UNIVERSITY OF PITTSBURGH
SWANSON school of engineering
Power & Energy Initiative

# Stability and Control of a MVAC & MVDC System with Weak AC Grid Connection

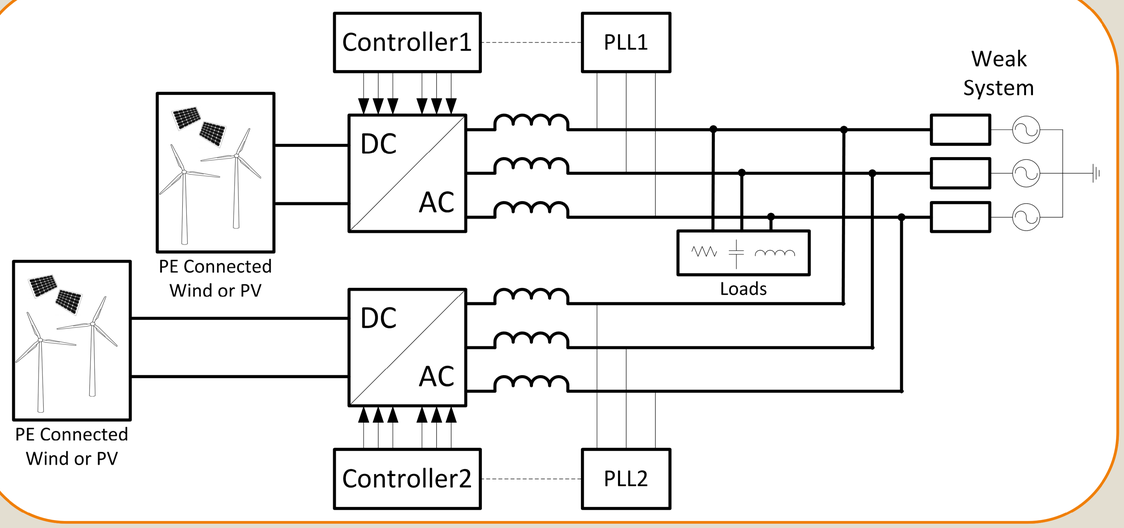

**Graduate Student: Matthew Korytowski**

**Academic Advisors: Dr. Gregory Reed and Dr. Thomas McDermott**

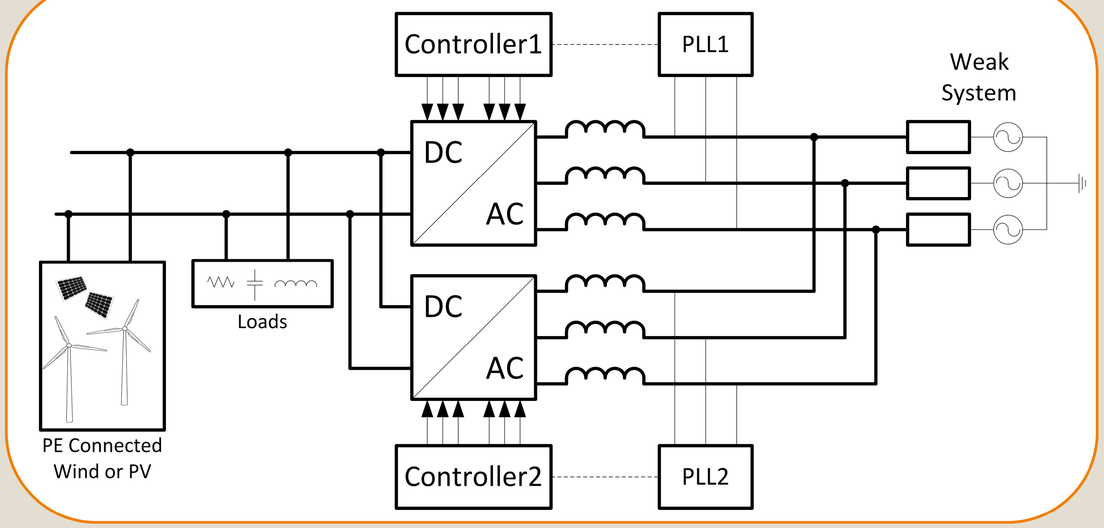

Ben Franklin Technology PArtners

ABB

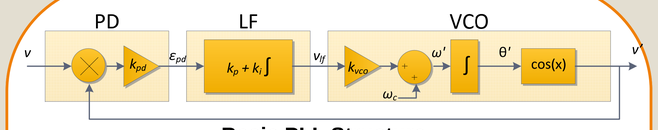
## MVAC Network




## MVDC Network

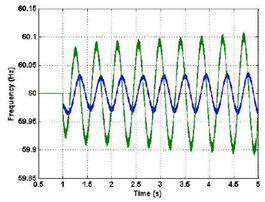



## PLL Instability




**Basic PLL Structure**

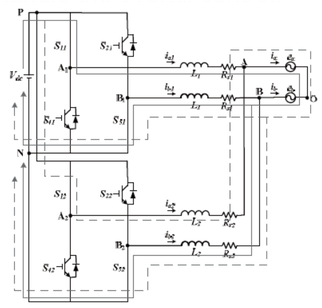
It has been shown in literature that when multiple PLLs are connected to a weak system at a common point, they may become unstable. This is an important issue to investigate since an oscillating frequency may cause distributed resources to trip off the grid and become unavailable. Possible solutions to solve the instability issues include optimizing the PI control parameters, decoupling the PLLs from the weak system, or a combination of the two.




D. Dong, "Ac-dc Bus-interface Bi-directional Converters in Renewable Energy Systems,", Dissertation; Virginia Polytechnic Institute, 2012.

## Parallel Converter Control

A prominent concern with converters operating in parallel are the circular currents that flow between them. This causes unbalanced load sharing, current distortion, and leads to increased stress on one converter over another as well as degraded performance. One method of overcoming this is to use a load sharing algorithm where the converters are able to communicate with each or to use some form of master/slave control. However, the pitfall with master/slave control is the dependence upon one unit to handle the overall control.




C.-T. Pan and Y.-H. Liao, "Modeling of circulating currents for grid-connected parallel three-phase inverters," in 2008 SICE Annual Conference, 2008.

## What Defines a Weak Grid/Connection?

Mathematically, a weak grid is defined by the ratio of inductance over resistance or X divided by R. A large value, of say 10 or 15, is considered good and designates a strong grid whereas lower values, especially less than one, correspond to a weak system. A weak system is more prone to instability and power quality issues. Such issues include voltage drop, voltage flicker, frequency deviations, and harmonic distortion. Wind resources are often located far from where they are needed thereby also being connected to weaker points in the grid. Overcoming these weak grid issues is therefore very important.

## Operation Modes and Transitions

In the realm of microgrids and distributed generation, operation modes and transitions are very important to investigate and understand. Examples of operation modes include grid-connected, islanding, and faults that occur while in either mode such as being grid-connected while a fault occurs on the connected wind resources. Monitoring and controlling the transitions from one mode to another are vital to prevent unwanted transients and to maintain stability at all times.