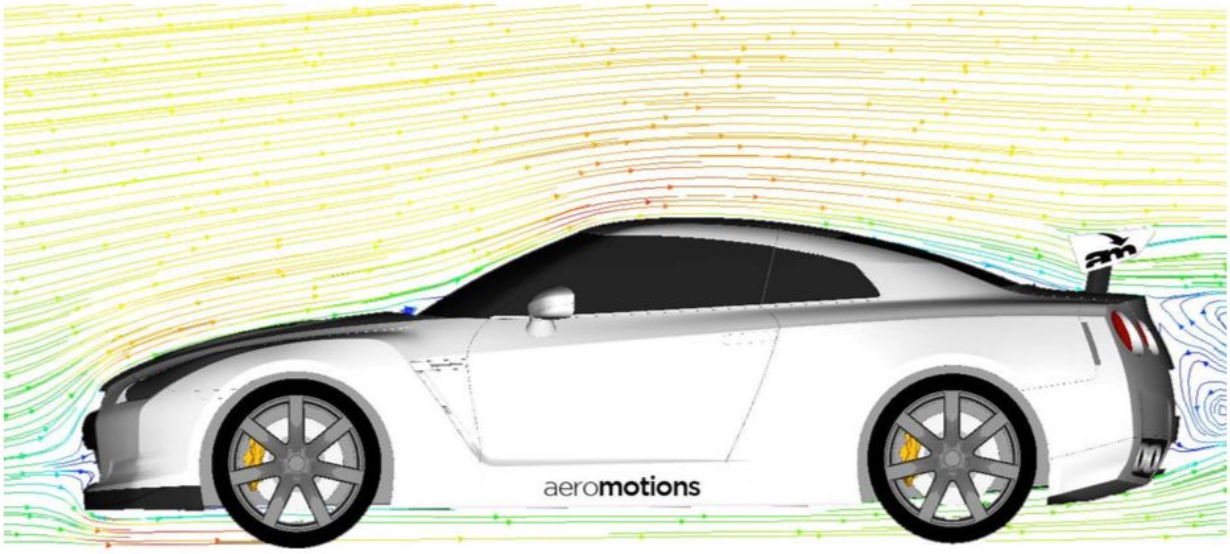
Version .9 10/21/20

Angle of Attack (AoA) and Stall Angle

The Angle of Attack, sometimes referred to as wing angle, is the angle of the airfoil (wing) relative to the airflow in front of it (we use degrees of angle as a measurement). Increasing the AoA increases downforce and drag, while lowering it decreases downforce and drag. However, you must never increase the AoA beyond the Stall Angle or decrease the AoA below zero degrees (0º). The Stall Angle, in layman's terms, refers to the maximum AoA that can be achieved before the airfoil stalls, or fails to produce lift (downforce in automotive terms). The Aeromotions Airfoil, in clean air when the air is coming directly at the airfoils, has a stall angle of 14.2º. But because the AoA is measured from the angle of incidence (shown with the GT-R below), or angle at which the airflow contacts the airfoil, the stall angle is car dependent. While stall angle is almost always different between car models (i.e., different shapes), the excessive rake or changes to the upper surfaces of the same model car can influence the stall angle.



CFD image
As you can see, the effective stall angle on a GT-R is 7.4º based on the way airflow follows the rear window and interacts with the airfoil. Modifying the height or mounting of the wing will change the stall angle.

GTR AoA image
The AoA should be measured or referenced from a flat driving surface and the top edge of the Aeromotions endplate.

TOP TIP: Measure AoA from the top edge of the endplate with an angle finder. We laser align and machine our endplates to be perfectly “zeroed out” at *the exact* aerodynamic AoA of the airfoil.

*****NOTE:** Stall Angle should be defined by an Authorized Aeromotions Dealer, Tuner, or Specialist.

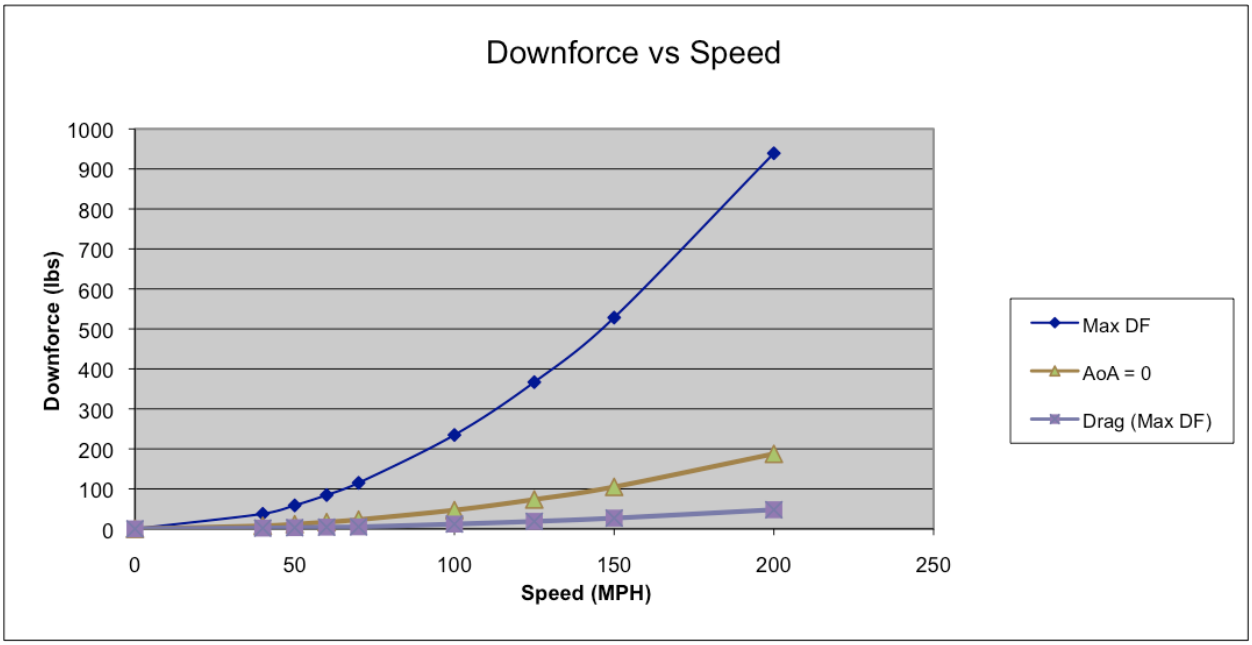
Tuning Static or Cornering AoA

Aerodynamics tuning is both an art and science. While we have taken the science to a whole new level, there is still a bit of art that relates to car setup and driver preference.

Top Tip: Don't just crank it up to 11. Driver preference is much more important than max downforce. Any adjustments are about balance and personal feel.

The optimal static or cornering angle should be adjusted based on your preferred feel of balance and the balance of other components on the car. Front aerodynamics(splitters), spring rates, and rake angles all play a part in finding balance. Because of our unique, high performance airfoil, small wing angles produce much more downforce than standard wings at the same angle. When tuning on a new car, the goal is to get the rear aero (wing, diffuser, etc) to balance the front aero (splitter, canards, etc), and maintain proper suspension damping at the same time. As a rule of thumb, a 30-60mm front splitter should start with 3-4 degrees of wing angle, and increase 1 degree at a time until balance is achieved.

Note: if you increase the AoA to the point that rear grip is compromised, you have very likely passed the stall angle.



As the graph shows, the effect of the wing will increase with the square of speed. Low speed handling is dominated by tires and suspension, high speed handling is dominated by aero. The crossover point is somewhat unique to each car and setup.

Top Tip (R.Static Only): Each hole equals 1º change in AoA.
Just like our signature endplates, we laser align the machining process so that each hole in the stainless steel brackets is equal to a 1º change in Angle of Attack

GTR:
This graph gives the maximum downforce as a function of speed for the Nissan GTR at 7.4 degrees. Taller wing heights and aggressive rake angle will change this.

Dynamic Explanation

Aeromotions Dynamic Wings™ use our proprietary algorithms calculated against vehicle speed and gravitational (G) forces to provide the optimal Angle of Attack (AoA)

Aeromotions Dynamic Wings™ automatically provide downforce when and where you need it, and reduce drag when you don't. Downforce and drag both increase exponentially relative to vehicle speed, so there are many times on a racetrack where too much downforce and drag reduce lap times and top speed, as well as increasing vehicle component wear. Using real time input from the Dynamic Module 3-axis accelerometers (G-Force) and vehicle speed input from your car's ECU, our proprietary algorithms provide the optimal Angle of Attack (AoA, aka wing angle) ranges across to most effectively reduce lap times and increase endurance. While our Dynamic Wing™ Modules do a majority of the hard work for you, we have simplified the tuning process by isolating 3 main Dynamic groups that have threshold (or outer limit) settings.

Cornering Angle: This Angle of Attack (AoA) should be set to provide the level of downforce needed to balance your car at turning traction limits. This AoA is dependent on car setups and driver preference. Cornering Angle is also be the index, or relative AoA for which the other settings can be determined, i.e., Cornering is the wing's "at rest" AoA from which the AoA is either increased for braking and decreased for drag reduction.

Braking Angle: This setting is like an "Air Brake" in which the AoA is increased to a high downforce and high drag level for maximum stopping power and braking balance. Much like setting the brake bias on your car, this setting can also be tweaked to find the ultimate braking balance front to rear. For example, a front engined car may require additional AoA to offset a forward weight bias in braking, while a rear engined application may need less braking AoA.

However, do not increase the braking AoA past the stall angle unless you are familiar with this approach. When AoA (braking or otherwise) surpasses stall, the wing is not creating downforce, but only drag.

Braking angle is engaged when parallel (forward) G-Forces are high and vehicle speed decreases rapidly.

Straightaway Angle: Just like the Drag Reduction Systems (DRS) found in Formula racing, the Straightaway angle is a low drag and low downforce AoA meant to increase top speeds and passing speeds, as well as reduce unnecessary wear on components. For example, incredible downforce at high speeds can create excessive tire wear, increased suspension tax?, and reduce your vehicle's ride height to dangerous levels (up to ~2-3" in many cases). An Aeromotions wing will go into straightaway mode when vehicle speeds increase rapidly (over predetermined MPH), longitudinal (straight) G-forces are high and lateral G-Forces are low (i.e., not in a hard corner).

How to change these settings can be found later in this manual.

S1/2 ECU

Dynamic Wing S1 & S2
Aeromotions Dynamic Wings™ come with a baseline plug-and-play tune developed for your car based on a number of known OE variables. The Aeromotions ECU will automatically provide ample downforce in corners, more downforce when you brake, and drag reduction on the straightaways to help increase top speeds. The baseline tune should work very well out of the box, but Aeromotions Dynamic Wings™ can and should be tuned for your driving preference, aerodynamic modifications such as splitters, and other suspension modifications such as spring rate and damping. It should be noted that aerodynamic modifications that create more downforce (like your Aeromotions Wing) will consequently require stiffer springs and other suspension or chassis improvements.

	R35 GTR
The Low Speed Maneuvering Threshold	70
The High Speed Maneuvering Threshold	120
Straightaway Speed (also limits braking and roll motion)	140

Top Tip: We recommend using one of the additional track maps to play around or change tuning, so that the default map & tune can remain unchanged. The only way to revert back to the default map & tune is a hard reset or factory reset, the latter of which can only be done by Aeromotions.

Get to know the Aeromotions ECU:

The S.Series ECU has a number of buttons and visual feedback mechanisms for easy interaction. The low profile buttons are located underneath the corresponding interface elements, and the core buttons have a built in LED to indicate the current menu or option selection. Note: the S1 & S2 use the same ECU, but the left /right and split options only correspond to controlling an S2.Dynamic.

Starting from upper left and moving counterclockwise.

1) 10 segment LED indicator screen: The 10 LEDs in this screen are used to indicate a number of options like Vehicle Speed Sense (in PPM), Accelerometer sensitivity, Track Maps, etc.

2) Up and Down buttons: These plus and minus buttons are most used to increase or decrease the wing angle (AoA) between the wing angle groupings, but are also used as the main up/down +/- for other options like Vehicle Speed Sense (in PPM), Accelerometer sensitivity, Track Maps, etc.

3) Left and Right Buttons (S2 Only): These buttons select the specific wing halves of the S2, and allow them to be individually “trimmed.” The orientation referenced is standing behind the car looking forward towards the front of the car.

4) Thresholds: These allow specific control of wing angle grouping thresholds, i.e. when the desired wing angle is triggered or invoked. These settings control speed and/or accelerometer sensitivity and are typically advanced settings.

5) Wing angle control: These buttons allow the different wing angle groupings to be selected and modified. See the Advanced Tuning section for more on configuring these settings.

6) Track Map: The S.Series can store up to 10 additional “Track Maps” that can be saved. For example, you may want to save a specific tune for a high speed track and another for a low speed track. The stock tune is stored in track map 1. Holding down the “Track Map” button and pressing the “UP” or “DOWN” button cycles through ten different maps. The selected map is indicated on the 10 Segment LED by a single lit LED. Track Map “0” (all LED’s flash as a block) locks out the wing at the Cornering angle. The wing will function as a static wing.

7) Speed Set: This is the button to enter the Vehicle Speed Set Up Mode, which allows the configuration of proper Pulse Per Mile (PPM) Input from your car’s ECU, as well as the setting mode for setting the MPH threshold for the straightaway speed. See more on this in XXXXX

8) Split (S2 Only): Pressing the “Split” button toggles the split ON and OFF. When the “Split” is ON, the wing halves will move independently to aid weight transfer in cornering, and the “Split ON” LED will light up.

First startup

Once all electrical connections have been made and the wing properly mounted (and checked for free motion) as stated during the install procedures, the wing can be turned on for the first time.

When you turn the car’s ignition on for the first time, the wing should go through a "Pre-Flight Check”, where the wing will move to each of the programmed angles. Watch to ensure the wing moves smoothly, and freely. The wing will skip this Preflight Check if the car starts to drive.

Note: if the wing does not move, recheck all of your electrical connections to ensure a good ACC 12V+ and ground source and that the Power Pods are connected to the Aeromotions ECU. If there are (error lights) on the ECU and the wing was not moving freely, disconnect the tie rods and make sure the wing halves move freely.

Speed Setup
All Aeromotions Dynamic Wings™ need to have an accurate Vehicle Speed Sensor (VSS) input from your car's ECU (OE or Stand alone) in a Pulse Per Mile (PPM) format. Most use the provided CanBus adapter to output a signal, which is the default setting for the Aeromotions ECU. However, some applications have a custom output. This PPM can be set easily by the following:

Setting the Vehicle Speed Sensor
The Pulses Per Mile (PPM) that the ADAPT Controller reads from the vehicle is programmable in wings sold after March 2013. The PPM only has to be set once, then is stored in the ADAPT Controller. To set the PPM, Power On the ADAPT Controller while depressing the SPEED SET Button. A single LED on the 10 LED Bar display will be illuminated to indicate which PPM is selected as shown in the table below:

LED PPM VEHICLE
1. 3,600 CAN Adapter
2. 4,000 EVO and Corvette
3. 8,000 GT-R
4. 10,000
5. 45,056 Porsche

Use the UP and DOWN arrow keys while depressing the SPEED SET Button to select the PPM for your car. For example, for a GT-R, the 3rd LED would be lit.

Powering OFF the ADAPT Controller will return it to normal operation and it will remember which PPM you selected.

Checking the VSS Pulse and Scaling
Holding down the "Speed Set" button puts the controller in Speed Setup mode. While holding the Speed Set Button, The 10 segment LED will flash with each pulse from the VSS as the car is driven forward. This is best observed at low speeds. After verifying the pulses at low speed, the 10 Segment LED can be used to verify the accuracy of the scaling. Above 50 mph, the LED's on the 10 Segment LED will light to indicate the vehicle speed. Each LED represents 10 mph over 50 mph. For example, one lit LED indicates 60mph, two lit LEDs is 70mph, and 5 lit LED's would shows 100mph.

Trimming Wing Angles (S2 Only)

After turning on your wing for the first time, you may have trim the wing halves so that the trailing edges are aligned horizontally. It is best to measure the AoA of each half (as instructed in the Tuning AoA section), and adjust the wing half the is off by the most. With the car's ignition in the ON position and after the Pre Flight Check movement, press the desired Left or Right button and increase or decrease the wing angle to align with the other. The right or left selection should be indicated by an LED signifying which wing half has been selected.

Note: Delicate or very close adjustment should be done mechanically using the tie rod ends underneath the wing.

Your Aeromotions Wing should now be ready to use!

Optional Wired Remote:

Holding down a button will move the Dynamic Wing to that angle:
B (Braking)
M (Maneuvering Low Speed)
S (Straightaway)

While holding the wing angle button, push the up or down arrow keys to change the angle of both wing halves. Holding the arrow key will cause the wing to move up or down until the arrow key is released. The computer will store this new angle when you let go of the angle button (B,M,S).

Pro Tip: If adjustment is to be made by remote, it's best to change to a new Track Map so the default map is not overwritten. Please see Track Map section of this manual.

Note: when parked, holding M will not cause the wing to move; this is the default position when the car is at rest.

Wing Tuning:

The S.Series wings can be easily tuned by following the below instructions. Start by turning the car's IGN on to start the wing. **After the pre flight check, the wing will be in the Cornering angle.**

Top Tip: Save the default tune and make adjustments on a new track map.
The stock tune is stored in track map 1. Holding down the "Track Map" button and pressing the "UP" or "DOWN" button cycles through ten different maps. The selected map is indicated on the 10 Segment LED by a single lit LED. Track Map "0" (all LED's flash as a block) locks out the wing at the Cornering angle. The wing will function as a static wing.

Note: Angle adjustments are very fine near the highest and lowest angles of attack which helps dial in the perfect max angle before stall. Because of the cam or eccentric effect designed into our Compact Integrated Actuator Design, the increase and decrease of wing angle based on a single button push is non-linear. This means that one button press does not correspond to a single measure of adjustment.

Adjusting The Wing Angles
The wing angle groupings are set by holding down any of the four below "Wing Angle" buttons and adjusting the Arrow (+) and Arrow (-) buttons. The Arrow (+) button increases the AoA creating more downforce (until stall), and the Arrow (-) decreases the AoA reducing downforce and drag.

The "Left Set" and "Right Set" LED's indicate which wing halves will be moved. This can be toggled by pressing the "Left Set" or "Right Set" buttons. If both lights are on, both wing halves will move when holding a wing angle button, and pressing the UP or DOWN arrows. If only the right light is on, pressing the UP or DOWN arrow will only move the right side.

S2 Trim Note: It is typically only necessary to adjust the Wing Angle Groupings as single element wing, i.e. the two halves should be at the same AoA when in braking, cornering, or straightaway. Deviations in wing half AoA is exclusively controlled by the Aeromotions ECU and does not need to be changed as it is relative to G-Force. However, because of some slight differences, the wing halves will need to be “Trimmed” to align at different Wing Angle Groups. For example, the wings halves may be perfectly aligned at the Cornering angle, but slightly misaligned at the Airbrake wing angle.

NOTE: Angle adjustments are very fine near the highest and lowest angles of attack to provide the best possible adjustment resolution.

Braking Angle
The wing moves to this high downforce, high drag angle during braking. Note: this angle is typically strong out of the box, but optimal settings should be dialed in based on balance and driver preference.

Setting Braking Angle: Pressing and holding the Braking button will put the wing into Air Brake mode. Increase and decrease the High Speed Corner AoA by using the Up Arrow (+) and Down Arrow (-) while continuing to hold the High Speed Corner Button.

Note: do not increase the AoA past the stall angle unless you are fully aware of the consequences.

Cornering Angle
This is both the “at rest” and default wing angle – used for both cornering and when car is standing still. This is the most important wing angle, which is provides balance and grip during the mechanical to aerodynamic transition for the bulk of track speeds. Increasing or decreasing this angle will change the car’s balance in corners.

Setting Cornering Angle: Pressing and holding the Cornering Angle button will allow you to adjust the angle. While continuing to press the Cornering Angle button, you can increase the wing’s AoA by pressing the UP Arrow (+) button or or decrease by pressing the Down Arrow (-).

Note: since this is the default angle, pressing this button will not cause the wing to move.

S2 Only: As described in the First Startup section, you may need trim both wing halves to the correct angle the first time you use the wing. Please refer to this section for instructions. To move the Right wing half (passenger side) only, toggle the right LED on (Click “R”). Holding the Cornering Angle button down, press the Arrow (+) or Arrow (-) to adjust the Right wing half.

High Speed Cornering Angle

This angle allows a different maneuvering angle to be set for high speeds. This wing angle does not normally need to be changed, as it is for very high speed situations over **140 mph** by default. An example requiring an update to this would be a long, high speed corner going into a bank (add track examples), or where you need additional grip beyond 160mph.

Setting High Speed Angle: Pressing and holding the High Speed Corner button will put the wing into high speed cornering mode. Increase and decrease the High Speed Corner AoA by using the Up Arrow (+) and Down Arrow (-) while continuing to hold the High Speed Corner Button.

Straightaway Angle

The wing moves to this low drag angle when it detects the car is on a straightaway. Roughly 0º AoA should be the optimal DRS or Straightaway angle. At 0º, the Aeromotions airfoil will still produce some downforce, but almost zero drag.

Setting Straightaway Angle: Pressing and holding the Straightaway button will put the wing into Drag Reduction System D.R.S. mode. Increase and decrease the Straightaway AoA by using the Up Arrow (+) and Down Arrow (-) while continuing to hold the High Speed Corner Button.

Adjusting the Thresholds

These allow specific control of wing angle grouping thresholds or “rules", i.e. when the desired wing angle is triggered or invoked. These settings control speed and/or accelerometer sensitivity and are typically advanced settings. It is usually not necessary to change these unless you are doing comprehensive testing in a controlled environment, or are looking for a very specific set of AoA, speed, and G-Force rules. One example would be using the Aeromotions Dynamic Wing™ system in drag racing and your vehicle has very aggressive launch force that needs to be mapped to a speed variable.

Braking Threshold

This threshold essentially controls the system sensitivity of the on-board 3-axis accelerometers. Holding down the “Braking Threshold” button allows the deceleration value that causes the wing to move to “Braking Angle” to be adjusted using the “Up” and “Down” buttons. The “Braking Threshold” value is displayed on the 10 Segment LED where each lit LED is 1/10th of a “G” as it relates to G-forces. Increasing this value will in effect require higher braking G-Forces to trigger the Braking Angle / Air brake. If you find that the Air Brake is too sensitive, turning this down will help.

Straightaway Threshold and Ruleset

There are two parts to setting when, where, and why the Dynamic Wing™ goes into Drag Reduction / Straightway speed mode. First is the Acceleration Threshold, which controls the system sensitivity of the on-board 3-axis accelerometers as it relates to forward G-forces. The

second is the Speed Threshold which determines the speed in MPH that the DRS/Straightaway angle is triggered.

Acceleration Threshold
Holding down the “Acceleration Threshold” button allows the acceleration value that causes the wing to move to the “Straightaway” angle to be adjusted using the “UP” and “DOWN” buttons. The “Acceleration Threshold” value is displayed on the 10 Segment LED where each lit LED is 1/10th of a “G” as it relates to G-Forces. If the DRS/Straightaway engages too easily on acceleration, turning this up a little will correct it.

Speed Threshold
The speed threshold determines when the wing reduces angle for high speed straightaways as it relates to vehicle speed (MPH). To adjust the speed threshold, hold down the “Speed Set” button and the “Straightaway” button at the same time, and adjust the “Straightaway Speed Threshold” using the “UP” and “DOWN” buttons. The “Straightaway Speed Threshold” will be displayed on the 10 Segment LED as described above: each lit LED represents 10 mph over 50 mph.

****Note:** each race car setup is unique. Dynamic Wings are programmed to work with the stock upper surfaces of the car. Any aerodynamic modification to the car, such as roof scoops or vortex generators, can change the airflow and necessitate adjustment to the tune.

Dynamic ECU Wiring

Connections on the Dynamic Module. The Aeromotions ECU has two main harnesses:

Power Cable
- **RED:** +12V switched (IGN) Power
  - Requires minimum 10A circuit
- **BLACK:** Ground
  - Requires good chassis ground.
  - Remove paint, etc. for good ground contact to chassis

VSS Cable
- **BLUE:** VSS (Vehicle Speed Sensor) Input
  - This wire is for required Vehicle Speed Signal captured in Pulse Per Mile (PPM)
  - The Aeromotions ECU supports PPM (Pulse Per Mile) of 2,000, 3,600, 4,000, 8,000, 10,000, 36,000. Default PPM is set at 3,600
  - For a stand alone ECU, the output signal should be a square wave (OC) of 0-5V or 0-12V

    - A sine-wave output from a hall effect sensor will not work.
- **BROWN:** NOT USED
- **BLACK:** Extra Ground
    - Provided to reduce interference.
    - Typically, it can be left disconnected.

Data Logging Output Cable (Optional add-on)
These wire(s) can be connected to a Data Logger. The wing angle position is output as an analog voltage from 0-5V. It's best to measure voltage at different AoA's as a reference when setting up your data logger settings. Much like a TPS or EFI add-on, the baseline (low AoA) voltage and max AoA voltage setting needs to be referenced – 0v ≠ 0º AoA, etc.

Note: The wires only output different wing angles on the S2. On the S1 and S13, both wires track the same and only one needs to be used.

!: Always diode isolate these outputs.

- **BLUE:** Left (US driver side) Power Pod output on S2
- **BROWN or RED:** Right (US passenger side) Power Pod output on S2
- **BLACK:** Common Ground

Optional CAN BUS Interface adapter.
The included CAN adapter is very useful for getting the factory ECU's VSS signal off of the CAN network, which can sometimes be pulled from the OBD II port. Simply provide the CAN interface adapter with Power (12v) and CAN hi/lo.

Wiring:
- BLACK: Ground
- RED: Power +12V switched (IGN) and fused.
- YELLOW: CAN High
- BLUE: CAN Low
- ORANGE: VSS output for Aeromotions ECU INPUT