Appendix for: Large-Signal Stability of Power Systems with Mixtures of GFL, GFM and GSP Inverters

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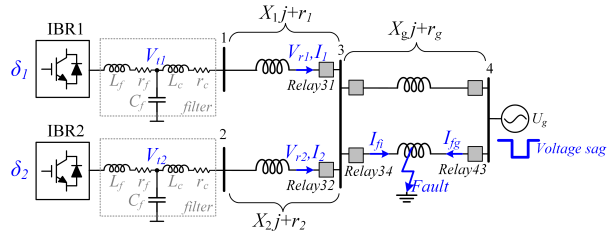

Fig. 2. Two-inverter system and detailed configurations used in EMT simulation.

APPENDIX B
EMT SIMULATION PARAMETERS

TABLE B1
SYSTEM PARAMETERS IN TWO PARALLELED GFL INVERTERS SYSTEM

Parameters	Value (p.u.)
Base frequency ω_s	50 Hz
Grid voltage U_g	1
DC voltage U_{dc}	2.5
LCL Filter impedance $L_fj + r_f$	$0.2j + 0.002$
LCL Filter capacitance C_f	0.01
Inner current control loop bandwidth	1 kHz
PLL controller of IBR1 k_{pll1}	$10 \times 2\pi$
PLL controller of IBR1 k_i	2π
PLL controller of IBR2 k_{pll2}	$10 \times 2\pi$
PLL controller of IBR2 k_i	2π
Frequency limit of PLL ω_{limit}	± 0.2
Current reference of IBR1 I_{1d}	0.8
Current reference of IBR2 I_{2d}	0.4
Line impedance Z_1	0.2j+0.002
Line impedance Z_2	0.2j+0.002
Line impedance Z_g	0.35j or 0.4j
Fault resistance R_f	0.02

TABLE B2
SYSTEM PARAMETERS IN GFL - GFM(GSP) INVERTERS SYSTEM

Parameters	Value (p.u.)
Base frequency ω_s	50 Hz
Grid voltage U_g	1
Impedance Z_1	0.5j+0.025
Impedance (include virtual one) Z_2	0.1j+0.002
Impedance $2Z_g$	0.6j+0.03
Fault resistance R_f	0.001
Fault position (from the infinite bus)	0.8
IBR1 - GFL	
Inner current control loop bandwidth	1 kHz
PLL controller k_{pll1}	$2.5 \times 2\pi$
PLL controller k_i	$0.25 \times 2\pi$
Frequency limit of PLL ω_{limit}	± 0.2
Current reference I_{1d}	1
DC voltage U_{dc}	2.5
LCL filter impedance $L_fj + r_f$	0.2j+0.02
LCL filter capacitance C_f	0.01
IBR2 - GFM	
$P-\omega$ droop gain $k_{p-\omega}$	$2.5 \times 2\pi$
Power reference P_{ref}	0.6 in Section IV-A, 0 in Section IV-B
Voltage reference V_{gfm}	1
Inner voltage control loop bandwidth	200 Hz
Inner current control loop bandwidth	1 kHz
LCL filter impedance $L_fj + r_f$	0.2j+0.02
LCL filter capacitance C_f	0.1
Current limit I_{limit}	2
$P-\omega$ droop time constant τ_p	$1/(25 \times 2\pi)$
IBR2 - GSP	
Voltage droop m_q	1 or 4 in Section IV-A, 2 in Section IV-B
Voltage reference V_{ref}	1
Current reference I_{2d}	0.6 in Section IV-A, 0 in Section IV-B
Voltage droop filter time scale τ_v	$1/(50 \times 2\pi)$
PLL controller k_{pll2}	$k_{p-\omega} \cdot \frac{1}{X_{2sum}}$

TABLE B3
SYSTEM PARAMETERS IN THE GFM - GSP INVERTERS SYSTEM

Impedance Z_1	0.5j+0.025
Impedance Z_2	0.1j+0.002
Impedance $2Z_g$	0.6j+0.03
Fault resistance R_f	0.001
Fault position (from the infinite bus)	0.8
IBR1 - GFM	
$P-\omega$ droop gain $k_{p-\omega}$	$2.5 \times 2\pi$
Power reference P_{ref}	0.8
Voltage reference V_{gfm}	1
Inner voltage control loop bandwidth	200 Hz
Inner current control loop bandwidth	1 kHz
Current limit I_{limit}	2
$P-\omega$ droop time constant τ_p	$1/(25 \times 2\pi)$
IBR2 - GSP	
Voltage droop m_q	0, 2, or 4
Voltage reference V_{ref}	1
Current reference I_{2d}	0.2
Voltage droop filter time scale τ_v	$1/(50 \times 2\pi)$
PLL controller k_{pll2}	$6 \times 2\pi$
PLL controller k_i	$0.6 \times 2\pi$