AOC 15/50 WIND TURBINE GENERATOR

BRIEF OPERATION DATA AND TECHNICAL SPECIFICATIONS

Atlantic Orient Canada Inc.
Wind Energy Systems for the World

ATLANTIC ORIENT CANADA INC.
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1.0 General Description and Features of the Turbine

The designation 15/50 refers to the 15 m diameter fibreglass rotor and its projected rated output of 50 kW. This rated output is achieved at 12 m/s (26.8 mph) by the 50 Hz version and at 11.3 m/s (25.3 mph) by the 60 Hz one.

The AOC 15/50 includes the following design features:

- Advanced NREL thick series airfoils
- High strength to weight ratio fiberglass blades
- Electro-magnetically/actively controlled tip brakes
- Single piece hub casting
- Rotary transformer to power the tip brake magnets
- Integrated planetary gearbox
- Induction generator
- Single piece cast tower top with turn table yaw bearing
- Uniformly tapered lattice tower
- Dynamic brake
- PLC based controller with adaptive features
- Optional tilt-up tower

Both turbine versions are designed to cut in at 4.6 m/s (10.2 mph). The 50 Hz version reaches its peak continuous output of 55 kW at 15 m/s (34 mph); the 60 Hz one achieves its peak of 65 kW (60 Hz) at 16 m/s (36 mph). Assuming 100% availability and average wind speeds of 8 m/s (18 mph), the 50 Hz wind turbine is calculated to produce approximately 190,000 kWh per year and the 60 Hz one, 215,000 kWh. In average wind speeds of 6.7 m/s (15 mph), the 50 Hz version produces approximately 145,000 kWh annually and the 60 Hz one, 153,000 kWh.

The wind turbine is based on a simple design with no nacelle. The standard tower is a 24.4 m (80 ft) tall, self-supporting lattice structure. The gearbox is integrated in the single piece cast housing. See Figure 2-2 for a more detailed view of the drive train assembly. The generator is flange mounted to the planetary gearbox, with the parking brake coupled directly to the generator.

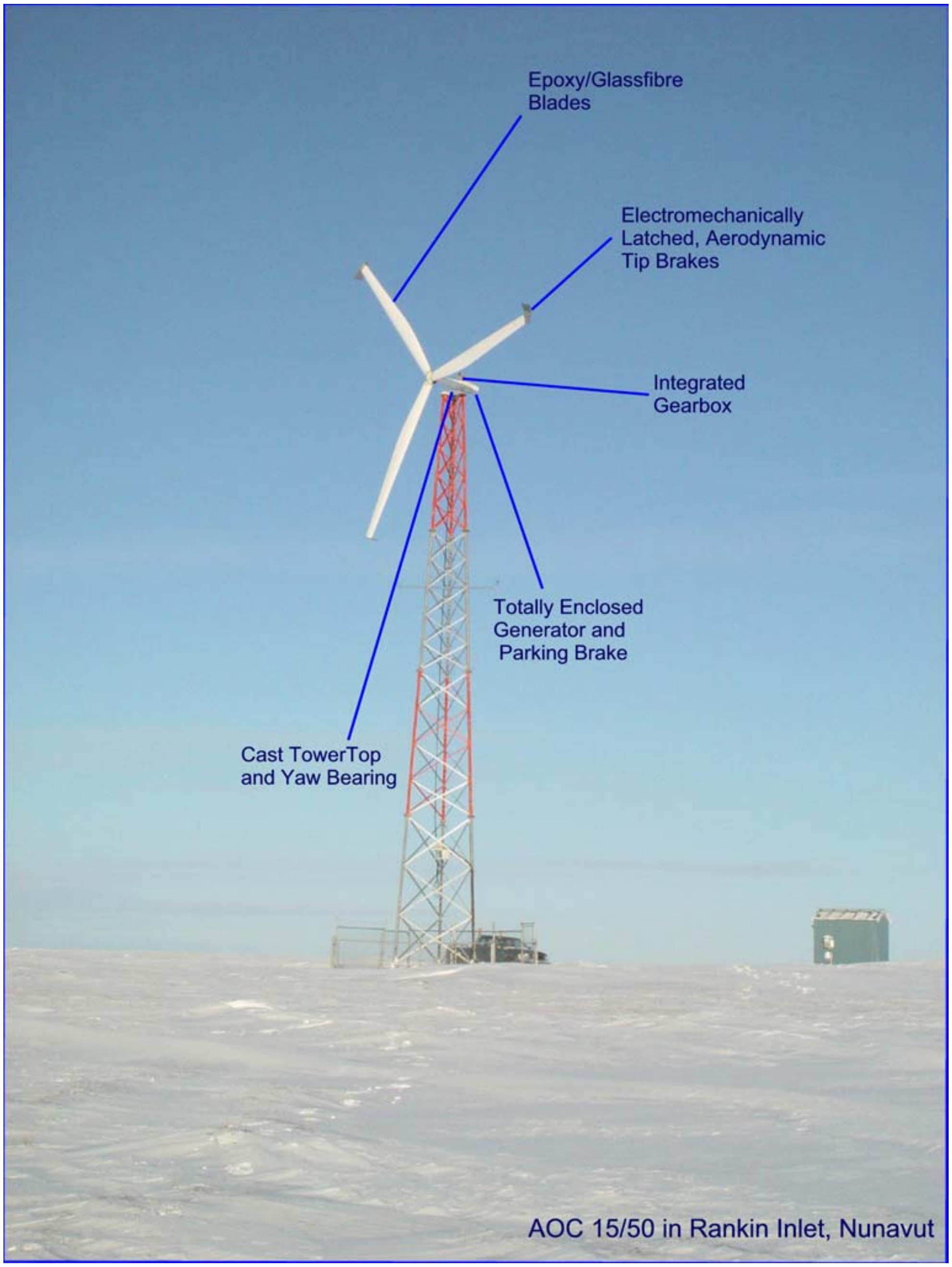

Figure 2-1 AOC 15/50 Wind turbine

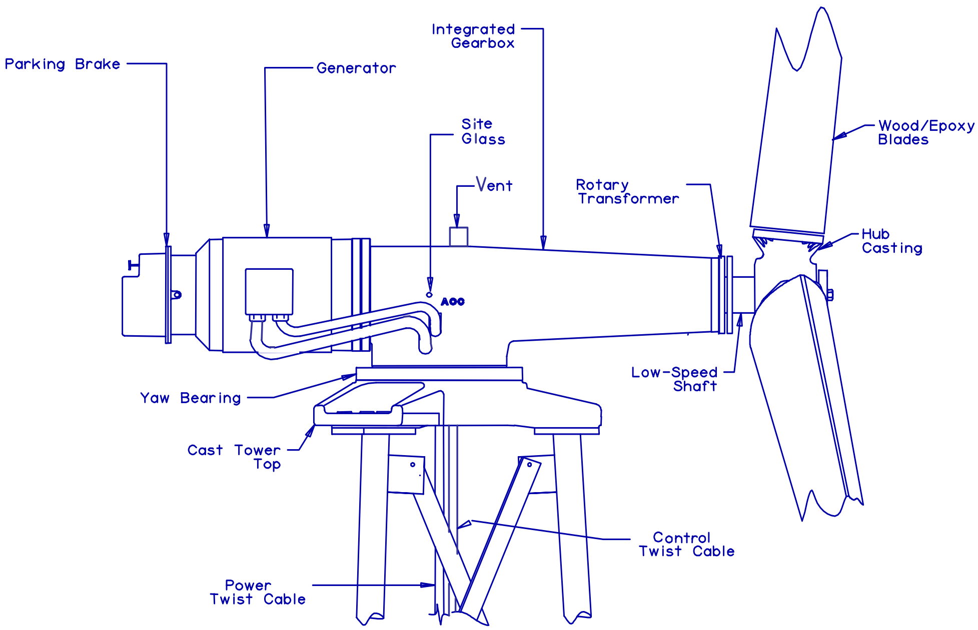

Figure 2-2   AOC 15/50 Wind turbine assembly, drive train detail

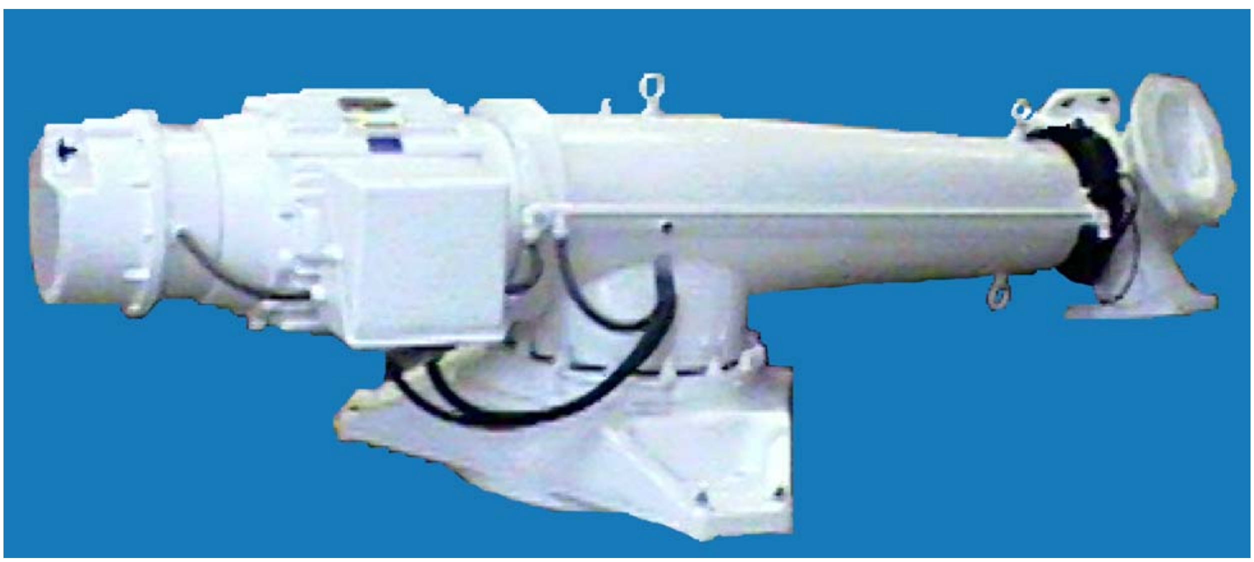

Figure 2-3   AOC 15/50 Drive train assembly

2.0 Control System Description

The following parameters are monitored by the wind turbine's control system. It initiates shutdowns when faults have been detected to protect the wind turbine from mechanical and electrical damage.

UTILITY NETWORK:

- Over/under voltage
- Phase loss
- Phase reversal
- Over/under frequency (optional)

TURBINE:

- Generator temperature
- Rotor speed
- Power (derived from rotor speed)
- Parking brake current

SYSTEM:

- Wind speed (redundant anemometers)
- Ambient temperature switch (optional)

2.1 Operation Description

The AOC 15/50 is a downwind turbine, i.e. its blades rotate downwind of the drive train assembly. Furthermore, it has no active yaw control and depends on its blades to track the wind. In winds outside of the required wind band, the PLC (Programmable Logic Controller) disconnects the wind turbine from the grid and parks it; the wind turbine is brought to a complete stop. The parking brake remains applied, thereby preventing the blades from rotating. However, they will still track the wind and the wind turbine will pivot about its yaw bearing accordingly.

The AOC 15/50 has three main modes of operation: test, off and on. The setting of the TEST/OFF/ON switch determines the parameters monitored by the PLC and which other switches can be activated. When the turbine TEST/OFF/ON switch is set to OFF, the PLC only monitors grid faults.

Once the turbine TEST/OFF/ON switch is set to ON, the PLC starts evaluating the wind speed data which, together with the generator rotor speed, is the most important source of input data to the PLC; grid related parameters and thermal relays play a secondary role.

The wind speed is measured using two cup anemometers. For the wind turbine to start-up and continue running the wind speed has to fall within a specified speed band, which is 3.6-22.3 m/s (8-50 mph) in the case of the AOC 15/50. Its cut-in speed of 4.9 m/s (11 mph) is slightly higher than its minimum operational speed because of the inertia of the rotor and drive train that must be overcome initially. Once the wind speed conditions are met, the parking brake is released and the generator starts rotating, at which point PLC starts monitoring the generator rotor speed.

The wind turbine is not connected to the grid automatically once the parking brake has released the generator rotor. Additional conditions must be met and provided no faults are registered once the wind turbine has been connected to the grid it will stay on-line. The generator shaft speed is measured using two speed sensors from which the PLC can tell whether the shaft speed falls within the required range. Since power produced is proportional to rotor speed, the rotor speed is also used to check for excessive power generation.

Whenever the wind and/or shaft speeds deviate from the specified values the PLC initiates a shutdown of the wind turbine system. However, in order to avoid unnecessary shutdowns, each fault is monitored for a set period to confirm that it is not due to a temporary deviation but to a definite change in the operating conditions. Since faults impact on the system with varying degrees of severity, in terms of possible electrical or mechanical damage, the time delays after which a shutdown is initiated differ.

Should the PLC register a fault that requires the wind turbine to be shut down, it does so in a set sequence. First the tip brakes are deployed, followed almost simultaneously by the dynamic brake. The parking brake is deployed last after a variable time delay, generally set to 4 seconds. Following any deployment of the brakes the wind turbine enter a cooling cycle that overrides all other information to the PLC which would otherwise start the wind turbine up again.

The dynamic and parking brakes can be tested individually when their test switches are set to ON and the TEST/OFF/ON switch is set to TEST.

3.0 Electrical Interface to Utility

The utility interface is site specific and must be coordinated with the local utility or other responsible party. A kWh meter for each machine is recommended.

The wind turbine may be interfaced with a preexisting low voltage 480V 60Hz (400V 50Hz) supply or it may require its own step up transformer to the system distribution voltage.

- Interface at the 400/480 VAC level:

  For single wind turbine installations the wind turbine can be interfaced directly with the 480/400 VAC utility system, if sufficient transformer capacity exists (75 kVA per turbine). This also applies to commercial and industrial installations with an adequately sized 480/400 VAC panel and distribution system. The wind turbine should be on a dedicated circuit breaker/fuse of proper capacity rating.

- Interface at voltage levels greater than 480/400 VAC:

  For single or multiple wind turbine installations it may be necessary and/or desirable to install a step up transformer between the 480/400 VAC wind turbine and the higher voltage utility system. For example, in a single unit installation interfacing with a 13.8 kV utility system, a minimum 75 kVA transformer with a 13.8 kV/480V ratio would be necessary. Since wind turbine output is variable, care must be taken to properly size the step-up transformer. The winding configuration may also affect system performance. The AOC 15/50 generator is WYE connected. The interfacing transformer is typically connected with WYE primary and DELTA secondary.

Figure 7-1 illustrates the simplest form of a utility interface. Utility interconnection should be specifically engineered for each site. This manual only suggests installation procedures from the control box to the wind turbine. Applicable national and local codes must be followed. Careful research and consultation during the planning stage can avoid expensive and dangerous mistakes. A licensed electrician may be required to install all interconnection wiring.

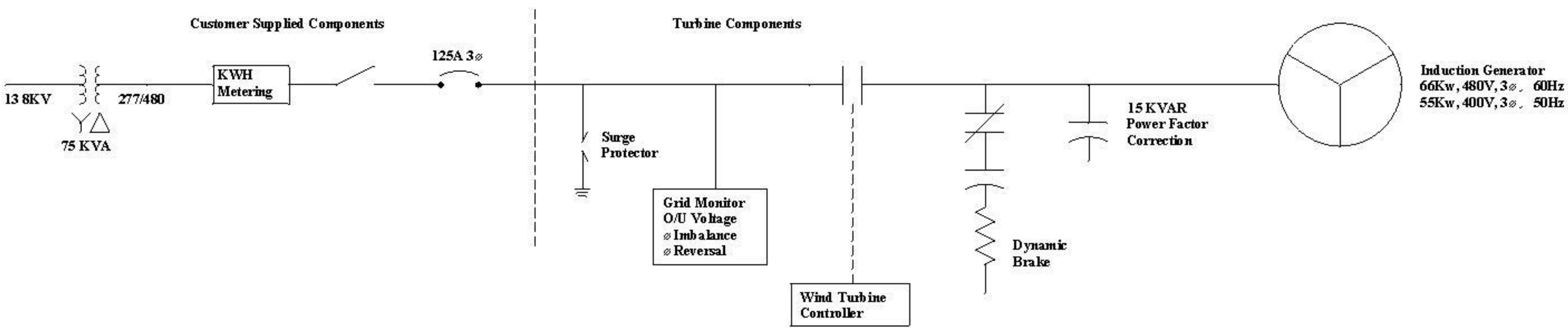

Figure 7-1 Typical electrical installation

3.2.1 Power and Control Cable

The power cable for an AOC 15/50 must be of a sufficient ampacity rating to carry the rated generator current (86 Amperes). The National Electrical Code and the IEC Code list the ampacity of various cable types.

The minimum cable sizes (see Appendix M) were calculated based on general assumptions regarding service transformer rating and utility line capacity. Cable sizes were also selected to take varying distances between the tower and control boxes into account. They are meant for general planning only and should not replace site specific electrical engineering.

The power cable must be of appropriate insulation and construction to satisfy national and local electrical code specifications for the specific distribution system. AOC does not recommend the use of direct buried cable, unless it is armored, due to the increased potential for faults.

It is necessary to consider the economics associated with increasing power cable size from the minimum required, in order to increase the net energy output (in kWh) of the wind system through reduced line losses. The increase in revenue from a larger cable must be weighed against its higher initial cost. Determining the optimum cable size requires the following:

- Consideration of initial expenditures
- Effects of line loss on kWh production
- Projections of kWh production over time
- Interest rates as a reference in determining the economic value of increased initial investment

AOC 15/50 SPECIFICATIONS

SYSTEM

Type	Grid Connected
Configuration	Horizontal Axis
Rotor Diameter	15 m (49.2 ft)
Centerline Hub Height	25 m (82 ft)

PERFORMANCE PARAMETERS

Rated Electrical Power	50 kW @11.3 m/s (25.3 mph)
Wind Speed	@hub height 25 m (82 ft)
cut-in	4.6 m/s (10.2 mph)
shut-down (high wind)	22.4 m/s (50 mph)
peak (survival)	59.5 m/s (133 mph)
Calculated Annual Output	
@ 100 % availability	5.4 m/s (12 mph) 87,000 kWh
	6.7 m/s (15 mph) 153,000 kWh
	8.0 m/s (18 mph) 215,000 kWh

ROTOR

Type of Hub	Fixed Pitch
Rotor Diameter	15 m (49.2 ft)
Swept Area	177 m²(1902 ft²)
Number of Blades	3
Rotor Solidity	0.077
Rotor Speed @ rated wind speed	65 rpm
Location Relative to Tower	Downwind
Cone Angle	6º
Tilt Angle	0º
Rotor Tip Speed	51 m/s (114 mph) @ 60 Hz
Design Tip Speed	6.1

BLADE

Length	7.2 m (23.7 ft)
Material	Epoxy /glass fibre
Airfoil (type)	NREL, Thick Series, modified
Twist	7° outer blade
Root Chord	457 mm (18 in) @ 4% 279 mm (11in)
Max Chord	749 mm (29.5 in) @ 39% 2925 mm (115 in)
Tip Chord	406 mm (16 in) @ 100 % 7500 mm (295 in)
Chord Taper Ratio	± 2:1
Overspeed Device	Electro-magnetic tip brake
Hub Attachment	Embedded female bolt receptors
Blade Weight	150 kg (330 lbs) approximate

GENERATOR

Type	3 phase/4 pole asynchronous
Rated Temperature	-25°c
Frequency (Hz)	60 Hz
Voltage (V)	480, 3 phase @ 60 Hz
kW @ Rated Wind Speed	50 kW
kW @ Peak Continuous	66 kW
Speed RPM (nominal)	1800 @ 60 Hz
Winding Configuration	Ungrounded WYE
Insulation	Class F
Enclosure	Totally Enclosed Air Over (TEAO)
Frame Size	365 TC
Mounting	Direct mount to transmission
Options	Arctic low temp. shafting (-40°c)

TRANSMISSION

Type	Planetary
Housing	Ductile iron-integrated casting
Ratio (rotor to gen. speed)	1 to 28.25 (60 Hz)
Rating, output horse power	88
Lubrication	Synthetic gear oil/non toxic
Heater (option)	Arctic version, electric

YAW SYSTEM

Normal	Free, rotates 360 degrees
Optional	Yaw damping required when known conditions frequently exceed 50° yaw rate per second.

DRIVE TRAIN TOWER INTERFACE

Structural	Yaw bearing mounted on tower top casting
Electrical	Twist Cable

TOWER

Type	Galvanized 3 legged, bolted lattice , self-supporting
Tower Height	24.4 m (80 ft)
Options	30.5 m (100 ft), Tilt down 24.4 m (80 ft)

FOUNDATION

Type	Concrete or special
Anchor Bolts	Certified ASTMA-A-193-Grade B7

CONTROL SYSTEM

Type	PLC based
Control Inputs	Wind speed, generator shaft speed
Control Outputs	Line interconnection, brake deployment
Communications	Serial link to central computer for energy monitor and maintenance dispatch (optional
Enclosures	NEMA 1, NEMA 4 (optional)
Soft Start	Optional

ROTOR SPEED CONTROL

Production	Blade stall increases with increased wind velocity
Normal Startup	Aerodynamic, electrical boost if necessary
Shut-down	Control system simultaneously applies dynamic brake and deploys tip brakes. Parking brake brings rotor to standstill.

Back-up Overspeed Control: Centrifugally activated tip brakes deploy

BRAKE SYSTEM CONTROL

Fail-safe brakes automatically deploy when grid failure occurs.

APPROXIMATE SYSTEM DESIGN WEIGHTS

Tower	3,210 kgs	(7,080 lbs)
Rotor & Drivetrain	2,420 kgs	(5,340 lbs)
Weight on Foundation	5,630 kgs	(12,420 lbs)

DESIGN LIFE: 30 Years

DESIGN STANDARDS: Applicable Standards, AWEA, EIA and IEC

DOCUMENTATION:
Installation Guide and Operation & Maintenance Manual

SCHEDULED MAINTENANCE: Semi-annual or after severe events.

NOTE 1: Atlantic Orient Canada Inc.is constantly working to improve their products, therefore, product specifications are subject to change without notice.

NOTE 2: Power curves show typical power available at the controller based on a combination of measured and calculated data. Annual energy is calculated using power curves and a Rayleigh wind speed distribution. Energy production may be greater or lesser dependent upon actual wind resources and site conditions, and will vary with wind turbine maintenance, altitude, temperature, topography and the proximity to other structures including wind turbines.

NOTE 3: For design options to accommodate severe climates or unusual circumstances please contact Atlantic Orient Canada

NOTE 4: For integration into high penetration wind -diesel systems and village electrification schemes contact Atlantic Orient Cnada Inc. for technical support.