A panel PC instead of controls and instruments

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Abstract
Trepel, the leading manufacturer in the cargo high loader market, has introduced its product line, the Challenger tractor. These vehicles are able to handle push-back, maintenance towing and repositioning of any commercial aircraft, up to the Airbus A380, and almost every military airplane. The Challenger fleet is designed to perform under tough working conditions as well as extreme climatic conditions. The ballasted version of Challenger 700 can handle weights up to 600 t. Instead of usual controls and instruments, the dashboard is equipped with panel-PC from Janz Tec. This is the main control center of the tractor and the display of all relevant data provided by the internal CAN network.

The lead figure shows the ballasted version of a Challenger 700 with a weight of 70 t and an Airbus A380 ready to be pushed towards its launch-position. To offer the customers a maximum of performance these tractors are equipped with a diesel-engine (330 kW) and a ZF power shift transmission (6 gears forward, 3 gears backward). Another big benefit is the agility because of the four different steering-modes (front-axle-, rear-axle-, crab- and all-wheel-steering). For comfortable driving conditions a modern hydro-pneumatic front axle suspension system is installed.

Two control units

Two programmable mobile controllers are installed at different places. One is located in the driver´s cabin, the other in the middle of the tractor next to the main hydraulic system. Six CANopen devices are used to get the information from the binary switches and the analog sensors. They also drive the hydraulic valves, which are spread all over the machine. Some programmable µPLC´s are working with CAN layer-2 (they are used for add-ons) communication system.

The diesel-engine and the transmission use for data exchange a CAN network running the SAE J1939 protocol. As you can imagine it is not easy to recover a huge vehicle with a weight up to 70 t. Therefore, the system has been designed this way to ensure the utmost reliability.

The devices are connected to six different CAN ▷

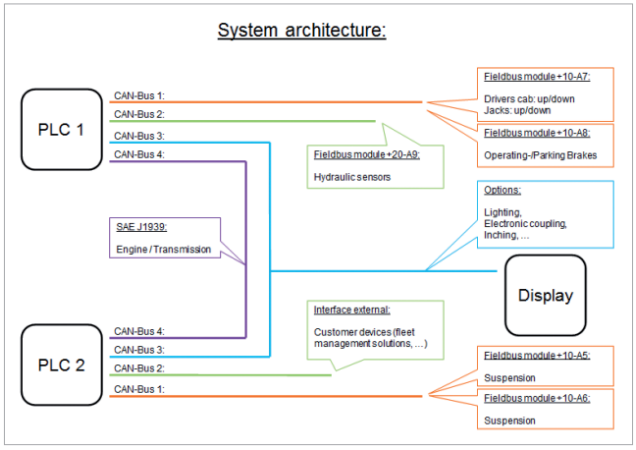

Figure 1: Network architecture with two PLCs and several CAN networks

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networks in order of their function and because of the different protocols used. Another reason is to maximize the immunity of the system against failures. Even if one CAN network breaks down, all the others keep on working and the tractor can be operated with a minimum of limitations. This, and the fact that there are some sorts of other emergency strategies, is very important for a highly reliable machine.

One CAN network is reserved just for customer devices such as fleet management solutions etc. Here almost every customer´s requirement can be fulfilled, no matter if it is CANopen, SAE J1939 or CAN layer-2 protocols. Different bit-rates are possible as well. Another CAN segment is used to build the 'backbone' for data exchange between all single devices. Every PLC, and of course the panel PC is connected to this backbone network. Each device transmits its set of data over a CAN layer-2 protocol. Needless to say it has access to all messages from the others.

One job of the two main PLC´s is to work as a CAN bridge/gateway. They receive the SAE J1939 messages from the power train CAN (engine and transmission) and make all necessary information accessible via the CAN 'backbone' network.

Display of the dashboard

The display is mounted in the center of the dashboard (behind the steering wheel).

It is a non-touch-version to avoid fingerprints on the screen and improve the readability. Its control-buttons (up/down, escape/enter) are installed separately to make them more reachable.

The display used in this application is basically an emVIEW-6 from Janz Tec. It offers all functions needed, such as a compact ARM-based system with small footprint and low energy consumption rates. Additionally the system can be used under rough working conditions because it also offers an extended temperature range. All the interfaces, which are needed, are included as well:

- One CAN interface (busmaster)
- Two 10/100-Mbit/s Ethernet ports
- Two USB V2.0 ports
- One serial EIA-232 interface

The device comes with all software support needed. It is equipped with Windows CE and Codesys, a soft PLC compliant to IEC 61131-3.

But the real important part is that the panel PC was customized to the very special requirements of Trepel. It has got a unique design and is now equipped with a daylight readable display. So the operators can read the display at any lighting condition.

The main display of the panel PC gives all important information to the driver.

It is designed to meet the needs of the operator. Everything is located on one page to give him a good overview. Here he can find an array of indicator lights, the engine-speed, two bar graphs and a text field for error messages, etc. Starting with simple things like the status of the battery charge control and the parking brake it also shows the steering-modes, the position of the axles, the actual gear and some additional information from the gearbox. The variable brightness makes it very easy to switch between day and night conditions.

Service and maintenance

Normally an external device will be plugged to a special diagnostic connector to give service personal the opportunity to check for error messages and other additional information about the status of the vehicle. One of the great advantages of the system configuration is that all these functions are integrated in the display. So there is no need to use additional equipment or any other computer device to check for errors and other diagnostic data of the vehicle. To make the system more service-friendly there are many different pages, which provide all available information.

For example about the engine, the power shift transmission, the steering system. Furthermore there is an error logbook, a page for service issues, visualizations of the fieldbus-modules, parameter, calibration, etc.

Usually the service engineer doesn´t need a laptop to do his maintenance job, neither for trouble-shooting. It only needs a few clicks to change the language or to adjust the date and time.

On the engine´s page there are several values displayed, such as the engine´s speed, the fuel consumption and the percentage load. The coolant-, intake-, and fuel temperatures are also shown. Another advantage is that it indicates all existing errors. It allows reading out the codes and how often the errors occurred very easy. In the past you had to decode the blinking-code of a diagnostic lamp to get the same result.

The transmission´s visualization behaves like the engine page. It reports different oil temperatures and rotation speeds, etc. The built-in error logbook saves every failure of the system on a flash card. Each entry ▷

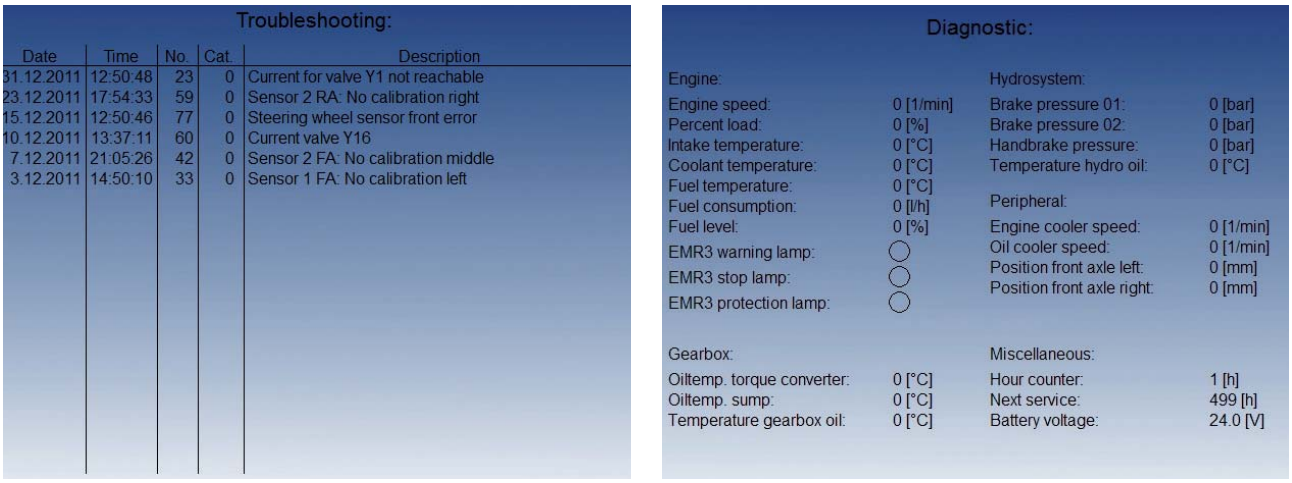

Figure 3: Diagnostic and trouble-shooting

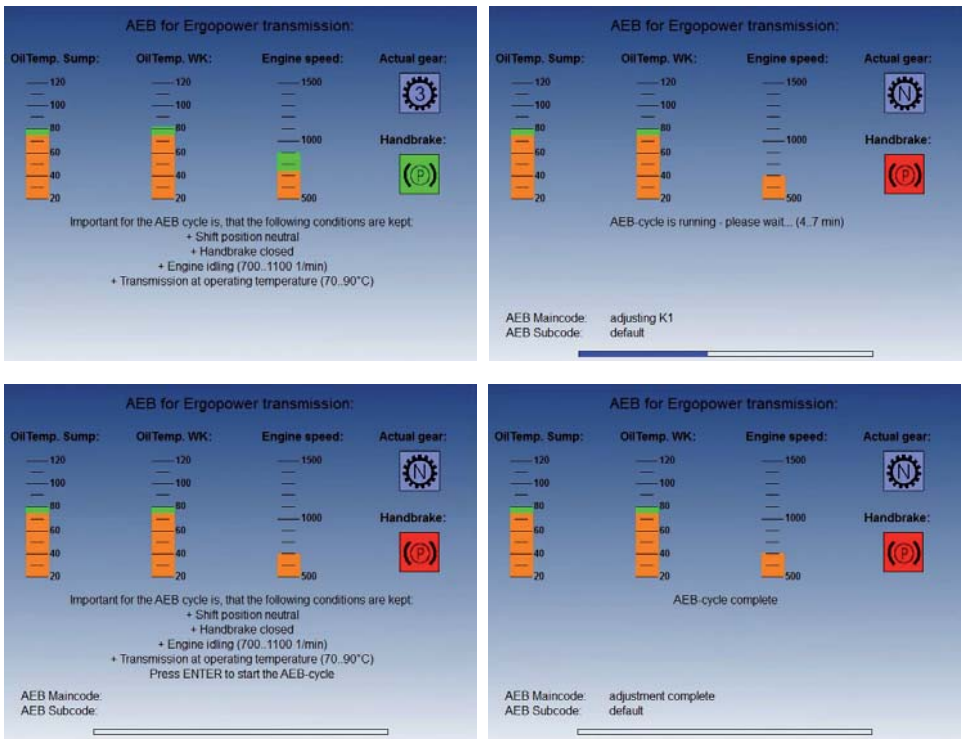

Figure 4: AEB-Start (service example)

gets a timestamp. Additionally a snap-shot from important system values is stored as well. This is helpful for later diagnostics. The entries can be listed chronologically to get a quick overview.

To get a deeper look into the electronic steering system there are separate pages with all the information. From just checking some settings up to calibrating a new angle sensor - everything is possible over the CAN bus.

To show you the service features of the display, we will take one maintenance procedure of the gearbox-controller as an example. This function is called AEB (automatic determination of filling parameters).At the initial startup of the transmission and after each periodic service a special cycle has to be performed. One way to do this is to buy special equipment and connect it to the gearbox-controller. The other and much easier and faster way is to use the panel PC. You just have to select the AEB-mode on the transmission´s page and enter the password to reach the visualization.

After you are in the AEB-mode the characteristic curve of the gearbox cooling-fan is moved to higher temperatures. This is helpful because the transmission´s oil has to be heated up to a certain value. The display shows any information the operator needs (temperatures, engine speed, actual gear and the status of the parking brake). It also tells the service engineer what starting conditions are necessary and when they are met.

Then the cycle can be started – just by pressing the enter-button. This information is transmitted via the CAN bus to one of the PLCs. There it is translated into the SAE J1939 protocol and transmitted to the gearbox-controller. Once the cycle is running its status is displayed to give the operator a direct feedback of the process. Finally the system shows if the process ended successfully or has been aborted by an error and which kind of error occurred.

For a quick and comfortable I/O-check the system provides a separate visualization to display which input- or output-channel is switched on or off. The values of the analogue inputs are shown as well as their pendants, the PWM-outputs.

However, these pages can be used for trouble shooting of the CAN bus as well. They show some CANopen-specific data like the node state of each slave. For example:

- Status 03 – The configuration of the device is actually running.
- Status 05 – The device is normally running.
- Status 97 – The device is optional and didn't answer the SDO-request of the master.
- Status 98 – A wrong device was installed.

Last but not least it is displayed if the device is online or not.

This information helps to locate where the possible problem is and decreases the machine´s downtime. ◀

Conclusion

There are a lot of reasons to use CAN networks for vehicles like Challenger:

- Modular construction
- Reduced wiring complexity
- Faster installation
- Easy diagnostic (self-test)
- Open for add-ons
- Fail-safe
- etc.

The fact that CAN protocol automatically detects transmission errors and retransmits the faulty messages prevent errors in the system, too.

"We think, that CAN´s success story will continue!"

The authors