UPDATES of NSF I/UCRC GRAPES-KOREA SITE

School of Electrical and Electronic Engineering
Yonsei University, Seoul, Korea
Prof. Yong-June Shin

NSF I/UCRC GRAPES IAB Meeting
Columbia, SC
2016. 5. 25
I. Korea NRF Program for GRAPES-Korea Site

II. Introduction of GRAPES Korea Members
# Global Research Program

## Part I. Global Research Lab.

**Objective:**
Promote international collaborative research between Korean and foreign laboratories

**Sponsor:** Korea National Research Foundation (NRF)

**Details**
- **Research Period:** 6 years (3+3)
- **Budget:** 500,000,000 KRW per year ($500,000)
- **Number of Beneficiary Programs:** New 8 programs (2016)
- **Investigators:**
  - Prof. Yong-June Shin (P. I.)
  - Prof. Gilsoo Jang (Korea Univ.)

$60,000/ year subcontract from Korea to U.S.

## Part II. Global Research Development Center

**Objective:**
Attract innovative foreign research center and promote international collaborative research

**Sponsor:** Korea National Research Foundation (NRF)

**Details**
- **Research Period:** 6 years (2+4)
- **Budget:** 600,000,000 KRW per year ($600,000)
- **Number of Beneficiary Programs:** New 3 centers (2016)
- **Investigators:**
  - Prof. Yong-June Shin (P. I.)
  - Prof. Gilsoo Jang (Korea Univ.)
  - Prof. Kyeon Hur

Final candidate of this program at 2015
Research Topic

Research Topics of GRAPES Korea Site: HVDC based Future Grid

I. HVDC Scheme
High-tech Power Electronics/HVDC System Design

II. HVDC Cable
Cable Diagnosis & Health Index

III. Wide Area Monitoring
Wide Area Monitoring and Control

IV. Grid-Connected HVDC
HVDC Grid Diagnosis

Offshore, Cable, Grid, Grid-Connection
Research Plan

Annual Research Plan & Co-workers

1st Year (’16.9.-’17.8.)
- Fundamental Technology
  - HVDC Design
  - HVDC Control System

2nd Year (’17.9.-’18.8.)
- Monitoring & Control
  - Wide Area Stability Index
  - Dynamic Line Rating
  - HVDC System Monitoring

3rd Year (’18.9.-’19.8.)
- Real-Time Operation
  - Cable Diagnosis
  - Real Time Operation
  - Wide Area Monitoring

Device

Wide Area

Future Electric Grid

International Cooperation

FRL Member

Co-Workers
Overview

I. Korea NRF Program for GRAPES-Korea Site

II. Introduction of GRAPES Korea Members
Managing Departments

YONSEI UNIVERSITY

- Best Private University in Korea
- 3,500 Faculty Members in 3 Campuses
- Dual Degree M.S. / PhD. Program with USC
- 60 Tenured / Tenure-Track Faculty Members (EE)
- 250 M USD Annual Research Expenditure
- Supergrid Research Center

KOREA UNIVERSITY

- ISEP with 289 Prestigious Schools Worldwide
- Joining Universitas21 (Including Univ. of Virginia)
- Reinforcing International Organization (APRU, etc.)
- 49 Full-Time Professors, 4 Adjunct Professors
- Cutting-edge Research about Power System
- Flexible Energy System Research Center
Academic Career

- 2012 - Now Associate Professor
  Yonsei University, Seoul, Korea
- 2011 - 2012 Associate Professor with tenure
  University of South Carolina
- 2004 - 2010 Assistant Professor
  University of South Carolina
- NSF CAREER Award, IEEE Senior Member
  IAEA CRP Chief Scientific Investigator

Education

- Ph.D. University of Texas at Austin (2004)*
- M.S. Univ. of Michigan, Ann Arbor (1997)
- B.S. Yonsei University, Seoul, Korea (1996)
  *Military service 05/15/2001~01/10/2003

Research Interests

- Smart Grid (Synchrophasor)
- Power Electronics (FACTS)
- Power Quality
- Power Cable Diagnostics and Prognostics
- Electric Ship
- Applied Signal Processing (Time-Frequency Analysis)

Research Group: Power IT LAB.

- M.S./Ph.D. : 15
  Ph.D. : 3
  M.S. : 4
- KNRF National Research Laboratory (NRL) Program
### Transmission and Distribution

- **Voltage-only Fault Locator & Power Quality in Smart Grid**
  - Yonsei Super-Grid Research Center
    Sponsor: ROK Ministry of Trade, Industry and Energy
  - Transient Stability Improvements in Wind Farms Using Power Electronics and FACTS Devices
    Sponsor: GRAPES Industry University Collaborative Research Center

### Synchrophasor

- **PMU (Phasor Measurement Units)**
  - Development of Fault Detection Technique Via Wavelet Transformation of PMU signals in Electric Power Grids
    Sponsor: KEPCO / Korea Electrical Engineering & Science Research Institute

### Cable Diagnostics / Prognostics

- **TFDR (Time-Frequency Domain) Diagnostics / Prognostics**
  - Diagnostics and Monitoring of Electric Power Systems for Super Grid
    Sponsor: Korea National Research Foundation
  - Diagnostics and Prognostics of C&I cable in Nuclear Power Plants
    Sponsor: Korea National Research Foundation
Members of Power IT Lab.
Prof. Gilsoo Jang

Education

- Ph.D. Iowa State University, Ames, Iowa (1997)
- M.S. Korea University, Seoul, Korea (1994)
- B.S. Korea University, Seoul, Korea (1991)

Research Interests

- Power System Dynamics and Control
- Integration of Renewable Energy Resources
- Power Quality
- Application of Power Electronics on Power System

Academic Career

- 2008 - Now Professor
  Korea University, Seoul, Korea
- 2007 - 2008 Visiting Associate Professor
  Cornell University, NY, USA
- 2000 - 2008 Assistant & Associate Professor
  Korea University, Seoul, Korea
- IEEE Senior Member, Editor of IEEE T Smart Grid, MKE
  Minister Citation, Yeonam Foundation Fellowship, Who’s
  Who in Science and Engineering,

Research Group: Power & Energy LAB.

- Ph.D. Student: 10
  M.S. Student: 2
- Power Generation & Electricity Delivery Core
  Technology Program
  (Supported by Korea Institute of Energy Technology Evaluation and
  Planning)
- National Research Laboratory (NRL) Program
  (Supported by KNRF)
HVDC Application & Control

- HVDC Interaction with AC grid
- HVDC Operation Scheme with regard to Efficiency and Stability
- Grid Segmentation by HVDC
  Sponsor: KEPCO, LS Industrial System, Hyosung Power & Industrial Systems

Multi-Frequency Operation

- Increase the Power System Efficiency by Restructuring the Grid as Multi-frequency
- Develop the Operation Scheme Under Multi-Frequency Environment
  Sponsor: Korea Institute of Energy Technology Evaluation and Planning

Wind Farm Modeling & Control

- Wind Farm Modeling and Control
- Minimize the Mechanical Fatigue by Using Wind Source Forecast
- Maximize the Wind Farm Generation by Controlling Each Turbine
  Sponsor: Samsung Heavy Industries

Runtime Wind Farm Forecasting
Members of Power & System Lab.

ByongYoon Shin  
Ph.D.  
Power & Energy Lab

SeungMin Jung  
Ph.D.  
Power & Energy Lab

QingLei Guo  
Ph.D.  
Power & Energy Lab

BoKyung Ko  
Ph.D.  
Power & Energy Lab

JaeWan Seo  
Ph.D.  
Power & Energy Lab

KiSuk Kim  
Ph.D.  
Power & Energy Lab

SungChul Hwang  
Ph.D.  
Power & Energy Lab

JaeHyeong Lee  
Ph.D.  
Power & Energy Lab

HyunWook Kim  
Ph.D.  
Power & Energy Lab

YeunTae Yoo  
Ph.D.  
Power & Energy Lab

ChangHee Han  
M.S.  
Power & Energy Lab

Seung Jin Chang  
M.S. / Ph.D.  
Power & Energy Lab
Prof. Kyeon Hur

Education

- Ph.D. University of Texas at Austin (2007)
- M.S. Yonsei University, Seoul, Korea (1998)
- B.S. Yonsei University, Seoul, Korea (1996)

Research Interests


Academic Career

- 2014 - Now  Associate Professor
  Yonsei University, Seoul, Korea
- 2010 - 2014  Assistant Professor
  Yonsei University, Seoul, Korea
- 2008 - 2010  Senior Project Scientist, Project Manager
  Electric Power Research Institute,
  Palo Alto, USA
- IEEE Senior Member, Cigre Member (B4.62 WG),
  Editor of Journal of Power Electronics

Research Group: Smart Grid LAB.

- M.S. / Ph.D. : 12
  Ph.D.: 4
  M.S. : 2
- HULab (Hyosung-University Lab)
- Next Generation Super Grid Research Center
## Modular Multilevel Converter (MMC) – Design and Operation

**Design of MMC-HVDC**
- Designing Cell Capacitance
- Defining Number of Redundant Submodule

**MMC-HVDC Control, Operation, and Protection**
- Defining P – Q Capability under changing MMC and Grid Operating Conditions
- Grid Stability Improvement using MMC

**DC Grid Modeling**
- Efficient Modeling of MMC and DC Grid using Parallel Computing Method
  Sponsor: KEPCO, LS Industrial Systems, Hyosung Power & Industrial Systems

## PQ Concerns of Wind Integration

**Improved Modeling and Analysis of Stochastic Harmonics and Resonance Issues of Wind Energy Grid Interconnection**
- Analysis of Stochastic Harmonic Characteristics of Wind Turbines
- Improved Wind Turbine Modeling for Probabilistic Harmonic Generation
- Investigation of Resonance Issues Based on Stochastic Harmonic Characteristics
  Sponsor: KETEP

## Impact of Increasing Converter-Based Generation

**Penetration Level Rise and DG Fluctuation Impact on Small Signal Stability**
- Wind Impact on Small Signal Stability based on mode coupling
- Analysis of Penetration Level Rise
- Impact of Decreased Inertia Constant
- Damping Controller Design
  Sponsor: KETEP, Korea National Research Foundation
Members of Smart Grid Lab.

Hee Jin Kim
Post Doctor
Smartgrid Lab.

Jae Woong Shim
M.S. / Ph.D.
Smartgrid Lab.

Da Ham Min
M.S. / Ph.D.
Smartgrid Lab.

Kyung Sung An
M.S. / Ph.D.
Smartgrid Lab.

Young Ho Cho
M.S. / Ph.D.
Smartgrid Lab.

Jae Kyoong Kim
M.S. / Ph.D.
Smartgrid Lab.

Se Hyun Kim
M.S. / Ph.D.
Smartgrid Lab.

Jae Sik Kang
M.S. / Ph.D.
Smartgrid Lab.

Nehal Helay
Ph.D.
Smartgrid Lab.

Sang Min Kim
M.S. / Ph.D.
Smartgrid Lab.

Choong Man Lee
M.S. / Ph.D.
Smartgrid Lab.

Hyun Jae Lee
M.S. / Ph.D.
Smartgrid Lab.

Kyung Han Jun
M.S. / Ph.D.
Smartgrid Lab.

Woo Choul Kim
M.S.
Smartgrid Lab.

Jee Hoon Lee
M.S. / Ph.D.
Smartgrid Lab.

Young Joon Lee
M.S.
Smartgrid Lab.

Jong Seo Na
M.S. / Ph.D.
Smartgrid Lab.

Hae Won Seo
M.S. / Ph.D.
Smartgrid Lab.
Korea IAB Members

**KEPCO (KEPRI)**
- **Korea Electric Power Corporation (KEPCO)**: Transmission, Distribution & Retail
  
  | Power System          | • Transmission technology
                        | • Applied superconductivity and underground transmission
                        | • Distribution IT
                        | • Power system protection

  | Green & Smart Energy | • New & renewable energy
                        | • Power storage
                        | • Power plant life assessment

**KERI**
- **Korea Electro-technology Research Institute (KERI)**: Government-funded National Research Institute

  | Advanced Power Grid      | • Smart power grid
                            | • Smart distribution
                            | • Electrical environment research
                            | • Power telecommunication research

  | HVDC                    | • Power conversion & control
                            | • Power semiconductor
                            | • Superconductivity research
Korea IAB Members

**KPX**
- **Korea Power Exchange (KPX)**
  : Electricity Market & System Operation
  - Power system supervisory control
  - Maintaining the demand and supply balance
  - Efficient market operation
  - Reliable power system operation
  - Fault prevention and rapid restoration
  - System voltage and frequency control

**KDN**
- **Korea Electric Power Data Network (KDN)**
  : Total Power IT Service on Power Grid
  - Power Communication IT
    - Power line communication
    - Maintenance professional (M-Pro)
  - Power Generation & Dispatching IT
    - Energy management system (EMS)
    - Electric power trade system
  - Transmission & Transformation IT
    - Wide area monitoring system
    - Power equipment condition monitoring diagnosis system
    - SCADA system of substation control center
Korea IAB Members

**HYUNDAI**
Heavy Industries
- Transformer / Switchgear
- Integrated Control & Monitoring Systems
- Solar Power System
- Wind Turbine System
- Energy Storage System (ESS)
- Sales in 2013: $24,284 M (USD)

**LS IS**
(Industrial System)
- Converter Transformer
- Electronic Meter
- HVDC
- Power Semiconductor
- Photovoltaic System
- Sales in 2013: $2,352 M (USD)

**HYOSUNG**
- Transformer
- Substation Automation
- Shunt Reactor
- Low / High Voltage Motor
- Wind Turbine Generator / Gear unit / Tower
- Sales in 2013: $550 M (USD)
Korea IAB Members

LS CS (Cable & System)

- Extra-high Voltage Cable
- Submarine Cable
- Industrial Devices
- Harness & Module
- Structured Cabling System

LG Chem

- Energy Storage System
- Battery Management System
- Power ancillary service
- ESS for household use
- Uninterruptible Power Supply (UPS)
Framework for GRAPES-Korea

- **Stability**
  - Phasor Measurement Unit (PMU)
  - Real-Time Stability Index (SI) Monitoring

- **Operation**
  - Dynamic Line Rating (DLR) of HVDC
  - Optimal Capability
  - Real-Time Control

- **Monitoring**
  - HVDC Fault Detection / Location
  - Artificial Intelligence (AI) Based Classification

**Grid-Connected HVDC**

- **System Design**
  - Modular Multi-level Converter (MMC)
  - MMC-HVDC Modeling
  - MMC-HVDC Topology

- **Control**
  - MMC Based Back-to-Back (BTB) Control
  - BTB HVDC Fault Analysis / Location

- **Cable Diagnosis**
  - HVDC Cable Fault Location
  - Health Index (Thermal, Electrical, Mechanical)

**HVDC System**

*Future Grid Global Research Lab.*
Vision for GRAPES-International

 Establishment of Korea-U.S. I/UCRC

University Members

U.S I/UCRC

Korea I/UCRC

Industry Members

University Members

Industry Members
Thank you for your attention
Back Up Slides
GRAPES Investment

Overview of GRAPES Investment

- **Human Investment**
  - Dual Degree
    - MOU of Korea and America Universities
    - Exchange of Graduate & Professional Personnel

- **Financial Support**
  - NSF Supplementary Funding
  - In-Kind Support (Research Facilities at UA/USC)

- **Academic Cooperation**
  - Cooperative Research & Academic Advisor
  - Invited Lecture & International Conference

- **Technical Exchange**
  - Exchange of Intellectual Properties
  - Provision of Power Electronics Technology