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Assembly Procedure

English Version

***„Torcman eco** 280-xx“*
***„Torcman eco** 350-xx“*
***„Torcman eco** 430-xx“*

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*This instruction may only be used in conjunction with **Torcman** products !*

Important Note - Please Read !!!!

These instructions are a step-by-step description for the assembly of ***"Torcman eco"*** Brushless Outrunner Motors. They should allow even the less experienced model builder to put together a highly efficient and long-living motor. The basic requirements for success are, besides a basic set of tools, a few manual skills, patience and having fun doing the work. If you are a beginner in the field of motor building we advise you to follow the instructions – don't skip any steps or change the sequence of the assembly. If you are already an experienced motor builder you are welcome to improvise or improve whenever you feel like it. We would like to warn you, though, that saving a few grams here and there may decrease the robustness and reliability of your product. Every part has been optimized in several stages of practical tests so that in most cases modifications wouldn't yield any further improvements.
For your health we recommend to use superglue only in well-ventilated rooms!

If you are interested in further technical details and advantages of the LRK-Motor please visit the ***Torcman*** Webpage (http://www.torcman.de) or go directly to Peter Rothers's LRK-website at http://www.torcman.de/peterslrk/index.html .
If questions should remain open, please don't hesitate to address your inquiries by email to one of the upper mentioned addresses – you will receive fast and qualified assistance. Also with the computation of optimal winding we are gladly helpful.

The described motor was especially developed for use in electric model planes, but may also be used in ship or car models. Also the use of these motors (especially the 10pole versions) in electrical model helicopters becomes more and more important.
Using this motor for anything except the purposes mentioned above is not recommended without consultation of ***Torcman*** . Due to the use of modern materials and the elaborate principal of the construction this is an extremely powerful motor which poses a danger to the user or people nearby if used in combination with a propeller. The usual safety precautions are to be observed in order to prevent accidents. Persons may never stay laterally or in front of a turning propeller.
As this product is not preassembled, we decline any claims of compensation – the builder is responsible for his own product.
Faulty parts, which can definitely be traced back to a material defect will be replaced free of charge within the guarantee period.
All components of the engines are available as spare parts - please use only original parts from ***Torcman*** for replacements.

Table of Contents :

1. Checklists for required Materials and Tools

Checkliste 1 - Do I have all required materials?

- Set of 5 turn parts (Front Shield, Stator-/ Bearing-Bushing, Inference Ring, Driver Plate)
- Statorblock of the matching length and inner diameter including 2 Stator Front Insulators
- Stator Slot Insulator Material (high temp. isolation paper or self adhesive *Kapton* foil)
- 14 Magnets of matching size and length (10/20 magnets for 10pole versions)
- 2 Ball Bearings of matching size
- Shaft with appropriate diameter and length
- Screws (3x Worm Screw for shaft, 2x Countersunk Screw for Front Shield)
- Superglue, Epoxy Glue „Uhu-Plus Endfest 300", Adhesive Cloth Tape
- Epoxy Resin and Microballoons for filling out the Gaps between the Magnets
- Heat Shrinkable or Fiberglass Enforced Tube with appropriate diameter
- Copper Magnet Wire (resistant up to 150°C) – Diameter see calculation formula

Checklist 2 - Do I have all necessary Tools and Aids?

- Vice
- Caliper
- Leather (or Gardening) Gloves or round timber (15 to 25mm diameter) for Winding
- Sharp Knife to skin the Copper Wire
- Edge Cutter/ Pliers / Small Scissors (Nail Scissors)
- Flat Wrench or better Bushing Wrench SW11 (TM280), SW13/17 (TM350), SW21 (TM430)
- Allen Key for Worm Screw (SW1.5 / 2))
- TORX-Key T8 (TM280), T10 (TM350), T15 (TM430)
- Hot Air Gun or Cigarette Lighter for the Heat Shrinkable Tube
- Soldering Iron (min 40W) + Tin Solder
- Universal-DVM or Continuity Tester
- Small Piece of Sharpened 1.5mm Epoxy Plate to stuff/fasten the Wire
- Sandpaper (grain 150-220) to roughen the areas to be glued

Important Notice:

We advise you to read and study these instructions before beginning. Otherwise you might get unsatisfying results and waste time unnecessarily.

So, get started – it's worth it!!!

2. The Stator

2.1 Calculating the Required Number of Winding-Turns, Diameter and Length of the Wire

At this point you need to have decided what you want to use the motor for later. By defining different parameters like the number of batterie cells, the maximum electrical input power, used propeller, rotational speed, running time etc. you can calculate the optimal winding pretty exactly. To get the maximum efficiency, you should try to store as much copper as possible in the stator slots and keep the electrical resistance of the winding as low as possible – which means that you should use wire with the largest possible gage (engl. gauge).
These two characteristics are contradictory in most cases, so that it is often reasonable to wind more than one wire parallel. This results in a higher total wire cross section in spite of using a thinner, more flexible wire.
We advise beginners to use wire with a maximum diameter smaller of 0.8mm for TM280, 1.0mm for TM 350 and 1.1mm for TM430 and to only parallel-wind 2 wires at once – it's enough of a challenge.

An Excel Program, which can calculate everything to an accuracy of 1% can be found on the CD supplied with the kit. The most actual version of this program can be downloaded from the ***Torcman*** Homepage http://www.torcman.de.
The operation is explained in the program.
As the wire diameter should already be known when ordering a kit, ***Torcman*** offers its customers also the free service to accomplish the computation when requested by Email.

The following formulas will help you to calculate the winding parameters of your "Dream Motor" very fast and without a lot of background knowledge - all you need is a pocket calculator. Some things needed to be simplified so that the accuracy of the final result may be reduced about 10%. Deviations of this magnitude can be easily compensated by variation of the propeller.
A rule of thumb for the required electrical power is 75-125W per kilogram of weight for electric sailplanes and 150-250W per kilogram for motor planes or hotliners.

Predetermined Parameters :

Z - *Number of NiCd or NIMH Cells*
P - *desired output power in Watts*
n - *number of propeller-turns per minute (check the attached Aeronaut Graph)*
H - *length of the stator (metal only) in mm*
D - *stator diameter in mm*

Subsequent colorized values are valid for a TM350-20 with :
Example: ***Z***=10, ***P***=400W, ***n***=6550rpm for LS 14x8 (see Graph), ***H***=20mm, ***D*** = 35mm

Wanted :

N **–** *Number of winding turns per tooth in a delta connection with serial wired, opposite coils. (most used winding and wiring manner)*

Approach :
Pick a propeller which fits to your model according to the Aeronaut-Graph in the Appendix (consider flight speed, cross section of the fuselage, etc.) and read off the number of turns ***n*** which belongs to the output power ***P***.

1. Calculating the working current :

$I = P / (Z * 1.05)$ Example : I=400/(10*1.05)=38A (for pushed cells use factor 1.10)

2. Calculating the EMK (**E**lectro**M**agnetic**F**orce)-Voltage of the motor

$U_{emk} = Z * 1.26 - I * (Z * 0.006 + 0.03)$ Example: U_{emk}= 10 * 1.26 - 38 * (10 * 0.006 + 0.03) = 9.18 V

3. Calculating the Number of Turns per Volt

$ns = n / U_{emk} + 4 * I$ Example: ns = 6550 / 9.18 + (4 * 38) = 865/V/min-1

4. Calculating the Number of Winding Turns per Tooth **N**

for TM280 : $N = 270000 / (H * ns)$
for TM350 : $N = 220000 / (H * ns)$ Example: N = 220000 / (20 * 865) = 12.7 ~ 13 Turns/Tooth
for TM430 : $N = 163000 / (H * ns)$

Please consider :
In the case of using the Actro Controller the number of winding turns is to be reduced by 8%!

5. Calculating the Wire Gage (engl. Gauge) **A**

for TM280 : $A = 9 / N$
for TM350 : $A = 14 / N$ Example: A = 14 / 13 = 1.07 mm^2
for TM430 : $A = 25 / N$

6. Calculating the Wire Diameter **D**

For a Singular Winding :

$D = 1.13 * \sqrt{(A)}$ Example: D = 1.13 * √ (1.12) = 1.2 mm

for 2 Parallel Wires :

$D = 0.8 * \sqrt{(A)}$ Example: D = 0.8 * √ (1.12) = 0.85 mm

The motor in the example above must be wound with 12 turns of 1.2mm diameter (single wire) or 0.85mm (double wire) of isolated copper wire (copper magnet wire) to achieve the desired power with the given parameters. Yet, a 1.2mm wire is very difficult to wind without damaging the stator plates, a parallel-wind with 2 wires is the preferred solution. Theoretically, you could wind even more, even thinner wires in parallel, but then the filling degree of the slots would get worse and a well sorted winding installation would be almost impossible.

Table of maximum Number of Winding Turns (by experience) :

Stator\Draht	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1.0	1.1	1.25	1.4
TM280	44	36	32	28	24	20	16	12	-	-	-	-
TM350	50	44	36	32	28	26	24	22	20	18	12	-
TM430		-	-	40	36	34	32	30	28	24	20	18

The maximum number of windings is only half as big if you use parallel winding!

Calculating the required wire length L per coil (= 2 teeth) with 100mm connection length :

H_g = Total Stator Height (= H + 2mm)
N = Number of Windings /tooth

TM280 : $L = N^* (4^* H_g +18) + 200mm$ (double for parallel winding !!!)
TM350 : $L = N^* (4^* H_g +24) + 200mm$ (double for parallel winding !!!)
TM430 : $L = N^* (4^* H_g +28) + 200mm$ (double for parallel winding !!!)

Using the above example (Hg = 22mm, N = 13turns) you would need a wire length
L = 13* (4*22mm + 22mm) + 200mm = 1630m ,
doubled for parallel winding :
1630mm * 2 = 3260mm.
But to be on the safe side you should round up to 3.5m. Altogether 3*3.5m=10.5m of copper wire with a diameter of .85mm are necessary. If wire of this diameter isn't available, please round up or down to the closest value.

Wire Cross Section and Resistance for single to 4xparallel winding

Wire Diameter without Isolation [mm]	Copper-Cross Section A [mm²]	Resistance [Milliohm/m]	Ax2 [mm2]	Resistance [Milliohm/m]	Ax3 [mm2]	Resistance [Milliohm/m]	Ax4 [mm2]	Resistance [Milliohm/m]
0.30	0.071	247.57	0.141	123.79	0.212	82.52	0.28	61.89
0.35	0.096	181.89	0.192	90.95	0.289	60.63	0.38	45.47
0.40	0.126	139.26	0.251	69.63	0.377	46.42	0.50	34.82
0.45	0.159	110.03	0.318	55.02	0.477	36.68	0.64	27.51
0.50	0.196	89.13	0.393	44.56	0.589	29.71	0.79	22.28
0.55	0.238	73.66	0.475	36.83	0.713	24.55	0.96	18.41
0.60	0.283	61.89	0.565	30.95	0.848	20.63	1.13	15.47
0.65	0.332	52.74	0.664	26.37	0.995	17.58	1.33	13.18
0.70	0.385	45.47	0.770	22.74	1.155	15.16	1.54	11.37
0.75	0.442	39.61	0.884	19.81	1.325	13.20	1.77	9.90
0.80	0.503	34.82	1.005	17.41	1.508	11.61	2.01	8.70
0.85	0.567	30.84	1.135	15.42	1.702	10.28	2.27	7.71
0.90	0.636	27.51	1.272	13.75	1.909	9.17	2.54	6.88
0.95	0.709	24.69	1.418	12.34	2.126	8.23	2.84	6.17
1.00	0.785	22.28	1.571	11.14	2.356	7.43	3.14	5.57
1.05	0.866	20.21	1.732	10.11	2.598	6.74	3.46	5.05
1.10	0.950	18.41	1.901	9.21	2.851	6.14	3.80	4.60
1.15	1.039	16.85	2.077	8.42	3.116	5.62	4.15	4.21
1.20	1.131	15.47	2.262	7.74	3.393	5.16	4.52	3.87
1.25	1.227	14.26	2.454	7.13	3.682	4.75	4.91	3.57
1.30	1.327	13.18	2.655	6.59	3.982	4.39	5.31	3.30
1.35	1.431	12.23	2.863	6.11	4.294	4.08	5.73	3.06
1.40	1.539	11.37	3.079	5.68	4.618	3.79	6.16	2.84
1.45	1.651	10.60	3.303	5.30	4.954	3.53	6.61	2.65

2.2 Preparation for Winding:

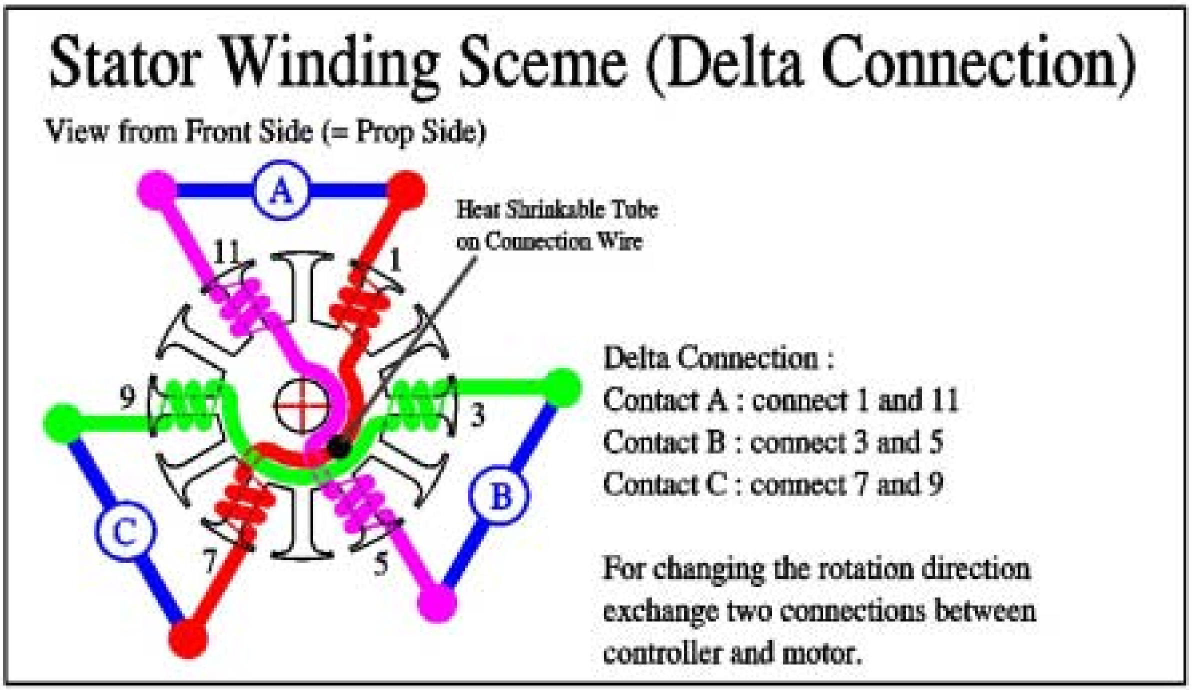
Label the six poles which have to be wound (every second) with water resistant felt-tip pen with the numbers 1/3/5/7/9/11 - see Winding Scheme. Then the stator socket is slid into the stator block and bolted with the bearing bushing. To do that, clamp the socket with its flange into the vice careful - for the protection of the stator bushing cover the the vice with with adhesive cloth tape. Tighten the screw connection with a suitable fork wrench or better, with a suitable hex nut - the stator block must not be able to be rotated against the stator bushing any more.

Before winding starts, the isolating inserts for the stator slots made of high temperature isolation paper must be cut to correct size. The use of the provided heatproof fishpaper (0,1 - 0.25mm thickness) is recommended. The size of the dies depends on stator diameter and length:

Length x Width = (Total Stator Length +2mm) x 24mm for TM280 (e.g.13x24mm for TM280-10)
Length x Width = (Total Stator Length +2mm) x 28mm for TM350 (e.g.16x28mm for TM350-12)
Length x Width = (Total Stator Length +2mm) x 32mm for TM430 (e.g.34x32mm for TM430-40)

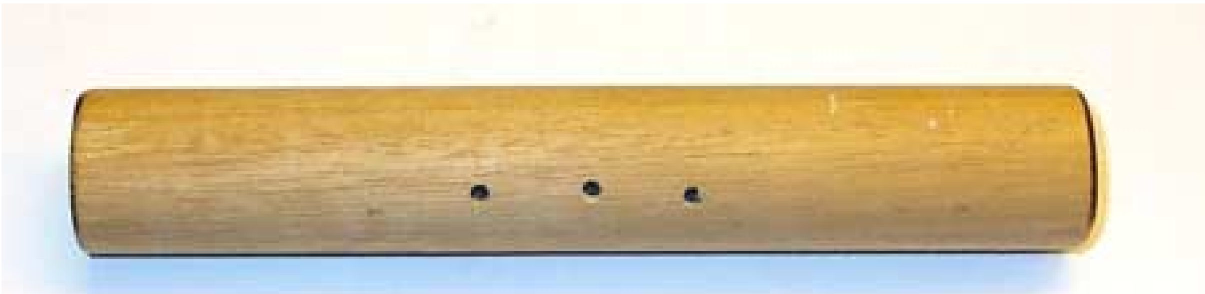
Winding pattern for delta connection

(Interconnection of the coil winding pairs on front side):

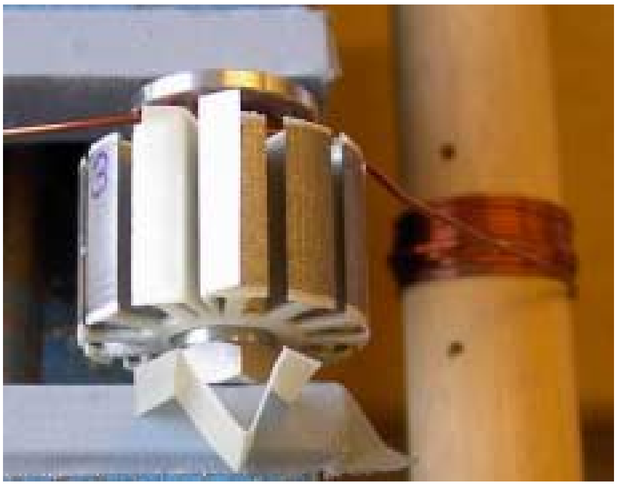


2.3 Winding the coils :

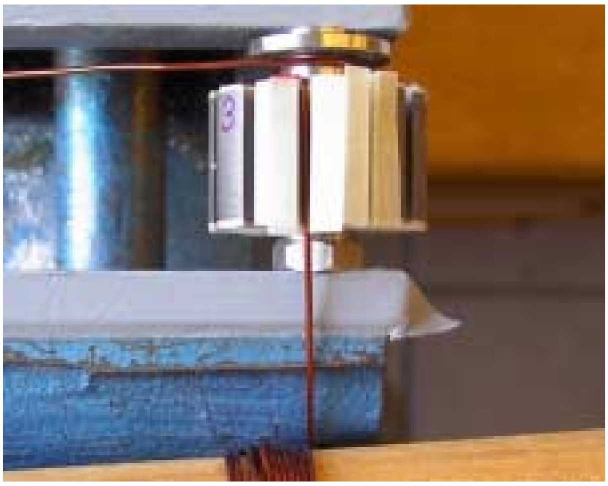
In the following, parallel-winding with 2 wires will be described. Please skip the corresponding steps if you are using a singular wire.
First, the three pieces of wire must be cut to the calculated length and straightened if required. Remove the isolation coating for about 20mm from all wire ends using a sharp knife or sanding paper. Next twist the ends of each wire together (2-3 turns) and fold the wire in half. Mark each piece of double-wire in the middle using a permanent marker. Slide a short piece of heat shrinkable tube 14/20/25mm (TM280/350/430) to the marked position and fix it with a heatgun or cigarette lighter. Instead of heat shrinkable tube, fiber strengthened tube can also be used. It should be fixed with a small drop of super glue. Now the parallel wire is ready to be applied. We recommend to print out the last page of this procedure as a winding protocoll – it can also be used as documentation for follow up projects.
Make sure you have extra wire – learning to wind takes practice but only practice makes perfect.
The order of winding is tooth 1/7 – 3/9 – 5/11, always starting with the centerpoint of the wire (at the mark) and winding towards the ends. The advantage in doing this is, that you need only to count the number of turns for the first tooth, and decide for the other teeth by measuring the remaining wire length. Since one coil is about 60mm long (valid for the 20mm stator), mistakes in the number of turns are almost impossible. Nevertheless it is no mistake to track all winding turns on the checklist of the protocoll.
Since, depending on the wire size, high traction power is necessary for the winding, the use of leather (garden) gloves is recommended. Better handling is achieved when using a round timber (see picture). This is a piece hard round wood with 15-25mm diameter, 120 -180mm length and a cross hole in the center. On this round timber the complete coil for a tooth is then rolled up, and unreeled turn by turn when winding the stator. Thus also the handling of long wire ends is simplified.

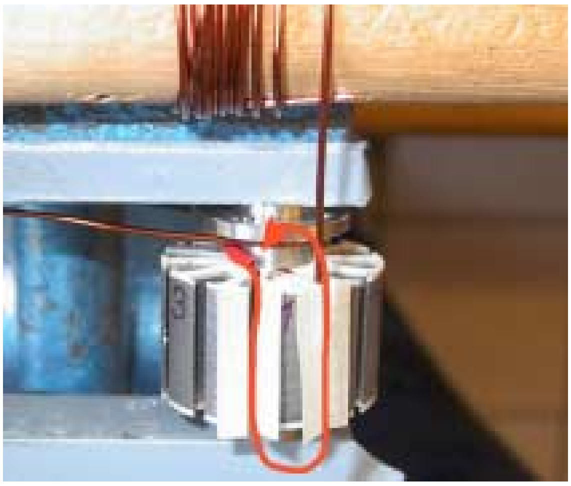


First of all, the stator assy is clamped into the vice (cover clamping yaws !) with tooth 1 showing to the upper side (see picture). Put the wire at its center isolation between the flange of the stator bushing and the stator and wind it once around the stator bushing. The isolation tube must be positioned exactly between the two teeth which are wound. The loose end (for the coil of tooth 7) must be securely fastened (the use of a ferrule is recommended here). To detect short ciruits during the winding process the use of a circuit indicator (you can use a DVM, a little lightbulb or buzzer with batterie) is advised. This will help you to recognize and repair short circuits during the winding process. One contact should be fastened to the loose end, the other to the stator bushing. It is important to remove the insulation from the end of the wire first.
Fold the isolation paper dies to a V-form as shown and slide them into the stator slot.



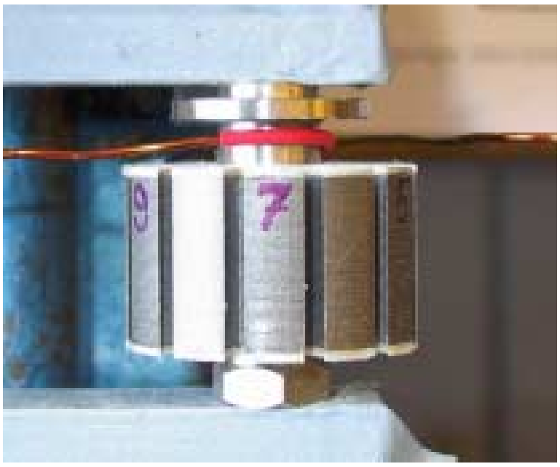
Now the first coil may be wound – please refer to the photos and winding sceme, especially for the information about the direction in which you need to wind. Starting in the middle of the wire, the two opposite teeth have to be wound in the **same direction**, in our case, counter-clockwise (referring to tooth 1 or 7). **In the end the wire entry and the wire exit have to be on the same side for all 6 teeth**. The wires should be close together without intersecting each other.
After every turn press the wire against the wall of the tooth with a small piece of Epoxy (1.5mm) or plywood. It is recommended to use a tally sheet where you draw a line for every successful installed turn in the beginning.
To pull wire of diameters larger than 0.7mm we advise you to use the wooden timber as described above.



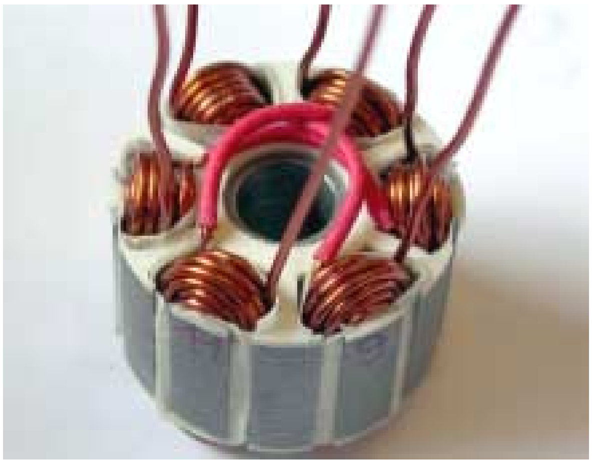


Before the second or third last turn justify the excess length of the fishpaper at the two unwound neighbour teeth. The two internal projections are shortened to 3-4mm and slided under the exterior. This groove cover can additionally be sealed with superglue - surplus adhesive has to be removed immediately.

Take the stator block out of the vice and unwind the loose end from the stator bushing.
Check the position of the protection tube on the wire and correct if required.



Wrap the wire around the stator bushing to the second tooth (tooth 7) and thread it into the slot. Clasp the stator back into the vice with tooth 7 pointing up and wind the second tooth in the same rotational direction.



Repeat the whole procedure for teeth 3/9 and 5/11 in the same way until all of the wire ends are of the same length – this guarantees the same number of turns for every coil. Don’t forget to install the heat shrinkable tube between the coils and work as efficiently as possible – don’t waste any room.
If all of the coils have been finished make sure that there are no short circuits between either coils and stator or between coil and coil.
If a inductance instrument (LCR Meter) with the range from 30 to 200 uH is available, the unconnected pairs of coils can be examined for same number of turns, and in addition, for short-circuits of the turns among themselves. The three measured values may not differ any more than 4% from each other, otherwise there is an problem in the coil which has to be fixed.
To inspect of the bridge connections remove the stator bushing once more. If everything is correct , seal the upper and lower bulges with some drops epoxy resin. This prevents later movements in the coil and associated short-circuits.

When the stator bushing is finally installed, take care, that one of the threaded holes of the mounting flange points exactly to tooth 11 of the stator. This allows an optimized wiring of the controller terminals through the front shield.

Coils 1 and 11, 3 and 5 and 7 and 9 have to be connected to each other for the delta connection and positioned so, that all of the terminals are oriented to one side. 1/11 will be in the middle between 3/5 and 7/9. Cut all of the wires to the final (equal) length and cover them with heat shrinkable or fiber enforced tube. When using heat shrinkable tube, install two tubes one upon the other in the outlet area of the front shield.

Now the ball bearings are pressed into the bearing bushing and stator bushing. Don't tilt the bearings and don't press with high force at the inner ring.. Pressing in with the vice (with protected cheeks) works fine. If the bearings do not stick enough in their bushings, fix them with some locking glue (Loctite 648 o.ae.) or super glue. To do this, push the bearings approx.. 30% into the hole and apply a very small quantity of adhesive with a pin. Then press in the bearing with a cloth, which takes up the surplus adhesive.

Strip all wire ends carefully for about 10mm with a sharp knife (remove **all** isolation !) and apply tin to the singular wires. Twist the ends as shown and solder the wires together. Install the front shield and fix it with 2 srews included in the kit). This step finishes stator assembly, which is most of the overall work.

3. The Rotor

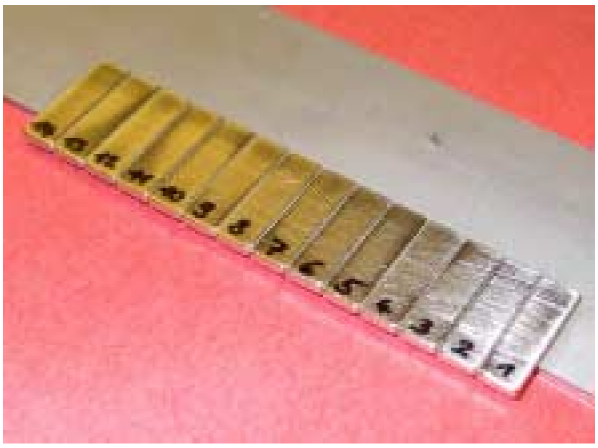
3.1 Glueing the Rotor and the Magnets

The ***„Torcman eco“*** Kit is desgned in a way, that no tools or special parts are required for installation and glueing the magnets into the inference ring. To glue the mgnets you should use Uhu Plus Endfest 300 – superglue, etc. don’t work as well, because of the remaining gaps. **Attention! Handle the magnets with utmost care and never let them snap against each other – they are very brittle and break easily!!!**

First, the parts which are to be glued must be prepared. Roughen the inside surface of the inference ring with fine sandpaper and degrease it with acetone or alcohol. Do the same for the flange of the driver plate which contacts the inference ring. Spread the flange thin with UHU-Plus (fill up groove), but keep the magnet alignment teeth free of glue. Slide the driver plate slowly into the inference ring as far as possible. **Check again that ther is no glue between the teeth !** To speed up the curing, the rotor can be put into the oven at 50-60°C , standing on the driver plate on the middle row of the oven. **In no case the rotor may be placed on the bottom of the oven, since there often occur much higher temperatures .** After 30 minutes you can continue with the installation of the magnets when doing warm curing.

Line up the 14 magnets on a flat piece of steel and make sure that the polarity is changing from N to S with every position. Check that no poles of the same kind are next to each other (take the last magnet and guide it over the row – it must be alternately pushed away and adducted .

Then use fine sandpaper (150 – 220) to roughen the nickel surface and degrease it with alcohol. Number the magnets from 1 to 14 using a permanent marker. Then apply a thin layer of Uhu Plus (mix well) with a spatula or your finger.



Now the magnets can be inserted into the rotor starting with number 1. Insert one magnet after the other, making sure to leave no gaps and always going in the same direction around the rotor. You must hold the magnets tightly with a pliers during this step because they are so strong that they would keep getting attracted to one another otherwise. After all the magnets have been inserted remove any glue remains and make sure that all the magnets have been put in correctly. The hardening of the glue in the oven **should not be done at temperatures above 60°C** since higher temperatures would damage the magnets.

Attention !

Notice that most ovens do not regulate the temperature very well. Therefore we recommend to heat up the oven to the destination temperature, switch it off and then put the rotor inside for curing.

After another 30minutes the rotor will be hardened and can be taken out of the oven.

3.2 Filling the magnet spaces

The following steps – the sealing of the spaces between the magnets – may seem unnecessary but it will effectively prevent the magnets from breaking out during high power operation.
Sealing the gaps with thickened epoxy doesn't add too much weight and takes only some minutes of time.

Mix a small amount of epoxy (5-10g) and add microballoons until the mixture is solid enough to keep from flowing. Use a spatula to fill the gaps between the magnets and make sure to trap as little air as possible. Remove any extra glue afterwards (use a small stick). Clean the magnets and remove any remaining glue with the help of a cloth soaked with Methanol or Acetone

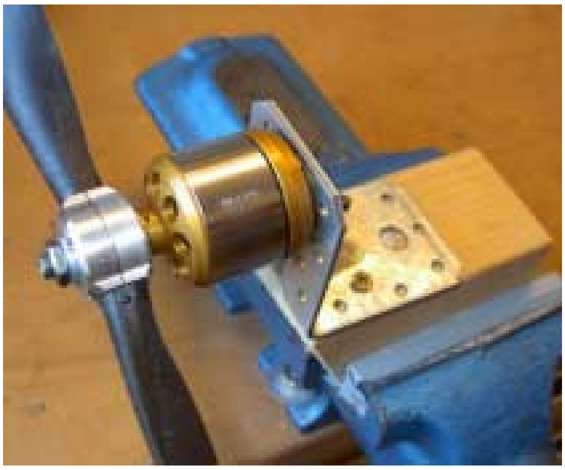
You can either let the rotor dry overnight or bake it at a temperature of 60°C again (see notice above !), depending on the kind of epoxy you used.
Afterwards the only thing you still have to do is to install the shaft and to fasten it tightly and uniformly with the 3 worm screws in the driver plate.
If the shaft should not be able to be pushed in without force, warm up the driver plate (use hot air gun or place briefly on stove plate) before inserting the shaft. If the motor is intended to be used in a very high power range, it is recommended to secure the shaft additionally with Loctites 601 or 648 in the driver plate. Alternatively you can grind small notches into the shaft (Dremel with thin grinding wheel) for a safer halt of the screws. As an option, ***Torcman*** also supplies shafts with a small flange, which supply a fixed stop.. However these are intended to be used when installing the motor at the opposite side (see to chapter 5 "Tipps for Installation").

3.3 Assembly of Stator-Rotor

Now it's showtime – but be careful !
When you slide the rotor (with the rotor shaft ahead) through the ball bearing onto the stator the two parts will be strongly attracted to each other. **The rotor is not allowed to snap in** since this might damage the wheel-bearing. Besides that you might jam your fingers between the front shield and the inference ring. The best way to prevent this from happening is to hold the stator at the stator block in one hand and to push the rotor against the fingers with the other. Then you slowly move your fingers back until the rotor has gently slid into the stator. If everything has been done right you should be able to turn the rotor easily while holding the motor at the frontshield with one hand. If you hear any rubbing noise or feel any resistance you should check the rotor and the coils and cut off or bend back any projecting parts. In most cases either the fine tips of the stator teeth will have got a bit bent during the winding or otherwise the coil will be sticking out too far and touches the magnets of the inference ring.

4. First Steps – Test Run

If you have got this far there's no keeping you back – you've got to try the thing out. But please keep cool and don't rush anything. For the first test you can either put the motor into a model or build a temporary mounting bracket. Then connect the three coil connections to the controller. Since these motors automatically get their RPM limited by the connected controller, you can use them safely without a propeller. To prevent damage to the controller you should do the first couple of tests with an almost empty battery. The more elegant way would obviously be to use a current limited power supply- but unfortunately most of the the brushless controllers don't work with these power supplies. Depending on the winding parameters you will have to expect an idle current between 1 and 5A at full speed.
First turn on the transmitter, then connect the controller and, if required the receiver supply (if a controller with optocoupler is used). Depending on which controller you use, the setup will have to be done according to its instructions.
With programmable controllers like the ***"Hacker Master"*** it is recommended to start with ***timing 3*** (18 degrees of "preignition") and ***switching frequency 8kHz***. In later tests *timing 4* and *other switching frequencies* can also be tested. Running the motor without "preignition" can overheat the controller or engine.
Next, slowly push the throttle control on the transmitter up. If the motor works fine you can increase the rotation speed to the maximum. Since this motor operates without a load neither the motor nor the controller should generate observable heat. The motor should run quietly, without any brushing noise and without vibrating.
If your motor does any of these things turn it off, disconnect the battery and search for and solve the problem. If the motor turns in the wrong direction only two of the three connections between the controller and the motor should be swapped.
If the controller switches off early you might have an empty battery. Try again using a partly loaded one.



If that works you can try to use the motor loaded, which means with attached propeller. Check and make sure you have enough room first – the propeller shouldn't be able to hit anything. **Always** start the motor standing **behind** it – if a propeller tackles it can only fly to the front or the side (if the propeller tears to the front).
To figure out the exact characteristics of the motor it is necessary to measure current, voltage and RPM's. When running the propeller used for the winding calculations with the indicated number of cells you can check and make sure that the motor is operating in the expected power range by the measuring the RPM's. Exact measurement which show the real power at the shaft and the efficiency of the motor require expensive and elaborate technical equipment.
If desired your engine can be measured against payment in the ***Torcman*** laboratory and the results will be evaluated and documented.

5. Tips for Installation

5.1 Internal Installation

The ***Torcman*** motor series was designed consciously for the installation into model aircraft fuselages.. For mounting the engine, only a frame (Fiber Epoxy or plywood) is required, which provides the appropriate drillings. Their positions and dimensions can be seen in the drawing/table on the following page. Epoxy Fiber Frames for all motors with different diameters are available as ***Torcman*** accessories.
Although motors constructed using the LKR principle have a very good efficiency, the coils still heat up when highly loaded and need to be cooled with fresh air. An established way to do that is to drill the motor mounting plate with the same hole pattern as the motor front shield. You can use the front shield to mark the holes or even to drill them through. If the motor still heats up too much, you should give the fuselage some openings on the side.
The following points are to be considered:

- the motor attachment screws may not exceed the prescribed immersion depth, otherwise short-circuits with the coil can be the result !!!
- sufficient space for the cables must be provided, so that they cannot touch the rotor. The cables should be fixed in the fuselage with appropriate clamps or tape.
- with very slim fuselages may require the use of an extension kit, which is available as ***Torcman*** accessory.



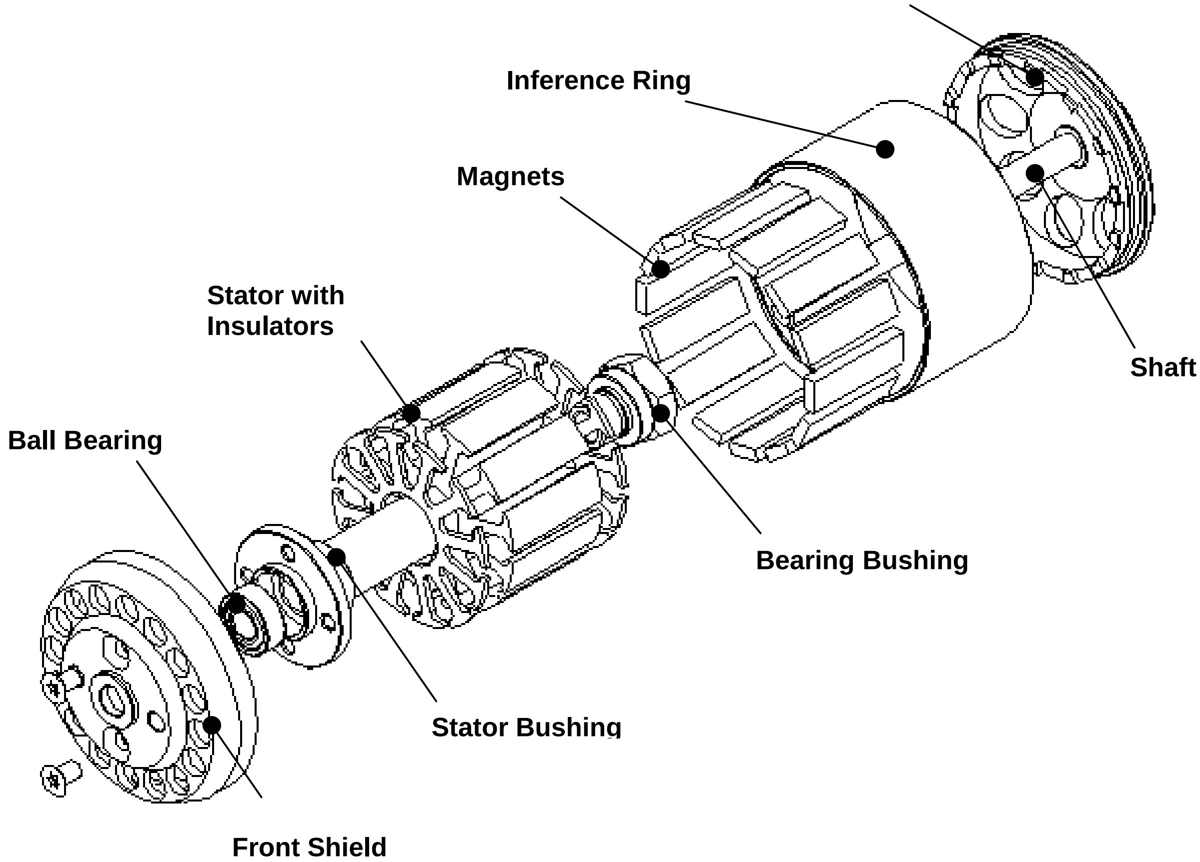

5.2 External Installation

With small modifications all types of the Torcman series can be mounted also in reverse direction. For this the shaft must be only passed through on the driver side and requires a hard stop on the front side, which leads the traction power of the propeller to the ball bearing. When using the motor in pressure mode this feature is not necessary. To facilitate this, special shafts with collar are available as ***Torcman*** accessories. It is also possible to install a set collar and a short brass tube to hold the rotor in place (see picture). Here must be taken care of a very firm fit of the set collar – providing the shaft with a groove/flattening is recommended. As with the internal installation, the mounting frame should be provided with the same drilling pattern as the front shield for cooling.
The following points are to be considered:

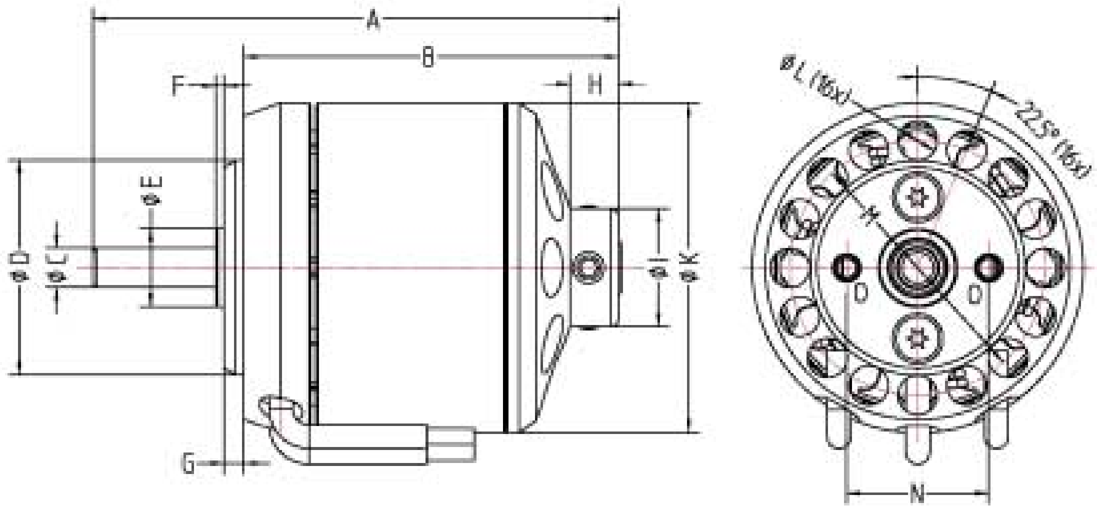
- the motor attachment screws may not exceed the prescribed immersion depth, otherwise short-circuits with the coil can be the result !!!
- that motor frame must be constructed rigid enough, since the entire mass of the motor plus propeller is now attached from the same side
- use only well balanced propellers




6. Exploded View / Components / Dimensions



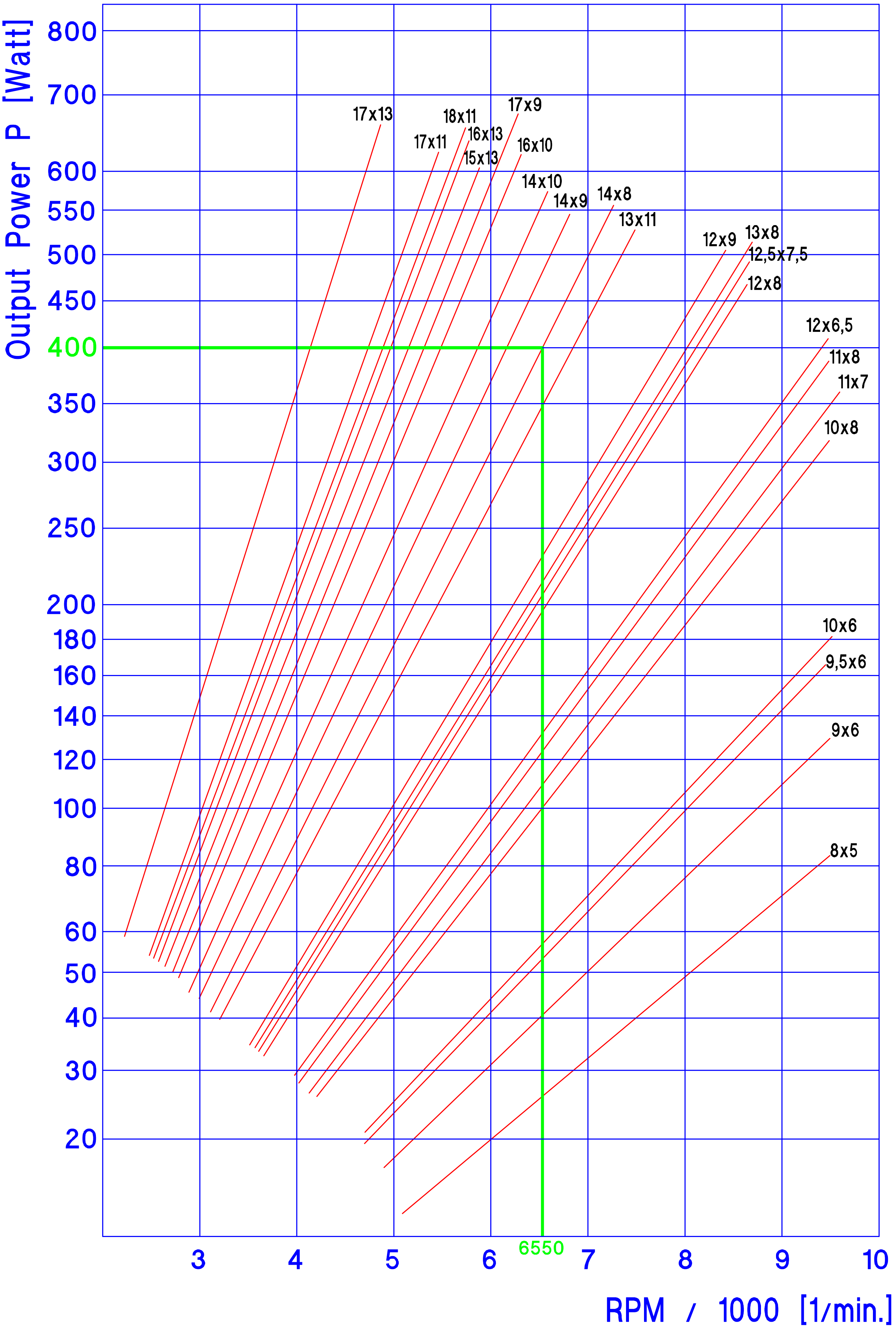
7. Dimensions



	A(*)	B	C	D	E	F	G	H	I	K	L	M	N	O	P
280-05	40	26.0	4.0	21.5	8.0	0.8	2.0	4.0	11.0	34.4	4.0	26.0	15.0	M2.5	4.5
280-10	50	31.0	4.0	21.5	8.0	0.8	2.0	4.0	11.0	34.4	4.0	26.0	15.0	M2.5	4.5
280-15	50	36.0	4.0	21.5	8.0	0.8	2.0	4.0	11.0	34.4	4.0	26.0	15.0	M2.5	4.5
280-20	60	41.0	4.0	21.5	8.0	0.8	2.0	4.0	11.0	34.4	4.0	26.0	15.0	M2.5	4.5
350-12	60	40.0	5.0	27.3	10.0	1.0	2.5	6.0	15.0	42.0	5.0	32.4	18.0	M3	5.0
350-20	75	48.0	5.0	27.3	10.0	1.0	2.5	6.0	15.0	42.0	5.0	32.4	18.0	M3	5.0
350-28	80	56.0	5.0	27.3	10.0	1.0	2.5	6.0	15.0	42.0	5.0	32.4	18.0	M3	5.0
430-20	80	53.5	6.0	34.0	12.0	2.0	3.0	6.0	18.0	52.0	6.0	41.0	24.0	M4	7.5
430-30	90	63.5	6.0	34.0	12.0	2.0	3.0	6.0	18.0	52.0	6.0	41.0	24.0	M4	7.5

AERONAUT CAM CARBON

Valid for 42mm Center Part !!!



TORCMAN Winding Protocoll

Statordiameter : ____mm   Stator Length : ____mm

Calculated Number of Turns : ____   # of Parallel Wires : ____

Wire diameter : ____mm   Insulator-Die Size : __ x __ mm

Calculation of the required wire length L per Winding (= 2 teeth) including 100mm connection wire :

H_g = Total Stator Height (~ H + 2mm)   /   N = Number of turns / tooth

TM280 : $L = N^* (4^* H_g +18) + 200mm$ (double for parallel winding !!!)
TM350 : $L = N^* (4^* H_g +24) + 200mm$ (double for parallel winding!!!)
TM430 : $L = N^* (4^* H_g +28) + 200mm$ (double for parallel winding!!!)

Calculated Wire Length : ______mm   Pre-cut Length : ______mm

Checklist and Measuring Results :

	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Resistance Ri (Milliohm)	Inductivity L (Microhenry)	Remaining Wirelength [mm]
Tooth 1													
Tooth 7													
Tooth 3													
Tooth 9													
Tooth 5													
Tooth11