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:
   \[ v_{iabc} = R_{abc} + (d_{abc} + iL_{abc}) + v_{gabc} \]

2. Model in Ku components (complex form of Park components):
   \[ v_{if} = [R + L(d/dt + j\omega)]i + \frac{v_{g/-} + v_{g/}e^{-j2\omega t}}{} \]
   \[ = \text{transformed grid voltage (sags)} \]

3. ODE solution (assumptions: \( R \ll L \))
   \[ i_t = \frac{1}{X}[v_{g/-} - v_{iff} + (v_{g/-} - v_{g/})e^{-j2\omega t}] \]

Limaçon of Pascal

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

2. Complex equation:
   \[ z = x + jy = \frac{b}{a}e^{j\theta} - a \]

3. Comparison with \( i_t \):
   \[ a = \frac{2j}{X}(v_{g/-} - v_{iff}) = \frac{2j}{X}v_{g/}; \quad b = \frac{2j}{X}(v_{g/-} - v_{g/} + v_{g/}) \]

Inverter behavior under sags (simulation results with MATLAB™)

Type A sag

Type C sag

Type F sag

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.