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A Parametric Approach for the Study of Three-phase Inverters Subject to Grid Faults

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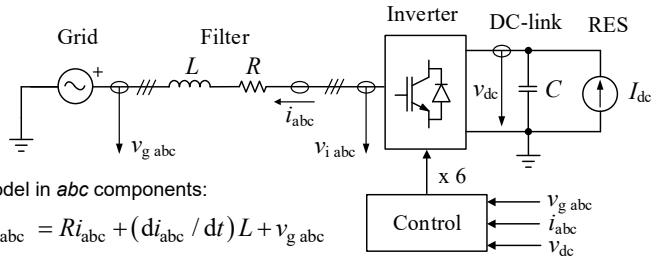
Introduction:

- ✓ Simple model of three-phase grid-connected inverters powered by a renewable energy source (RES).
- ✓ Behavior prediction under a faulty grid (voltage sags).
- ✓ Parametric approach: limaçon of Pascal + 3D plots.

Inverter model under sags



1. Model in *abc* components:

$$v_{i\,abc} = Ri_{abc} + (\mathrm{d}i_{abc}/\mathrm{d}t)L + v_{g\,abc}$$

2. Model in *Ku* components (complex form of *Park* components):

$$v_{if} = [R + L(\mathrm{d}/\mathrm{d}t + \mathrm{j}\omega)]i_f + \boxed{v_{gf}^{+} + v_{gf}^{-}\mathrm{e}^{-\mathrm{j}2\omega t}}$$

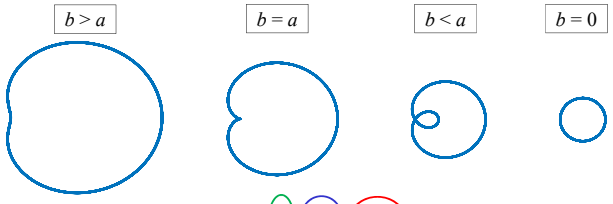
= transformed grid voltage (sags)

3. ODE solution (assumptions: $R \ll L$ and v_{if} = constant):

$$i_f = \frac{\mathrm{j}}{X}\left[\left(v_{gf}^{+} - v_{if}\right) + \left(v_{gf\,st} - v_{gf}^{+} + v_{gf}^{-}\right)\mathrm{e}^{-\mathrm{j}\omega t} - v_{gf}^{-}\mathrm{e}^{-\mathrm{j}2\omega t}\right]$$

Limaçon of Pascal

1. Polar coordinates: $r = b + a\cos(\theta)$

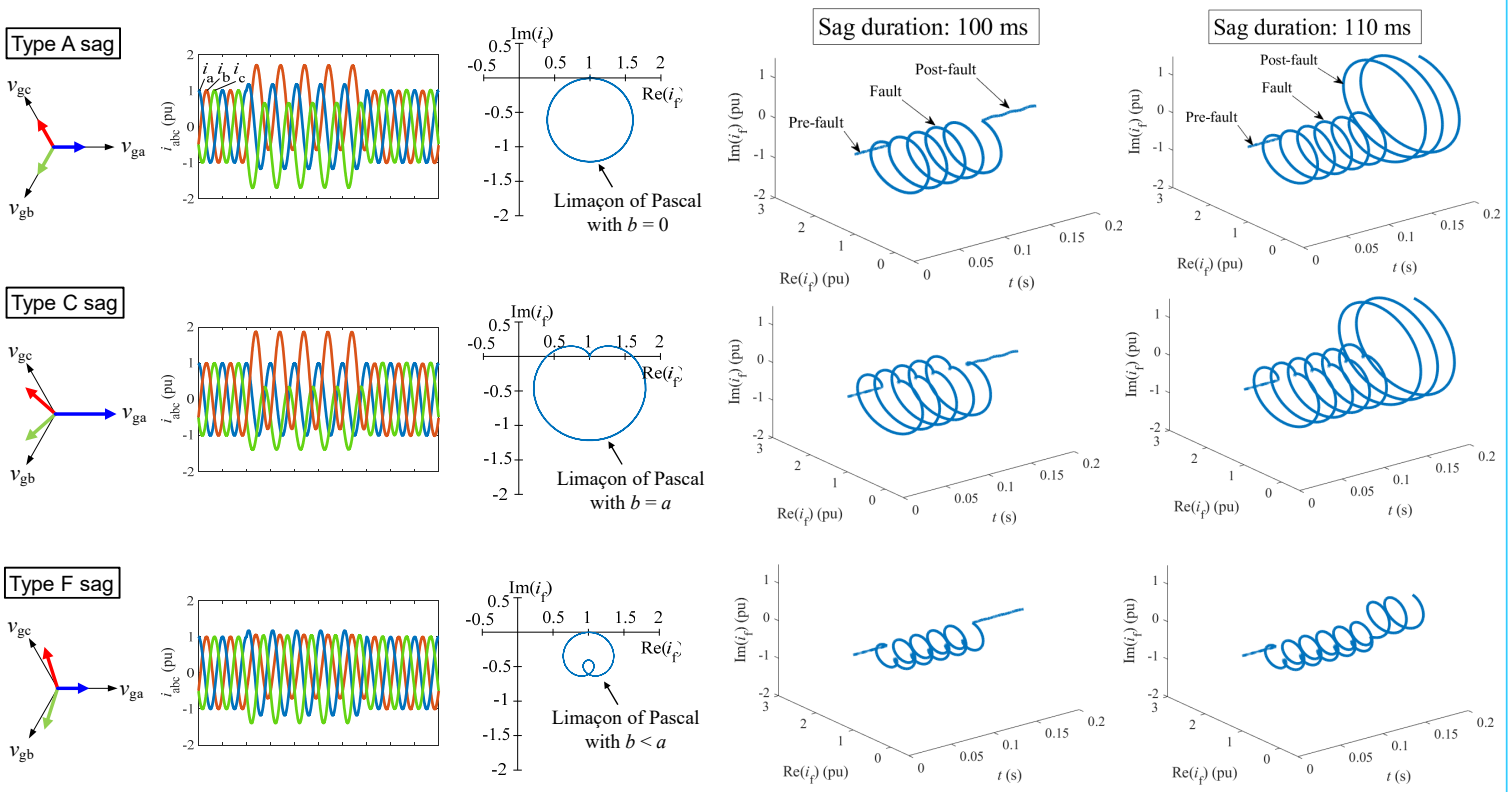


2. Complex equation: $z = x + \mathrm{j}y = \frac{a}{2} + b\mathrm{e}^{\mathrm{j}\theta} + \frac{a}{2}\mathrm{e}^{\mathrm{j}2\theta}$.

3. Comparison with i_f: $i_f = \frac{\mathrm{j}}{X}\left[\left(v_{gf}^{+} - v_{if}\right) + \left(v_{gf\,st} - v_{gf}^{+} + v_{gf}^{-}\right)\mathrm{e}^{-\mathrm{j}\omega t} - v_{gf}^{-}\mathrm{e}^{-\mathrm{j}2\omega t}\right]$

$$a = \frac{2\mathrm{j}}{X}\left(v_{gf}^{+} - v_{if}\right) = -\frac{2\mathrm{j}}{X}v_{gf}^{-} \quad ; \quad b = \frac{\mathrm{j}}{X}\left(v_{gf\,st} - v_{gf}^{+} + v_{gf}^{-}\right)$$

Inverter behavior under sags (simulation results with MATLAB™)



Conclusions:

- ✓ Comprehensive analysis of three-phase grid-connected inverters operating under voltage sags.
- ✓ Novelty: parametric approach (limaçon of Pascal + 3D plots).
- ✓ Simplistic tool that can be used for grid-connected inverters to achieve fault ride-through (FRT) capability.