

Understanding Output Voltage, Current and Power with Permanent Magnet DC Generators

The output voltage of a permanent magnet dc generator depends on the shaft rpm and the load. All Windstream permanent magnet generators will operate at any voltage within the operating envelope indicated on the published specifications. **The rpm required to reach any particular voltage is determined by the load** - the lighter the load, the lower the rpm needed to reach the specified voltage.

We have performance curves for each generator to show the rpm vs. load relationship. One of the curves shown in the specifications is the no-load (open-circuit) voltage, and the other curve is the short-circuit current. The performance at any load and rpm can be calculated knowing these factors plus the internal resistance of the generator.

An example of a battery charging application (24V)

The float voltage of a 24 volt battery is typically 27.6 volts. By controlling the generator rpm, it can be made to deliver 27.6 volts, or in the case where the input rpm is variable, such as from a wind turbine, a 24 volt voltage regulator can be used to limit the output voltage to the battery to 27.6 volts, no matter what the rpm (within the operating ranges of the generator and regulator).

When charging a battery with a permanent magnet dc generator, the generator rpm first has to rise to the point where its output voltage reaches the battery terminal voltage - a discharged 24 volt battery might have a terminal voltage of 20 or so. As soon as the generator exceeds that voltage, current starts to flow into the battery, and the effort required to turn the generator (i.e. input torque) increases. **As long as that amount of torque can be supplied by whatever is turning the generator, the battery will continue to charge.**

As soon as the battery becomes fully charged, no more charging current will flow, and the load disappears. If the generator continues to be driven, then the output voltage, with no load, will rise, and that could damage the

battery unless limited by a voltage regulator, or by disconnecting the generator when the charging current drops to zero or the battery terminal voltage reaches 27.6.

When charging a battery from a permanent magnet dc generator, it is also necessary to insert a diode into the charging circuit so that, if the generator rpm drops, the battery does not start to turn the generator like a motor, which discharges the battery. This is particularly important with variable power sources like wind turbines or human power generators. The diode acts like a one-way valve, allowing current to pass into the battery but not out. A voltage regulator includes an internal diode, so no additional diode is needed when using a voltage regulator.

Current and RPM when connected to a load

The current ("amperage") of a dc generator at any rpm is governed **only** by the load put on it, not by its rpm - **if you run a generator with no load, the current stays at zero no matter how high the rpm**. Only the generator terminal voltage goes up, but no matter how high the voltage, if there is no load, there is no current flow.

So the only limitation on rpm on a low rpm generator, as long as the current is kept within the limit for that generator, is if it is turned so fast with no load that the voltage rises so high that it could arc from one commutator segment to the next. As long as there is a load, preventing the voltage from rising to the arcing level, you can use a dc generator at any rpm you want.