

# Gyro Based Active Screw rod Suspension System

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**ABSTRACT:** The main task of the suspension system is to provide a comfortable and safe ride. Usually the suspension consists of passive force elements which are designed to optimize the trade-off between ride comfort, suspension travel and wheel load variations. Thanks to the suspension, the human body is protected against uncomfortable bumps in the road. By selecting the right spring and damper characteristics, the suspension functions as a filter and only passes those frequencies which are less uncomfortable for the human body. However, the characteristics should also guarantee a safe ride. Therefore, the wheel load variation should be small in order to prevent the wheels from losing contact with the road. All this should be achieved in the available suspension travel. The only contacts between car and road are the four contact patches of the tires and it is very important to exploit these areas optimally. Therefore, usually a system of links connects the unsprung mass (wheel, brake, steering hub) to the sprung mass (car body).

## I. INTRODUCTION

Active suspension is automotive suspension that maintains vertical and horizontal movement of the chassis relative to the wheels and road. Vehicles body is controlled by an onboard system having Microcontroller and Gyroscope embedded in it. There by delivering extreme level of traveling comfort and handling power. Skyhook theory is an idea that an object can maintain a stable posture if it is travelling suspended by an imaginary straight line, a skyhook. A vehicle contacts the ground through the spring and damper in a normal spring damper suspension. To achieve the same sustainability in the Skyhook theory, the vehicle must contact the ground through the spring, and the imaginary line with the damper. G.Priyandoko et al. (June 2008) Vehicle active suspension system using skyhook adaptive neuro active force control [1]. Huijiangao et al. (Aug 2005) Multi-objective control of vehicle active suspension systems via load-dependent controllers [2]. D.Hrovat et al. (Sep 1995) Optimal active suspension structures for quarter-car vehicle models [3]. S.J.Mcmanus et al. (may 2002) Evaluation of vibration and shock attenuation performance of a suspension seat with a semi-active Magneto rheological fluid damper [4]. N.Giorgetti et al. (Jun 2005) Hybrid model predictive control application towards optimal semi-active suspension[5]. michal maniowski et al. (Sept 2006) Elastokinematic modeling and study of five-rod suspension with subframe[6]. Yahava m.d. sam et al. (Mar 2004) A class of proportional-integral sliding mode control with application to active suspension system[7]. C.Poussot Vassal et al. (dec 2008) A new semi-active suspension control strategy through LPV technique[8]. M.C.V Rao et al. (Jan 1997) A tunable fuzzy logic controller for vehicle-active suspension systems[9]. T.Yoshimura et al. (Jan 2001) Construction of an active suspension system of a quarter car model using the concept of sliding mode control[10]. Mohammad mehdi et al. (Feb 2009) Impedance control of an active suspension system[11].

### Advantages of an active suspension

In an active suspension system, the passive force elements are replaced or assisted by active force elements. These elements are able to produce a force when required and act independent of the suspension condition. Therefore, the trade-off between ride comforts, suspension travel and wheel load variations can be better resolved. Furthermore, an active suspension system can be used in order to eliminate body roll during cornering. As a consequence, the wheels can be oriented optimally with respect to the road both in case of encountering a bump

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Vol. 6, Issue 3, March 2017

and during cornering. The mentioned trade-off disappears, and also an anti-roll bar is not needed anymore. Thanks to this system, the complicated and space consuming suspension links can be replaced with a compact and simple trailing arm suspension.

The compact suspension system allows for designing a smaller and lower car without affecting its interior space. This leads to lower air drag. Also, static load variations can be taken care of. In case of an active suspension system with variable spring stiffness, this stiffness can be adjusted proportionally to the change of mass. As a consequence, the natural vertical frequency of the car's body will not change and can be chosen at a frequency which is less uncomfortable for the human body. In case of a passive suspension system, a significant portion of the available suspension travel is used to take care of static load variations and of body roll caused by cornering. The active suspension system can take care of these variations by adjusting its stiffness. Therefore, a lower initial stiffness can be used which is favorable for the comfort level.

An active suspension system introduces the possibility to adjust the suspension setup to the type of driving situation and to individualize the handling characteristics and comfort level of the vehicle. The short trip to the supermarket may well be a bit bumpy, but the long boring drive to office should rather be more comfortable. Thanks to this, a possible passenger is able to serenely check his or her e-mail, schedule a meeting or glance through the minutes of yesterday's meeting without getting carsick. Because every single person is different, everybody puts different demands on the suspension characteristics. Because the car may be used by different persons every now and then, the suspension of the car should be adjustable such that a broad spectrum of handling-, steering- and comfort characteristics can be achieved.

One could think of a system which allows the driver to switch between pre-programmed suspension conditions, from soft to hard and several conditions in between, or a manually programmed condition. Everyone can then drive the car he or she prefers. Thanks to the development of a large number of Advanced Driver Assistance Systems (ADAS), the active safety of future cars will increase tremendously. Nevertheless, the suspension should always guarantee maximal grip on the road surface to take care of unexpected hazardous situations.

The price of energy is ever increasing and thus an important issue in designing a car is its energy consumption. An active suspension system provides a lot of possibilities to improve the ride but often consumes a large amount of energy. It is an enormous challenge to make it energy efficient. An addition may be to implement dampers which are capable of converting their dissipated power into electrical power. In Appendix II simulations are performed in order to determine the amount of energy that is dissipated by the dampers on different road classes. Results show that, except in case of poor road quality, only a small amount of energy is dissipated by the dampers. Therefore, this option is not further investigated in this report.

## Active roll control

In this chapter, roll control in literature will be studied first. Safety systems installed on most modern cars, like ABS and ESP, are used to limit the amount of roll for vehicle rollover prevention. An active suspension system has been implemented in several state-of-the-art cars, mainly with the goal to reduce the amount of body roll. The result is a higher maximal cornering velocity and an improved directional stability especially when taking emergency evasive actions. This increase in safety will generally come at the cost of additional consumption of energy however. The active suspension

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Vol. 6, Issue 3, March 2017

system designed in the previous chapter, together with a controller to level the car, will be used in a simulation to examine the effect of body roll elimination on the maximum lateral acceleration of the car.

## Roll control in literature

Roll control in literature mainly focuses on vehicle rollover prevention instead of complete body roll elimination. The goal of rollover prevention is to avoid this very specific type of accidents, whereas the goal of body roll elimination is to optimize the contact between tire and road surface and thus to improve the cornering characteristics of the vehicle. In general, two different situations in which rollover may arise can be distinguished. Rollover caused by extreme maneuvering at high speeds on a plane surface, is the first case. The second one is called tripped rollover. In this case the vehicle has already started skidding and rollover occurs because the wheels hit an obstacle or encounter soft soil. Modern vehicle dynamics control systems like the Electronic Stabilization Program (ESP) use individual wheel braking to avoid skidding and thus help to prevent tripped rollover. Their primary task is stabilization of the vehicle's yaw motion.

Martens [2005] investigates the influence of a number of active safety systems, such as ESP, active steering, active suspension and active roll control on vehicle stability. These systems react faster, more accurate and flexible than the driver if an unexpected deviation from the vehicle's desired yaw rate occurs. The ESP system requires little additional hardware as it makes use of the Anti-lock Braking System (ABS) which is present on most of today's vehicles. Roll dynamics is much faster affected by steering than by braking. A steering/braking control system supports the driver in case of emergency as it allows larger obstacle avoidance maneuvers. If steer-by-wire technology is present in the vehicle, the potential of active steering can be utilized. Vehicle stability may be improved by implementing a suspension system with active roll control which is capable of reducing sudden load transfer in roll direction due to slaloming for example. A vehicle equipped with all these systems is best capable of avoiding rollover.

## Roll control in practice

The suspension of a luxury car is usually designed with emphasis on comfort. Because of the accompanying soft suspension settings the vehicle will roll excessively during cornering, resulting in a decrease in comfort and an inferior contact between tires and road. Therefore, most high-end car manufacturers have developed a suspension system which is able to reduce or even eliminated body roll. This system can also be used to eliminate pitch in order to increase the comfort level of the car.

## II. MATERIALS AND EQUIPMENTS

### Gyroscopic sensor

A gyroscope is a device used primarily for navigation and measurement of angular velocity. Gyroscopes are available that can measure rotational velocity in 1, 2, or 3 directions. 3-axis gyroscopes are often implemented with a 3-axis accelerometer to provide a full 6 degree-of-freedom (DoF) motion tracking system. Gyroscopes have evolved from mechanical-inertial spinning devices consisting of rotors, axles, and gimbals to various incarnations of electronic and optical devices. Each exploits some physical property of the system allowing it to detect rotational velocity about some axis.

### Electronic control unit

In automotive electronics, Electronic Control Unit (ECU) is a generic term for any embedded system that controls one or more of the electrical system or subsystems in a transport vehicle. The development of an ECU involves both hardware and software required to perform the functions expected from that particular module. Automotive ECU's are being developed following the V-model. Recently the trend is to dedicate a significant amount of time and effort to develop safe modules by following standards like ISO 26262. It is rare that

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Vol. 6, Issue 3, March 2017

a module is developed fully from scratch. The design is generally iterative and improvements are made to both the hardware and software. The development of most ECU's are carried out by Tier 1 suppliers based on specifications provided by the OEM.

## Threaded Rod

A threaded rod, also known as a stud, is a relatively long rod that is threaded on both ends; the thread may extend along the complete length of the rod. They are designed to be used in tension. Threaded rod in bar stock form is often called all-thread.

## Servomotor

A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. Servomotors are not a specific class of motor although the term servomotor is often used to refer to a motor suitable for use in a closed-loop control system.

## Gears

A gear or cogwheel is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part to transmit torque. Geared devices can change the speed, torque, and direction of a power source. Gears almost always produce a change in torque, creating a mechanical advantage, through their gear ratio, and thus may be considered a simple machine. The teeth on the two meshing gears all have the same shape. Two or more meshing gears, working in a sequence, are called a gear train or a transmission. A gear can mesh with a linear toothed part, called a rack, thereby producing translation instead of rotation.

## Alternator

An alternator is an electrical generator that converts mechanical energy to electrical energy in the form of alternating current. For reasons of cost and simplicity, most alternators use a rotating magnetic field with a stationary armature. Occasionally, a linear alternator or a rotating armature with a stationary magnetic field is used. In principle, any AC electrical generator can be called an alternator, but usually the term refers to small rotating machines driven by automotive and other internal combustion engines. An alternator that uses a permanent magnet for its magnetic field is called a magneto. Alternators in power stations driven by steam turbines are called turbo-alternators. Large 50 or 60 Hz three phase alternators in power plants generate most of the world's electric power, which is distributed by electric power grids.

## Long Nut

A coupling nut, also known as extension nut, is a threaded fastener for joining two male threads, most commonly a threaded rod, but also pipes. The outside of the fastener is usually a hex so a wrench can hold it. Variations include reducing coupling nuts, for joining two different size threads; sight hole coupling nuts, which have a sight hole for observing the amount of engagement; and coupling nuts with left-handed threads. These are used to make up long rod assemblies from shorter lengths of rods. The rods are threaded into the coupling nut for a certain distance. Coupling nut dimensions are described by the Industrial Fasteners Institute in standard IFI-128. It is given a plain finish. It is either cold drawn or hot rolled depending on the bar stock used. Coupling nuts threaded with two different thread sizes and profiles are called reducing coupling nuts. Coupling nuts can be used to tighten a rod assembly inward or to press a rod assembly outward.

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Vol. 6, Issue 3, March 2017

## Working

The system is simple and it is closed loop system. The electronic device comprises of gyroscope and the microcontroller unit and the mechanical unit comprises of gears, screw rod and suspension shock absorber.

## Electronic process

The electronics device comprises of gyroscope and the microcontroller unit in which the sensor sends the signal to the micro controller when there is variations in vehicle position. The microcontroller actuates the servo motor

## Mechanical process

A suspension system for electrically adjusting a vehicle height comprising: a shock absorber an electric motor including a rotator; and a device including a threaded rod, one end of the threaded rod being rigidly secured to the rotator, and a threaded inner periphery, into which the threaded rod is screwed, wherein the device converts a rotational movement of the rotator into a linear movement of the shock absorber.

The microcontroller actuates the servo motor so that screw rod rotated by the gear coupled with motor.

When the vehicle moves on rough roads the level and position of vehicle is changed so that the microcontroller sends the angle to mc for processing then the screw rod is adjusted by the motor so that vehicle position is set normal and it runs smoothly.

## III. RESULT AND DISCUSSION

- The additional elements of an active suspension system are able to produce forces when required and therefore the trade- off between ride comfort, suspension travel and wheel load variations can be better resolved.
- An active suspension system can be used in order to eliminate body roll during cornering investigated which can prevent suspension travel under a varying load theoretically without consuming energy.
- However, the goal of implementing system into a vehicle differs from the goal of this report, maximizing lateral acceleration by levelling the car in an energy efficient manner.
- A performance improvement controller determines the required force the actuator has to produce in order to level the car or improve the comfort level for example.
- Several state-of-the-art cars are equipped with active suspension systems in order to reduce the amount of body roll. The result is a higher cornering velocity and an improved directional stability especially when taking emergency evasive actions.
- This increase in safety will generally come at the cost of additional consumption of energy
- Usually the suspension consists of passive force elements which are designed to optimize the trade-off between ride comfort, suspension travel and wheel load variations.
- The geometry design of the suspension links is a trade off between optimal orientation of the wheels in case of bumps in the road or during cornering.
- Furthermore, the springs should be stiff enough to avoid exaggerate body roll or pitch during cornering, accelerating and braking.
- Modern suspension systems provide possibilities for optimizing the trade-offs, but will never be able to eliminate the conflicts. Moreover, they are complex and space consuming.

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Vol. 6, Issue 3, March 2017

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