Shimano E8000 Bearing change

Contenido

Introduction

There is a thread in emtbforums where some forum members are sharing their knowledge about the replacement of bearings in Shimano E8000 motor. But as the information is not in order and has been evolving during time, it is a long task to read the complete thread, understand it and extract valid conclusions, so I have complied this document with the information provided in the original thread, and I hope it is more organized and understandable**, but it is still highly recommended that you read completely the original thread and understand it**. The original thread is in:

https://www.emtbforums.com/community/threads/steps-e8000-motor-service.16542/.

There is also a video posted in youtube that shows the bearing change: "Shimano E8000 Motor overhaul and bearing replacement."

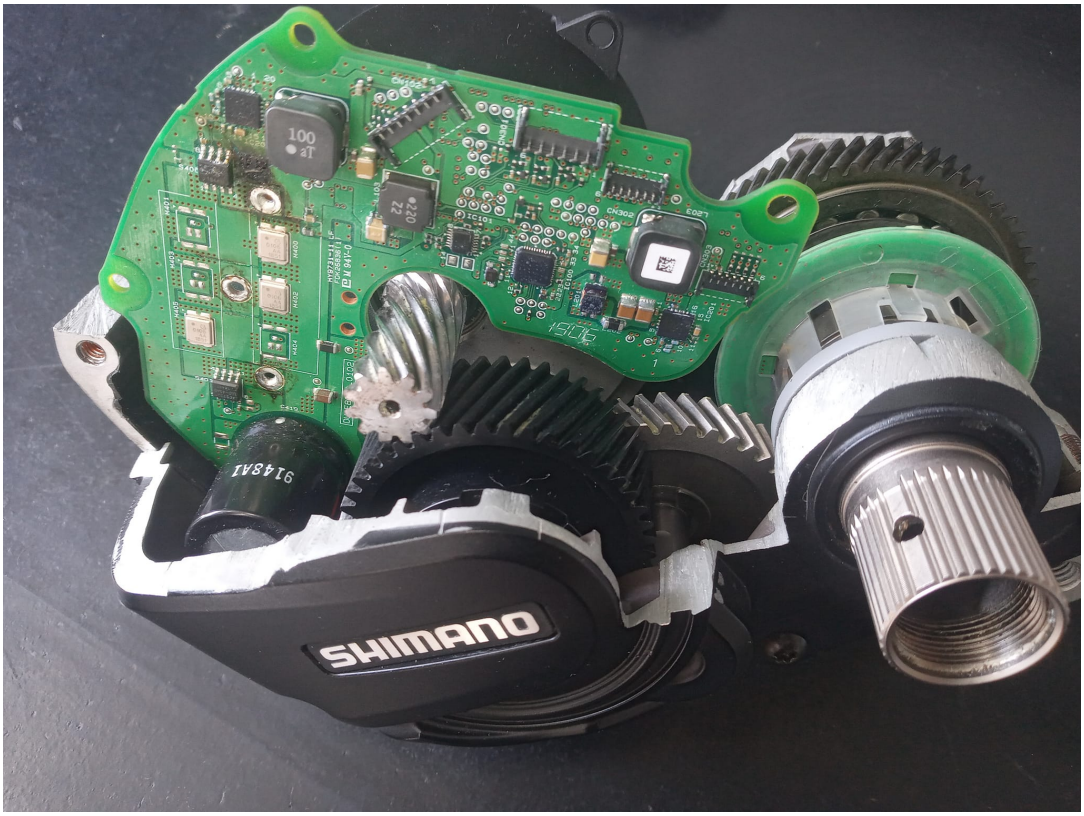
https://www.youtube.com/watch?v=Jf5th-WTBCI&t=1961s

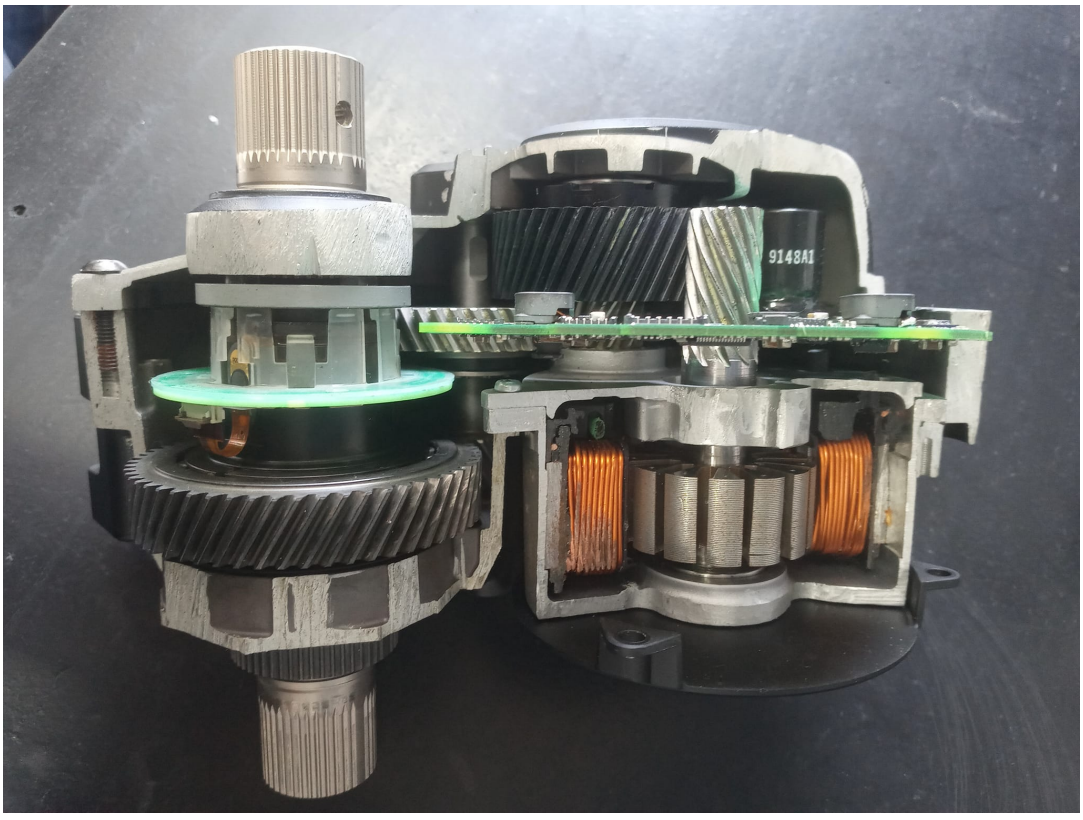
The Shimano E8000 motor has internal bearings and gaskets that are standard and available in stores, although there are other parts like: sprockets, clutch-bearings, gaskets, electronic PCBs, connectors that are not standard nor available and Shimano does not sell spare parts, so in case they break you will have to either transplant them from a broken donor motor or buy a new motor from Shimano for around €1150 - €1300.

NOTICE that some of the explanations and pictures in this document may not apply to all motor versions and there might be minor variations where you'll have to apply common sense or ask in the Forum Thread

INSIDE THE MOTOR: HOW THE SPROCKETS LOOK LIKE

The following pictures show a motor with a cut out case and it can be seen how the sprocket engage to reduce the high RPM out of the motor to the lower rider cadence in crankshaft.



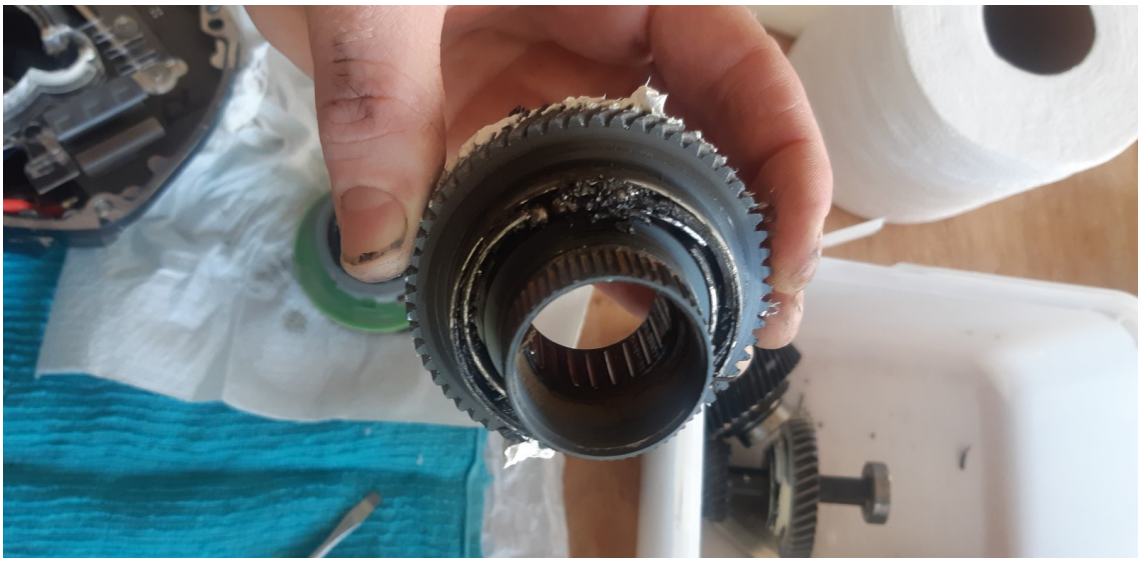


CONSEQUENCES OF DAMAGED BEARINGS

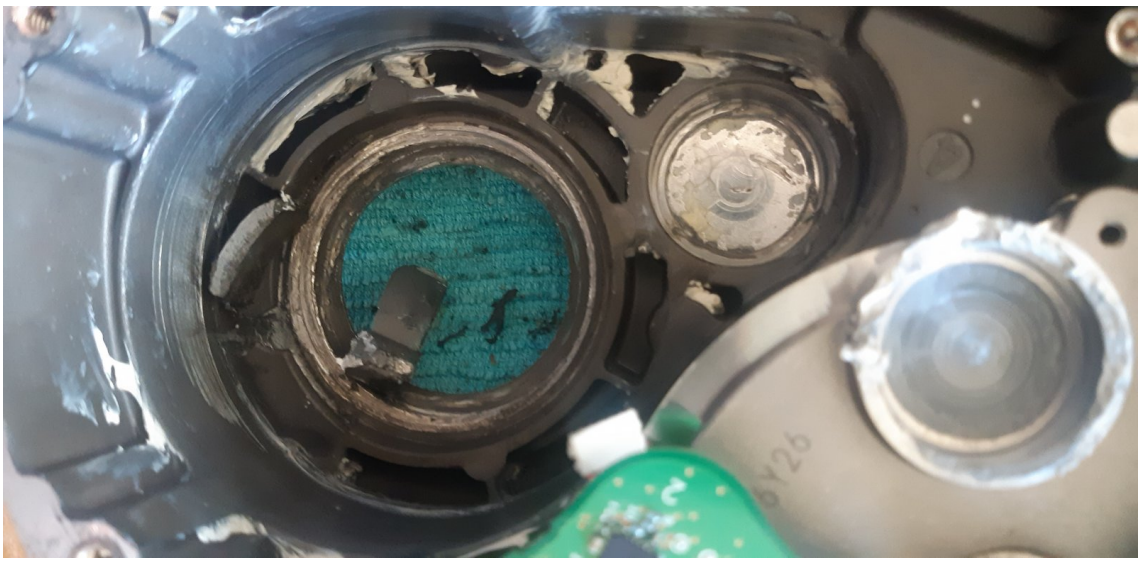
There are 6 standard bearings and two cage bearings (all of them are listed in following pages), but the two large bearings located in the crankshaft are the ones that suffer the most from water and dirt ingress and also from impacts when cranks hit rocks or branches, and they are more likely to break or get damaged.

So in case that you hear a grinding noise or you feel that the cranks do not rotate smoothly while rotating in any direction, then it is likely that one of your crankshaft bearings is shot.

If you replace the damaged bearing when it starts to fail and before it collapses, then you may avoid that this damaged bearing causes a bigger or even un-repairable damage to the motor. In the case below, the shot bearing damaged the housing in case, and now it is required to change the motor housing from a donor motor.



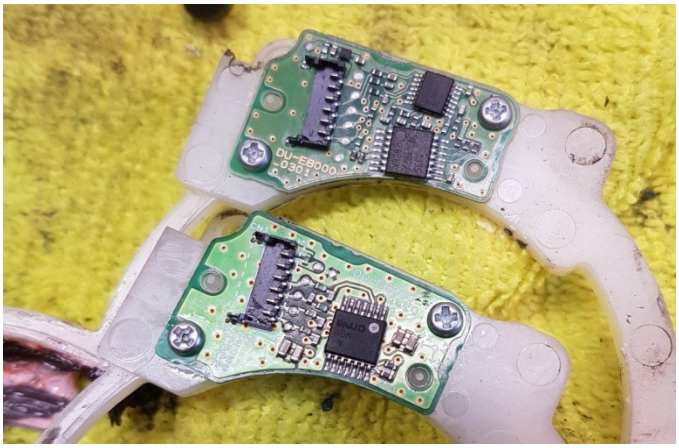
Damaged Bearing and below the damaged bearing housing in the motor case



E8000 MOTOR REVISIONS:

Shimano E8000 was released around 2017 and was discontinued for new bikes around 2020 when EP8 was released, during this period of time E8000 has had different versions with changes of mechanic parts and electronic PCBs (Printed Circuit Boards).

As an example, these are two different versions of one of the PCBs (Printed Circuit Board).



So if you plan to swap parts between motors you have to take into account the motor version, according forum member cream, some of the motor parts are not interchangeable between different Motor Versions: " There are several hardware revisions for E8000 electronics (and mechanics) and some will use different cadence sensor PCB among other things. These are not interchangeable across hardware revisions."

E8000 motors from early production (not verified, but let´s say until around 2018 or 2019) had a good design of the internal sprockets and clutches, but during a period of time (Around 2019 - 2020, TBC), there were newer motor revisions where the design was updated (Probably Cost Reductions) but not fully tested by Shimano and Motors manufactured in this period have the issue explained below. Later Motors Versions, (after 2020?) had a additional re-design and the previous issue was fixed.

Sprocket Grinding issue

The issue for Motors Versions from manufacturing period 2019 - 2020 (TBC) is that some of the sprockets move and tilt along the shaft and interfere with other sprockets, causing to rub and grind against each other thus resulting in lower performance, higher battery usage and a temperature increase inside the motor. As a consequence, the grease inside the motor used to lubricate the sprockets reaches a too high temperature and degrades, losing its lubricating properties, transforming itself in a thick black gum, and then the lack of lubrication causes teeth of the sprockets to become damaged.

Sprocket with degraded grease transformed in gum:

Some forum members tried to fix the issue by opening the motor periodically to clean the grease and add fresh grease to sprockets and bearings, but this does not fixes the main issue and the problem reoccurs shortly. The definite fix is to substitute the sprockets with parts from a donor motor that does not suffer this design issue.

E8000 PERIODIC MAINTENANCE AND GREASING:

For motors with good sprockets without the Grinding issue, it is recommended to open and re-grease the motor every 4000Km, but be aware that the warranty will be voided. In my case, I opened the motor after the warranty expired (7500Km) and bearings were fine, no water nor rust and rotating smoothly, but there was a lack of grease, so I only greased bearings and seals, and when I tested the bike with the greased motor, the Power usage had improved by 28%

REMOVING THE MOTOR FROM THE BIKE FRAME:

Before removing the motor from the bike frame, you must first disconnect the electrical cables to the battery, display, you should follow instructions in Shimano manual: **DM-E8000-10-ENG.pdf**

https://si.shimano.com/#/es/search/Keyword?name=e8000

In some models of eBike, the motor fits very tight in the cradle and after removing the screws the motor is stuck in the frame cradle, one way to get it out is to lose the screws one turn and use a hammer and a screwdriver to hit gently the screw heads, mainly on the left side where there are some washers that can get stuck.

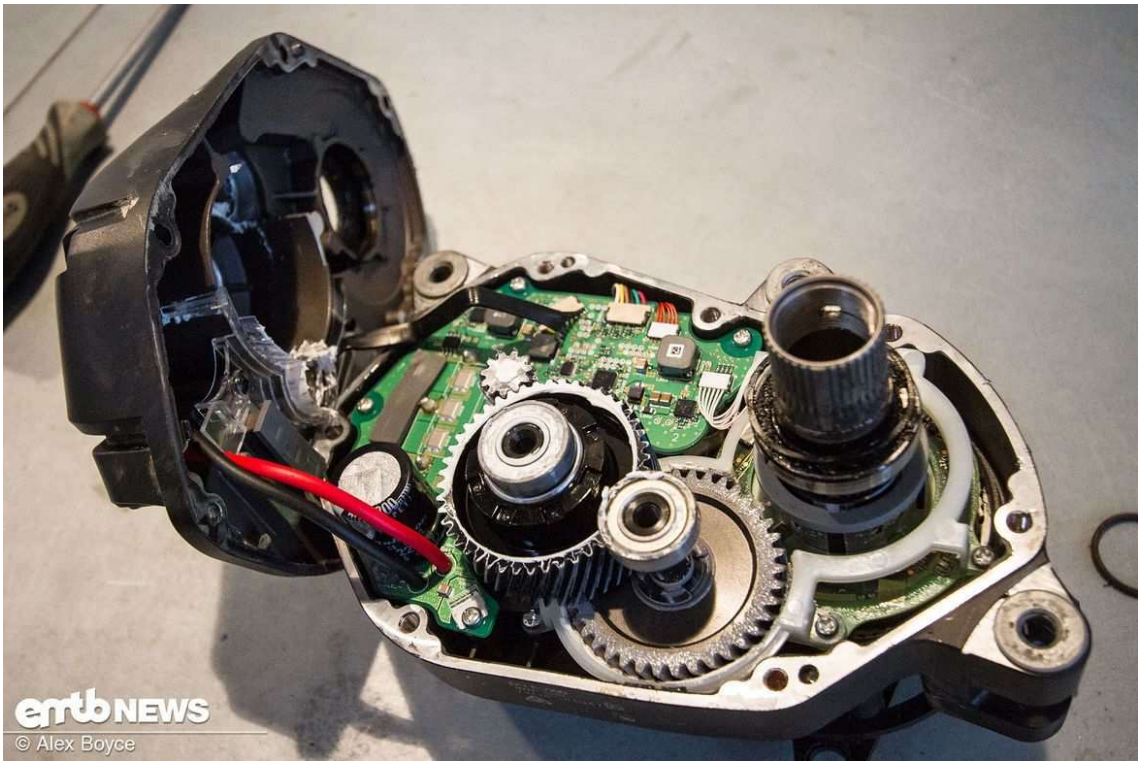
INSIDE THE MOTOR

Opening the Motor

• Clean motor external case from mud, dust, debris.

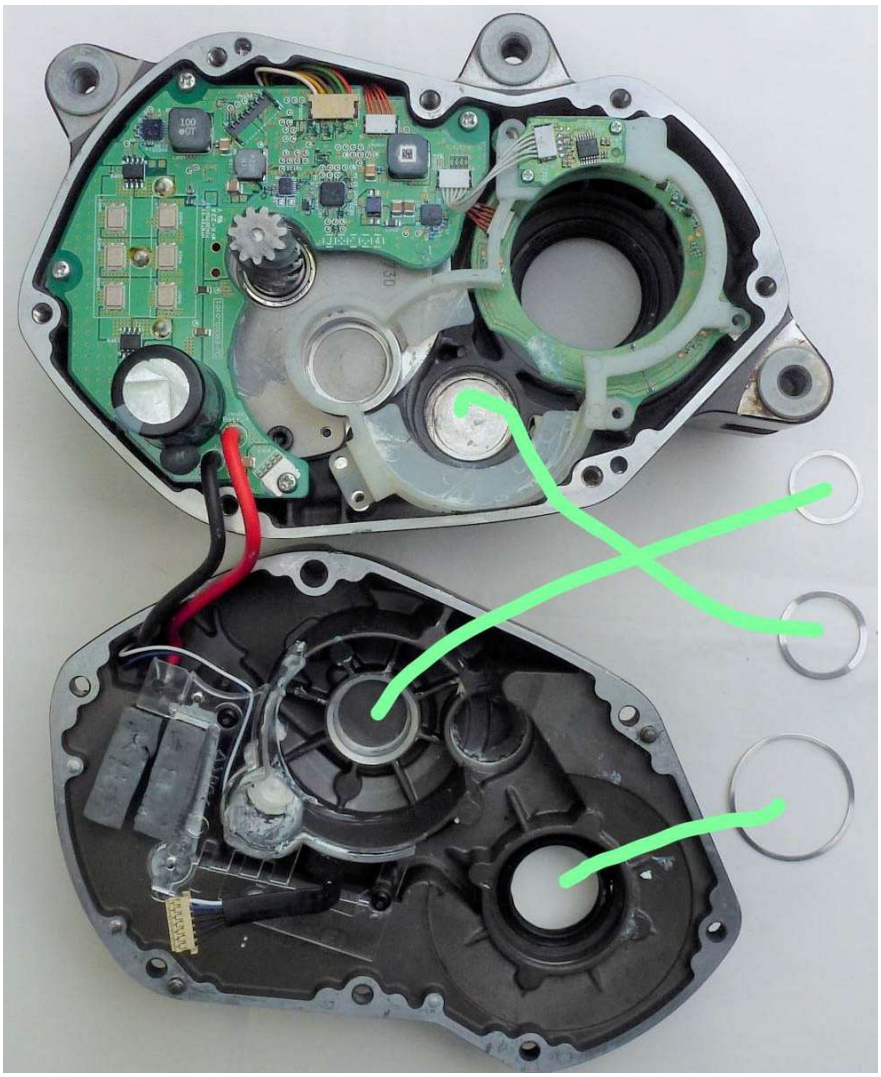
• Remove the circlip washer on bottom bracket axle, chainring side.

• Remove the case torx screws, then hit gently the motor housing perimeter using a plastic hammer and then cut the silicone gasket by inserting a blade a few mm, now the upper part of the casing can be separated, but be careful because there are cables that go from it to the Main PCB in the other part of the case, before opening it totally, disconnect the internal flat cable that runs between case upper and lower sides.



When opening the case the two halves are still joined by some cables, the Red and Black ones do not have to be unsoldered but the flat black cable has to be unplugged in the connector, it carries the signals from the case connector where the external cables of the display, magnet wheel and DI2 derailleur are plugged into the motor.

Also, keep in mind that in some bearings there are shim preload washers that lay between the bearing and the casing, in picture below you can see the washers and their position. TAKE NOTE OF WHERE THEY ARE MOUNTED!!!



Shim preload washers (After removing the sprockets)

There are three shim preload washers with the following dimensions:

- OD: 36,5mm ID: 33,5mm Thickness: 0,70mm
- OD: 21,5mm ID: 18,5mm Thickness: 0,28mm
- OD: 25,5mm ID: 21,5mm Thickness: 0,55mm

Removing the sprockets from Motor

The sprockets have helicoidal teeth, and this means that it is not possible to remove them by pulling straight, so my recommended procedure is:

- Loose partially the four screws that hold the white plastic frame, but do not remove them yet.
- Press a little the crankshaft from outside the motor case until the lower bearing is loosened from case and crankshaft can be moved a little bit.
- Now lift partially the crankshaft and rotate and lift the two intermediate sprockets (the black plastic one engaged to the motor axle and the one next to it), this will loosen the bearings housed in the case and they can be lifted a little.
- With the crankshaft lifted a little, wiggle the two sprockets while pulling them, remember that you have to free the helicoidal teeth. Finally you will be able to fully lift them and remove from the case.
- Now remove totally the four screws holding the plastic frame, disconnect the white cable connector and now you can remove the frame with the small PCB
- Disconnect the orange cables connector going to the annular PCB, and now you can remove this PCB. Try not to touch the electronics because it can be damaged by electrostatic discharges from your fingers.
- Now remove the crankshaft with attached black sprocket with a Sprag Clutch bearing inside, torque sensor and bearings.
- There is another preload washer in the case, remove and keep it.

BEARINGS

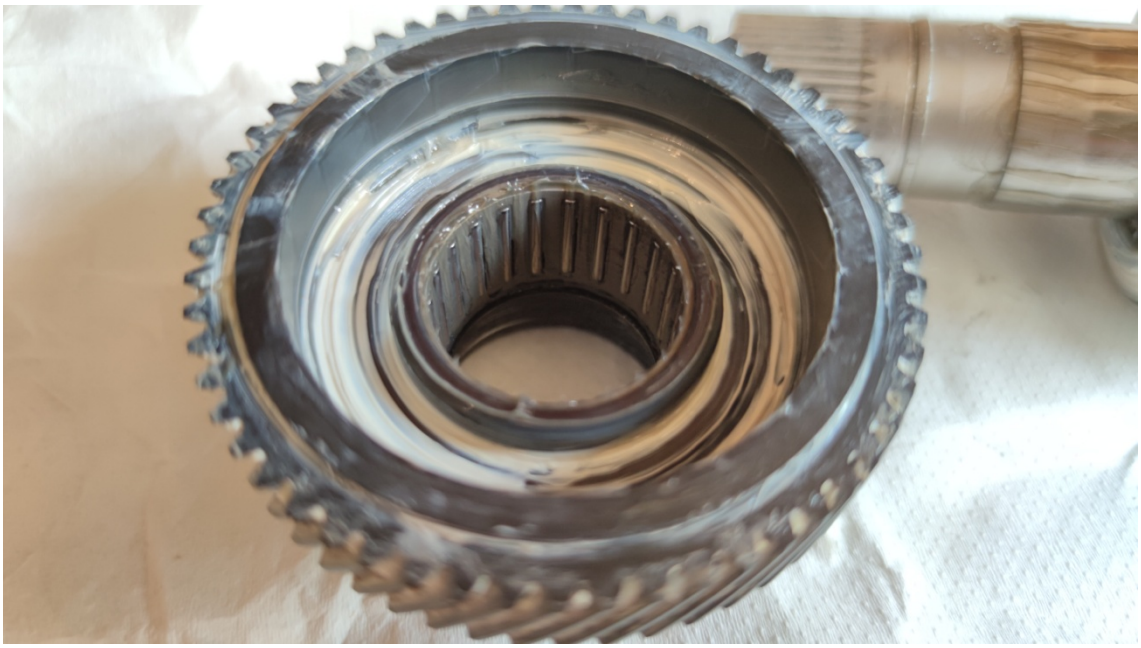
There are four small bearings on the sprocket shafts: 6000ZZ (10x26x8mm) and 3 x 6900ZZ (10x22x6mm, but these don't usually get damaged.

The left large sprocket has inside a directional roller clutch (Sprag clutch) (All motor versions), the right large sprocket has another sprag clutch (ONLY early motor versions, later versions do not have it). If you do require to access sprag clutch rollers it, you will need to remove a circlip. These are Shimano specific and not available, so if they break you have to from a damaged donor motor.

There are two larger bearings in the crackshaft and they may become damaged in case water gets its way through the case seals

- On the left side of the bottom bracket is bearing 6808D (40x52x7mm) with a brown (rubber) sealing gasket.
- On the right side is the 6805Z (25x37x7mm) bearing that has a metal seal that has less friction but also less protection against water ingress and that is the reason why this bearing usually causes problems. You will notice when it is damaged because it makes a grinding noise and doesn't turn smoothly.

The large sprocket in the crankshaft can be disassembled easily just by pulling it from the crankshaft, and you'd get these:



Now the sprocket has been separated from the internal Sprag Clutch and its rollers. It can me seen a Cage Roller Bearing inside the sprocket that normally does not get damaged and can be greased with white lithium grease. BUT for Sprag Rollers it shouldn't be used White Lithium grease, it is required a grease with less density as it will be explained later.

Removing Ball Bearings from Shafts

To extract the Ball Bearings, use a bearing puller extractor (aliexpress.com/item/33046983579.html size 40x80mm.) and if there is no room for the extractor nails then you have to make a little space by lifting the bearing using a flat screwdriver.

When removing the 6805Z, you have to be careful not to damage the annular magnet (Cadence measurement magnet) and also the torque sensor and the flexible PCB cables that are inserted into the connectors in the annular PCB that rotates with the crankshaft.

Removing Cage Roller Bearings from inside Torque Sensor

Inside the Torque Sensor Main shaft there is a large cage bearing 17mm wide and next to it is a 25x29x2mm rubber gasket. The bearing is loose but the gasket presses and to remove it you can insert a ratchet socket (18mm may fit) on the side where the sprocket with internal clutch goes and tap it gently to push the bearing and the gasket. Care must be taken not to damage the gasket because it cannot be purchased.

Inside the torque sensor shaft there is a smaller cage bearing, 10mm wide. Normally it does not need to be replaced and instructions for removing it are not available.

Check these caged bearings and if they are rusted or pitted with the grit that normally makes it past these seals, they should be replaced. If they are not damaged, you just can clean and grease them with White Lithium grease.

On the sides of the motor case, around the bottom bracket position, there are sealing gaskets that protect the large bearings (NSK 6805Z and NSK 6808D) from water ingress.

INSTALLING THE BEARINGS

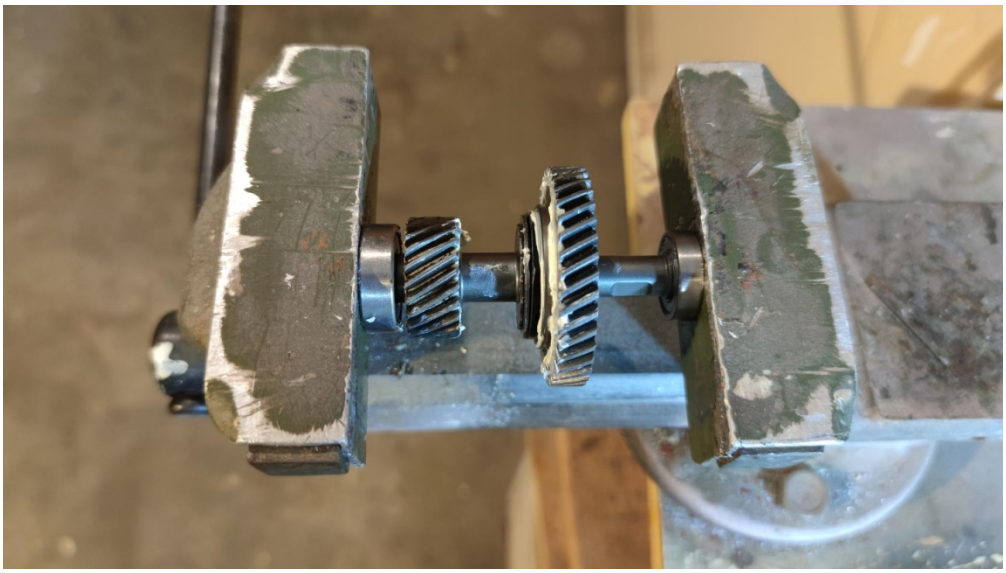
Crankshaft Large Bearings

To insert the new bearings you'll need a small hammer and a puncher to insert the bearing by gently tapping the puncher ON THE INNER RACE OF THE BEARING while rotating the tapping point around the perimeter every quarter turn until it settles. A better choice might be to use metal tubes to press them in place using a vice or a large diameter long bolt. There may be a special tool or bearing press, but I don't know about it.

Using a metal tube with 41-42mm inner diameter to press the bearing in place

Shaft Small Bearings

The bearing can be pressed in place using a vice:



BUT the bearings inner race are not aligned with the shaft end, that is, the bearing protrudes from the shaft 0,5 or 0,8mm, depending on the bearing position, to get this spacing, it could be used a thin washer with OD 6 or 8mm, depending on the bearing inner race diameter, this washer is inserted inside the bearing inner race while it is pressed in the vice.

Recommendations from Bearing Man:

- The wave preload washers, if flattened, should ideally be changed or at least some form put back into them. This should stop your sprockets grating without changing any design parameters.
- If a bearing needs to be pulled back on a shaft, it should, ideally, be replaced because you will be pulling on the outer race and this can damage the race and balls leading to premature failure.

CLEANING AND GREASING

If the "old" motor grease is contaminated with dirt and you clean it with solvent, then you will have to use new lube, but keep in mind that there are different types. The following is a summary of opinions in the forum.

Plastic - Metal Sprockets

The sprockets have a lot of white grease, if when disassembling the sprockets you remove the grease and keep it, it is possible to re-use it again. If there is not enough, a specific grease for plastic and metal sprockets can be used. The most used among forum members is **MOLYKOTE PG-75.**

Metal to metal sprockets

It is also used **MOLYKOTE PG-75** grease for metal to metal sprockets.

Cage bearings inside the main shaft

The bottom bracket spins inside these bearings, so it's metal to metal and I probably **White Lithium grease** is fine.

Bearings - Directional Roller Clutch (Sprag Clutch)

These bearings have sprag clutches with rollers and springs inside that make the bearing only rotate in one direction. If it is necessary to grease them, be very careful because if they are greased with a non-specific grease they will get stuck. Only use the specific grease for this type of bearing: **Shell Gadus S2 V100 2**

MOTOR CASE CLOSING AND SEALING

When closing the motor housing, it must be sealed against water by using a specific silicone, apply a cord of silicone in one of the motor cases, close the motor with the bolts, let it dry and then remove the excess of silicone with a cutter. The silicones that are normally used are:

- Loctite 5926
- Hylomar Blue

Forum Member Jimmyboy has an interesting improvement to avoid water ingress through seal in Crankshaft Cage Roller Bearing (Not Verified): When I dismantled my motor it was in pretty good shape and only showed signs of minor water ingress into the needle roller bearing area which was caused by water getting past the seal between the drive shaft and the chainring shaft so I have now packed bearing protection grease or Motorex behind the locking ring and large circlip. I think the purpose of the big ring is to provide a large surface area to give some splash protection especially if packed with grease as I did.

MATERIAL LIST

BEARINGS for E8000:

• 1 x Bearing 6808DD (40x52x7mm).

• 1 x Bearing 6805ZZ (25x37x7mm).

• 1 x Bearing 6000ZZ (10x26x8mm).

• 3 x Bearing 6900ZZ (10x22x6mm).

• 1 x Needle roller bearing K25 29 17 (25x29x17mm).

• 1 x Needle roller bearing K25 29 10 (25x29x10mm)

They can be purchased here, although you may find them locally in any Industrial Store:

https://www.ebikemotorcentre.com/shimano/

The large bearings located in the bottom bracket are the ones that suffer the most from water and dirt ingress and also from impacts when cranks hit rocks or branches, and they are the first that break or get damaged. Normally it is recommended to change the large bearings in crankshaft: 6808DD (40x52x7mm), 6805ZZ (25x37x7mm) and check the needle bearing K25 29

17 (25x29x17mm) and replace if required. In the bearing Reference Numbers, the suffixes ZZ and DD indicate the type of sealing in the sides, which provides the protection of the internal balls and races against water.

The bearing that is more frequently damaged is the 6805ZZ, possibly because the seal does not fully protect against water ingress. Some people in the forum have installed a new type of bearing with suffix 2RS or LLB or LLU which has a rubber seal that has a better protection against water and has only slightly more friction than the original metallic one.

Most motor manufacturers use a rubber outer seal and a steel inner bearing cover to save on friction. You start to tread a thin line between water resistance and battery consumption.

A summary of the Bearing Seal types:

- DD is made of rubber and provides high protection against water but has more friction
- ZZ is metallic, has less friction but also less water protection.
- Bearing Man has suggests that another seal choice for the large bearings could be:
    - LLU, with 2 rubber seals with labyrinth sealing and these are better but have higher friction.
    - LLB, with 2 rubber seals with labyrinth sealing but with lower friction, maybe a better choice.

BEARINGS for EP800:

The following information was provided in the forum, but has not been confirmed yet:

- The motor rotor has a 6900zz and a 6901z.
- The 1st gear shaft and 2nd gear shaft have two 608zz each.
- BB spindle has a 6805zz and 6808.
- The needle bearing is 25mm ID x 29mm OD x 17mm (more like 16.6mm).

Case Seals (NOT VERIFIED):

The information for the seals has provided by a forum member but has not been verified, so take it with a pinch of salt:

• Bottom bracket seal, on the motor housing, 25x32x4mm Nitrile Rubber Rotary Shaft Oil Seal Springless Design VC Style type shaft seal (garterless)).

https://simplybearings.co.uk/shop/p28291/25x32x4mm-Nitrile-Rubber-Rotary-Shaft-Oil-Seal-Springless-Design-VC-Style/product_info.html

• Bottom bracket seal, on the chainring side motor housing, 35x44x4mm (Dual lip shaft seal (garterless). PLN242048 Polini Oil Seals used in Variomatic Yamaha T-max 500 Injection. Found in motorcycle shops

• Inside the bottom bracket and where the large cage bearing is, there is a 25x29x2mm gasket (VC type shaft seal (garterless)). Unidentified and not available.

TOOLS AND GREASES:

• Bearing puller extractor, the 40x80mm size is fine, you can buy it anywhere, Aliexpress:

aliexpress.com/item/33046983579.html

• Grease for metal and plastic sprockets: MOLYKOTE PG-75. The 1 kilo can is €70. In some bike online stores they sell small cans repackaged by them that contain about 100g of product.

https://www.tiendamtb.com/es/varios/2013-grasa-molykote-pg-75-para-plastico-y-metal-30ml.html?search_query=molykote&results=2#/formato-150ml

https://www.ebikemotorcentre.com/product/gear-grease-for-ebike-motors/

• Grease for Directional Clutch (Sprag Clutch). If you disassemble and clean them, you have to be very careful and use only the specific grease for this type of bearing: Shell Gadus S2 V100 2

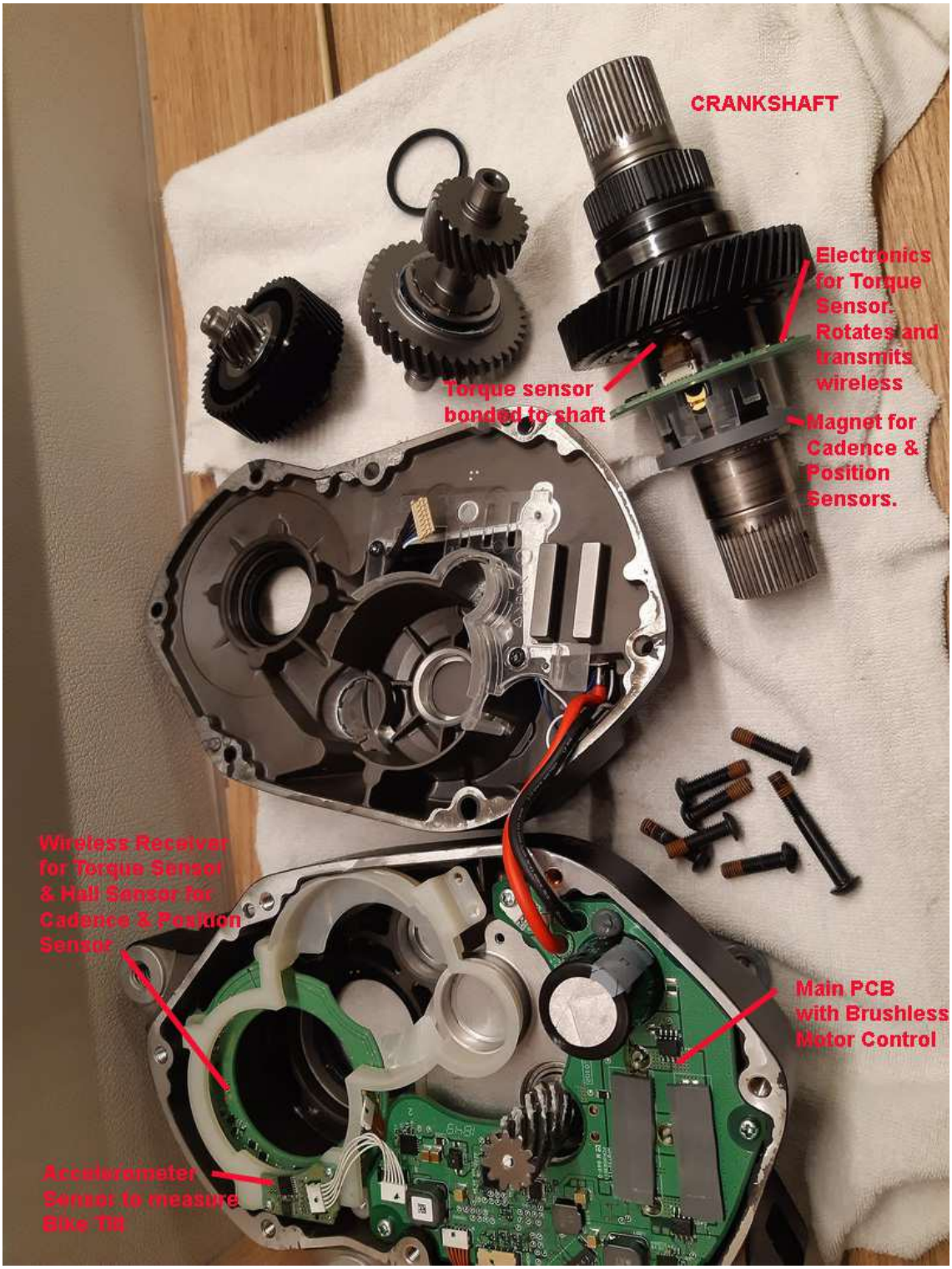
https://ebikemotorrepair.com/product/low-pressure-gadus-grease-for-sprag-and-clutch-bearings/

• Blue Hylomar or Blue Loctite 5926 silicone for motor gaskets.

• Solvent to clean the sprockets

ANEXES (Only for Geeks)

Motor Sensor Layout



EXPLANATION OF THE CADENCE, TORQUE AND TILT SENSORS

In image above you can see the components that make up the sensor system:

Cadence sensor:

• There is a circular gray magnet on the bottom bracket.

• In the motor casing there is a green circular PCB that does not rotate. The Hall Effect Sensor is mounted on this PCB, it is the one that detects the position of the gray magnet and when the bottom bracket rotates it can measure the cadence and also the position of the cranks. It is necessary to measure the position of the cranks because during motor operation the power is modulated according to the position of the crank while the rider is pedaling.

• If the gray magnet is disassembled, it is important to reassemble it in the same position and orientation as it was originally, otherwise, the crank position measurements will be wrong.

Torque Sensor:

• While the rider is pedaling, he exerts a force and a torque that is received by the bottom bracket, this torque will deform the crankshaft very slightly and proportionally to the torque exerted by the rider.

• To measure this deformation of the bottom bracket there are two "Strain Gauge" type sensors bonded to the bottom bracket and covered with putty, they generate analog electric current proportional to the crankshaft deformation and then this current is converted to a digital data that contains the torque exerted by the rider.

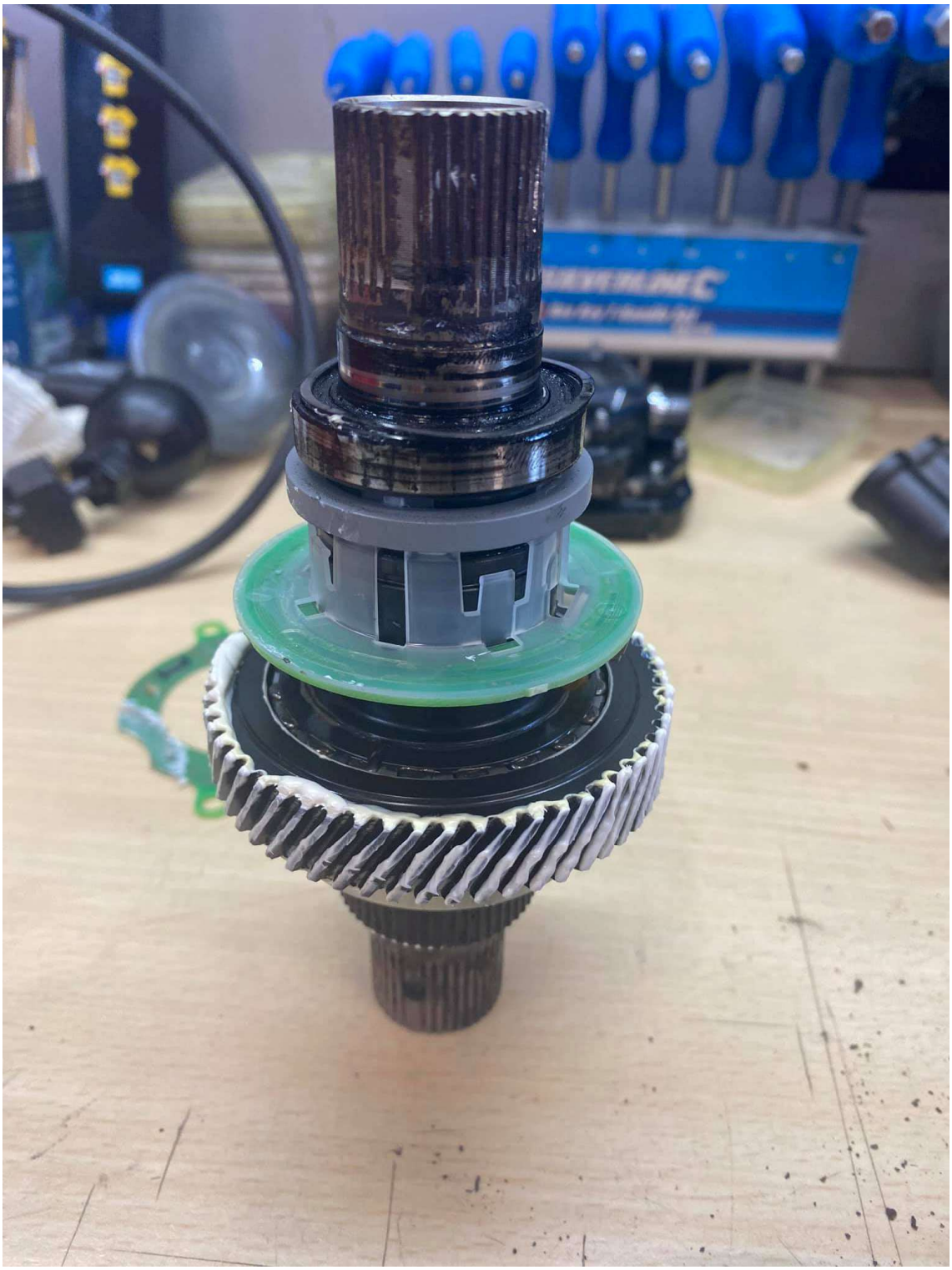
• These two torque sensors are connected to a green PCB that is located on the bottom bracket axle and rotates together with it and the measured electrical data is transmitted wirelessly (It could be NFC or similar) to a second fixed PCB (Does not rotate) which is screwed to the motor case and connected by cables to the main large PCB that has the control for the brushless motor.

•If a motor fails with a Torque error (E01020, 21,22) it may be repaired by replacing Torque sensor with one from a "Donor" motor. But there are different opinions whether this repair will be successful or not:

1. Forum member "cream" says: I've repaired many Shimano steps motors, and I can tell you for sure that you can use a good torque sensor from another motor, no need for recalibration.
2. One forum member says that a E8000 "expert" told him that during the motor manufacturing process, Shimano calibrates the torque sensor and stores the calibration values in processor memory on the motor's Main PCB, so If this is true, it is not possible to "transplant" a Torque sensor from another Motor because the calibration data in the Main Board Memory would not match. It would be necessary to transplant the Bottom Bracket with Torque Sensors together with the Main PCB.

Accelerometer/ Tilt Sensor:

Close to the annular PCB there is another small PCB with a white cable connected to the Main PCB, its function is to mount a digital accelerometer that measures the tilt of the eBike.



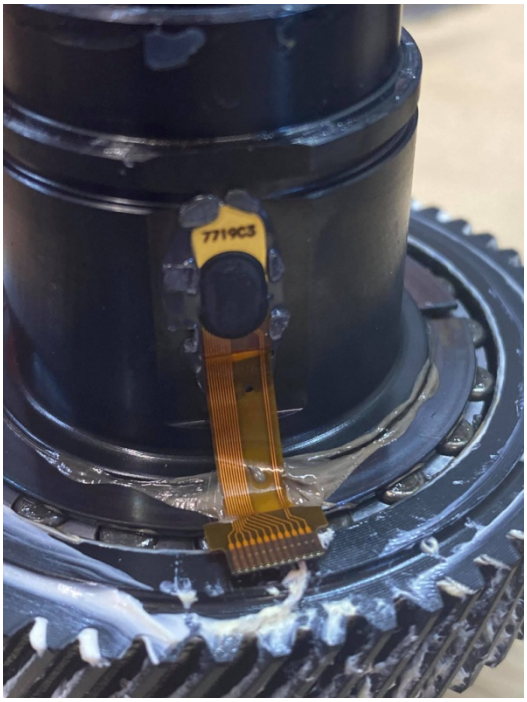
Bottom bracket is assembled together with :

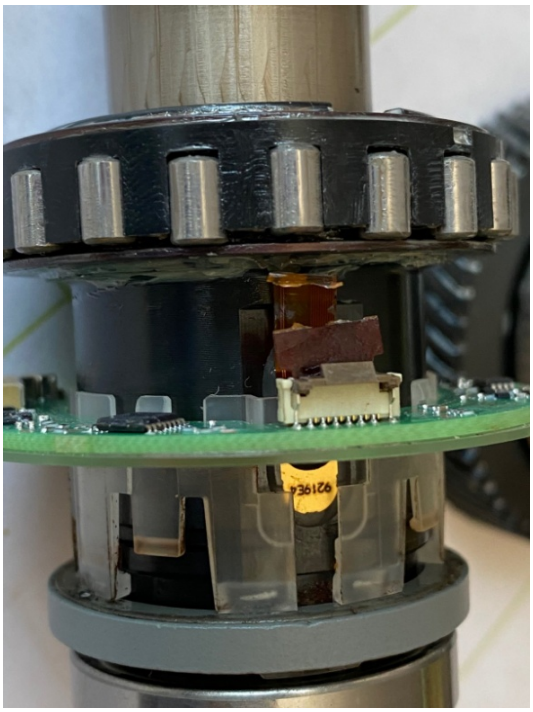
• Bearings, Sprag-clutch inside sprocket

• Torque sensors, bonded to the shaft with putty and connected with a flat cable to the rotating PCB

• Gray casing that has the cadence sensor magnet inside


The main shaft with the roller bearings, where the bottom bracket is inserted





In the first photo we see the torque sensors that are of the "Strain Gauge" type and are bonded to the shaft with putty. In the second photo we see the rollers of the Sprag- clutch which us inside the black sprocket.

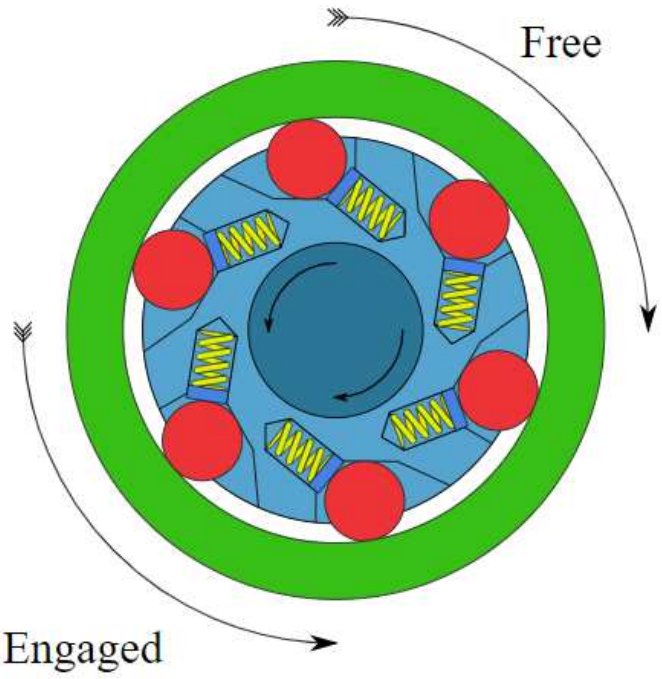
BEARINGS - CLUTCHES

They are of the roller type and there are two of them mounted inside the large sprockets. They are Shimano specific and not available to buy, if they break, then there is no replacement.

One of them allows the cranks to turn backwards relative to the chainring, this clutch is inside the big black sprocket on the axle. Its purpose is to allow the pedals to rotate more slowly than the chainring in case the motor rotates faster than the rider's pedal strokes.

The second clutch allows the motor to turn freely backwards relative to the chainring, it is located inside the second large metal sprocket. Its purpose is to allow the motor to turn more slowly than the chainring in case the rider pedals faster than the motor rotations.

They are not available to change, but if necessary they can be disassembled, cleaned and greased, but be careful that you only have to use the specific grease or they will get stuck. You have to take note of how the rollers and springs are mounted and use quality thin needle-nose pliers and tweezers to mount back the rollers and springs in place.



E8000 MOTOR ELECTRONICS REPAIR:

On 10 December 2021, forum member cream made a very interesting post where he shared is knowledge about repairing the E8000 Electronics Boards:

I'm new to this forum but I had my fair share of time spent on solving errors regarding to Steps motors. I fixed almost all faults, except some water damage units and of course, the most common, torque sensor failure.

Here are my own findings regarding E8000 inner workings, Some errors encountered and my description added:

- E01020 ---- torque sensor disconnected
- E01021 ---- torque sensor (startup values)not plausible
- Obs: Can also trigger WS013 when the torque sensor intermittently outputs a signal, but it's outside normal startup value (with no load)
- E01041 ---- Motor hall sensor failure/temp sensor failure (check electric motor for damage on the hall sensor/temp sensor pcb, coils)
- E01003 ---- Battery voltage monitor failure
- E01030, E01031 ---- Cadence sensor fault (check the magnetic ring on the crankshaft or the cadence sensor pcb)

Booting to menu:

- E01022----- Possible something related to current sensing
- Obs: Boot to menu, walk assist works, only appearing when using power assist, as soon as the motor starts, regardless of assist level.
- E020 ---- Motor - > battery communication fault, electrical fault on battery data lines (battery, connection with the motor, motor pcb.

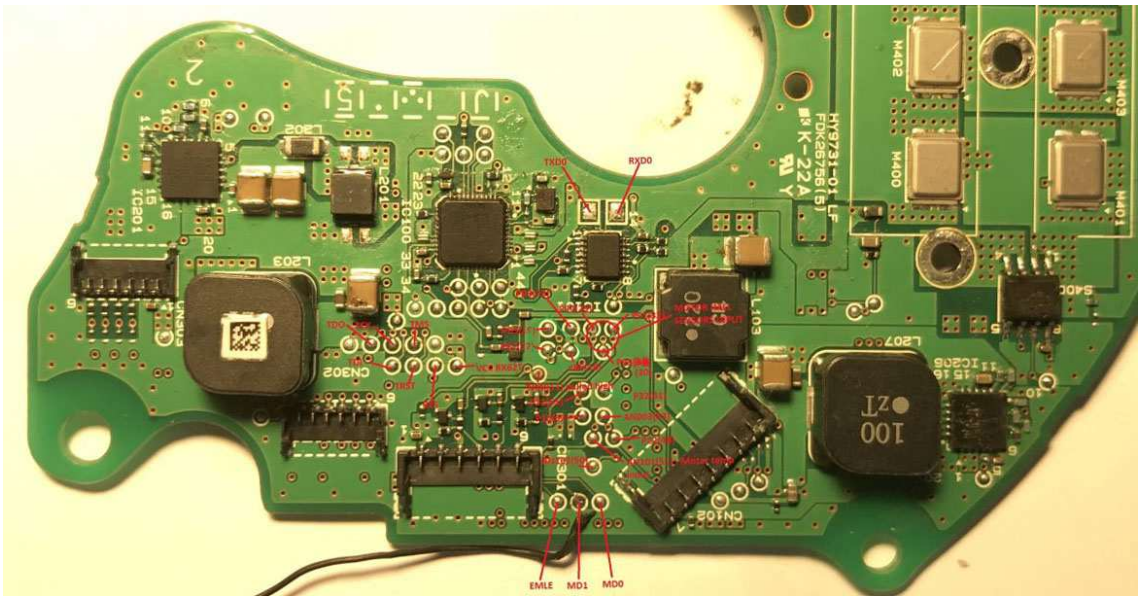
Regarding torque sensor. So many parts and so small factor both on rotary and stationary PCB, not easy to reverse engineer. I found out that the signal that the assembly transmits to the mainboard is digital, possible I2C. The sensors themselves (the ones glued to the metal part) are not simply gauge sensors but they also have a digital part under the black resin, maybe something like an analog front end with the force sensor intergrated in the chip...again, complicated. I've attached some pictures of whats underneath it, but my microscope is not so good.

If there are any calibration, they are stored on the chip directly glued to the crank rotating piece. Replacing only the metal part with the sensors will cure the problem. The rotary and stationary pcb don't fail so easily, the same goes for the mainboard...unless water goes inside.

I've searched a lot about manufacturers for force sensors with digital output, and found something that looked a bit in the right direction manufactured by ALPS but it's just a hunch. All seems surrounded by secrecy. The chip that bridge the communication between display,

battery and motor control MCU is something I didn't find any reference to maybe it was overprinted with some Shimano part number.

About main PCB:



Power parts in Control Board

- MAX17504(IC201)-----> 8v primary output (display, DI2, etc), 5V LDo secondary
- 8v primary switched through M202 to
- 1. Display and other DI2 accessories
    - //2. IC203---5v LDO-marking D9F 500--->mcu power supply, hall sensor board supply, gyro board supply) trhough a a diode
- 2. IC204(LDO) marking C4N 561 3.3v v ---> Logic ic SN74LVC07A (IC101) and unknoun chip (IC100, marking G9GXW 710S4d)
    - MAX17504(IC205)----->lights supply
    - MAX17502/1(IC202)--->7v primary output, 5v LDO Secondary
    - primary output to

Power part--motor driver/control

- MP6530 --- 3 phase gate driver
- Custom Infineon Directfet MOSFET part numbering 6x, direct replacement: IRF6648TRPBF
- ACS723T LLC-45AB (bidirectional current sensing IC up to 45A) 2x (for phase current sensing)
- EW-610B --- bipolar Hall latch sensor (3x) (for rotor positioning)
- Standard NTC for motor temperature sensing (value unknown)

Logic control

- Main MCU ?? ---marking F562TADDFM, RX62TA

(https://www.renesas.com/eu/en/produ...ssors/rx/rx600/rx62t/device/R5F562TADDFM.html)