BATC

HSCAN-500k ECU Requirements Specification

Physical/ Data Link/Interaction Layer

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Version History

Version	Date	Description of changes
1.0	2009-06-18	Initial creation
1.1	2012-02-27	Add the requirement of edge steepness
1.2	2013-11-14	Delete chapter Network Management
1.3	2015-7-13	Update the document name 、 page header、page footer
1.4	2018-8-15	1、add 1.2、2.9、4.1.2、 6chapter 2、update to bus termination、bus voltage 、edge steepness、CAN ID、timeout operation voltage 3、delete CAN message identifier
	2018-12-27	1、update 6.3
	2019-1-17	Update $U_{TxValid}$ in Table 6-4: Operating conditions parameter

1 Scope

This document specifies the requirements for the network interface of the ECUs that are connected to HS_CAN 500K CAN of the vehicles from BATC.

The document contains physical layer 、 data link layer、 Interaction layer of all CAN specific ECU aspects.

High Speed BUS 500kbit/sec

For the ECU suppliers it acts as a requirements document for the CAN interface of the ECUs. The implementation of the ECUs has to meet this specification to ensure the compatibility with other ECUs.

1.1 Target Group

This document is intended to be read by the ECU suppliers to implement the hardware and software of their ECUs. Furthermore it has to be considered by the design and test team to specify the vehicle functions and to integrate and verify the network.

1.2 Architecture of Communication System

CAN bus concept includes a approximate architecture of communication with a layered structure according to Figure 1-1 below.

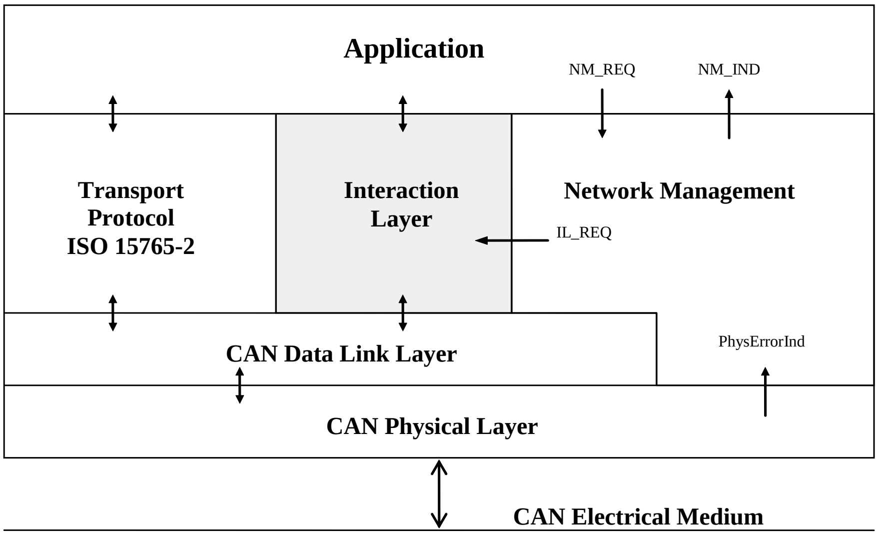


Figure 1-1: Architecture of Communication System overview

2 Physical Layer

2.1 Circuit diagram

In this section, a circuit proposal for the CAN connection of an ECU is given. As an example, it shows a TJA1040 transceiver.

Independent of the used transceiver, the schematic part for the CAN lines shall be implemented as given in Figure 2-1.

In the individual ECU implementation some specific parts can be different due to the used CAN transceiver and CAN controller but shall be agreed with BAIC.

Note: It is assumed that the microcontroller has an internal CAN controller.

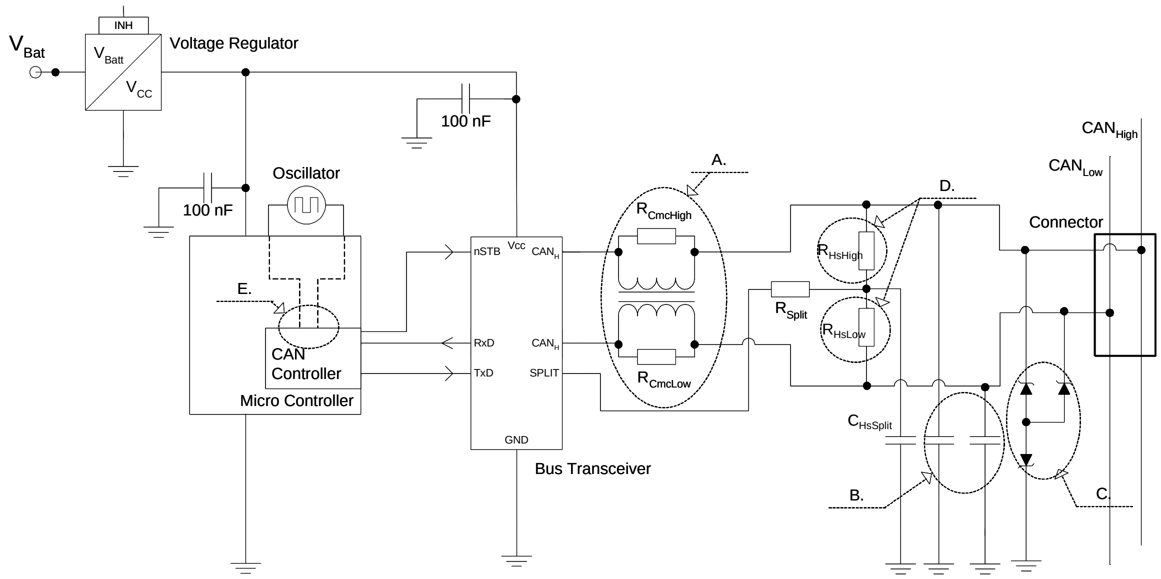


Figure 2-1: Circuit diagram with TJA1040 bus transceiver

As an exemplary circuit proposal for the HS CAN connection for any kind of ECU, the circuit diagram (Figure 2-1) shows a TJA1040 bus transceiver with SPLIT pin.

The components used and the design remarks are described below:

- Remark A: Common mode chokes improve the symmetry of the CAN transceiver.
- Remark B: EMC capacitors are used to filter HF noise from the CAN lines.
- Remark C: Zener diodes as clamping devices.
- Remark D: Split termination resistors yield a lower static load than a single resistor.
- Remark E: Oscillator which is used to generate the CAN clock.

2.2 Components

2.2.1 Bus transceiver

The High Speed CAN bus transceiver shall be compliant to [ISO2].

ECUs shall use a transceiver, for which the input resistance between CAN_H and CAN_L for shall be floating when the transceiver is powered off, such as Philips TJA1040/TJA1042. If the ECUs need wake-up or sleep, it should use a transceiver with wake-up and sleep functions, such as TJA1041/TJA1043. However, any other transceiver can be used if it has the same functionality and properties. The usage of transceivers which are different from the transceivers used in the examples shall be agreed with BAIC.The tests carried out to verify compliance shall follow the [GIFT2] test specification.

No matter which transceiver is used, it shall show optimal passive behavior if it is unpowered. The leakage current of its bus pins shall be zero amperes when its supply voltage is zero volts.

2.2.2 Oscillator

The CAN controller input frequency $F_{HsOscCAN}$ and the corresponding tolerance $D_{fHsOscCAN}$ of the clock generator for the CAN controller shall be in the range given in Table 2-1.

Parameter	Symbol	Min	Nominal	Max	Unit	Comment
CAN controller input frequency	$F_{HsOscCAN}$	1	-	>1	MHz	The frequency has to be chosen according to CAN parameters (bit timings, etc.). It has to be an integer multiple of the CAN baud rate.
CAN controller input frequency tolerance	$D_{fHsOscCAN}$	0	-	0,1	%	This is the frequency tolerance the oscillator for the CAN con-troller may have, The tolerance includs tolerance due to temperature 、aging and manufacturing

Table 2-1: Oscillator parameter range

The oscillator type (preferably a crystal oscillator) can be selected by the ECU supplier, and the use of microcontroller internal clock sources (e.g. PLL). can not be selected by the ECU supplier

2.2.3 Microcontroller and CAN controller

The microcontroller and the CAN controller can be selected by the ECU supplier. The selec-tion shall be confirmed by BAIC.

The CAN controller in the ECU shall be compliant to [ISO1].

The conformance shall be approved by verification with an [ISO16] conformance test.

2.2.4 **Connector** mounting

Transceiver should be mounted as close as possible to the connectors. No other IC may be located between connector and transceiver.

2.2.5 Termination

There are terminal ECU and split terminal ECU for CAN net；

The two bus-terminating ECUs shall always be present on the bus ， The termination resistors R_{HsHigh} and R_{HsLow} for terminal ECU shall be selected as 62Ω 。The termination resistors RHsHigh and RHsLow shall be placed within, the two On-Board ECUs which are located at the greatest bus distance from each other.

Split terminal resistors $R_{HsHighsp}$ and $R_{HsLowsp}$ is only for ECUs that shall use split pin termination not for all ECUs that have split pin.That shall be placed in a way that they are easy to replace.and allows the adjustment of their values to the given network topology.

Their tolerances ($D_{RHsHigh}$, D_{RHsLow}) and their power dissipation W_{HsRCAN} shall be chosen according to the value ranges given in Table 2-2.

The following table shows termination resistors 、tolerances and power dissipation of the termination resistors.

Parameter	Symbol	Min	Nominal	Max	Unit	Comment
termination resistors（High）	R_{HsHigh}	60	62	65	Ω	
termination resistors（Low）	R_{HsLow}	60	62	65	Ω	
Split pin termination resistors（High）	$R_{HsHighsp}$	-	-	-	Ω	Determine values based on network architecture
Split pin termination resistors（Low）	$R_{HsLowsp}$	-	-	-	Ω	Determine values based on network architecture
Power dissipation	W_{HsRCAN}	220	250	1000	mW	Power dissipation of the termination resistors.
Resistor tolerance (High)	$D_{RHsHigh}$	-1	0	1	%	A low tolerance of the termination resistors is required for a high symmetry of the CAN signal lines to optimize the EMC
Resistor tolerance (Low)	D_{RHsLow}	-1	0	1	%	A low tolerance of the termination resistors is required for a high symmetry of the CAN signal lines to optimize the EMC

Table 2-2: Resistors 、Tolerances and power dissipation of the termination resistors

Optionally, R_{Split} can be placed with 0 ohm resistor to improve the EMC performance if there are unpowered ECUs while some ECUs still keep CAN communication.

The capacitor $C_{HsSplit}$ shall be dimensioned according to Table 2-3.

Parameter	Symbol	Min	Nominal	Max	Unit	Comment
Split termination capacitor	$C_{HsSplit}$	4,7	4,7	47	nF	

Table 2-3: Split termination capacitor

2.2.6 EMC and ESD components

The ECU supplier shall design the PCB with space for load options.

By default, these optional components shall not be loaded.

Places for capacitors and diodes which are not loaded shall be left open.

Places for chokes which are not loaded shall be bypassed by a "0 Ohm resistor".

The current load options are:

- Common mode chokes (H_{HsCmc})
- EMC capacitors (C_{HsEmc})
- Clamping devices. Zener diodes or other components have to be optionally used as clamping devices for ESD protection.

An overview of valid parameter ranges are given in Table 2-4.

Parameter	Symbol	Min	Nominal	Max	Unit	Comment
common mode choke	H_{HsCmc}	0	-	70	µH	The common mode chokes improve the symmetry of the CAN_{High}/CAN_{Low} signal lines. The following or equivalent types shall be used: - ACT3225 or ACT4532 series (TDK) - B82790-S0513-N201 (EPCOS)
Clamping device capacitance	$C_{HsZener}$	0	-	30	pF	The following characteristics shall be considered: The use of clamping devices impacts the capacitive load of the ECU.
Clamping device voltage	$V_{HsZener}$	27	27	>27	V	The zener diodes must not clamp bus voltages between ±27 V due to possible shortcuts to battery voltage.
capacitor	C_{HsEmc}	0	-	100	pF	Capacitors for EMC improvement.

Table 2-4: The table shows allowed ranges for the EMC and ESD components

After EMC and ESD measurement, it is decided by the supplier whether the optional components shall be loaded or not. If an optional component is chosen to be loaded, it shall be used with its smallest possible value.

2.3 Loop delay

The loop delay for the transceiver ($t_{HsLoopDelayRxTx}$) and for the complete circuit ($t_{HsLoopDelay}$) shall meet the values given in Table 2-5.

The loop delay tHsLoopDelay is composed of the CAN transceiver (tHsLoopDelayRxTx), the CAN controller and passive components.

Parameter	Symbol	Min	Nominal	Max	Unit	Comment
Loop delay transceiver	$t_{HsLoopDelayRxTx}$	0	-	255	ns	The loop delay includes the bus transceiver delay from transmit to receive part.
Loop delay	$t_{HsLoopDelay}$	0	-	400	ns	Total Loop delay

Table 2-5: Loop delays

2.4 Wiring

The wiring of the bus transceiver shall be done using the mandatory pins. As an example, the pins of the transceivers used in the circuit diagrams above are mentioned here.

Pin Name	Description	Remark in circuit dia-gram	Mandatory or optional
TxD pin	Transmit data input from the microcontroller.	-	Mandatory
RxD pin	Receive data output to the microcontroller. Used also to notify a wakeup event in case of an ECU local operating mode. If the CAN controller does not support a wakeup by the RxD pin, the error pin has to be used instead to notify a wakeup event. A loss of a wakeup event shall be excluded by the design of the ECU.	-	Mandatory
NSTB pin	Input control signal to select the standby and sleep mode of the bus transceiver.	-	Mandatory

Table 2-6: The wiring table explains how the transceiver pins are connected and if they are obligatory or optional

2.5 PCB guidelines

Each of the following design rules shall be considered equally for the development of the printed circuit board to ensure optimal EMC behavior.

- The CANHigh and CANLow, referred to as the signal lines shall have the same length on the circuit board.
- The length of the signal lines shall always be short.
- The signal lines shall be routed in parallel with a minimum distance.
- The signal lines must not have 90° angles. Instead, two 45° sections should be used.
- For the signal lines, no via holes shall be used.
- The signal lines must never cross each other.
- No other IC shall be placed between the bus transceiver chip and the connector.

- Common mode chokes shall be placed near to the bus transceiver.
- Termination resistors shall be placed near to the bus transceiver.
- The capacitors shall be placed near to the connector.
- The clamping diodes shall be placed near to the connector.
- RxD and TxD lines between the CAN controller and the bus transceiver shall be short.
- RxD and TxD lines shall not be crossed.

The printed circuit board shall be designed to avoid:

- TxD dominant clamping (short circuit between TxD and Vcc)
- RxD recessive clamping (short circuit between RxD and GND)
- RxD and TxD short circuit

The ground shift that shall be tolerated between any two ECUs without malfunction ranges between $V_{HsGndShiftMin}$ and $V_{HsGndShiftMax}$ with no explicit nominal value, as given in Table 2-7. This implies the CAN transceiver has a common mode range $V_{HsCMRangeRxTx}$ as given in Table 2-7.

Parameter	Symbol	Min	Nominal	Max	Unit	Comment
Ground shift	$V_{HsGndShift}$	-2	-	2	V	The value for the maximum ground potential shift between two ECUs.
Common mode range	$V_{HsCMRangeRxTx}$	-12	-	12	V	The common mode range of the CAN transceiver.

Table 2-7: The range of ground shift to be tolerated

2.6 Capacitive Load

The total capacitive load C_{HsNode} between a CAN signal line (CANHigh/CANLow) and ground for a single ECU shall meet the values given in Table 2-8.

Parameter	Symbol	Min	Nominal	Max	Unit	Comment
total capacitive load	C_{HsNode}	0	-	100	pF	Total capacitive load of CAN_{High} and CAN_{Low} to ground for a single ECU.

Table 2-8: The range for allowed capacitive load of an ECU

2.7 Bus voltage levels

The bus voltage levels for High Speed CAN are shown in Figure 2-2. The figure shows the levels in recessive and dominant state. In recessive state or during the bus idle period, the signal lines are torn to a voltage level determined by the termination together with the high impedance of the input circuits of each node. During dominant state, the recessive state is overwritten and the magnitude of the resulting actual differential voltage depends on how many units are driving the dominant state simultaneously, namely during arbitration.

The bus voltage levels shall be implemented according to the definition in Table2-9 、 Table 2-10 .

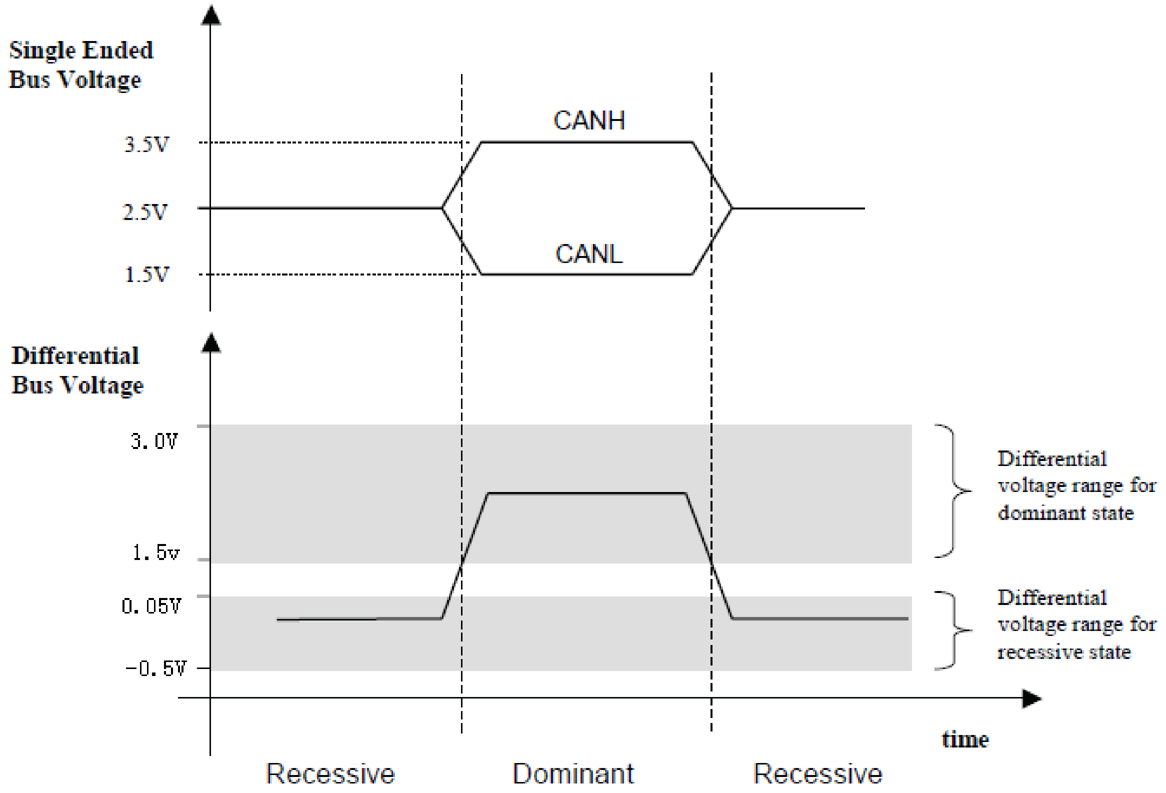


Figure 2-2: Bus voltage levels for High Speed CAN.

Note: The voltage levels refer to the CAN line bus level with connected termination.

Voltage	Min(V)	Nom(V)	Max(V)
V[CAN_H]	2.75	3.5	4.5
V[CAN_L]	0.5	1.5	2.25
V[Diff]	1.5	2.0	3.0

Table 2-9 Dominant output levels of the ECU

Voltage	Min(V)	Nom(V)	Max(V)
V[CAN_H]	2.0 V	2.5 V	3.0 V
V[CAN_L]	2.0 V	2.5 V	3.0 V
V[Diff]	-0.5 V	0 V	0.05 V

Table 2-10 Recessive output levels of the ECU

2.8 Edge steepness

According to ISO 11898-1 the slew rate of the differential CAN signal shall be within one time quantum. The following table shows the detailed slew rate (10%-90%) of CAN signals:

CAN signal slew rate	Min.	Max.
CAN_H	20ns	200ns
CAN_L	20ns	200ns
CAN_diff	20ns	200ns

Table 2-12 Slew rate of CAN signals(rise edge)

CAN signal slew rate	Min.	Max.
CAN_H	20ns	400ns
CAN_L	20ns	400ns
CAN_diff	20ns	400ns

Table 2-13 Slew rate of CAN signals(fall edge)

The following picture shows the detailed specification:

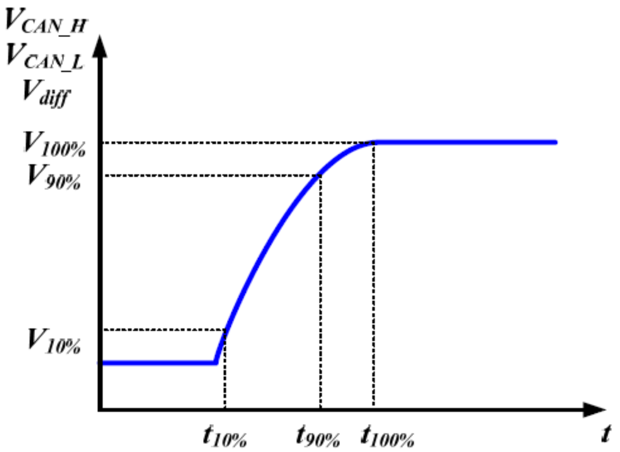


Figure 2-3 Edge steepness of CAN signal (rise edge)

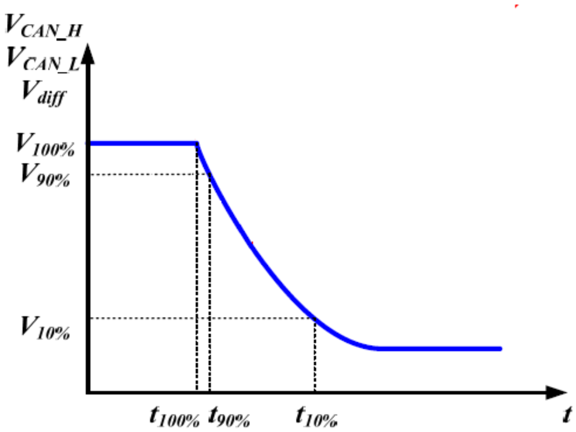


Figure 2-4 Edge steepness of CAN signal (fall edge)

2.9 Other

The physical layer issues that are not defined in this article follow ISO2 implementation .

3 Data Link Layer

The data link layer encapsulates messages in data frames in transmit direction and extracts messages from data frames in receive direction.

The tasks of the Data Link Layer are done by the CAN controller that implements the CAN protocol in hardware and the CAN driver that acts as an interface to the other communication layers.

Concerning the bus interface, the CAN protocol is standardized and conformance tests guarantee the compatibility between the implementations of different semiconductor vendors.

The internal interface between CAN controller and microcontroller is hardware specific and is handled by the CAN driver.

3.1 Specification

The implementation of the CAN protocol must be compliant to [ISO1].

3.2 Bit timing parameters

The bit shall have a length of tBit as defined in Table 3-1. It can be divided into three segments:

- The synchronization segment (SYNC) is the expected slot to see the edge if the bit value changes between two successive bit times.
- TSEG_1 compensates the signal propagation time that is caused by the hardware devices and the bus cable. Additionally, TSEG_1 includes a time buffer which can be lengthened to shift the sampling point to adapt to edges coming too late within the local bit time.
- TSEG_2 can be shortened to compensate for edges which are received too early within the local bit time.

The sample point is a certain point in the bit time, where the signal is evaluated.

The sample point tSP shall be set as defined in Table 3-1.

The number of sample points NSP, which the CAN controller uses for detecting the bit level, shall be set to the value that is defined in Table 3-1.

The sample point is located between TSEG_1 and TSEG_2. TSEG_1 can be lengthened and TSEG_2 can be shortened to dynamically adjust the sample point of asynchronous ECUs within a certain range during operation. This is called resynchronization.

Resynchronization is limited to a maximum time tSJW,Max, that is defined by the parameter synchronization jump width (SJW). SJW shall be set as defined in Table 3-1.

SYNC, TSEG_1, TSEG_2 and SJW are integer multiples of the internal time base t_Q of the CAN controller called time quanta (TQ).

The total number of time quanta per bit is called NBT and shall have the value that is defined in Table 3-1.

The length of the SYNC segment is always one time quantum.

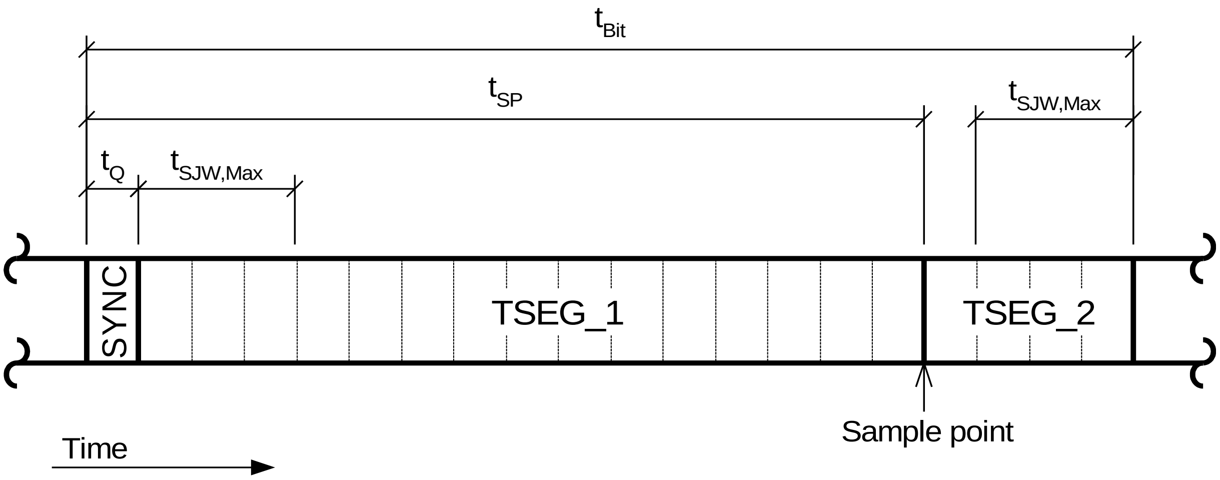


Figure 3-1: CAN bit timing model

Table 3-1 describes the edge ESync which shall be used for synchronization.

The following table contains the ranges and nominal values of the CAN relevant parameters.

Parameter	Symbol	Min	Nominal	Max	Unit	Comment
Bit time	t_{Bit}	1998	2000	2002	ns	This is equivalent to a nominal baud rate of fBus = 500 kbps.
Nominal Bit Time in TQs	NBT	8	16	22	TQ	Number of time quanta which form one bit.
Sampling point position	t_{SP}	75	80	82	%	Percentage of the bit time, where the sample is taken.
Synchronization jump width (SJW)	SJW	2	-	3	TQ	Maximum number of time quanta for resynchronization. If NBT is less or equal than 21 a SJW of 2 has to be set. If NBT is greater than 21 a SJW of 3 has to be set.
Synchronization edge	ESync	-	0	-		The edge used to perform synchronization. rec. to dom. = 0; dom. to rec. = 1
Number of sam-ple points	NSP	-	1	-		Number of samples per bit

Table 3-1: CAN parameters

3.2.1 CAN parameter sets

Exemplary CAN parameter sets of TSEG_1, TSEG_2, SJW and the resulting sampling point are given in the Table 3-2.

NBT	SYNC	TSEG_1	TSEG_2	SJW	Sample Point
8	1	5	2	2	75,0 %
9	1	6	2	2	77,8 %

10	1	7	2	2	80,0 %
11	1	8	2	2	81,8 %
12	1	8	3	2	75,0 %
13	1	9	3	2	76,9 %
14	1	10	3	2	78,6 %
15	1	11	3	2	80,0 %
16	1	12	3	2	81,3 %
17	1	12	4	2	76,5 %
18	1	13	4	2	77,8 %
19	1	14	4	2	78,9 %
20	1	15	4	2	80,0 %
21	1	16	4	2	81,0 %
22	1	16	5	3	77,3 %

Table 3-2: Equivalent examples of nominal bit timings

3.3 Frame types

3.3.1 Data frames

Only standar data frames with a format compliant to [ISO1] shall be used for the CAN communication.

If any not used but [ISO1] compliant data frame is received, it shall be ignored and shall not cause error frames.

The requirements for the sender and the receivers are given as follows:

- Sender:
- Only one ECU is permitted to send the data frame. All other ECUs shall not send the data frame.
- Receiver:
- All receivers shall receive and process the data frame.
- An ECU that is not a receiver of the data frame shall ignore it.

The data length code (DLC) of a data frame shall range from 0 to 8.. Other combinations of identifier and DLC shall not be sent. It is assured by the CAN protocol that the DLC is equal to the data length.

If an ECU receives a data frame with a DLC that is greater than expected, it shall be processed in the same way as a frame with the expected DLC.

If the DLC is smaller than expected and the message does not contain all signals an ECU expects to receive, the complete data frame shall be ignored.

That means if DLC is smaller than expected but all expected signals are received, the message shall be processed as normal.

3.3.1.1 Classical Base Frame Format

Data frames in the Classical Base Frame Format t (as defined in [ISO1]) shall be used for CAN communication.

3.3.1.2 Extended format data frames

Data frames in Classical Extended Frame Format (as defined in [ISO1]) shall not be used for CAN communication.

The reception of data frames in the Classical Extended Frame Format shall be ignored without any effect on the ECU.

3.3.2 Remote frames

The ECU shall not send remote frames (as defined in [ISO1]) on the bus.

The reception of remote frames shall be ignored without any effect on the ECU.

3.4 CAN identifiers

CAN identifiers are grouped by their functionality. The identifier categorizes the data content of the data frame.
Additionally, the priority of the data frame is determined over its CAN identifier. Also CAN identifier stands for a priority, lower value means a higher priority.

The functional groups are Application, Network Management, Development and Diagnostics.

- **Application:** Identifiers of this group are used for normal operation.
- **Network Management：** The Network Management functionality controls the behavior of ECUs connected to the CAN network during the start-up and shut-down phases. The NM ID of every ECU is from 0x400 to 0x47F。

  Development: Identifier range for development. It is divided into the subgroups of ECU specific development and calibration development.

  ECU specific development: A range of identifiers that the ECU supplier can use for its own development related ECU tests (e.g. publishing of ECU internal values). Each ECU has its own ECU specific identifiers (for restrictions see section 3.4.1).

  Calibration development: Identifier range for calibration. Every ECU has its own ECU specific CAN identifiers for calibration.

- **Diagnostics:** Identifier range is from 0x700-0x7FF for diagnostics purposes.

The exact mapping of identifier, DLC and messages to CAN data frames and the assignment of the sending ECU of each CAN frame is done in [CMX].

3.4.1 Restrictions for ECU specific development identifiers

The restrictions of messages from the identifier range "Development - ECU specific development" differ according to the vehicle development phase:

- **Vehicle development phase**:

  ECU identifiers for development messages used in development phase of the ECU shall be disabled when the ECU is released and provided to the vehicle manufacturer.

  It can be switched between both modes (enable and disable transmission of development messages) by a simple control mechanism of the application, e.g. by a flag in the RAM.

- **Vehicle series production**:

  The transmission of messages with ECU specific development identifiers shall be excluded by appropriate design measures for series production.

  It shall be guaranteed that the development identifiers will not be sent in case of any ECU malfunction.

  It shall be guaranteed the development identifiers cannot be enabled by non-authorized persons.

  This shall be done by a removal of the corresponding code segments or by protected diagnostics modes, which requires a special authorization procedure.

4 Interaction Layer

The interaction layer has two views on the data that is transmitted and received:

- **Signal view:** An information entity that is exchanged between applications is called a signal. The interaction layer handles signals from 1 bit to 64 bit. Every signal that is transmitted on the CAN is assigned to a message.
- **Message view:** A message is 1 to 8 bytes long and operates as a container for signals. CAN communication is based on message exchange. Messages are packed together with the CAN identifier and the DLC and are sent on the CAN as data frames.

Every signal has its own properties which influence the transmission of the message containing the signal. The transmission type of a message is built from the properties of all related signals. Not all combinations of signals are allowed.

4.1 Message transmission

Transmission types of messages are described in this section. A transmission is triggered by a signal access/change and/or it is initiated cyclically.

4.1.1 Basic transmission types

4.1.1.1 Periodic

A message with the transmission type *"periodic"* consists only of signals that are sent in a cyclic way.

Periodic messages are transmitted asynchronously from the change of signal values as depicted in Figure 4-1.

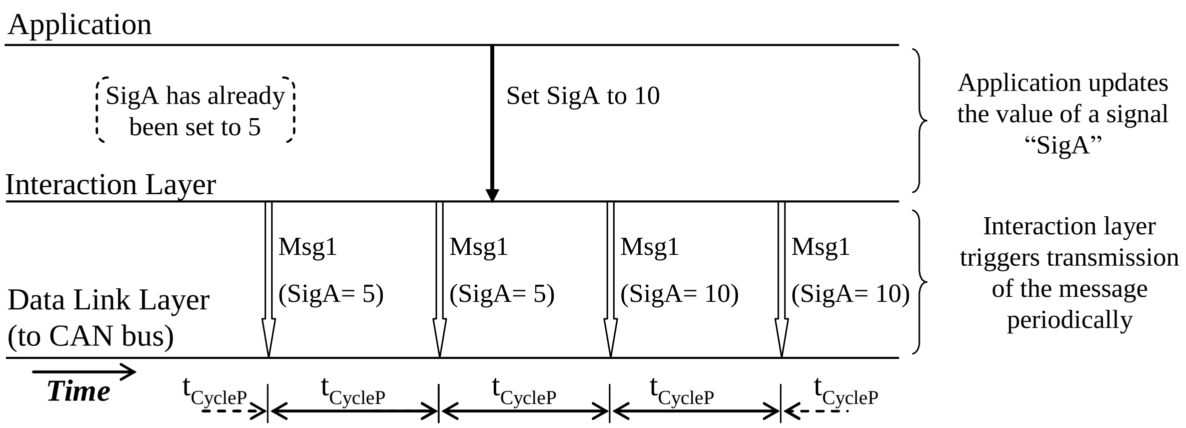


Figure 4-1: Timing diagram *periodic*

The signal with the shortest latency determines the static cycle time of the whole message.

The static cycle time of the cyclic messages of the network varies between 5 ms and 1000 ms.

Periodic messages shall be transmitted with the cycle time t_{CycleP} which is defined in Table 4-1

The message shall be sent at the beginning of a cycle.

The timing parameter of the transmission type *periodic* is given in Table 4-1.

Parameter	Symbol	Min	Nominal	Max	Unit	Comment
Cycle time	t_{CycleP}	90% $t_{CyclePNom}$	Defined in [CMX]	110% $t_{CyclePNom}$	ms	

Table 4-1: Timing parameter of the transmission type *periodic*

4.1.1.2 On event

A transmission of a message with the transmission type "on event" shall be initiated by a change of a trigger signal within the message as described in Figure 4-2.

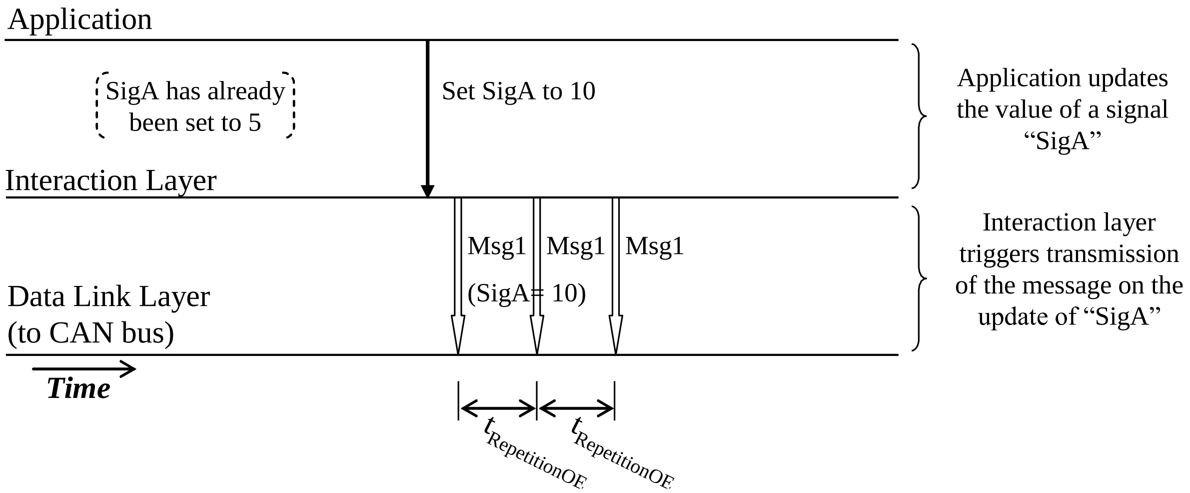


Figure 4-2: Timing diagram *on event*

An *on event* message contains *trigger signals* and *passive signals*:

- 1 to 64 *trigger signals*:

  The message is event triggered if at least one signal is a trigger signal. Even all signals in the message can be trigger signals.

  A value change of a trigger signal shall trigger a message transmission.

- 0 to 63 *passive signals*:

  If all signals in a message are event triggered, there is no passive signal in the message. However, an event triggered message has at least one trigger signal. So the maximum number of passive signals is 63.

  A value change of a passive signal shall not trigger a message transmission.

Several signals can trigger the message transmission independently.

To avoid the loss of information the message shall be sent $N_{RepetitionOE}$ times after the event has occurred, see Table 4-2.

(CR1708) The time between the repetitions shall be $t_{RepetitionOE}$, as given in Table 4-2 and Figure 4-2.

The timing parameters of the transmission type *on event* are given in Table 4-2.

Parameter	Symbol	Min	Nominal	Max	Unit	Comment

Number of repetitions	$N_{RepetitionOE}$	-	3	-		After the last change of a trigger signal of one message the message is transmitted $N_{RepetitionOE}$ times. Detailed defined in [CMX]
Time between repetitions	$t_{RepetitionOE}$	45	50	55	ms	Detailed defined in [CMX]

Table 4-2: Timing parameters of the transmission type *on event*

4.1.2 Combined transmission types

Combined transmission types are derived from the basic transmission types and inherit their properties.

4.1.2.1 • Periodic and on event

The transmission type *"periodic and on event"* combines the transmission type *periodic* (see section 4.1.1.1) with *on event* (see section 4.1.1.2) as depicted in Figure 4-.

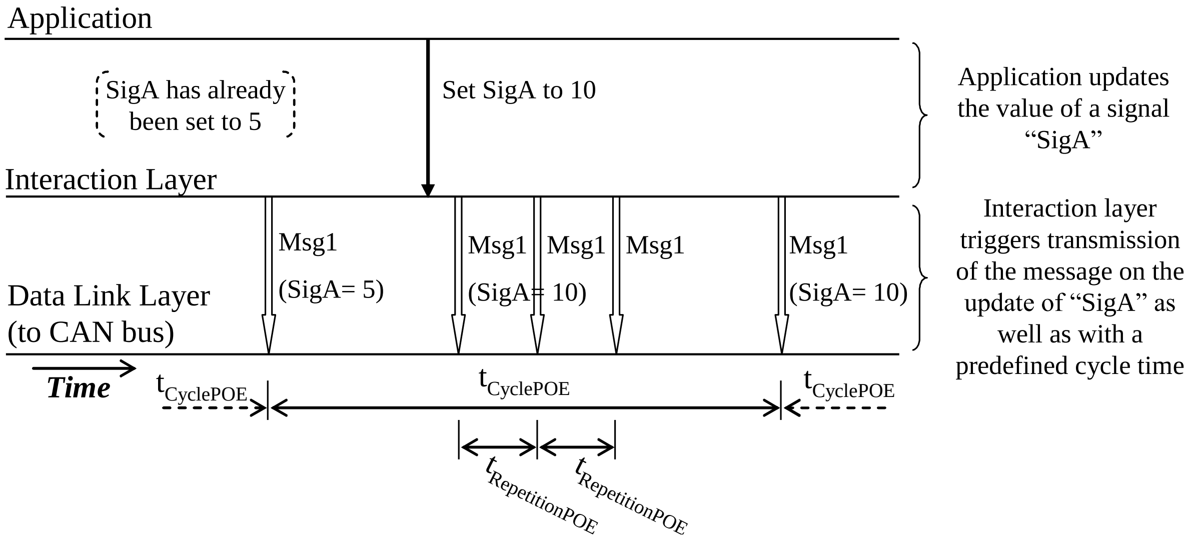


Figure 4-3 : Timing diagram *periodic and on event*

The message shall be transmitted cyclically with the cycle time $t_{CyclePOE}$, which is defined in Table4-3.

The recommended cycle time for $t_{CyclePOE}$ ranges from 100 ms to 1000 ms.

If an event occurs the message shall be transmitted $N_{RepetitionPOE}$ times, see Table4-3.

A *periodic and on event* message contains *trigger signals* and *passive signals*:

- 1 to 64 *trigger signals*:

  The message is event triggered if at least one signal is a trigger signal. Even all signals in the message can be trigger signals.

  A value change of a trigger signal shall trigger a message transmission.

- 0 to 63 *passive signals*:

If all signals in a message are event triggered, there is no passive signal in the message. However, an event triggered message has at least one trigger signal. So the maximum number of passive signals is 63.

A value change of a passive signal shall not trigger a message transmission.

Transmissions by on event shall not change the time between two periodic transmissions.

If a periodic and an event triggered message condition overlaps, the message shall be sent only by $N_{RepetitionPOE}$ times.

The time between the repetitions $t_{RepetitionOE}$ shall be chosen as defined in Table4-3.

The timing parameters of the transmission type *periodic and on event* is given in Table4-3.

Parameter	Symbol	Min	Nominal	Max	Unit	Comment
Cycle time	$t_{CyclePOE}$	90%tCyclePOENom	Defined in [CMX]	110%$t_{CyclePOENom}$	ms	The cycle time is defined in [CMX].
Number of repetitions	$N_{Repetition-POE}$	-	3 Detailed defined in [CMX]	-		After the last change of a *trigger signal* of one message the message is transmitted $N_{RepetitionPOE}$ times.
Time between repetitions	$t_{Repetition-POE}$	45	50	55	ms	Detailed defined in [CMX]

Table 4-3: Timing parameters of the transmission type *periodic and on event*

4.1.3 Limitations of transmission types

The following rules apply in addition to all transmission types specified in section 4.1.1.and 4.1.2 They override the described timing diagrams if the specific condition is fulfilled.

4.1.3.1 Delay time between messages

The delay time t_{Delay} defines a period after a transmission of a message.

After a message is sent, there shall be no repeated transmission with the same message identifier for the time t_{Delay} (see Table 4-4).

The delay is relevant under the following conditions:

- *On Event*: If a trigger event occurs within t_{Delay} after another trigger event.
- *Periodic and On Event:* Either if a trigger event occurs within t_{Delay} after a periodic message transmission or if the event occurs within t_{Delay} after another trigger event.

The delay time is required to limit the busload that is caused by each message.

Figure 4- shows an example message transmission with the transmission type *on event*. Although the signal value has been changed to 20 and then 7 in a short time, the next transmissions of the message are delayed for t_{Delay}.

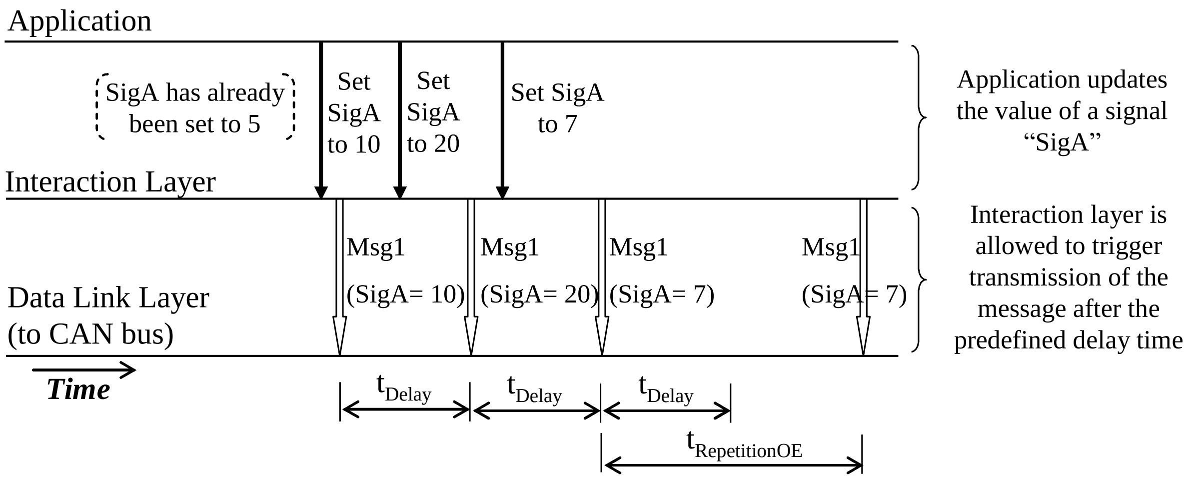


Figure 4-4: Delay time example

The delay time is given in Table 4-4

Parameter	Symbol	Min	Nominal	Max	Unit	Comment
Delay time	t_{Delay}	5	10	40	ms	The minimal delay between the transmissions of two messages with the same identifier. t_{Delay} is fixed to the nominal value and can not be adjusted.

Table 4-4: Delay time

4.2 Message reception

If an ECU is defined in [CMX] as a receiver of a message, this message shall be received and processed correctly. A loss of a corresponding message is not allowed.

4.3 Signal characteristics

4.3.1 Signal format

The bit and byte-order of the signal values shall be transmitted and interpreted according to the Motorola format (big endian, forward MSB).

Therefore the start position of a signal is the most significant bit of the most significant byte from the beginning of the message.

Bit indexing of the bits in a byte decreases from the left to the right ("Sawtooth") as shown in Figure 4-5.

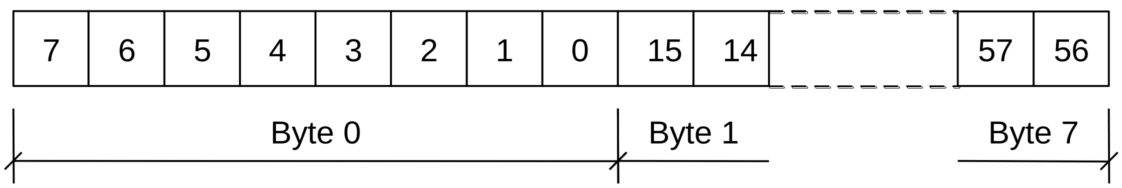


Figure 4-5: Bit positions in the data field of a CAN frame

An example of a message that contains a signal with a length of 10 bits is depicted in Figure 4-6

The signal is transmitted on the CAN bus in the order as shown in Figure 4-6.

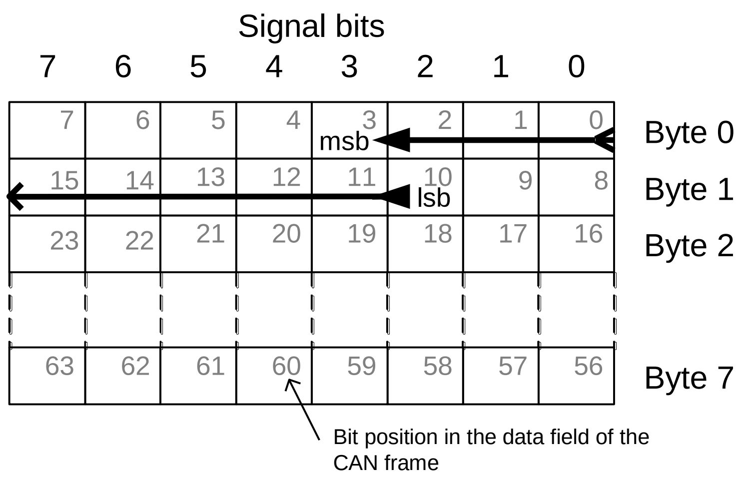


Figure 4-6: Example of a message with a 10 bit signal

Unused bits within a message shall be set to 0. As a consequence unused bytes shall be set to 0x00.

4.3.2 Signal consistency

Table 4-5 defines the conditions for sending valid signals:

After the start delay for valid signals $T_{SignalValid}$ the ECU shall send valid signals as long as the supply voltage is in the range that is defined by $U_{TxValid}$.

Conditions for valid signals are given in Table 4-5.

Parameter	Symbol	Min	Nominal	Max	Unit	Comment
Voltage range for transmitting valid signals	$U_{TxValid}$	8.5	9	16.5	V	Supply voltage range for the transmission of valid signals.
Start delay for valid signals	$T_{SignalValid}$	0	Refer to chap 6	---	ms	If the message transmission is enabled but the valid signal values are not available, an ECU shall set default or invalid values for its transmitting signals as defined in [CMX]. An ECU is not allowed to send valid signals values until $t_{TxValid}$, when $U_{TxValid}$ Refer to chap 6

Table 4-5: Conditions for valid signals

5 Transport Protocol

The transport protocol incorporates a transport mechanism that can be used to transfer messages with more than 8 bytes of payload data.

The transport protocol follows the requirements defined in [ISO5-2].

6 General requirements

6.1 Network startup and shutdown for Battery fed ECUs

Battery fed （KL30）ECUs shall implement Network Management， further the implementation of the network management refer to【BATC NM】。

6.2 Network startup and shutdown for Ignition fed or ACC ECUs

6.2.1 Network startup for Ignition fed ECUs

ECU power supply and CAN interface in ignition fed systems are switched on by a Clamp KL15 or ACC input. CAN communication is only possible if the Clamp KL15 or ACC is switched on.

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

1. Since the CAN communication is always running if Clamp KL15 or ACC is switched on, no wake up plausibility checks are required.

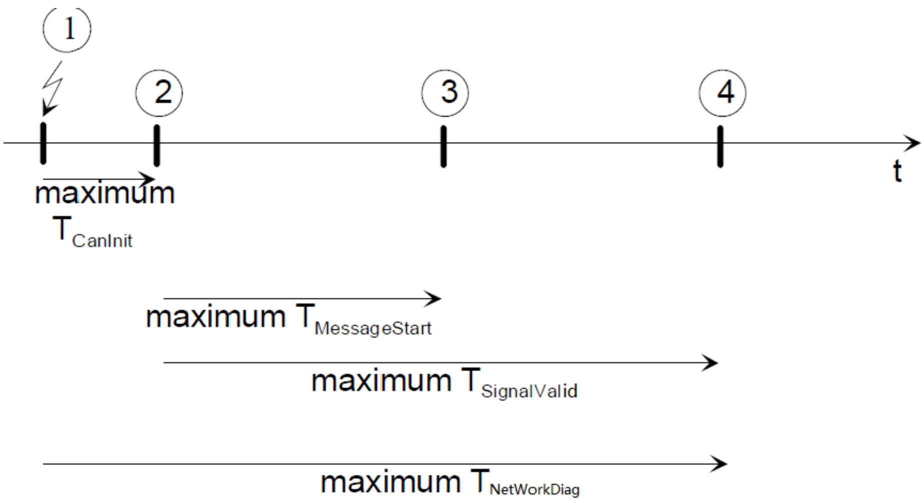
2. CAN initialization shall be executed as fast as possible. The maximum time for an ECU to begin transmitting own CAN messages is $T_{CanInit}$. The starting point for $T_{CanInit}$ begins when ClampKL15 or ACC switches to system voltage.

3. 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 $T_{MessageStart}$ all cyclic messages shall be transmitted uniformly at least once with the defined cycle time. The cyclic message with the highest priority shall be transmitted first at the beginning of $T_{MessageStart}$. Within $T_{MessageStart}$ 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 after the expiration of $T_{CanInit}$.

4. Valid values shall be transmitted prior to the expiration of $T_{SignalValid}$. $T_{SignalValid}$ starts simultaneously with $T_{MessageStart}$ right after the expiration of $T_{CanInit}$.

5.When Clamp KL15 is switched on and $T_{NetworkDiag}$ has elapsed, the "CAN-Timeout" and "signal implausible" event storage shall be activated. Battery fed ECUs shall not monitor signals from ignition fed ECUs until ignition is switched on and $T_{NetworkDiag}$ has elapsed.

about Startup procedure and StartupTiming caused by Ignition on ,Please refer to fig6-1 and table 6-1.



1 Clamp 15 is turned on

2 ECU starts with sending messages and is ready to receive messages

3 ECU has transmitted all cyclic messages as describes in the[CMX]at minimum at the first time

4 ECU transmits all signal values no longer with "Default-Value"
Start of the network is finished!

Fig6-1 Startup procedure caused by Ignition on

Name	Definition	Nominal	Range
$T_{CanInit}$	Time frame within which the application initializes the CAN hardware and becomes ready to receive and transmit messages after the Clamp 15 or ACC is switched on	200	0-200
TMessageStart	Time frame within which all cyclic messages have to be transmitted at least once. TMessageStart starts after the expiration of TCanInit	300	0-300
TSignalValid	Time frame within which all signals shall have plausible values. In principle the signals shall have plausible values as soon as possible. (when cycle time >600ms, TSignalValid can extend the time.) TSignalValue starts simultaneously with TMessa-geStart right after the expiration of TCanInit.	400	0-400
TNetworkDiag	Time since the Clamp 15 is switched on to the end of the start up sequence of the Diag related net-work(the "CAN-Timeout" and "signal implausible" event storage active)	5000	

Table 6-1 StartupTiming for Ignition fed ECUs [ms]

For some ECUs more restrictive requirements regarding TCanInit and/or TSignalValid may apply. Refer to the ECU specification.

6.2.2 Shutdown

The transitions from network active to network inactive shall be initiated by the state change from IGN ON to IGN OFF for Ignition fed ECU.

In the state network inactive an ECU shall not transmit application messages. Exceptions can be defined.

The timing of the transition from network active to network inactive ($t_{ShutdownIGN}$) shall be as defined in Table 6-2.

Table 6-2 defines the shutdown behavior.

Parameter	Symbol	Min	Nominal	Max	Unit	Comment
Shutdown time after IGN OFF	$t_{ShutdownIGN}$	0	-	100	ms	Reference: Transition from IGN ON to IGN OFF.

Table 6-2: Shutdown behavior of an ECU

All states that do not require CAN communication are summarized in the state *network inactive*. The behavior in the *network inactive* state depends on the function of the individual ECU.

6.2.3 ECU states

Table 6-3 summarizes the ECU states and the transmitting and receiving activity of application messages in these states.

As long as an ECU stays in a state in which the transmission is disabled, it shall reject all transmission requests from the application, i.e. no transmission requests are allowed to be pending if transmission is enabled again.

ECU State	Transmitting activity	Receiving activity	Remarks
Network active	Enabled	Enabled	-
Network inactive	Disabled	Disabled	-
Bus off error	Disabled	Enabled*	The ECU enters the bus off state immediately after a certain number of transmit errors have been detected. * Receiving activity is enabled only after the CAN controller has left its internal bus off error state after 128 x 11 recessive bits have been seen on the bus.
Over-/undervoltage error	Disabled	Enabled	In this error state no message can be sent. However, messages have to be received.

Table 6-3: ECU states

6.3 Supply voltage and network time conditions

The supply voltage level affects the transmission of all CAN messages as follows:

- At the latest Ttx_stop after the ECU supply voltage has left the range from Vlow to Vhigh the ECU shall disable the transmitting activity and shall change to an over-/undervoltage error state. The previous state is saved.
- Receiving activity should be enabled as long as possible.
- When the supply voltage is within the range from Vlow to Vhigh for at least Ttx_restart again, the ECU shall be in network active state.unless otherwise specified in other document.
- When ECU supply voltage is within the range from Vdiag_high to Vdiag_low, the ECU does not have diagnostic function unless otherwise specified in other document.
- If local ECU supply voltage had decreased below Vdiag_low ,then the ECU shall resume diagnostic capability within a time of Tdiag_restart from the time when the voltage increases to Vdiag_low.
- If local ECU supply voltage had rised above Vdiag_high ,then the ECU shall resume diagnostic capability within a time of Tdiag_restart from the time when the voltage increases to Vdiag_high.
- The error behavior(e.g. displaying an error or entering a specific error mode) in case of an over- or under voltage condition is described in [DIG].
- If the message transmission is enabled but the valid signal values are not available, an ECU shall set default or invalid values for its transmitting signals as defined in [CMX].

The operating conditions are given in Figure6-2 and Table 6-4。If any ECU needs deviations because of specific functionality, it has to be agreed by BATC.

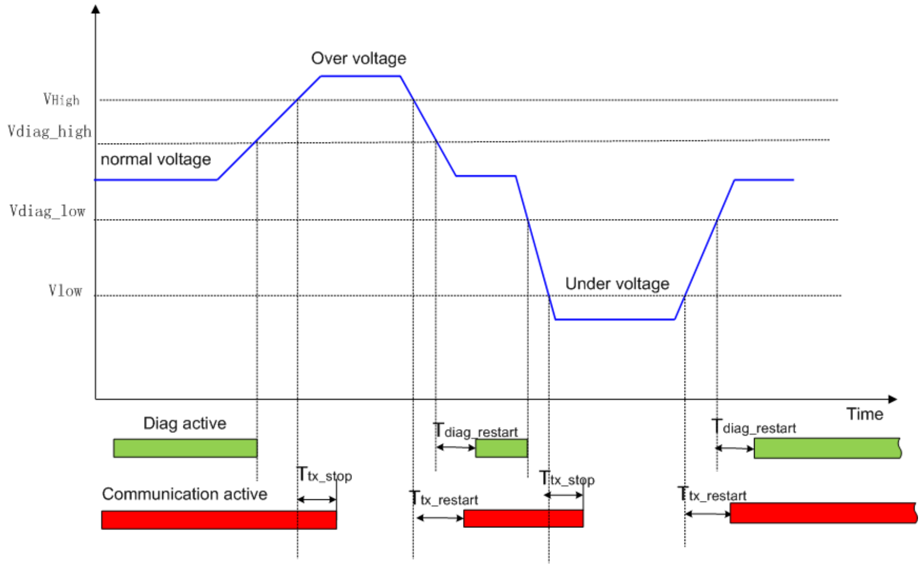


Figure 6-2: Operation voltage condition

Parameter	Symbol	Min	Nominal	Max	Unit	Comment
Transmission low voltage	Vlow	6.5	7	7	V	Minimum network transmission operating voltage。 CAN communication is allowed but not forced if the ECU operating voltage is below Vlow
		6	6	6.5	V	Minimum network transmission operating voltage for node associated with engine start such as immobilizer data or crank command
Transmission high voltage	Vhigh	18	18	18.5	V	Maximum network transmission operating voltage for node independent of engine start。CAN communication is allowed but not forced if the ECU operating voltage is higer than Vhigh
		26	26	26.5	V	Maximum network transmission operating voltage for node associated with engine start such as immobilizer data or crank command 。ECU shall support communication in the range of 18V to 26.5V for 1minute（jump start conditions）
Leave network active delay	Ttx_stop	180	200	220	ms	If the battery voltage has left Vhigh or Vlow the ECU has to disable the transmission of all CAN messages after Ttx_stop.
over-/under voltage delay time	Ttx_restart	180	200	220	ms	Time that start message transmission after the over or under voltage condition has recovered.
Voltage range for transmitting valid signals	$U_{TxValid}$	<=8.5	---	>=16.5	V	Supply voltage range for the transmission of valid signals This definition is based on the vehicle function definition.
Diag low voltage	Vdiag_low	8.5	9	9		Minimum diagnostic voltage
Diag high voltage	Vdiag_high	16	16	16.5		Maximum diagnostic voltage
diag restart time after over-/under voltage	Tdiag_restart	TNetworkDiag		---		Time that start diagnostic related network after the over or under voltage condition has recovered

Table 6-4: Operating conditions parameter

7 Network Error Handling

This section defines how an ECU detects and recovers from network errors and how the network is affected in case of ECU errors.

7.1 Bus Off

The CAN controller uses counters for reception and transmission errors. When the transmission error counter (TEC) exceeds the value of 255, the CAN controller shall go into bus off state.

The following actions shall be done immediately after the *bus off* condition occurred:

- The transition from network active state to a bus off specific error state shall be performed.
- Any transmission of application messages shall be disabled.
- The CAN controller shall be reset. Pending messages in the data link layer shall be discarded.

After $N_{BusOffCount}$ (see Table 7-1) consecutive bus off states without any successful message transmission of the corresponding ECU in between, a diagnostics trouble code (DTC) shall be recorded, i.e. DTC Test Failed.

Details about the handling of DTCs are described in [DS].

Parameter	**Symbol**	**Min**	**Nominal**	**Max**	**Unit**	**Comment**
Consecutive bus off counter	$N_{BusOffCount}$	-	2	-		Number of *bus off* conditions that need to occur before a DTC has to be recorded

Table 7-1: DTC recording in case of consecutive *bus offs*

When ECU moves into the Bus-off mode, ECU shall only store the Bus-off DTC, no longer record node missing or timeout DTC

The transition from the bus off specific error state to network active state shall be done $t_{BusOffRecovery}$ (see Table 7-2 and Figure 7-1) after detection of the bus off condition.

If the messages are transmitted successfully again after the recovery from the bus-off state, the logged Bus Off DTC shall be set as DTC Test Passed.

After $t_{BusOffRecovery}$ from the bus off occurrence, the transmitting activity shall be enabled again.

The first transmit message after *bus off* condition can be any application message.

Figure 7-1 shows the sequence after one bus off and a successful recovery.

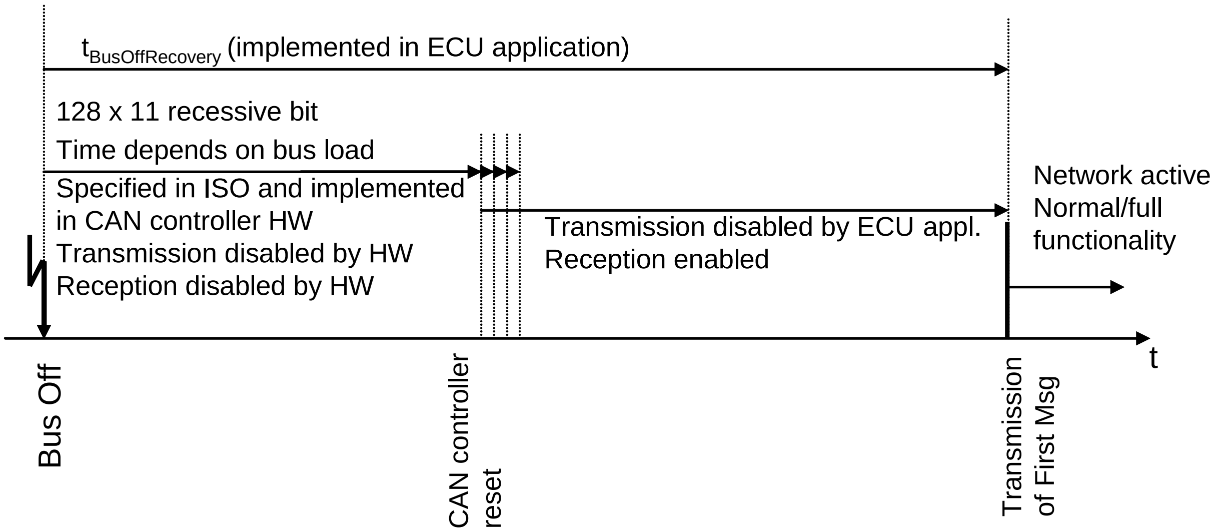


Figure 7-1: Sequence after a Bus Off and a successful recovery

The recovery timing is given in Table 7-2.

Parameter	Symbol	Min	Nominal	Max	Unit	Comment
Bus off recovery time	$t_{BusOffRecovery}$	170	200	230	ms	Time for bus off recovery.

Table 7-2: *Bus off* timing

7.2 Message timeout handling

The receivers of a signal are defined in [CMX]. Receivers have to monitor the availability of the corresponding messages in order to detect timeout conditions.

Timeout monitoring is applicable only for the messages grouped as Application

The timeout monitoring shall be enabled during the network active state.

The timeout detection is disabled during the following conditions:

- Always for messages of the transmission type “on event”
- For specific messages which have already been detected as timeout until the message with the same identifier is received
- The engine cranking and the associated fluctuations of the voltage within 5S

If a message is missing for $N_{TimeoutAccept}$ times of its cycle time (see Table 7-3), a timeout occurs for the message and the corresponding signal values shall be set to the appropriate values (e.g. default or invalid) defined by [CMX].

Timeout monitoring timing parameter is described in Table 7-3.

Parameter	Symbol	Min	Nominal	Max	Unit	Comment
Timeout acceptance factor	$N_{TimeoutAccep}$	-	10	-		1、The nominal cycle time multiplied by the factor is the timeout period for timeout detection 2、Specific reference diagnostic specifications （DIAG）

Table 7-3: Timeout acceptance factor

Table 7-4 shows the details for the timeout period depending on the transmission type.

Transmission Type	Timeout Period	Remark
Periodic	$t_{CycleP.Nominal}$ x $N_{TimeoutAccept}$	
On event	-	Not Applicable

Table 7-4: Timeout time depending on the transmission type

7.3 Robustness

Robustness shall be guaranteed for exceptional network conditions that must not affect the local ECU functions.

Additionally, exceptional ECU conditions shall not affect the remaining network. That means the ECU shall not disturb or influence the bus operation. Especially the communication between other nodes shall not be affected.

At the same time, the ECU shall be able to handle these errors and maintain its own operation as far as possible, i.e. local ECU functions shall not be affected.

Exceptional network conditions:

- Any bus error
- Busload of 100 % with messages of one or multiple identifiers (any message, any data)

Exceptional ECU conditions:

- Defect of the ECU including any hardware and/or software malfunctions
- Loss of power or ground
- Undervoltage and overvoltage conditions
- ECU reset caused by the software, battery low condition or a watchdog trigger
- ECU initialization including the initialization of the CAN controller and/or bus transceiver

An exceptional network or ECU condition shall not disturb the transition to network inactive.

8 Appendix

8.1 Glossary

Abbreviation	Term	Definition
BCAN	Body CAN	
CAN	Controller Area Network	
DTC	Diagnostic Trouble Code	
DUT	Device Under Test (a single ECU under test)	
ECU	Electronic Control Unit	
EMC	Electromagnetic Compatibility	
ESD	Electrostatic Discharge	
BAIC	Beijing Automotive	
BATC	Beijing Automotive Technology Center CO., LTD	
IGN	Ignition	
ISO	International Standardization Organization	
LSB	Least Significant Byte	
lsb	least significant bit	
MSB	Most Significant Byte	
msb	most significant bit	
PCAN	Powertrain CAN	
PCB	Printed Circuit Board	
PLL	Phase Locked Loop	

8.2 References to documents

ID	Description	Version
ISO1	ISO 11898-1:2003: Road Vehicles - Interchange of digital informa-tion - Part 1: Controller Area Network data link layer and medium access control	2015
ISO2	ISO 11898-2 Road vehicles - Controller area network (CAN)- Part2: High Speed Media Access Unit	2015
ISO5-2	ISO 15765-2:2004: Road Vehicles - Diagnostics on controller area network (CAN) - Part 2: Network layer services	2004
ISO15-4	ISO 15765-4:2004: Road Vehicles - Diagnostics on controller area network (CAN) - Part 4: Network layer services	2004
ISO16	ISO 16845:2004(E): Road vehicles - Controller area network (CAN) - Conformance test plan	First edi-tion,

		2004-03-15
GIFT2	GIFT/ICT CAN High-Speed Transceiver Conformance Test Specification	v1.0, 2004
GIFT3	GIFT/ICT International Transceiver Conformance Test Specification	V1.4, 2006
BATC NM	BATC_HSCAN_ECU_RS_NM	
CMX	Communication Matrix	
DIAG	Diagnostic Specific Information for every ECU	
ID	Network ID definition rule specification	

8.3 Terminology

In the current document, the following defined terminology prescription applies. The usage of

- "Shall" expresses an obligatory / mandatory requirement.
- "Should" expresses a recommendation or an advice.
- "Must" expresses a legal or normative requirement.
- "Will" expresses a precautionary consideration or an additional / optional feature.
- "Can" expresses a permitted practice / method, not to be considered as a requirement.