

# A Salient-Pole Synchronous Generator with Permanent Magnets between the Field Poles

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Salient-pole synchronous generators (SGs) have been widely used as hydro-generators, engine generators, wind generators, and so forth. One of the problems with the conventional SGs is the magnetic saturation in the field poles. The magnetic saturation limits the terminal voltage and requires more excitation power.

In this paper, a new type of SG termed the PMa-SG is presented to reduce the magnetic saturation in the field poles. A cross section of the proposed PMa-SG is shown in Fig. 1. In the PMa-SG, permanent magnets (PMs) are placed between the adjacent pole shoes, and the PM fluxes are generated in the opposite direction of the fluxes produced by the field currents. Therefore, the magnetic saturation in the field poles is reduced, and a higher voltage can be induced in the armature winding.

Using finite element analysis (FEA), the performance of an 8-pole PMa-SG (rated at 2.8 MVA, 800 V, and 50 Hz) was compared with that of a conventional SG of the same size, and the reduction effect of the magnetic saturation of the PMs was examined. The

results show that:

(1) The terminal voltage is 23% high;

(2) The output power is 22.5% large.

The details regarding the above results are shown in Table 1.

To verify the results computed by FEA, a 4-pole prototype (rated at 2.0 kVA, 160 V, and 60 Hz) was built and tested. The results of verification experiments are shown in Table 2. As is clear from the table, the terminal voltage and output power of the PMa-SG are significantly improved, and the validity of the FEA simulations can be confirmed.

Thus, the PMs placed between the pole shoes reduce the magnetic saturation in the field poles and effectively increase the terminal voltage and output power.

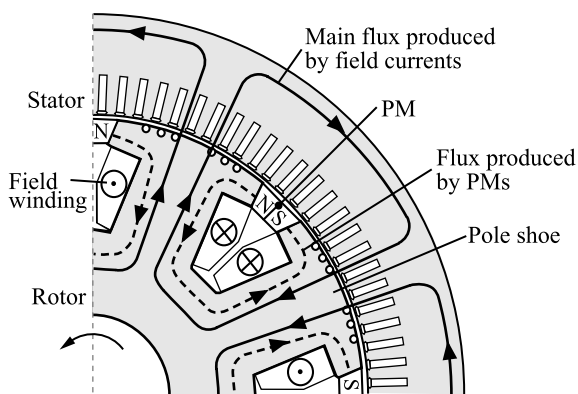


Fig. 1. Cross section of a PMa-SG

Table 1. Results computed by FEA (saturation factor = 1.1)

	Conventional SG	PMa-SG
Terminal voltage	651 V	801 V (+23.0%)
Armature current	2021 A	2021 A
Power factor	1.000	0.995 (lead)
Output power	2.275 MW	2.787 MW (+22.5%)
Field current	207.9 A	207.9 A

Table 2. Results of verification experiments (saturation factor = 1.045)

	Conventional SG	PMa-SG
Terminal voltage	120 V	160 V (+33%)
Armature current	7.5 A	7.5 A
Power factor	1.0	1.0
Output power	1.5 kW	2.0 kW (+33%)
Field current	1.75 A	1.93 A