BS ISO 11898-6:2013

BSI Standards Publication

Road vehicles — Controller area network (CAN)

Part 6: High-speed medium access unit with selective wake-up functionality

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National foreword

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Part 6:
High-speed medium access unit with selective wake-up functionality

Véhicules routiers — Gestionnaire de réseau de communication CAN —

Partie 6: Unité d'accès au médium haute vitesse avec fonctionnalité de réveil sélectif

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Foreword

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The committee responsible for this document is ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronic equipment*.

ISO 11898 consists of the following parts, under the general title *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*

— *Part 4: Time-triggered communication*

— *Part 5: High-speed medium access unit with low-power mode*

— *Part 6: High-speed medium access unit with selective wake-up functionality*

Introduction

This International Standard was first published as one document in 1993. It covered the controller area network (CAN) data link layer, as well as the high-speed physical layer.

In the reviewed and restructured ISO 11898 series:

— ISO 11898-1 describes the data link layer including the logical link control (LLC) sublayer and the medium access control (MAC) sublayer as well as the physical signalling (PHS) sublayer;

— ISO 11898-2 defines the high-speed medium access unit (MAU);

— ISO 11898-3 defines the low-speed fault-tolerant medium access unit (MAU);

— ISO 11898-4 defines the time-triggered communication;

— ISO 11898-5 defines the power modes of the high-speed medium access unit (MAU);

— ISO 11898-6 defines the selective wake-up functionality of the high-speed medium access unit (MAU).

Road vehicles — Controller area network (CAN) —

Part 6:
High-speed medium access unit with selective wake-up functionality

1 Scope

This part of ISO 11898 specifies the controller area network (CAN) physical layer for transmission rates up to 1 Mbit/s. It describes the medium access unit (MAU) functions.

This part of ISO 11898 represents an extension of ISO 11898-2 and ISO 11898-5, specifying a selective wake-up mechanism using configurable CAN frames.

Physical layer implementations according to this part of ISO 11898 are compliant with all parameters of ISO 11898-2 and ISO 11898-5. Implementations according to this part of ISO 11898, ISO 11898-2, and ISO 11898-5 are interoperable and can be used at the same time within one network.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 7637-3, *Road vehicles — Electrical disturbances from conduction and coupling — Part 3: Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines*

ISO 11898-1, *Road vehicles — Controller area network (CAN) — Part 1: Data link layer and physical signalling*

ISO 11898-2:2003, *Road vehicles — Controller area network (CAN) — Part 2: High-speed medium access unit*

ISO 11898-5:2007, *Road vehicles — Controller area network (CAN) — Part 5: High-speed medium access unit with low-power mode*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11898-1, ISO 11898-2, and ISO 11898-5 and the following apply.

3.1
bias unit
subpart of the transceiver which provides the biasing voltage

Note 1 to entry: Figure 1 depicts the subparts of a transceiver.

3.2
bit rate
number of bits per time during transmission, independent of bit representation

3.3
CAN node
communication participant of the CAN system which contains typically a transceiver, a CAN controller, and a processing unit

3.4
CAN controller
subpart of a CAN node which implements the data link layer protocol and the physical signalling as defined in ISO 11898-1

3.5
data mask bit
optional configuration bit to disable the data length code (DLC) and data field judgment for the wake-up frame validation

3.6
decoding unit
subpart of the control unit with selective wake-up function which analyses the CAN communication to detect wake-up frames

Note 1 to entry: Figure 1 depicts the subparts of a transceiver.

3.7
mode control unit
subpart of the transceiver with selective wake-up function which controls all functions and other subparts of a transceiver

Note 1 to entry: Figure 1 depicts the subparts of a transceiver.

3.8
selective wake-up
functionality of a transceiver to make the operation of a CAN system with partial networking possible

3.9
receiver
subpart of the transceiver which is responsible to transform physical bus signals to logical signals and provides them to the CAN controller

Note 1 to entry: Figure 1 depicts the subparts of a transceiver.

3.10
transceiver
component that adapts logical signals to the physical layer and vice versa

Note 1 to entry: Figure 1 depicts the subparts of a transceiver.

3.11
transmitter
subpart of a transceiver which is responsible to transform logical signals to physical bus signals and sets them on the bus

Note 1 to entry: Figure 1 depicts the subparts of a transceiver.

3.12
CAN activity filter time (of a CAN node)
t_{Filter}
duration of dominant and recessive bus-levels on the bus lines CAN_H and CAN_L for detecting activity on the CAN bus

3.13
wake-up frame
CAN frame which causes a wake-up of one or more CAN nodes after being analysed

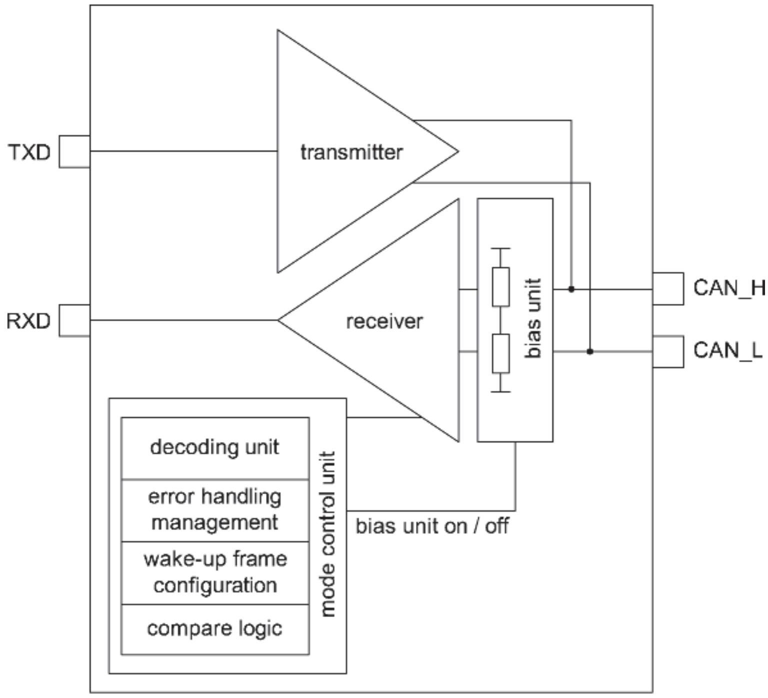


Figure 1 — Subparts of a transceiver

3.14
wake-up pattern
two periods of dominant bus-levels, separated by a period of recessive bus-level each of at least t_{Filter}

4 Symbols and abbreviated terms

For the purposes of this document, the symbols and abbreviated terms given in ISO 11898-1, ISO 11898-2, and ISO 11898-5 and the following apply.

ID	Identifier field
PHS	Physical signalling
R_{IN}	Internal receiver input resistors
V_{CAN_H}	Voltage on CAN_H bus line
V_{CAN_L}	Voltage on CAN_L bus line
V_{diff}	Differential CAN voltage (= $V_{CAN\_H} - V_{CAN\_L}$)
WUF	Wake-up frame
WUP	Wake-up pattern

5 Functional description of medium access unit (MAU) with selective wake-up functionality

5.1 General

This specification discloses the respective hardware functionalities for CAN high-speed transceivers with selective wake-up capability. The transceivers with this capability shall be interoperable with CAN transceivers according to ISO 11898-2 and ISO 11898-5 (for details, see Clause 7).

If CAN transceivers with selective wake-up function are used, it is possible to define sub-networks of nodes, which only change to active state if they receive a configured wake-up frame.

The node state is changed from inactive to active only if the transceiver has received a frame and accepted it as a wake-up event. Acceptance of a CAN frame as a wake-up event is done by the mode control unit of the transceiver by comparing configured and received ID and, if not disabled, DLC and data. Configuration is done via implementation specific interfaces (e.g. host interface). In case of erroneous communication, the transceiver shall wake-up upon or after an overflow of the internal error counter.

CAN transceivers with selective wake-up function are able to recognize and decode CAN frames by the decoding unit. An automatic voltage biasing function at CAN_H and CAN_L is used in CAN transceivers with selective wake-up function.

5.2 Compliance classes

The following compliance classes are defined.

— Compliant to ISO 11898-6:

The CAN transceiver fulfils all requirements of this part of ISO 11898.

— Compliant to automatic voltage biasing as defined in ISO 11898-6:

The CAN transceiver fulfils only the requirements of the automatic voltage biasing at the CAN pins (see 5.4.3.2).

5.3 Configuration and status data

5.3.1 General

The transceiver shall support read access to all its configuration data.

5.3.2 List of configuration data

The following configuration data are given.

— ID	(mandatory)
— ID mask	(mandatory)
— DLC	(mandatory)
— Data field bits	(mandatory)
— Bit rate	(mandatory)
— Data mask bit	(optional)
— Frame error counter overflow threshold value	(optional)

5.3.3 List of status data

Furthermore, the following status data are defined.

— Frame error counter value (optional)

5.3.4 Optional support of data mask bit

Optionally, a data mask bit can be implemented to indicate if the DLC and data field bits shall be part of the WUF validation (data mask bit set) or if only the ID field shall be considered for the WUF validation (data mask bit not set).

If the data mask bit is not implemented, the DLC and data field bits shall be part of the WUF validation.

5.4 Physical medium attachment sublayer specification

5.4.1 General

Two different termination models are recommended for the high-speed medium access unit according to Figure 2:

— termination with single resistor between CAN_H and CAN_L;

— split termination dividing the single resistor into two resistors with same value in series connection, while the centre tap is connected to a grounding capacitor and optionally to a dedicated split supply.

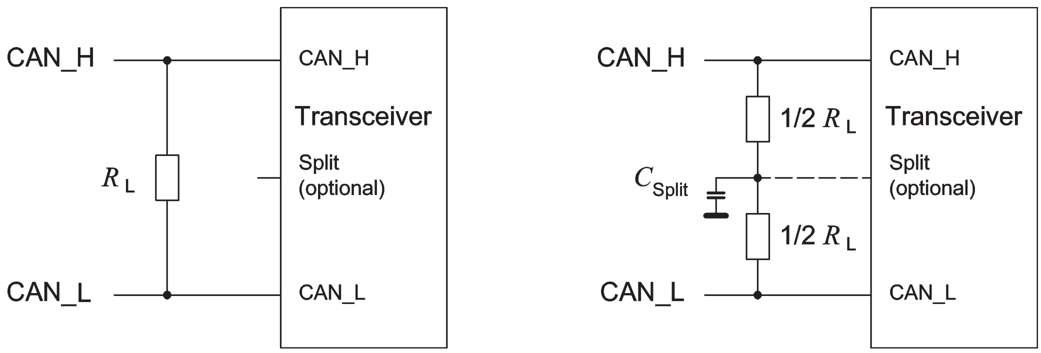


Figure 2 — Termination variants, single-resistor termination, and split termination

In order to support low-power functionality, two different modes of operation are defined as follows.

— Normal mode: (as defined in ISO 11898-2)

— Low-power mode, which is split into the two following sub-states:

  — without selective wake-up function: (as defined in this part of ISO 11898 and in ISO 11898-5)

  — with selective wake-up function: (as defined in this part of ISO 11898)

5.4.2 Bus levels during normal mode

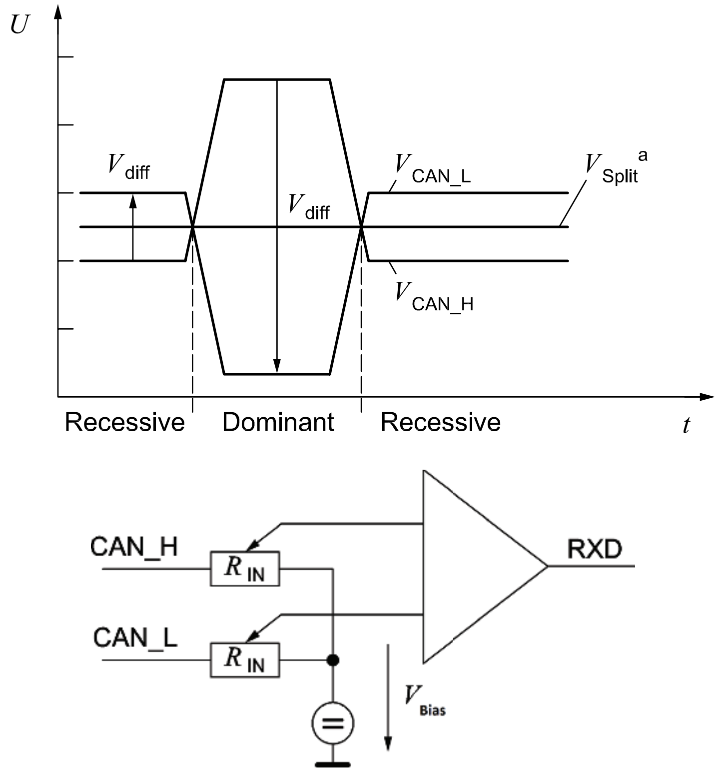
The CAN bus lines have one of the two logical states: recessive or dominant (see Figure 3).

The bus lines are in recessive state if the transmitters of all CAN nodes are switched off. In this case, the mean bus voltage is generated by the termination and by the internal resistance of each CAN node's receiver. In the recessive state, V_{CAN_H} and V_{CAN_L} are fixed to a mean voltage level determined by the bus termination. V_{diff} is less than a maximum threshold. The recessive state is transmitted during bus idle (see ISO 11898-1) or a recessive bit. Figure 3 illustrates the maximum allowed differential recessive bus voltage. Typically, the differential voltage is about 0 V.

Optionally, the recessive bus state can be stabilized, making use of a dedicated split termination voltage (V_{Split}). This optional output voltage can be connected to the centre tap of the split termination resistors. Whenever the receiver is not actively biasing towards 2,5 V, the optional V_{Split} shall become floating.

A dominant bit is sent to the bus if the transmitter of at least one unit is switched on. This induces a current flow through the termination resistors and, consequently, a differential voltage between the two wires of the bus. A differential voltage greater than a minimum threshold represents the dominant state. The dominant state overwrites the recessive state and is transmitted during a dominant bit.

During arbitration, various CAN nodes can simultaneously transmit a dominant bit. In this case, V_{diff} exceeds the V_{diff} seen during a single operation. Single operation means that the bus is driven by one CAN node only.



Key

a Optional.

Figure 3 — Physical bit representation and simplified diagram of transceiver bias implementation

5.4.3 Bus levels during low-power mode

5.4.3.1 General

During low-power mode, the transmitter shall be entirely disabled. Within low-power mode of a transceiver, it shall not be possible to actively drive a differential level to the bus lines.

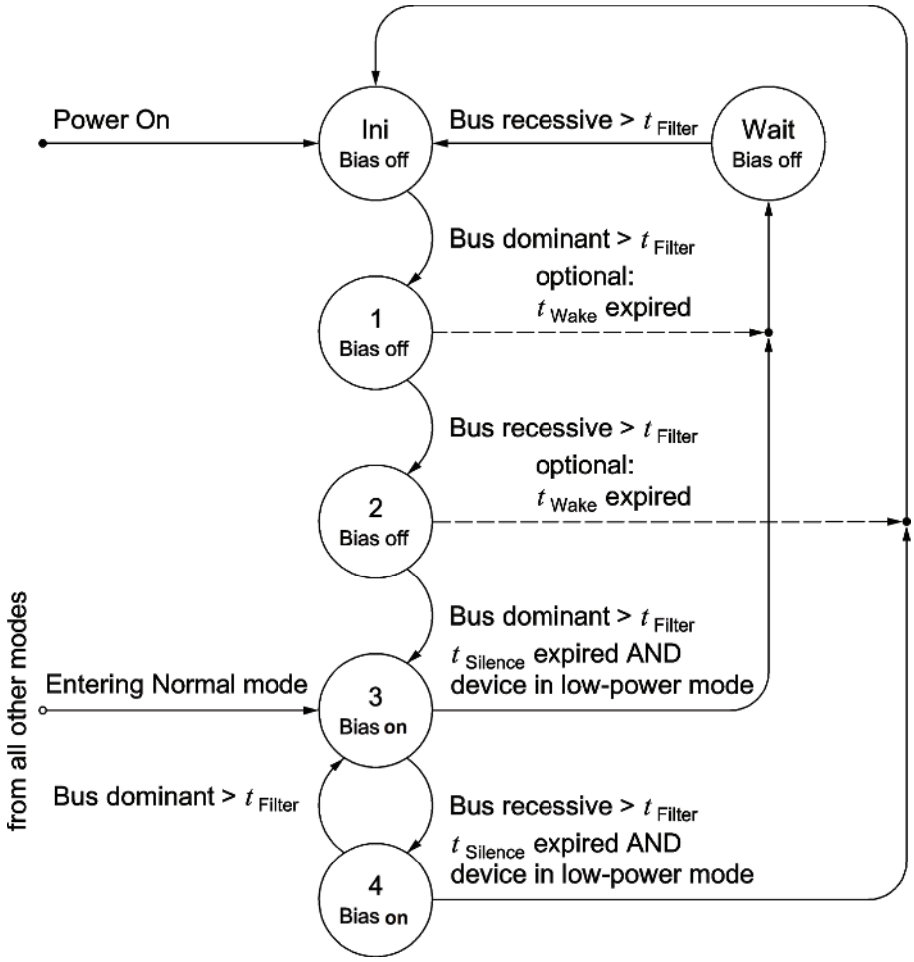
5.4.3.2 Automatic voltage biasing in low-power mode

Compared to the low-power mode behaviour described in ISO 11898-5, the voltage biasing in low-power mode is different.

If there has been no activity on the bus for longer than $t_{Silence}$, the bus lines shall be biased towards 0 V via the internal receiver input resistors R_{IN}.

If wake-up activity on the bus lines is detected (refer to 5.4.5.1), the bus lines shall be biased to 2,5 V via internal receiver input resistors R_{IN}. The biasing is activated not later than t_{Bias}.

Voltage biasing of the bus lines shall be possible, even if only the battery supply is connected to the transceiver.



NOTE The transition from state “Ini” via state 1 and state 2 to state 3 describes a wake-up pattern detection following the definition in ISO 11898-5.

Figure 4 — WUP detection and bias control

The detection of “bus dominant” and “bus recessive” depends on whether the transceiver is in normal mode or low-power mode; in low-power mode, the filter time t_{Filter} is applied. The state-machine in Figure 4 defines the biasing behaviour for all operation modes. When entering state 1 or 2, the optional timer t_{Wake} is reset and restarts; when entering state 3 or 4, the timer $t_{Silence}$ is reset and restarts.

From the physical point of view, there are two defined operating conditions: biasing towards 2,5 V (bias on), whenever bus communication is active, and biasing towards 0 V (bias off), whenever the bus communication is inactive. Biasing is done via the internal receiver input resistors R_{IN}.

While the bias is off, the optional split termination voltage (V_{Split}) output shall behave high-resistive (floating), in order not to increase the current consumption unnecessarily.

If biasing is turned off, WUP detection shall be active.

5.4.4 Behaviour during transition from normal to low-power mode

If selective wake-up is enabled, decoding of CAN data and remote frames shall also be supported during mode transitions. If the received frame is a valid WUF, the transceiver shall indicate a wake-up.

5.4.5 Wake-up out of low-power mode

5.4.5.1 Wake-up pattern

During low-power mode, a transceiver shall monitor the bus lines, CAN_H and CAN_L, for WUPs. A wake-up shall be performed if the selective wake-up function is disabled and a WUP has been received (i.e. being in state 3 or 4, see Figure 4).

The individual time thresholds (t_{Filter}, t_{Wake}, t_{Silence}) of the implementation can be adapted according to the target bit rate of the system. The time thresholds shall stay within the defined minimum and maximum timings as defined in Table 3.

5.4.5.2 Wake-up frame

5.4.5.2.1 General

A transceiver with selective wake-up function shall monitor the bus lines, CAN_H and CAN_L, for WUFs. A wake-up shall be performed if the selective wake-up function is enabled and a “valid WUF” has been received. After switching on the bias, the implementation can ignore up to four (or up to eight in case of a bit rate higher than 500 kbit/s) CAN data or remote frames and shall not ignore any following CAN data or remote frame.

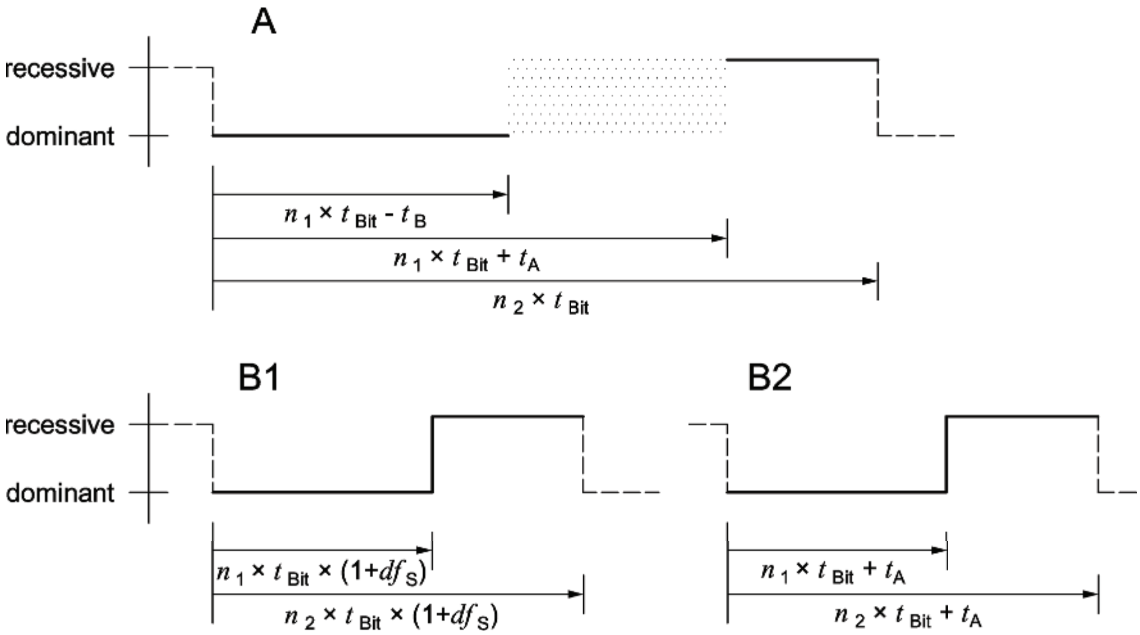
5.4.5.2.2 Bit decoding

A received frame shall be decoded correctly in case the timing of the analogue signal on the bus complies with one of the two following types of signals:

— the bit stream consists of multiple instances of the signal shape A (to handle ringing);

— the bit stream can be assembled out of multiple instances of the signal shape B1 and one instance of signal shape B2 (to handle sender clock tolerance and loss of arbitration).

These two types of signals are shown in Figure 5.



Key

n_1 number of consecutive dominant bits {1, 2, 3, 4, 5}

n_2 number of bits between two falling edges {2, 3, ..., 10}; $n_2 > n_1$

t_A $0 \le t_A \le 55$ % of t_{Bit} (product-specific higher maximum values for t_A are allowed)

t_B $0 \le t_B \le 5$ % of t_{Bit} (product-specific higher maximum values for t_B are allowed)

t_{Bit} bit time

df_S transceivers according to this part of ISO 11898 shall tolerate sender clock frequency deviations up to at least ±0,5 %

Figure 5 — Signal shape A and B of analogue signal on the bus for bit reception

Edges in the grey shaded time span of signal A shall be ignored and shall not cause decoding errors.

5.4.5.2.3 WUF validation

If all of the following conditions are met, a valid frame shall be accepted as a valid WUF.

— The received frame is a CAN data frame in case the optional data mask bit is set or not implemented. The frame might also be a remote frame in case the data mask bit is implemented and not set.

— The ID (as defined in 8.4.2.2 in ISO 11898-1) of the received CAN frame is exactly matching a configured ID (in the control unit) in the relevant bit positions. The relevant bit positions are given by an ID mask (in the control unit). See this mechanism illustrated in 5.4.5.2.5.

— The DLC (as defined in 8.4.2.3 in ISO 11898-1) of the received CAN data frame is exactly matching a configured DLC. Refer to 5.3.4 in case of an implementation of the optional data mask bit. See this mechanism illustrated in 5.4.5.2.6.

— In case the DLC is greater than 0, the data field (as defined in 8.4.2.4 in ISO 11898-1) of the received frame has at least one bit set in a bit position which corresponds to a set bit in the configured data mask. Refer to 5.3.4 in case of an implementation of the optional data mask bit. See this mechanism illustrated in 5.4.5.2.7.

— A correct cyclic redundancy check (CRC) has been received, including a recessive CRC delimiter and no error according to 10.9 in ISO 11898-1 is detected prior to the acknowledgement (ACK) Slot. Figure 6 depicts the bits which are considered as “don’t care”.

NOTE A CAN frame that is received with non-nominal substitute remote request (SRR) bit is accepted as a valid frame.

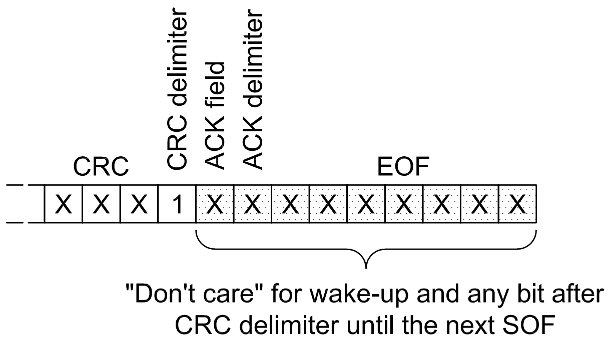


Figure 6 — "Don't care" bits for frame decoding

5.4.5.2.4 Frame error counter mechanism

Upon enabling the selective wake-up function and also on expiration of $t_{Silence}$, the counter for erroneous CAN frames shall be set to zero. The initial value of the counter is zero. This counter shall be incremented by one when a bit stuffing, CRC, or CRC delimiter form error according to ISO 11898-1 is detected. If a frame has been received, which is valid according to the definition in 5.4.5.2.2, and the counter is not zero, then the counter shall be decremented by one. Dominant bits between the CRC delimiter and the end of the intermission field shall not increase the error counter.

On each increment or decrement of the counter, the decoder unit in the transceiver shall wait for at least 6 and at most 10 recessive bits before considering a dominant bit as a start of frame. Figure 7 depicts the position of the mandatory start of frame (SOF) detection in case of a received CAN frame and in case of an error scenario.

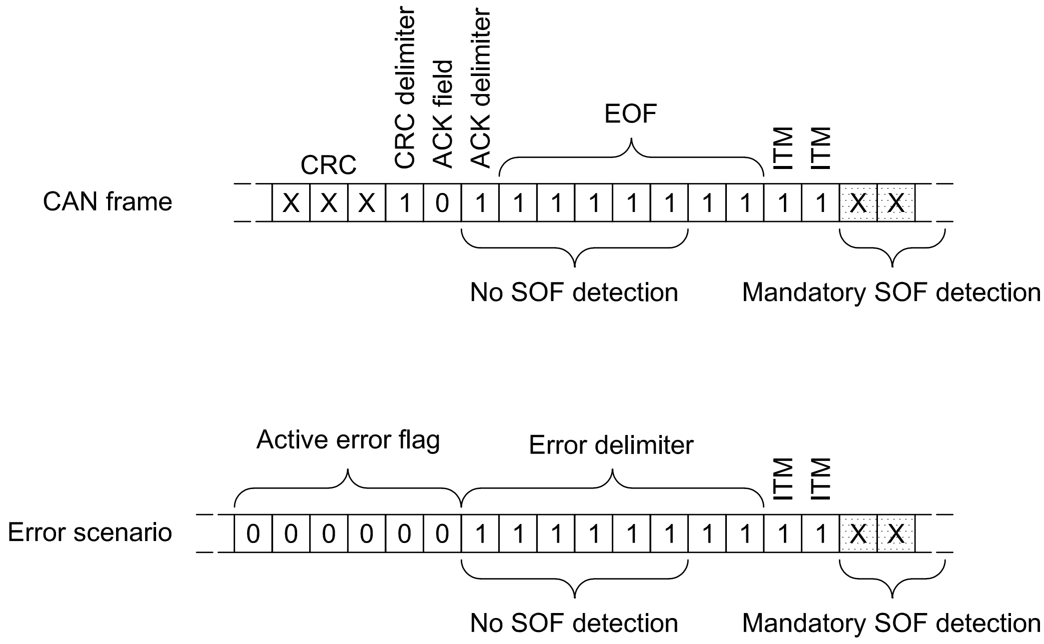


Figure 7 — Mandatory SOF detection after CAN frame and error scenario

If the frame error counter overflow threshold value is not implemented (see 5.3.2), a wake-up shall be performed on counter overflow with the 32nd increment immediately or upon the next received WUP. If the frame error counter overflow threshold value is implemented, a wake-up shall be performed on counter overflow immediately or upon the next received WUP.

Up to four (or up to eight in case of data rate > 500 kbit/s) consecutive CAN data and remote frames that start after switching on the bias might be either ignored (no error counter increase in case of failure) or judged as erroneous (error counter increase even in case of no error).

If bit r0 and r1 values are inconsistent to ISO 11898-1 is not in the scope of this part of ISO 11898.

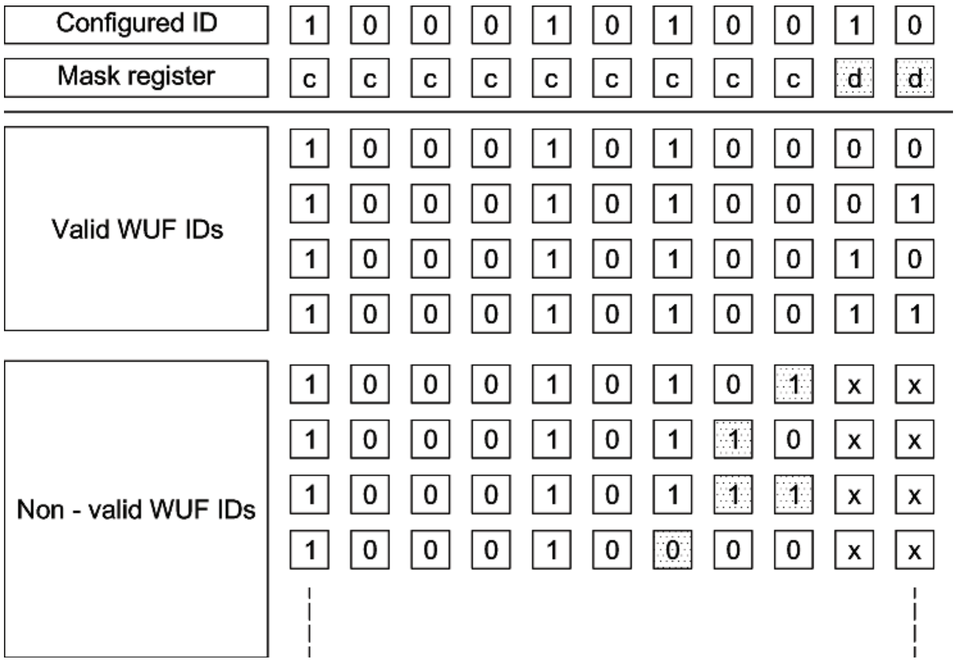
5.4.5.2.5 WUF ID evaluation

A CAN-ID mask mechanism shall be supported to exclude ID-bits from comparison. 11-bit and 29-bit CAN-IDs and ID-masks shall be supported.

All masked ID bits except "don't care" shall match exactly the configured ID bits. If the masked ID bits are configured as "don't care", then both "1" and "0" shall be accepted.

Either "1" or "0" may represent "do not care" in the mask register.

Figure 8 shows an example for valid WUF IDs corresponding to the ID mask register.



Key

d "don't care"

c "care"

Figure 8 — Example for ID masking mechanism

5.4.5.2.6 WUF DLC evaluation

If the DLC is configured to be part of the WUF evaluation (refer to 5.3.4), then a frame can only be a valid WUF when the DLC of the received frame matches exactly the configured DLC.

5.4.5.2.7 WUF data field evaluation

A frame can only be a valid WUF if at least one logic 1 bit within the data field of the received WUF matches to a logic 1 of the data field within the configured WUF.

Figure 9 shows an example with a non-matching and a matching ID field.

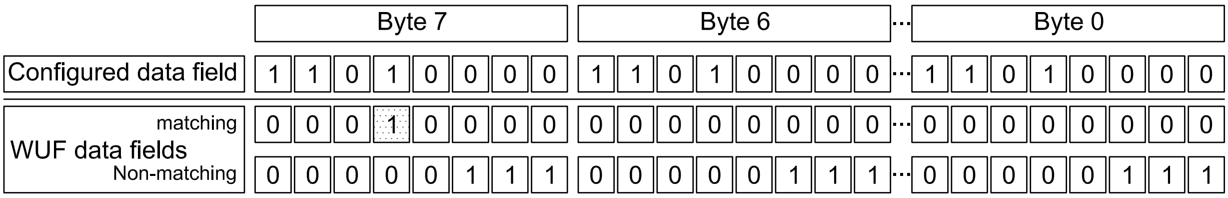


Figure 9 — Example of the data field within the received CAN frame

With this mechanism, it is possible to wake-up up to 64 independent groups of ECUs with only one wake-up frame.

6 Conformance tests

The conformance test case definition and measurement setups to derive the parameters are not in the scope of this part of ISO 11989.

7 Electrical specification of high-speed medium access unit (HS-MAU)

7.1 Physical medium attachment sublayer specification

7.1.1 Bus levels

All parameters according to bus levels are specified in ISO 11898-2:2003 and ISO 11898-5:2007.

7.1.2 Disturbance by coupling

The tolerated disturbances of CAN_H and CAN_L by coupling are defined in accordance with ISO 7637-3:1990, test pulses 3a and 3b.

7.2 CAN transceiver

7.2.1 General

All data given in Tables 1 and 2 are independent of a specific physical layer implementation. The parameters specified in these tables shall be fulfilled throughout the operating temperature range as specified for every individual CAN node.

Table 1 defines the transceiver input leakage current at the bus pins if the transceiver is unpowered.

Table 1 — Transceiver input current (unpowered)

Parameter	Notation	Unit	Value			Condition
			min.	nom.	max.	
Input leakage current	I_{CAN_H}	µA	−10	—	+10	CAN_H and CAN_L = 5 V, all supply voltages are shorted to GND.
	I_{CAN_L}	µA	−10	—	+10	

7.2.2 Transceiver input and output levels

The parameters given in Table 2 shall be tested at the CAN_L and CAN_H pins of each CAN node, according to the conformance tests as specified in Clause 6 of ISO 11898-5:2007 and Clause 6 of ISO 11898-2:2003.

All other transceiver input and output levels are specified in ISO 11898-2:2003 and ISO 11898-5:2007.

Table 2 — Transceiver DC parameters for recessive state

Parameter	Notation	Unit	Value			Condition
			min.	nom.	max.	
Differential input voltage, normal mode[a]	V_{diff_N}	V	—	—	0,5	[b c]
Differential input voltage, low-power mode[c]	V_{diff_LP}	V	—	—	0,4	[b c]

[a] The threshold for receiving the dominant and recessive bits ensures a noise immunity of 0,3 V and 0,5 V, respectively. The lower value for the dominant state is motivated by the fact that a lower load resistance between CAN_H and CAN_L is seen (the capacitance of the supply voltage source is the reason that the internal resistance of the bus driver driving the dominant bit is connected in parallel to the bus load resistance).

[b] Range for receiving a recessive bit.

[c] Reception shall be ensured within the common mode voltage range specified in Table 1 in ISO 11898-5:2007 and Table 2 in ISO 11898-5:2007, respectively.

7.2.3 AC parameters

The parameters given in Table 3 shall be tested at the CAN_L and CAN_H pins of each CAN node, according to conformance tests 6.6 in ISO 11898-2:2003 and 6.5 and 6.6 described in ISO 11898-5:2007.

Table 3 — Transceiver AC parameters

Parameter	Notation	Unit	Value			Condition
			min.	nom.	max.	
Bit time	t_B	cf. ISO 11898-5:2007, Table 11				
Propagation delay TXD to RXDrec. to dom. / dom. to rec.	t_{Prop}					
CAN activity filter time	t_{Filter}	µs	0,5	—	5[a]	low-power mode, R_L = 60 Ω, UCM according to Table 2 in ISO 11898-5:2007 (min and max. common mode bus voltage), I has to guarantee a differential dominant voltage according to Table 2 in ISO 11898-5:2007 with a variable pulse length $t_{Pulse} = t_{Filter(min)} \dots t_{Filter(max)}$
Bias reaction time	t_{Bias}	µs	—	—	200	load R_L = 60 Ω; C_L = 100 pF; C_{GND} = 100 pF
Wake-up time out	t_{Wake}	ms	0,5	—	10	This parameter is optional.
Timeout for bus inactivity	$t_{Silence}$	s	0,6	—	1,2	
Internal capacitance	C_{in}	cf. ISO 11898-5:2007, Table 11				
Differential internal capacitance	C_{diff}					

[a] It should be noted that the max. filter time has an impact to the suitable wake-up messages, especially at high baud rates. For example, for a 500 kBit/s system, a message needs to carry at least three similar bit levels in a row in order to safely pass the wake-up filter. Shorter filter time implementations might increase the risk for unwanted wake-ups due to noise. The specified range is a compromise between robustness against unwanted wake-ups and freedom in message selection.

Bibliography

[1] ISO 7498-1, *Information technology — Open Systems Interconnection — Basic reference model: The Basic Model*

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Useful Contacts:

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Knowledge Centre
Tel: +44 20 8996 7004
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BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

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