Eoltec Scirocco E5.6-6

Installation & Maintenance Manual

Rev. 1.9

Written by Rob Beckers

www.solacity.com

Contents

Introduction

Congratulations with your purchase of the 6 kW Eoltec Scirocco wind turbine! The Scirocco was originally designed for the high winds of the Orkney islands, in the Atlantic ocean, north of Scotland. It is a rugged wind turbine that handles very high wind speeds well. Due to its high-efficiency blades and alternator the turbine is very good at harvesting the maximum amount of energy available in the wind, including in low wind areas. Because of its heritage, a Scirocco will stand up to winds of 215 km/h (135 mph). That is a category 3 hurricane!

The Scirocco is engineered with just a few moving parts and uses high quality components, so it can produce energy over a long period of time with very little maintenance. By taking a little planning and care during installation your turbine will live up to its potential. This manual was written to help you with that.

Only a grid-tie installation is discussed in this manual. Battery charging (off-grid) with a Scirocco is possible, and most of what is written in here still applies. Talk to your dealer, or contact us, if you want to use your Scirocco off-grid.

Safety Warning!

The Scirocco is a large and heavy wind turbine. Towers are even larger and certainly a whole lot heavier, and unless it is a tilt-up tower they also involve working at great heights. Installing a tower or Scirocco windmill can be dangerous and involves skills that require experience. The difference between a wind turbine that breaks down quickly, versus one that works for many years is in the installation details. *This is a job that is well beyond the average do-it-yourselfer, and really should be done by a professional wind turbine installer! If that is not reason enough, the Eoltec warranty is only valid when a qualified installer does the job.*

Electrical shock hazard: The wind turbine alternator can produce voltages in excess of 240 Volt AC. The voltage into the inverter exceeds 350 Volt DC. *These voltages can easily injure and even kill you!* Do not touch any wires or electrical connections unless the wind turbine has been stopped, the alternator shorted out with the stop switch, and the breakers for the inverter switched off. Wait at least two minutes, until well after the inverter lights and display turn off, indicating that all the capacitors have been discharged and it is safe to touch wires.

Never try to manually stop the spinning turbine blades! There is considerable momentum and energy stored in their rotation, and suddenly stopping them will cause damage to yourself and the blades.

Important Notes!

The Scirocco wind turbine is by-and-large a trouble-free machine that should give you many years of energy production. However, there are a few ways that are virtually guaranteed to (eventually) do damage to the turbine, and we want to point them out to you in this highly visible place of the manual. This is nothing to get alarmed about, for the vast majority of installed Sciroccos the items listed below will never be an issue. We just want you to be aware of them.

1) If you are going to mount a Scirocco on a **self-support tower or monopole**, you have to make sure that the resonant frequencies of the tower-turbine assembly are as follows:

   - **First natural mode ≤ 1.5 Hz.**
   - **Second natural mode ≥ 6.8 Hz.**

   This is probably gobbledygook for most readers; a structural engineer will understand. The engineer also needs to know that tower top weight is 202 kg and horizontal thrust is 580 daN @ 60 m/s wind speed.
   Improper resonant frequencies will cause the tower and turbine to vibrate violently at certain wind speeds, causing damage due to the shaking. This is what we in the business call 'an undesirable outcome' that should be avoided. If you are buying a tower through us (Solacity Inc.) we have already done the engineering to make sure the tower assembly complies with this requirement.
   Guyed towers are not nearly as critical, since the guy wires provide dampening for any oscillations. Also, the resonant frequency cannot be calculated easily for guyed towers. For those towers just observe the turbine while it goes through its RPM range (90 - 250 RPM) and adjust the guy tension, if needed, in such a way that no resonance occurs.

2) Never stop the turbine by shorting the alternator (throwing the stop-switch) when it is turning faster than 40 RPM (just under one full rotation of the blades per second). There is a spring in the alternator that has to absorb tremendous forces if the rotor is suddenly stopped at high RPMs, and it will eventually break if this is done one time too often. Use the manual stall brake first, and wait for the RPM to drop, then apply the stop switch. The manual stall brake will let you stop the turbine at any RPM and wind speed without the chance of doing damage.

3) The alternator of the Scirocco is 3-phase. If one of its phase-wires gets disconnected (due to of a loose contact for example) the alternator will run single-phase, and this creates a downright nasty vibration, which will eventually break parts in the alternator. For this reason we prescribe the use of a thermal breaker in the wiring diagram; it is there to disconnect the entire alternator when there is the loss of a phase, and in doing so it protects the alternator. Consequently, if the thermal breaker trips it is a very good idea to check if all three phases are indeed still connected after resetting it (by putting

a current clamp meter on the phase leads and measuring that all three are supplying current while the turbine is running). If the thermal breaker trips regularly in high winds, even though everything is connected as it should, it may just need to be adjusted to a slightly higher current value.

4) To make it less likely for the alternator to run single-phase we supply the PVI-WIND box (the Power-One rectifier used with the Scirocco) with 30A fuses (instead of the factory installed 20A ones). These fuses should never blow during normal use; however, if one of them does it needs to be replaced with the same type 30A fuse. The thermal breaker, not the fuses, provides overcurrent protection for the wiring and PVI-WIND box.

5) If you have a tilt-up tower be sure to raise and lower it <u>without</u> the turbine, to test if everything is working as it should. If your tower has guy wires, this is also the time to adjust the guy wire tension, so only some fine-tuning is needed after the turbine has been installed and the tower raised.

Site Selection

Wind is the fuel that drives a wind turbine. A windmill needs to be placed where the wind is; putting it on too short a tower is like installing solar photovoltaic panels in the shade. Neither will work very well. Not just any wind will do, a wind turbine needs air that moves uniformly in the same direction. Eddies and swirls, 'turbulence' in short, do not make good fuel for a wind turbine. The rotor cannot extract the energy from turbulent wind, and the constantly changing wind direction due to turbulence causes excessive wear and premature failure of your turbine. This means that you want to place your turbine high enough to catch strong winds, and above turbulent air. Since the price of towers, their foundation, and installation goes up quickly with height there is a limit to what is practical and affordable. This section is intended to help you decide what tower height works best for your turbine.

The rule of thumb for turbine height is *a minimum of 10 meters (30 feet) plus the length of a turbine blade above the tallest obstacle (trees, house etc.) in a 150 meter (500 feet) radius, with a tower height of at least 19 meters (60 feet)*. This should really be regarded as an absolute minimum for a wind turbine; at 10 meters above an obstacle there will still be some amount of turbulence and additional clearance is highly desirable. For example, if you have trees that are expected to grow up to 60 feet high, it is advisable to use a 100 feet tower. Likewise, a 60 feet tower should only be used when the terrain is very, very flat with no obstacles in a wide area around, for example at the edge of the sea, or on top of a cliff with a clear area around it, or in the tundra. For most situations a 60 feet tower will only save a little money up front, while short selling energy production in the long run.

The one exception to choose a very short tower on purpose is in case your area experiences very high winds for much of the year. For example, next to the Atlantic Ocean, or at great altitude in the mountains. In that scenario sufficient energy production is a given, and it can be more important to keep the turbine and tower close to the ground (say at 12 meters, or 40 feet), to keep the wind forces under control, to avoid massive towers and wind damage. Make no mistake though, even in this scenario you trade-off energy production (and probably quite a bit of it) for the sake of a better-protected turbine and more manageable cost.

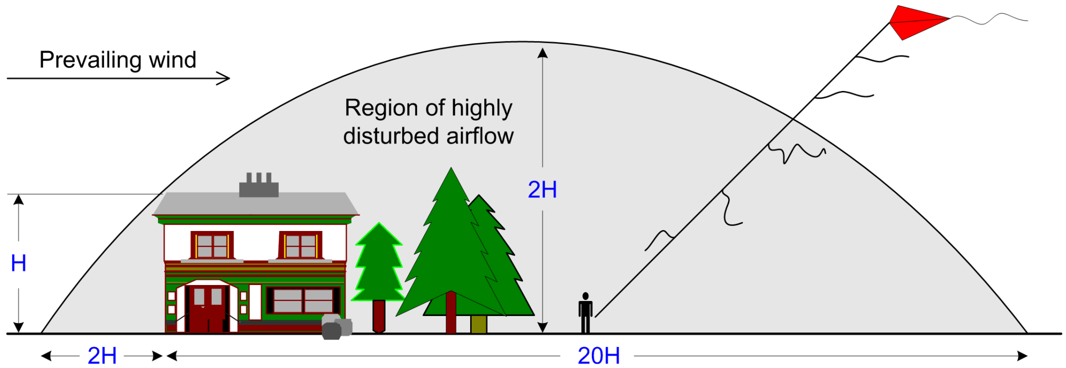


Figure 1: Zone of disturbed airflow

To go beyond the rule of thumb, the airflow over any blunt obstruction, including a tree, tends to create a "bubble" of turbulent air of twice the height of the obstacle, extending 20 times the height of the obstacle behind it. So, your 30 feet high house disturbs the air up to 600 feet away. That tree line with 100 feet trees disturbs the air up to 200 feet high at a distance of 1000 feet away! Figure 1 illustrates this. Locate your wind turbine either upwind of the obstructions, or far enough downwind. Notice from the figure that preference should be given to a site upwind of obstructions, but keep in mind that tall features downwind of the turbine can also influence the wind going through the blades, as shown in figure 1.

Upwind and downwind are relative to the prevailing wind direction; where the wind blows from most of the time. A wind atlas can sometimes tell you what your prevailing wind direction is, and if there is one at all. Some sites have winds that did not read the rulebook, and there it is equally likely to blow from more than one direction.

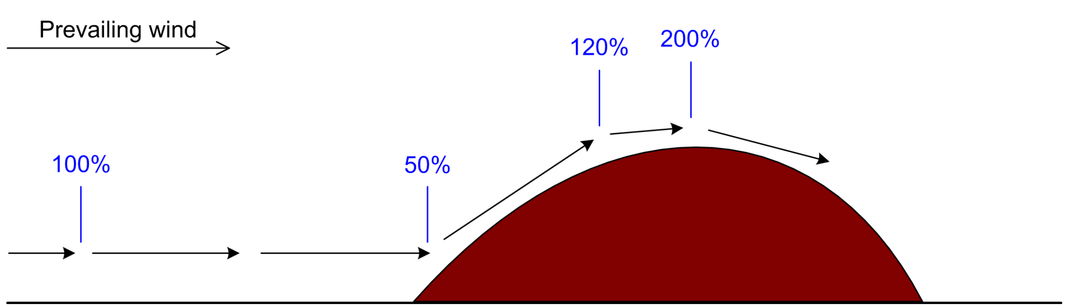


Figure 2: Increase in wind speed over a smooth hill

When it comes to wind turbines, the bottom of a hill, valley, or ravine makes for a poor place to site a windmill. The wind tends to drop in speed at the bottom of a smooth hill, and then speed up as it goes up the hill, reaching around twice the wind speed at the top of the hill. Figure 2 shows this. You can use this effect to your advantage if you have hills on your property.

For obstructions that are not smooth, such as a cliff (i.e. a sudden rise in the landscape) it gets trickier: Sharp edges create turbulence, as illustrated in figure 3. The airflow at the top of the cliff can be stronger than the average wind speed in the area, but close to the cliff's edge it may also be very turbulent, making it a poor site for a turbine. If you have a cliff edge on your property and want to use it for siting your turbine, you should still use a 60 feet high tower to get above turbulent air. Even if it seems that the wind is always blowing hard at the cliff's edge.

The lee side (downwind of the prevailing winds) of a bluff object makes for a very poor wind turbine site. The bluff object will create large turbulence on its downwind side, and the average wind speed will drop off precipitously as well. This leaves no energy for the wind turbine to harvest.

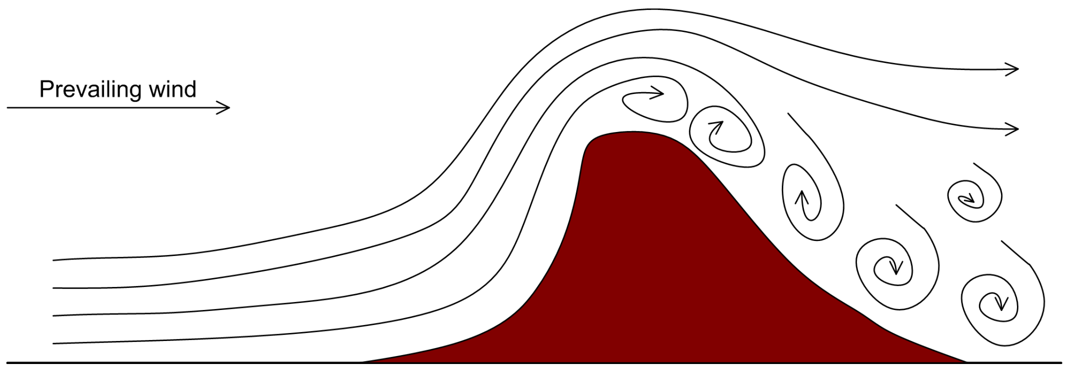


Figure 3: Airflow over a bluff object, such as a cliff

There actually is a cheap way to visually find out at what height turbulent air ends, and smooth, laminar airflow begins. Just fly a kite at your proposed wind turbine location on a windy day, preferably when the wind is coming from the prevailing direction. A helium-filled balloon that is large enough will do the job too. To visualize airflow, use tape-streamers tied to the kite's string every 15 feet or so (home improvement stores sell rolls of plastic marking tape in fluorescent colors for very little money). Wildly fluttering tape indicates turbulence, smoothly extended tape means smooth air. The direction of the streamer will tell you something too. Be sure to take the angle of the kite's string into account when calculating height.

The energy in the wind increases with the cube of the wind speed ($P \propto v^3$), and wind speed increases with height. An increase of just 26% in wind speed means twice as much power available in the wind, and your wind turbine will produce almost twice as much! A small additional investment in tower height may therefore be well worth it, thanks to the increased energy production. If you know the annual average wind speed for your location (from weather data, a wind atlas, local weather station etc.) you can use the Eoltec spreadsheet to get a good idea of the energy a Scirocco wind turbine will produce if placed in smooth, laminar airflow. Weather data usually reports wind speeds at 10 meters above ground level, the spreadsheet can take care of translating that into a wind speed at turbine height. See http://www.solacity.com/Docs/Scirocco%20Production.xls

If you have sufficient space for guy wires, we advise to use a tilt-up tower for your Scirocco. They are economical, costing only a little bit more than the cheapest type of tower (a fixed guyed tower), and allow the turbine to be installed on the ground. Annual maintenance can also be done on the ground, by tilting the tower down. This saves in crane expenses, and makes installation and maintenance much safer because the work does not have to be done at dangerous heights.

Another aspect of proper windmill siting is the distance from occupied buildings. All wind turbines produce some amount of sound. Even though the Scirocco is one of the most quiet wind turbines on the market (no, this is not just marketing hype, it really is quiet), it too produces sound. Some people find its sound soothing, since it tells them they are making energy, while it drives others absolutely bonkers. For that reason it is a good idea to place your wind turbine some distance away from your house (and especially from the neighbors!), 100 feet is a good number for minimum separation (and at least 3x that much for the neighbors). That is not to say that closer cannot be done, but you will have to honestly assess how the turbine's sound will affect you. Generally, a Scirocco that is placed in smooth air will be almost inaudible unless the wind starts blowing very hard. At that point the blades pitch to stall angle, causing the air to swirl across the blades instead of flowing smoothly, and this increases the audible sound. When this happens it can be heard over the wind when you are in close proximity (and downwind sound will carry further than upwind). There also is such a thing as too much distance, since the length and gauge of the wiring that is needed will increase. With the ever-increasing price of copper this makes it more expensive to install your turbine (aluminum wire can be a cheaper alternative).

Since we are talking about buildings: Despite the current marketing pitch of many small wind turbine manufacturers, it is generally a very bad idea to mount a wind turbine (any turbine, not just a Scirocco) directly onto a building. The airflow that close to the building is generally very turbulent, leading to premature failure and poor power production, and it is usually noisy. Every wind turbine has some amount of vibration associated with it, and this too will be noticeable inside the house. Just say "no" to building mounted turbines!

Electrical Installation

After selecting the site and tower height, it is time to install the electrical parts. The tower and wiring get installed before the wind turbine. The bits and pieces that make up the electrical parts of a Scirocco installation consist of a number of major components:

1. **The stop switch:** The stop switch is normally mounted close to the turbine tower. The stop switch is wired to short-circuit the wind turbine's alternator. An alternator that is shorted out is hard to turn; it will stop the turbine, and prevent it from spinning. For lightning protection it is advantageous to first run the tower wiring into the ground, then back up to the stop switch (instead of directly from the tower to the switch).

2. **The thermal breaker box:** The alternator of the Scirocco has 3 wires coming out, all three are used for moving energy; it is a 3-phase alternator. In case one of the 3 phases gets disconnected it causes a mechanical vibration in the alternator that eventually leads to permanent damage. A thermal breaker is used to sense, and completely disconnect the alternator in case a phase is disconnected, protecting the alternator.

3. **The rectifier box:** The alternator delivers 3-phase variable voltage, and variable frequency AC. The inverter needs DC to work. The rectifier box turns AC into DC, and provides some overvoltage and overcurrent protection. The rectifier box used for the Scirocco is a PVI-WIND-BOX from Power-One. The stock fuses in the wind box are replaced by 30A fuses on delivery, for example type Littlefuse KLKD-30. This is to ensure that these fuses will never blow (under normal conditions), since that would cause the alternator to run single-phase. Instead the thermal breaker will disconnect all 3 phases in case of overcurrent.

4. **The inverter:** The inverter takes variable voltage DC on its input and turns this into grid-quality AC, to feed energy back from the wind turbine onto the grid. The inverter that is used with the Scirocco is a PVI-6000-OUTD-US-W from Power-One. The inverter also takes care of loading the Scirocco optimally for every wind speed, to get the maximum amount of energy out of the wind. This is done by using Maximum Power Point Tracking or MPPT.

Electrical Diagram

An electrical diagram can be found on the next page, in figure 4. You can also find the latest PDF version of this schematic online on our Web site, at http://www.solacity.com/Docs/Scirocco%20Hookup.pdf

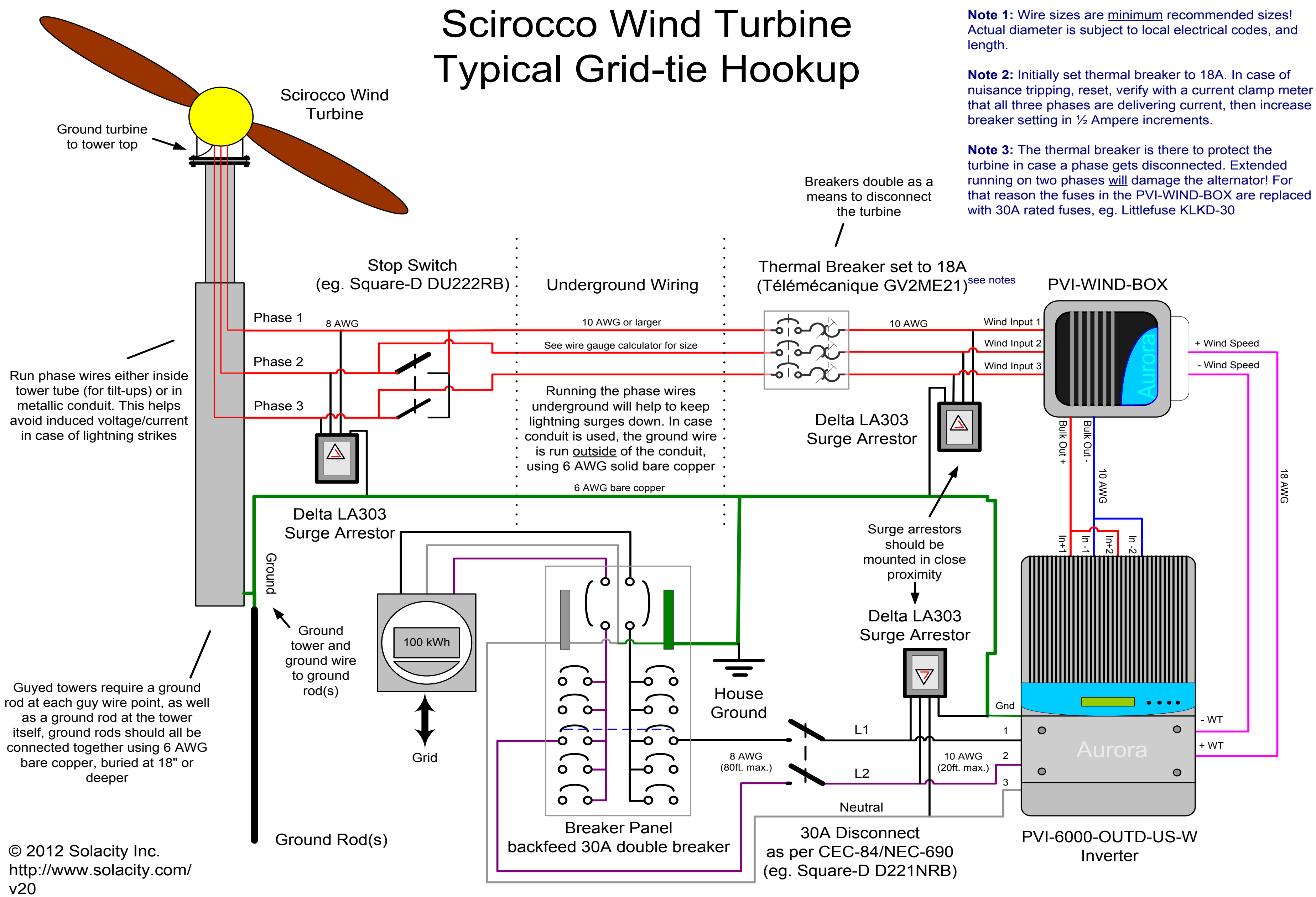


Figure 4: Scirocco electrical connections

Wire Gauge

The proper conductor size is important. Not only to keep cable losses down, but also because of the way the Power-One Aurora inverter works: This is an MPPT type inverter. MPPT ensures that the wind turbine is always loaded optimally; to extract the maximum amount of energy possible for every wind speed. The output power of the inverter is determined by measuring turbine RPM (to be exact, the inverter uses frequency, which is directly proportional to turbine RPM). The frequency of the voltage coming from the alternator (through two signal wires coming from the PVI-WIND-BOX) is sent to the inverter, and it then uses a lookup table inside the inverter to determine the power the inverter will put out to the grid. That means if the turbine RPM tells the inverter that 5 kW of power should be delivered to the grid, the inverter will try to draw as much current as it needs to, in order to insert that amount of power into the grid. If the conductors are sized too small this results in excessive current draw, excessive voltage drop, and excessive power requirements on the turbine's alternator, possibly more than it can handle, causing damage. In short, the proper conductor size really is important. Ideally we would like to see less than 2.5% losses, but to keep the wire size and price within reason it will work as long as losses stay under 4% at maximum output power (most of the time a wind turbine produces far less than maximum output power, so your actual overall losses will be well below 4%).

The following is a table of minimum copper conductor sizes vs. distance between turbine and inverter (based on 4% maximum losses). Do not forget to include the tower height into the total wire length:

Turbine – Inverter Distance		**Conductor Size**
200 feet or less	60 meters or less	10 AWG
200 – 500 feet	60 - 150 meters	8 AWG
500 – 800 feet	150 – 240 meters	6 AWG
800 – 1000 feet	240 – 300 meters	5 AWG
1000 – 1200 feet	300 – 360 meters	4 AWG
1200 – 1600 feet	360 – 480 meters	3 AWG
1600 – 2000 feet	480 – 600 meters	2 AWG
2000 – 2500 feet	600 – 750 meters	1 AWG
2500 – 3200 feet	750 – 960 meters	0 AWG
For greater distances use the wire gauge spreadsheet at http://www.solacity.com/Docs/Scirocco%20Wire%20Gauge.xls		

A wire size of 10 AWG should be regarded as the absolute minimum, and used only if the distance from tower top to inverter is less than 200 feet. For larger wire sizes you can use 8 AWG from the tower top to the stop switch (assuming no more than 120 feet is used), and then go to the larger wire size from the stop switch to the thermal breaker. This will make it a bit easier to wire up the turbine and run the wiring down the tower. If at all possible the wiring should go into the ground, to make it less likely for lightning to damage the inverter. It does not need to be in conduit, suitable cable such as Teck90 can be buried directly. In case conduit is used, place solid bare copper ground wire outside of the conduit.

Lightning Protection

Wind turbine towers unfortunately make great targets for lightning. Luckily there is much that can be done to make an installation more lightning-proof. Some of it costs money, some of it is a matter of just installing things the right way. For much more information on lightning, and lightning protection, please see the pages on lightning and surge protection on our Web site at http://www.solacity.com/Lightning.htm. It is always a good idea to understand what you are up against, and the site has a number of pages that describe in detail what lightning is, how it does its damage, how to properly ground a tower, route wires, and use lightning and surge arrestors to increase the chances for the inverter to survive.

The turbine stop switch is normally mounted close to the tower. One way to do this is by mounting the stop switch on to a pressure treaded wooden pole placed directly into the ground. It is desirable to run the wiring that comes down from the wind turbine and tower directly into the ground, and then up again to the stop switch. This helps mitigate lightning damage: In case of a tower strike there will be a voltage difference of 1 kV or more for each foot of the tower (or in other words; a 100,000 Volt voltage difference between top and bottom of a tower is nothing special). That means a cable coming off the tower at 3 feet above ground level will have a voltage difference of 3 kV relative to ground. Running the cable into the ground and back up again prevents this to a certain degree. Similarly, the cable from the stop switch to the thermal breaker should be run in the ground rather than above it.

The first LA303 surge arrestor is mounted with the stop switch (the Delta surge arrestors are rated for outside use). The two arrestors in the turbine's 3-phase wiring work together to make for a stepped approach in removing voltage spikes off the lines; the first arrestor shorts out surges coming from the tower wiring, while the second arrestor works in conjunction with the inductance of the long wires from stop switch to inverter to take care of the left-over surge before it enters the electronics. To protect against surges coming from the grid side there is a third arrestor near the grid wires of the inverter. Together with the arrestor mounted near the thermal breaker it keeps the voltage difference between the wind and grid sides in check. Both of these arrestors should be mounted not too far apart so they both ‘see’ the same ground potential in case of a surge.

The Delta arrestors are not the greatest in lightning/surge arrestors, however, they do work and are affordable. Their main downfall is the high pass-through voltage in case of a direct lightning strike. There are better arrestors out there, though these professional parts come at a very steep price.

Equipment Installation

It is preferred to mount the thermal breaker, PVI-WIND box rectifier and PVI-6000 inverter inside, though it is possible to mount all the components outside. The thermal breaker can be mounted in a NEMA-3 enclosure, while the PVI-WIND box and PVI-6000 come in a NEMA-4 rated enclosure (for those not familiar; those are all rated for outside use and electrical inspectors have no issue with this). If the PVI-WIND box and PVI-6000 are installed outdoors, please mount them in a place that is predominantly in the shade. Both boxes produce quite a bit of heat, and rely on passive cooling. Baking them in the sun will cause them to cut back on output power, and shorten their life expectancy.

For mounting the interior components, the thermal breaker box, PVI-WIND box, and PVI-6000, it is suggested to use a piece of ¾” plywood as a solid base to hang components onto. There is also some benefit in putting thin aluminum sheeting over the plywood, such as that used as flashing stock in the building industry, and grounding it. A conductive backing for the electronics will provide a good single point ground plane to mitigate lightning damage.

The black aluminum cooling fins on the PVI-WIND rectifier box have to be mounted vertically, so convection air can move through them freely! This means the heat sink needs to be on the left or right side of the box, when it is mounted. There should be at least 8” of clearance above and below the cooling fins of the box, so air can circulate. It needs cool air, so do not put it above warm objects such as the inverter.

The stock fuses in the PVI-WIND box are replaced upon delivery by 30A fuses (Power-One uses 20A fuses). For example, type Littlefuse KLKD-30. This is to ensure that under normal conditions no single fuse will blow, since that would cause the alternator to run single-phase, which in turn leads to damage to the alternator if allowed for long periods of time. The thermal breaker provides proper overcurrent protection instead of the fuses, and it will disconnect all three phases at the same time if needed. When replacing the fuses in the wind box please ensure that 30A types are used.

The Polarity of the inverter wiring is important! Wiring the inverter with reverse polarity is not covered under warranty, and can result in an expensive repair bill!

The PVI-WIND box has a type of connector that is not easy to work with. Do not make it any harder than needed, and use 10 AWG wires between the thermal breaker and PVI-WIND box, and again from PVI-WIND box to the inverter (assuming these components are mounted close to each other so these wires are relatively short). The connectors are opened by inserting a small flat-blade screwdriver into the slot just above the wire opening, and then using it as a lever by pulling upward on the end of the screwdriver. To make it easier to insert a screwdriver into the connectors for the frequency signal connecter it is a good idea to temporarily remove the three spade connecters right in front of it, with the black, yellow, and white wires (just make sure they are reconnected exactly as they were before).

There are two official ground points on the inverter; one is the bolt at the bottom of the PCB marked 'ground' (in the middle), the second are any of the threaded ends sticking out from the chassis. One way to go is to crimp a wire onto an eye and put it on the PCB bolt.

When you are done with the wiring, make sure to engage the stop switch so the turbine is stopped when it gets installed, and during raising of the tower in case a tilt-up tower is used. Keep the shipping boxes for the inverter and PVI-WIND box. If repairs are needed they are the best way to ship these components back.

Please refer to the Power-One manuals for their specific mounting instructions.

Scirocco Installation

The following is a step-by-step description of the installation of a Scirocco wind turbine. To make the installation a success, it helps to prepare. While two can do an installation, ideally it takes three people. This is due to the weight and size of some of the components; it takes two people to hold them up, a third to bolt them on. In fact, for lifting and holding the very heavy alternator in position it would not hurt to have a fourth person on hand.

It is a good idea to take pictures of the various stages of turbine assembly. In case of problems they can later be used for trouble shooting, without having to actually disassemble the turbine. In particular, pictures of the blade roots with the slewing rings attached are important for diagnostics.

Here is a list of tools and other items that will be needed:

- A tarp of approximately 10x20 feet to work on, so any dropped bolts and nuts will not disappear in the grass or gravel, and parts are kept clean.
- A few (scrap) pieces of 2x4 wood, of about two feet long each, to hold down the tarp edges in case of wind, and to support various parts during installation.
- Three concrete cinderblocks, plus some rope, to tie the tail down
- Strain relief for the tower wiring (see below).
- If needed, an M6x25 stainless steel bolt (or similar size), large washer, and nylock nut for tower top grounding and hanging the strain relief (also bring a drill!).
- Clear silicone glue/caulk for use as sealant.
- A small amount of dielectric grease to water- and corrosion proof the electrical connections.
- Loctite 243®, the removable/medium-strength type.
- Lithium soap complex based grease, rated NLGI-2 GC-LB. Easiest to work with is in the form of a small plastic tub, for example available from NAPA auto parts stores (see figure 5).
- Metric socket and ratchet kit.
- Torque wrench with a range of approx. 10 ft-lbs (14 N-m) through 88 ft-lbs (120 N-m).
- A set of regular open- and box-end wrenches in metric sizes.
- 6 mm Allen (hex) key. A simple L-shaped Allen key works best.
- 10 bolts, usually M10x45 class 8.8 (or imperial size alternative), plus nuts and washers, for the tower top flange.
- In case of the optional manual stall brake: 3 to 4 mm diameter (1/8") steel cable (stainless or galvanized) to run from tower top to the brake handle, plus wire rope clips.

Figure 5: Lithium grease

Please treat the torque values as law! Especially when it comes to bolts going into aluminum parts, such as at the blade roots. It is very easy to over-torque the bolts, causing the aluminum thread to strip out (This can be fixed using a Heli-Coil®, but it is better to avoid having to fix it in the first place).

Bringing multiple bolts/nuts up to their torque value is done in stages: Typically they are first all set to approximately 1/3 of the final torque value, then 2/3, and finally the full torque is applied. Bringing a bolt up to torque takes some of the strain off its neighbours, making it necessary to re-torque the other bolts; therefore go around over every bolt/nut at least twice to make sure they are all properly fastened.

Unless otherwise noted, put a little Loctite 243 on the thread of every bolt before putting the nut on (the exception are those bolts that go into aluminum, they are greased before inserting them, to avoid binding up). The same goes for the tower. Wind turbines operate in a hostile environment, subject to movement and vibration. Loctite helps keep the bolts and nuts from working loose over time. Loctite is not glue; it sets up in the absence of oxygen, such as between the threads of a bolt and nut when they get tightened.

The grease nipples are meant for maintenance and not used during installation. Do <u>not</u> pump any additional grease into the bearings and slewing rings. They come pre-greased and adding extra grease does no good at the time of installation (overlubrication can in fact cause additional wear by excessive churning of the grease and sliding instead of rolling of its members, until the excess has worked itself out of the bearing).

It is a good idea to hang on to the packing crates of the turbine for a little while, until you have confirmed that everything works as it should. The crates are needed in case parts have to be shipped back.

Please keep in mind that the Scirocco wind turbine has a design life of 20 years of operation under very harsh conditions. All the materials you select for this installation, as well as the workmanship, should reflect this. For example, plastic tie-wraps have no place in a wind turbine installation. Even the UV resistant ones only last three to five years before becoming brittle and breaking (if you want to use tie-wraps; there are stainless steel ones that will last forever, make sure they cannot abrade the wires though).

Manual Stall Brake

The manual stall brake adds a handle to the base of the tower, with a 4 mm steel cable going up the tower that connects to the yaw assembly. The handle allows for the turbine blade pitch to be manually changed to stall angle. This means the wind no longer has any ‘grip’ on the blades and they will slow down, regardless of the wind speed (Yes, you can even use this in a class-3 hurricane, if you can get to the tower!). Once the blades have slowed down to less than 40 RPM the stop switch is engaged to short out the alternator. This will stop and lock the turbine blades in place.

Without the manual stall brake, the blades can only be stopped in light winds, through use of the stop switch (To prevent turbine damage, only use the stop switch if the blades spin at less than 40 RPM!). The manual stall brake makes maintenance easier and safer, and it is useful to be able to stop and lock the turbine in case extreme winds are forecasted, for peace of mind.

The manual stall brake adds three parts to the turbine assembly process: A large pin that goes through the alternator, a small bracket to prevent the steel cable from rotating, and a handle for the foot of the tower.

Figure 6 has an overview of the various Scirocco components, as well as assembly and torque instructions.

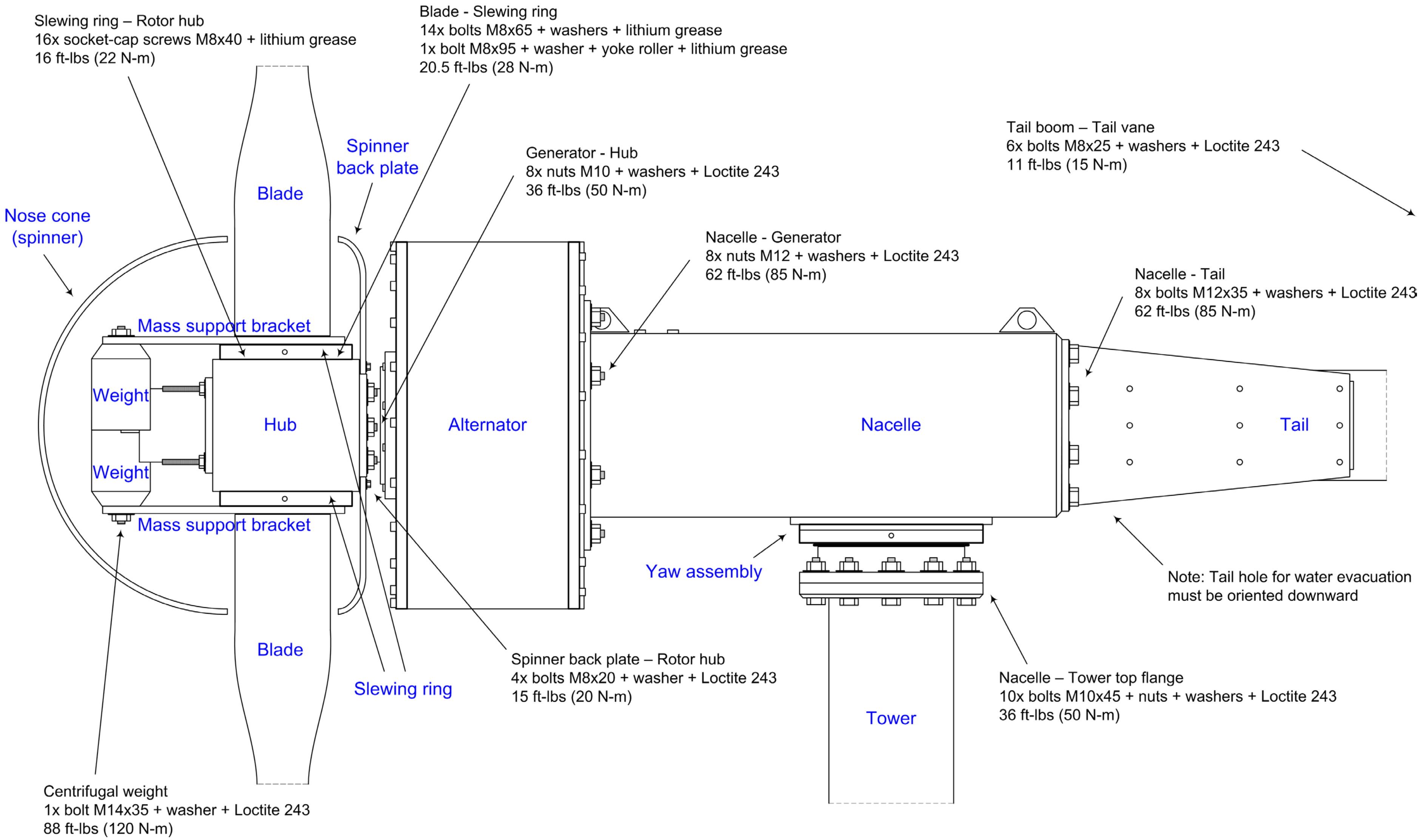


Figure 6: Scirocco overview

Step 1 – Nacelle Assembly

The first step is to take the turbine nacelle, and connect the 3 phase wires coming from the slip-ring assembly to the wires/cable going down the tower. The order in which the phases are connected is not important.

Figure 7: Strain relief

One possibility for connecting these wires that is durable, is by using the splice kits available for well pumps. They consist of a crimp-on connector plus a piece of shrink-tubing that encloses the splice and makes it watertight. The crimp-on connectors can also be filled with solder using a torch, in addition to crimping, making for a connection that will last forever. For larger wire diameters split-bolts are a good alternative. In case of screw-type connections it is recommended to use a small amount of dielectric grease to make the connection more moisture and corrosion proof. The wires that go down the tower should not put strain on the splices nor the slip ring assembly. Use an appropriate strain relieve device to take the load off. The type that looks like a mesh 'Chinese finger trap' is suggested; for example those from Hubbell going under the name "Kellems strain relief", as shown in figure 7. If individual wires are used, each wire should have an individual strain relief.

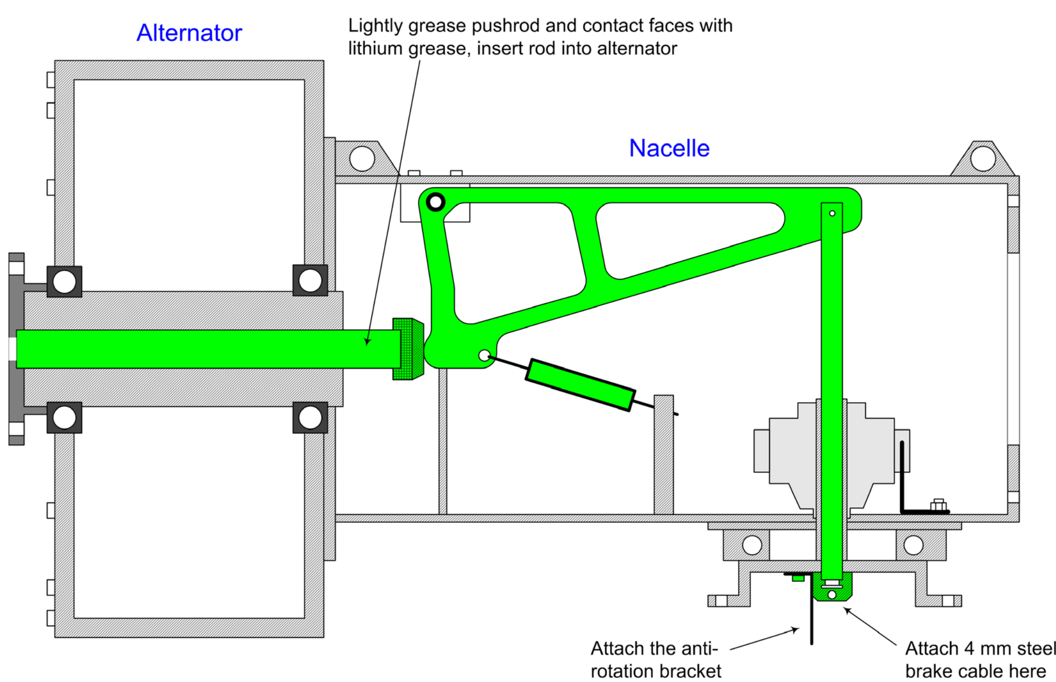


Figure 8: Manual stall brake mechanism

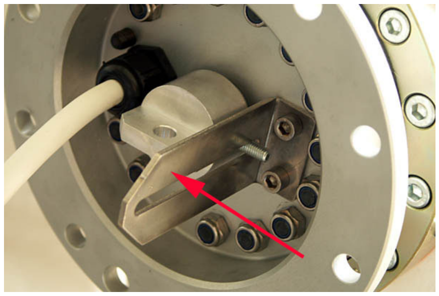


Figure 9: Stall brake bracket

For a Scirocco with manual stall brake: Figure 8 shows the components involved in the manual stall brake. Most of it comes already assembled. At this time run the steel brake cable through the tower. Next put a little Loctite 243 on the threads of the two bolts that hold the anti-rotation bracket and install the bracket in its place, as shown in figure 9. Now attach the steel cable to the eye at the bottom of the yaw assembly.

Connect the ground wire (green) coming from the slip-ring assembly to a suitable point on the tower. Use a small amount of dielectric grease so the connection will stand the test of time. A suggestion is to drill a small hole in the tower top and use a stainless steel bolt, a (large) washer, and nylock nut to connect the ground wire to the tower (with an eye crimped to the wire). The same bolt can also be used to hang the strain relief for the tower cable. In case of a manual stall brake, take care that the steel stall brake cable and electrical wires are not tangled or chafing.

Now bolt the nacelle to the tower top flange using ten M10 bolts and nuts. Put a small amount of Loctite 243 on the bolt threads and place washers under the nuts. Torque to **36 ft-lbs (50 N-m)**.

Step 2 – Alternator Assembly

Next is the alternator. The alternator is very heavy and awkward to hold. To avoid injury, it takes at least two people to lift up the alternator, and keep it in position,. A third person then puts the nuts on.

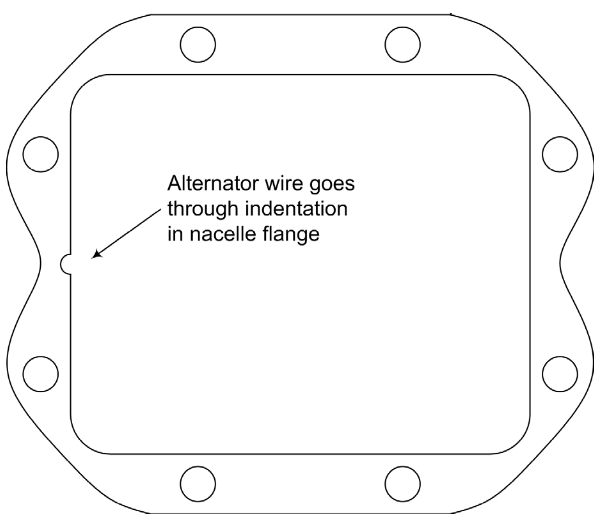


Figure 10: Nacelle front view

For a Scirocco with manual stall brake: Put a small amount of lithium grease on the push rod and its contact faces (both ends), and insert the rod through the center hole in the alternator. It sometimes takes a certain amount of persuasion to insert the pin for the first time. It is allowed to use a rubber mallet. Once inserted the push rod should not bind and move freely. See also figure 8.

While handling the alternator, be mindful of the wires and avoid pinching them. The alternator cable needs to enter the nacelle **where the notch is**, on the left side when facing the nacelle from the front, as in figure 10.

Add a thin bead of clear silicone caulk to the nacelle flange, where it bolts to the alternator, to make a watertight seal. Add a small amount of Loctite 243 to each thread on the alternator. Then lift the alternator in place.

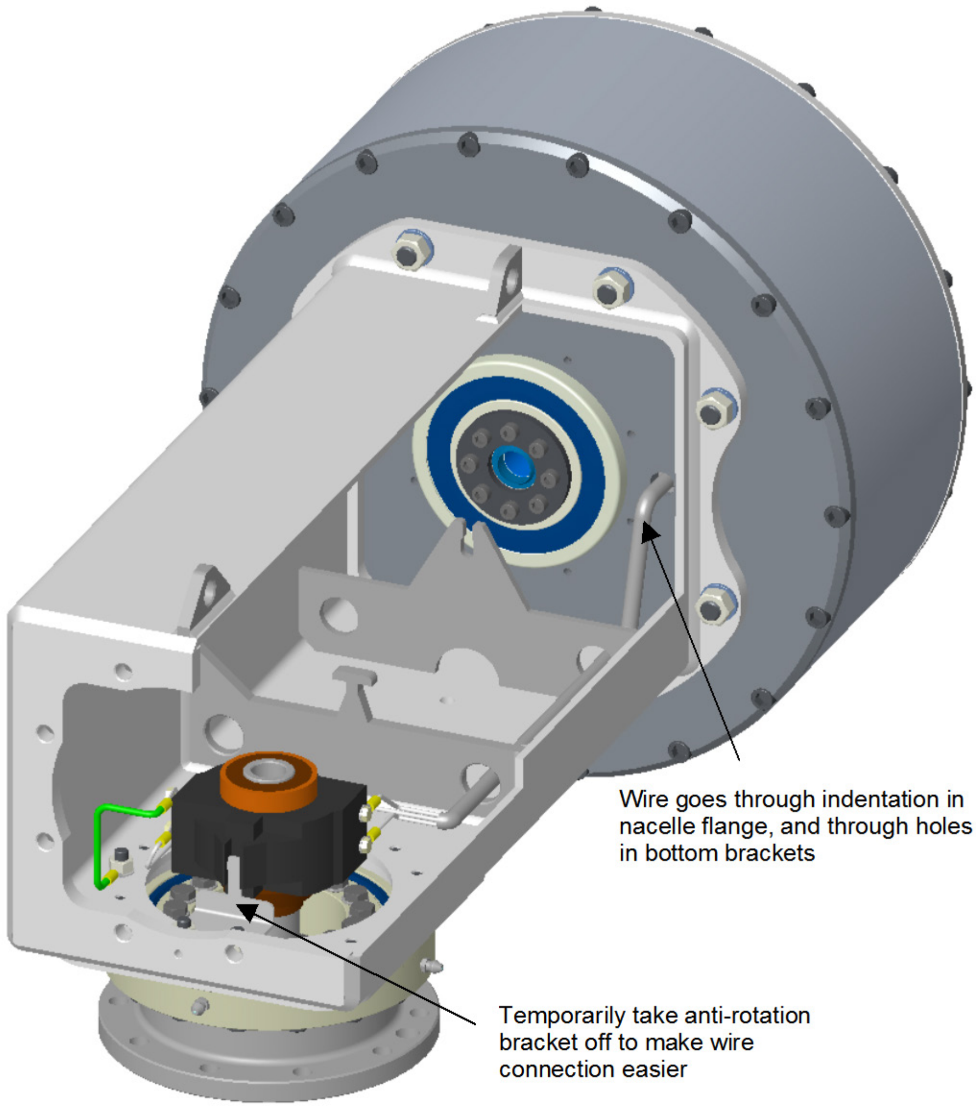


Figure 11: Nacelle wiring

The wires go into the nacelle, through the holes in the brackets, as shown in figure 11. Fasten the alternator with eight washers plus M12 nuts; tighten to **62 ft-lbs (85 N-m)**.

Step 3 – Electrical Connections

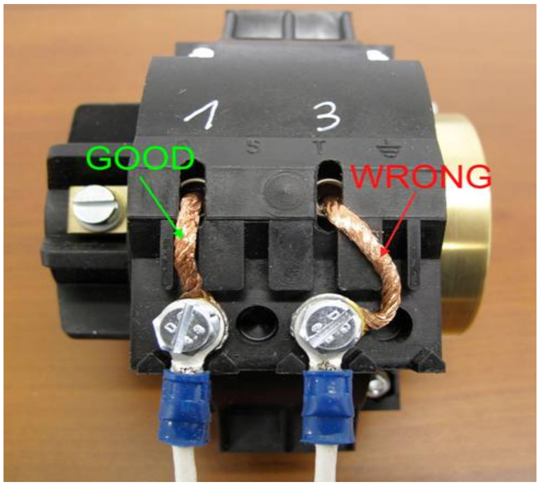


Figure 12: Slip-ring wiring

Loosen the slip-ring assembly anti-rotation bracket by taking the two small bolts out that hold it to the nacelle. The slip-ring assembly can now be rotated freely, making it much easier to attach the alternator wires to the slip rings. Rub a little dielectric grease on the connectors at the end of the wires to promote a good long-term electrical connection, and bolt them to the three free locations on the slip-ring assembly. The order of the wires is not important. Do not modify the grounding wire. Be careful when tightening the slip-ring connection bolts, they are small and easy to strip (officially it is 1.5 ft-lbs (2 N-m), but most torque wrenches are not that precise). **Make sure that the brush wires are in their slots**, and not pulled sideways since this can impede free movement of the brush, as depicted in figure 12.

When the wires are connected, return the slip-ring assembly to its original position, add a drop of Loctite 243 to the threads of the two small bolts, and put the anti-rotation bracket back in place. Torque for these bolts is not critical, and around **7 to 14 ft-lbs (10 – 20 N-m)**.

Step 4 – Tail Assembly

At this point the tail gets added to the turbine. First lay down a thin bead of silicone caulk on the mating surface of the nacelle, to form a watertight seal. Add a small amount of Loctite 243 to the threads of the eight M12 tail bolts.

The tail boom has a small drainage hole, position it so this is points downward once the turbine is upright. Tighten the bolts to **62 ft-lbs (85 N-m)**.

You can now use a rope and the three concrete blocks to pull the tail down, so it is horizontal. Loop the rope twice around the tail surface, and then through all three concrete blocks. The blocks will have enough weight to hold the tail down, even when the rest of the turbine gets assembled.

The final part for the tail is to bolt the tail vane on. Figure 13 shows in detail how the fin surface is connected to the tail boom. Verify that it is facing in the correct direction, then, for each of the six bolt holes; assemble the two plastic spacers, put a bolt through with washers on each side, add a small amount of Loctite 243 to the M8x25 bolt threads, and torque them down to **11 ft-lbs (15 N-m)**.

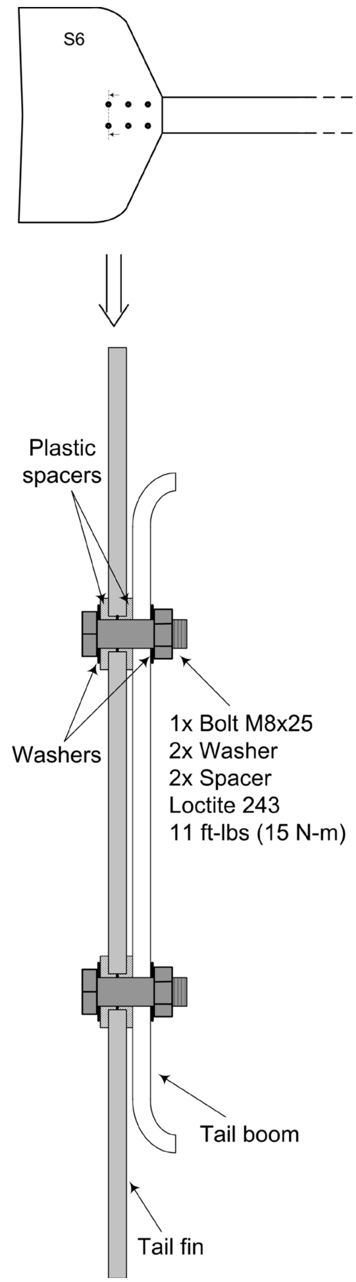


Figure 13: Tail Vane

Step 5 – Blade Assembly

The next step is to prepare the blades and hub for installation. For this it is most convenient to work on a tarp, on the ground. Use one or two pieces of 2x4 wood set on their side to lift the blade root off the ground a few inches. Also orient the blade in such a way that the trailing edge faces left, when viewed into the blade root, as shown in the figure 14. This will make installation easier and mistakes less likely.

Apply a thin layer of lithium grease over the blade flange; this is the mating surface of the blade and the centrifugal mass support. The grease is meant to provide a seal to keep water out. A thin layer is all it takes.

Stick the two centering parts in the corresponding holes in the blade root, and then push the centrifugal mass support piece onto the centering parts. Take care that the support piece is oriented properly. There are four possible ways to put the support piece on, three of them are wrong; it should point to the “1 o’clock position”, with the two notches as in the drawing (the smaller notch is up, the larger notch is facing down).

Now take the slewing ring and apply a thin layer of lithium grease to the surface that mates with the mass support, to provide a seal. The side that faces the mass support has holes that match the centering parts, only one side has these, making it easy to identify the correct side. On the opposite side of the slewing ring there is a ‘missing’ (plugged) bolt hole, and a location next to it with a machined socket for a sleeve. Line up the slewing ring so these face towards the trailing edge, as shown in figure 14.

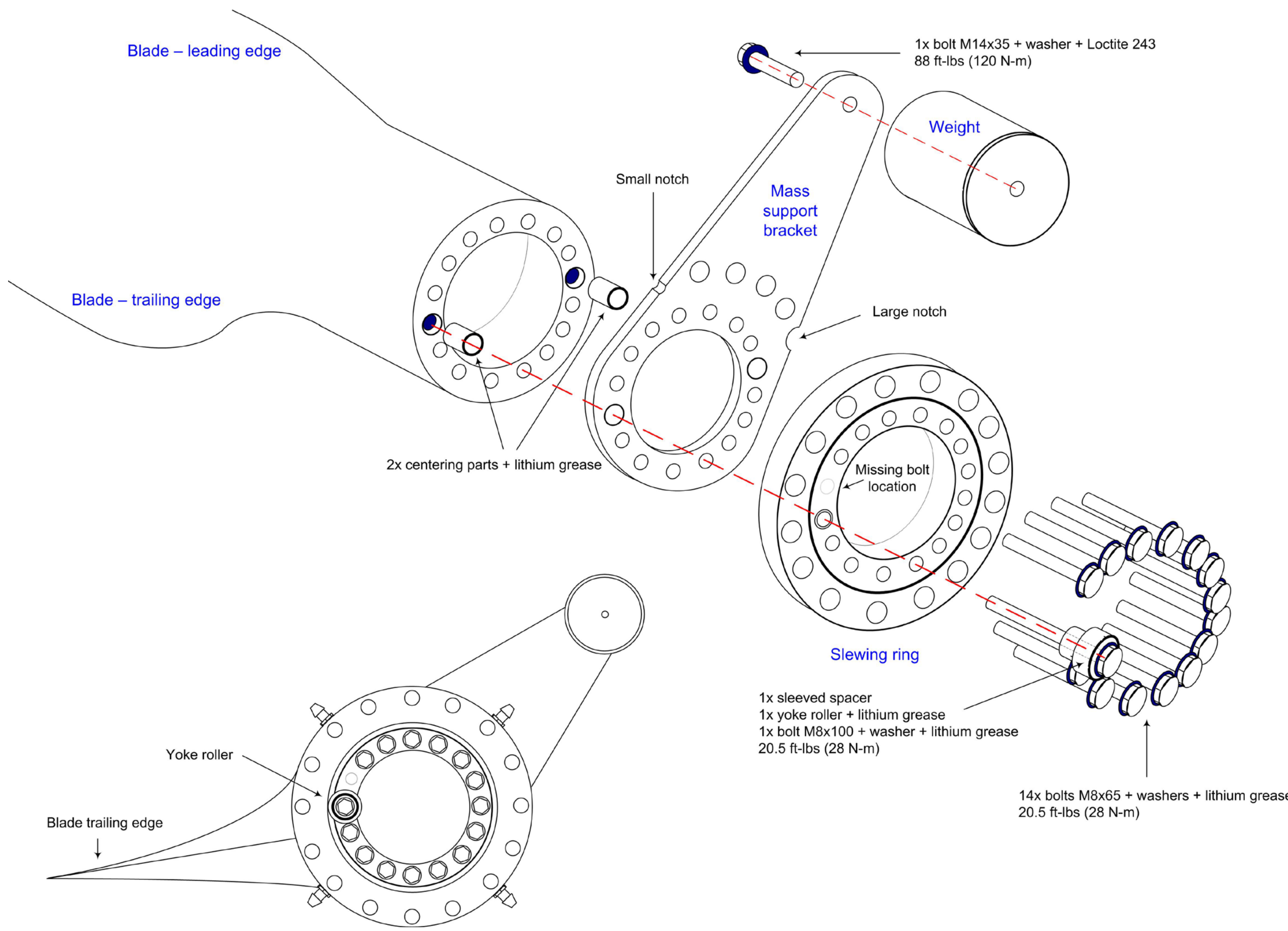


Figure 14: Blade assembly

The slewing ring is fastened to the blade (with the mass support sandwiched in between) through fifteen M8 bolts. Most bolts have only washers. One bolt, the longer one, has a yoke roller and spacer with a sleeve on it, as well as a washer. **First take the bolt plus yoke roller and spacer, put a little lithium grease on its thread, and stick it through the slewing ring hole that corresponds with the centering part. The sleeve will fall into the socket machined into the slewing ring.** There is only one location where the spacer with its sleeve will fit, so there is only one way to make this fit, as shown in the illustration. Now attach the slewing ring to the blade and thread in the yoke roller bolt, preferably starting it by hand, to avoid cross-threading**. It is very important that the yoke roller bolt goes through the centering part, on the blade's trailing edge side! Please make sure this is done right!** Please also be sure to include the spacer with the yoke roller; the yoke roller (bearing) needs to be on the outside, closest to the end of the bolt. The drawing illustrates this.

Take the other fourteen M8 bolts plus washers, put a little grease on their threads, and thread them into the remaining holes of the slewing ring. It is better to start them off manually if possible, since it is easy to cross-thread them into the relatively soft aluminum blade root. Tighten the bolts in stages, first to a torque value of 7 ft-lbs (10 N-m), then 14 ft-lbs (20 N-m), and to their final value of **20.5 ft-lbs (28 N-m)**.

Sometimes the holes in the slewing ring and the centering parts do not quite match up properly. To make sure that they are seated fully, it is advised to take a rubber mallet and lovingly tap the outside of the slewing ring (while a second person holds the blade in place), going around its circumference. The term ‘lovingly’ is used on purpose; please be delicate! Only use a rubber mallet, not a steel hammer! With this done, check the bolts again to make sure they have the proper torque.

Repeat for the second blade; there is no ‘left’ or ‘right’ blade, both are identical.

Step 6 – Hub Assembly

At this point we assemble the two blades to the hub. This is easiest to do on the ground. It is very important to keep all foreign matter out of the hub! That also includes water if you are installing the turbine in a time of the year when frost is common (since it can turn to ice, ‘gluing’ the parts inside together). Anything that can block the proper movement of the pitch control mechanism will cause the turbine to overspeed, and if the turbine overspeeds Bad Things Will Happen™! Refer to figure 14 for details.

The first step is to apply a thin layer of lithium grease on the surface of the slewing rings that will mate to the hub. Also add some grease to the yoke roller surface.

With the blade flat on the ground, and the hub facing up (so the little brass vent cap is pointing up), mate the blade with the hub. **Make sure that the yoke roller of the blade is properly inserted into the corresponding notch in the black steel block inside the hub!** It should be nearly impossible to connect the blades to the hub the wrong way, but who knows what is possible when one really tries…

The outer part of the slewing ring can now be rotated freely, in such a way that the boltholes in the slewing ring match those in the hub. The exact position of the slewing ring is not important, but it is advised to position the grease nipples such that you have easy access to them once the hub is attached to the alternator. A grease nipple that faces towards the alternator will not be accessible with a grease gun.

With the boltholes lined up, add some lithium grease to the threads of the sixteen M8 socket cap (Allen/hex-key) screws and thread them in. If possible, start them off by hand, to avoid cross threading into the aluminum hub. The boltholes that fall through the mass support bracket can be reached by manually rotating the mass support bracket a little (you will feel it push against a spring in the hub, it takes a little bit of force to move it).

Officially these M8 bolts should be tightened in stages to **16 ft-lbs (22 N-m)**. However, you will find that it is impossible to get a regular torque wrench in there. There is very little clearance between the blade and the bolts. What seems to work reasonably well is a plain L-shaped Allen key. A torque of 16 ft-lbs is "tight" when doing this by hand with a short Allen key, but not as tight as "hang onto the Allen key for dear life". Given the short arm of an Allen key it should be hard to over-torque these bolts manually. Still, this is aluminum thread that is easy to strip, so some care should be used. Go around the all the bolts at least twice, to make sure they are all tightened equally.

Do the same for the second blade to complete the hub assembly. Do not yet attach the centrifugal weights, they can be added later and would just make it harder to lift the entire assembly at this point.

Step 7 – Attaching the Hub to the Alternator

Apply a thin film of lithium grease to the alternator flange, where it will mate to the hub. Since this connects aluminum to steel (dissimilar metals) it is good to put some grease on the entire flange surface. Also add some Loctite 243 to the threads that stick out the backside of the hub.

First put the fiberglass spinner back plate in place (which will hold the nose cone), but do not attach it yet. Leaving it loose will give a little bit more room to maneuver for the next part. Now lift the hub plus blades assembly onto the alternator. Put washers and the eight M10 nuts onto the threads. Good manual dexterity and very slender fingers are a definite plus for this; there is virtually no room between the hub and alternator to work.

A regular torque wrench will not fit into the space between hub and alternator. The type that fits here is called a 'crowfoot torque wrench', they can be hard to find. If you happen to have such a torque wrench, the torque for these nuts is **36 ft-lbs (50 N-m)**. When manually tightening these nuts they should be pulled fairly tight (assuming a normal size wrench). The steel studs mounted into the hub, and the nuts, are made from hardened steel, making stripping of the thread unlikely.

The last step is to add a little Loctite 243 to the threads of the four M8x20 bolts that hold the nose cone back plate in place, add a washer, and tighten them in their place. As before, a regular torque wrench will not fit here and torque is not critical, if you have a crowfoot wrench they can be tightened to **15 ft-lbs (20 N-m)**.

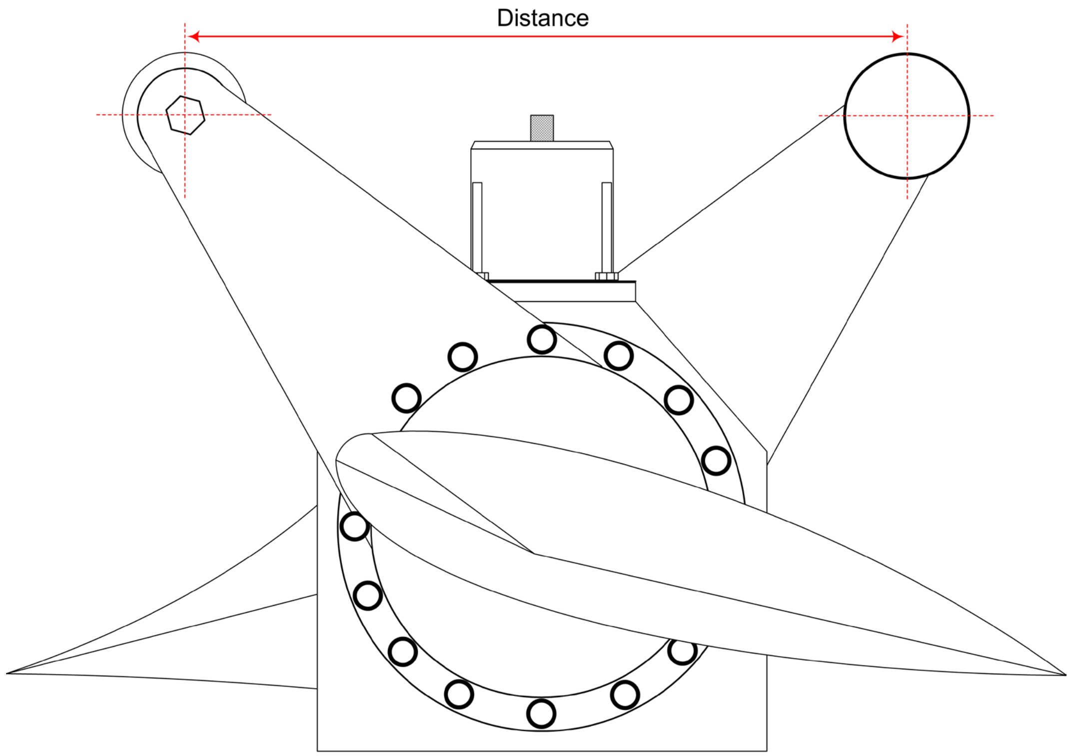
Step 8 – Attaching the Centrifugal Weights

The two centrifugal masses are connected to their support bracket with an M14 bolt plus washer each. Add some Loctite 243 to the thread of each bolt first. The weights face towards the center of the hub. Tighten the bolts to **88 ft-lbs (120 N-m)**.

At this point check the center-to-center distance between the centrifugal weights: With the blades in their starting position (the weights as close to each other as they will go) you should measure **27.2 cm ± 0.5 cm (10 11/16" ± 3/16")**. With the blades in their running position (pushing the weights apart through the weak spring, until the resistance of strong spring is felt) their center-to-center distance should measure **31.4 cm ± 0.5 cm (12 3/8" ± 3/16")**, as depicted in figure 15. *If a different distance is measured the blades were <u>not</u> assembled correctly, and you have to go back to step 5!* The most likely cause of error would be that the yoke roller was not inserted into the hole of the blade that holds the centering piece. Also check the orientation of the blades at this time; as unbelievable as it sounds, people have installed the blades with the wrong side facing the wind. Needless to say, the turbine will not work in that case. With the blades horizontal the trailing blade edge should point down on the left side, and up on the right side when viewed facing towards the turbine from the front (i.e. from the direction where the wind would blow from).

Check that the pitch control mechanism is moving freely and working. By manually pulling the weights outward a little, the blade pitch should change a few degrees, from start to running pitch. This is the first of two springs, there is a second spring that is much harder to deform and that comes into play during running. You can test it by pulling the weights apart with considerable force. Just feel if the pitch mechanism moves smoothly through the first spring, and into the second spring. There is no need to move the weights all the way to their final stops, just test the beginning of the strong spring range.

Figure 15: Blade installation verification



Starting pitch (weights pushed together):
Distance = 27.2 cm (+/- 0.5 cm)

Running pitch (weights pulled apart):
Distance = 31.4 cm (+/- 0.5 cm)

Step 9 – Installing the Nose Cone

The final piece-de-resistance is the nose cone (or spinner). The holes between the nose cone and the back plate have been drilled manually at the same time. So, try each of the two possible positions of the nose cone vs. back plate to find which position has the holes align best. **Please verify that neither the back plate nor the nose cone rub against the blades at any point.** The blades have to be able to rotate, and change pitch freely. If there is rubbing between blades and nose cone, use a coping saw or similar tool to enlarge the cut-outs in the nose cone slightly. The 8 stainless steel screws are self-threading, just tighten them.

Step 10 – Installing the Manual Stall Brake Handle

If your Scirocco has a manual stall brake there is one more step to take care off: Installing the brake handle at the foot of the tower. The brake lever itself comes with the Scirocco, but due to the variety of towers that can be used you will have to find out for yourself how best to attach the brake lever to the tower, make holes in the tower as needed, and connect the steel brake cable (running through the center of the tower) to the lever. Take care to mount the brake cable and handle such that the cable can move freely and does not bind or chafe. The steel cable should not interfere with the electrical wiring either.

With the handle in the "off" position (pointing up, the steel cable slack), loosen the M6 bolt and adjust the cable (as pictured in figure 16) so the slack is just out of the wire. Now move the handle slowly to the "on" position (as pictured in figure 16), and check that the cable is positioned with a 0.5 – 2 mm (1/64" – 3/32") offset, as shown. If the cable is binding up too tight before reaching the "on" position, loosen the M6 bolt and reposition the cable slightly, then try again. After everything has been adjusted properly you should see the blades re-pitch (so that if the turbine was spinning, they will stall and slow down) while the stall handle is pulled to the "on" position.

It is important to make sure the steel cable is adjusted properly and the blades fully reach their stall position when the brake is engaged. Be sure to check the offset in the "on" position as indicated in figure 16.

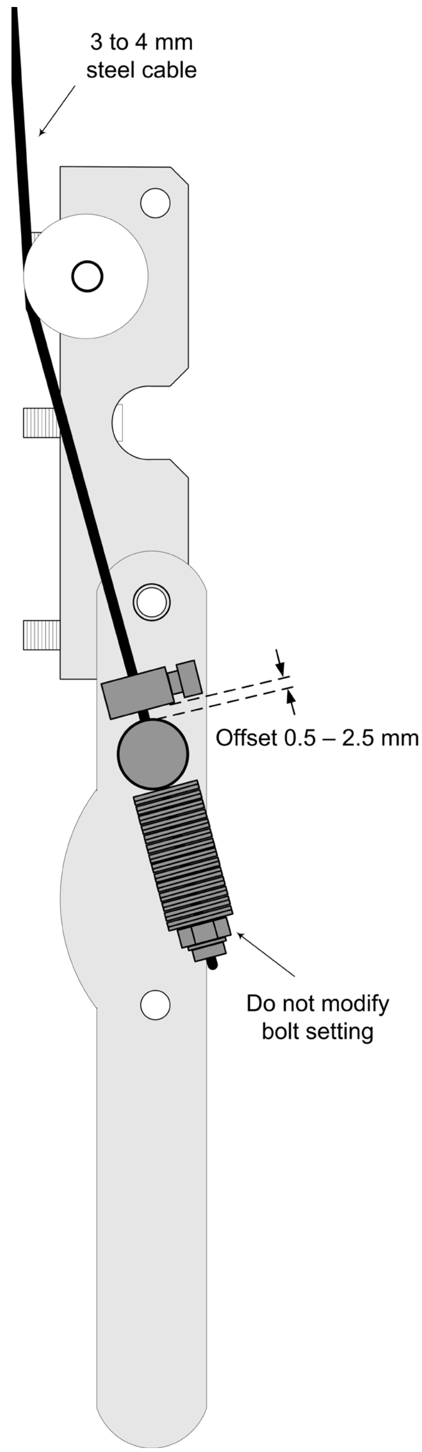


Figure 16: Stall brake handle

Be sure to read the section on stopping of the wind turbine if you have a manual stall brake! ***It is particularly important that the turbine alternator is shorted out by using the stop switch once the turbine RPM has dropped to less than 40*****. Failing to short out the alternator can cause the turbine to start spinning up again, rotating in the reverse direction.**

Note: The brake cable is not supplied with the Scirocco package. You have to supply your own 3 to 4 mm diameter steel cable, with a length in accordance with your tower height.

Commisioning

If you have a tilt-up tower, you should have already raised and lowered it without the turbine, and adjusted the guy wires (if applicable). If there are issues in raising the tower you want to find out about them before a heavy turbine is installed on top.

Before raising a tilt-up tower make sure the stop-switch is applied. This will short out all three phases of the alternator and keep the turbine from spinning up in the wind. If you have a manual stall brake verify that it is working correctly by pulling the handle, and observing that the blades change to stall angle.

If applicable, raise the tower at this point. Leave the stall brake handle in the "on" position (blades stalled), with the stop switch engaged (alternator shorted), while raising the tower. For a tilt-up tower or guyed tower, check the tension of the guy wires after raising the tower.

Verify all electrical connections, to make sure they are all connected correctly, and that all wires are tightened down properly in their terminal blocks. Verify that the thermal breaker is set to the proper current, 18A, and the three fuses in the PVI-WIND box are rated at 30A. Switch both the thermal breaker and AC (grid) disconnect (or breaker) "off", the rectifier and inverter are not connected to turbine or grid. With that done, release the manual stall brake and stop switch, so the turbine starts spinning (assuming there is some wind blowing).

Observe the turbine; it should run smoothly. Since no power is being extracted from the alternator at this time, it will quickly spin up to the maximum RPM of 245, even in light winds. Some blade noise is normal; it will actually be quieter once the alternator puts a load on the turbine. A little vibration is normal as well, but this should be minimal. If excessive vibration is observed, or the tail moves sideways rapidly (with each revolution of the turbine) shut the turbine down as described in the next paragraph and trouble-shoot.

At this time verify that the manual stall brake and stop switch work properly: Pull the manual stall brake handle to the "on" position, observe that the blades change pitch, and wait for them to slow down. This should not take long. Once the RPM drops to 40 or less (just over one full revolution every two seconds), apply the stop switch and observe that the turbine stops spinning very suddenly. Always apply the stop switch after the stall brake is enabled, without the stop switch the rotor can start spinning in the opposite direction, and there will be no RPM control if that happens. **Never apply the stop switch when the turbine is spinning faster than 40 RPM.** Applying the stop switch is much like sticking a broom handle in a spinning bicycle wheel; it is very sudden and very hard on the turbine and alternator. With the stop switch applied the blades will still move slowly. This is normal.

In case the stop switch does not appear to have any effect when it is applied as described above, verify the wiring. Some electricians seem to believe a switch should open or close the three phase wires, and wire it up incorrectly. The stop switch should short out the three phase wires when it is in the "on" position, and do nothing in the "off" position. The phase wires are connected through to the thermal breaker and rectifier (PVI-WIND-BOX) at all times, regardless of the position of the stop switch. The thermal breaker provides a means to disconnect the phase wires, to isolate the alternator from the inverter. The stop switch is not meant to do this.

Measure the phase-to-phase voltage for all three phases (there are 3 combinations to measure). The voltage should be approximately equal for all three phases. Even in moderate winds, without a load on the alternator, the voltage should be around 215 – 270 Volt AC phase-to-phase, and the frequency (if you can measure it) 40 – 48 Hz. If you measure a higher voltage or frequency it means the pitch control mechanism is not working as it should, and the turbine is overspeeding. In that case, please shut down the turbine and troubleshoot. **Do not switch on the thermal breaker if the voltage is higher than indicated above, since this will damage the inverter!**

If everything checks out so far, switch on the grid AC to the inverter, and push the thermal breaker button to connect the turbine to the inverter. The inverter should now go through its startup sequence, and start exporting power to the grid. This can take a few minutes. If the inverter is powered up (display shows numbers), the DC voltage is within the normal range (0 .. 350 Volt DC), there are no error messages, but no power is being exported to the grid: Verify the two frequency lines (low voltage wiring) between the PVI-WIND-BOX and the inverter. Make sure the '+' and '-' on the PVI-WIND-BOX correspond with the same terminals on the inverter. It is the frequency signal that tells the inverter how much power to extract from the alternator, and export to the grid. If the frequency signal is missing there will be no error message, and the inverter will show zero power.

Once it is exporting power to the grid, use a clamp-type current meter to measure each of the 3 phase lines coming into the PVI-WIND box, and make sure each phase line carries current (they should carry approximately the same current each). This is important! **If one of the lines is not showing a current this needs to be resolved**; allowing the turbine to run single-phase for long periods of time will damage the alternator due to the vibration it causes.

If you get to this point and all is working as it should, go to the setup menu of the inverter, and set the date and time properly. In case there is a feed-in tariff, the 'cash' setting in the inverter setup can be adjusted to the proper currency and value per kWh. The 'partial' counter in the inverter should also be reset to zero, by going to the 'partial' menu and holding the 'enter' key for 3 seconds (see the inverter manual).

Use & Maintenance

To get the maximum number of years of trouble-free energy production out of your Scirocco wind turbine some care during use and maintenance is needed.

Running the Wind Turbine

Thanks to its pitch control mechanism, it is perfectly fine to let a Scirocco run without any electrical load, for example when the grid is down, or the turbine's breaker has been switched off. If the wind turbine is not going to be producing energy for a long period of time, for example if the inverter has been sent out for repairs, it is best to stop the turbine if you have a manual stall brake (by applying the stall brake, followed by the stop switch). Without a manual stall break it is better to leave the turbine running unloaded then to stop it by short-circuiting the alternator. With only the stop switch applied, it can cause the turbine to spin up in very strong winds even with the alternator short-circuited, causing the alternator to burn-out in short order.

Stopping the Wind Turbine

If you have a Scirocco with the stall brake installed, the turbine can be stopped at any wind speed by pulling the stall brake handle at the base of the tower. The manual stall brake will pitch the blades to stall angle, so the wind no longer has 'grip' on them. With the stall brake applied the blades will slow down. Once blade RPM drops to 40 or below (a full revolution will take just about two seconds) the turbine stop switch should be used to short-circuit the alternator and bring the windmill to a full stop.

It is important that a Scirocco with manual stall brake is kept short-circuited (stop switch applied) when the stall brake is applied and the spinning has slowed down! Not doing this can cause the turbine to start turning again, with the rotor spinning in the reverse direction.

For a Scirocco without the stall brake, the turbine can be stopped by applying the stop switch to short-circuit the alternator. **Only use the stop-switch when turbine RPM is less than 40! If the turbine does now stop rotating within 5 to 8 seconds, immediately release the stop switch!** Let it run for some time, to give the alternator time to cool down, and try again during a lull in the wind. Slow rotation (less than 2 RPM) is normal with the stop switch applied and the alternator short-circuited. **If wind speeds over 80 km/h (50 mph) are expected a turbine without manual stall brake should not be left with the alternator short-circuited.** The high winds could overpower the alternator, and start the turbine spinning again, destroying the alternator in the process. If such high winds are expected it is better to let the turbine run freely.

Annual Maintenance

In a reasonably windy place a wind turbine can run 7000 hours or more per year. If it were a car, going at 50 km/h (30 mph), it would travel 350,000 km (or 200,000+ miles). For this reason it is strongly recommended to carefully inspect and maintain your Scirocco once a year.

Once a year lubricate the slewing rings attached to the blade roots (by removing the nose cone), as well as the yaw bearing. All have grease nipples for this purpose; use a manual grease gun with a flexible extension hose to pump grease into the bearings (any automotive store sells grease guns and cartridges). NLGI-2 GC-LB rated lithium soap complex based grease should be used (without any additives such as molybdenum). Please take care not to overpack the bearings; grease does not have to be oozing out of the seals for lubrication to be effective; a squirt or two with the grease gun lever for each of the 4 grease nipples is all it takes (if one of the grease nipples is inaccessible do not worry, getting grease into the other 3 will do the job).

Take a close look at the blades, especially to check for wear of the leading edges. Also check for loose bolts or nuts. The torque values for all bolts are listed in this manual. Verify that the 8 nuts holding the hub on to the alternator are all still tight.

This is also a good time to check the tower for loose bolts/nuts, and check and adjust the tension of guy wires (if present).

When the turbine is running and producing power, use a clamp-type current meter to verify that all three AC phase lines coming into the PVI-WIND box are carrying current. They should measure about the same amount of current each. In case one of them is not carrying current it is imperative to find the cause and correct it: Running the alternator single-phase for extended periods of time will cause damage!

Since the electronics (inverter, wind interface box etc.) tend to get installed in a dark and forgotten corner of the house, it is a good idea to check periodically if the heat sinks are clean, and the air can move trough them freely. Dusting them off with a vacuum cleaner from time to time may be in order.

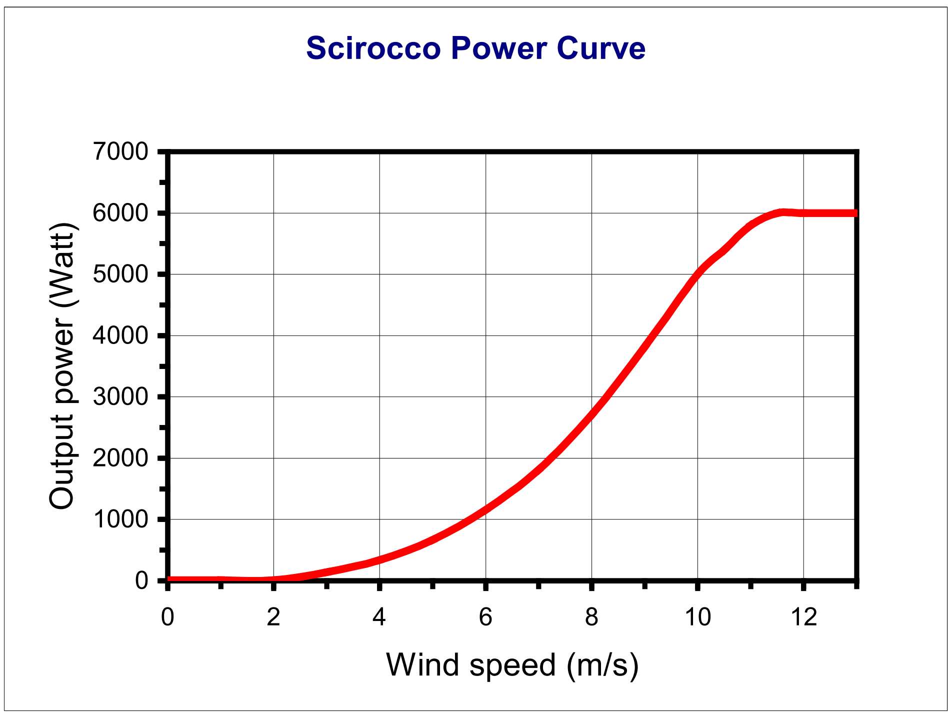
Scirocco Specifications

Rated output power	6 kW at 11.5 m/s (40 km/h) and above
Cut-in wind speed	Less than 2.7 m/s (9.7 km/h)
Survival wind speed	60 m/s (215 km/h)
Rotor diameter	5.6 meter (18.4 ft)
Swept area	24.6 m^2 (265 ft^2)
Blades	2 molded fiberglass-epoxy, aluminum root inserts
Overspeed control	Centrifugal pitch regulator, stalls blades
Rotational speed	80 – 245 RPM
Tip speed	23 – 70 m/s
TSR	6.3 at rated power
Shutdown system	Alternator short-circuit, optional manual stall brake
Alternator type	Neodymium, permanent magnet
Alternator output	6.5 kW, 3 phase, 0 – 240V AC, 0 – 46 Hz
Tower top weight	202 kg (450 lbs)
Horizontal thrust	5800 Newton (1300 lbs) at 60 m/s
Maintenance	Annual inspection and lubrication
Warranty	5 years

Power Curve

The power curve shows how much output power the inverter would produce if the wind would blow at a constant speed through the blades of the turbine. Power curves do not tell you how much energy the wind turbine will produce for your location; they form the basis for the calculations that estimate energy production. Power curves can also be useful for comparing wind turbines.

Please note that the Scirocco wind turbine does not furl, something most other small wind turbines do. Power output stays constant at 6 kW from 11.5 m/s onward, no matter how hard the wind blows. Power output for furling type wind turbines tends to drop off after they reach maximum output.

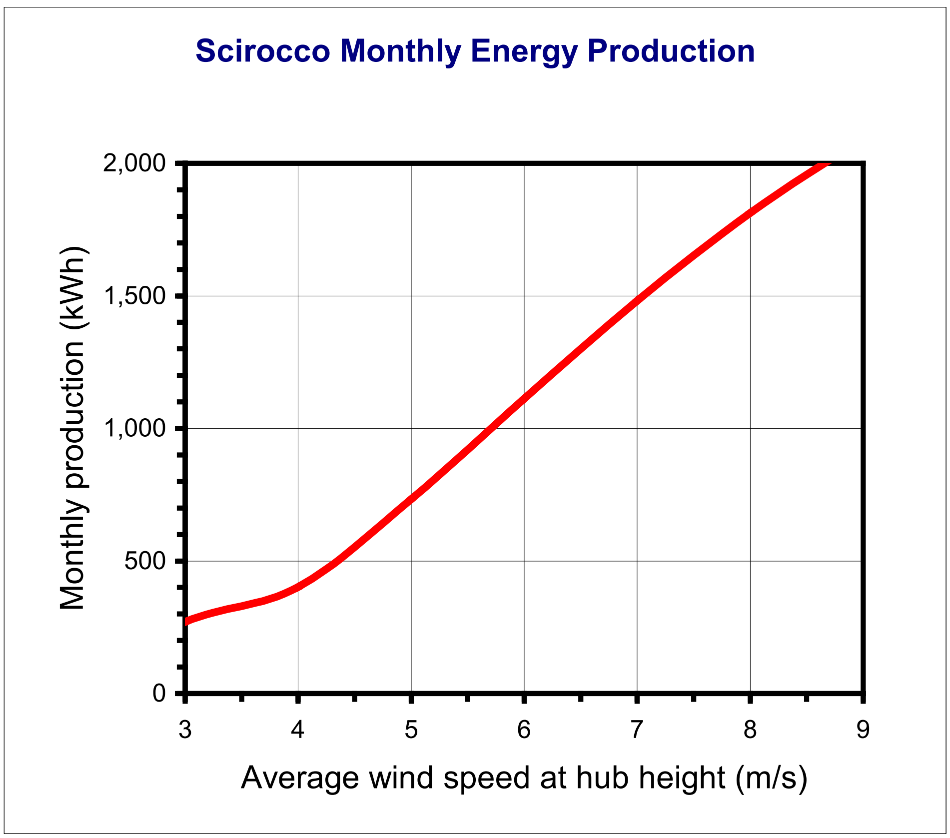


Production Curve

To get an estimate of the energy production that can be expected the Scirocco production graph can be used. It shows expected monthly production, for an annual average wind speed measured at the height of the turbine hub.

Please note that this graph is meant for sites that are on land (to get technical: it uses a Weibull distribution with k=2). Scirocco estimated energy production is for smooth, laminar airflow only, if the wind turbine is placed in turbulent air the energy production will be less, quite possibly much less.

Most meteorological wind data, such as annual average wind speed, is reported for a height of 10 meters above ground level. To translate this wind speed at 10 meters to a wind speed at hub height the Eoltec production spreadsheet can be used. This spreadsheet can also be used to do a more detailed analysis of expected energy production. See http://www.solacity.com/Docs/Scirocco%20Production.xls



Warranty Statement

Eoltec SAS - ABS, Porte de L'Arenas, Hall C - 06299 Nice Cedex 3 - France
Tel. +33(0)870.468.432 Fax : +33.04.88.13.05.70
Email: info@eoltec.com www.eoltec.com

- 5 Year Limited Warranty for Scirocco E5.6-6 Wind Turbine -

What is covered :

Eoltec's Scirocco E5.6-6 wind turbines are warranted against defects in design, material, and workmanship, under normal use for which it is intended.

Warranty duration is five year, from installation date or at the latest 3 months from delivery date .

During the warranty period Eoltec will repair or replace, at its' option, defective components or assemblies. Eoltec will also pay one-way shipping charges.

Final customer or installer will be responsible for removing the turbine to the tower and shipping the turbine or defective part or assembly (if needed) to Eoltec and re-installing.

Before any warranty action an agreement must be issued from Eoltec repair service.

What is not covered :

1) Towers, equipment, materials, or supplies not manufactured by Eoltec.
2) Eoltec's equipment that has been modified or altered without Eoltec's prior approval.
3) Damage or loss of function sustained during periods with wind speeds exceeding 60 m/s.
4) Damage or loss of function due to improper wiring or installation.
5) Damage or loss of function due to contact with flying debris.
6) Damage or loss of function due to lightning.
7) Repairs performed by other than authorized Eoltec's service person.
8) Acts of God.
9) Incidental or consequential damages.

Miscellaneous :

- Eoltec's Scirocco wind turbine must be installed and wired by a qualified installer.
- Eoltec's Scirocco wind turbine must be connected only to electronic validated by Eoltec.
- Eoltec's Scirocco wind turbine must be mounted on appropriate tower.
- For self supported tower, the resonant frequency (first natural mode) of tower-turbine assembly must be lower than 1.5 Hertz.
- For guyed tower, guys must be set adequately to avoid resonance in the working range (90-250rpm).

Warranty validation process :

For each installation, the warranty will be validated by Eoltec only after reception of the following documents :

1) Location of the installation, date of starting.
2) Description of the installation (tower type and height, electronic scheme, power electronic type, etc…).
3) List of the device(s) under warranty with serial number(s) if present.
4) Pictures of the turbine and tower installed.
5) Pictures of the electric installation.

After reception of the documents, Eoltec will send a letter to confirm the warranty validation, or request more information if necessary.