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Adaptive Loss of Field Protection

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Motivation/Objective

- Implement adaptive LOF relays for generator protection with wide area measurements so that these generator protection schemes can adapt with the change of system conditions

- Prevent mis-operation of LOF relay when settings are not appropriate and avoid delayed operation

Tasks

- Development of the adaptive LOF relaying scheme

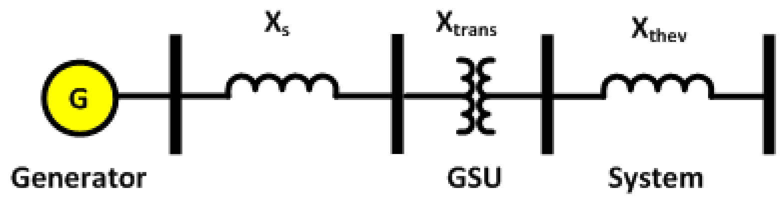
- Testing of the schemes through simulations of the 'California study system' to determine the group LOF relay settings for generators

- Determine system's current operating condition using the Wide Area Measurements (WAM)/PMU data

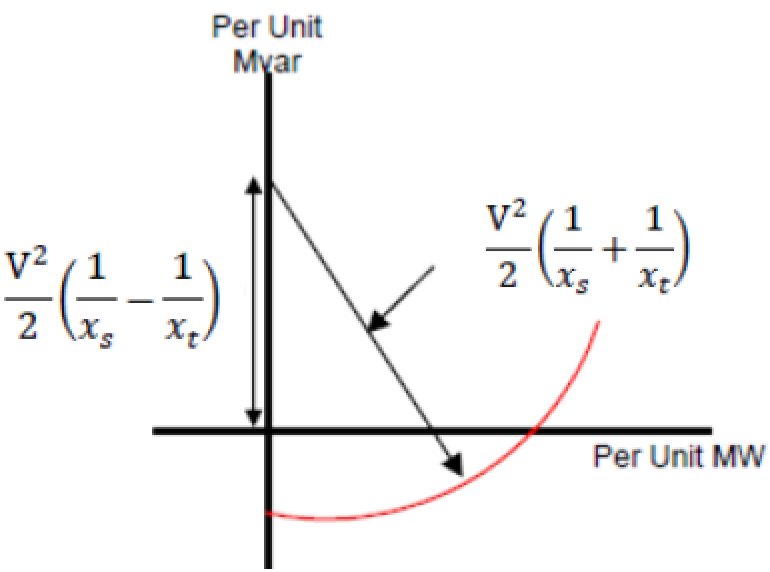
Methodology

Graphical Method for Steady State Stability Limit;

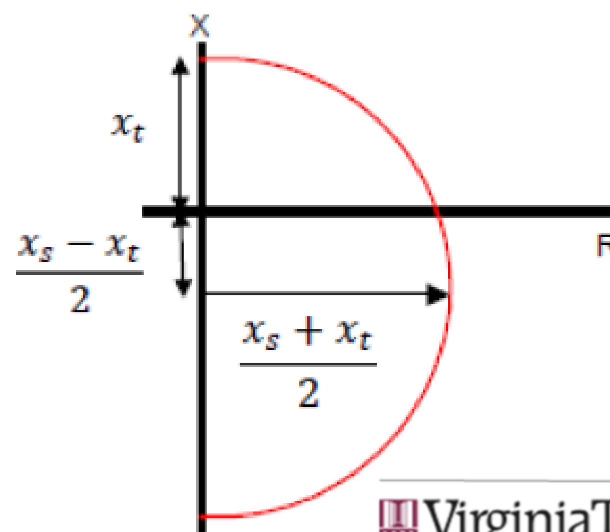
where, $x_t = x_{trans} + x_{thev}$



MW – MVAR per unit plot



R – X Plot



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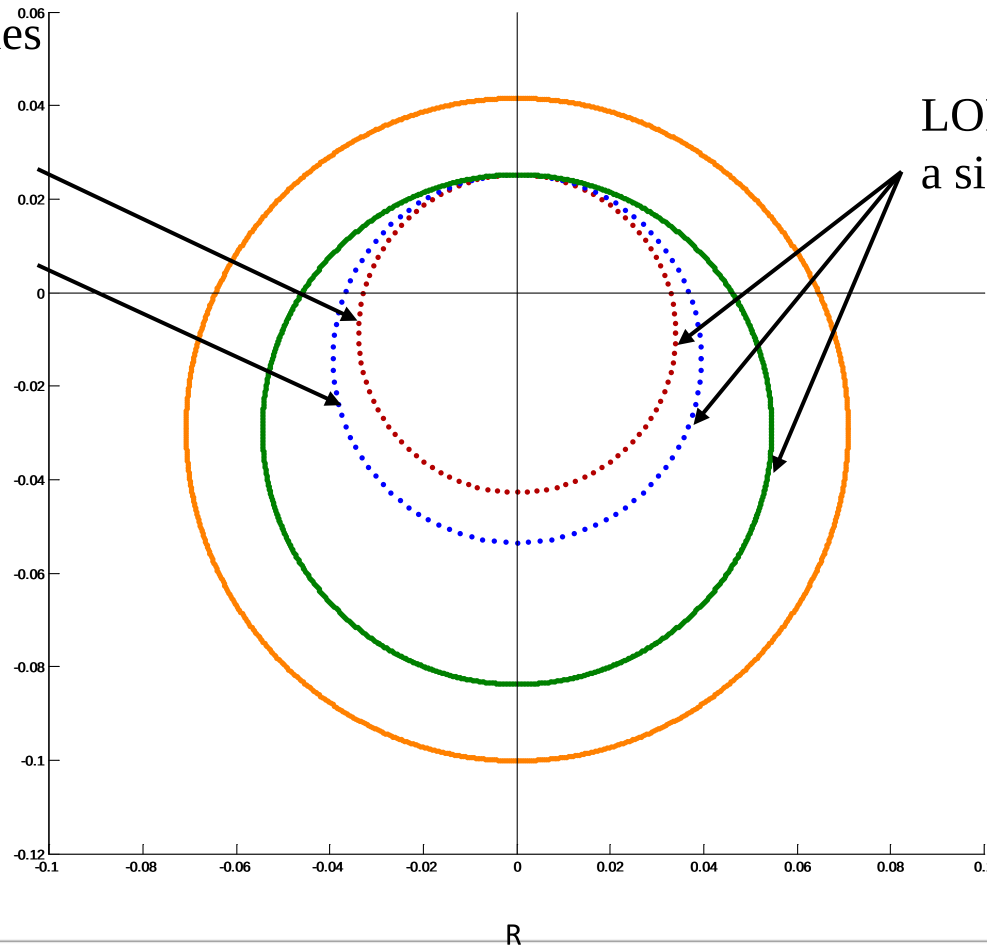
Methodology

Steady state stability limit circle can be adaptively fit for different operating conditions using PMU measurements

2 concentric circles

- Inner circle is stability limit
- Outer circle is for an alarm

LOF group setting for a single generator



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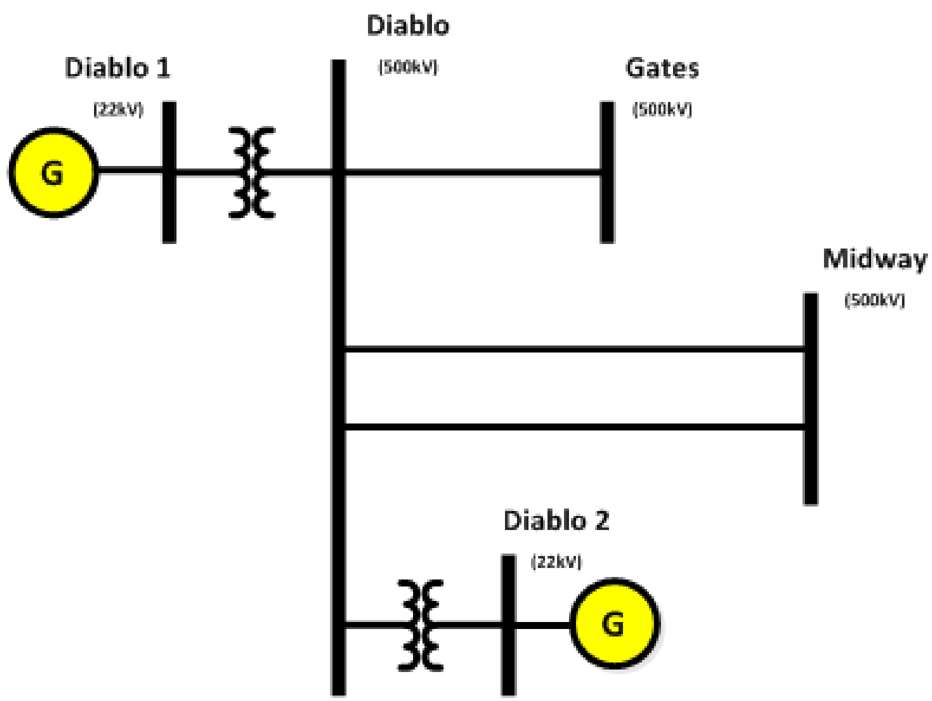
Case Study

Loss of Field Relay at Diablo1 (22kV), 36411

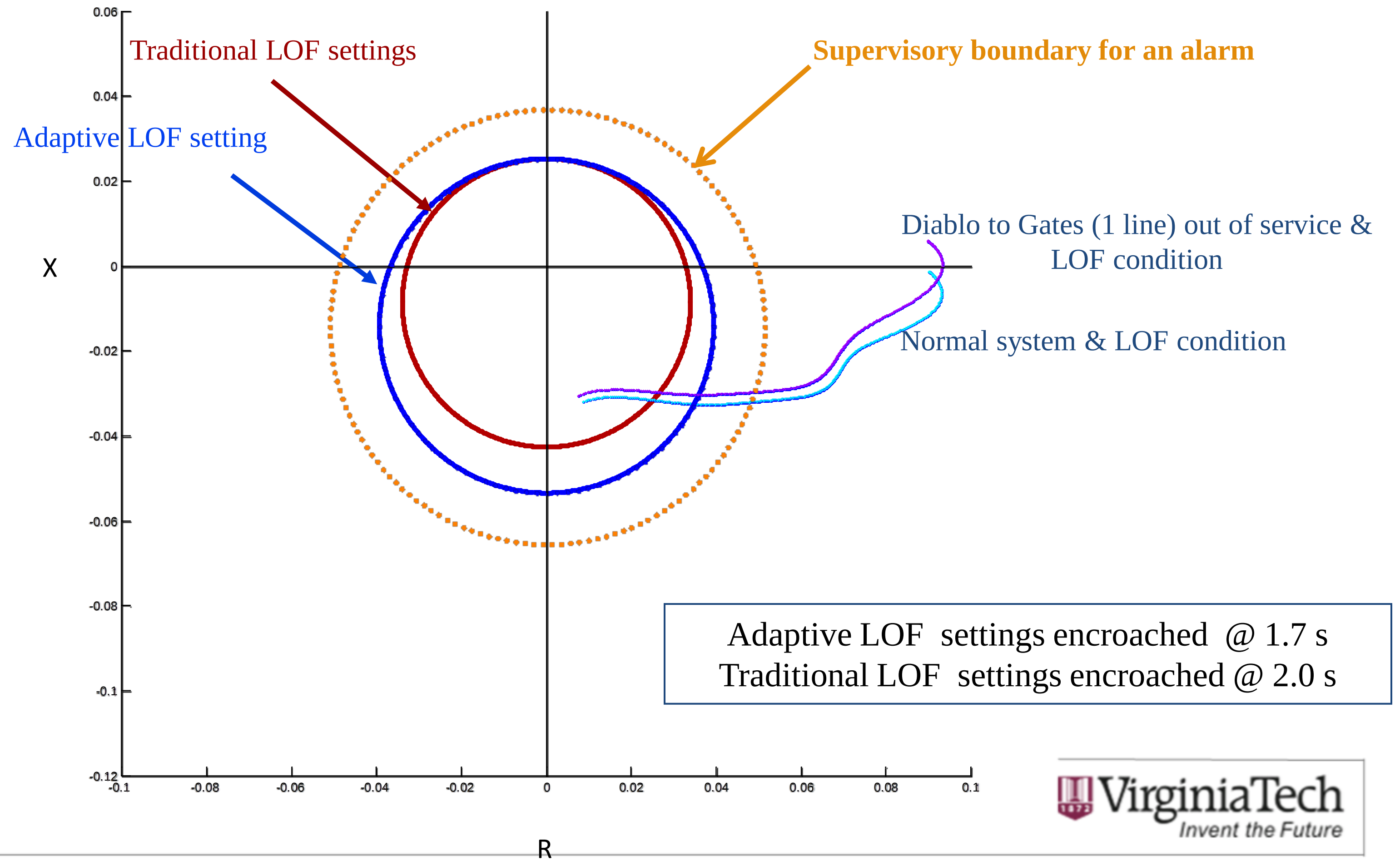
1180 MW Generator



Results

Apparent Impedances seen by Relay after LOF conditions

Loss of Field relay at Diablo1 (22 kV), 36416

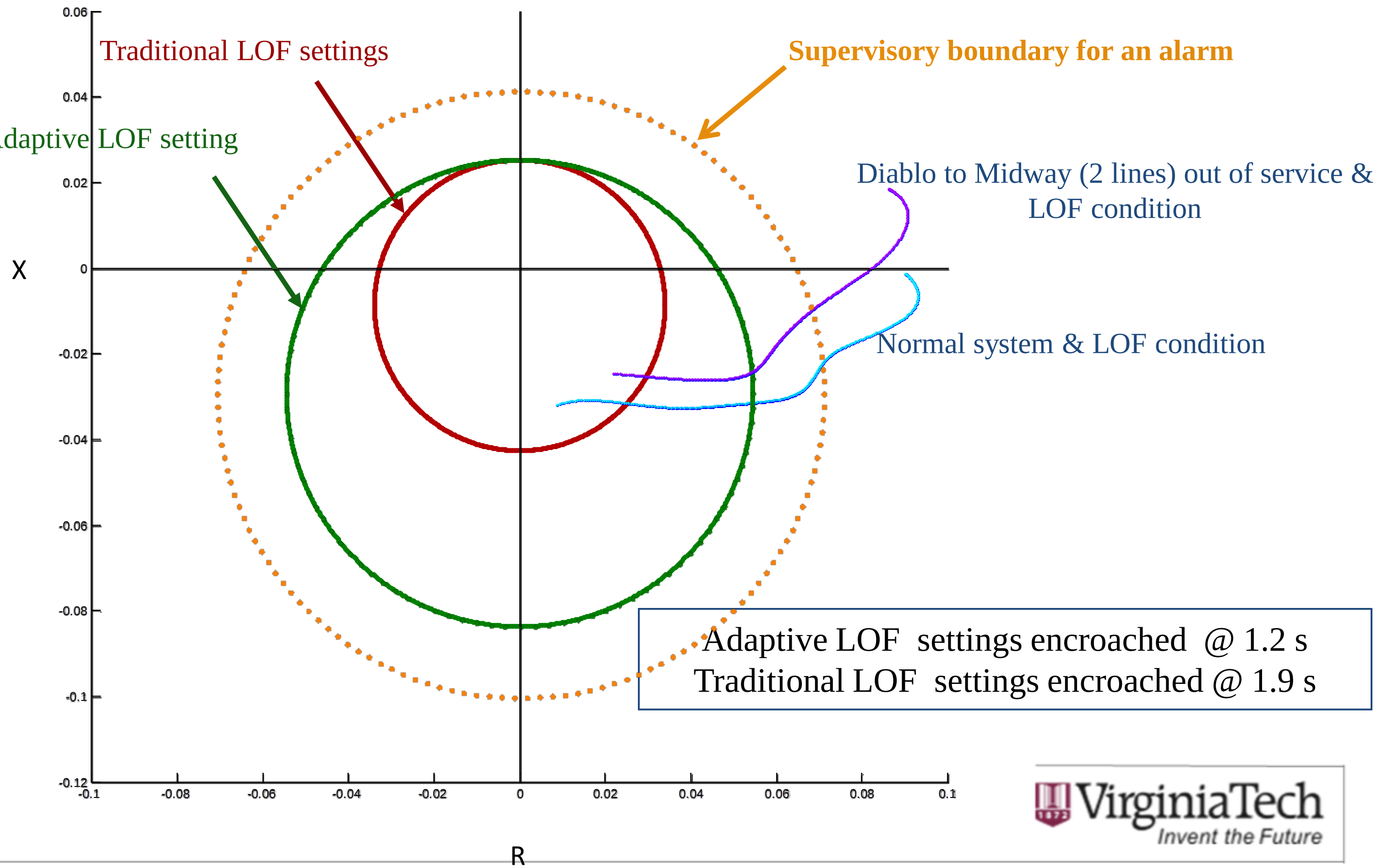


Adaptive LOF settings encroached @ 1.7 s
Traditional LOF settings encroached @ 2.0 s

Results

Apparent Impedances seen by Relay after LOF conditions

Loss of Field relay at Diablo1 (22 kV), 36416



Conclusion

- The traditional LOF protection might mis-operate
- The change of the system operating conditions can be identified and appropriate adaptive settings can be selected
- This improves the reliability and the operating speed of the LOF protection

References

[1] Horowitz, S. H.; Phadke, A. G., *Power System Relaying*, Research Studies Press, Taunton, Somerset, England, 1992.

[2] Loss-of-Field Relay Operation during System Disturbance Working Group Report - June 1971, W. F. Mackenzie, J. A. Imhof C. Dewey, S. H. Horowitz et al, IEEE Transactions on Power Apparatus systems, vel. PAS-94, no. 5 , September/October 1975.

[3] "Protective Relaying Theory and Applications" edited by Walter A. Elmore, ABB Power T&D Company Inc. Coral Springs, FL, 1994.

[4] Bi, Tianshu, Sui, Jiayin, Yu, Hao, Yang, Qixun, "Adaptive loss of field protection based on phasor measurements", Power and Energy Society General Meeting 2011, IEEE, Detroit, MI, USA, October 2011.

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