27Th November 2003
Version 1.0

WHITELINE Flat out
PO Box 5666, Minto, NSW, 2566 Australia
Ph: 61 2 9603 0111 Fax: 61 2 9820 2500
E-mail: admin@whiteline.com.au
A.B.N. 93 051 207 535

# Discussion Paper

# Effect of Anti-Squat Adjustment in Solid Axle 4 Link Rear Suspension Systems

Example used is Commodore 1990 VG utility fitted with Whiteline KTA103 adjustable upper trailing arms.

Prepared by

Jakub Zawada B.E. (Mech)

WHITELINE Flat out
PO Box 5666, Minto, NSW, 2566 Australia
Ph: 61 2 9603 0111 Fax: 61 2 9820 2500
E-mail: admin@whiteline.com.au
A.B.N. 93 051 207 535

## Introduction

There are a large number of cars that have been manufactured with live rear axles. Most can fall into the category in which they are located by an upper and lower trailing arm (2 upper, 2 lower, 4 in total) with a panhard rod or Watts linkage as a lateral restraining link. The arrangement of these trailing links can establish the location of the side view instant center, the point that the rear axle rotates about at that instant (only at that instant as this "center" usually moves with wheel travel).

The instant center is the key point that is used to determine how much anti-squat the rear suspension has, and by modifying the position of the instant center, the anti-squat can be increased or decreased.

## Anti – Squat

Anti-Squat is a suspension characteristic that can be introduced in the rear suspension to reduce the amount of suspension compression travel during acceleration. This only applies to cars that are either four-wheel drive or rear wheel drive; no anti-squat system can be implemented on a front wheel drive car. This is because in its action of reducing the amount of compressive suspension travel (or squatting in the rear) during acceleration, it uses the traction force that the driving wheels develop.

With 100% anti-squat, there will be no compression of the rear suspension during acceleration (the springs do not "feel" any load and therefore do not compress, the suspension links and chassis take 100% of the weight transfer load). This does not infer that there is little or no weight transfer to the back wheels. Anti-Squat does not change the steady state value of the force at the tyre contact patches during acceleration.

## Effects of Anti – Squat

Anti-Squat (AS) can limit the amount of compression in the rear end (limit the chassis pitch angle). This can help any problems in suspension geometry, which may suffer from excessive chassis pitch angles.

Longitudinal weight transfer can be increased to the rear wheels with the implementation of AS. With the AS, the rear end will not compress during acceleration (or be limited depending of the % of AS), this will lead to the CG (mass center) to not drop down slightly while accelerating (especially if the CG is rearward based). Weight transfer is a function of CG height, the higher the CG the more weight transfer there is to the rear in acceleration. Therefore if the CG does not drop during acceleration, more weight can be

WHITELINE Flat out
PO Box 5666, Minto, NSW, 2566 Australia
Ph: 61 2 9603 0111 Fax: 61 2 9820 2500
E-mail: admin@whiteline.com.au
A.B.N. 93 051 207 535

transferred onto the rear wheels. It can even be set so that the CG will rise during acceleration (more than 100% anti-squat), this could further increase weight transfer.

AS has the effect of increasing the spring rate, as the rear end does not compress as much during acceleration. This can decrease the transient response time in weight transfer and chassis steady state positions.

## Suspension Measurement

A 1990 Holden VGU utility was used to measure all the suspension points for a rear live axle. The car was of standard height and standard suspension with wheel center to guard heights of 402, 400, 392, 395mm (LF, LR, RF, RR). The only assumption that was made was that of the CG height which was assumed to be at around 750mm above the ground.

## Calculation of Anti – Squat

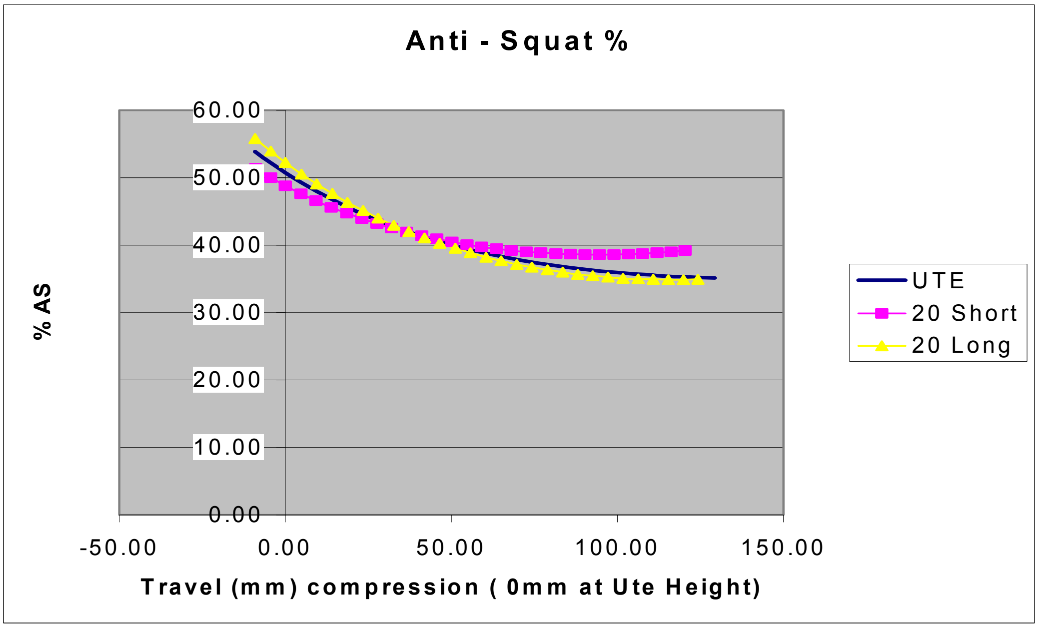
From the measurements taken from the car, the % AS was calculated to be 52% at standard height. The value is surprisingly high, expected values where in the region of 20 – 30%. The fact that this car is a utility may give reason to such a high % of AS. High values of AS can lead to high friction levels in suspension joints and this could lead to lock-up and harshness if not taken into account. Some very high performance sports cars run in the range of 60% AS.

## Variable Length Links (KTA103)

By introducing some variable length upper links or trailing arms into the suspension (KTA103 uses turnbuckle adjustable arms to replace the solid upper trailing arms) the side view instant center can be changed and therefore the amount of AS in the suspension.

WHITELINE Flat out
PO Box 5666, Minto, NSW, 2566 Australia
Ph: 61 2 9603 0111 Fax: 61 2 9820 2500
E-mail: admin@whiteline.com.au
A.B.N. 93 051 207 535

The following plot shows the % AS versus the compression travel of the suspension with the upper link at standard length, +20mm length and –20mm length. 0 mm compression travel corresponds to the standard utility height, and the positive travel means lower vehicle heights.




At standard utility (0 mm compression travel) height, by increasing the upper link length 20mm there is an increase of % AS from approximately 50.7% to 52.3%. Accordingly by reducing the upper link length by 20mm there is a reduction of % AS from 50.7% to 48.8%.

An interesting thing to note, at around 35mm compression travel (corresponding to a wheel center to guard height of 365mm) there is an inversion of the relationship. Beyond this travel (more than 35mm or vehicles lower than 365mm wheel center to guard) the opposite happens, lengthening the link will decrease the % AS, while shortening the link will increase the % AS.  At 330mm standard % AS is 37.7%, with +20mm in upper link AS = 37.2%, and with –20mm in upper link AS = 39.2%.

## Warning – Accuracy of Suspension Measurement

The calculation of % AS is very delicate in this vehicle example, small variations in measurements of the link end points can give large variations in the position of the instant

WHITELINE Flat out
PO Box 5666, Minto, NSW, 2566 Australia
Ph: 61 2 9603 0111 Fax: 61 2 9820 2500
E-mail: admin@whiteline.com.au
A.B.N. 93 051 207 535

center which defines the % AS incorporated into the rear suspension. All effort was made to ensure accurate measurement, although some error will undoubtedly be involved.

**Conclusion**

By using links that can be varied in length, the characteristic and magnitude of the anti-squat that is designed into the rear suspension can be modified. Though the amount of change that is shown in the plot seems low, from practical experience with changing link lengths, there is a substantial change in anti-squat. This could be the effect of measurement error or the fact that small changes produce large effects.