The Baserunner V6
Motor Controller

User Manual – *Rev0*

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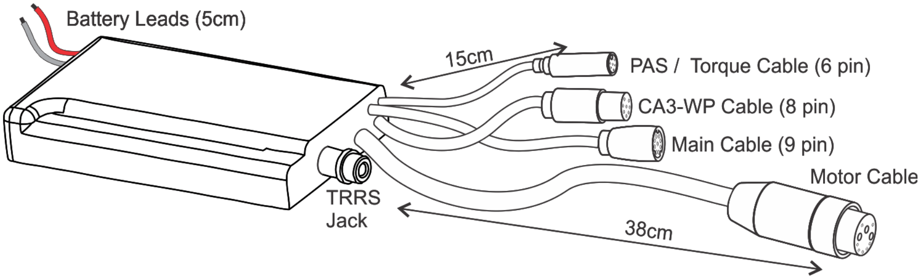
1 Introduction

Thank you for purchasing the Baserunner V6 motor controller based on Accelerated Systems Inc. (ASI)'s BAC555 / BAC355 devices.



This manual covers two production models: the Baserunner V6_L10 and the Baserunner V6_Z9. The L10 model is intended for larger motors that use the L1019 connector, while the Z9 model is for smaller motors using the common but lower current Higo Z910 (or equivalent) 9 pin motor plug.

Features of the Baserunner V6 include:

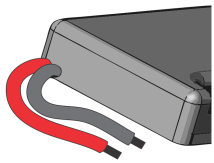
- Shallow form factor can fit in select battery cradles
- User programmable parameters for customized tuning
- 20V - 60V operating range (24V – 52V nominal batteries)
- Compatible with both Cycle Analyst and certain 3rd party displays
- Supports throttle, PAS and torque sensor control
- Waterproof design with potted electronics
- Proportional and powerful regenerative braking
- Smooth and quiet field-oriented drive
- Supports thermal rollback in thermistor-equipped motors
- Field weakening to boost top speed
- Operates both sensored or sensorless, even at high eRPM's

Unlike standard trapezoidal or sine wave controllers, the Baserunner V6 is a field oriented controller that must be tuned to your motor for proper operation. This process is detailed in Section 6.2.

2 Connectors

The controller has been connectorized to achieve maximum versatility with minimal wiring, using a combination of waterproof over-molded ebike plugs for signals and popular compact connectors for high current.

2.1 Battery Power



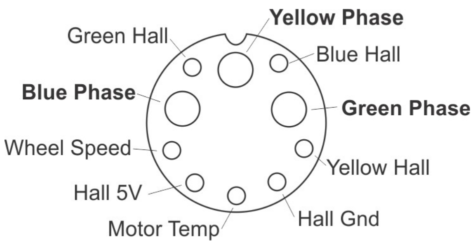
DC Power Pinout

The short 5cm leads for the battery pack emerge on the back end of the controller. When supplied with a downtube battery these leads will be soldered to the mating cradle connectors, while they may be unterminated or fitted with Anderson Powerpoles when purchased alone.

- Warning – The controller may suffer irreparable damage if leads are hooked up in reverse polarity. Always check the polarity of the connector before applying power.

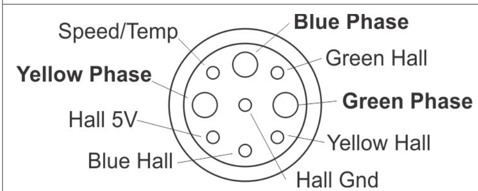
2.2 Motor Cable

The motor connection has 38cm lead to either a HiGo L1019 connector or a Z910 connector depending on the model. This length is sufficient to reach a rear hub motor on most bikes with the controller mounted on the downtube or seat-tube. Front hub installations are supplied with a 60cm motor extension cable.



Baserunner_L10 Motor Plug Pinout

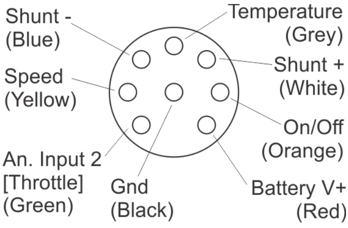
The Higo L1019 cable has three motor phase pins capable of 80 amps peak / 45A continuous, along with 7 small signal wires for hall position, speed encoder, and motor temperature.



Baserunner_Z9 Motor Plug Pinout

The Z910 cable has three motor phase pins capable of 55 A peak / 30A continuous, along with 6 signal wires. The one additional wire can be either motor speed, motor temperature, or combined speed and temperature.

2.3 Cycle Analyst WP8 Plug



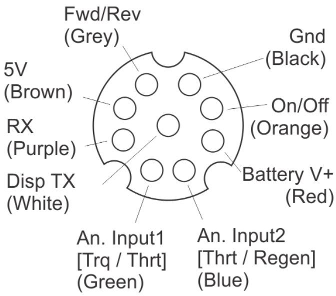
CA3 WP8 (Female) Pinout

The connector for the Cycle Analyst cable uses the waterproof 8-pin Z812 Higo standard.

This connector taps into the controller's shunt resistor for analog current and power sensing, passing through the motor's speed and temperature signals as well.

Cable Length = 15 cm

2.4 Main9 Signal Plug



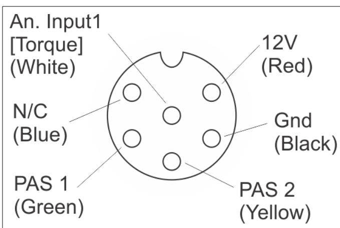
Main9 (Female) Pinout

An alternate interface is provided via the 9 pin Mains cable. This uses the Signal D 1109 Connector from Cusmade, and supports conventional ebike wiring strategies for 3rd party display consoles.

It shares several signals with the WP8 plug, but rather than using the shunt resistor for current sensing, it has TX and RX pins that communicate digitally to the display.

Cable Length = 15cm

2.5 PAS / Torque Plug



6 Pin (Female) PAS Pinout

Finally there is a 6 pin HiGo MiniB Z609 plug for connection of a PAS sensor or Torque Sensor.

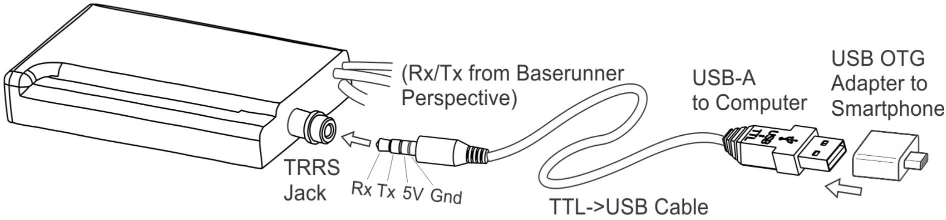
Note that the **PAS 2** pin shares the same signal as the **Fwd/Rev** input of the Main9 cable, and can be configured for either function. (See section 8.2)

Similarly, the Torque (white) lines is the same as the green wire on the 9pin cable.

Cable Length = 15 cm

2.6 Communication Port

A TRRS jack embedded in the controller can be used for connecting to a computer, Android smart phone, or potential Bluetooth dongle (future product).



The communication standard uses a 0 to 5V level serial bus. Grin produces a 3m long TTL->USB adapter cable to connect the unit with the USB port of a standard computer. This is the same communication cable used with the *Cycle Analyst* and *Satiator* products. Third party USB->Serial cables, such as FTDI's part number TTL-232R-5V-AJ are also compatible.

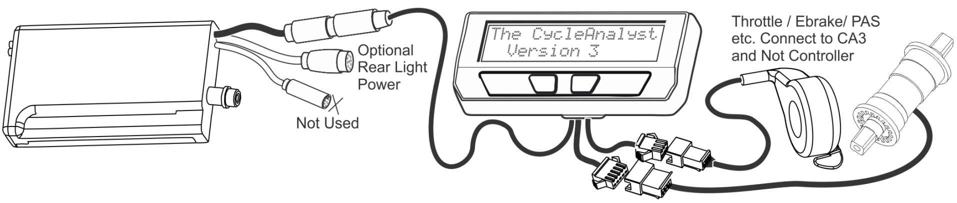
An additional USB-OTG adapter is needed when connecting to an Android smartphone via the phone's smaller Micro USB or USB-C port.

3 Wiring Strategies

The Baserunner V6 has three supported hookup modes. It can be connected under the full control of a V3 Cycle Analyst, under the control of a 3rd party display with a Superharness, or "headless" with no display at all.

3.1 Cycle Analyst Based Hookup

A setup using the latest V3 Cycle Analyst (CA3-WP) provides the most versatility with mode presets, customizable PAS behavior, advanced regen features, and easy performance adjustments on the road.



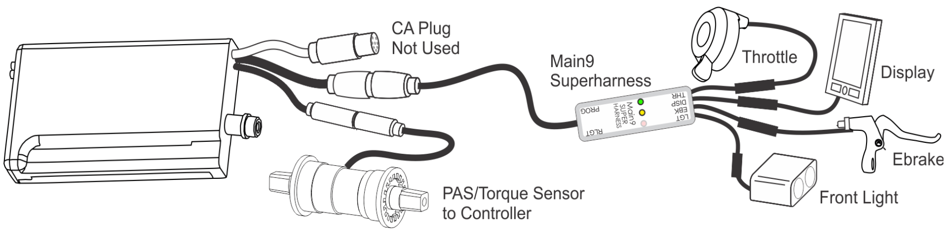
In this arrangement the Baserunner controller acts as a slave device. All throttle, ebrake, and PAS or torque sensors are plugged in directly to the Cycle Analyst.

The Cycle Analyst is responsible for determining the desired ebike behavior and sending a suitable throttle signal to the controller. It is an independent device that *does not communicate* with the controller in any way, it only sends a bidirectional throttle / regen voltage signal.

The 6 pin PAS plug of the controller is typically not used in this arrangement except as a possible Fwd/Rev input source. The 9 pin Mains cable either can be left unterminated, or it can be used as a power tap for running rear lights, using a 9 to 2 pin power adapter cable.

3.2 3rd Party Display Hookup with Superharness

The Baserunner V6 can be used with certain third party displays (from King Meter, Star-Union, APT etc.) that communicate using the KM5s and other supported digital protocols. This is achieved with a Main9 cable harness which splits out the signals into separate plugs for throttle, display, ebrakes, and front light.

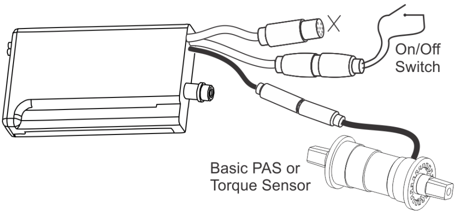


If an (optional) PAS or Torque sensor is used, this is hooked up to the 6 pin PAS plug of the motor controller itself. The Cycle Analyst plug is not used.

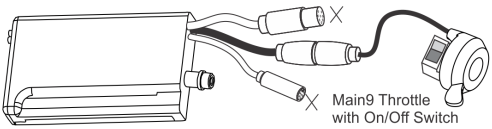
The display has the on/off power control and up/down settings to set the assist level, but otherwise plays a passive role in the actual system behavior. Grin's Superharness solution for the Main9 cable provides further functionality to allow the swapping of digitial ebrakes, analog ebrakes, dual throttles, or bidirectional throttles without changing any controller configuration.

3.3 Headless System

Finally, the Baserunner V6 can be run with only a throttle on the Main9 plug, or a PAS / Torque sensor plugged into the 6 pin PAS plug. In these arrangements, it is essential to wire up the on/off power switch on either the WP8 plug or the Main9 connector for the controller to turn on, as outlined in Section 8.1. Grin supplies an “All-in-one” throttle device that has a built-in voltmeter and on/off switch for use convenient use in such Barebone systems.



Headless PAS System
(Not Recommended)



Headless Throttle System

This minimal approach with a PAS sensor does not provide for any means to adjust the assist level outside of reprogramming the controller. For that reason it has limited usefulness and is not recommended. A display unit with up/down buttons is required to vary the amount of assist while riding.

3.4 Network Control - Advanced

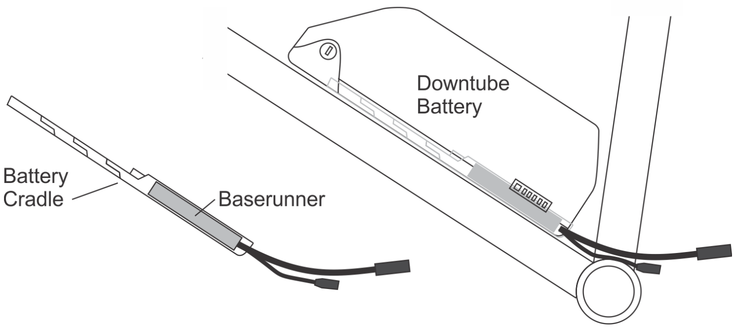
There is a 4th option, which is to control the Baserunner V6 entirely by digital commands over the Modbus network through either of the two serial ports (TRRS jack or Tx + Rx on Main9). This option is available to technical users with existing firmware and software expertise. Grin can provide the basic protocol documentation on request, but provides no hand-holding or support beyond that.

4 Controller Mounting

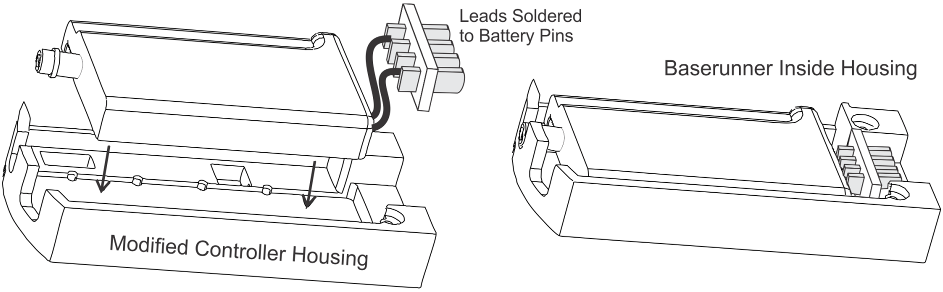
The Baserunner V6 controllers can be installed either by mounting inside a downtube battery cradle or externally on the bike.

4.1 Battery Cradle Mount

The Baserunner's low profile allows it to just fit inside a modified controller housings of both Reention and Hailong downtube battery casings.

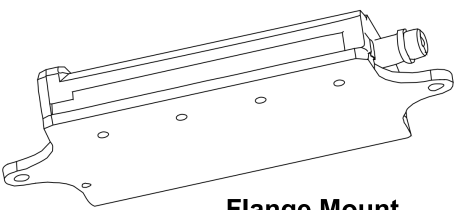


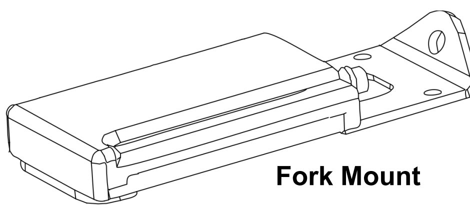
Note that the stock controller housings have to be milled out with a larger internal pocket for the Baserunner to fit, they will not work in a standard housing. Grin supplies these modified controller housings.



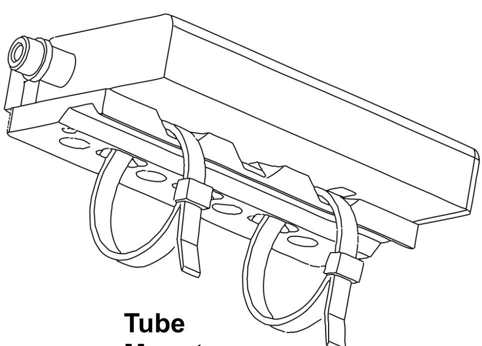
4.2 External Mount

For use in other applications, Grin also produces mounts to secure the Baserunner to a flanged plate, a round tube, and the fender bolt of a Brompton bicycle fork.





For optimal performance, the controller should be installed such that the metal mounting plate is exposed to airflow to keep the controller cool, and not tucked inside a bag or insulating box. This will noticeably improve the maximum power at thermal rollback compared to a controller that is in still air.



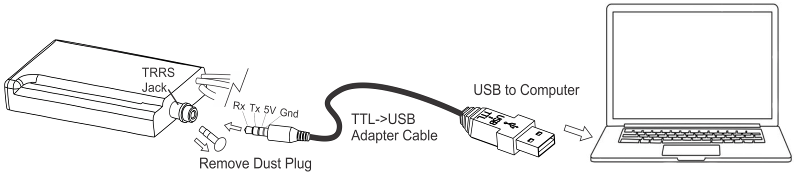
5 Phaserunner Software Suite

The Baserunner V6 is already preconfigured if it is purchased as part of a conversion kit from Grin, no tuning of the parameters should be necessary and this section can be skipped.

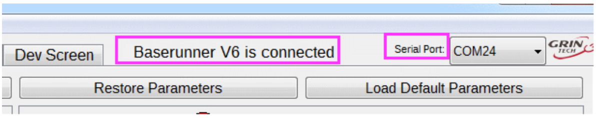
Otherwise, programming requires a computer, a TTL-USB programming cable, and the **V2.0 or later** *Phaserunner Software Suite*. The V1.7 and earlier software releases will give an “unrecognized device” error message.

This software is available for Linux, Windows, MacOS and Android (beta) from our webpage:

http://www.ebikes.ca/product-info/phaserunner.html



With the Baserunner V6 powered on, plug in the TTL->USB cable from your computer to the device. There may be a dust plug on the TRRS port that must be pulled out first. After launching the *Phaserunner Suite* software, select the COM port associated with the USB cable and you should see “*Baserunner V6 is connected*” on the top.



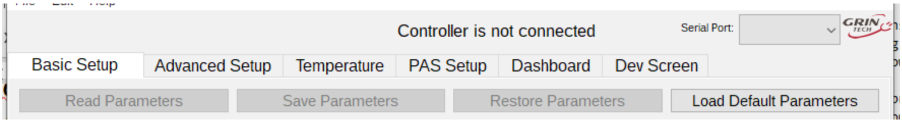
If you see “*Controller is not connected*,” check that the selected serial port is correct and that the USB->TTL device shows up in your device manager as a COM port (Windows), ttyUSB (Linux), or cu.usbserial (MacOS).

If your system does not recognize the USB serial adapter, or has frequent COM timeouts, then you may need to download and install the latest virtual COM port drivers directly from FTDI: http://www.ftdichip.com/Drivers/VCP.htm

During the setup process we recommend having the controller powered by a battery pack and not a general power supply, as electrical noise from power supplies can interfere with stable communication.

5.1 Software Suite Interface

The software suite is divided into 6 separate tabs for different functions:



Basic Setup - This tab allows you to configure the motor parameters, power, speed, and current limits, torque ramping, and other commonly adjusted behaviors. It also shows any active controller faults or warnings.

Advanced Setup - This tab has values that require deeper system familiarity to modify, such as throttle mapping, fault voltages, and sensorless start behavior.

Temperature - The temperature tab is for configuring thermal rollback for motors that have an internal temperature sensor hooked up to the controller. Generally this internal rollback is only used on systems without a Cycle Analyst.

PAS Setup - The pedal sensor tab is only present if the controller has pedal sensing activated, ie. it does not show up in Cycle Analyst systems. This is where Cadence or Torque sensor parameters are configured, along with the behavior for each assist level.

Dashboard - The dashboard presents a real-time view of all the what's going on, including battery voltage, amps, pedal torque, vehicle speed, motor RPM, assist level etc. The exact list of items shown will automatically change based on the controller configuration.

Any of the values displayed can also be selected for plotting on a graph and later saved for analysis and diagnostics purposes.

Dev Screen - The Dev Screen provides a behind the scenes look at all communication between the software suite and the actual motor controller. It shows a list of all currently unsaved parameters, it allows you to read or write individual parameters by address, and also update the controller firmware.

6 Setting Up Default Parameters

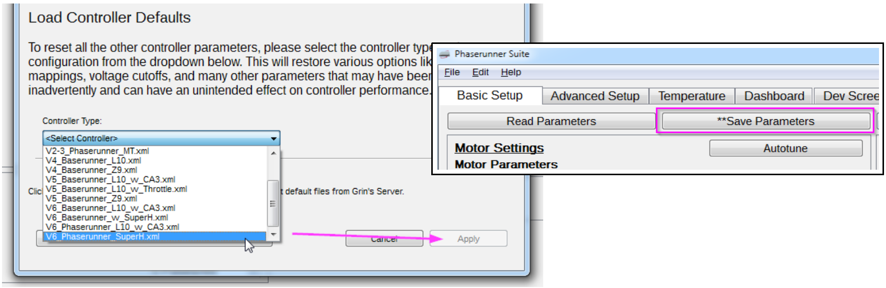
Basic Setup tab

If the Baserunner V6 was purchased independent of a kit or is being moved from one ebike system to another, you will need to change it's configuration. With hardware supplied by Grin, this can all be accomplished in a couple steps using preloaded defaults for the **Controller**, the **Motor**, and the (optional) **PAS sensor**, and then customizing the **Battery Limits** to your pack. .

6.1 Loading Controller Default Parameters

There are two sets of parameter defaults for the motor controller itself depending on whether it is being run with a V3 Cycle Analyst, or with a Superharness and 3rd party display. To load Grin's baseline factory controller settings, click on "Load Default Parameters" and then open the "Controller Type" dropdown list:

- Select ***V6_Baserunner_w_CA3*** for Cycle Analyst or Headless Systems
- Select ***V6_Baserunner_w_SuperH*** for 3rd party Display System

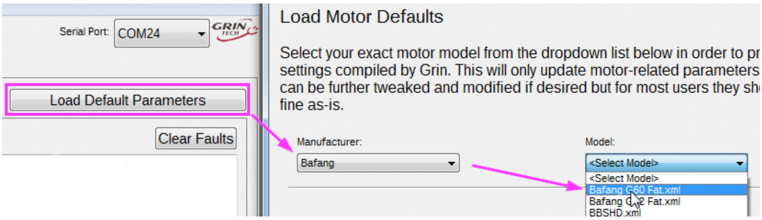


Click "Apply", followed by "Save Parameters". This restores all parameter settings except those related to the motor itself to Grin's factory default configuration.

6.2 Loading Default Motor Parameters

Unlike a generic trapezoidal or sinewave controller, a field-oriented motor controller needs to be tuned and configured to match the specific motor it is driving. Incorrect motor parameters can result in, noisy operation, reduced efficiency, or constant shutdown faults.

The *Phaserunner Software Suite* comes equipped with default motor settings for all the hubs supplied by Grin plus some other common motors. With your Baserunner V6 connected, click on "Load Default Parameters" and select the manufacturer and motor model number from the new window. Clicking on “Apply” will return you to the “Basic Setup” tab with all the motor’s parameter fields populated to their correct values.



Install these new settings to the Baserunner V6 via the “Save Parameters” button.

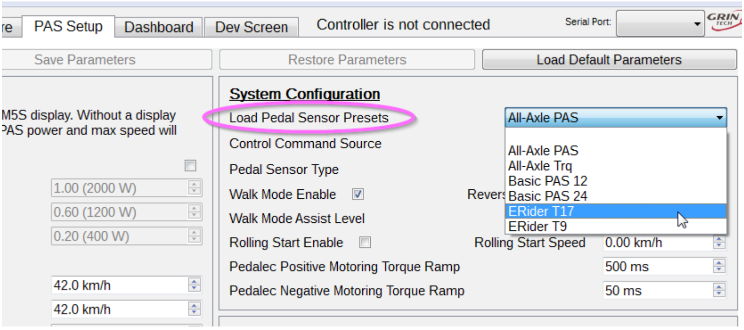
Apply some throttle and your motor should run smoothly. If it does not run as expected, or you are moving to a system with a motor model that does not have a premade default file, see section 7.1 Motor Autotune.

6.3 Pedal Sensor Defaults (Superharness Only)

PAS Setup tab

NOTE: *This section only applies to Superharness setups where a pedal sensor is plugged into the controller's 6 pin PAS plug. For a Cycle Analyst system, the pedal sensor behaviour is entirely managed by the CA3 and the Baserunner V6 is not involved.*

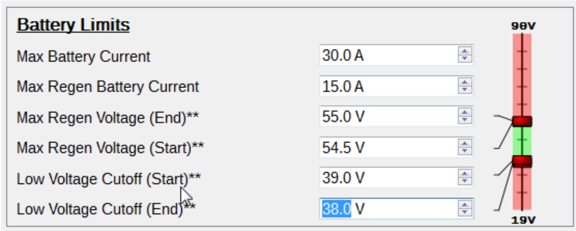
The PAS Setup tab allows you to manage the pedal sensor control parameters. With a pedal sensor from Grin, simply select the matching sensor from the preset dropdown menu and all relevant parameters will be updated along with default assist levels.



6.4 Battery Limits

Basic Setup tab

With motor and PAS sensor configured, you may also want to set the battery voltage and current settings to appropriate values for your particular pack.



6.4.1 Battery Current Limits

Set “Max Battery Current” to a value that is equal to or less than the battery’s discharge current rating. If unsure of this, a value of 2C or twice the amp-hour capacity is a reasonable guess. So a 12 amp-hour battery should support a 24 A max discharge, a 15 Ah battery should support a 30 A discharge etc. Higher battery currents will result in more power, but can also stress the battery cells, resulting in shorter battery life. Excessively high values can cause the BMS circuit to trip, abruptly shutting down the pack.

If you are setting up a system with regenerative braking and have a BMS circuit that shuts off if it detects excessive charge current, you will also need to further limit the “Maximum Regen Battery Current” to a value lower than the BMS trip current.

Otherwise it's not usually an issue with modern lithium cells to have short duration peak regen current levels of 2C, ie double the battery amp-hours. A high regen battery current limit is recommended to get full regen braking force at all speeds. Do not set the maximum regen current to the limit recommended for the charging port of the battery (eg. 5 amps) as that will result in a very underwhelming braking force at all but the slowest speeds.

6.4.2 Battery Voltage Limits

In addition to the battery current limits, the controller can further limit discharging when the pack is low or regen charging when it is fully charged.

We recommend setting “Max Regen Voltage (Start)” to the same value as the full charge voltage of your battery, with the “Max Regen Voltage (End)” to about 0.5V higher than that. This will ensure you can do regen even with a mostly charged battery.

The “Low Voltage Cutoff (Start)” and “Low Voltage Cutoff (End)” values can be set just above the BMS cutoff point of your battery. The table below shows typical values for regular lithium-ion cells.

Nominal Pack Voltage	24V (7s)	36V (10s)	48V (13s)	52V (14s)	72V (20s)
Low Voltage Cutoff	20.3 V	29.0 V	38.0 V	40.6 V	58.0 V
Max Regen Voltage	29.4 V	42.0 V	54.6 V	58.8 V	84.0 V

If you are using a V3 Cycle Analyst, we recommend leaving these values at the default 19.5/19.0 volts and use the CA3’s low voltage cutoff feature instead. That way you can change the cutoff voltage without a computer if you ever need to swap batteries.

7 Additional Parameter Editing

For most users, applying the default parameter covered in Section 6 will be sufficient for great ebike performance. If you have specific needs beyond this, then many other behaviours can be tweaked through the various tabs.

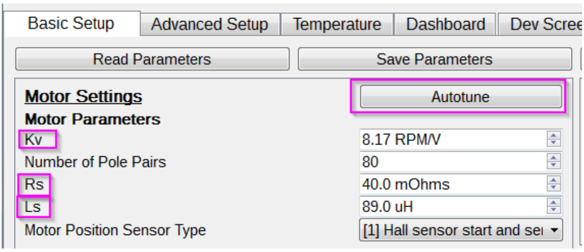
7.1 Motor Autotune

Basic Setup tab

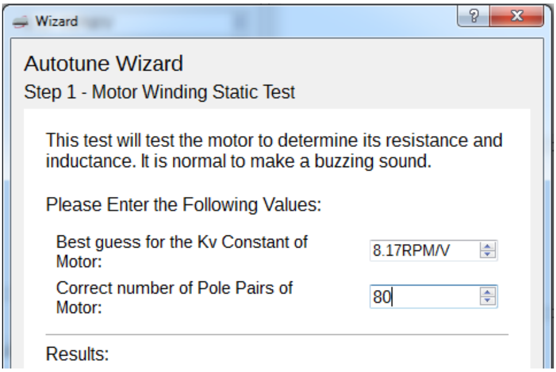
If the motor being driven is not available in our list of motor presets, then it will be necessary to configure the controller parameters manually.

Please Note: *When tuning your* Baserunner V6 *to a motor via the software suite, it is essential that your bike is propped up so that the powered wheel can rotate freely, both forwards and backwards. With a rear hub motor, also ensure that the cranks can rotate freely.*

The Autotune routine from the Basic Setup tab can automatically detect motor parameters like the motor speed constant (kV), resistance of one motor phase to neutral (Rs), and the inductance of motor phase to neutral (Ls).



The start of the Autotune process asks for your best guess of the motor's kV in rpm/V, as well as the number of pole pairs in the motor. The firmware uses these initial parameters for determining the test current frequency.



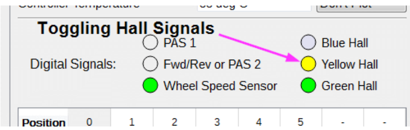
The Autotune routine will usually work fine even if your initial guess for the kV value is incorrect. Most ebike hub motors fall within 7-12 rpm/V and an initial guess of 10 will usually work.

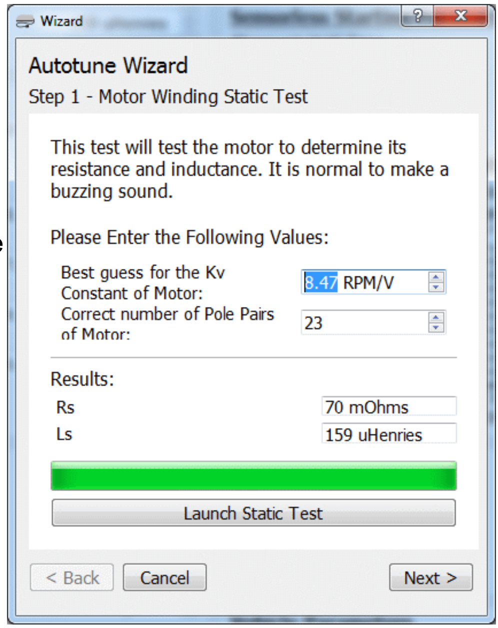
The effective pole pairs is a count of how many electrical cycles corresponds to one mechanical revolution of the wheel and must be set correctly. The Baserunner V6 needs this information to correlate it's electrical output frequency with the wheel speed. In a direct drive (DD) motor, it is the number of magnet pairs in the rotor, while in a geared motor you need to multiply the magnet pairs by its gear ratio. The following table lists the effective pole pairs for many common motor series.

Table 1: Effective Pole Pairs of Common DD and Geared Hub Motors

Motor Family	# Pole Pairs
Crystalyte 400, Wilderness Energy	8
Crystalyte 5300, 5400	12
TDCM IGH, TSM-A5	16
Crysatlyte NSM, SAW	20
Grin All Axle, Crysatlyte H, Nine Continent, MXUS and Other 205mm DD Motors	23
Magic Pie 3, FH/RH212	26
Bafang BPM, Bafang CST	40
Bafang G01, MXUS XF07	44
Bafang G02, G60, G62	50
Shengyi SX1/SX2	72
eZee, BMC, MAC, Puma, GMAC	80
Bafang G310, G311	88

For motors not listed, either open the motor to count the magnets pairs (and gear ratio), or count the number of Hall cycles that take place when you manually turn the wheel backwards one revolution. You can monitor the number of toggling Hall transitions via the “Dashboard” tab of the software suite.



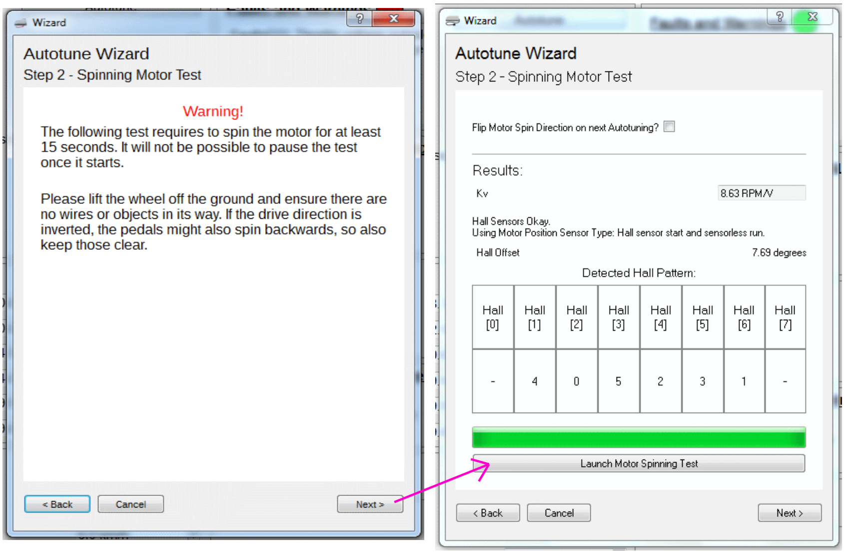


Once the “kV” and the “Number of Pole Pair” values are entered, launch the “Static Test.” This test will produce three short buzzing sounds, and determine the inductance and resistance of the motor windings. The resulting values will be shown on the screen.

Next, launch the “Spinning Motor Test” which will cause the motor to rotate at about half speed for 15 seconds. During this test, the controller will determine the actual kV winding constant for the hub, as well as the pinout and timing advance of the Hall sensors if they are present. If the motor spins backwards during this test, check the box “Flip Motor Spin Direction on Next Autotuning?” and relaunch the “Spinning Motor Test.”

During the spinning test, the Baserunner V6 will start the motor in sensorless mode. If the motor fails to spin and just starts and stutters a few times, first double check your starting values for effective pole pairs and KV. If they are indeed correct, you may need to adjust the sensorless starting parameters as described in section 7.3, “Tuning the Sensorless Self Start,” until the motor is spinning steadily. If the spinning test detects a valid Hall sequence, the final screen will show the hall timing offset and resulting hall table.

If the direction of rotation is backwards, select the “Flip Motor Spin Direction..” checkbox and run the spinning motor test again.



7.2 *Motor Phase Current and Power Settings*

Basic Setup tab

There are motor power and current limits distinct from the battery current limits (covered in 6.4 Battery Limits).

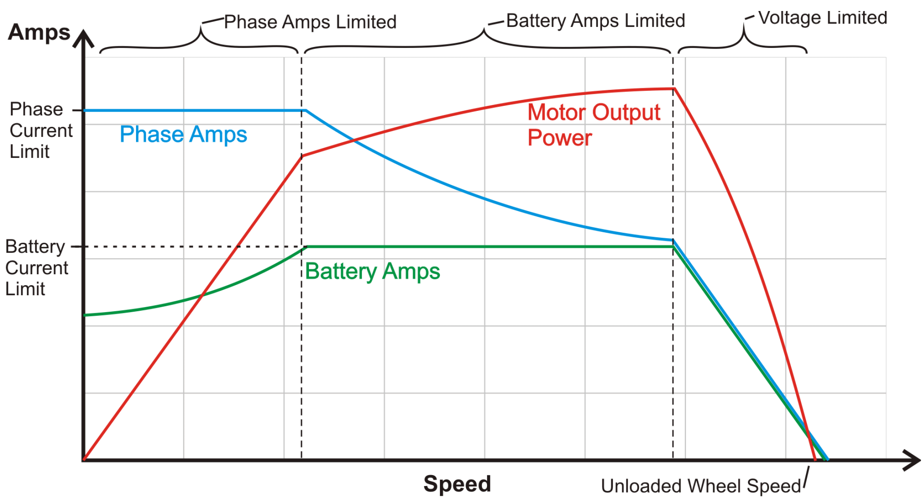
“Max Power Limit” puts an upper limit on the total watts that will be allowed to flow into the hub motor. This value has a similar effect to a battery current limit, but it is dependent on voltage. A value of 2000 Watts will limit battery current to 27 amps with a 72V pack, while allowing over 40 amps with a 48V pack.

In addition to regulating the current flowing in and out of the battery pack the Baserunner V6 can independently control the maximum *phase* currents that flow between the controller and motor. It is this motor phase current that both generates torque and causes the motor windings and motor connector to heat up. At low motor speeds this phase current can be many times higher than the current flowing in or out of the battery.

“Max Phase Current” determines the peak amps, and hence torque, put through the motor while accelerating at full throttle assuming no other limits are reached.

The "Max Regen Phase Current" value directly sets the peak braking torque of the motor at full regen. If you want a strong braking effect, then set this to the same value as the forward phase current limit. If the maximum braking force is too intense, then reduce its value.

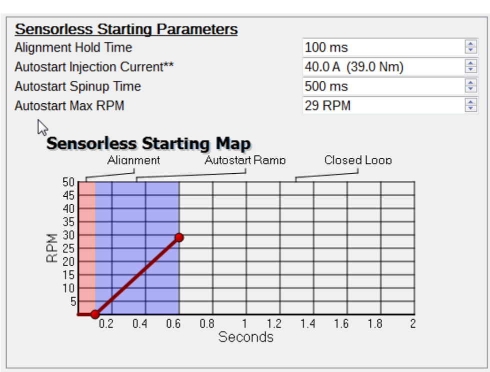
The following graph illustrates the interplay between motor phase current, battery current, and motor output power for a typical setup. When riding at full throttle, low speeds will be phase current limited, medium speeds will be battery current limited, and high speeds will be limited by the voltage of your battery pack.



7.3 Tuning the Sensorless Self Start

Advanced Setup tab

If you are running a motor without hall sensors in sensorless mode, then you may need to tweak the sensorless self start behaviour.



When a brushless motor is run sensorless and started from a complete stop, the motor controller attempts to ramp up the motor's rpm to a minimum speed so that it can latch onto the rotation (closed loop).

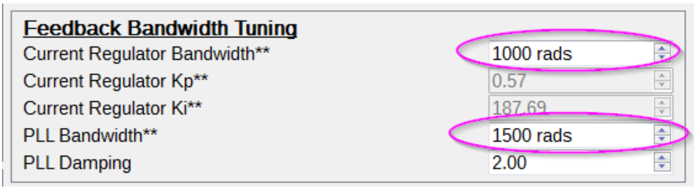
It does this by first injecting a static current into the phase windings to orient the motor into a known position.

The controller then rotates this field faster and faster until reaching the “Autostart Max RPM” value.

As initial values, set the “Autostart Injection Current” to 50-80% of your maximum phase current, an “Autostart Max RPM” between 5% to 10% of the running motor rpm, and an “Autostart Spinup Time” from 300 to 1500 milliseconds, depending on how easily the motor can propel the bike up to speed.

On bikes that you pedal to help get you underway, a short 200 to 300 millisecond ramp will often work best, while a much longer ramp is required if you need to start moving without pedaling.

If you feel the motor repeatedly trying to start when applying throttle, the “Autostart Spinup Time” may be too short, the “Autostart Injection Current” may be insufficient, or the “Autostart Max RPM” may be too low. You may also generate faults such as “Instantaneous Phase Overcurrent.” To correct this particular fault, try increasing the “Current Regulator Bandwidth” and/or adjust the “PLL Bandwidth”. These parameters are found under “Feedback Bandwidth Tuning” on the “Basic Setup” tab.



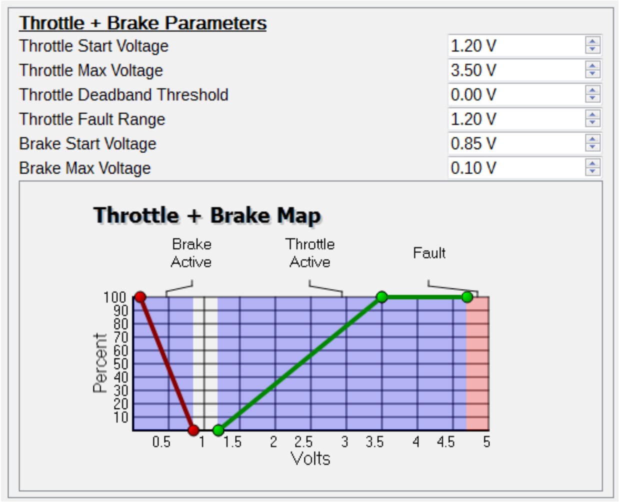
7.4 Throttle and Regen Voltage Maps

Advanced Setup tab

With most ebike controllers, the throttle signal controls the effective voltage and hence unloaded rpm of the motor. With a Baserunner V6, however, the throttle is directly controlling the motor torque.

If you pick the motor off the ground and give it just a tiny amount of throttle, it will still spin up to full rpm as there is no load on the motor. People sometimes mistake this behavior as an all-or-nothing throttle response. If you apply partial throttle *while riding*, you will get a proportional torque from the motor which will stay constant even as the vehicle speeds up or slows down. This is different from standard ebike controllers, where the throttle more directly controls motor speed.

By default, the Baserunner V6 is configured so that active throttle starts at 1.2V, and full throttle is reached at 3.5V, which is broadly compatible with Hall Effect ebike throttles. The same signal for the throttle is also used in our default configurations to control regenerative braking.



The regen voltage is mapped by so that regenerative braking starts at 0.8V and reaches maximum intensity at 0.10V. This way there is no overlap between the throttle region and the braking region and a single wire can control both ranges.

7.5 *Field Weakening for Speed Boost*

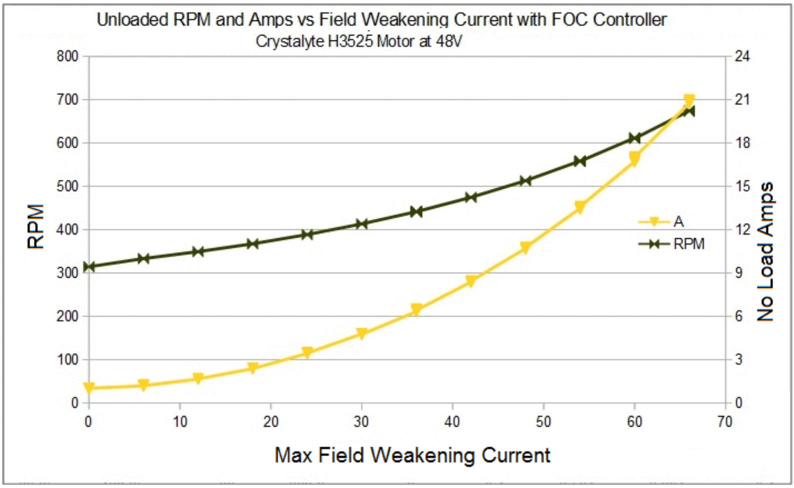
Basic Setup tab

The Baserunner V6 can boost the top speed of your motor beyond what is normally possible from your battery voltage. This is accomplished by injecting a field weakening current in advance of the torque producing current.

The amount of speed boost received for a given field weakening current will depend on the winding characteristics of your particular motor. A trial and error approach is recommended, increasing in small increments until the desired top speed is achieved.

Increasing a motor's top speed in this way is less efficient than using a higher voltage pack or a faster motor winding, but for a speed boost of 15% to 20%, the additional losses are quite reasonable.

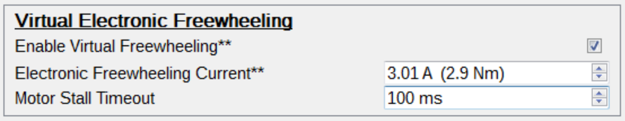
The following graph shows a large direct drive hub motor's rpm as a function of field weakening current. The upper black line is the motor's measured rpm, while the initially lower yellow line is the no-load current draw, reflecting the amount of extra power lost due to field weakening. We can see that at 20 amps of field weakening, the motor speed increases from 310 rpm to 380 rpm, while the no load current draw is still just under 3 amps.



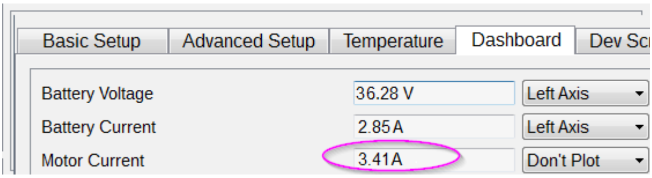
7.6 *Virtual Electronic Freewheeling*

Dashboard/Basic Setup tabs

The Baserunner V6 controller can be set to inject a small amount of current into the motor, even when the throttle is off. When properly tuned, this current injection can overcome the drag torque present in hub motors capable of regenerative braking, allowing them to spin freely when pedaling without any throttle.



To setup this feature, we recommend first going to the “Dashboard” tab. With the system running under throttle with no load on the motor, note the “Motor Current” value.



Navigate back to the “Basic Setup” tab, check “Enable Virtual Freewheeling,” and set “Electronic Freewheeling Current” to a value ~25% less than that of the observed unloaded motor current. The “Motor Stall Timeout” setting determines when this injection current will stop once the motor comes to a stop.

Once the values for “Virtual Electronic Freewheeling” are set, the controller will typically draw between 10 to 30 watts in order to overcome the motor’s drag even after the throttle is released. Regenerative braking will usually recapture more energy than is used by the injection current.

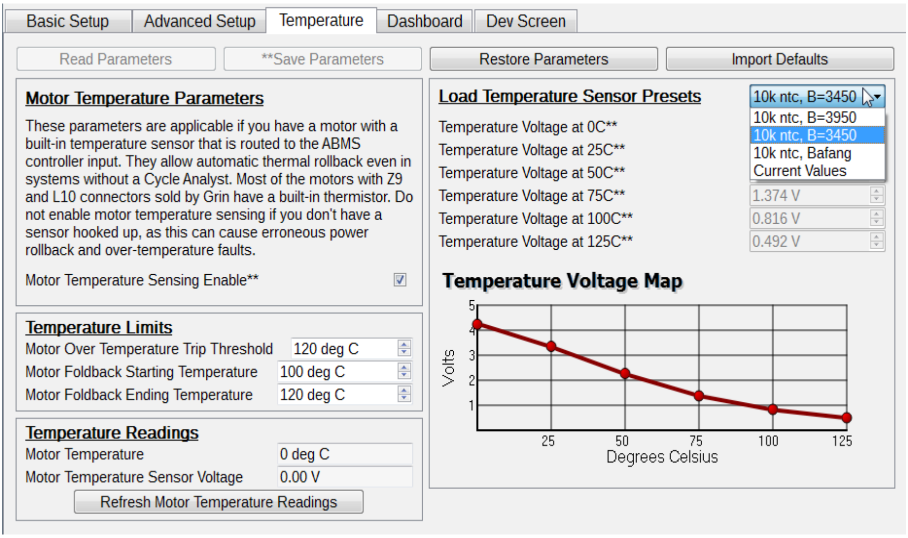
Users of mid-drive motors can also use this feature to keep the drive train always engaged, eliminating windup delay and harsh clutch engagement when throttle is applied and the motor comes up to speed.

Note that when the bicycle has come to a complete stop, the injection current will only return after the throttle has been applied and released.

7.7 Motor Temperature Sensing

Temperature tab

The Baserunner V6 has the ability to sense motor temperature and prevent the motor from overheating by automatically rolling back the max phase current. An entire tab in the software suite is dedicated to the motor thermal rollback settings. A six point table maps the voltage that corresponds to the temperatures of 0°, 25°, 50°, 75°, 100°, and 125°C. For convenience we have provided a drop-down selection of the three thermistor types commonly used on hub motors. These values can be input manually for compatibility with other temperature sensors.

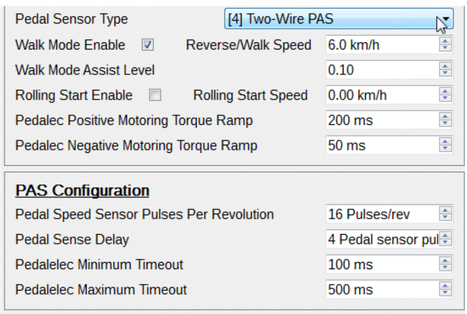


This feature allows for safe operation of motors in Barebones or Superharness kits without a V3 Cycle Analyst. If you have a Cycle Analyst we recommend using the CA3's thermal rollback features instead, and leaving the controller's "Motor Temperature Sensing Enable" rollback unchecked.

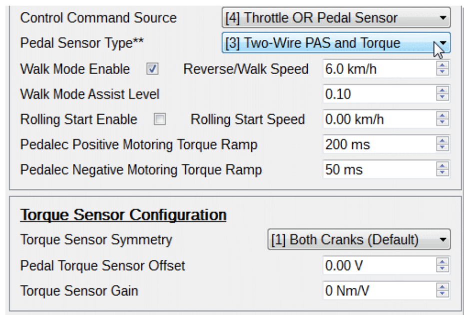
7.8 Pedal Sensor Parameters (Superharness)

PAS Setup tab

NOTE: *This section only applies to Superharness setups where a pedal sensor is plugged into the controller's 6 pin PAS plug. For a Cycle Analyst system, the pedal sensor behaviour is entirely managed by the CA3 and the Baserunner V6 is not involved.*



Config Options for PAS Sensor



Config Options for Torque Sensor

If you are using a torque or cadence sensor for which we don't have a preset, then these value will need to be input manually based on the signal levels of your particular sensor. Each parameter has a tooltip that will pop up when the mouse hovers over.

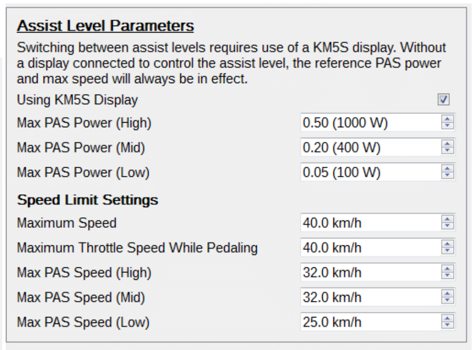
The pedal sense delay parameter controls how much crank rotation will trigger the PAS power to engage. If the value is too low with high pulse pedal sensors, then small bumps in the crank will cause the motor to engage. Set this high enough that the power only starts when you actively pedal, but low enough that it responds without too much delay.

If you have a torque sensor, you need to know both the offset voltage at rest as well as the sensitivity to pedal torque in Nm/V. The Symmetry type determines how the torque signal is averaged. "Both Cranks" will average over half a pedal rotation, while "Single Side" will average a full crank rotation and then double the value.

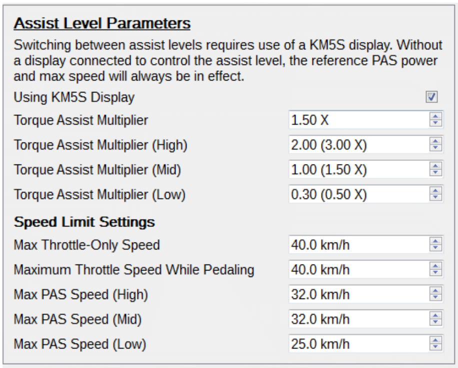
7.9 Setting Assist Levels (Superharness)

PAS Setup tab

The ASI firmware on your Baserunner V6 allows you to configure three unique power and speed limit setpoints to determine the behavior in a low, middle, and high power assist level.



Example Assist Levels in PAS Mode



Example Assist Levels in Torque Mode

The assist level multiplier scales several items:

- With a PAS sensor, the PAS power is scaled in addition to the maximum phase current. A setting of 0.5 for one mode means both that PAS power will be half the maximum power limit, and the maximum phase current will be half as well.
- With a Torque sensor, the primary control “Torque Assist Multiplier” determines how the measured pedal torque is scaled to motor output torque. A value as 1.5 as shown above means 10Nm on the pedals will result in 15 Nm from the motor.

  The assist multiplier scales this value, in addition to the maximum phase current. Values greater than 1 will provide higher assist ratios, but cannot increase the maximum phase current farther than the existing max.

7.9.1 Assist Speed Limits

In addition to the these three assist levels, you can also set three distinct speed limits for each of the three levels. These speed limits apply while pedaling under PAS control without the throttle active. Separate speed limits are used for throttling without pedaling, and throttling while pedaling.

7.9.2 Display Assist Levels

PAS Setup tab

While the Phaserunner supports 3 assist modes, most displays are set to have between 4,5, or even 9 assist levels, not just three. So these 3 reference points are further interpolated to provide up to 9 unique settings.

This detail can be confusing. The KM5s display protocol does not communicate an explicit assist level to the motor controller (ie low, middle, or high). Rather it transmits a 0-100% PWM value, and the controller is left to interpret this. ASI has chosen to interpret those values based on the following table:

Display Assist %	Power Limit	PAS Speed Lim	5 Level Disp.	9 Level Disp.
<25%	Assist Off	N/A	Off	Off
25-32%	**Low**	**Low**	Level 1	Level 1
33-41%	¾ Low ¼ Mid	¾ Low ¼ Mid		Level 2
42-49%	½ Low ½ Mid	½ Low ½ Mid	Level 2	Level 3
50-57%	¼ Low ¾ Mid	¼ Low ¾ Mid		Level 4
58-65%	**Med**	**Med**	Level 3	Level 5
66-74%	¾ Mid ¼ High	¾ Mid ¼ High		Level 6
75-82%	½ Mid ½ High	½ Mid ½ High	Level 4	Level 7
83-90%	¼ Mid ¾ High	¼ Mid ¾ High		Level 8
91-100%	**High**	**High**	Level 5	Level 9

Values less than 25% are treated as no assist. The “Low” settings for power and speed limits are used between 25-31%. The “Middle” settings are applied if the PWM range is between 58% and 65%, while the “High” settings are used whenever the PWM is greater than 91%.   If the display sends out a PWM value outside of these numbers, then the controller will use an in-between value based on the table above.

Many displays have hard coded PWM values for each assist level, and in some cases these do not align well with the interpolation table, ie two levels that both have the same assist, or a value below 25% that results in no assist. Better displays (including all models offered by Grin) allow custom configuration of what PWM% is sent for each assist mode, giving some flexibility to explicitly select the power and speed you get for each value.

A preview table is provided in order to conveniently see the result of these assist settings. This is how it looks for the PAS and Torque values above, with the display set to 5 and 9 assist levels respectively:

Assist Level Chart

Number of Display Assist Levels: 5

In between the Low, Medium, and High assist levels are three additional interpolated assist levels that can be selected by the display, yielding up to 9 levels in total. The Display % shows the assist setting range on the display which will map to that particular level.

Level	Display %	Max Speed (km/h)	PAS Power (W)	Max Motor Torque (Nm)
1 (Low)	25-32	25.0	100	4.3
	33-41	26.8		7.5
2	42-49	28.5	250	10.7
	50-57	30.3		13.9
3 (Mid)	58-65	32.0	400	17.1
	66-74	32.0		23.5
4	75-82	32.0	700	29.9
	83-90	32.0		36.3
5 (High)	91-100	32.0	1000	42.7

Example of PAS Assist with 5 Levels

Assist Level Chart

Number of Display Assist Levels: 9

In between the Low, Medium, and High assist levels are three additional interpolated assist levels that can be selected by the display, yielding up to 9 levels in total. The Display % shows the assist setting range on the display which will map to that particular level.

Level	Display %	Max Speed (km/h)	Torque Multiplier	Max Motor Torque (Nm)
1 (Low)	25-32	25.0	0.45	25.6
2	33-41	26.8	0.71	40.6
3	42-49	28.5	0.97	55.5
4	50-57	30.3	1.24	70.5
5 (Mid)	58-65	32.0	1.50	85.4
6	66-74	32.0	1.88	85.4
7	75-82	32.0	2.25	85.4
8	83-90	32.0	2.63	85.4
9 (High)	91-100	32.0	3.00	85.4

Example of Torque Assist with 9 Levels

That dashboard tab allows you to see in realtime the current assist level and study how this changes as you push up and down on the display buttons.

Average Pedal Speed	0.00 RPM	Don't Plot
Average Pedal Torque	0.00 Nm	Don't Plot
Assist Level	0.00 per unit	Don't Plot
Speed (Ref/Limit) Command	0.00 per unit	Don't Plot

7.10 Speed Limiting

The vehicle has several configurable speed limit setpoints. The Basic tab includes the general global speed limit for throttle control as well as a maximum reverse speed or walk speed if a display supporting walk mode is used.

Vehicle Parameters

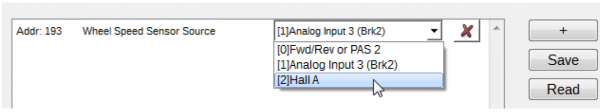
Wheel Diameter	28.5 inch
Maximum Speed	40.0 km/h
Regen Brake Speed Minimum	1.0 km/h
Reverse/Walk Speed	6.0 km/h
Wheel Sp. Sensor Pulses Per Rev	0 Pulses/rev

Maximum Throttle Speed While Pedaling	40.0 km/h
Max PAS Speed (High)**	40.0 km/h
Max PAS Speed (Mid)	32.0 km/h
Max PAS Speed (Low)	25.0 km/h

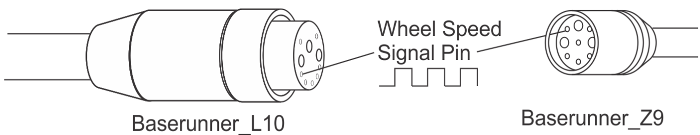
Meanwhile the PAS tab has settings related to speed limits at different assist levels.

7.10.1 Speed Computation

The Baserunner V6 has multiple options for determining how vehicle speed is determined. With direct drive motors, the vehicle speed is derived from the motor RPM and wheel diameter rather than any external signals. This is ensured by setting the wheel speed signal source parameter to Hall A and will be set that way by our default motor profiles.



For geared motors that freewheel or mid-drive motors, the motor RPM is not directly tied to the wheel and the Baserunner V6 requires some other input signal to determine the vehicle speed when the motor is not running. This would be fed into the wheel speed signal line of the L1019 connector or the Z910 connector, and the “Wheel Speed Sensor Source” must be set to “Analog Input 3(Brk2)”. See section 8.3 for more details.

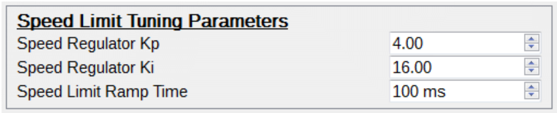


The “Wheel Sp. Sensor Pulses per Rev” and “Wheel Diameter” must then be set accurately for correct calculation of vehicle speed. Geared hub motors with speed sensors typically have 6 pulses, while a solution using a spoke magnet would be 1 pulse per rotation. A setting of ‘0’ forces the controller to use the motor rotation for vehicle speed regardless of signal source.

7.10.2 Speed Limit Control Loop

Advanced Setup tab

Any time an electric motor is asked to drive at a fixed speed, a set of control parameters determines how the power is scaled back as the limit is reached so that a stable speed is maintained under changing loads without overshoot or oscillations. The total inertia of the vehicle and torque output of the motor will impact this behavior, and these values may need adjustment if the speed limit is not smooth.

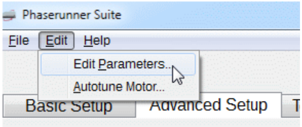


The “Speed Regulator Ki” and “Speed Regulator Kp” values should be adjusted and compared while riding the vehicle, not with the wheel spinning in free air as that greatly changes the ideal control characteristic.

The speed limit ramp time controls the maximum acceleration rate of the wheel, and can be an extremely useful parameter to limit the tendency of wheels to skid or lurch on sudden throttling. Practical values to use this features will be in the 1000's of mS.

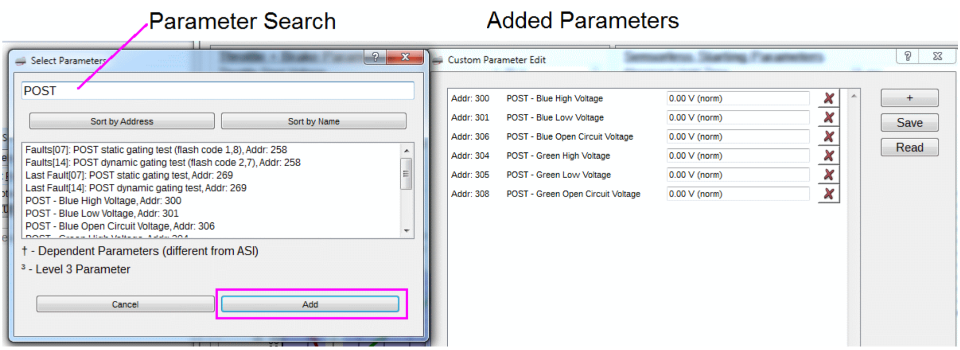
7.11 Edit Parameter Menu

In addition to the parameters accessible from the software suite GUI, there are hundreds of other parameters present in ASI’s controller firmware. Most of these are not relevant for the functionality brought out with the Baserunner V6, but advanced users already familiar with ASI’s controller ecosystem may want to edit specific values.



That can be done by selecting Edit → Edit Parameters. This produces a pop-up list searchable both by parameter address and description, and multiple parameters can be control selected at the same time to show up on this window.

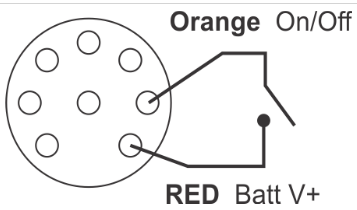
Selected parameters not shown elsewhere in the suite can then be edited and saved at will. Grin does not provide any documentation or support for these additional parameters.



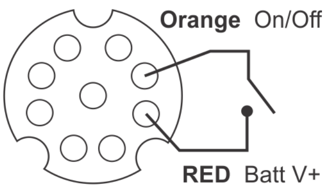
8 Additional Details:

8.1 Turning the Controller On and Off

In order to power up, the Baserunner V6's on/off wire must be shorted to battery V+, through either the WP8 plug or the Main9 plug. This is accomplished either with a Cycle Analyst plugged into the WP8 plug, or via the display's on/off with a Main9 harness. If battery power is applied without the on/off input connected to V+, the controller won't be turned on and won't connect to a computer.



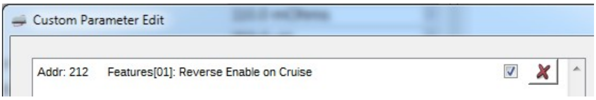
CA WP8 Plug On/Off Wiring



Main9 Plug On/Off Wiring

8.2 Reverse Mode

The signal *PAS 2* used in the 6 pin PAS plug is electrically equivalent to the *FWD/REV* pin in the Main9 plug. This input is configured as a reverse switch input by enabling “Reverse on Cruise” for applications that require direction reversal. It is enabled by default with Cycle Analyst systems, but is unchecked with Superharness defaults.



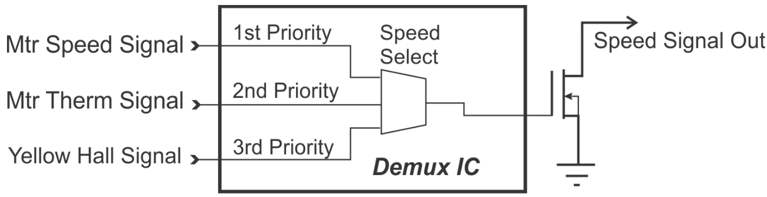
Grin offers an unterminated 6 pin Higo cable that can be wired to any convenient switch for forwards/reverse control. It is not possible to have forwards/reverse control with a Superharness system that *also* has a quadrature (2 wire) cadence sensor as they share the same digital input signal, and turning the cranks would cause the motor to alternate forwards and reverse.

If the motor is simply spinning backwards for your application and you want to change the direction of rotation without adding a fwd/rev switch, then follow the instructions in 7.1 Motor Autotune. Check the checkbox “flip direction on next autotune”. This will change the default spin direction.

8.3 Wheel Speed Sensing

The Baserunner V6 will automatically select the source of the wheel speed signal for vehicle speed measurement. This is handled in hardware with a separate demux chip inside the device and can come from one of three sources:

1. *The motor speedometer signal (White wire of L1019 cable)*
2. *The motor temperature signal (Grey in L1019 cable / White in Z910)*
3. *The motor's yellow hall sensor signal*



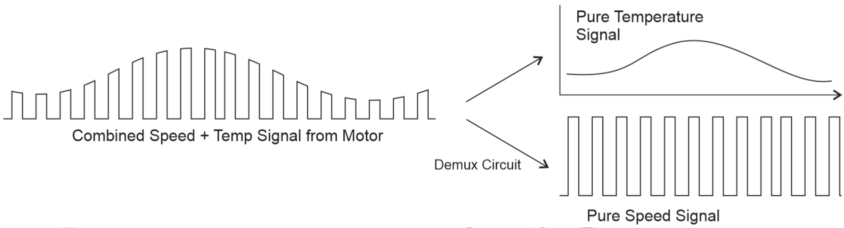
The chip will look for signals in the priority above, and whichever highest priority signal is active will get transmitted both to the Cycle Analyst and also the controller's external speed sensor input (Analog In 3, Brk2).

Notice that the controller and Cycle Analyst (if connected) compute the speed independently from each other. The Cycle Analyst speed is always based on the pulse frequency of the “Speed Signal Out” and the configuration in the Cycle Analyst for pulses/rotation and wheel circumference.

The Baserunner's internal vehicle speed reading depends on the speed signal source and the *controller* settings for wheel size and pulses.

8.4 Combined Temp / Speed Signal

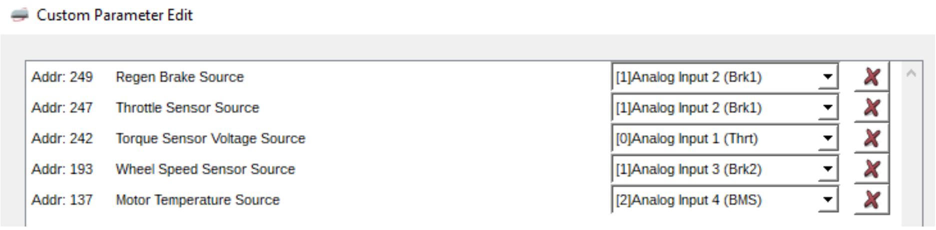
The Baserunner V6 will work with combined temperature and speed signals that are present on the temperature input pin. If there are no speed pulses present on the “Wheel Speed” signal, and the temperature signal periodically drops to 0V, then the Baserunner V6 will treat those 0V pulses as speed signals to track wheel rotation. These decoded speed and temperature signals are transmitted both to the CA3 and the controller.



8.5 *Signal Mapping*

The Baserunner V6 uses the Analog Input 2 (Brk1) signal as both the throttle and regenerative brake signal source. This differs from the earlier Baserunner controllers which used separate signals for “Throttle Sensor Source” and “Regen Brake Source”, which were then shorted externally in the connector wiring.

The previous Analog Input 1 (Thrt) of the controller is now mapped to be a torque sensor input source, while inputs that were previously unused are now being used.



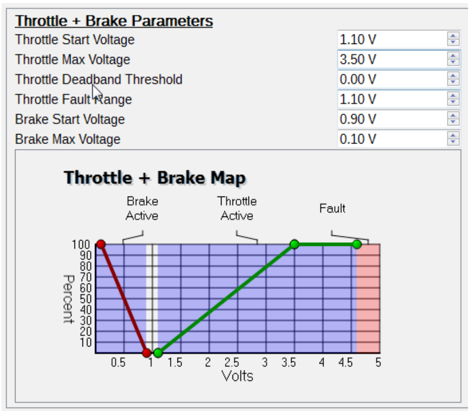
These settings can be seen by going *Edit → Edit Parameters* as shown above. The difference between earlier Phaserunner devices and Baserunner V6 are summarized in the table below:

Input Source	Baserunner (V1-V4)	Baserunner (V5-V6)
Throttle Source (CA)	Analog Input 1 (Thrt)	Analog Input 2 (Brk1)
Regen Brake Source	Analog Input 3 (Brk2)	Analog Input 2 (Brk1)
Torque Sensor Source	N/A	Analog Input 1 (Thrt)
Motor Temperature	N/A	Analog Input 4 (ABMS)
PAS1	N/A	Digital Input 2 (PFS)
PAS2	N/A	Digital Input 1 (Cruise)
Wheel Speed Sensor	Hall A	Analog Input 3 (Brk2)
Fwd/Rev	Digital Input 1 (Cruise)	Digital Input 1 (Cruise)

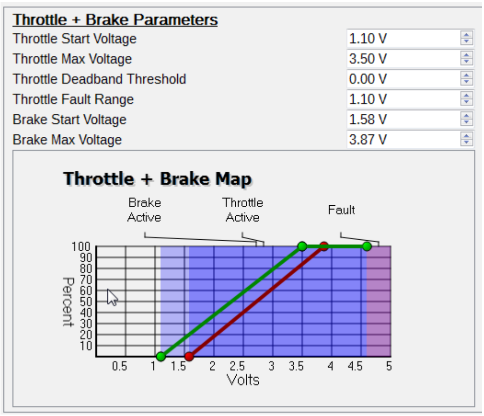
These changes were necessary to fully support the independent use of torque sensors and throttles on the same controller. As a result, if full parameter settings saved from a Baserunner V3 or older device are then imported to the Baserunner V6 or vice versa, the controller is unlikely to function until the signal mapping is corrected as per the table above.

8.6 Independent Regenerative Braking

The Baserunner V6 by default has both the throttle signal source and the regen brake signal source coming from the same line, Analog Input 2, which floats at 1V when disconnected. This allows for a single wire to control both power and braking. Both Grin's Superharness and Cycle Analyst are able to merge various ebrake inputs into this combined regen/throttle signal.



Throttle + Brake Map for Combined Signal



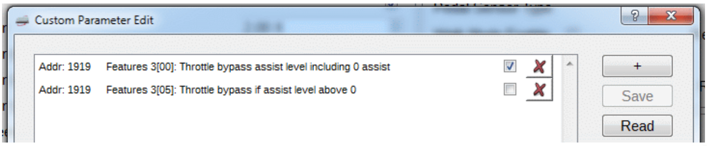
Example for Independent Throttle and Brake

If completely independent throttle and regen brake signals are desired without using Grin's Superharness device, then the throttle signal source can be changed to Analog Input 1, available on both the Main9 and 6 pin PAS cables. Separate sensors can be used to control braking and throttling. If both regen brake and throttle are active at the same time the braking signal will override the throttle. Note that this negates any possibility of a torque sensor which otherwise would use Analog Input 1.

8.7 Limit Throttle to Assist Level

The default settings allow the throttle to operate from 0-100% regardless of what assist level the display is at. This ensures you can always quickly access full motor power when required via the throttle, and it allows the system to continue operating fine even if the display is no longer functional.

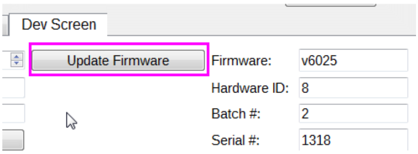
If you would prefer the maximum power and speed limits for throttle control to also match the assist power/speed levels set in 7.9, then uncheck the “Throttle bypass assist level” setting in Feature3 via the edit->edit parameters menu.

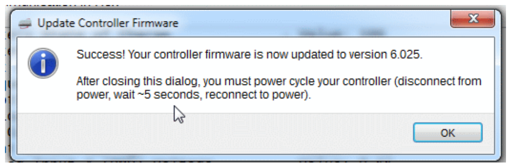


This option can be sensible if there is no pedal sensor on the bicycle so that the display levels still have an effect.

8.8 Updating Controller Firmware

Since the V2.0 release, the Phaserunner Suite software also has the ability to update the firmware loaded on the motor controller. The current firmware can be seen from the “Dev Screen” tab, and the button “Update Firmware” presents a list of currently available firmware versions that can be installed.





Most Baserunner V6 devices shipped prior to 2024 came with 6.023 firmware. This release has bugs and limitations in how it interacts with 3rd party displays, and needs to be upgraded to **6.025 or later** for use with a Main9 harness and 3rd party display.

9 Cycle Analyst Settings

Current Sensing [Cal->RShunt]

The Baserunner V6 uses a 1.00 mΩ +- 0.02 mΩ shunt resistor for current sensing. The exact calibrated value is laser engraved on the controller heatsink. In order to have the most accurate readout of battery current, ensure that the *Cycle Analyst's* “RShunt” value is set to match this.

Throttle Out [ThrO->Up/Down Rate] [SLim->Int,D,PSGain]

Because the Baserunner V6 uses a torque throttle rather than a voltage throttle, the entire throttle voltage range is always active. Optimal settings for the throttle output on a V3 Cycle Analyst will differ than that for generic ebike controllers.

The ramp up and ramp down rates as well as the feedback gain settings (AGain, WGain, IntSGain, DSGain, PSGain) can be set much higher than with a conventional controller with a voltage throttle. Good starting values are:

- Throttle Up Ramp: 6 V/sec
- WGain: 50-100
- AGain: 300-400
- IntSGain: 100-150
- DSGain: 600-800
- PSGain: 2-3 V/kph

10 LED Flash Codes

A small red indicator LED is present on the underside of the controller. This shines downward through a hole in the controller baseplate and can provide useful feedback on the controller status. However in some installations the light is obscured and difficult to see.

It is a useful to examine the LED for troubleshooting any fault behaviors, which will be communicated by the following flash table. For example, for a 2-4 flash code, the LED will blink twice in quick succession, followed by a short pause, then four more blinks, followed by a long pause, at which point the flash code will repeat. Some faults will clear automatically once the condition clears, such as “Throttle Voltage Outside of Range,” while other faults may require turning the controller off and on.

Table 2: LED Fault Flash Codes

1-1	Controller Over Voltage
1-2	Phase Over Current
1-3	Current Sensor Calibration
1-4	Current Sensor Over Current
1-5	Controller Over Temperature
1-6	Motor Hall Sensor Fault
1-7	Controller Under Voltage
1-8	POST Static Gate Test Outside Range
2-1	Network Communications Timeout
2-2	Instantaneous Phase Over Current
2-3	Motor Over Temperature
2-4	Throttle Voltage Outside of Range
2-5	Instantaneous Controller Over Voltage
2-6	Internal Error
2-7	POST Dynamic Gate Test Outside Range
2-8	Instantaneous Controller Under Voltage
3-1	Parameter CRC Error
3-2	Current Scaling Error
3-3	Voltage Scaling Error
3-4	Headlight Under Voltage
3-5	Torque Sensor
3-6	CAN Bus
3-7	Hall Stall
4-1	Parameter2CRC

The LED may also flash several different warning codes. These warnings do not stop the controller from running and will appear as various limits are reached in normal operation, they are not usually a cause for any concern.

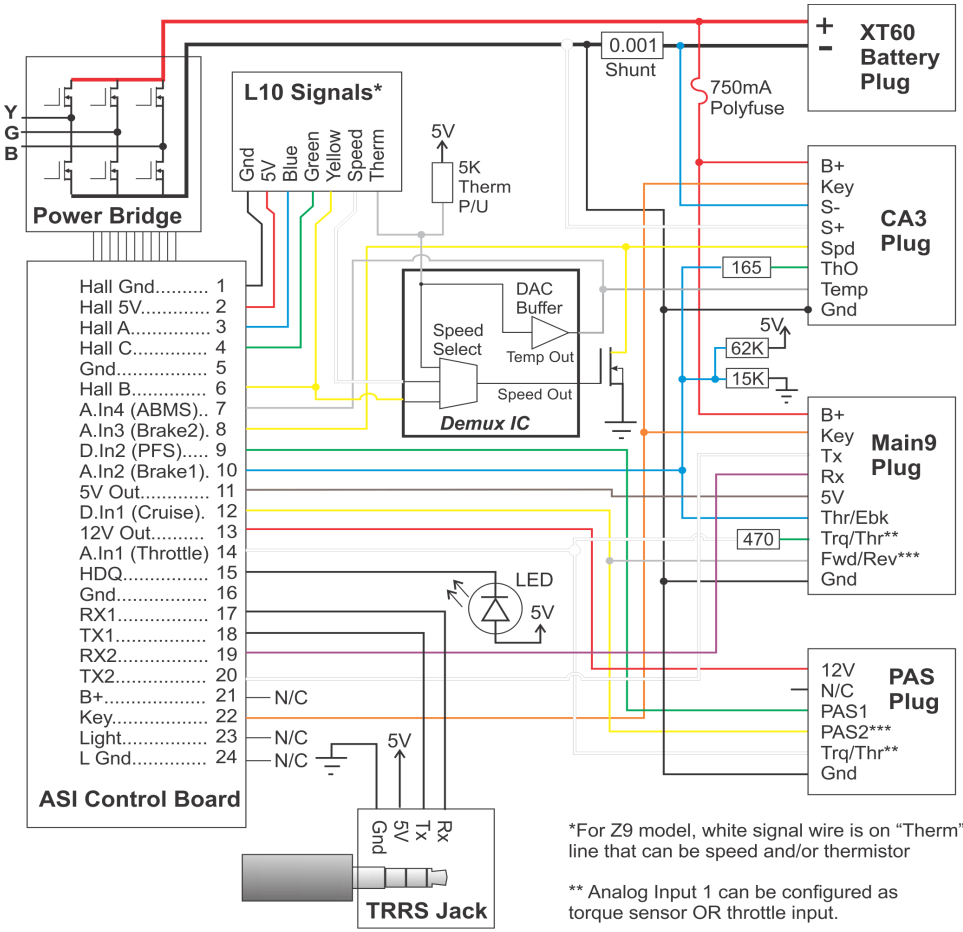
Table 3: LED Warning Flash Codes

5-1	Communication Timeout
5-2	Hall Sensor
5-3	Hall Stall
5-4	Wheel Speed Sensor
5-5	CAN Bus
5-6	Hall Illegal Sector
5-7	Hall Illegal Transition
5-8	Low Voltage Rollback Active
6-1	Max Regen Voltage Rollback Active
6-2	Motor Overtemperature Rollback
6-3	Controller Overtemperature Rollback
6-4	Low SOC Foldback
6-5	Hi SOC Foldback
6-6	I2tFLDBK
6-7	Reserved
6-8	Throttle fault converted to warning

When corresponding with Grin about Baserunner troubleshooting, note in advance if the LED is flashing when the fault occurs, and include the flash code in the correspondence.

11 Functional Schematic

The Baserunner L10/Z9 controller has an ASI BAC555/BAC355 control and power board at the base, but with an intermediary daughter card PCB for additional signal conditioning and cable termination. This diagram illustrates the internal signal wiring and explains how the different connector pins are wired.



*For Z9 model, white signal wire is on "Therm" line that can be speed and/or thermistor

** Analog Input 1 can be configured as torque sensor OR throttle input.

*** Digital In 1 can be used either as 2nd PAS signal or FWD/REV control input.

12 Specifications

12.1.1 Electrical

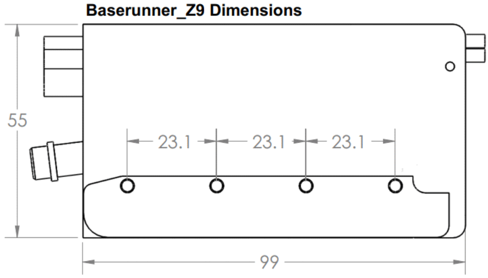
Peak Battery Current	Programmable up to 80A (L10) or 55A (Z9)* Phase A limits practical value to ~40A (L10) 25A (Z9)
Peak Phase Current	Programmable up to 80A (L10) or 55A (Z9)*
Peak Regen Phase Current	Programmable up to 80A (L10) or 55A (Z9)*
Continuous Phase Current	Approximately 50A (L10), 30A (Z9) at thermal rollback, varies with air flow and heat sinking
Phase Current Rollback Temp	90°C Internal Temp (casing ~70°C)
Max Battery Voltage	60V (14s Lithium, 17s LiFePO4)
Min Battery Voltage	19V (6s Lithium, 7s LiFePO4)
eRPM Limit	Not recommended above 60,000 eRPM, though it will continue to function beyond this.
Max Batt+ Current for Lights on Main9 or CA3 Plugs	750 mA (limited by self resetting polyfuse)
RShunt for Cycle Analyst	1.00 mΩ

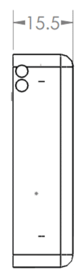
*Thermal rollback will typically kick in after 1 to 2 minutes of peak phase current, and then phase current will automatically reduce to maintain controller rollback temperature.

12.1.2 Mechanical

Dimensions LxWxH	104 / 99 x 55 x 15.5 mm (L10 / Z9)
Weight	0.25 / 0.20kg (L10 / Z9)
Signal Cable Length	15cm to Connector End
Motor Cable Length	38cm to Connector End
Waterproofing	Fully Potted Circuitry, IP rated signal plugs

Baserunner_Z9 Dimensions





Baserunner_L10 Dimensions