

Development of a New Multi-link Rear Suspension

Reo Koide, Yoshihiro Kawabe, Keiichi Nakajima and Kiriya Kazuhiro
Nissan Motor Company Ltd.

ABSTRACT

The requirements of suspension systems have become increasingly complex in recent years due to the expansion of global markets and diversification of the conditions under which vehicles are used in different parts of the world. It is also becoming increasingly important to ensure that vehicles offer the secure handling stability which are expected by drivers, but can also provide an adequate level of ride comfort when driving on a wide diversity of road surfaces in all parts of the world. From an environmental viewpoint, it is also essential to achieve weight reductions for better fuel economy.

To meet these wide-ranging requirements, we have developed a new multi-link rear suspension that has a simple link configuration and a lower link that features a connecting bushing mechanism developed by Nissan. This innovative new connecting bushing mechanism not only helps to provide better handling stability by ensuring high stiffness and an adequate level of compliance steer, but also helps to improve the ride comfort by suitably controlling the behavior of tires when they encounter irregularities in the road surface, thereby providing a safe and comfortable driving experience suitable for a high-performance passenger vehicle. The new link layout enabled us to reduce the number of components compared with current multi-link suspensions, we have also achieved weight reductions by precisely controlling the load transmitted to links and suspension members.

In this paper, we introduce the purpose, structure, characteristics and advantages of this suspension.

CITATION: Koide, R., Kawabe, Y., Nakajima, K. and Kazuhiro, K., "Development of a New Multi-link Rear Suspension," *SAE Int. J. Passeng. Cars - Mech. Syst.* 5(2):2013, doi:10.4271/2012-01-0978.

INTRODUCTION

Our current multi-link rear suspension⁽¹⁾ is used across a wide range of models including the Nissan Altima and Infiniti G37, and has been highly regarded by customers due to the superior handling stability and ride comfort. We have started the development of a brand-new multi-link rear suspension with the aim of making improvements in three areas:

- i). Achieving the contradictory goals of improving handling stability and ride comfort, while delivering reduced road noise.
- ii). Weight reduction to contribute to lower fuel consumption.
- iii). Providing greater freedom in vehicle packaging by making the suspension layout more compact.

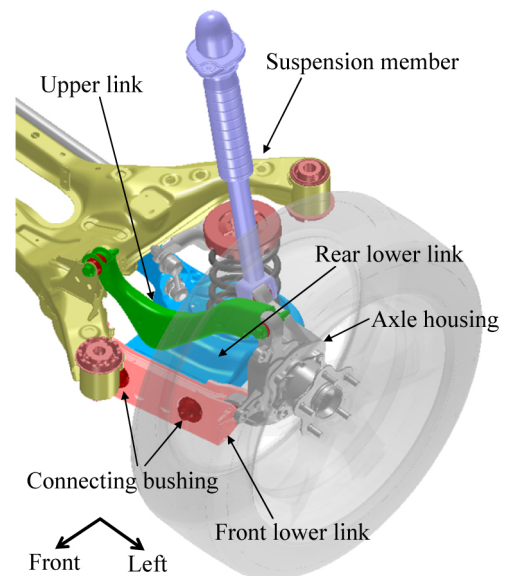


Figure 1. New multi-link rear suspension

CONSTRUCTION

As shown in [Figure 1](#), the new rear suspension features three links - an upper link and front/rear lower links. The suspension member and axle housing are connected via bushings. As shown in [Figures 2](#) and [3](#), the front and rear lower links are elastically coupled via connecting bushings, and connecting pins provided on the rear lower link are bolted to connecting bushings provided on the front lower link.

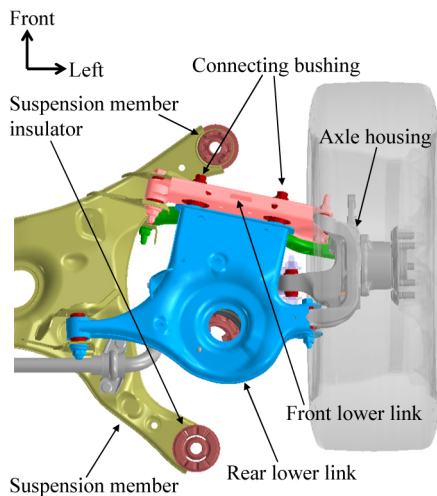


Figure 2. Bottom-view of new rear suspension

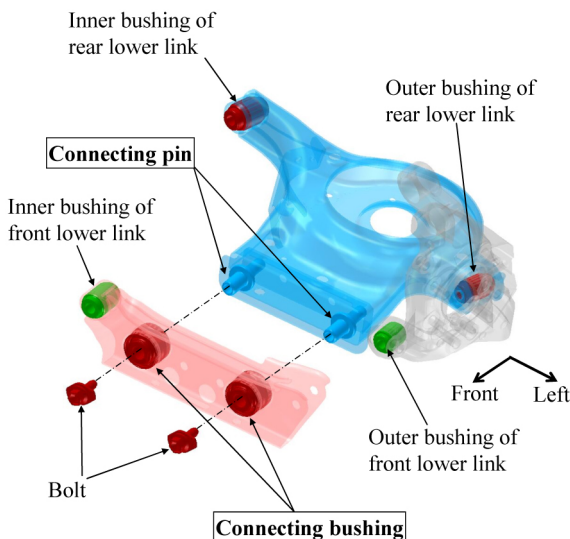


Figure 3. Construction of lower link

MAJOR FEATURES

1. Rear Suspension Performance Requirements for Handling and Ride Comfort

Having a rear suspension system with high lateral stiffness is essential for agile handling.

When the front tire is steered, vehicle starts to yaw due to front tire lateral force. Accordingly, the lateral force is also generated in the rear tire due to the slip angle. Agile handling can be achieved by minimizing the front and rear tire lateral force generation timing. A suspension with high lateral stiffness, have less outer-rear tire displacement due to bushing deformation, which means rear lateral force is generated as soon as the front tire is steered.

To enhance the handling and ride performance which is already at the high level with the current suspension system, our development has aimed to balance this high lateral stiffness and various other requirements, such as:

- 1). Understeer in lateral force compliance steer
- 2). Low longitudinal stiffness of the suspension
- 3). Toe-in in longitudinal force compliance steer during braking

The new rear suspension system achieves high performance while solving trade-off problems by adopting unique structure where the front lower link and rear lower link are linked by connecting bushings, appropriate link layout, and optimum control of the suspension bushing stiffness including the connecting bushings. The following section introduces these features more in detail.

2. Achieving High Lateral Stiffness Without Compromising Understeer Characteristic in Lateral Force Compliance Steer

During cornering and changing lanes, cornering force is maximized and the vehicle behavior is stabilized (understeer) by applying a tire slip angle (toe-in) to the outer-rear tire towards the center of the corner. In other words, the lateral force compliance steer of the rear suspension is toed-in.

As shown in [Figure 4](#), a line connecting inner and outer bushings on front lower link (axis A-B) and that of rear lower link (axis C-D) intersects at point E. The point E is placed behind the tire lateral force input point by X in longitudinal direction of the vehicle so that it generates a torque in the toe-in direction. This results in a link action which the front attachment point of the axle housing (point A) is pulled in towards the inner suspension relative to the rear attachment point (point C) so that the toe-in angle θ_1 of the lateral force compliance steer is achieved.

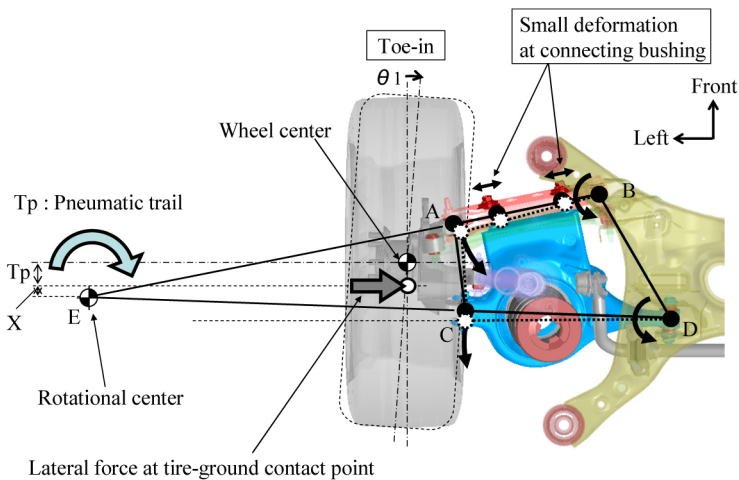


Figure 4. Link motion with deformation of connecting bushings by lateral force input

Setting the radial stiffness of front lower link bushings less than the rear lower link stiffness results front bushings to deflect more than rear, creating one-rotational motion as a trapezoidal link, which ensures lateral force compliance steer toe-in of θ_2 .

These angles θ_1 and θ_2 assure sufficient toe-in in lateral force compliance steer during cornering.

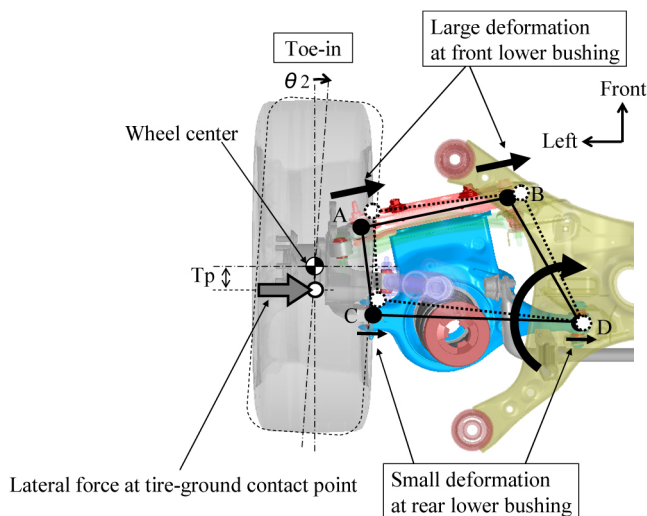


Figure 5. Link motion with deformation of lower link bushings by lateral force input

The inner and outer bushings in lower link have high radial stiffness which ensures high lateral stiffness of the suspension. This high radial stiffness is possible due to the toe-in mechanism described in Figure 4, where front lower link bushing no longer has to be accounted for toe-in and thus the stiffness can be increased. Figure 6 shows this new suspension system has better lateral stiffness and toe-in characteristics than any other suspension systems.

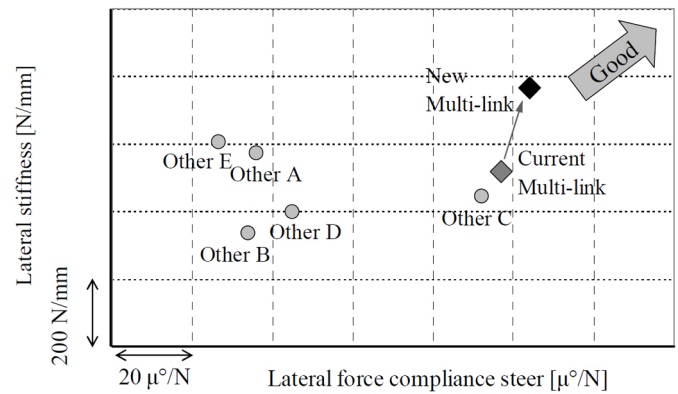


Figure 6. Lateral stiffness and lateral force compliance steer

3. Achieving high lateral stiffness without compromising low longitudinal stiffness

It is well known that in order to reduce longitudinal vibration level due to impact force at the wheel centers occurring when a vehicle drives over small bumps or pavement joints, it is effective to reduce the longitudinal stiffness of the suspension.

As shown in Figure 7, when the wheel center is subjected to an input force towards the rear of the vehicle, the connecting bushing deflects. Consequently, the tire is displaced rearwards, resulting in low longitudinal stiffness of the suspension. This deflection in the connecting bushing allows inner and outer bushings of the lower link to have high lateral stiffness, achieving high lateral suspension stiffness without compromising ride comfort over small obstacles (Figure 8). Moreover, we have selected a rubber material with a high loss factor for this connecting bushing to suppress longitudinal vibration quickly after the impact.

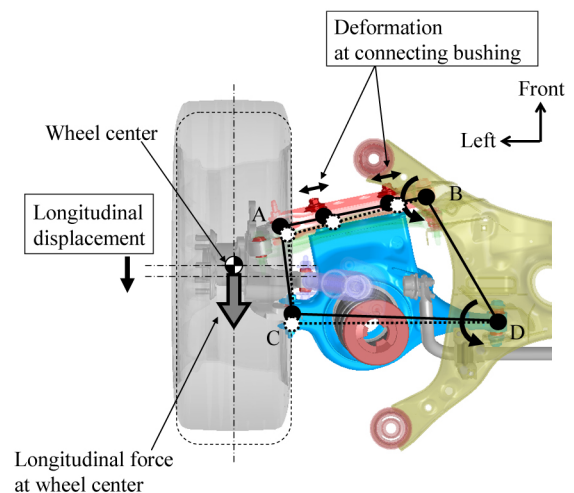


Figure 7. Link motion with deformation of connecting bushing by longitudinal force input at wheel center