A benchmark test system to assess angle stability in power systems with grid-forming power converters: Data

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1 Introduction

This document describes the data of a benchmark test system to assess angle stability in power systems with grid-forming voltage source converters (GFM-VSC). This test system was used in [1].

2 Benchmark test system

Nominal voltage and frequency of the system are 220 kV and 50 Hz, respectively. Parameters of line 2-3 are $r_g = 0.01$ pu, $x_g = 0.1$ pu (base values for pu: 220 kV and 100 MVA). Initial operating point of the GFM-VSC is $P_g^0 = 70$ MW and $v_g^0 = 1$ pu. Constant modulated voltage set-point term was set to $e_m^0 = 1.0057$ pu.

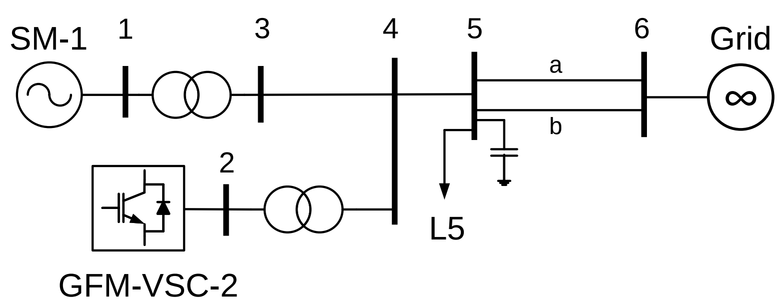

Figure 1: Test system.

3 Synchronous machine

4 GFM-VSC power converter

$$i_{g,q}^{ref'} = \frac{v_{g,d} - e_{m,d}^0}{x_{cv}}, \; i_{g,d}^{ref'} = \frac{e_{m,q}^0 - v_{g,q}}{x_{cv}}. \tag{1}$$

Data of GFM-VSCs are provided in Table 1.

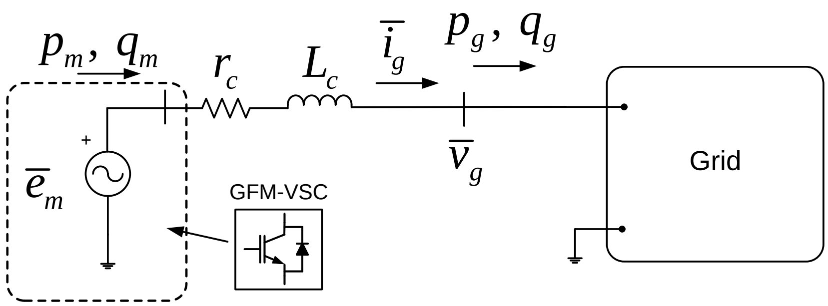

Figure 2: Equivalent model of a Grid-Forming Voltage Source Converter (Grid-forming voltage source converter (GFM-VSC)) connected to the grid.

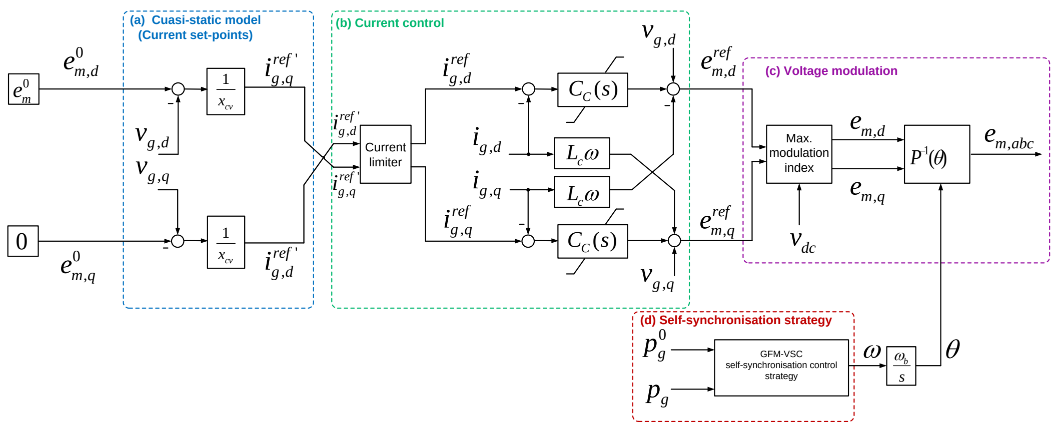

Figure 3: General scheme of the control system of a GFM-VSC.

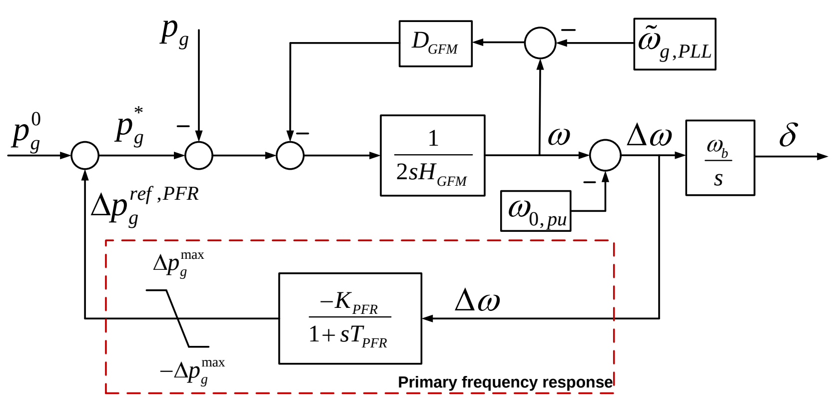

Figure 4: GFM-VSC control scheme.

Table 1: Parameters of the GFM-VSCs

Parameters VSC's rating are base values for pu	**Values**
Rating VSC, DC voltage, AC voltage	900 MVA, 640 kV, 220 kV
Max. current	1.20 pu (equal priority for $d-q$ axes)
Series resistance ($r_{c,i}$) / reactance ($x_{c,i}$) (series reactor + transformer) (transformer: 900 MVA 220/320 kV)	0.005 pu / 0.15 pu
Current control bandwidth ($\omega_{n,CC}$)	1500 rad/s
Current control prop. / int. gains ($K_{C,P,i}$ / $K_{C,I,i}$)	1.0027 pu / 1074.3 pu/s
Quasi-static model, virt. reactance (x_v / x_{ev})	0 pu / 0.15 pu
Emulated inertia ($H_{GFM,i}$)	5 s
Primary freq. controller ($K_{PFR,i}$ / $T_{PFR,i}$)	20 pu / 1 s
Primary freq. controller limit ($\Delta p_{g,i}^{max}$)	1 pu
PLL control bandwidth ($\omega_{n,PLL}$)	500 rad/s
PLL control porp. / int. gains ($K_{P,PLL}/K_{I,PLL}$)	3.1831 pu / 795.7747 pu/s
PLL frequency saturation ($\Delta\omega_{PLL}^{max}$)	± 0.1 pu

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References

[1] R. E. Ávila Martínez, J. Renedo, L. Rouco, A. Garcia-Cerrada, and L. Sigrist, "On the definition of angle stability in power systems with grid-forming power converters," *Universidad Pontificia Comillas, Madrid, Spain*, vol. Working paper, no. IIT-25-332WP, pp. 1–3, 2025.