Paris Session 2022

Influence of Inverters Based Sources on Protections Devices

B5 PROTECTION AND AUTOMATION

PS1 - Adressing protection related challenges in network with low-inertia and low fault-current levels, Q1.02

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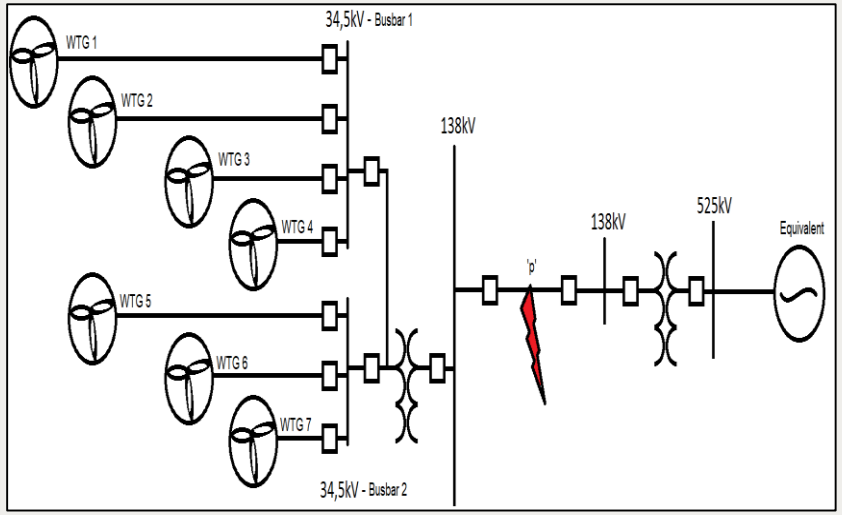
Presentation Time to be Proposed: 3 or 4 min

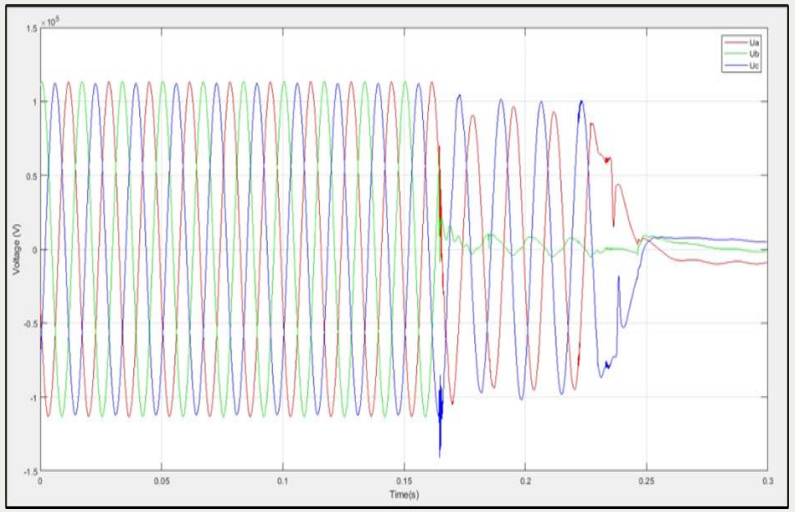
Question 1.02: Are risks of distance protection maloperation or failure to trip limited to transmission lines directly connected to the wind power plant or do you see broader implications for protection further away from the wind power plant point of connection to the transmission grid?

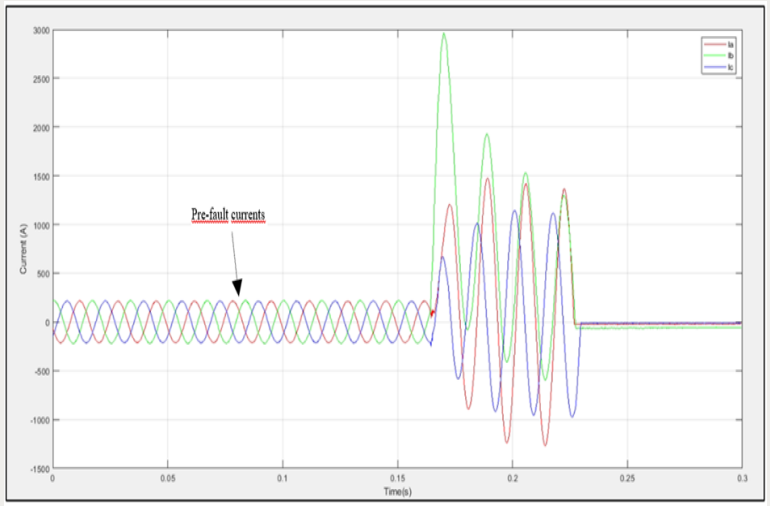
The main points can be highlighted, in general, as:

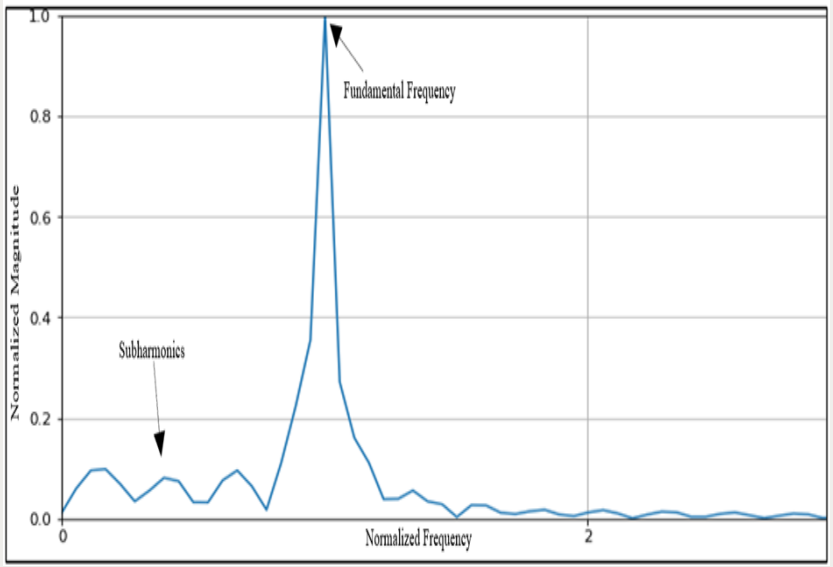
- During the period of the fault the Inverter Based Source (IBS) waveform output tends to be distorted and can influence the expected behaviour of the frequency/angle on the phasor's estimation process;
- IBS output frequency could be unstable and generate abnormal frequency with unexpected Rate-of-Change of-Frequency (ROCOF);
- IBS fault current magnitude contribution will be almost nominal value as limited by the thermal rating of the power electronic components;
- IBS reacts to a system fault with two distinctive period, the transient and steady-state period. The transient period varies between half a cycle to 1.5 cycles;
- IBS fault current sequence components, magnitude and angle, will depend on the IBS control setting and the generating conditions before the fault;
- IBS control system tends to contribute with balance fault currents during balanced and unbalanced fault and might not provide adequate negative sequence components to be used by the protection and control elements that depends on the negative sequence quantities (it depending on the grid code requirements).

Influence from Harmonic (Subharmonic) on Protection System Performance – Real Disturbance on BIPS





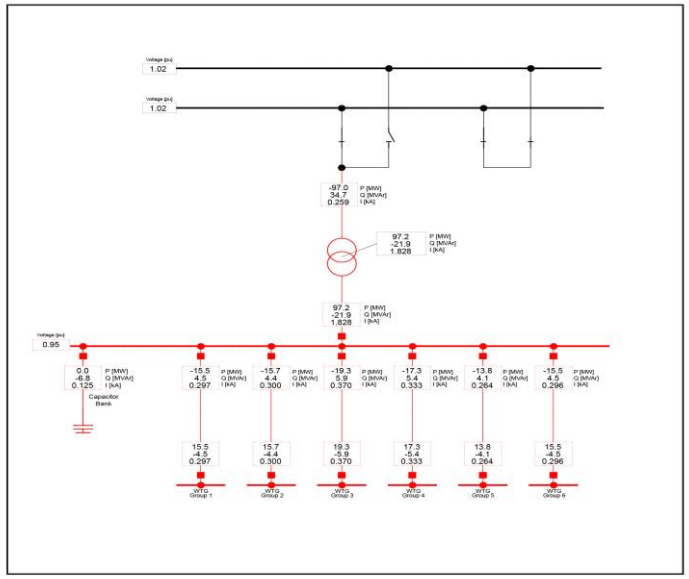


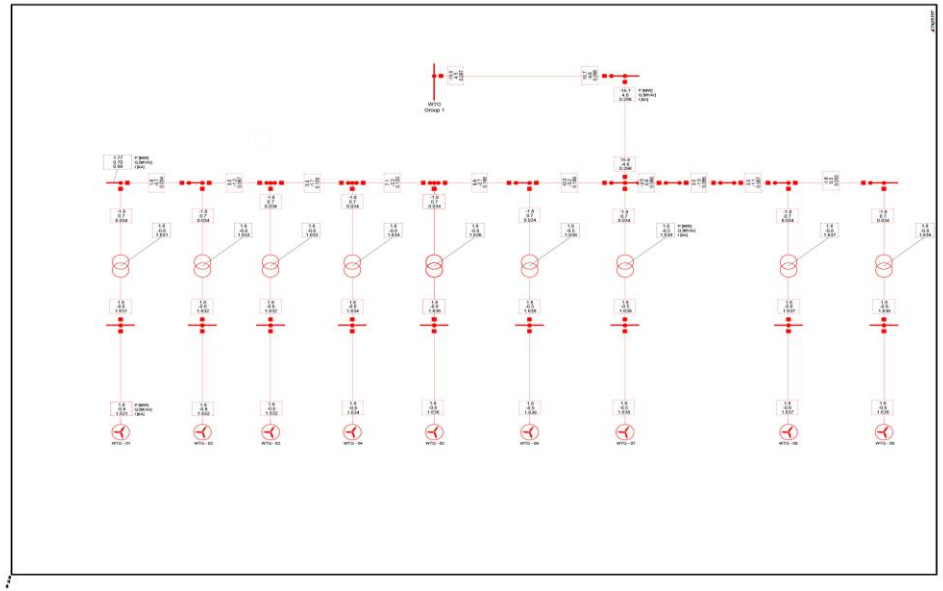


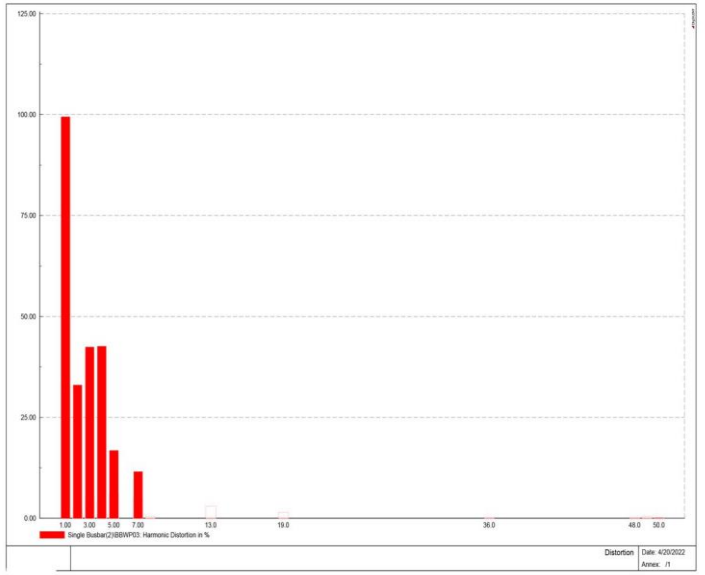
Subharmonics: 6, 20 and 30 Hz (10% 60 Hz)

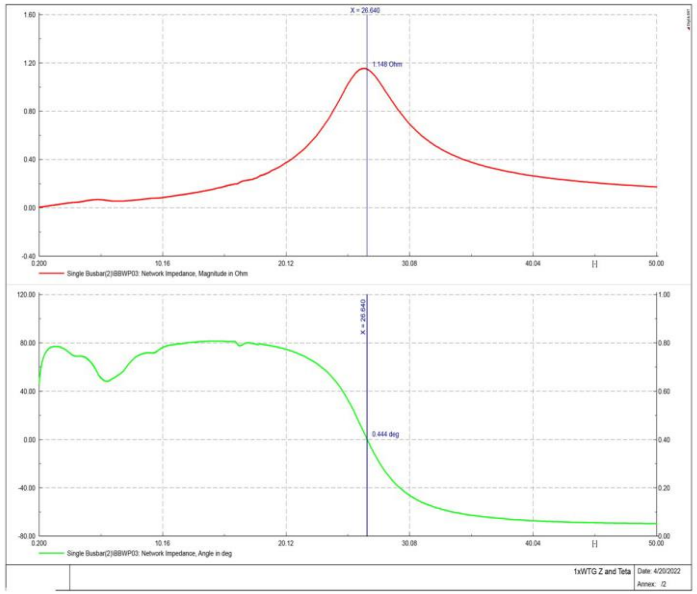
- Protection IEDs will work with one sliding FT window ➔ beind able to capture the 3 fault cycles, but to perform harmonic content, capturing the subharmonic the sliding window size should be ➔ 60 Hz/5Hz or 12 data cycles;
- If the protection IEDs work with one slidding window with 12 data cycles length➔ it will be possible to discriminate the subharmonic ➔ however, its processing will include time delay.
- The subharmonics can cause instability on the phasor domain processing (DC shift), thus, causing instability/oscillation in frequency/angle estimation by IEDs (under/overreaching, for example by 21/21N elements)

Influence from Harmonic (Subharmonic) on Protection System Performance – Simulted System EMT Software









The main points can be highlighted, in general, as:

- Necessary to have correct representation of voltage harmonic sources of WTG, in the EMT simulation tools;
- Necessary to have adequate modeling for the WTG controls, including Phase-Locked Loop (PLL) which will influence the frequency/angle behavior;
- Adequate representation of the electrical network, in order to verify the points of paralell resonance ➔ overvoltage!

Conclusions and Main Recommendations:

- During the fault, the transient response of the inverter can compromise the behavior of the fundamental components and add other frequency components in the output signals;
- The estimation algorithms used in commercially available relays are sensitive to interharmonics and subharmonics, depending on the quantities ➔ instability/oscillation of the phasors can occurs;
- Due to phase estimation errors, the Zone 1 relay distance element at PCC may overreaching for internal faults close to the remote terminal. Further analysis is needed to avoid maloperation of Zone 1 for external faults near the remote terminal. Changes to the Zone 1 configuration guidelines may be required;
- Line differential protection schemes tend to work correctly for most cases, regardless of phase estimation errors;
- Models suitable for EMT tools must be taken into account for the simulations;
- The manufacture´s recommendations of IEDs have been adopted as best practices, however, it is understood that the problem is not yet solved and needs further research and properly investigation;
- The use of time domain protections with phasor domain protections should also be evaluated;
- Finally, it is recommended to evaluate the local protection but also the remote distance and directional protections (up to adjacent busbars), for the coordination schemes.