



GTpro3 Xtreme Tilton Pedals Setup Guide



Features and Benefits

- Built using real Tilton 600 Series after-market automotive pedals
- Adjustable pedal stops for both ends of travel on throttle
- Magnetic Hall-Effect sensor on throttle pedal is contact-less for long life and high accuracy
- Brake can read up to 175lbs of pedal force, can be higher upon request
- Brake has exponentially increasing resistance like real brakes
- Brake pedal firmness is infinitely adjustable
- Brake designed to push back with hydraulic fluid rather than a stiff spring
- Real master cylinder on brake and clutch with metal reservoir to eliminate breakage and leaks
- Industrial pressure sensor on master cylinders reads pedal forces with high accuracy
- Pedal adjustability as possible in a real car
- Remote sensor unit for brake has user-changeable resistance modules to tailor the pedal resistance
- Brake pedal has small initial dead zone typical of the master cylinder bypass valve closing
- Optional resistance modules provide different brake pedal resistance effects
- Pedal Control Unit (PCU) designed to look like a race car 'black-box'
- Microcontroller based PCU with program switch and status LED (exiting the game is not required to make adjustments)
- PCU firmware is upgradable
- Reads pedals up to 15,000 times per second
- Up to 1,000 pedal updates sent to game per second (PC Limitation)
- Only updates PC when there are changes in pedal positions to conserve bandwidth
- Electronic adjustable dead zones and limits for all pedals
- Selectable response (linearity) curves for all pedals imitates characteristics of various brake pad compounds, clutch materials, and carburetor/throttle body responses
- Can Disable Clutch and/or handbrake to Optimize Processing
- Stores Five Profiles in Internal EEPROM
- All Settings Stored In Black Box EEPROM to work across all games
- Powered by USB
- For PC only
- Compatible with Win XP, Vista, 7, 8 and 10 (32- and 64-bit)
- Simple Installation
- Free Technical Support

Congratulations on your purchase of the most realistic sim-racing pedals available. This setup guide will help you get the most out of your new GTpro3 Xtreme pedals. Your GTpro3 pedals will provide you with all the adjustability that they would have in a real race car in order to provide you with the purest sim-racing experience possible.

About this Manual

As we continue to improve the design of the pedals, some photos may not reflect all the upgrades and therefore may differ from the product you receive.

Tools and Items Required for Installation (not included)

- Mounting bolts, nuts and washers
- USB Cable Type-A Male to Type-B Male
- Drill and drill bits
- Screwdrivers and wrenches

WARNING!

Please secure the cap on the brake master cylinder after filling with a long tie wrap or other adequate means if it is accessible to pets or children.

Step 1: Getting Your Pedals Ready for Installation

Mount the slave cylinder to the mounting bracket as shown.

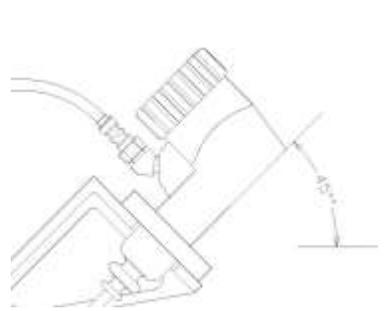


The brake pedal has been secured in the down position to prevent air from getting trapped at the pressure sensor during shipping. This is done to avoid the need to bleed the brake at the time of installation. Do not remove the strap yet.



Remove the "leak-prevention" stoppers from the reservoir

and store them for transporting your pedals in the future. Check that it is filled to about 30% capacity with fluid.



Set the pedal assembly tilted to 45 degrees, as shown, for a period of 5 minutes to allow any air bubbles to rise to the top of the reservoir. Remove the strap holding down the pedal and press on the pedal with your hand, the pedal should not move more than ¼ inch (6mm) before the stacking units begin to squeeze. Turn assembly upright and do not lay it sideways from this point forward.

If the pedal does move more than ¼ inch (6mm) without squeezing on the stacking units then air has made its way into the system during shipping. To remove the air, begin by removing the nuts that keep the stacking units in place (refer to figure 3 on next page) and putting the wing nut back on. Keep the pedal assembly tilted as indicated above and hold the remote sensor assembly below the height of the pedal. While holding the sensor assembly with the hose exiting straight up, pump the stacking unit shaft in and out with your hand about 5 to 10 times to flush any air bubbles to the reservoir above. Reinstall the stacking units and test the pedal, if the problem persists then repeat the steps above.

The pedal should also be pumped before any racing to prime the system and build up pressure in the system.

ATTENTION! The clutch reservoir ships empty and should remain empty at all times. This is intentional. Adding fluid will overload the sensor and will result in permanent failure.

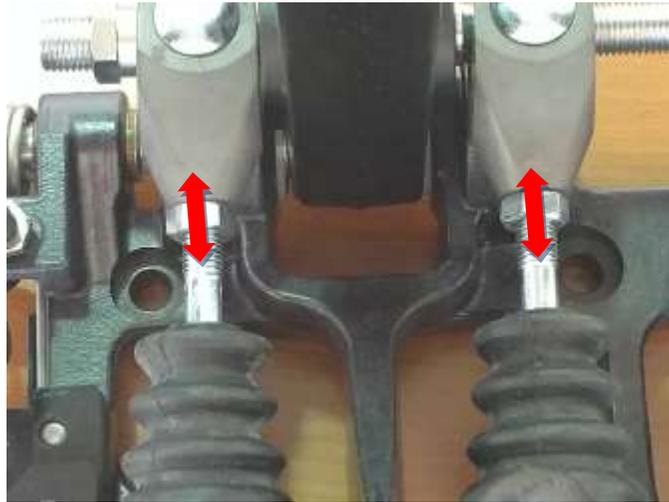
Step 2: Mounting Your Pedals

Ricmotech recommends hard mounting the pedals directly to your sim-racing chassis. The mounting positions suggested are only that, a suggestion. Please feel free to change the placement of the pedals to accommodate your preferred driving style.

Pre-drill mounting holes in the floor of your racing simulator according to the template provided. Secure the pedals using 5/16 inch or 8mm thick bolts or screws (not included). Use nuts and washers to be sure the screws will not pull out.

Route the cables to avoid having them get pinched or chafed using the supplied cable straps. Mount the PCU in a location that is both out of the way and within reach of the programming switch.

The initial position of the brake pedal can be adjusted by threading the master cylinder rod into or out of the clevises. First loosen the jam nut and then rotate the master cylinder shaft. After you have reached the desired position tighten the jam nut to prevent it from moving.



The starting and ending positions of the throttle pedal can be adjusted by turning the stop screws located to the left of the throttle pedal. Turning clockwise will reduce the travel and counter-clockwise will increase the travel. Tighten the lock nuts when complete to prevent the settings from changing. Over-extending the pedal range is not recommended as it places additional strain on the spring which may cause them to break. The spring is a consumable item and replacements can be purchased as needed.



Similarly, the clutch pedal ending position can be adjusted by turning the stop screw located to the right of the pedal. Turning the screw clockwise will reduce the travel, while turning the screw counter-clockwise will increase the travel. Tighten the jam nut when the adjustments are complete to prevent the setting from changing.



When any adjustments are made to the travel of the throttle or clutch pedal, those pedals should be recalibrated, as per Step 5, in the PCU box so the electronics learns the new range of travel for the pedal.

There are 2 sets of stop screws included. One set has a soft nylon tip to reduce noise at the ends of the pedal range, while the other set has a durable hard tip. Use whichever ones work best for your application.

The pedal faces can be installed in one of 4 different positions vertically



and 3 different positions horizontally. The height can be adjusted to two different positions by moving the pedal face to the other screw hole and can be set to 2 additional positions by flipping the pedal face upside-down.

The holes are drilled off-center to allow four different positions.

Three different horizontal positions can be attained by moving the pedal to one of the other three mounting holes on the pedal arm.

Step 3: Making the Connections

Plug the three (3) 4-pin connectors for the Throttle, Brake and Clutch to their respective connectors on the PCU (pedal control unit) by color-matching the cables to the jacks on the PCU. Plug the USB cable (sold separately) to an available USB port on your PC. Drivers will install automatically. You may click "Skip obtaining driver software from Windows Update" to install the drivers faster.



Windows will install its internal drivers. The pedals are powered from the USB port, no external power is required. You should see the LED pulse a red “heartbeat” signal.

Step 4: Test Your Pedals to be Sure Windows has Installed Drivers Correctly

Windows XP, Vista, 7 and 10: click Start, type: **joy.cpl** and ENTER

On Windows 8 and 8.1 go to the Start screen, type: **joy.cpl** and ENTER

The Game Controllers panel will open and there should be a controller named GTpro Pedals, double click on it. A window with several axis and buttons should appear. Press each pedal in sequence and verify the X, Y and Z axis respond. If they do then Windows has properly installed the drivers and the data is getting to the PC. There are other axis and buttons displayed in this window. Those are not used at this time but are there for future use.

If your Game Controllers panel opens but does not show any axis or buttons, please go to the next step. There is an unresolved Windows issue that may cause this. **Your pedals will still function in the game.** If you wish to resolve the issue and are comfortable navigating through the windows registry, then please contact Ricmotech support and someone will walk you through the steps to resolve this.

Open your favorite racing sim title and navigate to the controllers setup screen. Set the new axis for each pedal according to that software’s procedure. It is recommended to calibrate each pedal to its maximum and remove any linearity or other custom settings in the sim. The pedal PCU will allow customizations to be done and will be retained in the pedal PCU memory. The settings in the pedal PCU will work in every game. Setting custom settings in both the pedals and the game can yield undesired results.

Step 5: Programming and Calibration

The PCU for the GTpro pedals retains all the settings and profiles in its internal memory. You can plug the PCU into any available USB port and even into a different PC and all the settings will be retained.

During final assembly of your pedals, a test configuration was programmed into the PCU and will still be there as a starting point when it arrives to you. Before making changes to the programming of the PCU, please familiarize yourself with the programmable features listed below.

Profiles: You may create five profiles which can be saved and later retrieved for use with different drivers or simulation titles. To create a profile simply change the settings to your preferences and then save the profile to one of the memory locations. To retrieve a profile, simply load the profile from

the memory location you desire and those settings will replace the settings currently in the pedal controller. These settings will remain even after shutting down your pedals or connecting to another PC.

Pedal Max Travel (Sensitivity) Calibration: Each pedal can be calibrated to a maximum travel distance. This allows the pedals to output their full signal range even if you have adjusted the travel of the pedal to less than its full range. Alternatively, you can calibrate this to part way of the pedal travel. For instance, you may want to depress the clutch only half-way to get full engagement, pressing the pedal more than half way will not generate any additional output.

Pedal Dead Zone Calibration: Each pedal can be calibrated to have a dead zone. With this setting, the pedal will remain ‘dead’ until it has been pressed down a predetermined amount. This will avoid applying brakes if you simply bump into the pedal, or prevents the clutch from slipping if your foot is riding the clutch pedal.

Clutch Enable/Disable: Turns off the clutch pedal and increases the update rate to the remaining pedals. Set to disable if clutch pedal is not connected.

Handbrake Analog/Digital/Disabled: Sets the output for the optional handbrake. Set to analog for games that support it, otherwise set to digital. When set to digital, the handbrake will trigger when it is pulled over 50% of its calibration. Set to disable if handbrake is not connected.

Handbrake Calibration: Operates the same as Max Travel and Dead Zone Calibration for the pedals.

Invert Axis: Most games and racing simulations will function regardless of this setting. If you find that your software accelerates and brakes when you *let go* of the pedal, then set this option to ‘inverted’ to correct this.

Smoothing: Both the throttle and the brake have a smoothing adjustment. Some computers have power fluctuations which cause the axis to flutter. Increasing the smoothing setting reduces the flutter. Use the least amount of smoothing required to eliminate objectionable flutter.

Linearity: Linearity settings allow you to modify the behavior of a pedal axis. See Linearity profiles at the end of this manual

Programming is done with the 2-way toggle switch and the red/green LED. The toggle switch can be moved to 2 positions, ‘Yes’ and ‘No’ and each position is marked | for Yes and || for No. The LED will flash red and green to confirm the selection of options.

The mechanics of programming

Programming settings on the pedal controller involves 4 steps:

1. Enter program mode.
2. Select the programming option.
3. Follow the steps for that particular setting.
4. The controller returns to normal operating mode.

If another setting option is to be changed, the 4 steps above should be repeated. This was designed this way to avoid being lost in a several layers of menus.

Step 1. Enter programming mode by clicking and holding the switch to No (|) until one long green pulse of the LED confirms you have entered programming mode.

Step 2. Click the switch to Yes (|) the number of times corresponding to the option you wish to select, the green LED will flash each time the switch is clicked. For example, to select option 1 click the switch once, to select option 2 click the switch twice, to select option 3 click three times, etc.
NOTE: Failing to click or clicking more than 14 times results in a long red flash and the controller returns to normal operating mode.

Step 3. After 3 seconds, the LED will flash green confirming the selection you made. Skip to the respective section on this sheet and follow those instructions.

Option 1 – Load Profile

1. Click | according to the profile you wish to load.

Click 1 Time	Load Profile 1
Click 2 Times	Load Profile 2
Click 3 Times	Load Profile 3
Click 4 Times	Load Profile 4
Click 5 Times	Load Profile 5

2. After 3 seconds, the LED will flash indicating the selection you made.
3. The controller will exit program mode with your new settings and return to normal operating mode.

Note: Failing to click or clicking more than 3 times results in a long red flash and the controller returns to normal operating mode.

Selecting a profile which has not been previously programmed may set up the pedals with non-functional settings.

Option 2 – Save Profile

1. Click | according to the profile you wish to load.

Click 1 Time	Save Profile 1
Click 2 Times	Save Profile 2
Click 3 Times	Save Profile 3
Click 4 Times	Save Profile 4
Click 5 Times	Save Profile 5

2. After 3 seconds, the LED will flash indicating the selection you made.
3. The controller will exit program mode with your new settings and return to normal operating mode.

Note: Failing to click or clicking more than 3 times results in a long red flash and the controller returns to normal operating mode.

Option 3 – Calibrate Throttle Pedal

The LED will pulse red 1 time indicating you are at Max Limit setting. You may click || if you want to skip this part.

1. Press the pedal to the maximum travel you desire. It does not have to be all the way down. The LED will pulsate red if you have reached maximum travel of the pedal.
2. Release the pedal.
3. Click | to accept and the LED will pulse green 1 time to confirm, or click || to skip/cancel.

The LED will pulse red 2 times indicating you are at Dead Zone setting. You may click || if want to skip this part.

1. Press the pedal for the desired dead zone. Do not press the pedal if you would rather have no dead zone. The LED will pulsate red to indicate it has reached maximum.
2. Release the pedal.
3. Click | to accept and the LED will pulse green 2 times to confirm, or click || to skip/cancel.

The controller will exit program mode and return to normal operating mode and should show a “heartbeat”.

Option 4 – Calibrate Brake Pedal

The LED will pulse red 1 time indicating you are at Max Limit (Sensitivity) setting. You may click || if you want to skip this part.

1. Press the pedal to the maximum force you desire. It does not have to be all the way. The LED will pulsate red if you have reached the maximum range of the pedal.
2. Release the pedal.
3. Click | to accept and the LED will pulse green 1 time to confirm, or click || to skip/cancel.

The LED will pulse red 2 times indicating you are at Dead Zone setting. You may click || if want to skip this part.

1. Press the pedal to the end of the desired dead zone. Do not press the pedal if you would rather not have a dead zone. The LED will pulsate red to indicate it has reached maximum.
2. Release the pedal.
3. Click | to accept and the LED will pulse green 2 times to confirm, or click || to skip/cancel.

The controller will exit program mode and return to normal operating mode and should show a “heartbeat”.

Option 5 – Calibrate Clutch Pedal

The LED will pulse red 1 time indicating you are at Max Limit setting. You may click || if you want to skip this part.

1. Press the pedal to the maximum travel you desire. It does not have to be all the way down. The LED will pulsate red if you have reached maximum range of the pedal.
2. Release the pedal.
3. Click | to accept and the LED will pulse green 1 time to confirm, or click || to skip/cancel.

The LED will pulse red 2 times indicating you are at Dead Zone setting. You may click || if want to skip this part.

1. Press the pedal to the end of the desired dead zone. Do not press the pedal if you would rather not have a dead zone. The LED will pulsate red to indicate it has reached maximum.
2. Release the pedal.
3. Click | to accept and the LED will pulse green 2 times to confirm, or click || to skip/cancel.

The controller will exit program mode and return to normal operating mode and should show a “heartbeat”.

Option 6 – Clutch Enable/Disable

1. Click | according to the setting you desire.

Click 1 Time	Enable the Clutch Pedal
Click 2 Times	Disable the Clutch Pedal

2. After 3 seconds, the LED will flash indicating the selection you made.
3. The controller will exit program mode and return to normal operating mode and should show a “heartbeat”.

Note: Failing to click or clicking more than 2 times results in a long red flash and the controller returns to normal operating mode.

Option 7 – Handbrake Mode

- Click | according to the setting you desire.

Click 1 Time	Set Handbrake to Analog
Click 2 Times	Set Handbrake to Digital
Click 3 Times	Disable Handbrake

- After 3 seconds, the LED will flash indicating the selection you made.
- The controller will exit program mode and return to normal operating mode and should show a “heartbeat”.

Note: Failing to click or clicking more than 3 times results in a long red flash and the controller returns to normal operating mode.

Option 8 – Calibrate Handbrake (must be done for analog and digital handbrake mode)

The LED will pulse red 1 time indicating you are at Max Limit setting. You may click | | if you want to skip this part.

- Pull the handbrake to the maximum travel you desire. It does not have to be all the way up.
- Release the handle.
- Click | to accept and the LED will pulse green 1 time to confirm, or click | | to skip/cancel.

The LED will pulse red 2 times indicating you are at Dead Zone setting. You may click | | if you want to skip this part.

- Pull the handle for the desired dead zone endpoint. Do not pull the handle if you would rather have no dead zone.
- Release the handle.
- Click | to accept and the LED will pulse green 2 times to confirm, or click | | to skip/cancel.

The controller will exit program mode and return to normal operating mode and should show a “heartbeat”.

Option 9 – Invert All Axis

- Click | according to the setting you desire.

Click 1 Time	Normal Axis (all axis are 0 at rest)
Click 2 Times	Inverted Axis (all axis are 1023 at rest)

- After 3 seconds, the LED will flash indicating the selection you made.
- The controller will exit program mode and return to normal operating mode and should show a “heartbeat”.

Note: Failing to click or clicking more than 2 times results in a long red flash and the controller returns to normal operating mode.

Option 10 – Throttle Pedal Smoothing

- Click | according to the setting you desire.

Click 1 Time	No Throttle Smoothing
Click 2 Times	Light Throttle Smoothing
Click 3 Times	Medium Throttle Smoothing
Click 4 Times	Heavy Throttle Smoothing

- After 3 seconds, the LED will flash indicating the selection you made.
- The controller will exit program mode and return to normal operating mode and should show a “heartbeat”.

Note: Failing to click or clicking more than 4 times results in a long red flash and the controller returns to normal operating mode.

Option 11 – Brake Pedal Smoothing

- Click | according to the setting you desire.

Click 1 Time	No Brake Smoothing
Click 2 Times	Light Brake Smoothing
Click 3 Times	Medium Brake Smoothing
Click 4 Times	Heavy Brake Smoothing

- After 3 seconds, the LED will flash indicating the selection you made.
- The controller will exit program mode and return to normal operating mode and should show a “heartbeat”.

Note: Failing to click or clicking more than 4 times results in a long red flash and the controller returns to normal operating mode.

Option 12 – Throttle Linearity

- Click | according to the setting you desire (see table at right).

Click 1 Time	Flat
Click 2 Times	A Weighted (recommended)
Click 3 Times	B Weighted
Click 4 Times	AB Weighted

- After 3 seconds, the LED will flash indicating the selection you made.
- The controller will exit program mode and return to normal operating mode and should show a “heartbeat”.

Note: Failing to click or clicking more than 4 times results in a long red flash and the controller returns to normal operating mode.

Option 13 – Brake Linearity

- Click | according to the setting you desire (see table at right).

Click 1 Time	Flat
Click 2 Times	A Weighted
Click 3 Times	B Weighted
Click 4 Times	AB Weighted (recommended)

- After 3 seconds, the LED will flash indicating the selection you made.
- The controller will exit program mode and return to normal operating mode and should show a “heartbeat”.

Note: Failing to click or clicking more than 4 times results in a long red flash and the controller returns to normal operating mode.

Option 14 – Clutch Linearity

- Click | according to the setting you desire (see table below).

Click 1 Time	Flat
Click 2 Times	A Weighted
Click 3 Times	B Weighted (recommended)
Click 4 Times	AB Weighted

- After 3 seconds, the LED will flash indicating the selection you made.
- The controller will exit program mode and return to normal operating mode and should show a “heartbeat”.

Note: Failing to click or clicking more than 4 times results in a long red flash and the controller returns to normal operating mode.

Option 15 – Handbrake Linearity

- Click | according to the setting you desire (see table below).

Click 1 Time	Flat
Click 2 Times	A Weighted
Click 3 Times	B Weighted (recommended)
Click 4 Times	AB Weighted

- After 3 seconds, the LED will flash indicating the selection you made.
- The controller will exit program mode and return to normal operating mode and should show a “heartbeat”.

Note: Failing to click or clicking more than 4 times results in a long red flash and the controller returns to normal operating mode.

Option 16 – Heartbeat Mode

- Click | according to the setting you desire.

Click 1 Time	Enable
Click 2 Times	Disabled

- After 3 seconds, the LED will flash indicating the selection you made.
- The controller will exit program mode and return to normal operating mode and should show a “heartbeat”.

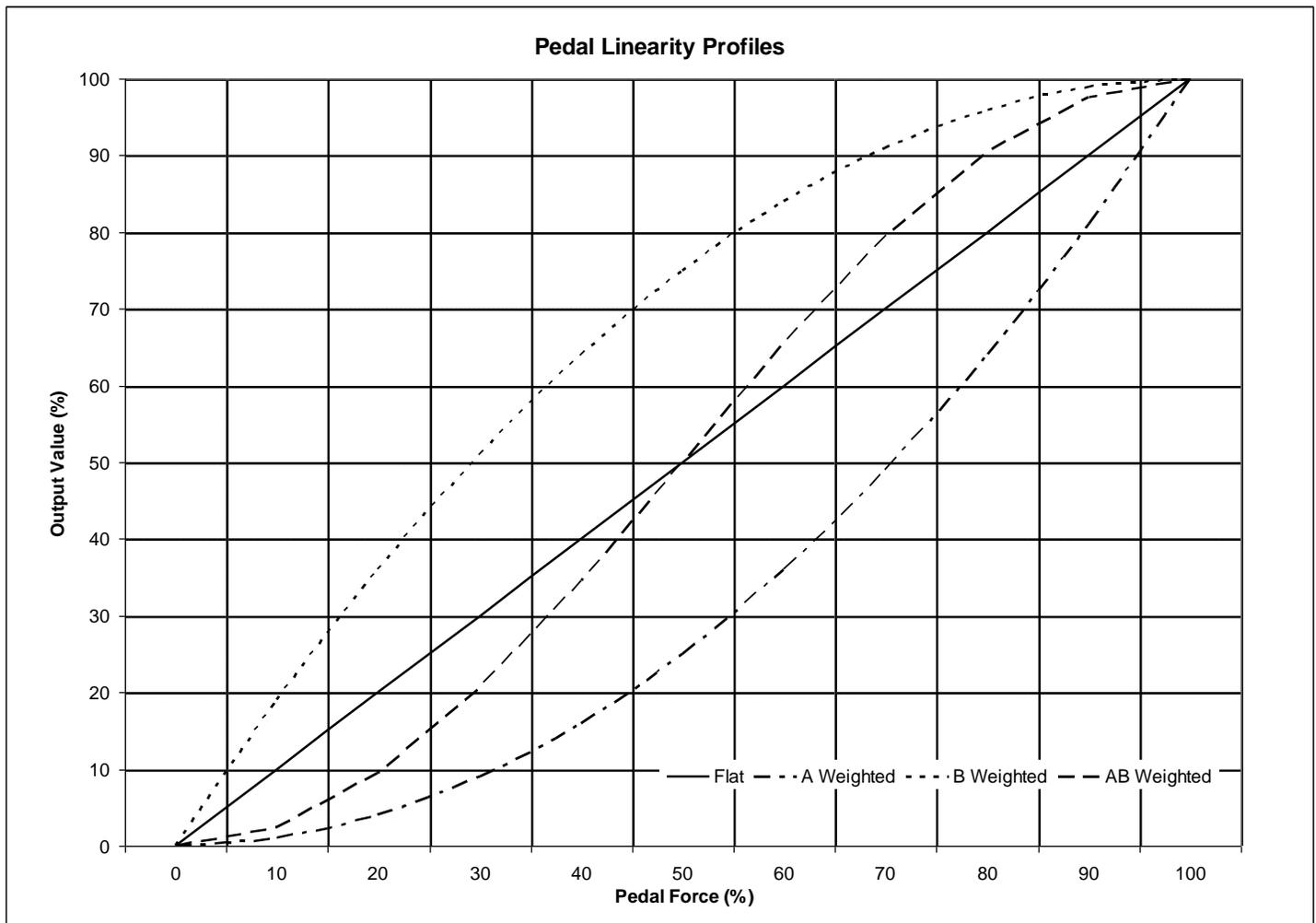
Note: Failing to click or clicking more than 2 times results in a long red flash and the controller returns to normal operating mode.

The Concept of Linearity Curves

Linearity curves allow the pedal axis to be tailored to allow better modulation at various ranges throughout the pedal travel or force application. For instance, on a certain track, you may prefer to have better modulation at the low-end of the throttle range to help with slippery turns or perhaps you prefer to have better modulation at the high-end of the throttle range to better control over-steer. At first, these linearity profiles may appear to act like “cheats” in order to compensate for car or track conditions. In reality, these linearity profiles replicate various adjustments which can be done in a real race car and tailored to the driver’s preferences. Throttle response linearity can be adjusted to your preference much like it can easily and legally be done in a real race car by using different throttle cams or fuel mappings. Brake linearity can easily be modified in a real race car by changing brake pad compounds and rotor machining and the brake pedal on your Real-Gear pedals can be adjusted to replicate a similar level of customization.

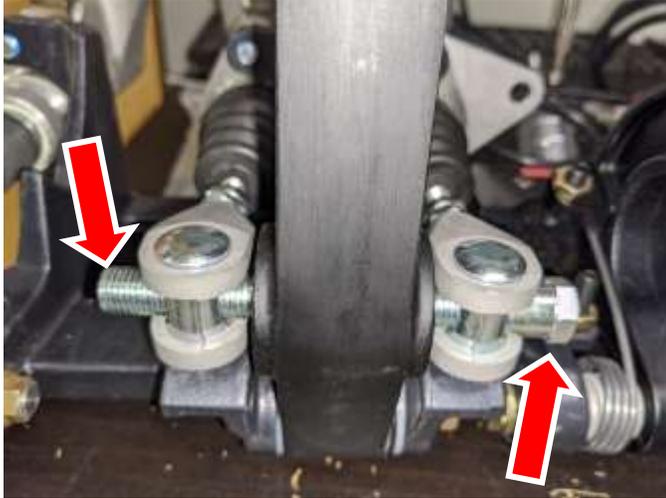
The curves below are a representation of the four available linearity profiles available for each pedal. Effectively, the closer to horizontal the curve is, the greater the level of modulation while the more vertical the curve is, the lesser the level of modulation. Of course, there is always a trade-off; when modulation is increased at one area of pedal travel, it must be reduced in another area. The flat curve, as it implies, has equal modulation throughout its range. The A-weighted curve has increased modulation near the end of its range, while sacrificing modulation toward the beginning of its range.

It is best to try all the curves with different cars and tracks until you find the one that helps you achieve faster lap times. It is not uncommon to find that different linearity profiles work best on different car and track combinations. Adjusting the linearity curves is much like tailoring a car setup to a different track, there is no one correct curve.



Adjusting the Brake Pedal Firmness

The firmness can be adjusted by turning the “bias” screw. Loosening the bias locknut and turning the screw clockwise will make the pedal firmer, while turning the screw counter-clockwise will make the pedal softer. It is possible to add a remote bias adjuster to perform this operation while sitting in the driver’s seat. Tighten the locknut when adjustments are complete to prevent the adjustment from changing.



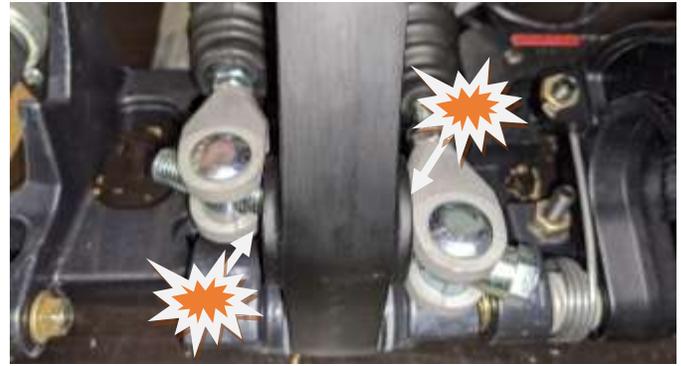
It is recommended to first adjust the pedal firmness to your liking first, then calibrating the point of maximum braking electronically (100% braking).



An optional brake tuning kit is available for those that want to tailor the sensation of the brake pedal. The kit includes two soft bushings (orange), two medium bushings (black), and one hard spacer. When these are used in conjunction with the original bushings (hard red bushing and extra-hard black bushing) there are 10 combinations possible.

The pedals are set up so that the master cylinder on right is at its firmest, while the master cylinder on the left is set softer and can be adjusted by changing bushings. The “bias” adjustment allows the user to make the pedal favor the soft side or the firm side. This is how infinite adjustability is achieved.

Care should be taken when softening the brake pedal to be sure mechanism does not bind causing strain to the pedal and master cylinder assembly. In the extreme position the pedal can achieve be certain the knuckles do not bind against both sides of the pedal arm. The mechanism can slide side-to-side so at least one side needs to have clearance.



When placing the bushings on the slave cylinder, it does not matter in which position they are placed, the resulting firmness is the same. Use the table below to achieve the desired firmness, where 1 is the softest combination and 10 is the firmest combination.

Bushings Combinations		
Bushing 1	Bushing 2	Firmness Rating
Stepped Black	Hard Spacer	10
Stepped Red	Hard Spacer	9
Cylindrical Black	Hard Spacer	8
Cylindrical Orange	Hard Spacer	7
Stepped Black	Stepped Red	6 (Stock)
Stepped Black	Cylindrical Black	5
Stepped Black	Cylindrical Orange	4
Cylindrical Black	Cylindrical Black	3
Cylindrical Black	Cylindrical Orange	2
Cylindrical Orange	Cylindrical Orange	1

This pedal set has the ability to replicate the pedal firmness of various styles of race cars. There are many factors that affect the way a pedal should feel based on the type of car being simulated. In a white paper titled "Brake Systems and Upgrade Selection" published by Stephen Ruiz, Engineering Manager and Carroll Smith, Consulting Engineer at StopTech LLC, all aspects of a high performance racing brake system are discussed. The full document is available at:

<http://www.stoptech.com/technical-support/technical-white-papers/brake-system-and-upgrade-selection>

For our purposes, we are only interested in the section about brake firmness and modulation. Here is an excerpt as it applies to racing simulators:

BRAKE PEDAL FIRMNESS AND MODULATION

The human brain/body system modulates most effectively by force, not by displacement. The side control sticks on current fighter aircraft hardly move. The feel of the brake pedal should approach the firmness and consistency of a brick. There are several factors at work here:

1) Brake hoses: Optimum pedal firmness cannot be achieved with the stock fabric reinforced rubber flexible hoses which swell under pressure - decreasing pedal firmness while increasing both pedal travel and brake system reaction time. The first step in upgrading the braking system of any vehicle is to replace the OEM flexible hoses with. . .

2) Master cylinders and Caliper piston diameters: While it is true that the most effective master cylinder arrangement is the twin cylinder with adjustable bias bar that is universal in racing, replacing the OEM master cylinder on a road going car is simply not practical. When selecting an aftermarket system, make sure that the caliper bores are designed for the specific application.

3) Disc run out and thickness variation: Run out in excess of six thousandths of an inch (0.006") can be felt by the driver as can more than 0.001" of thickness variation and any amount of material transfer from overheated pads. Run out is caused by poor design of either vanes or the junction between the friction surfaces and the mounting bell, by poor machining, by thermal stress or by any combination of the three.

4) Caliper and caliper mounting stiffness: Clamping force tries to open the opposing sides of the calipers - resulting in a longer than optimum pedal travel and uneven pad wear. The only solution is optimal mechanical design and material selection - there is no effective development fix for "soft" calipers. . .