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PMSM-Magnetic Lead Screw model based studies on passive and semi-active suspension

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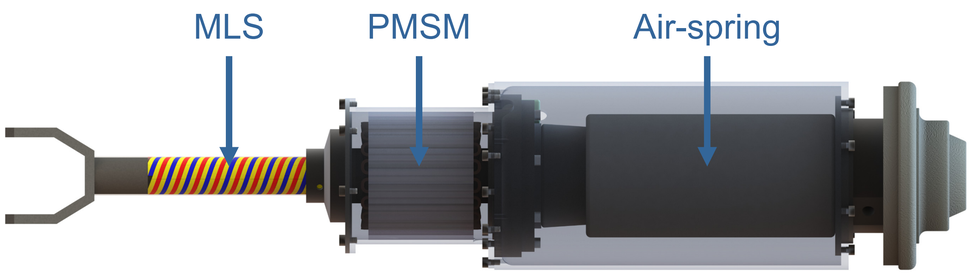
1. Introduction

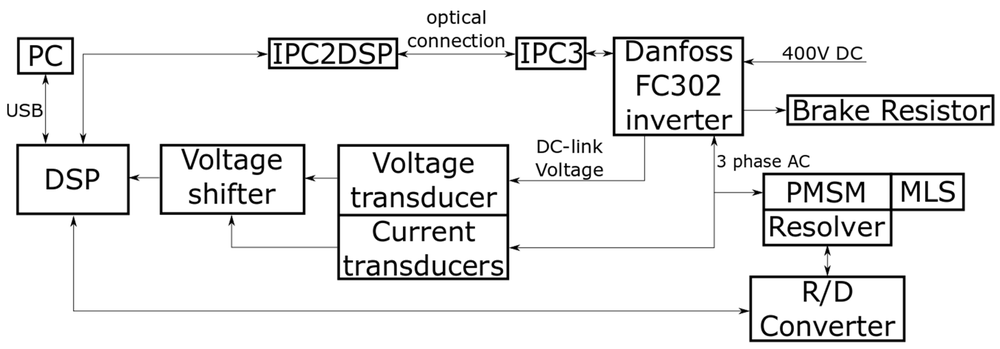
The project encompasses the use of PMSM-Magnetic Lead Screw (MLS) assembly as a passive and semi-active SkyHook based algorithm suspension unit.



The MLS is inspired by a the design of mechanical lead screw, however the thread is made of helically shaped magnets. The advantage of using magnets is no direct contact resulting in low friction and limited wear. In conjunction with an air-spring and PMSM, the assembly can be used as a shock absorber in a vehicle. The setup allows to generate a damping force independent of suspension velocity.

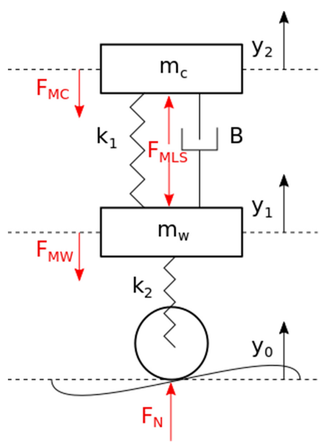
2. Methods

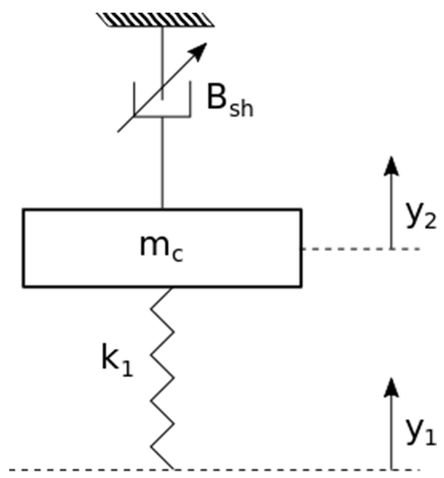
The completion of hardware setup extends the components of the test platform by additional modules.



The inverter supplies PMSM with three phase current, which magnitudes are measured by transducers. Braking action is identified by measuring DC-link. The sensor measurements are brought down to values the microprocessor can handle. The resolver is used to find the rotor angular position of the PMSM. The system runs with developed software on microprocessor.

The studies upon suspension schemes were limited to Quarter Vehicle Model (QVM), constituting a two degree of freedom spring-damper-mass system. The rim, tire, brake constitute the wheel mass being attached to the chassis by a spring, a small passive damper due to friction and the MLS. The resilience of the tire modelled as an additional spring bonding it with the road.

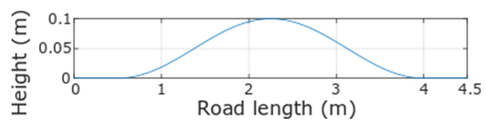


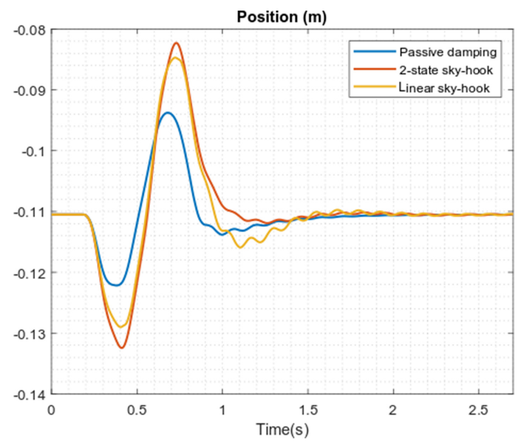


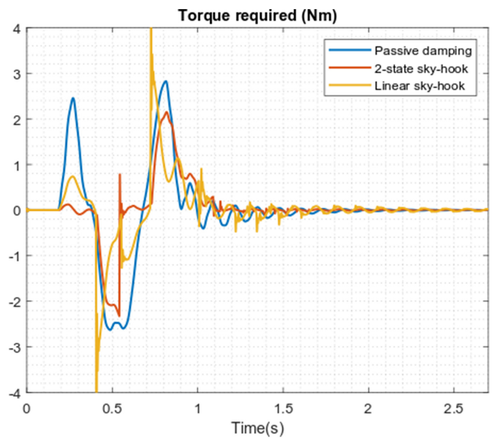
The characteristic of the passive system was compared with semi-active suspension systems. Conceptually, the SH is based on the damper attached between the sprung mass and a fictional reference in the sky. This causes that the shock absorber delivers a force proportional to the chassis speed rather than the relative velocity between the sprung and un-sprung mass.

3. Simulated results

The ability of the suspension to restore the relative position between the sprung mass and the wheel exposed to speed bump can be seen on the right.



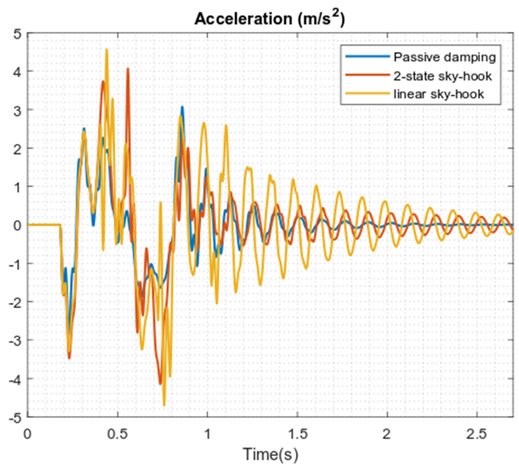




The torque requested by linear SH reaches highest extremes. The spikes are also shortest observed. The passive scheme noted 40% lower peak which was yet extended in time.

Suspension scheme	Required work
Passive	30.84 J
SH On/Off	19.64 J
SH Linear	18.73 J

The acceleration in the two state SH has the lowest peaks. The highest peak value is observed in the passive system, however the linear SH needs longest time to settle.



4. Conclusions

In order to investigate behaviour of passive and semi-active suspension schemes the PMSM-MLS assembly has been incorporated with the established QVM. On account of building an expectation concerning provided drive characteristics, the systems were simulated. The studies show that while the traditional passive damping scheme is capable to provide good overall performance, the SH schemes offer improvements in different areas. The SH schemes manage to reduce the variation in vertical position and velocity of the chassis by allowing the suspension to be compressed more. Furthermore, the two-state SH also lowers the peaks in vertical acceleration of the sprung mass. The SH schemes show reduction in work performed to damp the oscillations, while the two-state SH demands least torque. Consequently, the SH with on/off policy is expected to be the most suitable system among the studied suspension schemes.

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