

Operation of a Sub Synchronous Oscillation Protection Relay during Commissioning

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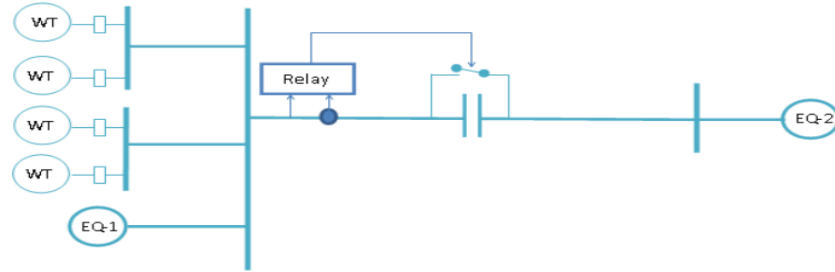
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Outline

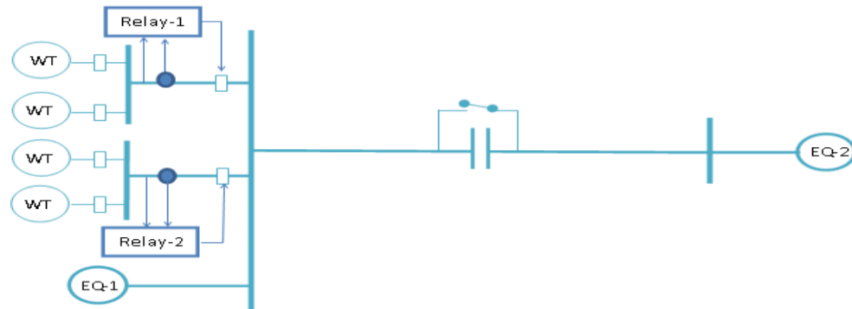
- Introduction to SSO/SSCI relay applied to Type-3 windfarm
- Application Case- Simplified SLD
- Event Captured by the Relay
- Event Analysis
- Findings
- Solutions

SSO/SSCI relays applied to Type-3 windfarms

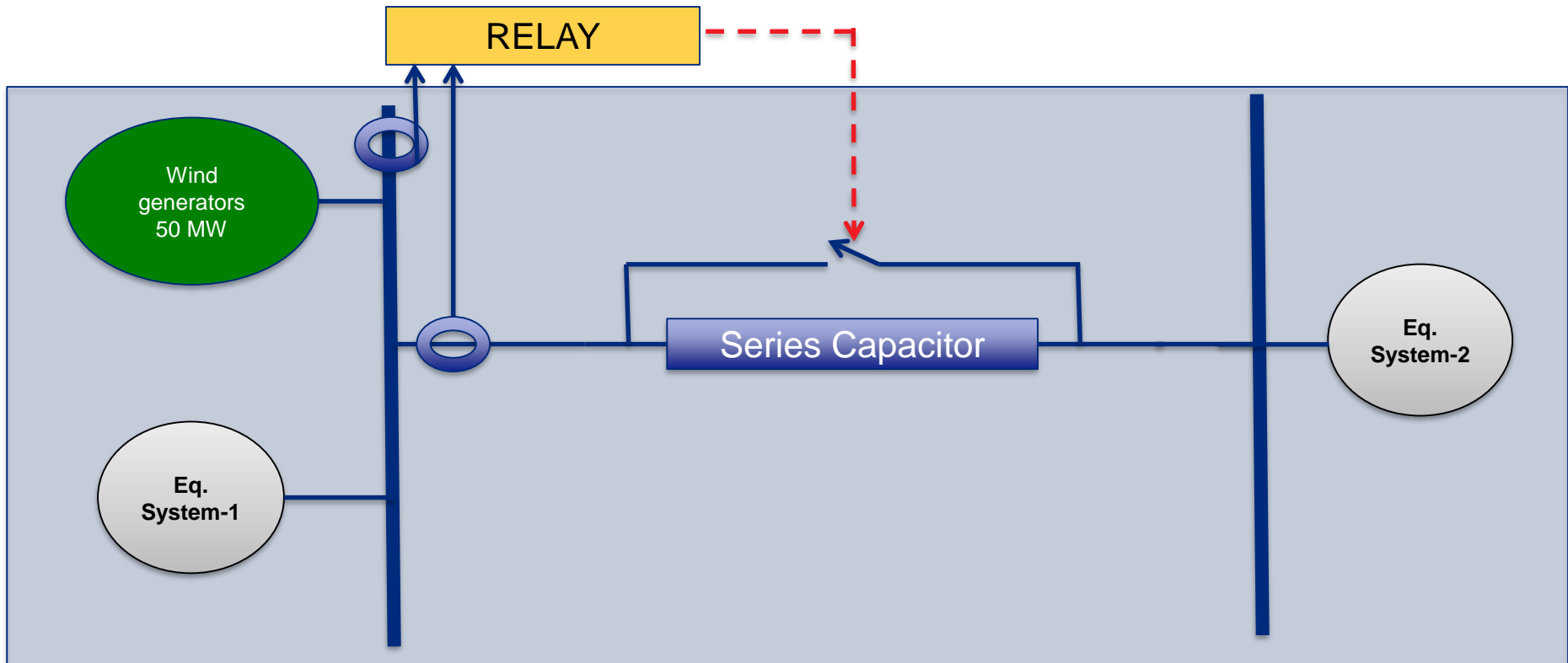
- By-passing series capacitor



- Tripping windfar



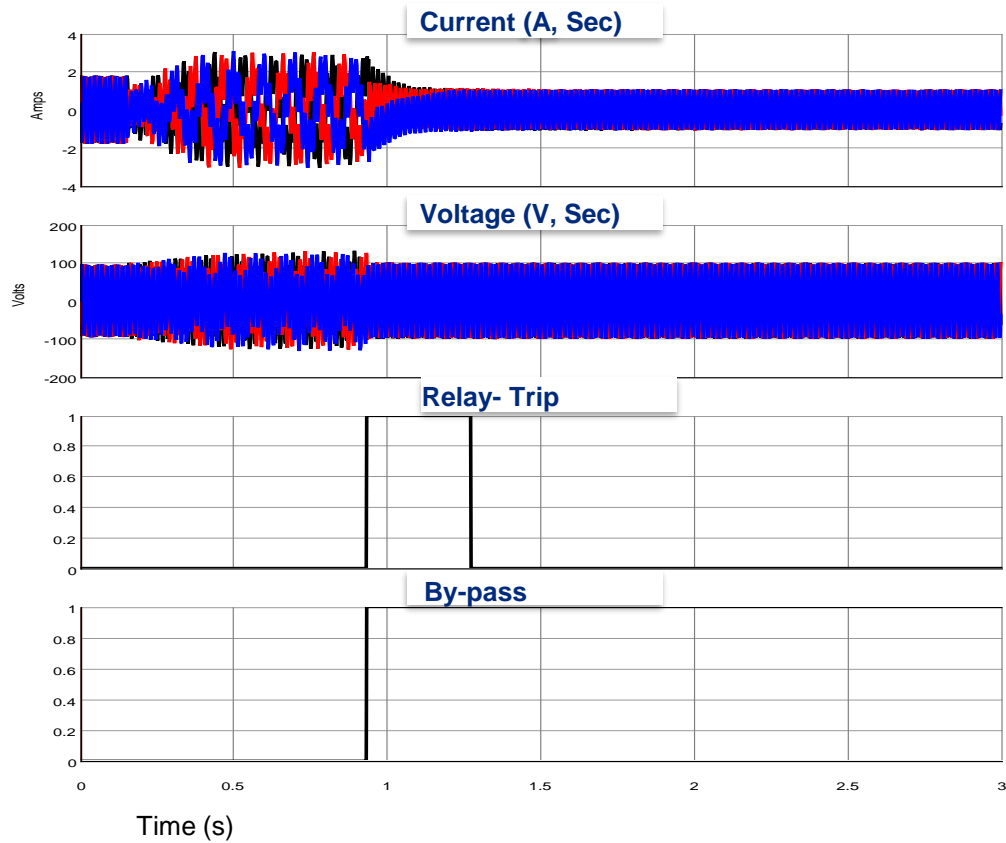
Example: Application



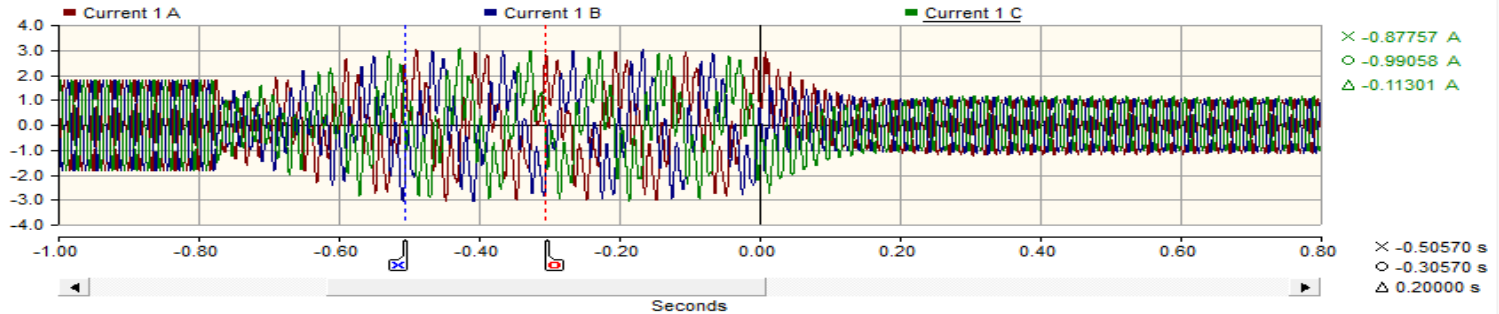
Example: Settings

- Settings
 - Voltage sub-harmonics
 - **5-55 Hz** nominal sub-harmonics at 5% with **0.5 s** delay
 - Current sub-harmonics
 - **5-55Hz** nominal sub-harmonics at 5% with **0.5 s** delay
 - **5-55 Hz** nominal sub-harmonics at 10% with **0.4 s** delay
- Key considerations
 - Nature of sub-harmonics
 - Effect of normal faults
 - Effect of non-faulty events
 - Sources of errors (CTs, PTs, CVTs, etc.)
 - Limitations in modelling and simulation
 - Coordination with primary protection scheme

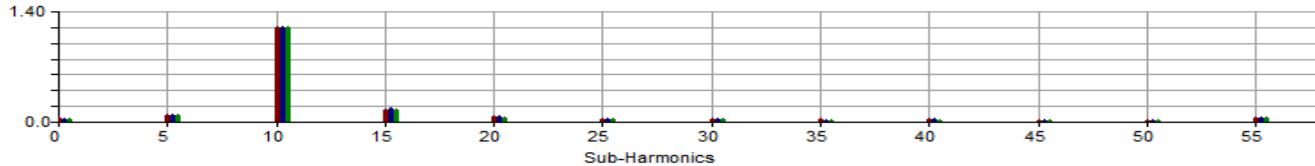
Mitigation of SSCI



Sub-harmonic Spectrum



b-Harmonic Magnitude (RMS)

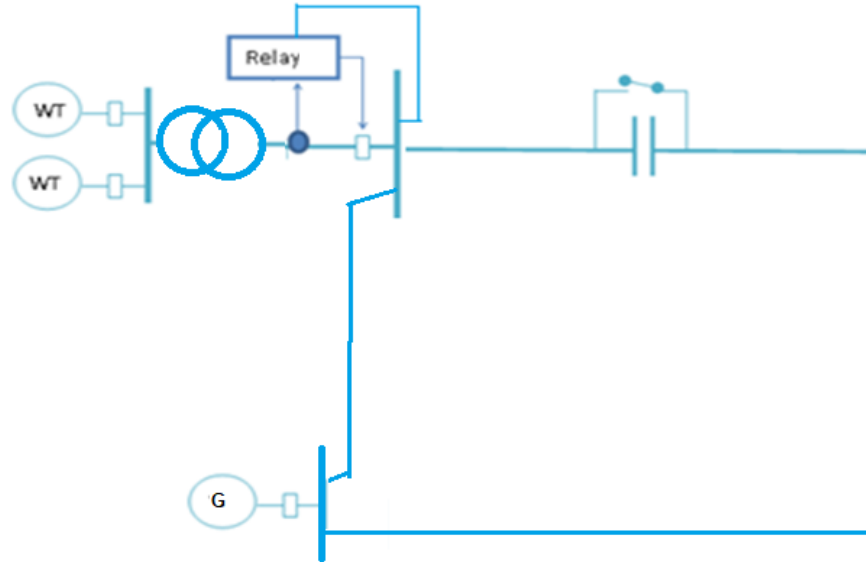


	Current 1 A	Current 1 B	Current 1 C
Fundamental (A-RMS)	0.73165	0.74200	0.76032
TSHD (%)	167.34161	165.27340	161.23167
Dominant SH Frequency (Hz)	10.57067	10.62545	10.59288
Dominant SH Magnitude (A-RMS)	1.22945	1.23565	1.23414

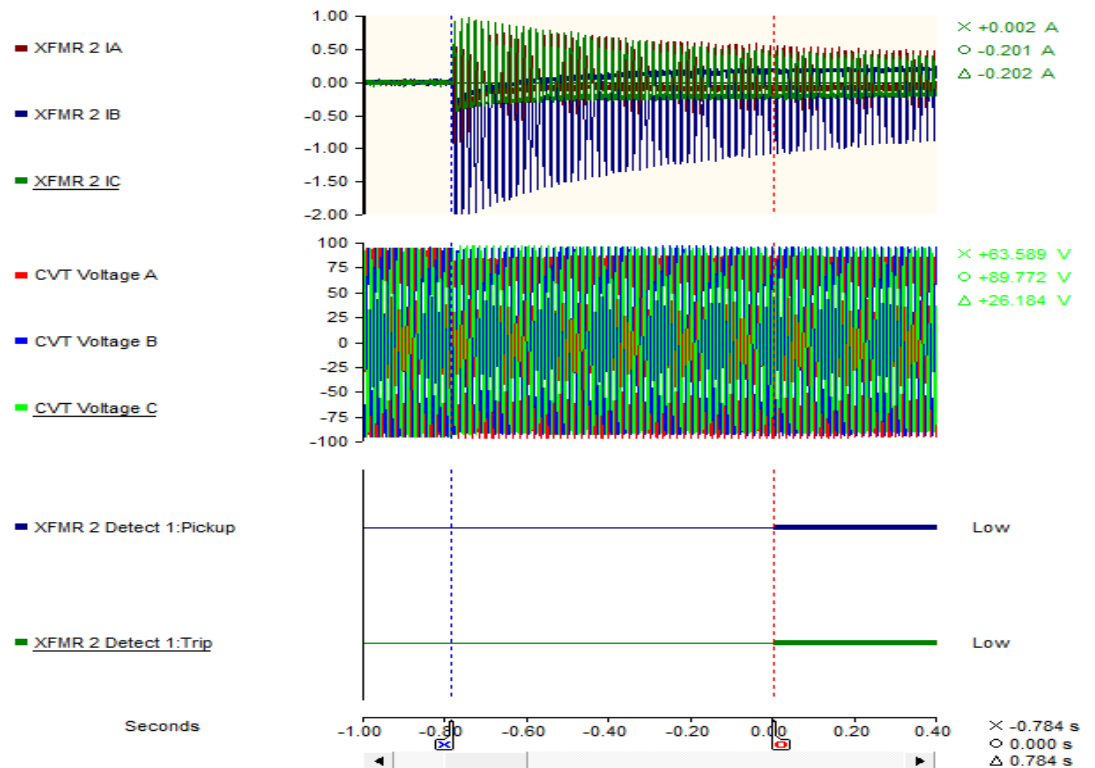
Frequency (Hz)	Current 1 A Mag (A-RMS)	Current 1 B Mag (A-RMS)	Current 1 C Mag (A-RMS)
0	0.05083	0.04703	0.04598
5	0.09718	0.09497	0.09109
10	1.20327	1.20409	1.20579
15	0.15503	0.17215	0.16221
20	0.07793	0.07090	0.06685

Commissioning Test

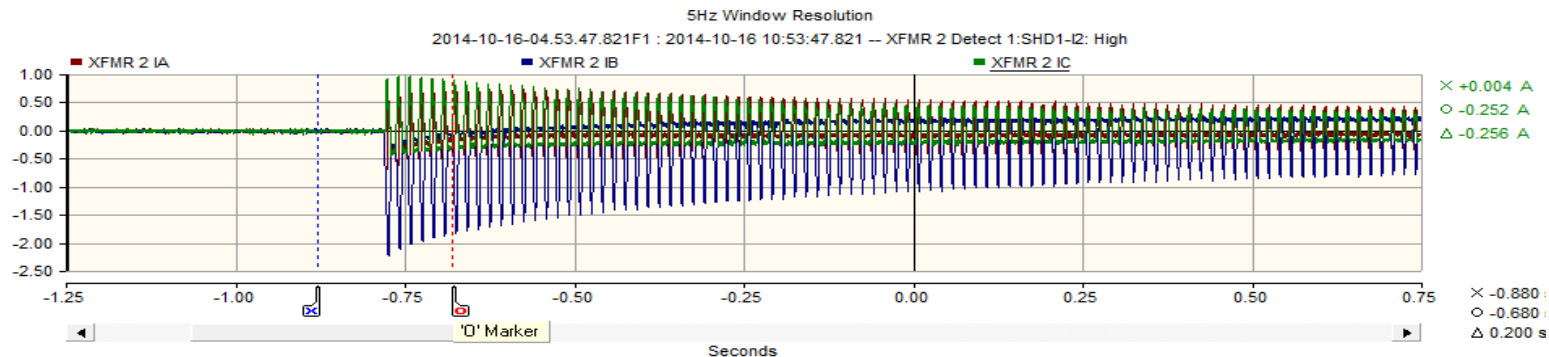
- Simplified SLD



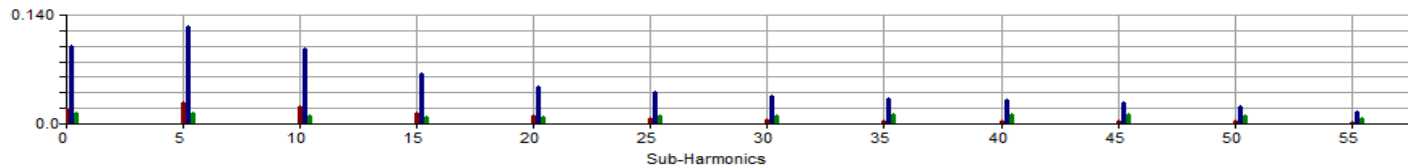
Event Captured by the Relay: Transformer Inrush



Event Analysis



Sub-Harmonic Magnitude (RMS)



	XFMR 2 IA	XFMR 2 IB	XFMR 2 IC
Fundamental (A-RMS)	0.180	0.422	0.283
TSHD (%)	23.924	46.614	13.497
Dominant SH Frequency (Hz)	7.213	2.784	2.579
Dominant SH Magnitude (A-RMS)	0.040	0.178	0.022

Frequency (Hz)	Mag (A-RMS) IA	Mag (A-RMS) IB	Mag (A-RMS) IC
0	0.019	0.100	0.014
5	0.028	0.126	0.015
10	0.023	0.097	0.011
15	0.015	0.065	0.009
20	0.011	0.048	0.009

Finding and solutions

- *Advanced band pass filtering*
 - Advanced band pass filtering has been applied to remove the impact of the initial high magnitude transient.
 - Filtering has been applied depending on the start and end frequencies.
 - This helps to prevent possible misoperations due to the initial transients.

Finding and solutions cont...

- *Harmonic blocking*
 - The harmonic blocking (2nd and 5th) feature has been implemented
 - This avoids possible misoperations of sub harmonic calculations during energization conditions.

Current 1

Detector 1

Name:

Pickup Delay: s

Minimum Frequency: Hz

Maximum Frequency: Hz

Pickup Counter Threshold: 0 to disable

Nominal Ratio

Enabled Setting: % of 5A = 1.00A

Fundamental Ratio

Enabled Setting: %

Total Sub-Harmonic Distortion

Enabled Setting: %

Operations / Duration Setting

Enabled Duration: minute

Number of Operations: operations/duration

Second Harmonic Blocking

Enabled Threshold: % of 5A = 1.00A

Cross Blocking

Fifth Harmonic Blocking

Enabled Threshold: % of 5A = 1.00A

Cross Blocking

Conclusion

- An unexpected operation of a subharmonic protection relay observed during a commissioning procedure is discussed.
- Solutions are proposed to overcome the impact of the harmonic are discussed.
 - Band-pass filtering
 - Harmonic blocking