ELECON - TURBOWINDS
DESIGN AND SUPPLY OF T600

TECHNICAL DATA

Table of Contents

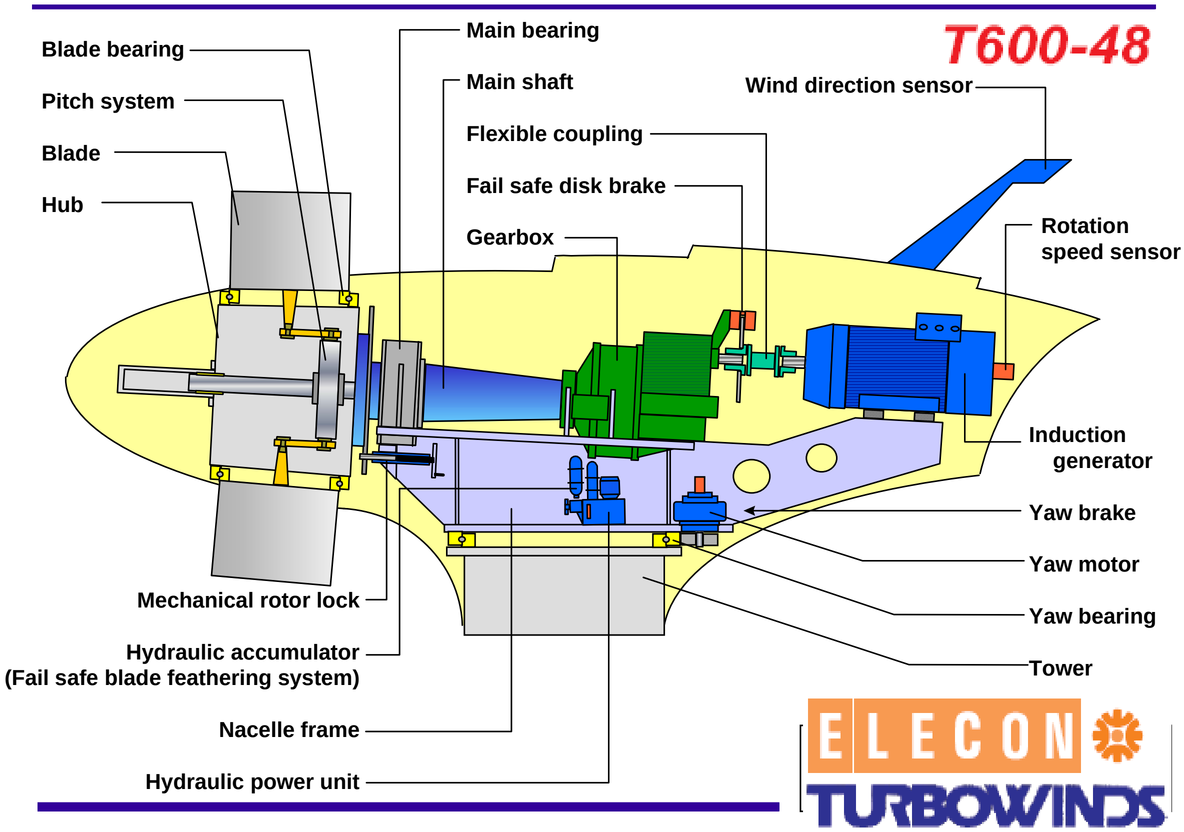
1 GENERAL DESCRIPTION

The T600 is designed to allow wind turbine generators to function automatically on an unmanned basis. Depending upon wind conditions, this includes automatically starting, normal generator operation, automatically stopping and in abnormal circumstances automatic trip/lockout.

The WTG is a horizontal axis wind turbine with an upwind rotor.
The size of the T600 is 600 kW with a rotor diameter of 48 m.

The generator offered is a dual speed generator, 600/120 kW.

The blade pitch control is ACTIVE STALL.



1.1 Standards

INTERNATIONAL ELECTROTECHNICAL COMMISSION

IEC 61400-1 Wind turbine generator systems

TECHNICAL DATA

TECHNICAL INFORMATION	**T600-48 TURBOWINDS**
1 Wind Turbine	
Manufacturer	**ELECON - TURBOWINDS N.V.**
Type and Model number	**T600-48 DS**
Rated power, kW	**120 / 600 kWatt (dual speed)**
Wind speed at hub height:	
Cut-in, m/s	**3.5 m/sec**
Rated, m/s	**12.5 m/sec**
Cut-out, m/s	**25 m/sec**
Maximum designed (survival), m/s	**60 m/sec**
Rotor diameter	**48 m**
Hub height	**50 m**
Method of control	**full blade pitch active stall**
System design life for all components, yr	**20 years**
Approval / type - certification Quality control system certification Power curve certification	**C-WET** **ELECON** **CIWI Holland**
2 Rotor	
Number of blades	**3**
Diameter, m	**48 m**
Speed, rpm	**15.3 / 23 rpm**
Swept area	**1809 m²**
Direction of rotation (looking upwind)	**clock-wise**
Location relative to tower	**upwind**
Type of Hub	**Rigid**
Tilt angle	**4 degrees**
Cone angle	**-2 degrees**
Method of speed control	**pitch regulation + active stall**
3 Blade	

Manufacturer	**LM**
Type and model	**23.3P**
Length, m	**23.2 m**
Material	**Fibre glass**
Weight, kg/blade	**2300 kg**
Blade bearing diameter (internal/external), m	**1.25 m / 1.46 m**
4 Drive Train Shaft speeds:	
Low speed, rpm	**15.3 / 23 rpm**
High speed, rpm	**1200 /1800 rpm**
Main shaft :	
Material	**34CrNiMo6**
Length and diameter	**2.05m - 0.48m**
Bearings	**SKF**
Gear Box:	
Manufacturer and type	**ELECON / Flender , planetary-parallel**
Ratio	**65.2**
Rating, kW	**600 kW**
Service factor	**1.3**
Efficiency (at rated power conditions)	**96** %
Lubrication	**splash**
Bearings	**SKF**
dba at 1 meter distance	**80 dba**
Brake:	
Manufacturer and type	**SIME**
Location, HSS/LSS	**HSS**
Flexible coupling :	
Manufacturer and type	**ELECON/ Flender GKG**
5 Yaw Drive Manufacturer and type	
Yaw rate, deg/sec	**0.5 deg r/sec**
Yaw error dead band	**5 degrees**
Yaw drive (electric/hydraulic)	**Hydraulically**
Yaw brake	**Hydraulically yaw brakes**
Turntable	**ball bearings**
Pressure	**180 bar**
Moment , Nm	**23.8 kNm**
6 Pitch Drive	

Manufacturer and type	**Parker or Equivalent**
Pitch rate, Deg./sec.	**4.6 deg/sec**
Pitch mechanism, electric/hydraulic	**Hydraulically**
Pressure	**225 bar**
Cylinder force ,kN	**250 kN**
Feathering system (including backup)	**Hydraulically**
7 <u>Tower</u>	**T600-48 TURBOWINDS**
Type and Material	**ST 42**
Height, m	**50 m**
Diameter and Thickness at top, cm	**209.4 cm - 1.2 cm**
Diameter and Thickness at base, cm	**314.0 cm - 2.5 cm**
Tower Layout	**cylindrical – tapered**
First bending frequency , Hz	**0.9 Hz**
Access to nacelle	**inside tower**
Corrosion prevention	**3 coat painting**
Withstanding seismic loads	**0.35 g**
8 <u>Power Generation System</u>	
<u>Generator:</u>	
Manufacturer	**ABB / Siemens**
Type and Model number	**M2CG 400 XL 4/6**
Rating, kW	**120/ 600 kW**
Rated current	**123/566 Amp**
Slip	**0.7 % / 0.9 %**
Power Factor (100%-75%-50%-25%)	**0.89 - 0.88 - 0.85 - 0.68**
Voltage, V	**690 VAC**
Frequency, Hz	**60Hz**
Speed, rpm	**1200/1800 rpm**
Insulation	**class F**
Maximum working temperature, C	**45 degrees ambient temp**
Efficiency (100%-75%-50%-25%)	**96.9 % - 96.7 % - 96.2 % - 94.1% respectively**
Winding protection type	**IP 55**
Safety device	**3 PTC's per generator**
dBA at 1 meter distance	**< 85 dBA**
Connection to grid, direct/soft	**soft started**
<u>Electricals:</u>	**T600-48 TURBOWINDS**
Reactive power compensation &APFC	**50/150 kVar ,& 175KVAR,**

	8 steps
Net power factor after compensation (100-75-50-25 %)	**0.97 - 0.99 - 0.99 - 1**
Grid control	**Voltage-Current-Asymmetry**
Power control	**active power transducer**
Main supply	**690 VAC**
Protection	**Power varistors**
Contactor/light supply	**110VAC/220VAC**
Control system supply	**24VAC-> 24 VDC + batteries**
Independent over speed control	**master and back-up brake**
9 Control System	**T600-48 TURBOWINDS**
Manufacturer	**Turbowinds**
Type of supervisory	**microprocessor INTEL**
digital inputs	**48 inputs (opto-isloated)**
digital outputs	**48 outputs (opto-isolated)**
analog inputs	**16 analog inputs (10 bits)**
analog outputs	**4 analog outputs (8 bits)**
synoptical panel	**96 colour leds , LCD display**
remote control	**RS232 full remote control**
battery back-up	**2 months**
lightning protection	**transorbs**
10 Turbine controls	
Software	**Turbowinds (assembler)**
Power	**full blade pitch - active stall**
Software controls	
Over speed rpm’s	**1823 rpm’s , 1890 rpm’s**
voltage	**10 %**
frequency	**1 Hz**
asymmetry	**5 %**
Wind speed	**3.4 m/sec - 25 m/sec**
Hardware controls	
Over speed relay rpm’s (in controller)	**1920 rpm’s**
Over speed brake rpm’s (independent , fail safe)	**1950 rpm’s**
11 Weights (in kg.)	
Wind turbine total (excluding tower)	**35.000 kg**
Tower (50 m)	**54,000 kg**
Rotor (including blades)	**12.000 kg**
Above tower (including rotor)	**35.000 kg**

Gear Box	**4.500 kg**
Generator	**3.100 kg**
Heaviest piece to be handled during erection	**tower and nacelle**

2 MECHANICAL

2.1 Rotor

The rotor assembly consists of the blades and hub including the connection of the blades to the hub. The blades are connected to the hub through a bearing connection allowing the blades to be rotated during operation. The rotor will be self-starting.

a) Blades

The blades are fibreglass and manufactured in materials, which do not create any interference to television or FM radio reception.

The blades are of a standard and proven type.

The blades are designed for low aerodynamic noise generation.

The blades have a matt finish with adequate abrasion resistance to prevent appreciable degradation in performance between specified maintenance periods.

Adequate drainage is provided to prevent condensation build-up in the blades.

All blades have an identification plate which shows the year of fabrication, serial number, weight and the number (s) of the other blade (s) forming a set of blades.

(b) Hub

The design of cast hubs in general is in accordance with the appropriate national standards for cast iron .

(c) Rotor Locks

To enable maintenance to be carried out safely on the rotors, means of locking the turbine rotor shaft in the stationary position is provided.

(d) Failsafe

Pitch regulation is failsafe so that in the event of loss of control blades will return to the feather position.

2.2 Braking System

Two independent braking systems are included. Both systems are independent and fail-safe. The maximum over speed does not endanger the machine.

Braking systems are capable of being tested regularly in a manner, which does not endanger the WTG in the event of a failure.

Under normal operational conditions the braking system is be capable of bringing the rotor to idling speed and eventually to a complete stop where this is required.

The braking system is operable from the nacelle as well as from the tower base control board.

a) Hydraulic System

Provisions are included to prevent over pressure in the system.

The hydraulic system does not operate when the machine is idle unless manually operated for maintenance purposes. If the pressure falls or leaks occur in the system the WTG will be stopped.

b) Pressure Components

All pressure vessels, pipes, valves and other components, which will be subject to pressure, will be subjected to hydraulic pressure tests in the works. The test pressures will be 1.5 the maximum working pressure and will be applied for 30 minutes.

2.3 Nacelle

The turbine unit includes a nacelle to house and support the rotating machinery in board of the rotor hub and to given protection to control and instrumentation equipment that needs to be located at this level. The nacelle is fully enclosed against the elements with a robust weatherproof corrosion resistant housing for all the generating equipment. It provides sufficient access and natural light for one operator to be able to inspect all components and carry out routine maintenance e.g. oil change, greasing or brake adjustments. It is constructed in such a manner as to provide a safe working area with regard to the height above ground and the close proximity to rotating components.

There is sufficient room inside the nacelle to carry out normal maintenance on the equipment inside.

Observation of the turbine blades and hubs is possible from the nacelle. The equipment such as anemometers and wind vanes and lightning conductors are fitted on the roof of the nacelle, access to the roof is provided. Access is also provided to the external parts of the rotor. Attachment points are provided for harnesses when staff is working in exposed positions. The nacelle provides adequate noise isolation and insulation to ensure that levels of noise at ground level meet guaranteed levels.

2.4 Yawing System

A yaw system is provided to enable the turbine to face into the wind when it is operational. Each wind turbine generator has its own yaw sensor.

The yaw system automatically untwists the power cables after a specified number of turns have been experienced (one turn when not connected parallel with the grid while two turns when connected to the grid).

A mechanical locking device is provided to prevent yawing of the nacelle when maintenance is being carried out on the yaw motors and brakes.

2.5 Power Transmission

a) Main Shaft

The main shaft is designed for all relevant load conditions including extreme and fatigue loading and the material used is ductile.

b) Shafts and Couplings

Turbo winds supplies suitable shafts and couplings for supporting and connecting the main rotating components. They are designed for the maximum torque loading that can be transmitted with appropriate allowance for the continuous variation in torque, braking loads and frequency of starts and stops and loads due to generator short circuits.
Couplings are capable of accommodating the maximum misalignments and axial displacements which are expected.

c) Gear box

The gear box is of adequate strength to meet all loads imposed on them. In addition to those during normal operation these will include loads due to braking, both normal and emergency, generator short circuits and starting. They will not suffer any damage during overs peed following the operation of the over speed trip devices. The design, manufacture and installation of the gearboxes is such that the external noise arising from them is kept to a minimum.
An oil temperature gauge is fitted on each gearbox. Filler and drain plugs are provided.
The oil is cooled by external oil cooler when a certain oil temperature level is reached.

d) Guards

All rotating and moving components including couplings will be enclosed or guarded so that it is not possible for operators to come into contact with them when the machinery is moving or when there is any risk of it moving. Where the guards are in the form of doors, locks will be provided.

2.6 Bearings

All bearings supplied are designed for the life of the plant.

3 GENERATOR

The double speed generator is a 3-phase medium voltage induction type. The generator has a soft start system (patented soft resistor system) to avoid excessive inrush current during starting.

The generator supplied is of standard design. It is capable of operating with high reliability under all operating conditions with due allowance for the variable output imposed by the fluctuations in wind speed. It is capable of handling load rejection and other system faults including the maximum over speed that it can reach on operation of the over speed trips

The generator is connected to the grid by a “patented” soft start system to ensure a gentle increase of the current. The starting device will ensure a soft start whether the WTG is started manually or by the control system. The starting device is short circuited when the generator has been connected to the grid.

The generator is designed to avoid the build up of condensation in the windings by the use of anti-condensation heaters.

In considering the design of the generator cooling air fan Turbo winds ensures that this complies with noise limitations.

The bearings can be efficiently lubricated at all running speeds. Provision is made for preventing lubricant from gaining access to the windings or other current carrying parts.

The generator will be capable of withstanding the maximum overload conditions for the maximum conceivable duration.

The generator is constructed to withstand direct connection at synchronous speed to the grid.

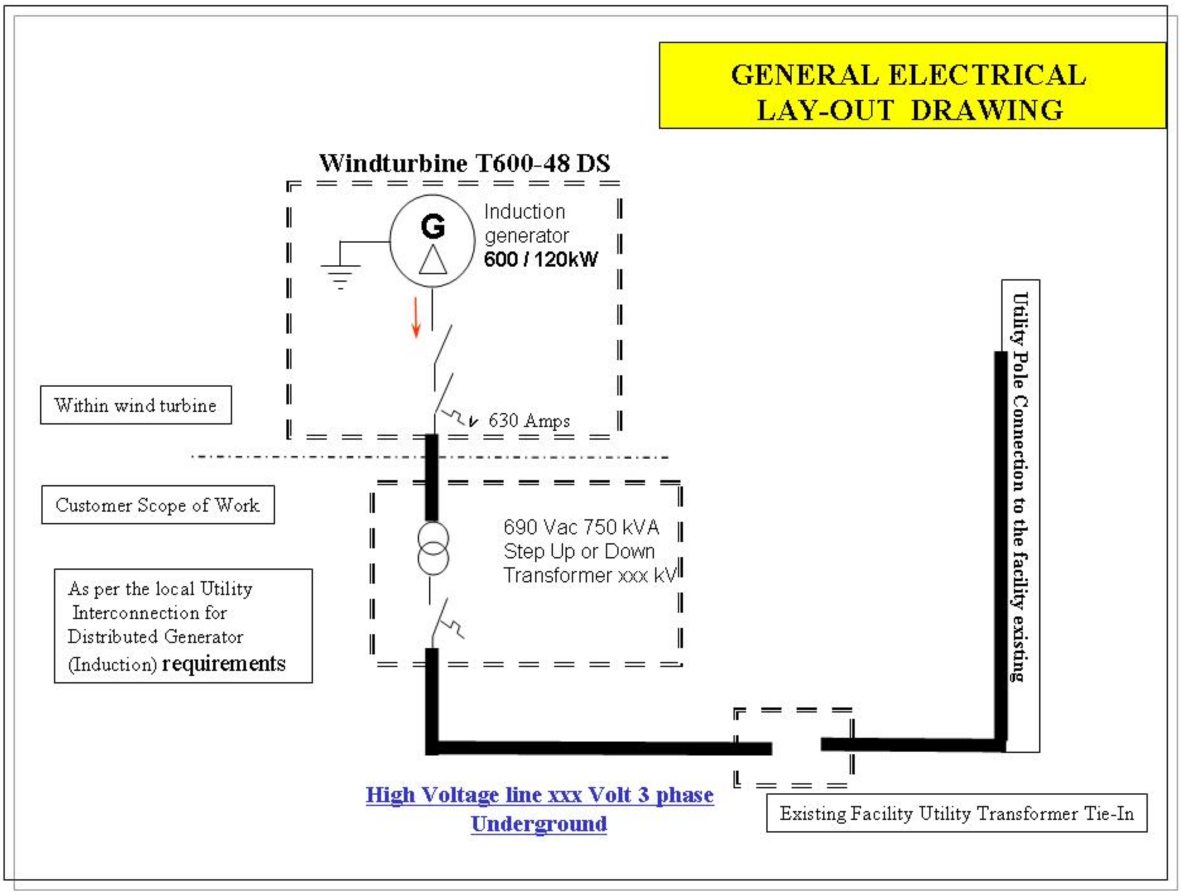
The generator is provided with temperature sensors incorporated in the stator windings for temperature protection.

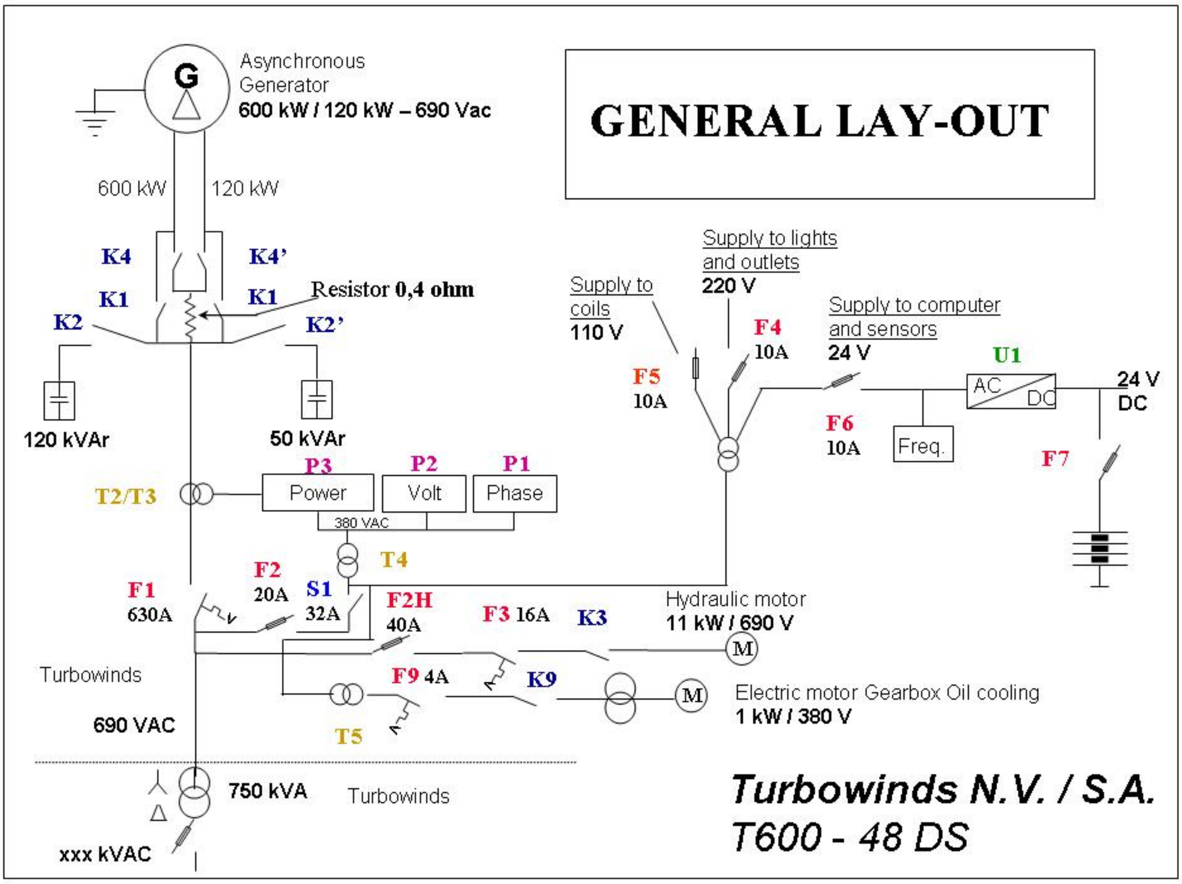
4 ELECTRICAL

The electrical installation is designed for continuous operation under the specified Site climatic conditions. Circuits with different voltages will be segregated .

Due to high humidity conditions anti-condensation heaters are needed where necessary.

Single line diagram :





Main Electrical Component Manufacturers

Main Circuit Breakers:
F1: Main Circuit Breaker (Klockner-Moeller) – UL 489 / CSA 22.2 no. 5,1
F4/F5/F6/F7 Circuit Breakers (ABB) – UL listed
K1/K2/K3/K4: Contactors – ABB – UL listed
Capacitor Bank Units – ABB
CLMD 83 690/50-120 (120 kvar)
CLMD 63 690/50-50 (50 kvar)

Reactive power compensation Schemes

For 600 KW generator the power factor at full load is 0.89 without power factor correction. Therefore reactive power consumed is approx. 307 kVAR. Switching on both capacitors banks of 170 kvar (120+50), the power factor will be 0.975

For 120 KW generator the power factor at full load is 0.82 without power factor correction. Therefore reactive power consumed is approx. 83 kVAR.

Switching on one small capacitor banks of 50 kvar, the power factor will be 0.96

4.1 Circuit Protection

Each generator has separate short-circuit protection and overload protection on all phases.

The protective devices are rated for making/breaking the maximum short-circuit current which can occur at the point of installation where it is used.

Contactors applied for connection of the generator to the gird have a breaking capacity larger than the direct on line starting current for the generator when operating as a motor.

Hydraulic pumps, yaw motor and power supplies for control circuits, have individual protection against short circuits and overload.

Over current relays are adjustable at least within the range 90-110% of the rated full load current.

4.2 Protection Requirements

The protection system for each generator should include the following:

1. Negative Phase Sequence (NPS) protection
2. Frequency
3. Over current
4. Over voltage

4.3 Capacitor Banks

Capacitor banks & APFC panel are provided to ensure that the power factor is almost unity.

The cut-in and cut-out of the banks will be automatically controlled by separate contactors.

The capacitors will be of the metallised film type, and correspond to the rated voltage and frequency.

The capacitors are provided with a means of draining the stored charge and of preventing charge build up during maintenance work.

The capacitor bank is enclosed so that persons cannot come in to accidental contact or bring conducting material into accidental contact with exposed energised parts, terminals or buses associated with them.

The enclosure and capacitor cases will be earthed for protection.

4.4 Power Transformers (For reference only)

Turbowinds recommends use of step up or step down transformer of 750 kVA from 690 V to the facility service voltage for interconnection of wind turbine generator as per the local utility requirements.

Transformers shall be located at out door on the plinth with well equipped 2 pole DP structure.

The transformers are required to design set up with off load tap changing facilities on the high voltage side with a minimum range of +5 % to –5 % in 2.5 % steps and suitable transformer impedance for the duty. Tap changers will be manually operated. Indication of tap position is clearly visible from ground level.

The transformer is accessible only to authorised personnel.

4.5 Earthing (For reference only)

The WTG earthing grid is designed for adequate dissipation capacity from earth current under the most severe conditions in high earth fault current concentration areas; grid spacing will be sufficient for maintaining voltage gradients.

A terminal bar for equipment earthing is provided and secured inside each enclosure for the attachment of the earth conductor and all the internal/external earth conductors.

The terminal bar is bonded to the cabinet and to all non current conducting parts.

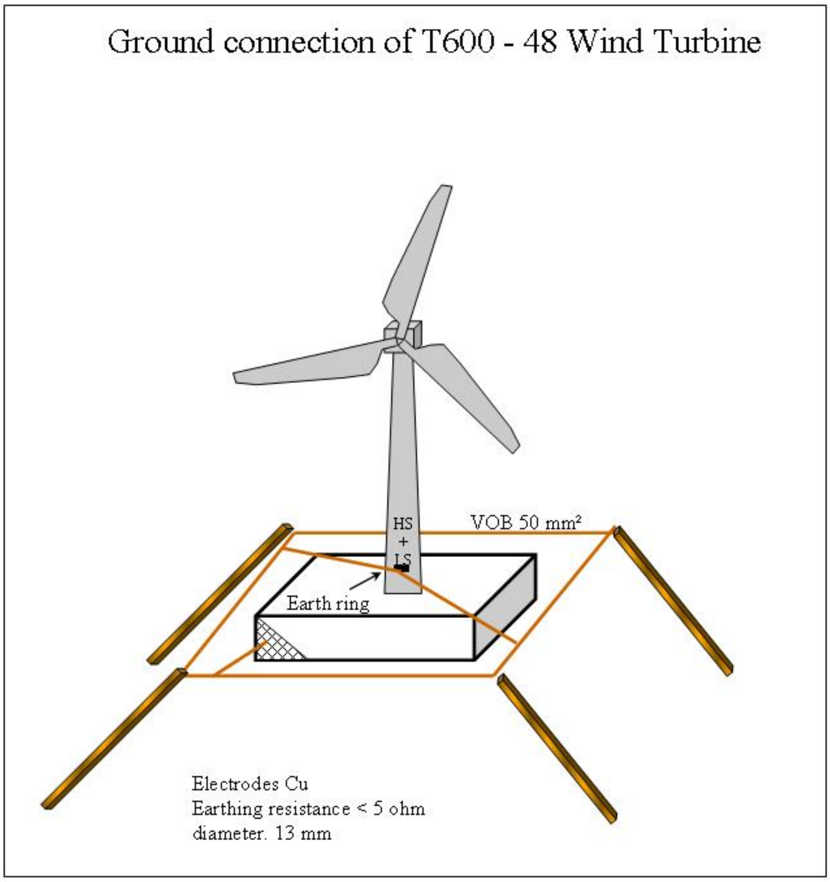
Bonding is provided where necessary to assure electrical continuity and the capacity to conduct safely any fault current likely to be imposed.

A bonding jumper is a wire, bus, screw or similar suitable conductor.

All metal parts are bonded to earth using a stranded copper conductor of minimum size 1.5 mm^2. All earth screws will be high strength bronze.

An earthing grid using a ring conductor with earthing rods with a minimum diameter of 13 mm will be installed to give a maximum resistance of 10 ohm at each WTG or to the requirements of local regulations. The materials used will be compatible with the existing environmental conditions. The resistance will be confirmed by means of primary injection testing prior to commissioning.

All above ground earth cables will be insulated.



4.6 Interconnection (For reference only)

The interconnection between wind turbines and step up transformers is an underground cabling system will be as per the local code requirements and utility interconnection requirements for Induction generators.

4.7 Tower Facilities

One standard 10A 220V general-purpose single phase electric outlet is installed in the base of the tower, in close proximity to the main internal light switch. The main internal light switch operates all lights within the tower. Lights are installed to provide adequate lighting in all areas within the wind turbine tower, at the base and at the top.

One standard 10A 220V general-purpose single-phase electric outlet is provided in the nacelle.

5 CONTROLS & INSTRUMENTATION

5.1 Control Principles and Scope

The control system is designed for safe and efficient operation, control and monitoring of the wind farm and individual WTGs based on an automatic, unattended operation using microprocessor systems.

Turbowinds offers proven equipment, of which Turbowinds can demonstrate satisfactory experience.

Components sensitive to extreme temperatures and/or high humidity are protected against these conditions to insure reliable operation.

The control system is self-monitoring such that a safe shutdown occurs in the case of a control system malfunction.

The control system is readily expandable to allow for future additions and modifications.

There is no possibility of self-excitation of any wind turbine due to transmission line capacitance.

<u>Optional :</u>
The control system provides a central monitoring and control system for the Wind Farm with individual local controllers at each WTG. These systems will include:

(a) Information for the operator, both locally and remotely, to be able to quickly identify faults and initiate remedial action.

(b) A comprehensive log of historical and real time information to monitor specific plant condition.

(c) Modem and interface cards to interface for remote access.

(d) a personnel pager interface and auto dialler whereby any alarm from the Wind Farm (in the unattended model) activates a selected pager alerting operations personnel to the alarm type.

(e) an Uninterruptible Power Supply (UPS).

(f) The software is developed using a standard programming language.

5.2 Wind Turbine Generator Controller

The following commands are included as a minimum for each WTG:

- Reset WTG

- Stop WTG – normal and emergency
- Start yawing right or left
- Stop yawing
- Start WTG
- Change control limits

Adequate provision is made for interlocks to prevent unsafe operation of the WTG while site personnel are working on them.

The WTG manufacturer's standard instrumentation for unattended, automatic operation is acceptable consistent with it including the minimum instrumentation required to carry out all service and set up functions required by the service manuals and the grid connection authority.

The control panel is provided with a display, to present the data and status of the WTG.

The computer system monitors and displays the following parameters for the WTG:

- Voltage (V), in rms values
- Frequency (Hz)
- Generator revolution speed (rpm)
- Actual active power production (kW)
- Accumulated energy for each WTG (kWh)
- Operation hours for each WTG (h)
- Entry alarms
- Type of fault and time for shut down (error code, month, day, hour and minute)
- Status of each Generator
- Yaw system position
- Wind speed and direction
- Trending graphs for above data

Display lay outs:

Screen 1:

RPM	BLADE	Yaw	kWsec	Mast	wind	Freq
1808	235	30046	602G	15.5	15.2	60.1 Hz

RPM's: are measured 1 rpm accurate and each 100 msec.
BLADE: blade position, measured by analog input and each 50 msec.
Yaw: yaw position, 0.05 degrees accurate and measured each 100 msec.
KWsec.: kWatt last second, 0.5 kW accurate and measured each 50 msec.
Mast: this is the windspeed sent by central datacomm computer (if available) and measured from a central windspeed mast.
Wind: this is the windspeed from the windspeed meter mounted at the back of the nacelle (1 second average).
Freq.: grid frequency, 0.1 Hz accurate and measured each 1 msec.

Screen 2:

RPMmax	RPMmin	Windmin	Volt	position
1815	1798	15.1	692	3 - 20

RPMmax: maximum rpm which has been measured while connected.
RPMmin: minimum rpm which has been measured while connected.
Windmin: this is the windspeed from the windspeed meter mounted at the back of the nacelle (1 minute average).
Volt: voltage from the grid between lines 1 and 3 measured each 100 msec and 1 Vac accurate.
position: this indicates if the windturbine is in idling mode (1), measuring mode (2), climb up mode (3) or in connected mode (4). Together with the position mode, the timer countdown is shown in seconds.

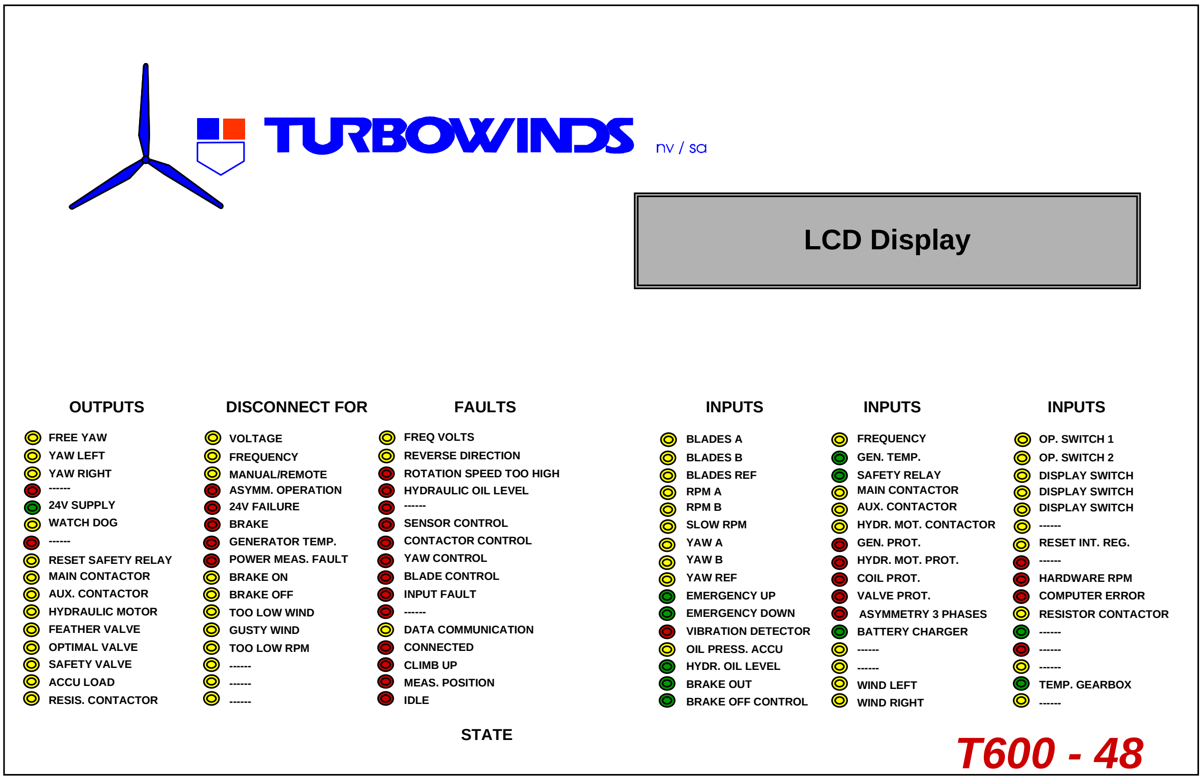
Screen 3:

kWmin	kWhour	kWhmot	Produced	Operated
602G	595G	00014	1820M872k	07613h46

kWmin: kWatt produced during last minute.
kWhour: kWatt produced during last hour.
kWhmot: kWh consumed by the windturbine due to low winds.
Produced: total produced MWh and kWh since beginning of power production.
Operated: total hours and minutes connected to the grid.

Screen 4 to 8 :

See chapter 8 for a complete list of possible display messages on these screens.



6 TOWER

The wind generator support structure is a single tubular steel column with a neat and visually unobtrusive appearance designed fabricated and erected in accordance with Standard Technical Specification for Structural Steelwork.

Safe and sufficient access to the nacelle will be provided directly from the tower using an internal ladder. Tower access and cabling will be designed to avoid interference and ensure safe conditions.

A platform is provided close to the top of the tower at an adequate height for safe and easy inspection of the yaw arrangement and for access to the nacelle.

An inspection platform is also included below each tower section assembly in the case where bolted joints are used.

The internal access does not interfere with any cables, which may hang down the tower.

A floor is foreseen at the base of tower at an adequate height to ensure easy access to and readout from the controller unit.

The tower is designed to avoid critical resonances at the normal rotational speed of the wind turbine and to ensure the necessary safety against dynamic and extreme loads. The tower is designed to withstand all possible load cases.

Where bolted flange connections are used for tower section assembly adequate protection will be applied before assembling to ensure full resistance against intrusion of water and moisture.