nationalgrid

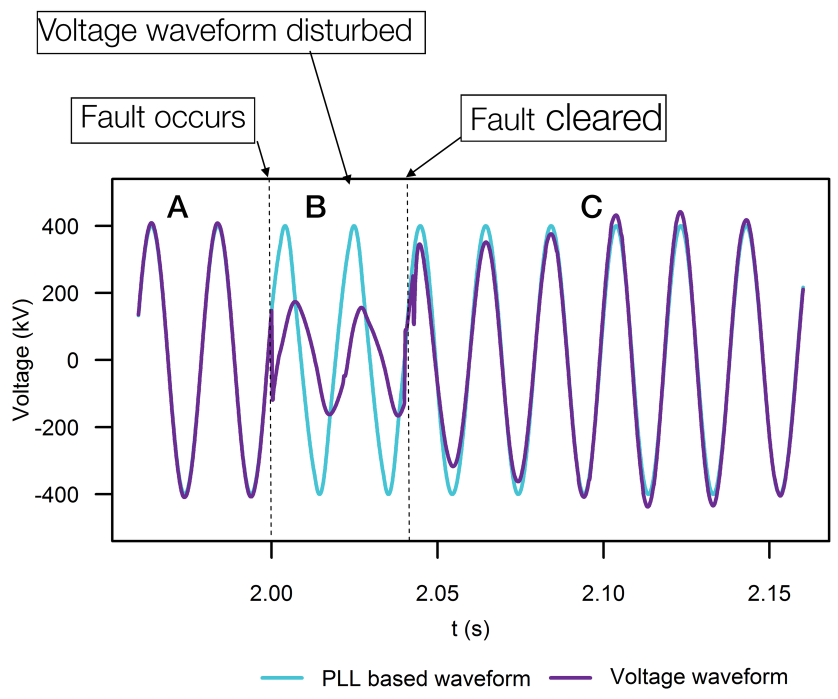
Performance of Phase-locked Loop Based Converters

System Operability Framework

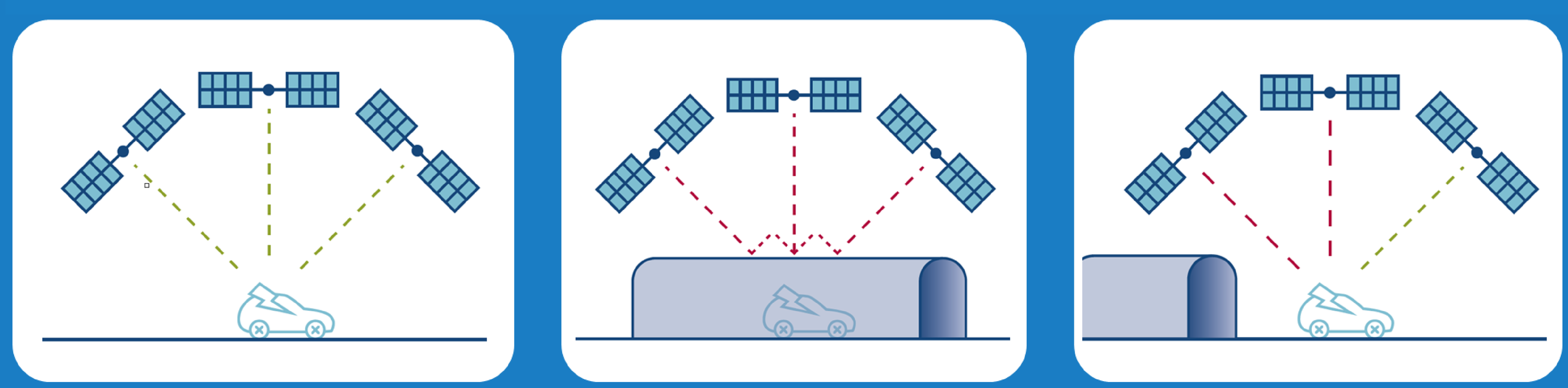
We found there is an increasing risk of converter instability as the system strength of the electricity network is decreasing. The timing and impact of this risk need further exploration. National Grid wishes to work with manufacturers, developers and any other interested parties to further explore the risk of converter instability.

Phase-locked Loop (PLL)

- Synchronise non-synchronous technologies to the electricity network
- Measure phase position from three-phase voltage waveform
- Need to keep track of network voltage to maintain converter stability
- If track of the network is lost, converter instability could happen, causing damage to equipment and loss of generation



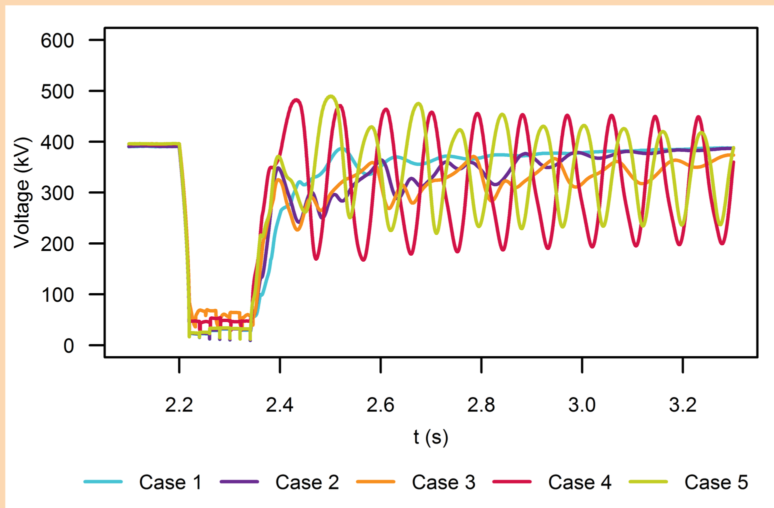
PLL based converter is like a motorist with a SatNav system



Case A	Case B	Case C
Accurate measurement of network information	Weakened voltage reference	Phase Jump in voltage waveform measured
Converter maintains synchronism with the electricity network	PLL behavior depends on design, and may not support wider system stability	Delayed or failed response to new conditions drives converter instability

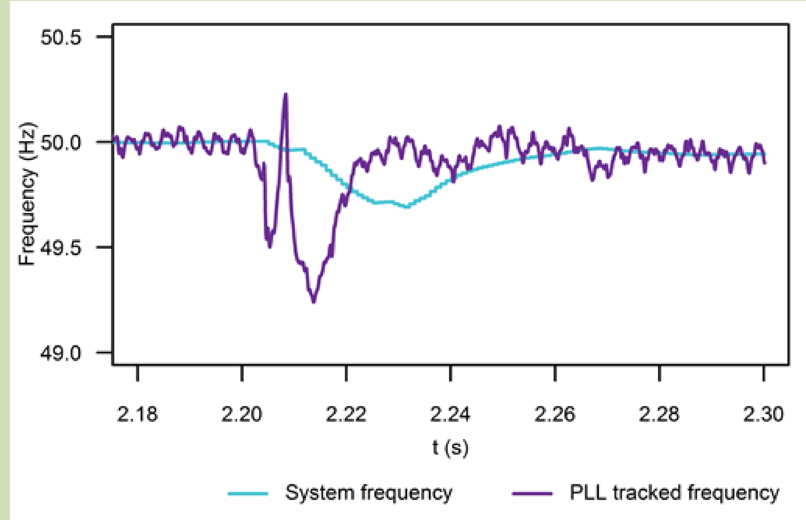
What have we found?

Impact of system strength



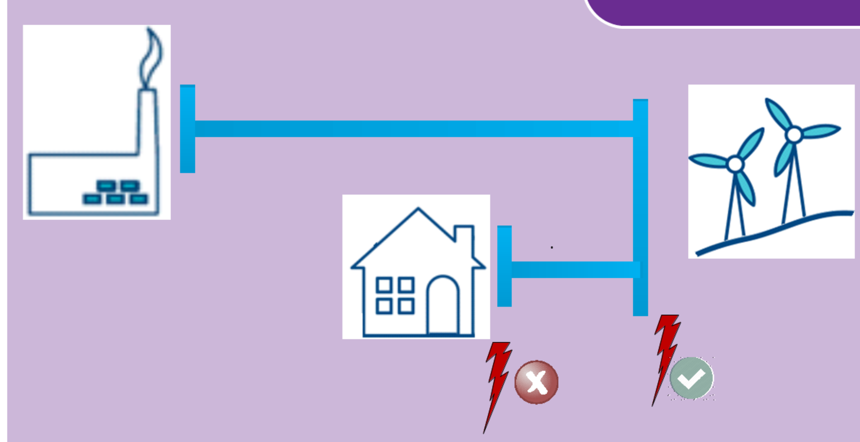
- System Strength reduces from case 1 to case 5
- Risk of converter instability increases as system strength decreases

Performance in frequency disturbance



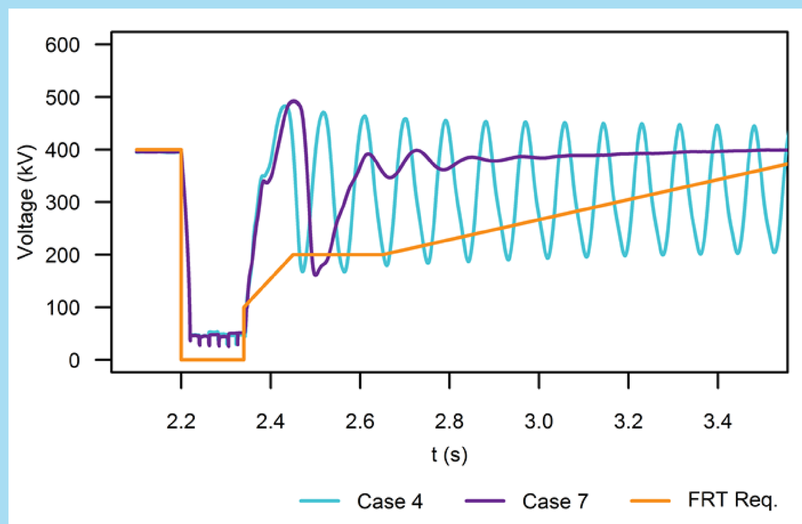
- Deviation lasts for 40ms
- This model (CIGRE benchmark PLL) is secure for frequency disturbances discussed in SOF2016

Impact of fault location



- PLL is more resilient to faults at converter site than remote faults
- Fault-ride through capability of converters impacted by both voltage magnitude and phase change
- Important to understand what this means for distributed generation during transmission fault

Impact of gains in PLL



- A range of PLL settings have been considered to seek to tune PLL across the conditions studied
- Voltage performance improved by reducing values of gains from case 4 to case 7
- No single set of PLL gains is suitable for all the scenarios.

In this assessment

- CIGRE developed converter model is used
- We have limited access to the detailed design of PLLs in real converters

Next step

- Collaborate with manufacturers/developers and other interested parties
- Test converter models from manufacturers based on our network scenarios

We want to achieve

- With industry collaboration define the scale and timing of this risk in electricity network
- Options to mitigate this risk

- What can you do to help?
- What do you need from us?

Please contact us:

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