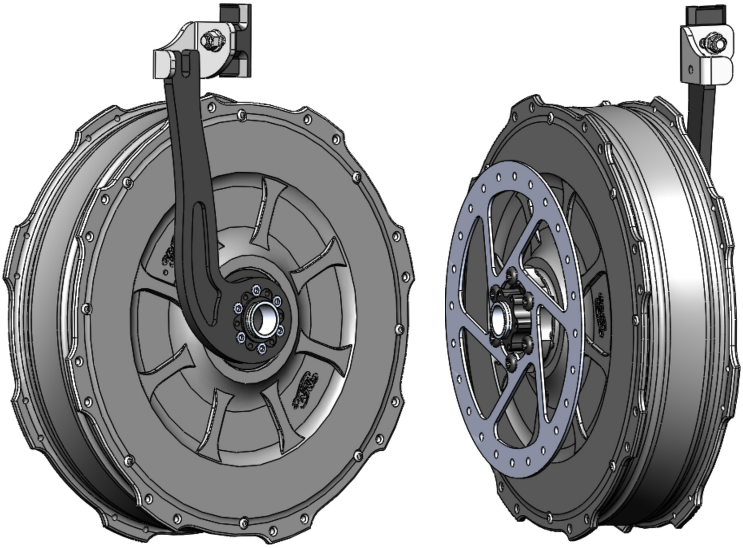
The Grin All-Axle Motor
Front V3 Model

Owner's Manual – *Rev 0*



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1 Introduction

Thank you for purchasing the universal V3 Front All-Axle hub motor from Grin Technologies. This efficient and robust direct drive hub motor can provide years of ebike joy on almost any bicycle platform.

Features of the Front All-Axle motor include:

- Light weight for its power class (4.05 kg vs typical 5.5-6 kg)
- Compatible with almost all thru-axle and quick release dropouts
- Integrated torque arm for secure installation
- Waterproof L1019 controller connector for hall and phase leads
- Embedded thermistor for motor temperature sensing
- Capable of over 80 Nm peak torque, and 30-40 Nm continuous
- Made in Vancouver, Canada

2 Components

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

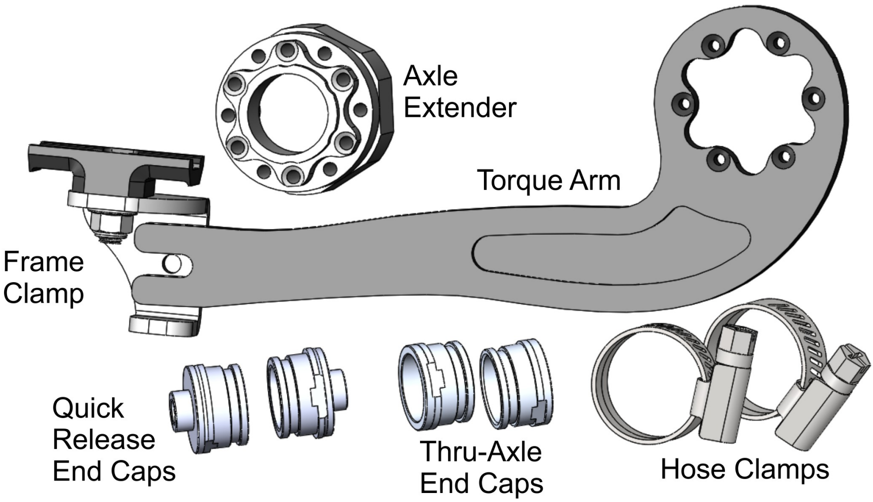


Figure 1: Depending on the adapter kit purchased with your motor, various end caps and spacers may be present to properly align the motor inside your fork.

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 thru-axle spindles.

2.2 Axle Extenders

The 135x9 and 150x15 fatbike adapter kits also include a 20 mm axle extender which increases the effective axle length on the left disc side of the hub.

2.3 Disc Spacers

We include an optional 1.5 mm disc spacer and end-cap spacer in case the particular caliper is too wide to fit between the gap and scrapes against the side plate. See section 8.2. These spacers should only be used if needed.

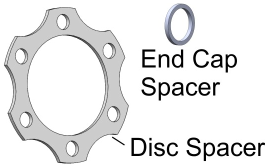


Figure 2: These spacers are optional and provide extra disc clearance.

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

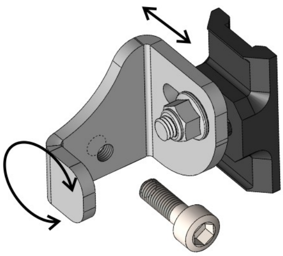


Figure 3: Frame clamp can both swivel and slide in and out, allowing correct alignment over a range of fork geometries.

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 various hardware adapters onto the hub.

3.1 Axle Extender (Fatbike adapters only)

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

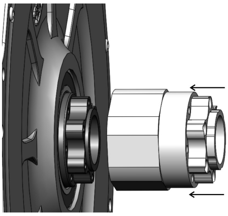


Figure 4: Axle Extender.

3.2 Torque Arm

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

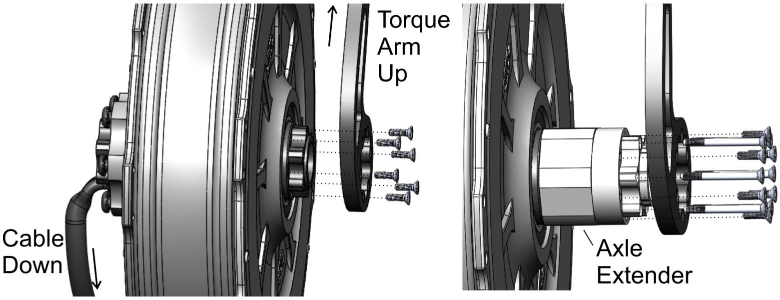


Figure 5: The torque arm screws should include a drop of threadlocker on the threads. Tighten with T10 Torx wrench (included) to 1 Nm.

Secure the torque arm to the motor axle with the six supplied M3x10mm screws. These screws do not transmit torque, rather they simply hold the torque arm in position. In the fatbike adapter kits, the axle extender is held tight with six M3x35mm screws, while six M3x40 screws hold the torque arm in place.

3.3 Disc and Disc Spacer

If the bike uses disc brakes, install the disc rotor to the disc side plate using the six M6x10 torx screws. With the fatbike adapter kits for 135mm and 150mm forks, the disc attaches to a disc spacer first.

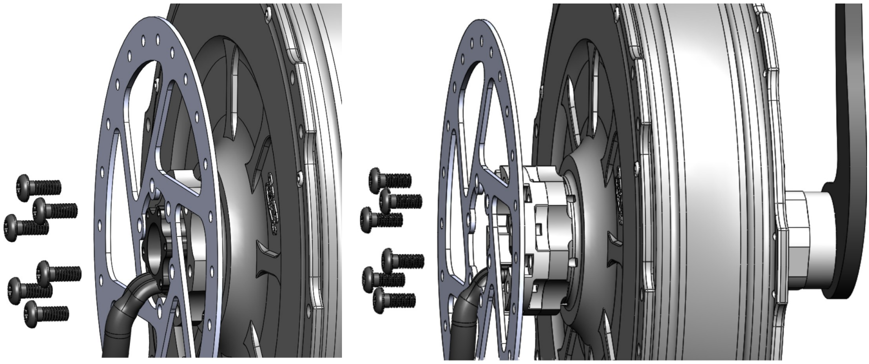


Figure 6: Mounting the Disc Rotor, Standard (left) and Fatbike (right). A narrow 1.5 mm spacer may be used under disc rotor for larger caliper clearance. See Section 8.2 Disc Caliper Clearance.

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.

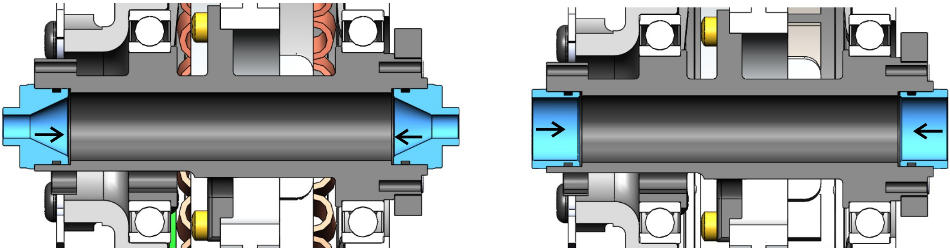


Figure 7: Example of quick release (left) and thru-axle (right) end caps, slid into place. In most adapter kits the left and right caps are identical.

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.

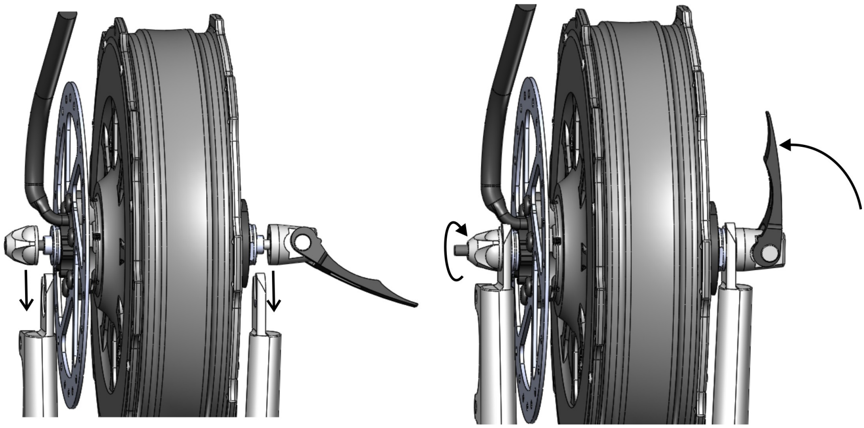


Figure 8: Install hub with torque arm behind fork blade. Ensure that cable exits down and out of dropout slot without getting pinched.

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.

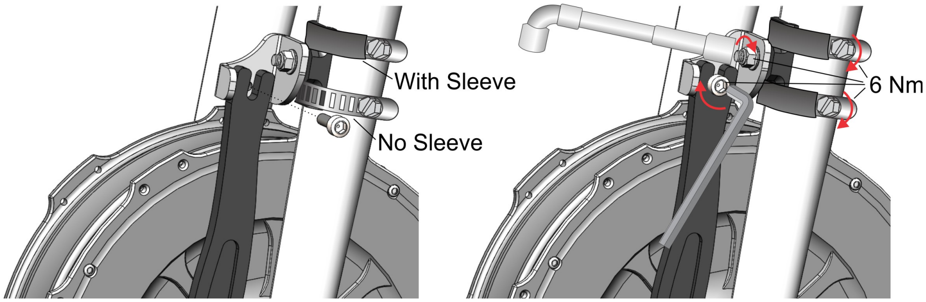


Figure 9: Frame Clamp installed to fork. Once aligned, all fasteners should be tightened to 6 Nm. Rubber sleeve can be cut to size and slipped over hose clamps.

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.

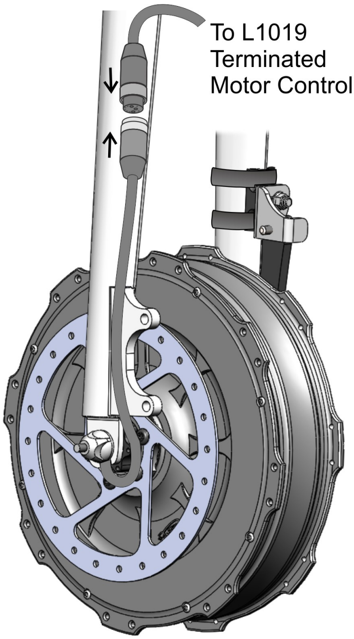


Figure 10: Cable will usually be held snug to fork with zip ties.

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.

5 Power and Speed

The Front All-Axle motor is available in 3 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-AA2705R	Fast Winding	5T	12 rpm/V
M-AA2706R	Standard Winding	6T	10 rpm/V
M-AA2708R	Slow Winding	8T	7.5 rpm/V

Table 1: The three winding speed options. Note that most ebike hub motors spin at 7-8 rpm/V, so the "Slow Winding" is not actually that slow.

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 typically 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 (8T) Wind		Standard (6T) Wind		Fast (5T) Wind	
	20”	26”	20”	26”	20”	26”
36V	26 kph	34 kph	34 kph	45 kph	41 kph	54 kph
48V	34 kph	45 kph	46 kph	60 kph	55 kph	72 kph
52V	37 kph	49 kph	50 kph	65 kph	60 kph	78 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 nothing stopping you from 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. That is a very common misconception. All 3 motor windings are capable of producing the same torque and power, but a faster wind motor needs more phase amperage to reach that torque. It is only when your *motor controller* is limiting the phase current that you will see more torque from the slower motor wind.

5.3 Short Term and Continuous Power

The power output capability of an electric motor depends on both how fast the motor is spinning and how long it needs to run for. Table 3 summarizes the output power the All-Axle hub can sustain both continuously and over a 5 minute period when the maximum allowable core temperature is defined (somewhat arbitrarily) at 110°C. This table assumes a 20°C ambient air temperature and that the motor has a passing airflow consistent with being in a 26” diameter wheel.

Wheel Speed	Continuous Power		5 Minute Power	
	Dry	w/Statorade	Dry	W/Statorade
100 rpm	*250 W*	*340 W*	*500 W*	*575 W*
200 rpm	*560 W*	*785 W*	*1040 W*	*1235 W*
300 rpm	*900 W*	*1275 W*	*1590 W*	*1830 W*
400 rpm	*1250 W*	*1840 W*	*2110 W*	*2420 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 watts through the motor.

Be aware that the L1019 connector can also become a bottleneck, especially with fast motor windings. While it can handle 80-90 A for short times, the plug risks melting if it is used for long periods above 55 amps.

5.4 Official Rated Power

As both the designer and manufacturer of this motor, Grin has full discretion over its official power rating. 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 100 rpm 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 just under 200 rpm wheel speed. As per Table 3, that is 500 watts.

For the USA, we define the rated motor power as the general continuous power capability at 20 mph cycling speeds (~250 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 8 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 8 mL of Statorade to extend the usable power window before thermal rollback.

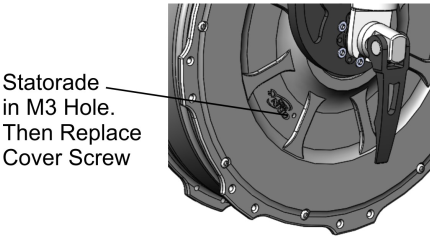


Figure 11: Statorade Fill Port.

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.

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.

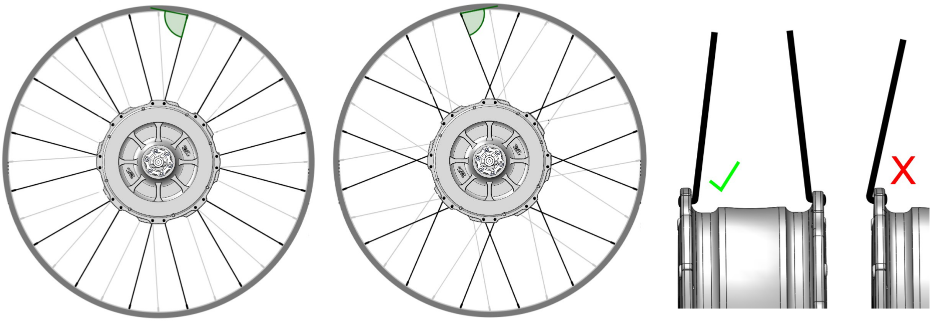


Figure 12: 0 Cross (left) is recommended, but for 24" and larger 1 cross (middle) is OK too. Even if dishing optimization suggests otherwise, lace both left and right side spokes with elbows in.

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. The exact amount of clearance available depends on the disc spacer used with the adapter set as shown in Table 4.

In cases where 18mm of caliper clearance doesn't quite fit your calipers, we also include a 1.5mm disc rotor spacer and a 1.5mm end cap spacer that can be installed on the left side of the motor to increase the clearance to 19.5mm. See Figure 2. This also increases the effective axle length from 100mm to 101.5mm, but that is usually not a problem.

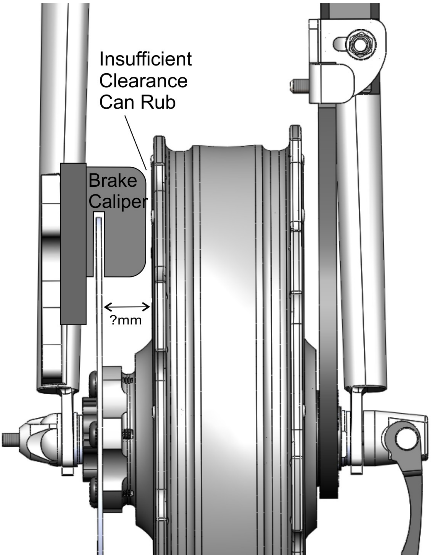


Figure 13: Illustration of Caliper Clearance.

Adapter Kit	Axle Extender	Disc Spacer Used	Max Caliper Width
100x9 QR	None	None / 1.5 mm	18 mm / 19.5 mm
100x12 TA	None	None / 1.5 mm	18 mm / 19.5 mm
100x15 TA	None	None / 1.5 mm	18 mm / 19.5 mm
110x15 TA	None	5 mm	22 mm
135x9 QR	20 mm	13 mm	>25 mm
150x15 TA	20 mm	9 mm	>25 mm

Table 4: Disc Spacer and Clearance Details for Each Adapter Kit.

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 5: 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 6: 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 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.

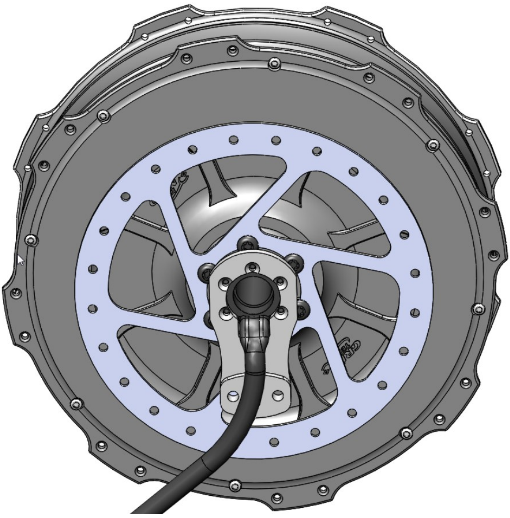
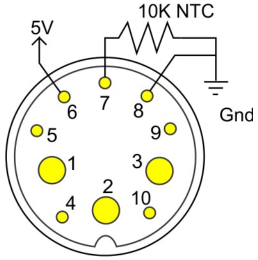


Figure 14: Torque Arm for single side installations on same side as cable and disc rotor.

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 (5-15V OK)	Red
7 = Thermistor (10K B3450)	Grey
8 = Hall Gnd	Black
9 = Yellow Hall	Yellow
10 = Blue Hall	Blue

9.2 Electrical - Motor

Winding	**5T (Fst)**	**6T (Std)**	**8T (Slw)**
Grin SKU	M-AA2705	M-AA2706	M-AA2708
Motor Kv	12 rpm/V	10 rpm/V	7.5 rpm/V
Motor Ki (Inverse of Kv)	0.79 Nm/A	0.95 Nm/A	1.28 Nm/A
Resistance (Phase to Phase)	268 mΩ	145 mΩ	100 mΩ
Inductance (Phase to Phase)	680 uH	380 uH	260 uH
Maximum Torque*	80 Nm for up to 1 minute		
Continuous Torque to 110C**	30 Nm standard, 40 Nm with Statorade		
Motor Hystersis Drag	0.6 – 0.7 Nm Typ.		
Motor Eddie Current Drag	0.0005 Nm/rpm		
Rated Power (EU/UK/Au/NZ)	250 Watts (100 rpm, no statorade)		
Rated Power (Canada)	500 Watts (190 rpm , no statorade)		
Rated Power (USA)	740 Watts (250 rpm, with statorade)		
Motor Hall Power	5 V-12 V 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	53 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	54.5mm
Weight (motor only)	4.05 kg
Cable Length	260 mm to end of connector

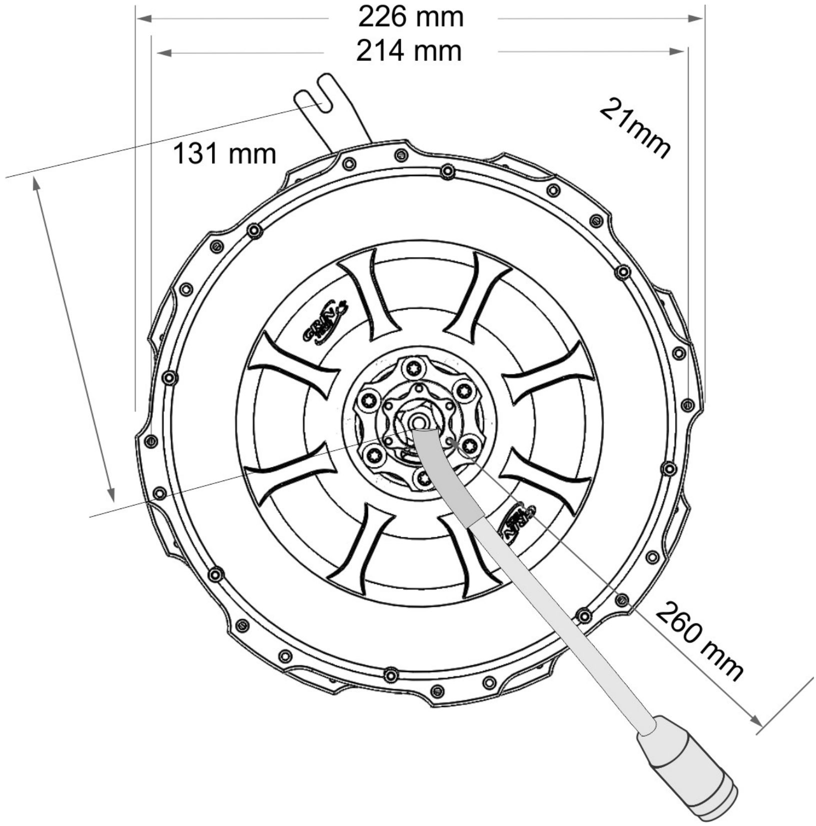


Figure 15: Mechanical Drawing