STADLER

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| *Project:* | |
| *Document:* | BB00690107001 |
| *Revision / Date:* | A0/ 29.10.18 |
| *Created:* | P. Ramón |
| *Number of pages:* | 13 |
| | **RELEASED** |

# CAN Subsystems Requirements.

# Technical Specification.



**Stadler Rail Valencia S.A.U.**

| Rev | Motivation | Date | Created | Approved | Released |
|---|---|---|---|---|---|
| -- | First Edition | 18.01.13 | P. Ramón | F. del Río | A. García |
| A0 | Stadler Rail Valencia | 23.10.18 | R. Martinez | F. del Río | A. García |
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**Table of contents**

# 1 Document Scope

The purpose of this document is to provide an overview of the features and requirements of the CAN card for the subsystems connected to the TCMS of Stadler Rail Valencia Vehicle.

# 2 Target.

# 3 Acronyms.

| | |
|---|---|
| CAN | Controller Area Network |
| CiA | CAN in Automation:. Organization of CANbus producers and users |
| COB | Communication Object. (CAN Message) A unit of transportation in a CAN Network. Data must be sent across a Network inside a COB. |
| COB-ID | Communication Object Identifier. Identifies a COB uniquely in a Network. The identifier determines the priority of that COB in the MAC sub-layer too. |
| NMT | Network Management. One of the service elements of CANopen Application Layer in the CAN Reference Model. It performs initialisation, configuration and error handling in a CANopen network. |
| PDO | Process Data Object: CAN message for transmitting data |
| SDO | Service Data Object: CAN message for transmitting configuration data |
| DSP | Draft Standard Proposal |
| DS | Draft Standard |

# 4 References.

| ***Ref.*** | ***Document*** | ***Description*** |
|---|---|---|
| 1 | EN 50121-3-2 | Railway applications-Electromagnetic compatibility-Rolling stock-Part 3-2:Rolling stock apparatus |
| 2 | EN 50124-1 | Railway applications-Environmental conditions for equipment-Part 1: Equipment on board rolling stock. |
| 3 | EN 50125-1 | Railway applications- Environmental conditions for equipment- Part 1: Equipment on board rolling stock |
| 4 | EN 50155 | Railway applications- Electronic equipment used on board rolling stock. |
| 5 | EN 61373 | Railway applications- Rolling stock equipment-Shock and vibration test |
| 6 | EN 50343 | Railway applications- Rolling stock- Rules for installation of cabling |
| 7 | EN 50153 | Railway application- Rolling stock- Protective provisions relating to electrical hazards |
| 8 | EN 45545-2 | 8 |
| 9 | DIN 5510-2 | Preventive fire protection in railway vehicles - Part 2: Fire behaviour and fire side effects of materials and parts - Classification, requirements and test methods |
| 10 | NFF16-101<br>NFF16-102 | Railway rolling stock: Fire behaviour; Choice of materials. |
| 11 | EN 50128 | Railway applications – Communications, signalling and processing systems-software for railway control and protection Systems |
| 12 | CiA DS 301 | CANopen application layer and communication profile |
| 13 | ISO 11898 | Road Vehicles – Controller area network (CAN). |
| 14 | IEC 61375 | Electronic railway equipment - Train communication network (TCN) - Part 3-3: CANopen Consist Network (CCN) |

# 5 General description.

The protocol running on the CAN network is the CANopen protocol specified by CiA. For further information please refer to the document 'Application Layer and Communication Profile' released by CiA DS 301 [12] and Standard IEC 61375 -3- 3 [14].

To run the CANopen network a CANopen manager is required. The CANopen manager will be implemented into the node VCU (Vehicle Control Unit). The CANopen manager includes the functionalities of the NMT Master and the configuration manager used to configure all other nodes during boot-up.

All other nodes on the network shall act as CANopen Slave.

The Bit-rate used on the CANopen network is fixed at 250 kbps. Optionally, this value shall be configurable.

## 5.1 Communications. Data exchange over the network.

The data exchange over CAN network will be realized by using Process Data Objects (PDO) and Service Data Objects (SDO).

As a minimum, the transceiver shall operate in can 2.0B passive mode: support 11 bit address format, but recognize messages in extended format and ignore them (does not generate an error message).

Anyway, Stadler Rail Valencia requirement is that the communication exchange must support 29 bit address, but it will be able to be configured also to operate with 11 bit address (CAN2.0A)

The subsystem has to implement a NMT Slave state machine. The CANopen Master will use
NMT Objects to start and stop the NMT Slave. After a NMT command "Start Remote Node", the NMT Slave will start sending their existing, enabled TxPDO's.

### 5.1.1 Transmission modes

The suppliers shall be use the Event-driven transmission as a transmission mode.

### 5.1.2 Remote Transmission Request

Remote transmission request shall not be used.

## 5.2 Error Control Protocol.

To build a node guarding system the heartbeat protocol shall be used. The heartbeat protocol defines an Error Control Service without need for remote frames. A heartbeat producer (NMT slave and master are heartbeat producer) shall transmit a heartbeat message cyclically. The heartbeat consumer (NMT master) guards the reception of the heartbeat within the heartbeat consumer time. If the heartbeat is not received within the heartbeat consumer time a heartbeat event shall be generated.

The NMT master is the heartbeat consumer for every defined slave being in the network.

The NMT slaves are not required to guard the reception of any heartbeat. However, they are not prohibited to selectively guard the reception of some heartbeat, especially the one of the CANopen Master, if their internal functionality requires it.

## 5.3 Synchronisation object.

The network master (Vehicle Control Unit) will broadcast cyclically a synchronization object (per default: every second).

Subsystems are free to use it when required. However, message bursts can be expected if the number of synchronous PDOs is considerable. So usage of synchronous PDOs shall be minimized and event and time triggered PDOs shall be preferred wherever possible.

If the equipment does not need the synchronization object, the subsystem shall simply ignore the sync message.

## 5.4 Time Stamp.

The Time Stamp master will broadcast cyclic an official time to all slave nodes. Any subsystem that uses an internal real time clock shall synchronies it to the Time-Stamp received at least each 5s.
UTC CAN

## 5.5 SDO management.

Subsystems shall provide one SDO channel as defined in CANopen Specification. This channel shall be used for network configuration

Under normal use, one SDO channel is enough to perform all NMT tasks.

## 5.6 PDO configuration.

By default, each subsystem can use CANopen default PDO configuration, which means 4 TX and 4 RX PDOs. For most subsystem, this is sufficient. For some others, additional PDOs are required.

For the additional TX and RX PDOs the CANopen Master will assign, in the configuration phase, the corresponding Communication Object Identifier (COB-ID).

For this reason the objects defining the PDO communication parameters (1400h to 15FFh and 1800h to 19FFh) (only the PDO communication parameters objects for existing RX PDOs and TX PDOs have to be implemented), sub-index 01h, has to be implemented.

## 5.7 PDO Update Rate.

The PDO update rate is defined by the Objects PDO communication parameters (1400h to 15FFh and 1800h to 19FFh), sub-index 02h has to be implemented (rw access).
For further specifications of the PDO update rates the sub-indexes 03h and 05h can be implemented optionally (rw access)..

## 5.8 Inhibit Time

The default inhibit time for the TPDOs (from subsytem to VCU) is 25ms.
The default inhibit time for the RPDOs (from VCU to subsystem) is 50ms (VCU cycle time).

## 5.9 Event Time

The default event time for the TPDOs (from subsystem to VCU) is 1000ms.
The default event time for the RPDOs (from VCU to subsystem) is 1000ms.

## 5.10 Dictionary objects to be implemented.

In an advanced stage, the minimum dictionary objects will be agreed, which have to be implemented in a sub-system acting as a CANopen Slave in a CANopen network controlled by a CANopen Master.

### 5.10.1 Standard Objects

Table 47: Standard Objects

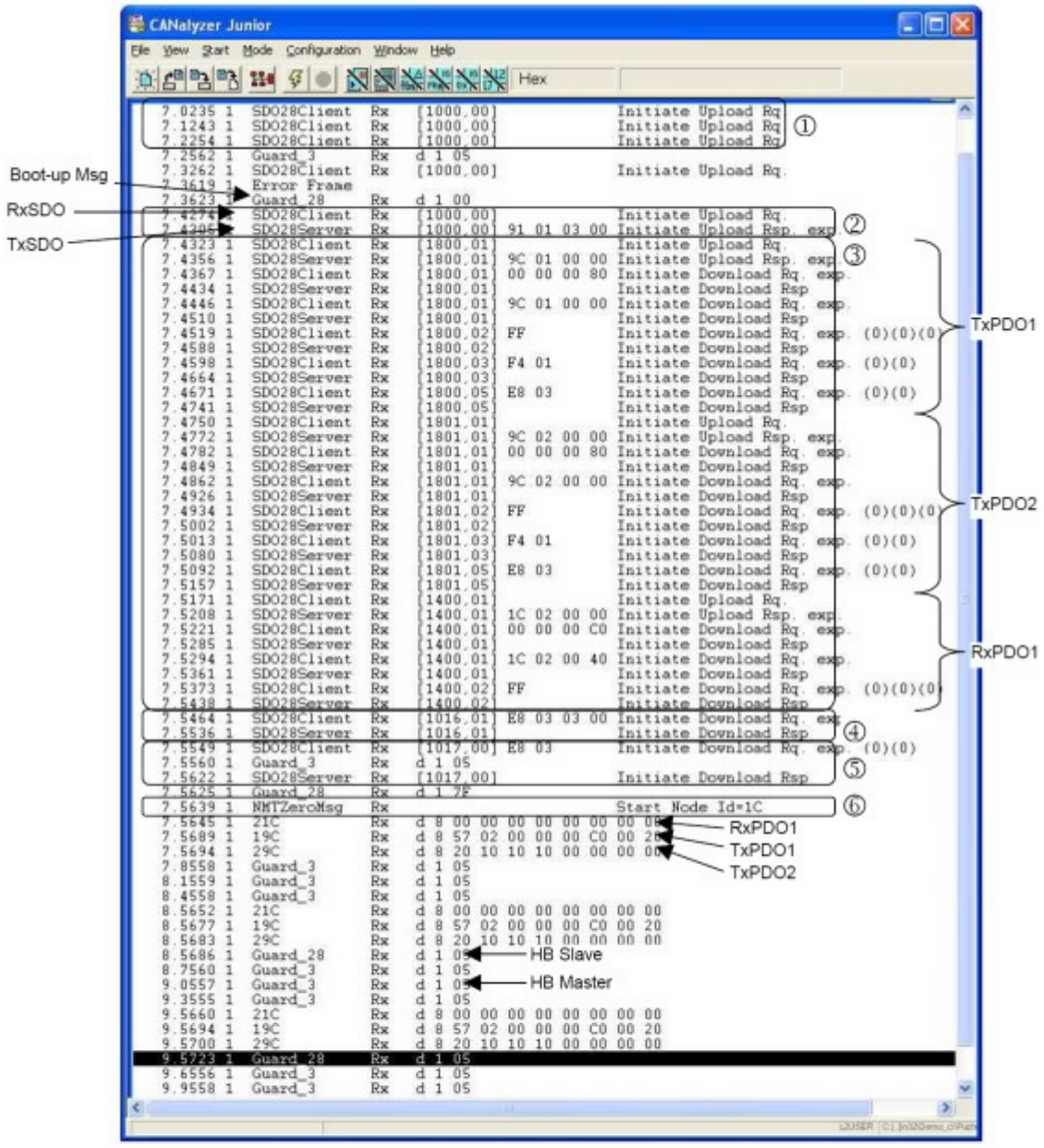
| Index (hex) | Object (Symbolic Name) | Name | Type | Acc.[1] | M/O |
|---|---|---|---|---|---|
| 1000 | VAR | device type | UNSIGNED32 | ro | M |
| 1001 | VAR | error register | UNSIGNED8 | ro | M |
| 1002 | VAR | manufacturer status register | UNSIGNED32 | ro | O |
| 1003 | ARRAY | pre-defined error field | UNSIGNED32 | ro | O |
| 1004 | reserved for compatibility reasons | | | | |
| 1005 | VAR | COB-ID SYNC | UNSIGNED32 | rw | O |
| 1006 | VAR | communication cycle period | UNSIGNED32 | rw | O |
| 1007 | VAR | synchronous window length | UNSIGNED32 | rw | O |
| 1008 | VAR | manufacturer device name | Vis-String | const | O |
| 1009 | VAR | manufacturer hardware version | Vis-String | const | O |
| 100A | VAR | manufacturer software version | Vis-String | const | O |
| 100B | reserved for compatibility reasons | | | | |
| 100C | VAR | guard time | UNSIGNED16 | rw | O |
| 100D | VAR | life time factor | UNSIGNED8 | rw | O |
| 100E | reserved for compatibility reasons | | | | |
| 100F | reserved for compatibility reasons | | | | |
| 1010 | ARRAY | store parameters | UNSIGNED32 | rw | O |
| 1011 | ARRAY | restore default parameters | UNSIGNED32 | rw | O |
| 1012 | VAR | COB-ID TIME | UNSIGNED32 | rw | O |
| 1013 | VAR | high resolution time stamp | UNSIGNED32 | rw | O |
| 1014 | VAR | COB-ID EMCY | UNSIGNED32 | rw | O |
| 1015 | VAR | Inhibit Time EMCY | UNSIGNED16 | rw | O |
| 1016 | ARRAY | Consumer heartbeat time | UNSIGNED32 | rw | O |
| 1017 | VAR | Producer heartbeat time | UNSIGNED16 | rw | O |
| 1018 | RECORD | Identity Object | Identity (23h) | ro | M |
| 1019 | | reserved | | | |
| ::::: | ::::: | ::::: | ::::: | ::::: | ::::: |
| 11FF | | reserved | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Server SDO Parameter** | | | | | |
| 1200 | RECORD | 1st Server SDO parameter | SDO Parameter (22h) | ro | O |
| 1201 | RECORD | 2nd Server SDO parameter | SDO Parameter (22h) | rw | M/O** |
| ::::: | ::::: | ::::: | ::::: | ::::: | ::::: |
| 127F | RECORD | 128th Server SDO parameter | SDO Parameter (22h) | rw | M/O** |
| **Client SDO Parameter** | | | | | |
| 1280 | RECORD | 1st Client SDO parameter | SDO Parameter (22h) | rw | M/O** |
| 1281 | RECORD | 2nd Client SDO parameter | SDO Parameter (22h) | rw | M/O** |
| ::::: | ::::: | ::::: | ::::: | ::::: | ::::: |
| 12FF | RECORD | 128th Client SDO parameter | SDO Parameter (22h) | rw | M/O** |
| 1300 | | reserved | | | |
| ::::: | ::::: | ::::: | ::::: | ::::: | ::::: |
| 13FF | | reserved | | | |
| **Receive PDO Communication Parameter** | | | | | |
| 1400 | RECORD | 1st receive PDO Parameter | PDO CommPar (20h) | rw | M/O* |
| 1401 | RECORD | 2nd receive PDO Parameter | PDO CommPar (20h) | | M/O* |
| ::::: | ::::: | ::::: | ::::: | ::::: | ::::: |
| 15FF | RECORD | 512th receive PDO Parameter | PDO CommPar (20h) | rw | M/O* |
| **Receive PDO Mapping Parameter** | | | | | |
| 1600 | RECORD | 1st receive PDO mapping | PDO Mapping (21h) | rw | M/O* |
| 1601 | RECORD | 2nd receive PDO mapping | PDO Mapping (21h) | rw | M/O* |
| ::::: | ::::: | ::::: | ::::: | ::::: | ::::: |
| 17FF | RECORD | 512th receive PDO mapping | PDO Mapping (21h) | rw | M/O* |
| **Transmit PDO Communication Parameter** | | | | | |
| 1800 | RECORD | 1st transmit PDO Parameter | PDO CommPar (20h) | rw | M/O* |
| 1801 | RECORD | 2nd transmit PDO Parameter | PDO CommPar (20h) | rw | M/O* |
| ::::: | ::::: | ::::: | ::::: | ::::: | :::: |
| 19FF | RECORD | 512th transmit PDO Parameter | PDO CommPar (20h) | rw | M/O* |
| **Transmit PDO Mapping Parameter** | | | | | |
| 1A00 | RECORD | 1st transmit PDO mapping | PDO Mapping (21h) | rw | M/O* |
| 1A01 | RECORD | 2nd transmit PDO mapping | PDO Mapping (21h) | rw | M/O* |
| ::::: | ::::: | ::::: | ::::: | ::::: | ::::: |
| 1BFF | RECORD | 512th transmit PDO mapping | PDO Mapping (21h) | rw | M/O* |

* If a device supports PDOs, the according PDO communication parameter and PDO mapping entries in the Object Dictionary are mandatory. These may be read_only.
** If a device supports SDOs, the according SDO parameters in the Object Dictionary are mandatory.

[1)] Access type listed here may vary for certain sub-indices. See detailed object specification.

### 5.10.2 Start up example




① CANopen master polling an expected CANopen Slave with a poll cycle of 100ms, using the mandatory object 1000h. No answer from the expected sub-system (sub-system is not connected to the CANopen bus).

② The sub-system is connected to the CANopen bus and node boot-up is finished. The sub-system answers to the SDO request of the CANopen master.

③ The CANopen master configures the Rx and Tx PDOs, objects 14xxh and 18xxh

④ The CANopen master configures the Consumer HB, object 1016h

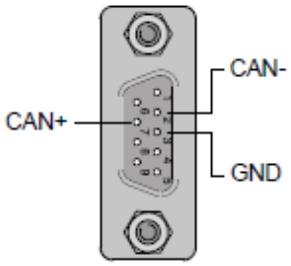
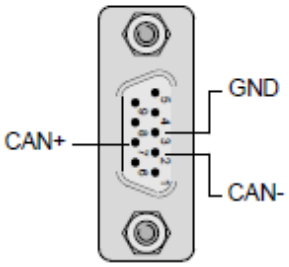
⑤ The CANopen master configures the Producer HB, object 1017h
⑥ The CANopen master starts the sub-system

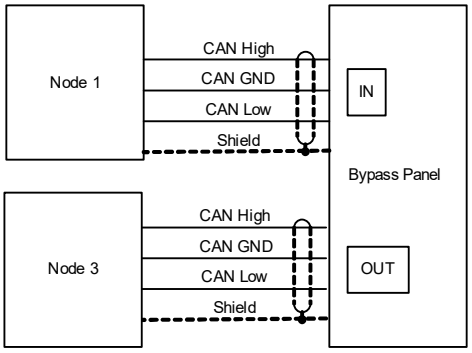
Until the phase ⑥, the sub-system is in pre-operational mode. After the phase ⑥, the sub-system is in operational mode and PDOs can be exchanged.
Directly after the phase ⑤ (configuration of the Producer HB), the sub-system sends its HB telegram. This HB is then sent every second, according to the choosen configuration.

## 5.11 Hardware requirements

### 5.11.1 CAN Interface

The connection between nodes will be as following:

| Interface | X1: CAN1 out | X2: CAN1 in |
|---|---|---|
| |  |  |
| | Fig.3.13: Pin assignment X1, X3 | Fig.3.14: Pin assignment X2, X4 |
| **Connector** | D-sub 9-pin, male (UNC 4-40) | D-sub 9-pin, female (UNC 4-40) |
| **Pin assignment** | Pin 2 CAN– Data line –<br>Pin 3 GND CAN reference point<br>Pin 7 CAN+ Data line + | |




It will be appreciate that CAN GND will be in pin 3.

The CAN interface will be opto-isolated, in order to achieve a barrier isolation.

### 5.11.2 Line termination

**(TBD, OPTIONALLY)**

CAN interface shall include an on-board line termination 120 Ohms, enabled by jumper and software.

The software configurable line termination will avoid the communication loss in the CAN bus in case of one of the side of the network is cut (or a connector is loose).

The CAN node will be able to detect communication errors and introduce the line termination to, in fact, close the communication bus.

| Note: CAN card recommendation “intelligent CAN/CANopen CAN-104” from “janztec” |
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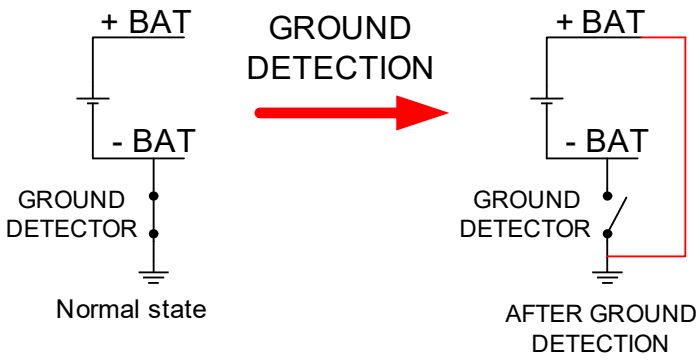
### 5.11.3 Ground fault philosophy

In the train set, a connection between the negative of the battery and the earth through a detector will exist. In case that we have any connection between battery positive and the earth this detector will open the connection and the battery negative start to fly as shown in the following picture:




To avoid any malfunction the equipment should have enough isolation and will be forbidden to connect CAN GND to the earth.

If the CAN driver does not use an opto-isolated circuit, CAN GND must be referenced to -BAT.