

Alban Engine Power Systems

Consultant's Corner: Transient Reactance

Reactance defined

Understanding transient reactance

Listed reactance per unit values (transient, subtransient, synchronous, negative sequence and zero sequence) are used extensively for comparison in gen set specification, but are also a source of confusion.

This first part of a three-part series defines transient reactance.

Identifying a generator's transient reactance helps the specifier approximate voltage dip when large motors are started. It also helps the specifier approximate the current in a three-phase short-circuit condition to specify correct circuit breaker protection.

Transient reactance is usually expressed by the symbol $X'd$. Reactance figures are always used with a related KVA rating (base KVA, the ampere rating (base amperes), and the related voltage, (base voltage). The various ratings a gen set may have do not change its inherent reactance.

You'll find reactance stated as a per unit (P.U. or p.u.) value, and can be expressed as a percentage of some whole value. Because it is a pure number, it has no label (e.g. volt, ampere or Ohms) until it is applied against the line-to-neutral value at the KVA and ampere or volt condition identified by the generator's reference number and/or rating.

It's important to always convert to line-to-neutral voltage for correct reactance comparisons. To convert line-to-line voltage to line-to-neutral voltage, divide the line-to-line voltage by square root 3. This is your base voltage.

To convert, use Ohm's Law: Divide the line-to-neutral rated voltage by the rated line amperes, then multiply by the P.U. value to get Ohms reactance.

For example: If transient reactance is 0.2490 per unit, base voltage is 480 and base amperage is 263:

$$277/263 \times 0.2490 = 0.262 \text{ Ohms}$$

How generator sizing affects reactance

Most engineers prefer data presented in the following format: line-to-line voltage, prime power KVA line amperes (at the listed line-to-line voltage), and the line-to-neutral reactances in the per-unit value.

The various ratings a gen set may have do not change its inherent reactance. However, the per-unit value reactances do change directly with the generator kW rating.

Per-unit reactance changes inversely (voltage down, reactance up) with the square of the voltage ratio if the KVA rating stays the same. For example: If at 480 volts, the listed transient reactance is 0.2490, and the base voltage will be reduced to 416 volts, the per-unit transient reactance at the lower voltage is:

$$(480/416)^2 \times 0.2490 = 0.3310 \text{ P.U.}$$

Other reactance terms

Caterpillar regularly quotes direct axis reactance per unit values. Occasionally, quad axis figures are requested and can be supplied.

Reactances are generally quoted at magnetic saturation. However, in some cases, specifiers request an unsaturated value of reactance, which can be supplied by special request.

Call us

When considering reactances in your specification process, call us. We are here to help you obtain the proper specifications so you or your client can make the best gen set selection decision.