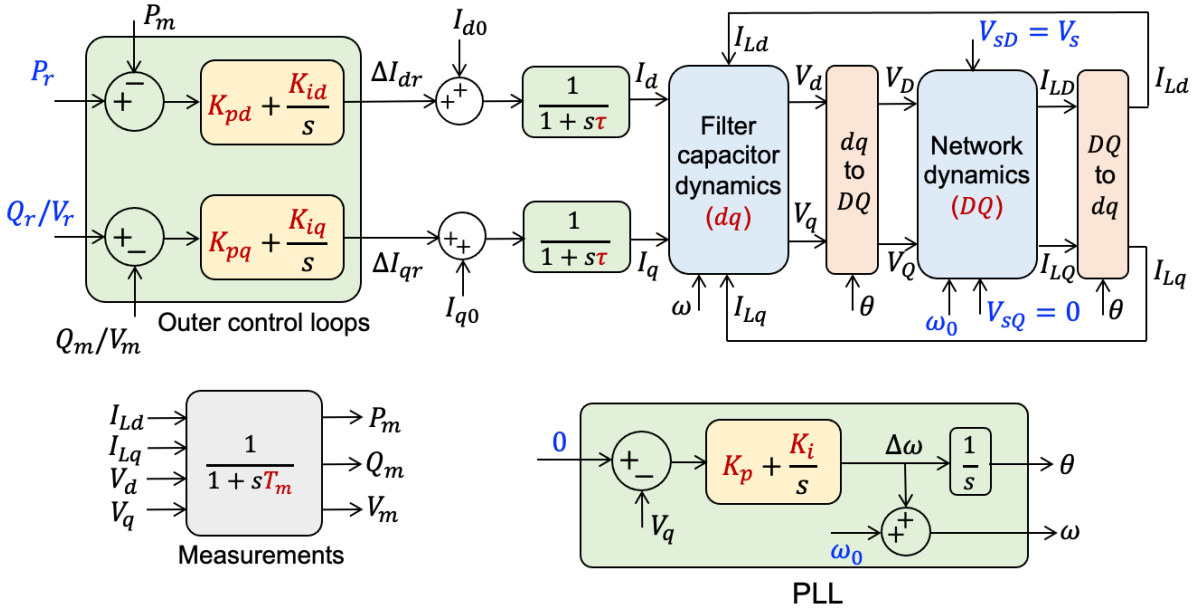
Validation of small-signal analysis of an IBR connected to an infinite bus ($V_s = 1\angle 0°$ pu)

1 Grid following (GFL)

1.1 Model



1.2 GFL with P-Q control

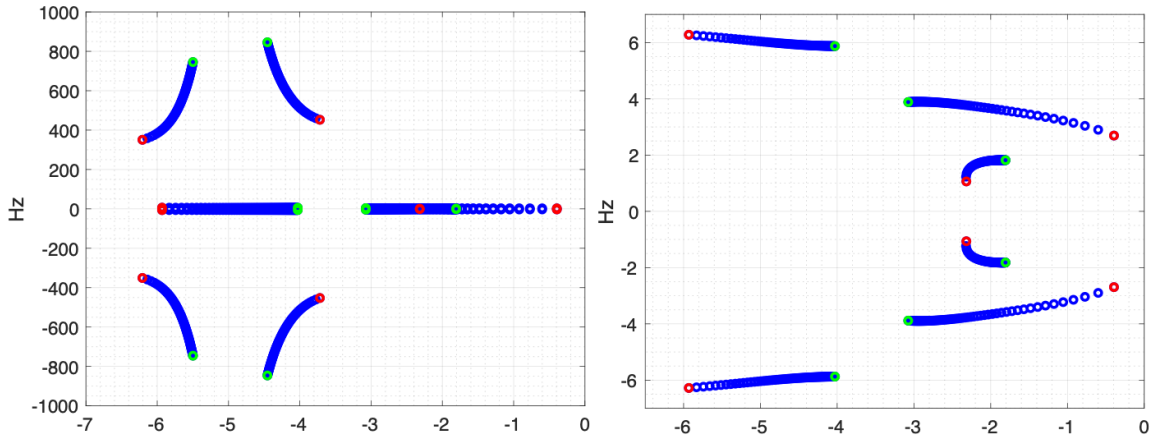
ω_0	314 rad/s	SCR	2	$K_{p-\mathrm{PLL}}$	-20.65
V_s	1.0 pu	$\mathrm{BW_{PLL}}$	4.74 Hz	$K_{i-\mathrm{PLL}}$	-234.82
P_r	1.0 pu	$\mathrm{BW_P}$	10.17 Hz	$K_{p-\mathrm{P}}$	1.37
Q_r	0.23 pu	$\mathrm{BW_Q}$	10.17 Hz	$K_{i-\mathrm{P}}$	88.42
X/R	5.0	$\mathrm{BW_I}$	500 Hz	$K_{p-\mathrm{Q}}$	-1.08
B_f	0.02 pu	T_m	50 ms	$K_{i-\mathrm{Q}}$	-46.13

$$\mathrm{BW_I} = \frac{1}{\tau}$$

$$\mathrm{SCR} = \frac{1}{Z}$$

where Z is the impedance of the network

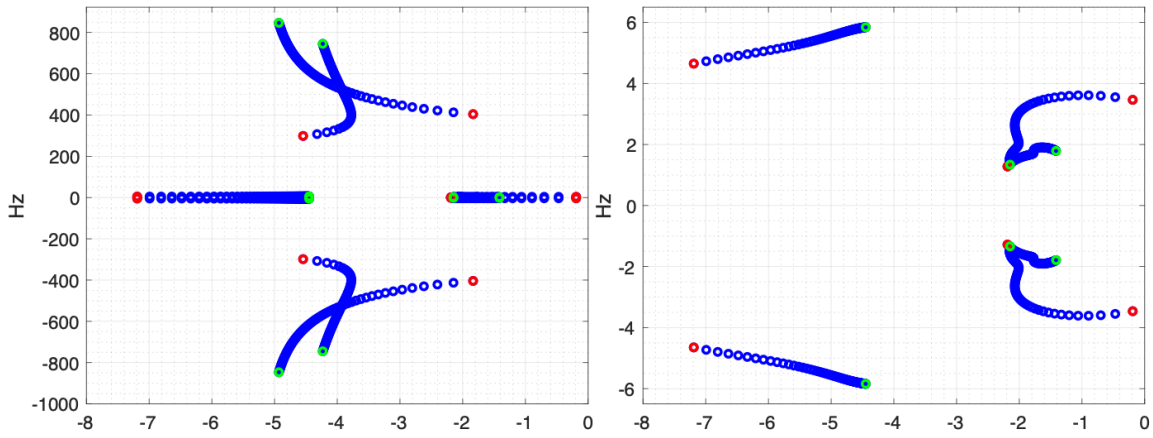
SCR 5.0o → 1.3o $\quad \frac{X}{R} = 5, P = 1.0$ pu



1.3 GFL in P-V control

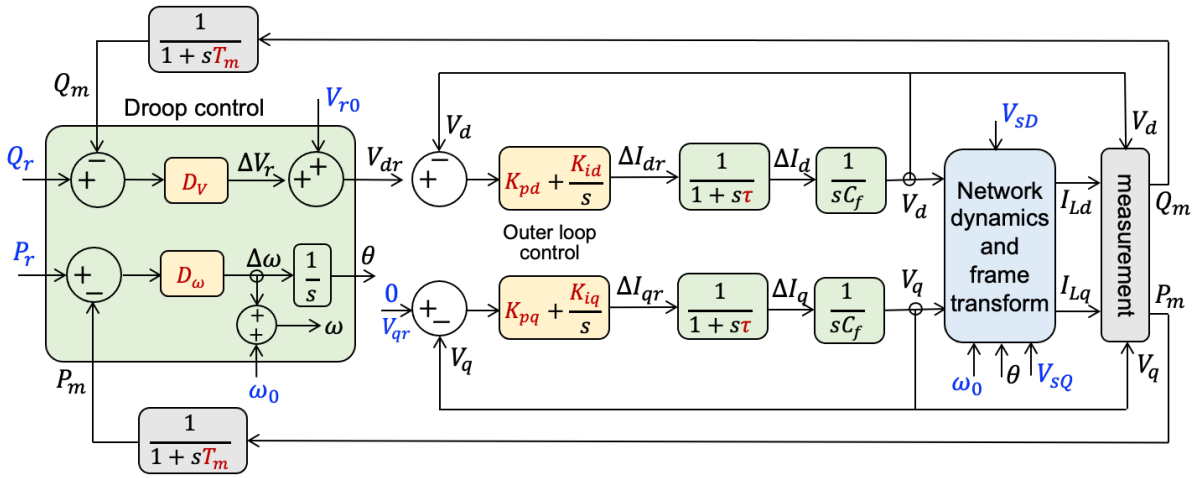
ω_0	314 rad/s	SCR	2	$K_{p-\mathrm{PLL}}$	-18.4
V_s	1.0 pu	$\mathrm{BW_{PLL}}$	4.08 Hz	$K_{i-\mathrm{PLL}}$	-180.25
P_r	1.0 pu	$\mathrm{BW_P}$	10.66 Hz	$K_{p-\mathrm{P}}$	1.39
V_r	1.0 pu	$\mathrm{BW_Q}$	10.66 Hz	$K_{i-\mathrm{P}}$	99.42
$X/_R$	5.0	$\mathrm{BW_I}$	500 Hz	$K_{p-\mathrm{V}}$	-2.19
B_f	0.02 pu	T_m	50 ms	$K_{i-\mathrm{V}}$	-101.83

SCR 5.0o → 1.3o $\quad \frac{X}{R} = 5, P = 1.0$ pu



2 Grid forming (GFM) with droop

2.1 Model



ω_0	314 rad/s	SCR	2	D_ω	0.05×ω_0
V_s	1.0 pu	BW_V	33.3 Hz	D_V	0.05
P_r	1.0 pu	BW_I	500 Hz		
Q_r	0.23 pu	T_m	50 ms		
X/R	5.0	K_{p-V}	0.00853		
B_f	0.02 pu	K_{i-V}	0.3062		

SCR 5.0o → 1.3o $\quad \frac{X}{R} = 5, P = 1.0$ pu