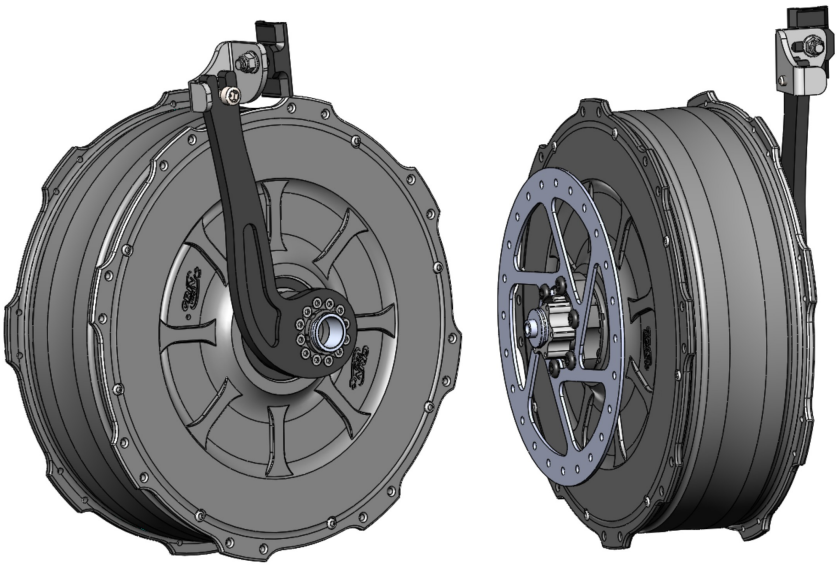
# *The Grin All-Axle Motor*
## *Fat (45mm) Front Model*

Owner's Manual – *Rev 0*



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# 1 Introduction

Thank you for purchasing the universal V3 Fat Front All-Axle hub motor from Grin Technologies. This efficient and robust direct drive hub motor fills a void in the market for fatbike fork compatibility and will provide years of service.

Features of the Fat Front All-Axle motor include:

- Light weight for its power class (5.95 kg vs typical 8-10 kg)
- Compatible with thru-axle and quick release fatbike forks
- Integrated torque arm for secure installation
- Waterproof L1019 controller connector for hall and phase leads
- Embedded thermistor for motor temperature sensing
- Capable of over 120 Nm peak torque, and 40-60 Nm continuous
- Made in Vancouver, Canada

# 2 Components

In addition to the hub motor itself, the motor package will include additional hardware such as disc spacers, axle end caps, axle extenders, and of course, a torque arm. These are identified below:

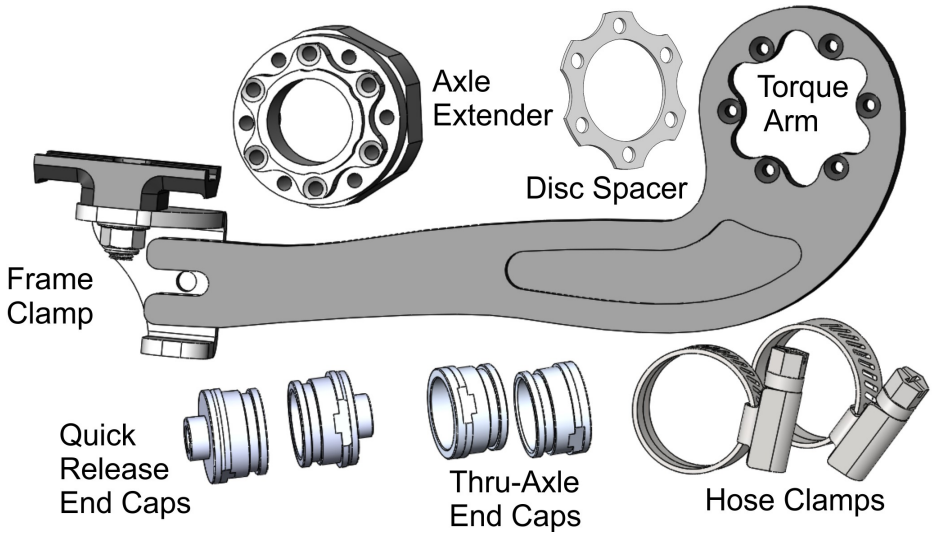



**Figure 1: Adapter hardware present with front fat All-Axle motor kits to achieve proper alignment with different fork standards.**

## 2.1 Axle End Caps

The axle end caps fit inside the ends of the axle to provide the correct spacing and termination for either quick release or 15mm thru-axle spindles.

## 2.2 Axle Extenders

The 135x9 and 150x15 fatbike adapter kits include short axle extender which increases the effective axle length on the left disc side of the hub for proper 135mm and 150mm spacing. Without an extender, the axle is 120mm long.

## 2.3 Disc Spacers

The standard installation includes a 2mm disc spacer for alignment of the rotor 15mm inside the dropout. An additional 5mm disc spacer is included for forks with a 10mm spacing from dropout to rotor.

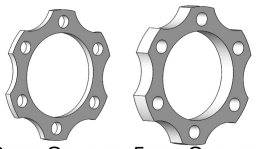



**Figure 2: Disc Spacers**

## 2.4 Torque Arm

The torque arm is a pivotal part of the motor system that transmits all of the motor torque safely to the bicycle fork without putting any spreading force on the dropouts. It uses a snug splined interface that can withstand tremendous spinning force from the axle, with virtually no play when the torque direction alternates during regenerative braking.

## 2.5 Frame Clamp

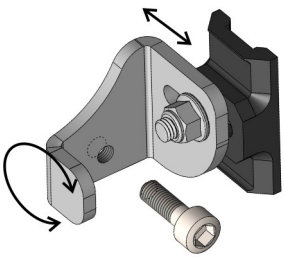


**Figure 3: Frame clamp can both swivel and slide in and out, allowing correct alignment over a range of fork geometries.**

The swiveling frame clamp provides a versatile attachment point for the torque arm to connect with the fork blade via a pair of hose clamps. Once the frame clamp is installed, it can stay in place allowing the torque arm to detach with just a single fastener.

# 3 Installation

Before mounting the motor to the bicycle fork you may first need to install the hardware adapters onto the hub.

## 3.1 Axle Extender

Fit the axle extender over the non-disc side of the axle. It is a tight fit and may need to be tapped on.

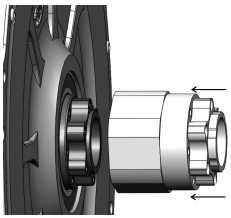


**Figure 4: Axle Extender.**

## 3.2 Torque Arm

Orient the torque arm on the axle such that the cable points down when the arm is pointing up.

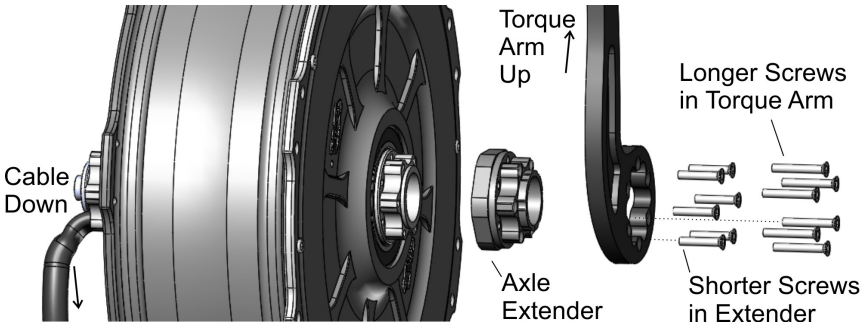



**Figure 5: The torque arm screws should include a drop of threadlocker on the threads. Tighten with T10 Torx wrench (included) to 1 Nm.**

This torque arm + extender assembly is held snugly in place with a total of 12 M3 screws, 6 longer screws that pass through the torque arm and 6 slightly shorter screws for just the axle extender. All 12 screws should be tightened to 1 Nm.

## 3.3 Disc and Disc Spacer

Some fatbikes forks will have correct disc rotor alignment with the 2mm disc spacer which places the rotor 15.5mm from inner dropout face. This is the same standard as a normal REAR hub. Other fatbike forks expect the disc rotor positioned 10.5mm from the dropout face which is the norm for front forks. In this case, both the 2mm and 5mm spacers are used and a longer M5x16 rotor bolt is required to secure the stack.

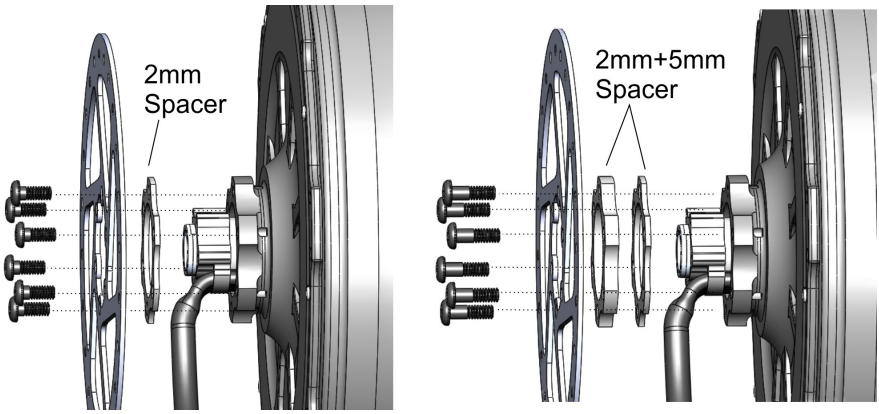



**Figure 6: Depending on your fork, either one or both disc spacers will be required for the caliper alignment.**

The disc rotor screws should be fastened to 7 Nm of torque using a T25 torx driver.

## 3.4 Axle End Caps

Insert the left and right side end caps into the axle. These pieces are held snug with a small O-ring to provide sufficient friction that they stay in place when the wheel is removed from the bike.

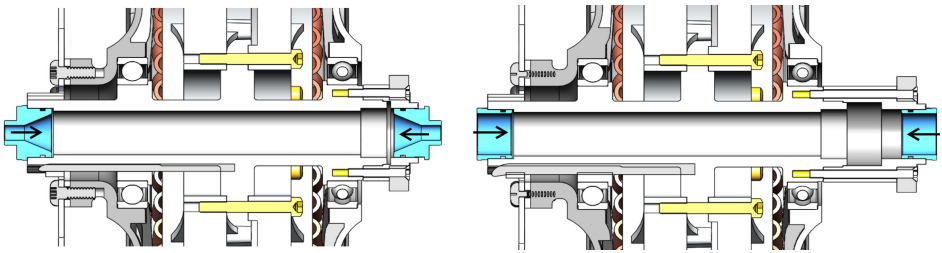


**Figure 7: 135mm Quick Release (left) and 150mm thru-axle (right), end caps are slid into place.**

## 3.5 Wheel Insertion

The completed hub motor can now be dropped into the bicycle fork just like any other front bicycle wheel. This is easiest with the bike upside down. Carefully place it into the fork, aligning the disc rotor between the brake calipers, then loosely secure the quick release or thru-axle spindle.

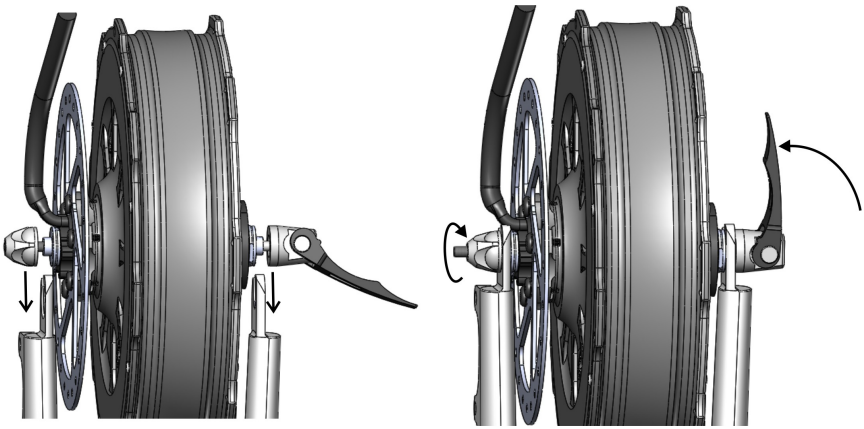


**Figure 8: Install hub with torque arm behind fork blade. Ensure that cable exits down and out of dropout slot without getting pinched.**

## 3.6 Attaching the Frame Clamp

The frame clamp attaches to the fork blade with two hose clamps. A piece of rubber sleeve is included which can be cut to length and slipped over the hose clamp band to make this hardware more discreet.

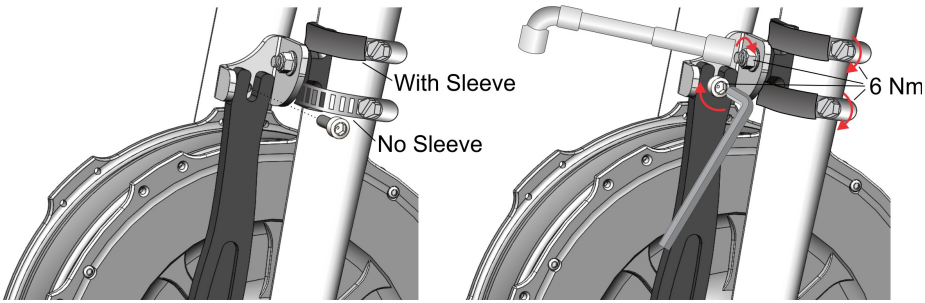



**Figure 9: Frame Clamp installed to fork. Once aligned, all fasteners should be tightened to 6 Nm. Rubber sleeve can be cut to size and slipped over hose clamps.**

Align the frame clamp with the torque arm and tighten up both the M5 nut and the hose clamp bands using the included socket wrench. Tighten the M5 bolt linking the torque arm to the frame clamp with a 5 mm Allen Key. With the torque arm now oriented, you can fully tighten the thru-axle or quick release.

When removing the wheel in the future, simply loosen the single M5 bolt linking the torque arm to the frame clamp and the torque arm will slide out.

# 4 Controller Hookup

If you have a Phaserunner or Baserunner controller from Grin terminated with an L1019 plug, these parts simply plug together on the fork blade.

The details of configuring your motor controller and/or Cycle Analyst are covered in their respective manuals. If you are using a third party motor controller, then it is up to you to either terminate your controller with a matching plug or cut off the L1019 plug and solder on connectors that match your controller.

Grin does not provide installation support for third party controller integration. All pertinent information required for doing this is in this document.

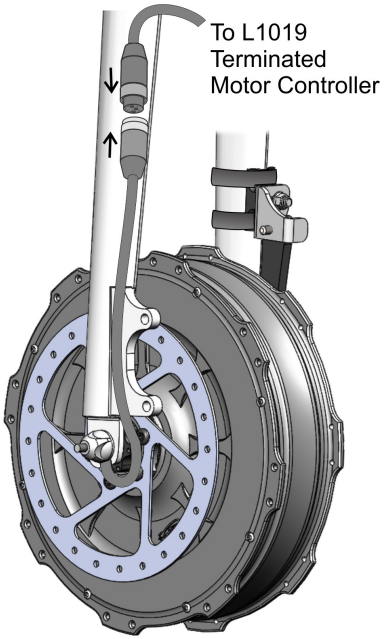



**Figure 10: Cable will usually be held snug to fork with zip ties.**

# 5 Power and Speed

The Fat Front All-Axle motor is available in 2 different winding speeds to achieve the required performance over a range of battery voltages, wheel diameters and target cruising speeds.

| Motor SKU | Name | Turns | Kv |
|---|---|---|---|
| M-AA4504R | Standard Winding | 4T | 9.0 rpm/V |
| M-AA4505R | Slow Winding | 5T | 7.2 rpm/V |

**Table 1: The two winding speed options.**

## *5.1 No-Load Speed Table*

The *unloaded* speed for each winding at different wheel diameters is summarized in Table 2. This is the no-load speed it will spin at with the wheel off the ground; actual cruising speeds will be 10-30% less than this depending on the vehicle loading. Please use Grin's online motor simulator tool to better understand the effect of vehicle type, hill grade, and rider weight on the fully loaded speed.

| Battery Voltage | Slow (5T) Wind | | Standard (4T) Wind | |
|---|---|---|---|---|
| | 20” | 26” | 20” | 26” |
| 36V | 24 kph | 31 kph | 30 kph | 39 kph |
| 48V | 32 kph | 42 kph | 40 kph | 53 kph |
| 52V | 35 kph | 42 kph | 43 kph | 56 kph |

**Table 2: This is how fast a given system will spin at full throttle with the wheel lifted off the ground and facing no resistance. The actual speed under any kind of load will always be less than this and is fully detailed on our Motor Simulator web app.**

In general the faster windings are used in smaller wheel diameters or lower voltage batteries, while the slower windings are better suited to larger rims or higher voltage packs. But there is no problem doing fast motors in big wheels or slow motor winds in small wheels if that provides the performance you want.

## *5.2 Winding Speed vs Torque*

Note that a faster motor winding does not mean a lower torque motor. However, it does mean that a higher phase current is required to achieve a given torque, and the current handling capability of the L1019 connector will become a bottleneck to high currents.

We recommend the slow motor winding if maximizing the peak motor torque output is a primary goal. Alternatively, cutting off and replacing the L1019 plug with a higher current connector will allow similarly high torques with the standard speed winding.

## *5.3 Short Term and Continuous Power*

The power output capability of an electric motor is highly variable and depends on both how fast the motor is spinning and how long it needs to run for. Table 3 summarizes the estimated output power the Fat All-Axle hub can sustain both continuously and over a 5 minute period when the maximum allowable core temperature is defined (somewhat arbitrarily) at 110C. This table assumes a 20C ambient air temperature and that the motor has a passing airflow consistent with being in a 20” diameter wheel.

| Wheel Speed | Continuous Power | | 5 Minute Power | |
|---|---|---|---|---|
| | Dry | w/Statorade | Dry | W/Statorade |
| 70 rpm | *250 W* | *600 W* | *600 W* | *660 W* |
| 100 rpm | *370 W* | *840 W* | *860 W* | *950 W* |
| 200 rpm | *840 W* | *1600 W* | *1700 W* | *1950 W* |
| 300 rpm | *1330 W* | *2500 W* | *2600 W* | *3000 W* |
| 400 rpm | *2200 W* | *3400 W* | *3500 W* | *4100 W* |

**Table 3: The motor power capability depends heavily on the motor speed. That's why it is better to characterize motors by their torque capability than their power output.**

As long as the control system is setup to measure the motor temperature and rollback power when it gets too hot, there is little harm in pushing high power levels through the motor.

Note that this table is based on the motor itself and does not include limitations that may come from the L1019 connector or the controller. The 5 minute power ratings involve phase currents that exceed 60-70 amps and will potentially melt the L10 plug, likely well before the motor itself becomes overheated.

## *5.4 Official Rated Power*

As both the designer and manufacturer of this motor, Grin has full discretion over the ill-defined concept of an official power rating, which can be any point on the previous table.

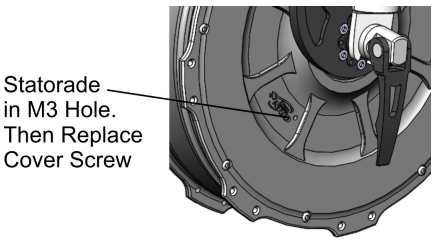
For the EU and Eurasia, we define the rated motor power as the maximum continuous output before thermal rollback in a worst case scenario of a slow 70 rpm (approx 10 kph) hill climb. As per Table 3, this is 250 watts.

For Canada, we define the rated motor power as the maximum continuous output in a more modest hill climb at 120 rpm wheel speed, which is 500 watts.

For the USA, we define the rated motor power as the general continuous power capability at 15 mph cycling speeds (~180 rpm), which is 750 watts.

# 6 Statorade Injection

As shown in Table 3, motor performance at high loads is increased significantly by the addition of 10 mL of Statorade ferrofluid which helps conduct heat from the stator core to the motor ring. If you routinely see core temperature exceeding 100°C, we highly recommend adding 10 mL of Statorade to extend the usable power window before thermal rollback.




Statorade is injected into the motor from a small M3 screw hole located on the right side plate. Add Statorade with a syringe tip with the hole on the bottom so that the fluid flows directly downwards and into the rotor magnets and avoids flowing over the motor bearings and torque sensor. Remember to put the screw back in to seal the hole.

**Figure 11: Statorade Fill Port.**

# 7 Service and Maintenance

Direct drive hub motors can be run for many years with no need for any scheduled maintenance. Frequent exposure to salty conditions can cause corrosion / pitting of aluminum metal over time, but this does not affect your motor's performance.

If the motor does need to be opened up for service (e.g. ball bearing replacement, torn cable repair), the motor must to be unlaced from the rim first. A gear puller is handy but not required. See Grin's disassembly video for further details.

# 8 Additional Points

## *8.1 Wheel Lacing*

The All-Axle motor uses 32 paired spoke holes, which results in the spokes having a tangential angle even in a 0 cross 'radial' lacing pattern. There is no need to cross the spokes with this hub.

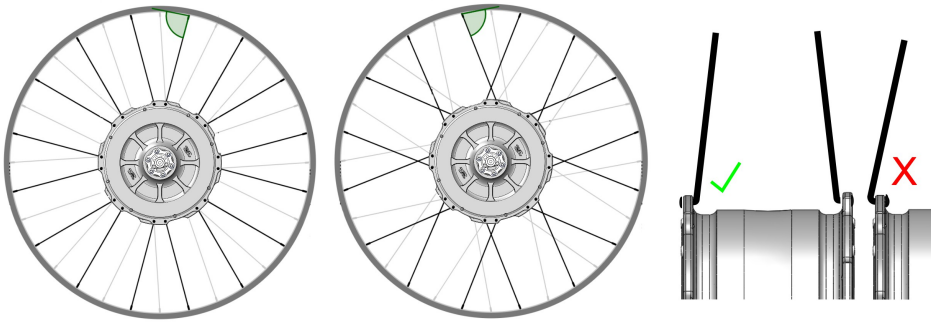



**Figure 12: 0 Cross (left) is recommended, but for 24" and larger 1 cross (middle) is OK too. Even if dishing optimization suggests otherwise, lace both left and right side spokes with elbows in.**

The side plates of the all-axle motor are counter-bored for the spokes to be laced with the elbows in, head out. This detail is important, as wheel builds with the spoke elbows out can put enough bending moment on the flange to cause the side plate to bow outwards, resulting in axle play.

## 8.2 Disc Caliper Clearance

Some hydraulic disc calipers are especially wide and may not fit between the rotor and the motor's side plate.

This is generally not an issue with these fat hubs as the disc spacers produce either a 20mm or 25mm gap that fits most hydraulic calipers on the market.

If the caliper just slightly scrapes the plate an additional 1mm shim will do the trick. Larger interference requires changing to a different caliper model.

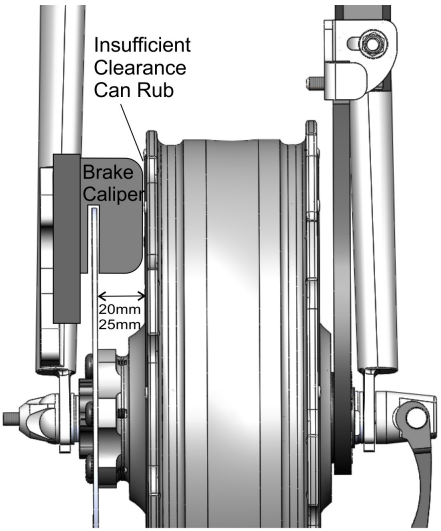



**Figure 13: Illustration of Caliper Clearance.**

## 8.3 Temperature Limits and Thermal Rollback

The temperature required to actually burn the enamel off the motor windings and cause permanent damage is very high, over 180°C, but allowing the motor to get close to this value is not recommended as the efficiency and performance plummet well before then. It is best to keep the motor core under 110-120°C, which provides significant headroom from actual damage and ensures that the outside shell of the motor is not uncomfortably hot.

In order to automatically scale back power as the motor heats up, the controller system must respond to the motor thermistor which is a 10K NTC with a 3450 Beta constant. The table below shows the expected thermistor resistance at different temperatures.

**Table 4: Thermistor Resistance Table.**

| Temperature | NTC Resistance | Voltage with 5K Pullup |
|---|---|---|
| **0 C** | 28.9 kOhm | 4.26 V |
| **25 C** | 10.0 kOhm | 3.33 V |
| **50 C** | 4.08 kOhm | 2.25V |
| **75 C** | 1.90 kOhm | 1.37 V |
| **100 C** | 1.13 kOhm | 0.82 V |
| **125 C** | 0.70 kOhm | 0.49 V |

## 8.4 Regenerative Braking

Direct drive motors can regeneratively brake extremely well and can produce the same braking force as acceleration force. Our integrated torque arm safely handles the alternating back and forth torque on the axle.

Regen can greatly reduce the wear rate of your mechanical brake pads and can take over 90% of braking duties. We highly recommend taking advantage of this feature and adding regen control to your system. The supported regen control options for Grin's three kit styles are summarized in the table below

**Table 5: Regen Brake Control Modes with Grin Kits.**

| Regen Mode | Barebones Kit | Superharness Kit | CA3 Kit |
|---|---|---|---|
| *Digital Brake Lever* | Supported | Supported | Supported |
| *Digital Lever +Throttle* | No | Supported | Supported |
| *Analog Lever* | No | Supported | No* |
| *Bidirectional Throttle* | No | Supported | No* |
| *Backwards Pedal* | No | No | Supported |
| *Speed limit* | No | No | Supported |
| *Assist Buttons* | No | No | Supported |

***Support anticipated in future firmware releases.**

Information on configuring the regen behavior is supplied with the motor controller and/or Cycle Analyst.

## 8.5 Anti-Theft Quick Release

Many anti-theft quick release skewers are available on the market requiring a special tool to remove the hub. For those concerned about motor security, we

recommend visiting your local bike store or searching online for anti-theft skewers compatible with your bike frame.

## 8.6 Single Side Mounting

The All-Axle motor is also unique in that it can be mounted to single sided spindles as commonly found in tadpole trikes, trailers, and quad bicycles. To support this application a special single side adapter is offered that acts as a torque arm on the disc side of the motor, so that the cable, disc rotor, and torque arm are all on the same side.

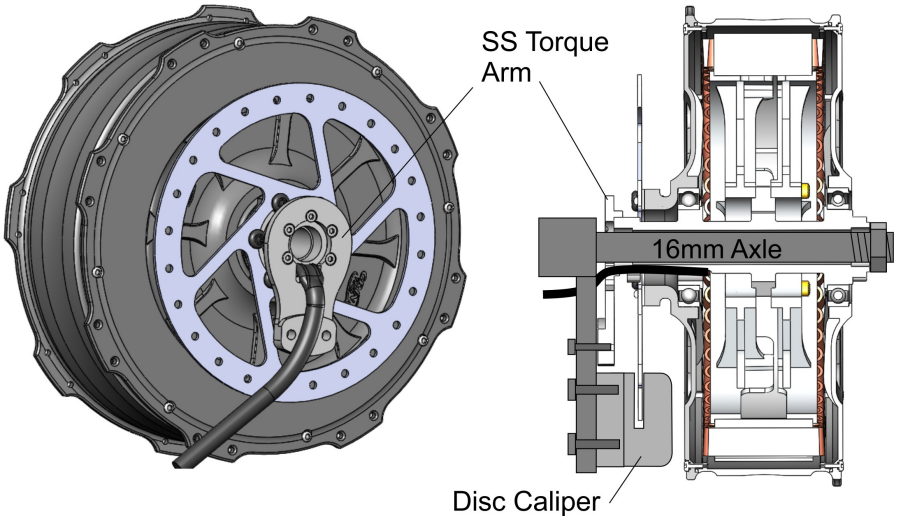
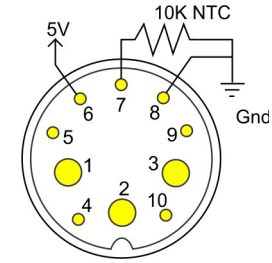



**Figure 14: Torque Arm for single side installations on same side as cable and disc rotor and must be secured to the frame. The surface plane of the torque arm is on the same plane as an ISO disc caliper mount. A strong 16mm chromoly steel axle is recommended.**

Details on single side installation are covered in a different installation manual.

# 9 Specifications

## 9.1 Electrical - Pinout




Male L1019 Cable

| | |
|---|---|
| 1 = Blue Phase ..... | **Blue** |
| 2 = Yellow Phase ..... | **Yellow** |
| 3 = Green Phase ..... | **Green** |
| 4 = Green Hall ..... | Green |
| 5 = Wheel Speed ..... | White |
| 6 = Hall Power (5-12V OK) ..... | Red |
| 7 = Thermistor (10K B3450) ..... | Grey |
| 8 = Hall Gnd ..... | Black |
| 9 = Yellow Hall ..... | Yellow |
| 10 = Blue Hall ..... | Blue |

## 9.2 Electrical - Motor

| **Winding** | **4T (Standard)** | **5T (Slow)** |
|---|---|---|
| **Grin SKU** | M-AA4504 | M-AA4505 |
| **Motor Kv** | 9 rpm/V | 7.2 rpm/V |
| **Motor Ki (Inverse of Kv)** | 0.79 Nm/A | 0.95 Nm/A |
| **Resistance (Phase to Phase)** | 102 mΩ | 155 mΩ |
| **Inductance (Phase to Phase)** | 240 uH | 330 uH |
| **Maximum Torque*** | 120 Nm for up to 1 minute | |
| **Continuous Torque to 110C**** | 40 Nm standard, 60 Nm with Statorade | |
| **Motor Hystersis Drag** | 1.0 – 1.2 Nm Typ. | |
| **Motor Eddie Current Drag** | 0.0008 Nm/rpm | |
| **Rated Power (EU/UK/Au/NZ)** | 250Watts (70 rpm, no statorade) | |
| **Rated Power (Canada)** | 500 Watts (120 rpm, no statorade) | |
| **Rated Power (USA)** | 750 Watts (180 rpm, no statorade) | |
| **Motor Hall Power** | 5V-12V DC | |
| **Hall Signal Level** | Open Collector, pull-up required on controller | |
| **Hall Timing** | 120 degree, 8 degree offset | |
| **Thermistor** | 10K NTC. 3450 Beta. Ground Referenced | |

*Maximum peak torque is typically limited by controller phase current.

**Continuous torque depends on passing air velocity and ambient temperature.

## 9.3 Mechanical

| | |
|---|---|
| **Spoke Flange Diameter** | 214 mm |
| **Spoke Flange Spacing** | 67 mm |
| **Spoke Size Compatibility** | 13g (2.0 mm) or 14g (1.8 mm) |
| **Spoke Holes** | 32, with 21 mm spacing between paired holes |
| **Dishing Offset** | 6 mm |
| **Motor Diameter** | 226 mm (flange), 212 mm (rotor) |
| **Motor Width** | 72.5mm |
| **Weight (motor only)** | 5.95 kg |
| **Cable Length** | 260 mm to end of connector |

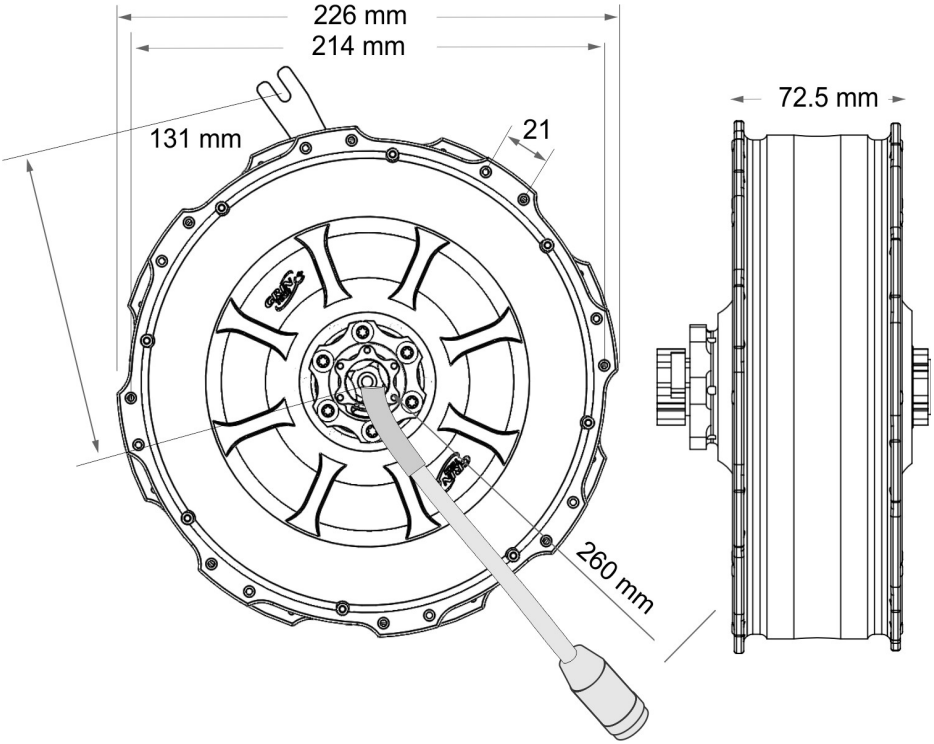



**Figure 15: Mechanical Drawing. Detailed drawings with various adapters are available in separate document.**