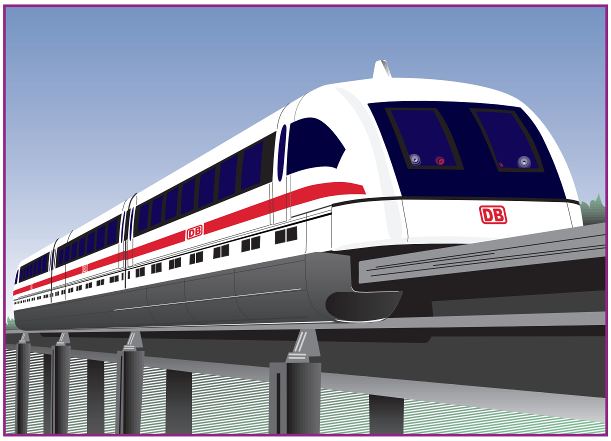
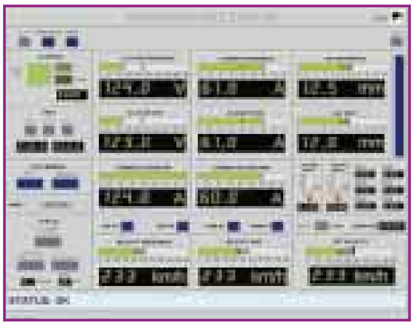
Application Note: Test System for the Transrapid

ME-6000





Simulation of the Transrapid Support Magnet Control

Reliable Data Generation with Opto-Isolated Analog Output Board

As the industrial production times are getting shorter and shorter, tests and simulation of components become more and more important. Test concepts are designed for the identification of weak points and the prevention of faults during operation. The process of simulation on test stands can help to identify faults in an early state of the production cycle. These faults can then be corrected before the product or component is integrated into a system. Tests are especially important in situations where people can be hurt as a result of a component or product malfunction. Preventing accidents also saves costs. All components of the German maglev (magnetic levitation) train Transrapid go through a variety of intense simulations or tests. For example the magnet control is checked on a test stand to eliminate faults during the trains journeys. This application note describes, how the test stand and the test sequences work.

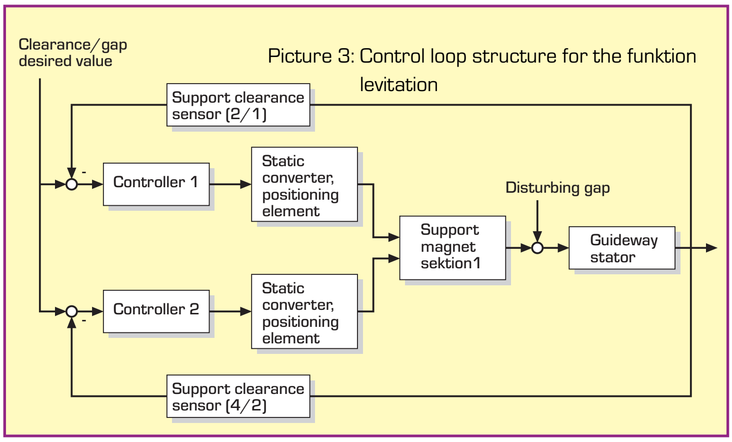
Picture 1a.

With the test stand described in this article, the magnet controllers used in the Transrapid can be tested within a closed control loop under dynamic load. The various positions must be defined by a binary code to identify the controllers. This helps to locate the controller within the vehicle in a case of malfunction. In this way the test stand will check whether the controller is coded correctly, and at the same time initialise the test process. Another important test is the monitoring of the vehicles lifting up and touching down, as this will be the base for all following tests. If there are any faults, the magnetic guidance control will not work properly. Another simulation determines whether the control functionality is carried out by the next magnet controller in case one of the other controllers does not work. The requirement for an error tolerant system is generated and tested through redundancy.

To simulate the dynamic system behaviour, velocity and disturbing gap signals can be generated with the analog output board ME-6100 from Meilhaus Electronic. This test checks the magnet controllers' dynamics. The deviation from the desired value can be stabilized in a reliable way throughout the Transrapid's entire speed range .

Test System

The test system which comes from the German engineering company LAQ Lasertechnik is based on their knowhow in maintenance measurements, data acquisition and processing as well as machine diagnostics (status monitoring). With this know how, and the concepts used for other test stands, the Transrapid test system can be configured in a short period of time.



Picture 3: Control loop structure for the funktion levitation

The test stand (**picture 1a - c**) for the Transrapid itself consists of a steel frame which carries the guideway stator, and the original vehicle components (skids, support magnets, support gap/clearance sensors and magnet controllers). The

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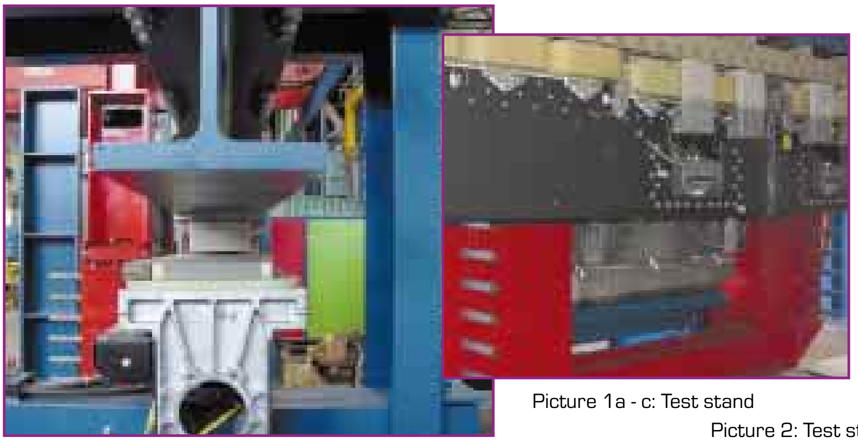


Picture 1a - c: Test stand

Picture 2: Test stand rack

components under test are wired according to the instructions from the company Thyssen Transrapid. The CAN protocol is used for transmission of the measurement data. The magnet controller's functionality is tested by introducing an interference gap signal which must be stabilized (**picture 3**). Switching off one magnet controller simulates a fault situation where the second controller must take control from the first.

The stationary magnetic field is generated with stator packs, through which a current of 60 ADC is flowing. The stator packs are integrated into the guideway.

Measurement

The measurement values show, whether the controllers are working properly or not. The test result is displayed on the screen in the user interface status line. If the controller is compliant with all current parameters, the output is "OK", otherwise the output is "Not OK".

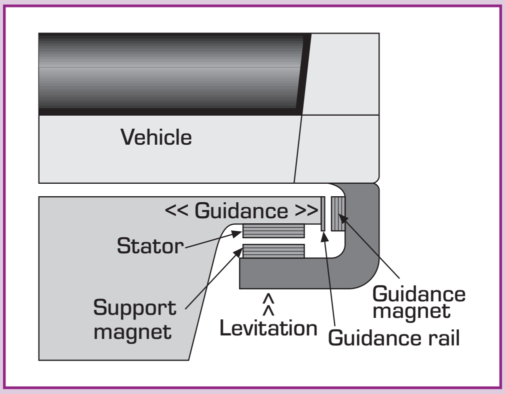
DAQ Boards used in the System

Industrial environments with high levels of noise often require an optical isolation and isolation of potentials between PC and the application. Very often, extensive external circuitries were necessary to achieve the opto isolation of individual analog output lines. Now the analog output board ME-6000/6100 offers an ideal solution, because it is available with two types of output channels: Opto-isolated D/A channels with common ground or "Island" channels. "Island" channels have a complete isolation between the individual channels and from PC ground (no common ground!). The PCI board ME-6000/6100 is available with 4, 8 or 16 output channels. The max. output range is ±10 V. Each channel has its own high precision 16 bit highspeed D/A converter with rates up to 500 kHz. The board version ME-6100 has additional FIFOs on channels 1 - 4 for extended output modes. Using these FIFOs the board can, for example, be used as a virtual waveform generator and/or can generate any kind of arbitrary analog signal from a user defined data set.

The board's task in the Transrapid test stand application is to deliver analog outputs and to work as a waveform generator. The board outputs the signals

Levitation - Guidance - Propulsion: The Maglev Train Principle

Magnetic levitation railways (maglev trains) like the German Transrapid do not have axles, wheels or pantographs, as they do not roll, but hover. A non-contact and wear-free electromagnetic levitation system replaces the mechanic wheel and rail system of classic trains.



This electromagnetic system has three basic functions: **Levitation, guidance and propulsion.**

The Transrapid's **levitation system** is built up of electronically controlled support magnets. They are located along the entire length and on both sides of the vehicle. They pull the vehicle up to the ferromagnetic stator packs. These stator packs are mounted to the underside of the rail guideway. Very little power is required for levitation, so this can be delivered by the on board batteries. The batteries are recharged while the vehicle is moving.

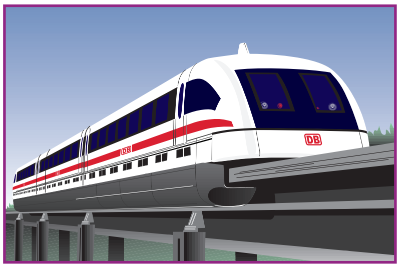
The **guidance** magnets along the entire length and on both sides of the vehicle keep the vehicle laterally on the track. The electronic system guarantees, that the gap of 10 mm remains constant all the time.

The motors of classic railway trains are built into the vehicles, whereas the Transrapid's non-contact **propulsion system** is built into the guideway: The Transrapid has what is called a longstator linear motor. It functions like an electric motor, but the stator is cup open, stretched, and mounted along the underside of the guide way. Inside the windings, a magnetic traveling field is generated, which moves the vehicle without contact. The vehicle's support magnets function as the rotor. By varying the frequency of the alternating current the speed can be regulated.

To **brake** the vehicle the motor is turned into a generator by reversing the direction of the traveling field. The braking energy can be fed back into the electrical network.

(Based in information from the Transrapid International GmbH & Co. KG Website: www.transrapid.de)

Application Note: Test System for Airplane Components



for the simulation of velocity and the interference gap. The waveform and parameters for amplitude and frequency are set in the software. The board is controlled using a LabVIEW application program. As the free software drivers for LabVIEW are included with the board from Meilhaus Electronic, the user finds all the components he needs for the integration on the CD-ROM (also includes the user manuals in English and German). To always keep the software drivers up-to-date Meilhaus Electronic has a free driver download section on the website. With these drivers the board could easily be integrated into the graphic software test program in the Transrapid application. The ready-to-use driver software helped to keep the test stand development time as short as possible. 4 analog output channels are used:

Uout_0 = v signal,
Uout_1 = interference gap signal,
Uout_3 = lifting,
Uout_5 = controller fault.

The FIFOs on the board allow continuous output. The signal for measuring the velocity is a square wave of amplitude 0.1 to 9.9 Volts, the signal for measuring the interference gap is a sine wave of ±10 Volts. This is a perfect application for the ME-6100's "Island" channels. The complete opto-isolation of all channels prevents the signals for velovity and the interference gap from having a disturbing influence on each other.

Summary
Reliable and constant interfaces for easy integration of new test systems into existing applications are important for system designers. This is especially true for situations where the hardware and software development is continuous. The analog output boards from Meilhaus Electronic are available in a variety of models, with the advantage of having a ready to use waveform generator. The isolation of the individual channels was also very useful for this application as it helped to avoid signals on one channel having any influence on the other channels.

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Information on the Transrapid:
www.transrapid.de

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Test System for Airplane Components

Detailed Security Tests for Airconditioning, Actuation and Landing Gear Systems

The high security standards in civil and military aviation require intensive tests of all components. These products can only be cleared to go into service after all functions and features have been carefully tested. Of course all series products as well as all repair devices are tested, before they are taken into operation. This application note describes a flexible data acquisition and control system, where signals from sensors and measuring amplifiers are processed. PCI Data acquisition boards are used to measure all signals and analog output boards control one or more control loops.

Picture 1: Test system in a 19" rack

Liebherr Aerospace Lindenberg GmbH, one of the leading European manufacturers for the aviation industry, develops and produces systems for air management, hydraulics, actuation, and landing gear, as well as the electronic components required to control them. The company supplies products used for civil and military aircraft of various categories (transport, feeder planes, fighters, and helicopters). Before any of these components (for example a climate pack or a nose landing gear) are integrated into an airplane, they must pass an extensive set of strict tests to guarantee their proper function and security.

The Testsystem
The system is integrated into a rack with wheels. It includes a 19" industrial PC (1,8 GHz, 256 MB etc.; operating system Windows NT 4.0 or 2000), 15" TFT in a 19" frame, a keyboard drawer and a connectivity patch bay (**picture 1**).

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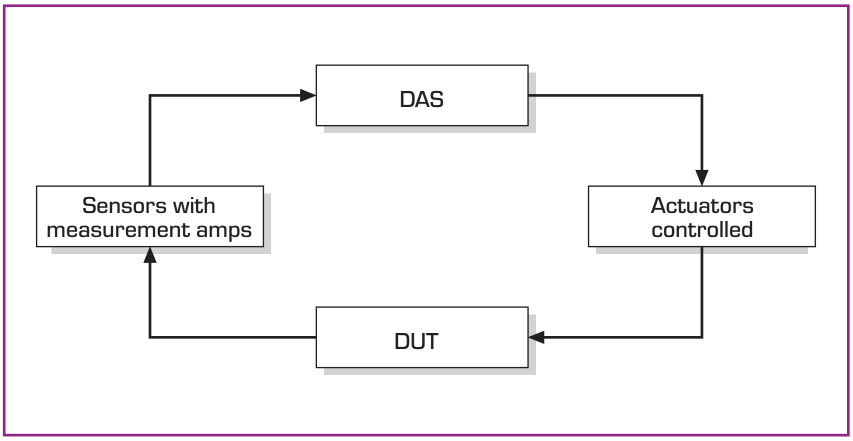


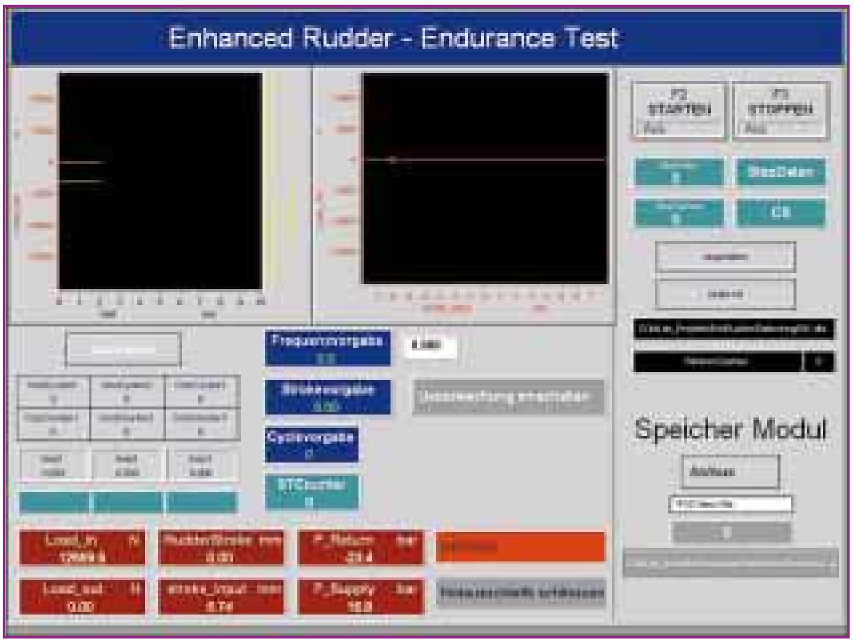
Picture 2. The block diagram shows the adaption of the test system to the measurement system. The DAS outputs nominal values to the PID controllers and/or directly to the actuators which are controlled that way. Loads are put on the device under test. This generates new sensor value which may cause another reaction again.

Together with the software MicroEdition from Stiegele Data Systems and the DAQ boards ME-2600i and ME-3000 as well as the connectivity panels from the ME-PA series it forms a powerful and flexible functional test system.

The connection to the device under test (DUT), the various measurement sensors, the power supplies (hydraulic and electric) for the DUT, and a load cylinder together are the “Test Rig”. The measurement sensors (and corresponding measurement amplifiers), the sensor evaluation, and the signal conditioning (up to the data acquisition and control system) together are the measurement system (**picture 2**).

For the test itself, the measurement amplifier MGC system from Hottinger is used, as well as 19” cassette system PID controllers from S-Elektronik and others. For security reasons the test stand has an emergency OFF system (S-Elektronik), which is activated when certain measurement values are exceeded. This emergency OFF system works with comparators from S-Elektronik. An additional emergency OFF condition was defined for a computer crash of the data acquisition and control system. When all components are connected to the test system, the complete measurement system has to be calibrated. From this moment on only physical dimensions are considered.

MLab is a universal data acquisition and control program and has a variety of action modules. MLab’s flexibility allows the programming of control systems in an action list. The storage module can store data sets depending on an event (trigger). This can be carried out with the sampling rate and/or with a corresponding factor. All relevant data is displayed online. This has the advantage that all data can be monitored at once allowing faults to be detected and corrected quickly. Multiple online displays can be integrated into one MLab project. The complete flow is controlled from MLab. More complex flows are configured in TestControl, another product



Picture 3: Function flow with MLab which is devided into various steps.

from MicroEdition, and carried out in MLab. More complexe flows are configured in TestControl, another product from MicroEdition, und carried out in MLab. MGraph is used to evaluate all measurement data afterwards or even during the test. The software has various export filters for several data formats (Matlab, Diadem etc.). The display (**picture 3**) shows a functional flow divided into several steps. Each step contains a variety of present signals, for example loads depending on the positions and oscillations. The “actual” and “desired” signals can be displayed online in a Y[T] diagram as can any other signals relevant for the test. It is important in projects like these to store the momentary status of the work flow. There is a ‘INI’ file for this. Every test of a device is specified in a certified test statement which describes the functionality and conditions that can occur during takeoff, touch down, or in flight. In the test statements all function parameters are defined through their value range. All channels available to the system or needed by the system are acquired with a defined sampling rate and stored to the hard drive, if required. Online operations can also be carried out which may be important for processing and evaluation later on during the test (**picture 4**).

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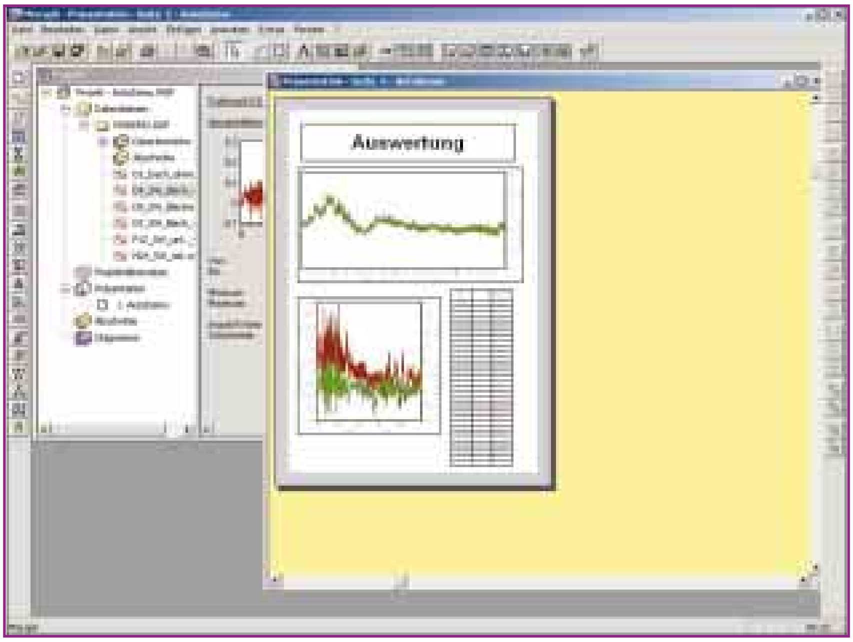

Picture 4: MGraph shows the evaluation and logging of the measurement data which can be used for calculations with various methods later on.

Test System Functionality

The flexible data acquisiton and control system has 8 analog outputs and 32 analog inputs. The signals coming from various measurement amplifiers or going to the control devices are connected to a ME-3000 panel system (ME-PA). The panels themselves are directly connected to 2 DAQ boards in the computer, using two round cables. The panel system has the advantage that it can be armed with additional components. In this test application for example, all 8 analog outputs and 32 inputs can be connected via panels in one rack.

The data acquisition boards in the system are 12 bit multifunctional cards from the Meilhaus Electronic ME-3000 and ME-2600i family. These boards have 4 analog output channels which can be used for simultaneous output. The boards also have 16 (single ended) or 8 (differential) analog inputs and two 16 bit wide digital I/O ports which can be configured independently. The ME3000 has additional features such as counter inputs.

The analog input voltage ranges vary from bipolar max. -10 to +10 V and unipolar 0 to +10 V. The output ranges are 0 to +10 V or max. ±10 V.

For the digital channels in the test system 16 opto-isolated inputs for 24 V signals and 16 relay outputs are used. The relays have a max. permanent current of 1.8 A. The system has one LED for each digital I/O line and a 24V power supply for the relay outputs. With its mobile computer which is separate from the main power supply, measurement data can be acquired any time it is required. So with its mobile computer which is independent from mains supply, measurement data can be acquired autonomously.

As data acquisition often requires realtime measurements with high sampling rates as well as data display, the software MLab and MGraph as a part of the MicroEdition package from Stiegele Data Systems is used. This combination of hardware and software has no problem achieving real time data acquisition rates of up to 1 KHz per channel. Together with the reliable 48-channel TTL digital I/O and counter board ME-1400 clock rates up to 1 kHz and more are possible. The board can also be configured for interrupt operation. For the digital channels TTL signals are used. In most cases, Liebherr uses two ME-2600i boards in their system. This doubles the number of channels available, especially the output channels. Boards from other suppliers which have the same number of inputs, often only have 2 analog outputs. This is not enough for the application described in this article.

Summary

The advantage of the Meilhaus Electronic boards for this application comes from the high number of channels available. The boards are supported by MicroEdition, so the integration into the test environment was quick and easy. With this software, even very complex test stand control systems can be created. These are often used for series production acceptance, or tests which run for long periods of time. The data is stored and processed according to the calibration and its physical dimension. A module of MicroEdition called MGraph allows the data to be evaluated at a later time, and can even generate a measurement protocol.

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Further information/link for the software:
Stiegele Datensysteme GmbH:
(www.microedition.de)

ME-2600i see page 14
ME-1400 see page 26