5Th December 2003
Revised version

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Discussion Paper

Effect of Whiteline Anti-Lift Kit (ALK)

Revised 5th December 2003

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Introduction to Anti-Dive and Anti-Lift

"Anti" features in suspension systems are a characteristic that can be used to influence the stiffness of the front or rear suspension under traction forces (under braking or accelerating).
The individual terms are relatively straightforward and self-explanatory with the "anti" reducing or totally restricting the characteristic (lifting or diving). In the front suspension there may be levels of anti-dive during braking and anti-lift during accelerating (assuming traction to the front wheels is present), similarly in the rear there could be anti-lift during braking and anti-squat during acceleration.
It should also be noted that these characteristic can also be reversed into a "pro" characteristic (as in pro-lift at the front under braking).

Anti features can only be implemented under the influence of the braking or accelerating forces at the wheels, for example a rear wheel drive vehicle cannot have an anti-lift characteristic in the front (as there is no drive to the front wheels).

These characteristics do not change the steady state load transfer (during braking or accelerating) at the tire contact patch. The load transfer during steady state acceleration or braking is a function of the wheelbase, CG height, and the braking force.

100% of anti-dive or anti-lift would give no deflections of the suspension (from the static ride height) during braking and accelerating. It does this by passing the extra load during accelerations through the suspension components instead of the spring. Similarly 0% anti-dive would pass the entire load through the spring giving maximum deflections.

Anti-dive and anti-lift are calculated by the position of the side view instant center; this imaginary point in space is generated by the geometry of the suspension system.

The Effect of the Whiteline Anti-Lift Kit (ALK)

The % anti-dive or lift in a suspension system (the Subaru WRX front end for example) is a function of the position of the side view instant center (SVIC). This SVIC is the pivot point for the side view swing arm (also the pivot point of the suspension at that instant), which is a line drawn from the tire contact patch to the instant center (under braking – for acceleration it is drawn from the wheel center).
The slope or angle of this swing arm (effectively the position of the SVIC) describes the amount of anti-dive and anti-lift present in the suspension system.

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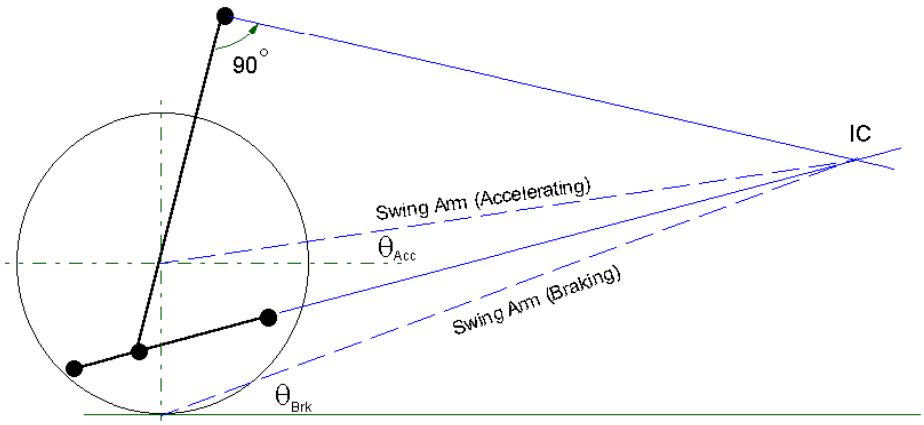
The SVIC is found by the intersection of two lines. The first is the projection of the lower control arm, say through the chassis mounts behind the front wheels, the second line is the normal to the axis of the strut tower at the top of the strut, projected behind the front wheel in the case of the Subaru WRX.
(Note: to be absolutely correct these lines should be projected onto the wheel center plane, so any lateral drop or rise in the control arms will effect the SVIC position. However in most cases the control arm angles are usually low, or flat when looking from the front of the car, and give minimal effect)

The diagram below shows the SVIC and swing arm details for the Subaru WRX.



Together with the position of the SVIC, the wheelbase, CG height, % front torque (for anti-lift under acceleration) and % front braking (for anti-dive) are required to calculate the amount of anti features in the front suspension.

With the ALK fitted to the WRX, the rear mount of the front lower control arm is lowered by approximately 20mm. There is also a castor change present by moving the mount outwards, this adds positive castor to the suspension.
The effect of this component results in the following anti-dive and anti-lift properties in the Subaru WRX, expressed as percentages in the following table.

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	Standard WRX	WRX with ALK	
Wheel Base	2530	2530	mm
CG Height	600	600	mm
% Front Braking	70	70	%
% Front Traction	60	60	%
SVIC Height	457	26.2	mm
Swing Arm Length	5949	11495	mm
% Anti-Dive	22.7	0	%
% Front Anti-Lift*	6.5	-6.1	%
* Negative value denotes pro-lift			

As can be seen from the table, the anti-dive reduces to 0% from 22.7% and the anti-lift is reduced to a pro-lift value of 6.1% from 6.5% anti-lift.

Effect of Anti-Dive and Anti-Lift as Modified by the Whiteline ALK

As mentioned previously if 100% anti-lift or anti-dive is incorporated then all the longitudinal load transfer experienced under braking and accelerating will pass through the suspension components (namely the control arms) leaving the springs unloaded with no deflection present (from static ride height). 0% would pass the entire load onto the spring giving maximum deflections.
This can be used to stiffen the suspension system under braking or accelerating.

In the case of the Subaru WRX fitted with the ALK, the suspension system becomes softer during braking and accelerating actions, as both anti-dive and anti-lift have been reduced. A softer suspension will give rise to larger deflections.

An experiment was then set out to show that this was the case. A standard Subaru WRX was used initially and deflections were captured using a digital video camera during acceleration runs. The same WRX was then fitted with an ALK and the procedure was repeated again. The results are shown in the following table.

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Whiteline ALK Test - 23.10.2002

Standard WRX

Measure A	Measure B	Ratio	Distance	Average (mm)
980	740	0.76	529	**517**
890	650	0.73	511	
890	650	0.73	511	

Standard WRX with ALK

Measure A	Measure B	Ratio	Distance	Average (mm)
900	690	0.77	537	**535**
870	660	0.76	531	
910	700	0.77	538	

Measure A = (700mm) Bottom of Sill to black trim below door Mirror
Measure B = Bottom of wheel to guard in Video
Average is actual bottom of wheel to guard distance

As can be seen from the table with the ALK fitted the WRX had a higher wheel (bottom of wheel) to guard height indicating higher deflections present.
This concurs with what is expected with the modified anti-lift percentages being reduced (to pro-lift in this case).

A softer front suspension during acceleration and braking will even out the load on the front tires, giving a higher total cornering load available or more front-end grip. This will lead to less understeer when cornering under power or brakes.
Another way of looking at this is that under power or brakes the effective spring stiffness is lower, reducing the front-end anti-roll resistance, hence reducing weight transfer at the front and less understeer.

Softer front rates will also allow better wheel tracking over rough roads, keeping the tires in contact with the ground.

The drawback of the ALK is that there is an increased amount of deflections or pitch; this can affect suspension geometry if there is a very large amount of pitch. However the ALK adds additional castor that will more than cover any reduction in castor due to excessive pitch during braking.

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Additional Discussion – Anti-Dive and NVH

Many sources describe that too much Anti-dive in the front end of suspension systems can have adverse effects. Anti-dive percentages of more than 50% are rarely seen in vehicles without very careful design to the suspension systems (for example non-compliant bearing type joints on the suspension), and some recommend ("Tune to Win" Carroll Smith) no more than 30% be used as even this much will have an undesirable effect.

The effect of Anti-dive is to increase the loading of the suspension components and suspension bushes. This increases deflection in the system that can affect the geometry (for example reducing castor under braking), and also increases friction in the bushes, which could lead to suspension lockup and less than adequate wheel tracking over the ground.

Such "stiction" and load transfer through the control arms into the chassis all work to raise the levels of NVH (noise vibration harshness). By decreasing the anti-dive from 23% to 0% with the ALK, any NVH associated with the anti-dive in the Subaru WRX has been removed, therefore assuming all things being the same (apart from the installation of a Whiteline ALK) there should be less NVH present.
This gives scope to increase the bush stiffness in search of enhanced suspension geometry control. Therefore it is can be possible to stiffen the bushes of the front suspension without raising the NVH level when the car is fitted with an ALK.

Conclusion

With the ALK fitted to the Subaru WRX, a softer suspension will be present during braking and accelerating. This will help traction, as the wheel will be able to track the ground more precisely. Also in terms of balance the front end will have a proportionally lower roll resistance during traction or braking, aiding in reducing the power understeer effect that is present in these cars.