Development of the Unbalanced Engineering Decoupled Torque Arm for the 4th generation F-body platform

Design Goals:

1. Increase corner exit traction
2. Decrease rear wheel hop under braking

The first design goal is an outgrowth of the increase in torque output of the 4th generation F-body platform over the 3rd generation for which this rear suspension was originally designed. This is especially true when engine modifications have increased torque output which often cannot be put to the ground on corner exit. To increase corner exit traction, the easy answer is to shorten the torque arm which will result in an increase the percentage of anti-squat and therefore provide additional on-throttle rear traction.

However, shortening the torque arm will increase the amount of rear anti-lift geometry which will result in increased wheel hop under braking. The tendency of the rear anti-lift geometry to cause wheel hop is exacerbated by the additional grip provided by race tires. The additional grip at the front allows much higher brake line pressures before the front tires begin to lock up. As a matter of course, the rear line pressure also increases and the rear anti-lift geometry pulls the rear tires off the ground which results in wheel hop.

To attain both these design goals, it is clear that two goals would require two different modes for the rear suspension, one to provide a higher % of anti-squat and one to provide less anti-lift – obviously a decoupled torque arm could provide both these modes. The final challenge is to fit the design into the confined space occupied by the original torque arm.

Goal 1: Additional Anti-Squat

To achieve additional anti-squat the easy answer is to shorten the effective length of the torque arm. After testing several lengths of acceleration beam, I settled on having a 35" effective length which provides 120% anti-squat with my current lower control arm settings. For reference the stock torque arm would have provided 38% anti-squat as illustrated in Figure 1. To reduce shock to the tires when transitioning back to the throttle, a rubber acceleration snubber is used to transmit load from the axle beam to the chassis mount. Under acceleration the sliding brake link is in the open position and therefore does not impact the function of the torque arm or position of the acceleration instant center.

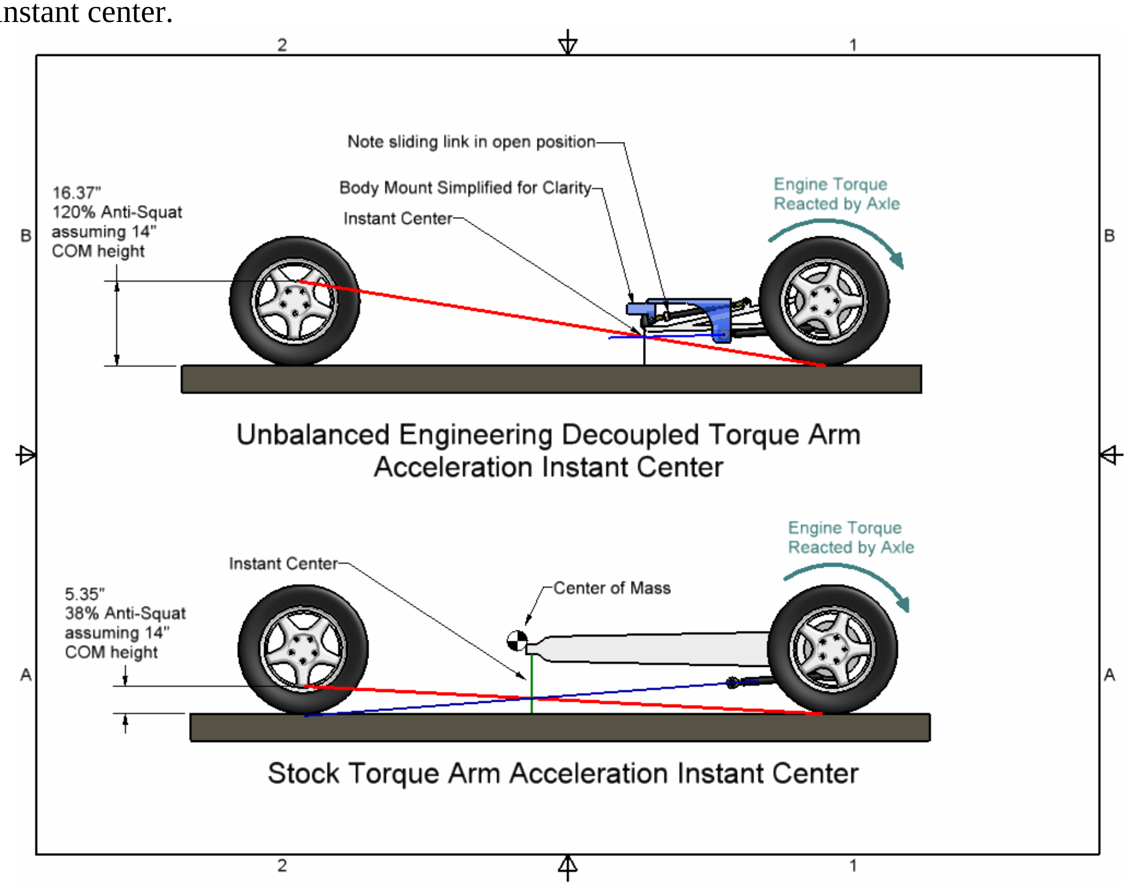

Figure 1. Unbalanced Engineering Decoupled Torque Arm Vs. Stock Torque Arm Under Acceleration

Goal 2: Reduced Rear Wheel Hop Under Braking

The primary means to reduce wheel hop under braking is to reduce the amount of rear anti-lift geometry. My goal was to remove all anti-lift geometry while not inducing any pro-lift geometry. Essentially that entails setting the rear instant center under braking at ground level.

To accomplish this goal would require decoupling the torque arm and using a 3 link to control the rear axle under braking. In this mode the acceleration snubber drops away from the pad it contacts under acceleration and the sliding brake link compresses. The brake link is also cushioned by a rubber washer to reduce shock loading when transitioning from throttle to brake. In order to reduce geometry change with suspension travel it was desirable to make the sliding brake link as long as possible.

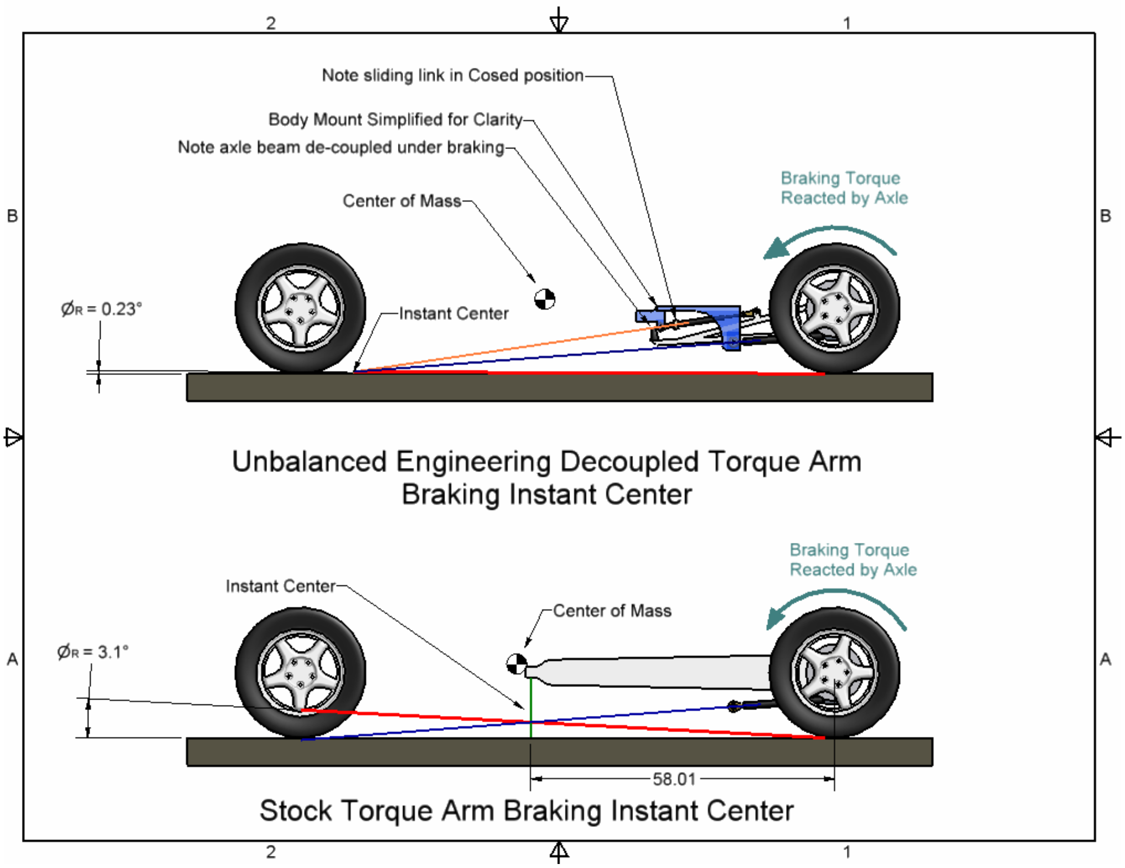

Figure 2. Unbalanced Engineering Decoupled Torque Arm Vs. Stock Torque Arm Under Braking

Load Distribution

Many aftermarket torque arms cause fatigue and then failure in the floor pan of the F-body. I wished to avoid this issues so I wanted to distribute the load over as wide an area as was feasible. The nature of the load applied to the chassis by a decoupled torque arm did make it easier to estimate the load in each mode and therefore ensure that the load was adequately distributed.

Originally I was going to triangulate to the transmission cross member, but that interferes with popular long tube headers that many potential customers would have installed. I therefore elected to mount the forward section of the torque arm to the factory G-load brace and then the rear mount would bolt through the factory sheet metal under the rear seat. To further stiffen the front mount, two ½" bolts were run through the TA and into the passenger compartment to further tie the mount to the floor pan stiffener under the rear mount points for the front seats.

The Packaging Challenge

Packaging turned out to be the most challenging part of the design of the new torque arm. The original torque arm is quite compact and the confined space in the F-body tunnel is typically reduced further by larger than stock diameter drive shafts and exhaust systems. After determining where the acceleration snubber was to be located, an axle beam was fabricated. This assisted in determining where the pad on the chassis mount would be in the tunnel.

We then turned to placing the braking link. After determining the ideal angle it was a matter of placing the link so that it could be as long as possible. This was very challenging since the rear/upper mount on the axle beam was very close to the inside of the tunnel and the forward/lower mount was restricted by the pad for the acceleration snubber. With these restrictions, the Brake link ended up 18.5" long. With the chassis, beam and brake link mounts in place we positioned a bent tube to tie them all together.

Brake Link Adjustment

In order to allow each user to adjust the torque arm for their particular ride height, brake forces ect, the sliding brake link is adjustable. Shims can be inserted for gross adjustment and for fine tuning and on car adjustment the rod ends also allow for change in length.

Safety Features

Due to the decoupled nature of this torque arm, it is possible for the acceleration beam to contact other objects, especially under braking. In order to keep this from occurring, a torque arm safety loop was added. This would not only keep the beam from contacting the ground if the braking link was adjusted too short, but it also would also keep it from contacting the drive shaft under any circumstances. I also considered also adding a drive shaft safety loop, but due to the differing rules in place for various governing bodies, I elected to allow each user to implement their own.

Geometry Change With Suspension Travel

One other major factor that had to be addressed was the change in geometry with suspension travel. This is essential to ensure proper function under braking. In the first prototype, the rubber washer used for the brake link was too soft. This allowed a significant amount of compression which resulted in the braking instant center migrating to above and behind the axle.

Once the linkage passes through this change point it would allow the acceleration beam to hit the ground if the safety loop was not present. With the safety loop in place, the result was much banging and wheel hop. Clearly this was undesirable. We then modified the location of the brake link mounts slightly and then changed to a firmer and thinner rubber washer which has removed this effect in most cases. In addition we also had to consider the ramifications of brake dive on the 3 link geometry.

Design Sensitivity

Originally I intended to provide adjustment for the upper rear brake link mount to allow customers to tune the amount of anti-lift generated by their particular ride height and lower control arm angle. Unfortunately there simply was not space to do so in the stock tunnel. In most cases that simply implies that this change in geometry must be supplied by changing the mount point of the lower control arms on the chassis side. That is easily accomplished in most cases since lower control arm brackets are a common aftermarket item on F-bodies.

However, there is one popular class of racing that does not allow this modification. Several customers in this class have had trouble getting their braking instant center in a desirable location due to their highly angled lower control arms and modest ride heights. One customer has added an additional bracket to allow the rear upper link to be mounted higher then it was delivered. He has relieved his tunnel extensively in this area so this modification is working in his case. Others in this class have been able to get away with just removing the rubber washer and therefore any compliance in the brake link.

Results

With this decoupled torque arm, shown in Figure 3, we have seen significant performance improvement over both stock length and short aftermarket torque arms. When combined with our panhard rod relocation brackets and lower control arm brackets this give the customer full control over their instant centers under acceleration, braking and roll. With a customer car, we obtained a decrease in lap time of more than 3 seconds at Buttonwillow by adding addition of the torque arm, panhard rod relocation brackets and then re-tuning with springs and shocks. With the torque arm alone we obtained 1.2 seconds.

Figure 3. Unbalanced Engineering Decoupled Torque Arm