

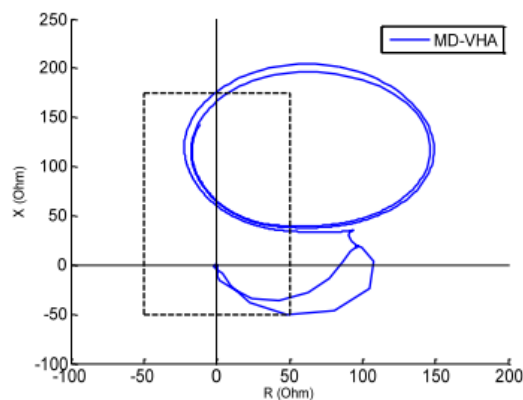
- **Question 2.05: What are the experiences to improve the practical application and verification of the protection in a real substation project?**

A: Regarding protection verification in a real substation project, our experience showed that:

Real time simulation and hardware-in-the-loop testing is fundamental because:

i) It reveals logic functions such as blocking logic which are not the core of the protection action, thus often are neglected and affect protection performance.

Ex: During an out-of-step logic hardware-in-the-loop testing and adjustment, it was verified that the number of inputs was affected by short-circuit quantities, undesirably. An illustrative case is presented below.



This OOS function has a non-conventional adjustment since it monitors quantities, not forming an electrical center. Also, this is a very sensitive function because its actuation leads to the split of two large power systems.

In response to the HIL verification, an Undervoltage blocking logic was incorporated into the out-of-step function to avoid undesirable actuations.

Reference: A Dynamic Equivalent Model for testing the Paraguayan-Argentinean Interconnected Power System devices using Hardware-In-the-Loop simulation, presented in IEEE Urucon, 2021.

ii) It reveals unwanted protection actuations or even incorrect actuations for specific system conditions.

iii) It allows fine tuning of protection pick-up and temporization values.

A: Regarding protection verification in a real substation project, our experience showed that communications' performance can only be evaluated based on field testing and measurements.