nationalgrid

Performance of Phase-Locked Loop Based Converters

Yun Li – *Power System Engineer*
System Performance Team
System Operator, National Grid

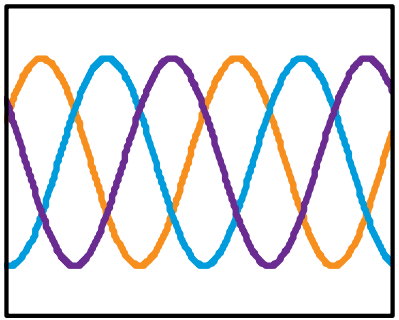
Phase-Locked Loop Based Converters

nationalgrid

Renewable generation and HVDC system

Converters adjust power to synchronize with the electricity network

Converters rely on PLL to see and react to network status

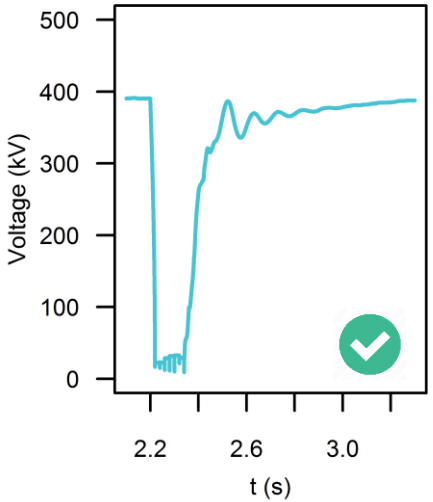


Greenwich Mean Time

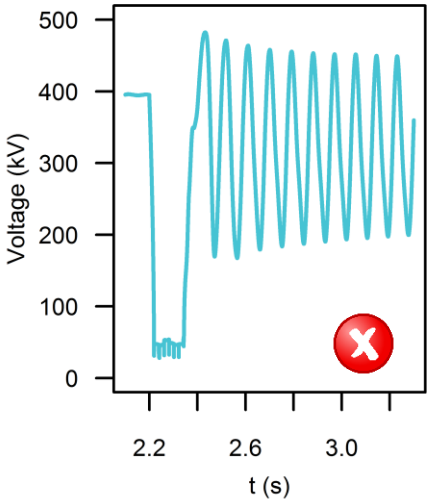
Phase-Locked Loop Based Converters

nationalgrid

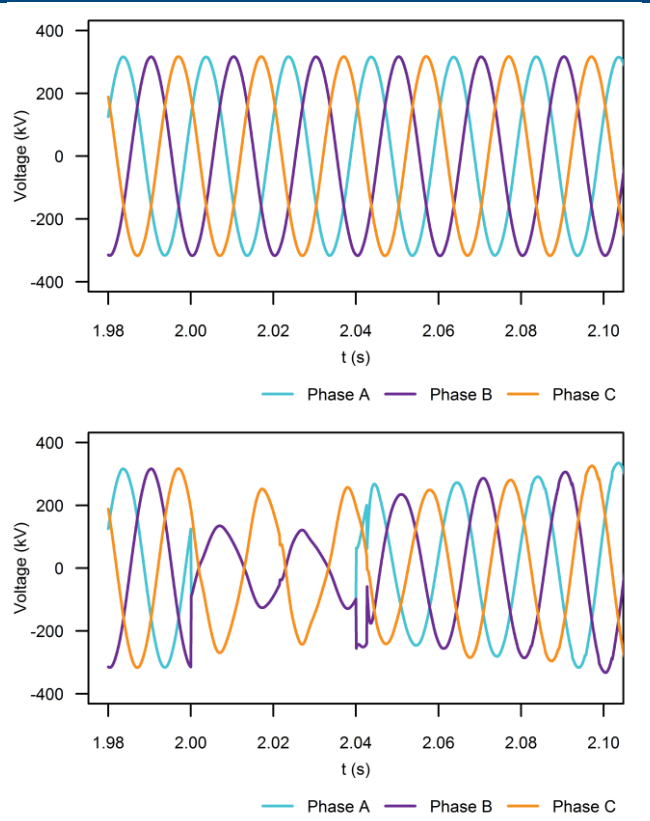
PLL keeps track of network during a fault, converter maintains synchronisation



PLL loses track of network during a fault, converter loses synchronisation



What is changing?



PLL measures voltage waveform

System strength is decreasing

PLL is more like to lose track of network

Understand the performance of PLL based converters when system strength is very low

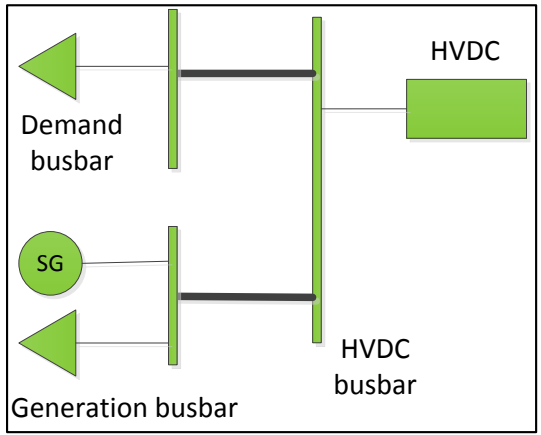
Our method

CIGRE developed Voltage Source Converter model

PSCAD software package

Simplified scaled network model

Voltage disturbance



Impact of System Strength

nationalgrid

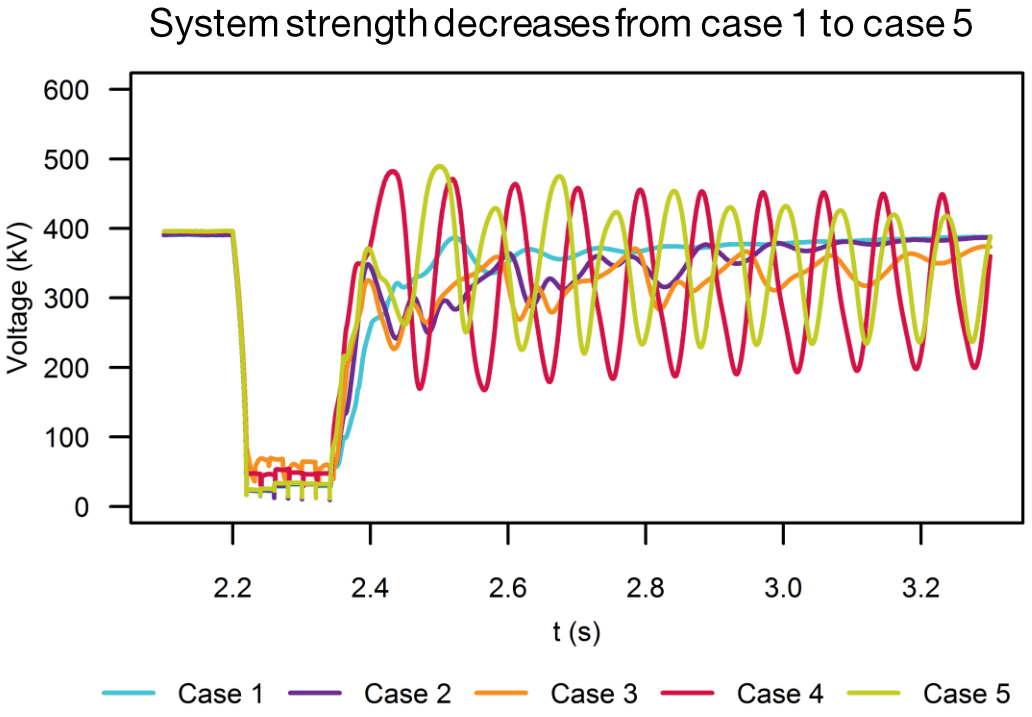
Risk of converter instability increases as system strength decreases

Case NO.	Short circuit current (Peak/@100ms kA)	Fault at HVDC busbar	Fault at demand busbar	Fault at gen. busbar
1	2.41/0.839	√	√	√
2	2.378/0.813	√	√	√
3	2.355/0.787	√	√	√
4	2.25/0.772	√	X	X
5	1.959/0.472	X	X	X

Impact of System Strength

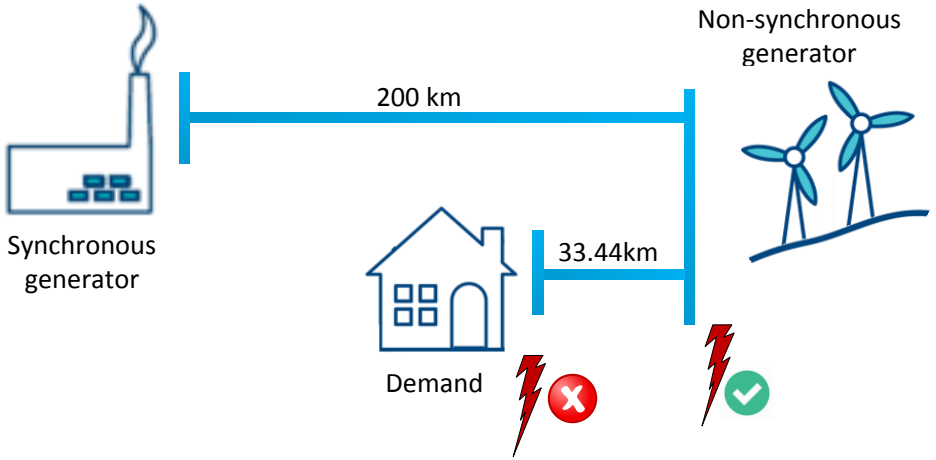
nationalgrid

Oscillatory instability could be induced in low system strength scenario due to PLL losing track of system voltage



Impact of Fault Location

A remote fault could lead to a lower margin of stability of the PLL converter compared to a fault occurring at the converter.

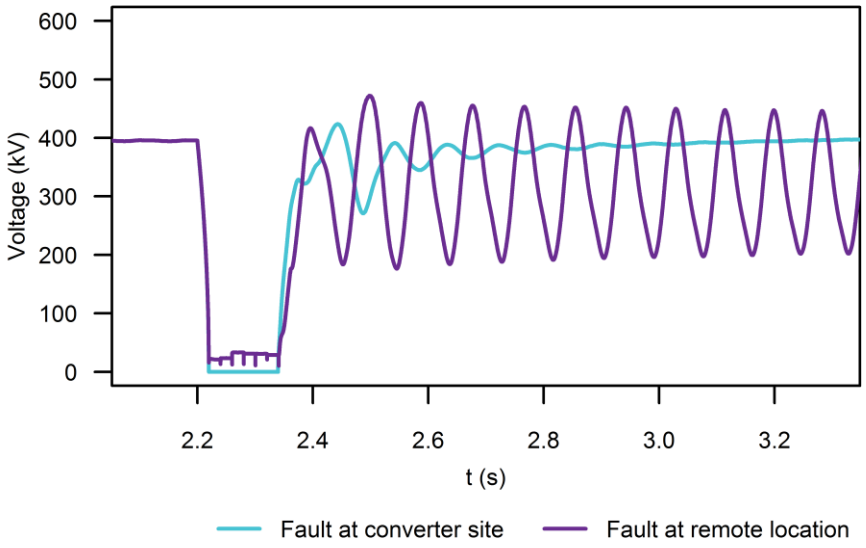


Impact of Fault Location

nationalgrid

Converter responds differently to these two faults.

Fault-ride through capability of converters relates to both voltage magnitude and its phase change.



Impact of PLL Settings

nationalgrid

PLL proportional/integral gains determine the speed of response of PLL.

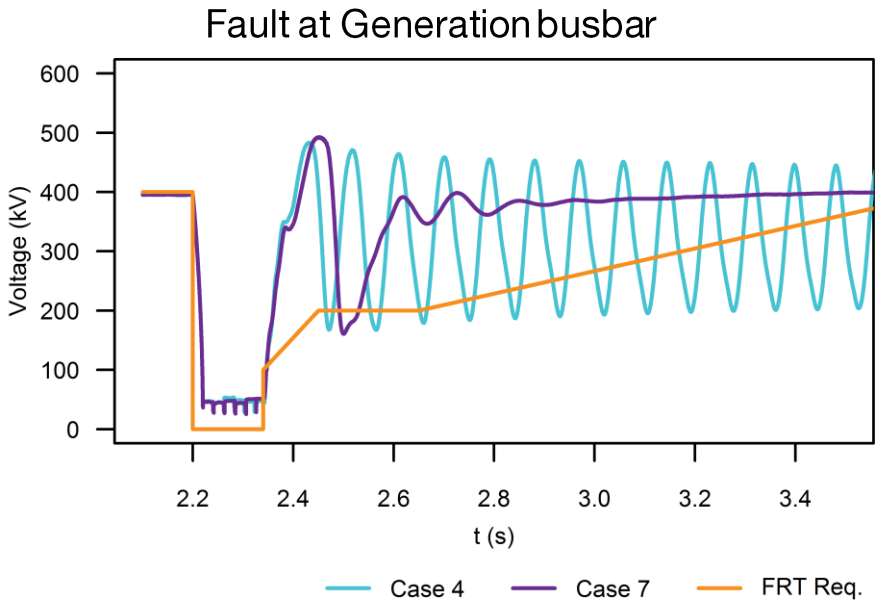
No single set of PLL gains is suitable for all the scenarios.

Case No.	Proportional/ Integral Gains	Fault at HVDC busbar	Fault at demand busbar	Fault at gen. busbar
4 (Weak system)	300/200	√	×	×
7 (Weak system)	75/50	√	√	×
2 (Strong system)	300/200	√	√	√
8 (Strong system)	75/50	×	×	×

Impact of PLL Settings

PLL proportional/integral gains determine the speed of response of PLL.

No single set of PLL gains is suitable for all the scenarios.



Summary of Findings

nationalgrid

Risk of converter instability increases as system strength decreases

A remote fault could lead to a lower margin of stability of the PLL converter compared to a fault occurring at the converter.

No single set of PLL gains is suitable for all the scenarios.

Next Step

We would keep discussing the findings with manufacturers, developers and any other interested parties. A stakeholder event would be held in March 2018.

We wish to work with manufacturers, developers and any other interested parties to further explore the risk of converter instability in the GB transmission network.

Q&A

Continue the conversation:

Our webpage:
www.nationalgrid.com/uk/publications/system-operability-framework-sof

Email us at: sof@nationalgrid.com