

Module 2 : Equipment and Stability Constraints in System Operation

Lecture 5 : Generator Constraints

Objectives

In this lecture you will learn the following

- Nature of generator constraints.
- Generator Capability curves.
- Typical rating of a large synchronous generator.

The Generator Capability Curves

Generator Limits: Generator Capability is constrained mainly by the following limits:

- Voltage limits: The terminal voltage of a generator is limited due to 2 reasons : 1) Dielectric 2) Heating in core due to excess magnetic flux. However, the maximum continuous limit due to excess flux is lower than that due to dielectric breakdown considerations. Therefore the limit due to excess flux is the "determining" limit. The flux in the core is also affected by the frequency (core flux is proportional to voltage/frequency).
- Armature Winding (heating) Limit: Armature winding heating results due to the resistive loss in armature windings.
- Field Winding (heating) Limit: Ohmic loss and consequent heating in the field winding, imposes a restriction on the maximum field current. Since field winding current is proportional to the field voltage (after electrical transients have died down), this limit is equivalent to a field voltage limit. Field current is higher when the generator supplies reactive power and is over-excited.
- Core-end heating limit: Core-end heating results when field current is low (under-excitation). During under-excitation conditions, the axial flux in the end region is enhanced. This results in heating which may limit the capability of a generator.

The heating limits are dependent on the efficacy of cooling. A higher pressure of the cooling medium (hydrogen) results in higher heating limits. Armature winding current limit is essentially an MVA limit since terminal voltage magnitude is maintained near the rated value. Therefore armature winding limit locus is a circle on the P-Q plane with origin as the center(**why ?**)

In practice, the field current of a generator is measured or estimated, and the excitation system of a generator is controlled so as to avoid exceeding field current limits. Excitation system controls are covered later in the course.

We shall now visualize a typical capability curve of a generator by an [example](#).

Voltage Limits

As mentioned in the previous slide, the voltage limit of a generator is mainly due to excess flux considerations. While the maximum continuous limit is about 1.05 pu at nominal frequency, a larger voltage can be tolerated for a short while (why?).

The typical allowable voltage (at nominal frequency) for different intervals of time are given below

V/Hz (pu)		1.25	1.2	1.15	1.10	1.05
Damage Time (in min.)	GEN	0.2	1.0	6.0	20.0	Infinity

Typical Name Plate Data of a Generator

Typical Data for a 247 MVA generator is given below:

MVA maximum continuous rating: 247 MVA

MW maximum continuous rating: 210 MW

Rated voltage: 15.75 kV

Rated stator current : 9050 A

Rated power factor : 0.85 lagging

Field current (at maximum continuous rating) : 2600 A

Field Voltage (at maximum continuous rating) : 315 V

Efficiency (at maximum continuous rating) : 98.55 %

Speed : 3000 rpm

Cooling System : Hydrogen at 3.5 kg/cm²

Recap

In this lecture you have learnt the following

- Generators are constrained by heating limits on the armature windings, field winding and core end region
- Field winding heating limit decides the capability in the over-excited region (lagging power factor) while core end heating determines the under-excitation capability (leading power factor)

Congratulations, you have finished Lecture 5. To view the next lecture select it from the left hand side menu of the page.