



PHASE

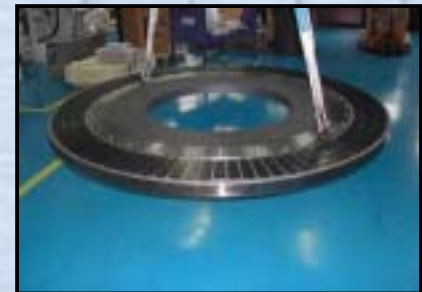


Direct drive large ring generators for wind power - the Phase Motion Control solution

Phase Motion Control



- Started in 1985 as a R&D house for research grade special motors and drives
- Started standard motor + drive production (*Ultract*) in 1992 for OEM Customers
- Started linear and torque motor production in 1994
- New *Wave*TM linear motors without cooling introduced 1998
- First 10 m diameter torque motor (VLT) produced 1992
- Largest PM motor produced to date: GRANTECAN, 16 m diameter



Phase Motion Control today



- **2001 production: average 1300 axes/month**
- **production centers: Genova, Turin (RCV), Ningbo (China)**
- **R&D in Genova, Italy headquarters**
- **New Genova headquarters opened Dec. 2000**
- **New Ningbo plant opened Dec 2001**
- **2001 group turnover 8 ME**



Company strategy



- **Competitive edge through innovation and performance - always one step ahead**
- **Magnetic, mechanical, electronic and software design integrated in all PMC products**
- **Technology trends:**
 - Direct drive: Large diameter motors & generators**
- **Linear motor**
 - Drive integrated into the motor**



Company production structure



- **Standard product line for automation**
 - Ultract II brushless motors, 0.2 to 450 Nm
 - AXV programmable motion platforms
 - TK torque motors
 - Wave linear motors
- **Custom and semicustom specialty drives**
 - **Custom:**
 - Large motor drives for scientific applications (e.g. 16 m dia, 180,000 Nm ring motor)
 - Aerospace and military
 - **Semicustom: special assemblies for specific sectors**
 - plastic injection molding machines
 - Impact forging hammers
 - Vertical lathes



Large diameter PM generators by Phase Motion Control: a long term involvement

- First 10 m diameter motor (VLT) double axial air gap, 1992, 10 m diameter permanent magnet
- 2,5 m motor for vertical lathes, BIMU 1993, double axial air gap
- VAL direct drive PM motor, 300 kW, 0.5 m, reverse cylindrical air gap, 1994
- 2 m diameter forging hammer single axial air gap, 1996

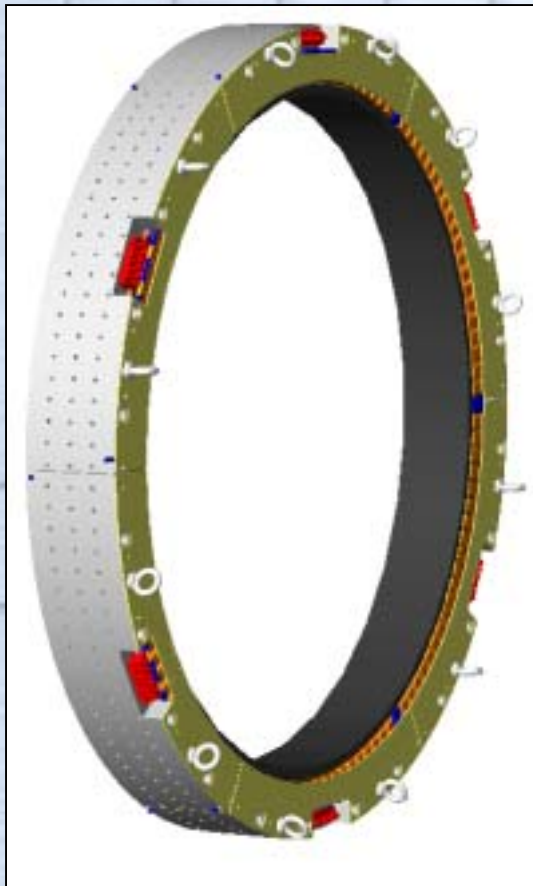


Large diameter PM generators by Phase Motion Control: ongoing development

- VLT Aux motors, 2.5 m diameter, single axial air gap, 1997
- GranTeCan 9 m diameter cylidric air gap PM motor, 2000
- GranTeCan 16 m diameter double axial air gap PM motor, 2001



Wind power direct drive generator technology by Phase Motion Control



- **Direct drive generators offer maintenance free operation and highest efficiency at the expense of large volume, mass, cost**
- **Phase Motion Control approach (pat.):**
 - Permanent magnet FeNdB design
 - Double cylindrical airgap
 - Epicyclic winding for lowest size
 - Segmented construction, max segment mass \leq 500 kg; segments can be assembled-disassembled separately without interrupting operation
- **Axial length \leq 500 mm**
- **Airgap 2 x 3 mm**



Wind power direct drive generator technology by Phase Motion Control 2

- The double airgap construction balances the magnetic strains within each sector so the mass of structure is minimized
- The segmented rotor can be assembled directly on the propeller hub
- The stator segments are positioned on the rim of the nacelle, radial thickness 320 mm
- Efficiency optimized for wind conditions, air cooled
- Optimized for rectifier load and for flux vector Control (Patented by PMC)
- Short circuit overload < 200% of rated torque
- Three initial designs for 600, 1200 and 2400 kW at 24,22 and 18 rpm

600 kW at 24 rpm TKD 2800-300-500



Key data:

8 segments

Diameter 2800 mm

Hole 2100 mm

Length 300 mm

Total mass 4500 kg

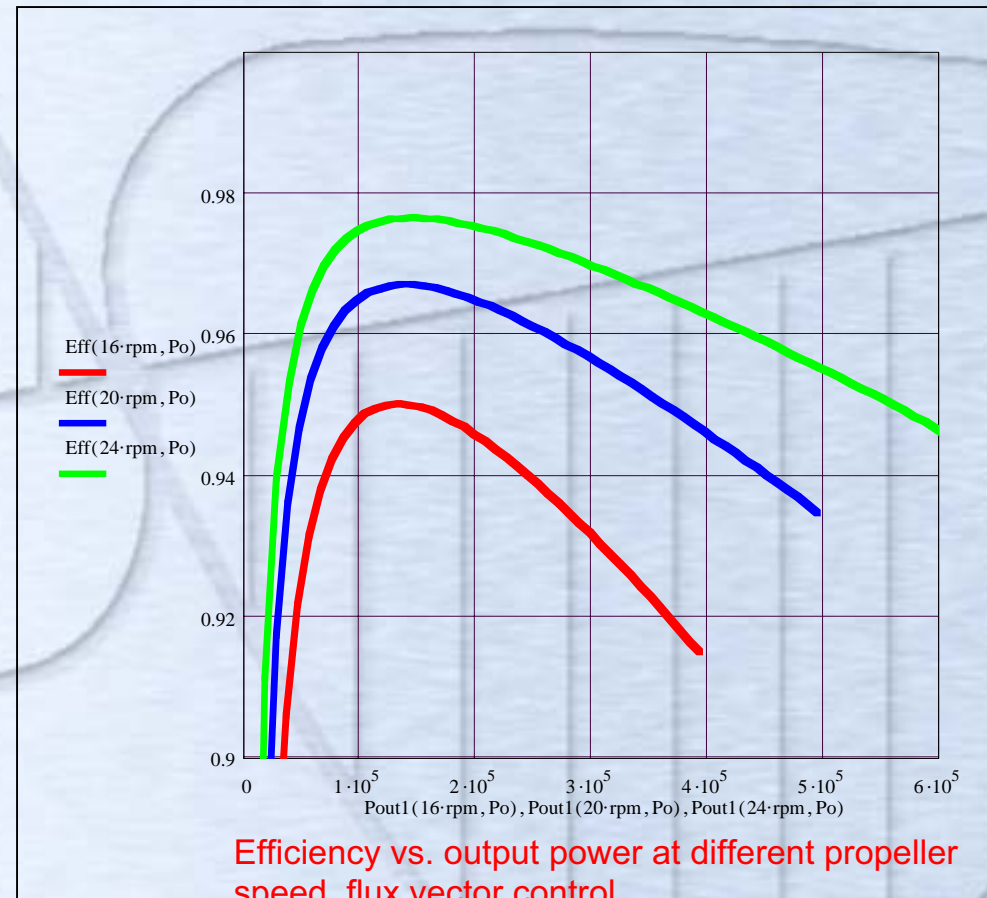
Electric data:

160 poles

Frequency 32 Hz at 24 rpm

690 V, 604 A

250,000 Nm



1.2 MW at 20 rpm TKD 3800-300-500

Key data:

12 segments

Diameter 3900 mm

Hole 3260 mm

Length 350 mm

Total mass 7200 kg

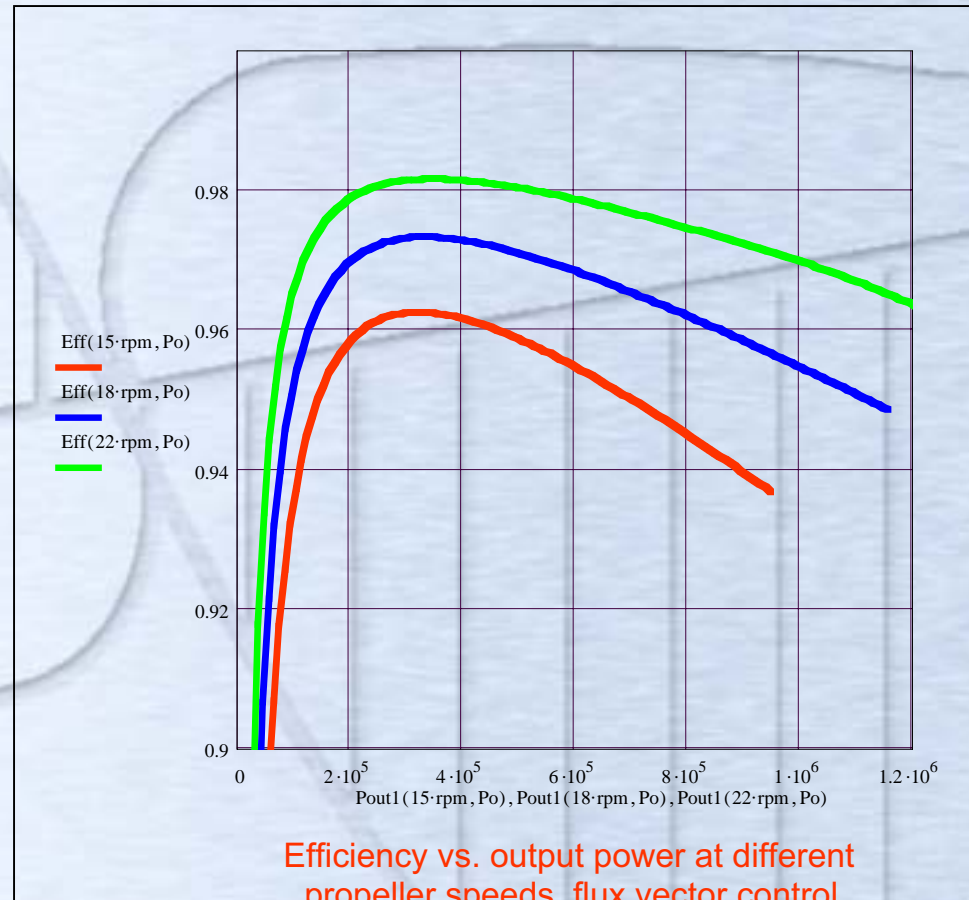
Electric data:

240 poles

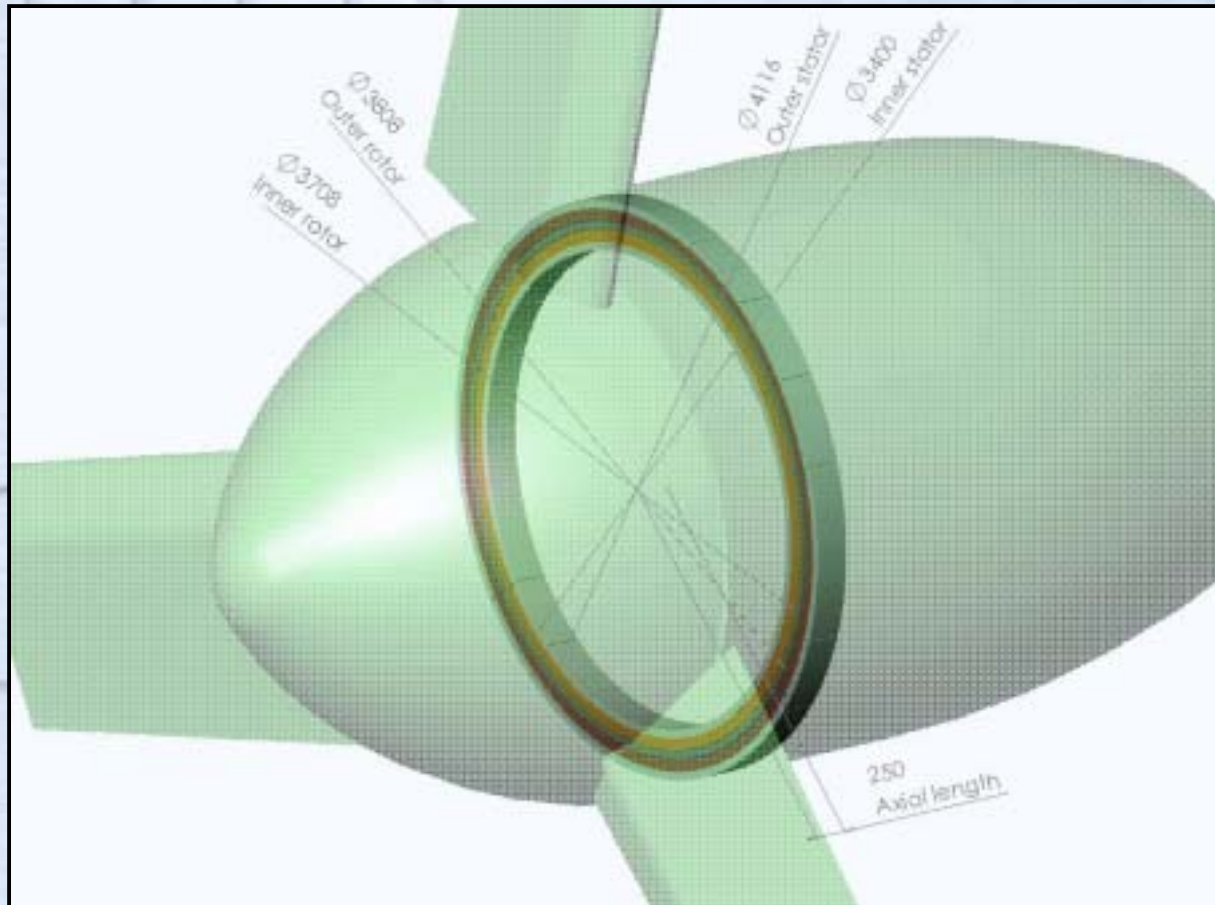
Frequency 40 Hz at 20 rpm

690 V, 1270 A

630,000 Nm



1.2 MW at 20 rpm
TKD 3800-300-500



2.4 MW at 18 rpm TKD 5200-300-600



Key data:

16 segments

Diameter 5200 mm

Hole 4500 mm

Length 400 mm

Total mass 10700 kg

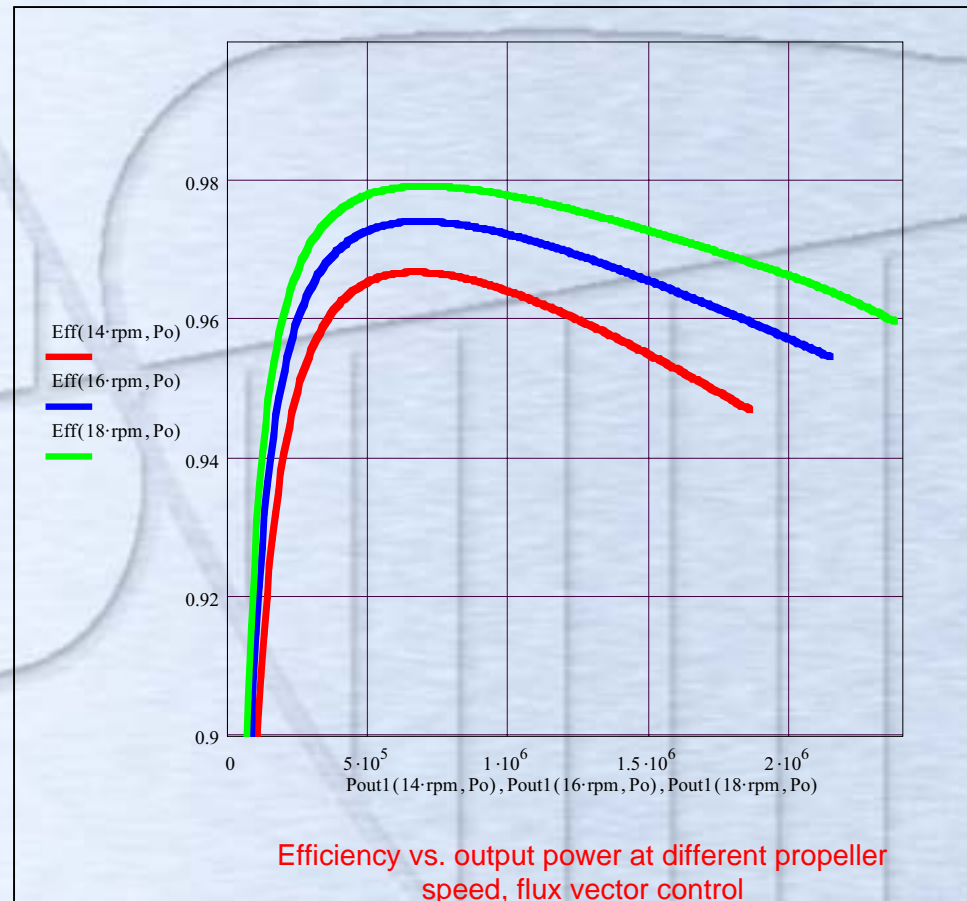
Electric data:

320 poles

Frequency 48 Hz at 18 rpm

690 V, 2350 A

1,300,000 Nm



Worldwide support and distribution network



- R&D, Company headquarters
- Manufacturing and support
- Authorized distributor



PHASE



**Leading the innovation in electric force,
motion and position control for automation**