Traction Control in Drag Racing

By Luke Robinson

Traction control, despite being widely used in road cars for many years (early units pioneered by Buick and Cadillac date back to the early 1970's) have not always been welcomed with open arms in the motorsport industry. Early systems were used in Formula 1 since 1990, and despite their simplicity offered a significant advantage, particularly in straight line acceleration. The use of traction control in Drag Racing has traditionally been banned, but in recent years there has been a paradigm shift that spawned the birth of racing associations with relatively open rulebooks, allowing cars that were previously considered 'Outlaws' to race in a professional championship. The loose rule set that these cars ran to fully embraced traction control technology, allowing record breaking runs to be made, and far fewer aborted runs due to overpowering of the track. The fact that traction control was legitimised in these associations (such as the PDRA) has led to huge advancements in the technology. The rise of 'no prep racing' (where no track preparation such as rubber sledding or traction compound is applied) has further expanded the number of racers using traction control systems, and it is not unheard of for racers from associations that don't allow traction control to use it to help establish a baseline tune-up for raceday.

History and functionality

Drag Race traction control systems differ vastly from passenger car and circuit race systems; this is due to the unique conditions Drag Racing places on the cars. Passenger car systems will quite often use data gained from the vehicles ABS sensors (to measure wheel speed), a control unit will process this data and compare wheel speeds to decide if one or more wheels have lost traction. The control unit will pulse the brakes on the wheels that have lost grip to slow them down and allow them to regain traction. Also, engine power will often be reduced by closing the throttle (on fly by wire throttle systems) or cutting fuel.

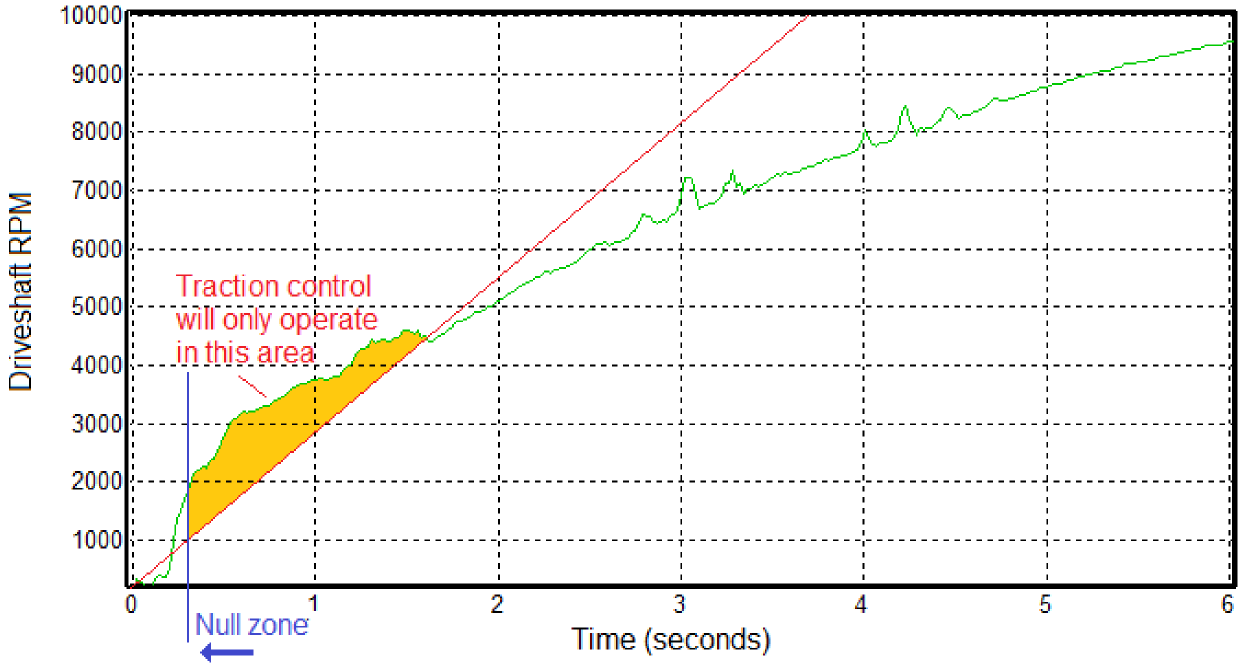
Circuit race traction control systems often also use ABS sensors or standalone wheel speed sensors to detect when wheel spin is present. Some systems will also use GPS data to compare wheel speed to measured ground speed. Some systems will apply braking force on the spinning wheels; others will reduce power, often in the form of a fuel or ignition cut.

Both these control strategies are problematic in the sport of Drag Racing. In terms of detecting wheel spin, individual wheel speed sensors are not practical, due to the fact that most cars use a spool (locked differential) on the driven wheels, and in the case of the traditional rear wheel drive Drag Car, it is not unusual for the front wheels to leave the ground on launch, and in extreme cases the cars can carry the front wheels in the air even further down the track. GPS systems, whilst accurate in certain situations, will not currently refresh fast enough for a control system to react to the difference in road speed and wheel speed. Moving on to controlling the wheel spin, it is currently rare in the Drag Racing world to control the throttle using a fly by wire system (and for the most part it is not allowed in the rule book), so controlling the throttle is not a practical option, also it is unlikely to react fast enough. Cutting fuel is not practical, especially on cars using power adders, as the engine will run lean and likely run in to detonation in the best case, and total destruction in the worse. Cutting spark can work on certain cars, although cars using nitromethane as a fuel are an exception as part way down the track combustion can take place due to 'dieseling' caused by hot exhaust valves, and a fuel which is explosive in its characteristics. The other problem with cutting spark is that is a 'hard cut', meaning that it could possibly slow the engine down too much, and ultimately slowing the car down.

It is difficult to pinpoint when traction control first entered the arena of Drag Racing, but Shannon Davis of Davis Technologies, who has long been at the forefront of traction control technology (and currently holds 8 US patents relating to his systems) first put together a Drag Race system in 2002. The first systems were relatively simple and were derived from Davis' successful circle track units that were on the market. They used a sensor on the driveshaft and would compare the measured acceleration of driveshaft RPM to a preset linear value. If the RPM exceeded the linear value of acceleration then a 12v output would be activated, which could be used to activate a step retard (a feature on many ignition systems which retards the ignition by a preset amount). There is a likelihood that other systems existed and may have used different strategies to combat wheel spin, however these were covert systems that remain heavily guarded secrets.

Non-self learning vs. self-learning

Drag racing traction control systems are often referred to as self-learning or non-self learning. This describes the unit's ability to learn the acceleration of the driveshaft RPM (in most cases). A non-self learning system will only compare the rate of acceleration of the driveshaft to a preset value. This works well to save a run from failure due to wheel spin, however the driveshaft rpm is not a linear curve, so it can only ever be truly accurate at one point in the run as illustrated in this diagram:

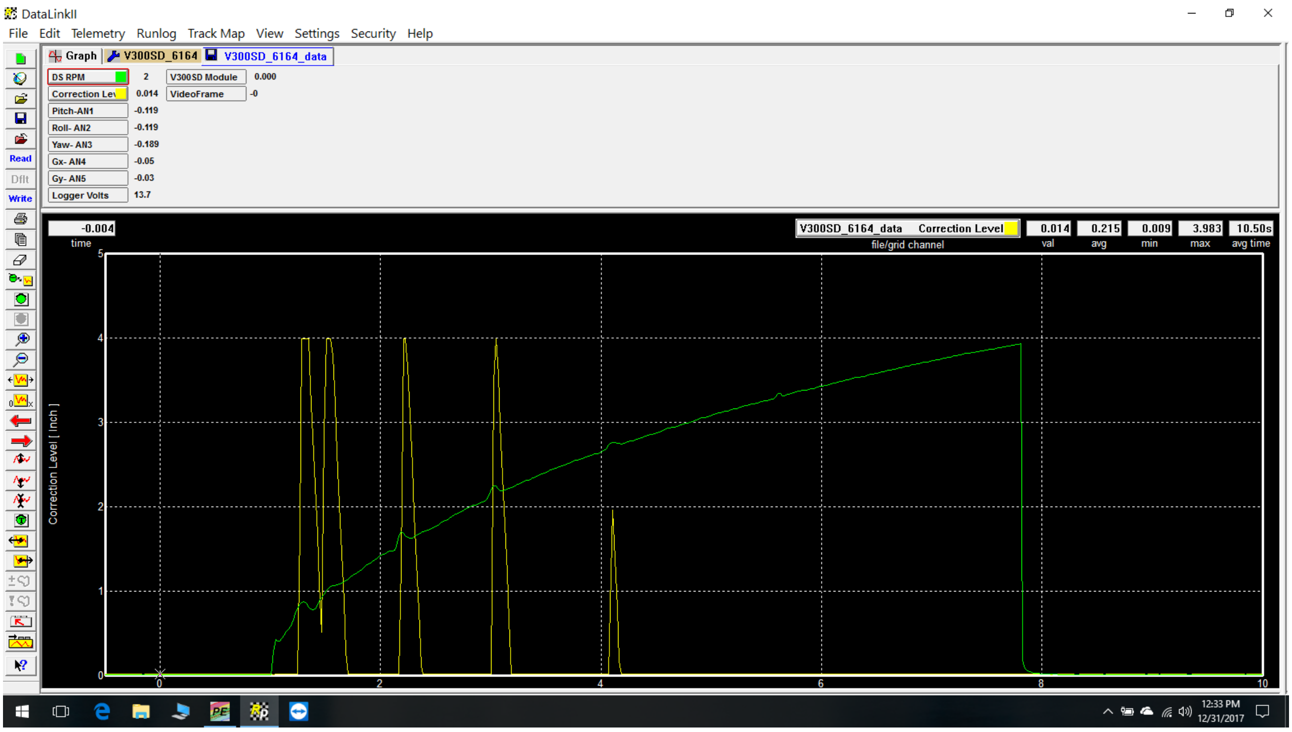


The diagram shows a null zone at the beginning of the graph where the rate of acceleration of the driveshaft is clearly greater than the predefined limit of acceleration. This zone is where the non self-learning system will not make any corrections until the driveshaft has reached the 'starting RPM'. This is necessary, as the driveshaft RPM is not linear, and thus the system must allow the car to get through this period of high driveshaft RPM acceleration before cutting the engine's power.

Despite the relatively simple operation of the non-self learning systems, they are effective at saving a run that would otherwise be aborted, and also they can correct minor slip situations such as gear changes or variations in the track surface, such as bumps or undulations.

Some systems such as the Davis TMS-Drag-Sportsman use a 12v output; upon activation this will turn on a step retard on the ignition system to reduce engine power. Other systems such as the Davis TMS-Drag-Sportsman-MAP, once wheel spin has been detected, will use a 0-5v output, which emulates a standard GM MAP sensor. This can be connected to an ignition system with a boost retard facility, and by emulating the signal that a MAP sensor would give, can therefore control the amount of ignition retard (within the parameters of the ignition system). A typical setup would see the ignition system setup to retard 10 degrees at full boost, thus the traction control system has 10 degrees of retard available to reduce engine power and bring the driveshaft RPM back within the preset value of acceleration. The TMS-Drag-Sportsman-MAP has controls for different driveshaft acceleration curves (using the "threshold" switch), a "% CUT" control (which allows the user to fine tune the amount of total ignition retard you use, for example if you set the ignition system to 10 degrees retard and use 50% "CUT" then it the system will use up to 5 degrees retard to reduce engine power), and "ramp in", which allows the system, once the RPM is back within the preset acceleration value, to ramp the ignition timing back in over a preset time period, using the GM MAP sensor output. There is also a "Mode" switch that allows the user to set the overall sensitivity of the system, meaning that the system can be tuned to correct larger slips, whilst not reacting to smaller slips which may not affect the car's performance. This system will typically use an 8 trigger sensor on the driveshaft, and can work to the resolution of the trigger, therefore the system can detect wheel spin every 1/8 of a turn of the driveshaft.

Self learning systems, such as the TMS-Drag-Pro (the step retard version which features a high and a low output so the user can select 2 values of step retard depending on the magnitude of the slip detected) and the TMS-Drag-Pro-MAP (which uses the GM MAP sensor emulation to control ignition retard), correct wheel spin in a similar way to non self learning systems, however they have the ability to compare the rate of acceleration of the driveshaft to a calculated threshold value which is constantly updated, based on the average of the previous measurements. For example, if the last 1/8 of a turn of the driveshaft is faster than the average of the last full revolution, then a slip is detected, and the system can reduce engine power to correct the wheel spin. This allows the system to detect wheel spin from the moment of launch, all the way through the run (if desired). The system is constantly accounting for track conditions, tyre condition, and any other variables to keep the internal settings updated, this happens up to 800 times a second. Effectively the system learns the average rate of acceleration of the drive shaft, and if there is a sudden spike in RPM above that learned rate which is being constantly updated, then a correction is made, the user doesn't have decide on the most suitable driveshaft acceleration curve and select a "threshold value", the system does it automatically, hence the "Self learning" moniker. This process has been patented by Shannon Davis of Davis Technologies, and the systems using this technology are the most sophisticated in the Drag Racing market today.



This image shows a Racepak data file of the Self learning traction control at work on a Pro Stock style car. The green line is driveshaft RPM, and the bumps in the curve show loss of traction (in this case on the gear shifts). The yellow line shows the corrections of the traction control system, the final correction being smaller in magnitude due to the loss of traction being less severe than the previous ones.

Depending on discipline (for example a car using a large bias ply tyre such as a Pro Mod or a car running in a no prep situation) it may be preferable to stop the traction control working early in the run, and allow the wheels to spin a certain amount, to let the car "get up on the tyre". This is where the tyre expands in diameter due to centrifugal force, resisting tyre shake where the tyre becomes unround. Therefore the Davis Drag-Pro systems have a "Starting RPM" feature, where the user can set the point at which the unit begins making corrections. For example, if the "Starting RPM" is set to 1800 RPM, then the unit is active and monitoring the driveshaft RPM, but is not making any corrections until the driveshaft reaches 1800 RPM. Similarly, there is an "Ending RPM" feature, which allows the user to set the point at which the unit stops making corrections. This can be useful if there are bumps downtrack, but limiting engine power would result in a loss of performance. There is also a "Null Zone" feature, which allows the user to set zones in the Driveshaft RPM curve, which can either limit the corrections to small corrections (in terms of ignition timing/engine power cut) or no corrections at all. Again, this can be useful if there is a sector of the track which is known to have bumps which could cause the Driveshaft RPM to flare.

Wheel Speed Management

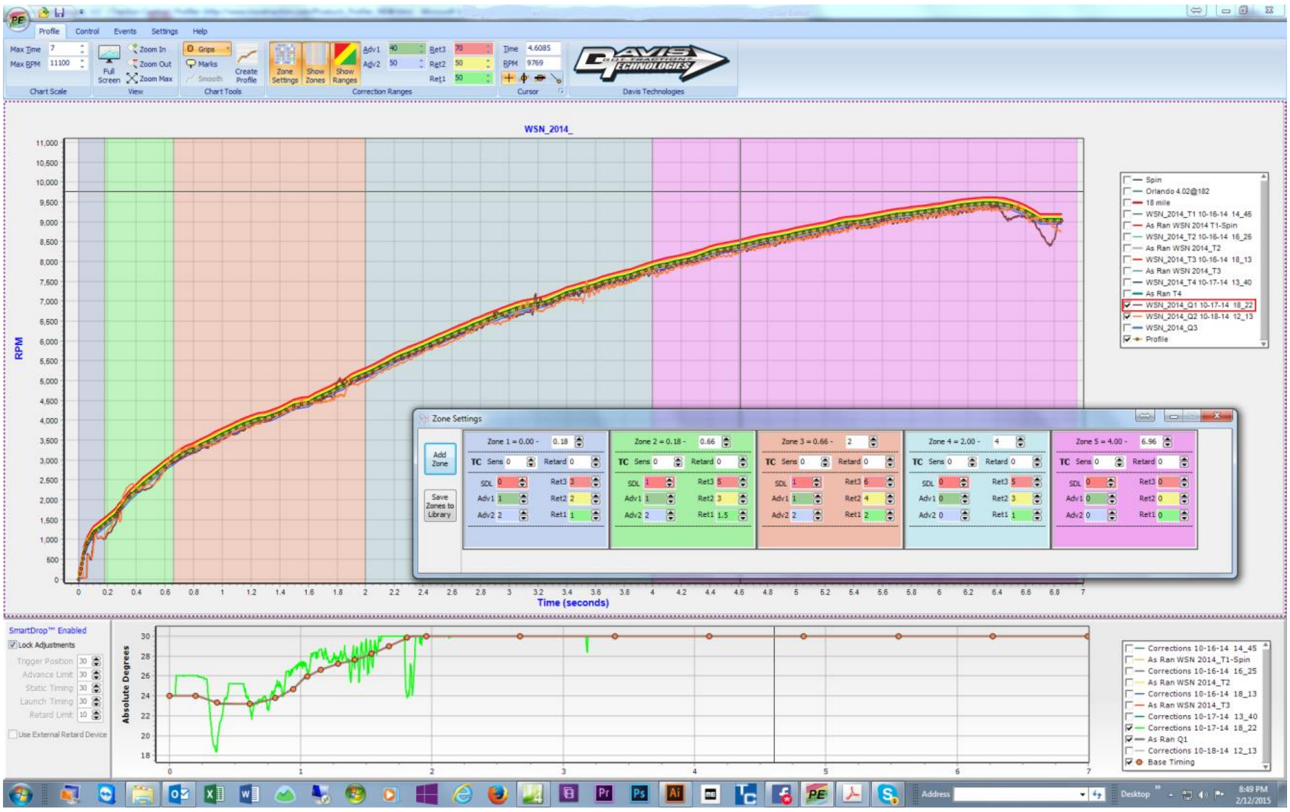
Wheel speed management is not to be confused with pure traction control, although the objective, and the control strategies are outwardly similar. Wheel speed management systems, instead of detecting and controlling wheel spin, are designed to maintain a predetermined acceleration curve of the driveshaft (and thus the rear wheels). Generally a baseline run will be set, and data from that run (in terms of driveshaft RPM) will be recorded. This data will be used to define the "control" driveshaft RPM curve, and the wheel speed management device will control engine power to maintain that curve on the following runs.

The early wheel speed management devices (such as the MSD Digital 7 7531) used rev limiting functions to keep the engine RPM below either a predetermined "slew rate" (a gear based rate of acceleration) or predetermined curve, set by placing dots on a graph (hence the term riding the dots). Individual cylinders would be dropped at random to maintain the engine RPM curve or maximum slew rate (and thus the traction of the driven wheels, as a spike in RPM would signify a loss of traction). This worked fairly well but there have been further advances in this technology. The principle of dropping cylinders was not the most popular with racers using nitrous oxide injection, or mechanical constant flow fuel injection, due to the fuel/nitrous being injected at a constant rate regardless of whether a particular cylinder was firing or not. This unburnt fuel or fuel nitrous mix could cause problems, although many racers used it successfully. Also limiting the engine RPM did not allow for certain situations that could arise such as a flaring torque convertor or a slipping clutch, which would not necessarily translate to a wheel spin situation.

A later version of wheelspeed management came in the form of MSD's ARC (Advanced RPM Control) module, designed to work with the successful MSD Power Grid ignition control system. This control module also uses a graph with dots plotting an RPM curve, however this system is designed to measure and control driveshaft RPM, a direct connection to the rear tyres. Another key difference to this system is that in addition to having a rev limiting function to control driveshaft speed, the ARC module will retard ignition timing to slow the acceleration rate of the driveshaft prior to the hard cut of a rev limiter kicking in. This system actually uses 3 curves, 2 are retard curves (one usually being set close to the desired driveshaft RPM, and with a low value of ignition retard, so that if the driveshaft RPM gets ahead of the curve it triggers this small ignition retard value, the second curve being plotted higher on the graph and set to trigger a higher value of ignition retard, thus limiting engine power further, and the 3rd curve being plotted higher still, this being attached to the rev limiting function of the module).

Taking the principle of wheelspeed management further is the Davis Technologies Profiler. The Profiler works in a similar way to the Davis Technologies traction control systems in that it manipulates ignition timing (in both retard and advance) to control engine power. The user will define an 'ideal' driveshaft RPM curve, usually by importing data from a data logger such as a

Racepak system. The included software uses 'grips' that allow the user to raise or lower certain areas of the curve, and also smooth the curve (imported data will often have spikes or lumps in the driveshaft RPM curve). Once the desired driveshaft curve has been set, taking into account the track condition, the software allows the user to set 3 'correction ranges' of ignition retard. These correction ranges are defined by various 'zones' that exist at various points of the driveshaft curve (each zone has a box where the user can set retard values for each correction range). When the driveshaft RPM exceeds the 'ideal' curve, the RPM will enter one of the 3 correction ranges. The higher the driveshaft RPM gets above the 'ideal' curve, the greater the level of ignition retard will be, as defined by the 3 zones. Above the 3 zones of ignition retard is a feature called 'Smart Drop', which will randomly cut ignition to up to 4 cylinders to bring the driveshaft RPM back within the limits of the curve.



This is a screenshot of the Profiler software, showing the 'ideal' Driveshaft curve (the dotted line) and the correction ranges above and below it, and also the various zones (highlighted in colour).

An interesting feature of the Profiler unit is its ability to advance ignition timing to add power, if the Driveshaft RPM is falling behind the 'ideal' curve too much. This usually happens when the track conditions are exceptional and the user has underestimated the level of grip, not applying enough power to the rear wheels. There are 2 correction ranges of ignition advancement, again defined by the user using the 'zone' method. To use the ignition advance features, the user must set the ignition trigger (usually a crank trigger) to the maximum ignition advance that is desired. For example, if the base ignition timing is 25 degrees, but the user has decided that 30 degrees is safe to run momentarily, then the trigger will be set to 30 degrees, the base timing on the Profiler software will be set to 25 degrees, and this will allow up to 5 degrees of ignition advance if the Driveshaft RPM is too low. The first correction range may be set at 3 degrees and the second correction range may be set at 5 degrees advance. This is an extremely helpful feature, as not only will it potentially make a run quicker, it will also show the user where they are a little light on power applied to the rear wheels (including clutch or convertor slippage). Therefore the user can make adjustments for the next run to make the most of the traction available.

In addition to the wheelspeed management functions, the Profiler has the ability to manage all the systems on a modern racecar. In fact, a Profiler can run an entire Pro Mod car, providing control for ignition, Rev Limiters, shift solenoids and torque convertor lockup/line pressure control solenoids and even solenoids for fuel leanout or nitrous oxide injection. Different versions are also available to integrate with popular EFI units such as the Holley Dominator and Fueltech, and an optional feature is the inclusion of Davis' self learning traction control strategies, making it a valuable tool in developing a car setup. The traction control system can correct any wheelspin, and analysing the data can show where the user defined driveshaft RPM curve is too high for the current track conditions.

The main difference between traction control and wheelspeed management is that traction control (especially the self learning systems) are designed to limit wheel spin completely of their own accord, whereas wheelspeed management systems require the user to plot exactly what they wish the car to do in terms of Driveshaft RPM, therefore if the user makes a bad call on the values entered on the wheelspeed management device, the car will also perform badly. A pure traction control device will to a certain degree save a run where the car setup is not quite optimised for the current conditions.