X SICEL 2021

Transición energética en la 4ta revolución industrial

Universidad Tecnológica de Pereira

UNIVERSIDAD NACIONAL DE COLOMBIA

XSICEL 2021
Transición energética en la 4ta revolución industrial

Inverter-Based Generation Electromagnetic Transient Model for Protection and Short Term Stability Studies based on Voltage Controlled Current Source

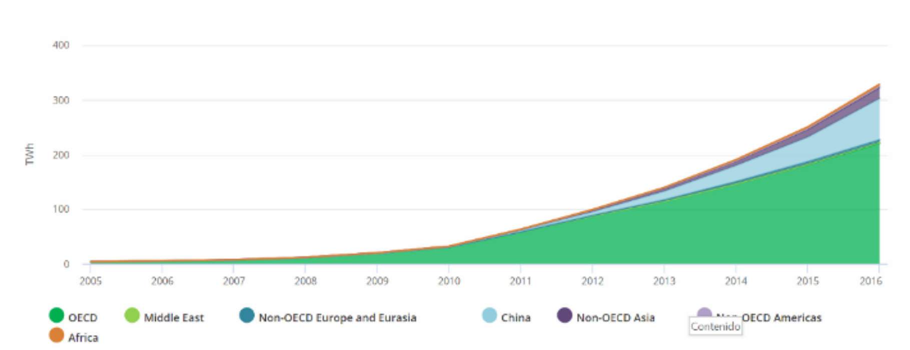
Authors: David Sanchez[1] - Ernesto Pérez[1] – Juan Piñeros[2] – Laura Agudelo[2]

Institutions:
Universidad Nacional de Colombia[1]
XM S.A. E.S.P.[2]

Contents

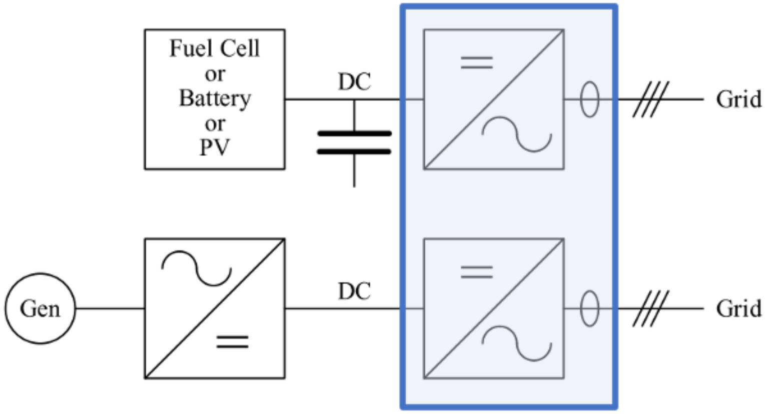
I. Introduction

World solar PV electricity production by region, TWh



World wind electricity production by region, TWh

From: Energy Agency iea: https://www.iea.org/statistics/kwes/supply/

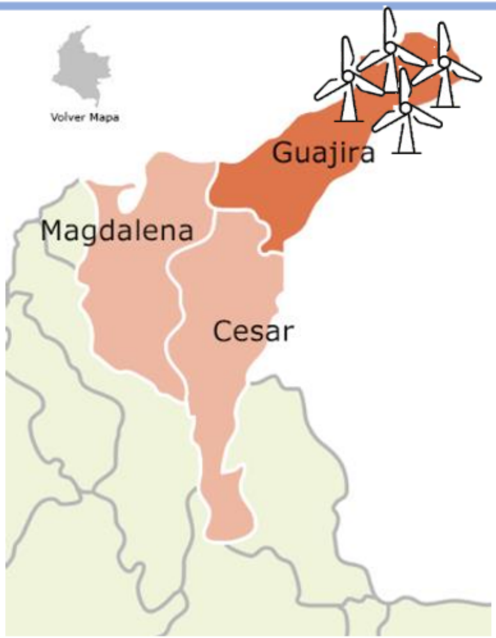


Dynamic behavior of solar and wind technologies is different compared with the conventional synchronous generation.

I. Introduction

- Weak systems require EMT models for studying IBG impacts.
- There is a lack of available generic EMT IBG models
- Detailed manufacturer models are a black box.
- Difficulty in standardizing the short-circuit calculations with renewables in different commercial software.

An IBG Model is needed to reproduce the challenges of these new generation properly



Colombian Case

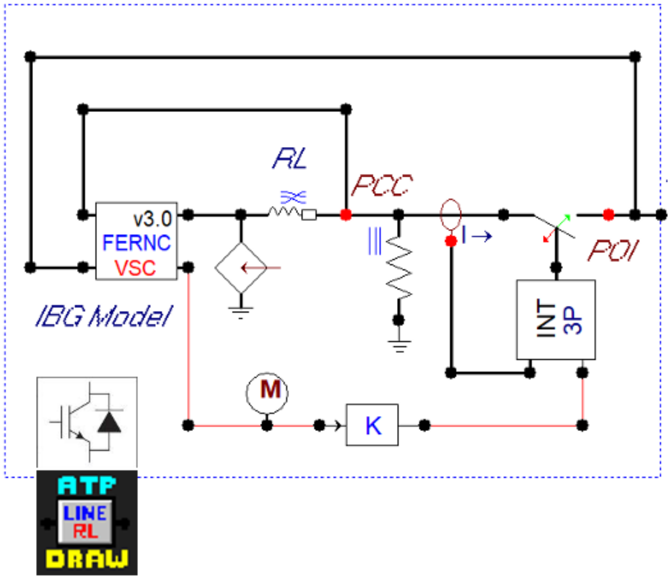
II. IBG Implementation Type Models

Characteristic	Switch Detailed	Average Controlled Voltage Source	Average Controlled Current Source
Inner PI Control Loop	Yes	Yes	No
PWM Module	Yes	No	No
IGBT capability	Yes	No	No
Harmonics	Yes	No	No
Time step	Tiny	Larger	Larger

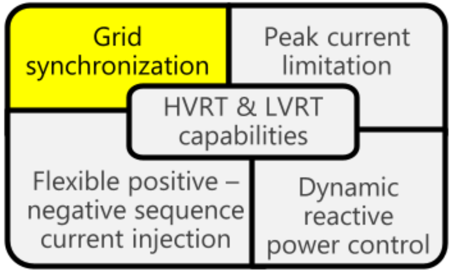
II. IBG Model Functionalities

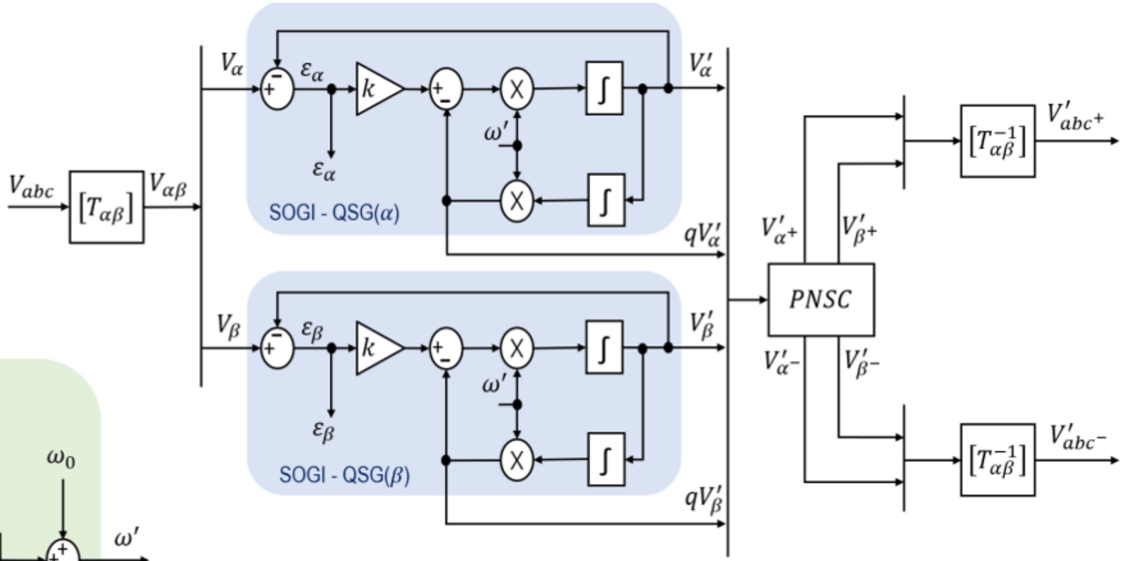
- Grid synchronization
- Peak current limitation
- HVRT & LVRT capabilities
- Flexible positive – negative sequence current injection
- Dynamic reactive power control

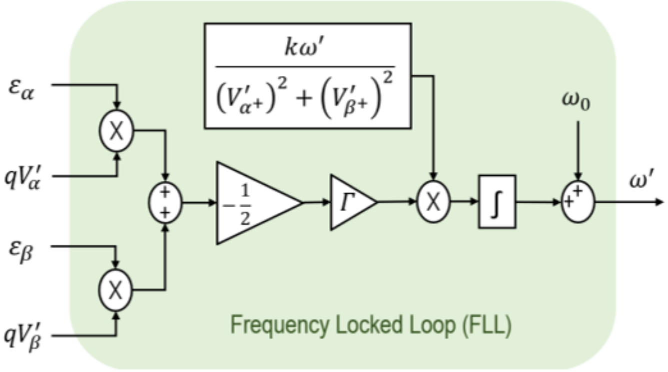
Controlled Current Source



III. Grid Synchronization Under Unbalanced Voltage



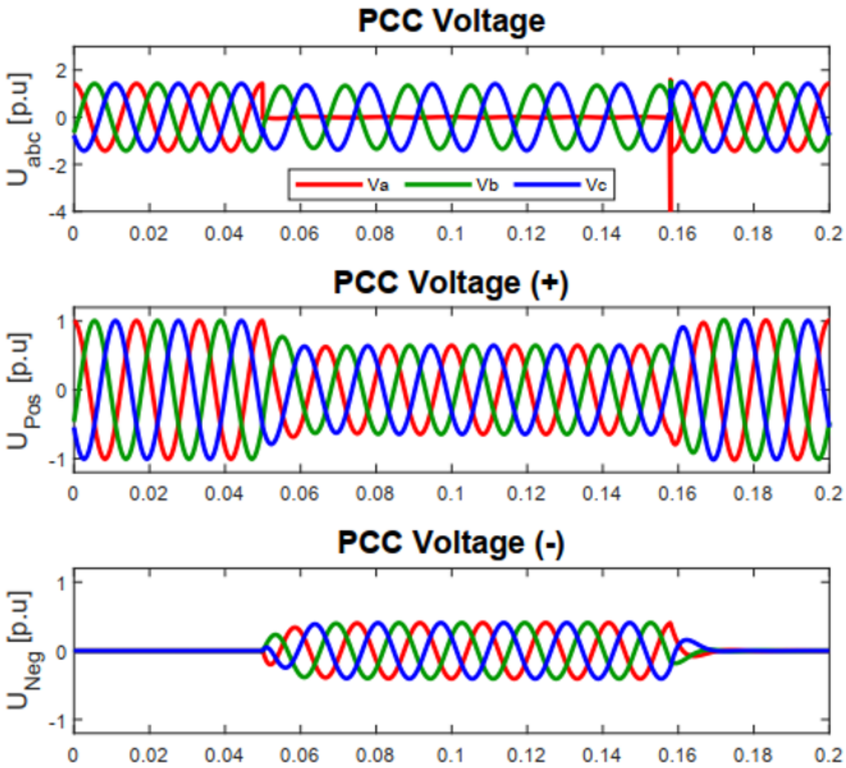


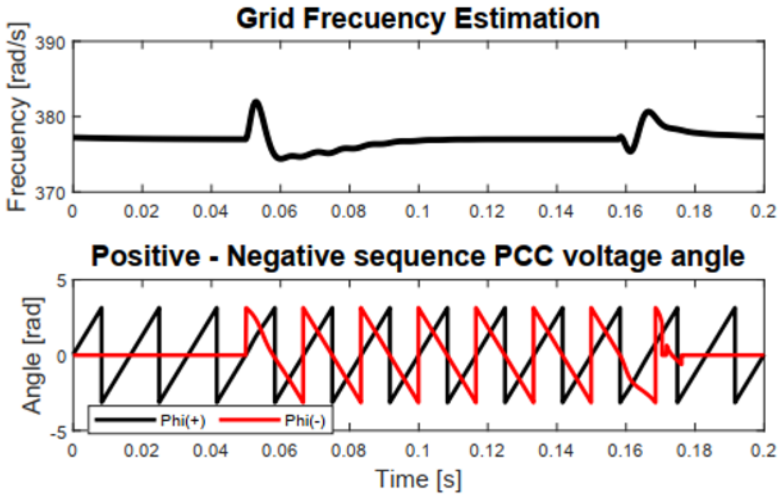


DSOGI - FLL

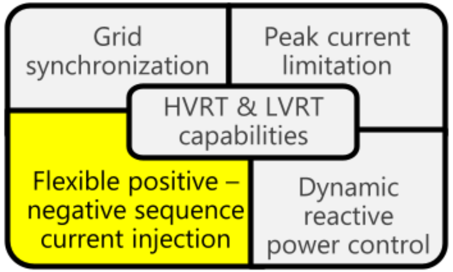
smoother response to disturbances

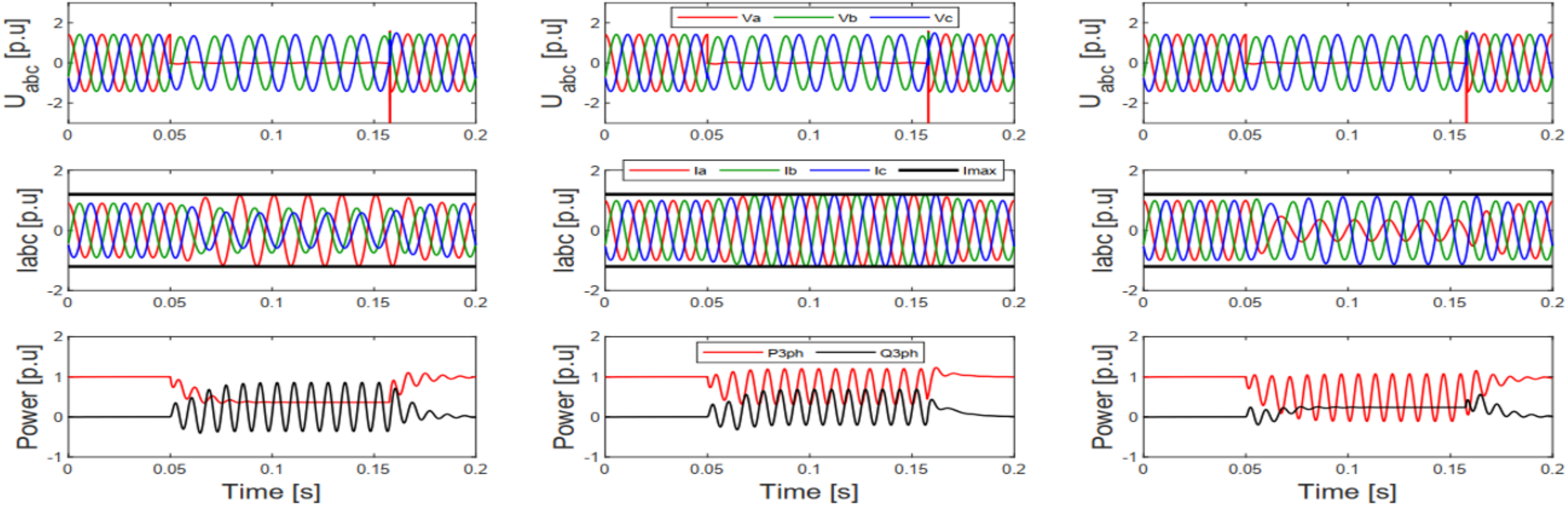
III. Grid Synchronization Under Unbalanced Voltage





III. Control Strategies Impact On Short Circuit Current



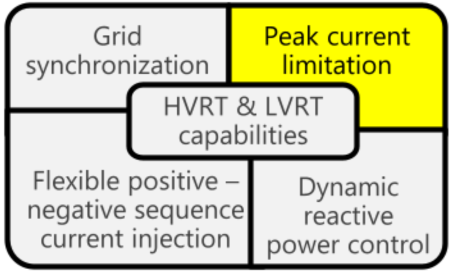


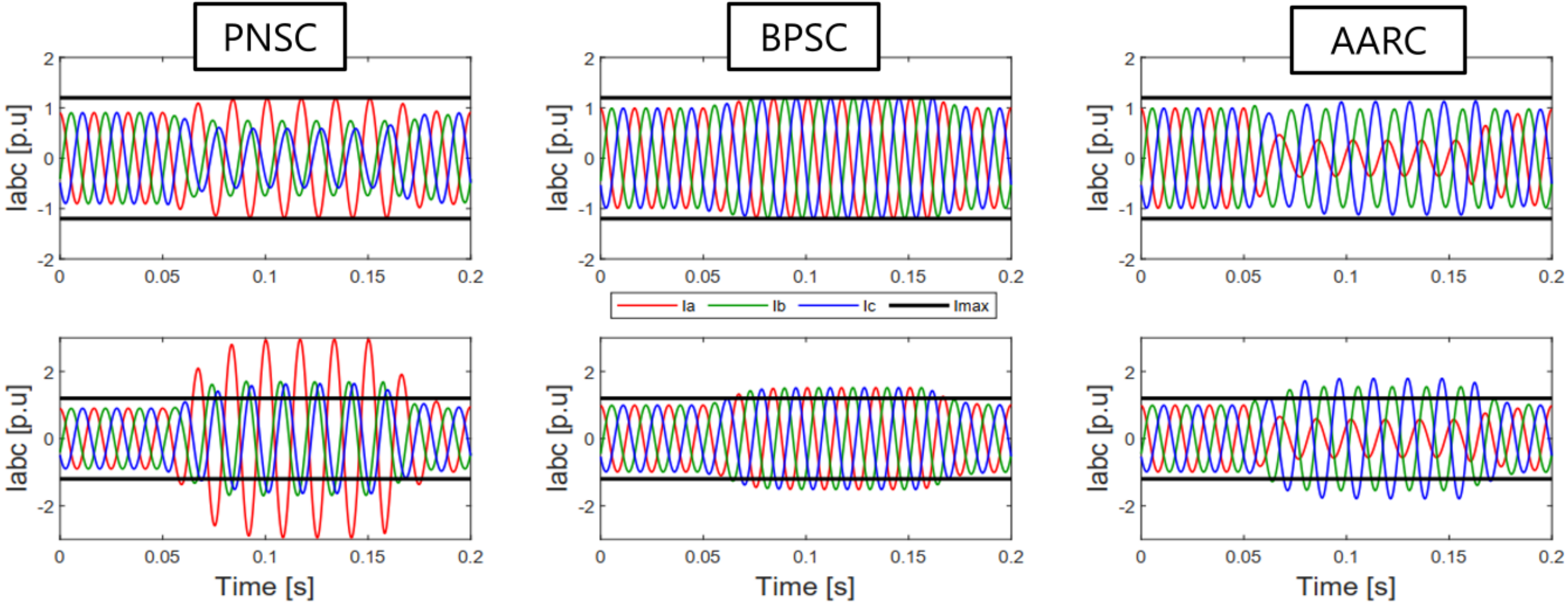
Positive Negative Sequence Control

Balanced Positive Sequence Control

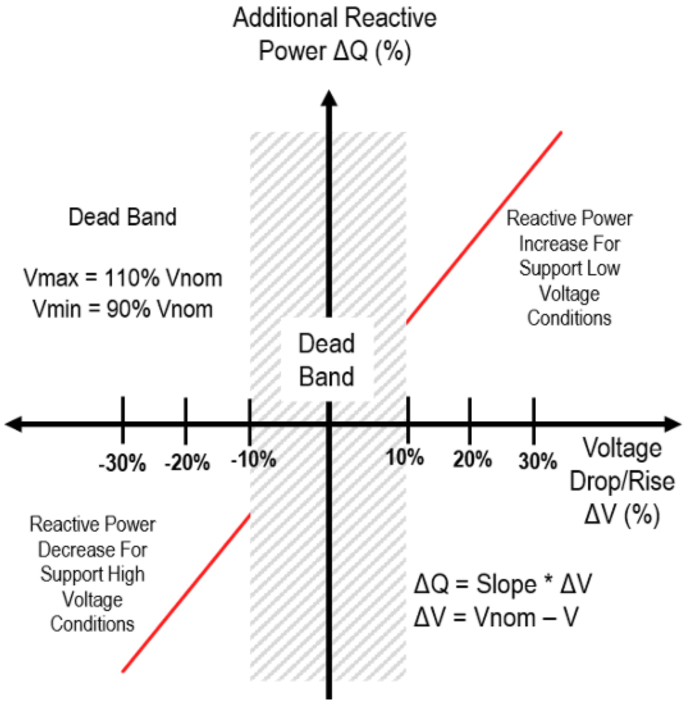
Average Active Reactive Control

III. Peak Current Limitation

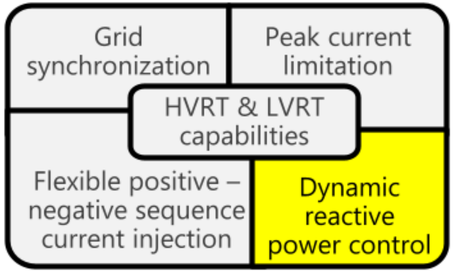


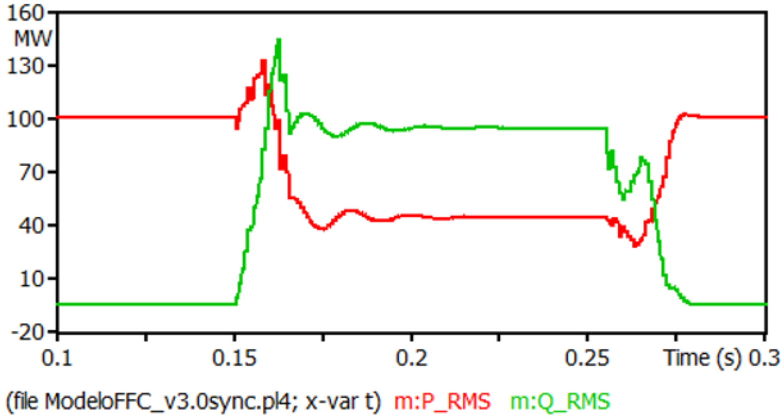


III. IBG Dynamic Reactive Power Control

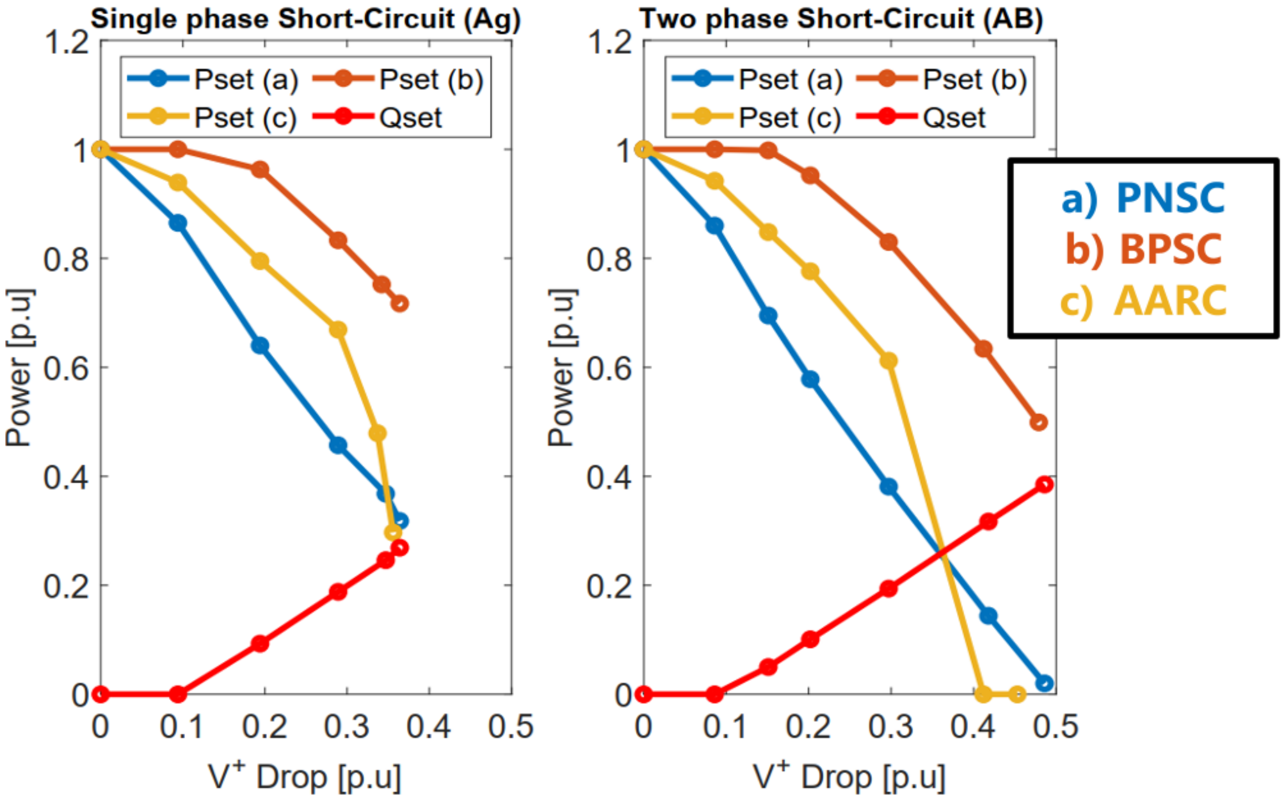


Q Priority for abnormal voltage conditions

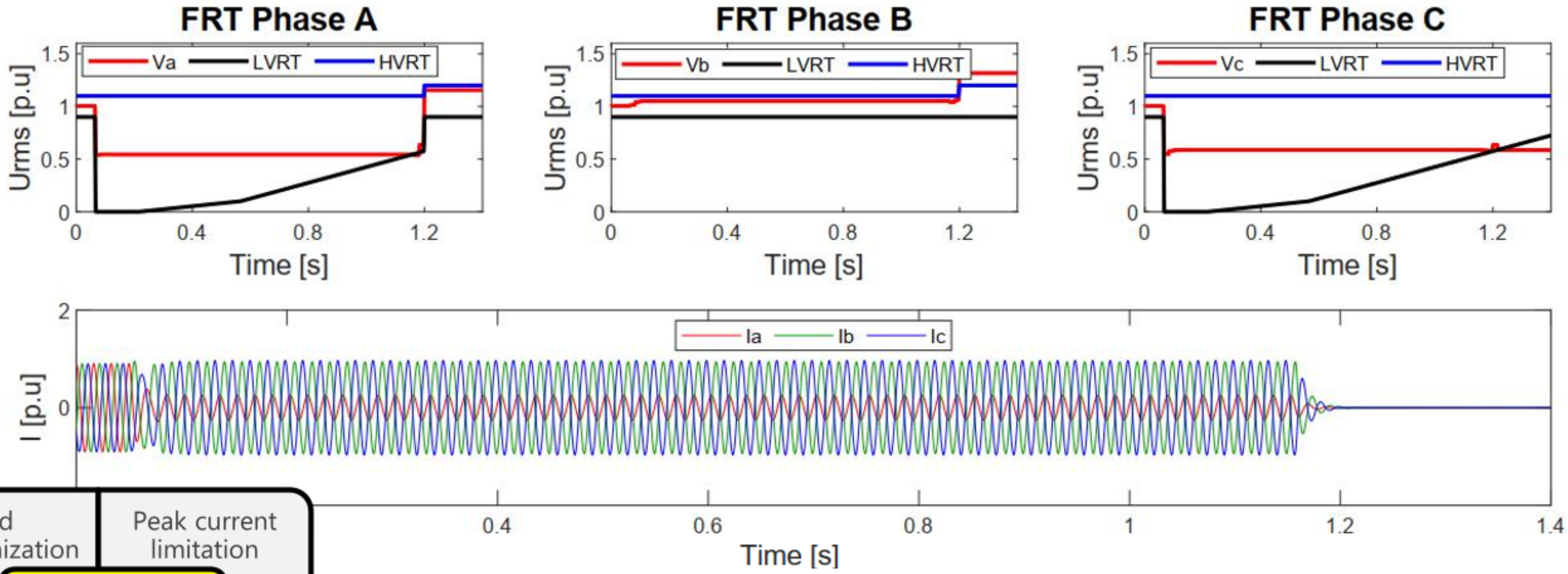


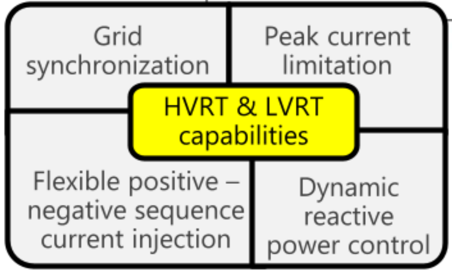


III. IBG Dynamic Reactive Power Control

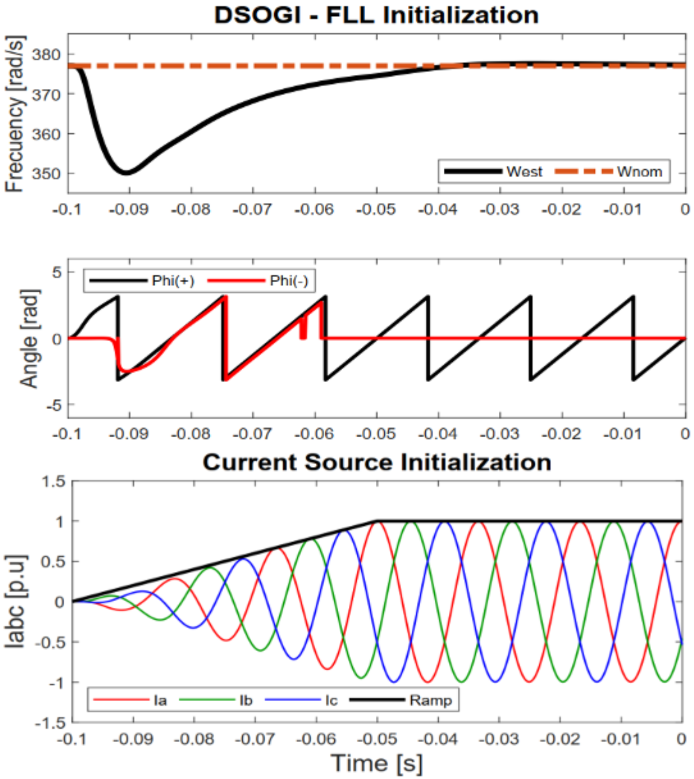


III. FRT IBG Capability Implementation





III. IBG Model Fast Initialization & Large Step Size – Low Computational Load



Theoretical wave results from time step simulation with 1 µs time step size

CONTROLLED CURRENT SOURCE MODEL & TIME STEP SIZE

	IBG Current Error (%)		
Step Size (μs)	Phase A	Phase B	Phase C
10	0.207	0.207	0.209
50	1.128	1.130	1.145
100	2.294	2.300	2.329
200	4.714	4.720	4.750
500	11.727	11.738	11.846
1000	25.294	25.450	25.508
2000	55.843	55.856	55.906

IV. Conclusions

It is presented a generic simplified EMT model for IBG power plants focus on short-circuit and short-term voltage stability to perform studies, including protection coordination. The presented voltage controlled current source focus is practical, efficient, and it integrates all the necessary functions to perform accurate simulations about transient and steady-state IBG behavior in EMT kind of simulations.

This model has been used in the study of future scenarios by the **"Energética 2030"** project and has served the Operator in protection analysis for regulation discussion, event analysis, and for understanding challenges of conventional protection systems in weak grids with high penetration of IBG Generation in the north of the Colombia Power System - SIN.

V. Questions