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Donghong Ning, Shuaishuai Sun, Haiping Du, Weihua Li, Wenxing Li

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Control of a multiple-DOF vehicle seat suspension with roll and vertical vibration

Donghong Ning[1, 2], Shuaishuai Sun[3], Haiping Du[2*], Weihua Li[3], Wenxing Li[2]

1. Automotive research institute, Hefei University of Technology, Hefei, 230000, China

2. School of Electrical, Computer and Telecommunications Engineering, University of Wollongong, Wollongong, NSW 2522, Australia.

3. School of Mechanical, Material and Mechatronic Engineering, University of Wollongong, Wollongong, NSW 2522, Australia

*hdu@uow.edu.au

Abstract

In this paper, the control of roll vibration and vertical vibration of a seat suspension caused by uneven road under both sides of tyres is studied. The heavy duty vehicles are generally working under severe conditions, where the uneven road can cause roll vibration and vertical vibration of the vehicle body and can have an effect on seat suspension. The conventional single-degree of freedom (single-DOF) seat suspension can only isolate the vertical vibration while the roll vibration will be totally transferred to the driver's body. The high magnitude of driver body's lateral acceleration caused by roll vibration will influence drivers' health and have a negative effect on ride comfort. A two-layer multiple-DOF active seat suspension, which has a z-axis DOF in the bottom layer and a roll DOF in the top layer, is proposed in this paper. A non-singular terminal sliding controller is designed to control the top-layer to reduce the lateral acceleration and roll acceleration by tracking a desired roll angle. An H_∞ controller with disturbance compensation is applied to control the bottom-layer for vertical vibration isolation. Both controllers use the variables which can be measured or estimated in the practical application as feedback signals. Two inertial measurement units (IMUs) MPU9250 are used in order to estimate the rotary angles of the top and base platforms of the two-layer multiple-DOF active seat suspension. The effectiveness of the seat suspension and control method is validated by both simulations and experiments. A single-DOF active seat suspension and a well-tuned conventional passive one are applied for comparison. Based on ISO 2631, the vibration total value of frequency weighted root mean square (FW-RMS) acceleration of the multiple-DOF active seat surface has 29.8% and 23.6% reductions for evaluating its influence on health and ride comfort, respectively, when compared with the single-DOF active one. The proposed vibration isolation method can effectively reduce the whole body vibration (WBV) of heavy duty vehicle drivers, and it shows high potential for practical application.

Keywords: Vibration control, Multiple-DOF, Heavy duty vehicle, Whole body vibration, Ride comfort.