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WELCOME

Mark Ortiz Automotive is a chassis consulting service primarily serving oval track and road racers. This newsletter is a free service intended to benefit racers and enthusiasts by offering useful insights into chassis engineering and answers to questions. Readers may mail questions to: 155 Wankel Dr., Kannapolis, NC 28083-8200; submit questions by phone at 704-933-8876; or submit questions by e-mail to: markortiz@vnet.net. Topics and questions are also drawn from my posts on the tech forum at www.racecartech.com, where readers can see chassis consulting done for free. Readers are invited to subscribe to this newsletter by e-mail.

CHASSIS TROUBLESHOOTING GUIDE

From time to time, people ask me to write a simplified chassis troubleshooting guide, as some other writers and car builders have done. I have shied away from this because so many things can alter the way chassis variables work. For example, changes to the left springs of an oval track car work one way in steady-state cornering on a flat track, and the opposite way in steady-state cornering on a steep banking. Rear spring split works one way if the rear suspension squats under power, and the opposite way if it lifts. Anything that adds diagonal percentage tightens the car (adds understeer), except on entry when the car is mainly being slowed by the back wheels, if the retarding force is strong and cornering force is moderate. So I always ask a client about the car, the track, and the driver's style before trying to solve problems (although in some instances a question does have a quick, simple answer).

However, it is possible to create a simple troubleshooting guide *for a certain set of conditions and assumptions*. I will offer such a guide here, but I want to be very explicit about the assumptions:

- 1) The inside suspension is assumed to extend rather than compress in steady-state cornering. That is, the turn is assumed to be fairly flat, grip is assumed to be fairly good, and relationship between ride and roll rates is assumed to be fairly conventional. This will make the guide applicable to relatively flat ovals. It will also be applicable to most road course corners, but I will assume for this discussion that we are examining a left turn. Road racers will have to "think mirror image" when applying the rules to right turns.
- 2) The suspension is assumed to be free of large jacking forces. In braking, the front suspension compresses and the rear suspension extends. Under power, the front suspension extends and the rear suspension compresses.
- 3) The front brakes are assumed to do at least half of the braking. The driver is not assumed to be tossing the tail out with the brakes.
- 4) The surface is assumed to be smooth enough so that sprung mass motion creates most of the shock movement, rather than bumps. This means we are looking at low-speed damping.

We will need to break the turn down into five portions, rather than the customary three:

Early entry: Braking is hard, and brake application is either steady or increasing. Cornering force is present, and increasing, but still moderate compared to rearward force from braking. This phase of the cornering process may not exist in many corners on a road course, or a severely paperclip-shaped oval. In such cases, the driver will do the hard braking in a straight line, and start to ease out of the brakes as he/she begins to turn in. But on most ovals, this phase will usually be present. I quite often see oval track drivers turn before they lift, or about the same time. This phase may also be present in road course corners that are fast, last a long time, or require an in-fast-out-slow line.

In this phase, roll position is rightward from static (left turn, remember), and increasing. Roll velocity is rightward, and increasing. Pitch position is forward from static, and increasing. Pitch velocity is forward, and may be increasing or decreasing.

The most active corners of the car are the right front and the left rear. The right front suspension's position is compressed from static, and its velocity is in the compression direction. The left rear suspension's position is extended from static, and its velocity is in the extension direction.

Late entry: Braking is diminishing, and ends at the completion of this phase. With a capable driver, cornering force should build as braking force diminishes.

Roll position is rightward from static, and increasing. Roll velocity is rightward, and may be increasing or decreasing early in this phase. Late in this phase, roll velocity will be rightward and decreasing. Pitch position is forward from static, and decreasing (because braking is diminishing). Pitch velocity is rearward.

The most active corner in terms of position is the right front. It will generally see its greatest compression somewhere early in the late entry phase. (This varies depending on several factors, including anti-dive, anti-roll, and roll rate/ride rate relationship.) The left rear is also active in terms of position. It will see its greatest extension. The most active corners in terms of velocity are the left front and right rear. The left front is extending; the right rear is compressing.

Mid-turn: Braking has ended. The driver feeds in at least enough power to overcome drag. The car either holds steady speed or gently begins to gain speed. The car is approximately in steady-state cornering. Forward acceleration is negligible. Lateral acceleration is at its maximum. Duration of this phase may be considerable with a smooth driver in a long turn, or it may be negligible if the turn is brief or the driver is abrupt.

Roll position is rightward from static, and stable. Roll velocity is near zero. If the mid-turn phase lasts a noticeable length of time and steady-state cornering is closely approximated, pitch position will be close to static, and pitch velocity will be near zero.

If steady-state cornering is approximated, all corners of the suspension are active in terms of position, and none are active in terms of velocity. The more the turn is banked, the more the

rights are compressed and the less the lefts are extended. In corners around 15 degrees, the lefts neither

compress nor extend much, and at steeper angles the lefts compress. As stated earlier, we are not considering such cases here.

The car is sensitive to all of its springs, especially the rights, and none of its shocks.

Early exit: The driver begins to increase power application and allow the car to widen its arc. Lateral acceleration diminishes and forward acceleration increases.

Roll position is rightward from static, and decreasing. Roll velocity is leftward, and increasing. Pitch position is rearward from static, and increasing. Pitch velocity is rearward.

The most active corner in terms of position is the right rear. It will see its greatest compression during this phase. The left front is also active in terms of position. It will see its greatest extension. In terms of velocity, the most active corners are the right front and left rear. The right front is extending (de-compressing); the left rear is compressing (de-extending).

Late exit: Similar to early exit, except that forward acceleration is now the dominant factor and lateral acceleration is fading into insignificance. Lateral acceleration will be zero at the conclusion of this phase, or very nearly zero, and forward acceleration will be at its maximum.

Roll position is rightward from static, less than before, and diminishing. At the conclusion of this phase, roll position reaches approximately static (car is going straight). Roll velocity is leftward, and decreasing. Pitch position is rearward from static, and increasing. Pitch velocity is rearward.

The most active corners in terms of position are still the right rear and left front, but the relative significance of right rear compression is diminishing. At some point in this phase, right front and left rear positions reverse from earlier phases: the right front goes into an extended position and the left rear goes into a compressed position. This means that spring changes on these two corners work backwards from the way they worked in previous phases. The most active corners in terms of velocity are still the right front and left rear.

We pay attention to suspension position because it is the key to spring tuning. We pay attention to suspension velocity because it is the key to shock tuning. Note that early and late exit are similar in terms of suspension velocity, but qualitatively different in terms of suspension position.

Now that we know what the suspension is doing in the turn, we are in a position to predict the effects of spring and shock changes. Remember that the rules which follow are only as good as your situation's match-up to the one we're modeling here. If your rear suspension lifts under power or compresses in braking, or you run on steep banking, the rules change.

I am also including rules relating to other tuning variables such as tire stagger, brake bias, and so on. I have tried to keep the chart to a single page, with reasonable size print, so it is a useful basic guide but cannot be a comprehensive reference work.

CHASSIS TROUBLESHOOTING CHART

CAUTION: See the rest of this publication for important information on applicability of these rules.
Tuning factors listed are the *most* influential ones for the phase of cornering specified,
but are not the *only* influential ones.

TO TIGHTEN LOOSE CAR

Early Entry	Stiffer right springs, especially RF Softer left springs, especially LR Stiffer RF compression damping Softer LR extension damping More front brake Less front and rear tire stagger More static diagonal percentage
Late Entry	Stiffer RF spring Softer LR spring Stiffer LF extension damping Softer RR compression damping More front brake Less front and rear tire stagger Higher front/lower rear roll center Stiffer front/softer rear anti-roll bar(s) More static diagonal percentage
Mid-turn	Stiffer front springs, especially RF Softer rear springs, especially RR Stiffer front/softer rear anti-roll bar(s) Higher front/lower rear roll center Less rear tire stagger More static diagonal percentage
Early Exit	Softer RR spring Stiffer LF spring Softer RF extension damping Stiffer LR compression damping Less rear tire stagger Higher front/lower rear roll center Stiffer front/softer rear anti-roll bar(s) Aim rear wheels leftward More static diagonal percentage
Late Exit	Softer right springs, especially RR Stiffer left springs, especially LF Softer RF extension damping Stiffer LR compression damping Less rear tire stagger Aim rear wheels leftward More static diagonal percentage

TO LOOSEN TIGHT CAR

Softer right springs, especially RF Stiffer left springs, especially LR Softer RF compression damping Stiffer LR extension damping More rear brake More front and rear tire stagger Less static diagonal percentage
Softer RF spring Stiffer LR spring Softer LF extension damping Stiffer RR compression damping More rear brake More front and rear tire stagger Lower front/higher rear roll center Softer front/stiffer rear anti-roll bar(s) Less static diagonal percentage
Softer front springs, especially RF Stiffer rear springs, especially RR Softer front/stiffer rear anti-roll bar(s) Lower front/higher rear roll center More rear tire stagger Less static diagonal percentage
Stiffer RR spring Softer LF spring Stiffer RF extension damping Softer LR compression damping More rear tire stagger Lower front/higher rear roll center Softer front/stiffer rear anti-roll bar(s) Aim rear wheels rightward Less static diagonal percentage
Stiffer right springs, especially RR Softer left springs, especially LF Stiffer RF extension damping Softer LR compression damping More rear tire stagger Aim rear wheels rightward Less static diagonal percentage

For help with cars or situations not covered here, call Mark Ortiz at 704-933-8876 or e-mail markortiz@vnet.net.