EMT Study – Cheat Sheet- Distribution System Planning

February 2023

Section 7.4 of IEEE 1547-2018 and Section 6.4 of ATCO's Technical Interconnection Requirements for Inverter based DERs states that:

"A) The DER shall not cause the fundamental frequency line-to-ground voltage on any portion of the Area EPS that is designed to operate effectively grounded, as defined by IEEE Std C62.92.1, to exceed 138% of its nominal line-to-ground fundamental frequency voltage for a duration exceeding one fundamental frequency period.

B) The DER shall not cause the line-to-line fundamental frequency voltage on any portion of the Area EPS to exceed 138% of its nominal line-to-line fundamental frequency voltage for a duration exceeding one fundamental frequency period."

The DER shall not cause the instantaneous voltage at the PCC to exceed the magnitudes and cumulative durations shown in Figure 6. The cumulative duration shall only include the sum of periods for which the instantaneous voltage exceeds the respective threshold.

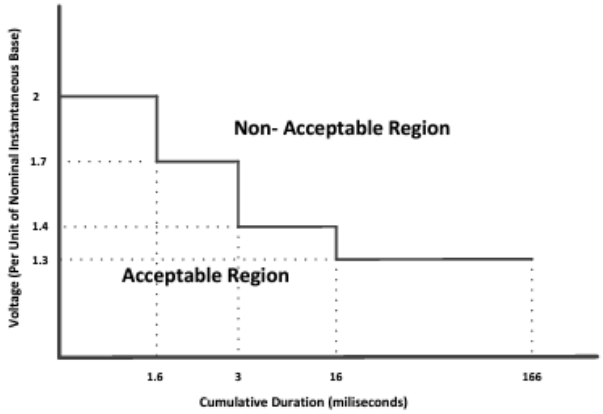


Figure 6. Transient overvoltage limits

As well, Section 3.3.5 of the Standard for the Interconnection of Generators to ATCO Electric's Distribution system states the following:

Interconnection grounding - During unbalanced fault conditions on the distribution line, ungrounded generator / transformer configurations can cause damaging over voltages on the distribution system. The DG owner is responsible to provide for a design that limits over voltages.

In summary, the DER customer is responsible to ensure the DER is effectively grounded and performing within limits during all scenarios.

FAQ

Why do we care about effective grounding?

DER customers need to maintain effective grounding. Otherwise, when an island happens due to switching or faults, if the DER is not effectively grounded, the DER can cause temporary overvoltage (TOV) on unfaulted phases. This TOV can cause damage to major equipment.

If ATCO does not have confirmation that the DER is effectively grounded in all scenarios, including in island scenarios and in ground faults and load rejection scenarios, there is a risk that a TOV could damage not only the DER and ATCO assets, but other nearby customer assets. This is an unacceptable risk.

How do we check effective grounding?

Things to look at include transformer configuration (for example a delta configured DER connected to a delta-delta transformer is cause for concern because there is no obvious path to ground!) as well as whether the site has equipment such as NGRs. Then, further study is required, in some cases ATCO can accept steady-state analysis on Coefficient of Grounding (CoG). In other cases ATCO needs an EMT study from the customer to prove acceptable CoG. Finally, for certain inverters that have met industry standard testing and certifications, no further study is needed (see flow-chart at the end of this document).

Also, the current desensitization due to the DER should be less than 10% for all scenarios (for fault impedance of both 0 ohm and 20 ohm).

How do we check current desensitization?

ATCO requires that any DER connected to the system does not desensitize the ground fault protection by more than 10%. This can be defined by:

$$DI(\%) = 100\% \times \left(1 - \frac{I_{SCafter}}{I_{SCbefore}}\right)$$

Where $I_{SCafter}$ is the short circuit current seen by the utility protective relay with the DER connected to the system with its output at full capacity. $I_{SCbefore}$ is the short circuit current seen by the utility before the DER connected to the system.

Is a Yg-Yg transformer good enough?

Short answer - no. According to EPRI's paper on Effective Grounding for Inverter-Connected DER, depending on the load-gen ratio, effective grounding can still be a concern even with a Yg-Yg.

What is an EMT Study?

An EMT study is a customer-provided transient study performed in a time domain program such as PSCAD, to analyze the CoG and determine that Load Rejection Over Voltage (LROV) and Ground Fault Over Voltage (GFOV) remain within acceptable limits. This is required for generators without a clearly defined sequence impedance (inverter-based generators).

When do we need an EMT study?

For inverter-based DER projects, ATCO recommends customers to use an inverter that is UL 1741 SB, and tested for Ground Fault Over Voltage (GFOV) and Load Rejection Over Voltage (LROV). These inverters have been adequately tested for TOV and results were within acceptable limits. Therefore, an EMT study is not required for these inverters.

ATCO will accept UL 1741 SA and UL 1741 SB inverters that have not been tested for GFOV and LROV, but will require a customer-supplied EMT study proving effective grounding requirements in IEEE 1547 have been met.

How do we test for effective grounding for machine-based generators?

Unlike inverter-based generation, for machine-based generators (synchronous and induction), the positive, negative, and zero sequence impedances are clearly defined. As a result, a simpler approach can be used. The customer must demonstrate that their coefficient of grounding (CoG) is less than 80%. Note that for machine based DER, the CoG calculation can be simplified by assuming Z1=Z2. The same cannot be assumed for inverter-based DER. The negative sequence impedance of an inverter could theoretically be infinite.

Is a UL 1741 SB Certified Inverter acceptable for waiving transient study requirements?

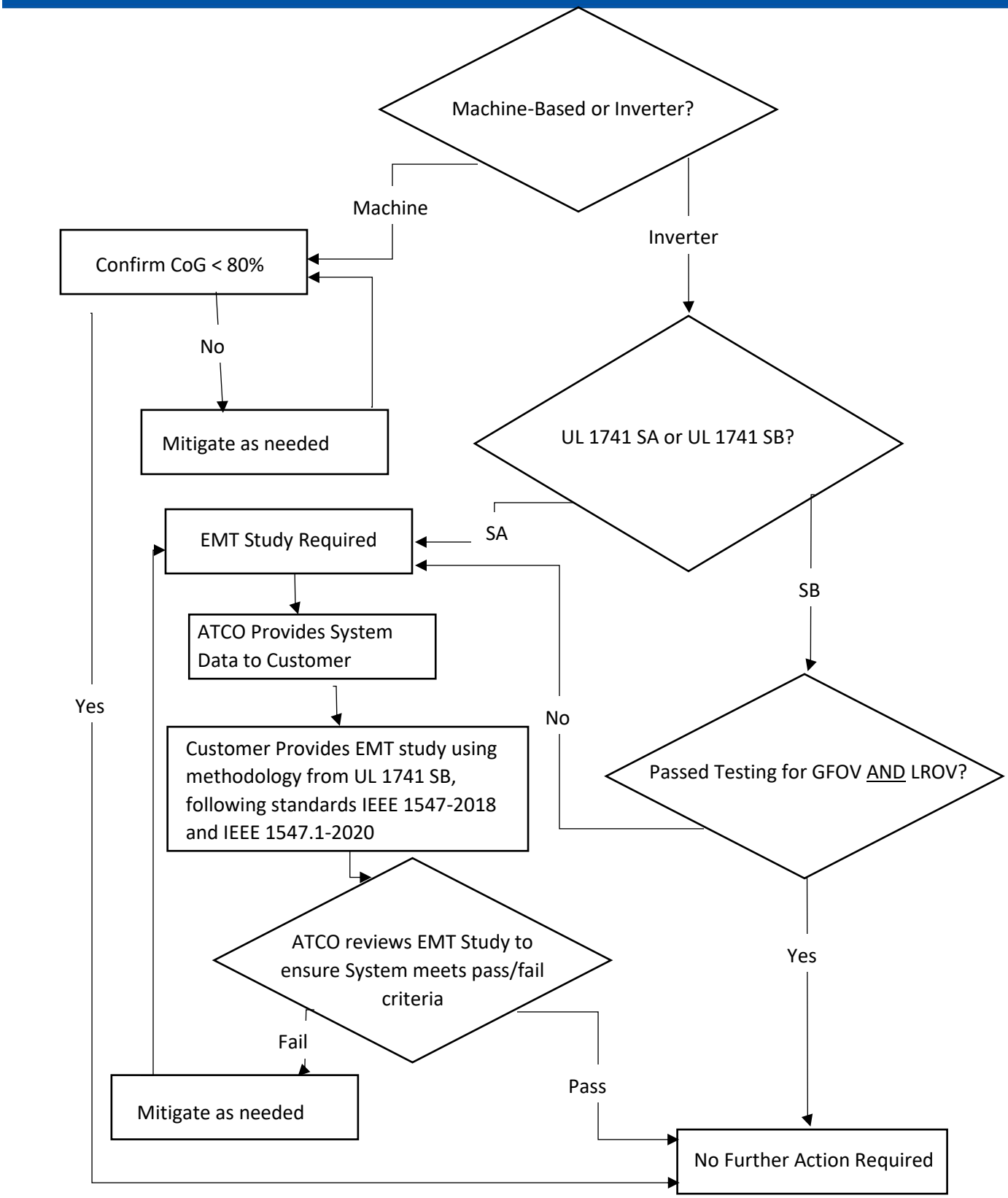
Not necessarily. In IEEE 1547.1-2020 (IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces) it states that “type tests” (manufacturer or lab tests) for GFOV and LROV are optional. Therefore, it is important to check the UL 1741 SB inverter datasheet to see if those tests were performed and passed. If not, then EMT study is still required.

Who does the EMT study?

The customer or a consultant hired by the customer. ATCO will review the study and accept/reject, but the customer is responsible for the study and authentication.

Where can a customer learn more about what is required in their EMT study?

This white paper is an excellent resource explaining the requirements.


Machine-Based or Inverter?
Machine
Inverter
Confirm CoG < 80%
No
Mitigate as needed
UL 1741 SA or UL 1741 SB?
SA
SB
EMT Study Required
ATCO Provides System Data to Customer
Customer Provides EMT study using methodology from UL 1741 SB, following standards IEEE 1547-2018 and IEEE 1547.1-2020
ATCO reviews EMT Study to ensure System meets pass/fail criteria
Fail
Mitigate as needed
Pass
Yes
No
Passed Testing for GFOV AND LROV?
Yes
No Further Action Required