

# CAN application – Driving controls in the cab of railway engines.

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**During the current development of a modular drivers desk for trains a major factor that has to be considered is the input and wiring of the control signals. There are up to about 45 controls situated over the complete desk. The CAN (open) Bus system was selected for this purpose in order to maintain a flexible approach with a minimum of costs .**

**When considering railway applications it is very important that all the standards and specifications (EN50155 etc.) are complied with and that the system guarantees an extremely competent method of control signal transfer. The controls must provide a high availability so that failures very rarely cause a break down.**

**The paper describes the principles behind a 2 channel CAN System with control input backup via the display terminals of the dashboard in the cab. The aim is to maintain control over the main important input functions despite failures.**

## 1) The basic set-up

The drivers desk is composed of three main parts, the display area, the dashboard area (the horizontal part) with most of the important input control switches and the area under the dashboard comprising of the foot area and the left and right enclosures. (see diag 4). Some of these enclosures also have less important control input switches such as temperature, air conditioning or instrument lighting. The main controls (the important controls) on the dashboard are divided up into three control units one of which can be seen in diag1.



diag 1

These units may be considered as metal boxes containing two or more CAN modules. Each module has 8 inputs or outputs, and has its own CAN address and transmits 8 signals from the controls to the CAN Bus or in the case of the

few outputs from the CAN bus. Two completely separated CAN Buses referred to as channel 1 (CAN1) and channel 2 (CAN2) provide a redundant system. All the important controls are supplied with double contacts, so that the same input signals can be fed to CAN channel 1 and CAN channel 2 simultaneously. Less important control inputs are only fed to channel 2. Controls that are not situated together are wired to control units placed at convenient positions in the left and right enclosures, if the signals are of the "less important type" the units may not have more than one CAN module. Here are a few examples of the important controls based on the German railway:

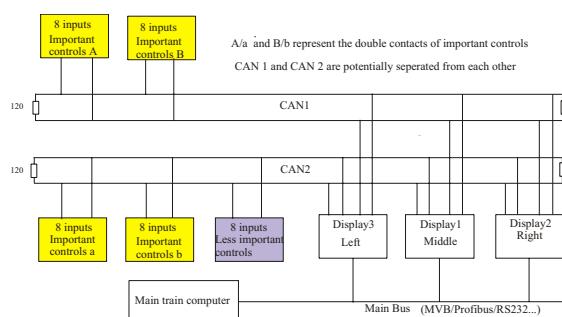
Pantograph/sand	(Stromabnehmer)
Main switch	(Hauptschalter)
Train-running control	(PZB/LZB)
Carriage power	(ZS)
Master controller	(fahren/bremsen)

In the German system there are approximately eight important controls, five of which are listed above. For other countries this may differ, but this is a description of the principles and not the final set-up or the actual controls.

In order to keep the subject fairly simple only five CAN input modules will be considered, two on channel one and three on channel two.

There are three TFT displays in the dashboard (European Drivers Desk Concept), the lefthand display presents diagnostic information, the middle display driving data such as speed, signals etc. and the righthand display information such as brake pressures etc. All three displays have processors and are each connected to both CAN channels.

Each display is provided with two CAN channels (potentially separated from each other) see diag 2 .



diag 2

The displays fulfil their primary functions described above as well as serving as gateways between the CAN system and the main Bus system wired to the main train computer. This main Bus system could be MVB (Multi Function Vehicle Bus), Profibus, RS232 or other Bus systems. Three sets of signals are available on this Bus system.

## 2) The displays

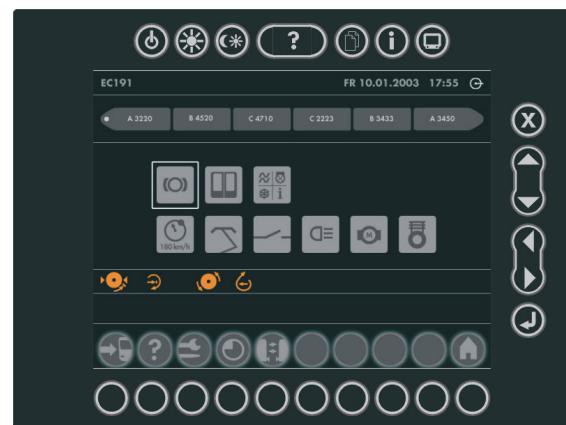
The three Displays have basically the same software, the display with the minimum work load is selected at the start as master for both CAN channels. (this would be either the left or right display). This display also functions as the backup input for the important signals in case of signal failure and as output module for the few outgoing signals (such as headlight dip/undip). The master function uses the Flyingmaster technique. The displays each have a set of input switches either touchscreen, foil or discrete buttons. These switches maintain their usual

functions as well as providing the backup input possibility. The main application software is based on the European Drivers Desk Concept, the subsidiary application is the backup and gateway function.

## 3) The backup input

The use of this input is dependent upon the failure recognition by the driver or the main computer which receives all data including failure status from the CAN system and can therefore decide if such an action is necessary.

In case of failure the backup input mode is selected with the appropriate bottom button. see diag 3.



diag3

The control symbols then appear on the "master screen" at the bottom . see diag 3a.



diag3a

Having entered the input mode, the switch under the relevant function symbol is activated, this starts the next input stage and the required backup input function can be entered. In the case of a deadmans pedal (Sifa) the input may be entered continuously. The input function can be changed or left by pressing the "home" symbol switch. Pressing this button again leaves the backup input program. All inputs are registered and sent to the main Bus system along with the failure status signals and the signals that are functioning normally.

The main application continues to run on the top part of the screen.

#### **4) The CAN Bus Systematic**

Each CAN module reacts to changes in the signal status (event triggered), all eight inputs are then transmitted on the Bus. Each module, (including the displays) sends heartbeats. At start up the master sends the appropriate configuration.

As already mentioned the important signals are present on both channels, therefore there are so called "data pairs" (groups of eight signals with the same information content on CAN1 and CAN2). The less important signals are not paired, but are also present in groups of eight on CAN2. The CAN channels operate in the "usual way" without any particular special effects. The baud rate is set at 500 KB/second

which is a comfortable value for the 10-12 m length of CAN cable per channel. Both channels operate continuously.

When considering the expected maximum number of controls, the number of CAN modules on channel 1 will be approximately seven and on CAN 2 ten (this excludes the modules in the displays). The exact number is of course dependant upon the actual requirements for the particular application, and how many inputs or outputs are available at each CAN module. It is probably sensible not to have too many inputs/outputs per module in case of module failure.

#### **5) The evaluation of the CAN data at the terminals**

Each of the terminals evaluates the input CAN data and writes it into a port for transfer to the main Bus system (MVB, Profibus, RS232 etc.).

The "master terminal" enables the backup input. Some of the logical decisions and software considerations will now be explained, they are basically valid for each display.

##### **5a) Time considerations**

It is not important if data from each channel does not arrive at completely the same time. The SW compares the "data pairs", if they are not identical the comparison is repeated for a certain time. After this time if the data is then still different the data is considered as faulty and the appropriate action is taken. This is only relevant for important control data present on both channels.

##### **5b) Heartbeats**

Heartbeats indicate that the modules are alive

and show the status of the modules (bootup, stopped, operational or pre-operational).

All CAN modules as well as the terminals send heartbeats. When all heartbeats are present the "data pairs" are compared, when identical, they are registered with the less important data on CAN channel 2 ready for transfer to the main Bus system. When the "data pairs" are not identical a message appears on the master terminal screen and the (backup) input via the switches (buttons) is available. If all heartbeats from CAN1 and CAN2 are not registered then the complete system is not working and the backup input is available at the terminal as described above. If CAN1 or CAN2 stops sending heartbeats then the other CAN channel that is working is used for the data registration.

Probably the most usual case would be a partial failure (i.e. one or more modules on CAN 1 or CAN 2 stops sending heartbeats).

The action that then takes place is dependent upon the type of data

(i.e.whether “data pair” , or less important signals ) and which channel is faulty.

If CAN 2 modules that send less important signals do not send heartbeats then only a warning message appears on the screen and a fault message is sent to the main computer.

#### **5c) Display failure**

All the displays send heartbeats, therefore one display can see if the other displays are also working correctly. The master function can be

transferred by the Flying Master from one display to the other. Alternatively the Master function can be changed via the main computer

that receives all data from each display. A third alternative would be a manual change via the driver. At start up the Master function is allocated to one display (see (2)), the display with master function on at least one channel remains as backup input terminal. If the “backup input display” is faulty the next display can be used as backup. If two displays are not working properly then the third display can be used (as backup). This maintains a high system availability. The exact switching criteria will not be discussed here because first of all it is complicated and secondly dependent upon the customer requirements and control philosophy.

#### **5d) The output to the main Bus**

This will normally be in the form of a port (256 Bytes) with its own address for each display (when considering the MVB Bus). The input control data along with all error bits, status bits and the backup inputs are contained in this port.

### **6) General considerations**

CAN Standards such as DSP 307 CAN open Framework for Maritime Electronics or DSP 304 Safety-Relevant Communication are certainly of interest.

The 304 is centered on safety. The 307 is for complex systems with multiplexed PDOs it uses heartbeats as well as Flying

master and is similar. It doesn't however suggest the use of a display backup input. The described system may be considered as a way of using redundant parts to increase the availability of the system. In other words it provides a means of help in the case of control input breakdown, and enables the driver to at least reach the next station instead of blocking the rail section with all the inconveniences that result. The decision whether the driver is allowed to make use of this feature is another matter.

### **7) The Project Stand**

A demonstration drivers desk was exhibited at the InnoTrans 2004 Trade Fair in Berlin (September2004), see diag 4 The data from two displays in the drivers desk (one acting as backup input) was fed over COM interfaces to a computer and evaluated using Lab View. The CAN application software was of a prototype nature and is in the process of being further developed and refined. The final development will take place after discussion with potential customers.



diag 4

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