Title	**Influence of the Steering Actuator's Dynamics on a Rollover Mitigation with Active Brake and Active Steering Interventions for Light Commercial Vehicles (LCV)**
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Abstract:

Rollover Situations

Electronic controllers for vehicles support a driver during dynamic manoeuvres and stabilize the vehicle with the help of systems like ESP (Electronic Stability Program) and AFS (Active Front Steering), having a significant share in avoiding accidents [1].

Vehicles with a high centre of gravity are brought into focus on account of their tendencies to roll over due to great lateral accelerations or a build-up of the roll angle after a jerking of the steering wheel. This "un-tripped rollover" can be avoided with active safety systems, yet the support of the known controllers is not always enough to prevent the tipping over.

Rollover Prevention

Prerequisite for triggering particular measures of rollover prevention is the reliable discrimination of the rollover event [2, 3, 4]. Possible anti-rollover measures are appropriate interventions with active brake [5, 6], active steering [7] or with active suspension [8].

At the Robert Bosch GmbH, a study accomplished the prevention of un-tripped rollover, providing a controller approach [9] to discriminate the rollover situation and to calculate the set points for the stabilizing interventions using the ESP signals. Active steering and active brake interventions stabilize the vehicle accordingly, so that the driver can cope with the rollover risk – at utmost driving stability and comfortable handling of the vehicle.

This contribution focuses on the actuating dynamics of the AFS and their influence on the valuation criteria vehicle stabilisation, agility and comfort with respect to the rollover mitigation (ROM) function. The ROM-function itself was already published in [9]. The ROM-controller was implemented in a LCV to evaluate its performance at different steering gradient settings.

Performance Evaluation

As appropriate manoeuvre to provoke rollover, the "fishhook" [10] was exercised at 80 km/h with different system settings:

- ESP,
- ESP and AFS with slow steering interventions (ESP-AFS_{slow} , actuator speed ~140 deg/s referred to pinion),
- ESP and AFS with steering interventions of a mean actuator speed (ESP-AFS_{medium}, ~250 deg/s),
- ESP and AFS with fast steering interventions (ESP-AFS_{fast}, ~500 deg/s).

The evaluation with different steering gradients showed, that the stabilizing performance of the ROM-controller is so much the better, the higher the actuator speed is set. With ESP, the vehicle didn't tip over during the fishhook, but the rollover danger remained high, especially with additional load. ROM-control with ESP-AFS_{slow} already accomplished the improvement of vehicle stability, however, it is the slowest, still applicable actuator speed setting. The control with ESP-AFS_{medium} resulted in a clear improvement on the subjects of all valuation criteria compared to ESP-AFS_{slow}. Yet the setting of ESP-AFS_{fast} showed another significant improvement considering all valuation criteria.

During the test manoeuvres, the driver's subjective perception inside the vehicle was, that the ESP-AFS_{medium} almost performed like the setting ESP-AFS_{fast}. Nevertheless, the evaluation of the measured data showed, that ESP-AFS_{medium} – still with a controller parameterization of ESP-AFS_{slow} – performs rather at a mean value between the slowest and the fastest AFS-actuator speed setting. Thus, another improvement can be achieved by adapting the controller parameters to the higher actuator speed.

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