

# Modeling of PMU-Based Automatic Re-synchronization Controls for DER Generators in Power Distribution Networks using Modelica and the OpenIPSL

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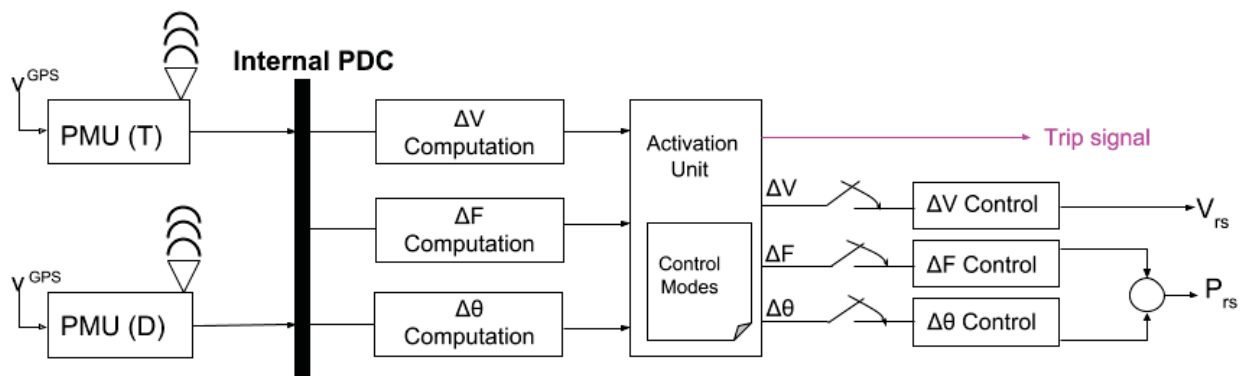
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## Abstract

Re-synchronization is traditionally coordinated between the electric power transmission network operators and power plants in an isolated portion of the grid in order to maintain the balance between the power supply and demand. This task can be challenging when one portion of the distribution grid contains small generators having low inertia which is the case of Distributed Energy Resources (DER), such as small hydro, wind and solar power plants. As the number of DER continues to increase with the rise of renewable energy sources located at the lower voltage networks, automatic re-synchronization method that can be applied to a great number of DER are desirable.

The paper describes the architecture and modeling of an automatic re-synchronization controller shown in Figure 1, which can be applied to synchronize an islanded portion of the grid by using remote measurements to drive a Distributed Energy Resource (DER) within the islanded network. The controller's re-synchronization function uses bus frequency measurements, which are derived using bus voltage phasors and a new bus frequency computation technique that can be used during the execution of dynamic simulations.

This paper also introduces a new bus-angle difference control function within the re-synchronization control system, which allows monitoring the phase angle difference between two buses so to avoid unwanted re-synchronization. The effect of the angle difference control function is evaluated using a controlled circuit breaker considering different power dispatch levels of the generator in the distribution network model. Both deterministic and stochastic load models are used to analyze the performance of the automatic re-synchronization control system.



**Figure 1.** Architecture of the Automatic Resynchronization controller