

10 kW, 15 phase Axial Flux Pancake Generator for 2-Blade Wind Turbine

Abstract

A 10 kW permanent magnet electric generator has been built and tested for use with a high TSR, 5 m blade diameter wind turbine. The system was configured for 15 phase, 15 coils and 16 poles. Each coil is individually rectified to dc, reducing cogging and allowing better control over the output voltage. Total cost of the generator was AU\$873 and was constructed with typical home-workshop tools.

Keywords: Wind power, Permanent Magnet Generator, 10 kw wind turbine

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1. Construction of the Permanent Magnet Generator



Figure 1. Rear half of the generator motor

The rear plate (rotor) is mounted on a trailer axial bearing and holds the first set of 16 neodymium magnets.



Figure 2. Front half of generator rotor

The front plate holds the second set of 16 neodymium magnets. This plate is bolted to the rear half of the generator rotor, completing the magnetic circuit.



Figure 3. Generator Stator

15 Independent coils have been fixed into the stator using 24 hour epoxy resin. The coils have a thickness of 12 mm, measuring 2.5 Ohms each and are wound using 0.6 mm diameter wire. This stator will be remade out of fibreglass, and the holes in the centre of the coils will be reduced to increase the power output. Epoxy and aluminium should be avoided in the generator. Epoxy softens at temperatures as low as 60°C and aluminium has no fatigue limit, so any infinitesimally small stresses will eventually cause failure.

2. Generator Assembly



Figure 4. Front half of generator rotor with magnets attached

16 magnets are fitted into the slots of both the front and rear plates. The magnets are arranged with alternating poles around the circumference of the plate. 32 holes have been drilled into both plates to help cooling of the coils.

The generator was assembled with the stator coils sandwiched between the two sets of magnets. A clearance of 2mm was given between coils and magnets. Care was taken in assembly as the magnetic force acting on the 32 magnets can be up to 640Kg!

The generator spins feely until current flows and this is due to no iron being in the stator. The absence of cogging significantly helps starting in very low wind.

3. Total cost of the Permanent Magnet Generator

System cost (AUD)

Magnets	\$500
2000m 0.6mm magnet wire	\$88
2 Trailer axles	\$60
Steel	\$50
Primer and enamel paint	\$70
Welding rods	\$20
Metal cutting discs	\$40
Connector strips	\$25
Bolts and nuts	\$20

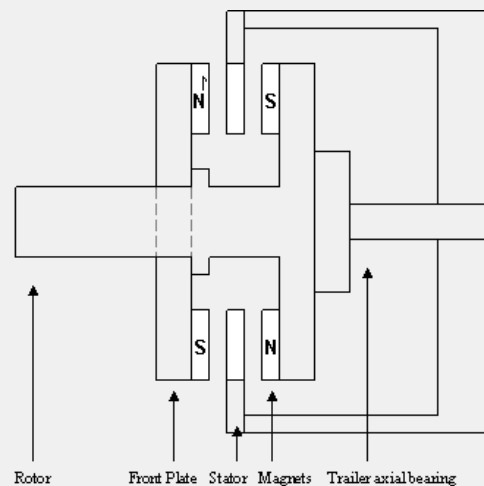
Total cost \$873

The generator was tested by attaching the drill to the generator. The speed of the drill and generator was controlled by an auto-transformer. Only one of the coils was put under load. The power produced by the coil was multiplied by 15 to get the total power of the generator.



Figure 5. Assembled generator

The neodymium magnets used are grade N38 with dimensions; 2 inch x 1 inch x 0.5 inch, magnetised through the thickness.

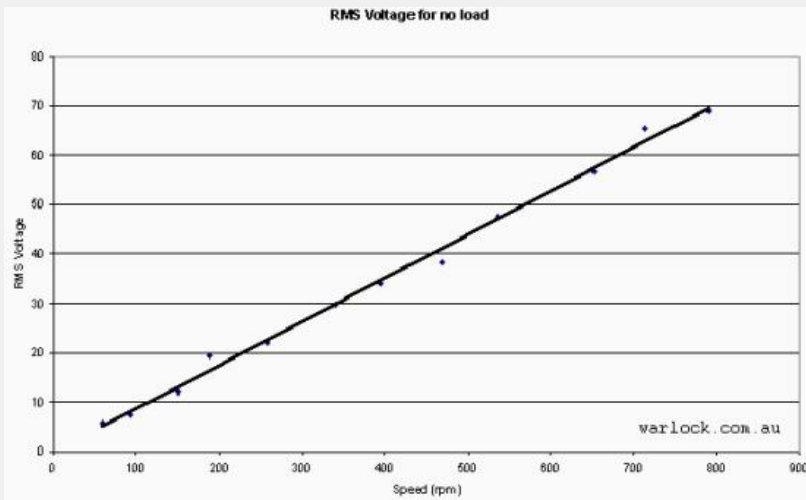


Rotor Front Plate Stator Magnets Trailer axial bearing

4. Testing the Permanent Magnet Generator



Figure 6. Testing the assembled generator



Voltage and frequency was measured on a oscilloscope. Generator speed, open circuit voltage and voltage under load (2.5 Ohms) were recorded. Speeds above 500RPM generated considerable heat and requires cooling.

5. Measured results of the Permanent Magnet Generator

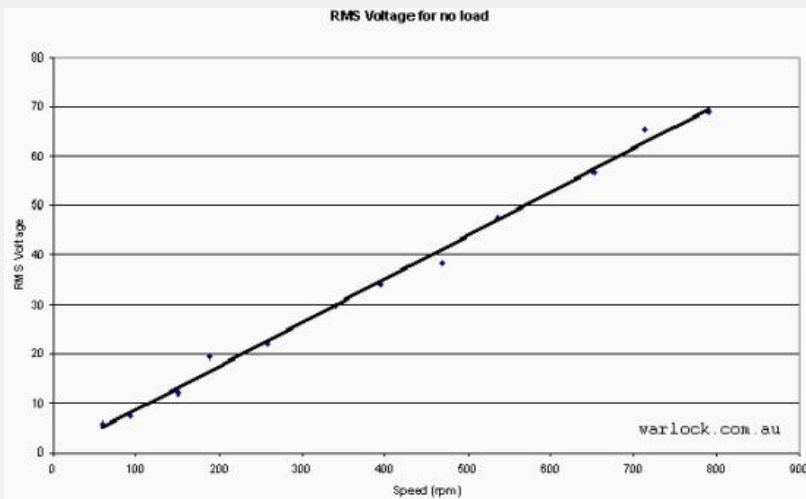


Figure 7. Measured RMS Voltage under no load, internal resistance is 2.5 Ohms

Figure 8. Measured voltage into matched load (2.5 Ohm)

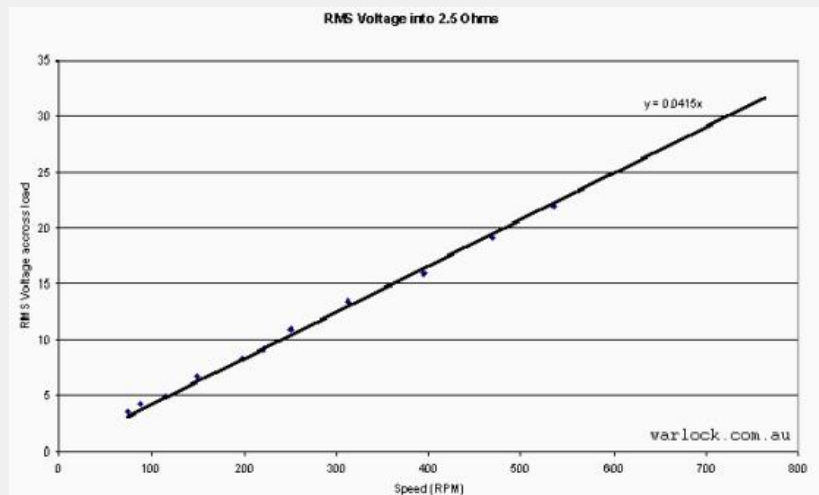
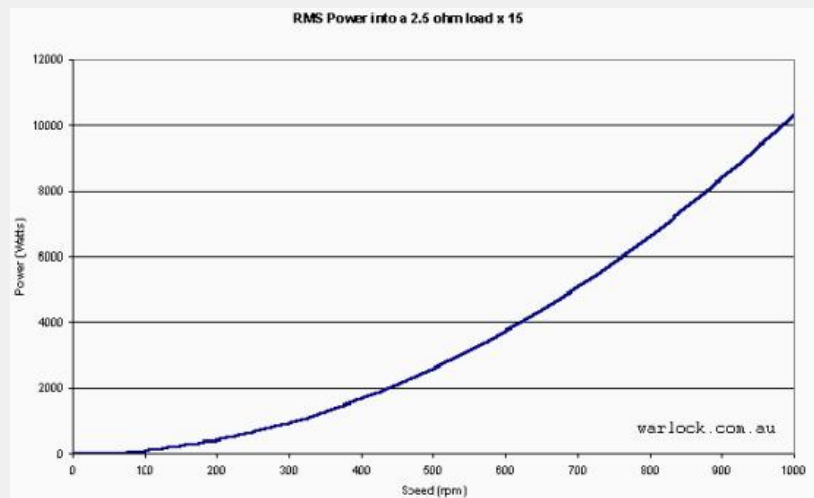


Figure 9. Measured RMS power generated for all 15 coils into a matched load

RMS Power is calculated using the equation;

$$P = 15 \times (V^2 / R)$$



6. Equipment used

Arc welder
Angle grinder
Drill
Hacksaw
Oscilloscope
Auto-transformer

7. Conclusion

A generator capable of generating up to 10kW built using cheap, readily obtainable parts for a total cost of **\$873**. This compares favourably as an inexpensive alternative to the commercial generators.