

Validation of the Geometric Method for Large-Signal Stability Analysis of Two Parallel Grid-Following Converters

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Abstract –The increasing penetration of inverter-based resources (IBRs) is fundamentally changing the power system dynamics, resulting in weaker-grid conditions with reduced system inertia and more frequency fluctuations. These conditions also raise questions about the validity of classical stability analysis. In this paper, the large-signal stability of grid-interfaced power converters in a wind power system application is investigated, comparing the Time-Domain model with the analytical model.

First, an average value model of a single grid following (GFL) converter is developed and implemented in a PLECS environment together with its control strategy. Second, the analytical model for the single GFL converter is presented based on the average value model. A transient stability analysis is then performed using the Geometric Method for the analytical model, which is then compared to Time-Domain simulations. The same procedure is subsequently applied to two GFL converters connected in parallel.

Results show good agreement between the analytical and Time-Domain models under strong-grid conditions. However, discrepancies between the GFL Time-Domain and the analytical models show the fault trajectories advancing at different speeds. The differences are caused by the reduced order of the analytical model, which does not capture the dynamics represented in the Time-Domain model.

Overall, the Geometric Method provides a good approximation of the system behaviour, particularly under strong-grid conditions, although discrepancies with the Time-Domain model become more pronounced as the grid strength decreases. This trend is observed for both the second-order single GFL converter and the two parallel GFL converters.

Keywords: Large-Signal Stability, Grid Following, Multiple Converter Wind Power System, Protections, Time-Domain Simulation, Analytical Model.

1. INTRODUCTION

Renewable energy sources (RES) start to account for larger shares of electrical production, forcing the displacement of conventional power plants. This change has a direct impact on the stability dynamics of the power system, which has traditionally relied on large power plants generating power through synchronous generators (SGs). SGs contribute to grid stability through the kinetic energy stored in their rotating masses, which opposes sudden power imbalances during fault conditions.

This physical inertia is not present in inverter-based resources (IBRs), weakening the grid stability as the ratio of electricity generation shifts toward RES. Moreover, most RES are inherently variable over time. Therefore, the stability of IBR dominated power systems becomes reliant on the interaction of converter control structures during severe grid disturbances such as short circuit faults and voltage sags.

Large-signal disturbances are common in power systems; consequently, it is necessary to investigate whether a converter can recover stability after a grid fault [1]. Moreover, national grid codes require grid-connected converters to provide Low Voltage Ride Through (LVRT) capability. Besides Time-Domain simulation, the stability of converters can be analysed through their dynamic model by using approaches such as the Geometric Method or the Lyapunov method [2]. The Equal Area Criterion, which is a common analysis method for transient stability in SGs, is not often used in converters because it does not consider damping; therefore, it can only be used in systems where damping is positive.

The increased introduction of IBRs into the electrical grid is partially explained by the rapid adoption of solar

power and wind turbines (WT). WTs transform the mechanical power of the wind into electricity. One of the most common topologies is the Type 4 WT shown in Figure 1 where the transformation is done through a generator connected to the grid through a back-to-back converter [3]. One of the advantages of this approach is the decoupling between the grid and the generator: there is an AC/DC conversion (generator side converter) and a DC/AC conversion (grid side converter) [4]. Depending on how the synchronisation with the grid is done, the grid interfacing converter can be either a Grid Following (GFL) or Grid Forming (GFM) converter. GFL converters, which are within the scope of this work, control the output AC current by synchronising it with the grid [4]. The synchronisation is usually done with a PLL, which includes a PI controller [5].

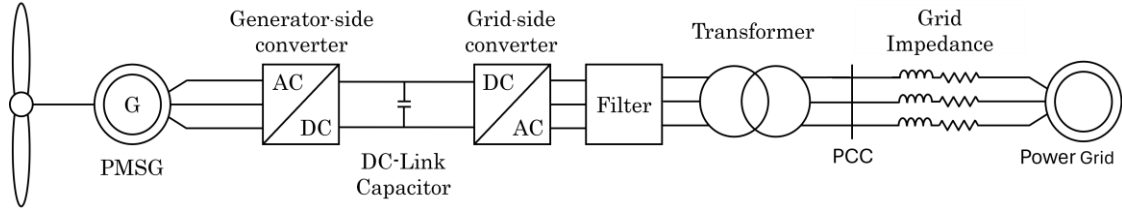


Figure 1. Schematic of a Type 4 wind turbine and its connection to the grid.

Transient stability analysis of power converters is widely studied in the literature. Reference [1] investigates the effects of a weak grid on the stability of a GFL converter, focusing on the PI parameters of the PLL. Reference [6] compares GFL and GFM controls analysing the system parameters, providing a damping coefficient criterion to determine whether a converter is suitable for a strong or weak grid. Reference [2] performs a comparative analysis of GFL and GFM converters for a 10 kW application based on the Geometric Method, the Lyapunov method, and Time-Domain simulations. Although comparative studies, such as in [2], have been conducted, it is not clear to what extent the analytical methods are reliable compared to Time-Domain simulations. Moreover, the literature is based on low power and voltage applications.

The purpose of this paper is to investigate the transient stability of both a single GFL converter and two parallel GFL converters in a WT application. The data is based on a string of the Anholt offshore wind farm [7]. In order to simplify the complexity of the analysed system, an aggregated model of the wind turbines connected to the same string is considered. It is possible to aggregate single wind turbine's converters belonging to the same power plant to study low-frequency dynamics, such as synchronisation controls or fault-ride through controls [7], [8]. This is justified because: 1) wind turbines within a farm usually employ very similar control strategies with closely matched parameters; 2) the internal electrical network of a wind farm is typically strong, which leads to very small voltage and angle differences among the individual units. Furthermore, the project focuses on the grid-side converter. Because the time scales of the current controller and PWM switching are significantly faster than those associated with the transient-stability phenomena, the current control and switching behaviour is neglected and the output of the converter is an ideal current source.

The content of the paper is as follows. Section 2 presents the structure, Time-Domain models, and analytical models of the single GFL converter and the two parallel GFL converters system. Section 3 introduces the Geometric Method and describes its application to the two analysed systems. Section 4 presents the simulation setup and compares the Geometric Method with the Time-Domain simulations for both configurations. Finally, Section 5 summarises the main findings and outlines directions for future research.

2. GRID INTERFACING CONVERTERS

2.1 Single GFL Converter

2.1.1 Time-Domain Model

GFL converter control synchronises its internal reference frame with that of the grid voltage: this is achieved with the phase-locked loop (PLL). A schematic of a GFL converter with PLL synchronisation can be seen in Figure 2. A PLL is a feedback control system that generates a reference signal which tracks the phase of an input signal. The Synchronous Reference Frame PLL (SRF-PLL) is the most used, due to its simplicity and performance under balanced grid conditions. The input is the measured voltage at the point of common coupling (PCC): the three-phase voltage V_c , which is first transformed into the rotating dq-frame. The PLL is then modelled as a PI controller and an integrator, as seen in Figure 2. The output of the PLL is then the estimated grid angle θ_{pll} and its

corresponding frequency ω_{pll} .

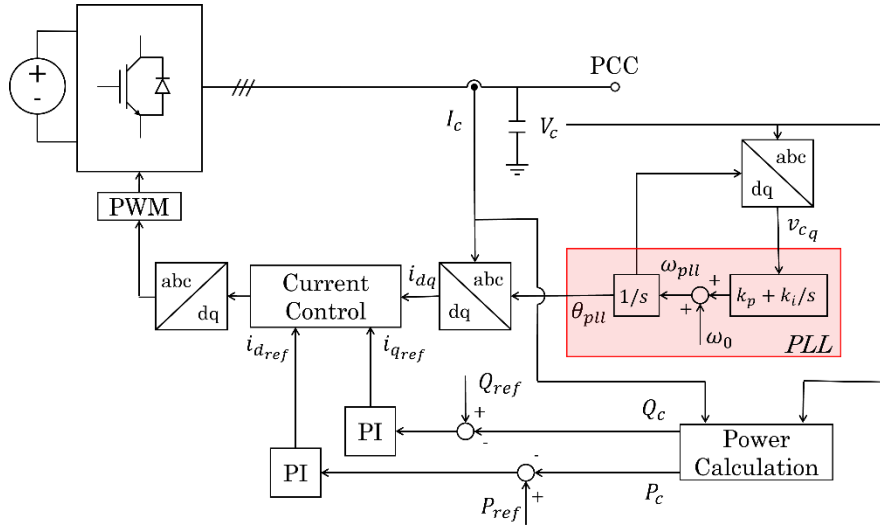


Figure 2. GFL converter with the PLL synchronisation control highlighted in the red box. The measured grid voltage at PCC is shown as V_c .

The Time-Domain model of the single GFL includes the PLL to determine θ_{pll} and ω_{pll} . However, the outer control loops are neglected because the time scale is different than the studied large-signal phenomena. Consequently, the GFL is simplified to an ideal current source, where the phase is determined by the PLL. During normal operation, the converter is set to inject d-component current. The Time-Domain model is implemented in PLECS. Notice that the wind turbine model shown in Figure 1 includes a filter and a transformer to interface with the grid. In this paper filtering is not considered, since prior work has shown that filter capacitor dynamics can be neglected without a significant loss of accuracy in large-signal models [9], and transformer impedance is aggregated with grid impedance.

2.1.2 Analytical Model

The analytical model is based on the PLL shown in Figure 2. The dynamics of the PLL depends on the q-axis component of the transformed V_c [1]. V_{cq} , the q-axis component, is defined as:

$$V_{cq} = R_g \cdot I_{cq} + X_g \cdot I_{cd} + \frac{X_g \cdot I_{cd}}{\omega_0} \omega_p + V_g \cdot \sin(\theta_g - \theta_{pll}) \quad (1)$$

From (1), the dynamic model of the PLL can be defined as a second-order differential equation (2) [2].

$$\frac{k_1}{k_i} \ddot{\delta} + k_2 \dot{\delta} + V_g \sin(\delta) = R_g \cdot I_{cq} + X_g \cdot I_{cd} \quad (2)$$

Where δ is defined in (3). k_1 and k_2 can be found in (4) and (5). k_1/k_i represents the equivalent inertia, and k_2 is the damping.

$$\delta = \theta_{pll} - \theta_g \quad (3)$$

$$k_1 = 1 - \frac{k_p \cdot X_g \cdot I_{cd}}{\omega_0} \quad (4)$$

$$k_2 = \frac{k_p}{k_i} \cdot V_g \cdot \cos(\delta) - \frac{X_g \cdot I_{cd}}{\omega_0} \quad (5)$$

2.2 Analytical Model of Two Parallel GFL Converters

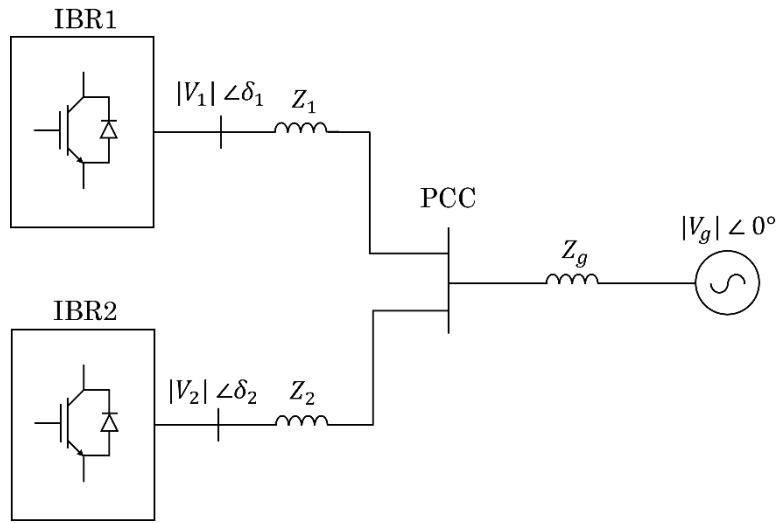


Figure 3. Two converters connected to the grid. It includes the impedance between the converters and the PCC (Z_1 and Z_2) and the grid impedance Z_g .

Considering the PLL dynamic model shown in Figure 3, the output of the PI control can be modelled as:

$$\omega_p = \dot{\delta} = k_p \cdot V_{cq} + k_i \cdot \int V_{cq} dt \quad (6)$$

With two GFL in parallel as shown in Figure 3, one must consider the dynamics of both inverters to derive the analytical model of the system, shown in (7).

$$\begin{cases} \dot{\delta}_1 = k_{p1} \cdot V_{cq1} + k_{i1} \cdot \xi_1 \\ \dot{\xi}_1 = V_{cq1} \\ \dot{\delta}_2 = k_{p2} \cdot V_{cq2} + k_{i2} \cdot \xi_2 \\ \dot{\xi}_2 = V_{cq2} \end{cases} \quad (7)$$

The output quadrature voltage component of each IBR V_{cqi} can be derived from Figure 3 using Kirchhoff's voltage law and considering $X_{1sum} = X_1 + X_g$ and $X_{2sum} = X_2 + X_g$:

$$\begin{cases} V_{cq1} = X_{1sum} I_{cd1} + X_g I_{cd2} \cos(\delta_2 - \delta_1) - V_g \sin \delta_1 \\ V_{cq2} = X_{2sum} I_{cd2} + X_g I_{cd1} \cos(\delta_1 - \delta_2) - V_g \sin \delta_2 \end{cases} \quad (8)$$

3. TRANSIENT STABILITY ANALYSIS – GEOMETRIC METHOD

3.1 Single GFL Converter

The Geometric Method is a transient stability assessment method applicable to power converters. It determines stability boundaries through the stable and unstable manifolds of saddle equilibria. Applied to power converters, this consists of finding the manifolds of unstable equilibrium points (UEPs), which determine whether post-fault states remain stable or diverge [10]. The stability zone determined by the manifolds is called Basin of Attraction (BOA).

The stable equilibrium point (SEP) defines the power angle δ and angular frequency ω during normal

operation. This can be found considering steady-state conditions of the dynamic model (2), as shown in (9).

$$\delta = \text{asin}\left(\frac{X_g \cdot I_{cd}}{V_g}\right) \quad (9)$$

Because of the periodicity of the sine function, the SEPs can be defined to be $(\delta + 2\pi k, \omega_0)$, where k is an integer and ω_0 is the fundamental angular frequency. Similarly, the UEPs can be found from the SEPs to be $((1 + 2k)\pi - \delta, \omega_0)$. To determine the BOAs, the manifolds are found by reverse-time integration from the UEPs. This is performed by using the ODE45 function in MATLAB.

Figure 4 shows an example of BOA and fault trajectory obtained using the Geometric Method. SEP 1 is the SEP during normal operation, where the power angle is close to 0 rad and the angular frequency 100π rad/s. When a severe grid fault occurs, the angular frequency and power angle increase: it is shown as the red trajectory in Figure 4. The converter can recover stability depending on the fault clearance time: if the fault trajectory ends within the BOA, it will recover its stability (green trajectories); if not, it will lose synchronism (black trajectory). Notice that the converter will recover stability if the fault trajectory ends within the BOA of another SEP (e.g. SEP2, corresponding to an equivalent periodic equilibrium).

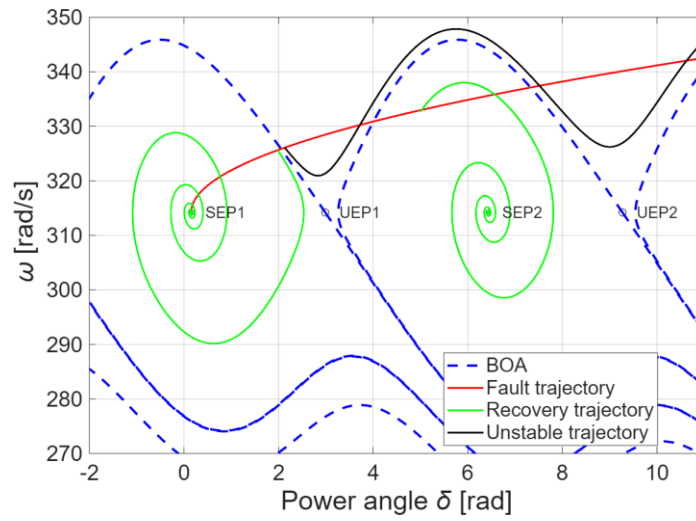


Figure 4. Trajectories for different fault clearance times (green and black) after a severe grid fault (red), where the BOA of two SEPs is found from the UEPs with reverse-time integration (blue-dashed trajectories).

3.2 Two Parallel GFL Converters

For the two-converter system, the Geometric Method is extended to the coupled nonlinear dynamics introduced in Section 2.2. The first step is to determine the equilibrium points (EPs) of the system by imposing zero time derivatives in (7). By substituting the expressions of the quadrature voltage components in (8), the equilibrium conditions are obtained as:

$$\begin{cases} V_{cq1} = X_{1sum}I_{cd1} + X_g I_{cd2} \cos(\delta_2 - \delta_1) - V_g \sin \delta_1 = 0 \\ V_{cq2} = X_{2sum}I_{cd2} + X_g I_{cd1} \cos(\delta_1 - \delta_2) - V_g \sin \delta_2 = 0 \end{cases} \quad (10)$$

Because of the sine and cosine nonlinearities in (10), multiple EPs may exist and are determined using a grid-based search strategy. Once the phase-plane is divided into a mesh, EPs can be found by solving (10) with a non-linear solver (for example, fsolve in MATLAB), applied multiple times starting from the different points of the defined grid.

Once the EPs are found, they need to be classified as SEPs and UEPs. To do this, the Jacobian matrix of the system is evaluated at each EP, and its eigenvalues are computed. The sign of the real parts of these eigenvalues reveals the type of EP:

- SEP: All eigenvalues have negative real parts.
- Saddle Point (UEP): One eigenvalue has a positive real part, the rest are negative. The system is unstable in one direction but stable in all others. Saddle points lie on the boundary between stable and unstable regions.
- Unstable Node (UEP): All eigenvalues have positive real parts. The system moves away from this point in every direction, it is fully unstable.

The BOA can later be found by applying reverse-time integration starting from the Saddle Points.

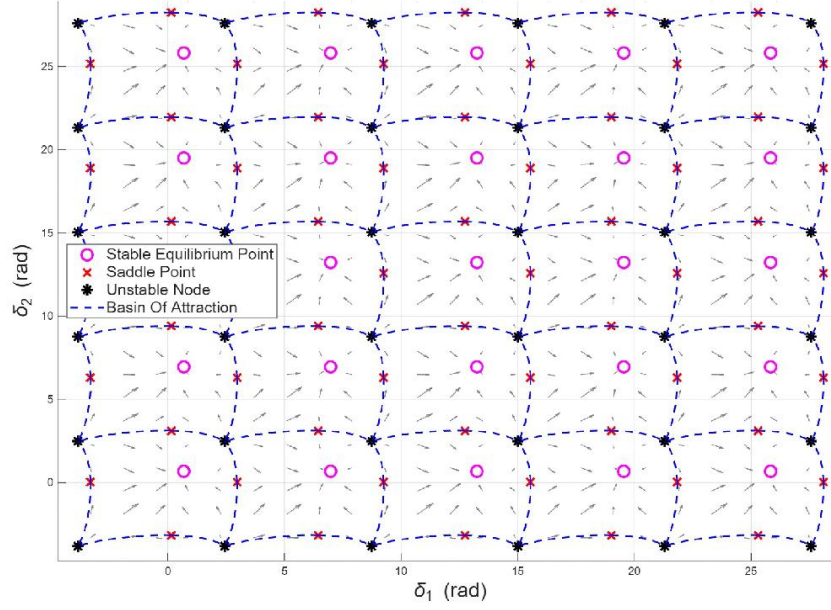


Figure 5. BOA and Equilibrium Points of the two parallel GFL converters system.

4. SIMULATION RESULTS

The case study is based on the 400 MW Anholt wind farm [11]. A whole string of 9 turbines, each rated at 3.6 MW (32.4 MW in total) and connected to a medium-voltage grid of 33 kV, is considered as a single grid-interfaced converter (Table 1). The transient stability of the system is assessed under three different grid impedances, and the corresponding per-unit values are reported in Table 2. Each simulation considers a grid fault lasting $t_{fault} = 150$ ms, as 150 ms represents a commonly adopted fault-ride-through time scale in several European grid codes.

4.1 Single GFL Converter Results

The parameters used in the PLL for the single GFL converter are presented in Table 3. These values make the system underdamped. The results of the simulations can be seen in Figure 6, Figure 7, and Figure 8. In these, the fault trajectories are shown in red, the recovery trajectories are shown in green, and the BOA boundaries are shown as blue dashed lines. To distinguish the two methods, the Time-Domain (TD in the legend) simulation results are presented as a solid line, and for the Geometric Method (GM in the legend) as a dashed line.

Table 1. Simulation parameters.

Symbol	Quantity	Value	Unit
P	Rated power	32.4	MW
V_g	Grid line-to-line RMS voltage	33	kV
V_{sag}	Line-to-line RMS voltage during the fault	0.3	kV
ω_s	Base Angular Frequency	$100 \times \pi$	rad/s
t	Fault duration	150	ms

Table 2. Grid-strength scenarios and corresponding equivalent grid impedances.

Strength	Value in p.u.
Strong	0.1
Medium	0.3
Weak	0.5

Table 3. PLL parameters of the single GFL converter.

Symbol	Quantity	Value	Unit
k_p	Proportional gain of the PI controller	48	-
k_i	Integral gain of the PI controller	1058	-

For each scenario, two different plots can be found. On the left, the fault trajectory for the Geometric Method starts at the SEP, and the recovery trajectory starts where the fault trajectory stops. On the right plot, the Geometric Method is performed considering the jump in ω that occurs when a fault occurs or is cleared. In Figure 6 (right), the initial points used in the Geometric Method are indicated with the red (fault) and green (recovery) arrows. To consider these jumps, the results of the Time-Domain simulation are required.

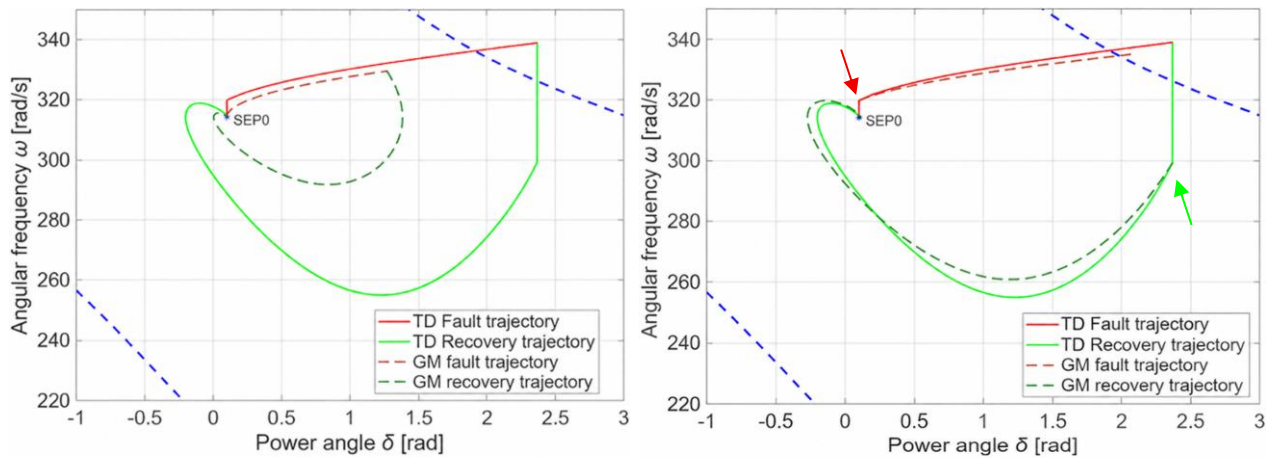


Figure 6. Trajectories for the Time-Domain simulations (TD) and Geometric Method (GM) for the GFL converter in the strong grid strength scenario for a fault duration of 150 ms. On the left, the GM is performed from SEP0; on the right, the GM is performed from the initial condition obtained from the Time-Domain results.

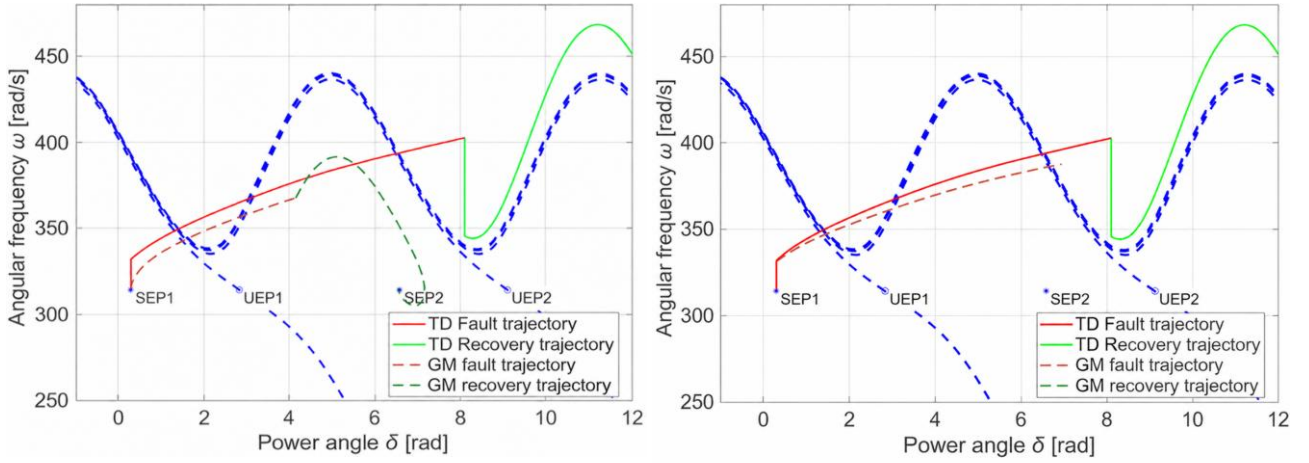


Figure 7. Trajectories for the Time-Domain simulations (TD) and Geometric Method (GM) for the GFL converter in the medium grid strength scenario for a fault duration of 150 ms. On the left, the GM is performed from SEP0; on the right, the GM is performed from the initial condition obtained from the Time-Domain results.

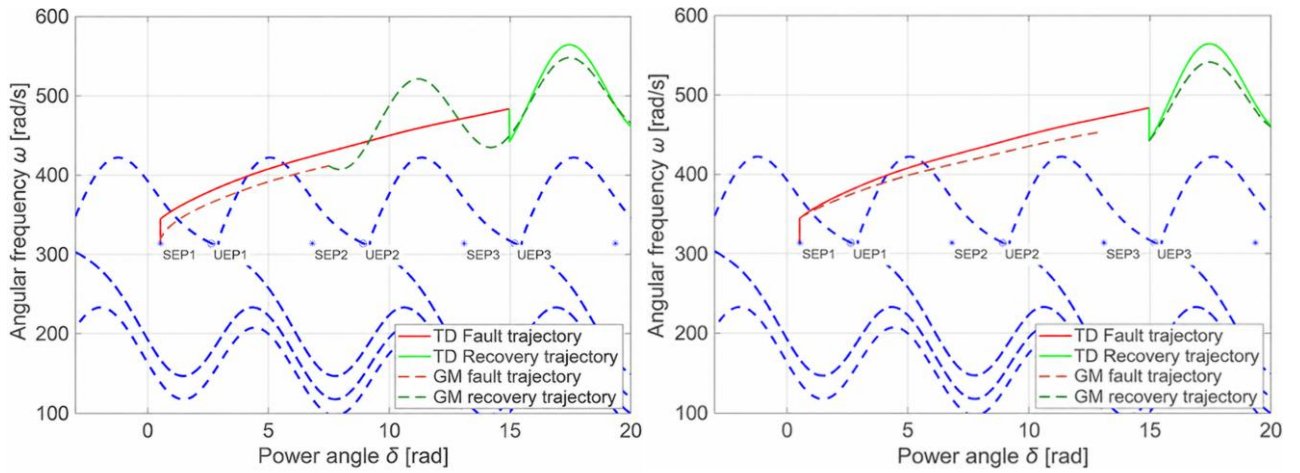


Figure 8. Trajectories for the Time-Domain simulations (TD) and Geometric Method (GM) for the GFL converter in the weak grid strength scenario for a fault duration of 150 ms. On the left, the GM is initialised at SEP0; on the right, the GM is performed from the initial condition obtained from the Time-Domain results.

The results show that the initial point of the fault and recovery trajectories has a significant influence on the GM. For example, in Figure 7 (left), the GM shows that the converter is able to recover stability when the fault is cleared, while the Time-Domain simulation results show that the converter loses synchronism. When the GM considers the jump in ω (right), the results converge with those of the Time-Domain simulation and the converter loses synchronism.

The fault trajectory predicted by the GM evolves more slowly than the corresponding time-domain trajectory. These differences between the two methods are due to the simplification of the analytical model compared to the Time-Domain. The analytical model is a second-order model, which does not take into account the fast electromagnetic dynamics associated with the grid inductive impedance. A higher order analytical model would reduce the differences.

The converter is shown to be able to regain stability after the fault in the strong grid scenario (Figure 6). However, Time-Domain simulations show that the converter cannot recover stability after the fault in weaker grid conditions, as seen in Figure 7 and Figure 8. The GFL converter is more stable in strong grid conditions.

A comparison was carried out to determine the difference in fault-trajectory times. Table 4 compares the Critical Clearing Time (CCT) obtained with the GM and the time-domain model. The CCT is defined as the maximum duration for which a fault can persist before the system loses synchronism. The CCT for both the Time-Domain and analytical models is obtained by iteration, adjusting the fault duration time until a value was found where the system would regain stability.

Table 4. Comparison of analytical and Time-Domain methods. The table shows the time for each method's fault-trajectory to reach the perimeter of the initial BOA, for each grid strength

Grid strength	CCT (GM)	CCT (TD)	Δt
Strong	0.192 s	0.164 s	0.028 s
Medium	0.0845 s	0.066 s	0.0185 s
Weak	0.0500 s	0.036 s	0.0140 s

4.2 Multiple GFL

To validate the results obtained by the GM, a Time-Domain simulation of the system depicted in Figure 3 is carried out. Two models of the single GFL converter are connected in parallel and analysed under the same grid fault condition of the previous section. The PI controller of the two IBRs is designed to be overdamped. Table 5 and Table 6 present the parameters used in Geometric Method and Time-Domain simulations.

The results of the simulations can be seen in Figure 9, Figure 10, and Figure 11. The fault trajectory of the Time-Domain simulation is shown in solid red while the one that is obtained by the analytical model in dashed black. The recovery trajectories are shown in solid green for the Time-Domain solution and in dashed orange for the GM. To distinguish the two methods, the Time-Domain (TD in the legend) simulation results are presented as a solid line, and for the Geometric Method (GM in the legend) as a dashed line.

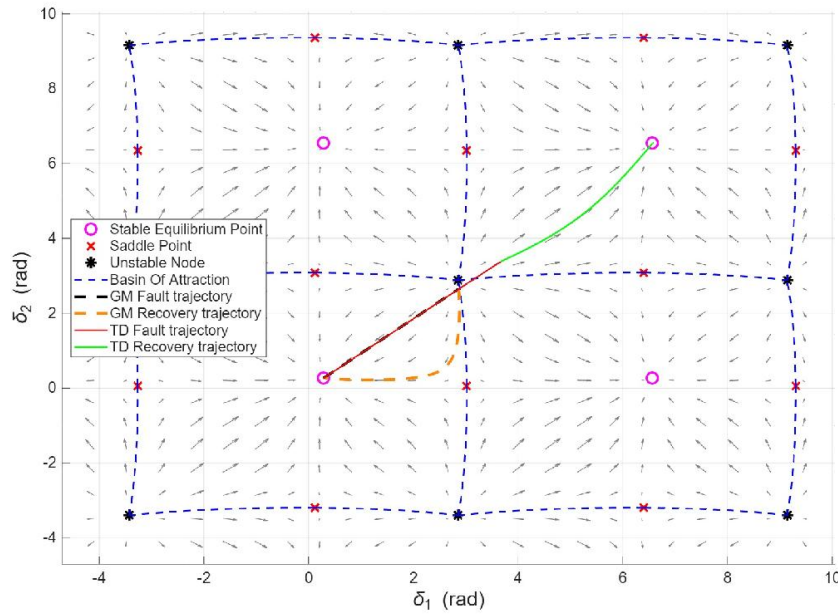


Figure 9. Fault trajectories of Time-Domain and Geometric Method simulation with strong grid. Fault duration set to $t_{fault} = 150$ ms.

Figure 9 presents the simulation results of the two parallel GFL inverters operating in a strong grid subject to a fault duration of $t_{fault} = 150$ ms. Prior to the fault inception, both the GM and TD trajectories start from an identical steady-state equilibrium point. When the fault occurs, the two models follow the same path. However, after fault clearance GM simulation ends in SEP1, while the Time-Domain simulation ends in SEP2 since the fault is cleared after its trajectory falls within the BOA of SEP2. Thus, Time-Domain and the Geometric Method predict different numbers of phase slips before resynchronisation in this case.

Furthermore, the post-fault recovery trajectory of the Time-Domain simulation follows the vector field of the BOA. The fault trajectory computed through the Geometric Method is slower than the Time-Domain simulation, as in the single converter configuration. Nevertheless, during the post-fault recovery phase, the Time-Domain trajectory closely follows the analytical vector field generated by the Geometric Method.

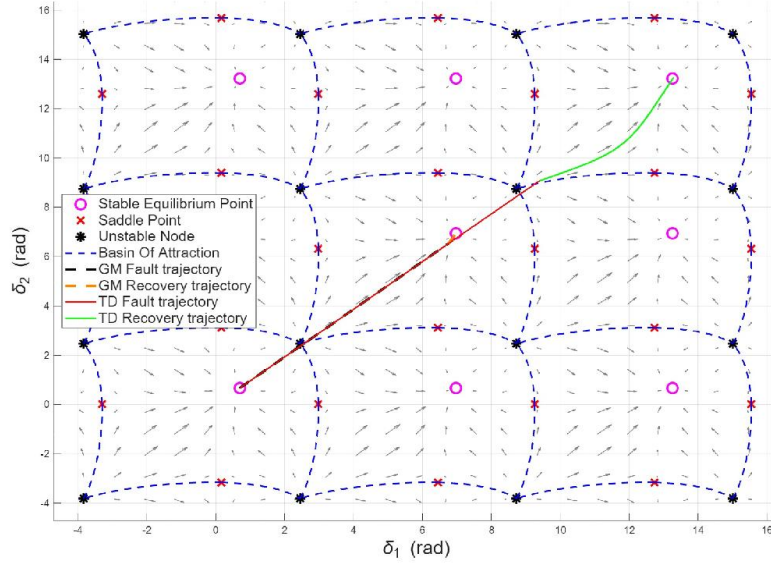


Figure 10. Fault trajectories of Time-Domain and Geometric Method simulation with medium strength grid. Fault duration set to $t_{\text{fault}} = 150$ ms.

The dynamic response of the system under a medium strength grid configuration subject to a fault duration of $t_{\text{fault}} = 150$ ms is depicted in Figure 10. Due to the increased grid impedance with respect to the strong grid scenario, the post-fault voltage degradation at the PCC is significantly more severe, thereby accelerating the phase angle divergence of both parallel converters. For the same fault duration, both GM and TD simulations start from the same equilibrium point, i.e. SEP1, but are cleared within different BOAs.

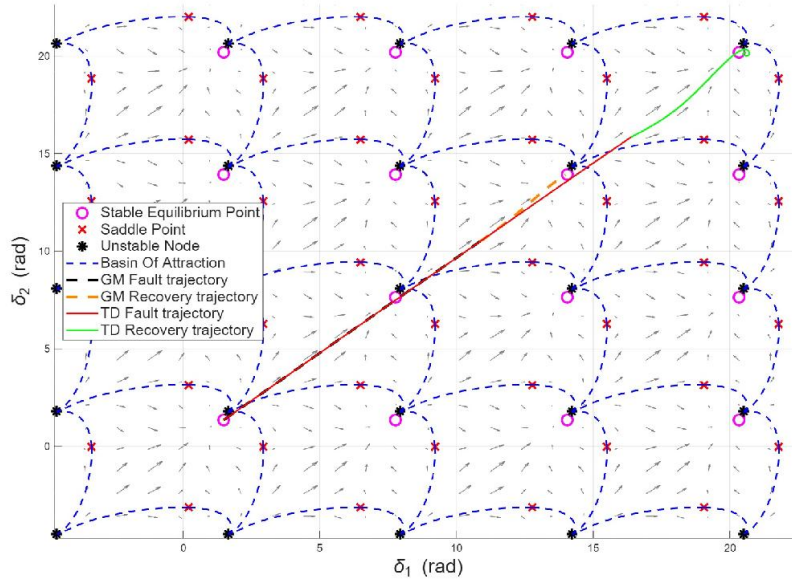


Figure 11. Fault trajectories of Time-Domain and Geometric Method simulation with weak grid. Fault duration set to $t_{\text{fault}} = 150$ ms.

Results show that the two GFL converter system does not experience standard out-of-step synchronism loss; instead, it successfully re-establishes stability across every grid strength scenario under the considered 150 ms fault duration. Figures 10 and 11 show that weaker grid strength results in a faster variation of the converter phase angles δ_1 and δ_2 , thus longer trajectories that end up in more distant SEPs after the same clearing time.

As discussed for the single converter systems, the Geometric Method does not account for the electromagnetic transients of the grid inductance. This discrepancy becomes more pronounced as the grid becomes weaker. Furthermore, Figure 11 shows that higher values of the impedance affect the geometry of BOAs to an increasingly curved shape, while SEPs get closer to the Unstable Nodes.

Overall, despite the faster evolution of the fault trajectory observed in the Time-Domain simulations compared with the Geometric Method, the latter provides a good approximation of the two-converter system behaviour and provides a useful representation of the BOAs across the three analysed grid-strength scenarios, although with increasing temporal discrepancies as the grid becomes weaker.

Table 5. Characteristics of the two parallel GFL converters.

Symbol	Quantity	Value	Unit
k_{p1}	Proportional gain of the PI controller	$10 \times 2 \times \pi$	-
k_{i1}	Integral gain of the PI controller	$2 \times \pi$	-
k_{p2}	Proportional gain of the PI controller	$10 \times 2 \times \pi$	-
k_{i2}	Integral gain of the PI controller	$2 \times \pi$	-

Table 6. Simulation parameters for the two parallel GFL converters system.

Symbol	Quantity	Value	Unit
P	Rated power	32.4	MW
V_g	Grid line-to-line RMS voltage	33	kV
ω_s	Base Angular Frequency	$100 \times \pi$	rad/s
V_{sag}	Line-to-line RMS voltage during the fault	0.3	kV
I_{1d}	Current reference IBR1	1	p.u.
I_{2d}	Current reference IBR2	0.8	p.u.
Z_1	Inter-array line impedance of IBR1	0.1j	p.u.
Z_2	Inter-array line impedance of IBR2	0.1j	p.u.

5. CONCLUSION

This paper investigated the large-signal stability of a single GFL converter and two parallel GFL converters by comparing a reduced-order analytical model, analysed through the Geometric Method, with Time-Domain simulations. The results show that the Geometric Method provides a good approximation of the overall system behaviour, particularly under strong-grid conditions. However, the accuracy of the predicted fault trajectories decreases as the grid becomes weaker, mainly because the reduced-order analytical model does not capture the fast electromagnetic dynamics represented in the Time-Domain model.

For the single GFL converter, the Time-Domain fault trajectory evolves faster than that predicted by the Geometric Method. This difference is also reflected in the Critical Clearing Time, which is consistently overestimated by the analytical model.

Furthermore, the instantaneous jump in angular frequency occurring at fault inception and clearance is not inherently reproduced by the reduced-order model. When this jump is accounted for using the Time-Domain initial condition, the alignment between the two approaches improves significantly. This, however, introduces a dependence on the Time-Domain simulation and therefore limits the standalone applicability of the present analytical formulation.

For the two-converter system, the Geometric Method provides a useful representation of the BOAs and provides a representative approximation of the system trajectories for all three analysed grid-strength scenarios. Nevertheless, the Time-Domain trajectories evolve faster and may enter a different basin of attraction after fault clearance, leading to a different final stable equilibrium point. These discrepancies become more pronounced as

the grid impedance increases.

Overall, the Geometric Method is suitable for obtaining a qualitative and approximate assessment of large-signal stability and for identifying the stability regions of GFL converter systems. Its main limitation is the reduced temporal accuracy of the analytical model, particularly under weaker-grid conditions. Future work should therefore focus on improving the analytical formulation so that the fast transient effects and the frequency jump at fault inception and clearance can be represented directly, reducing the dependence on Time-Domain simulations and improving the accuracy of the stability assessment.

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DECLARATIONS

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Data availability: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author(s).

Author contributions: Conceptualisation, G.G. and F.B.; investigation, C.J.B. and G.U.T.; writing—original draft preparation, C.J.B. and G.U.T.; writing—review and editing, C.J.B., G.U.T., G.G. and F.B.; supervision, G.G. and F.B. All authors have read and agreed to the published version of the manuscript.

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