ABS Test Bench for Teaching and Research

- ABS test bench at Graz University of Technology
- Controlled by MicroAutoBox
- Trials on both innovative and conventional ABS and ASR algorithms

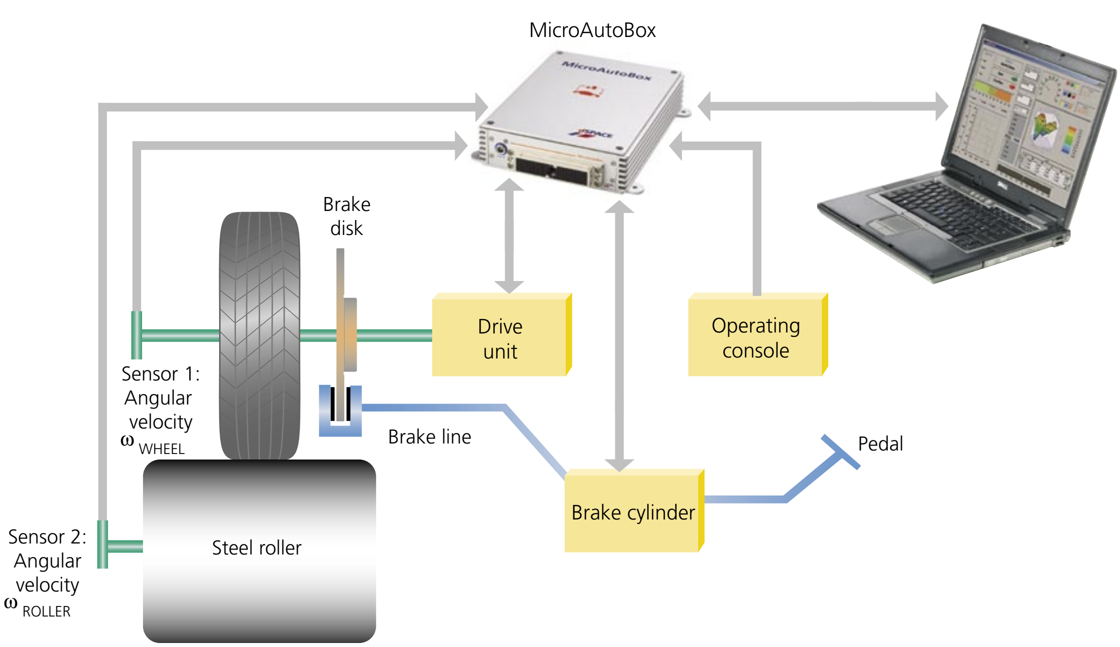
A test bench for testing anti-lock braking (ABS) and anti-slip (ASR) algorithms was developed and set up at the Institute of Automation and Control at Graz University of Technology in Austria. A MicroAutoBox from dSPACE performs all the sequence control for the test bench, making it easy to implement both conventional and innovative ABS and ASR concepts with MATLAB®/Simulink®, Stateflow®, and TargetLink.

Modern information technologies are opening up new ways of designing and controlling mechatronic systems. One precondition for this is a profound understanding of the underlying principles. At the Institute of Automation and Control, we developed and set up an ABS test bench for laboratory and research activities. This fulfills a main research focus in the automotive field at Graz University of Technology, and students can familiarize themselves with professional development tools at an early stage.

Design and Functional Principle

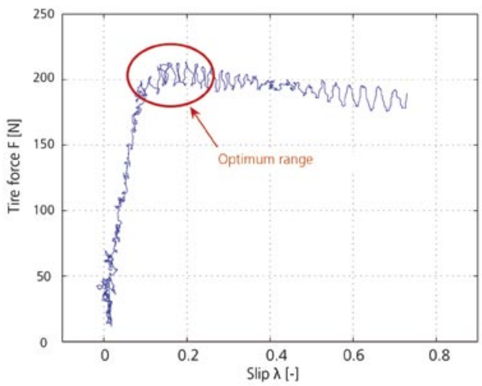
A wheel with a tire rests on a steel roller whose surface replicates the road surface and whose mass represents the inertia of the vehicle that has to be braked. First the drive unit accelerates the wheel. The contact between the tire and the road surface rotates the roller so that its circumferential speed matches the speed of the vehicle. When this has reached the reference value, the drive unit is deactivated and the system is ready for braking. To create a realistic braking scenario, the components used have to be precisely adjusted to one another (for example, the geometry of the steel roller). In addition, we use components from production vehicles such as the brake system from a VW Golf. To measure the speed at which the wheel and steel roller rotate, inductive sensors from a production vehicle and also incremental encoders are available. The brake is activated by a foot pedal. It is currently not possible to trigger it electronically. To measure the rotational speeds and control the whole test bench, a MicroAutoBox from dSPACE is used.

▼ Schematic of the test bench with components.

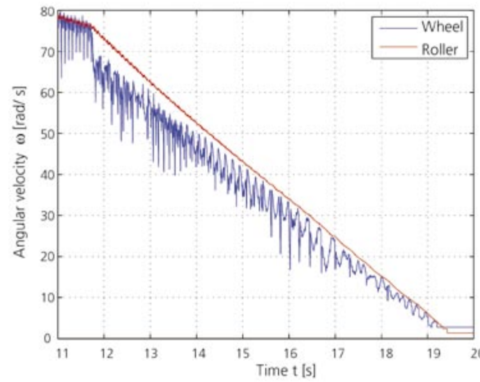


Implementing an ABS Algorithm

A typical student assignment is to design an intuitive anti-lock braking system. The system has to use MicroAutoBox to maximize the transmittable braking force between wheel and roller by setting the optimum slip. With the mechanical design of the test bench as a starting point, the students produce a mathematical model for the "wheel" and "roller" subsystems and for coupling them via the



▲ *Slip characteristic curve of the contact force between wheel and roller, ascertained experimentally.*

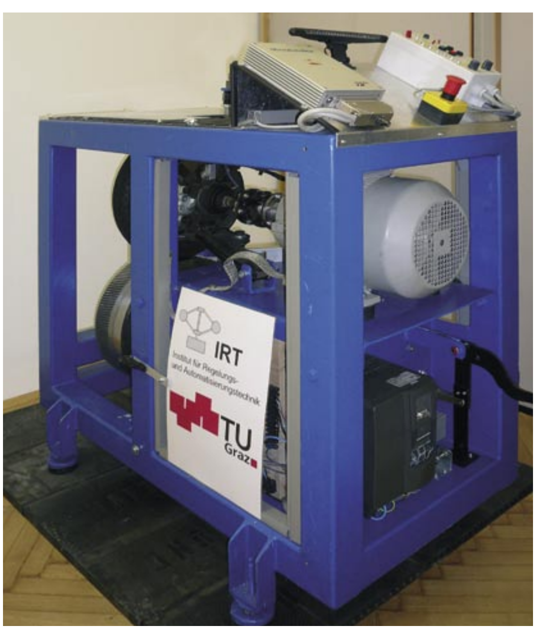


▲ *Behavior of the angular velocity of wheel and roller during a controlled ABS braking procedure.*

slip-dependent wheel force. The students discover that they can find the slip characteristic curve experimentally by start-up trials. The temporal derivation of the measured angular velocity that this requires

> *"The combination of MATLAB and dSPACE products lets us test the algorithms that were designed in teaching or research quickly and easily on the real system."*
> ***Dr. Martin Horn, Graz University of Technology***

is performed with the Derivate Estimation Toolbox developed at the Institute. This toolbox puts the ideas of the differential algebra into practice, using



▲ *Design of the test bench with MicroAutoBox and operating console.*

a MATLAB S-function designed for both simulation under Simulink and the real-time application on the MicroAutoBox. The optimum brake slip is the range on the slip characteristic curve that has maximum longitudinal force. Using MATLAB/Stateflow, the students then design a sequence logic that activates the appropriate valves in the brake circuit to hold the slip as close as possible to the optimum that was determined experimentally. The ABS strategy is transferred straight to the MicroAutoBox with the Stateflow Coder.

Outlook

We already ran trials on several promising approaches to ABS algorithms on the test bench described here. In particular, we developed a wheel slide protection concept for rail vehicles based on sliding mode methods. We will soon have completed the necessary conversion of the test bench to represent the wheel/rail contact.

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Glossary

Incremental encoder –
Sensor for capturing changes in position (linear or rotating).

Sliding mode –
Robust control method for nonlinear systems with restricted parameter variations and/or model uncertainties.