Chassis & dynamics: transformation, technology and opportunity

By Michael Murphy
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Such models are based on multi-dimensional polynomials or neural networks that cover a parameter space determined by the researchers during one or more simulated manoeuvres. As a result, the test procedure is reproducible, the parameter space is investigated comprehensively, the results are realistic and it is possible to determine the best possible solution, which is the solution in which it is impossible to make one characteristic better without making another worse. Extending the results of theoretical modelling, various test bench interfaces enable validation and calibration by applying them to physical models that approximate the real world of the vehicle dynamics system in a robust, safe and reproducible way.

3.2.1 Actuators

However, to underscore the challenges inherent in modelling, attempts to model the simple step behaviour of a single actuator are illustrated in Figure 3 in which the experimental model, the physical model and that test rig results deviate further and further, respectively, from the reference behaviour, which represents the theoretical ideal.
Design and specification of components – steering, suspension, brakes, traction control and tyres

5.1 Steering

Hydraulically-assisted power steering first became available in 1951 on the Chrysler Imperial in the US and led to rapid adoption of the technology in that market and further afield. Later, as FWD became the dominant light vehicle configuration, power-assisted steering gained widespread market penetration to alleviate the increased steering effort required along with that introduced through the use of wider tyres and the trend for vehicles to become heavier as safety and convenience systems were added. The trend for variable power steering assistance was initiated on the innovative 1970 Citroën SM on which it provided very little assistance at high speeds but increased the level of assistance significantly at low speeds to help with tight turns and parking manoeuvres.

Traditionally, all power steering assistance was provided hydraulically via a V-belt driven from the engine crankshaft pulley. However, as fuel prices have increased and regulations requiring improving fuel economy have come into force, engineers have worked to develop electrically-powered systems that eliminate the parasitic losses associated with a continuously-driven hydraulic pump and draw power only as required. EPS systems can improve fuel economy by between 3% and 5% compared to a hydraulic system that operates at all times.

The development of EPS has also been driven by the emergence of hybrid-electric vehicles that can shut off the internal combustion engine (ICE) while coasting so that an ICE-driven power steering system is not adequate for their needs. Pure electric vehicles with no ICE need an electrically-driven system if power-assisted steering is necessary.

5.1.1 Electro-hydraulic power steering

Electro-hydraulic power steering (EHPS) systems were initially regarded as an interim step towards fully electric systems by removing the belt-driven, constantly-operating hydraulic pump and decoupling the braking system from the ICE so that it draws power only as required. While it still has the disadvantages of weight, packaging requirements, complexity and the need for regular maintenance associated with a hydraulic system, along with the environmental issues related to hydraulic fluid, EHPS provided useful energy savings, was readily adapted to existing vehicle platforms with hydraulic systems and offered cost advantages over traditional systems. However, the energy demand to electrically power the hydraulic pump could be high at times, particularly during parking manoeuvres. Early examples included the Servotronic system developed by ZF and eSteering by Dana.

EHPS systems can be fully compatible with active steering systems that can vary the steering wheel input required at low speeds and with advanced systems that can be integrated with ESC systems to enable steering interventions as well as the brake and engine torque inputs employed to improve stability.
improved passenger comfort while larger suspension movements result in increased damping force to improve road-holding and stability. The ZF Sachs Sensitive Damping Control system incorporates a second valve mounted on the piston rod and suspended between two springs within the damper. Under smaller suspension deflections, both valves allow hydraulic fluid to pass, providing a lower damping rate and a more comfortable ride. Under larger suspension deflections, the secondary valve closes so that the primary valve alone controls damping at a higher damping rate to improve road holding and vehicle dynamics.

Tenneco produces the Frequency Selective Damping (FSD) system that was developed and patented by Koni. The hydraulic valve system in the FSD system provides two different damping characteristics depending on the frequency of suspension movement by controlling a parallel fluid flow next to the one going through the piston. When the suspension movement is around 10Hz, low damping forces are applied by opening the valve to ensure comfort. When suspension frequency is low, high damping forces are applied by closing the valve to ensure good road-holding and handling.

BWI produces a range of passive dampers on which smart valves generate multiple damping curves that enable the suspension to react appropriately to different input amplitudes and velocities. BWI also produces a tuneable internal hydraulic rebound stop to replace traditional deformed tube and flexible rubber stops. The hydraulic rebound stop comprises a plastic moulding with a sleeve, an elastic ring and a piston. The switching point, the level of damping force and the speed at which it increases can be adjusted. Bypass slots in the sleeve and the self-sealing ring allow the damping force at the end of the piston stroke to be increased even when the rod speed is decreasing. The system de-activates as soon as the stroke reverses, allowing compression damping forces to immediately build up again.

Monroe developed its first Kinetic System to provide a bridge between off-road ability, on-road performance and comfort, and enhances both comfort and handling characteristics. The system utilised hydraulic and pneumatic interconnections between the vehicle's springs and actuators integrated into the stabiliser bars. Two hydraulic lines connected the front and rear actuators at points both above and below the internal pistons so that suspension travel movement pumped hydraulic fluid between two, interconnected, double-acting hydraulic cylinders at the front and rear of the vehicle. During cornering roll motion, the hydraulic pressure produced by the suspension movement operated actuators that stiffened the stabiliser bars to minimise the roll angle. The hydraulic interconnections enabled the wheels to move independently and maintained almost the same load pressure at full wheel movement in either direction as it did on flat ground. It could be fitted in combination with any spring system and stabiliser systems.

Although Monroe’s Digital Ride Control Valve (DRiV) technology does include electronic control within the valve, there is no ECU and Monroe classifies it as an affordable adaptive system designed for small and medium passenger cars. It features four small valves in the rod guide with the electronics and sensors integrated in the damper.

ZF Sachs developed the Nivomat hydro-pneumatic, automatic levelling system for small to mid-size passenger and commercial vehicles. Nivomat uses the movement of the suspension to literally pump itself up until it attains an optimal ride height for the load it is carrying. This normally occurs during the first few hundred metres of travel following any change in the vehicle’s loading. An oil reservoir, a pressure accumulator, a pump, a height sensor and the control mechanism are all integrated into the damper units and it can be fitted in place of a conventional damper, a spring-and-damper assembly, or a suspension strut.

5.2.7 Semi-active suspension systems

Semi-active suspension systems utilise electronic control to vary the damping rates. Although some suppliers developed and offered semi-active stabilisers, they have been superseded by active stabiliser systems, in part because semi-active damper systems also tend to provide a stabilising function so that separate variable stabiliser control is not required.

Semi-active stabiliser systems were first developed to provide variable stabilisation on vehicles with high centre of gravity such as off-road 4WD vehicles that do not have semi-active or active damping. One example developed by TRW was the Semi-Active Roll Control (SARC) system that had a locking device built into the stabiliser bar that was unlocked during straight-ahead driving, decoupling the stabiliser from the
5.3.6 Electric parking brake

EPB systems are now commonplace and provide a significant step along the road towards EMB and brake-by-wire systems, particularly in terms of consumer acceptance. An EPB system replaces the components of a mechanical parking brake system, which include either a hand lever or foot pedal and the cable or other mechanical components connecting them to the brake mechanism. Operation is via a switch or button and the system automatically applies sufficient torque to ensure safe parking and provide anti-creep and hill-start functions. Furthermore, these can be extended to include more advanced safety functions such as the prevention of roll away through the EPB being automatically applied should the driver open the door or release their seatbelt.

Continental developed an EPB and an EHP. The EPB consists of an electronic controller and an electro-mechanical central actuator that can activate either duo-servo brakes or a combined calliper operated via Bowden cables. As well as the usual advantages of an EPB such as simple operation, it is capable of providing an emergency braking function if the main brake system fails or an EPB emergency function via the main brake system in connection with ESC. The EHP has smaller packaging requirements than the EPB because it is integrated into the brake calliper. It is capable of developing its own hydraulic pressure and can be locked electromechanically. As well as reduced weight compared to the EPB, the EHP can also operate as part of a parking assistance system and a vehicle immobiliser.

Continental has also developed an EPB system for drum brakes with lower-priced vehicle segments in mind. The system incorporates two actuators and their control software integrated into the drum-brake base panel on the rear axle. It features bracing for the two brake shoes, a dual-acting hydraulic cylinder for the service brake, and mechanical adjustment. The electronics that activate the actuators are integrated into the ESC system.

Figure 52: Continental drum-brake EPB system


PBR International has developed two EPB systems. One uses an electromechanical device to pull the cables of a conventional parking brake system but the other is fully integrated into the rear calliper and eliminates
In February 2015, IndustryARC forecast that the EPS market will exhibit growth of 11.4% by 2020, driven by consumer demand for improved fuel economy. The company estimated the EPS market at worth US$26bn in 2014 with column-assist systems accounting for US$14bn that year and forecast that the overall EPS market will increase to approach US$50bn in 2020. In April 2015, TechNavio forecast that the global EPS market with grow at a CAGR of 8.63% between 2014 and 2019.
Denso International

OVERVIEW

Denso was established in 1949 and is one of the leading suppliers of automotive systems and components. The company has operations in nearly 38 countries, including Japan, United States, Canada, Mexico, Brazil, Argentina, Netherlands, France, Germany, United Kingdom, Spain, Italy, Belgium, Portugal, Sweden, Hungary, Poland, Czech Republic, Russia, Australia, Singapore, Thailand, Indonesia, Vietnam, Malaysia, India, Republic of Korea, Taiwan, China, Philippines, Saudi Arabia, Turkey, United Arab Emirates, South Africa, Morocco, Cambodia, Pakistan and Myanmar.

Headquartered in Aichi, Japan, the company operates through 200 fully owned subsidiaries and 32 equity joint ventures with more than 140,000 employees with global consolidated sales of US$34.68 billion for the fiscal year 2015.

Denso divides its business into two business groups – Automotive and Consumer & Industrial Products. However, most of the business comes from the Automotive Business group only which accounted for 98% of Denso’s overall sales in the 2015 financial year.

KEY PEOPLE

- Nico Carucci, Regional Manager at DENSO Automotive Deutschland GmbH
- Vinciane Adam, Senior Sales Engineer – DENSO Automotive Deutschland GmbH

CHASSIS AND SAFETY DIVISION

Denso develops various driving assist systems with a focus on sensing technology that monitors driving situations. Whether developing Lighting Control Systems, Steering Systems, Airbag ECUs or Brake Control Systems, Denso pursues the prevention of accidents and injuries. The Chassis Division consists of the following products:

1. Steering System
2. Brake Control system

The Steering segment of Denso consists of the following components:

1. Electric Power Steering Motor
2. Steering Torque Sensor
3. Electric Power Steering Control Unit
4. Variable Gear Ratio Steering Motor
5. Variable Gear Ratio Steering control unit.

The Brake Control System consists of the following components:

1. Brake Pressure Sensor
2. Wheel Speed Sensor
3. Inertia Sensor for ERC system
4. Accelerometer for Suspension