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CAN Networking Performance Specification for 125kBd/500kBd networks

Foreword

This document defines the CAN networking performance specification for vehicle multiplexing communication system and the electronic control modules using Controller Area Network (CAN) on certain DaimlerChrysler vehicle models.

Changes

Initial document

NOTE: The English and German version of this jointly developed engineering standard are equivalent. For all other translations, no guarantee can be made as to the accuracy of the technical information.

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Contents

1 Scope

This CAN network specification document contains implementation requirements for ECUs used on DaimlerChrysler vehicles.

Vehicle Networking Groups of Mercedes-Benz, Chrysler Group or Mitsubishi Motor Company will determine the respective vehicle lines that this specification applies.

Refer also to the specification (Ausführungsvorschrift) "CAN networking details" in the latest version for the appropriate vehicle line.

Refer all questions to the Vehicle Networking group.

1.1 Deviations

Deviations from the requirements contained in this standard are only allowed if agreed to explicitly and documented between the supplier and the appropriate DaimlerChrysler design and release area.

2 References

2.1 International CAN-Standards

Bosch CAN Specification 2.0 part B shall be followed when designing the CAN ECUs and the CAN network systems. Standard message format with 11-bit identifier shall be used. Remote frame and overload frame as specified in Bosch 2.0 are not used.

The following versions of the Bosch CAN specifications provide the processing capability of standard and extended identifiers.

Table 1: CAN-Standards

ISO-Std.	Type	Content
11898	Road vehicles - Controller area network (CAN)	Part 1: Data link layer and physical signalling Part 2: High-speed medium access unit Part 3: Low-speed fault tolerant medium dependent interface
15765	Diagnostics	Diagnostics on CAN

2.2 DaimlerChrysler Standards

- DC-10615, Electrical System Performance Requirements for Electrical and Electronic Components
- DC-10614, EMC Performance Requirements - Components
- DC-10730, E/E - Standard software for ECUs - General requirements
- DC-10746, Diagnostic Performance Requirements Standard

The releasing area for each of these documents shall be contacted to determine the correct revision level required for your vehicle line.

3 Abbreviations, Acronyms, Definitions, & Symbols

CAN	Controller Area Network
Clamp-15/87	Ignition feed
Clamp-30	Battery feed
CMC	Common Mode Choke
ECU	Electronic Control Unit
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference
IOD	Ignition Off Current Draw
ISO	International Standards Organization
NM	Network Management
PLL	Phase Lock Loop
SAE	Society of Automotive Engineers
SNA	Signal Not Available
VMM	Vehicle Message Matrix

4 Regulated Substances and Recyclability (only valid in the US)

All materials, procedures, processes, components, or systems must conform to the current regulatory (governmental) requirements regarding regulated substances and recyclability.

5 Physical Layer

5.1 Battery fed (Clamp 30) 125 kBd and 500 kBd ECU

5.1.1 Transceiver Circuit Specifications

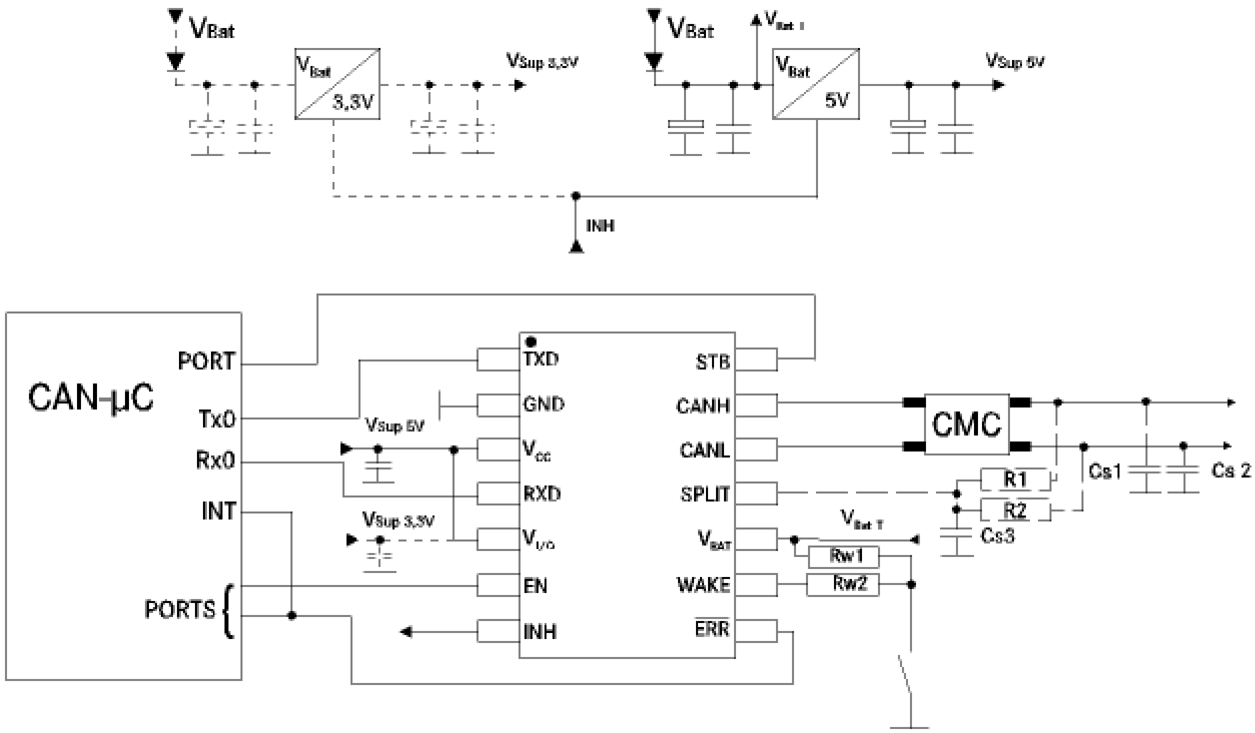


Figure 1: Transceiver circuit of a battery fed ECU in a 125kBd or 500kBd network

For EMI reasons, all transceiver circuit components shall be arranged close together on the circuit board.

Refer to section 5.5 for the values of resistors R1/R2 and capacitor Cs3.
Reserve Cs1 and Cs2 =47pF as an option for EMC optimization.

A local input switch (normally open) can be connected to pin WAKE and V_{BAT} through resistors Rw1 = 6.8 kΩ and Rw2 = 3.0 kΩ to signal a local wakeup to the transceiver. If the local wake up function is not needed, the WAKE input must be grounded through Rw2.

CMC = Common Mode Choke, refer to section 5.6.

If a controller below 5V is used (e.g., 3.3V see figure 5/1), a separate voltage regulator with INH shall be used. INH inputs of both voltage regulators are controlled by the transceiver. The controller’s supply voltage is connected to the pin $V_{I/O}$ for “level adaptation.”

Depending on the controller/software, a connection to an interrupt input ($\overline{\text{ERR}}$-INT) may be necessary.
If the local “wake up“ function is not needed, the WAKE input must be grounded.

Any deviation in the transceiver circuit design shall be coordinated with the Networking group.

5.1.2 Bus voltage levels for battery fed ECUs

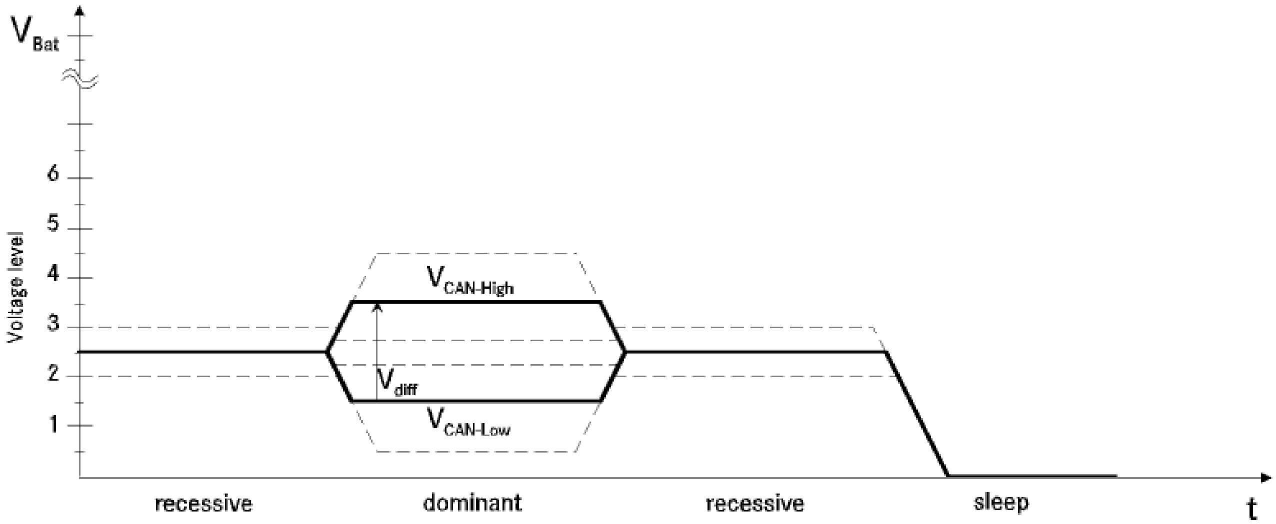


Figure 2: CAN-Bus Voltage Level according to DIN ISO 11898

All threshold voltages are specified in the respective transceiver device specification.

5.2 Ignition fed (Clamp 15, 87) 125 kBd and 500 kBd ECU

The ECU power supply and the CAN interface in these systems is turned on by Clamp 15 or Clamp 87. Communication through the CAN is only possible if the clamp 15 or 87 is switched on.

5.2.1 Transceiver Circuit Specifications

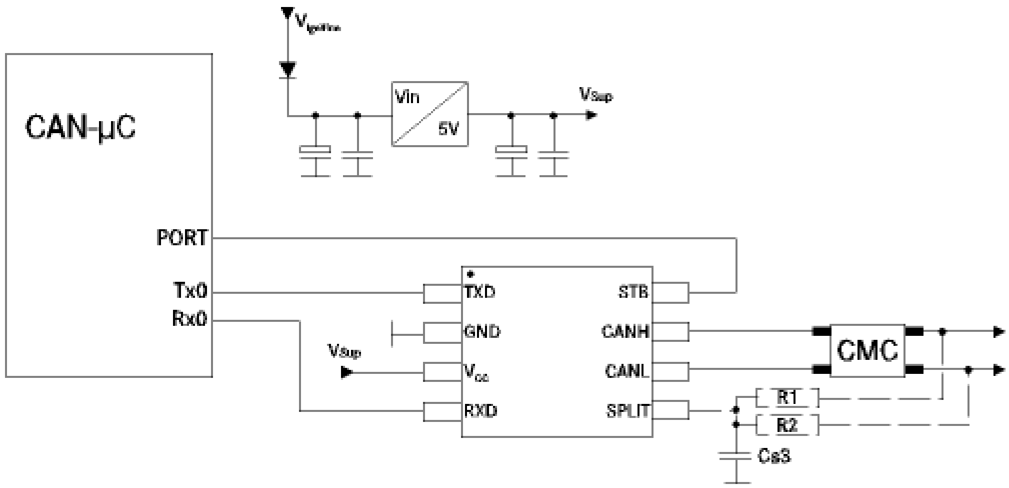


Figure 3: Transceiver Circuit of an ignition fed ECU in a 125 kBd or a 500 kBd network

For EMI reasons, all transceiver circuit components shall be arranged close together on the circuit board.

Refer to section 5.5 for the values of resistor R1/R2 and capacitor Cs3.

For the Common Mode Choke (CMC) refer to section 5.6

Any deviation in the transceiver circuit design shall be coordinated with the Networking group.

5.2.2 Bus voltage levels for ignition fed ECUs

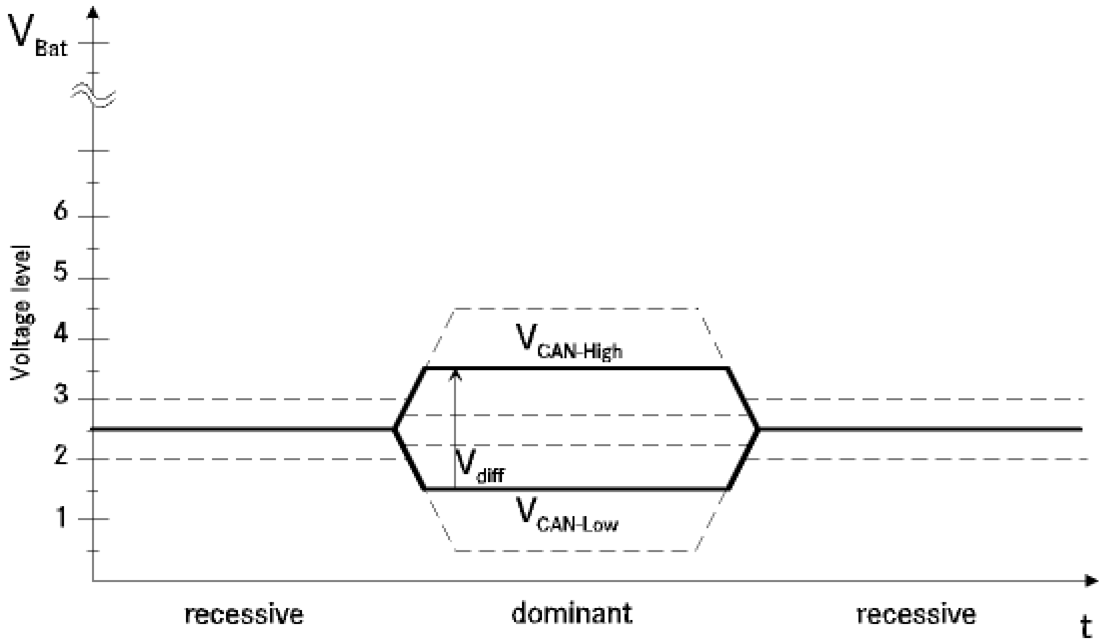


Figure 4: CAN-Bus Voltage Level according to DIN ISO 11898

All threshold voltages are specified in the respective transceiver device specification.

5.3 System Basis Chip

For the ECUs using system basis chip (SBC) with combined CAN transceiver, voltage regulator and watch dog, the CAN circuit design shall also refer to section 5.

5.4 Transceivers

DaimlerChrysler Core Networking maintains list of recommended CAN transceivers in the CAN Networking Details document (Ausfuehrungsvorschrift).
If a supplier finds it necessary to deviate from this list, Core Networking shall be contacted for transceiver qualification requirements.

5.5 Termination

Refer to the specification (Ausführungsvorschrift) "CAN networking details" in the latest version. for the appropriate vehicle line to get the termination requirements for your ECU.

5.6 Common Mode Choke

A Common Mode Choke(CMC) shall be used in every CAN ECU. DaimlerChrysler Core Networking maintains list of recommended CMCs in the CAN Networking Details document (Ausfuehrungsvorschrift).
If a supplier finds it necessary to deviate from this list, Core Networking shall be contacted.

5.7 Oscillator Tolerance

The oscillator provides the reference timing for the CAN controller. The oscillator frequency must be chosen as an integer multiple of the baudrate to ensure proper CAN communication. The more precise the oscillator, the more stable the bit timing. The controller and the oscillator must be coordinated to each other with a corresponding circuitry.

A PLL is often included to generate the timing for the CAN controller in the manufacturer's controller application notes. Tests have shown that increasing the processing load of the microcontroller can lead to a jitter effect in the CAN signal (which often already exceeds the required tolerance). As far as this is concerned, there must be proof from each manufacturer that this can be prevented.

5.7.1 500 kBd Network

Only crystals shall be used for clock generation. Other clock generators, e.g. ceramic resonators are not allowed.

Tolerance: < ± 0.15 % above temperature and aging

5.7.2 125 kBd Network

Generally crystals shall be used for clock generation. For other clock generators, e.g. ceramic resonators, the tolerance must be within < ± 0.3 % accross temperature and life cycle aging. The fulfilment of this requirement accross temperature and aging must be confirmed with suitable documentation. It is up to the supplier to provide documentation, e.g. manufacturing process, sorting process etc., which proves that all resonators and crystals delivered to DaimlerChrysler or their suppliers will fulfil this requirment and availability for the life cycle of the vehicle.

5.8 Bit timing

The Bit timing parameters of ECU CAN channels shall be set according to the following requirements depending on the CAN network speed.

Table 2: 500 kBd Network

Baudrate	500kBaud ±0.15%
Synchronization	recessive → dominant
Sample Point	one SP at 75%-81.25% of bit time
Time quanta Bit NBT	typ. 10-20
SJW	18.75%-25% of bit time

Table 3: 125 kBd Network

Baudrate	125kBaud ±0.3%
Synchronization	Recessive → dominant
Sample Point	one SP at 75% of bit time
Time quanta Bit NBT	typ. 12-16
SJW	25% of bit time

6 Vehicle Message Matrix

The Vehicle Message Matrix (VMM) documents all parametric message information concerning network messages for a particular vehicle line. Each vehicle line may have a unique VMM to describe CAN communications. All ECUs must use the VMM for the ECU's vehicle line. From the VMM the DBC file is generated. This is used to generate driver structures for each ECU. VMM and DBC file are developed and released through the Vehicle Networking Group.

Editing the VMM and DBC file without the specific instructions from the Vehicle Networking group is prohibited.

The Vehicle Networking Group will not support ECUs, where the settings have been edited manually from other persons without the instructions of the Vehicle Networking group.

6.1 Application Messages

The application messages are reserved for a supplier specific communication and shall not be used for communication with other ECUs in any case and shall not be used in the vehicle. The application message shall not disturb the regular ECU. For these messages no further communication requirements such as transmit cycle are defined by DC.

6.2 Transport Protocol Messages

The Transport Protocol uses these messages. The timings and launch types of these kind of messages are defined in the transport protocol specification or will be handled during runtime through the algorithm in the transport protocol. A typical transport protocol message is a diagnostic message.

6.3 Network Management Message

The Network Management uses the network management messages to control the network. For timings and launch types refer to DC-10730, E/E - Standard software for ECUs - General requirements.

6.4 Message Transmit Types

The transmit type describes when or under which conditions a message shall be transmitted. The launch type is signal-specific. The VMM refers to the different message launch types, which shall be implemented by the transmitting ECU if this message launch type is required in the VMM. The following launch types are currently supported.

6.4.1 Cyclic

A Cyclic message is any message that is launched on a regular periodic schedule, independent of a change to the signals contained in the message.

6.4.2 Spontaneous

A spontaneous message is an application driven message.

6.4.3 Cyclic on Change

A Cyclic on Change message is any message that is launched on a periodic frequency schedule as long as the signals contained in the message are not changing. This message shall be re-launched whenever any signal(s) changes, with a minimum interframe spacing specified in the VMM.

6.4.4 By Active Function (BAF)

A BAF message is only transmitted at a specific periodic rate when any signal in the message does NOT equal the default value (defined in the VMM). The message has to be discontinued after transmitting the default value(s) for the number of times defined in the DBC file, when ALL signals become default.

6.4.5 Fast

Cyclic with fixed cycle time t_z as long as all signals are equal with the default value, cyclic with different fixed cycle time t_{z2}, as long as any signal(s) is not equal with the default value.

6.4.6 On Change

An on-change message is only transmitted *m* times if the a signal value changes. *M* is defined in the DBC file.

Table 4: Transmit Types

Transmit type	Cycle time	Transmit para-meter	Transmit start	Transmit how	Transmit end
Cyclic	t_z	-	Bus awake	cyclic with fixed cycle time t_z	Bus enters sleep mode
Spontaneous	-	t_{min}	When the application gives the command and the network is awake	Once with min. interval t_{min} from last message	After Transmitted once
Cyclic + change	t_z	t_{min}	Bus awake	Cyclic with variable cycle time t_z, i.e., if a signal value is changed, a message with the new signal value is Transmited with the min. interval t_{min} from the last message	Bus enters sleep mode
BAF	t_z	n	Signal <> ***Default value***	Cyclic with fixed cycle time t_z	Signal = ***Default***, transmitted n times, $n \geq 0$
Fast	t_z	t_{z2}	Bus awake	cyclic with fixed cycle time t_z as long as signal = ***Default***, cyclic with different fixed cycle time t_{z2}, as long as signal <> ***Default***	Bus enters sleep mode
On change	t_{min}	m	If signal value is changed and the network is awake	m times cyclical with min. interval t_{min} from last message, $m \geq 1$	after transmitted m times

Default is displayed independent of the Transmit type for each signal in the VMM.
t_{min} , n and m are standard values. They are defined globally in the DBC file. Unless otherwise stated in the VMM, m and n have the following values.

$n = 1$
$m = 3$

The tolerance values of time t_{min} are shown below.

Table 5: Tolerances of time t_{min}

Baudrate	nominal value	Minimum value	Maximum value
Low speed network (125 kBd)	20ms	15ms	30ms
High Speed network (500 kBd)	5ms	4ms	10ms

The average cycle time (t_z and t_{z2}) of a message shall be within +/- 2% of the specified message cycle time in the VMM. The minimum and maximum values of the cycle time shall not exceed tolerance given in figure 5.

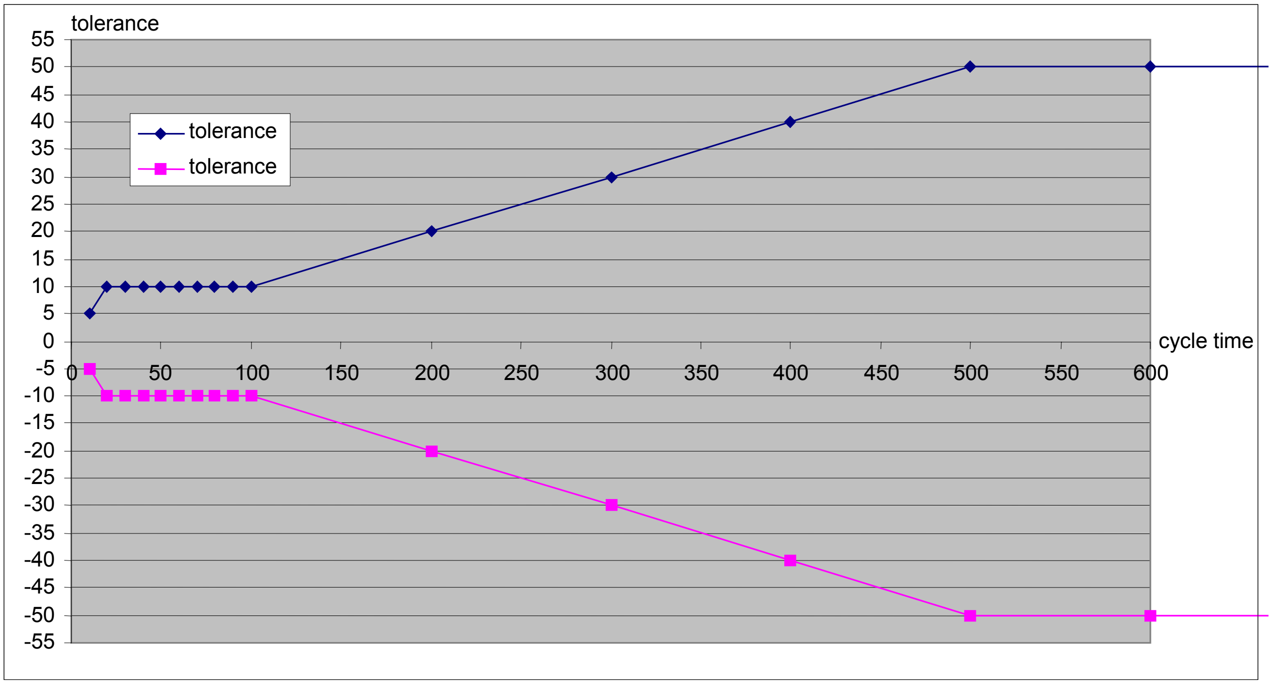


Figure 5: Maximum tolerances of t_z and t_{z2}

6.5 Signal Timeout

The VMM specifies signal timeouts. The timeout is specified by a number in the VMM with a value greater than or equal to 2. The timeout value is the number of message cycles after which the receiver of a signal should set an indication that the signal is now considered missing. A signal timeout may be applied to any message having a cyclic rate (not spontaneous). The timeout period for a message is determined by the timeout value of each signal the message contains. The timeout value which bases on the VMM value and message cycle time is calculated as follows:

Timeout Value = (Message Cycle Time) * (Number in the VMM + 0.5)

6.6 Signal Default value

The VMM defines a default value for signals where applicable. Signals in spontaneous messages do not have a default value. The default value is the value that is assigned to a signal during ECU initialization at power up before plausible data are available. The default value may be the same as the Signal Not Available value.

6.7 Signal Not Available value

The VMM defines a "signal not available" (SNA) value for signals where applicable. One-bit signals do not have SNA values. Signals in spontaneous and BAF (By Active Function) messages also do not have a SNA value. The SNA value must be assigned to a signal by the sender when the input is unknown, or becomes unavailable. The SNA value may be the same as the default value.

6.8 Signal Packet

A signal packet is part of a CAN message consisting of one or more signals having coherent values that require simultaneous change before transmission.

6.9 VMM Change management

VMM changes are performed through a change management process. All changes for a new version are made and distributed by the Vehicle Networking Group.

6.10 VMM releases

Releases of VMMs are handled by the Vehicle Networking Group. Releases generally follow the vehicle development process. Dates for releases are set in coordination with all ECU engineers and follow the project timing of the specific model family.

7 Gateway Data Handling

The Gateway ECUs provide the ability to transfer data bi-directionally between two or multiple vehicle networks.

The requirements in this section only apply to gateway data exchange between two on board CAN networks.

7.1 Types of routing

Two types of routing are carried out by the Gateway ECUs, Message and Signal Routing.

7.1.1 Message routing

Message routing is defined as the routing of an exact replica, in terms of both structure and timing, of the received message from one Bus onto the target Bus. I.e. the gateway routes this message only if and when it receives it.

7.1.2 Signal-/Signal packet routing

All signal packets and signals are routed through a communication software module. Cycle time, transmit type or message content may be rebuilt within the gateway. Messages on the target network are sent after initialization, if there are no messages on the source network, all the signals in the message to the target network will have the default value.

7.2 Timeout of gateway signals

7.2.1 Behavior for sleep mode

Because of the different sizes and structures different networks may go into sleep mode at different times. This behavior shall be considered in the receiving ECUs during the use of the gatewayed signals.

7.2.2 Behavior for message routing

If an ECU discontinues transmission of a message on the source network it will not be transmitted to the target network. The timeout monitoring of the gateway signals by the receiving ECUs on the target network can be treated the same way as normal signals in that network, with exception of the special behavior described in section 7.2.3.

7.2.3 Behavior for signal- and signal packet routing

In signal routing, if an ECU discontinues transmitting a message on the source network, the gateway signals transmitted to the target system will be set to the default values if there is a timeout value defined for the particular signals. If there is no timeout value defined, the gateway will continue to send the last valid value received before receive message failure.

A timeout monitoring in the receiving ECU observes the gateway but not the transmitting ECU on the source network.

If a gateway signal is monitored, a SNA value has to be defined for this signal. In this case the default value equals the SNA value. In addition within the gateway the timeout monitoring for the source network has to be activated.
A SNA value does not indicate a normal timeout, because SNA values will also be used during the Bus wake up and sleep procedure.

7.3 Routing times

The gateways shall route the messages and signals within an appropriate time depending on the routing types „message routing“ and „signal or signal packet routing“.

In case of message routing the messages shall be routed through the gateway within 5 ms.

In case of the signal or signal packet routing the signals or signal packets are routed through the gateway and copied in a new message which shall be transmitted as specified with the transmit types in the VMM. Therefore the routing times depends on the transmit times of the appropriate transmit type which is described in table 7/1. Maximum time of $t_{process}$ shall be 5 ms.

Table 6: Routing times of the different Transmit Types for “signal routing” or “signal packet routing”

Transmit type	Cycle time	Transmit parameter	Maximum routing time	Description
Cyclic	t_z	-	$t_z + t_{process}$ ms	Different cycle times in the receiving network and the transmitting network
Spontaneous	-	t_{min}	-	Shall not be used for signal or signal packet routing
Cyclic + change	t_z	t_{min}	$t_z + t_{process}$ ms	
BAF	t_z	n	$t_z + t_{process}$ ms	
Fast	t_z	t_{z2}	$t_z + t_{process}$ ms $t_{z2} + t_{process}$ ms	t_z or t_{z2} whatever time is active
On change	t_{min}	m	$t_z + t_{process}$ ms	

8 DC Standard Software

DaimlerChrysler recommends the use of Standard Software. Refer to DC-10730, E/E - Standard software for ECUs - General requirements for details.
At it's discretion, DC may provide the suppliers with standard software modules and a related generation tool for specific microcontrollers and compilers. These provided standard software modules and the related generation tool shall be only used for the specified DaimlerChrysler projects.

The standard software modules shall not be changed without the approval and involvement of DaimlerChrysler. Please refer all change requests, suggestions or technical questions to your contact in the Networking/Software Group.

Refer to DC-10730, E/E - Standard software for ECUs - General requirements for a list of provided standard software modules (if applicable), the generation tool including the supported microcontrollers.

The Software modules shall only be used in the ECU for the supported microcontrollers.
Where applicable, DaimlerChrysler will be the center for distributing the standard software modules and the generating tool. The delivery dates are based on the project milestones in each model line.
Suggestions, irregularities, and complaints should be promptly reported to the Networking/Software Group of the model line.

Supplier is responsible for meeting all project milestones and deliverables regardless of the supplier of standard software i.e either obtained from DC or other.

8.1 Network Management

Every ECU shall implement the Network Mangagement. Refer to DC-10730, E/E - Standard software for ECUs - General requirements.

8.2 Unsupported Microcontrollers or Compilers

To avoid any disruption in the network ECUs using unsupported microcontrollers or compilers shall implement the communication behavior as described in the VMM and the specifications for standard software modules, i.e.

- CAN-Driver
- NM
- Diagnostic Specification
- Transport Protocol

Refer to DC-10730, E/E - Standard software for ECUs - General requirements.

9 General requirements

9.1 Network Sleep

9.1.1 General

To maintain vehicle quiescent current to the absolute minimum, all networks need to switch to a network sleep mode if communication is not needed. The application software of each ECU shall instruct its Network Management to enter network standby/sleep mode as soon as it determines that the network communication is not absolutely required.

Network sleep is NOT necessarily the same as ECU sleep. An ECU may continue to manage inputs and outputs and not require the network to be active. Incorrect “Sleep” implementation may lead to an ECU not allowing the network to achieve network sleep, creating excessively high IOD.

The network management message is the communication tool used by the network management module to reach consensus for network sleep based on the network sleep indicator of all ECU’s in the ring.

All ECUs send a sleep indication bit to let others know whether or not it requires the network. The network is allowed to sleep if and only if each ECU shows "Ready to sleep" indication. Any of the ECUs, upon monitoring the sleep indication of all ECUs may send a sleep acknowledgement message. Once such a message is transmitted all ECUs simultaneously enters into the network sleep mode after a specified delay.

9.1.2 Sleep Strategy

Network sleep is an application decision. Each ECU must determine the criteria under which it will be “ready for network sleep”. These criteria should be chosen to allow network sleep as soon as the ECU requires no further information from other ECUs on the network to perform its activities. The sleep strategy shall not be affected by any CAN message or signal timeout detection. All ECUs shall set their sleep indication immediately with the following general exeptions:

- The ECU shall not set its sleep indication to „sleep“ if the application requires a CAN communication to perform its activities
- No ECU shall set its sleep indication to „sleep“ within $T_{StartUpSleepDelay}$ after the first valid message is observed on the Bus or after aborting $T_{WaitBusSleep}$
- The ECU, that reads (and reports on the network) the ignition switch status, shall not set its sleep indication to “sleep” while the ignition switch is not in the “lock” position
- The ECUs shall not set its sleep indication to “sleep” if they are involved in an active diagnostic session. Involved ECUs are the ECUs which are not in the default/passive diagnostic session and all gateways which are involved in the diagnostic communication
- If an ECU finds itself alone on the network, it cannot build a logical ring with other ECUs and could not process any functions where other ECU informations are needed. After an appropriate time the network management will enter a network management-specific limphome mode. In this mode the ECU has immediately to go to network sleep, if there are no application specific limphome requirements to keep the communication ongoing and $T_{StartUpSleepDelay}$ elapsed

Table 7: Sleep Timing

Names	DEFINITION	SPECIFICATION	
		Minimum	Maximum [1]
$T_{StartupSleepDelay}$	Time frame within the application shall set its sleep indication bit after the startup of the network, if the application doesn't require CAN communication. The time starts with the first CAN message on the network of the ECU.	5000 ms	(number of ECUs*$T_{RingType}$)+ 5000 ms

[1] The transmit time of the network management message with the set sleep indication bit depends on the ECU position in the logical ring and the actual position of the token of the logical ring and could therefore be delayed through the network management algorithm. The range of delay is minimum 0ms and maximum (number of ECUs in the logical ring) * $T_{RingType}$. For the value of $T_{RingType}$ refer to DC-10730, E/E - Standard software for ECUs - General requirements

9.2 Bus Wake-up and CAN Initialization

For the realization of distributed functions in a vehicle it must be possible to switch the CAN network from standby mode to operation mode at anytime. To keep the power consumption to a minimum, switching to operation mode (wakeup) is allowed only, if communication is necessary for the processing of functionality. Otherwise functions have to be handled locally to reduce the bus operation time.

Any local wake up event has to be checked for plausibility before the connected network is woken up. E.g. local wake up events are internal timers, interrupts, sensors and so on. The plausibility has to be done independently of the type of connection, including sub busses like LIN, to the related ECU. If a functionality could be processed locally in an ECU or in a local sub network, like LIN, the connected CAN network shall stay in sleep.

In the following the wake up behavior of an ECU is described.

1. A voltage level change[1] or bit interferences on the network lines shall not cause the start of network communication. If the voltage change on the Bus does not indicate a wakeup event the ECU shall remain in sleep mode.

2. If the physical layer signals a wake up event[1] on the network lines while the CAN hardware is in sleep mode, the CAN hardware (physical layer and CAN microcontroller) and the standard software modules shall be initialized. In this stage, an ECU shall not transmit its own messages. Initialization shall be executed as fast as possible. After the time $T_{CanInit}$ all ECUs must be ready to receive and transmit messages. The maximum time for $T_{CanInit}$ shall not exceed 120ms. The starting point begins with the first activity on the network signalled through the physical layer. After the initialization the time $T_{WakeUpTimeOut}$ begins.

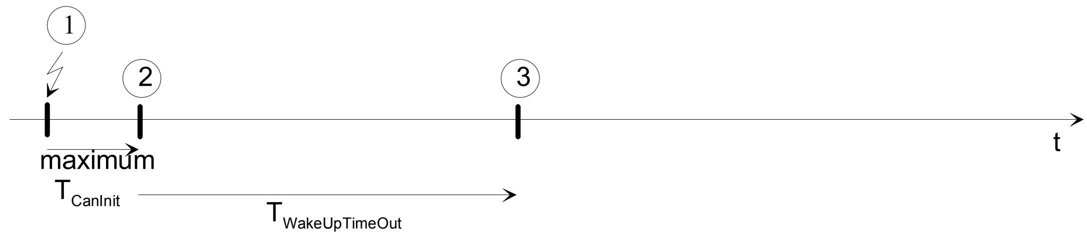
3. If no valid message is received within $T_{WakeUpTimeOut}$ it shall be concluded that the network voltage change is not caused by an wakeup event. The CAN hardware shall be set back to sleep mode. In that case the whole ECU shall be set to the power down mode as soon as possible to reduce ignition off draw. $T_{WakeUpTimeOut}$ starts after the expiry time of $T_{CanInit}$.

4. If within $T_{WakeUpTimeOut}$ a valid message has been received, it will confirm a wakeup event. In this case $T_{WakeUpTimeOut}$ shall be suspended and the ECU shall participate in the regular network communication and start transmitting ist own message. Network management shall be started in normal mode and afterwards transmission of normal messages shall begin. If an ECU has to transmit several cyclic messages, these messages shall not be sent back to back (without any pause in between) in order to prevent bursts during wake up. Within the time $T_{MessageStart}$ all cyclic messages shall be transmitted at least once with the defined cycle time. To prevent a delay of the wake up of other ECUs, signals shall be set to the default values if no valid information can be obtained. $T_{MessageStart}$ starts with the expiry time of $T_{WakeUpTimeOut}$.

5. To run the application in a network it is necessary to transmit signals with correct values. Therefore it is required, that after the wake up procedure possible default values are replace with true values as soon as possible. Valid values shall be transmitted at the latest by time $T_{SignalValue}$. $T_{SignalValue}$ starts simultaneously with the time $T_{MessageStart}$ right after the expiry of $T_{WakeUpTimeOut}$.

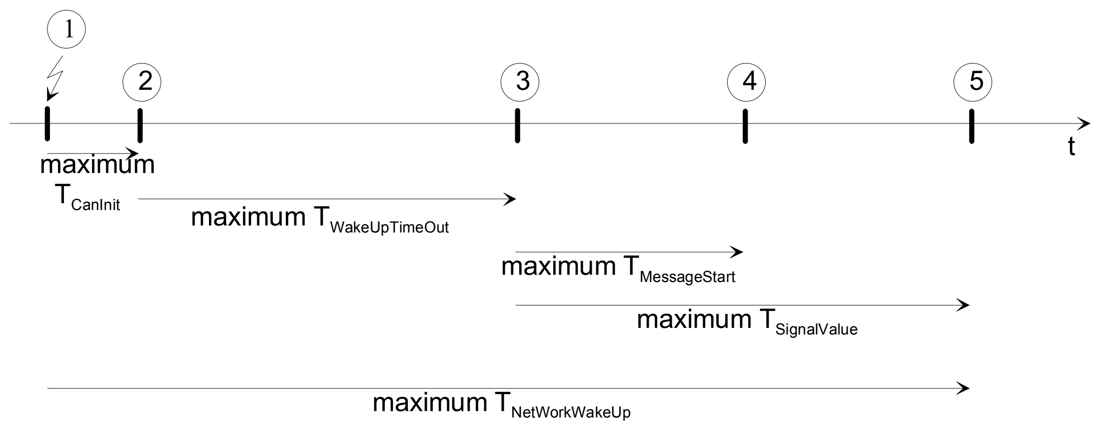
[1] A specific change in the voltage on the physical layer indicates a wakeup event. However, similar changes as well as others may also be caused by other disturbances such as EMC.

Figures 6 and 7 illustrate the wake up procedures from a network perspective.



1. CAN Physical Layer detects CAN activity and informs the application
2. ECU is ready to receive and transmit messages
3. ECU hasn't received any CAN message; ECU goes back to the status ECU-Sleep or ECU-Power Down
   CAN network will not start!

Figure 6: Wake-Up sequence caused by an interference



1. CAN Physical Layer detects CAN activity and informs the application
2. ECU is ready to receive and transmit messages
3. ECU received at the end of $T_{WakeupTimeOut}$ a CAN message; ECU starts with transmiting OSEK networkmanagement messages and other cyclic CAN messages
4. ECU has transmited all cyclic messages as describes in the VMM at minimum at the first time
5. ECU transmits all signal values no longer with "Default-Value"
   Start of the network is finished!

Figure 7: Wake-Up procedure caused by a valid CAN message

In the following table the different timings during wake up are listed.

Table 8: Wake-Up Timing

NAMES	DEFINITIONS	SPECIFICATION		
		Typical	Minimal	Maximal
$T_{CanInit}$	Time frame within which the application initializes the CAN hardware and becomes ready to receive and transmit messages after the physical layer signals network activity	60 ms	0 ms	120 ms
$T_{WakeUpTimeOut}$	Time frame within an activity signalled from the physical layer has to be confirmed as a CAN message. If a correct message is received during this time frame the time window shall be terminated	20 ms [1]/ 100 ms [2]	-	500 ms
$T_{MessageStart}$	Time frame in which all cyclic messages have to be transmitted at least once	100 ms	0 ms	300 ms
$T_{SignalValue}$	Time frame in which all signals shall have plausible values. In principle the signals shall have plausible values as soon as possible	200 ms	0 ms	600 ms
$T_{NetWorkWakeUp}$	Time since the first wakeup signal from the physical layer to the end of the start up sequence of the network	480 ms	0 ms	1220 ms
[1] for 500 kBd network [2] for 125 kBd network				

After the maximum of $T_{NetWorkWakeUp}$ the „CAN-Timeout“ and „signal implausible“ events storage shall be activated.

ECUs may start communication at every point in time, if an internal event requires network communication. A plausibilty check shall be conducted first in order to prevent faulty network activity (i.e. in case of interferences). The application shall transmit the wake up reason via the user data. (refer to section 9.8)

A network mangement message shall be used to wake up the network.

9.3 Network power down procedure

The ECUs connected to the networks are powered down before the networks enter bus sleep mode. Network enters sleep mode when all the ECUs in a network signal that the network communication is no longer needed for the functionalities of the ECU at the moment and the $T_{WaitBusSleep}$ has elapsed or when the ECU has detected an incorrect network wakeup, that means $T_{WakeUpTimeOut}$ has elapsed.

If the network is powered down through network management the application shall set the CAN transceiver into standby independent of internal ECU activites.

The network power down sequence shall be implemented using network management.

The implementation of network management is also required in order to abort a network power down and wake up sequence.

9.4 ECU Passive Mode

The usage of the ECU passive mode shall only be used during development. This mode must be disabled for series production. Refer to DC-10746, Diagnostic Performance Requirements Standard for details.

9.5 Operation during bus-off

When an ECU enters bus-off mode, it must do the following:

- Initialize immediately the CAN protocol chip for message reception only
- Pause all message transmission for one second
- After one second resume to normal operation. Normal operation begins with sending a Network Management Limp Home message.

Do the above indefinitely until normal operation (without errors) is restored.

9.6 ECU message handling with 100% bus load

The length of a CAN receive interrupt shall not exceed the length of the shortest CAN message on the Bus. It is up to the ECU developer to proof that this requirement has been met.

9.7 Reset Operation

The following reset condition has to be met:

- ECUs must not corrupt messages on the network while going into reset, during reset or coming out of reset.
- ECUs must be capable of coming out of reset and begin normal operation without requiring power or ignition reset.

9.8 User Data in Networkmanagement Messages

Only network-related information is transmitted on the user data. No application data shall be included within the user data. The user data services for wake up shall be supported.

The supplier shall provide the ECU specific user data, which are

- conditions for network wakeup
- reasons for keeping the BUS awake

The user data services shall be supported from every ECU in a network at any time when the network ist awake. In the list of reasons keeping the network awake the reason “Startup time $T_{StartupSleepDelay}$ is not finished” shall be included.

The data shall be documented in the VMM and shall be communicated to the VMM editor before the VMM changes are finalized.

The user data information are entered into the VMM.

10 CAN errors and behavior under certain vehicle conditions

10.1 States of a vehicle network

The possible states of a networking system are described in the following table. Errors regarding communication and power system shall only be stored in mode 5.

Table 9: Modes of a network from the perspective of the connected ECUs

Mode	Description
1. Off	- voltage supply of an ECU or network is switched off - ECU / network is not ready for processing of data
2. BUS sleep	- voltage supply is on - Ready - no function is executed Network is in BUS sleep mode
3. Initialization	- voltage supply is on - executing initialization - application which requires CAN communication is started The entire network starts with the initialization of BUS wake up mode
4. Working without failure	- voltage supply is on - initialization is done - running application without any restraint The entire network is in BUS wake up (active) mode
5. Working with failure	- voltage supply is on - initialization is done - running application, partially with restraint The entire network is in BUS wake up (active) mode
6. Power down	- voltage supply is on - executing power down sequence - no application which requires CAN communication is processed The entire network completed power down sequence of bus active mode and start bus sleep mode

10.1.1 Engine start

The engine cranking and the associated fluctuations of the voltage in the power system are a special condition for the vehicle network The definition of the engine start procedure for CAN ECUs is described with the signal Ign_On_StProc_Inact (ignition is on and start procedure is not active).

- Ign_On_StProc_Inact = 1 the start procedure is not active
- Ign_On_StProc_Inact = 0 the start procedure is active.

10.2 Voltage ranges outside of the limits specified for function

There may be a difference in voltage ranges within which the control and execution of the ECU function shall be ensured and within which the communication shall be ensured.

10.2.1 Communication

At least all ECUs shall guarantee proper CAN communication with a battery supply voltage required for group A components (refer to DC-10615, Electrical System Performance Requirements for Electrical and Electronic Components). If communication has to be continued below or above these limits because of functional requirements it shall run without errors.

ECUs shall fulfil the requirements on electromagnetic immunity required for group C (refer to DC-10614 EMC Performance Requirements - Components)

All communication shall be error free within the ECUs specified operating voltage range.

Only correct data shall be transmitted. If data is incorrect the SNA value shall be transmitted. If no SNA value is defined the default value shall be transmitted. Exceptions shall be defined in the component specification.

10.2.2 Function

The voltage limits for the guaranteed functionality of the ECU are defined in the ECU component specification.

10.3 Function deactivating in case of under- /overvoltage

In order to ensure proper communication of critical vehicle components at specified under and over voltages, it is required that none of the CAN ECUs shall interfere with or disrupt the bus traffic even if the battery voltage is outside its operating range. This may require that transceivers and other electrical loads are deactivated temporarily or completely at certain voltage conditions. This deactivation or load shedding is part of the electrical system's management. It is regulated by the definition of deactivating levels.

- refer to the component specification for defined power-off levels for features
- power-off levels are mandatory for the same loads in different vehicle lines
- power-off levels apply both to the central electrical system management of the battery/electrical system controller and to local voltage monitoring or analysis of the voltage signal transmitted via CAN

10.4 CAN Timeout and CAN signal failure

Refer to to DC-10746, Diagnostic Performance Requirements Standard regarding storage of errors for missing CAN messages as well as the receipt of CAN signals outside of the defined voltage range.

11 Vehicle Networking Breadboard

11.1 Breadboard Sample ECU

Before every prototype built phase the Vehicle Networking Group requires one ECU from every supplier/release engineer for the Networking breadboard in order to integrate all ECUs and test the Networking behavior. Delivery timing for these ECUs is highly dependant on vehicle build schedule and is determined and distributed during within vehicle coordination meetings.

11.2 Documentation for Breadboard ECU

The following information shall be provided to Core Networking together with the sample ECU.

- DC-part number for the ECU
- ECU Block diagram
- Pinning
- Circuit diagram of CAN interface (including oscillator, Central processing unit, all peripheral devices/components connected to the transceiver and CAN output circuit)
- Conditions, length and behavior for internal activies after BUS sleep
- Central processing unit type
- Transceiver type
- Common Mode Choke type
- Value of termination resistor (if applicable)
- Clock frequency
- Timequanta
- Samplepoint
- Synchronization jump width
- Hardware version
- Software version
- VMM version
- Diagnostic version

End of Main Document
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