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Innovating Energy Access for Remote Areas: Discovering Untapped Resources

A Novel Control Strategy for Power Sharing Enhancement of an Inverter-Based Microgrid

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Abstract & Objectives

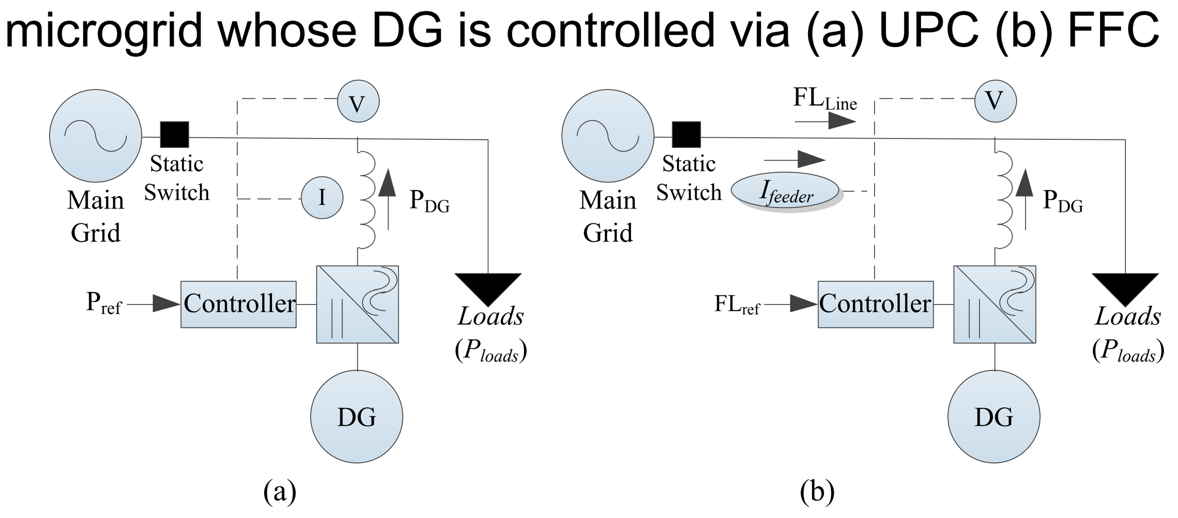
❖An innovative power sharing strategy for active power-frequency management of a couple of inverter interfaced distributed generators encompassed in a microgrid

❖ Basics: Two cutting-edge droop based methods called unit power control (UPC) and feeder flow control (FFC)

❖Refinement: UPC and FFC modification to enrich the transient response concurrent with steady state behavior.

UPC & FFC (basic methods)

A microgrid whose DG is controlled via (a) UPC (b) FFC



$$(1)\ \omega^* = \omega^0 - K^U.(P^* - P^0)$$

$$(2)\ K^U \triangleq \frac{-}{P_{max}}$$

$$(3)\ \omega^* = \omega^0 - K^F(FL^* - FL^0)$$

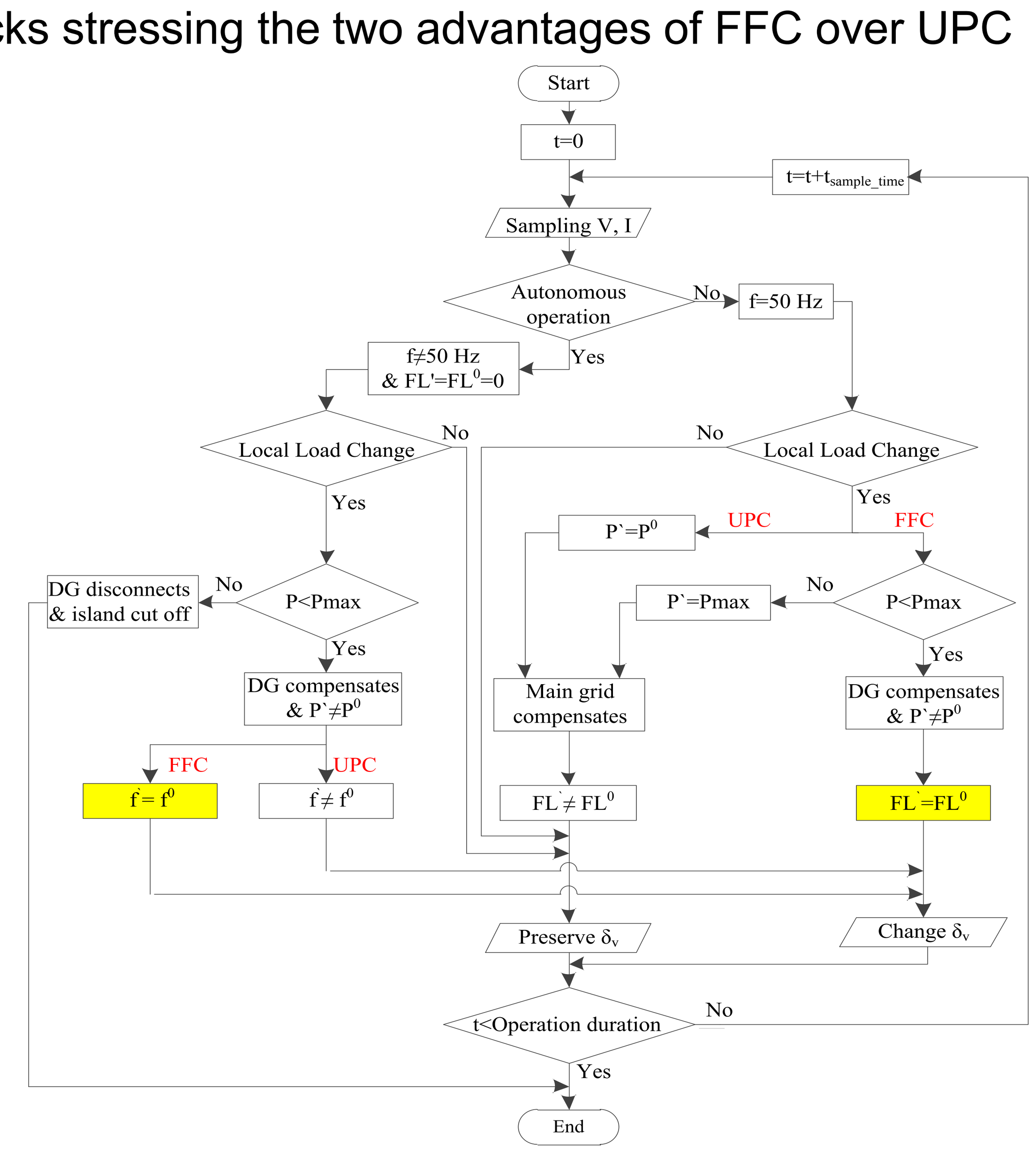
$$(4)\ FL_{line} + P_{DG} = P_{loads}$$

$$(5)\ K^F = -K^U$$

Handling islanding transition problem via FFC droop gains reconsideration based on DG distance from main grid coupling point

$$(6)\ \frac{1}{K_i^F} = -\sum_{g=i}^{n}\frac{1}{K_g^U}$$

Flowchart of basic UPC and FFC methods with highlighted blocks stressing the two advantages of FFC over UPC



Refinement (enrichment of transient responses of basic methods)

Derivation of detailed equations ruling the DG unit power interaction through its connection impedance

$$(7)\ P = \frac{R}{R^2+X^2}(V_s^2 - V_sV_0\cos\delta) + \frac{X}{R^2+X^2}(V_sV_0\sin\delta)$$

$$(8)\ Q = \frac{X}{R^2+X^2}(V_s^2 - V_sV_0\cos\delta) - \frac{R}{R^2+X^2}(V_sV_0\sin\delta)$$

$$(9)\ \frac{d\delta}{dt} = \frac{1}{(V_s)^2\cos\delta}\left(X\frac{dP}{dt} - R\frac{dQ}{dt}\right)$$

$$(10)\ \delta_0 - \delta_s = \int(\omega_0 - \omega_s)dt$$

$$(11)\ \omega_0 - \omega_s = \frac{1}{(V_s)^2\cos\delta}\left(X\frac{dP}{dt} - R\frac{dQ}{dt}\right)$$

$$(12)\ \omega^* = \omega^0 - K^U.(P^* - P^0) + K_d^U \times \frac{d\delta}{dt}$$

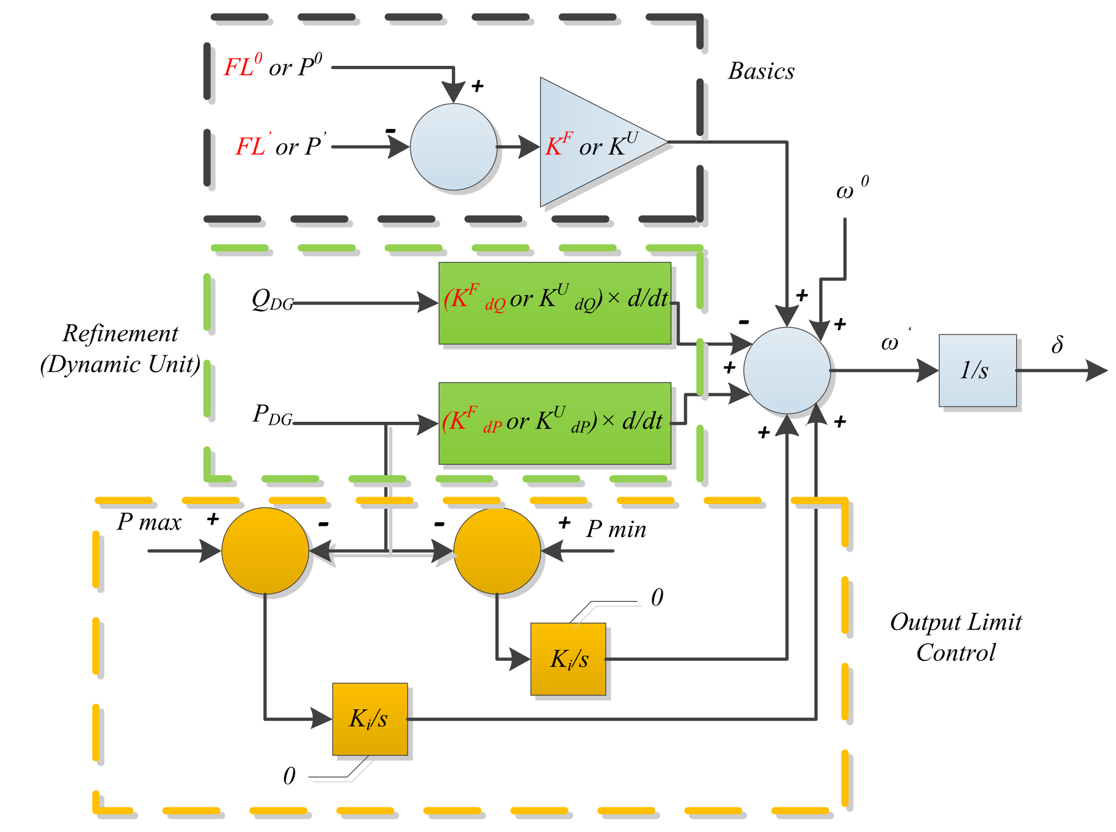
$$(13)\ \omega^* = \omega^0 - K^F(FL^* - FL^0) + K_d^F \times \frac{d\delta}{dt}$$

$$(14)\ \omega^* = \omega^0 - K^U.(P^* - P^0) + K_{dP}^U \times \frac{dP}{dt} - K_{dQ}^U \times \frac{dQ}{dt}$$

$$(15)\ \omega^* = \omega^0 - K^F(FL^* - FL^0) + K_{dP}^F \times \frac{dP}{dt} - K_{dQ}^F \times \frac{dQ}{dt}$$

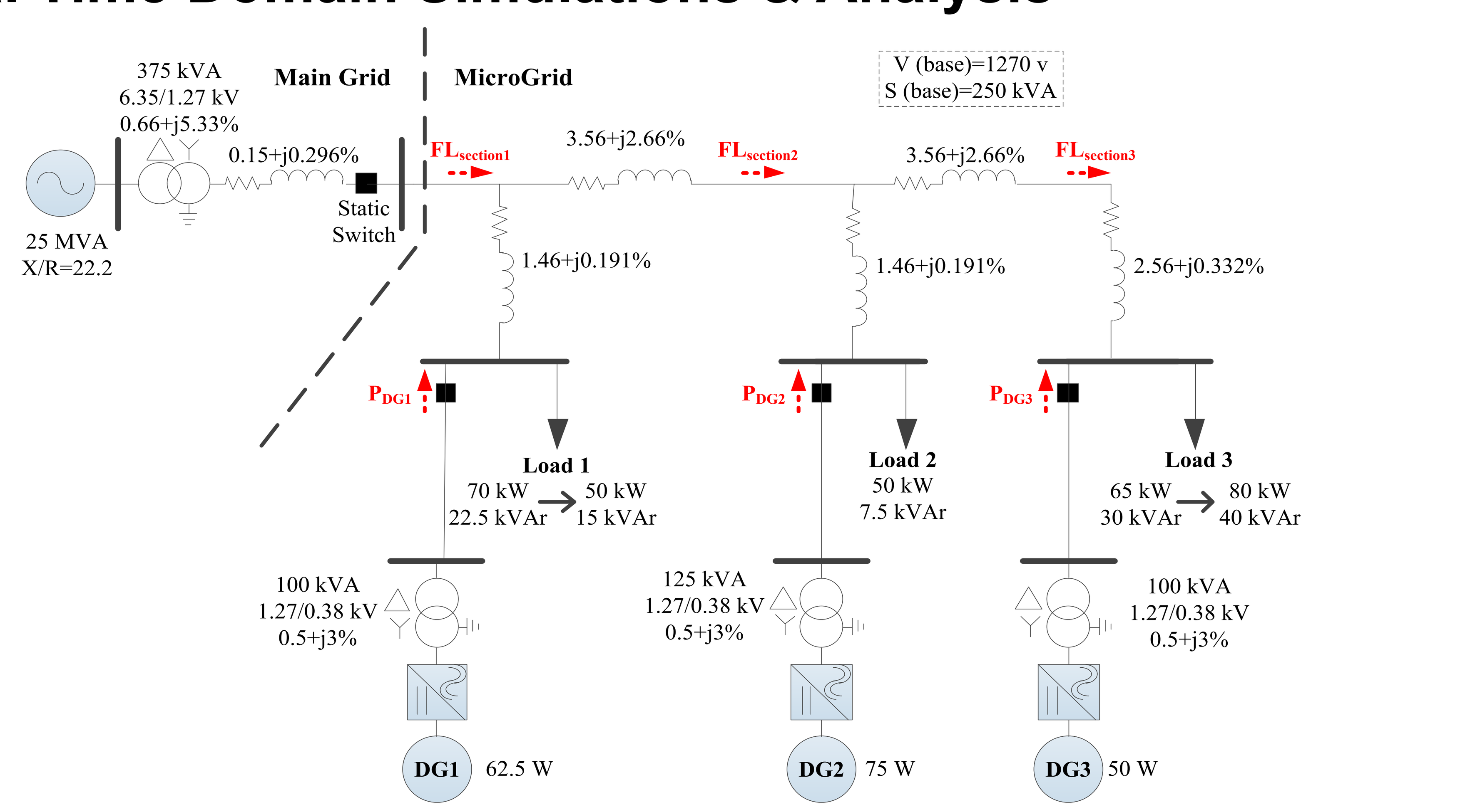
$$(16)\ K_{dP}^U = K_d^U \times \frac{X}{V_s^2\cos\delta} \quad or \quad K_{dP}^F = K_d^F \times \frac{X}{V_s^2\cos\delta}$$

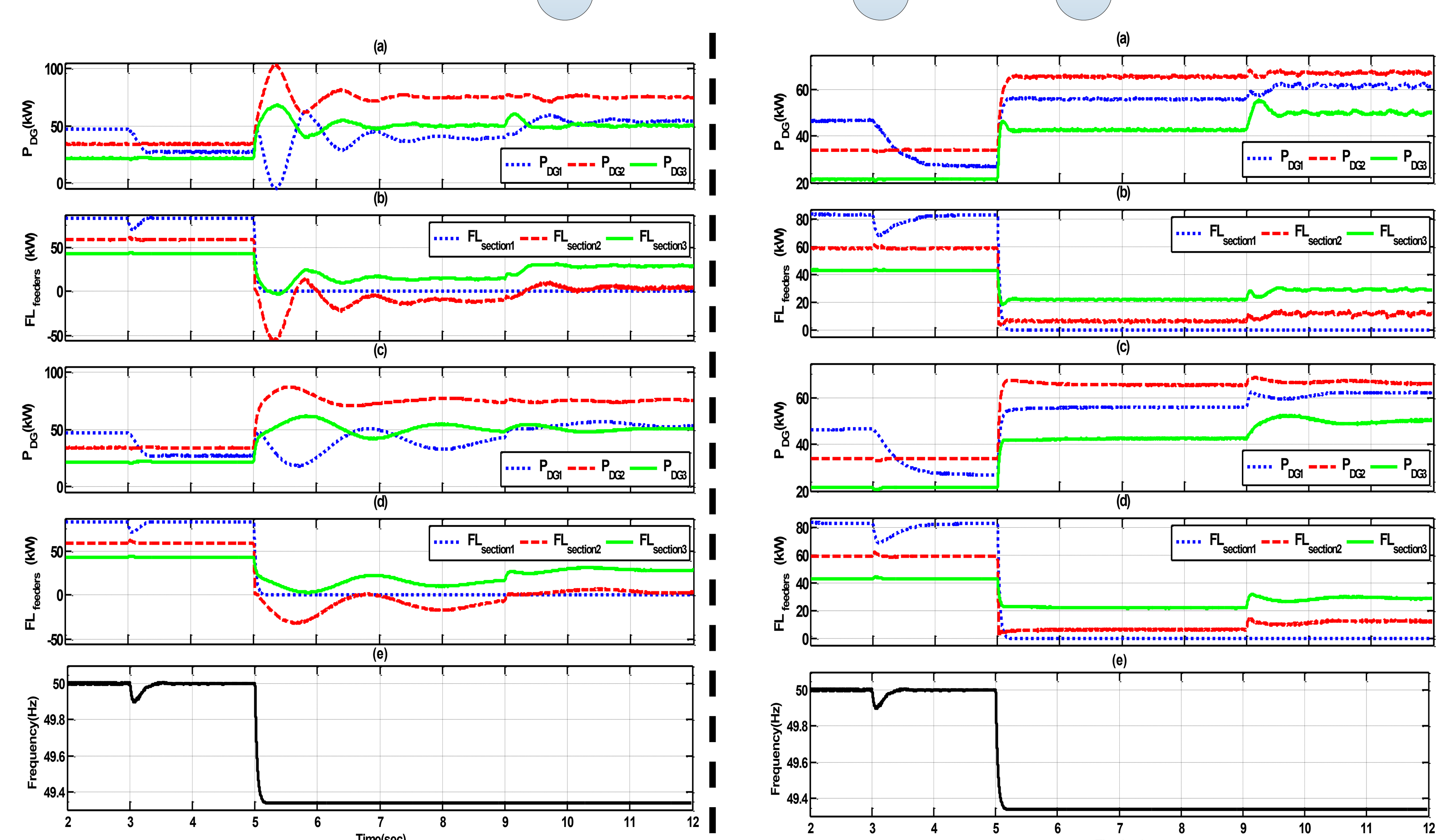
$$(17)\ K_{dQ}^U = K_d^U \times \frac{R}{V_s^2\cos\delta} \quad or \quad K_{dQ}^F = K_d^F \times \frac{R}{V_s^2\cos\delta}$$



The Proposed Control Strategy

Numerical Time Domain Simulations & Analysis





Static droop gains -0.05, +0.04 & -0.06 Hz/kW for DG1, DG2, DG3(a) (b) no dynamic unit. (c) (d) with dynamic unit

Static droop gains -0.05, +0.04 & -0.016 Hz/kW (modified based on distnce) (a) (b) without. (c) (d) with dynamic unit

Discussion & Conclusion

- ❖ Two droop based methods UPC & FFC for power sharing among DG units
- ❖ FFC the superior option: power flow regulation & preserving frequency in autonomous operation
- ❖ Droop gain reconsideration to handle loading of FFC controlled DGs during islanding transition
- ❖ Proposed dynamic unit guarantees smooth transient changes of DGs' output power
- ❖ Use care in setting dynamical gains to be proportional to inductive and resistive parts of output impedance of the under control DG unit

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BREG Berkeley Rural Energy Group

Technische Universität Berlin

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