Grid Forming inverter Stability Enhancement through DC bus Controller

SUNJOH CHRISTIAN, Ph.D. 3 year

Background

Increasing % of Inverter Base Resources (IBR)

$RoCoF = \dfrac{df}{dt}$

$RoCoF \sim \dfrac{1}{Inertia}$

Low Inertia causes **High RoCoF** resulting in <u>system instability</u>

- o **IBR Lack Inertia**
- o Increasing Integration of IBR result to **Low system Inertia**

Propose Method

GFL Inertia Control Model

DC source +Energy storage → VSG Control → Inertia control

The VSG equation is given as

$$2H_c \dfrac{d\omega_c}{dt} = P_{ref_c} - G_{t_c} - P_e + D(\omega_c - \omega_{pll})$$

Conventional GFL has No DC Control

Conventional GFL

Proposed GFL
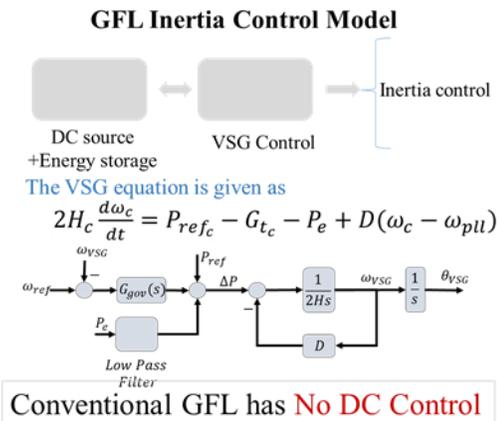
Simulation Configuration

Parallel Connection of GFL and SG
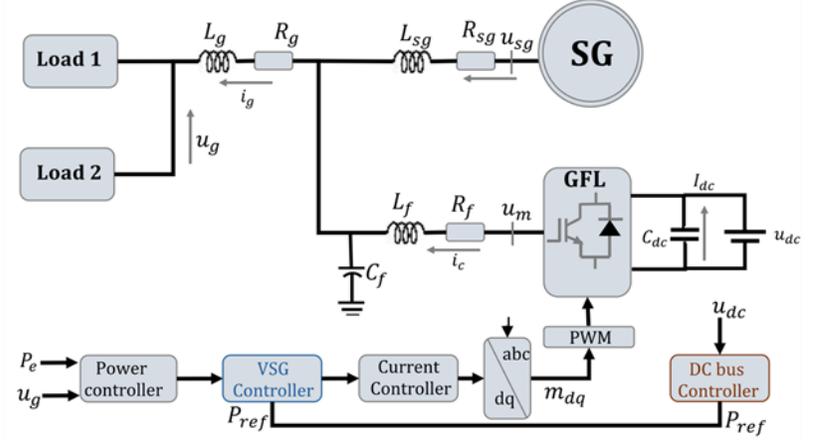
Let A : GFL Control TF,   B : SG Control TF

$$A = \dfrac{\Delta P_{out_c}}{\Delta \omega_g} = \dfrac{2H_c(\omega_n s) - D_c - k_{\omega_c}\left(\frac{1}{1+T_{\omega_c}s}\right)}{-\left(k_{p_d} + \frac{k_{id}}{s}\right)\frac{1}{2C_{dc}} - (k_{\omega_c}\left(\frac{1}{1+T_{\omega_c}s}\right) + D_c)(\frac{k_{pll}+s}{k_{ipll}ds}) - 1}$$

$$B = \dfrac{\Delta P_{out_{sg}}}{\Delta \omega_{sg}} = \dfrac{k_{psg}[(2H_{sg}\omega_{ref}s)(1+T_{\omega sg}) - k_{\omega sg}]}{(D_{sg}s - k_{psg})(1+T_{\omega sg}s)}$$

$$\dfrac{\Delta \omega_{sg}}{\Delta P_{load}} = \dfrac{Bs + k_{psg}}{k_{psg}(BP_{sg} + AP_c)}$$

The Grid connection Combined transfer function

Result

0.19pu

0.19 pu power reference compensation

0.15Hz

0.2Hz

0.2Hz Nadir gain and 1.5Hz deviation Compensation

From the result, The system can only support **50% GFL integration**

System Collapse at 60%

From the result, The system can support up to **60% GFL integration**

System Collapse at 70%

Frequency Response result
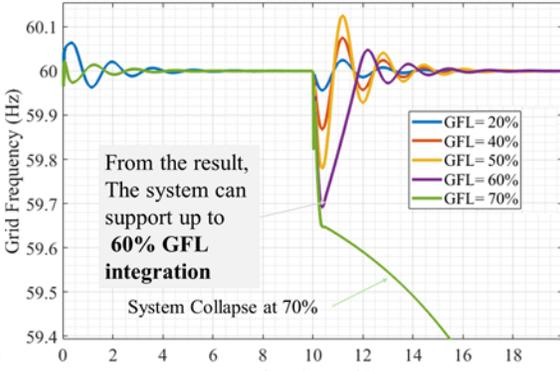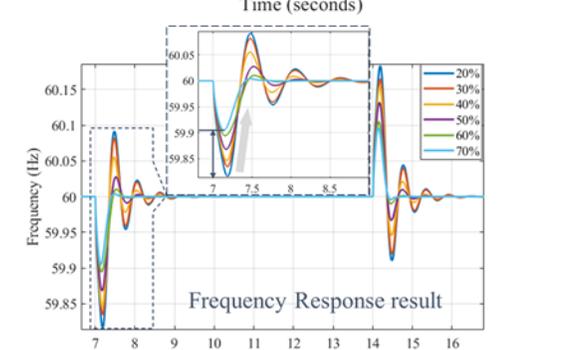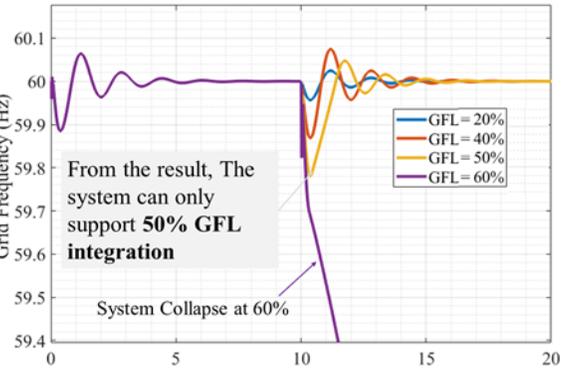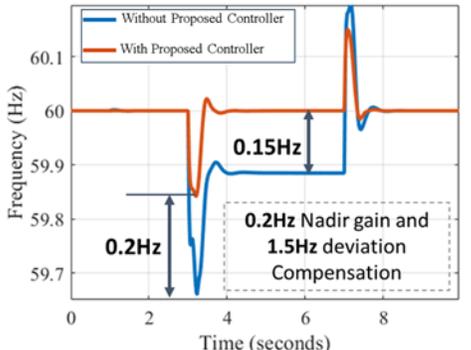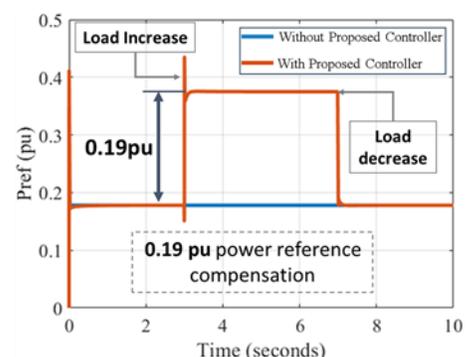
Conclusion

The GFL integration has been **Improved from 50% to 60%**