Creation of synthetic motor torques and brake forces for determination of desgin loads for railway vehicle bogies

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EXTENDED ABSTRACT

Passenger rail service has the potential to play a key role in future mobility [1]. A cost reduction supports that. Decreasing operation costs can be achieved by a low energy consumption. Precise knowledge about the loads which are acting on the vehicle during its lifecycle enables higher material utilization with simultaneously high safety against fatigue and therefore costs will decrease. The mentioned loads depend on different boundary conditions such as the vehicle or track properties. Due to changing boundary conditions and financial issues load measurements are only of limited use for new rail vehicles. Hence, it is mandatory to determine as precise design loads as possible in order to ensure a safe design of various components.

Nowadays, design loads are calculated using multibody simulation (MBS) [2], [3]. In addition to a valid multibody model of a rail vehicle, a so called operational scenario is required. The operational scenario consists of information about the track layout, track irregularities, driving conditions and vehicle conditions [4]. A methodology to create the required scenarios based on operational measurements is described in [4] and [5].

With the described seperation between scenarios and multibody model it is possible to simulate new vehicles with existing operational scenarios. Motor torque and brake force depends on the vehicle itself and not on the track. For instance, a locomotive driven train needs different motor torques for the same acceleration compared to a train with distributed drives. Therefore, the motor torque and braking force data can not be taken from the measurements. They have to be calculated specifically for each rail vehicle. This publication describes an approach for determining the motor torque and brake forces.

The calculation is based on the measured velocities and accelerations which are also used to generate the track data. It is assumed that the simulation vehicle reaches the same velocities and accelerations as the measurement vehicle. Hence, it is necessary to determine a mathematical relationship between velocity/acceleration and motor torque/brake force. To this end, measurements of a similar or the same vehicle compared to the simulation vehicle are used. Using the relationship of motor torque and acceleration determined by measurements the motor torque value for every arbitrary acceleration can be calculated. The procedure is similar for deceleration events. However, for braking the motor and the brake can be used individually or in combination. Based on the deceleration it is not possible to determine how the vehicle was braked. Therefore, a distribution is created for braking events, which describes the relative incidence of the different braking options in the deceleration classes. For the generation of motor torques and brake forces the distribution is reproduced.

For the validation of the approach the described correlations are created based on measurements. Subsequently, the synthetic motor torques and braking forces are generated. Figure 1 shows an example of the measured and synthetic time series of motor torque and braking force. It can be seen that especially the motor torque can be reconstructed precisely. For decelerations the real curves are slightly underestimated. In time periods with very high braking forces the velocity is zero. In these situations the brake is used as a parking brake. For the publication, simulations with two different sets of operational scenarios were carried out. The reference simulation is based on measured motor torques and brake forces. For the comparative simulation, the measured motor torques and braking forces are replaced by the synthetic time series. For both simulations the loads are obtained and compared. The results are only slightly different from each other. Simulation results show a good match to the measured data, indicating the validity of the described method.

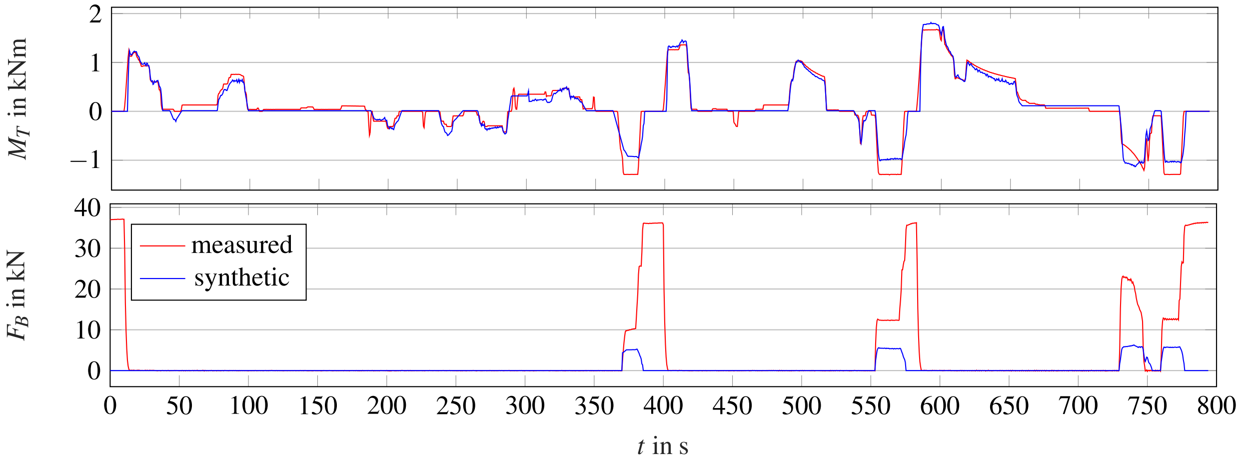

Figure 1: Comparison between measured and synthetic motor torque and brake force time series

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