5 ABW AWA Suspension Mechatronic Control Systems

5.1 Introduction

In this part of the book, we discuss vertical motion in the $z$-axis of an automotive vehicle. By vertical motion of an automotive vehicle, we mean how the vehicle responds to on/off road surface input.

The response of the vehicle to an on/off road surface input is predominantly influenced by the absorb-by-wire (ABW) all-wheel-absorbed (AWA) suspension mechatronic control system. On the other hand, the (DBW) all-wheel-driven (AWD) propulsion, brake-by-wire (BBW) all-wheel-braked (AWB) dispersion and steer-by-wire (SBW) all-wheel-steered (AWS) conversion mechatronic control systems may also be used to influence the absorbing (damping) capabilities of the vehicle; it is therefore not surprising that research on controlling the lateral motions of a vehicle has recently concentrated on integrating these systems into a ride-by-wire (RBW) or x-by-wire (XBW) integrated unibody, space-chassis, skateboard-chassis, or body-over-chassis motion mechatronic control hyper-system.

The ABW AWA suspension mechatronic control system is neither revolutionary nor an innovative concept. From the time of invention of the wheel, designers have endeavoured to soften the bumps and jolts of the on/off road surface by setting up a spring of some kind between the axle of the wheel and the vehicle body itself.

The ‘springs or compliances’ store energy, and precautions must be taken to avoid bouncing by inserting ‘shock absorbers or dampers’ that convert the spring’s mechanical energy into thermal energy (heat) that can be dispelled. Vehicular suspension components have in sequence controlled the design of vehicle body structures -- and even of wheels and tyres [AMT 2005].

A vehicular (or automotive vehicle) suspension mechatronic control system is the system that links the wheels of the vehicle to the vehicle’s body in a technique that isolates the vehicle’s body from jerks originating from driving on uneven on/off road surfaces.

The body of a vehicle is referred to as a ‘sprung mass’. The automotive vehicle wheels and components related to them are jointly referred to as ‘unsprung masses’.

Normally, automotive scientists and engineers attempt to reduce the total unsprung mass compliance to enhance both ride comfort and ride handling by trimming down the mass of each wheel and of the vehicular suspension components associated with it.
The vehicular suspension mechatronic control system suspends the vehicle's body a short distance above the on/off road surface and upholds the vehicle body at a relatively constant height to avoid it from pitching, swaying, or rolling. In order to sustain effective acceleration, braking, and cornering -- the components of good handling--the vehicular suspension mechatronic control system must also insure all wheel-tyres firmly in contact with the on/off road surface. The vehicular suspension mechatronic control system thus has an effect on a vehicle's ride comfort, performance, and safety.

Of course, it is very problematical to design a vehicular suspension mechatronic control system that affords both a smooth ride and good handling characteristics. And like most other mechanical devices in the vehicle, the conventional vehicular suspension mechatronic control system too has a history of its own.

In the beginning, it was argued that shock absorbers (dampers) were unnecessary if automotive vehicle springs were accurately designed and ordinary values of the vehicle velocity of $16 - 24$ km/h (10-15 mph) were maintained. However, most vehicular suspensions of the early period of automotive history were unproblematic and unsophisticated.

Primitive automotive vehicles had two rigid axles, one linking the two front wheels and the other linking the rear wheels. When one wheel reaches a bump, the wheel at the opposite end of the axle would also be in motion.

Shock absorbers (dampers) of the 1910’s were derived from one of the four principles, particularly, friction, fluidical (hydraulical and/or pneumatic), and mechanical spring.

One ‘modern-looking’ fluido-mechanical (F-M) shock built in 1906 was termed the ‘Graygood’. It was composed of a piston functioning in an F-M cylinder with a 10 cm (4 inch) stroke.

Conversely, in automotive vehicles where cost was of little concern, innovative designs, counting independent vehicular suspensions and telescoping F-M shock absorbers, were also accessible. For instance, the 1907 Pilain chassis had a fully independent rear suspension with universal joints situated at each end of the equal-length ‘jack’ shafts running to the wheels.

During 1925-35, changes in road and traffic circumstances influenced the development path of vehicular suspension mechatronic control systems. For instance, Cadillac enhanced the ride quality of its vehicles by minimising the unsprung mass.

John Warren Watson, an original equipment manufacturer (OEM) of ‘stabilisers’, said: "Although springs are almost entirely responsible for the way a car rides, the control mechanism determines what kind of springs can be used." He recommended that the two be designed in a harmonic systems approach.

The A.E. Forsyth Co. estimated that a variable spring was unrivalled. Its dual-chamber air spring could be inflated or deflated to enhance the ride. Formed like a wheel-tyre, the Forsyth spring embraced an inflatable inner tube inside a vulcanised body.