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EMT vz phase domain short circuit analysis for inverter based energy sources

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Are phasor-domain inverter models sufficient for most protection coordination studies and what are the key criteria for deciding when EMT simulations are preferred for evaluating protection performance over conventional phasor-domain short circuit analysis?

- The current practice in South Africa is to conduct EMT studies over and above the conventional phasor-domain short circuit analysis. In the South African power system network, most power is generated in the northern parts of the country. There are load centres in the western and southern parts of the country. To transmit power down to load centres, we have very long transmission lines with series capacitors and reactors for increasing load transferability and voltage management, respectively.
- Most of our inverter-based energy sources have been introduced into this heavily compensated network which also has FACTs devices. Many loop-in-loop-out connections have led to integrating these inverter sources in series with the series capacitors.

- When calculating the protection settings around such networks, we rely heavily on dynamic studies to cater for capacitor charging and discharging, voltage & current reversals. Sub-synchronous resonance studies are also conducted.
  - Standard fault analysis is done under static conditions
  - Once we have established the base setting value, we test the suitability of these settings by performing RMS studies with models of protection relays included in the simulations.
  - We further optimise instantaneous tripping elements by running EMT simulations. These simulations are conducted to check security of protection due to the influence of series compensation. In extreme cases where the security of protection is compromised, we switch off these elements.
  - Studies also check for sub-synchronous resonance, and should it be confirmed, damping is improved within the network.
  - The renewable energy plant models are also included as part of the study network.

- Conventional phasor-domain studies would not suffice to capture all the other high-frequency responses that might negatively influence our protection relays.
  - The calculated protection settings are verified in RMS model analysis.
  - Protection elements rely on the 50Hz signals, which RMS domain studies can sufficiently represent.
  - The generator is allowed a 6-month window to validate the RMS model using data available at the time of commissioning.
  - This serves to ensure accurate relay models with implemented protection settings for future network incident investigations.
  - The generator has a one-year window in which to validate the EMT model using data from network events.