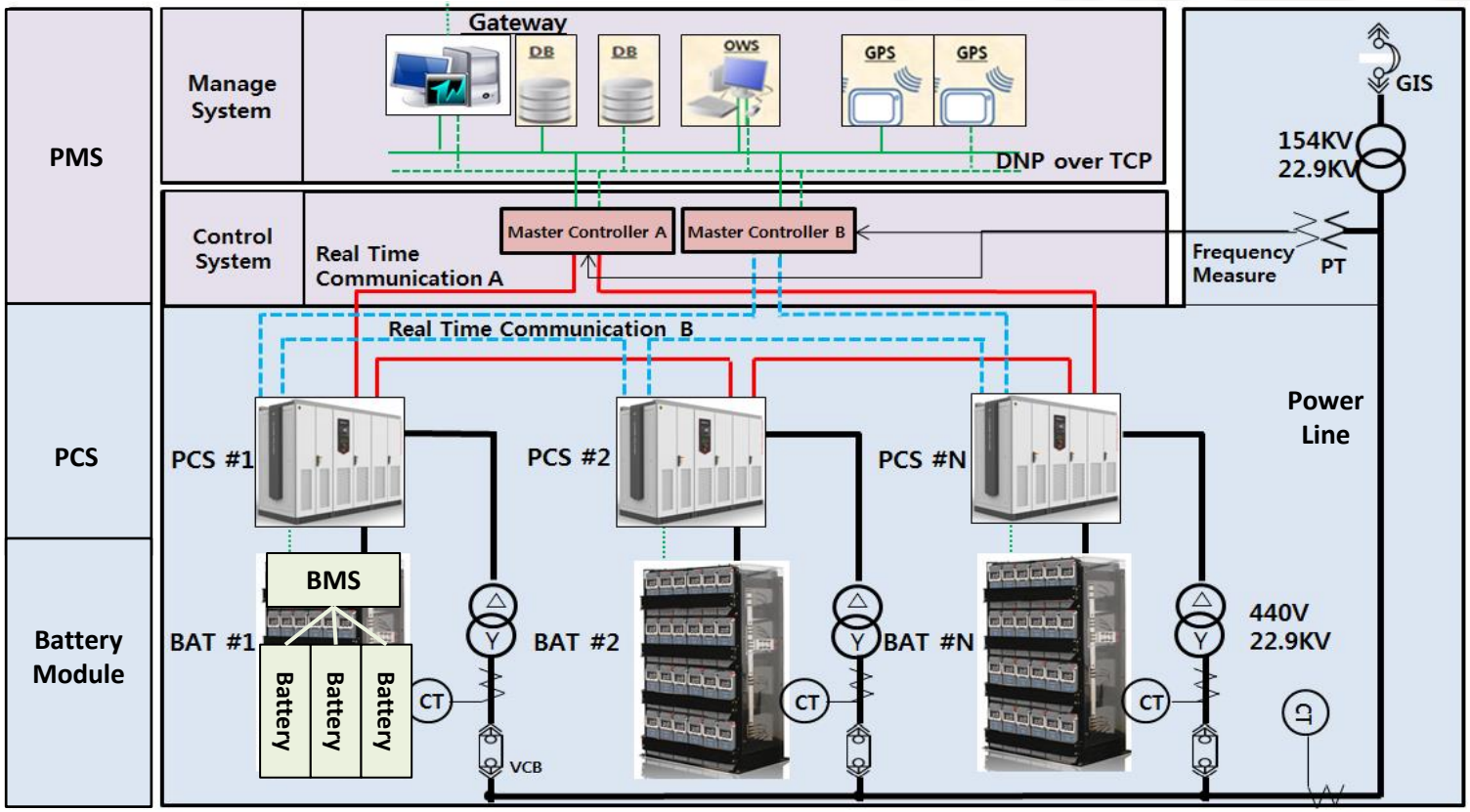
INTRODUCTION

- Energy Storage System (ESS) for Frequency Regulation
  - Battery allows the electric power grid to store the electric energy when load is lower than generation and utilize the stored energy when load is higher than generation
  - ESS provides efficiency of power plants and fast response for FR



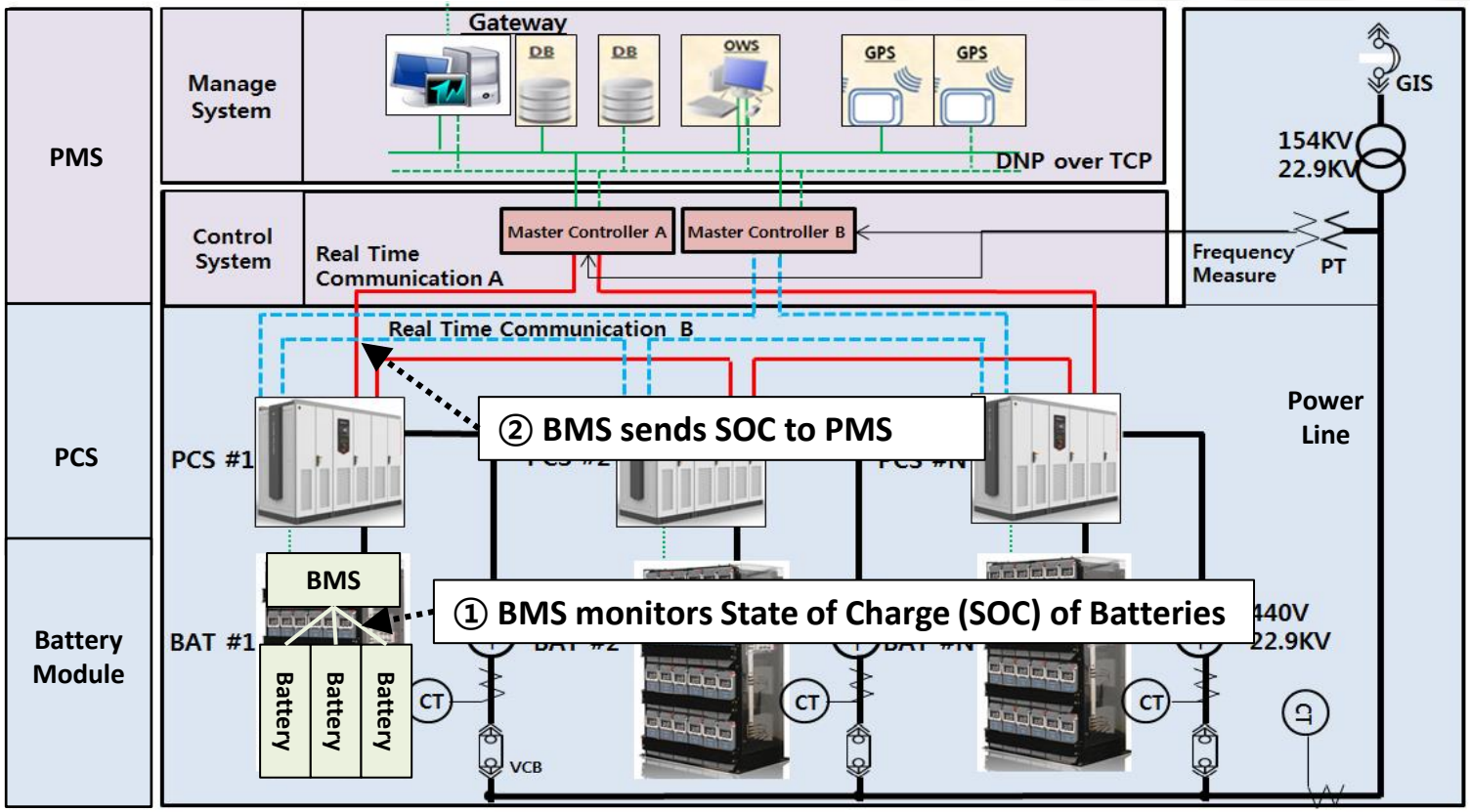
SYSTEM ARCHITECTURE OF ESS

- EES consists of…
  - Power Management System (PMS)
  - Power Conversion System (PCS)
  - Battery Management System (BMS) + Battery



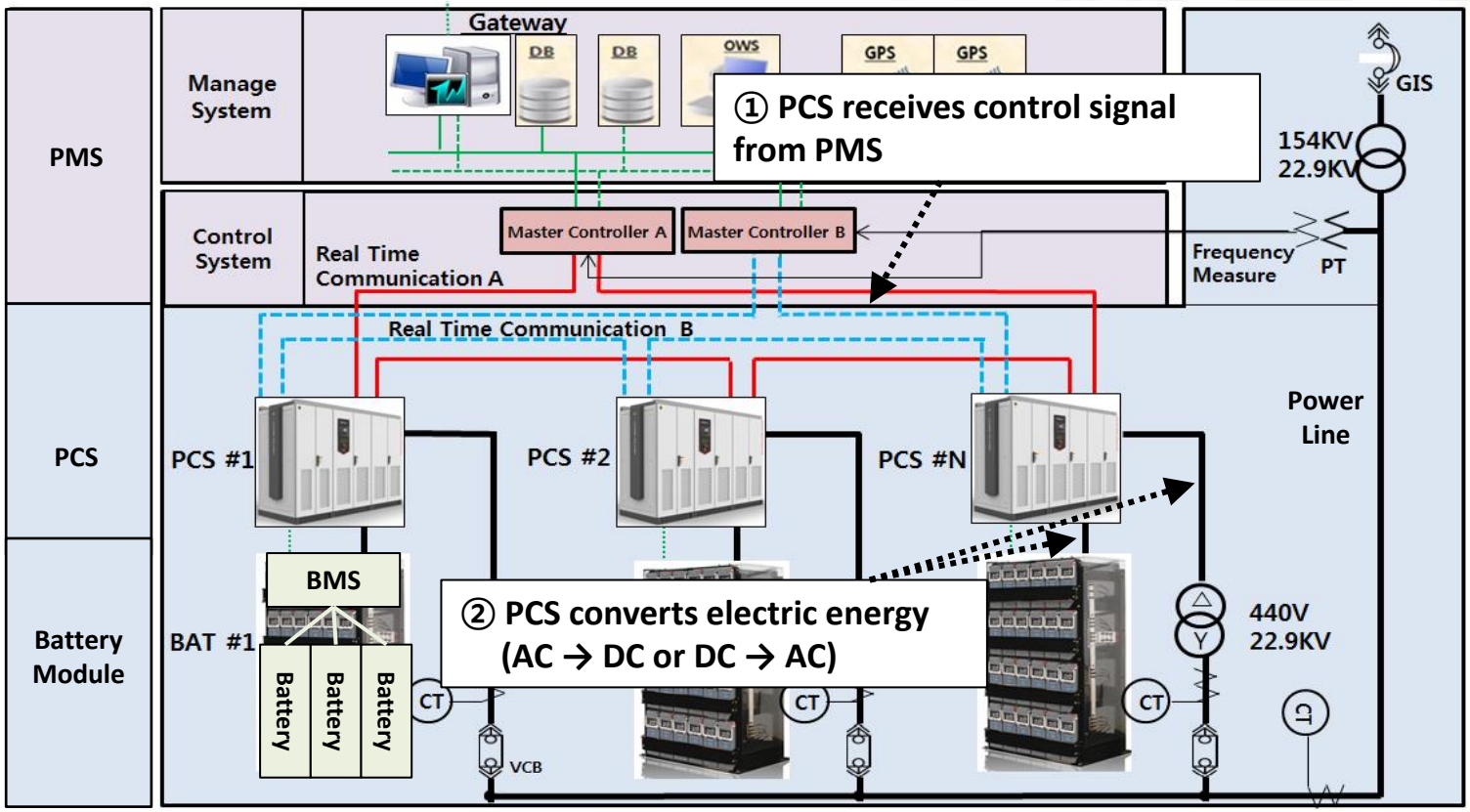
SYSTEM ARCHITECTURE OF ESS

- Battery Management System (BMS)
  - BMS monitors the state of battery to indicate the charge level of the battery
    - State of Charge (SOC)
    - Depth of discharge (DOD)



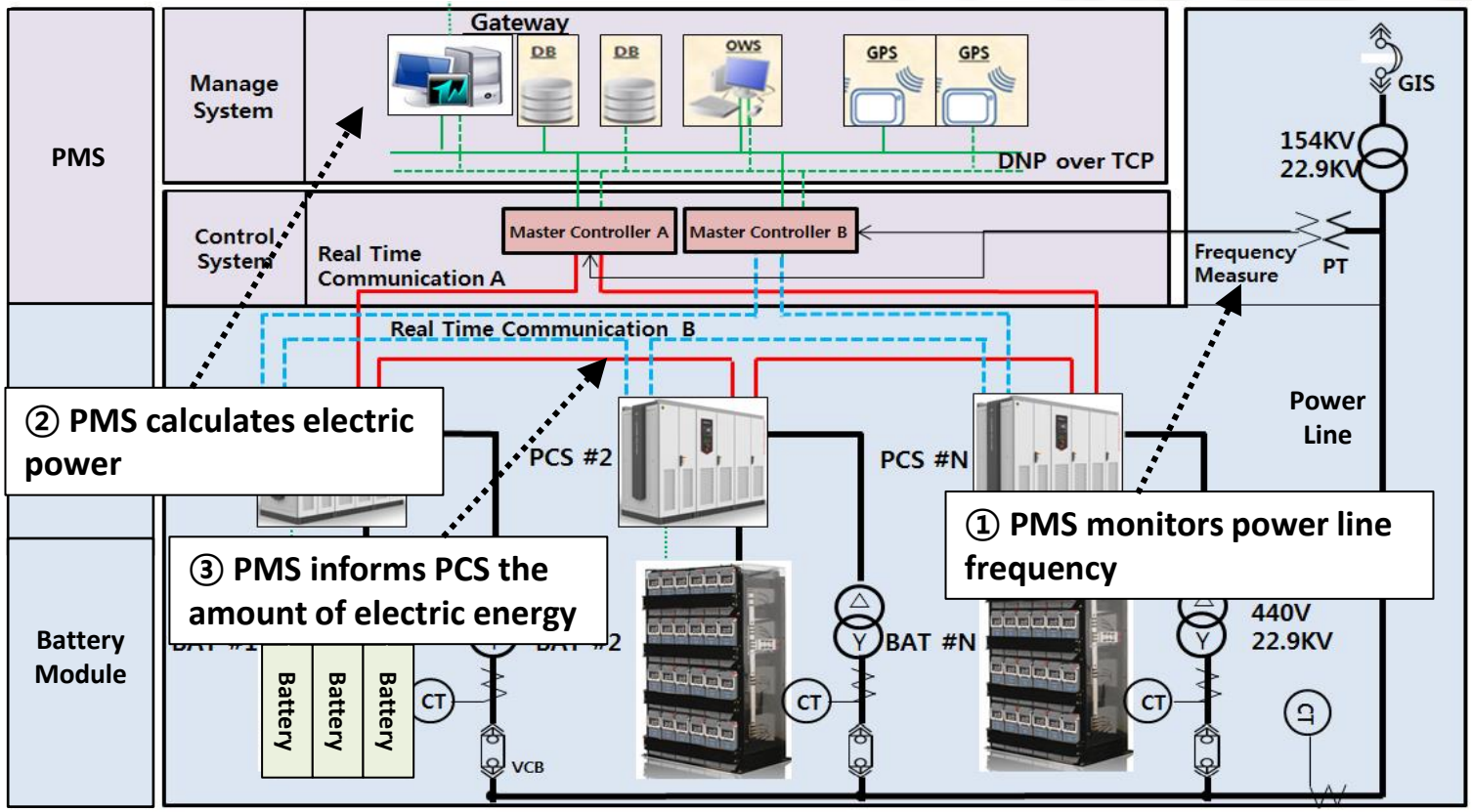
SYSTEM ARCHITECTURE OF ESS

- Power Conversion System (PCS)
  - PCS connects batteries to the power grid
  - PCS converts electric energy for batteries to charge/discharge according to the control signal from PMS



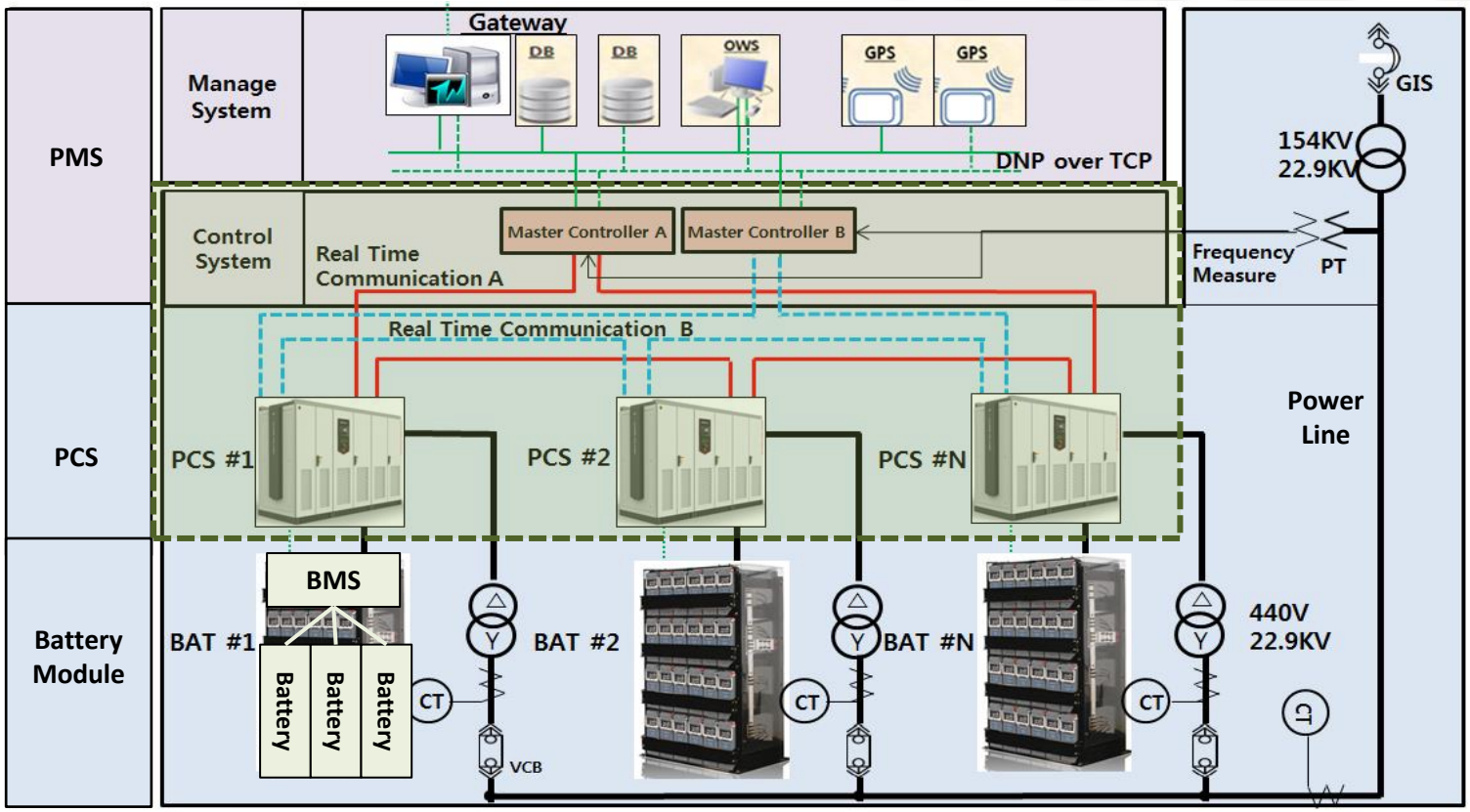
SYSTEM ARCHITECTURE OF ESS

- Power Management System (PMS)
  - Monitoring the power line frequency
  - Calculating the amount of electric energy for FR (by using frequency + SOC of batteries)
  - Dividing the amount of electric energy among all PCSs
  - Informing each PCS the amount of electric energy to charge/discharge



REAL-TIME COMMUNICATION

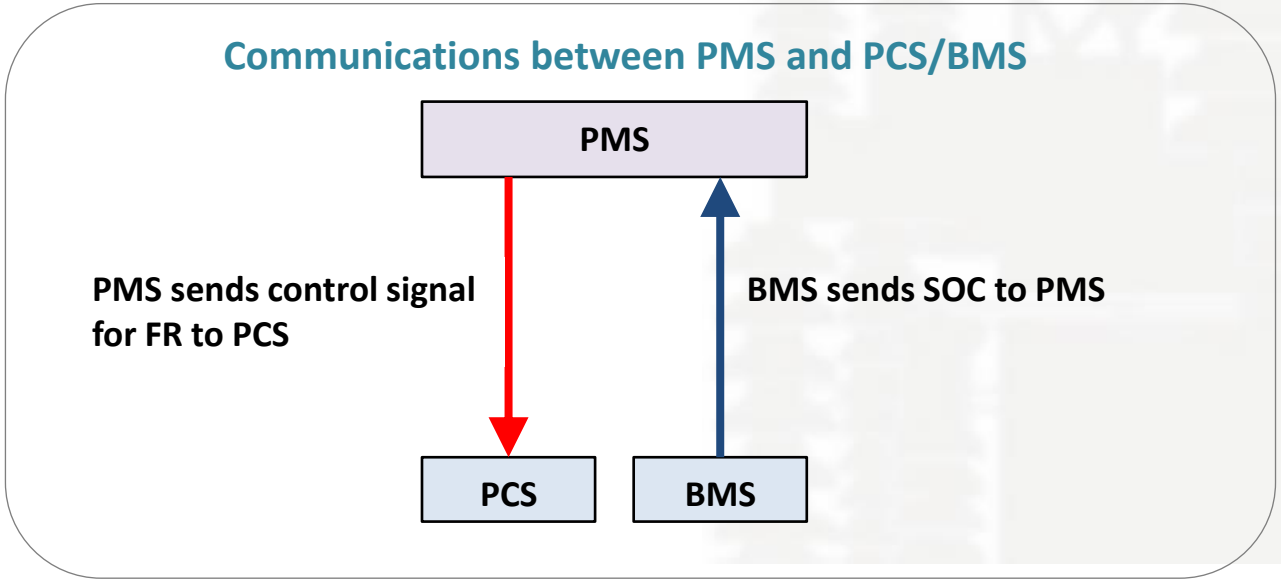
- Real-Time Communication
  - For real-time frequency regulation, the communication between PMS and PCS should be real-time
    - PMS should send the control signal for frequency regulation to PCS in real time



REAL-TIME COMMUNICATION

❖ Communication between PMS and PCS/BMS

- Two main communications
  - ① PMS → PCS: PMS sends control signal for frequency regulation to PCS
  - ② BMS → PMS: BMS sends SOC of batteries to PMS



REAL-TIME COMMUNICATION

❖ LSIS ESS Communication Assembly (LECA)

① We use a high-end industrial PC for the LECA in order to reduce the processing delay

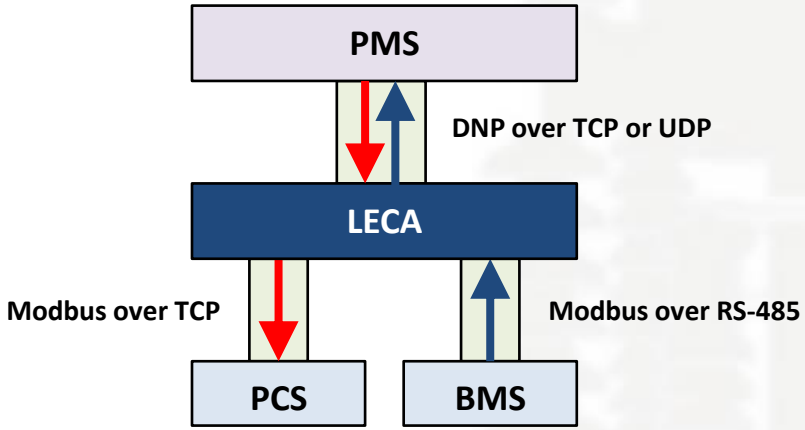
② The priorities of the processes for the communication between PMS and PCS are set higher than others

③ A real-time operating system (OS) is installed for the LECA's OS

④ In order to reduce TCP latency, we use the option called 'TCP_NODELAY'

→ The use of this option disables the Nagle's algorithm to reduce the latency

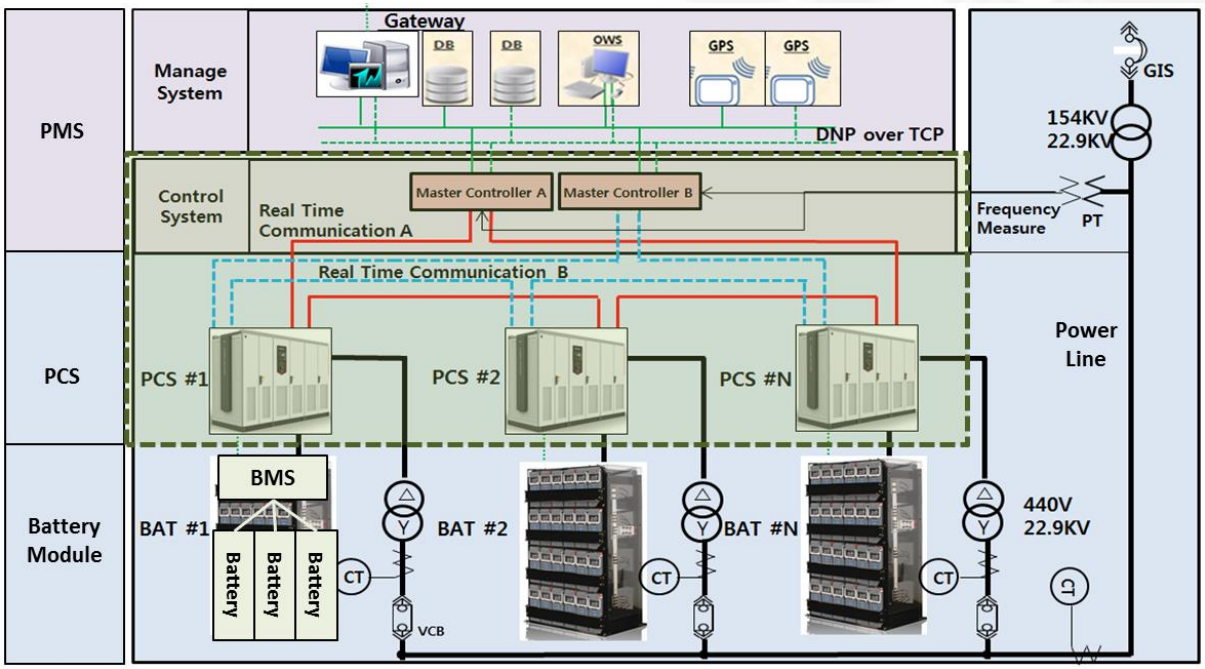
Communications between PMS and PCS/BMS



QUESTION AND ANSWER FOR Q1-19

Q1-19) The used technology in this pilot successfully used to regulate the frequency. Is this concept scalable?

- In order to increase the capacity, the number of PCSs should increase
  - This also results in increase of the data traffic between PMS and PCS
  - Then, the latency of the real-time traffic may not satisfy the threshold



QUESTION AND ANSWER FOR Q1-20

Q1-20) Is this solution usable as a local solution within Smart Grids?

- ESS can be used for frequency regulation or peak shaving (within Smart Grids) by changing the charge/discharge scheduling algorithm in PMS
  - Input of algorithm
    - Frequency Regulation: frequency deviation, SOC of battery, …
    - Peak Shaving (within Smart Grids): energy consumption, peak threshold, …