Using the Tekin RS / RS Pro with HotWire

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1. Introduction

Tekin improves the RS and RS Pro speed controls via firmware updates, applied by a Windows program called HotWire. Tekin shares the firmware updates with its customers at no charge. However the documentation of the firmware update process and of the firmware's features does not keep up with the pace of the improvements.

This document, drawn from Tekin's documentation, Tekin's forums (http://www.teamtekin.com/forums/) and from the Tekin RS thread on rctech (http://www.rctech.net/forum/electric-road/218152-tekin-rs-esc-sensored.html) , is intended to help other users of the RS and RS Pro. If you find errors or have suggestions for improving this document, send them by PM to MarkBrown on rctech.

This document is not intended to replace Tekin's documentation; it is a supplement.

This version of the document is current with HotWire version 3.32.2 and the "Vegas" release of firmware version 200. These are not available on the Tekin web site. Section 3 contains instructions for obtaining these versions of HotWire and firmware.

This document uses the term *RS* for the RS and the RS Pro collectively.

2. Basic concepts

2.1. HotWire: What is it?

The term *HotWire* refers to two things:

- The HotWire interface (Tekin part #1450): A small device that is used in programming a Tekin speed control. The HotWire interface plugs into a USB port on a PC and accepts the receiver plug from a Tekin speed control, such as the RS.
- The HotWire program: A Windows application that is used to update a Tekin speed control via the HotWire interface. The HotWire program is revised periodically to fix bugs and add functionality. The current released version is always available at http://www.teamtekin.com/hotwire.html .

In this document, most uses of the term HotWire are qualified: either "the HotWire interface" or "the HotWire program." When the term appears unqualified, its meaning should be evident from context.

2.2. RS firmware

The RS contains a microprocessor; the behavior of the RS is determined by *firmware* contained in the RS plus *configuration settings* of the firmware. Firmware consists of microprocessor instructions and static data; configuration settings consists of user-changeable variables, like *Drag Brake* and *Neutral Width,* read by the firmware.

The RS supports update of firmware and configuration settings via HotWire. Some configuration settings can also be updated by pressing buttons on the RS; other configuration settings, and firmware, can only be updated via HotWire. If you want to update these things at the track (you probably will), you'll need to have a PC and HotWire at the track.

2.3. HotWire and firmware versions

Different versions of HotWire, and different versions of firmware, have different features and behave differently. So it can be confusing to think you are running one version when you are really running another. That's why every version of HotWire and firmware is named by a unique version number. (Alas, Tekin still releases different firmware versions named by the same version number, despite pledging not to. Thus there are two different "version 200" firmware releases, the original one and the "Vegas" one; they both call themselves "version 200".)

HotWire version numbers contain dots; firmware version numbers do not.

The current (12/24/2009) version of HotWire is 3.32.2, and of firmware is 200. Version numbers always get larger as new versions are released; in HotWire version numbers, either the number before the dot is the same and the number after the dot increases, or the number before the dot increases. For instance, HotWire 2.9 was followed by 2.15, which *is* larger than 2.9 (though it might not look that way at first) because 15 > 9; version 3.24 is larger than either of these because 3 > 2. Successive released versions of the speed control firmware were numbered 180, 183, 189, 194, and 198. Firmware version 200 is in beta.

To determine the HotWire version running on your PC, use the *help* button on the HotWire portal screen, described in Section 5.2.

To determine the firmware version running on your RS, use the *view versions* button on the main HotWire screen, described in Section 5.3.

HotWire carries the firmware inside it; you can't obtain firmware as a file separate from HotWire. The only way to obtain a new firmware version is to update to a new HotWire version that contains the new firmware. This linkage makes sense if you consider that sometimes the firmware introduces new configuration settings (e.g. *Turbo Boost*, introduced in firmware version 200), and when this happens HotWire must be extended to let you change the new configuration settings.

Each HotWire version carries several firmware versions. That way, if you try the latest firmware, you can still roll back to an earlier firmware version without installing an older HotWire version. But running a new HotWire with old firmware can be confusing, since HotWire will display all of the settings that apply to the latest firmware, and some of these settings might not apply to the old firmware you are running.

To determine the set of firmware versions available for your RS, use the *view versions* button on the main HotWire screen, described in Section 5.3.

If you update HotWire to get a new firmware version, you must then update the firmware of your RS in order to actually *use* that firmware version. The HotWire UI may be showing you configuration settings specific to the new version, and it may happily update your RS with those settings, but that does *not* mean your RS has that firmware version. And the older firmware will silently ignore the new settings you have made.

To update the firmware of your RS, use the *view versions* and *update ESC* buttons on the main HotWire screen, described in Section 5.3.

3. Installing and updating the HotWire program

It is best to run HotWire on a laptop, both so you can take it to the track and so that the laptop battery will keep HotWire running during a firmware upgrade, even if somebody blows a fuse or unplugs your laptop's AC adapter. Interrupting a firmware upgrade can leave you with a broken RS that you'll have to send to Tekin for repair.

Don't plug the HotWire interface into your computer without installing the HotWire program first. Installing the HotWire program first ensures that the correct device driver becomes associated with the HotWire interface when you plug it in.

Some version of HotWire is always available at http://www.teamtekin.com/hotwire.html . Click the download link, and when Windows asks you whether to open, save, or cancel, choose save. Save it someplace where you'll be able to find it, like on your desktop.

At the present time, the most up-to-date version of HotWire ("200 Vegas", the version described in this document) is available only on request to rpike@teamtekin.com . Tekin's reason for distributing HotWire this way is to make is more likely that people read the instructions for using the newer firmware features ("boost" and "turbo") and don't wreck motors by overheating them. You'll receive HotWire as an attachment to an email message. The attachment purports to be a .txt file but isn't; Tekin does this to avoid problems with email filters. If you receive Hotmail via email and aren't sure how to change the .txt file attachment into a .zip file, watch this video: http://www.youtube.com/watch?v=tTp3tUL9u8Y .

HotWire is distributed as a .zip (compressed) file. Both Windows XP and Windows Vista include software that supports the .zip file format. Open the zip file, then copy all of the files inside to some new folder. I recommend giving this folder a name that's specific to the HotWire version, say "HotWire 3 32 2" for the 3.32.2 version. That way you can easily keep two versions: the current one and the "last known good" to revert to in case of problems. Once you've copied the contents of the zip file to a folder, delete the zip file. You can also delete the *autorun.inf* file from the folder.

To install HotWire, open (double-click) the file *setup.bat* (it is a very small file whose icon contains little gears) in the directory you just created, and click "run" if you get a security warning. *setup.bat* first uninstalls the version of HotWire that's currently installed, if any; then it installs this version of HotWire. Click "next" to all the prompts that the installer shows you, then click "close" on the final installer screen, and you've got HotWire!

There's a problem on Vista (and presumably on Windows 7 as well). If you run with User Account Control (UAC) turned on, HotWire's uninstaller does not fully uninstall the currently installed version, so the new version cannot fully install. Here is the work-around (the video above also covers this work-around). If HotWire is already installed, before opening *setup.bat*:

1. Open Control Panel, type "programs" in the search box, then click the "Programs and Features" link that appears. You'll see a list of installed programs.
2. Highlight *Tekin HotWire*, click Uninstall, and follow instructions.
3. Windows Explorer has a feature called "Show Hidden Files and Folders." If this feature is not enabled, enable it by:
    a. Open Control Panel, type "folder" in the search box, then click the "Folder Options" link that appears. A Folder Options dialog appears.
    b. You'll see three tabs at the top of the dialog; click "View".
    c. Scroll down the list of view settings and under "Hidden Files and Folders", click the "Show Hidden Files and Folders" radio button. Then click OK.
4. Now browse to C:\Users\[USERNAME]\AppData\Local\VirtualStore\Program Files where [USERNAME] is your username. If this folder contains a "Tekin HotWire" folder then delete that folder.
5. If you want to hidden files and folders to be hidden again, go revert the change you made to the Folder Options.
6. Reboot. When you system comes back up, open *setup.bat* and HotWire will install correctly.

You can avoid all this by turning UAC off before installing HotWire the first time. If you prefer to use UAC, by all means leave it turned on, but you'll have to work around the HotWire uninstaller bug as just described until Tekin fixes it.

With the HotWire program installed you can plug the HotWire interface into any USB port on your computer. Windows plug and play will find the correct driver automatically. The HotWire interface is regarded as a "USB Human Interface Device" by Windows. Each time you plug HotWire into a USB port that it hasn't been plugged into before, you'll experience a small delay as Windows plug and play does its thing. This is normal.

Tekin publishes a page containing help for solving installation problems: http://www.teamtekin.com/hotwire/installhelp/hotwirehelp.html . If you experience weird behavior while running the HotWire program (e.g. "cannot connect to database" messages), go to the Tekin install help page to download and install updates to the Microsoft .Net Framework, MDAC, and Windows Installer.

4. Connecting the RS to the HotWire interface

The first rule of HotWire is:

Never connect the RS to the HotWire interface while the HotWire interface is connected to (and therefore powered by) your PC.

So: first connect your RS to the HotWire interface, then connect the HotWire interface to your PC.

To connect your RS to the HotWire interface:

Disconnect the battery from your RS; the HotWire interface will supply the small amount of power that your RS needs.

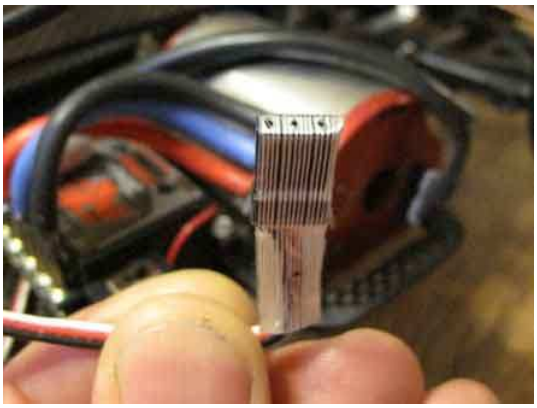
The RS power switch can be on or off. The motor can be connected or not.

Unplug your RS's receiver plug from your receiver, and plug it into the HotWire interface.

Plugging HotWire into external hubs is less reliable, so always plug your HotWire directly into a USB port on your computer.

With everything plugged in correctly and HotWire running, a green LED on the HotWire will blink, as will a red LED on the RS. With only the HotWire interface plugged in (no RS) and HotWire running, a green LED on the HotWire will be lit (not blinking).

The RS's receiver plug is JR style, and the HotWire interface's socket is Futaba style, so it is possible to plug the RS in backwards. No damage to the HotWire interface or the RS will result from doing this, but HotWire won't work, either. Match up the wire colors as you plug in, or, better, replace the plug with a Futaba if your receiver accepts Futaba plugs.



Disconnection is the reverse of connection. Unplug from the PC first (powering down the Hotwire interface), then unplug the RS from the Hotwire interface.

You will be unplugging the RS's receiver plug from your receiver more often than usual, in order to plug it into HotWire. Wrap a piece of thin strapping tape (the cheap *thin* tape, not the thick tape you might use to hold down batteries) around the receiver plug and up the receiver wires, and poke holes as shown in the photo. This "pull tab" gives you something to grab onto that's OK to grab; it is *not* OK to grab the receiver wire without using the tab as strain relief. (Some folks like using an extension cable to get the RS's receiver plug away from the receiver; such a cable is called an "aileron extension" in the RC plane world.)

The plastic case on the HotWire interface interferes with plugging the mini USB plug in all the way. It usually works anyhow. If it does not work for you (the HotWire program does not detect

the HotWire interface), carefully trim a small amount of plastic from the case to allow the mini USB plug to get farther into its socket.

5. Using the HotWire program

5.1. Startup

The process of installing HotWire creates a HotWire shortcut (whose icon is a red “T” for Tekin) on your desktop. (It does not create a start menu entry, so don’t lose the shortcut. To create a start menu entry for HotWire, simply copy the HotWire shortcut to your start menu directory, as documented in http://en.wikipedia.org/wiki/Start_menu#Technical_details .) Double-click on this shortcut to run HotWire.

5.2. HotWire portal window

If you run HotWire before connecting the HotWire interface to your PC, HotWire displays the message "Unable to find HotWire" and exits. The same thing happens if you unplug the HotWire interface while HotWire is running.

If you run HotWire with the HotWire interface connected, but no RS connected to the HotWire interface, HotWire displays its *portal screen*. The main thing on the portal screen is an animation showing the 1 – 2 sequence for plugging in the RS and the HotWire. The screen contains three buttons:

> *updates*: Checks with Tekin for updates (requires an internet connection).
>
> *help*: Displays the HotWire version number and product support contact information.
>
> *exit*: Exits HotWire.

5.3. Main HotWire window

If you run HotWire with your RS connected to the HotWire interface and the HotWire interface connected to your PC, HotWire detects the RS and displays an RS-specific “skin” (graphical background) for the main HotWire window.

If the firmware in your RS is not the latest firmware supported by this version of HotWire, HotWire will display the message:

> Your Speed Control contains software that may not be compatible with this HotWire.

After awhile the message goes away and you can use HotWire. The message is trying to warn you that HotWire might display settings that the firmware in your RS does not understand. If you upgrade to the latest firmware version, as described later in this section, you’ll stop seeing this message.

The unfamiliar appearance of the main HotWire window (for instance, the window lacks a title bar, and parts of the window are transparent) means you have to learn basic things over again to

use HotWire. To move the HotWire window around on the screen, drag the upper-right corner of the window. To close the window, exiting HotWire, click on the huge "X" near the upper-right corner of the window. I haven't found any way to minimize the HotWire window except to minimize *all* windows, e.g. by right-clicking the taskbar (the bottom area of the Windows screen) and selecting "Show the Desktop" from the context menu that appears.

The HotWire user interface deviates from normal Windows conventions in several more ways. Many elements of the user interface are blank until you hover the cursor over them, at which point they light up. The user interface displays elements that appear to be sliders, but you can't adjust them by sliding them. (Sometimes I can make them slide a little, but they don't work like a normal slider.) Most but not all sliders contain a context menu. Dialog boxes have time-outs, and in some cases there is no other way to close the dialog (and exit its mode) than to wait for its time to expire. Dialog boxes can be obscured by the windows of other applications. One dialog box is integrated visually with the main window, and cannot be dismissed. Non-modal UI elements including balloon help and up/down adjusters also have time-outs. One button (*apply settings*) that updates the RS is guarded by a confirmation dialog, but the other (*update ESC*) is not. The only form of help is pop-up balloons, but not all buttons have help balloons. Fortunately, the tasks you perform using HotWire are sufficiently simple that you will adapt to its peculiar user interface pretty quickly.

One simple rule will ease your use of the main HotWire window: Minimize all other windows before using HotWire. That way you won't miss a dialog box because it is hidden beneath some other application's window.

Here's how the main window works. There are check-boxes on the right side of the window for

Reverse Motor (Section 6.1)
1S LiPo (Section 6.2)
Sensored (Section 6.3)
Dual Mode (Section 6.3)

The latter two check-boxes are linked together: Checking one un-checks the other, so exactly one of the two is always checked.

After you click anywhere on the window (the upper right corner is always safe) to give it the focus, hovering the cursor over the name of any setting (*Drag Brake*, etc.) causes HotWire to display a balloon that briefly explains the setting. The balloons time out and disappear, but by moving the cursor away and then hovering again you can get the balloon to come back so you can read some more.

To adjust a setting that's represented as a slider you click either the up arrow (appears in the blank rounded-corner square above the slider when you hover there) or the down arrow (in the similar square below the slider), or you right-click the slider to obtain a context menu where you can select certain pre-set values. For instance, right-clicking the *Motor Type* slider displays a menu containing the names of the six possible values, so you needn't remember the mapping of names to numbers. (For some reason, right-clicking the *Timing Advance* and *Turbo Boost*

sliders does not display a menu, even though when you hover over these sliders they promise to.)

For *Voltage Cutoff*, to set a custom value you click the up arrow enough times and then a tiny number appears with little up and down triangles next to it. Clicking those triangles increases or decreases the custom cutoff value by a small amount (less than 0.1 volt).

I do not know how to create a custom *Throttle Profile* using HotWire; perhaps it is not possible yet.

The *Timing Advance* slider in dual mode is replaced by the *Timing Boost* and *Turbo Boost* sliders and *Turbo Delay* field in sensored-only mode; see Section 6.3.

There are four buttons to the right of the sliders for performing various actions. These buttons have no help balloons, so you need to know what they do:

> *current settings*: The UI displays the current settings, as read from the RS. So, for instance, if your RS is in dual mode the dual mode checkbox will be checked, the *TA* slider will be set to whatever *TA* is set in your RS, etc.
>
> *show defaults*: The UI displays the default settings values for the firmware version running in your RS.
>
> *view versions*: The right side of the window "slides out" to display the current firmware version of the RS, plus a list of available ("other") firmware versions. In this list, the current firmware version is selected initially; to select another version, in order to update the RS to that version using *update ESC* (below), click on the version you want. There is no way to make this display disappear once you've used *view versions*.
>
> *apply settings*: writes current settings values as displayed in the UI to the RS. You have to confirm that you really want to do it by clicking the *OK* button on a confirmation dialog that appears. The *OK* button is not visible until you hover over it. And you may need to click the *OK* twice, once for focus and once more to make it happen. It is not necessary to perform radio calibration (Section 9.2) after applying new settings, unless you've adjusted *NW*, in which case a calibration is a good idea.

Clicking the *view versions* button exposes the *update ESC* button. Clicking this button writes the currently-selected firmware version to the RS. This action has no confirmation dialog, and takes about one minute, during which time HotWire and the RS ***must not*** be disturbed. ***Do not unplug the RS or the HotWire while* update ESC *is running*.** Interrupting a firmware upgrade can leave you with a broken RS that you'll have to send to Tekin for repair. Always perform radio calibration (Section 9.2) after updating firmware.

6. RS behavior introduced after the manual was written

6.1. Reverse motor mode

In reverse motor mode, forward throttle makes the motor shaft turn clockwise (as seen when looking at the shaft end of the motor).

6.2. 1S LiPo mode

The voltage regulator in the RS will not "step-up" the 3.7 volts from a 1S LiPo pack to the 5-6 volts needed to operate the RS (not to mention a servo and certain receivers). Therefore when running a 1S LiPo you need either a receiver pack or an external voltage regulator.

With the RS in normal mode, when running with a receiver pack or external voltage regulator, you leave the speed control switch in the *off* position and power the RS from its receiver plug. The receiver pack or external voltage regulator has its own switch, and you use that switch to turn your car on and off. However the RS cannot provide voltage cutoff in this mode, so you run the risk of over-discharging your 1S LiPo.

With the RS in 1S LiPo mode, you leave the speed control switch in the *on* position, and the RS's voltage cutoff functions normally.

If you run a step-up voltage regulator containing its own voltage cutoff (e.g. the Novak 5474) then leave the RS in normal mode with the RS's switch in the *off* position.

6.3. Dual mode and sensored-only mode

The RS's firmware contains a brushless mode: dual or sensored-only.

In dual mode (the default), the RS uses the sensors only at very low speeds; then it changes to a fixed amount of timing advance (Section 6.3.1), determined without using the sensors. (The RS uses the voltage of the undriven phase wire, plus a bunch of software, to figure the timing without sensors.) If not all of the sensors are working (e.g. cable damaged) or the motor is sensorless, the RS does not use sensors at all in dual mode. Without sensors, you may notice the car go slightly in reverse before going forward when starting from a dead stop; this is not what you want at the start of a race! Dual mode avoids this bad behavior if sensors are available.

In sensored-only mode, the RS uses the sensors all the time (so long as they are working). To oversimplify: at low speeds it uses motor timing only, at medium speeds it uses motor timing plus boost timing (Section 6.3.2), and at high speeds it uses motor timing plus boost timing plus turbo timing (Section 6.3.3). Boost and turbo help spec motors like 10.5, 13.5, 17.5, and 21.5 turn perform at their best. Sensored-only mode has stronger brakes than dual mode.

In sensored-only mode, if the sensors are not working the RS switches silently to dual mode so it can continue running without sensors.

6.3.1.Timing Advance (dual mode): range 0 - 100

The firmware has a built-in notion of the maximum possible timing advance when running in dual mode; it is somewhere around 25-30 degrees. The *Timing Advance* setting is a percentage of this maximum. So to use half the maximum you'd set *TA* to 50, and to use maximum timing advance you'd set *TA* to 100.

TA has no effect on the motor's timing while running at very low RPMs using the sensors. The timing advance set in the motor is used during the sensored phase of dual mode. The sensored phase is very short: only a few inches of car movement.

If running in sensored-only mode it is a good idea to set *TA* to zero in case you have a sensor failure. With *TA* set to zero you'll notice the failure (by the performance loss) and you won't cook your motor. To set *TA* you check *dual mode*, set *TA*, then check *sensored* again.

6.3.2. Timing Boost (sensored-only mode): range 0 – 30

Timing Boost (typically called *boost* for short) is the number of degrees of timing advance that is added, under certain conditions, to the motor timing (the timing advance set in the motor) during sensored-only mode. The boost timing is not added at low throttle settings (the driver is *not asking* for more speed) or when the motor is drawing a lot of current (the car is *accelerating hard* and the extra timing would overheat the motor). The boost is added when near full throttle and drawing moderate current (medium to high speed). Boost timing is not added all at once, but the timing ramp-up is very fast, so it seems to be added all at once.

Section 8.1 discusses motor timing.

Notice that *Timing Boost* (sensored-only mode) is expressed in degrees while *Timing Advance* (dual mode) is expressed as a percentage.

6.3.3. Turbo Boost (sensored-only mode): range 0 – 20

Turbo Boost (typically called *turbo* for short) is the number of degrees of timing advance that is added, under certain conditions, to the motor timing and the boost timing during sensored-only mode. The turbo timing is added after the throttle has been wide-open (WOT) for a specified number of seconds, the *Turbo Delay (TD)*. The turbo timing is not all added in immediately after the turbo delay; it ramps up over a period of about a second. If you lift the throttle for more than an extremely short interval, the turbo timing is removed until the next time you apply WOT and hold it for *TD* seconds.

The delay *TD* is at least two-tenths of a second, the default, and can be increased from there in increments of a tenth-second. The only difference between the "Vegas" version 200 firmware and the previous version 200 is this minimum delay; it used to be a half-second.

The intent of turbo is to add speed at the end of long straight sections. There are not many such sections in most tracks so the added timing does not add significant heat to the motor, but the turbo still can give a significant performance advantage on long straights.

6.4. Stronger drag brakes

Current RS firmware gives a larger range of drag brake adjustment than the original firmware. With the original firmware, setting *DB* to the max (13) via the buttons gave 50% brake strength, but 50% proved too weak for use with some of the spec motors. With current firmware, setting *DB* to the max (13) gives 70% brake strength. With HotWire and current firmware you can set *DB* to 100% if you want. *DB* = 100 is intended for use by crawlers but can be used for any application.

6.5. Push Control

Push Control is a feature that continues applying a programmed amount of forward throttle for a period of time after the throttle returns to neutral from forward.

Current RS firmware supports Push Control in both brushed and brushless modes; the original firmware supported Push Control only in brushed mode.

There's a current fashion in 1/12th to run a little push in order to help carry more corner speed.

7. RS installation topics

The capacitor is part of the RS; it helps keep the RS cool. You must install it. If you plan to race mod TC, or *any* type of mod racing with 5.5 turn and lower brushless motors, you should buy a second capacitor from Tekin (part #3520 gets you two) and install it in parallel to the first one. If you don't do this, you run the risk of popping the capacitor and then damaging the RS. Insulate the capacitor leads with the included tubing to prevent shorts. The capacitor is marked with a dark crescent on the negative side. The negative lead is also shorter than the positive one.

When running the RS from a 1S LiPo you must run either a voltage booster or a receiver pack, otherwise the RS won't work. See Section 6.2 for 1S LiPo mode.

When soldering a wire to one of RS's solder posts, it is better to use a hotter iron for a shorter time than a colder iron for a longer time, to reduce heat transfer through the post to the interior of the RS. If you heat a post for too long you could damage the RS. Tin the wire, tin the top of the post, heat the wire while resting it on the top of the post, then heat the post. Some rosin flux helps the heat transfer. The wire can be oriented vertically (butt joint) or horizontally.

The RS's solder posts function as heat sinks, so do not remove them in an attempt to save weight, and do not cover them with shrink wrap or anything else. The posts are soldered to the PC boards using special high-temperature solder so you will likely damage the RS trying to remove them. The wires attached to these posts also dissipate some heat, though the insulation on these wires reduces their effectiveness as heat sinks; thicker wires are a bit more effective than thinner ones. To run mod TC with 4.5 turn and lower brushless motors, you should install a small fan blowing on the solder posts to keep ESC temps down for improved reliability and efficiency. If you aren't convinced you need a fan, make short runs at first and monitor the RS's internal temperature using the LED display as described in Section 9.7.

The RS is not waterproof, so to run it in wet conditions you must enclose it to keep it dry. In wet conditions the RS won't be working so hard, so heat dissipation should not be a major issue, but pay attention.

The RS Pro's weight without power wires is only about 35 grams. So be sure to re-balance and re-ballast your car after installing the new ESC.

8. RS tuning

8.1. Timing and its effects

ESC tuning is largely about timing. So it helps to understand the effects of timing before getting into the specifics of tuning.

Timing defined

To understand what timing is you must understand how the brushless motors used in RC cars work, which gets pretty technical. You don't absolutely need to understand what timing is (my explanation probably contains errors); if you don't care to wrap your head around this stuff, skip to the next section, on timing effects.

For background on brushless motors, read http://en.wikipedia.org/wiki/Brushless_dc_motor and http://www.motioncontrolonline.org/files/public/BrushlessOperation.pdf .

Our motors contain a single-pole rotor and three stator coils, connected in the "wye" configuration. (ROAR now allows "delta" motors in modified, but they are not common.) The ESC is capable of energizing (running current through) any *pair* of coils, in either polarity (direction of the current), producing six distinct magnetic field directions. Each of the six directions is used once on every rotation of the rotor; the ESC switches coil pairs and polarity every time the rotor turns 60 degrees.

A motor is neutral-timed if the rotor is 120 degrees from being aligned with the resulting magnetic field when the ESC begins energizing a pair of coils in a particular polarity, and is 60 degrees from being aligned when the ESC stops energizing them. In a neutral-timed motor rotating at constant speed, the rotor is at right angles (90 degrees) to the coils' magnetic field at the midpoint (in time) of the application of current to the coils. This is considered "neutral" because the right-angles alignment is the most efficient at turning the rotor (the magnetic turning force on the rotor varies as the sine of the angle between the rotor and the field).

Energizing the coils sooner than neutral is advanced timing; the number of degrees sooner is the amount of timing advance. Energizing the coils later than neutral is retarded timing; we never use retarded timing since it isn't helpful.

Timing effects

Increased timing advance (up to a point) causes the motor to produce more no-load RPM and to produce less torque. For a given final drive ratio (FDR), running with increased timing advance

produces more motor heat because of the lost torque. Increasing the FDR (in rough proportion to the timing increase) brings the heat back down to where it would have been without the increased advance. (Increasing the FDR too far has the opposite effect – motor heat increases *and* you lose top-end speed, a bad combination!) You might or might not be going faster around the track after increasing the timing and the FDR.

Decreased timing advance has the opposite effects: less no-load RPM and more torque. You can decrease the FDR without overheating because of the increased torque. You might or might not be going faster around the track after decreasing the timing and the FDR.

When running an ESC that does not vary the timing, like the Novak GTB, Novak's base recommendation (just a starting point for motor tuning) is to remove a pinion tooth for each 5 degrees of increased timing, and to add a pinion tooth for each 5 degrees of decreased timing.

Motor timing

The purpose of the sensors in a sensored motor is to measure the position of the rotor, i.e. the direction of the rotor's North pole. The motor contains three sensors, evenly spaced around the circle made by the end of the rotor. The position of these sensors relative to the three sensor coils determines the motor timing.

Here's Novak's explanation of motor timing on its Ballistic motors:

> *Our Ballistic motors come with their timing calibrated and set from the factory. Using custom built and calibrated electronic equipment we set each and every motor to 30 degrees of timing. After Calibration the timing label is added and this set timing corresponds to the "N" on the timing label on the side.*
>
> *Each line on the label denotes a 5 degree change, so the timing available on the motor the label corresponds as follows:*
>
> ```
> -3 -2 -1  N +1 +2 +3
> 15 20 25 30 35 40 45
> ```

So if you take a Ballistic motor with its timing set to "N", and hook it up to an ESC that does not vary the timing, like the Novak GTB, the ESC will run the motor with a constant 30 degrees of timing advance.

There's no doubt that Novak's way of setting motor timing is good, because it accounts for production tolerances in the positioning of the sensors and of the rotor. As far as I can tell, none of the other motor makers do what Novak does. They calibrate the motor timing during the design of the motor, then try to make their motors as identical as possible during manufacturing.

Unfortunately, the design-time calibration done by the other motor makers does not agree with the calibration performed by Novak's test equipment. What Novak calls 30 degrees of motor timing, everybody else calls 15 degrees; what Novak calls 15, everybody else calls zer0. Since Novak is outnumbered by the other motor makers, most people use the other motor makers'

definition of what zero motor timing is. A shame, but that's how it is. When it comes to this definition it is more important to be consistent than correct. So according to the other motor makers, the translation of Ballistic timing markers to motor timing is:

```
-3 -2 -1  N +1 +2 +3
 0  5 10 15 20 25 30
```

Here's the motor timing story for some other brands of motors:

- The old Trinity DUO motors have three sets of screw holes for the back endbell, 3mm apart. The motor diameter is 35.5mm so at the diameter each millimeter is 3.2 degrees, and the holes are about 10 degrees apart. Depending upon the set of holes you use, you get zero, 10, or 20 degrees of motor timing.

- The current Epic DUO 2 motors have continuously adjustable timing with timing marks 1mm (3.2 degrees) apart. Confusingly, the long mark is *not* zero timing. Zero timing is approximately three timing marks back from fully advanced timing. Fully advanced timing is approximately 10 degrees. (I know this makes no sense; why would most of the timing adjustment on the motor be negative? My source for DUO 2 timing information is John Tag, who I believe is trustworthy.)

- Tekin motors have continuously adjustable timing with a scale from zero to 24 degrees.

- Novak Velociti and SS motors are factory-calibrated to 15 degrees, like Ballistic motors. (The 3.5-turn motors come with a little less.) They just don't have a timing sticker. So if you've left the timing alone, or marked the timing ring with the factory timing before moving it for the first time, you can deduce the motor timing on these motors. My Novak SS 10.5 motor has 2mm of advance and 3mm of retard available, relative to the factory timing. So assuming that the factory timing is 15 degrees, the full range of motor timing adjustment on my Novak SS 10.5 motor is about 5 degrees to 21.5 degrees.

- Some SpeedPassion motors have no timing adjustment, but have 12 degrees of advanced timing.

8.2. General approach to RS tuning

The main rule of RS tuning is:

> *Always test setup changes by making short runs and measuring both lap times and the temperature of your motor after the run.*

For instance, if you normally run a 6 minute race, make a 3 minute test run. If your motor comes off above 135 degrees F, most likely it will be above 170 degrees F after a 3 minute run. In general you don't want your motor temperature to exceed 170 degrees F.

For accurate temperature readings, be sure to read a part of the motor that is not highly polished or reflective. Dark anodized aluminum surfaces are good. You can create a dark matte patch on a reflective metal surface using a black Sharpie pen.

In hot conditions, run a heatsink/fan on your motor to keep the temperature down. It makes a big difference.

An important corollary to the main rule:

> *You can't just copy somebody else's setup and expect it to work.*

Even if you are running the same car on the same track with the same motor as your buddy, the way you drive might mean that you need to gear differently to avoid cooking your motor. The way you use both the throttle and the brake make a big difference in motor temperature (and, of course, lap time). The more brakes you use, the hotter your motor runs. The more speed you carry through the turns, the cooler your motor runs. On different tracks, or with different cars, or with different motors, the differences will be even greater.

When you update the RS with new firmware you must test again to be sure that your current setups are still OK, since changes in the firmware can affect both performance and motor temperature.

With modified motors many drivers prefer dual mode. Dual mode makes the bottom-end of a modified motor easier to drive, because the ESC applies full timing advance even at low RPMs. Dual mode is accurate (it does not involve the vagaries of motor timing) so there's less risk of over-timing an unforgiving mod motor. And dual mode is simple: The only parameters are timing advance and gearing. With modified motors in touring cars you need to keep the motor efficiency up (heat is the enemy) which means not going wild with timing advance in dual mode. The lower the turns, the less the advance. E.g. for a 3.5 you'd set *TA* to 30 or 40 for starters; 60 is getting up there. On a really large, flowing track you might get to 90. For a 6.5 you'd start at 80.

For some drivers, dual mode feels *too* soft; they run sensored-only mode with modified motors. Sensored-only mode can improve your top end in modified, allowing you to run an extra wind for improved drivability. When trying sensored-only mode in modified, reduce the motor timing as far as you can handle, then bring up the boost and/or turbo slowly; it is easy to over-time a modified motor.

To get the best performance with spec motors (10.5, 13.5, 17.5, and 21.5) you will almost always run sensored-only mode. In sensored-only mode you have *five* parameters to play with: gearing, motor timing, boost, turbo, and turbo delay. It is easy to get lost! Here's one approach to finding a good setup:

- motor timing: On tracks with a lot of hard acceleration out of slow corners and enough traction, run zero motor timing. On more flowing tracks, add some motor timing, say 10 degrees. On tracks where you carry a lot of speed through all the

corners (as when running electric TC on a 1/8th gas track, or on some ovals) you might run 20 degrees motor timing.

If you add motor timing to an existing setup, expect to change gearing a lot. Gearing is far more sensitive to motor timing than to boost and turbo timing.

- boost: Leave turbo at zero and tune with boost and gearing to optimize your lap times, ignoring long straights. Throughout this discussion, "straights" include sweepers taken without lifting the throttle.

  Typically, motor timing plus boost should not exceed 30. On a huge track you might push the total timing up past this. On smaller indoor tracks you will probably be faster with less total timing; keep the heat down and gear up (reduce the FDR) a little. For instance on a small technical indoor track where the longest straight is 50 feet, try motor timing zero and boost 25.

  Because of the reduced motor timing, gearing will not resemble what you are used to with a no-added-timing ESC. You will run fewer teeth on the pinion, get more punch, yet equal or greater top end because the boost timing is adding many RPM to the motor.

- turbo and turbo delay: Once you have a good combination of gearing, motor timing, and boost, add in turbo (without making other changes) to optimize performance on the long straights. The longer the straight, the more turbo; if your track has less than a 120 foot run taken flat, start with 10 turbo or less. If the turbo it set too high and you are still accelerating strongly at the end of the straight you'll have a weak feeling at the braking point. If your track has no long straights (the longest is 80 feet or less), try 10 turbo with 0.5 delay and drop the pinion by about 2 teeth.

  The turbo delay is important: turbo boost should ramp up when the motor would be starting to top out with just the motor timing and boost. If the turbo comes in too soon you'll get a "flat spot" in the midrange acceleration due to the excessive timing, and you might have overheating problems. If the turbo is coming in too late, even with a short turbo delay such as 0.5 seconds, you were most likely under-geared before adding the turbo; add some teeth to your pinion and reduce boost as necessary to keep the motor temperature under control. It is easier to feel the car top out and then the turbo kick in, so when in doubt start with a longer delay and work down.

  Continue to experiment with gearing after adding in the turbo, but don't expect your gearing to change much. Working on gearing is still worthwhile: A one tooth gearing change can be the difference between a mediocre car and a really good one.

One problem with the recipe above is that it isn't easy to "optimize your lap times, ignoring long straights"; the only objective data at your disposal is your lap times. There's a natural tendency to end up with too much boost. The RS adds in boost timing very quickly, so when you use a lot

of boost your setup may be over-timed right after the boost kicks in, creating a flat spot in the acceleration. Try running less boost, like 10 or less, and a smaller FDR. Then you can run full turbo and tune by varying the gearing and (a fairly short 0.2 – 0.7) turbo delay. Since the turbo ramps in more slowly than boost, you can run more of it without creating a flat spot, as long as you get the delay right.

Adding timing will not always make you go faster. Sometimes you need to reduce timing and gear it up (reduce the FDR) to go fast.

Occasionally dual mode works well with spec motors, specifically 12th-scale 17.5 and WGT 10.5. For instance at the 2009 Cleveland Indoor Championships, Mark Calandra qualified 6th in Expert 10.5 World GT against tough competition using dual mode. Expect to change gearing when you switch from sensored-only to dual mode.

The discussion above is for on-road applications of the RS. Typical sensored-only off-road setups use more motor timing and less boost/turbo. As traction improves, you can use a more aggressive ESC setup. Dual mode can be the hot tip with lower traction.

When testing gear ratios, keep in mind that dropping teeth on the pinion does not always reduce motor temperatures. The motor will run very hot if it is spending most of its time running at high RPMs. Under these conditions adding a few teeth to the pinion will make the motor run cooler while making the car go faster too.

If you are new to brushless, you will soon discover that brushless motors have a lot of coast compared with brushed motors, so drag brake tuning is important. The default drag brake setting is zero; this will not be a good setting unless you love your car to coast (e.g. you are running a one-way setup on a TC). Experiment with higher drag brake settings, keeping an eye on motor temperature when you do so.

8.3. Sample setups

Here are a few sensored-mode setup recommendations reported on the rctech thread (http://www.rctech.net/forum/electric-road/218152-tekin-rs-esc-sensored.html):

- TC, 17.5 or 13.5 motor, 96 x 40 carpet track

  motor timing = 0
  boost = 28
  turbo = 10, turbo delay = 0.5.
  FDR: 17.5 motor = 4.5, 13.5 motor = 5.6

  For 21.5 use the same ESC setup and gear it up: FDR = 4.0.

- TC, 17.5 motor, 78 x 40 carpet track (low boost setup)

  motor timing = 0
  boost = 10

turbo = 20, turbo delay = 0.3
FDR = 3.8

- TC, 13.5 motor, 90 x 40 carpet track (IIC-like layout)

  motor timing = 5-10
  boost = 15
  turbo = 10, turbo delay = 0.2 – 0.4
  FDR = 6.2

- TC, 10.5 motor, medium-large flowing outdoor asphalt track

  motor timing = 10
  boost = 20
  turbo = 20, turbo delay 0.6
  FDR not specified

- TC, modified motor

  motor timing = 0 to 5
  boost = 0
  turbo, turbo delay: adjust turbo to suit track while keeping temps under control

- 12th scale, 13.5 motor, 1S battery, small technical carpet track with medium grip

  motor timing = 0
  boost = 25
  turbo = 20, turbo delay 0.5
  rollout 81.3mm

- off-road buggy, 17.5 motor

  motor timing = 10
  boost = 10 – 15
  turbo = 20, turbo delay = 0.5 for high traction, 0.7 for low
  FDR = 5.67 (72 spur, 33 pinion on RC10B4)

Tekin now has a page http://www.teamtekin.com/hotwire/ESCsetups containing team driver setups you might try.

9. "Classic" RS behavior

This section describes things that aren't specific to recent firmware versions. So the manual covers these things, though in some cases you need to read between the lines.

9.1. Buttons and LEDs and sounds

The RS has two buttons, labeled *MODE* (nearest the C motor phase wire) and *INC* (nearest the negative battery wire).

The RS has seven red LEDs arranged in a row. Call them *LED 1*, *LED 2*, … , and *LED 7*, with *LED 1* nearest the *MODE* button and *LED 7* nearest the *INC* button. The RS labels them *DB*, *BS*, *LM*, *NW*, *TP*, *MT*, and *VC* for their roles while programming the RS using the *MODE* and *INC* buttons, but chances are that you can't read the labels without a magnifying glass, and they are used for many purposes unrelated to programming. So numeric LED names work best.

The RS makes sounds when powering up and during calibration and programming. It makes both a penetrating *beep* sound and a warbling sound that Tekin calls *chime*. Some speed controls are able to make sounds only when connected to a motor, but the RS makes sounds all on its own.

9.2. Radio calibration

Before using your RS with a transmitter you haven't been using it with, or before using a firmware-updated RS for the first time with any transmitter, you must perform radio calibration. During radio calibration, the RS determines the pulse widths that correspond to neutral, full throttle, and full brake on the transmitter. You could tune your radio to match the RS's default pulse widths (1.5 milliseconds neutral, 2.0 milliseconds full throttle, 1.0 milliseconds full brake), but it is generally easier to calibrate the RS to the radio than the other way around.

Before performing radio calibration, make/verify these settings on your radio:

- Throttle channel reverse: off. (You may have to turn throttle reverse *on* for certain radios, particularly Futaba; see below.)
- Throttle channel sub-trim(s): neutral (check both the sub-trim and the fine trim).
- Throttle channel EPAs: full throw (100 on some radios, 120 on others).
- Throttle/Brake ATL: full throw (throttle ATL is an unusual thing for a radio to have, but brake ATL is common).
- Anti-lock brake function: off.

Then ensure that the RS is connected to a charged battery and to the receiver. Turn on your transmitter, put it down, then turn on the RS. Then:

Press and hold the *MODE* button on your RS. All LEDs go out. When the LEDs light up and the RS chimes, release the *MODE* button.

> *LED 4* blinks and the RS beeps with each blink. Wait for the RS to chime. (It has recorded your transmitter's neutral pulse width.)

LED 7 blinks and the RS beeps with each blink. Pick up your radio, hold the trigger on full throttle. Wait for the RS to chime. (It has recorded your transmitter's full throttle pulse width.)

LED 1 blinks and the RS beeps with each blink. Hold the trigger on full brake. Wait for the RS to chime. (It has recorded your transmitter's full brake pulse width.)

After a few more chimes, blinks, and beeps, radio calibration is complete and the RS is ready to use. *LED 4* stays on solid, except that every two seconds it goes out briefly and one or more other LEDs flash on briefly. (See Section 9.7 for what this means.)

The description above covers the "happy path" of radio calibration. Here are the failure possibilities and what to do if they strike you:

- Radio calibration fails while acquiring neutral if your transmitter's neutral pulse is not in the RS's acceptable range of 1.3 to 1.7 milliseconds. Use your transmitter's sub-trim function to make neutral calibration succeed. Move the sub-trim in one direction and, if that fails, the other, until the RS stops beeping at you.

- After you've acquired neutral, radio calibration fails while acquiring full throttle if your transmitter's idea about whether to increase or decrease the pulse width as throttle is applied does not match the RS's idea. If this happens, change the position of your transmitter's servo-reversing setting on the throttle channel. (On the Futaba 3PK, for instance, you will definitely have to select "REV"; might as well do it before you start.) If you made a sub-trim adjustment for neutral, you'll have to flip that adjustment around: If you trimmed in the forward direction, you'll now have to trim in the brake/reverse direction. These adjustments will get you through calibration unless you encounter the next issue.

- After you've acquired neutral, radio calibration fails if your transmitter's full throttle or full brake are not sufficiently far from neutral to satisfy the RS. The RS requires full throttle to be a pulse in the range of 1.7 to 2.4 milliseconds, and full brake to be in the range 1.3 to 0.6 milliseconds. If you've reduced your trigger's mechanical throw (a common thing to do in the brake/reverse direction), be sure you've adjusted your transmitter to match (e.g. on the Futaba 3PK, use the ADJST function).

9.3. The RS's special approach to neutral

When you power up a typical ESC it listens for pulses from the receiver, compares them to neutral (as determined by radio calibration), and does what you expect. So for instance if you've trimmed your throttle a bit in the forward direction to make the car creep forward at neutral (often used for 2WD cars, or 4WD cars with one-ways in the front), your car will creep forward. If you've trimmed your throttle a bit in the brake/reverse direction, the ESC applies brakes or goes into reverse, depending upon the mode the ESC is in.

The RS does not work this way. When you power it up, it listens for pulses from the receiver, compares them to neutral, and does nothing but flash LEDs until it sees a sufficiently long set of pulses at neutral. Then it chimes and is ready to go.

The RS's behavior can be useful for diagnostic purposes. After resetting the RS (Section 9.6), it reverts to the default settings for neutral, full throttle, and full brake given in the previous section. So you can use the RS to determine the pulse widths your transmitter is putting out. For instance if your transmitter sends a 1.3 millisecond neutral pulse, the RS will flash LEDs 1-3 to indicate that the pulse it is getting is shorter than its configured neutral of 1.5 milliseconds. If you then pull the throttle slowly and the RS initializes, you know that your transmitter is giving longer rather than shorter pulses as you pull the throttle. With the RS initialized, if you pull full throttle and get only LEDs 1-6 (say), this means that your transmitter is putting out a full throttle pulse shorter than 2.0 milliseconds.

The RS's behavior is also a safety feature: If you have selected the wrong model memory in your transmitter, your car won't run away. But the flip side is that with the RS, you are discouraged from dialing in forward creep or drag brakes from the transmitter. You are encouraged to adjust these things in the RS itself, using *PC* (for forward creep) and *DB*.

The RS's *PC* is nicer than forward creep because it only applies for a limited time when you go from forward throttle to neutral. Your starts will be better because you don't have to hold brakes on at the start. The RS's *DB* is nicer than transmitter-tuned drag brakes because with *DB* drag brakes are more consistent: You get the same amount of brake for the entire width of neutral.

But if you want to dial in creep or drag brakes while on the driver's stand, based on track conditions, the RS's approach will be more work for you. You need to perform the transmitter adjustment from neutral after powering up the RS, and return the transmitter to neutral after shutting off the RS. Perhaps in the future you'll be able to program the ESC of a running car through the transmitter, rather like F1 teams used to do, but not yet.

9.4. Changing settings

You can change seven of the RS's settings by pressing the RS's two buttons. Here's how:

> Each of the seven settings is represented by an LED (see Section 9.7 for the correspondence). Press the *MODE* button once to select the setting represented by *LED 1*, twice for *LED 2*, etc. The RS is in *setting selection mode*. Don't dawdle between presses or the RS will time out, chime a couple of times, then return to normal mode.
>
> Press the *INC* button once to display the current value of the selected setting (see Section 9.7 for how values are displayed). The RS is in *setting adjustment mode*. Press the *INC* button again (without waiting too long) to increase the value by one, twice to increase by two, etc. When the setting value reaches its maximum, the next press wraps the value to its minimum. To accept the current value, stop pressing the *INC* button. The RS will chime a couple of times, then return to normal mode.

Not bad, but if you have your laptop handy you'll probably use HotWire. It can change every setting, gives more control the settings that you are most likely to change, and is less error-prone. For instance, it might surprise you that changing *MT* using the buttons changes the brushless mode to *dual*! Adjusting *DB* using the buttons can also give surprising results.

9.5. Pit tune mode

By holding down *MODE* or *INC* while turning on the RS, then releasing the button, the RS enters *pit tune mode*. The RS confirms entry to this mode by "walking" two LEDs up then down the line of seven LEDs. Then *LED 1* starts blinking. The RS is not listening to the receiver (your transmitter can be off) and will not drive the motor.

At this point the RS is in setting selection mode (Section 9.4), as if you'd pressed *MODE* once, except there's no time-out. By pressing *MODE* you advance the blinking LED. By pressing *INC* you display the current value and the RS enters setting change mode, without timeout; if you keep pressing *INC* you change the setting. By pressing *MODE* you return to setting selection mode and can pick another setting. To leave pit tune mode, power off the RS.

Of course, HotWire is the ultimate pit tune mode.

9.6. Reset to firmware version default settings

Each firmware version has a default value for each setting. To return all settings to their default values using buttons:

> Press and hold *INC*, then press and hold *MODE*. All LEDs will go out.
>
> Release the buttons when the RS starts to chime and LEDs light up. The settings are reset and the RS returns to normal operation.

After performing a reset in this way, you must perform radio calibration (Section 9.2).

Of course you can perform a reset with HotWire by pressing *show defaults*, then *apply settings*.

9.7. What the LEDs mean

Setting selection mode (*MODE* pressed)

LED 1 (*DB*): *Drag Brake* selected.
LED 2 (*BS*): *Brake (and Reverse) Strength* (brushless) or *Push Control* (brushed) selected.
LED 3 (*LM*): *Current Limiter* selected
LED 4 (*NW*): *Neutral Width* selected.
LED 5 (*TP*): *Throttle Profile* selected.
LED 6 (*MT*): *Motor Type* selected.
LED 7 (*VC*): *Voltage Cutoff* selected.

Setting change mode (*INC* pressed); one of {*DB*, *BS/PC*, *CL*, *NW*} selected

LED 1: current value = 1.
LED 1+2: current value = 2.
LED 2: current value = 3.
…
LED 6+7: current value = 12.
LED 7: current value = 13.

Refer to Tekin's documentation for what the numbers 1 – 13 mean for each setting. Or, better, verify what they mean in current firmware using HotWire.

Setting change mode (*INC* pressed); one of {*TP*, *MT*, *VC*} selected

LED 1: current value = 1.
LED 1+2: current value = 2.
…
LED 1+2+ … +6: current value = 6.

Refer to Tekin's documentation for what the numbers 1 – 6 mean for each setting. Or, better, verify what they mean in current firmware using HotWire.

In 194 and later firmware, *MT* = 7 (all LEDs lit) means *BL-FW* with brushless mode = sensored-only.

Normal operating mode

LED 4 on, blinks off every two seconds and then *LED 1*, or *LED 1+2*, or … blink on: *LED 4* means neutral throttle (the LED in the *middle*, get it?) The number of LEDs that blink on when *LED 4* blinks off indicates the current ESC temperature, with LED 1 for a cold ESC and *LED 1+2+3+4+5+6+7* for an ESC on the verge of thermal shutdown. If you see six or seven LEDs lit you'd better fix what's causing it before the RS shuts down.

LEDs 5+6+7 dimly flickering: During normal operation with a sensored motor, LEDs *5*, *6*, and *7* light up in sequence as the three sensors report. With the motor running this causes these LEDs to flicker. By turning over the motor slowly by hand (no throttle) you can see the individual LEDs light up and thereby verify that the sensors on your motor are working. This is called the *sensor checker* function. You can check any motor by just plugging its sensor harness into the RS; no need to attach the motor power (phases A, B, C) wires.

LED 1, or *1+2*, … , or *1+2+3+4+5+6+7* on solid: Partial throttle (more LEDs for more throttle).

LED 7, or *7+6*, … , *7+6+5+4+3+2+1* on solid: Partial brake (more LEDs for more brake).

LEDs 1+2+3+4+5+6+7 blinking: Full throttle or full brake.

Error conditions

No LEDs lit: Speed control not powered up. Check battery charge, switch, and battery connection / polarity. Can also be caused by receiver cable plugged in backwards.

LEDs 1+2+3+4+5+6+7 flashing: No receiver pulses detected. Plug in receiver cable.

LEDs 1+2+3 flashing: Neutral not detected; all receiver pulses are shorter than neutral. Increase ESC's *NW* or increase Tx's sub-trim or perform radio calibration (Section 9.2).

LEDs 5+6+7 flashing: Neutral not detected; all receiver pulses are longer than neutral. Increase ESC's *NW* or decrease Tx's sub-trim or perform radio calibration (Section 9.2).

LEDs 1+3+5 flashing: Voltage cutoff has occurred, or thermal shutdown has occurred. For voltage cutoff, charge battery or decrease cutoff voltage. For thermal shutdown, wait for ESC to cool, then run a milder motor or install an ESC fan.

LEDs 1+2+6+7 flashing: Incorrect *Motor Type* selected, e.g. brushed motor connected to ESC but *MT* = 1 (brushless, forward/brake). Set the correct *MT* or correct your motor wiring or replace your defective motor.

LEDs 3+4 flashing: Short-circuit. Remove battery immediately and check all wiring including receiver and servo plugs.

10. Troubleshooting

Q: I installed HotWire 3.32.2, but when I run HotWire and do *view versions* I don't see version 200 in the list. Why?

Q: I installed HotWire 3.32.2, then upgraded my RS's firmware to version 200, but I'm not able to reduce *Turbo Delay* to 0.2 seconds. Why?

A: You haven't succeeded in installing HotWire 3.32.2. Review the instructions in Section 3, paying special attention to the "HotWire uninstaller does not remove 'VirtualStore' files" issue.

Q: The HotWire program doesn't detect that my HotWire interface is plugged in. Why?

A: Most likely, the mini USB plug is not fully seated in the socket on the HotWire interface. If you have this problem a lot, carefully trim a small amount of plastic from the HotWire interface's case to allow the plug to get farther into its socket.

Q: Why are the buttons on HotWire blank unit you hover over them? I *hate* this.

A: By design. Tekin is getting a lot of feedback on the HotWire UI. Stay tuned for improvements!

Q: I run a 64-bit version of Windows on my laptop because it has a lot of RAM. Can I use HotWire on my laptop?

A: Not with your 64-bit OS, unfortunately. You can partition your hard drive, set up a 32-bit OS on the second partition, and dual-boot.

Q: I have a Macintosh; can I run HotWire on it?

A: Some HotWire users have reported good results running HotWire under VirtualBox or VMware on a Mac.

Q: When I run HotWire all I see is the red portal screen with the picture of the HotWire interface, even though I've plugged my RS into the HotWire interface. Why?

A: Check the receiver plug on the RS. If the RS detects that it is plugged into the HotWire interface, it flashes *LED 4*. If *LED 4* does not flash you have a bad connection. Sometimes with a bad connection the RS thinks it is plugged into a receiver instead of the HotWire interface and flashes all the LEDs to say it can't detect a receiver pulse.

If the problem were with the HotWire interface not being detected by HotWire, HotWire would not show you the portal screen. It would say "No HotWire Detected" and close.

Q: Every time I run HotWire it says "Your Speed Control contains software that may not be compatible with this HotWire."

A: The firmware in your RS is not the latest firmware carried by your HotWire. If you upgrade your RS to the latest firmware, Hotwire will stop pestering you.

Q: When I run HotWire and click *view versions*, nothing "slides out" to the right; the window remains the same size. Why?

A: Check your screen resolution. If your screen resolution is too small (e.g. 800 x 600) you won't be able to see the entire HotWire window at once. The part of the window that "slides out" will be clipped off the right edge of the screen. This limitation can prevent you from using HotWire on some netbooks, since their screens are small.

Q: Feature *x* of new firmware version *y* does not work for me. Why?

A: Be sure that you've actually updated your RS to firmware version *y*, using *update ESC*. It isn't enough to just install a new HotWire version. Also be sure that you clicked on *apply settings*; otherwise the settings you changed in HotWire to use the new feature won't change in your RS.

Q: I just updated my firmware. Now my car is slow. Why?

A: You are not reaching full throttle; no wonder your car is slow! Always perform radio calibration after updating firmware.

Q: Using HotWire I set *MT* to *BL-FW* and brushless mode to sensored-only. Now when I view MT using the LEDs it shows all seven LEDs lit. But the RS manual says that BL-FW should show just LED 1. What gives?

A: The RS manual documents an earlier version of the firmware, and there is no documentation for the LEDs in the version you are using. If you view current settings with HotWire and they look OK, they are OK.

Q: I'm running a brushed motor; can I use the Timing Boost feature of the RS?

A: No. With a brushed motor (and *any* speed control) the timing is set mechanically.

Q: I set both *Push Control* (*PC*) and *Drag Brake* (*DB*) using HotWire. Why isn't the RS working the way I want with this combination?

A: The *PC* and *DB* settings are mutually exclusive. If *PC* is set, the RS applies a configurable amount of throttle when the trigger returns to neutral. If *DB* is set, the RS applies a configurable amount of brake when the trigger returns to neutral. You can't have it both ways.

Q: No matter what I do, I can't get my RS to calibrate.

A: Maybe it isn't getting a signal? Be sure that a receiver pin isn't bent; all three pins must engage the RS's receiver connector. To see what the RS does with no signal, remove the receiver connector from the receiver and power on the RS. All of the LEDs should flash. Perhaps you have one bad channel on your receiver. Try plugging into the steering channel and see if it will calibrate there.

Q: I'm performing radio calibration. The RS accepts my neutral, but it won't accept my full throttle. Why?

A: Perhaps you are using a Spektrum radio and have forgotten to turn on the transmitter? Spektrum receivers put out a neutral pulse when powered on, even if they aren't actually receiving anything. If this isn't the problem, please refer back to the directions in Section 9.2.

Q: I keep having to perform radio calibration because my RS can't find neutral when I power it up. Radio calibration does not make the problem go away, or it only goes away for awhile. Is this a problem with the RS?

Q: I plugged the battery into my RS with the polarity reversed. It was only that way for a short while. A little smoke came out. My RS is still working. Is it as good as new?

A: Probably not. The RS runs a bunch of FETs in parallel to achieve low on-resistance in each phase. Most likely you smoked a few of them, and weakened the rest. You can send your RS in for repair, but the warranty does not cover damage you cause by plugging the battery in backwards.

Q: When I power on my RS it takes a very long time to initialize, over a minute. Then it works fine. Why?

Q: My drag brakes are inconsistent. Why?

A: Your transmitter's neutral is wandering. Some radios can wander quite a bit as they get older. The throttle trigger's position sensor can come adrift inside the transmitter's case. A transmitter's neutral can be temperature dependent, or voltage dependent (another reason to keep your transmitter pack fully charged). Some transmitters have a "reset" function that causes the transmitter to re-learn its neutral positions; using this might help. When all else fails, increase *Neutral Width*. *NW* below 10 often causes problems.

If you are having problems with inconsistent drag brakes, try setting your *NW* = 25.

Q: Why are my brakes weak?

A: Perhaps you are locking up the wheels and that's why the brakes feel weak? When you apply full brake, do all the LEDs light up then start blinking? Do it a few times and make sure it reads full brake every time. If not, repeat radio calibration, following the instructions given in this document carefully. Set your brake endpoint to 15% below the maximum, perform radio calibration, then set your brake endpoint to the maximum. Have you mechanically limited your trigger movement on the brake side? If so, be sure to adjust your transmitter to match, or the range of brake pulses will be reduced. If this does not fix the problem, try increasing the Neutral Width (it should be no lower than 10). Be sure you have 100% Brake Strength programmed into the RS. Be sure you have Push Control turned off. If your transmitter has an anti-lock brake function, be sure it is turned off. Try another motor to see if the problem is related to the motor. Maybe the rotor is cooked. Dual mode has weaker brakes than sensored-only mode; try sensored-only. Some drivers report that the brakes work best when set to 100% in the RS and then set using the transmitter's ATL adjuster.

Q: Why does my turbo go away partway through a run?

A: Be sure you are running version 200 firmware, not version 199. Don't squeeze the throttle trigger extra hard during radio calibration. Set your throttle endpoint to 15% below the maximum, perform radio calibration, then set your throttle endpoint to the maximum.

Q: Can I adjust the minimum brake, i.e. the amount of brake I get with the first trigger motion forward from neutral?

A: No. The best you can do is to adjust the brake exponential to some positive value to make the brakes ramp up faster with the first trigger movement.

Q: I geared up and my car goes faster in top speed, but my brakes got weaker. Why?

A: The motor produces only a certain amount of torque for accelerating and braking. When you gear up (smaller FDR) you lose both acceleration and brakes; when you gear down (higher FDR) you gain acceleration and brakes. This is true for any ESC.

Q: My car is not the fastest off the line. Would a zero-delay turbo help? Does the RS have a special "start mode" I can use?

A: No and no. Perhaps the cars that are faster off the line aren't spinning their wheels, and your car is spinning its wheels?

Q: My car is fast at first but slows down during a run. My motor never temps over 160. What's wrong?

A: Check your rotor. When you turn the motor over by hand you should feel 6 thumps per revolution where motor cogs. If you get less than this the rotor is shot. If this isn't the problem, try swapping batteries to see if that helps.

Q: My RS makes a high-pitched whine right after I turn it on. Is this a problem?

A: This is the sound of the RS checking the type of motor you have connected, to avoid frying the RS if you happen to get the *Motor Type* setting wrong. The sound should only last a short time and then the RS should be silent with the throttle in neutral.

Q: I custom-set my *Voltage Cutoff* (*VC*) to 7 volts. Now when I'm driving my ESC shuts down with LEDs 1+3+5 blinking. After awhile it comes alive again, but the problem repeats. What's going on?

A: The voltage cutoff is kicking in. This function intended for use the LiPo only; set *VC* = 1 (cutoff disabled) with NiMh cells. If you want to run a custom cutoff voltage for 2S LiPo, set it slightly above 6 volts, say 6.2 or 6.4 volts, but not as high as 7 volts. Unlike some other ESCs, the Tekin voltage cut-off is a "hard" cut-off, so it will kick in if you dip below the prescribed voltage even momentarily under acceleration.

Q: My car runs fine for awhile, then just stops. The LED on my Spektrum receiver goes out. If I turn the RS off and back on again my car works fine, until it stops again. Is this caused by the RS?

A: Spektrum receivers, particularly the older ones, require that a receiver capacitor (Spektrum part #1600) be plugged into the battery slot. Without this capacitor, the receiver voltage drops too far (e.g. with the high current drain of a digital servo) and then the receiver locks up. This happens with all ESCs.

Q: My RS just goes dead while running. No LEDs on the ESC. Servo dead as well. Then it comes back all of a sudden.

A: Check both the receiver plug and the battery connections. On the receiver plug make sure all three wires are fully seated in the black plastic body. Sometimes the wires can work loose, migrate upward, and then make intermittent contact with the pins in the receiver. On the battery connections look for bad solder joints at both the RS and at the battery or connector. Pull on the joints to see if they are sound. Sometimes a solder joint in a side-by-side NiMh pack fails and the battery will work intermittently. Sometimes crud will accumulate inside the receiver case; open up the case and clean out the crud.

Q: When my RS is powered on the LEDs are very dim; steering works but no throttle.

A: First be sure that no buttons are stuck. The RS may be waiting for you to release a stuck button. Then try performing a reset (Section 9.6). If that does not work, try to flash the RS back to an older firmware version, then back up to the current version.

Q: Can my RS harm my motor?

A: Only if you configure the RS with too much timing and cook the motor.

Q: Can my motor harm my RS?

A: Yes, if the motor shorts out and you apply full throttle you are likely to cook the RS. If the car slows all of a sudden, resist the temptation to mash the throttle. Stop and find out what's wrong. (Easier said than done!)

Q: I have my RS set up in *Motor Type* = 4, i.e. brushed with forward and brake only. It ran for 2 minutes, then stopped with LEDs 1+2+6+7 flashing. I re-checked the *MT* setting with HotWire and it is still 4. Why does the RS think I have the wrong *MT*?

A: Double check all of your wiring. Be sure you don't have a hung brush. Try a different motor.

Q: My car won't accelerate from a standing start, but once rolling it runs OK. Why?

Q: My car cogs every time I hit the brakes and then hit the throttle again right away. When that happens, it makes weird squealing noises. Why?

Q: I ran my car into a flapper and the car bounced off backwards. When I gave the car forward throttle after the accident, the car went in reverse, then stopped and went forward! Why?

Q: I had a big accident and now my car has no turbo. Why?

A: If your car stutters under acceleration, first be sure you've set *VC* correctly. *VC* must be *off* when running NiCd or NiMh cells.

If this is not the problem, then most likely you have a sensor problem and your car is has started running sensorless. Use the RS's sensor checker. Having the car start in reverse and then correct itself often results from a sensor cable problem rather than an actual sensor problem. Be sure the cable is completely plugged into the RS. Try replacing the cable if your motor has a sensor cable connector. Try cleaning the sensors by opening up the motor and spraying with compressed air (*not* with motor spray!)

Check your motor power wires (phases A, B, C). If you have your motor wired wrong (e.g. A and B reversed) it will cause sensor issues. Check the solder joints at the motor and at the ESC. Try replacing the motor with a known good one

The squealing noise is the ESC driving the motor in sensorless mode.

Q: Can I use a different capacitor than the one that came with the RS?

A: Why would you want to do this? The Tekin capacitors were selected by Tekin's engineers for use with the RS. They are small, inexpensive, and easy to mount. There is no standard for what "low ESR" means, so putting another capacitor labeled "low ESR" on there might or might not work.

Q: I broke the plastic case of my RS. Can I get a replacement?

A: Yes. Send an email message describing your situation to support@teamtekin.com or to rpike@teamtekin.com (Randy Pike).