1287-95

NoordzeeWind

Near Shore Windpark

Wbr/Wm vergunningaanvraag NSW

Bijlage VI:

- Onderhoudsplan -

Bijlage II

Operation Manual – NM80 & NM92

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Operation Manual – NM80 & NM92

Document opgemaakt ten behoeve van Wbr/Wm vergunningaanvraag Near Shore Windpark.

Opgemaakt door:
NoordzeeWind consortium

Bestaande uit:

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Aangeboden aan:
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Rev.	Datum:	Status:
0	18-03-03	Concept; voor commentaar
1	16-06-03	Definitief; voor vergunningaanvraag

Operation Manual

NM80/NM92

TIC 726'003 GB

Preface and Revision

This operating manual relates to the NM80/2750 & NM92/2750 On-shore

The manual is the wind turbine generator owner's and operating manager's "vade mecum". It contains safety and operating instructions, together with a general description of the wind turbine generator's layout and design. It also describes the possible error situations and how to reset the control system and resume operations. This manual provides together with the Service Manual information on the service maintenance of the plant, to enable the owner or operator to take care of it and ensure that at all times the wind turbine generator is operating safely and correctly.

The manual is subject to revision based on current experience. This will maintain optimum performance and availability. The revision control system is described in the following..

The contents of the manual and the procedures in it have been generated by NEGM's R&D and Servicing Departments and prepared in consultation with suppliers and in accordance with approving authorities' recommendations and requirements. NEGM (TIC) urges users of this manual to forward any suggestions for corrections or improvements so that these can be incorporated in the next revision.

Manufacturer:

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Revision	Date	Description of changes
01	24-10-2002	New document
02		
03		

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1 General Information

1.1 The wind turbine generator

An NEGM wind turbine generator is a mechanical plant functioning as a power station and supplying electricity to the electricity grid. It is vital for safety that the plant is handled correctly and in accordance with this manual. Compliance with the manual's rules and instructions will ensure the plant a long service life and the minimum operating and maintenance costs.

NEGM's operating and control manual must be read carefully before operating the control system, mounting the tower or maintaining the plant. The safety regulations described in the next chapther must also be read and followed scrupulously.

1.2 Liability and guarantee

The turbine owner has general responsibility for the operation and safety of the plant and must prevent all risks of the grid being brought down by its operation. Normally the owner will cooperate with NEGM's Servicing Department over this, on the basis of a Servicing Contract.

If major renovation work or the replacement of large parts is to be carried out after the expiry of the guarantee or servicing period, the owner must contact NEGM's Servicing Department. It must be borne in mind that detailed knowledge of and experience with lifting equipment, weights and the weight distribution of the different components is necessary in order to avoid accidental damage or injury to parts or persons during this work.

NEGM accepts no liability for direct damage or injury or consequential claims arising where the turbine owner himself carries out work to the plant or has it done by persons not approved by NEGM.

The turbine owner should inspect the plant at regular intervals to familiarize himself with normal operation and noise patterns. In this way, non-conforming operating forms or noises can immediately reveal problems with the wind turbine generator, allowing the turbine owner to intervene and report the matter to NEGM's Servicing Department.

The wind turbine generator should be kept clean and tidy on safety grounds, and also to make it easier to detect leaks.

During the period that the turbine is covered by NEGM's guarantee or servicing contract, servicing and other work on the plant may only be undertaken by NEGM's service engineers or carried out by persons working under NEGM's instructions and liability. If the turbine owner carries out work on the plant himself without express consent or instructions from NEGM's Servicing department or has the work done by non-authorised persons for whom NEGM can have no responsibility, NEGM's guarantee and liability for servicing work shall be immediately void.

1.3 Maintenance and servicing

Prior to carrying out maintenance or servicing work it is an absolute requirement that the prescribed safety rules and requirements described in the service manual are read and observed.

Regular servicing routines are described in the Service Manual, which has been prepared for the use of NEGM servicing staff.

2 Safety

2.1 General Safety

A wind turbine power plant with its rotating mechanical parts presents many potentially dangerous situations.

The door to the wind turbine tower must be kept locked to prevent unauthorized persons gaining access or operating the control panel.

The safety rules, signs and instructions in the wind turbine must be followed. If a sign is damaged or unreadable it must be reported and replaced.

The following safety instructions must be read, understood and unconditionally followed.

Governmental or local safety regulations can extend or overrule parts of this chapter. Always be updated on local regulations.

NOTE: If doing Service & Maintenance or other work on the turbine the safety chapter in the Service manual must be read and followed. This safety chapter relates to normal visit and operating the turbine.

2.2 Approach to the Turbine

Adults must keep children under close surveillance.

Do not stand beneath the rotor or near the wind turbine when the rotor blades are covered with ice or in lightning storms.

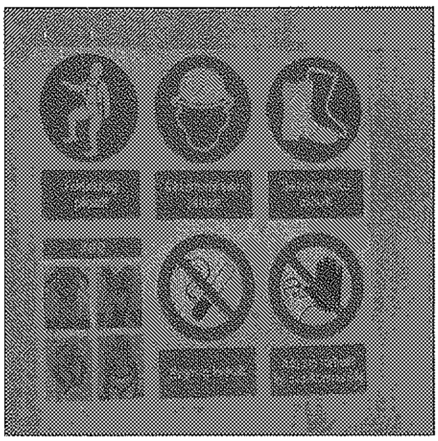
2.3 Entering and Ascending the Turbine

The wind turbine must always be shut down before ascent. If the stop command has not been given at the control panel before leaving the tower floor, the wind turbine will automatically stop when the platform hatch is opened during ascent.

A safety helmet must be used for head protection. Use suitable safety shoes for climbing the ladder.

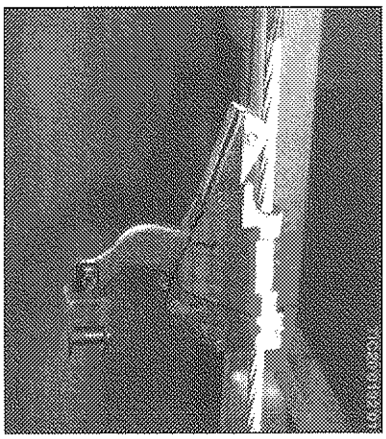
The safety harness and fall arrest must be used during ascent and descent. Instructions for using the safety harness are located just inside the tower entrance

Signs



Safety harness

Glider on ladder



Do not remain in the ladder shaft when another person is climbing and all hatches in the platforms must be closed after passage.

The remote control system must be locked and the controller set to "service mode" before ascent or inspection of the wind turbine to prevent undesired remote start commands.

Never climb the ladder or inspect the turbine alone. For safety reasons at least two persons must be present if any kind of job has to be carried out on the wind turbine.

Smoking is not allowed.

All persons present must always be aware of the location of the other individuals. Remember to tell the other persons when you intend to move to another location and what you will be doing, and make sure that everybody understands and confirms your message before you move.

2.4 In Case of Fire

In case of fire in the nacelle or the wind turbine controller the plant must be evacuated immediately and the power supply from the grid cut off as soon as possible, either at the power panel circuit breaker within the wind turbine or at the transformer station. If possible the operations manager must be informed without delay so that the necessary procedures relating to the grid can be implemented.

Put out the fire with the extinguisher if possible.

If the fire is out of control, the area around the wind turbine must be cordoned off and the Police/Fire Department/Service Department informed.

2.5 Lightning and thunderstorms

A thunderstorm entails the possibility of lightning striking the wind turbine in spite of all lightning protection equipment.

Do not remain inside or near the wind turbine and so be exposed to a possible fatal injury caused by lightning.

When the thunderstorm has passed over, personnel must wait at least an hour before approaching the wind turbine. Continuing rustling or hissing sounds from wet rotor blades show that they still carry an electric charge, so do not go near or touch the plant.

If the wind turbine is hit by lightning strike, the power supply must be cut off and the NEGM Service Department informed. Normally a strike will cause tripping of the maximum current breaker and damage of the lightning DEHN-Guard

2.6 In Case of Unusual Sound Patterns

It is always important for the wind turbine owner or operator to become familiar with the sound patterns of the plant. An unusual sound or noise often reveals that an abnormal or dangerous situation has occurred or is under development.

If unexplained or strange noises should occur during normal operation, the Service Department should be informed. Further the wind turbine should be stopped if it is judged that continued operation could turn out to be dangerous or cause greater damage and repair costs.

2.7 In Case of Run Away

An uncontrolled run away will hardly ever take place, because it would require a combination of many unfortunate circumstances. However, should an uncontrolled run away take place the area around the wind turbine must be evacuated immediately and the area cordoned off. Do not try to stop or save the wind turbine. The plant can be replaced - human lives cannot be!

No persons must venture closer than 500 metres to a runaway rotor.

2.8 In the Nacelle Compartment

A safety helmet must be used for head protection. Use suitable safety shoes for climbing the ladder. The safety harness and fall arrest must be used during ascent and descent

At wind speed above 8 m/s the nacelle hatch should not be opened unless the nacelle is positioned upwind or downwind. Regardless the nacelle orientation it is not allowed to open the hatches in wind speeds above 15 m/s.

2.9 Safety and emergency line

The turbine is fitted with two emergency lines, one for personnel protection named 'emergency line' and one for turbine-protection named 'safety line'. The emergency line contains several E-stop push bottoms and a switch at the hub hatch. The safety line contains vibration ball and over speed module (TAC85). If the emergency line opens, the safety line will be opened as well, because it is a 'slave' of the emergency line.

The control related components are listed below:

- Emergency stop push buttons
- Hub hatch switch
- Emergency relay
- Battery supply with charger
- TAC85 module
- Vibration ball
- Safety relay

If the safety line is opened, supplies to pitch system and stator contactor are removed, the blades will do a safety shutdown, and the converter disconnects immediately.

Note 1: The shaft brake is not applied by hardware in this situation.

Note 2: During a grid loss the safety line <u>will</u> remain opened

If the emergency line is opened, all supply to pumps, contactors etc (control voltage) are removed, and the shaft brake is applied. The shaft brake will also remain released during a grid loss, because the emergency line is supplied by a backup-battery. The safety line during a grid loss will be opened because the grid supplies it.

In case of one of the two lines is opened, the controller will do shut down sequencing to imitate the hardware opening the lines. If safety line is opened it will initiate a stop-function 'Idling stop'. If the emergency line is opened, it will also apply the brake immediately by using stop-function 'Apply shaft brake immediately'.

The figure below sketches the two lines.

If one of the components in the emergency line breaks the line, the emergency relay opens and supply to all contactors and relays are removed. The shutdown of the turbine is done by hardware, but the main controller will imitate it.

Due to an emergency stop the turbine will do a shut down as described in the following:

- The supply to all relays and contactors are removed
- The shaft brake is applied
- The pitch system is driving the blades to the stop position under blade battery control
- The stator contactor disconnects the stator from the grid

If one of the components in the safety line breaks the line, safety relay opens and the supply to pitch system and stator contactor are removed. The shut down of the turbine is done by hardware, but main controller will imitate it.

Due to a safety stop the turbine will shutdown as described in the following:

- Supply voltage to pitch system and stator contactor are removed
- The shaft brake will remain released
- The pitch system is driving the blades to the stop position under blade battery control
- The stator contactor disconnects the stator from the grid

TAC85 has two speed sensor inputs. One of the speed sensors is measuring the speed of the slow rotating rotor shaft (LSS) and the other at the fast rotating generator shaft (HSS). If one or both measured speed is above limits, the TAC85 will trip the safety line.

The main controller does not automatic restart after an emergency stop. Operator action is needed for starting the turbine after an emergency/safety stop. After a safety stop caused by a grid fault the main controller will automatic reconnect the safety line after power is recognized, if TAC85 or vibration ball is not detected.

3 Functional Description of wind turbine

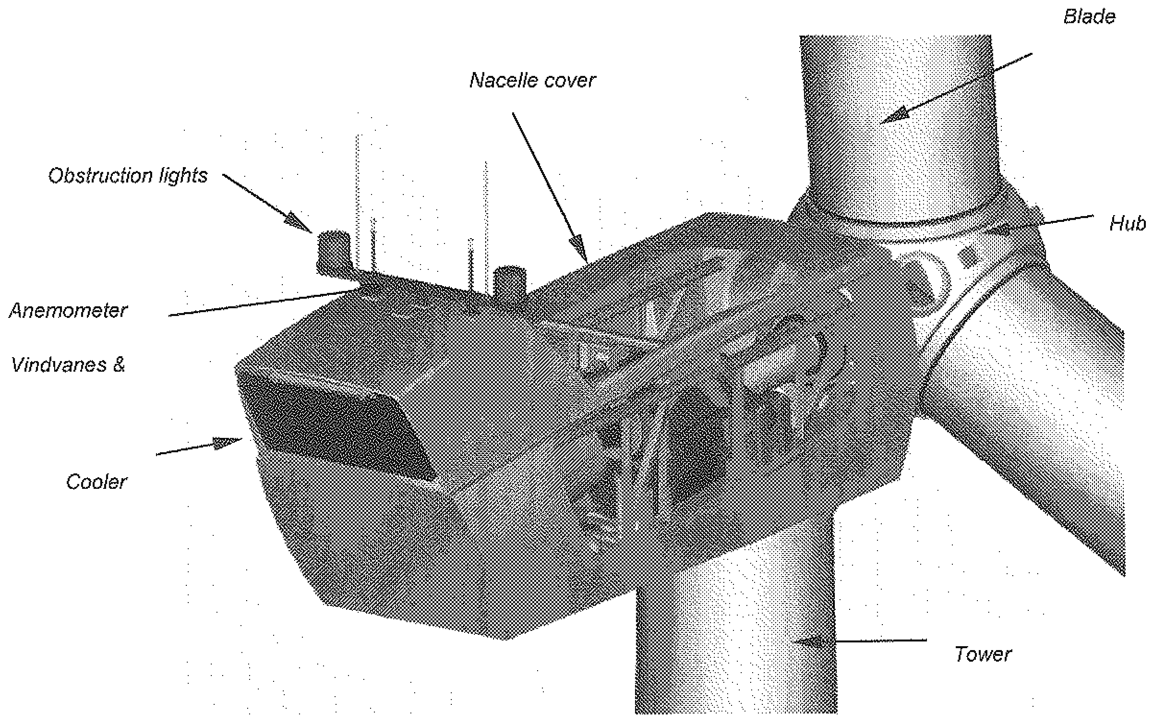
3.1 Wind Turbine Main Data Overview NM80

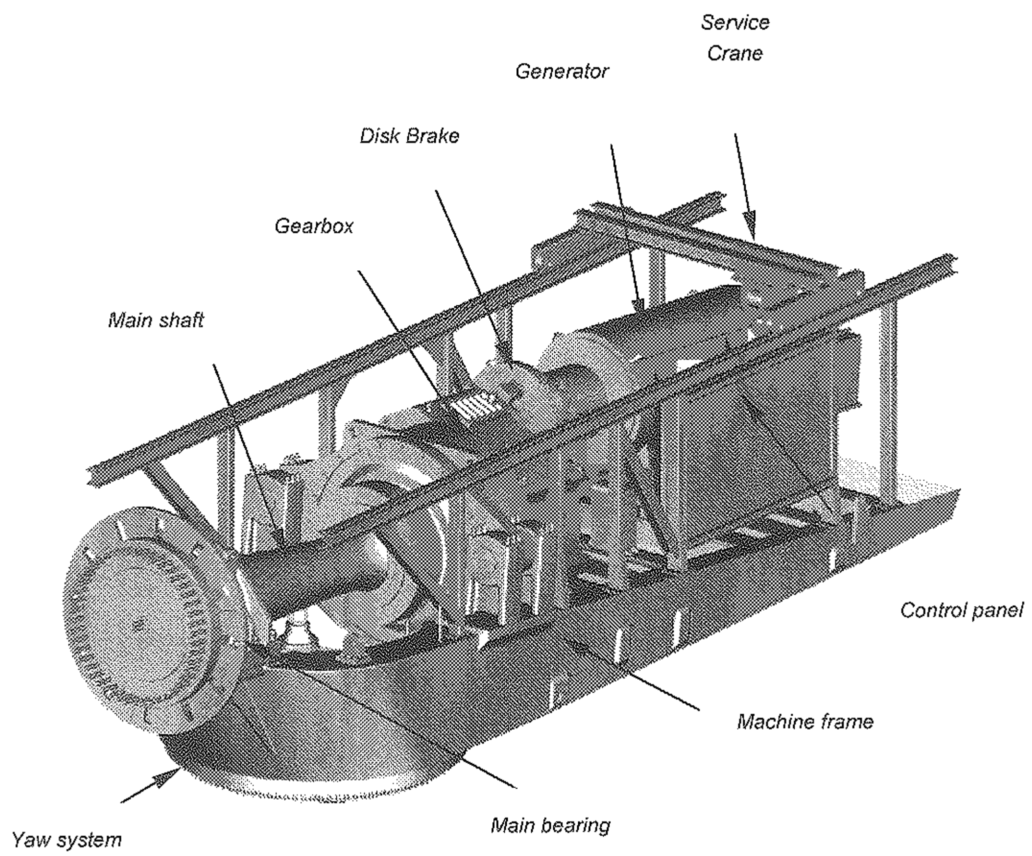
- Nominal power 2750 kW
- Nominal voltage 960 V / 670 V
- Rotor diameter 80 m
- Swept area 5027 m^2
- Rotational speed max. 17.5 rpm
- Control PRVS (Pitch Regulated Variable Speed)
- Generator Double feed asynchronous, water cooled
- Frequency converter IGBT PWM frequency converter
- Brake system Individual blade pitch with back up batteries, disk brake
- Hub height 60 m and 70 m

3.2 Wind Turbine Main Data Overview NM92

- Nominal power 2750 kW
- Nominal voltage 960 V / 670 V
- Rotor diameter 92 m
- Swept area 6648 m^2
- Rotor speed (max) 15.6 rpm
- Control PRVS (Pitch Regulated Variable Speed)
- Generator Doubl fed asynchronous, water cooled
- Frequency converter IGBT PWM frequency converter
- Brake system Individual blade pitch with back up batteries, disk brake on motor shaft
- Hub height 77,6 m and 80 m

3.3 Wind Turbine Component Overview





3.4 Control System

The TAC controller is the central control unit or the main controller in the wind turbine. Its primary purpose is to ensure that turbine's mechanical components are not subjected to any excess strain, whatever the operating conditions. To achieve this, the main controller must monitor wind speed, wind direction, temperature, pressure, speed of rotation, blades angle, current, voltage, etc. The monitor value measurements are gathered via the converter controller, the hub controller and two input/output modules called TOI#1 and TOI#2.

An important parameter is the measurement of the rotation speed and acceleration of the generator. An inductive detector placed on the flange of the generator shaft continuously checks this. Knowledge of the rotation speed and acceleration permits the frequency converter to adapt the generator output to the grid both at cut-in and at changes in wind speed during operation. A rpm sensor is also placed on the rotor shaft flange, where the bolt heads are used as an indicator. The turbine computer constantly monitors the rotor shaft speed measurement to confirm that the generator shaft sensor is transmitting the correct signal.

The main controller is in continual communication with the hub controller and the converter controller. The hub controller, which controls the turning of the blades, is acting as a servo on a pitch position reference signal. The converter controller, controls the generator torque, is acting as a servo on a generator torque reference signal.

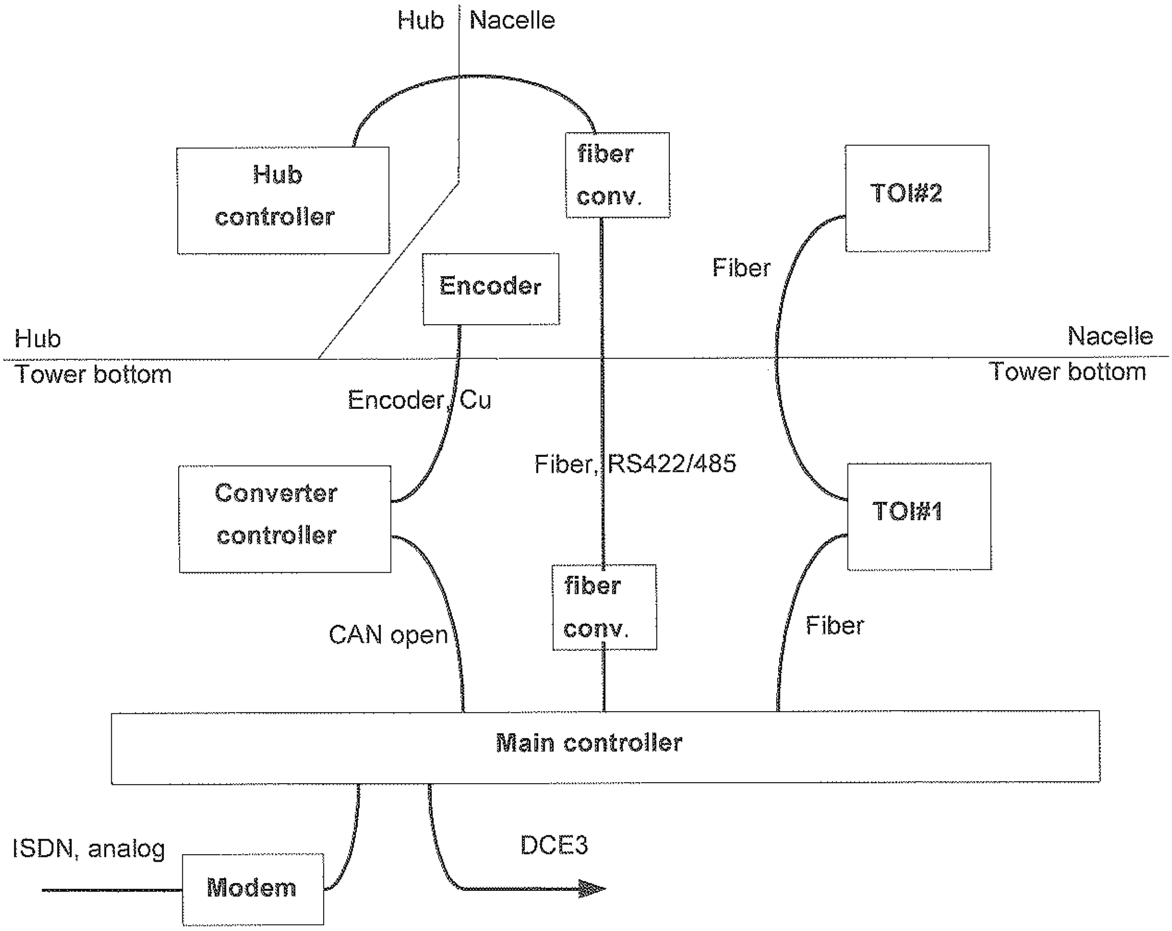
The hydraulic pressure levels are also monitored. When the start or stop command is given, the computer carries out various routines and testing functions which control the hydraulic systems, for the mechanical brake and the yawing system.

The main controller keeps the turbine in touch with the surroundings. The turbine is linked to a wind park monitoring server, or to the turbine owner and a service department via a built-in modem. Using the main controller display and keyboard it is possible to control all the turbine's functions. It is possible to control the turbine remotely from a PC.

The main controller collects and stores vital data about the wind turbine. This data can be downloaded via the serial communication channels or via modem, and can then be used in analyses. Remote control of the turbine and any such downloading of data require access to a special software program. This software is available on request from NEG Micon.

Turbine control system is distributed all over the turbine. The operation panel and the main panel are placed at the same level. The turbine controller contains several components. The most central controller components are described in chapter regarding controller panels.

The connection between the controller components is described in the following figure.



If a sensor measures values outside the selected operating parameters, the computer immediately shuts down the turbine. The cause of the operational stop is shown as text on the control system display.

For many of the possible error types an automatic start-up procedure is accepted once the operating parameters are normal again. For other errors a manual restart is necessary, using the control system or via remote control. In some situations it may be necessary to adjust or replace parts in the nacelle before the unit can be restarted.

Other areas of measurement not described here are located in the turbine control heavy current section, where there are motor protection checks and checks on fuses, relays and contacts

NOTE : Read Chapter 4 in this manual for more specifics on controller operation.

3.5 Turbine monitoring system

The main controller measure different turbine states variables via the two TOI's, the converter controller, the hub controller and the main controller it selves. The description of the states is grouped by types - temperatures, pressures, grid measurements, rotational speed, etc. The following section describes the variables.

3.5.1 Temperature monitoring

During operation, the controller monitors a number of turbine temperatures. Max/min values of these temperatures are stored in the controller. The temperature measurements are used for controlling subparts of the turbine like pumps, valves, motors, etc. The temperatures are also used for troubleshooting, i.e. the controller stops the turbine if one of the important temperatures exceeds or drops below a threshold values. If the alarm is on auto-reset, the specific alarm is active until the temperature is within the reset area. If the alarm has stop the turbine, the turbine automatic startup, when the alarm is reset.

The controller measure the temperature at the following locations:

1. Generator temperature
2. Generator bearing front temp.
3. Generator bearing rear temp.
4. Generator slip ring box temp.
5. Generator inlet temperature
6. Gear oil temperature
7. Gear bearing front temperature
8. Gear bearing rear temperature
9. Gear oil temp. after exchanger
10. Water temp. before cooler
11. Water temp. after cooler
12. Ambient temperature
13. Nacelle temperature
14. Yaw rim temperature
15. Main bearing temperature
16. Operation panel temperature
17. Main panel temperature
18. Control panel temperature
19. Converter ambient temperature
20. Stator filter temperature
21. Converter grid side 1 temp.
22. Converter grid side 2 temp.
23. Converter generator side 1 temp.
24. Converter generator side 2 temp.
25. Tower base temperature

26. Transformer temperature
27. Transformer room temperature
28. Transformer W1 temperature
29. Transformer W2 temperature
30. Transformer W3 temperature
31. Generator W1 temperature
32. Generator W2 temperature
33. Generator W3 temperature

Max/min values are used (by the turbine manufacturer) to establish whether there are any extreme temperatures that may adversely affect turbine service intervals.

3.5.2 Pressure monitoring

The controller continually monitors a number of pressures in the turbine. These pressures control the operation of the pumps and are used to monitor the turbine's operating condition. Any pressure reading outside the permitted levels will result in the turbine being stopped and an alarm message showing what detected alarm.

The following pressure readings are taken:

1. Pressure gear oil
2. Pressure gear oil filter
3. Pressure shaft brake
4. Pressure yaw brake

3.5.3 Humidity monitoring

The controller measure relative humidity (RH) in the turbine. The level of RH is important for safety of the turbine.

The controller measure the humidity at the following locations:

1. Humidity tower base
2. Humidity nacelle

3.5.4 Blade monitoring

The hub controller constantly monitors the angle of the blades. The blades must always have a position determined by the main controller (the TAC), which sends a constant flow of information regarding the desired position to the hub controller. The hub controller acts like a servo by following the position demanded from the main controller. If the blades do not turn as required, the turbine will be stopped and an alarm is triggered. Alarms detected in hub are transferred to the main controller, which handles further alarm sequencing, including displaying alarm-messages and eventually alarm call to hotline. The turbine is also stopped if the difference in the position of the blades during turning exceeds parameter-defined limits. In emergency situations, the hub is able to turn the blade to stop position using batteries.

3.5.5 Rotational speed monitoring

Inductive sensors are fitted on the turbine's low and high-speed shafts (HSS, LSS). These sensors give signals to the main controller, which in turn converts these to number of revolutions. The measurement point for the rotational speed is redundant, two sensor at the HSS and two sensors at the LSS. The redundant sensor configuration enables more reliable and more accurate measurement. If one sensor fails it is possible to carry on operating the turbine until the problem is fixed.

The speed on HSS and LSS is monitored constantly, and if the speed is found to be too fast, the main controller will stop the turbine. A decentralized safety module called TAC85, measure the speed of HSS and LSS, and shut down the turbine by braking the safety line if the speed is too high.

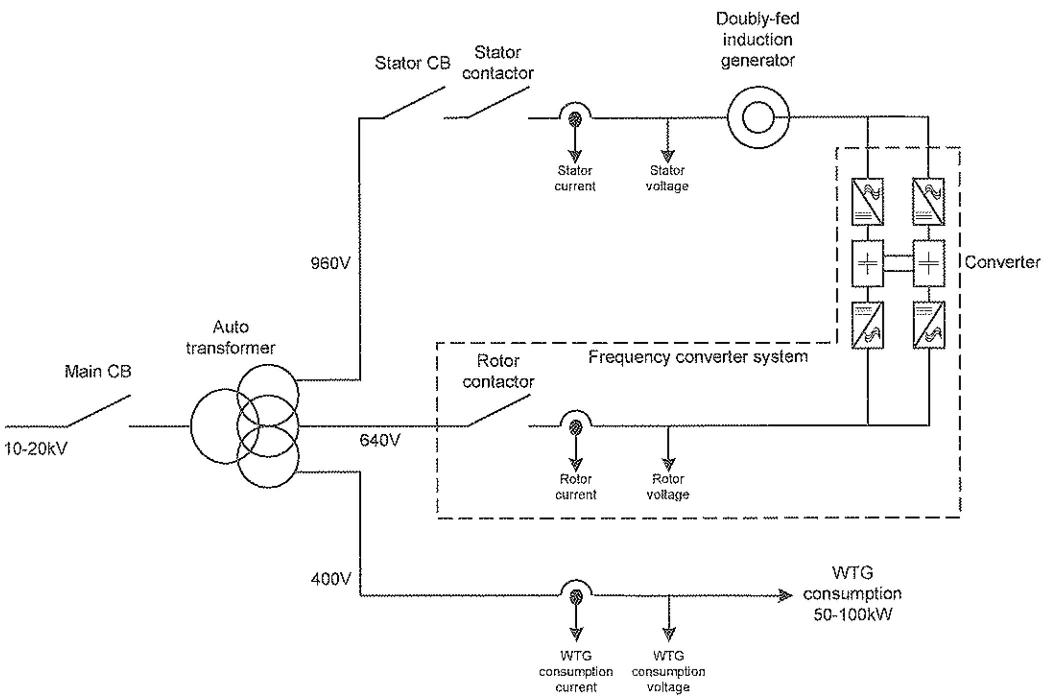
The speed signal is an important signal for the regulation algorithm. The control of the pitch position demand and the control of the generator torque demand are depending on the measured rotational speed.

3.5.6 Grid monitoring

The turbine is connected to the grid trough an autotransformer with three voltage levels.

1. WTG own consumption (400V)
2. Rotor connection via converter (640V)
3. Stator connection (960V)

The figure below is a rough sketch of the electric part of the WTG. The frequency converter system is marked with a dotted line.



The 960V measurements 'Stator current' and 'Stator voltage' and the 640V measurements 'Rotor current' and 'Rotor voltage' the converter controller uses to calculate the active and reactive power 'P_generator' and 'Q_generator'. The 400V measurements 'WTG consumption current' and 'WTG consumption voltage' the main controller uses to calculate the WTG own consumption active and reactive power 'P_consumption' and 'Q_consumption'.

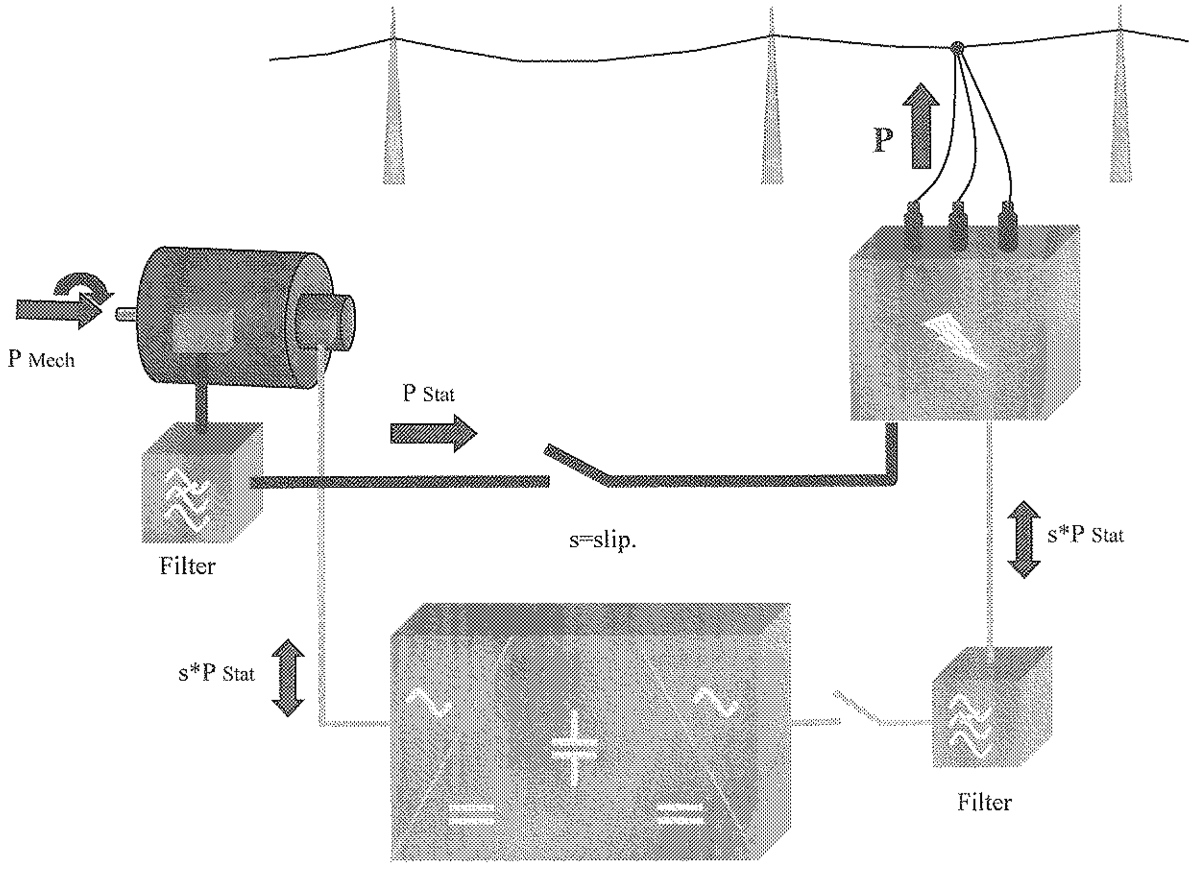
The main controller has three processors, one of which exclusively monitors and measures grid conditions on the WTG own consumption line. To perform this task, the processor uses an A/D converter with six analog input channels and a digital signal processor for the calculations of the various signals. The converter measures the grid condition at the grid side of the converter and the stator side of the generator, to secure the converter and the generator.

The grid data measured can be divided into the following groups:

Voltage	Voltage is measured continuously on all three phases. The values (RMS phase to ground) measured are stored and averaged using different averaging times. Voltage measurements, current and power factor are used to calculate turbine production and internal consumption. Voltage measurements are further used to stop the turbine in case of over voltage or under voltage.
Current	The current is measured continuously on all three phases. The values measured are stored and averaged using different averaging times. Current measuring and measuring of voltage are, among other things, used to calculate turbine production and auxiliary consumption. During operation, when the generator is connected to the grid, the current measurements are also used to monitor whether the load is symmetric in all three phases. If asymmetry is too high between the three phases, the turbine is stopped and an alarm message is displayed. The current measuring is further used to monitor failures of one or several phases.
Frequency	The frequency is measured continuously on one of the phases. The frequency values measured are stored and averaged using different factors. Frequency measuring is, among other things, used to stop the turbine in case of high frequency or low frequency.

3.6 Power drive and control

The electrical power drive system used in NM80-92/2750 is a double fed asynchronous generator and a frequency converter. The frequency converter is connected to the generator rotor through slip rings. The frequency converter can control the electromagnetic torque by acting on the electromagnetic field and the rotor current. As the frequency converter controls the electromagnetic field in the generator the reactive power can also be controlled. Regulating the pitch angle of the blades and the generator torque controls the speed of the turbine. Filters are built in to meet utility requirements regarding harmonic currents and voltages. Prior to grid connection, the generator is energized trough the rotor circuit, to completely eliminate current surges. In the figure below is seen a sketch of a double fed system. The Power range for the turbine is 0-2750 kW, within a voltage variation of ±10%, frequency variation of –5 to +3% and power factor from 0.9 inductive to 1.



3.7 Generator

The chosen generator suppliers have more than 1000 generators operating in field. The IP 54 protected generator has been designed according to NEGM. specifications. A 6-pole generator running at a nominal speed of 1100 RPM is used, compared to a 4 pole generator there will be less stress on the bearings. PT 100 sensors measure the temperatures of the electrically isolated ball bearings. Electrical isolated bearings, electrical isolated generator suspension and electrical isolated shaft are used to protect against damaging circulating currents.

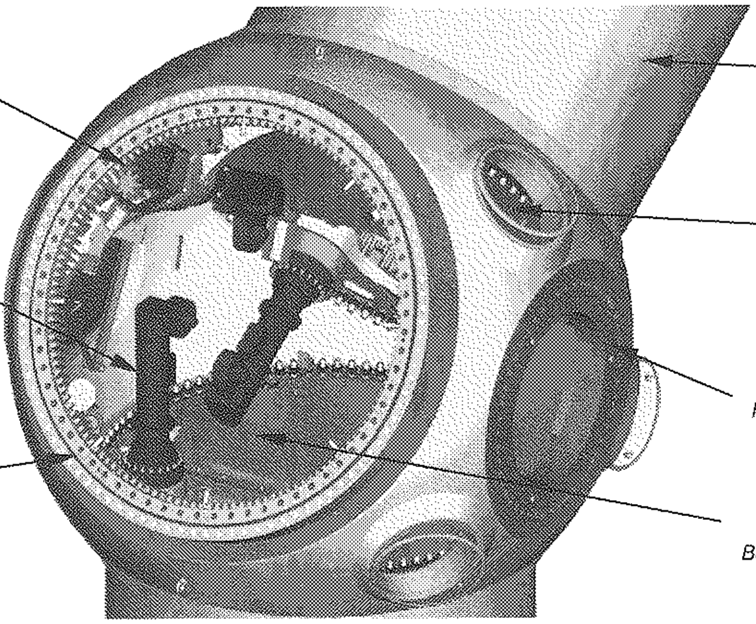
The generator is water jacket cooled. The water jacket cooling system is the primary cooling circuit. Water jacket cooled generators are standard for NEGM turbines. The liquid cooling circuit in the generator consists of a liquid inlet gland and a liquid outlet gland. The losses from the generator are transferred to the liquid in two separate ways at the same time. Directly by heat conduction from stator lamination to the liquid and further from the internal air-cooling circuit.

The slip ring is bought from suppliers with experience from more than 1000 systems. The design lifetime of the slip ring is at least 20 years and the service interval for the brushes is 8 month. Wear indicators are mounted on the brushes, so thereby service of the brushes can be done, before the brushes are worn out.

3.8 Frequency converter

The four-quadrant operating frequency converter is designed with the latest IGBT technology. The frequency converter controls the electromagnetic torque in the generator and thereby the speed in the turbine. By controlling the electrical torque in the generator, the flicker is reduced considerably. The converter also controls the reactive power in the wind turbine. Communication between the turbine controller TAC and the frequency converter is done by CAN bus. The frequency converter generates harmonics and therefore the stator circuit is equipped with filters, to meet grid requirements regarding harmonics.

3.9 Hub, Blades, Rotor System and Brake Strategy



The hub is cast SG Iron. The hub design is supported by full FEM calculations. Access to the hub is via one of 3 manholes at the rear of the hub, with easy access from the nacelle

They blades are of the type LM38.8P. The blades are 38.8 m long and made from fibreglass-reinforced polyester with a continuous fibreglass spar. The blade is mounted with a steel flange at the root end. The root has steel bushings to secure the strength of the blade.

The blade turning system consists of 3 independently controlled series-wound DC motors with integral brakes and absolute position encoders, each turning a pinion engaging with the inner race of a blade bearing via a 3-stage speed planetary reduction gearbox.

A 4-quadrant DC amplifier that receives a velocity demand from a controller in the hub drives each motor. The hub controller acts on input from the turbine main controller.

The rotor system is a Pitch Regulated system - the variation is arranged between 0 degrees and plus 90 degrees. This means that the leading edge is pointing into the wind direction during stop. Maximum power output corrections through blade pitch change will be made when a generator peak power output has been recorded. In order to gain valuable time as to re-adjust the blade pitch and to avoid peak power (at wind gust) to force high loads to the gearbox, variable speed rotation is introduced to the NM80. Please also see chapters regarding generator, electrical system and controller.

In the event of a safety system shutdown or loss of power/control system, an independent battery bank for each blade turns the blade to the stop position.

The rotor can automatically be put in the Y-position by use of the aerodynamic torque from the rotor. A sensor on the main shaft will apply the brake when the rotor has the right position. Each blade has an easy-to-fit maintenance lock that enables the blade to be locked in the parked position.

The blade turning system is the turbine main brake system. The mechanical brake is only used for servicing which requires stationary gear shafts or brake disk.

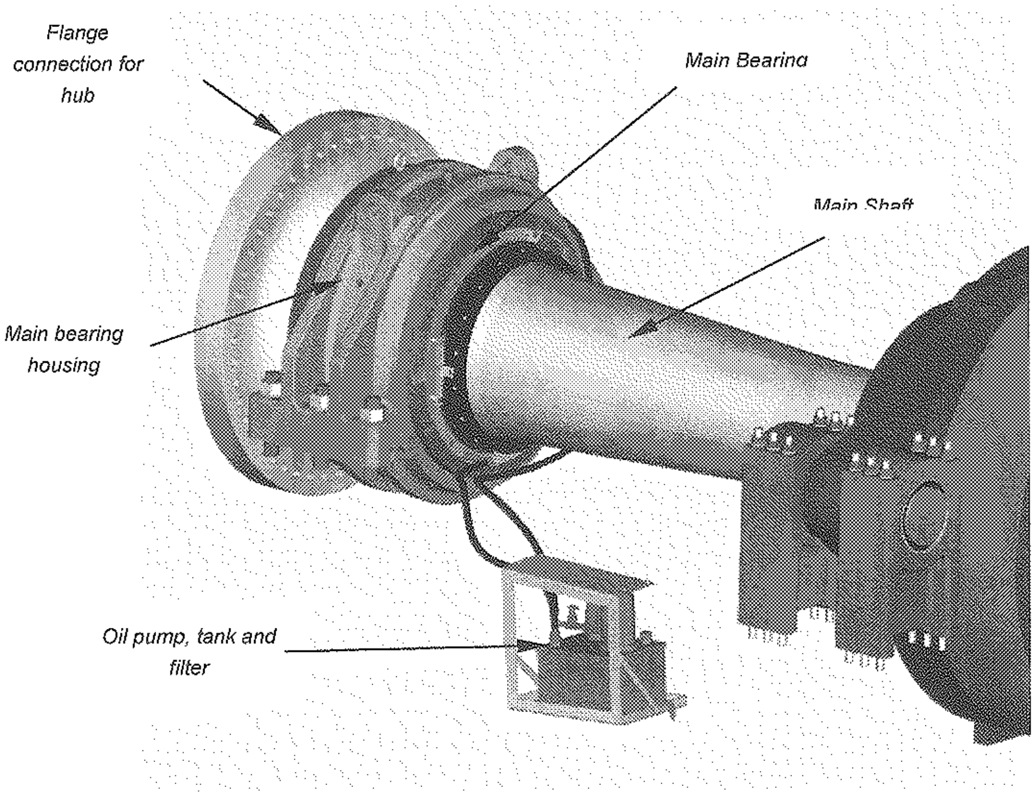
Emergency stop is performed when safety chain is activated as follows:

1. Disconnection of control voltage for all contactors
2. Disconnection of generator
3. Blades turns toward feather position on batteries
4. Turbine idling

Normal stop is performed for all other stop initiated by the control system as follows:

1. Blades turn with controlled speed towards feather position.
2. The generator follows the power speed curve and disconnected at n_{min} at zero power.
3. Turbine idling

3.10 Main Bearing & Shaft



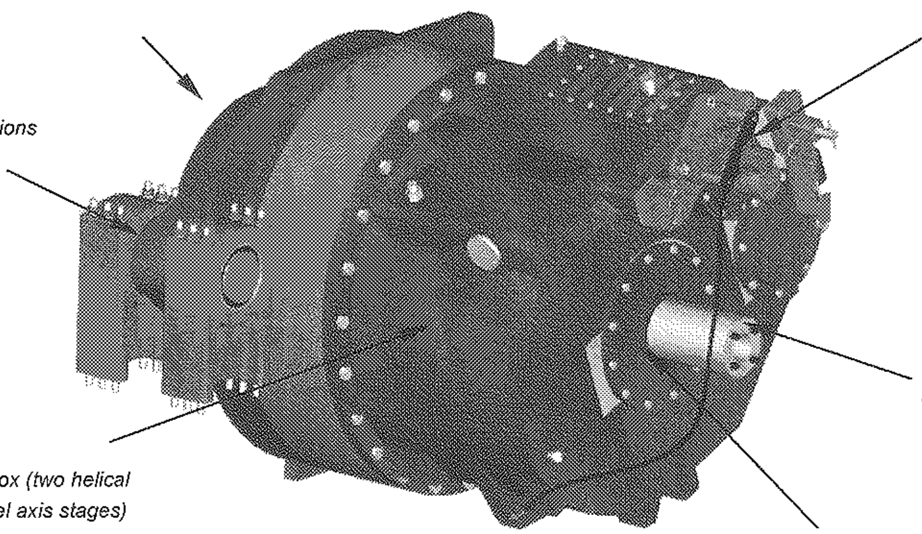
The main bearing is a double spherical roller bearing of the highest quality. Suppliers of this bearing are FAG and SKF. The main bearing arrangement is similar as on the other NEG Micon turbines, and for which good experience is gained.

The bearing is lubricated by an oil bath in the bearing housing and at regular intervals the oil is automatically changed by means of a separate oil pump with filter and tank. Excess oil returns to the oil tank.

The main shaft is supported by the main shaft bearing in front and connected to the gearbox input shaft at the other end.

The main shaft is hollow to allow for electrical power and communication lines to go from the nacelle to the pitch system in the hub. The main bearing housing is bolted directly onto the base frame.

3.11 Gearbox



NEG Micon uses custom-built gearboxes especially designed for the loads in a wind turbine with triple-point suspension. Safety factors required by the relevant standards have been considered when proving that all loads induced by the rotor are safely transferred.

Gearboxes selected for this project are based on well-proven designs but with adoptions to the special requirements of offshore wind turbines. Basic features of these gearboxes have already been tested in wind turbines of the relevant size onshore. Further, all experience derived from recent failure analysis, design improvement and verification testing on smaller wind turbine gearboxes has been addressed in the design of these gearboxes.

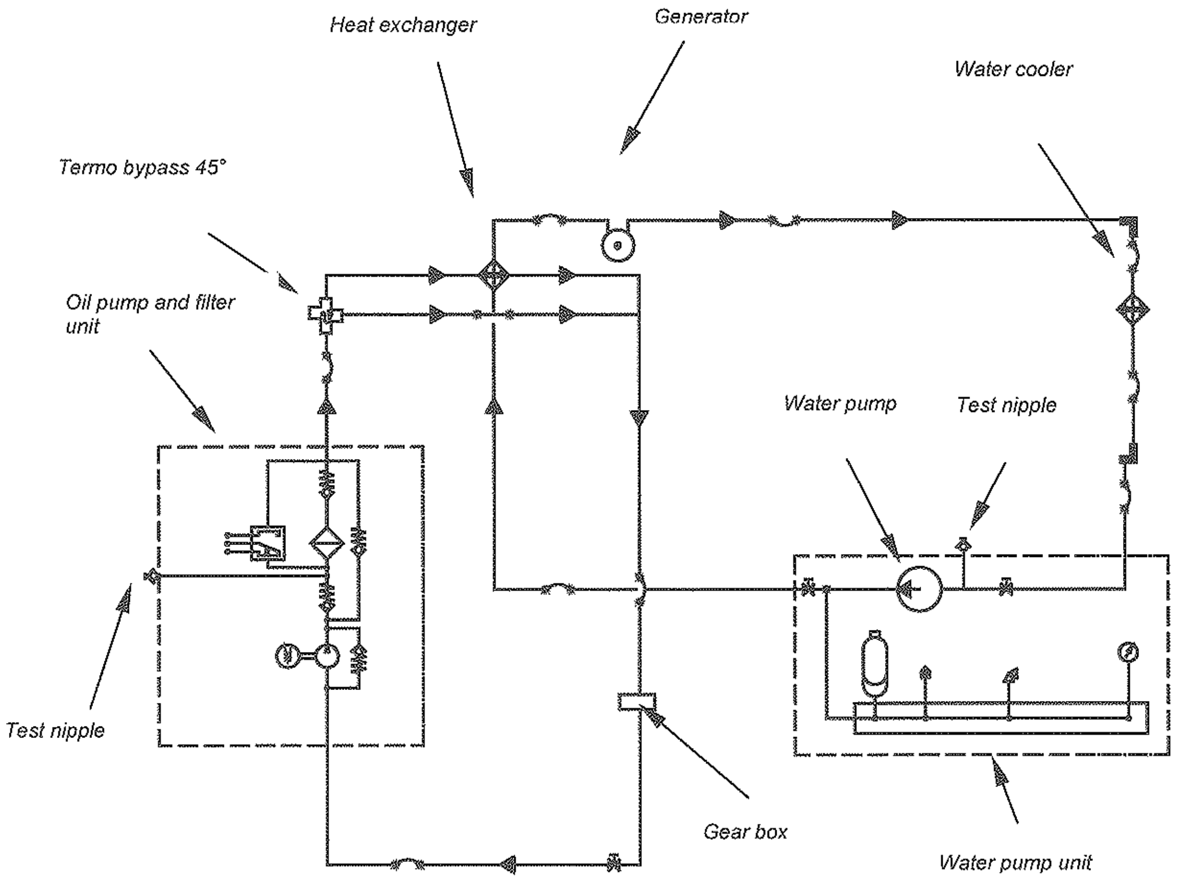
The gearboxes for NM 80/2750 are of a triple stage hybrid-design, consisting of one helical geared planetary stage and two helical geared parallel axis stages. The total gearbox ratio is selected such that the blade tip speed is optimised at the selected generator reference speed. Power control is affected by a combination of blade angle adjustment and speed variation.

The low-speed shaft in the gearbox is implemented as a hollow shaft. It encloses the rear end of the rotor shaft, and the connection is by a strong clip bushing. This special connection between the rotor shaft and gear box, forming a single unit in a three-point suspension (rotor main bearing and the two mountings on either side of the gearbox) prevents alignment problems

The gear housing may be cast, welded or a combination, custom-design as to NEG Micon's requirements and specifications. The front end of the gear housing forms the torque stay where all operation loads and load reactions are transferred to the machine base frame The ring gear of the planet stage is an integral part of the gear housing. The rear part of the gear housing holding the two parallel-axis stages, provides the linking points for a mechanical brake.

The gear housing also serves as an oil tank, holding a sufficient amount of oil for cooling and lubrication of all gears and bearings. The housing is designed for free flow of oil and possible debris towards a dead end at the lowest point of the oil sump. In the inclined assembly position, the external lubrication and cooling system with its filters is directly connected to the lowest point.

3.12 Lubrication & Cooling System



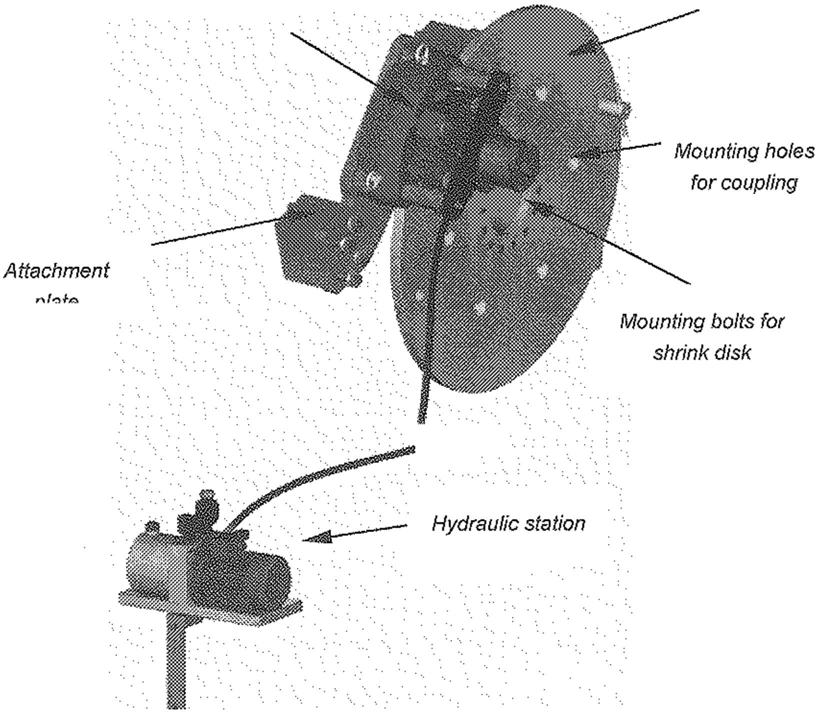
The external lubrication system has three main functions – it provides circulation, filtration and cooling of the gear oil. The gear oil pump circulates the oil through a mainstream filter unit with a thermo by-pass and through an oil/water heat exchanger.

The cooler liquid removes heat from the generator and is in turn cooled by a radiator on the nacelle roof, where airflow behind the blades has a very efficient action. Apart from the generator and the radiator, the circulation system consists of an electric pump, hoses and the heat exchanger, in which the gear oil is cooled. The system is simple and has proved to be both extremely efficient and reliable.

Water cooling also means that no air flow in the nacelle is needed. The nacelle cabin is effectively sealed and protected from attack from cooling air, which often contains humidity, salt, dirt or dust and thereby corrodes or dirties components, joining surfaces and bolts.

The cooler liquid is an antifreeze/water mixture. The cooling pump works continuously except in the case of emergency stop.

3.13 Disc Brake System



The brake has integral indicators that inform the control system if the linings become worn. Due to limited number of brake actions, the expected life time of the brake linings is long. The linings will be replaced as precaution on regular intervals (> 1 year).

The Disc brake is fitted to an attachment plate. This plate is bolted to the gearbox, which gives a strong and stiff support. The brake disc is connected with a shrink disc to the output shaft of the gearbox

There are fittings and equipment to lock the brake disk for servicing and other tasks

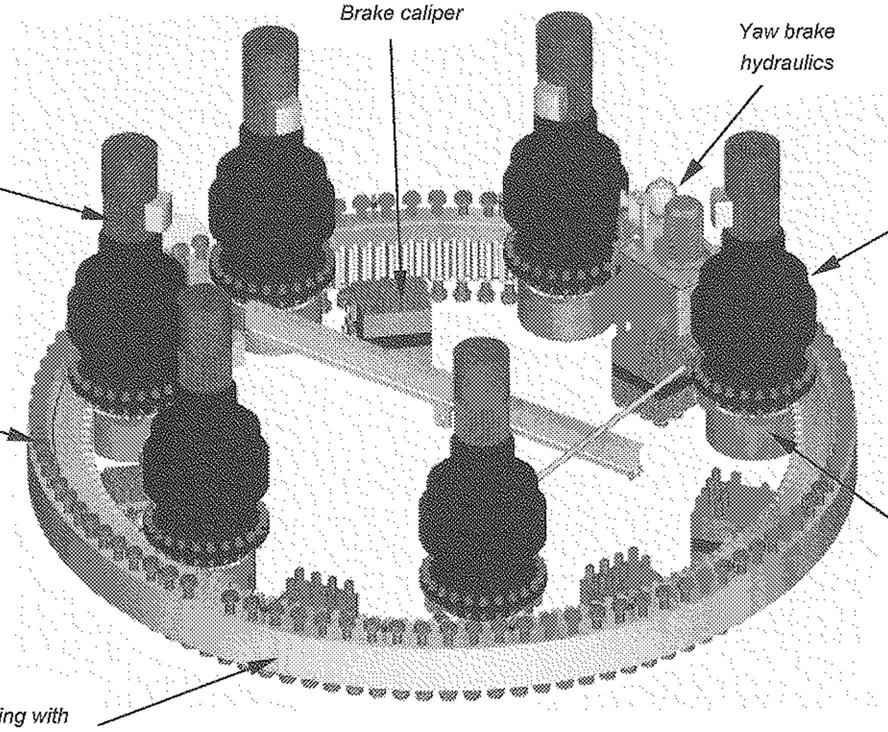
The mechanical brake is designed for parking and has a back-up system that will keep the brake disengaged in the event of a power cut. The mechanical brake is only used for servicing which requires stationary gear shafts or brake disk. The brake has integral indicators and temperature sensors, which inform the control system if the linings become worn or hot.

The hydraulic unit for the brake is an AVN-B12 type. The hydraulic unit will at normal operation; maintain a steady pressure to keep the brake disengaged. At grid failure it will keep the brakes disengaged for a limit period and at braking it will ensure a controlled reduction of the pressure providing a soft cut in of the brake.

3.14 Coupling

The generator is linked to the output shaft of the gear by a coupling, which transmits the driving moment to the generator without excessive loading on the generator bearings. The couplings and shaft are screened for safety reasons and protected from accidental contact. A rpm sensor is mounted on the generator shaft flange to measure rotation speed.

3.15 Yaw System



The yaw system is a derivative of the system that is in use on the majority of the NEG-Micon turbines. The main characteristic is simplicity due to the use of a minimum number of different parts and clear separation of functions. Special adoptions make it suitable for off-shore use.

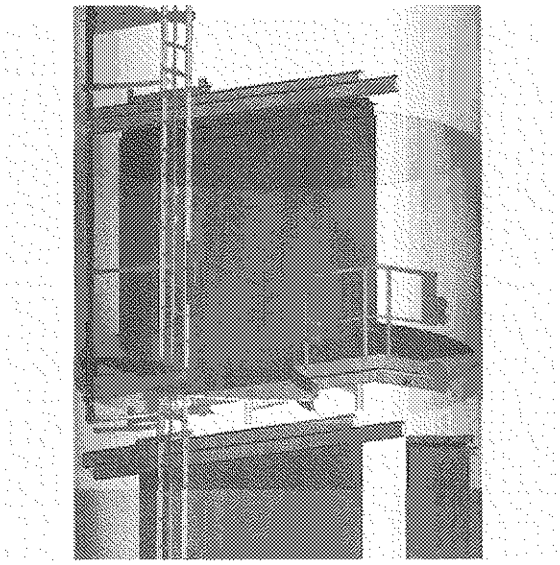
The yawing system is composed of the following parts:

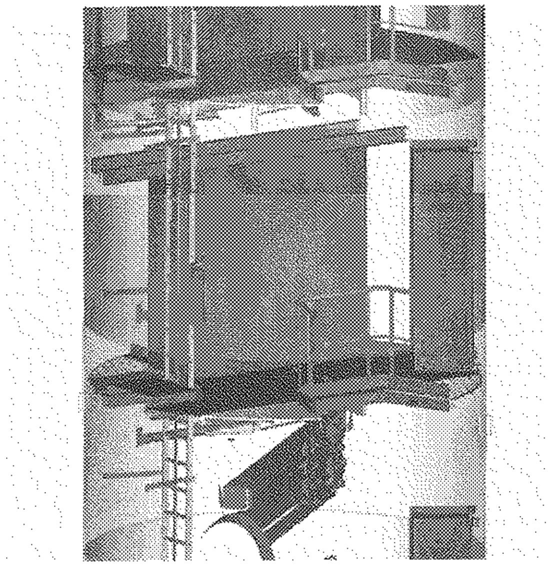
- One 4 point ball bearing with internal gear and mechanical lock.
- Five planetary gear drives that are driven by squirrel cage induction motors.
- Six hydraulic activated brake calipers.
- One brake disc ring at tower top flange on which the calipers act.
- One interface to enable the turbine controller to activate and deactivate the yaw system.
- One position-transducer that transfers the nacelle orientation to the controller.
- One vane on top of the nacelle cover that transfers the wind direction to the controller.
- One manual control box that enables manual yawing as is possible for the panel of the controller.

3.16 Controller Panels

The control of the wind turbine is split between several panels situated in the tower base, nacelle and rotor hub. The panels are divided logically in relation to their function and listed below, to describe the location in the turbine.

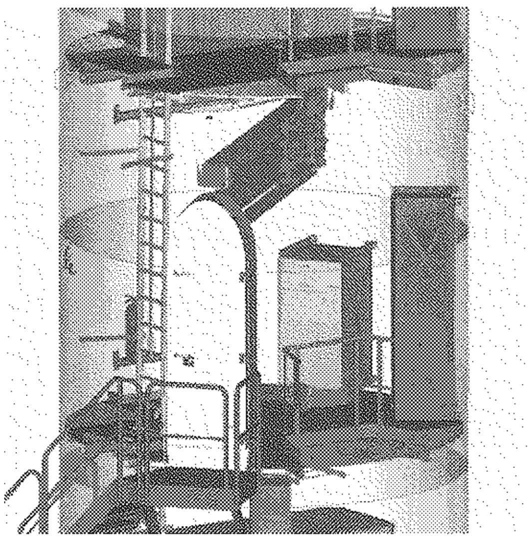
4. platform: Converter panel included converter controller and filter module:

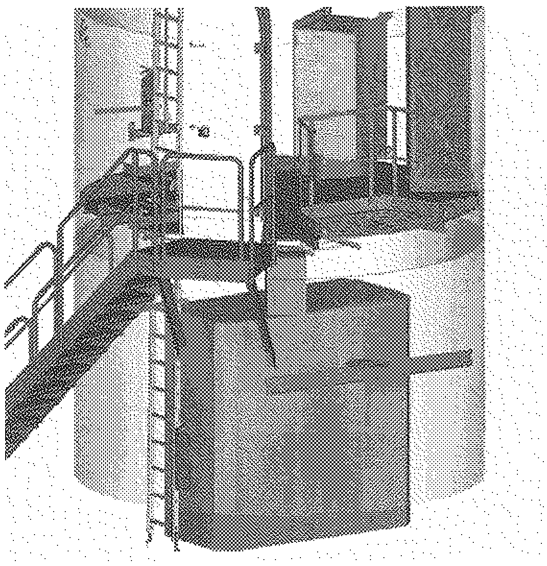




3. Platform med main operating control panels

2. Platform with Switch gear (left) og meter box





Tower base. platform with HV/LV-transformer

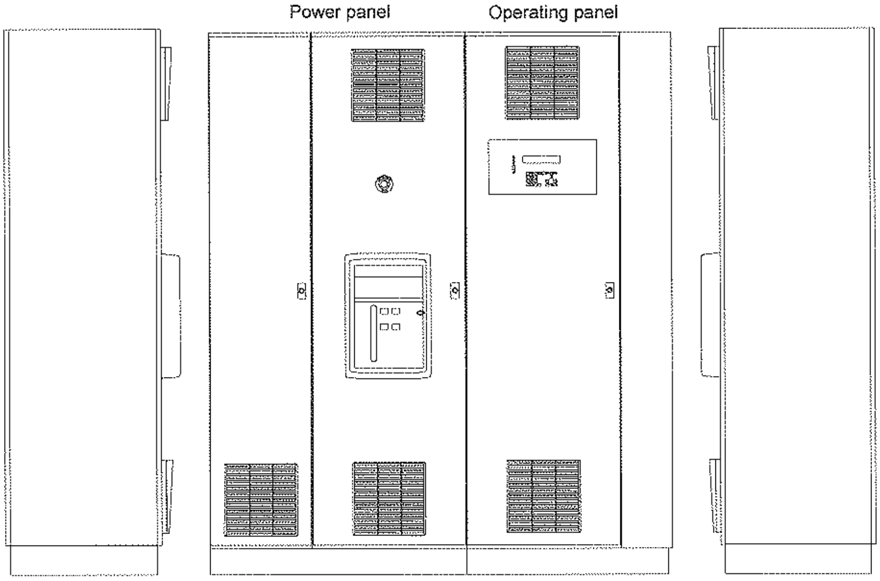
The following tower plan shows controller panels and medium voltage components. The drawing is not to scale and must be regarded for information only.

3.16.1 Main panel in tower

The power panel contains the components necessary for protecting and controlling the parts making up the generator stator circuit (main power circuit). See illustration of power cabinet below.

The panel is fitted with a lightning conductor for protecting the circuit from transients. Current and voltage in this circuit is measured and the results sent to the operating panel. Similarly, all signals used to control components in this cabinet derive from the operating panel.

Main voltage: 3x960Vac. ; Control voltage: 230 Vac/24Vdc



3.16.2 Operation panel (part off main panel)

The cabinet contains an operating panel allowing the wind turbine to be operated from the base of the tower. The cabinet includes the components necessary for controlling the units located at the base of the tower and for receiving signals from them. Transient protection of the necessary circuits will be located here. External communications links to and from the wind turbine must also be connected in a separate compartment of this cabinet.

The hour meters will be located on the front of the operating panel in the tower base.

Main voltage 3x400+N Vac; Control voltage 230 Vac/24Vdc

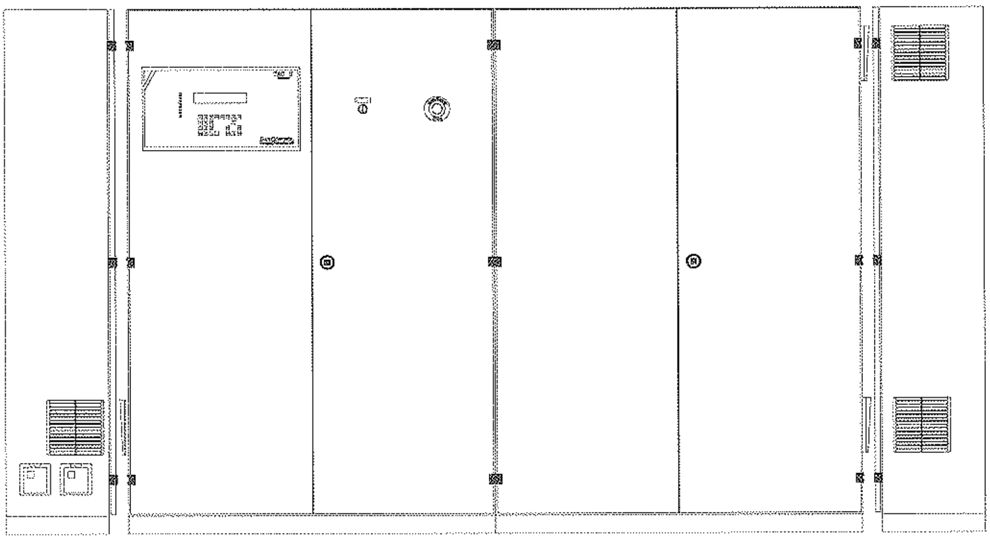
1.1.1 Frequency converter panel in tower

These contain all the power electronics together with control equipment for the frequency converter for the generator rotor circuit.

1.1.2 Control panel in nacelle

The cabinet includes the components necessary for controlling the units located in the nacelle and for receiving signals from them. The cabinet contains an operating panel allowing the wind turbine to be operated from the nacelle during servicing. See illustration of nacelle control panel below.

Main voltage 3x400+N Vac; Control voltage 230 Vac/24Vdc

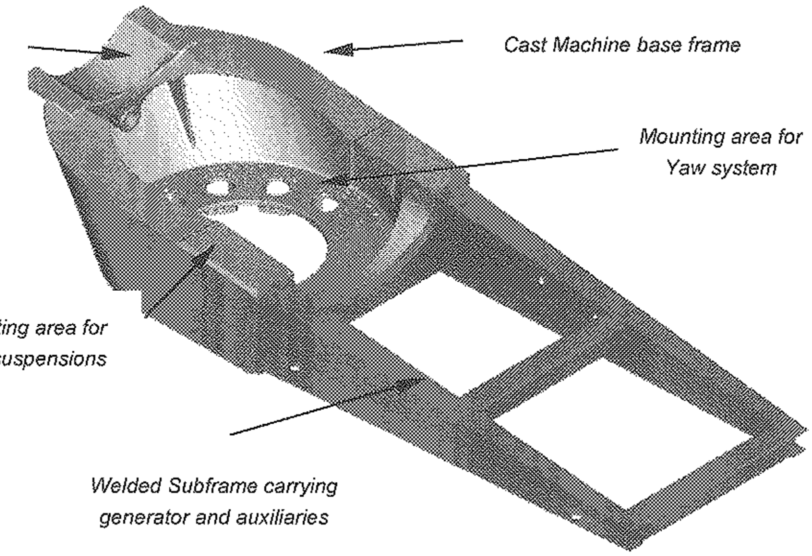


Control panel included the TOI#2 and the operator panel (OP) for remote control the main controller in the tower base.

1.1.3 Controller panels in rotor hub

There are four panels for controlling the pitch system: one main control panel, and three identical blade panels. The main control panel contains a 3-axis controller, which communicates with the main turbine controller (TAC II computer) via an RS485 serial link. The 3-axis controller receives pitch position and rate demands from the TAC II computer, and generates individual analogue velocity demands for the pitch drives for each blade. In addition to the 3-axis controller, the main control panel has a battery charger for charging the emergency stop batteries in each blade panel and power supplies for each blade box. Each blade box houses the pitch drive for that blade and the battery pack for that blade.

3.17 Machine Base Frame, Sub Frame & Nacelle Cover



The machine base frame is a rigid cast construction. The shape can be characterized as an open box frame. This shape is the direct derivative and optimisation of the machines frames as used for the 600-750-900-1000-1500 kW NEG-Micon product range

The Base frame supports the sub frame. Due to the relative high sides and the geometry of the base frame end plate, the sub frame that carries the generator and auxiliaries faces a stiff support. The sub frame itself is composed of 6 parts; 4 folded beams and 2 stiffener beams below the frame.

The nacelle cover is supported on both the machine frame and the sub frame by means of rubber-steel elements. Therefore a proper load distribution as well as a reduction of vibration level is obtained.

The nacelle cover is a self supporting glass fibre construction with a smooth shape. With six rubber elements it is attached to the machine frame and sub frame. Therefore a proper load distribution as well as a reduction of vibration level is obtained.

The rear top of the nacelle cover is supported and formed as a heli-hoist platform (optional). The cooler is mounted at the helio-hoist platform rail. Also the anemometer and wind vane is mounted on the nacelle cover.

Auxiliary equipment as well as a crane solution in the nacelle will provide the possibility of exchanging major components without taking the rotor and nacelle down.

3.18 Tower & foundation

The tower is tubular formed by rolled steel plates. All welds are regularly inspected during manufacture by an independent inspection body. The tower is sandblasted and effectively surface-treated for off-shore sites. The standard colour is grey-white, corresponding to the colour of the nacelle and blades.

The tower top flange is constructed as a wide flange which functions as an internal brake disk for the yawing brake system. The yawing ring is bolted directly to the top flange. To ensure perfect flatness and tolerances on the integrated top flange and yawing brake disk, the latter is welded separately to the upper tower shell, which is ¾ m high. It is then machined, and finally the tower top is welded to the other tower shells, which make up the top section.

The individual tower sections are bolted with flange joints. At each point where the tower is joined, a platform is inserted for inspection and tightening of tower bolts. The top platform gives a convenient standing height under the yawing system. From here there is internal access to the nacelle.

Access to the tower is through a lockable door at the base. Below the door platform the high voltage transformer is placed directly on the foundation concrete. At the door platform the MV- switchgear is placed as well as a turbine control panel for remote control of the turbine control system in the nacelle.

At the first platform the power panel is placed. And at the second platform the frequency converter is mounted.

The ladder is of aluminium and is in one piece right from the base of the tower to the top platform under the yawing system. It is fitted with a fall protection system mounted on the centre of the ladder rungs. The tower wall and the ladder fittings act as a back hoop.

The tower can be equipped with a lift. The lift will end just below the tower dampers at the tower top.

The tower and nacelle are lit by light fittings. There are also power sockets for tools etc.

A dehumidification device is installed at the base of the tower to control the internal climate. This ensures a good internal climate, effectively protecting the tower and bolt assemblies from corrosion, whatever the outside conditions.

Two types of offshore foundation are applicable for this turbine: A mono-pile foundation or a traditional concrete foundation. On the mono-pile solution an outside access platform is welded to the foundation steel section. On the concrete solution the foundation it selves serves as a platform.

3.19 Lightning protection

3.19.1 Total concept for lightning protection of wind turbine

To assess possible strike points on the NM80-92/2750 wind turbine, the Rolling Sphere method is used. An imaginary sphere is rolled over the wind turbine. Wherever the sphere touches the wind turbine, lightning strike is possible. The method takes into consideration the fact that lightning does not always strike the highest point. The diameter of the imaginary sphere is determined by the desired protection level. Here protection level 1 is applied, the strongest under IEC 61024. At protection level 1 the radius of the imaginary sphere is 20 m. All points which the sphere can touch on the wind turbine are possible strike points and are called lightning protection zone 0. Within lightning protection zone 0, components must be able to withstand a direct lightning strike.

Components in lightning protection zone 0 must be able withstand the full lightning current, set for offshore turbines at 200 kA 10/350 µs.

In the areas in which the imaginary sphere forms shadows there will be no direct lightning strikes but the components in these areas must be able to tolerate the full electro-magnetic field.

This area is called zone 0E. Zone 0E will for instance be the area where meteorological equipment is mounted.

The nacelle and glass fibre housing are constructed as a Faraday cage with a metal network in/under the glass fibre housing. The nacelle can then be considered as being in zone 1. In zone 1, possible lightning transients are further reduced. The level is 6 kV 1.2/50µs or 3 kA 8/20 8µs.

The wind turbine tower is also lightning-protected to level 1.

Metal electrical cabinets in lightning protection zone 1 should be regarded as lightning protection zone 2 internally. The level for lightning transients in lightning protection zone 2 is 0.5-2 kV 1.2/50 µs, depending on signal type.

Components in the individual lightning protection zones are overvoltage-protected at the levels indicated.

3.19.2 Overvoltage protection of components in lightning protection zone 2

Electronic components and other electronic equipment supplied by NEG Micon Control Systems have been tested to IEC 801-5. Supply cables have been tested to 2 kV common mode and 1 kV differential mode.

For communication purposes, optical cables are used, so here lightning arresters are not relevant.

3.19.3 Overvoltage protection of components in lightning protection zone 1

In lighting protection zone 1 are items such as the power panel, frequency converter panels, operating panel and control panel. Supply intake in the power panel is overvoltage-protected by lightning arresters with a nominal discharging current of 15 kA 8/20µ/s and a limit discharging current of 40 kA 8/20µ/s.

Signal cables are protected by screens. In addition signal cables from the control panel are protected by varistor clamps, capable of dealing with discharging current of 2.5 kA 8/50µ/s.

Power transformers have lightning arresters on the primary side. Various control transformers also have lightning arresters on the primary side.

3.19.4 Overvoltage protection of wind measurement equipment in zone 0E

Wind measurement equipment is mounted where no direct lighting strike can reach it. This is done by placing a lightning conductor on the boom on which the wind measurement equipment is mounted. Cables from the wind measurement equipment are led by pipes to the control panel, where the individual conductors are overvoltage-protected by varistor clamps capable of dealing with a discharge current of 2.5 kA 8/20μs.

3.19.5 Measurement report and documentation

At handover a report will be drawn up demonstrating/measuring the transition impedance from critical systems to earth, together with relevant documentation from the subcontractor and operating and maintenance guidance for periodic checks.

3.19.6 Blade protection

The turbine uses LM glass fibre blades or alike. The blades are lightning-protected with LM's standard solution with two sets of receptors on each side of the blade tip and with conductors leading down through the blade and connected to the blade flange. Leakage of the lightning current is not practised, i.e. the lightning current passes through the blade bearing. A non-corroding liquid damper using glycol is also installed, and electrically connected to the receptor.

3.19.7 Blade turning system

Lighting current passing through blade bearings will not cause any significant damage, as there is extremely good electrical contact through the blade bearing because either it is not in motion or it is moving slowly, so there is no lubricant film.

3.19.8 Spinner and transmission system

The gearbox is partially insulated, as it is suspended on rubber mountings. NEG Micon uses a discharge system placed on the locking wheel ahead of the main bearings, thus minimising lightning current through the main bearing. The discharge system consists of combs/collector shoes with replaceable copper brushes.

3.19.9 Main bearing

Due to the current development stage of the tendered wind turbine, the technical solution has not yet been finalised, in calculations, investigations and testing

If come out that's necessary the main bearing will get a brush device to guide the lightning current before it reach the main bearing

3.19.10 Gear

Due to the current development stage of the tendered wind turbine, the technical solution has not yet been finalised.

3.19.11 Nacelle

The nacelle is executed as a Faraday cage. The nacelle housing is in glass fibre with integral cable network or a cable network immediately beneath the housing. The cable network is connected to the metal frame of the housing, which in turn is equipotentially bonded with the base frame.

All major components in the nacelle are equipotentially bonded with the base frame.

The weather station on top of the cooler behind the nacelle is fitted with lightning conductors. The lightning conductor is equipotentially bonded with the base frame.

Lightning current from the blades is conducted to the base frame via the discharge system on the main shaft with copper brushes or carbon collector shoes. The base frame is part of the Faraday cage, so that minimum lightning current is conducted through the main bearing.

3.19.12 Yawing system

The lightning current is conducted through the yawing bearing. The yawing bearing is pretension and moves only very slowly, so for these reasons and due to its large dimension, there is good electrical contact through the yawing bearing.

The yawing bearing is dimensioned to 300,000 rpm at a much higher rotational speed. The yawing bearing is expected to undergo approx. 10,000 rotations during the lifespan of the wind turbine.

3.19.13 Tower

The lightning current is conducted down through the tower. The tower itself is used as conductor. Joints between tower sections are zinc-coated, giving good metallic contact all the way round.

3.19.14 Earthing system

The earthing device/system earth is executed as a foundation earth. The volume of the foundation compared with the specific resistance of earth means that the expected transition resistance to neutral earth for each foundation will be less than 2 ohm.

System earth is executed as a TN-S system. The TN-S system has a point in the supply system, the power transformer's star point, connected directly to earth, while exposed parts of the wind turbine are also connected to earth. Throughout the whole installation the TN-S system has separate neutral and earth conductors.

All protection conductors are as a minimum dimensioned and marked in accordance with the prescribed norms in the Directive for Electrical Installations and Machinery, which also refer to 439-1 low voltage panels.

3.19.15 Medium voltage plant

The power transformer has a lightning arrester on the high-voltage side.

3.19.16 Control system

Reference is made to section "Total concept for lightning protection of wind turbine"

A lightning strike detector of a make such as Jomitek is also fitted. Lightning strikes over 0.5 km are registered with a time stamp.

In the case of lightning strike in the tower construction in which the lightning detector is mounted, a relay signal is immediately emitted as an indication of lightning strike. In the case of a direct strike in the vicinity of the tower construction, no indication will be given. Nor will disruption to the 230 V supply trigger an indication. The lightning detector registers both weak and very strong strikes. In the case of error in the power supply, the lightning detector will continue to register lightning strikes and save this information until full power supply is restored and the relay signal can be released. The power supply is monitored and in case of error a relay signal is emitted.

The lightning detector system fulfils all relevant EU norms and Danish regulations, including the Heavy Current Order, the Low Voltage Directive and EMC. Park communication is done optically and will not send transients to other turbines.

4 Operation of controller

To describe the controller user interface, the description is split into three sections, keyboard, display and operator panel.

4.1 Keyboard

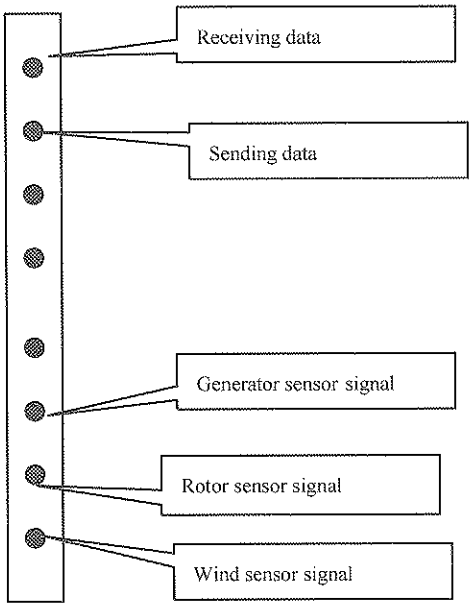
The keyboard is designed with pushbuttons to operate in the menu system (numerical buttons, arrow buttons, enter button), and push bottoms to overall operation command to the main controller (start, stop, reset, yaw buttons). The following table gives a brief description of the keyboard.

Numeric buttons	The numeric buttons is used for changing parameter values in the controller, e.g. date, time, parameters, etc.
Arrow buttons	There are four arrow keys on the front panel: ←, →, ↓ and ↑. These buttons are used to move through the menu system. There is an accelerator on these buttons in long menus, i.e. if an arrow button is held down the view in the menu will scroll faster and faster up or down through the menu. Pressing this button (←) moves the cursor one space to the left, or change the view to a higher level in the menu system. Pressing this button (↑) moves the cursor one space up in the menu system or in the current menu. Pressing this button (→) moves the cursor one space to the right, or moves the user to a lower level in the menu system. Pressing this button (↓) moves the cursor one space down in the menu system or in the current menu.
Enter	The Enter button is used for confirming the parameters entered by means of the numeric buttons and for starting or stopping the various test functions (see Service menu).
Yaw buttons	These two buttons are used for manual yawing. Manual yawing is started and stopped by pressing these two keys.
Reset	When this button is activated, alarms will be reset, if conditions for reset is OK.
Start	Use this button to start the wind turbine. If the turbine has any activated alarms while pressing the Start button, the effect is like pressing the Reset button. If the turbine doesn't have any active alarms, the turbine starts up the turbine.
Stop	Pressing Stop button stops the turbine using the blades. The display shows a manual stop message.
Prev.	Press this button to return to the previous menu.
Clear	This button will clear all data in the line where the cursor is located. This is done by pressing the Clear key and confirming with the Enter key.

4.2 Display

The display is a text-based version, with 4x40 characters. The display is illuminated when pres any of the buttons, and after a period with no menu activity the light will automatically turn off.

The main controller has eight LED's, which have the following information:



4.3 Operator panel

At the control panel located in the nacelle, an operator panel is present. The operator panel is a remote control to the menu in the main controller located in tower base. There is no difference in using the interface at the main controller in tower base and the interface at the control panel in the nacelle.

4.3.1 Panel configuration

An operation panel is located in the turbine nacelle, making it possible to control the turbine from the nacelle. The operation panel has the same keyboard and display as the main controller. The communication between the TAC and the operation panel is via fiber optic cables.

The Localmenu is activated by switching a random DipSwitch ON.

The panel will show the LocalMenu on the Display: (*The display will scroll when line 5 is displayed)*

Line 1: Program-number	1999159 - Rev. 01-04-16		
Line 2: ID Number	(Key 0 – 9)	00000011	
Line 3:	Protocol Mode	(Key left/right)	DCE0
Line 4:	Baudrate	(Key left/right)	19200
Line 5: Character set	Key left/right)	English	

Default OP settings

Line 1 shows program-number and revision-date. This line is only for information.

Line 2 shows the operating-panel (OP) ID number.

When using the DCE3-Protocol, make sure that the OP ID & the TAC ID are identical. Otherwise the TAC and the OP will not communicate.

The ID number is typed in using the keys "0 - 9". The "Enter" key saves the selected ID-number.

The ID-number can consist of max. 8 digits.

Line 3 shows the selected Protocol-Mode. Select either DCE0 or DCE3 protocol using the "Right-Arrow" or "Left-Arrow" key. "Enter" key saves the selected Protocol-Mode.

Line 4 shows the selected Baudrate. Select from 2400 -> 38400 baud using the "Right-Arrow" or "Left-Arrow" key. The "Enter" key saves the selected BaudRate.

Line 5 shows the selected Character set. The OP receives characters from the TAC. This function can convert the received character to a special character, like "æ, ø, å" in Danish.

(ä, ö, ü in German)

Generally:

"Right-Arrow" switches the current value one step up. (e.g. from 9600 to 19200 in selecting BaudRate)

If the highest value is reached, (38400) and the "Right-Arrow" is pressed again, the lowest value will be displayed. (2400)

"Left-Arrow" switches the current value one step down. (e.g from 19200 til 9600 in selecting BaudRate)

If the lowest value is reached, (2400) and the "Left-Arrow" is pressed again, the lowest value will be maintained. (2400)

"Enter" saves the selected values to the OP-Eeprom.

Discard Changes: Press "Up-Arrow" or "Down-Arrow". This will restore the original value.

A change is only valid by pressing "Enter".

4.4 Operation box

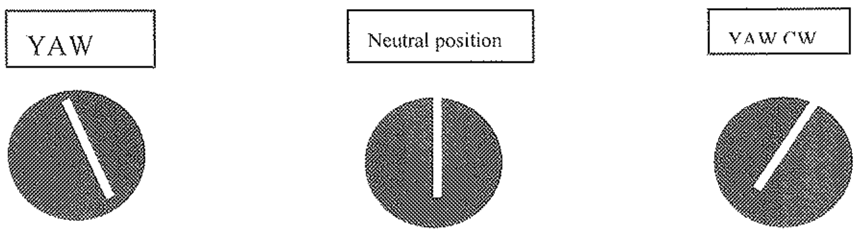
The operation box is located in the turbine nacelle, making it possible to manually control the yaw system. It is possible to move the box around the nacelle. This is used, for example, during maintenance work. The operation box has two switches: an emergency stop and a manual yaw switch for clockwise and counter-clockwise yawing.

4.4.1 Emergency switch

The emergency button on the operation box is connected to the emergency line. If this push button is activated the turbine will perform an emergency stop.

4.4.2 Yaw switch

The yaw switch has three positions – yaw CCW, yaw CW and neutral spring released position. If the yaw switch is turned as indicated in the figure below at left, the turbine will yaw counter-clockwise. When the switch is released, the switch automatically turns to the natural position. Similar action for yawing clockwise.

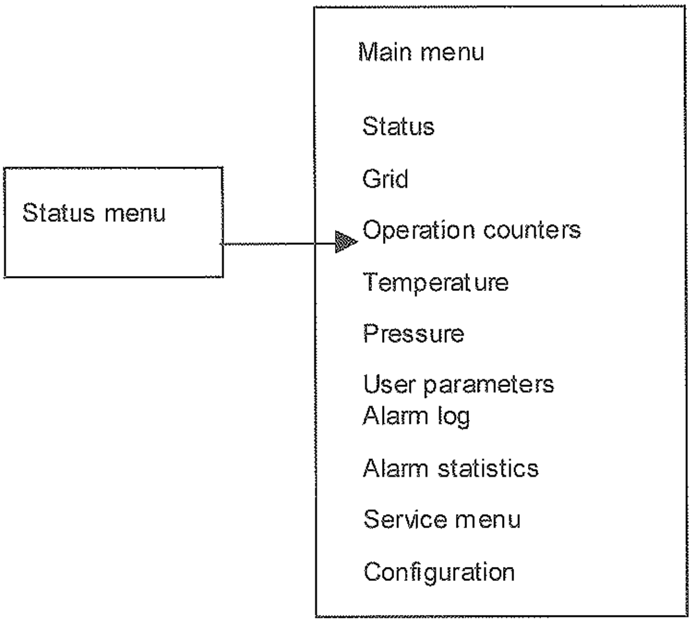


5 Description of menu system

The main controller menu system contains a status menu, and a number of sub menus. The arrow keys on the front are used to toggle between the menus.

After power-up, the main controller will display a start-up screen showing the software type and version of software executed on the main controller.

The status menu displays the fundamental states of the turbine. If the menu system isn't used for a period, the menu system automatically returns to the status menu. Pressing the right arrow key accesses the main menu. The main menu shows the menu structure illustrated below.



5.1 Status menu

The status menu shows the status of the wind turbine:

```
2002-08-23  11:36:11       Generation
Rotor: 16.5 RPM   Generator: 1101.2 RPM
2751 kW  15.6 m/s     PD  5.35°  AP  5.33°
Generation
                     1 sec.     1 min    10 min
Yaw fault [°]        -5.3        -1.3       0.2
Wind speed [m/s]     15.6        14.9      14.2
Power [kW]           2751        2750      2750
Nacelle position                          348 °
Yaw counter                                25 °
```

Line number:

1. Date, time and current operating status for the turbine.
2. Rotor rotational speed, generator rotational speed.
3. Current production, wind speed, pitch demand (PD) and actual pitch (AP).
4. Status line, this line describes the status for the turbine. This line shows any alarms recorded in the turbine. If no alarms/warnings are active the operation mode is displayed.

5. Location of 1-second data and location of 1-minute data and 10-minute data.

6. This line shows the average of yaw fault for 1-second, 1-minute data and 10-minute data.

7. This line shows the average wind speed for 1-second, 1-minute data and 10-minute data.

8. This line shows the average power production for 1-second, 1-minute data and 10-minute data.

9. This line shows the position of the nacelle relative to the geographic north.

10. The last line is the degree of cable twist relative to the cable twist center.

5.2 Grid menu

The grid menu contains measured data on the 400V power lines dedicated for turbine own consumption. At the bottom of the menu the total power production of the turbine is printed. The values in this menu are one-second average values.

```
               L1         L2         L3
Voltage       389        373        385
Current       790        771        795
KW          304.2      284.7      303.0
KVAr         -5.1       -3.9       -4.7
Cos phi     0.99        0.99       0.99
Quad.          3          3          3
   7.9 kW     -13,7 kVAr     50.0 Hz
```

Line number:

1. L1, L2, and L3 describe the phase concerned.

2. Voltage for the three phases.

3. Current for the three phases.

4. Individual power output for the three phases.

5. Individual reactive power output for the three phases.

6. Power factor for the three phases.

7. Quadrant position for the three phases.

8. Total power, reactive power and grids frequency.

5.3 Operation counters

This menu contains data about the turbine operation – production counters, consumption counters, and timers for different operations. There are further counters and timers on all motors, major contactors and mechanical parts, these are found in the Service menu.

```
Total                         kWh            hours
Subtotal                      kWh            hours
Total G                       kWh            hours
Sub G                         kWh            hours
Absorbed energy                                kWh
Acc. reactive effect                         kVArh
Power consumption (aux.)                       kWh
Time on                                      hours
Time ready                                   hours
Time alarm                                   hours
Time ok                                      hours
Time service                                 hours
Time T1                                      hours
Time T2                                      hours
Availability                                     %
Power down T3                                hours
```

A short explanation of the information in the menu:

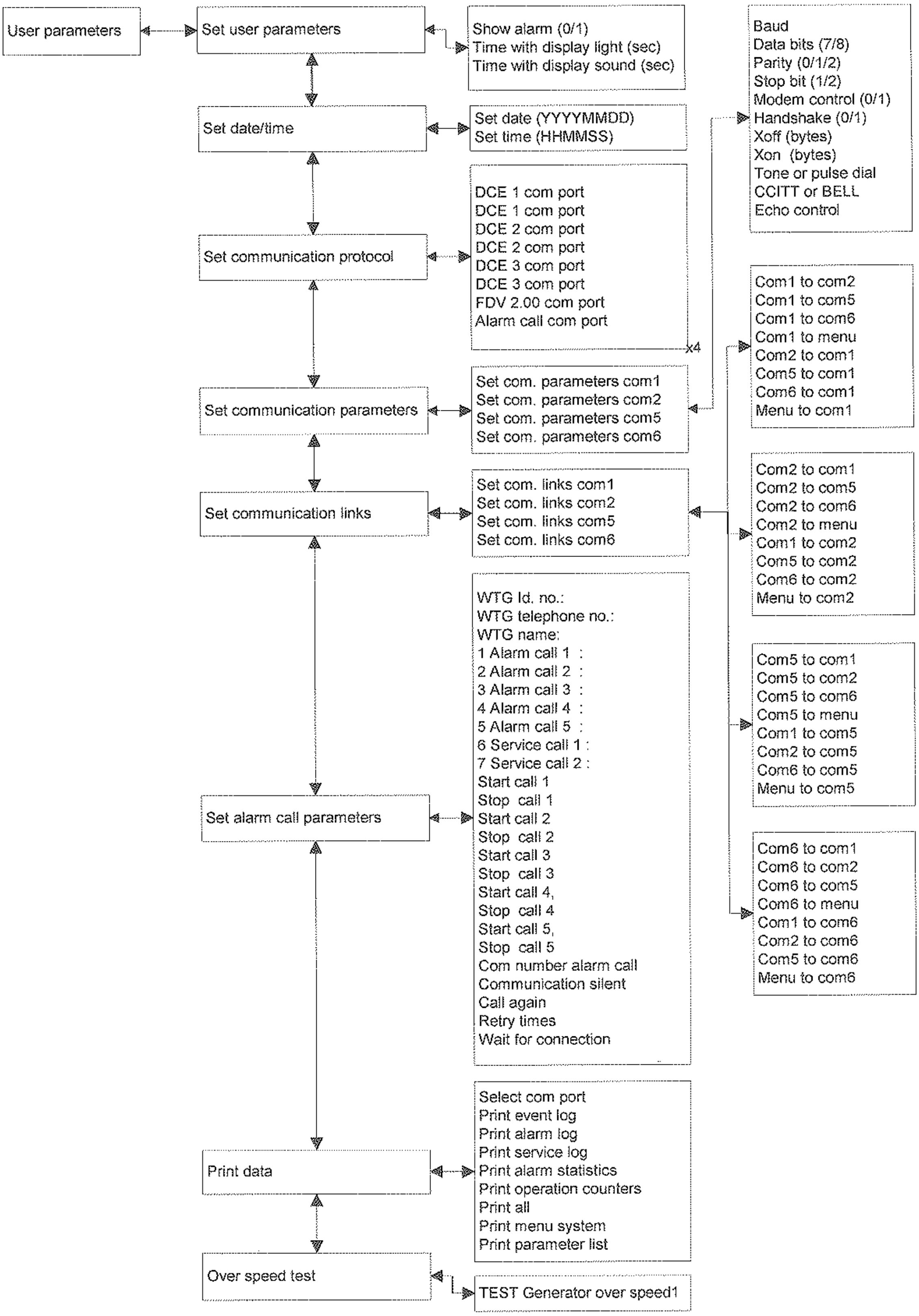
Total	This counter is showing the total production for the turbine.
Subtotal	The sub counters have the same function as the counter 'Total', but they have the possibility, to be cleared, by the user/turbine owner.
Gen. G	The counter is showing the production delivered by the generator.
Sub G	The sub counters have the same function as the counter 'Gen. G', but they have the possibility, to be cleared, by the user/turbine owner.
Absorbed energy	Counter for the negative produced energy measured by the tree measurement points.
Acc. reactive effect	Counter for accumulated reactive effect that the turbine has used.
Power consumption (aux.)	Counter for used power for turbine own consumption.
Time on	The time for grid connected to the turbine
Time ready	The time for shaft brake released.
Time alarm	The time the turbine has been standing with an alarm
Time ok	The time where the turbine has been without any alarms.
Time service	The time where the turbine has been in service mode (Service key).
Time T1	The T1 counter records the time during which the turbine brake is released and the wind speed lies between the minimum and maximum wind speed limits.
Time T2	The T2 counter records the time during which the turbine measures wind speeds between the minimum and maximum wind speed limits.
Availability	The turbine availability is calculated by using the T1 and T2 timer.
Power down T3	The T3 is a timer for no grid present.

The availability of the turbine is calculated for each turbine by the following formula:

The T1 and T2 counters are summation counters counting from the start-up of the turbine.

5.4 User parameters

Under the User parameter menu the following items can be found:



5.4.1 Set user parameter

This menu contains parameters for setting the display functions.

Show alarm (0/1)	If this is set to zero there will be no displaying of alarms in the last line in the menus.
Time with display light (sec)	Specifies the time the backlight is on after last key activation.
Time with display sound (sec)	Time length of the key sound, after pressing a key on the TAC controller.

5.4.2 Set date/time

Set date (YYYYMMDD)	Sets the year, month and day
Set Time (HHMMSS	Sets the time in the TAC controller.

5.4.3 Set communication protocol

The TAC II controller has the possibility to use the same protocol on two communications ports. This is only for DCE protocols. DCE x is an abbreviation for 'DanControl Engineering protocol x'. FDV 2.00 is an abbreviation for 'Forenede Danske Vindmølleproducenter' (United Danish Wind Turbine Manufacturers).

DCE 1 com port	This line is used for selecting the communications port for the DCE 1 protocol.
DCE 2 com port	This line is used for selecting the communications port for the DCE 2 protocol.
DCE 3 com port	This line is used for selecting the communications port for the DCE 3 protocol.
FDV 2.00 com port	This line is used for selecting the communications port for the FDV 2.00 protocol.
Alarm call com port	This line is used for selecting the communications port for the alarm call. The turbine will send the alarm message out on this port.
Set communication parameters	Set communication parameters com1 Set communication parameters com2 Set communication parameters com5 Set communication parameters com6 For each of the four communication ports there are the following set ups. The baud rate at which the computer receives and transmits via the serial communications port selected. Data bits (7/8) - Number of data bits required for the serial channel selected. Options are 7 or 8 bits. Parity (0/1/2) - This parameter is used to select the parity for the serial channel selected. The options are as follows: No parity = 0.

Odd parity = 1.

Even parity = 2.

Stop bit (1/2) - Used to determine whether 1 or 2 stop bits are to be used.

Modem control (0/1) - Setting this to "1", the computer modem is restricted to sending only if the modem is connected to another modem.

This means that the modem must be able to detect a DCD signal. If this is not the case, the modem will cease transmitting. (DCD is an acronym for Data Carry Detect).

Handshake (0/1) - This parameter tells the computer whether a handshake must be exchanged. Handshake means that input/output control depends on the input/output status.

Xoff (bytes)- Software control of data flow.

Xon (bytes) - Software control of data flow.

Tone or pulse dial - Is used to determine whether calls are to be made using tones or pulse.

The above parameters also apply to com 2, i.e. communications channel number 2.

Insofar as communications channel number 3 is concerned, the following two changes apply:

CCITT or BELL - The standard of the telecommunications network.

Echo control - Used in turbines that communicate through fiber. Type "1" to ignore the echo.

Set communication links

This menu is used when the turbine is set up in a park where the turbine has to communicate with the park master turbine or a park PC.

Set communication links com1:

Com1 to com2 -Transfer of all data that is received on communications port 1 to communications port 2

Com1 to com5 - Transfer of all data that is received on communications port 1 to communications port 5

Com1 to com6 - Transfer of all data that is received on communications port 1 to communications port 6

Com1 to menu - Transfer of all data that is received on communications port 1 to the TAC menu

Com2 to com1 - Transfer of all data that is received on communications port 2 to communications port 1

Com5 to com1 - Transfer of all data that is received on communications port 5 to communications port 1

Com6 to com1 - Transfer of all data that is received on communications port 6 to communications port 1

Menu to com1 - Transfer of all data that is received from the menu to communications port 1

Set communication links com2 - This menu is identical to the menu for communications port 1, but for communications port 2.

Set communication links com5 - This menu is identical to the menu for communications port 1, but for communications port 5.

Set communication links com6 - This menu is identical to the menu for

Communications port 1, but for communications port 6.

Set alarm call parameters

WTG Id. no. - This is an 8-digit identification number for the wind turbine.

WTG telephone no.: - The wind turbine telephone number.

WTG name: - The name of the turbine.

1-7 Alarm call 1-7 - The first -> seventh number the wind turbine calls when an alarm occurs

Start call 1-7 - Start time for wind turbine calls to the first number

Stop call 1-7 - Stop time for wind turbine calls to the first number

It is only possible to change the start and stop time for "Alarm call" numbers. The alarm call number is used for customers who do not wish to receive calls e.g. in the night.

The service number is used for calls to those persons or companies responsible for servicing the wind turbine.

Com number alarm call - The communications port that is used for sending the alarm call.

Communication silent - Silent time on the telephone line before an alarm is permitted.

Call again - Interval between retries to a specific number

Retry times - Number of retries to a telephone number in case of failure to connect.

Wait for connection - This checks and waits until the DCD (Data Carrier Detect) is present before the controller is starting to send data.

Print data

Select com port - The communications port selected here is used to send the data selected in the below mentioned lines.

Print event log (press Enter) - Using the arrows to place the cursor in this line and then pressing the enter key, will print the entire event log out.

Print alarm log (press Enter) - Using the arrows to place the cursor in this line and then pressing the enter key, will print the entire alarm log out.

Print service log (press Enter) - Using the arrows to place the cursor in this line and then pressing the enter key, will print the entire service log out.

	Print alarm statistics (press Enter) - Using the arrows to place the cursor in this line and then pressing the enter key, will print the alarm statistics.
	Print operation counters (press Enter) - Using the arrows to place the cursor in this line and then pressing the enter key, will prints the operations counters.
	Print all (press Enter)- This makes a print to the selected port with all the menus, event log, alarm log, service log, alarm statistics and operations counters.
	Print menu system (press Enter)- This makes a print of the menu system.
	Print parameter list (press Enter) - This makes a print of the parameter list.
Over speed test	Test generator over speed 1 (press enter)

5.5 Temperature menu

The Temperature menu shows the temperature at each of the measurement points used. The temperatures are as follows:

Generator temperature (maximum of generator winding temperatures)

Generator bearing front temp.

Generator bearing rear temp.

Generator slip ring box temp.

Generator inlet temperature

Gear oil temperature

Gear bearing front temperature

Gear bearing rear temperature

Gear oil temp. after exchanger

Water temp. before cooler

Water temp. after cooler

Ambient temperature

Nacelle temperature

Yaw rim temperature

Main bearing temperature

Operation panel temperature

Main panel temperature

Control panel temperature

Converter ambient temperature

Stator filter temperature

Converter grid side 1 temp.

Converter grid side 2 temp.

Converter generator side 1 temp.

Converter generator side 2 temp.

Tower base temperature

Transformer temperature (maximum of transformer winding temperatures)

Transformer room temperature

Transformer W1 temperature

Transformer W2 temperature

Transformer W3 temperature

Generator W1 temperature

Generator W2 temperature

Generator W3 temperature

The last six temperatures are hotspots in the transformer and the generator windings.

5.6 Pressure menu

This menu presents the displaying the various pressures that can be monitored:

```
Pressure gear oil                    bar
Pressure gear oil filter             bar
Pressure shaft brake                 bar
Pressure yaw brake                   bar
```

5.7 Alarm log

The alarm log is used to show the most recent 100 alarms recorded. The alarms are displayed in the following way: Log no., date, and time and alarm text.

```
1     * 2002-01-30 09:06:57.6050
009     Grid spikes L1
2       2002-01-01 19:06:55.4530
```

An asterisk "*" before the time indicates that the alarm is active. The alarm "Grid spikes" is active in this example.

5.8 Alarm statistics

Choosing the 'Alarm statistics' menu, statistics for all alarms are displayed. The number of occurrences and the most recent date and the total time recorded for the individual alarm.

It is furthermore possible to see whether the alarm is active. An asterisk in the last line indicates an active alarm. This is shown in the following example:

```
Alarm   601 Manual stop keyboard
Total       0.5 hours          5 Times
Last    2001-01-30 16:06:55.4530
Active : *
```

5.9 Alarm snapshot

For every alarm that occurs, the main controller saves a 'snapshot' of a fixed series of values. At the moment the alarm occurs the following values are logged:

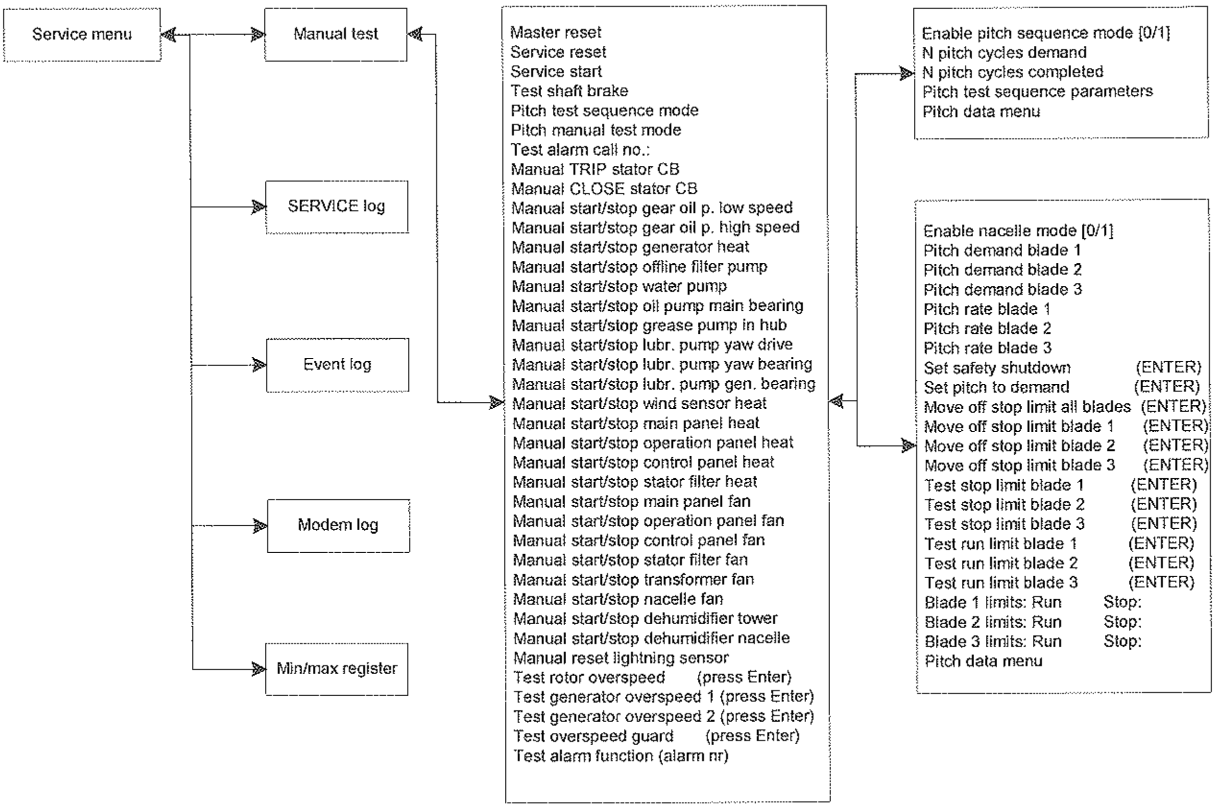
Rotor speed [RPM]	Rotational speed of the rotor
Generator speed [RPM]	Rotational speed of the generator
Windspeed left	1-sec averaged wind speed signal for the wind sensor 1 left
Windspeed left avg. 1 min	1-min averaged wind speed
Windspeed left avg. 10 min	10 min averaged wind speed
Windspeed right	1-sec averaged wind speed signal for the wind sensor 2 right
Windspeed right avg. 1 min	1-min averaged wind speed
Windspeed right avg. 10 min	10 min averaged wind speed
Winddir. left	1-sec averaged wind direction/yaw fault signal from the wind sensor 1 left
Winddir. left avg. 1 min	1-min averaged wind direction
Winddir. left avg. 10 min	10-min averaged wind direction
Winddir. right	1-sec averaged wind direction/yaw fault signal from the wind sensor 2 right
Winddir. right avg. 1 min	1-min averaged wind direction
Winddir. right avg. 10 min	10-min averaged wind direction
Cable twist counter	Cable twist counter relative to untwist center
Nacelle position	Nacelle position/direction relative to geographic north
Gear oil pressure	Pressure of gear oil before gear inlet
Gear oil filter pressure	Difference in pressure before and after oil filter
Shaft brake pressure	Pressure in the shaft brake calibre
Yaw brake pressure	Pressure in the yaw brake calibre
Humidity nacelle	Relative humudity in the nacelle
Humidity tower base	Relative humidity in the toqer base

Transformer W1 temperature	Transformer temperature located in the winding 1 hotspot
Transformer W2 temperature	Winding 2 hotspot
Transformer W3 temperature	Winding 3 hotspot
Transformer room temperature	Temperature measured in the transformer room
Tower base temperature	Temperature measured below the main panel
Main panel temperature	Temteration measured in the main panel
Operation panel temperature	Temperature measured in the operation panel located in the tower base
Converter ambeint temperature	Air temperature measured at converter panel inlet
Converter temp. grid side 1	Temperature measured on the converter cooling fan grid side 1
Converter temp. grid side 2	Temperature measured on the converter cooling fan grid side 2
Converter temp. generator side 1	Temperature measured on the converter cooling fan generator side 1
Converter temp. generator side 2	Temperature measured on the converter cooling fan generator side 2
Generator W1 temperature	Generator temperature located in the winding 1 hotspot
Generator W2 temperature	Winding 2 hotspot
Generator W3 temperature	Winding 3 hotspot
Generator bearing front temp.	Temperature measured in the generator bearing front nearby the generator
Generator bearing rear temp	Temperature measured in the generator bearing rear
Generator slip ring box temp.	Temperature measured in the slip ring box
Gear bearing front temp.	Temperature measured in the gear bearing front located at the HHS nearby the rotor
Gear bearing rear temperature	Temperature measured in the gear bearing rear located at the HHS nearby the generator
Main bearing temperature	Temperature measured in the main bearing
Water temperature before cooler	Water temperature measured between the generator and the cooler
Water temperature after cooler	Water temperature measured between the cooler and the heat exchanger
Gear oil temperature	Oil temperature in the gear oil sump inside the gear box
Gear oil temp. after exchanger	Oil temperature measured between the hear exchanger and the gear
Generator inlet temperature	Water temperature measured between the heat exchanger and the generator
Yaw rim temperature	Temperature measured at the yaw rim
Ambient temperature	Temperature measured below the nacelle
Nacelle temperature	Temperature measured in the nacelle below the control panel
Control panel temperature	Temperature measured in the control panel
Generator temperature	Maximum temerature of the tree generator winding temperatures
Transformer temperature	Maximum temerature of the tree transformer winding temperatures
Voltage L1	Voltage measured at the phase L1 on the WTG own consumption line
Voltage L2	Voltage measured at the phase L2 on the WTG own consumption line
Voltage L3	Voltage measured at the phase L3 on the WTG own consumption line
Current L1	Current measured at the phase L1 on the WTG own consumption line

Current L2	Current measured at the phase L2 on the WTG own consumption line
Current L3	Current measured at the phase L3 on the WTG own consumption line
Cos phi L1	Phase shifter measured at the phase L1 on the WTG own consumption line
Cos phi L2	Phase shifter measured at the phase L2 on the WTG own consumption line
Cos phi L3	Phase shifter measured at the phase L3 on the WTG own consumption line
Sin phi L1	Phase shifter measured at the phase L1 on the WTG own consumption line
Sin phi L2	Phase shifter measured at the phase L2 on the WTG own consumption line
Sin phi L3	Phase shifter measured at the phase L3 on the WTG own consumption line
kW L1	Phase L1 active power measured on the WTG own consumption line
kW L2	Phase L2 active power measured on the WTG own consumption line
kW L3	Phase L3 active power measured on the WTG own consumption line
kVAr L1	Phase L1 reactive power measured on the WTG own consumption line
kVAr L2	Phase L2 reactive power measured on the WTG own consumption line
kVAr L3	Phase L3 reactive power measured on the WTG own consumption line
Frequency L1	Thase L1 frequency measured on the WTG own consumption line
kWTotal	WTG total active production measured as a summation of all the voltage levels
kVArTotal	WTG total reactive production measured as a summation of all the voltage levels
kW1sec	1-sec averaged active power production measured on all the voltage levels
kW1min	1-min averaged active power production measured on all the voltage levels
kW10min	10-min averaged active power production measured on all the voltage levels
kVAr1sec	1-sec averaged reactive power production measured on all the voltage levels
kVAr1min	1-min averaged reactive power production measured on all the voltage levels
kVAr10min	10-min averaged reactive power production measured on all the voltage levels
Turbine mode	Number of actual WTG mode
Hub command	Number of command communicated to the hub controller
Pitch demand	Averaged pitch position demand
Pitch demand blade 1	Pitch demand for blade 1 communicated to the hub controller
Pitch demand blade 2	Pitch demand for blade 2 communicated to the hub controller
Pitch demand blade 3	Pitch demand for blade 2 communicated to the hub controller
Speed demand blade 1	Pitch rate/speed demand for blade 1 communicated to the hub controller
Speed demand blade 2	Pitch rate/speed demand for blade 2 communicated to the hub controller
Speed demand blade 3	Pitch rate/speed demand for blade 3 communicated to the hub controller
Blade 1 position	Actual pitch position for blade 1
Blade 2 position	Actual pitch position for blade 2
Blade 3 position	Actual pitch position for blade 3
Operating state blade 1	8 operating status bit for blade 1
Operating state blade 2	8 operating status bit for blade 2

Operating state blade 3	8 operating status bit for blade 3
Operating state blade unit	8 operating status bit for hub unit
Signal state 1	8 status bit for blade 1
Signal state 2	8 status bit for blade 2
Signal state 3	8 status bit for blade 3
Signal state ext. input 1	Extension 1 hub controller input
Signal state ext. output 1	Extension 1 hub controller output
Converter torque [%]	Actual generator torque in % of max torque
Converter speed	Rotational generator speed measured by the converter controller
Converter grid side voltage	Voltage measured on the frequency converter line
Converter grid side current	Current measured on the frequency converter line
Converter active power (total)	Active power measured on the frequency converter line and the generator stator line
Converter reactive power (total)	Reactive power measured on the frequency converter line and the generator stator line
Converter cycle counter	Converter incremental counter for the communication to the main controller.
Converter status 1	8 status bits from the converter
Converter status 2	8 status bits from the converter
Converter error 1	8 alarm bits from the converter
Converter error 2	8 alarm bits from the converter
Converter error 3	8 alarm bits from the converter
Converter error 4	8 alarm bits from the converter
Converter error 5	8 alarm bits from the converter
Converter torque demand [%]	Torque demand in % from main controller to the converter controller
Converter phi demand	phi angle demand in degree from main controller to the converter controller
Converter com. counter (send)	Main controller incremental counter for the communication to the converter controller.
Converter command	Converter command number from main controller to the converter controller

5.10 Service menu



In the manual test menu, the turbine's motors and various functions can be tested.

Master reset:

This will force the main controller to reset all active alarms. The controller will, by pressing master reset, make the controller reset under any conditions. This function can be useful during installation, if the controller has multiple alarms.

Service reset:

Some alarms need a 'service reset' don by authorized people. The 'keyboard reset' in front of the main controller panel is a non-critical reset procedure.

Service start:

This function makes it possible to start the turbine when the turbine is in service mode.

Test shaft brake:

This menu make is possible for the service personnel to manually operate the shaft brake.

The turbine has to be in service mode and with no active alarms that require shaft brake to stop, when this test is executed.

```
Apply shaft brake              (Press Enter)
Release shaft brake            (Press Enter)
Hydraulic shaft brake             145  Bar
Relief valve                        0  Bar
After pressure reduction            0  Bar
Start test relief valve        (Press Enter)
```

Pitch test sequence mode:

Only to be used by service personnel with thorough knowledge of the blade turning system.

This menu allows the manual operation of the blade turning system. The service key has to be turned before manual control is accessible. In addition, it is only possible to control the blade turning system manually if no alarm is active which normally uses blade turning system.

Pitch manual test mode:

This menu allows the manual operation of the blade turning system.

Test alarm call no:

This tests the turbines modem and telephone line. When testing, the desired alarm call number is selected. The desired number to call is found in the user menu, under set alarm call.

Test stator CB:

The stator CB is open/disconnected/tripped in the service mode by press Enter at the line 'Manual TRIP stator CB'. The stator CB is closed or connected via the line 'Manual CLOSE stator CB'.

For test fans, heaters and pumps it is possible to manually start and stop the devices. The items below describe the devices:

- Manual start/stop gear oil p. low speed
- Manual start/stop gear oil p. high speed
- Manual start/stop generator heat
- Manual start/stop offline filter pump
- Manual start/stop water pump
- Manual start/stop oil pump main bearing
- Manual start/stop grease pump in hub
- Manual start/stop lubr. pump yaw drive
- Manual start/stop lubr. pump yaw bearing
- Manual start/stop lubr. pump gen. bearing
- Manual start/stop wind sensor heat
- Manual start/stop main panel heat
- Manual start/stop operation panel heat
- Manual start/stop control panel heat
- Manual start/stop stator filter heat
- Manual start/stop main panel fan
- Manual start/stop operation panel fan

- Manual start/stop control panel fan
- Manual start/stop stator filter fan
- Manual start/stop transformer fan
- Manual start/stop nacelle fan
- Manual start/stop dehumidifier tower
- Manual start/stop dehumidifier nacelle

Manual reset lightning sensor:

It's possible to manually reset the lightening sensor, by press enter at this line.

Over speed test:

The alarms 254 'Rotor over speed', 251 'Generator over speed 1' and 253 'Generator over speed 2' is tested by using the build in test over speed function in this menu. By pressing enter at one of the lines the turbine will continuously increase the rotational speed without synchronize to the grid. When the alarm set point for the specific alarm is released the turbine will stop. The controller will only record the selected over speed alarm. This means the other two alarm types will not be triggered even if the limits for such alarms are exceeded. It is possible to interrupt the test while in progress by pressing 'stop'. For this test the over speed relay TAC85 should be set to a limit that is higher than the upper limit for the three alarms that can be set in the controller. The actual rotational speed shown on the display should be watched carefully during the test.

Test alarm function:

This test function make is possible to test the stop function for a specific alarm. Type in the alarm number.

5.10.1 Min/max register

A range of maximum and minimum values, which the computer has detected are shown in this menu. Each new minimum or maximum value is given a time stamp to show when the registration took place. All values in the menu can be reset to zero using the 'Install parameter' menu. Individual values can be reset to zero by pressing 'Clear' for the element required.

5.10.2 Input/Output

In this menu the actual state of the TOI inputs and outputs is shown.

5.10.3 Operation counters

All main controller outputs have time and activation counters. This means that the by-pass contactor has two lines. 'Times By-pass contactor ON' registers the number of activations of the output and 'Time By-pass contactor ON' the time the output has been activated. This is present for all lines in the menu. The time is in a 1/10 of an hour.

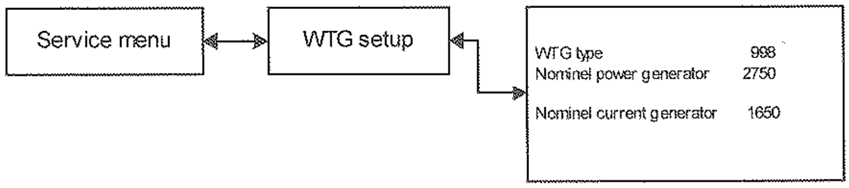
5.10.4 Wind sensors

The wind sensor output (wind speed, wind direction) is displayed in this menu.

5.10.5 Software versions

In this menu the controller's present software version and revisions can be seen.

5.10.6 WTG setup



In this menu the WTG setup is done:

WTG type:

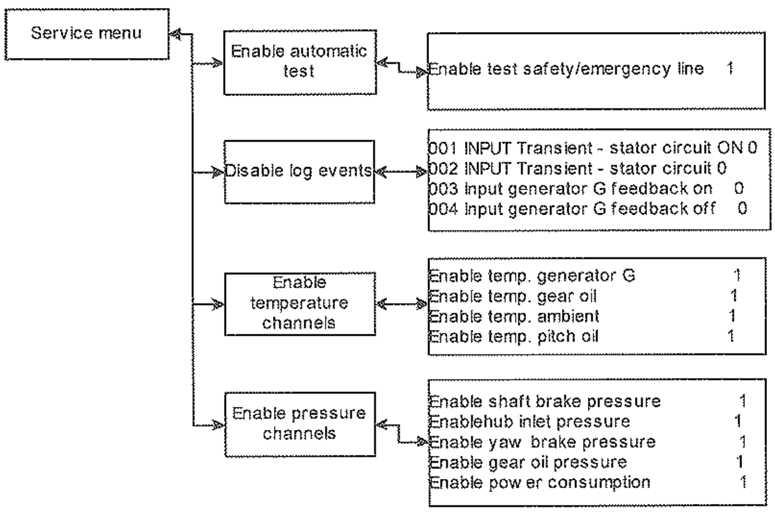
The turbine type is selected. When this is done the turbine makes a self-configuration. This means that the turbine is setting the control and regulation parameters, depending on turbine type. Turbine types can be seen in the WTG type list.

Nominal power generator:

This parameter is setting the nominal size of the generator. Selecting the type in the menu line "WTG types" will set up this parameter.

Nominal current generator:

Depending on generator type the current can differ, therefore it is possible to change the current.



Enable automatic test

Select which automatic tests to be performed.

Disable log events

Select which log events NOT to be written in the log by typing "1".

Enable temperature channels

Enable / disable temperature input.

Enable pressure channels Enable / disable pressure input by typing the number 1 or 0.

Appendix

Main specification NM80

Main specification NM92