BUMP STEER

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A. BUMP STEER DEFINITION

Bump steer is when you wheels steer themselves without input from the steering wheel. The undesirable steering is caused by bumps in the track interacting with improper length or angle of your suspension and steering linkages.

Most car builders design their cars so that the effects of bump steer are minimal. However, you must still take care to bolt on your suspension carefully so as not to create unwanted bump steer. Make sure that you are always using the correct components for a particular car. Bump steer must be designed into the car and cannot be adjusted out if improper parts are used or if pivot points are moved without considering bump steer design principles.

In order to accomplish zero bump the tie rod must fall between an imaginary line that runs from the upper ball joint through the lower ball joint and an imaginary line that runs through the upper a-arm pivot and the lower control arm pivot. In addition, the centerline of the tie rod must intersect with the instant center created by the upper a-arm and the lower control arm (See diagram below).

The instant center is an imaginary point that is created by drawing a line from the upper a-arm ball joint through the a-arm pivot where it is intersected by an imaginary line that extends from the lower ball joint through the inner control arm pivot. Where the two imaginary lines intersect is the instant center.

Sounds complicated? Really it is very simple. To achieve zero bump the front end must be designed correctly. The tie rod must travel on the same arc as the suspension when the car goes through travel. Simply matching lengths and arcs to prevent any unwanted steering of the front tires.

To exaggerate, if the tie rod were only 10" long and the suspension were 20" long then when the suspension traveled the tie rod angle would shorten much quicker than the suspension arc. In this scenario the tie rod would shorten much quicker through travel than the suspension and the car would toe in drastically over bumps. The shorter arc of the tie rod would pull on the spindle and toe it is through travel.

Bump Simplified

When designing a car, if the centerline of the outer tie rod lines up with the centerline of the lower ball joint, and the inner tie rod lines up with the lower pivot point then the length and angle of the tie rod and suspension will be the same resulting in zero bump. Most car builders design their cars in this fashion.

B. Preparing the Car for Bump Steer Measurement

Your front suspension must be complete and set for racetrack conditions before you can measure the bump steer. All components must be tight and in proper position and you will need a quality bump steer gauge.

1. Set the car to ride height.
2. Use the proper size tires and air pressures.
3. Caster must be set.
4. Camber must be set.
5. Toe in must be set.
6. Tie rod lengths must be set.
7. Steering should be centered (tie rod ends centered on inner pivot points lower ball joints).
8. Steering must be locked down.

9. Measure from the ground to the lower ball joint or other reliable reference point. Write it down.
10. Remove springs and disconnect sway bar.
11. Return the suspension to the proper height by using your reference number to the ground.
12. Obtain a supply of bump steer shims.
13. Bolt the bump steer plate on to the hub. Level the plate and note where the dial indicator is on the bump steer plate so that you can quickly return to the correct ride height.
14. Jack the suspension through 2”-3” of both compression and rebound travel and write down your results.
15. Shim as needed.

C. Making Bump Steer Corrections

Now that you have measured your bump steer you will need to adjust, shim or relocated the suspension components to get the exact reading that you desire. Below are some tips that will quickly guide you through the corrective process for cars with front steer style suspension.

Symptom	Cure
Symptom 1. Toes out in compression and in on rebound all in one direction.	**Cure 1.** Decrease shim on outer tie rod or lower the inner tie rod.
Symptom 2. Toes in on compression and out in rebound all in one direction.	**Cure 2.** More shim at outer tie rod or raise the inner tie rod.
Symptom 3. Always toes in both compression and rebound.	**Cure 3.** Lengthen the tie rod as it is too short.
Symptom 4. Always toes out on compression and rebound.	**Cure 4.** Shorten the tie rod as it is too long.

Symptom	Cure
Symptom 5. Toes out on compression, then in on rebound and then starts back towards out with more rebound travel.	**Cure 5.** Less shim at outer tie rod and shorten tie rod.
Symptom 6. Toes in on compression, then moves out on rebound and then starts back towards in with more rebound travel.	**Cure 6.** More shim at outer tie rod and lengthen tie rod.

D. Using the Bump Steer Gauge

Selecting a good bump steer gauge makes the process easier. I like the bump steer gauges that utilize only one dial indicator. One dial indicator bump steer gauges do the math for you and you avoid having to watch two dial indicators move at the same time. Sometimes when the bump is way out of adjustment it takes two people to watch both of the indicators. The one indicator design is much easier to use.

When you set up your bump steer gauge with the car at the proper height set the dial indicator at the center of the bump steer plate and be sure that the indicator is set in the middle of its range. You want to avoid running out of indicator travel.

Once the indicator is set simply jack the suspension through 2”-3” of compression. Stop at each inch and record your reading. Repeat the process through rebound and record those numbers at each 1-inch interval.

If the front of the bump steer plate is moving towards the engine then you have a bump in condition. If the front of the plate moves away from the engine then you have a bump out. The dial indicator will see small amounts so watch it carefully and note your results.

E. How Much Bump Steer?

Ideally you should run as little bump steer as possible. Most of the tracks we see today are old and bumpy. Bump steer on these rough surfaces causes the car to be unpredictable.

Some bump out can make the car more stable on corner entry. Bump in is almost always undesirable.

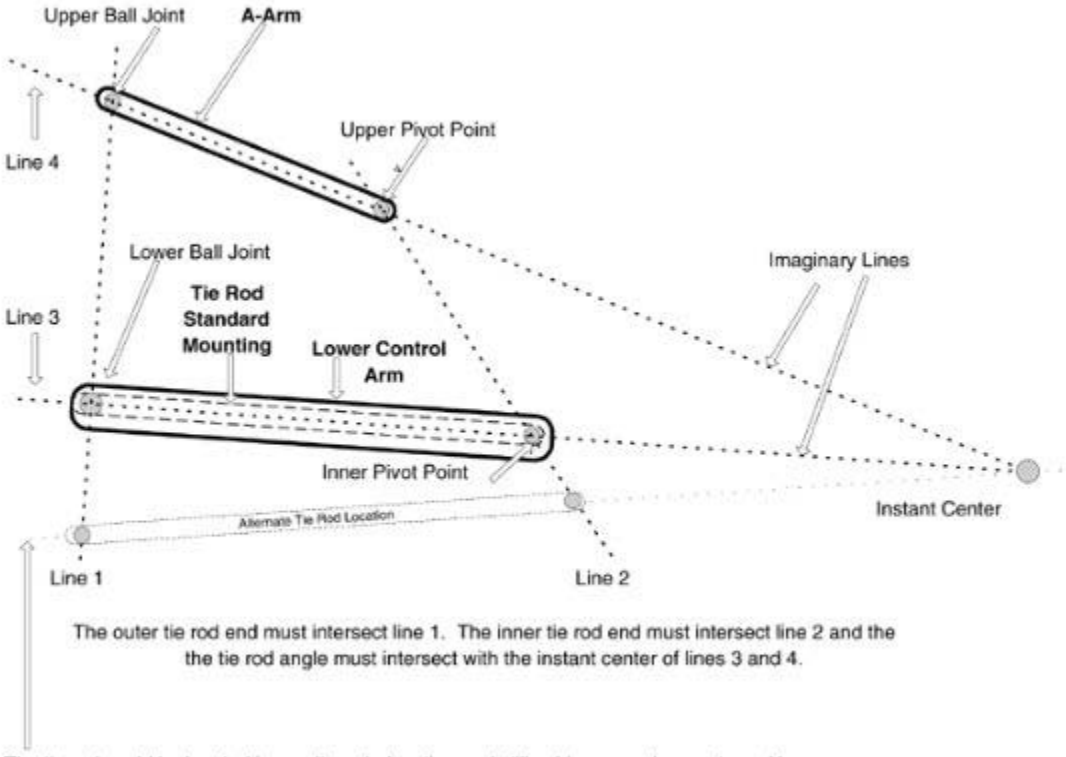
Some people use small amounts of bump out to create entry stability and an Ackerman type effect in the center of the turn where as the bump setting causes the LF to turn a bit farther than the RF as the RF compresses and the LF extends.

My recommendation is to run .005 to .015 thousands of bump out but never allow tires to bump in.

If you want Ackerman in the center of the turn then add Ackerman while maintaining proper bump. If you use bump to obtain some Ackerman effect the car will be unsettled as it goes over each bump, which will break the contact patch from the racing surface.

If the design of your car does not allow for such precise bump adjustments then more bump out is better than any bump in. However, strive to get the best bump numbers even if it means replacing parts. Excessive bump over .050 can slow your car down.

F. DIAGRAM



The outer tie rod end must intersect line 1. The inner tie rod end must intersect line 2 and the the tie rod angle must intersect with the instant center of lines 3 and 4.

The tie rod could be located in an alternate location and still achieve zero bump steer. You could place the outer tie rod end anywhere on Line 1 as long as the inner tie rod landed on Line 2 and the tie rod angle intersected with the instant center.

BUMPSTEER TECH – BACK TO BASICS

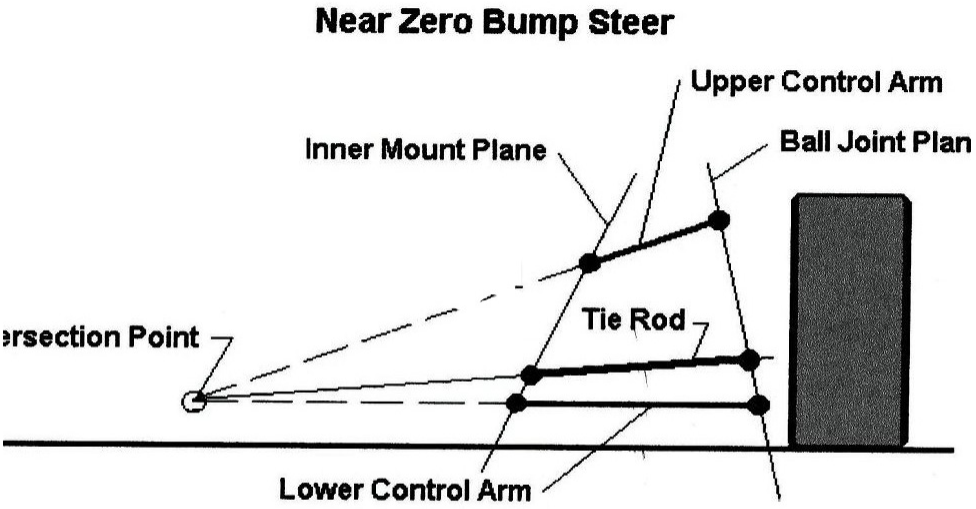
How Bumpsteer Occurs & More

By Bob Bolles, Circle Track Magazine

The mechanical phenomenon of bumpsteer is one of the basic elements of front end geometry. In racing, we want to reduce it to near zero. Here we will take a detailed look at B/S, explaining how it occurs and how we can recognize it, as well as how to eliminate it. This discussion is both basic and advanced, so don't stop reading just yet all you veterans.

Certain setups have evolved to where your bumpsteer might now be an issue. When you make changes to your antidive or moment center, you may be changing your bumpsteer characteristics. Or, when trying a new setup, such as the bump type of setups, you might be introducing B/S and not know it.

The greater amount of travel associated with those setups may be out of the range in which you last checked your B/S. As a result, the car may begin to behave erratically and cause the driver to be uncomfortable with the new setups.



Near Zero Bumpster

1. When the components that affect bumpsteer are arranged correctly, we will have near zero bumpsteer. The length of the tie rod must be equal to the length of the tie rod line as is passes through the ball joint line and the inner mount plane, but it can be outside those two. Many times you can eyeball the tie rod angle and note if it looks like it is pointing correctly before doing a detailed bumpsteer analysis.

Image courtesy of Circle Track Magazine

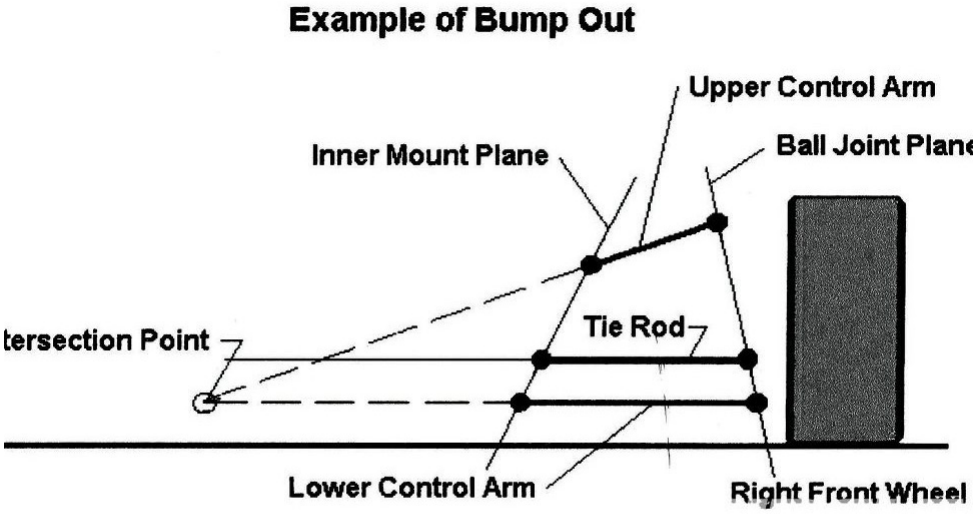
BASICS OF BUMPSTEER

As the chassis moves up and down, we want the front wheels to point in the same direction. It is most important for the wheels to have minimal bump when we are negotiating the turns. There are certain elements of the construction of the front end components that will make this happen.

The angles of the upper and lower control arms, meaning the angle of a line extending through the centers of rotation of the ball joints and inner mounts of each arm, intersect at a point we call the Instant Center (IC). In order to have near zero bumpsteer, the intended goal, we need to have the tie rods on each side point toward the IC for its side. This is one of two criteria for near zero B/S.

The other thing we need is for the tie rod to be a specific length. That length must be equal to the distance formed by 1: a line extending through the centers of rotation of the tie-rod ends, and 2: the tie rod line intersection with both; a: a line extending through both the upper and lower ball joints, and b: the plane that passes through the inner chassis mounts. This can get a little complicated, because although the ball joints do form a single line, the chassis mounts form a plane because of the front and rear mounts.

So, the inner tie rod intersection point is where the tie rod line intersects the plane of the inner mounts, and the outer line intersection point is where it intersects the ball joint line. A three-dimensional geometry program can simulate this very well, but most of us don't have the luxury of owning and/or knowing how to operate one of those. So, we must go through the process of physically measuring the B/S in our cars.



Bump Out

2. In this scenario, if the wheel moved up in relation to the chassis, the wheel would bump out. Remember that as the wheel moves, so does the Instant Center point, so the tie rod will always be misaligned.

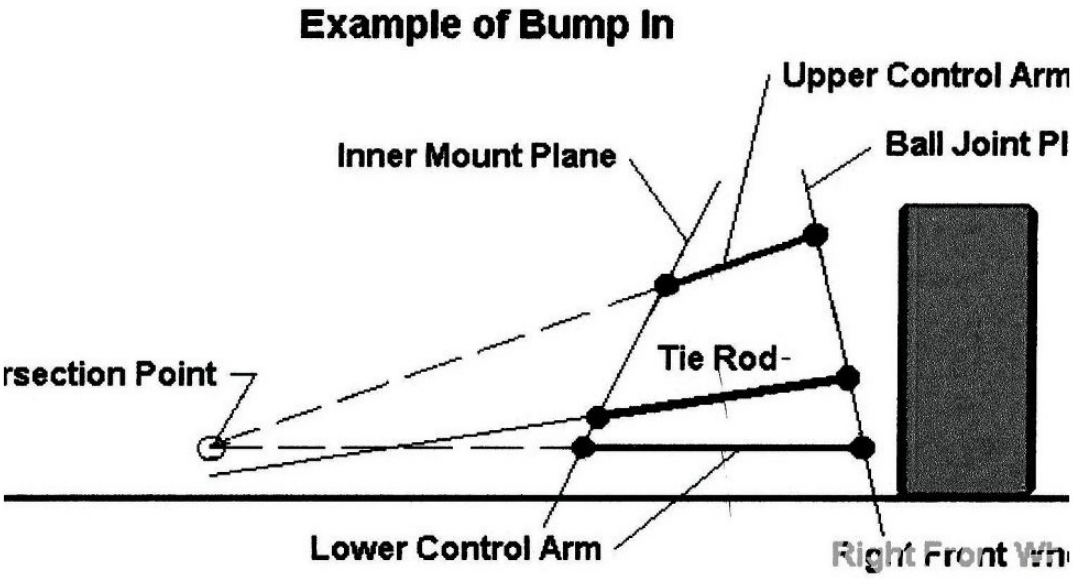
Image courtesy of Circle Track Magazine

WHAT CREATES BUMPSTEER?

When the tie rod is not aligned with the IC and/or the length is wrong for the system, we will have B/S. As the wheel moves vertically in relation to the chassis, the wheel will either steer left or right from the driver's perspective.

If the tie rod was pointed so the tie rod line passes below the IC, then the wheel will bump in (toward the centerline of the car) as the wheel travels up and bump out when the wheel travels down. If the tie rod line passes over the IC, then we will have bump out as the wheel travels up and bump in when the wheel travels down.

If the tie rod were too short, we would have bumpsteer in when the wheel travels in both directions from the static ride height position. If it were too long, then the wheel would bump out as the wheel traveled in both directions from ride height.



Bump In Jpg

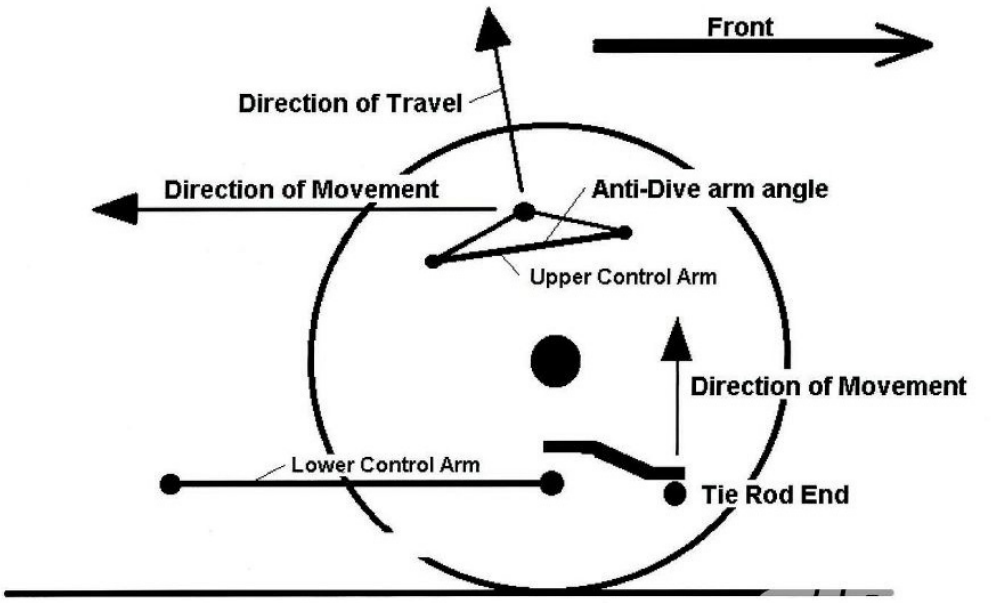
3. Here we will have a wheel that bumps in with upward movement of the wheel. On many cars, the tie rod is close to the same height as the lower control arm. If so, the tie rod should be the same angle from a front view as the lower control arm. If it is not, you know you have a problem.

Image courtesy of Circle Track Magazine

ANTIS AFFECT BUMPSTEER

In both dirt and asphalt racing, antidive and prodive are used in varying degrees. These effects cause changes to our B/S. This is because, with antidive for example, when the wheel travels up, the upper ball joint moves toward the rear of the car and this rotates the spindle. This rotation moves the outer tie-rod end upwards and changes the angle of the tie rod. Now it no longer points toward the IC.

Where we had near zero B/S before with no antidive, we now have B/S when the right front wheel travels up. With pro-dive, we see a similar affect, the tie-rod end moves down with vertical travel and again the tie rod is miss-aligned with the IC. If you originally checked your B/S and found it acceptable and then experimented with Anti's, and didn't recheck your B/S, you could, and probably do, have a problem.



Antidive Prodive

4. With antidive or prodive, when the wheel moves vertically, the spindle will rotate from a side view and the outer tie-rod end at the end of the steering arm will move vertically and change the angle of the tie rod line.

Image courtesy of Circle Track Magazine

MEASURING BUMPSTEER, SOME TIPS

When we steer our front wheels, we change the angles of our tie rods due to caster, camber, and spindle inclination on both sides. The tie-rod ends travel in an arc that is not parallel to the ground. This changes the outer tie rod height and therefore the B/S. It is for this reason that we recommend doing your B/S with the wheels both straight ahead and then again with the wheels turned equal to mid-turn steering at the track you will run.

We can measure our B/S using several different types of equipment. There is the double dial caliper system, the single dial system, and the laser system. Each one will tell us if the wheels steer when they are in bump or rebound.

The most common tool is the bumpsteer gauge. It consists of a plate bolted to the hub and a stand that holds either one or two dial indicators. It comes in two configurations, the double dial indicator type with a stationary stand and the single dial type with a swinging stand. With the later, when the wheel moves vertically, the stand follows the plate. With the double dial type, the two dial pins are always moving one way or the other. If the system has zero B/S, then both dials will move together the same amount.

If the front dial moves farther out as the wheel moves up, then we have bump-in at that wheel. If it travels less, then we have bump-out. Be sure to count the number of turns each dial makes when moving the spindle vertically. Subtract the readings to find the B/S amount related to the distance the wheel has moved. We usually refer to B/S as decimal inches of bump per whole inches of travel.

The single dial indicator gauge is a little different and one I personally like. Using a swing stand, it has one dial that rides on one side of the plate and a roller that rides on the other side. As the wheel moves vertically, the stand follows it in and out. If the wheel has zero B/S, then the roller and the dial shaft will move together the same amount and the dial will not change its reading. If the dial does move, it is recording the total amount of bumpsteer.

With the laser systems, the laser is mounted on the hub or wheel and we use targets placed ahead and behind the wheel center the same distance. This way, any difference in movement of the laser on the two targets, as the wheel moves vertically, will be divided by the distance to the target from the center of the wheel divided by the diameter of the tire.

So, if a tire where 28 inches in diameter (88-inch tire), and the targets were 112 inches away (28x4), we would divide the difference in movement of the laser front to rear by four. If the difference at the targets was 0.120 inch, then the wheel would be bumping 0.030-inch.

CONCLUSION

Once we understand all of the components that affect bumpsteer, we will know when to we need to re-measure the car so we can maintain near zero bumpsteer. If you make moment center changes, antis changes, spindle changes, or even change setups, you will need to remeasure your B/S.

If you have only measured bump at static ride height with the wheel pointed straight ahead, maybe it's time to remeasure the bump at mid-turn configuration. It could make a difference in how the car feels

to the driver as the car moves vertically on corner entry and when going over those bumps on a rough track.

Acceptable amounts of bumpsteer vary as to the intended use. But for most applications, up to 0.030-inch of bump is acceptable. Most teams try to reduce bump to under 0.010-inch when possible. Also, if you have bump and can't reach zero, have the right front bump out in upward movement, and the left front bump in with upward movement. That way, the driver corrects for the bumpsteer by turning left a slight amount more than normal, not counter-steering which would be uncomfortable.