

Lesson's learned from several simulation studies, it is clear that phasor-domain inverter models are not sufficient for many protection studies, and there are the key criteria for looking at time scale that simulation tool present from phasor-based which is tens of milli-seconds as compared to EMT simulations on micro-second time scale.

Best-in-class Real-time EMT simulation setup in a laboratory environment will be shared with results to evaluate various grid conditions with hardware in the loop, including inverter controller, EMT grid and protection relay. This helped to understand the behavior of protection system with various harmonics and transient signature.

EMT needed in converter control interactions with sampled values used for protection with harmonic content, rate of change of frequency & transient voltage scenarios. Examples such as

- Rate-of-change of frequency has impact on frequency tracking
- Inverter control dynamics, such as, delay in entering in LVRT mode (around a cycle & inverter design dependent) crow-bar effect of Type-3 my involves inter-harmonics (e.g., 78Hz in crow-bar) can impact frequency tracking; which is used to calculate phasors
- New Protection scheme utilizing multiple-harmonics components
- Transient over voltage at point of connection

Real-time EMT is needed to validate protection relay operational behaviors with transient, rate of change of frequency, inter-harmonics (crow-bar effect), harmonics and accuracy to calculate phasors which are used for most protection

