RESEARCH OF DYNAMIC MEASUREMENT CHARACTERISTICS OF WHEEL FORCE SENSOR

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Introduction
To measure the wheel forces and torques, the original hub can be replaced by the wheel force sensor (WFS). (Fig 1) Despite the high accuracy of the sensor, in dynamic situation the measured forces can still differ from the tyre forces.
• The amplitude and phase difference between the vertical forces from WFS and from the tyre contact area start to alter after the car body eigenfrequency.
• The difference can increase to about 60 % in amplitude and 30° in phase.
• The dynamic behaviour varies with the suspension damping rate. (Fig 2)
Therefore this research was motivated to get a physical understanding of the system and to find a solution to further increase the accuracy of the measurement.

Methods
Modelling and Simulation
• Three analytical models were built with mass, spring and damper to understand the dynamic measurement characteristics of the WFS. (Fig 3)

Results
• The tyre structure can influence the force transfer on servo-hydraulic shaker test bench.
• The linear simulation models can explain the main influence factors on four post test bench. (Fig 5)

Compensation
• With an additional acceleration sensor at wheel hub, the difference can be compensated in amplitude as well as in phase. The limiting of WFS can be extended from about 5 Hz to over 15 Hz. (Fig 6)

Conclusions
• Both tyre and suspension can influence the dynamic measurement characteristics of WFS
• The developed models correspond to the measurement to certain frequency range.
• Understanding of the non-linearity in the system is supposed to improve the quality of the simulation.
• With the correction method the limiting of the measurement can be extended.

Fig 1: left: WFS with rotary transmitter, rim- and hub adaption; right: WFS integrated with LGS and WPS on test vehicle (Pictures from A&D Europe GmbH)

Fig 2: Transfer function between wheel load from wheel force sensor and vertical force at tyre contact area dependent on different passive damper setting [Reul, 2011].

Fig 3: Schematic of simulation models

(a) Model 1(wheel)  (b) Model 2(wheel +tread)  (c) Model 3(wheel +tread +sidewall+air)

Fig 4: Test on a servo-hydraulic shaker test bench

Fig 5: Transfer function between wheel load from WFS and vertical force at tyre contact area, ID=900mA(middle), tyre pressure 2.55bar

Fig 6: Transfer function between wheel load compensated with hub acceleration and vertical force at tyre contact area, ID=900mA(middle), tyre pressure 2.55bar