

# Simulation of a Railway - Bogie

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## **Abstract**

The dynamic behaviour of a railway bogie has been investigated by using a mathematical model, a space state equation, for simulation with a computer. The comparison of a damped with a undamped bogie demonstrated that the driving stability at high speeds can be uprated after the installation of dampers acting in driving direction and allaround the vertical rotation axis of the bogie. The maximum speed of the damped bogie has amounted to 76 m/s.

### 1. Introduction

Nowadays, according to researches in the last two decades on the wheel-/rail-contact of railway vehicles, high speed trains have been developed which are capable of running up to 330 km/h and faster. Computer simulations have turned out to be a cheap and convenient method to describe the dynamical behaviour of technical systems.

This paper deals with investigations about the structural dynamics and influences of dampers in a railway bogie in motion. After small disturbances, railway bogies will return to their resting position in form of a damped sinusoidal vibration if they are operated below their critical speed. Geometry and mechanical properties of the following model should be similar to the high-speed-bogie like the German ICE train to find out the maximal possible velocity of this system. By using the appropriate physical relations for the actual bogie, its mathematical model is described with a matrix differential equation. The maximal speed depends on the system parameters of the bogie. By means of plotting the proper values of the differential equation system in a root-locus-diagram, the driving stability is indicated.

### 2. Mathematical Model

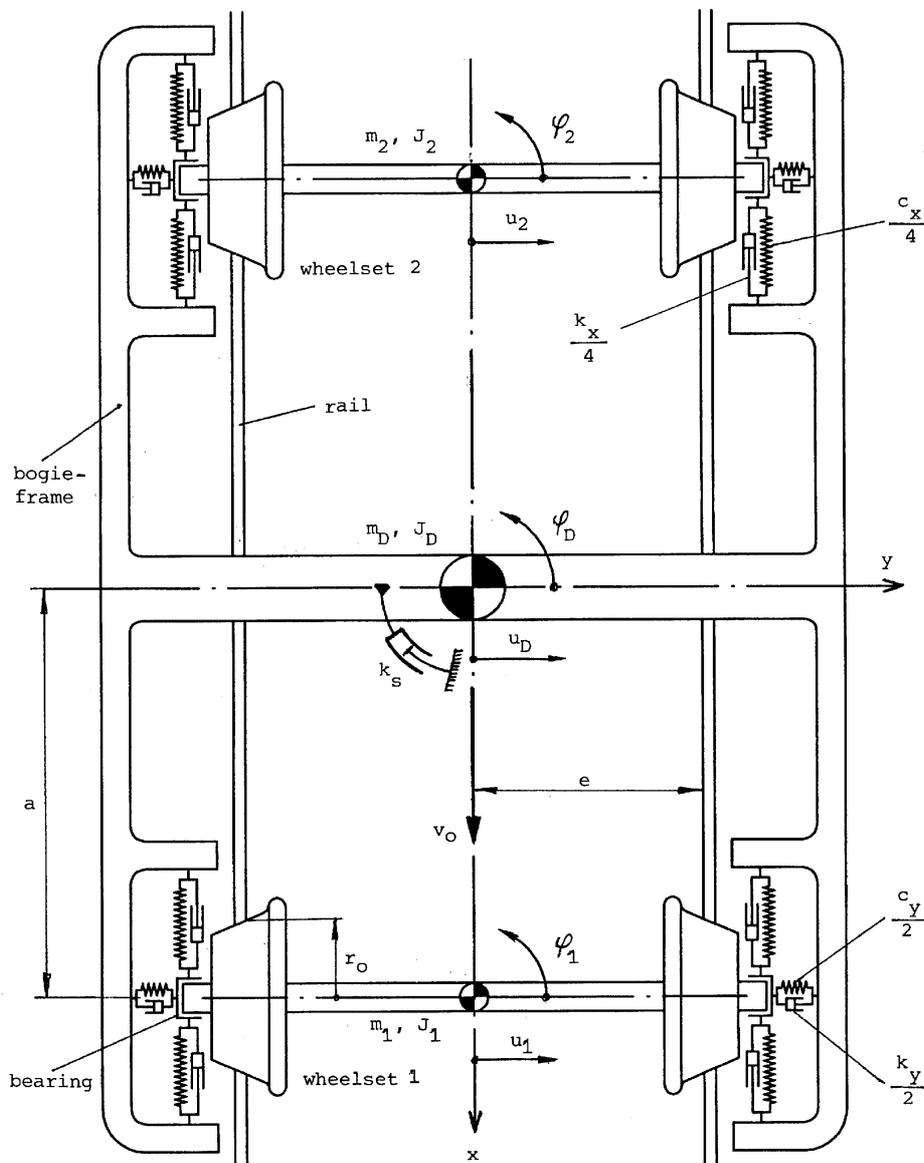


Fig. 1: Mathematical model of the bogie, topview.



### 3. Simulation Results

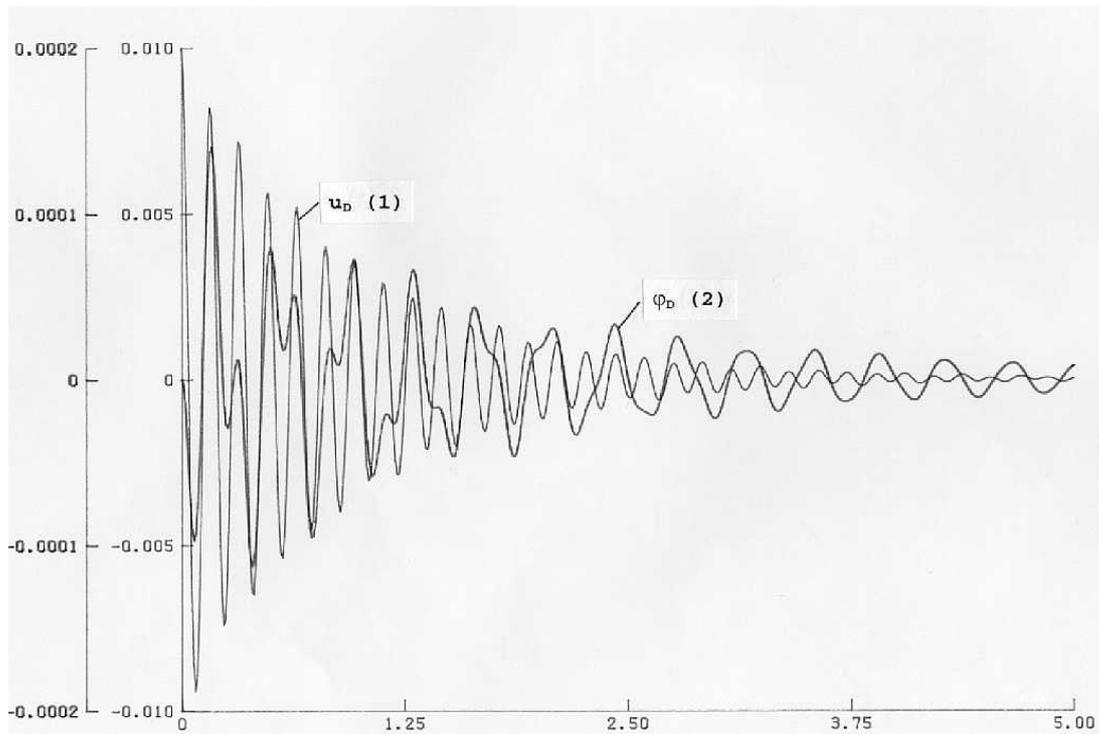


Fig. 2: Time histories of deflection  $u_D$  and twisting angle  $\varphi_D$

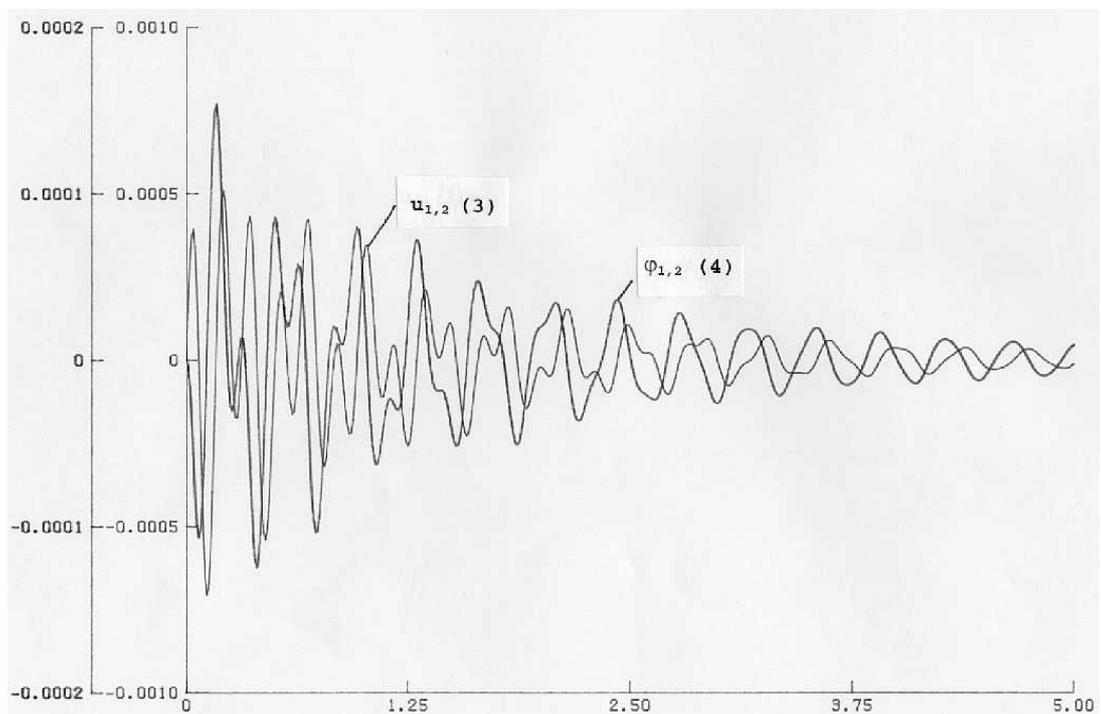


Fig. 3: Time histories of deflection  $u_{1,2}$  and twisting angle  $\varphi_{1,2}$

Fig. 2 and Fig. 3 show the deflections of the bogie frame and the wheelsets after an initial deflection of the frame in x-direction and at 75% of critical speed.

In Fig 2 the bogie frame displacement  $u_D$  is indicated by curve (1). The damped sinusoidal vibration is seen distinctly and dies out very well. The twisting angle  $\varphi_D$  shown in curve (2) does not show very good damping, but it is of a very small numerical value indicated in [rad].

In Fig. 3 it is clearly to be seen that the wheelset's lateral displacements  $u_1$  and  $u_2$  incited by an initial condition  $u_D=10$  mm are not so well damped as the vibratory movement of  $u_D$ . Attention has to be paid to the small numerical value as well, indicated in [mm]. It is detectable that the twisting angles  $\varphi_1$  and  $\varphi_2$  show the same gradient as  $\varphi_D$ .

#### 4. Conclusion

By using a mathematical model, the matrix differential equation of a damped railway bogie has been constructed. For simulation and for root-locus analysis with a computer, the equation system was needed in state space notation, which was generated by a preprocessor program. By means of the root-locus-diagram, the driving stability at high speeds has been investigated depending on the dampers settings. The running behavior of the bogie was simulated on a straight track and also in a curve. Simulations resulted in the observation that the critical speed may increase up to three times as much by taking advantage of installed dampers. The critical speed is 274 km/h. If the vehicle is turning in a curve, the transient response will be pretty similar to the behavior in longitudinal direction. According to experience, the critical speed can be increased by about another 50 km/h, if a wagon is taken into consideration, so that a critical speed of 350 km/h is attainable.

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