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Protection of distribution system with DG

Ground Faults

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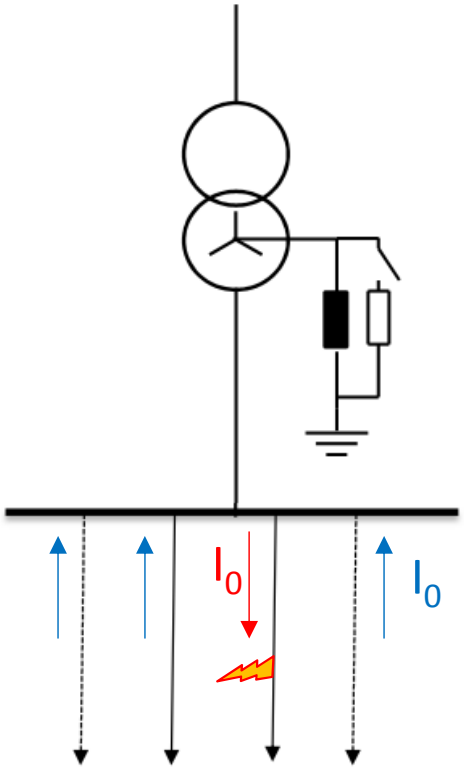
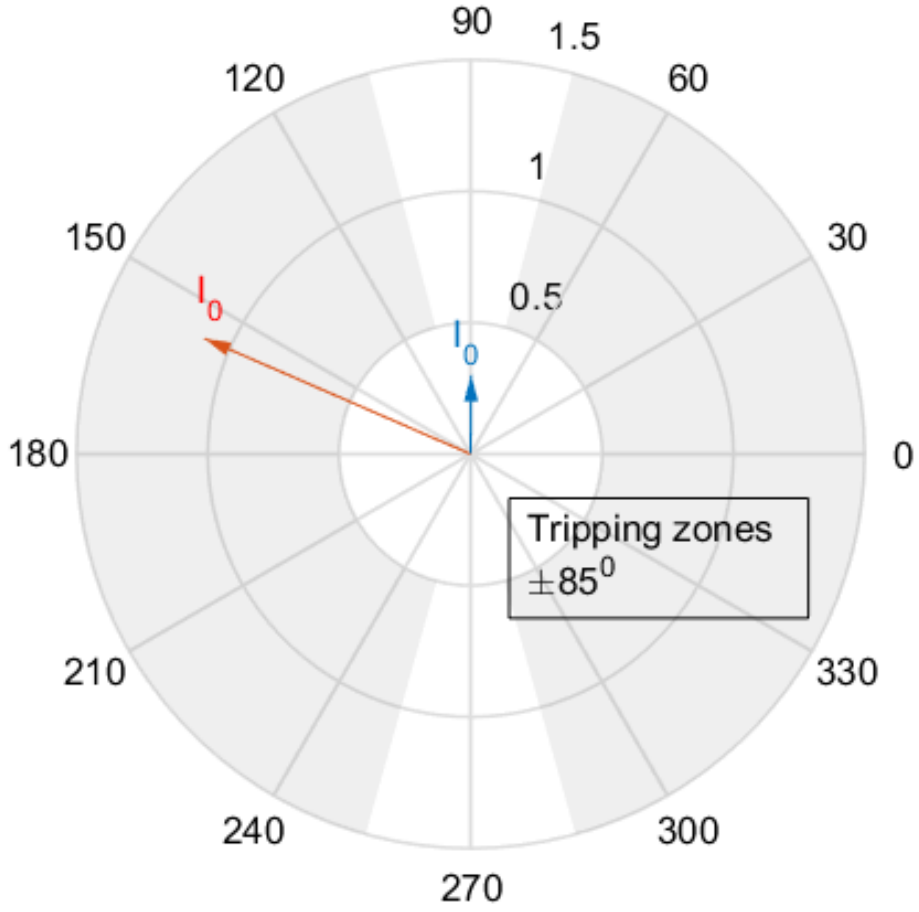
Outline

- Current methods on ground fault detection and location in compensated network
- Problems
- Solutions
- Fault location and presence of DG

Current methods on ground fault detection and location in compensated network

- Steady-state signals
- Indicator – U_0 (not reliable for HIF)
- Directional ground relays (wattmetric approach, $I_0 \cos\phi_0$)



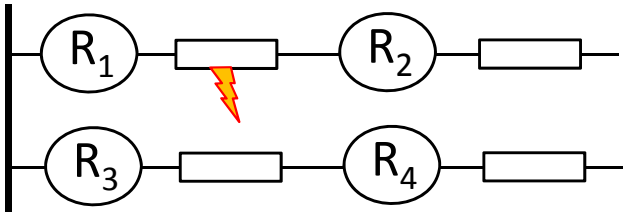


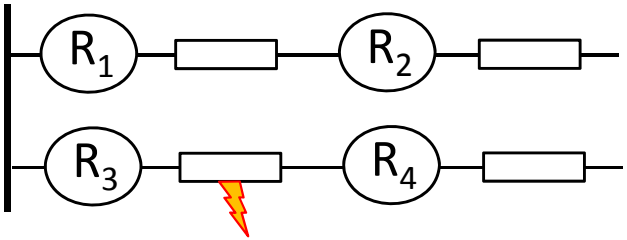
Shortcomings:

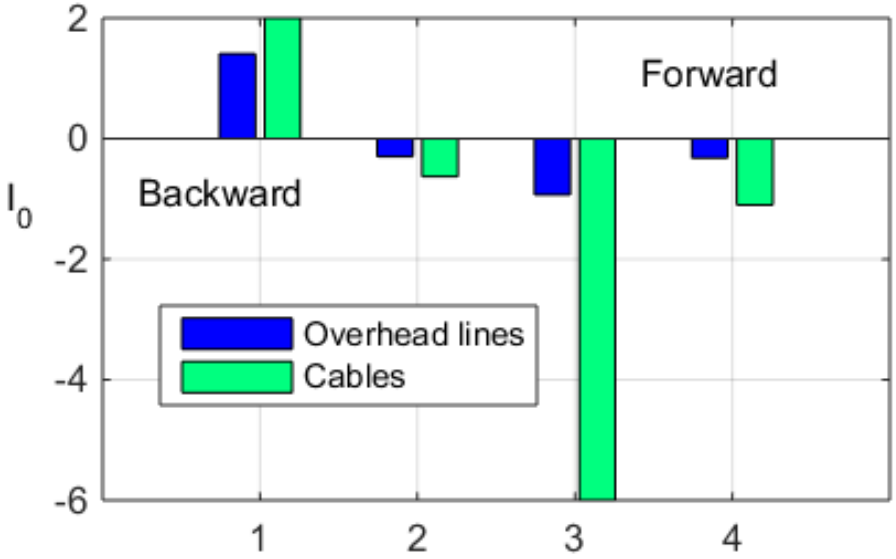
- Need of parallel resistor
- Risk of misoperation

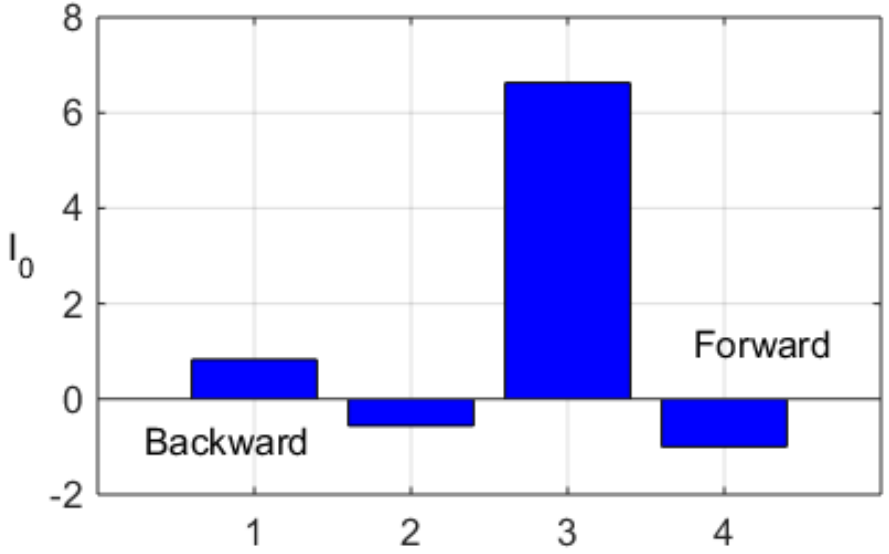
Challenges

- Need of additional equipment (+damping resistor)
- Blinding due to HIF, intermittent faults
- Networks with cable sections – large magnitudes of I_0 in healthy feeder sections (settings complexity)
- Disruption of directionality



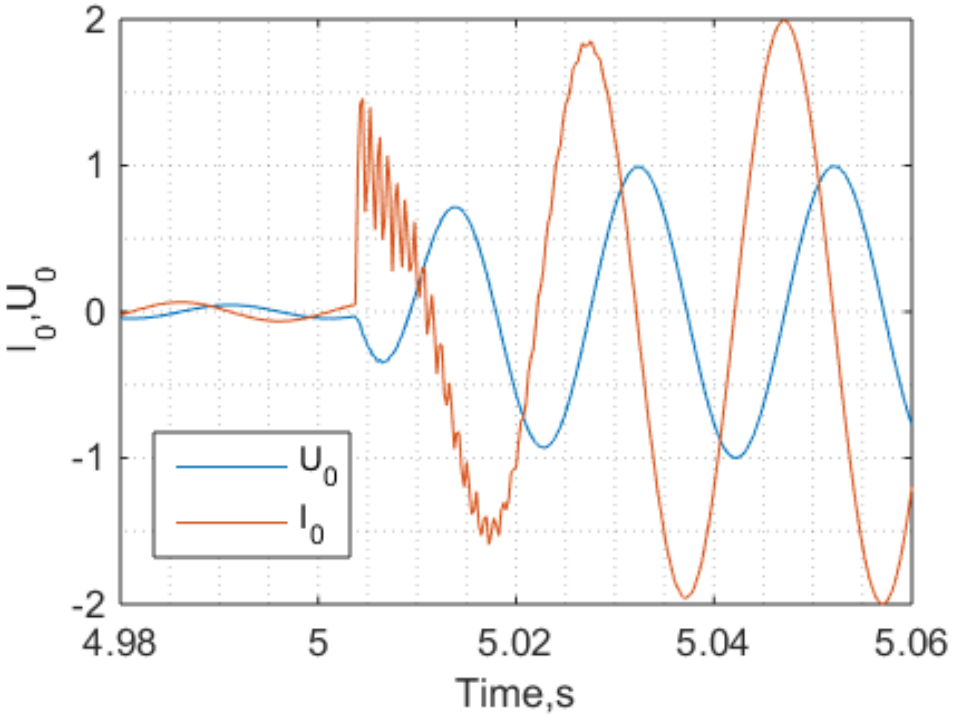


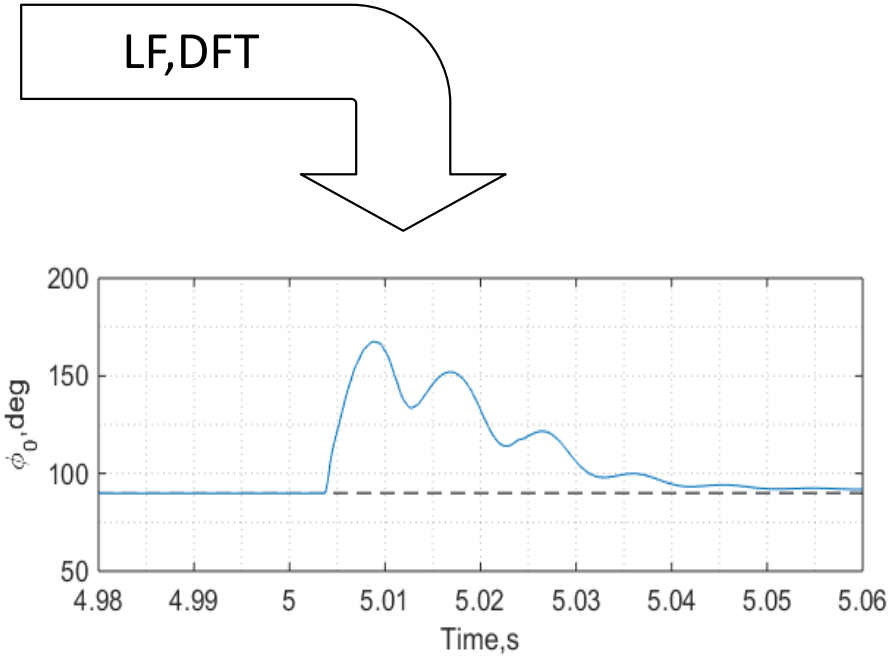




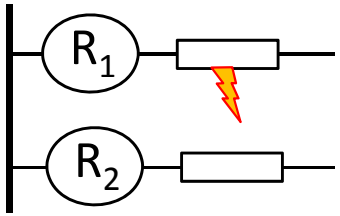
Proposed solutions

- Analysis of traveling waves of I_0,U_0
- Analysis of transient signals (I_0,U_0,φ_0)

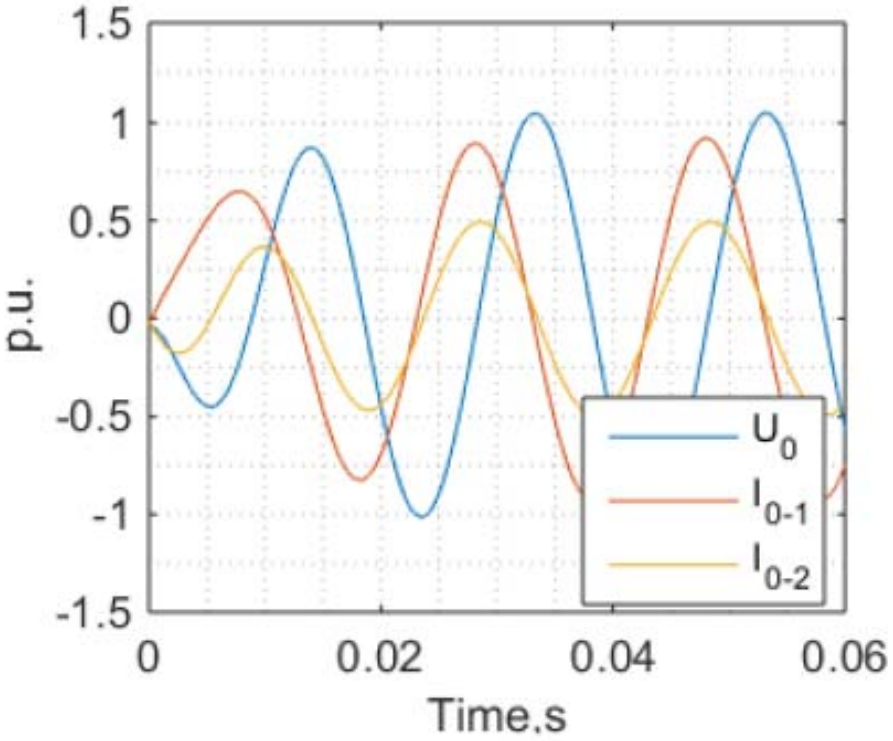


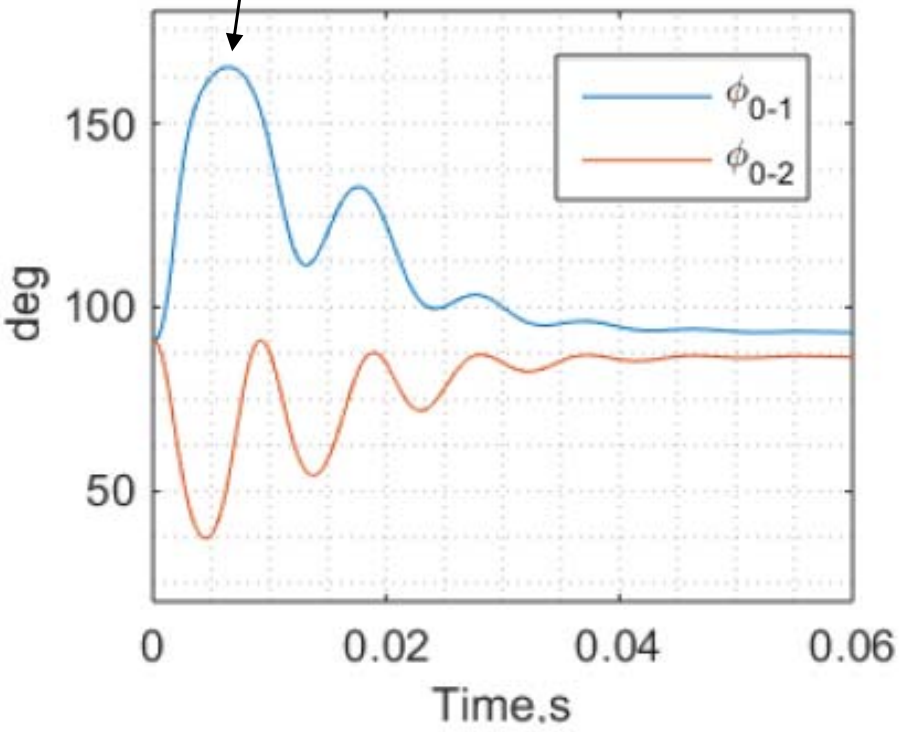


Selective principle



Positive deviation from pre-fault conditions for faulty feeder



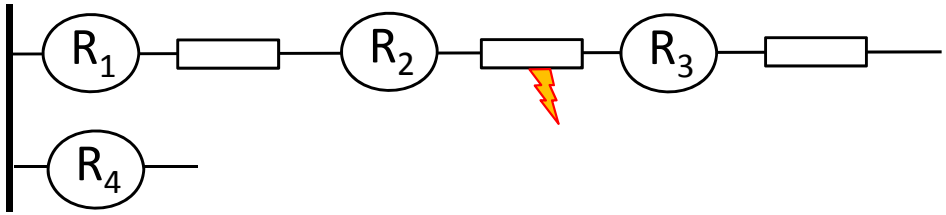


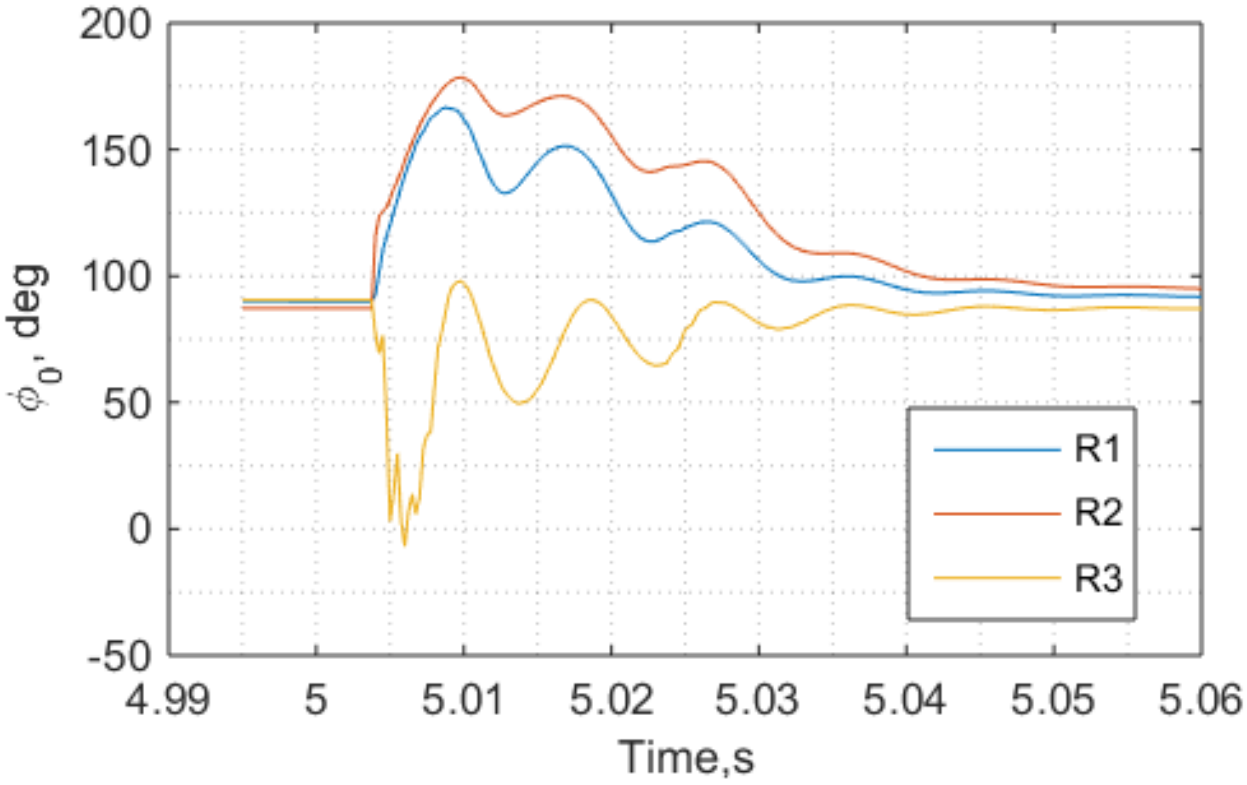
Research work content

- Types of transmission lines (overhead lines, cables)
- Compensation rate
- Capacitance imbalance in the network, different phases
- Inception angle
- Fault impedance
- Load imbalance
- Section disconnection (oscillations)

+combination → algorithm based on dynamic change of ϕ_0, capable to select faulty feeder and insensitive to factors affecting transient period

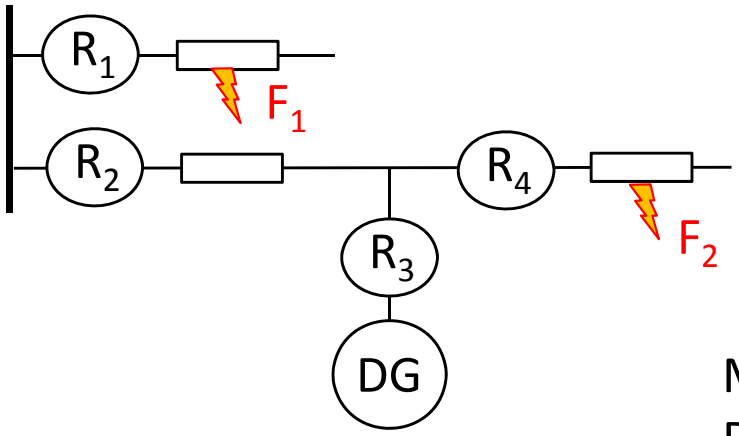
Faulty section location

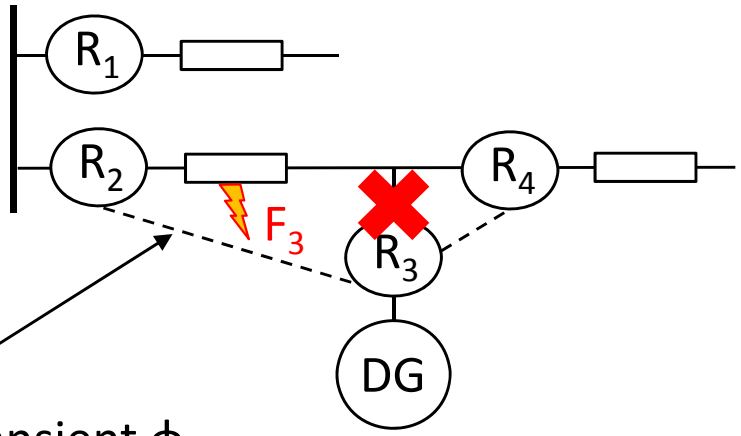




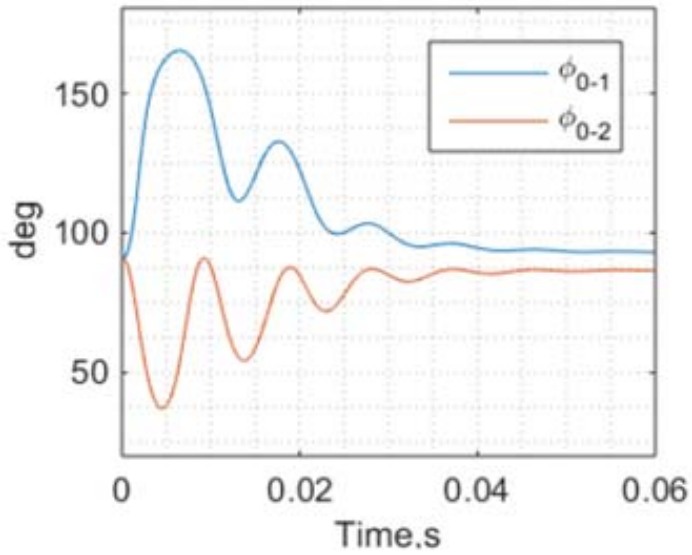
Presence of DG

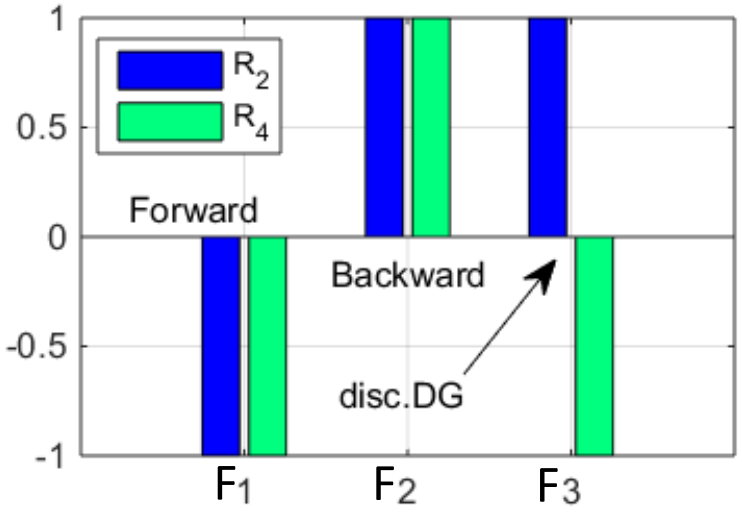
- No impact on I_0,ϕ_0 due to YD coupling transformer
- Fault location is important





Messages
Basis – transient ϕ_0





Summary

- Existing methods of ground fault location in compensated networks might be inadequate
- Methods based on transient signals are promising solutions
- Utilization of transient φ_0 gives reliable tool for fault location irrespectively of network type and fault origin
  - Application for fast disconnection of DG (communication technologies)

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Thank you
for
your attention!