DIY e-Bike Conversions
and
Solid Modeling

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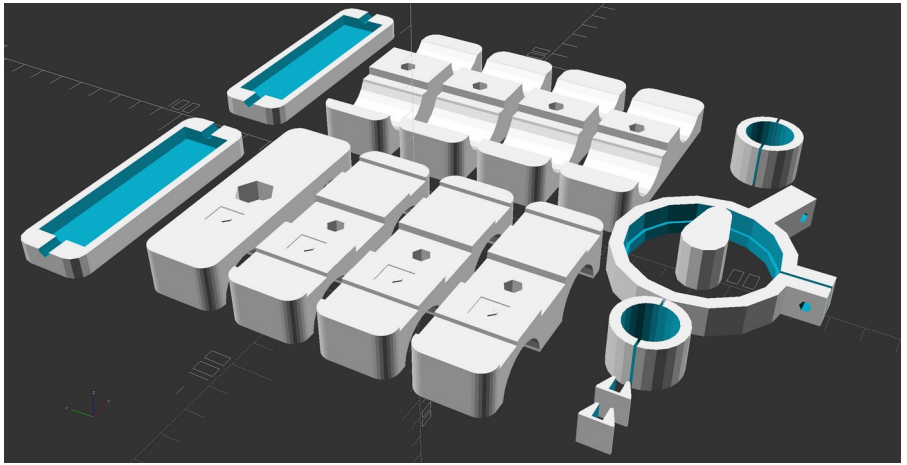
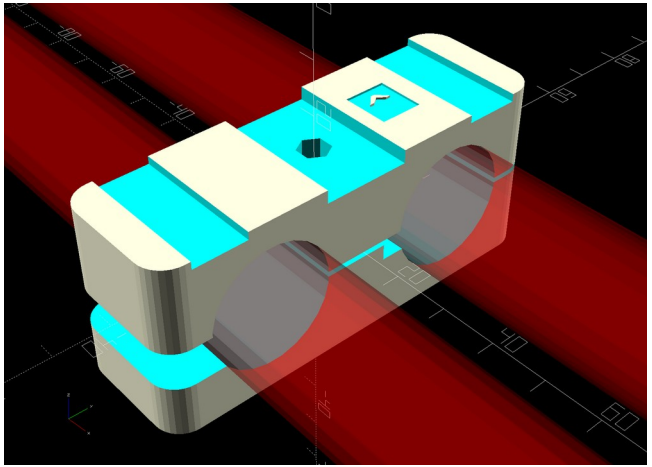
softsolder.com

ACM - Poughkeepsie Chapter
18 October 2021

Upcoming Events

- Terminology
- Legality
- Numerology
- Geometry
- Sensibility

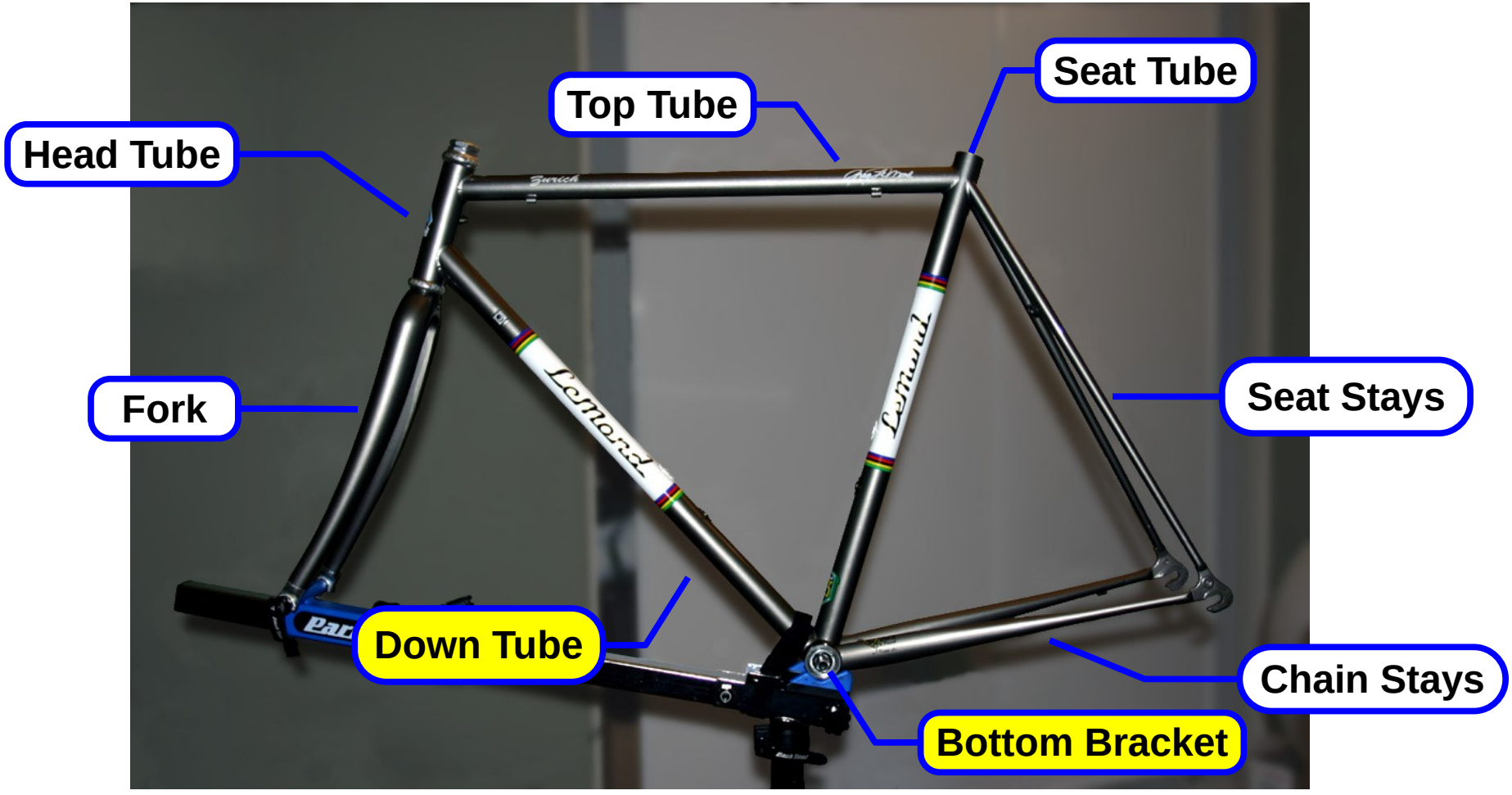




Clickable linkies!

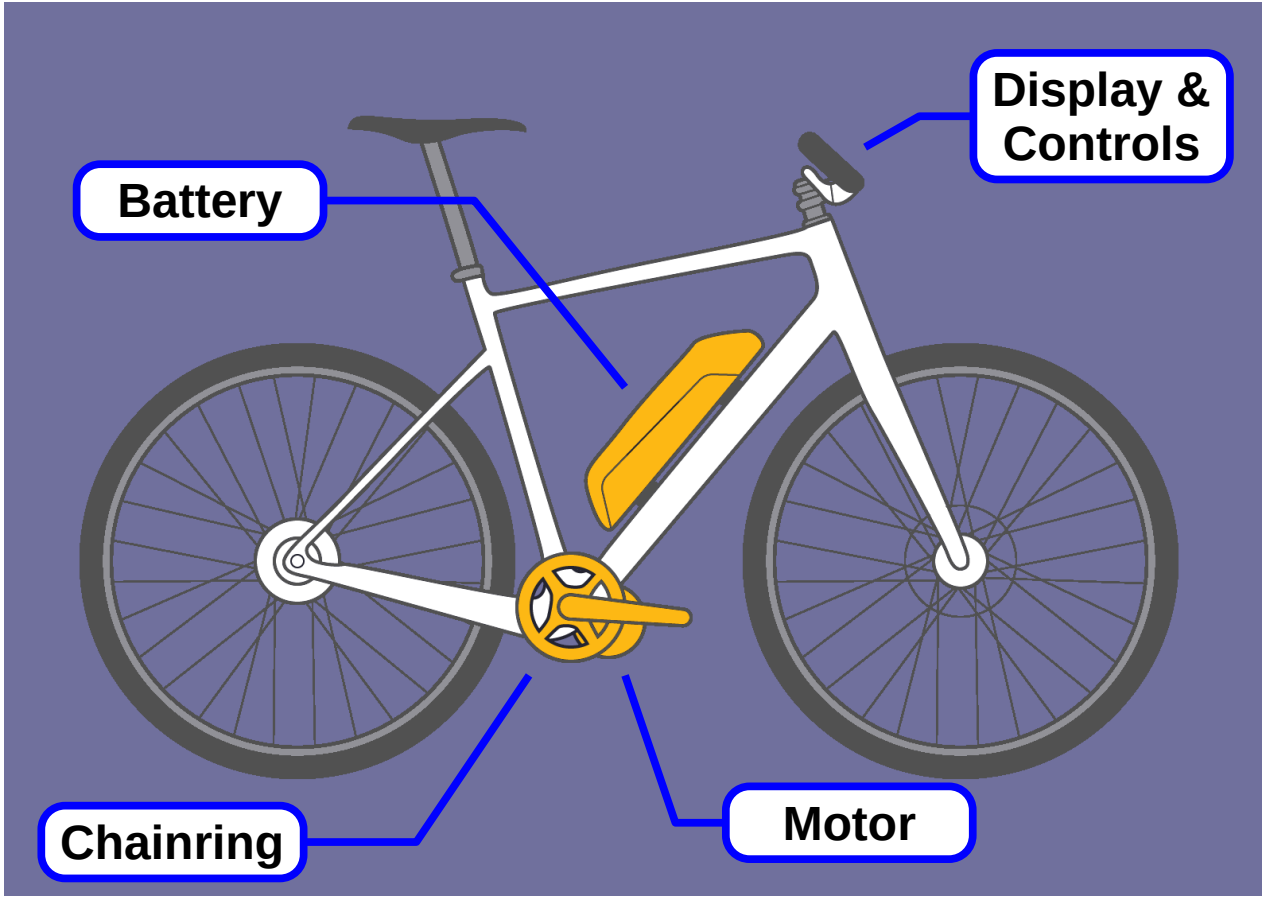
https://softsolder.com/

Bicycle Terminology



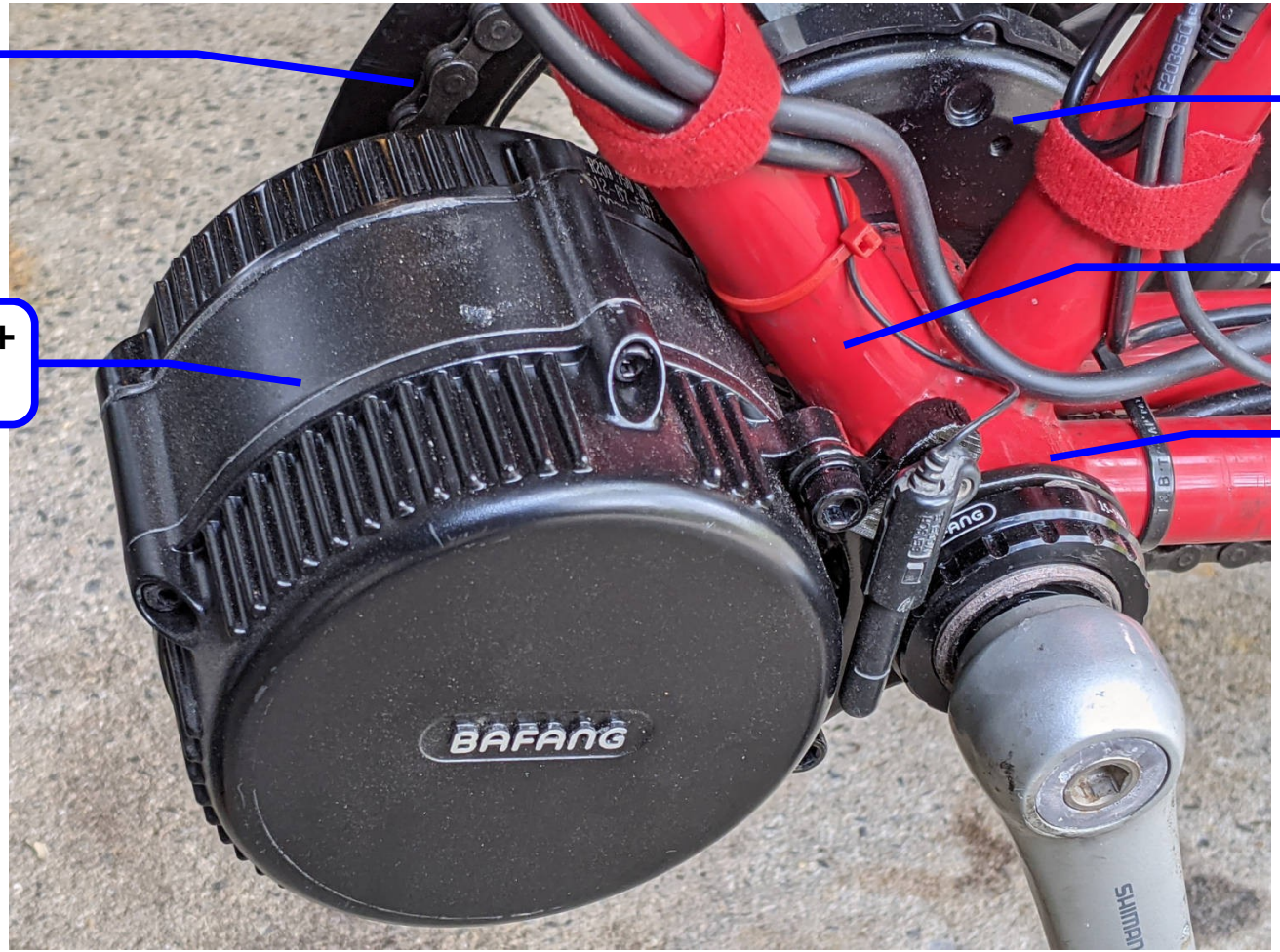
https://commons.wikimedia.org/w/index.php?curid=5759706

Mid-drive E-Bike Anatomy



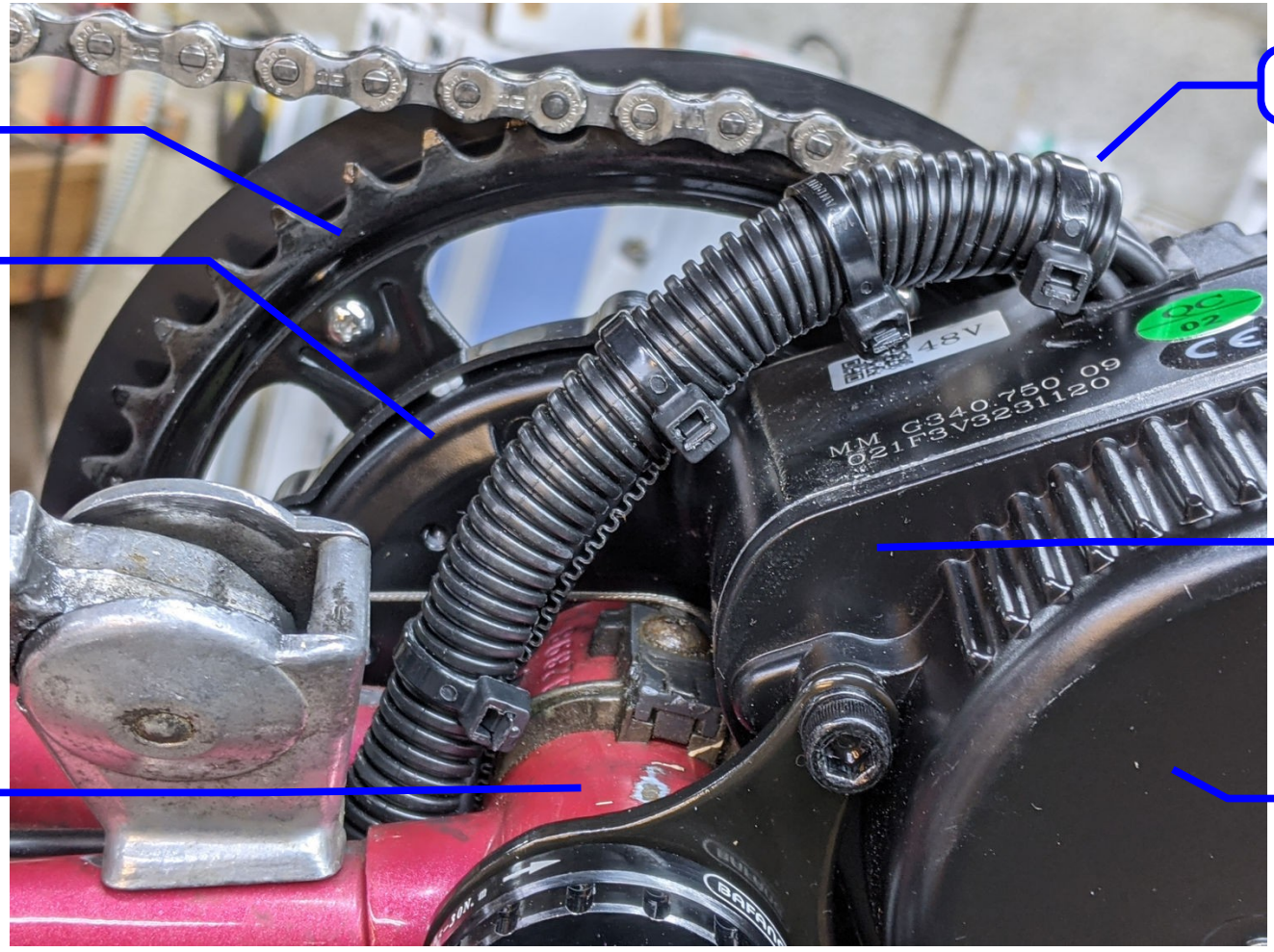
https://bafangusadirect.com/products/complete-bafang-750w-bbs02-mid-drive-ebike-motor-kit-battery

Brushless DC Motor



https://softsolder.com/2021/04/29/tour-easy-bafang-mid-drive-vs-cateye-cadence-sensor/

Brushless DC Motor

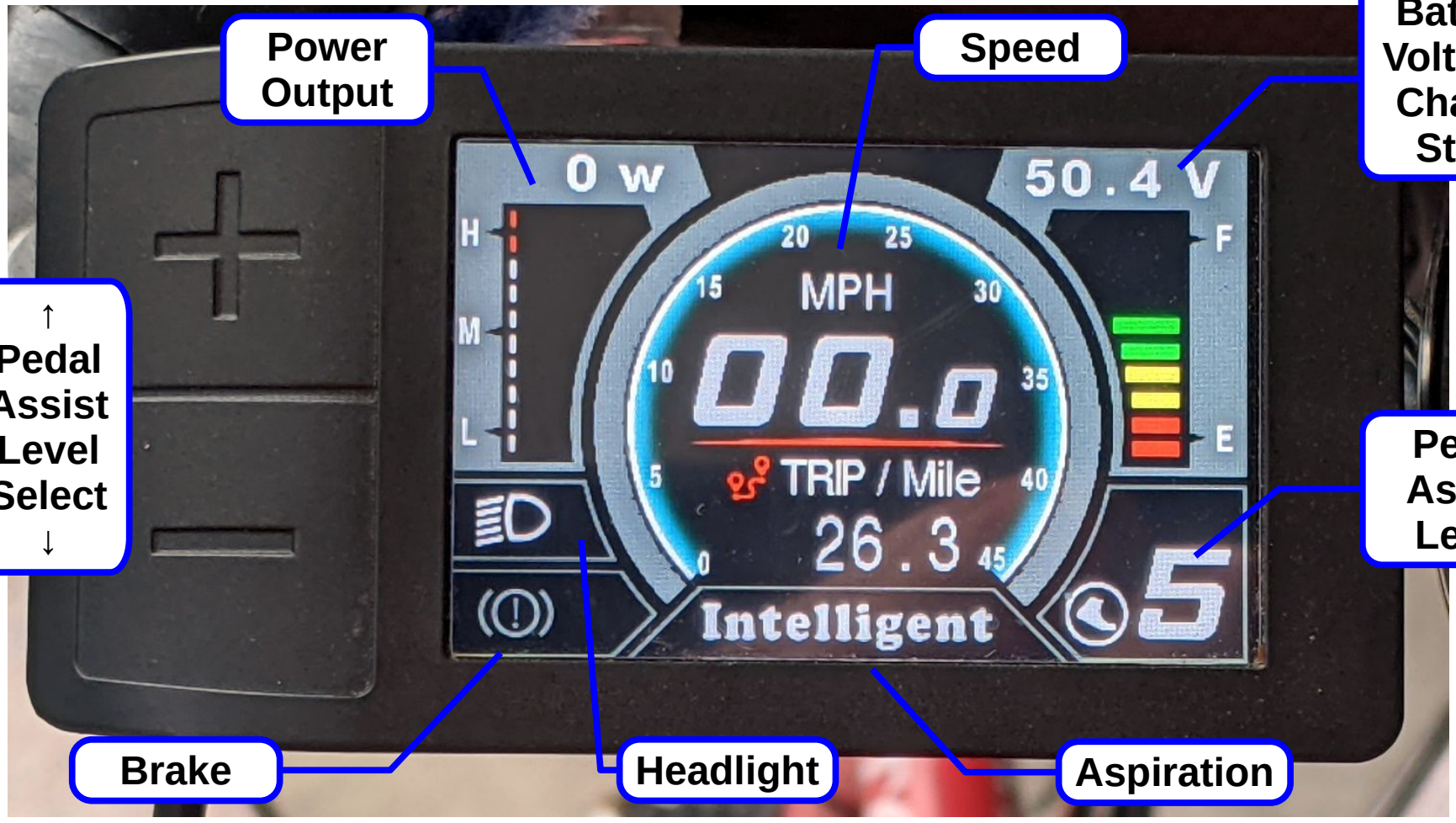


https://softsolder.com/2021/07/13/the-value-of-closeout-pictures/

Lithium Battery

https://softsolder.com/2021/06/25/bafang-bbs02-terry-symmetry-battery-mount/

Display + Controls



https://softsolder.com/2021/09/09/tour-easy-bafang-bbs02-lower-power/

Trigger Warning

Legal Verbiage

“Bicycle with electric assist”

A bicycle which is:

- No more than **thirty-six inches wide**
- And has an electric motor of **less than seven hundred fifty watts**

https://dmv.ny.gov/registration/electric-scooters-and-bicycles-and-other-unregistered-vehicles

E-bike Class 1

- A bicycle with electric assist having an electric motor that provides **assistance only when** the person operating such bicycle is **pedaling**
- And that **ceases to provide assistance** when such bicycle reaches **a speed of twenty miles per hour**

https://dmv.ny.gov/registration/electric-scooters-and-bicycles-and-other-unregistered-vehicles

E-bike Class 2

- A bicycle with electric assist **having an electric motor** that may be **used exclusively** to propel such bicycle
- And that is **not capable of providing assistance** when such bicycle reaches a speed of **twenty miles per hour**

https://dmv.ny.gov/registration/electric-scooters-and-bicycles-and-other-unregistered-vehicles

E-bike Class 3

- Solely within a city having a population of one million or more …

Rank	Name	2021 Pop. ▾	2010 Census	Change
1	New York City	8,230,290	8,190,210	0.49%
2	Buffalo	254,290	261,275	-2.67%
3	Rochester	205,077	210,217	-2.45%
4	Yonkers	201,344	196,407	2.51%
5	Syracuse	141,491	145,215	-2.56%
6	Albany	95,358	97,753	-2.45%
7	New Rochelle	78,027	77,233	1.03%
8	Cheektowaga	73,740	75,178	-1.91%
9	Mount Vernon	66,725	67,399	-1.00%
10	Schenectady	65,129	66,151	-1.54%
11	Brentwood	63,399	60,664	4.51%
12	Utica	59,170	62,209	-4.89%
13	White Plains	58,045	56,946	1.93%
14	Tonawanda	57,027	58,144	-1.92%
15	Hempstead	54,847	54,081	1.42%
16	Levittown	51,634	51,881	-0.48%

https://worldpopulationreview.com/states/cities/new-york

E-bike Restrictions

- You **can operate** an electric scooter or bicycle with electric assist on **some streets and highways** in New York State:
  - You can operate these devices on **highways with a posted speed limit of 30 MPH or less**
  - **Municipalities can further regulate** the time, place and manner of operation of these devices
  - You **cannot operate these devices on a sidewalk** except as authorized by local law or ordinance

https://dmv.ny.gov/registration/electric-scooters-and-bicycles-and-other-unregistered-vehicles

E-bike Restrictions

Q. Are e-bikes allowed on the Rail Trails?

A. Currently, e-bikes are not allowed on the Rail Trail systems

https://www.dutchessny.gov/Departments/Parks/FAQs-WRS-DRT.htm

Pop Quiz

https://electricbike-blog.com/2017/05/16/silence-infidel-the-real-reason-police-ignore-ebikes/

E-bike Regulations

“The best thing you can do

as an ebike advocate

is simply to wear a helmet

and to

obey the laws

as much as you can”

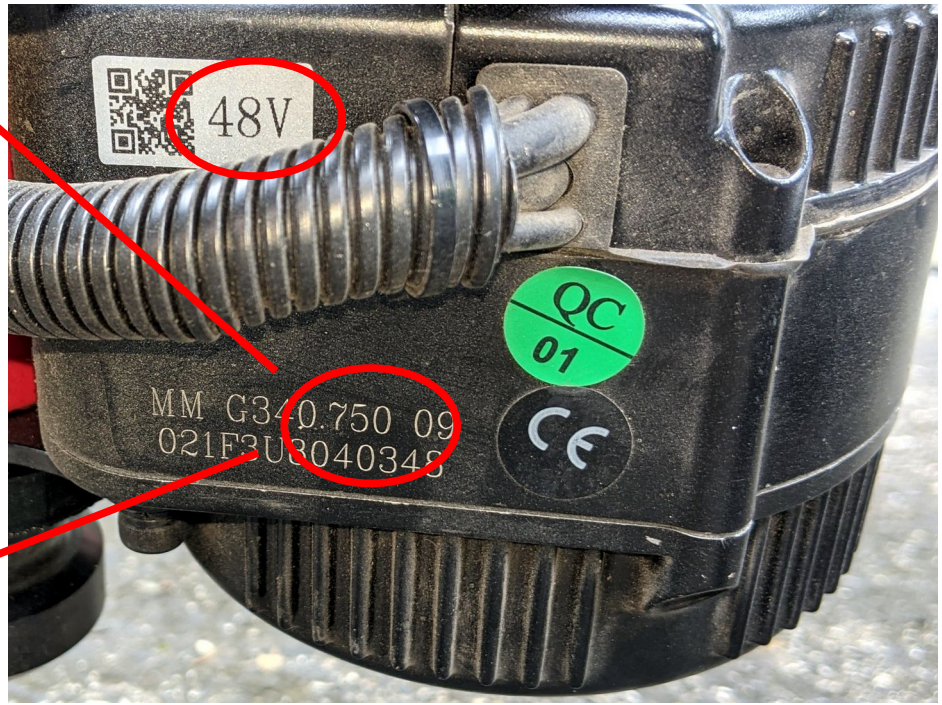
https://electricbike-blog.com/2017/05/16/silence-infidel-the-real-reason-police-ignore-ebikes/

Trigger Warning

Numbers

“An Electric Motor < 750 W”

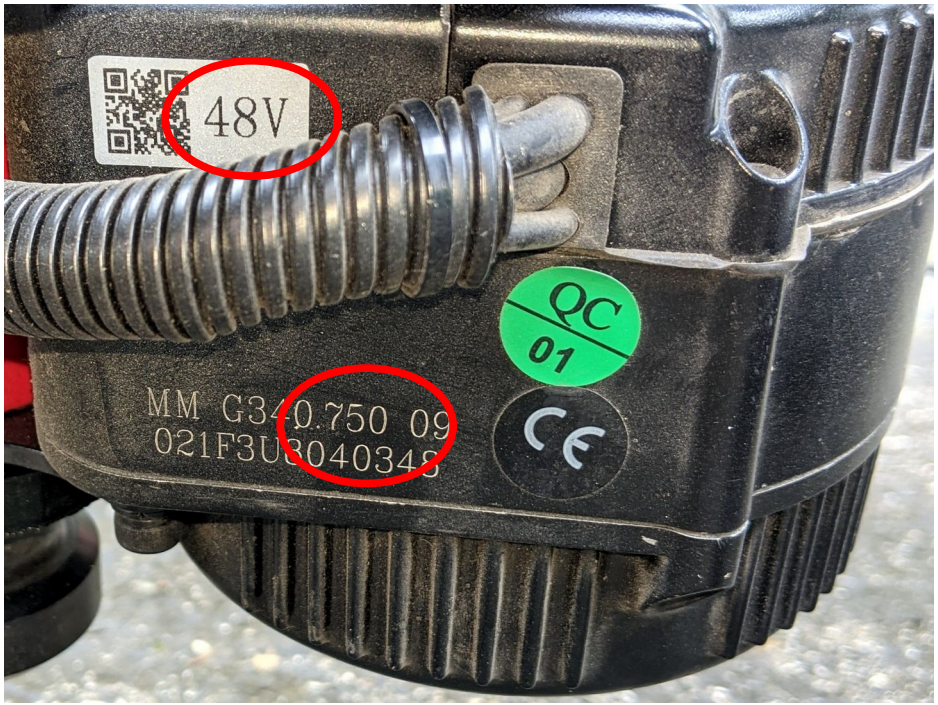
- Newest 750 W BBS02 Bafang Mid Drive Motor
- System Voltage: 48 V
- Upgraded … 25 A Controller
- Up to … 1152 W with 48 V battery



https://bafangusadirect.com/products/bafang-750w-bbs02-mid-drive-ebike-motor-kit

Specification Engineering

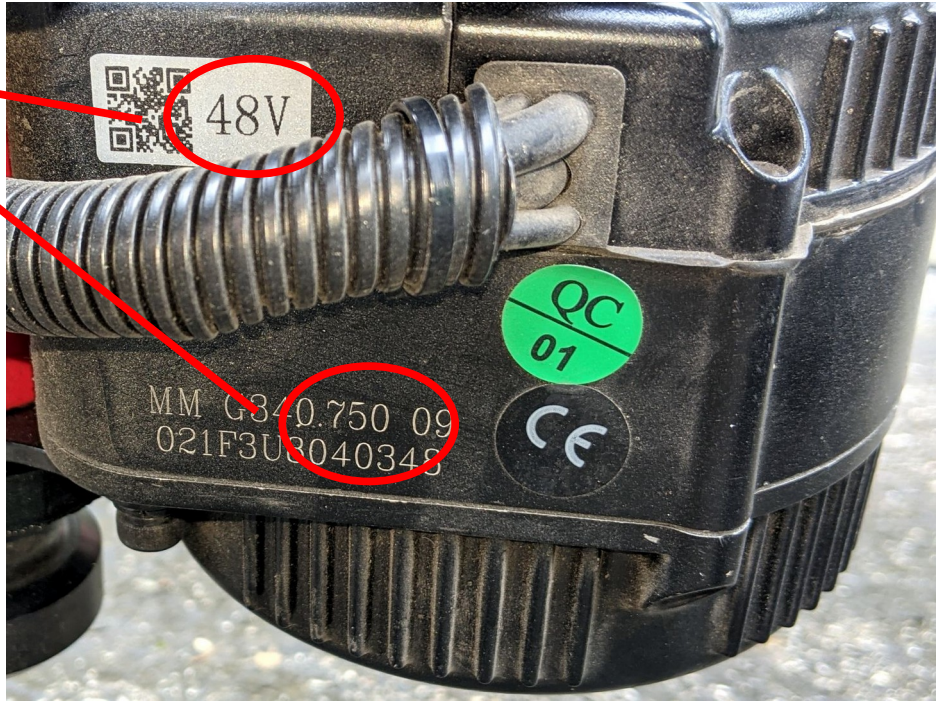
- Power = Volt × Amp
  - 1200 W = 48 V × 25 A
  - 1152 W = 48 V × 24 A
  - 750 W = 48 V × 16 A
- 750 W = 1 HP



https://bafangusadirect.com/products/bafang-750w-bbs02-mid-drive-ebike-motor-kit

Specification Engineering

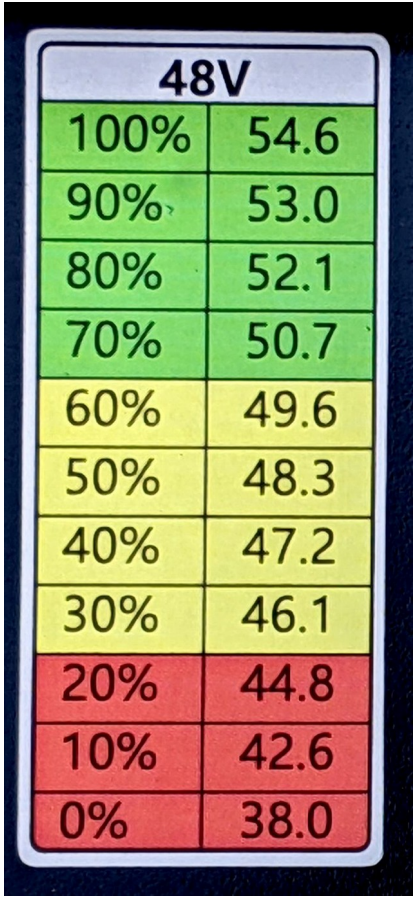
- Up to 1300 W
  with 52 V battery
  - 1300 W = 52 V × 25 A
  - 1248 W = 52 V × 24 A



https://bafangusadirect.com/products/bafang-750w-bbs02-mid-drive-ebike-motor-kit

Battery Charge vs Voltage

- Nominal 48 V battery
  - Full charge = 54.6 V
    - 4.2 V / cell
  - Half charge = 48.3 V
    - 3.7 V / cell
  - Discharged = < 42 V
    - 3.2 V / cell

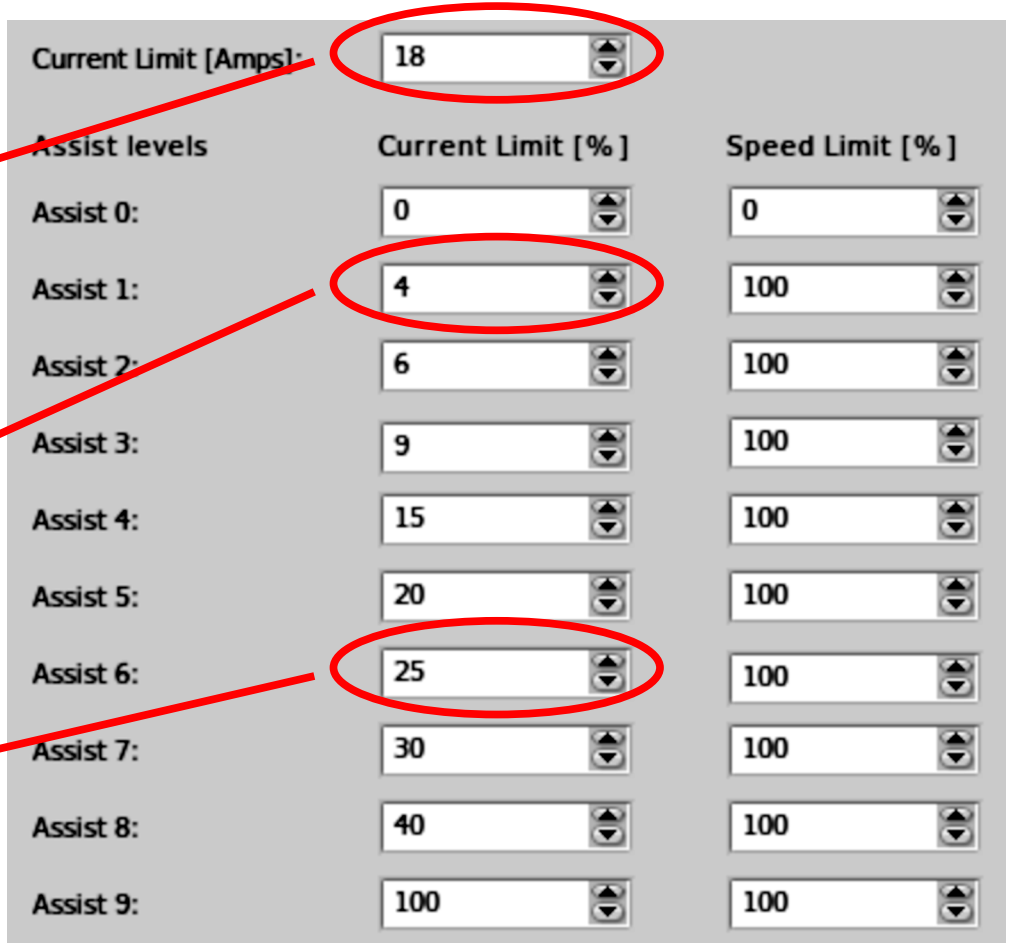


48V	
100%	54.6
90%	53.0
80%	52.1
70%	50.7
60%	49.6
50%	48.3
40%	47.2
30%	46.1
20%	44.8
10%	42.6
0%	38.0

https://bafangusadirect.com/collections/batteries

Maximum vs. Usable Power

- Overall Current Limit
  - 18 A = 75% max
    - **560 W**, kinda-sorta
- Per-Level Limits
  - **1**: 4% = **23 W**
  - **4**: 15% = 84 W
  - **6**: 25% = **140 W**



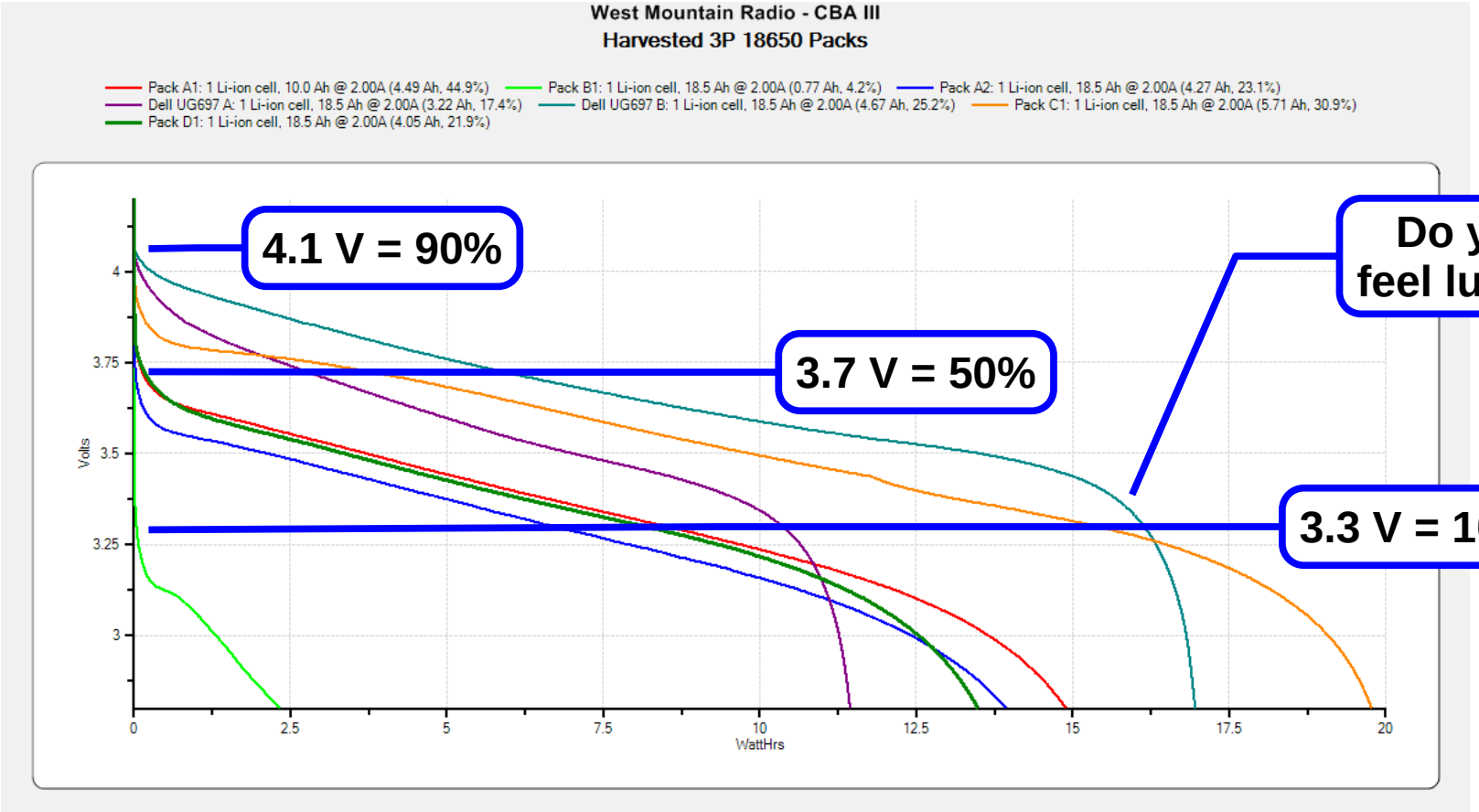
https://electricbike.com/forum/forum/builds/custom-ebike-motor-programming/bbshd-programming/43287-basics-of-programming-bbs02-and-bbshd-mid-drives

Battery Capacity

- 560 W·h battery
  - 56 W·h / 10% bar
- ≅ 7 mile / bar
  - ≅ 70 mile / charge
    - *Do you feel lucky?*
- ≅ 8 W·h / mile
  - *For our type of riding*

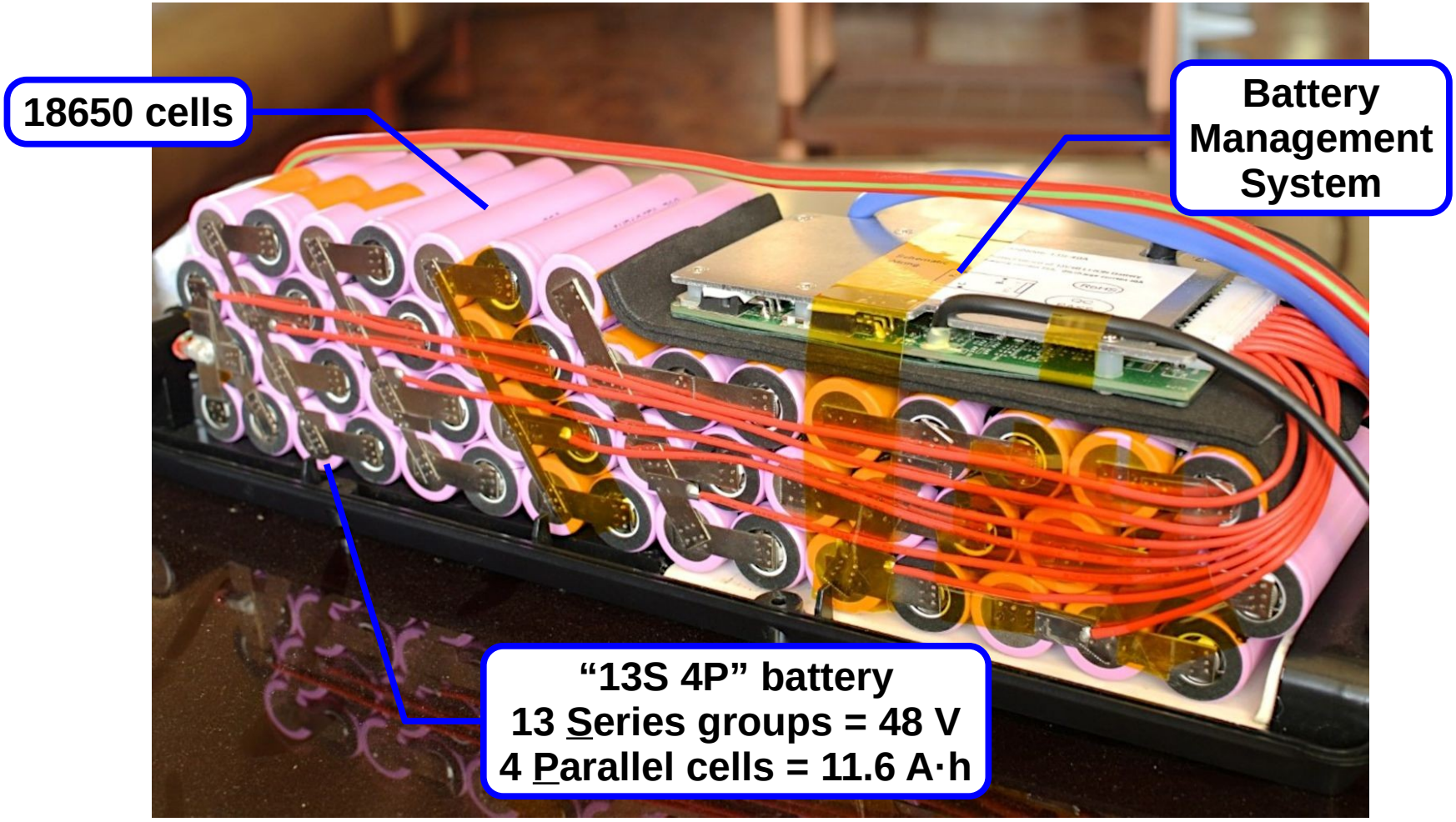
https://softsolder.com/2021/08/05/tour-easy-bafang-11-6-a%c2%b7h-range/

Range Anxiety



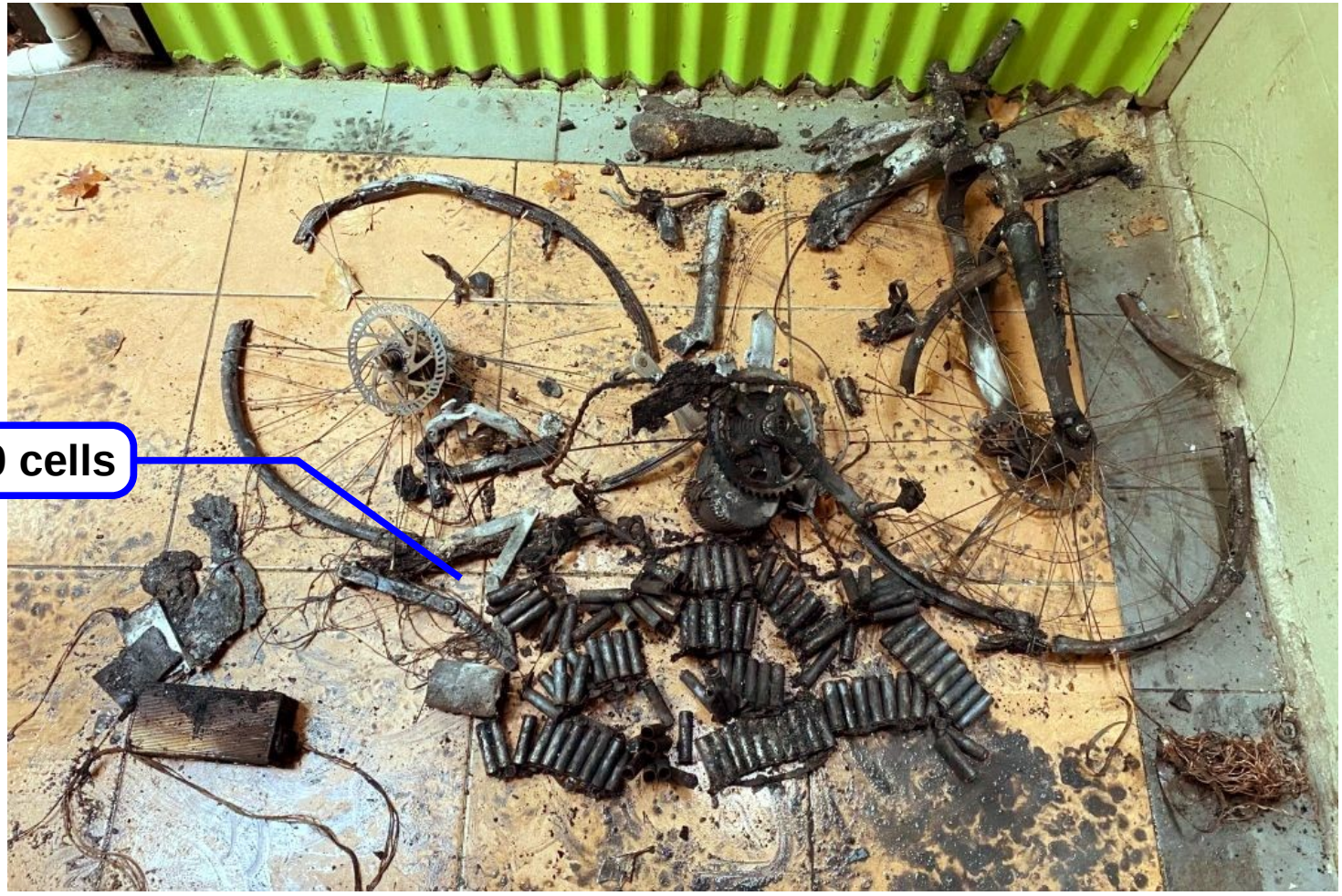
https://softsolder.com/2020/07/23/harvesting-18650-lithium-cells/

Lithium Battery Internals



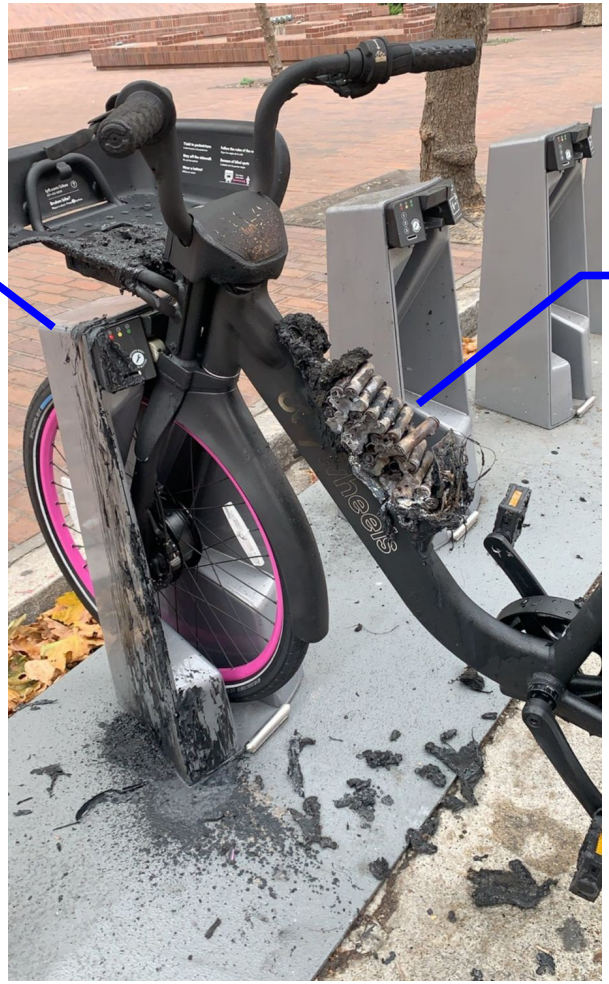
https://endless-sphere.com/forums/viewtopic.php?t=87475

Lithium Battery Anxiety



https://www.bbc.com/news/world-australia-56457294

Lithium Battery Anxiety



https://twitter.com/zrutta44/status/1155147459313598465

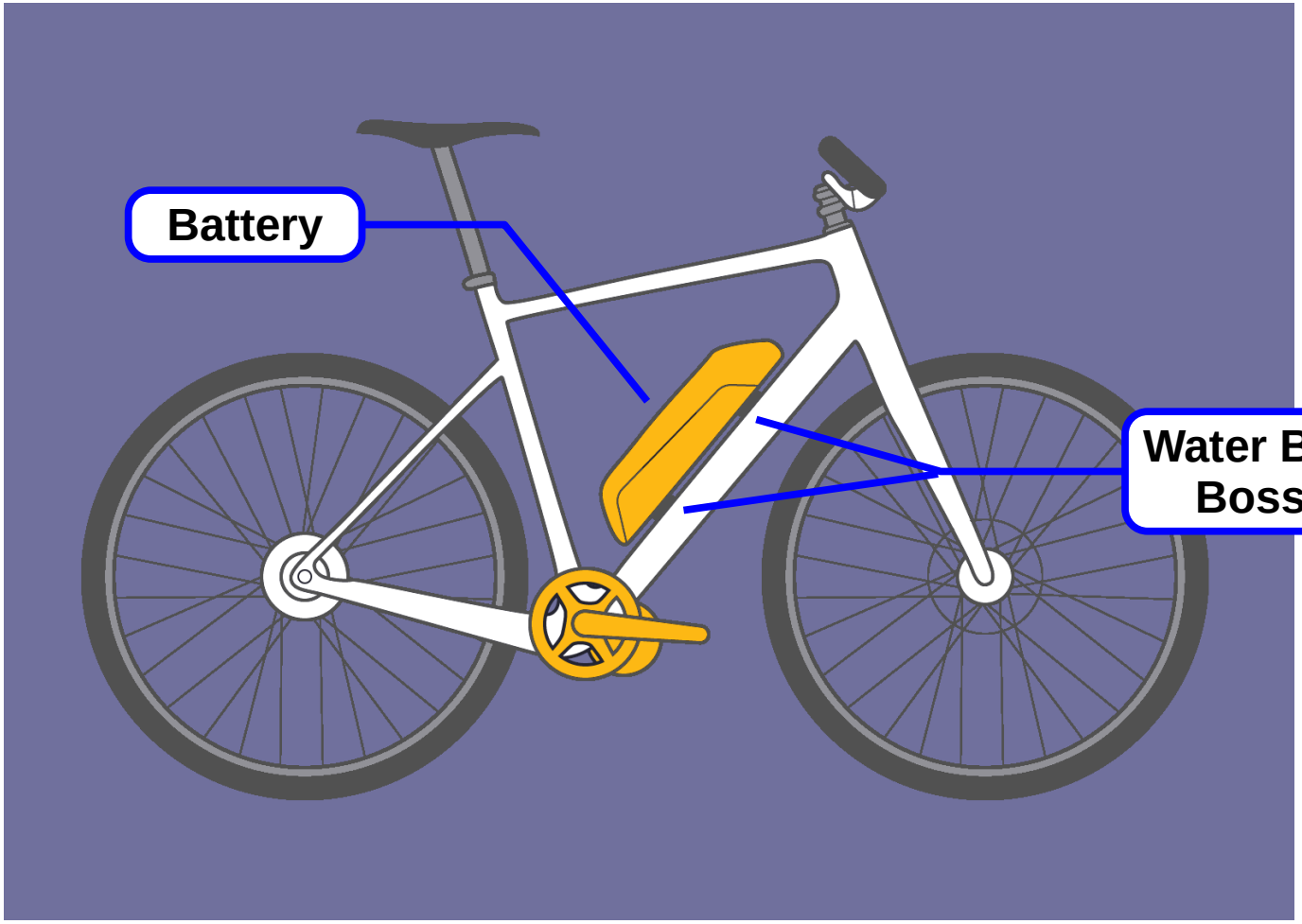
Lithium Battery Anxiety

https://www.washingtonpost.com/technology/2021/08/04/tesla-fire/

Trigger Warning

Geometry

Battery Attachment Points



https://bafangusadirect.com/pages/quiz

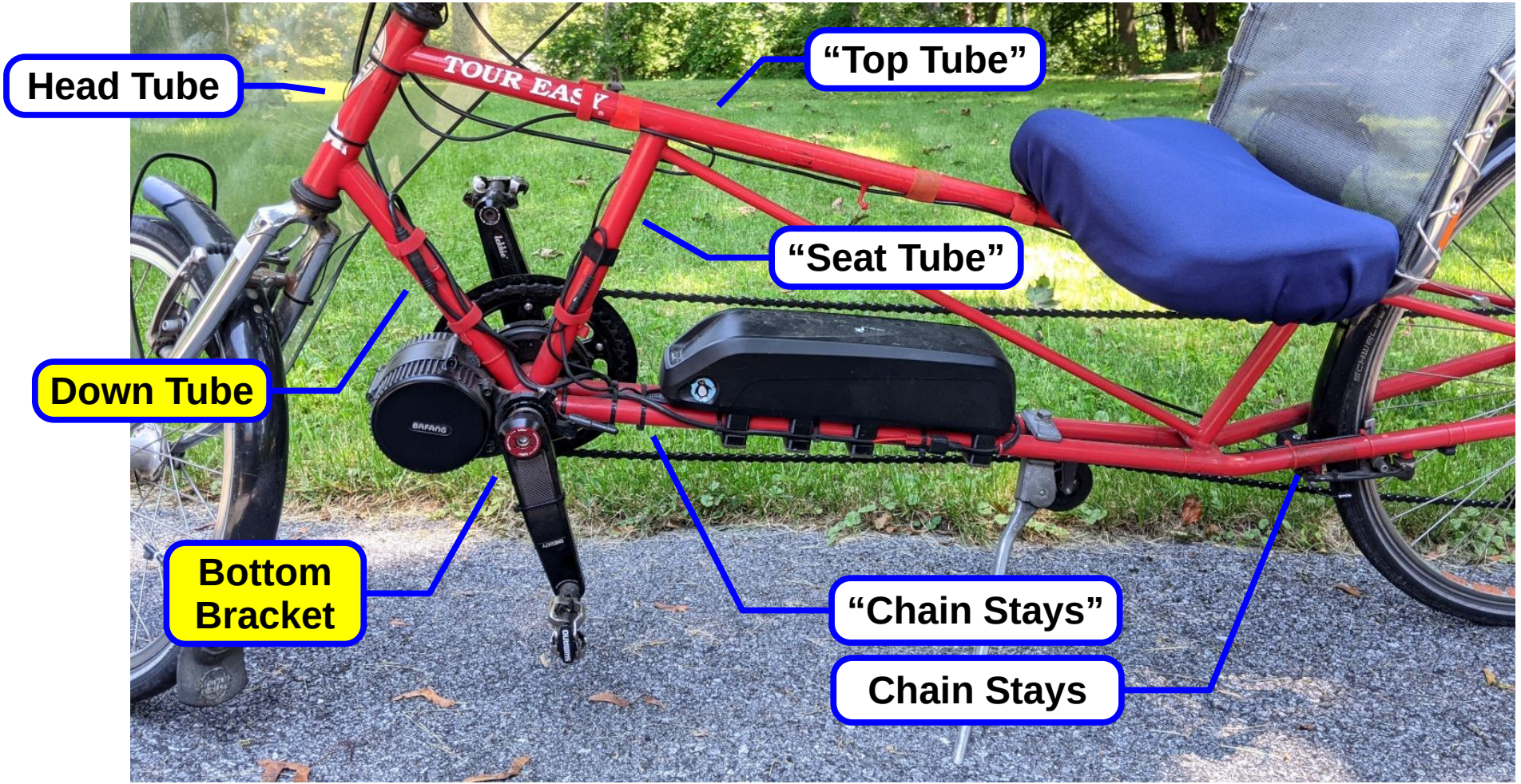
Water Bottle Bosses

https://phomphaustin.com/design/index.php?id=175009 (Dead Link)

Easy Racers – Tour Easy

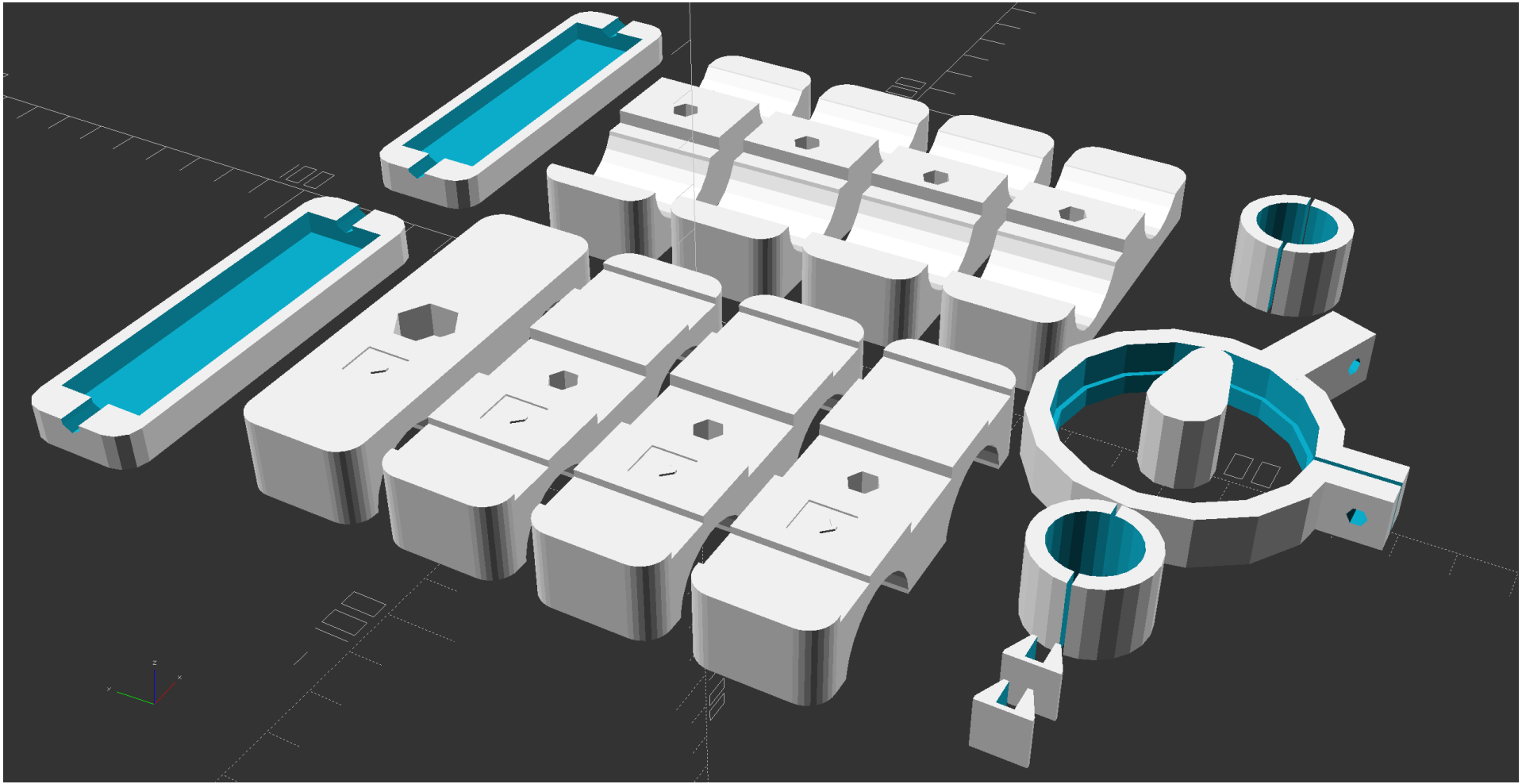
https://softsolder.com/2019/12/22/tour-easy-fairing-strut-mounts-redux/

Easy Racers – Tour Easy



https://softsolder.com/?s=%27tour+easy%3A%27+bafang

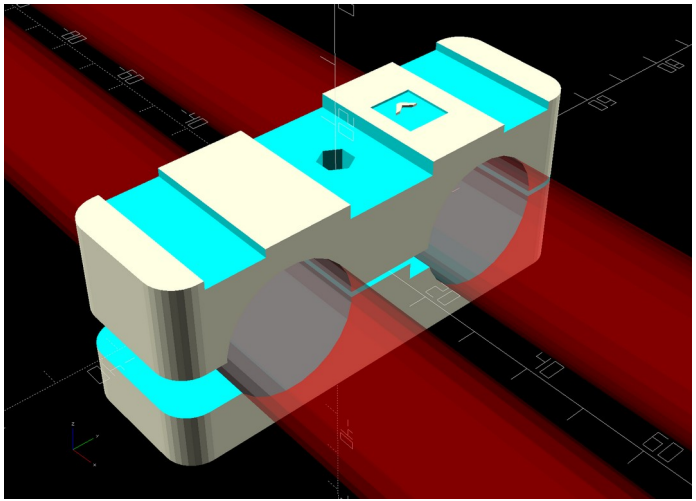
Tour Easy Fittings

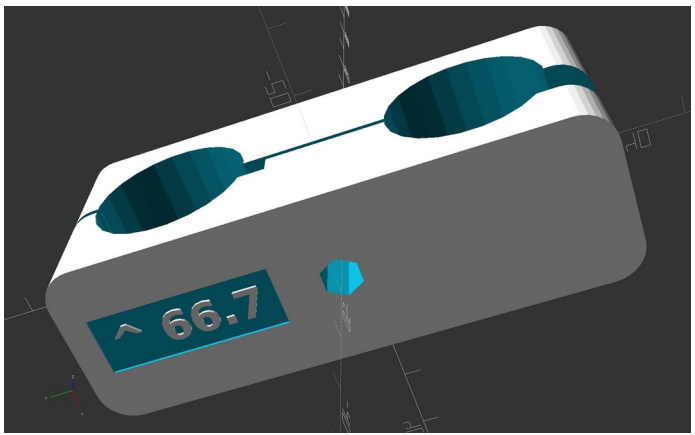


https://gist.github.com/ednisley/9a5accd911d28f702590e4b4e58bb19d

Battery Mount

- Clamp around “Chain Stays”
  - Tubes are *not* parallel
  - Each block is unique
- Top holds battery plate
  - Slots fit around features
  - Water bottle = M5 screw
- Wire / cable passages
  - Battery power wiring
  - Wheel speed sensor





https://softsolder.com/2021/04/21/tour-easy-bafang-48-v-11-6-a%c2%b7h-battery-mount/

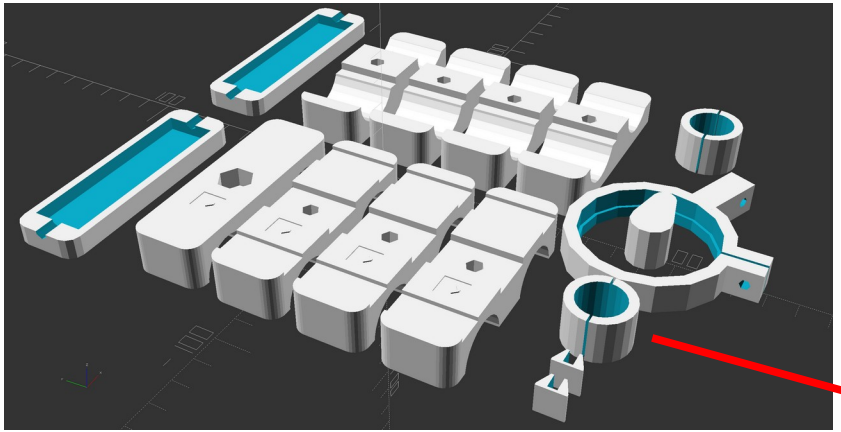
Battery Mount

https://softsolder.com/2021/04/21/tour-easy-bafang-48-v-11-6-a%c2%b7h-battery-mount/

Battery Mount

https://softsolder.com/2021/04/21/tour-easy-bafang-48-v-11-6-a%c2%b7h-battery-mount/

Display Adapter



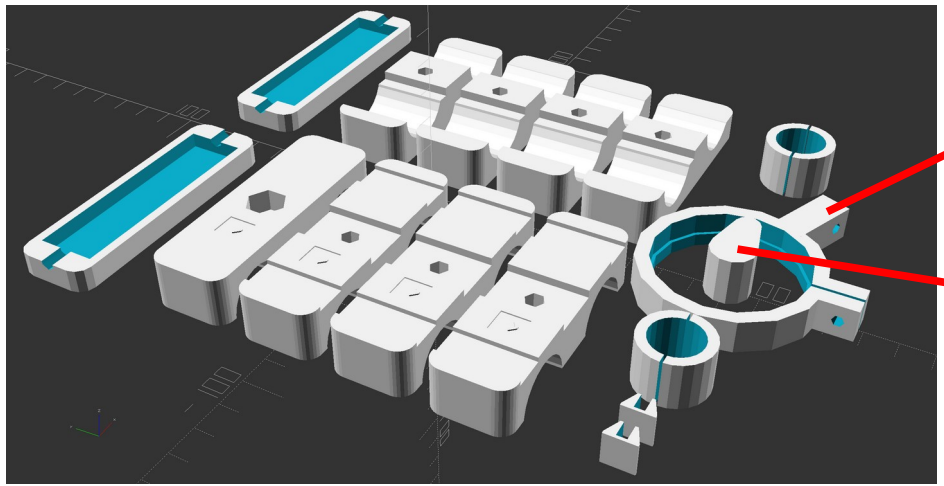
- Lathe project?
  - Make two identical
  - Or test-fit one
- 3D Printing FTW!

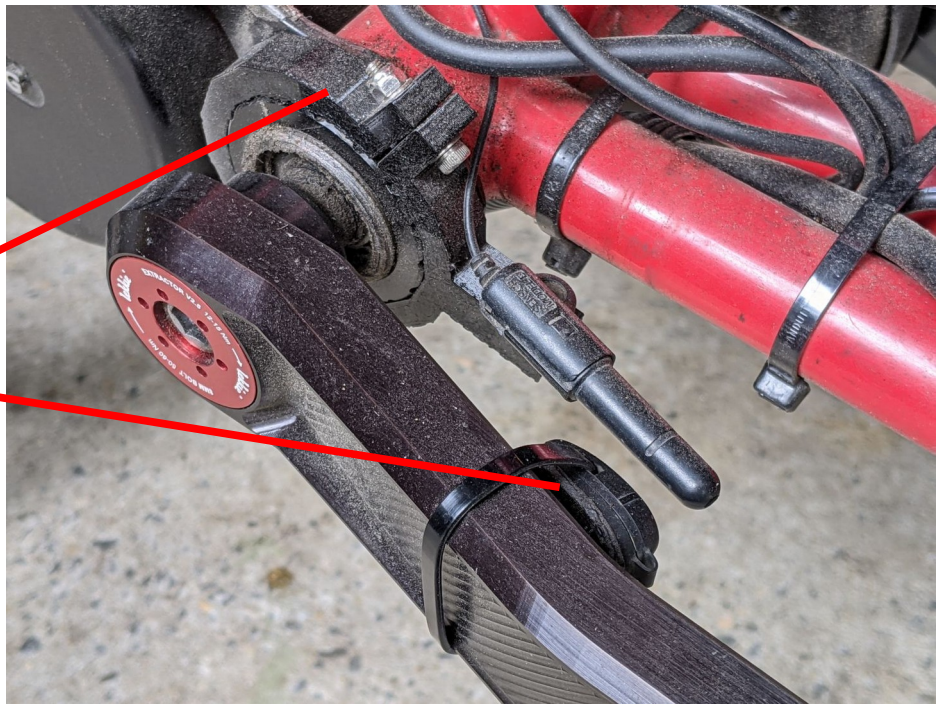
https://softsolder.com/page/2/?s=%27tour+easy%3A%27+bafang

Cadence Sensor Adapter 1

https://softsolder.com/2021/04/29/tour-easy-bafang-mid-drive-vs-cateye-cadence-sensor/

Cadence Sensor Adapter 2



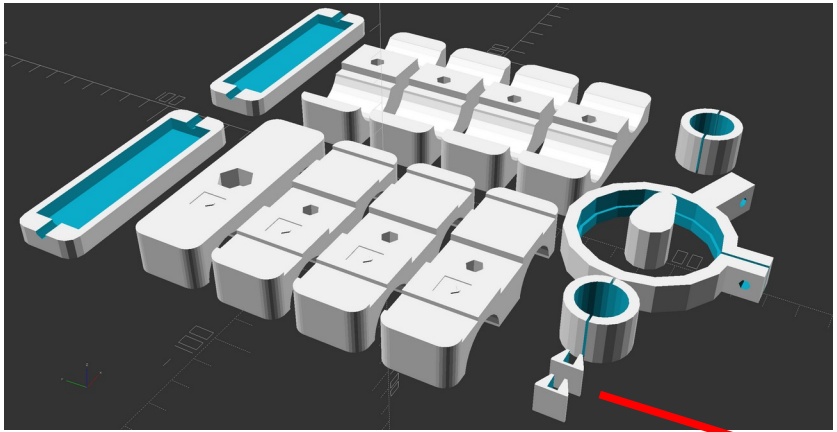


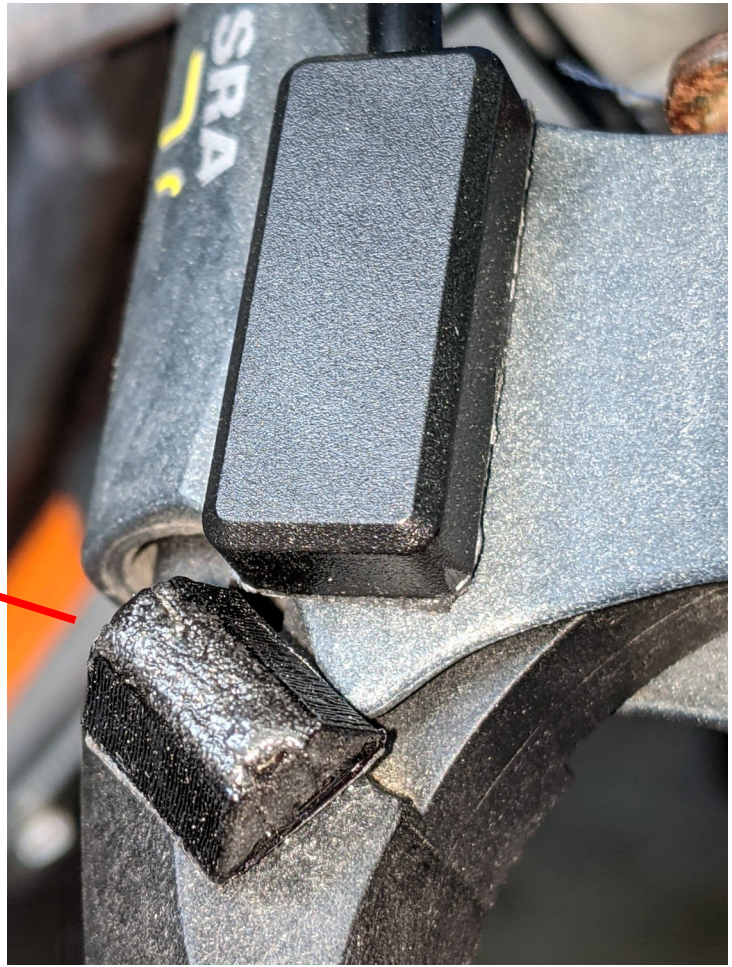
https://softsolder.com/2021/04/30/tour-easy-bafang-bbs02-pedal-offset-fix/

Lekkie Offset Crank

https://lekkie.tech/product/lekkie-buzz-bar-cranks/

Brake Sensor Magnet Mount

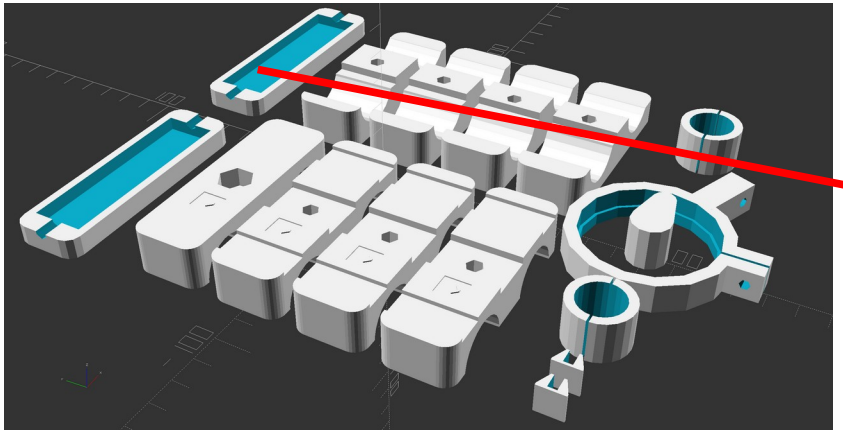


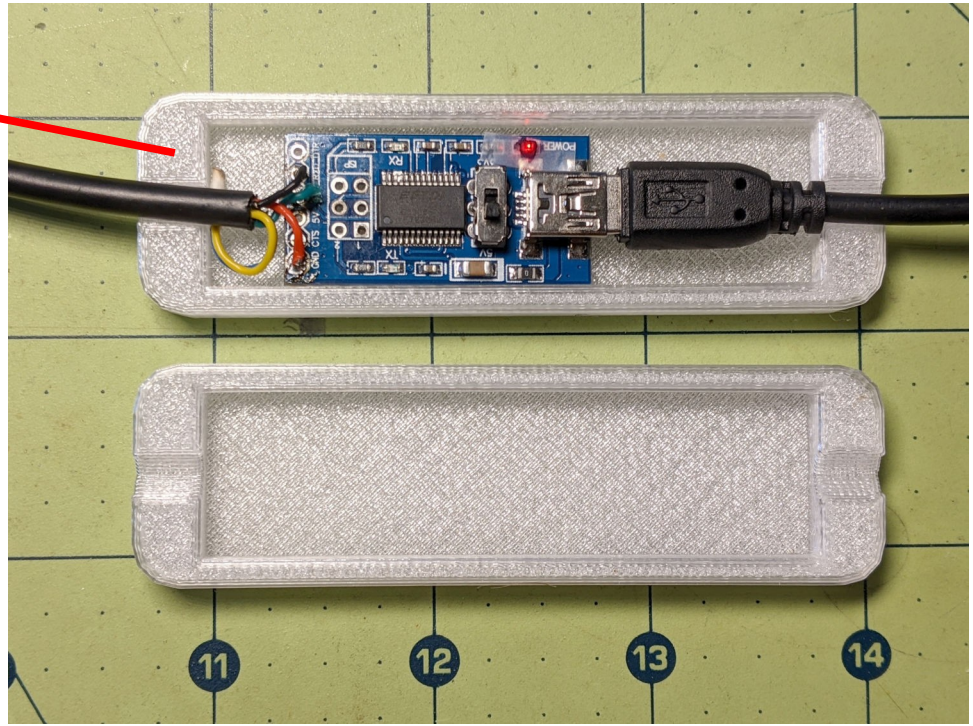


- OEM cost vs. *everything*
  - Bad magnet orientation
  - Magnetic field cancellation
  - Nickel plating vs. weather

https://softsolder.com/2021/05/10/bafang-brake-sensor-magnet-realignment/

“USB Programmer” Case

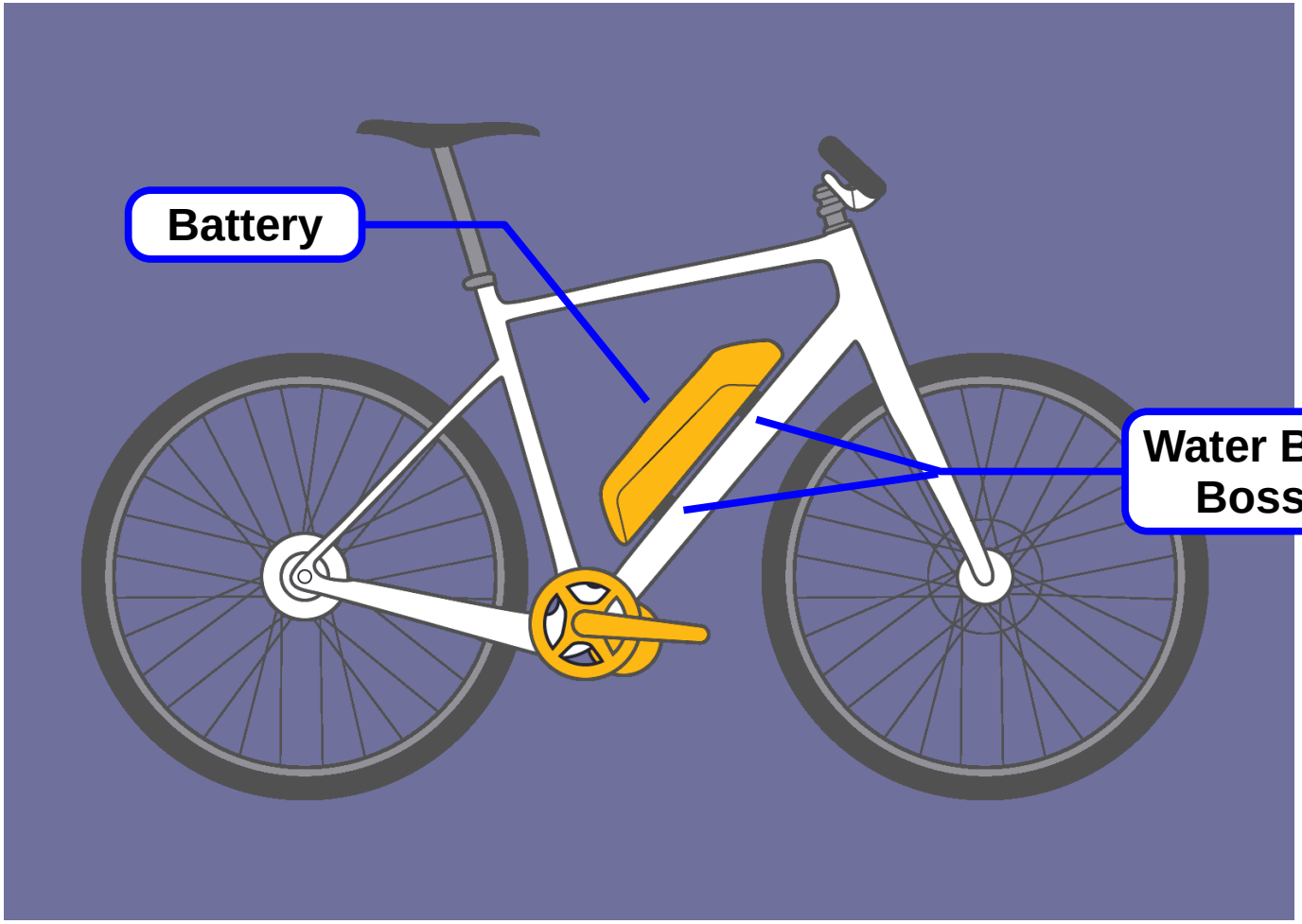




- Ya gotta have stuff …
- Or $20 from Amazon
  - Heatshrink “case”

https://softsolder.com/2021/05/10/bafang-brake-sensor-magnet-realignment/

Standard-size e-Bike

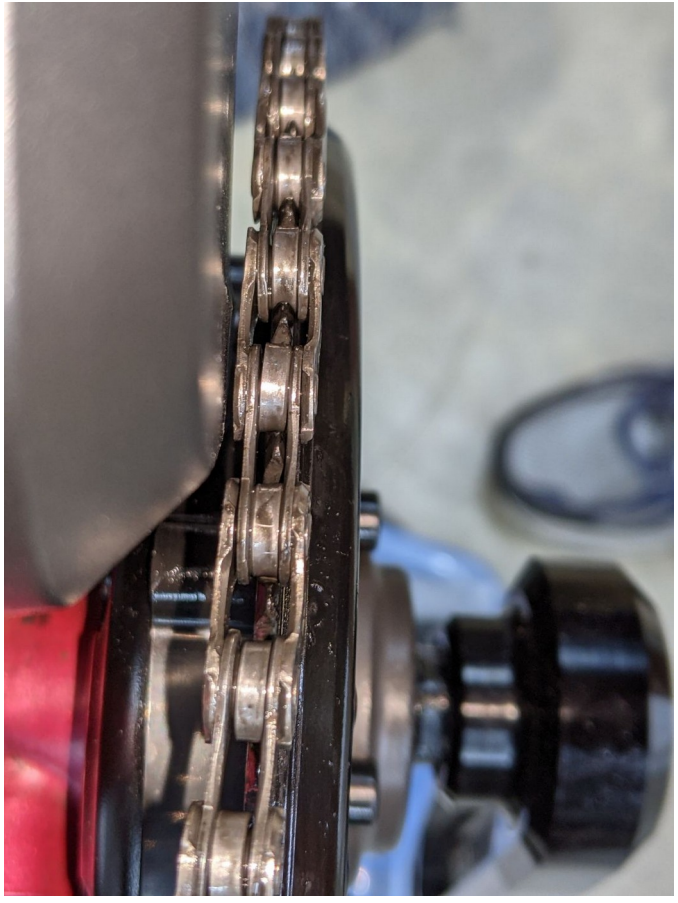


https://bafangusadirect.com/pages/quiz

Terry Symmetry Constraints

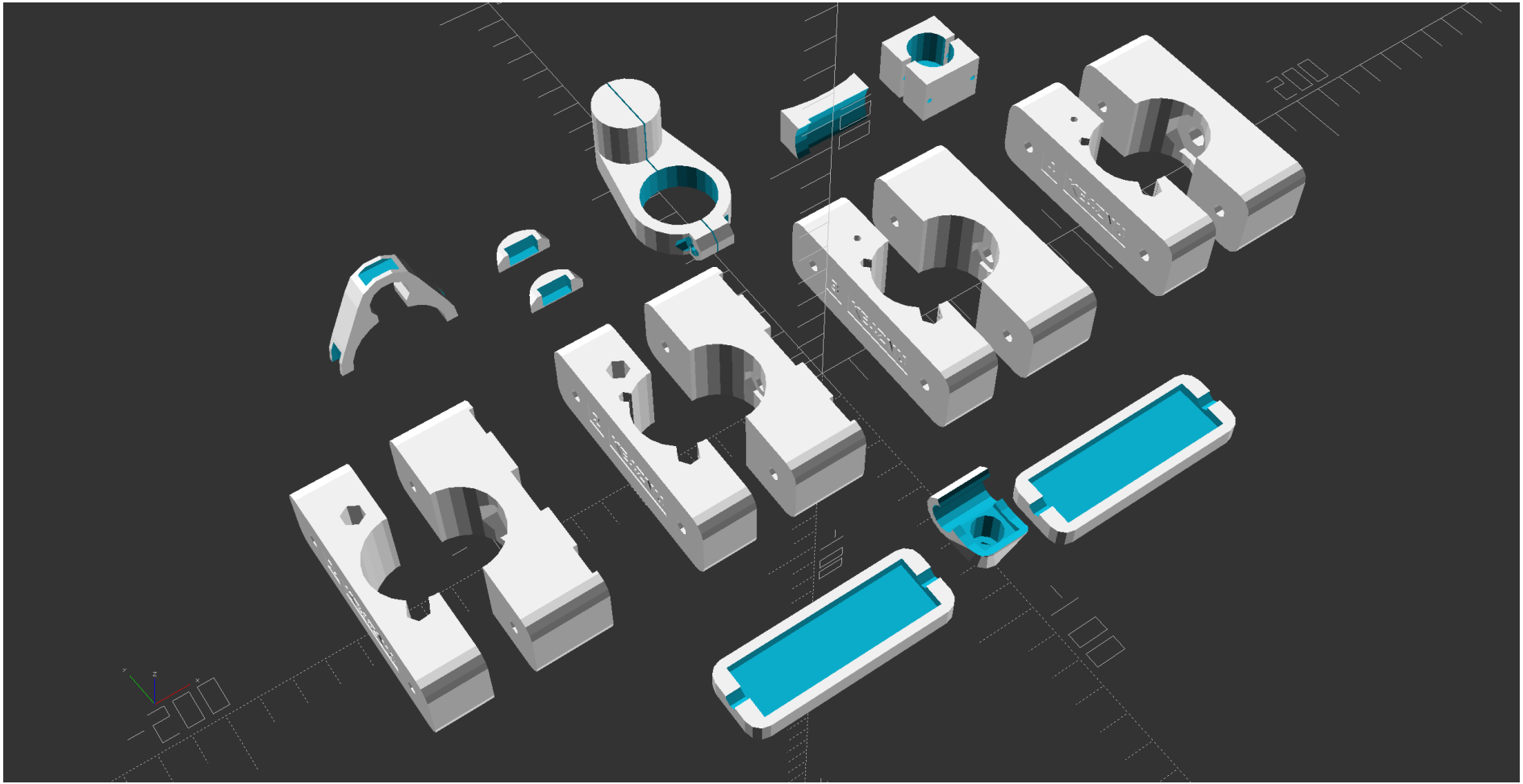
https://softsolder.com/2021/06/25/bafang-bbs02-terry-symmetry-battery-mount/

Terry Symmetry Chainline



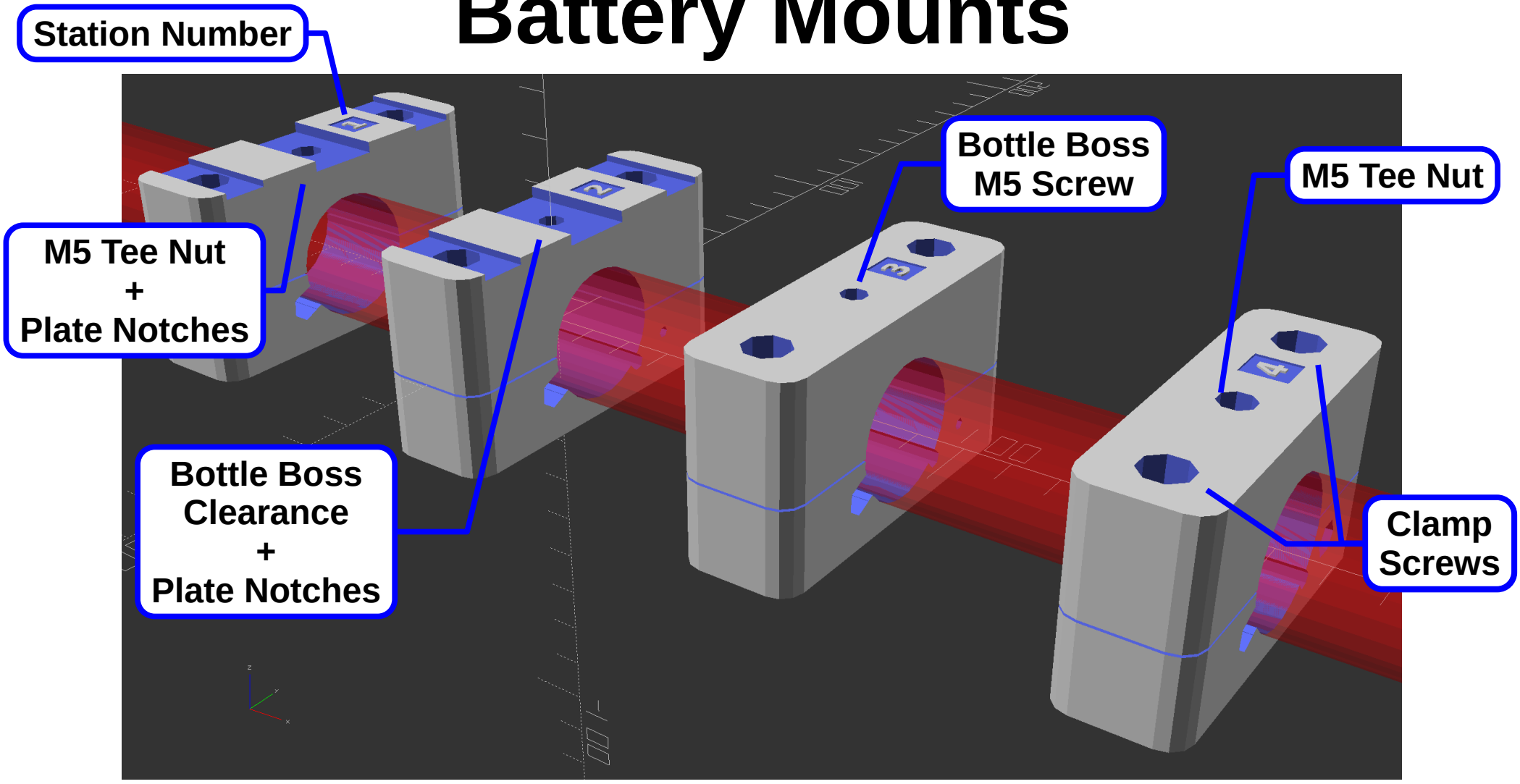
https://softsolder.com/2021/06/25/bafang-bbs02-terry-symmetry-battery-mount/

Terry Symmetry Fittings



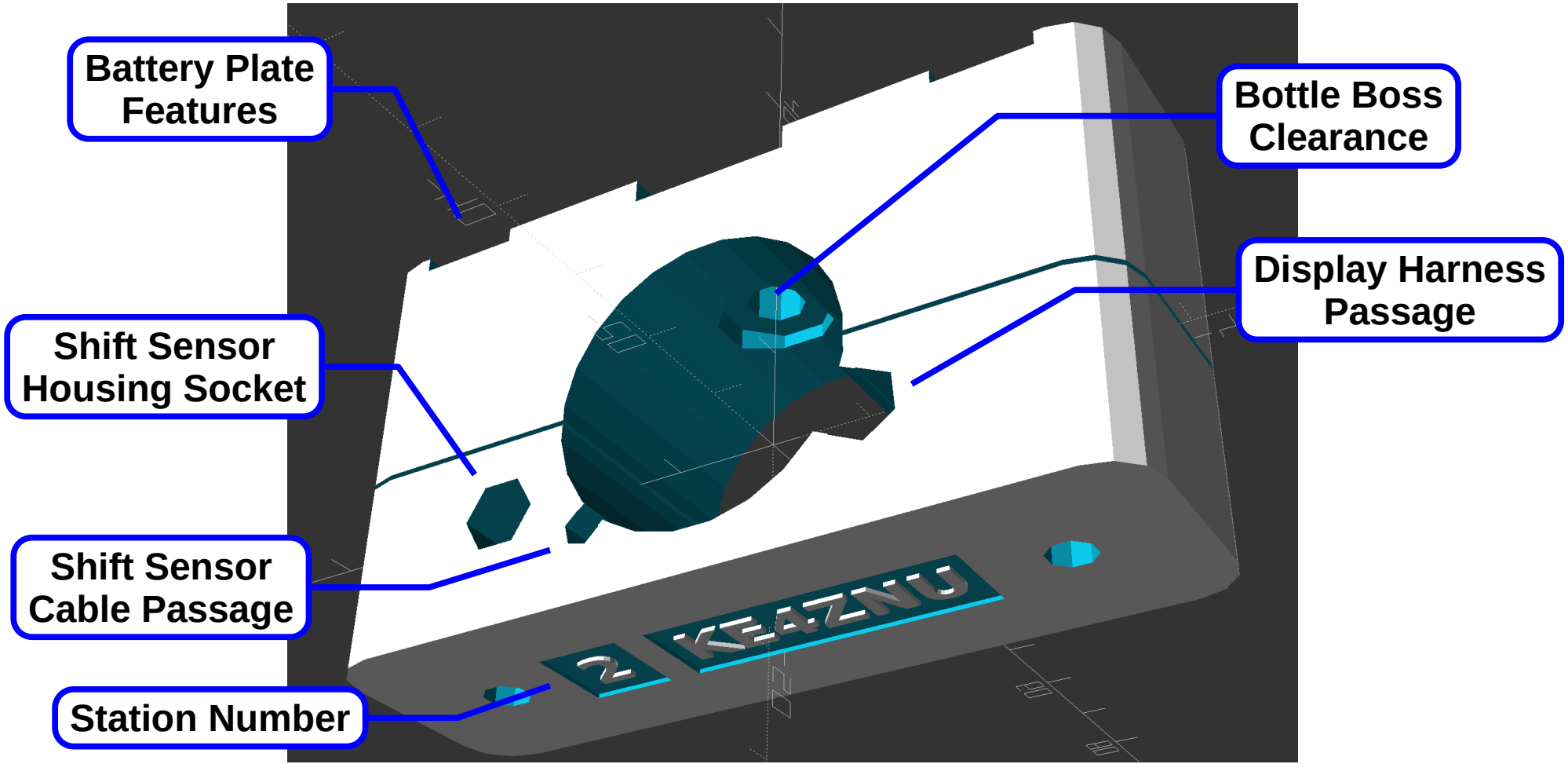
https://gist.github.com/ednisley/5244a30ea2373ca765dd59bc1d8710d0

Battery Mounts



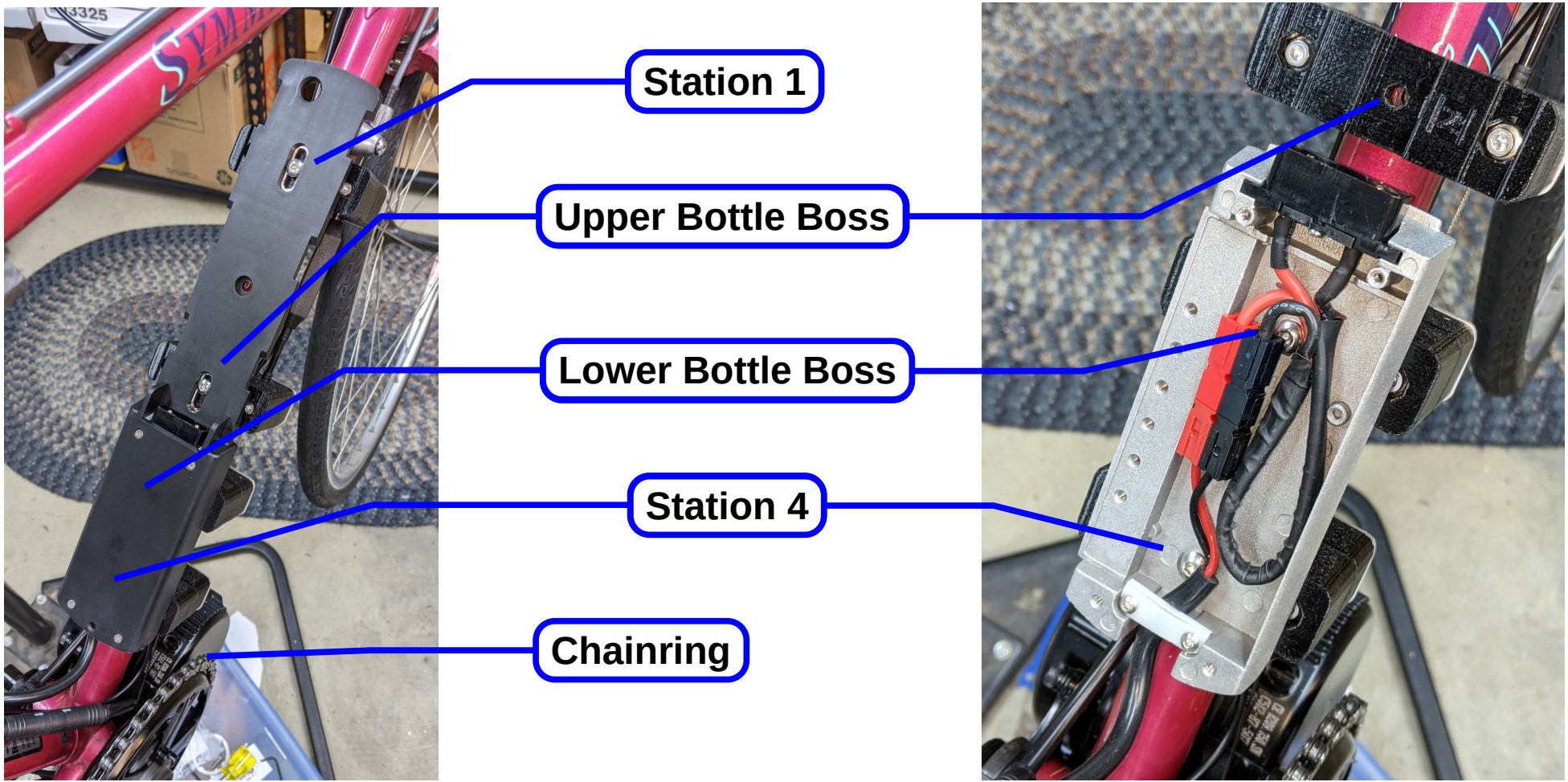
https://softsolder.com/2021/06/25/bafang-bbs02-terry-symmetry-battery-mount/

Battery Mounts



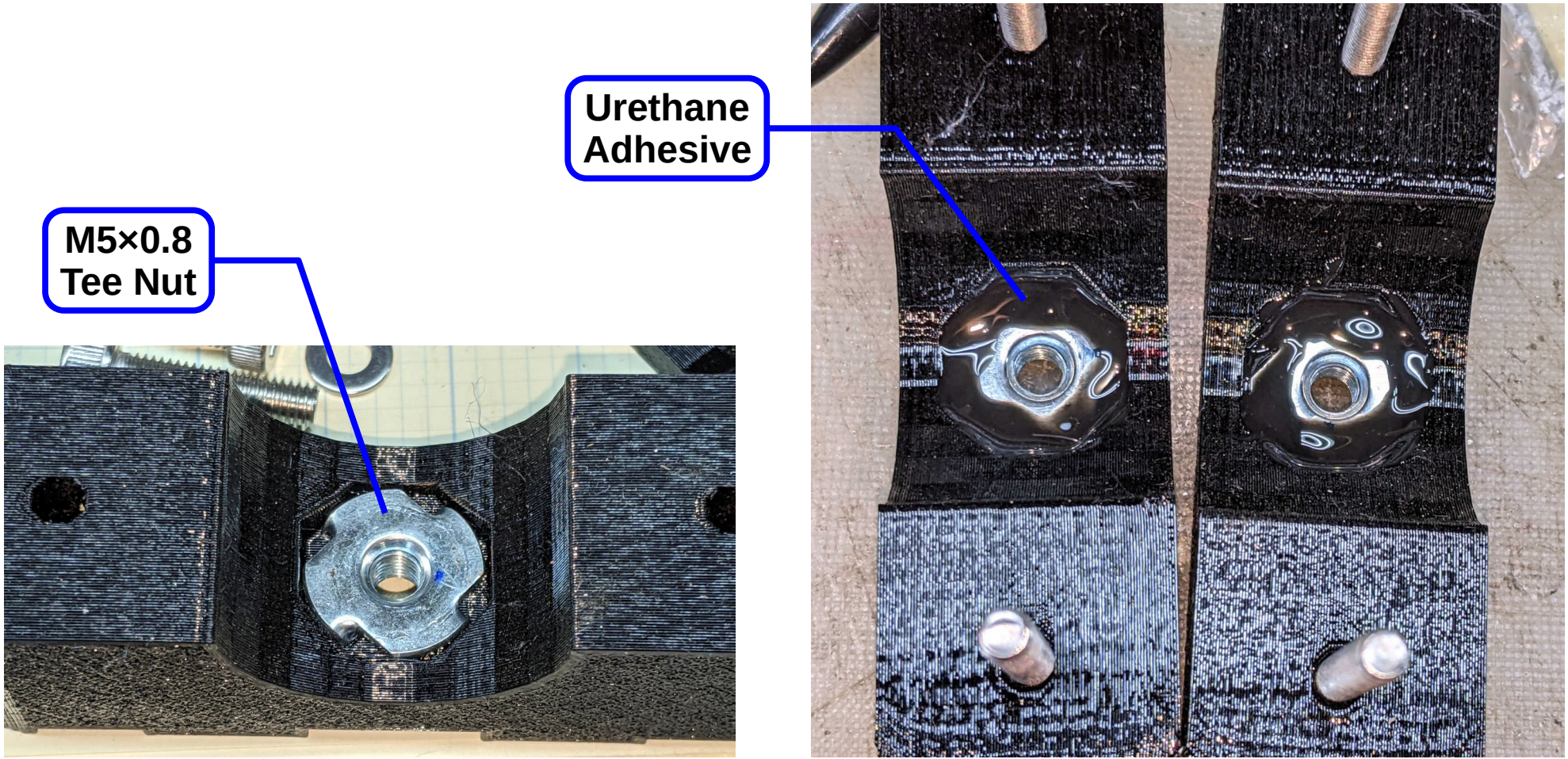
https://softsolder.com/2021/06/25/bafang-bbs02-terry-symmetry-battery-mount/

Battery Plate vs. Bottle Bosses



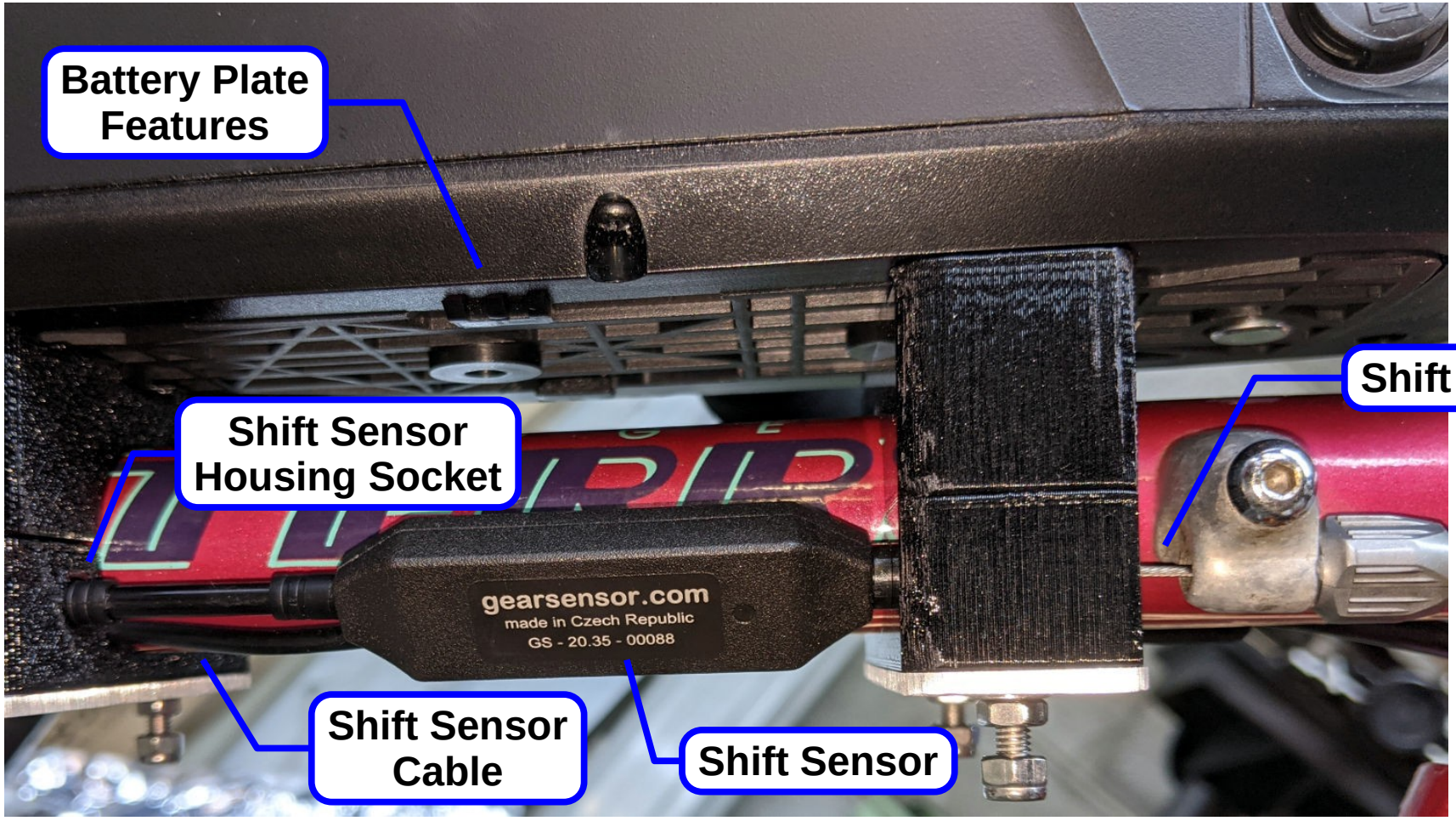
https://softsolder.com/2021/06/25/bafang-bbs02-terry-symmetry-battery-mount/

Tee Nuts



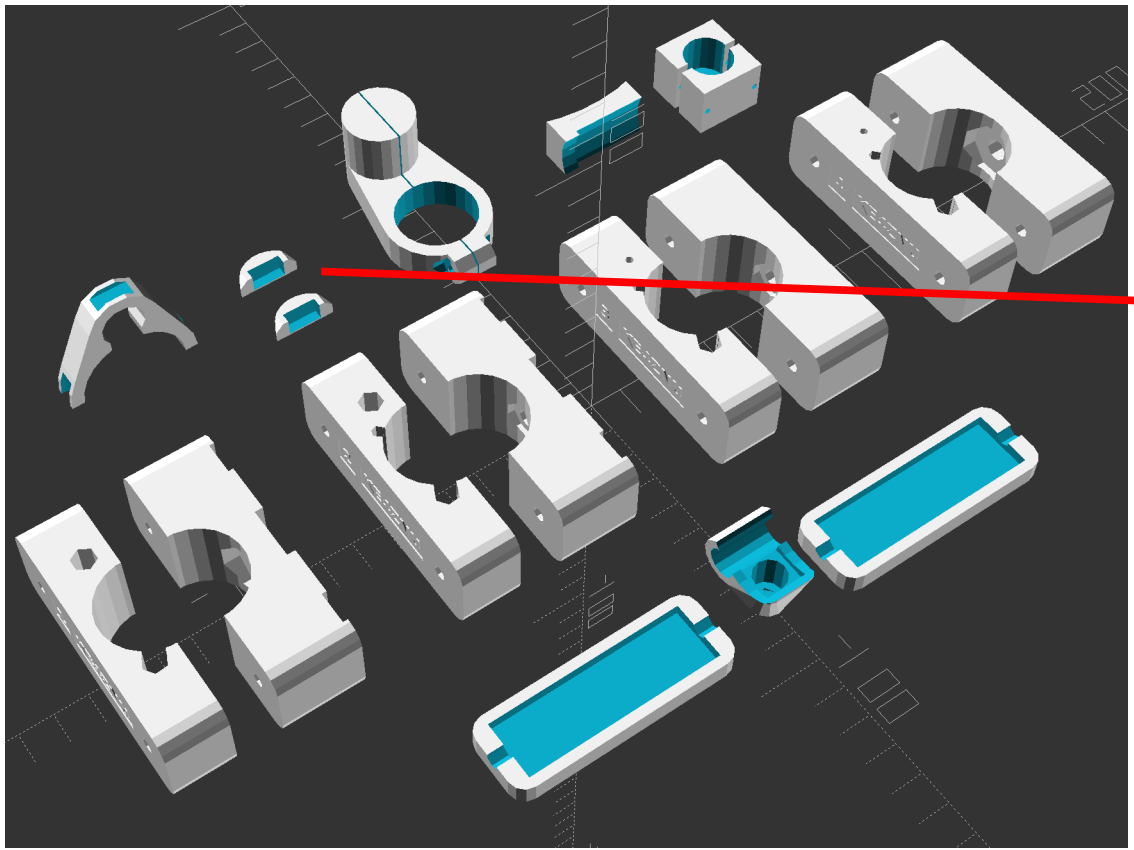
https://softsolder.com/2021/06/25/bafang-bbs02-terry-symmetry-battery-mount/

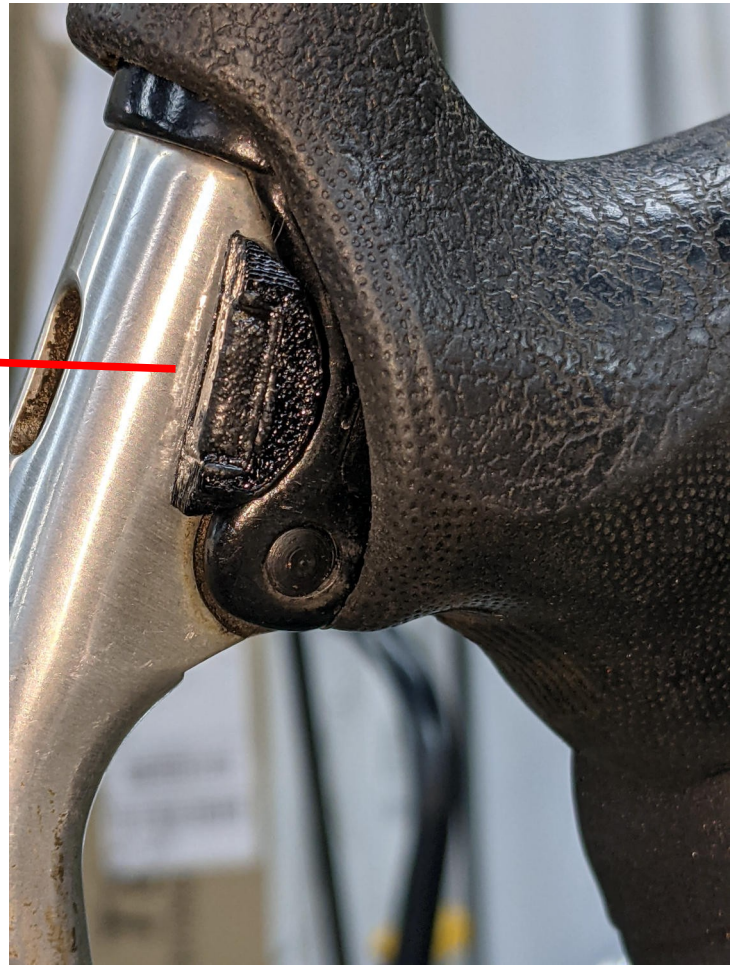
Shift Sensor Mount



https://softsolder.com/2021/06/30/bafang-bbs02-terry-symmetry-shift-sensor-cable-guides/

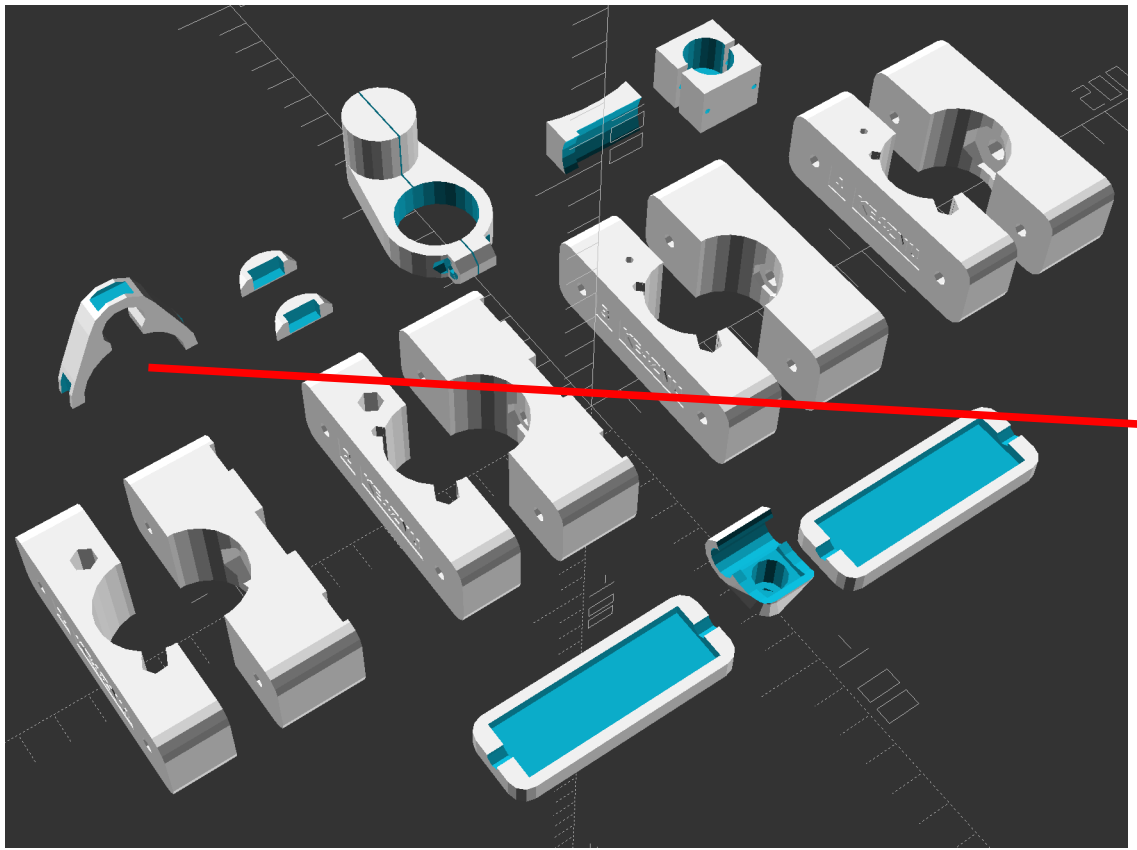
Brake Sensor Magnet Mount





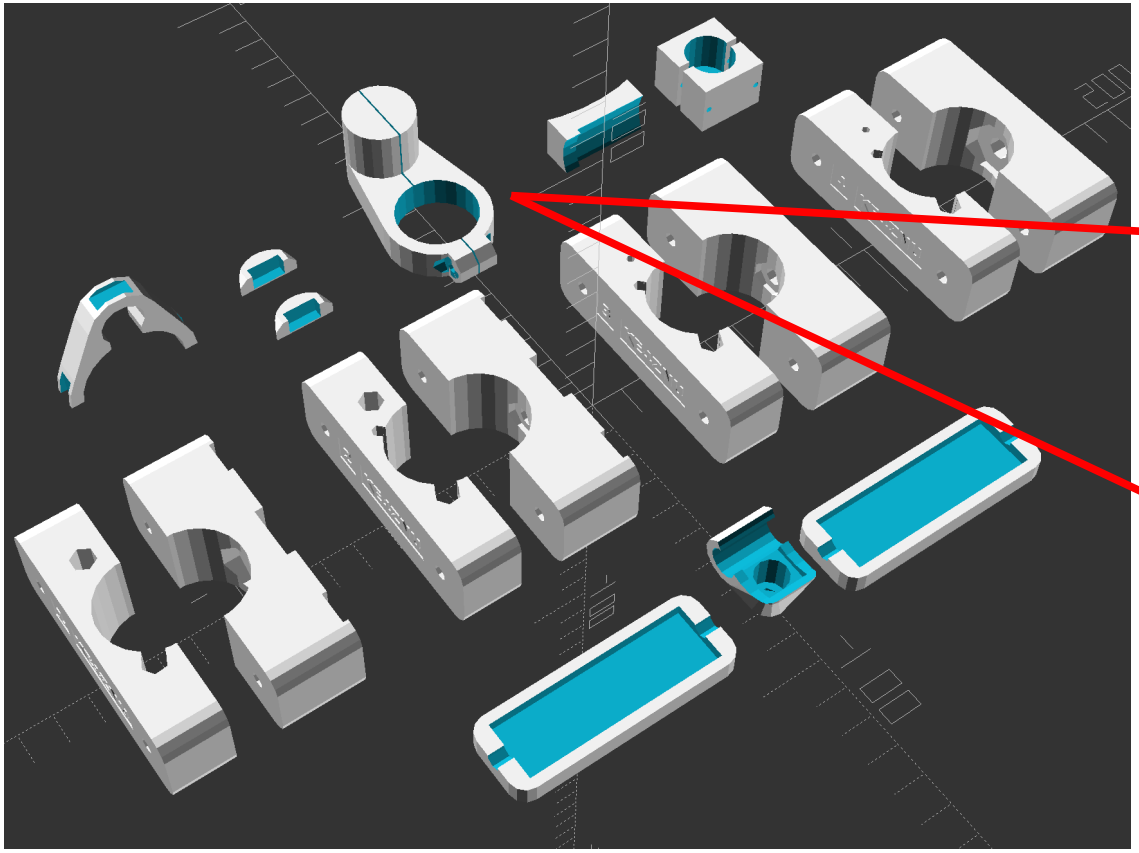
https://softsolder.com/2021/06/22/bafang-bbs02-terry-brake-sensor/

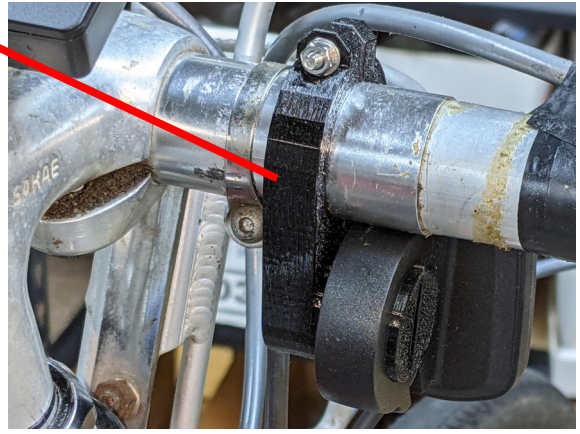
Head Tube Cable Clip



https://softsolder.com/2021/06/24/bafang-bbs02-terry-head-tube-clip/

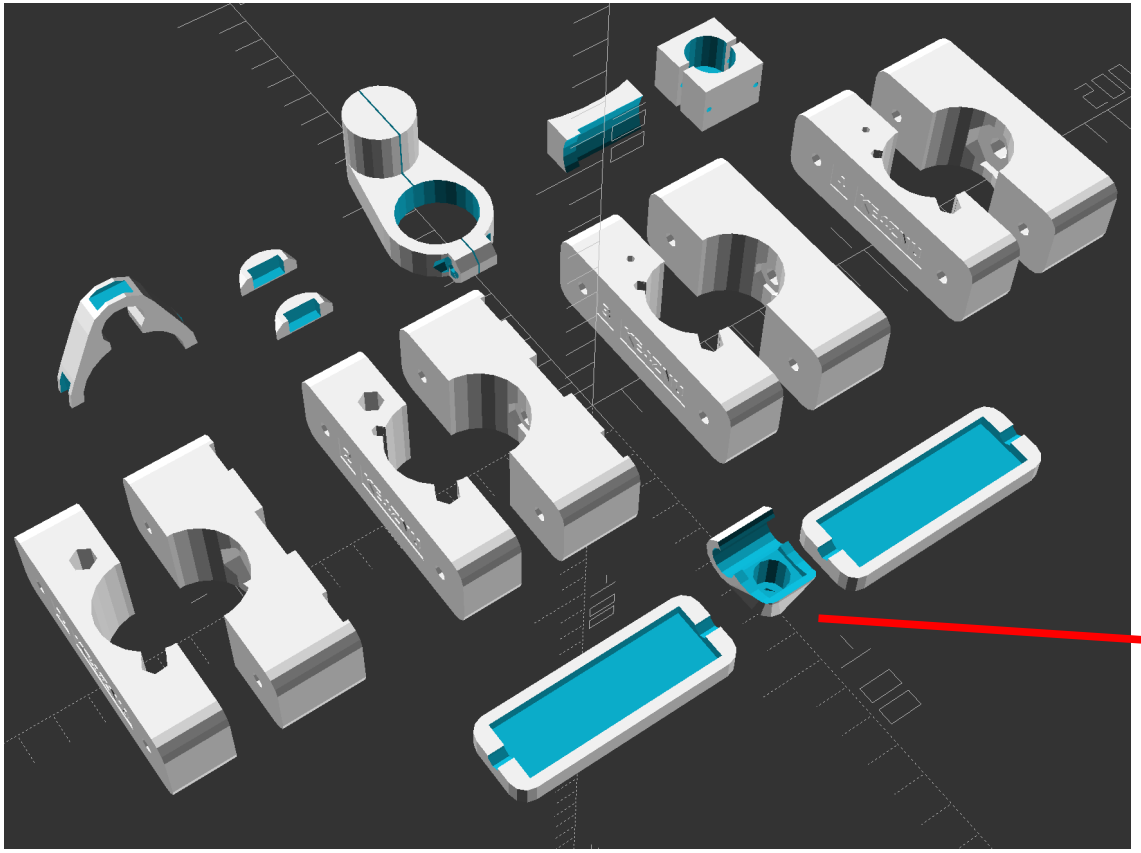
Display & Throttle Clamp Adapter

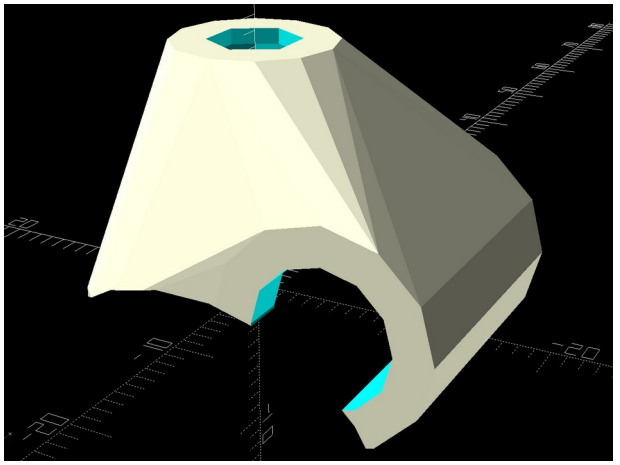




https://softsolder.com/2021/06/17/bafang-bbs02-drop-bar-display-adapter/
https://softsolder.com/2021/06/18/bafang-bbs02-drop-bar-throttle-adapter/

Shift Cable Stud Cap





https://softsolder.com/2021/06/23/bafang-bbs02-terry-cable-stop-cap/

Trigger Warning

Is This Sensible?

Standard Size & Standard Bike?

NO!

If you fit a standard bike *and* just want to ride again:

- Find and buy a new e-bike
  - If you can find one nowadays
  - The price will astound you
  - Want tweakable assist levels?

https://www.bicycling.com/bikes-gear/a22132137/best-electric-bikes/

Odd Size | Odd Bike?

YES!

- You *already have* a favorite bike
  - You don't *fit* a standard bike
  - You don't *want* a standard bike
- Buy a new full-custom e-bike?
  - If you can find / wait for it

https://bafangusadirect.com/products/complete-bafang-750w-bbs02-mid-drive-ebike-motor-kit-battery

? & !

Ed Nisley

Say “NISS-lee”, although we're on the half-essed branch of the tree

Engineer (ex PE), Hardware & Firmware Tinker, Author

Blog - The Smell of Molten Projects in the Morning - softsolder.com

Shop notes, Electronics, Firmware, Machinery, 3D printing, Curiosities

Digital Machinist - www.homeshopmachinist.net

Along the G-Code Way (2008 ...) - CNC, math, 3D printing

Circuit Cellar - www.circuitcellar.com

Firmware Furnace (1988-1996) - Nasty, grubby hardware bashing

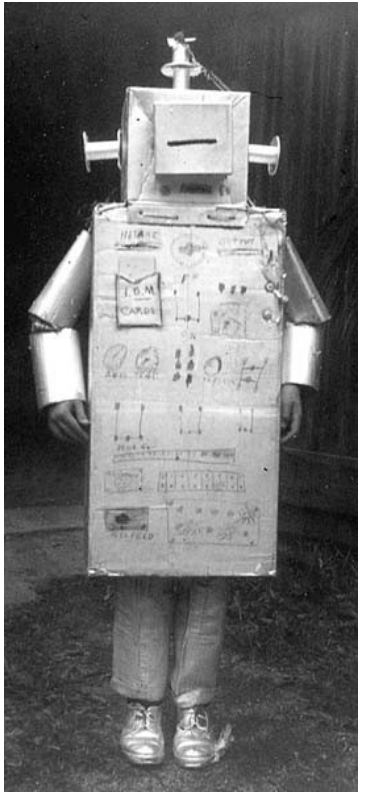
Above the Ground Plane (2001-2018) - Analog and RF stuff

Dr. Dobb’s Journal - www.ddj.com

Embedded Space (2001-2006) - All things embedded

Nisley’s Notebook (2006-2007) - Hardware & software collisions

Book! The Embedded PC's ISA Bus: Firmware, Gadgets, Practical Tricks



September
1962

If you can't read this
then
make a new friend
'way up front