The corporate research department of a leading Japanese car manufacturer requested a complete revamp of one of their rolling road test rigs. This test rig was built in 1991 using an AEG overriding control and ABB PAD drives together with ABB DMA motors. A well-known German company servicing and revamping motor and rolling road test rigs was in charge of the revamp.

**Rolling Road test rigs**
A rolling road or chassis dynamometer test rig measures the power delivered to the surface of the “drive roller” by a car wheel. It offers the possibility to simulate repeatedly different driving situations and driving cycles. Normally these kinds of test rigs are used for fuel economy tests, noise tests and other efficiency tests.

During most of the test cycles the electrical motors are operated in regenerative mode, thus regenerative ability of the converter module is a key requirement of such installations. To obtain accurate, repeatable simulation results torque control accuracy and stability are required as well. Due to the rolling road being dependent on the grip between the tire and the roller, there are two other important considerations to get accurate results. Firstly, the surface of the roller must offer sufficient grip for the tire to drive it with minimal slippage. Secondly, the roller diameter is also important. Because the larger the roller diameter, the less curved is the surface, resulting in a surface more like a flat road. The bending of the surface will affect the size and shape of the contact patch and therefore the grip between the tire and roller.

Once the car is positioned with the driven wheels on the rollers, it needs to be fixed. The car needs to stay on the rollers during the test, so the fixings keep it in place.

In order to adjust the rolling road to four wheel driven cars and different axis center distances the back drum can be moved.

**Key Issues of the revamp:**
- Modern control and visualization concept
- Improved ease to use
- 0.4 % precision on torque measurement
- 1 % accuracy in reproducibility
- Improved energy efficiency
- Improved safety concept
- Keeping the DC motors due to trusted DC control performance and reliability especially in torque control at low speeds
Challenges:
The life cycle status of original, ABB PAD thyristor drives was changed to obsolete and the spare part supply could not be guaranteed anymore. The original DC motors are in good shape. The reuse of the DC motors is mandatory.

To achieve best performance the customer decided to use high speed Ethernet fieldbus EtherCAT in this application. The size of the new drive and the modern protective and safety equipment must not exceed the size of the original installation.

EtherCAT:
EtherCAT (Ethernet for Control Automation Technology) is a Real Time (deterministic) Ethernet technology which aims to maximize the utilization of the full duplex Ethernet bandwidth. Full duplex allows bidirectional communication at the same time. It overcomes the overhead normally associated with Ethernet by employing “on the fly” processing hardware. An EtherCAT bus consists of a master system and up to 65535 slave devices connected via standard Ethernet cabling. The slave devices process the incoming Ethernet frames (information containing the bus data) directly. They extract or insert relevant data and transfer the frame to the next EtherCAT slave device. The last slave device in the bus segment sends the fully processed frame back, so that it is returned via the first slave back to the master as a response frame. There are several protocols that can be used as application layer. One protocol technology applied to EtherCAT is CANopen (CAN over Ethernet, CoE), which defines SDOs (Service Data Objects), PDOs (Process Data Objects) and the Object Dictionary structure to manage the parameters. Further information is available from the EtherCAT technology group (www.ethercat.org).

Ethercat Topology

On the level of the field devices, EtherCAT is typically operated in a logical ring topology.

Fundamental Principle:
The fundamental principle of EtherCAT is pass through reading. Pass through reading means that messages are not destined for a single node and consumed by that node. Instead, messages are transmitted to the following node in a string as they are processed. Input data to a node is read as the message is processed and output data is inserted in the message to the next node.

A single message is issued by the EtherCAT Master with data for all nodes. As the message is transmitted around the ring and back toward the Master, each node reads its inputs and adds its outputs to the message. When the message arrives back at the EtherCAT Master every node in the network has received new input data from the Master and returned new output data to the Master. Without the deficiency of small payloads or messages targeted to specific nodes, an EtherCAT network can achieve maximum bandwidth utilization. An EtherCAT network can be compared to a railway where each station can off-load and re-load train cars while the train moves through the station.

The ABB solution
ABB proposed using the DCS800 in its four quadrant configuration with RECA-01 EtherCAT interface. The DCS800 is unrivaled in module size for this current rating and regenerative capability. So the original cabinet could be reused not even consuming the full space inside the original cabinet. In normal operation of the test rig the converters are operated in torque control in case of a fast emergency stop they are switched to speed control via communication to shorten the deceleration time. Reusing the existing motor and installation parts, contributed greatly to the continuous struggle of the customer to offer their customer an optimal solution in terms of performance and costs.

RECA-01, EtherCAT adapter, has three different receive PDO types and three different transmit PDO types. Each PDO can have 0 to 8 application objects mapped inside it. So 8 words can be used for cyclic communication.

By using the easy to use PDO and SDO services the whole available data from the drive, e.g. field current, armature current, motor torque, motor speed could be easily integrated inside the test rig visualization and control concept, thus improving the ease to use. Due to continuous regenerative operation of the converter, external DC fuses were installed to protect the motor.

Installation data
- Two Motors:
  - Rated current: 579 A
  - Rated voltage: 400 V
  - Rated speed: 333 rpm
  - Field weakening: 1:3

Drives
2 times DCS800-S02-0820-04

Customer benefits
- Latest field bus technology
- Easy commissioning
- Reliable motors remain
- Field exciters integrated in the DCS800 modules
- Cost effective revamp concept
- Compact size of 4-Q DC drive

For more information please contact:
www.abb.de/motors&drives
dc-drives@de.abb.com