TJA1445

High-speed CAN transceiver with partial networking

Rev. 0.3 — 14 June 2023

Objective data sheet
CONFIDENTIAL

1 General description

The TJA1445 is a high-speed CAN transceiver that provides an interface between a controller area network (CAN) or CAN FD (flexible data rate) protocol controller and the physical two-wire CAN bus. TJA1445 transceivers implement the CAN physical layer as defined in ISO 11898-2:2016 and SAE J2284-1 to SAE J2284-5, making them fully interoperable with high-speed classical CAN and CAN FD transceivers. The TJA1445 was developed in compliance with ISO26262, achieving ASIL-B.

The TJA1445 features very low power consumption in Standby and Sleep modes. It supports CAN partial networking by means of selective wake-up functionality as specified in ISO11898-2:2016, making the TJA1445 the ideal choice for CAN system implementations where only nodes that are needed can be activated at any time. Nodes that are not needed for the function being performed can be powered down to minimize system power consumption, even when CAN bus traffic is running.

The TJA1445 includes an SPI for configuration, mode control and diagnostics. The TJA1445B additionally features three general-purpose I/O pins (GPIO) and a CAN transmitter enable/disable input.

The TJA1445 can be configured to ignore CAN FD frames while waiting for a valid wake-up frame. This additional feature of partial networking, called CAN FD passive, is the perfect fit for networks that support classical CAN or CAN FD communications. It allows classical CAN controllers that do not need to communicate CAN FD messages to remain in partial networking Sleep/Standby mode during CAN FD communication without generating bus errors.

2 Features and benefits

2.1 General

- ISO 11898-2:2016, SAE J2284-1 to SAE J2284-5 and SAE J1939-14 compliant
- ISO 26262, ASIL-B compliant
- Partial networking capability through selective wake-up functionality
- Configurable general-purpose I/O (GPIO) pins (TJA1445B)
- Second RXD and/or TXD pins (RXD2/TXD2), configurable via GPIO (TJA1445B)
- Direct transmitter on/off control input (TXEN_N) (TJA1445B)
- Autonomous bus biasing
- Low electromagnetic emission (EME) and high electromagnetic immunity (EMI)
- Qualified according to AEC-Q100 Grade 1
- VIO input for interfacing with 1.8 V, 3.3 V to 5 V microcontrollers
- Listen-only mode for node diagnosis and failure containment
- TJA1445A available in an SO14 package and leadless HVSON14 package with automatic optical inspection (AOI) capabilities
- TJA1445B available in a DHVQFN18 package with automatic optical inspection (AOI) capabilities
- Dark green product (halogen free and restriction of hazardous substances (RoHS) compliant)
- Selectable interrupts on RXD; option to signal only wake-up and power-on related interrupts or all interrupts

- 4-byte general-purpose memory
- SPI system reset
- End-of-line microcontroller flashing support through CAN pins
- Selectable WAKE pin filter time

2.2 Predictable and fail-safe behavior

- Undervoltage detection on all supply pins with defined behavior below the undervoltage thresholds
- Full functionality guaranteed from the undervoltage detection thresholds up to the maximum limiting voltage values
- Transceiver disengages from the bus (high-ohmic) when the battery voltage drops below the Off mode threshold
- Internal biasing of TXD to enable defined fail-safe behavior

2.3 Low-power management

- Very low-current Standby and Sleep modes, with host, local and remote wake-up capability
- Local wake-up via the WAKE pin
- Remote wake-up via a wake-up pattern (WUP) or wake-up frame (WUF)
- Configurable CAN wake-up pattern (dom-rec-dom according ISO11898-2:2016 or dom-rec-dom-rec according to upcoming ISO11898-2:2023 update)
- Wake-up frame according to ISO 11898-1:2016
- Entire node containing the TJA1445 can be powered down via INH while still supporting local and remote wake-up
- Only V_{BAT} is needed to support local and remote wake-up

2.4 Diagnosis and Protection

- Overtemperature diagnosis and protection
- Transmit data (TXD) dominant time-out diagnosis
- Bus dominant failure diagnosis
- Cold start diagnosis (first battery connection)
- High ESD handling capability on the bus pins (8 kV IEC and 8 kV HBM)
- Bus pins and VBAT protected against automotive transients

3 Ordering information

Table 1. Ordering information

Type number	Package		
	Name	Description	Version
TJA1445AT	SO14	plastic small outline package; 14 leads; body width 3.9 mm	SOT108-1
TJA1445ATK	HVSON14	plastic thermal enhanced very thin small outline package; no leads; 14 terminals; body 3 × 4.5 × 0.85 mm	SOT1086-2
TJA1445BHG	DHVQFN18	plastic thermal enhanced very thin small outline package; no leads; 18 terminals; body 3 × 4.5 × 0.85 mm	SOT2163-1

4 Block diagram

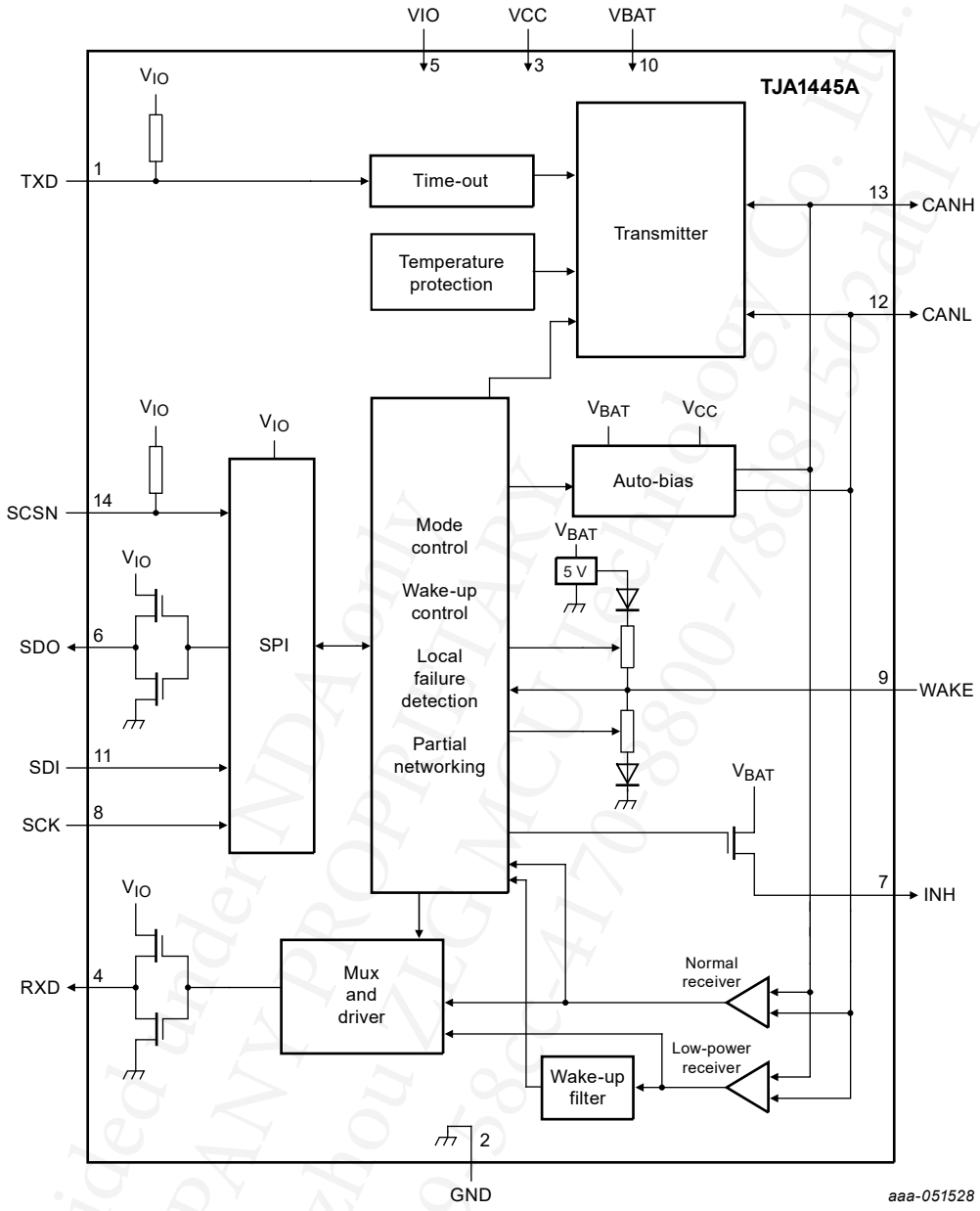


Figure 1. Block diagram: TJA1445A

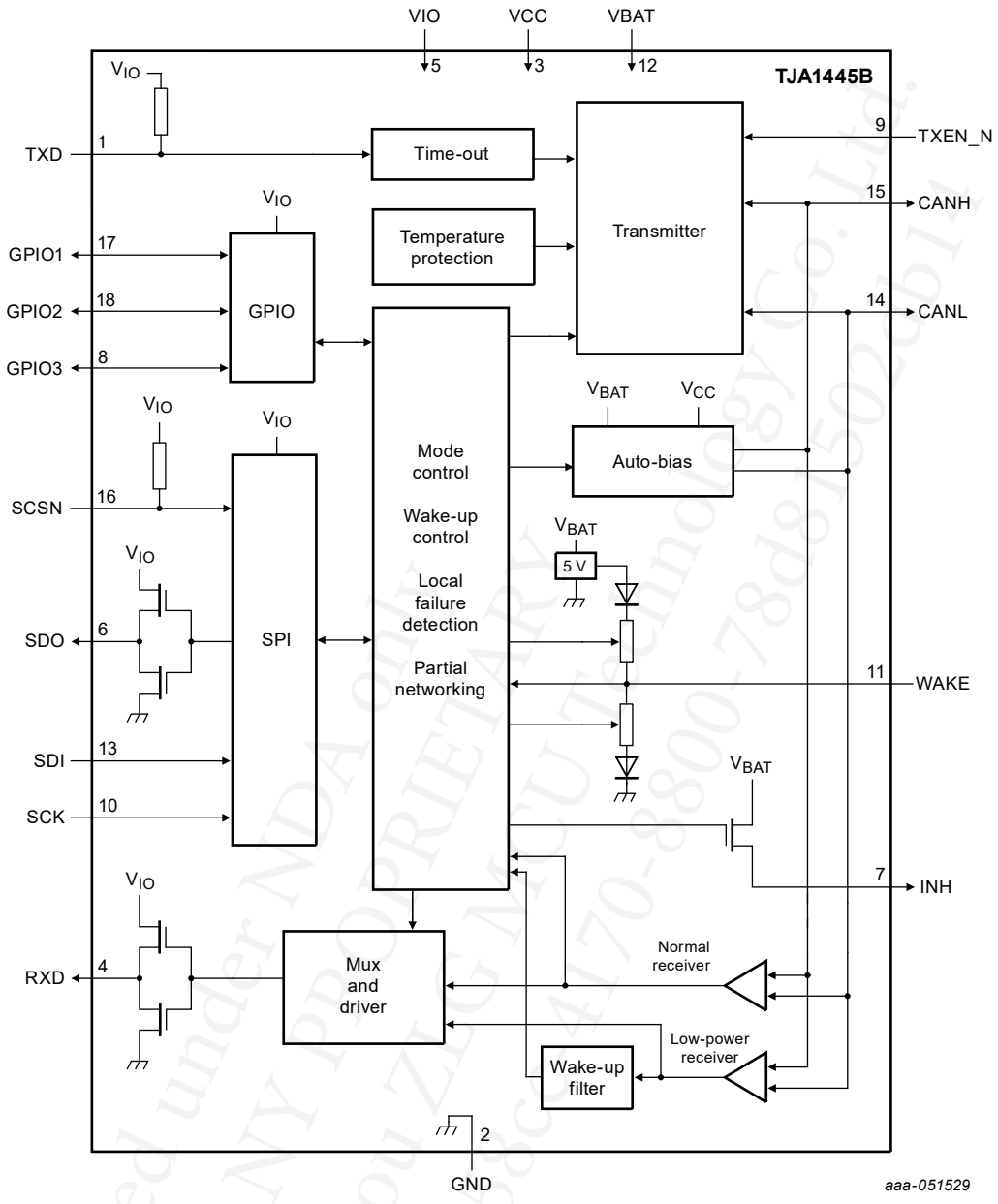


Figure 2. Block diagram: TJA1445B

5 Pinning information

5.1 Pinning

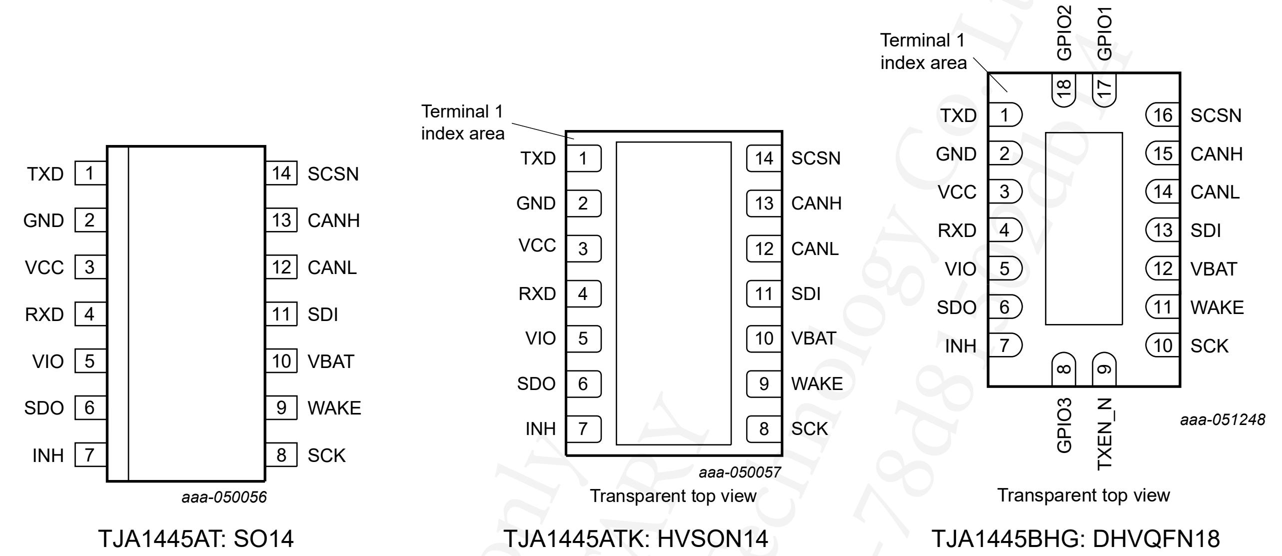


Figure 3. Pin configuration diagrams

5.2 Pin description

Table 2. Pin description: TJA1445A

Symbol	Pin	Type[1]	Description
TXD	1	I	transmit data input
GND[2]	2	G	ground
VCC	3	P	5 V supply voltage input
RXD	4	O	receive data output
VIO	5	P	supply voltage input for I/O level adapter
SDO	6	I	SPI data output
INH	7	AO	inhibit output for switching external voltage supplies or indicating wake-up from Sleep mode (active-HIGH)
SCK	8	I	SPI clock input
WAKE	9	AI	local wake-up input
VBAT	10	P	battery supply voltage input
SDI	11	I	SPI data input
CANL	12	AIO	LOW-level CAN bus line
CANH	13	AIO	HIGH-level CAN bus line
SCSN	14	I	SPI chip select input (active-LOW)

[1] I: digital input; O: digital output; AI: analog input; AO: analog output; AIO: analog input/output; P: power supply; G: ground.

[2] HVSON14 package die supply ground is connected to both the GND pin and the exposed center pad. The GND pin must be soldered to board ground. For enhanced thermal and electrical performance, it is also recommended to solder the exposed center pad to board ground.

Table 3. Pin description: TJA1445B

Symbol	Pin	Type[1]	Description
TXD	1	I	transmit data input
GND[2]	2	G	ground
VCC	3	P	5 V supply voltage input
RXD	4	O	receive data output
VIO	5	P	supply voltage input for I/O level adapter
SDO	6	I	SPI data output
INH	7	AO	inhibit output for switching external voltage supplies or indicating wake-up from Sleep mode (active-HIGH)
GPIO3	8	I/O	general purpose input/output 3
TXEN_N	9	I	CAN transmitter enable/disable input (active-LOW)
SCK	10	I	SPI clock input
WAKE	11	AI	local wake-up input
VBAT	12	P	battery supply voltage input
SDI	13	I	SPI data input
CANL	14	AIO	LOW-level CAN bus line
CANH	15	AIO	HIGH-level CAN bus line
SCSN	16	I	SPI chip select input (active-LOW)
GPIO1	17	I/O	general purpose input/output 1
GPIO2	18	I/O	general purpose input/output 2

[1] I: digital input; O: digital output; AI: analog input; AO: analog output; AIO: analog input/output; P: power supply; G: ground.
[2] DHVQFN18 package die supply ground is connected to both the GND pin and the exposed center pad. The GND pin must be soldered to board ground. For enhanced thermal and electrical performance, it is also recommended to solder the exposed center pad to board ground.

6 Functional description

6.1 Supply

Table 4. Supply description

Supply	Description
V_{BAT}	Main supply for the device, needed for all internal processes; supplies the CAN receivers
V_{CC}	Supply for the CAN transmitter and for bus biasing in Normal mode
V_{IO}	Reference level for the digital interface pins TXD and RXD, the SPI interface, TXEN_N and the GPIO pins

6.2 System operating modes

Table 5 contains a summary of the system finite state machine (FSM_MAIN) operating modes. A mode transition diagram is shown in Figure 4. Mode changes are completed after transition time $t_{t(moch)}$. Abbreviations used in the mode transition diagram are defined in Table 6.

Table 5. FSM_MAIN operating modes

Operating mode	Description
Off	The device switches to Off mode and is deactivated as a result of a low supply level on pin VBAT.
Boot	The device starts up and loads the configuration in Boot mode (it switches to Check_SNM mode after $t_{startup}$).
Check_SNM	The CAN bus is checked for a dominant state meeting Start-to-Normal mode (SNM) transition conditions.
Standby	Standby mode is the first-level low-power mode of the transceiver.
Sleep	Sleep mode is the second-level low-power mode of the transceiver. In this mode, pin INH is typically used to shut down the power supply to the host controller. Wake-up requests via the CAN bus or the local WAKE pin can be received in Sleep mode (if associated interrupts are enabled; see Table 35).
ListenOnly	In ListenOnly mode, only the CAN receiver is active.
Normal	Full transceiver and receiver capability is enabled in Normal mode.

Table 6. State diagram legend

Category	Abbreviation	Definition
VBAT pin status	BAT_UV	$V_{BAT} < V_{uvd(VBAT)}$ for $t > t_{det(uv)VBAT}$
	BAT_OK	$V_{BAT} > V_{uvd(VBAT)}$ for $t > t_{rec(uv)VBAT}$
Memory check during boot phase	BOOT_OK	passed internal memory consistency check
	BOOT_FAIL	failed internal memory consistency check
Start-to-Normal mode check	SNM	CAN bus must remain dominant for $t > t_{t(snm)}$ in Check_SNM mode; device switches to Normal mode (MC = Normal); SNMS = 1
	NO_SNM	CAN bus recessive in CHECK_SNM mode; device switches to Standby mode (MC = Standby); SNMS = 0
Wake-up request status	WAKEUP	valid local (WAKE) or remote (WUP/WUF) wake-up trigger received
	NO_WAKEUP	no valid local or remote wake-up trigger received
Wake-up source selection	WAKESOURCE_SELECTED	local (WAKE/GPIO) and/or remote wake-up source selected
Temperature status	NO_OVERTEMP	$T_j < T_{j(sd)rel}$
	OVERTEMP	$T_j > T_{j(sd)}$
Long V_{io} indervoltage detection	LONG_VIO	$V_{IO} < V_{uvd(VIO)}$ for $t > t_{det(uv)long}$
MCU reaction timeout	MCU_REAC_EXP	no SPI activity for $t > t_{to(MCU)}$
Mode select	MC_NORMAL	Normal mode (MC = 1111)
	MC_STANDBY	Standby mode (MC = 0110)
	MC_SLEEP	Sleep mode (MC = 0001)
	MC_LISTENONLY	ListenOnly mode (MC = 1000)

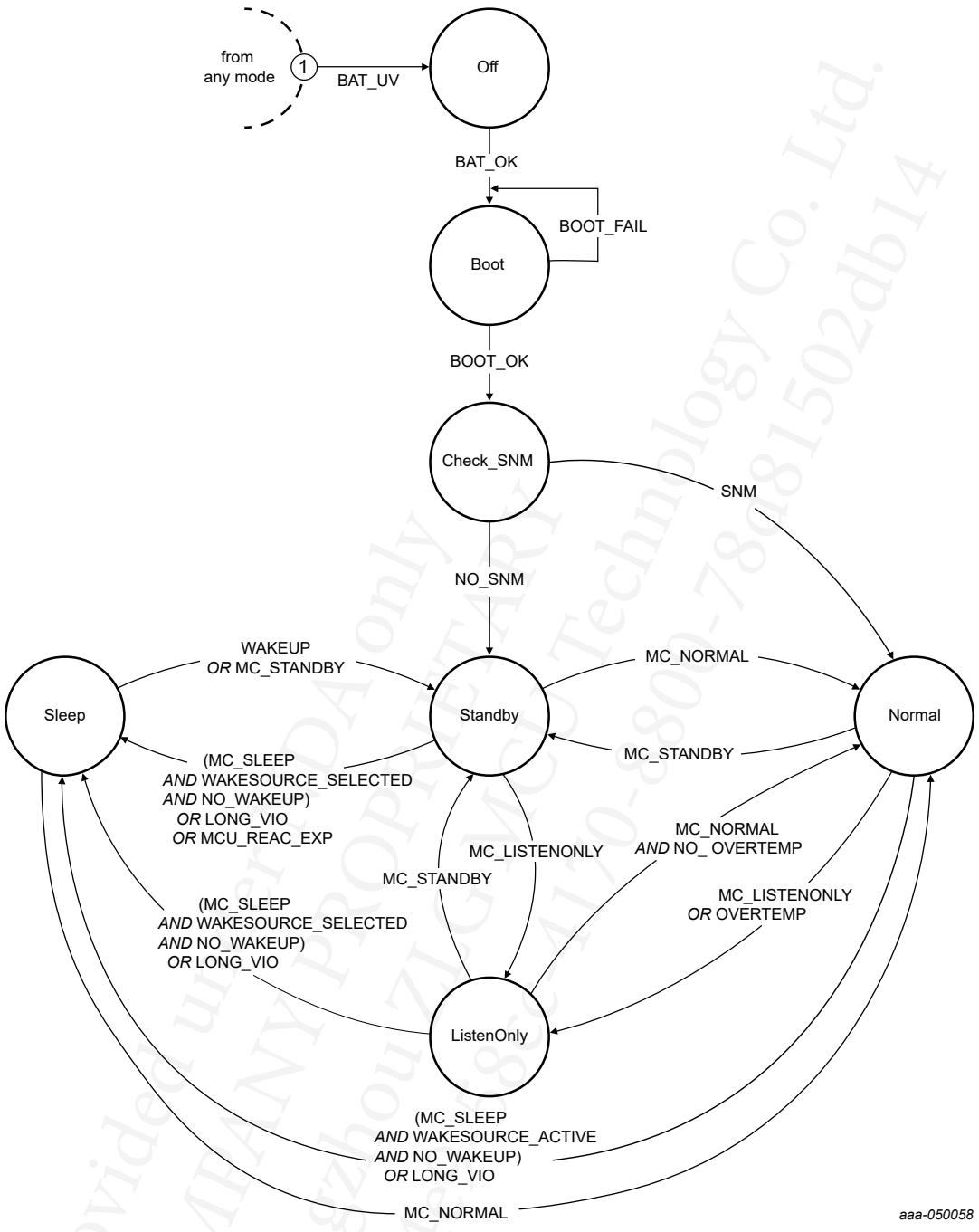


Figure 4. System state diagram (FSM_MAIN)

In the state diagram, all transitions are mutually exclusive. A battery undervoltage overrides any transition, indicated by '1' (priority 1) in Figure 4.

When the device powers up, the CAN bus is checked (in Check_SNM mode) for a bus dominant condition lasting longer than the start normal mode transition time ($t_{(snm)}$). When this condition is met (SNM), the devices switches to Normal mode, without the need for an SPI mode change command.

6.2.1 Pin and functional block states per operating mode

Table 7. Pin state per operating mode

All supplies within operating range with no error condition present.

Pin	Off/Boot/Check_SNM	Sleep	Standby	ListenOnly	Normal
TXD	high-Z	pull-up to V_{IO}	pull-up to V_{IO}	pull-up to V_{IO}	pull-up to V_{IO}
RXD	high-Z	V_{IO} or GND when interrupt pending[1]	V_{IO} or GND when interrupt pending[1]	CAN bus status	CAN bus status
SDO	high-Z	high-Z when SCSN HIGH	high-Z when SCSN HIGH	high-Z when SCSN HIGH	high-Z when SCSN HIGH
INH	high-Z	high-Z	V_{BAT}	V_{BAT}	V_{BAT}
SCK	high-Z	repeater	repeater	repeater	repeater
SDI	high-Z	repeater	repeater	repeater	repeater
SCSN	high-Z	pull-up to V_{IO}	pull-up to V_{IO}	pull-up to V_{IO}	pull-up to V_{IO}
TJA1445B only					
GPIO1	high-Z	GPIO	GPIO	GPIO	GPIO
GPIO2	high-Z	GPIO	GPIO	GPIO	GPIO
GPIO3	high-Z	GPIO	GPIO	GPIO	GPIO
TXEN_N	GND	pull-up to V_{IO}	pull-up to V_{IO}	pull-up to V_{IO}	pull-up to V_{IO}

[1] Interrupt pending: at least one bit set in one or more interrupt status registers (see Section 6.10.10).

Table 8. Functional state per System operating mode

Function	SPI configuration	Off/Boot/Check_SNM	Sleep	Standby	ListenOnly	Normal
SPI		off	on	on	on	on
CAN		high-Z	GND or 2.5 V bias (autobias)	GND or 2.5 V bias (autobias)	2.5 V bias and RX active	2.5 V bias and TX active
Local wake-up		off	on	on	on	on
CAN wake-up	PNCOK = 0	off	on	on	off	off
	PNCOK = 1	off	off	off	off	off
Partial networking	PNCOK = 0	off	off	off	off	off
	PNCOK = 1	off	on	on	on	on
Overtemp[1]		off	off	off	off	on

[1] Overtemperature detection remains active after a transition from Normal mode to ListenOnly mode due to an overtemperature condition.

6.2.2 Local wake-up via the WAKE pin

The device monitors the WAKE pin and can be configured to respond on a rising and/or falling edge:

- A WPR interrupt is generated on a rising edge if WPRE = 1 (see Table 35)
- A WPF interrupt is generated on a falling edge if WPFE = 1 (see Table 35)

The wake-up detection filter time, the pulse width needed to trigger a wake-up event (t_{wake}), is configured via bit WFC in Table 34. The WAKE pin status can be read via bit WPS in the System status register (Table 16). The GPIO pins on the TJA1445B can also be configured as V_{IO} level wake pins (see Section 6.8).

6.3 CAN operating modes

Table 9 contains a summary of the CAN finite state machine (FSM_CAN) operating modes. A mode transition diagram is shown in Figure 5. Abbreviations used in the mode transition diagram are defined in Table 10.

Table 9. CAN operating modes

Operating mode	Description
CAN Off	The CAN transceiver is disconnected from the bus (high-Z)
CAN Offline	The CAN transceiver is in a low-power mode, able to react to a wake-up pattern (WUP) on the bus
CAN OfflineBias	The CAN transceiver is in a low-power mode, able to react to a wake-up pattern (WUP) or wake-up frame (WUF) on the bus
CAN ListenOnly	Only the CAN receiver is active, the RXD pin reflects the CAN bus status and is able to capture a wake-up frame (WUF)
CAN Active	The CAN transceiver is active and able to capture a wake-up frame (WUF).

Table 10. State diagram legend

Category	Abbreviation	Definition
CAN bus events	BUSSILENCE	CAN bus idle for $t > t_{to(silence)}$
	WUP	valid CAN wake-up pattern detected
VCC pin status	VCC_OK	$V_{CC} > V_{uvd(VCC)}$ for $t > t_{rec(uv)}$
	VCC_UV	$V_{CC} < V_{uvd(VCC)}$ for $t > t_{det(uv)}$

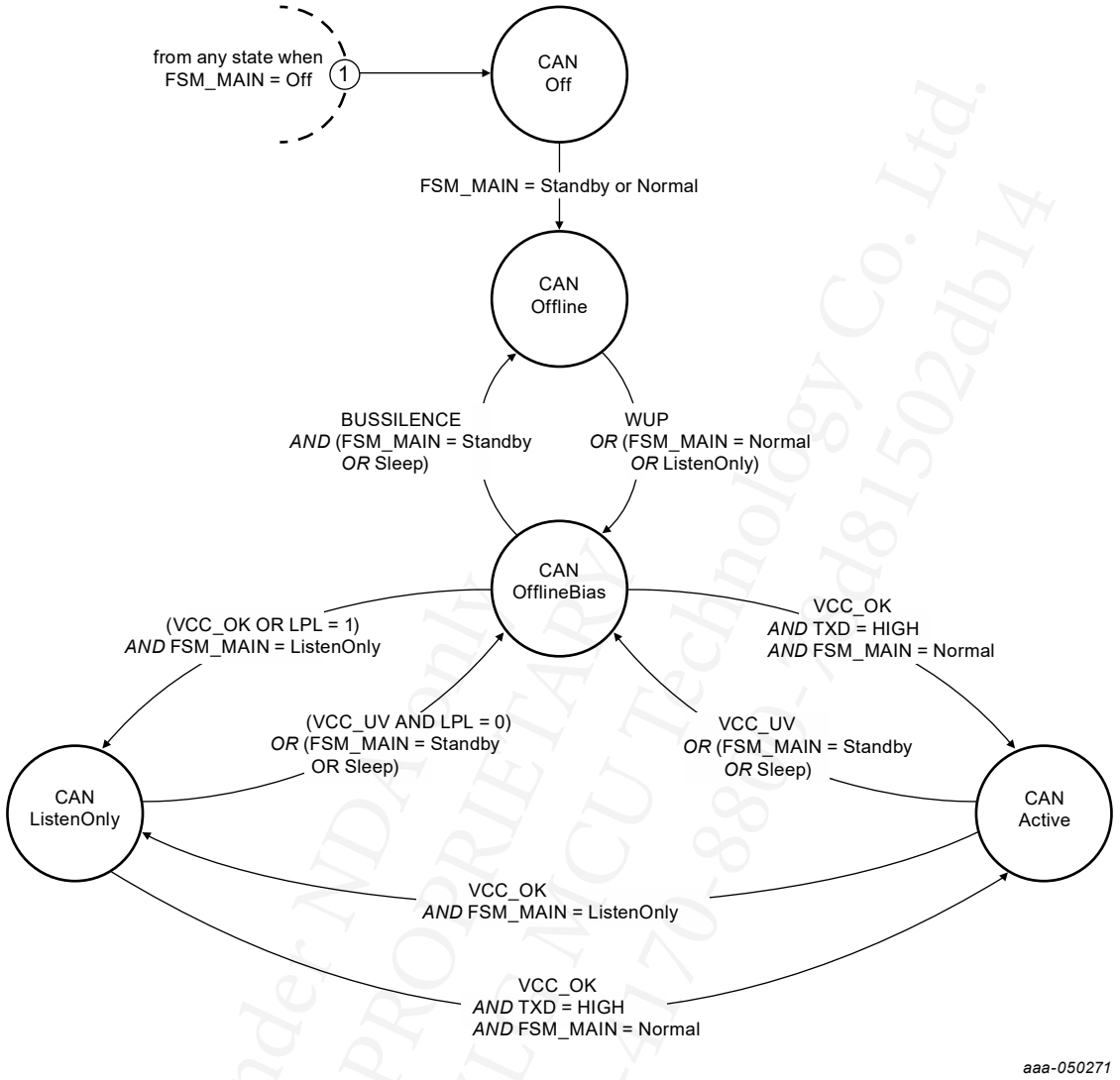


Figure 5. CAN state diagram (FSM_CAN)

All transitions are mutually exclusive. A battery undervoltage overrides any transition, indicated by '1' (priority 1) in Figure 5.

6.3.1 Functional block state per CAN operating mode

Table 11. Functional block state per CAN operating mode

Block	SPI configuration	CAN Off	CAN Offline	CAN Offline Bias	CAN Listen Only	CAN Active
CAN transmitter	LPL = 0	off	off	off	recessive	active [1]
	LPL = 1	off	off	off	off	active [1]
CAN receiver		off	off	off	active	active

Table 11. Functional block state per CAN operating mode*...continued*

Block	SPI configuration	CAN Off	CAN Offline	CAN Offline Bias	CAN Listen Only	CAN Active
CAN bias	VBATVCC = 1	high-Z	GND	$V_{CC}/2$	$V_{CC}/2$	$V_{CC}/2$
	LPL = 0 and VBATVCC = 0	high-Z	GND	2.5 V derived from V_{BAT}	$V_{CC}/2$	$V_{CC}/2$
	LPL = 1 and VBATVCC = 0	high-Z	GND	2.5 V derived from V_{BAT}	2.5 V derived from V_{BAT}	$V_{CC}/2$

[1] If TXEN_N is HIGH in TJA1445B, status will be recessive

6.3.2 CAN wake-up

The TJA1445 supports remote wake-up via a CAN wake-up pattern (WUP) or selective wake-up via a CAN wake-up frame (WUF).

6.3.2.1 CAN wake-up pattern (WUP)

The CAN wake-up pattern (WUP) is used for two purposes:

- To activate CAN biasing in CAN Offline mode (transition from CAN offline to CAN OfflineBias)
- To trigger a CAN wake-up event

The following conditions must be met to trigger a wake-up event via a CAN WUP:

- The CAN transceiver is in CAN Offline or CAN OfflineBias mode
- CAN wake-up enabled (CWE = 1)
- CAN wake-up frame detection (WUF) deactivated (CPNC = 0 or PNCOK = 0)

The TJA1445 supports both the standard (ISO11898-2:2016) and the extended (anticipated from the ISO11898-2:2023 update) wake-up patterns (see Figure 6 and Figure 7). The WUP is selected via bit CWC in the CAN configuration register (Table 18).

The wake-up pattern consists of:

[ISO11898-2:2016 standard WUP]

- a dominant phase of at least $t_{wake(busdom)}$ followed by
- a recessive phase of at least $t_{wake(busrec)}$ followed by
- a dominant phase of at least $t_{wake(busdom)}$

[ISO11898-2:2023 WUP extension]

- followed by a recessive phase of at least $t_{wake(busrec)}$

Dominant or recessive bits between the phases shorter than $t_{wake(busdom)}$ or $t_{wake(busrec)}$, respectively, are ignored.

The complete dominant-recessive-dominant (standard WUP) or dominant-recessive-dominant-recessive (WUP extension) pattern must be received within $t_{to(wake)bus}$ to be recognized as a valid wake-up pattern (see Figure 6 and Figure 7). Otherwise, the internal wake-up logic is reset. The complete wake-up pattern then needs to be retransmitted to trigger a wake-up event.

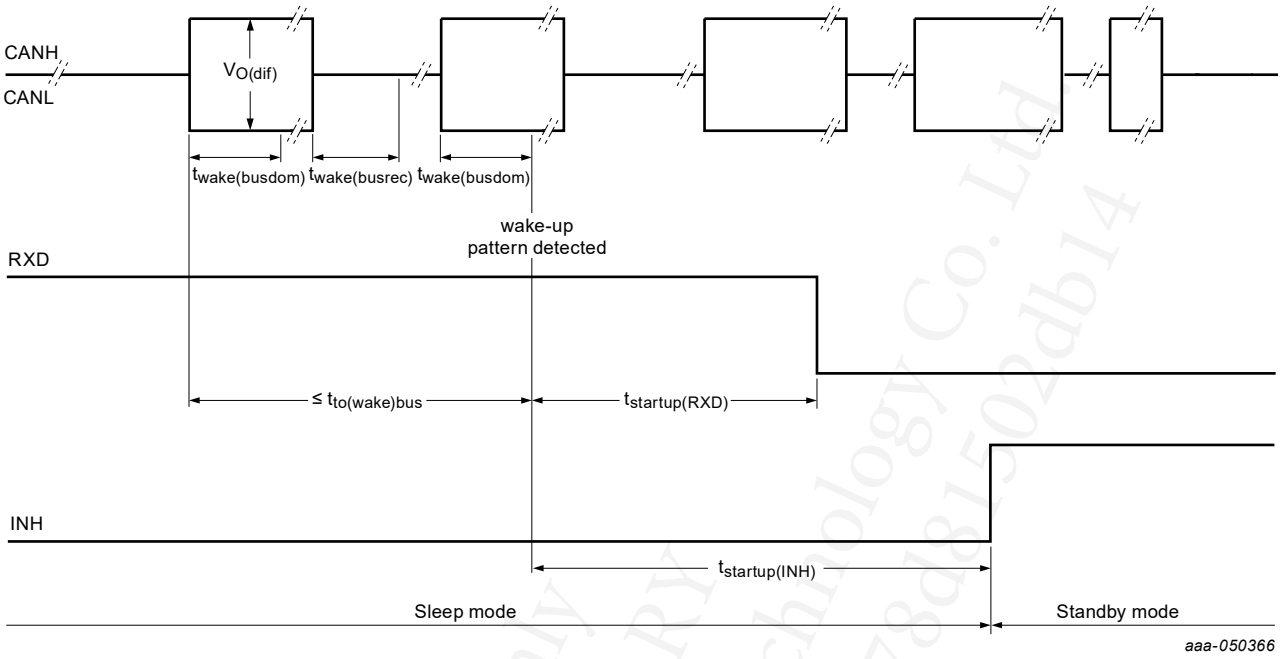


Figure 6. Standard wake-up pattern in Sleep mode with CWE = 1, PNCOK = 0 and CWC = 0

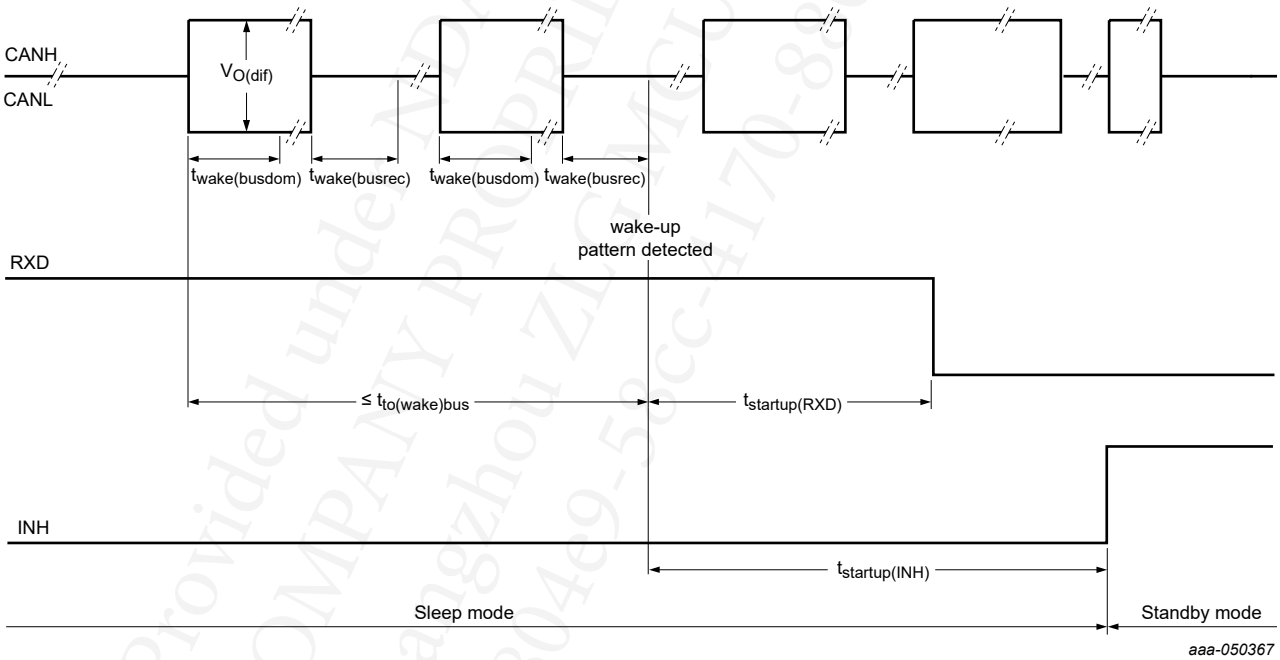


Figure 7. Extended wake-up pattern in Sleep mode with CWE = 1, PNCOK = 0 and CWC = 1

6.3.2.2 CAN wake-up frame (WUF)

CAN partial networking through selective wake-up detection allows a device in a CAN network to be selectively woken up in response to a dedicated wake-up frame (WUF) on the CAN bus.

Selective wake-up detection uses one of two filtering methods:

- Identifier-only filtering (PNDM = 0)
- Identifier + data mask filtering (PNDM = 1)

The following conditions must be met to enable CAN WUF functionality:

- The FSM_CAN is in CAN OfflineBias, CAN ListenOnly, or CAN Active mode
- CAN wake-up enabled (CWE = 1)
- CAN partial networking configured correctly (PNCOK = 1)
- CAN partial networking enabled (CPNC = 1)
- No CAN partial networking error detected (CPNERRS = 0)

The TJA1445 clears PNCOK after a further write access to one or more of the CAN partial networking configuration registers:

- Partial networking data rate and filter configuration register (Table 31)
- Partial networking frame control register (Table 30)
- Partial networking data mask registers (Table 29)
- Partial networking ID registers (Table 27)
- Partial networking ID mask registers (Table 28)
- Partial networking and CAN configuration register (Table 32)

Storing a new configuration involves multiple write cycles to the registers; setting PNCOK signals to the device that the configuration has been loaded.

The arbitration bit rate is selected via bits CDR (see Table 31). CAN bit rates of 50 kbit/s, 100 kbit/s, 125 kbit/s, 250 kbit/s, 500 kbit/s, 667 kbit/s and 1000 kbit/s are supported during selective wake-up.

6.3.2.2.1 Identifier matching

The wake-up frame format, standard (11-bit) or extended (29-bit) identifier, is selected via bit IDE in the frame control register (Table 30).

- IDE = 0: standard CBFF (classical base frame format, 11-bit)
- IDE = 1: extended CEFF (classical extended frame format, 29-bit)

A valid WUF identifier is defined and stored in the ID registers (Table 27). An ID mask can be defined to exclude selected bits from being evaluated during WUF detection. The ID mask is defined in the mask registers (Table 28), where a 1 means ‘don’t care’.

When PNDM = 0, a valid wake-up frame is detected and a wake-up event is captured (CAN wake-up interrupt generated; see Table 38) when:

- the identifier field in the received wake-up frame matches the pattern in the ID registers (excluding the masked bits)
- the frame is a valid CBFF or CEFF frame according to the ISO 11898-1:2016 (including CRC and CRC delimiter)

6.3.2.2.2 Data field matching

In addition to the identifier field, the data field in the CAN frame is also evaluated during WUF detection when PNDM = 1.

The data field indicates the nodes to be woken up. Within the data field, groups of nodes can be pre-defined and associated with bits in a data mask. By comparing the incoming data field with the data mask, multiple groups of nodes can be woken up simultaneously with a single wake-up message.

The data length code (bits DLC in the frame control register; Table 30) determines the number of data bytes expected (between 0 and 8) in the data field of a CAN wake-up frame. If one or more data bytes are expected

(DLC ≠ 0000), at least one bit in the data field of the received wake-up frame must be set to 1 and at least one equivalent bit in the associated data mask register in the transceiver (see Table 29) must also be set to 1 for a successful wake-up. Each matching pair of 1s indicates a group of nodes to be activated (since the data field is up to 8 bytes long, up to 64 groups of nodes can be defined).

If DLC = 0000, a node will wake up if the WUF contains a valid identifier and the received data length code is 0000, regardless of the values stored in the data mask (the data field is not evaluated when DLC = 0000). If DLC ≠ 0000 and all data mask bits are set to 0, the device cannot be woken up via the CAN bus (note that all data mask bits are set to 1 by default; see Table 29). If a WUF contains a valid ID but the DLCs (in the Frame control register and in the WUF) don't match, the data field is ignored and no nodes are woken up.

Remote frames do not contain data, but request data and can have a DLC ≠ 0000; so remote frames are not supported when PNDM = 1. If remote frames need to trigger a wake-up, identifier-only filtering should be selected (PNDM = 0).

When PNDM = 1, a WUF is detected when the following conditions are met:

- The identifier field in the received wake-up frame matches the pattern and format in the ID registers (Table 27), excluding masked bits.
- The received CAN frame is not a Remote frame.
- The received data length code matches the DLC setting in the frame control register (Table 30).
- DLC ≠ 0000 and at least one bit in the data field of the received frame is set with the corresponding bit in the associated data mask register (Table 29) also set.
- The frame is a valid CBFF or CEFF frame according to the ISO 11898-1:2016 (including CRC and CRC delimiter).

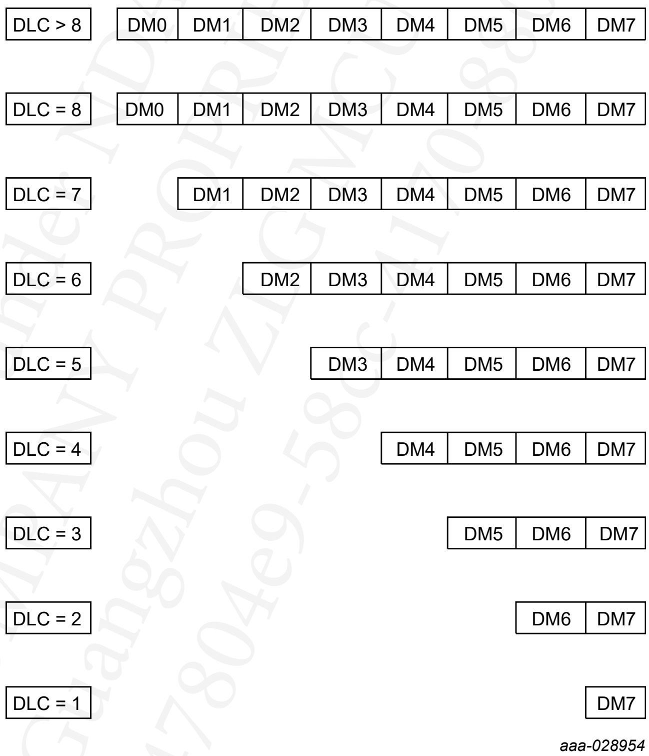


Figure 8. Data mask register usage for different values of DLC

6.3.2.2.3 WUF error processing

If the TJA1445 receives a CAN message containing a protocol error (e.g. a 'stuffing error') transmitted in advance of the ACK field, an internal error counter is incremented. If a classical CAN message (CBFF or CEFF) is received without any errors appearing in front of the ACK field, the counter is decremented. Data received after the CRC delimiter and before the next SOF is ignored by the CAN wake-up frame detector module. If the counter overflows (counter > 31), a frame detect error is captured (PNFDER = 1) and the device wakes up.

The error counter value can be read via bits PN_ERR_ERROR_COUNT (Table 26). The counter is reset to zero when no activity is detected on the CAN bus for $t_{to(silence)}$ or selective wake-up detection is disabled (CPNC = 0). The status, whether the last frame was decoded successfully, can be determined via bit LFDS in the partial networking status register (Table 25).

If selective wake-up is disabled (CPNC = 0) or partial networking is not configured correctly (PNCOK = 0), wake-up will be performed as described in Section 6.3.2.1.

6.3.2.2.4 CAN FD passive

CAN frames in the ISO 11898-1:2016 compliant FD base frame format (FBFF) or FD extended frame format (FEFF) are not supported for selective wake-up. The device can be configured to tolerate these frames or treat them as invalid frames via bit PNECC in the partial networking control register (Table 32).

With PNECC = 0, the error counter is incremented when an FBFF or FEFF frame is received. FBFF and FEFF frames are ignored when PNECC =1 and the error counter is not affected.

CAN FD tolerance is supported as described in the ISO11898-2, bit filter 1 and 2 standard. The TJA1445 also supports additional bit filter settings for higher data rates up to 8 Mbit/s (see bit IDFS in Table 31).

6.4 Interrupt processing

A number of events can be captured and reported to the host via the interrupt mechanism. Pin RXD is used to signal an interrupt event in Standby or Sleep mode. Two options are supported:

- RXDINTC = 0: RXD goes LOW when a wake-up or power-on interrupt is pending
- RXDINTC = 1: RXD goes LOW when any interrupt is pending

Interrupts are enabled individually via dedicated bits in the interrupt enable registers (see Section 6.10.10). When an interrupt is generated, pin RXD goes LOW to alert the host. The host can then determine which event triggered the interrupt by polling the interrupt status registers. PO and PNFDER interrupts are always enabled; so they do not have associated interrupt enable bits.

Interrupts are cleared by writing 1 (W1C) to the relevant interrupt status bits. Clearing an interrupt does not necessarily mean the event that triggered the interrupt has been resolved. If there is a collision, setting the interrupt takes precedence over clearing the interrupt.

6.5 Device ID

A byte is reserved in the register map for the unique device identification code; see bit IDS in Table 44.

6.6 Lock control

Sections of the register address area can be write-protected to prevent unintended modifications. Note that this facility only protects locked bits from being modified via the SPI and will not prevent the TJA1445 updating registers. Sections that can be locked are detailed in Section 6.10.11.

6.7 General-purpose memory

The TJA1445 allocates 4 bytes of memory to store user information. The general-purpose registers can be accessed via the SPI at address 0xFF0 to 0xFF3 (see Section 6.10.12). The general-purpose registers are not cleared during a software reset.

6.8 GPIO pins - TJA1445B only

The TJA1445B contains three configurable general-purpose I/O pins that can be assigned to a number of functions (see Table 22, Table 23 and Table 24).

The GPIOs can be individually configured as digital input, output or inactive (repeater) pins:

- input options: floating, pull-up, pull-down or repeater
- output options:
  - push-pull
  - open-drain high-side driver
  - high-side driver plus weak pull-down
  - open-drain low-side driver
  - low-side driver plus weak pull-up

For a number of functions, the GPIO pins can be configured as active-HIGH or active-LOW, selected via bits GPPx in Table 20.

Table 12. Configurable GPIO functions

GPIO function	Description
Digital input, output or inactive	-
TXEN_N input	CAN transmitter disabled when GPIO pin driven HIGH
INT_N interrupt output	active-LOW by default (GPPx = 0); LOW signals an interrupt is pending
Additional RXD output (RXD2)	GPIO1 only, two options: • CAN bus forwarded to both RXD and RXD2 (via GPIO1) outputs • CAN bus forwarded to RXD2 only; RXD forced HIGH
Additional TXD digital interface (TXD2)	GPIO2 only, two options: • TXD and TXD2 (via GPIO2) data fed to the CAN bus - the CAN bus will be recessive only when both TXD and TXD2 are HIGH • only TXD2 enabled (TXD input ignored) - the CAN bus is driven dominant when TXD2 is LOW
V_{CC} undervoltage status output	active-HIGH by default (configurable via GPPx), HIGH indicates V_{CC} undervoltage detected (UVCCS)
TXD dominant status output	active-HIGH by default (configurable via GPPx), HIGH indicates TXD clamped dominant (TXDDOMS)
TXD2 dominant status output	active-HIGH by default (configurable via GPPx), HIGH indicates TXD2 clamped dominant (TXD2DOMS) - GPIO1 and GPIO3 only
CAN WUP detect status output	active-HIGH by default configurable via GPPx), HIGH indicates WUP detected
CAN WUF detect status output	active-HIGH by default (configurable via GPPx), HIGH indicates WUF detected
CAN bus biasing status output	active-HIGH by default (configurable via GPPx), HIGH indicates bus biasing is active
WAKE pin rising edge detect output	active-HIGH by default (configurable via GPPx), HIGH indicates rising edge detected on WAKE pin

Table 12. Configurable GPIO functions *...continued*

GPIO function	Description
WAKE pin falling edge detect output	active-HIGH by default (configurable via GPPx), HIGH indicates falling edge detected on WAKE pin
CAN in Active mode and ready to transmit status output (CTS)	active-HIGH by default (configurable via GPPx), HIGH if CAN in Active mode
CAN in ListenOnly mode status output	active-HIGH by default (configurable via GPPx), HIGH if CAN in ListenOnly mode
Low-voltage wake-up input	wake-up on rising, falling or both edges on GPIO pin
INH2: low-voltage inhibit output	active-HIGH by default (configurable via GPPx), HIGH if INH2 activated

The status of the GPIO pins, HIGH or LOW, can be read via bits GPIOxS in the GPIO status register (Table 21).

6.9 Failure handling

The TJA1445 incorporates a number of safety features used for error detection and processing.

6.9.1 TXD dominant timeout

A LOW level on pin TXD (or on GPIO2 in TJA1445B when configured as a second TXD input, see Section 6.8) persisting longer than $t_{to(dom)TXD}$ releases the bus lines to recessive state. This feature prevents the CAN bus being blocked by continuous dominant clamping. A CAN failure interrupt is generated (TXDDOM/TXD2DOM = 1), if enabled (TXDDOME/TXD2DOME = 1), when a TXD dominant timeout is detected. The TXD dominant status can be read via bit TXDDOMS/TXD2DOMS in the CAN status register (Table 19).

6.9.2 CAN transmitter enable/disable(TXEN_N) - TJA1445B only

On the TJA1445B, the CAN transmitter can be enabled/disabled via the TXEN_N input. The GPIO pins can be configured as additional transmitter enable/disable signals (see Section 6.8). A HIGH level on pin TXEN_N, or on a GPIO pin configured as a TXEN_N input, disables the transmitter, releasing the bus lines to recessive state independent of the level on pin TXD and/or TXD2 (if configured on GPIO2). The TXEN_N status can be read via bit GPIO1S, GPIO2S and GPIO3S in the GPIO status register (Table 21).

6.9.3 Bus dominant timeout

A dominant state on the CAN bus lasting longer than $t_{to(dom)bus}$ generates a CAN bus failure interrupt (BUSDOM = 1), if enabled (BUSDOME = 1; Table 36). The status of the bus can be read via bit BUSDOMS in the CAN status register (Table 19).

6.9.4 V_{BAT} undervoltage

The TJA1445 monitors the supply voltage on pin VBAT. It switches directly to Off mode when V_{BAT} drops below the undervoltage detection threshold, $V_{uvd(VBAT)}$ for $t_{det(uv)}$. As a consequence, bit PO is set (see Table 38).

6.9.5 V_{IO} undervoltage

The TJA1445 monitors the supply voltage on pin VIO. When V_{IO} drops below the undervoltage detection threshold $V_{uvd(VIO)}$ for longer than $t_{det(uv)long}$, the device switches to Sleep mode and the wake-up sources (CWE, WPRE and WPFE) are enabled automatically. A long VIO undervoltage interrupt is generated (LUVIO = 1) , if enabled (LUVIOE = 1; see Table 16). On recovering from an undervoltage event, the TJA1445 switches back to the selected mode (MC).

The long undervoltage detection time, $t_{det(uv)long}$, is selected via bit LUVIOSEL in the system configuration register (Table 17).

6.9.6 V_{CC} undervoltage

The TJA1445 monitors the supply voltage on pin VCC. When V_{CC} drops below the undervoltage detection threshold $V_{uvd(VCC)}$ for longer than $t_{det(uv)}$, a V_{CC} undervoltage interrupt is generated (UVCC = 1), if enabled (UVCCE = 1; Table 35). The V_{CC} undervoltage status can be read via bit UVCCS in the system status register (Table 16).

6.9.7 Overtemperature

The TJA1445 monitors the junction temperature. When the junction temperature exceeds $T_{j(sd)}$, the device switches from Normal mode to ListenOnly mode (see Figure 4). An overtemperature interrupt is generated (OT = 1), if enabled (OTE = 1; see Table 38). The device recovers and switches back to Normal mode when the junction temperature falls below the shutdown release threshold, $T_{j(sd)rel}$. The overtemperature status can be read via bit OTS in the system status register (Table 16) when the device is in Normal or ListenOnly mode.

6.9.8 MCU reaction timeout

When the TJA1445 enters Standby mode from Boot or Sleep mode, the wake-up sources (CWE, WPRE and WPFE) are enabled automatically and the MCU reaction timeout timer is started. If a valid SPI frame is not detected within $t_{to(MCU)}$, the device switches to Sleep mode and waits for a wake-up request.

The MCU reaction timeout time depends on the long undervoltage threshold, selected via bit LUVIOSEL in the system configuration register (Table 17 and Table 48).

6.9.9 ISO pulse protection

To prevent the device being damaged during positive ISO7637 pulses, the power supply current at pin VBAT increases when V_{BAT} rises above 28 V (by default). ISO pulse protection can be disabled by setting bit ISODIS = 1 (see Table 17). In this case, an external clamp is needed below 40 V.

6.10 SPI interface

The serial peripheral interface (SPI) provides the communication link with the microcontroller. The SPI is configured for full duplex data transfer, so status information is returned when new control data is shifted in. The interface also offers a read-only access option, allowing registers to be read back by the application without changing the register content.

The SPI uses four interface signals for synchronization and data transfer:

- SCSN: SPI chip select; active LOW
- SCK: SPI clock
- SDI: SPI data input
- SDO: SPI data output; floating when pin SCSN is HIGH (may need external pull-up or pull-down if not available in the host controller)

Bit sampling is performed on the falling edge of the clock and data is shifted in/out on the rising edge, as illustrated in Figure 9.

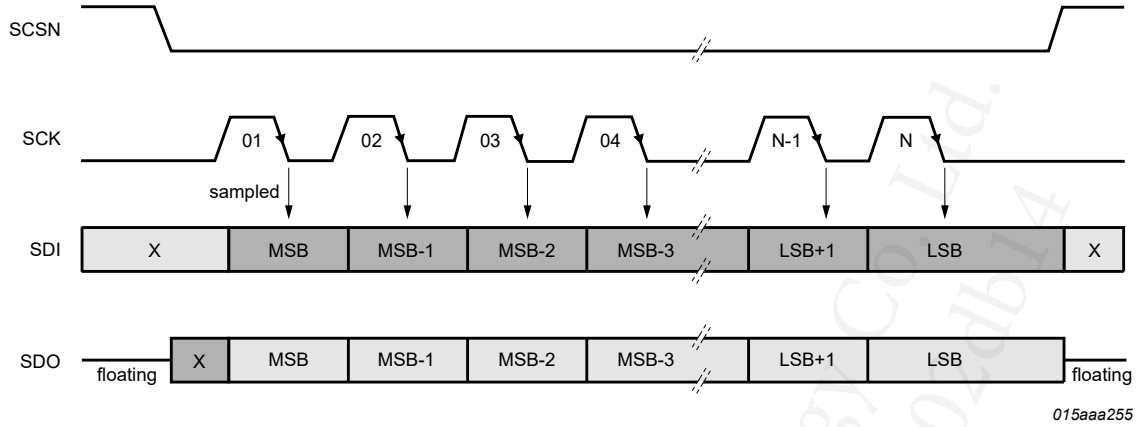


Figure 9. SPI timing protocol

The SPI data in the TJA1445 is stored in a number of dedicated 8-bit registers. Each register is assigned a unique 12-bit address. A minimum of three bytes (24 bits) must be transmitted to the TJA1445 for a single register read or write operation. A maximum of six bytes (48 bits) can be transmitted for a 4 data byte access.

The first byte contains the 8 most significant bits of the address; the second byte contains the 4 least significant bits of the address, a 'read-only' bit, a 2-bit payload size (PLS) and a parity bit. The read-only bit must be 0 to indicate a write operation and 1 to indicate a read operation. PLS indicates the number of data bytes being transmitted:

- 00 - 1 data byte
- 01 - 2 data bytes
- 10 - 3 data bytes
- 11 - 4 data bytes

The parity bit covers the address bits, read-only bit and PLS bits. It must be calculated in the user application as part of the SPI command indicating even parity, creating an even number of 1s in the first 2 bytes including the parity bit.

The third and subsequent bytes contain the data to be written. For two or more data bytes (PLS ≠ 00), the register address is incremented automatically after each data byte, see Figure 10.

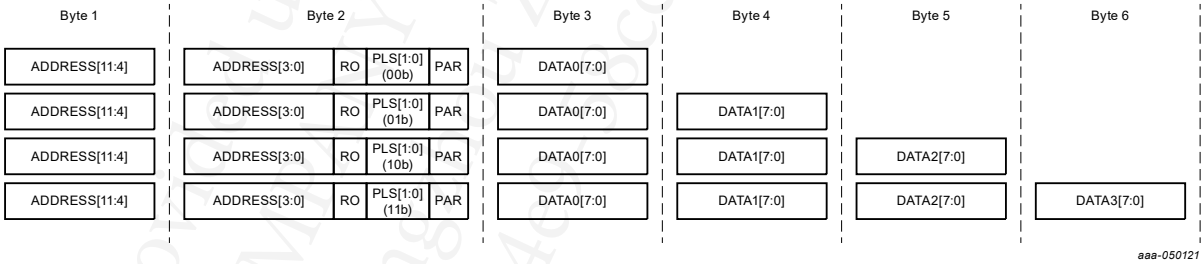


Figure 10. SPI addressing

During the SPI data, read or write operation, the first 15 bits received on pin SDI are returned via pin SDO; bit 16 returns the parity calculated for these 15 bits. During the data phase of the SPI protocol, the contents of the addressed register is returned via the SDO pin.

The device tolerates attempts to write to registers that do not exists.

6.10.1 SPI error handling

The TJA1445 can detect a number of SPI transmission failures:

- an incorrect parity bit was received
- the number of clock cycles exceeds the expected number of bits based on the PLS value
- an address rollover (> 0xFFF) was detected
- an undefined MC code was received
- a write access was attempted to a locked register
- an illegal sleep command was received (no wake-up source enabled)
- the SPI message was not completed (SCSN HIGH) within the timeout time, $t_{to(SPI)}$

In all cases, an SPI fail interrupt is generated.

In the case of an incorrect parity or too many clock cycles, pin SDO goes LOW until the next rising edge on SCSN. When the duration of the SPI message exceeds $t_{to(SPI)}$, the SDO pin goes LOW.

6.10.2 SPI system reset

A system reset can be forced via the SPI, causing the device to restart via Boot mode. A system reset is initiated by writing, consecutively, 0x01 then 0x80 to bits SFR in the system reset register (see Table 33). Both SPI accesses should be 24-bit. Any deviation from this sequence will abort the system reset.

Information that was in the general-purpose memory (Table 43) when the reset was initiated will still be available after the reset sequence has been completed.

6.10.3 SPI register map

Table 13. SPI register map overview

Register type	Address	Register name
Mode control	0x000	Mode control register
Interrupt enable	0x010	System interrupt enable register
	0x011	CAN interrupt enable register
	0x012	GPIO interrput enable register - TJA1445B only
Partial networking	0x020	Partial networking ID register 0
	0x021	Partial networking ID register 1
	0x022	Partial networking ID register 2
	0x023	Partial networking ID register 3
	0x024	Partial networking ID mask register 0
	0x025	Partial networking ID mask register 1
	0x026	Partial networking ID mask register 2
	0x027	Partial networking ID mask register 3
	0x028	Partial networking data mask register 0
	0x029	Partial networking data mask register 1
	0x02A	Partial networking data mask register 2
	0x02B	Partial networking data mask register 3
	0x02C	Partial networking data mask register 4
	0x02D	Partial networking data mask register 5
	0x02E	Partial networking data mask register 6
	0x02F	Partial networking data mask register 7
	0x030	Partial networking frame control register
	0x031	Partial networking data rate and filter configuration register
	0x032	Partial networking and CAN configuration register
Configuration	0x040	Wake-up pulse configuration register
	0x041	CAN configuration register
	0x042	GPIO1 configuration register - TJA1445B only
	0x043	GPIO2 configuration register - TJA1445B only
	0x044	GPIO3 configuration register - TJA1445B only
	0x045	GPIO polarity configuration register - TJA1445B only
	0x046	System configuration register
Lock	0x050	Lock control register
Interrupt status	0x060	System interrupt status register
	0x061	CAN interrupt status register
	0x062	Partial networking interrupt status register
	0x063	GPIO interrupt status register - TJA1445B only

Table 13. SPI register map overview *...continued*

Register type	Address	Register name
General status	0x070	Mode status register
	0x071	System status register
	0x072	CAN status register
	0x073	Partial networking status register
	0x074	GPIO/TXEN_N status register - TJA1445B only
	0x075	Partial networking error count status register
Reset	0xFE0	System reset register
General-purpose memory	0xFF0	General-purpose memory register 0
	0xFF1	General-purpose memory register 1
	0xFF2	General-purpose memory register 2
	0xFF3	General-purpose memory register 3
ID	0xFFF	Device identification

6.10.4 System control and status registers

Reset values are indicated by '*'.

Table 14. Mode control register (address 000h)

Bit	Symbol	Access	Value	Description
7:4	reserved	R	-	always write 0000; ignore on read
3:0	MC	R/W	0001	Sleep mode
			0110*	Standby mode
			1000	ListenOnly mode
			1111	Normal mode

Table 15. Mode status register (address 070h)

Bit	Symbol	Access	Value	Description
7:4	reserved	R	-	ignore on read
3:0	MCS	R	0001	Sleep mode
			0110	Standby mode
			1000	ListenOnly mode
			1111	Normal mode

Table 16. System status register (address 071h)

Bit	Symbol	Access	Value	Description
7	reserved	R	-	ignore on read

Table 16. System status register (address 071h)*...continued*

Bit	Symbol	Access	Value	Description
6	FSMS	R		most recent Sleep mode transition:
			0	triggered by SPI
			1	triggered by VIO undervoltage or MCU timeout
5	OTS	R		overtemperature status available when MC = Normal and MCS = Normal/Listen Only
			0	no overtemperature or MC ≠ Normal
			1	overtemperature detected
4	reserved	R	-	ignore on read
3	UVCCS	R		V_{CC} undervoltage status
			0	no undervoltage on VCC
			1	V_{CC} undervoltage detected
2	NMS	R		Normal mode status
			0	device entered Normal mode after power up
			1	device did not enter Normal mode power up
1	SNMS	R		Start-to-Normal mode status
			0	device did not enter Normal mode after power up (bus dominant for $t < t_{(snm)}$ or recessive; NO_SNM)
			1	device entered Normal mode after power up due to CAN bus clamped dominant (SNM)
0	WPS	R		WAKE pin status
			0	WAKE pin LOW
			1	WAKE pin HIGH

Table 17. System configuration register (address 046h)

Bit	Symbol	Access	Value	Description
7:4	reserved	R	-	always write 0000; ignore on read
3	ISODIS	R/W		ISO pulse control:
			0*	enable active ISO pulse protection
			1	disable active ISO pulse control
2	RXDINTC	R/W		interrupt signaling at RXD in Sleep/Standby modes
			0*	wake-up and power-on interrupts detected
			1	all enabled interrupts detected
1	LUVIOSEL	R/W		long VIO undervoltage detection time select:
			0	$t_{det(uv)long1}$
			1*	$t_{det(uv)long2}$
0	VBATVCC	R/W		VBAT/VCC configuration

Table 17. System configuration register (address 046h)*...continued*

Bit	Symbol	Access	Value	Description
			0*	separate VBAT and VCC supplies; typical application; autobiasing supplied from V_{BAT}
			1	common VBAT and VCC supplies; applications with permanently active regulator; autobiasing is supplied from V_{CC}

6.10.5 CAN configuration and status registers

Reset values are indicated by '*'.

Table 18. CAN configuration register (address 041h)

Bit	Symbol	Access	Value	Description
7:6	reserved	R	-	always write 00; ignore on read
5	TXRXLP	R/W		TXD-to-RXD loopback:
			0*	normal TXD and RXD behavior
			1	TXD is forwarded to RXD and CAN bus remains recessive in CAN Active mode
4	TX2RX2LP[1] *TJA1445B only*	R/W		TXD2-to-RXD2 loopback:
			0*	normal TXD2 and RXD2 behavior
			1	TXD2 is forwarded to RXD2 and CAN bus remains recessive in CAN Active mode
3:2	reserved	R	-	always write 00; ignore on read
1	LPL	R/W		low-power ListenOnly mode enable:
			0*	low-power ListenOnly mode disabled
			1	low-power ListenOnly mode enabled
0	CWC	R/W		CAN wake-up pattern selection:
			0*	ISO 11898-2:2016 wake pattern (dom-rec-dom)
			1	ISO 11898-2:2023 wake pattern (dom-rec-dom-rec)

[1] GPIO1 configured as second RXD output (RXD2) and GPIO2 configured as second TXD input (TXD2).

Table 19. CAN status register (address 072h)

Bit	Symbol	Access	Value	Description
7	CTS	R		CAN transceiver status:
			0	CAN transceiver not in Active mode
			1	CAN transceiver in Active mode
6:4	reserved	R	-	ignore on read
3	CBSS	R		CAN bus silence status:
			0	CAN bus activity detected
			1	no CAN bus activity detected for longer than $t_{to(silence)}$

Table 19. CAN status register (address 072h)*...continued*

Bit	Symbol	Access	Value	Description
2	BUSDOMS	R		BUS clamped dominant status:
			0	CAN bus not clamped dominant
			1	CAN bus clamped dominant
1	TXD2DOMS *TJA1445B only*	R		TXD2 clamped dominant status:
			0	TXD2 not clamped dominant
			1	TXD2 clamped dominant
0	TXDDOMS	R		TXD clamped dominant status:
			0	TXD not clamped dominant
			1	TXD clamped dominant

6.10.6 GPIO configuration and status registers: TJA1445B only

Reset values are indicated by '*'.

Table 20. GPIO polarity configuration register (address 045h)

Bit	Symbol	Access	Value	Description
7:3	reserved	R	-	always write 00000; ignore on read
2	GPP3	R/W		GPIO3 polarity:
			0*	default polarity
			1	inverted polarity
1	GPP2	R/W		GPIO2 polarity:
			0*	default polarity
			1	inverted polarity
0	GPP1	R/W		GPIO1 polarity:
			0*	default polarity
			1	inverted polarity

Table 21. GPIO status register (address 074h)

Bit	Symbol	Access	Value	Description
7:4	reserved	R	-	ignore on read
3	TXENS	R		TXEN_N pin status:
			0	TXEN_N LOW
			1	TXEN_N HIGH
2	GPIO3S	R		GPIO3 pin status:
			0	GPIO3 LOW
			1	GPIO3 HIGH
1	GPIO2S	R		GPIO2 pin status:
			0	GPIO2 LOW

Table 21. GPIO status register (address 074h) *...continued*

Bit	Symbol	Access	Value	Description
			1	GPIO2 HIGH
0	GPIO1S	R		GPIO1 pin status:
			0	GPIO1 LOW
			1	GPIO1 HIGH

Table 22. GPIO1 configuration register (address 042h)

Bit	Symbol	Access	Value	Description
7:5	GPIO1C	R/W		GPIO1 pin configuration:
			000	input: floating output: push-pull
			001	input: pull-up output: open-drain high-side driver
			010	input: pull-down output: high-side driver plus weak pull-down
			011*	input: repeater output: open-drain low-side driver
			100	input: repeater output: low-side driver plus weak pull-up
			101 - 111	reserved
4:0	GPIO1FS	R/W		GPIO1 function select:
			0x00*	GPIO1 inactive; repeater function active, independent of GPIO1C
			0x01	input
			0x02	output: LOW when GPP1 = 0; HIGH when GPP1 = 1
			0x03	TXEN_N input; CAN transmitter disabled when GPIO pin driven HIGH
			0x04	INT_N interrupt output; active-LOW when GPP1 = 0 (default); active-HIGH when GPP1 = 1
			0x05	reserved
			0x06	GPIO1 configured as second RXD output (RXD2); CAN bus forwarded to both GPIO1 (RXD2) and RXD
			0x07	reserved
			0x08	GPIO1 configured as second RXD output (RXD2); CAN bus forwarded to GPIO1 (RXD2) only; RXD forced HIGH
			0x09	V_{CC} undervoltage status output (UVCCS)[1]
			0x0A	TXD dominant status output (TXDDOMS)[1]
			0x0B	TXD2 dominant status output (TXD2DOMS; available when GPIO2 configured as TXD2)[1]
			0x0C	wake-up pattern detect output[1]
			0x0D	wake-up frame detect output[1]

Table 22. GPIO1 configuration register (address 042h)*...continued*

Bit	Symbol	Access	Value	Description
			0x0E	CAN bus biasing status output (HIGH, by default, indicates that CAN bus biasing is active)[1]
			0x0F	WAKE pin rising edge detect output[1]
			0x10	WAKE pin falling edge detect output[1]
			0x11	CAN Active mode ready-to-transmit status output (CTS)[1]
			0x12	CAN ListenOnly mode status output[1]
			0x13	rising edge wake-up detection input
			0x14	falling edge wake-up detection input
			0x15	rising or falling edge edge wake-up detection input
			0x16	INH2 output[1]
			0x17 to 0x1F	reserved

[1] Active-HIGH when GPP1 = 0; active-LOW when GPP1 = 1

Table 23. GPIO2 configuration register (address 043h)

Bit	Symbol	Access	Value	Description
7:5	GPIO2C	R/W		GPIO2 pin configuration:
			000	input: floating output: push-pull
			001	input: pull-up output: open-drain high-side driver
			010	input: pull-down output: high-side driver plus weak pull-down
			011*	input: repeater output: open-drain low-side driver
			100	input: repeater output: low-side driver plus weak pull-up
			101 - 111	reserved
4:0	GPIO2FS	R/W		GPIO2 function select:
			0x00*	GPIO2 inactive; repeater function active, independent of GPIO2C
			0x01	input
			0x02	output: LOW when GPP2 = 0; HIGH when GPP2 = 1
			0x03	TXEN_N input; CAN transmitter disabled when GPIO pin driven HIGH
			0x04	INT_N interrupt output; active-LOW when GPP2 = 0 (default); active-HIGH when GPP2 = 1
			0x05	GPIO2 configured as second TXD input (TXD2); TXD and TXD2 (via GPIO2) data fed to the CAN bus
			0x06	reserved

Table 23. GPIO2 configuration register (address 043h)*...continued*

Bit	Symbol	Access	Value	Description
			0x07	GPIO2 configured as second TXD input (TXD2); only TXD2 (via GPIO2) data fed to the CAN bus; TXD input ignored
			0x08	reserved
			0x09	V_{CC} undervoltage status output (UVCCS)[1]
			0x0A	TXD dominant status output (TXDDOMS)[1]
			0x0B	reserved
			0x0C	wake-up pattern detect output[1]
			0x0D	wake-up frame detect output[1]
			0x0E	CAN bus biasing status (HIGH, by default, indicates that CAN bus biasing is active)[1]
			0x0F	WAKE pin rising edge detect output[1]
			0x10	WAKE pin falling edge detect output[1]
			0x11	CAN Active mode ready-to-transmit status output (CTS)[1]
			0x12	CAN ListenOnly mode status[1]
			0x13	rising edge edge wake-up detection input
			0x14	falling edge edge wake-up detection input
			0x15	rising or falling edge edge wake-up detection input
			0x16	INH2 output[1]
			0x17 to 0x1F	reserved

[1] Active-HIGH when GPP2 = 0; active-LOW when GPP2 = 1

Table 24. GPIO3 configuration register (address 044h)

Bit	Symbol	Access	Value	Description
7:5	GPIO3C	R/W		GPIO3 pin configuration:
			000	input: floating output: push-pull
			001	input: pull-up output: open-drain high-side driver
			010	input: pull-down output: high-side driver plus weak pull-down
			011*	input: repeater output: open-drain low-side driver
			100	input: repeater output: low-side driver plus weak pull-up
			101 - 111	reserved

Table 24. GPIO3 configuration register (address 044h)*...continued*

Bit	Symbol	Access	Value	Description
4:0	GPIO3FS	R/W		GPIO3 function select:
			0x00*	GPIO3 inactive; repeater function active, independent of GPIO3C
			0x01	input
			0x02	output: LOW when GPP3 = 0; HIGH when GPP3 = 1
			0x03	TXEN_N input; CAN transmitter disabled when GPIO pin driven HIGH
			0x04	INT_N interrupt output; active-LOW when GPP3 = 0 (default); active-HIGH when GPP3 = 1
			0x05	reserved
			0x06	reserved
			0x07	reserved
			0x08	reserved
			0x09	V_{CC} undervoltage status output (UVCCS)[1]
			0x0A	TXD dominant status output (TXDDOMS)[1]
			0x0B	TXD2 dominant status output (TXD2DOMS; available when GPIO2 configured as TXD2)[1]
			0x0C	wake-up pattern detect output[1]
			0x0D	wake-up frame detect output[1]
			0x0E	CAN bus biasing status (HIGH, by default, indicates that CAN bus biasing is active)[1]
			0x0F	WAKE pin rising edge detect output[1]
			0x10	WAKE pin falling edge detect output[1]
			0x11	CAN Active mode ready-to-transmit status output (CTS)[1]
			0x12	CAN ListenOnly mode status[1]
			0x13	rising edge edge wake-up detection input
			0x14	falling edge edge wake-up detection input
			0x15	rising or falling edge edge wake-up detection input
			0x16	INH2 output[1]
			0x17 to 0x1F	reserved

[1] Active-HIGH when GPP3 = 0; active-LOW when GPP3 = 1

6.10.7 Partial networking registers

Reset values are indicated by '*'.

Table 25. Partial networking status register (address 073h)

Bit	Symbol	Access	Value	Description
7	SYNCS	R		CAN partial networking sync status:
			0	CAN partial networking core not ready to decode frame
			1	CAN partial networking core ready to decode frame
6	CPNERRS	R		CAN partial networking error status:
			0	no CAN partial networking error detected; PNFDER = 0 and PNCOK = 1
			1	CAN partial networking error detected; PNFDER =1 or PNCOK = 0; wake-up via WUP only
5	CPNS	R		CAN partial networking status:
			0	CAN partial networking configuration error detected; PNCOK = 0
			1	CAN partial networking configuration OK; PNCOK = 1
4	LFDS	R		last frame decode status:
			0	most recent CAN frame not decoded successfully
			1	most recent CAN frame decoded successfully
3:0	reserved	R	-	ignore on read

Table 26. Partial networking error count status register (address 075h)

Bit	Symbol	Access	Value	Description
7:5	reserved	R	-	always write 000; ignore on read
4:0	PNERRCNT	R/W		CAN partial networking error count status:
			00000*	0
			00001	1
			00010	2
			00011	3
			...	...
			11111	31

Table 27. Partial networking ID registers 0 to 3 (addresses 020h to 023h)

Addr.	Bit	Symbol	Access	Value	Description
020h	7:0	ID7:ID0	R/W	00h*	bits ID7 to ID0 of the extended frame format
021h	7:0	ID15:ID8	R/W	00h*	bits ID15 to ID8 of the extended frame format
022h	7:2	ID23:ID18	R/W	00h*	bits ID23 to ID18 of the extended frame format bits ID5 to ID0 of the standard frame format
	1:0	ID17:ID16	R/W	00h*	bits ID17 to ID16 of the extended frame format

Table 27. Partial networking ID registers 0 to 3 (addresses 020h to 023h) *...continued*

Addr.	Bit	Symbol	Access	Value	Description
023h	7:5	reserved	R/W	00h*	always write 000; ignore on read
	4:0	ID28:ID24	R/W	00h*	bits ID28 to ID24 of the extended frame format bits ID10 to ID6 of the standard frame format

Table 28. Partial networking ID mask registers 0 to 3 (addresses 024h to 027h)

Addr.	Bit	Symbol	Access	Value	Description
024h	7:0	M7:M0	R/W	00h*	ID mask bits 7 to 0 of extended frame format
025h	7:0	M15:M8	R/W	00h*	ID mask bits 15 to 8 of extended frame format
026h	7:2	M23:M18	R/W	00h*	ID mask bits 23 to 18 of extended frame format ID mask bits 5 to 0 of standard frame format
	1:0	M17:M16	R/W	00h*	ID mask bits 17 to 16 of extended frame format
027h	7:5	reserved	R/W	00h*	always write 000; ignore on read
	4:0	M28:M24	R/W	00h*	ID mask bits 28 to 24 of extended frame format ID mask. bits 10 to 6 of standard frame format

Table 29. Partial networking data mask registers 0 to 7 (addresses 028h to 02Fh)

All data mask bits are set to 1 by default.

Addr.	Bit	Symbol	Access	Value	Description
028h	7:0	DM0	R/W	FFh*	data mask 0 configuration
029h	7:0	DM1	R/W	FFh*	data mask 1 configuration
02Ah	7:0	DM2	R/W	FFh*	data mask 2 configuration
02Bh	7:0	DM3	R/W	FFh*	data mask 3 configuration
02Ch	7:0	DM4	R/W	FFh*	data mask 4 configuration
02Dh	7:0	DM5	R/W	FFh*	data mask 5 configuration
02Eh	7:0	DM6	R/W	FFh*	data mask 6 configuration
02Fh	7:0	DM7	R/W	FFh*	data mask 7 configuration

Table 30. Partial networking frame control register (address 030h)

Bit	Symbol	Access	Value	Description
7	IDE	R/W		identifier format:
			0*	standard frame format (11-bit)
			1	extended frame format (29-bit)
6	PNDM	R/W		partial networking data mask:
			0	data length code and data field are ‘don’t care’ for wake-up
			1*	data length code and data field are evaluated at wake-up
5:4	reserved	R	-	always write 00; ignore on read

Table 30. Partial networking frame control register (address 030h)*...continued*

Bit	Symbol	Access	Value	Description
3:0	DLC	R/W		number of data bytes expected in a CAN frame (DLC):
			0000*	0
			0001	1
			0010	2
			0011	3
			0100	4
			0101	5
			0110	6
			0111	7
			1000	8
			1001 to 1111	8

Table 31. Partial networking data rate and filter configuration register (address 031h)

Bit	Symbol	Access	Value	Description
7:4	IDFS	R/W		idle detection filter select:
			0000*	bitfilter 0: ignore < 5.0 % of bit time; detect > 17.5 % of bit time
			0001	ISO bitfilter 1: ignore < 5.0 % of bit time; detect > 17.5 % of bit time
			0010	ISO bitfilter 2: ignore < 2.5 % of bit time; detect > 8.75 % of bit time
			0011	bitfilter 3: ignore < 18 ns; detect > 93 ns
			0100	bitfilter 4: ignore < 42 ns; detect > 119 ns
			0101	bitfilter 5: ignore < 67 ns; detect > 145 ns
			0110	bitfilter 6: ignore < 91 ns; detect > 170 ns
			0111 to 1111	reserved
3	reserved	R	-	always write 0; ignore on read
2:0	CDR	R/W		CAN data rate selection:
			000	50 kbit/s
			001	100 kbit/s
			010	125 kbit/s
			011	250 kbit/s
			100*	500 kbit/s
			101	667 kbit/s
			110	reserved (PNCORE disabled)
			111	1 Mbit/s

Table 32. Partial networking and CAN configuration register (address 032h)

Bit	Symbol	Access	Value	Description
7:3	reserved	R	-	always write 00000; ignore on read
2	PNECC	R/W		partial networking error counter control:
			0*	CAN FD frames will increment error counter
			1	CAN FD frames will not increment error counter
1	PNCOK	R/W		CAN partial networking configuration:
			0*	partial networking register configuration invalid (wake-up via standard wake-up pattern only)
			1	partial networking register configuration valid
0	CPNC	R/W		CAN selective wake-up enable:
			0*	disable CAN selective wake-up
			1	enable CAN selective wake-up

6.10.8 System reset register

Table 33. System reset register (address FE0h)

Bit	Symbol	Access	Value	Description
7:0	SFR	W		software-forced system reset:
			01h	set up system reset
			80h	confirm system reset

6.10.9 Wake-up pulse configuration register

Reset values are indicated by '*'.

Table 34. Wake-up pulse configuration register (address 040h)

Bit	Symbol	Access	Value	Description
7:1	reserved	R	-	always write 00h; ignore on read
0	WFC	R/W		wake-up pulse width (t_{wake}) on WAKE pin
			0*	short wake-up time
			1	long wake-up time

6.10.10 Interrupt registers

Reset values are indicated by '*'.

Write 1 to clear (W1C) interrupt status bit after interrupt detected.

Table 35. System interrupt enable register (address 010h)

Bit	Symbol	Access	Value	Description
7	reserved	R	-	always write 0; ignore on read
6	CWE	R/W		CAN wake-up interrupt enable:
			0*	disable CAN wake-up interrupt

Table 35. System interrupt enable register (address 010h)*...continued*

Bit	Symbol	Access	Value	Description
			1	enable CAN wake-up interrupt
5	OTE	R/W		overtemperature shutdown interrupt enable:
			0*	disable overtemperature shutdown interrupt
			1	enable overtemperature shutdown interrupt
4	SPIFE	R/W		SPI failure interrupt enable:
			0*	disable SPI failure interrupt
			1	enable SPI failure interrupt
3	UVCCE	R/W		V_{CC} undervoltage interrupt enable:
			0*	disable V_{CC} undervoltage interrupt
			1	enable V_{CC} undervoltage interrupt
2	LUVIOE	R/W		long V_{IO} undervoltage interrupt enable:
			0*	disable long V_{IO} undervoltage interrupt
			1	enable long V_{IO} undervoltage interrupt
1	WPRE	R/W		WAKE pin rising-edge interrupt enable:
			0*	disable WAKE pin rising-edge interrupt
			1	enable WAKE pin rising-edge interrupt
0	WPFE	R/W		WAKE pin falling-edge interrupt enable:
			0*	disable WAKE pin falling-edge interrupt
			1	enable WAKE pin falling-edge interrupt

Table 36. CAN interrupt enable register (address 011h)

Bit	Symbol	Access	Value	Description
7:4	reserved	R	-	always write 0000; ignore on read
3	CBSE	R/W		CAN bus silence interrupt enable:
			0*	disable CAN bus silence interrupt
			1	enable CAN bus silence interrupt
2	BUSDOME	R/W		CAN bus dominant interrupt enable:
			0*	disable CAN bus dominant interrupt
			1	enable CAN bus dominant interrupt
1	TXD2DOME *TJA1445B only*	R/W		TXD2 dominant timeout interrupt enable:
			0*	disable TXD2 dominant timeout interrupt
			1	enable TXD2 dominant timeout interrupt
0	TXDDOME	R/W		TXD dominant timeout interrupt enable:
			0*	disable TXD dominant timeout interrupt
			1	enable TXD dominant timeout interrupt

Table 37. GPIO interrupt enable register (address 012h) - TJA1445B only

Bit	Symbol	Access	Value	Description
7:3	reserved	R	-	always write 00000; ignore on read
2	GPIO3E	R/W		GPIO2 interrupt enable:
			0*	disable GPIO2 interrupt
			1	enable GPIO2 interrupt
1	GPIO2E	R/W		GPIO2 interrupt enable:
			0*	disable GPIO2 interrupt
			1	enable GPIO2 interrupt
0	GPIO1E	R/W		GPIO1 interrupt enable:
			0*	disable GPIO1 interrupt
			1	enable GPIO1 interrupt

Table 38. System interrupt status register (address 060h)

Bit	Symbol	Access	Value	Description
7	PO[1]	R/W1C		power-on interrupt:
			0	no power-on interrupt detected
			1*	power-on interrupt detected
6	CW	R/W1C		CAN wake-up interrupt:
			0*	no CAN wake-up interrupt detected
			1	CAN wake-up interrupt detected
5	OT	R/W1C		overtemperature warning interrupt:
			0*	no overtemperature warning interrupt detected
			1	overtemperature warning interrupt detected
4	SPIF	R/W1C		SPI failure interrupt:
			0*	no SPI failure interrupt detected
			1	SPI failure interrupt detected
3	UVCC	R/W1C		V_{CC} undervoltage interrupt:
			0*	no V_{CC} undervoltage interrupt detected
			1	V_{CC} undervoltage interrupt detected
2	LUVIO	R/W1C		long V_{IO} undervoltage interrupt:
			0*	no long V_{IO} undervoltage interrupt detected
			1	long V_{IO} undervoltage interrupt detected
1	WPR	R/W1C		WAKE pin rising-edge interrupt:
			0*	no WAKE pin rising-edge interrupt detected
			1	WAKE pin rising-edge interrupt detected
0	WPF	R/W1C		WAKE pin falling-edge interrupt:
			0*	no WAKE pin falling-edge interrupt detected

Table 38. System interrupt status register (address 060h) *...continued*

Bit	Symbol	Access	Value	Description
			1	WAKE pin falling-edge interrupt detected

[1] PO interrupt is always enabled.

Table 39. CAN interrupt status register (address 061h)

Bit	Symbol	Access	Value	Description
7:4	reserved	R	-	always write 0000; ignore on read
3	CBS	R/W1C		CAN bus silence interrupt:
			0*	no CAN bus silence interrupt detected
			1	CAN bus silence interrupt detected
2	BUSDOM	R/W1C		CAN bus dominant interrupt:
			0*	no CAN bus dominant interrupt detected
			1	CAN bus dominant interrupt detected
1	reserved *TJA1445A*	R	-	always write 0; ignore on read
1	TXD2DOM *TJA1445B*	R/W1C		TXD2 dominant timeout interrupt:
			0*	no TXD2 dominant timeout interrupt detected
			1	TXD2 dominant timeout interrupt detected
0	TXDDOM	R/W1C		TXD dominant timeout interrupt:
			0*	no TXD dominant timeout interrupt detected
			1	TXD dominant timeout interrupt detected

Table 40. Partial networking interrupt status register (address 062h)

Bit	Symbol	Access	Value	Description
7:3	reserved	R	-	ignore on read
2	PNFDER[1]	R/W1C		partial networking frame detection error interrupt:
			0*	no partial networking frame detection error interrupt detected
			1	partial networking frame detection error interrupt detected
1:0	reserved	R	-	ignore on read

[1] PNFDER interrupt is always enabled.

Table 41. GPIO interrupt status register (address 063h) - TJA1445B only>

Bit	Symbol	Access	Value	Description
7:3	reserved	R	-	ignore on read
2	GPIO3	R/W1C		GPIO3 interrupt:
			0*	no GPIO3 interrupt detected
			1	GPIO3 interrupt detected

Table 41. GPIO interrupt status register (address 063h) - TJA1445B only>*...continued*

Bit	Symbol	Access	Value	Description
1	GPIO2	R/W1C		GPIO2 interrupt:
			0*	no GPIO2 interrupt detected
			1	GPIO2 interrupt detected
0	GPIO1	R/W1C		GPIO1 interrupt:
			0*	no GPIO1 interrupt detected
			1	GPIO1 interrupt detected

6.10.11 Lock control register

Reset values are indicated by '*'.

Table 42. Lock control register (address 050h)

Bit	Symbol	Access	Value	Description
7:5	reserved	R	-	always write 000; ignore on read
4	LKGPM	R/W		Lock control: general-purpose memory registers (0xFF0 to 0xFF3):
			0*	SPI write access enabled
			1	SPI write access disabled
3	LKRST	R/W		Lock control: system reset register (0xFE0):
			0	SPI write access enabled
			1*	SPI write access disabled
2	LKCFG	R/W		Lock control: System/Wake/CAN configuration registers (0x40 to 0x46):
			0*	SPI write access enabled
			1	SPI write access disabled
1	LKPNC	R/W		Lock control: partial networking configuration registers (0x020 to 0x032):
			0*	SPI write access enabled
			1	SPI write access disabled
0	LKIE	R/W		Lock control: interrupt enable registers (0x010, 0x011, 0x012 - TJA1445B only):
			0*	SPI write access enabled
			1	SPI write access disabled

6.10.12 General-purpose memory registers

The TJA1445 allocates 4 bytes of memory for general-purpose registers used to store user information. The general-purpose registers can be accessed via the SPI at address 0xFF0 to 0xFF3. Note that these registers are not cleared during a software reset.

Table 43. General-purpose memory registers 0 to 3 (addresses FF0h to FF3h)

Addr.	Bit	Symbol	Access	Value	Description
FF0h	7:0	GPM[7:0]	R/W	00h*	general-purpose memory 0
FF1h	7:0	GPM[15:8]	R/W	00h*	general-purpose memory 1

Table 43. General-purpose memory registers 0 to 3 (addresses FF0h to FF3h)*...continued*

Addr.	Bit	Symbol	Access	Value	Description
FF2h	7:0	GPM[23:16]	R/W	00h*	general-purpose memory 2
FF3h	7:0	GPM[31:24]	R/W	00h*	general-purpose memory 3

6.10.13 Device identification register

Table 44. Device identification register (address FFFh)

Bit	Symbol	Access	Value	Description
7:0	IDS	R	-	device identification number:
			01h	TJA1445A
			02h	TJA1445B
			03h to FFh	reserved

7 Limiting values

Table 45. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134); all voltages are referenced to pin GND, unless otherwise specified; positive currents flow into the IC.

Symbol	Parameter	Conditions	Min	Max	Unit
V_x	Voltage on pin x[1]	pins VCC, VIO	−0.3	+6	V
			-	+7[2]	V
		pin VBAT	−0.3	+40	V
		pin INH	−0.3	V_{BAT}+0.3[3]	V
		pins CANH, CANL, WAKE	−36	+40	V
		pins RXD, TXD, SCSN, SCK, SDI, SDO, TXEN_N, GPIOx	−0.3	V_{IO}+0.3[4]	V
$I_{O(INH)}$	output current on pin INH		-2	-	mA
$V_{(CANH-CANL)}$	voltage between pin CANH and pin CANL		−40	+40	V
V_{trt}	transient voltage	on pins VBAT, WAKE, CANH, CANL; ISODIS = 0 [5]			
		pulse 1	-100	-	V
		pulse 2a	-	+75	V
		pulse 3a	-150	-	V
		pulse 3b	-	+100	V
V_{ESD}	electrostatic discharge voltage	IEC 61000-4-2 (150 pF, 330 Ω discharge circuit) [6]			
		on pins CANH, CANL; on pin VBAT with 100 nF capacitor; on pin WAKE with 33 kΩ resistor	-8	+8	kV
		Human Body Model (HBM)			
		on any pin [7]	-4	+4	kV
		on pins CANH, CANL [8]	-8	+8	kV
		Charged Device Model (CDM) [9]			
		on any pin	-500	+500	V
		on corner pins [10]	-750	+750	V
T_{vj}	virtual junction temperature	[11]	-40	+150	°C
T_{stg}	storage temperature	[12]	-55	+150	°C

[1] The device can sustain voltages up to the specified values over the product lifetime, provided applied voltages (including transients) never exceed these values.
[2] The device can withstand voltages between 6 V and 7 V for a total of 20 s over the product lifetime.
[3] Absolute maximum of 40 V.
[4] Subject to the qualifications detailed in Table notes 1 and 2 above for pin VIO, and for VIO-related input pins.
[5] Verified by an external test house according to IEC TS 62228, Section 4.2.4; parameters for standard pulses defined in ISO 7637, part 2.
[6] Verified by an external test house according to IEC TS 62228, Section 4.3.
[7] According to AEC-Q100-002.
[8] Pins stressed to reference group containing all ground and supply pins, emulating the application circuits (Figure 15 and Figure 16). HBM pulse as specified in AEC-Q100-002 used.
[9] According to AEC-Q100-011.
[10] Only valid for TJA1445AT.

[11] In accordance with IEC 60747-1. An alternative definition of virtual junction temperature is: $T_{vj} = T_{amb} + P \times R_{th(j-a)}$, where $R_{th(j-a)}$ is a fixed value used in the calculation of T_{vj}. The rating for T_{vj} limits the allowable combinations of power dissipation (P) and ambient temperature (T_{amb}).

[12] T_{stg} in application according to IEC61360-4. For component transport and storage conditions, see instead IEC61760-2.

8 Thermal characteristics

Table 46. Thermal characteristics

Value determined for free convection conditions on a JEDEC 2S2P board.

Symbol	Parameter	Conditions[1]	Typ	Unit
$R_{th(j-a)}$	thermal resistance from junction to ambient	SO14	85	K/W
		HVSON14	71	K/W
		DHVQFN18	69	K/W
$R_{th(j-c)}$	thermal resistance from junction to case[2]	HVSON14	34	K/W
		DHVQFN18	29	K/W
Ψ_{j-top}	thermal characterization parameter from junction to top of package	SO14	8	K/W
		HVSON14	11	K/W
		DHVQFN18	9	K/W

[1] According to JEDEC JESD51-2, JESD51-5 and JESD51-7 at natural convection on 2s2p board. Board with two inner copper layers (thickness: 35 µm) and thermal via array under the exposed pad connected to the first inner copper layer (thickness: 70 µm).

[2] Case temperature refers to the center of the heatsink at the bottom of the package.

9 Static characteristics

Table 47. Static characteristics

T_{vj} = -40 °C to +175°C; V_{CC} = 4.5 V to 5.5 V; V_{IO} = 1.71 V to 5.5 V; V_{BAT} = 4.75 V to 40 V; R_L = 60 Ω unless specified otherwise; all voltages are defined with respect to ground; positive currents flow into the IC.[1]

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Supply; pin VCC						
V_{CC}	supply voltage		4.5	-	5.5	V
V_{uvd}	undervoltage detection voltage	[2]	4	-	4.5	V
V_{uvhys}	undervoltage hysteresis voltage		50	-	-	mV
I_{CC}	supply current	Normal mode; dominant; V_{TXD} = 0 V				
		$t < t_{to(dom)TXD}$	-	40	60	mA
		short circuit on bus lines; -3 V < (V_{CANH} = V_{CANL}) < +40 V	-	-	125	mA
		Normal mode, recessive; V_{TXD} = V_{IO}	-	6	9	mA
		Listen-only mode, LPL = 0	-	6	9	mA
		Listen-only mode; LPL = 1; VBATVCC = 0; T_{vj} < 150 °C	-	-	23	µA
		Listen-only mode; LPL = 1; VBATVCC = 1; T_{vj} < 150 °C	-	90	165	µA
		Standby or Sleep mode; T_{vj} < 85 °C	-	-	2	µA
		Standby or Sleep mode; T_{vj} < 150 °C	-	-	23	µA

Table 47. Static characteristics*...continued*

T_{vj} = -40 °C to +175°C; V_{CC} = 4.5 V to 5.5 V; V_{IO} = 1.71 V to 5.5 V; V_{BAT} = 4.75 V to 40 V; R_L = 60 Ω unless specified otherwise; all voltages are defined with respect to ground; positive currents flow into the IC.[1]

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
I/O level adapter supply; pin VIO						
V_{IO}	supply voltage		1.71	-	5.5	V
V_{uvd}	undervoltage detection voltage	[2]	1.5	-	1.71	V
V_{uvhys}	undervoltage hysteresis voltage		33	-	-	mV
I_{IO}	supply current	Normal or Listen-only mode; V_{TXD} = V_{IO}	-	-	3	µA
		Standby or Sleep mode;; T_{vj} < 85 °C	-	-	2	µA
		Standby or Sleep mode; T_{vj} < 150 °C	-	-	<tbd>	µA
Supply; pin VBAT						
V_{BAT}	battery supply voltage		4.75	-	40	V
		extended range	4.25	-	40	V
V_{uvd}	undervoltage detection voltage	all modes [2]	4.25	-	4.75	V
I_{BAT}	battery supply current	Normal mode; pin INH left open; V_{BAT} ≤ 28 V	-	-	400	µA
		Listen-only mode; pin INH left open; V_{BAT} ≤ 28 V	-	-	525	µA
		Sleep or Standby mode; CAN Offline Bias mode; pin INH left open; CWE = 1; CPNC = 1; PNCOK = 1; V_{WAKE} = V_{BAT}; V_{BAT} ≤ 28 V				
		VBATVCC = 0; Tvj < 85 °C	-	-	450	µA
		VBATVCC = 0; Tvj < 150 °C	-	-	500	µA
		VBATVCC = 1; Tvj < 85 °C	-	-	350	µA
		VBATVCC = 1; Tvj < 150 °C	-	-	375	µA
		Sleep or Standby mode; CAN Offline mode; pin INH left open; V_{WAKE} = V_{BAT}; V_{BAT} ≤ 28 V				
		Tvj < 85 °C	-	<tbd>	22	µA
		Tvj < 150 °C	-	<tbd>	30	µA
		V_{BAT} = 32 V; ISODIS = 0; additional current due to V_{BAT} being increased to 32 V		<tbd>	0.5	mA
		V_{BAT} = 40 V;ISODIS = 0; additional current due to V_{BAT} being increased to 40 V		<tbd>	1.8	mA
CAN transmit data input; pin TXD						
V_{IH}	HIGH-level input voltage		$0.7V_{IO}$	-	-	V
V_{IL}	LOW-level input voltage		-	-	$0.3V_{IO}$	V

Table 47. Static characteristics...*continued*

T_{vj} = -40 °C to +175°C; V_{CC} = 4.5 V to 5.5 V; V_{IO} = 1.71 V to 5.5 V; V_{BAT} = 4.75 V to 40 V; R_L = 60 Ω unless specified otherwise; all voltages are defined with respect to ground; positive currents flow into the IC.[1]

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{hys(TXD)}$	hysteresis voltage on pin TXD		50	-	-	mV
R_{pu}	pull-up resistance		20	-	80	kΩ
$I_{IL(off)}$	Off state input leakage current	Off or Boot mode or $V_{IO} < V_{uvd(VIO)}$; 0 V < $V_{TXD} < V_{IO}$	-5	-	+5	μA
C_i	input capacitance	[3]	-	-	10	pF
CAN receive data output; pin RXD						
I_{OH}	HIGH-level output current	$V_{RXD} = V_{IO}$ - 0.4 V	-10	-	-1	mA
I_{OL}	LOW-level output current	V_{RXD} = 0.4 V	1	-	10	mA
$I_{IL(off)}$	Off state input leakage current	Off or Boot mode or $V_{IO} < V_{uvd(VIO)}$; 0 V < $V_{RXD} < V_{IO}$	-5	-	+5	μA
Inhibit output pin; pin INH						
ΔV_H	HIGH-level voltage drop	$\Delta V_H = V_{BAT} - V_{INH}$; I_{INH} = -1 mA	0	-	1	V
		$\Delta V_H = V_{BAT} - V_{INH}$; I_{INH} = -2 mA	0	-	2	V
I_L	leakage current	Sleep mode; Off mode	-2	-	2	μA
$I_{O(sc)}$	short-circuit output current	V_{INH} = 0 V	-15	-	-2	mA
Serial peripheral interface						
input pins SDI, SCK and SCSN						
V_{IH}	HIGH-level input voltage		$0.7V_{IO}$	-	-	V
V_{IL}	LOW-level input voltage		-	-	$0.3V_{IO}$	V
V_{hys}	hysteresis voltage		50	-	-	mV
R_{pd}	pull-down resistance	on pins SCK and SDI; $V_{SCK} = V_{IL}$; $V_{SDI} = V_{IL}$	20	-	80	kΩ
R_{pu}	pull-up resistance	on pins SCK and SDI; $V_{SCK} = V_{IH}$; $V_{SDI} = V_{IH}$	20	-	80	kΩ
		on pin SCSN	20	-	80	kΩ
$I_{IL(off)}$	Off state input leakage current	pins SDI and SCK; Off or Boot mode or $V_{IO} < V_{uvd(VIO)}$; 0 V < $V_{SDI} < V_{IO}$; 0 V < $V_{SCK} < V_{IO}$	-5	-	+5	μA
C_i	input capacitance		-	-	10	pF
output pin SDO						
I_{OH}	HIGH-level output current	V_{SDO} = VIO - 0.4 V	-10	-	-1	mA
I_{OL}	LOW-level output current	V_{SDO} = 0.4 V	1	-	10	mA
$I_{OL(off)}$	Off state output leakage current	$V_{SCSN} = V_{IO}$ or Off or Boot mode or $V_{IO} < V_{uvd(VIO)}$; 0 V < $V_{SDO} < V_{IO}$	-5	-	+5	μA
General purpose I/Os; pins GPIOx (TJA1445B only)						
I_{OH}	HIGH-level output current	V_{GPIOx} = VIO - 0.4 V; depending on GPIO configuration	-10	-	-1	mA

Table 47. Static characteristics...*continued*

T_{vj} = -40 °C to +175°C; V_{CC} = 4.5 V to 5.5 V; V_{IO} = 1.71 V to 5.5 V; V_{BAT} = 4.75 V to 40 V; R_L = 60 Ω unless specified otherwise; all voltages are defined with respect to ground; positive currents flow into the IC.[1]

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
I_{OL}	LOW-level output current	V_{GPIOx} = 0.4 V; depending on GPIO configuration	1	-	10	mA
V_{IH}	HIGH-level input voltage	depending on GPIO configuration	$0.7V_{IO}$	-	-	V
V_{IL}	LOW-level input voltage	depending on GPIO configuration	-	-	$0.3V_{IO}$	V
V_{hys}	hysteresis voltage	depending on GPIO configuration	50	-	-	mV
R_{pu}	pull-up resistance	depending on GPIO configuration	20	-	80	kΩ
R_{pd}	pull-down resistance	depending on GPIO configuration	20	-	80	kΩ
$I_{OL(off)}$	Off state output leakage current	high-Z or $V_{IO} < V_{uvd(VIO)}$; 0 V < $V_{GPIOx} < V_{IO}$	-5	-	5	µA
C_i	input capacitance	[3]	-	-	10	pF
Transmitter enable/disable input; pin TXEN_N (TJA1445B only)						
V_{IH}	HIGH-level input voltage		$0.7V_{IO}$	-	-	V
V_{IL}	LOW-level input voltage		-	-	$0.3V_{IO}$	V
V_{hys}	hysteresis voltage		50	-	-	mV
R_{pu}	pull-up resistance		20	-	80	kΩ
C_i	input capacitance	[3]	-	-	10	pF
Local wake-up input; pin WAKE						
R_{pu}	pull-up resistance	$V_{WAKE} > V_{th(wake)(max)}$ for $t > t_{wake(max)}$	100	-	400	kΩ
R_{pd}	pull-down resistance	$V_{WAKE} < V_{th(wake)(min)}$ for $t > t_{wake(max)}$	100	-	400	kΩ
$V_{th(wake)}$	wake-up threshold voltage	Sleep or Standby mode	1.8	-	2.6	V
V_{hys}	hysteresis voltage		90	-	-	mV
Bus lines; pins CANH and CANL						
$V_{O(dom)}$	dominant output voltage	CAN Active mode; V_{TXD} = 0 V; $t < t_{to(dom)TXD}$; $V_{CC} \geq 4.75$ V				
		pin CANH; R_L = 50 Ω to 65 Ω	2.75	3.5	4.5	V
		pin CANL; R_L = 50 Ω to 65 Ω	0.5	1.5	2.25	V
V_{TXsym}	transmitter voltage symmetry	$V_{TXsym} = V_{CANH} + V_{CANL}$; C_{SPLIT} = 4.7 nF; f_{TXD} = 250 kHz, 1 MHz or 2.5 MHz [3] [4]	$0.9V_{CC}$	-	$1.1V_{CC}$	V
$V_{cm(step)}$	common mode voltage step	[3] [4] [5]	-150	-	+150	mV
$V_{cm(p-p)}$	peak-to-peak common mode voltage	[3] [4] [5]	-300	-	+300	mV
$V_{O(dif)}$	differential output voltage	CAN Active mode; dominant; Normal mode; $V_{CC} \geq 4.75$; V_{TXD} = 0 V; $t < t_{to(dom)TXD}$ [4]				
		R_L = 50 Ω to 65 Ω	1.5	-	3	V

Table 47. Static characteristics...*continued*

T_{vj} = -40 °C to +175°C; V_{CC} = 4.5 V to 5.5 V; V_{IO} = 1.71 V to 5.5 V; V_{BAT} = 4.75 V to 40 V; R_L = 60 Ω unless specified otherwise; all voltages are defined with respect to ground; positive currents flow into the IC.[1]

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
		R_L = 45 Ω to 70 Ω	1.4	-	3.3	V
		R_L = 2240 Ω [3]	1.5	-	5	V
		CAN Active mode; recessive; no load				
		recessive; CAN Active, CAN Listen-only or CAN Offline Bias mode; V_{TXD} = V_{IO}	-50	-	+50	mV
		CAN Offline mode; no load	-0.2	-	+0.2	V
$V_{O(rec)}$	recessive output voltage	CAN Active, CAN Listen-only or CAN Offline Bias mode; V_{TXD} = V_{IO}; VBATVCC = 1 or VBATVCC = 0 and V_{BAT} ≥ 5.5 V; no load	2	2.5	3	V
		CAN Offline mode; no load	-0.1	0	+0.1	V
$V_{th(RX)dif}$	differential receiver threshold voltage	-12 V ≤ V_{CANH} ≤ +12 V; -12 V ≤ V_{CANL} ≤ +12 V				
		CAN Active, CAN Listen-only or CAN Offline Bias mode	0.5	-	0.9	V
		CAN Offline mode	0.4	-	1.1	V
$V_{rec(RX)}$	receiver recessive voltage	-12 V ≤ V_{CANH} ≤ +12 V; -12 V ≤ V_{CANL} ≤ +12 V				
		CAN Active, CAN Listen-only or CAN Offline Bias mode	-4	-	+0.5	V
		CAN Offline mode	-4	-	+0.4	V
$V_{dom(RX)}$	receiver dominant voltage	-12 V ≤ V_{CANH} ≤ +12 V; -12 V ≤ V_{CANL} ≤ +12 V				
		CAN Active, CAN Listen-only or CAN Offline Bias mode	0.9	-	9	V
		CAN Offline mode	1.1	-	9	V
$V_{hys(RX)dif}$	differential receiver hysteresis voltage	-12 V ≤ V_{CANH} ≤ +12 V; -12 V ≤ V_{CANL} ≤ +12 V; CAN Active, CAN Listen-only or CAN Offline Bias mode; no load	50	-	-	mV
$I_{O(sc)}$	short-circuit output current	-15 V ≤ V_{CANH} ≤ +40 V; -15 V ≤ V_{CANL} ≤ +40 V	-	-	115	mA
$I_{O(sc)rec}$	recessive short-circuit output current	-27 V ≤ V_{CANH} ≤ +32 V; -27 V ≤ V_{CANL} ≤ +32 V; Normal or Listen-only mode; V_{TXD} = V_{IO}	-3	-	+3	mA
I_L	leakage current	V_{CC} = V_{IO} = 0 V or pins shorted to GND via 47 KΩ; V_{CANH} = V_{CANL} = 5 V;	-10	-	+10	µA
R_i	input resistance	-2 V ≤ V_{CANL} ≤ +7 V; -2 V ≤ V_{CANH} ≤ +7 V	16	32	50	kΩ
ΔR_i	input resistance deviation	0 V ≤ V_{CANL} ≤ +5 V; 0 V ≤ V_{CANH} ≤ +5 V	-3	-	+3	%
$R_{i(dif)}$	differential input resistance	-2 V ≤ V_{CANL} ≤ +7 V; -2 V ≤ V_{CANH} ≤ +7 V	32	64	100	kΩ

Table 47. Static characteristics*...continued*

T_{vj} = -40 °C to +175°C; V_{CC} = 4.5 V to 5.5 V; V_{IO} = 1.71 V to 5.5 V; V_{BAT} = 4.75 V to 40 V; R_L = 60 Ω unless specified otherwise; all voltages are defined with respect to ground; positive currents flow into the IC.[1]

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$C_{i(cm)}$	common-mode input capacitance	[3]	-	-	20	pF
$C_{i(dif)}$	differential input capacitance	[3]	-	-	10	pF
Temperature detection						
$T_{j(sd)}$	shutdown junction temperature	[3]	180	-	200	°C
$T_{j(sd)rel}$	release shutdown junction temperature	[3]	175	-	195	°C

[1] All parameters are guaranteed over the junction temperature range by design. Factory testing uses correlated test conditions to cover the specified temperature and power supply voltage ranges.
[2] Undervoltage is detected between min and max values. Undervoltage is guaranteed to be detected below min value and guaranteed not to be detected above max value.
[3] Not tested in production; guaranteed by design.
[4] The test circuit used to measure the bus output voltage symmetry and the common-mode voltages (which includes C_{SPLIT}) is shown in Figure 18.
[5] See Figure 11.

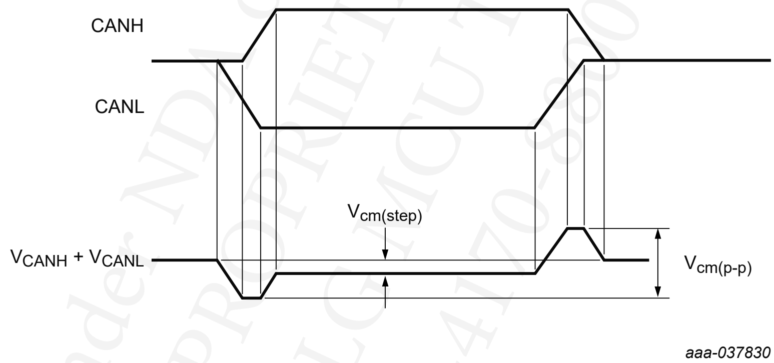


Figure 11. CAN bus common-mode voltage according to SAE 1939-14

10 Dynamic characteristics

Table 48. Dynamic characteristics

T_{vj} = -40 °C to +175 °C; V_{CC} = 4.5 V to 5.5 V; V_{IO} = 1.71 V to 5.5 V; V_{BAT} = 4.5 V to 40 V; R_L = 60 Ω unless specified otherwise; all voltages are defined with respect to ground.[1]

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
CAN timing characteristics; $t_{bit(TXD)}$ ≥ 200 ns; see Figure 12, Figure 13 and Figure 17						
$t_{d(TXD-busdom)}$	delay time from TXD to bus dominant	Normal mode	-	-	102.5	ns
$t_{d(TXD-busrec)}$	delay time from TXD to bus recessive	Normal mode	-	-	102.5	ns
$t_{d(busdom-RXD)}$	delay time from bus dominant to RXD	Normal or Listen-Only mode	-	-	131	ns
$t_{d(busrec-RXD)}$	delay time from bus recessive to RXD	Normal or Listen-Only mode	-	-	131	ns
$t_{d(TXDL-RXDL)}$	delay time from TXD LOW to RXD LOW	Normal mode	-	-	210	ns
$t_{d(TXDH-RXDH)}$	delay time from TXD HIGH to RXD HIGH	Normal mode	-	-	210	ns
CAN FD timing characteristics according to ISO 11898-2:2016; see Figure 13 and Figure 17						
$t_{bit(bus)}$ [2]	transmitted recessive bit width	2 Mbit/s ($t_{bit(TXD)}$ = 500 ns)	435	-	530	ns
		5 Mbit/s ($t_{bit(TXD)}$ = 200 ns)	155	-	210	ns
Δt_{rec}	receiver timing symmetry	2 Mbit/s	-65	-	+40	ns
		5 Mbit/s	-45	-	+15	ns
$t_{bit(RXD)}$ [3]	bit time on pin RXD	2 Mbit/s ($t_{bit(TXD)}$ = 500 ns)	400	-	550	ns
		5 Mbit/s ($t_{bit(TXD)}$ = 200 ns)	120	-	220	ns
Dominant time-out times						
$t_{to(dom)TXD}$	TXD dominant time-out time	V_{TXD} = 0 V; Normal mode [4] [5]	0.8	-	4	ms
$t_{to(dom)bus}$	bus dominant time-out time	$V_{O(dif)}$ > 0.9 V; Normal or Listen-Only mode [4] [5]	0.8	-	4	ms
Bus wake-up times; pins CANH and CANL; see Figure 6 and Figure 7						
$t_{wake(busdom)}$	bus dominant wake-up time	CAN Offline mode [4] [6]	0.5	-	1.45	µs
$t_{wake(busrec)}$	bus recessive wake-up time	CAN Offline mode [4] [6]	0.5	-	1.45	µs
$t_{to(wake)bus}$	bus wake-up time-out time	CAN Offline mode [4] [5]	0.8	-	9	ms
$t_{d(busact-bias)}$	bus bias reaction time	CAN Offline mode	-	-	250	µs
$t_{to(silence)}$	bus silence time-out time	timer reset and restarted when bus changes from dominant to recessive or vice versa	0.6	-	1.2	s
Serial peripheral interface timing; pins SCSN, SCK, SDI and SDO; see Figure 14						
$t_{cy(clk)}$	clock cycle time	Normal, Listen-Only, Standby or Sleep mode	250	-	-	ns
$t_{SPILEAD}$	SPI enable lead time	Normal, Listen-Only, Standby or Sleep mode	50	-	-	ns

Table 48. Dynamic characteristics*...continued*

T_{vj} = -40 °C to +175 °C; V_{CC} = 4.5 V to 5.5 V; V_{IO} = 1.71 V to 5.5 V; V_{BAT} = 4.5 V to 40 V; R_L = 60 Ω unless specified otherwise; all voltages are defined with respect to ground.[1]

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
t_{SPILAG}	SPI enable lag time	Normal, Listen-Only, Standby or Sleep mode	50	-	-	ns
$t_{clk(H)}$	clock HIGH time	Normal, Listen-Only, Standby or Sleep mode	100	-	-	ns
$t_{clk(L)}$	clock LOW time	Normal, Listen-Only, Standby or Sleep mode	100	-	-	ns
$t_{su(D)}$	data input set-up time	Normal, Listen-Only, Standby or Sleep mode	50	-	-	ns
$t_{h(D)}$	data input hold time	Normal, Listen-Only, Standby or Sleep mode	50	-	-	ns
$t_{v(Q)}$	data output valid time	C_L = 30 pF; Normal, Listen-Only, Standby or Sleep mode; pin SDO	-	-	50	ns
d(SDI-SDO)	SDI to SDO delay time	C_L = 30 pF; Normal, Listen-Only, Standby or Sleep mode; SPI address bits and read-only bit; pin SDO	-	-	50	ns
$t_{WH(S)}$	chip select pulse width HIGH	Normal, Listen-Only, Standby or Sleep mode	250	-	-	ns
$t_{d(SCKL-SCSN)}$	delay time from SCK LOW to SCSN LOW	Normal, Listen-Only, Standby or Sleep mode; pin SCSN	50	-	-	ns
$t_{to(SPI)}$ [7]	SPI time-out time		1.6	-	2.4	ms
CAN partial networking						
$N_{bit(idle)}$	number of idle bits	before a SOF is accepted; CWE = 1; CPNC = 1; PNCOK = 1 [4]	6	-	10	-
$t_{fltr(bit)dom}$	dominant bit filter time	arbitration data rate ≤ 500 kbit/s; CWE = 1; CPNC = 1; PNCOK = 1; PNECC = 1; IDFS = 0x0 [4] [8]	5	-	17.5	%
		data phase bit rate less than or equal to four times the arbitration bit rate or 2 Mbit/s, whichever is lower;CWE = 1; CPNC = 1; PNCOK = 1; PNECC = 1; IDFS = 0x1 [4] [8]	5	-	17.5	%
		data phase bit rate less than or equal to ten times the arbitration bit rate or 5 Mbit/s, whichever is lower;CWE = 1; CPNC = 1; PNCOK = 1; PNECC = 1; IDFS = 0x2 [4]	2.5	-	8.75	%
		CWE = 1; CPNC = 1; PNCOK = 1; PNECC = 1; IDFS = 0x3 [4]	18	-	93	ns

Table 48. Dynamic characteristics...*continued*

T_{vj} = -40 °C to +175 °C; V_{CC} = 4.5 V to 5.5 V; V_{IO} = 1.71 V to 5.5 V; V_{BAT} = 4.5 V to 40 V; R_L = 60 Ω unless specified otherwise; all voltages are defined with respect to ground.[1]

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
		CWE = 1; CPNC = 1; PNCOK = 1; PNECC = 1; IDFS = 0x4 [4]	42	-	119	ns
		CWE = 1; CPNC = 1; PNCOK = 1; PNECC = 1; IDFS = 0x5 [4]	67	-	145	ns
		CWE = 1, CPNC = 1, PNCOK = 1, PNECC = 1; IDFS = 0x6 [4]	91	-	170	ns
Interrupt time-up time; pin RXD; GPIOx (when configured as an interrupt output; TJA1445B only)						
$t_{to(int)}$	interrupt time-out time		0.9	-	1.1	ms
General purpose I/Os; pins GPIOx (TJA1445B only)						
t_{fltr}	filter time	pin configured as input except when TXD2 option is selected for GPIO2 [9]	1	-	10	µs
$t_{w(min)}$	minimum pulse width	pin configured as output except when RXD2 option is selected for GPIO1	3	-	-	µs
Transmitter enable/disable input; pin TXEN_N (TJA1445B only)						
t_{fltr}	filter time	[9]	1	-	5	µs
Mode transitions; see Section 6.2, Figure 6 and Figure 7						
$t_{t(moch)}$	mode change transition time	[4]	-	-	50	µs
$t_{startup}$	start-up time	[4]	-	-	1	ms
$t_{startup(RXD)}$	RXD start-up time	after local or remote wake-up detected [4] [10]	0	-	20	µs
$t_{startup(INH)}$	INH start-up time	after local or remote wake-up detected; transition from Sleep to Standby [4] [11]	0	-	40	µs
$t_{t(snm)}$	SNM transition time	bus dominant time for Start-to-Normal mode boot	11	-	16	ms
$t_{to(MCU)}$	MCU time-out time	LUVIOSEL = 0	940	-	1300	ms
		LUVIOSEL = 1	1880	-	2600	ms
Local wake-up input; pin WAKE, see Section 6.2.2 and Table 34						
t_{wake}	wake-up time	in response to a falling or rising edge on pin WAKE; Standby or Sleep mode [12]				
		short wake-up time: WFC = 0	20	-	50	µs
		long wake-up time: WFC = 1	12	-	18	ms
Undervoltage detection; see Section 6.2 and Figure 5						
$t_{det(uv)}$	undervoltage detection time	≥ 100 mV input overdrive				

Table 48. Dynamic characteristics*...continued*

T_{vj} = -40 °C to +175 °C; V_{CC} = 4.5 V to 5.5 V; V_{IO} = 1.71 V to 5.5 V; V_{BAT} = 4.5 V to 40 V; R_L = 60 Ω unless specified otherwise; all voltages are defined with respect to ground.[1]

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
		on pin VBAT [4]	-	-	30	μs
		on pin VCC [4]	-	-	30	μs
		on pin VIO [4]	-	-	30	μs
$t_{det(uv)long}$	long undervoltage detection time	on pin VIO; LUVIOSEL = 0; $t_{det(uv)long1}$ [4] [13]	100	-	160	ms
		on pin VIO; LUVIOSEL = 1; $t_{det(uv)long2}$ [4] [13]	850	-	1150	ms
$t_{rec(uv)}$	undervoltage recovery time	≥ 100 mV input overdrive				
		on pin VBAT [4]	-	-	50	μs
		on pin VCC [4]	-	-	50	μs
		on pin VIO [4]	-	-	50	μs

[1] All parameters are guaranteed over the junction temperature range by design. Factory testing uses correlated test conditions to cover the specified temperature and power supply voltage ranges.
[2] $t_{bit(bus)} = \Delta t_{bit(bus)} + t_{bit(TXD)}$.
[3] $t_{bit(RXD)} = \Delta t_{bit(RXD)} + t_{bit(TXD)}$.
[4] Not tested in procduction; guaranteed by design
[5] Time-out occurs between the min and max values. Time-out is guaranteed not to occur below the min value; time-out is guaranteed to occur above the max value.
[6] A dominant/recessive phase shorter than the min value is guaranteed not be seen as a dominant/recessive bit; a dominant/recessive phase longer than the max value is guaranteed to be seen as a dominant/recessive bit.
[7] See Section 6.10.1.
[8] Up to 2 Mbit/s data speed.
[9] Pulses shorter than the min value are guaranteed to be filtered out; pulses longer than the max value are guaranteed to be processed.
[10] When a wake-up is detected, RXD start-up time is between the min and max values. RXD cannot be relied on below the min value; RXD can be relied on above the max value; see Figure 6 and Figure 7.
[11] INH switches HIGH between the min and max values after a wake-up had been detected. INH is guaranteed to be floating below the min value and guaranteed to be HIGH above the max value; see Figure 6 and Figure 7.
[12] The device is guaranteed to wake up above the max. value and guaranteed not to wake up below the min. value.
[13] An undervoltage longer than the max value is guaranteed to force a transition to Sleep mode; an undervoltage shorter than the min value is guaranteed not to force a transition to Sleep mode.

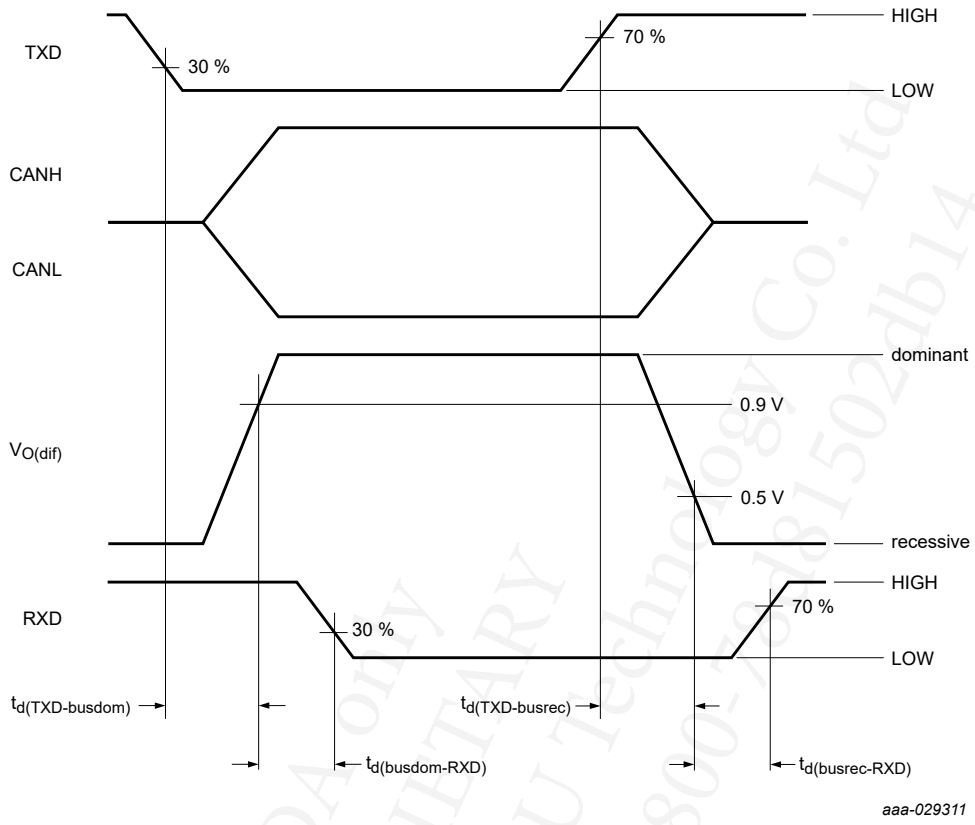


Figure 12. CAN transceiver timing diagram

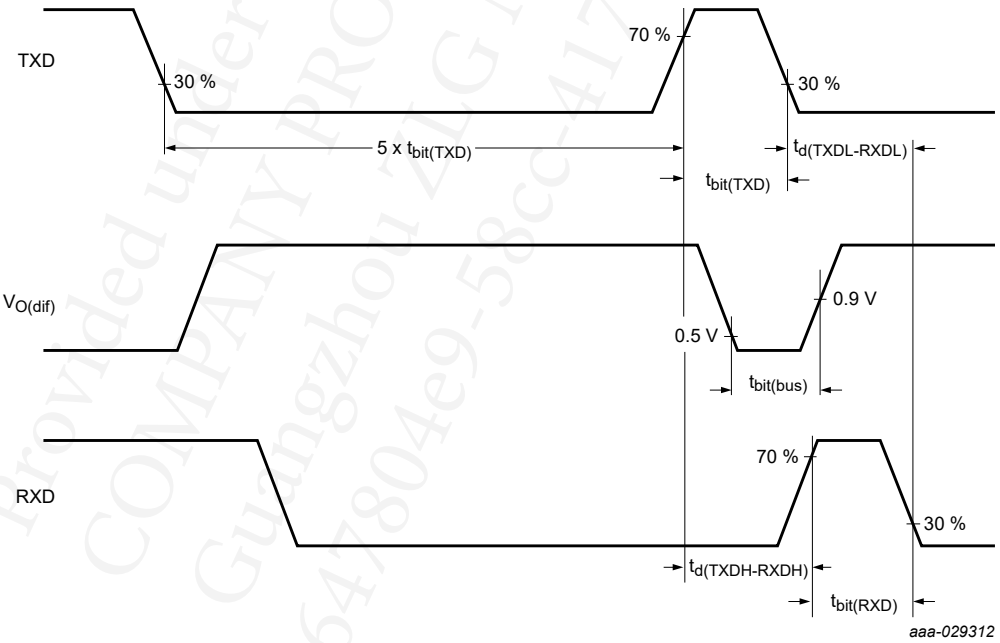
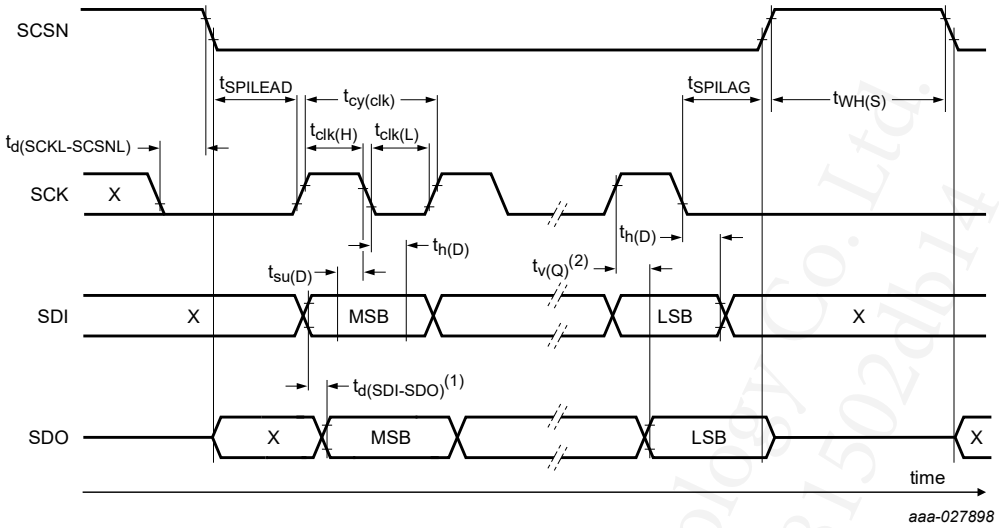


Figure 13. CAN FD timing definitions according to ISO 11898-2:2016



(1) The SDI to SDO delay time is valid for SPI address bits and the read-only bit.

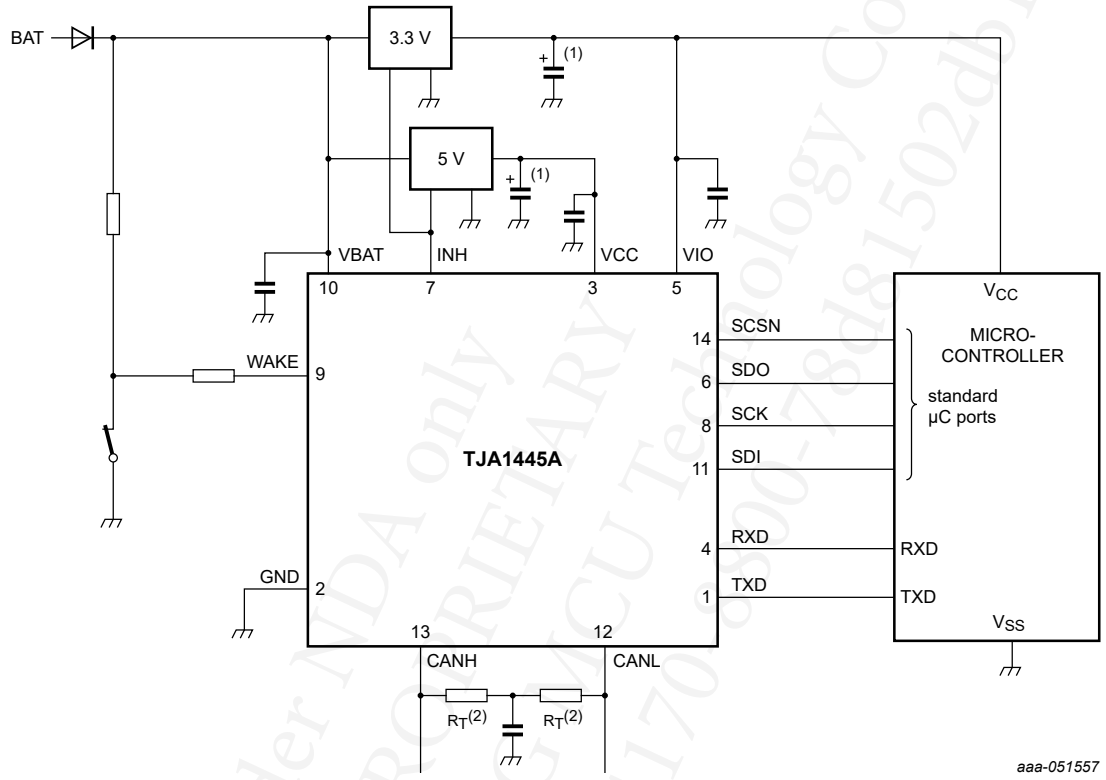
(2) The data output valid time is valid for the SPI data bits.

Figure 14. SPI timing diagram

11 Application information

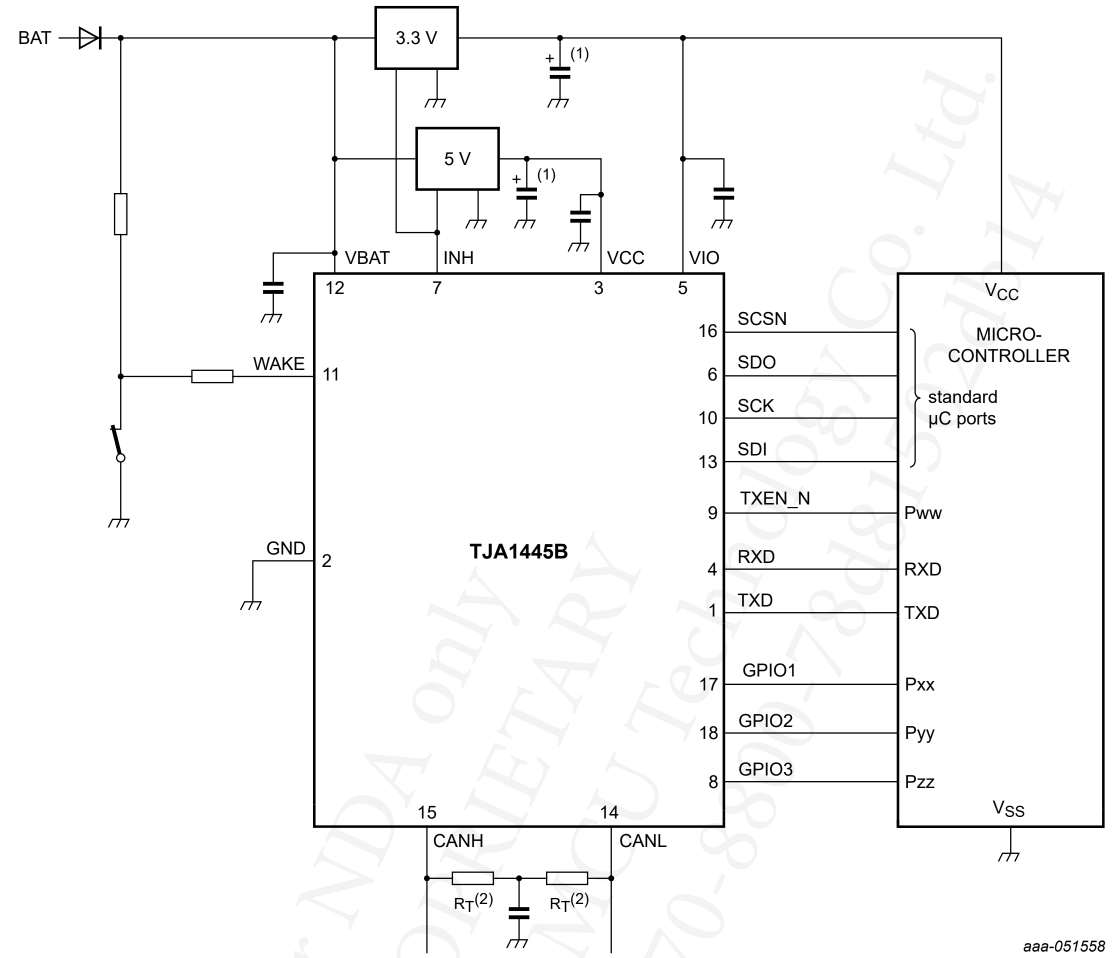
The minimum external circuitry needed with the TJA1445 is shown in Figure 15 and Figure 16. See the application hints (Section 11.2) for further information about external components and PCB layout requirements.

11.1 Application diagram



(1) Optional, depends on regulator.

Figure 15. Typical TJA1445A application with a 3.3 V microcontroller



(1) Optional, depends on regulator.

Figure 16. Typical TJA1445B application with a 3.3 V microcontroller

11.2 Application hints

Further information on the application of the TJA1445 can be found in NXP application hints AHxxxx *'TxxxxApplication Hints'*, available on request from NXP Semiconductors.

12 Test information

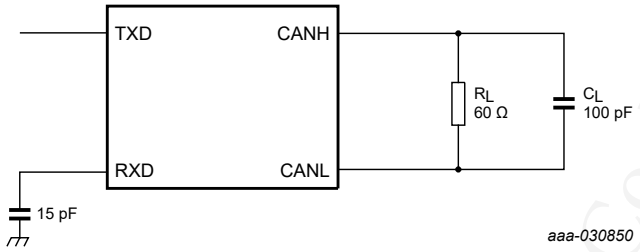


Figure 17. CAN transceiver timing test circuit

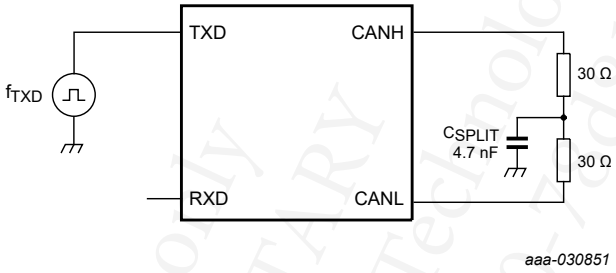


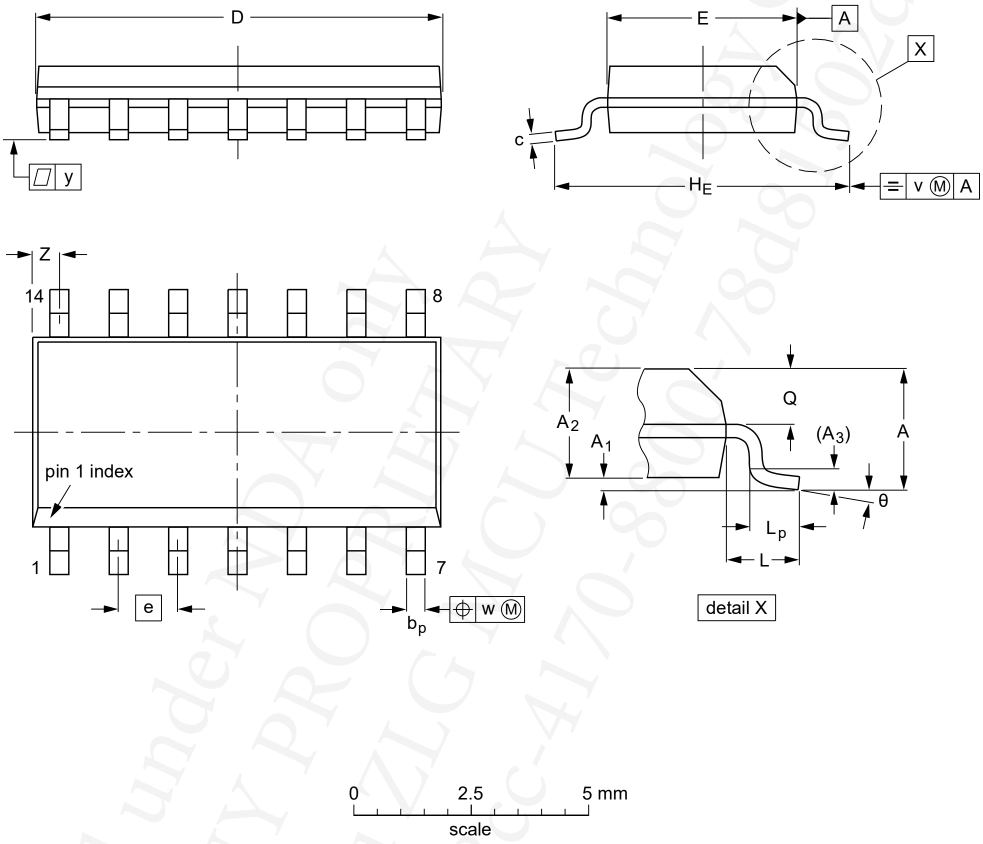
Figure 18. Test circuit for measuring transceiver driver symmetry

12.1 Quality information

This product has been qualified in accordance with the Automotive Electronics Council (AEC) standard *Q100 Rev-H - Failure mechanism based stress test qualification for integrated circuits*, and is suitable for use in automotive applications.

13 Package outline

SO14: plastic small outline package; 14 leads; body width 3.9 mm **SOT108-1**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	D(1)	E(1)	e	H_E	L	L_p	Q	v	w	y	Z(1)	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	8.75 8.55	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8° 0°
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.35 0.34	0.16 0.15	0.05	0.244 0.228	0.041	0.039 0.016	0.028 0.024	0.01	0.01	0.004	0.028 0.012	

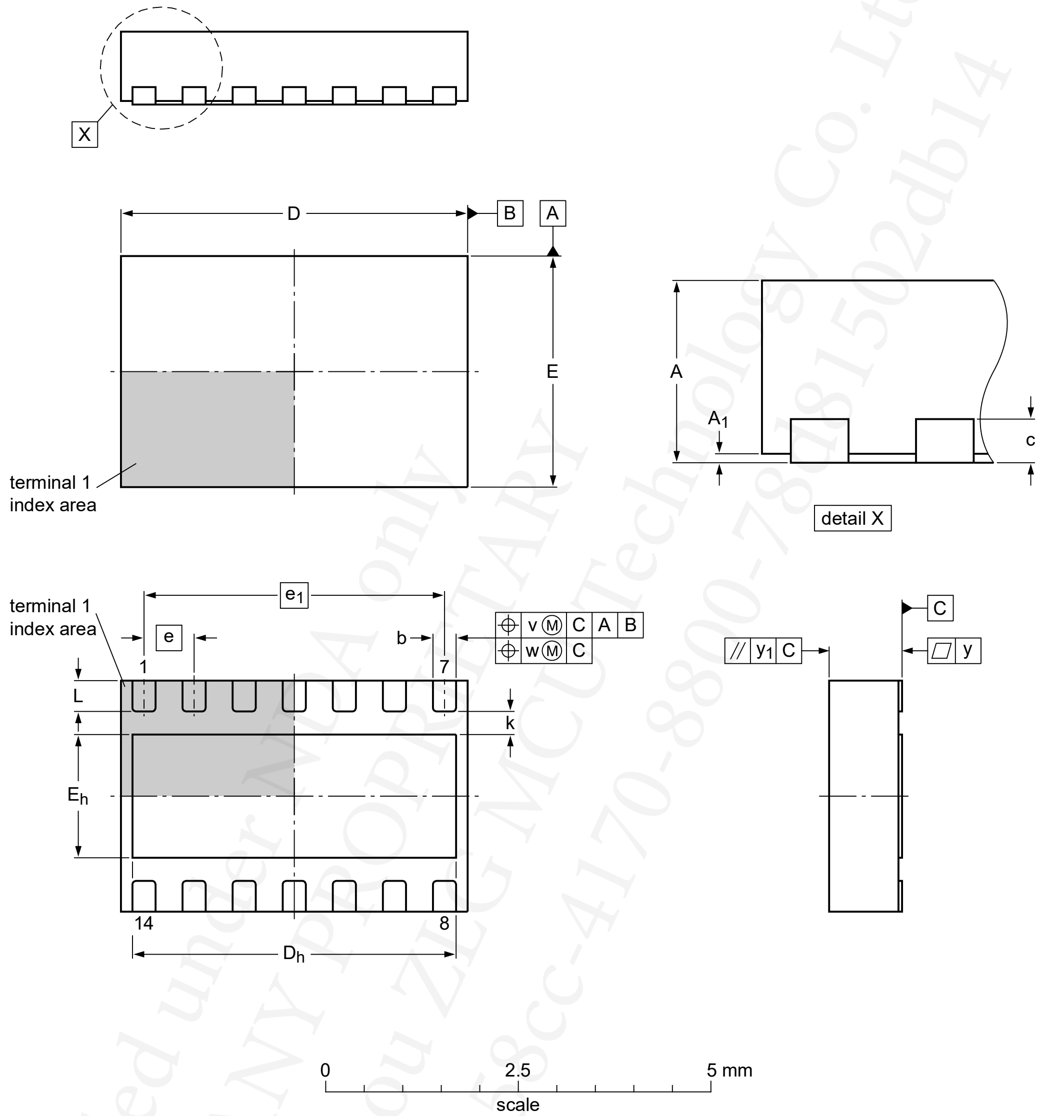
Note

1. Plastic or metal protrusions of 0.15 mm (0.006 inch) maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT108-1	076E06	MS-012				~~99-12-27~~ 03-02-19

Figure 19. Package outline SOT108-1 (SO14)

HVSON14: plastic, thermal enhanced very thin small outline package; no leads; 14 terminals; body 3 x 4.5 x 0.85 mm **SOT1086-2**



Dimensions

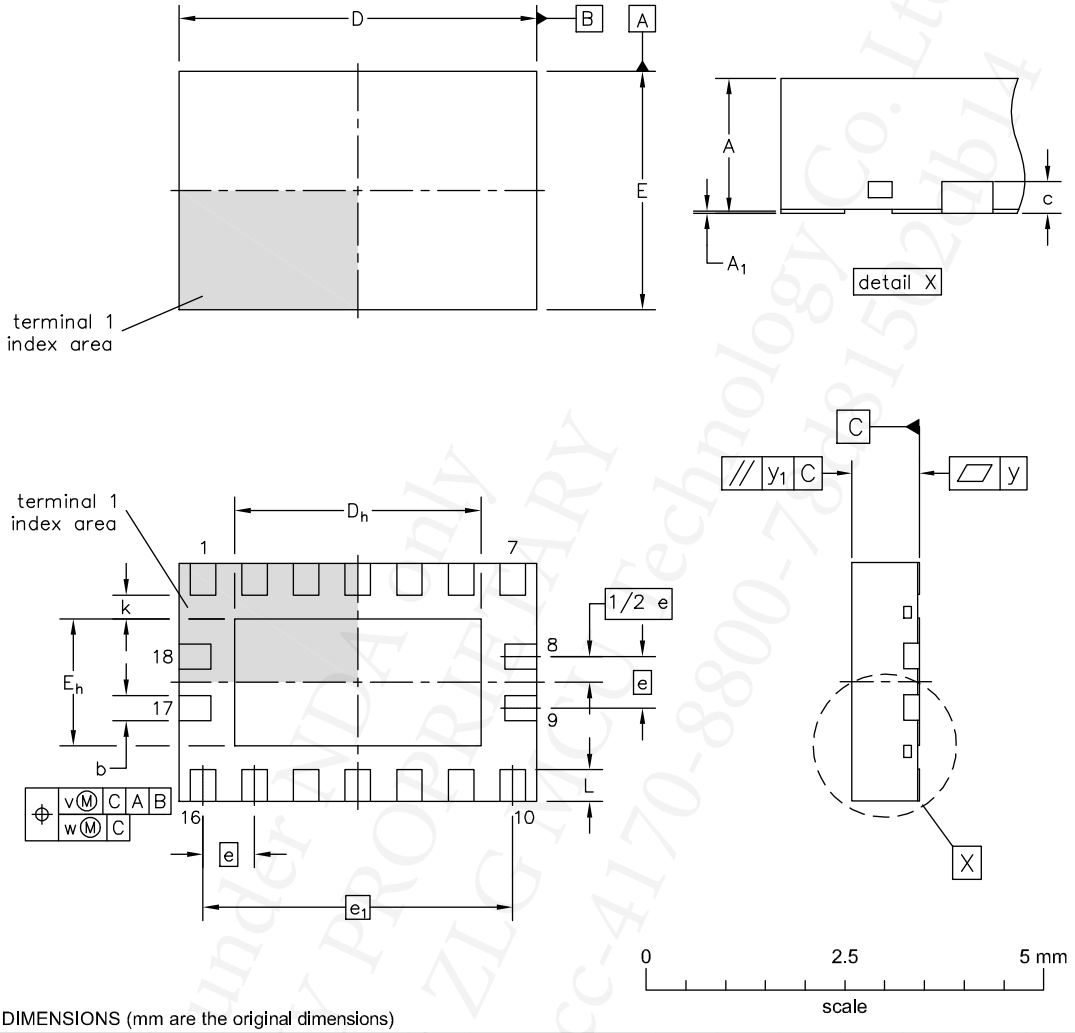
Unit		A	A_1	b	c	D	D_h	E	E_h	e	e_1	k	L	v	w	y	y_1
mm	max	1.00	0.05	0.35		4.6	4.25	3.1	1.65			0.35	0.45				
	nom	0.85	0.03	0.32	0.2	4.5	4.20	3.0	1.60	0.65	3.9	0.30	0.40	0.1	0.05	0.05	0.1
	min	0.80	0.00	0.29		4.4	4.15	2.9	1.55			0.25	0.35				

sot1086-2

Outline version	References				European projection	Issue date
	IEC	JEDEC	JEITA			
SOT1086-2	- - -	MO-229	- - -			~~10-07-14~~ 10-07-15

Figure 20. Package outline SOT1086-2 (HVSON14)

DHVQFN18: plastic dual in−line compatible thermal enhanced very thin quad flat package; no leads; 18 terminals; body 3.0 x 4.5 x 0.85 mm SOT2163−1



DIMENSIONS (mm are the original dimensions)

Unit[1]	A	A_1	b	c	D	D_h	E	E_h	e	e_1	k	L	v	w	y	y_1
max	1.00	0.05	0.35		4.60	3.15	3.10	1.65			0.35	0.45				
mm nom	0.85	0.03	0.32	0.20	4.50	3.10	3.00	1.60	0.65	3.90	0.30	0.40	0.10	0.05	0.05	0.10
min	0.80	0.00	0.29		4.40	3.05	2.90	1.55			0.25	0.35				

Note
1.Plastic or metal protusions of 0.075 mm maximum per side are not included.

DATE: 06 DEC 2022

MECHANICAL OUTLINE PRINT VERSION NOT TO SCALE	STANDARD: NON JEDEC	DRAWING NUMBER: 98ASA01851D	REVISION: O	

Figure 21. Package outline SOT2163-1 (DHVQFN18)

14 Handling information

All input and output pins are protected against ElectroStatic Discharge (ESD) under normal handling. When handling ensure that the appropriate precautions are taken as described in *JESD625-A* or equivalent standards.

15 Soldering of SMD packages

This text provides a very brief insight into a complex technology. A more in-depth account of soldering ICs can be found in Application Note *AN10365 “Surface mount reflow soldering description”*.

15.1 Introduction to soldering

Soldering is one of the most common methods through which packages are attached to Printed Circuit Boards (PCBs), to form electrical circuits. The soldered joint provides both the mechanical and the electrical connection. There is no single soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and Surface Mount Devices (SMDs) are mixed on one printed wiring board; however, it is not suitable for fine pitch SMDs. Reflow soldering is ideal for the small pitches and high densities that come with increased miniaturization.

15.2 Wave and reflow soldering

Wave soldering is a joining technology in which the joints are made by solder coming from a standing wave of liquid solder. The wave soldering process is suitable for the following:

- Through-hole components
- Leaded or leadless SMDs, which are glued to the surface of the printed circuit board

Not all SMDs can be wave soldered. Packages with solder balls, and some leadless packages which have solder lands underneath the body, cannot be wave soldered. Also, leaded SMDs with leads having a pitch smaller than ~0.6 mm cannot be wave soldered, due to an increased probability of bridging.

The reflow soldering process involves applying solder paste to a board, followed by component placement and exposure to a temperature profile. Leaded packages, packages with solder balls, and leadless packages are all reflow solderable.

Key characteristics in both wave and reflow soldering are:

- Board specifications, including the board finish, solder masks and vias
- Package footprints, including solder thieves and orientation
- The moisture sensitivity level of the packages
- Package placement
- Inspection and repair
- Lead-free soldering versus SnPb soldering

15.3 Wave soldering

Key characteristics in wave soldering are:

- Process issues, such as application of adhesive and flux, clinching of leads, board transport, the solder wave parameters, and the time during which components are exposed to the wave
- Solder bath specifications, including temperature and impurities

15.4 Reflow soldering

Key characteristics in reflow soldering are:

- Lead-free versus SnPb soldering; note that a lead-free reflow process usually leads to higher minimum peak temperatures (see Figure 22) than a SnPb process, thus reducing the process window
- Solder paste printing issues including smearing, release, and adjusting the process window for a mix of large and small components on one board
- Reflow temperature profile; this profile includes preheat, reflow (in which the board is heated to the peak temperature) and cooling down. It is imperative that the peak temperature is high enough for the solder to make reliable solder joints (a solder paste characteristic). In addition, the peak temperature must be low enough that the packages and/or boards are not damaged. The peak temperature of the package depends on package thickness and volume and is classified in accordance with Table 49 and Table 50

Table 49. SnPb eutectic process (from J-STD-020D)

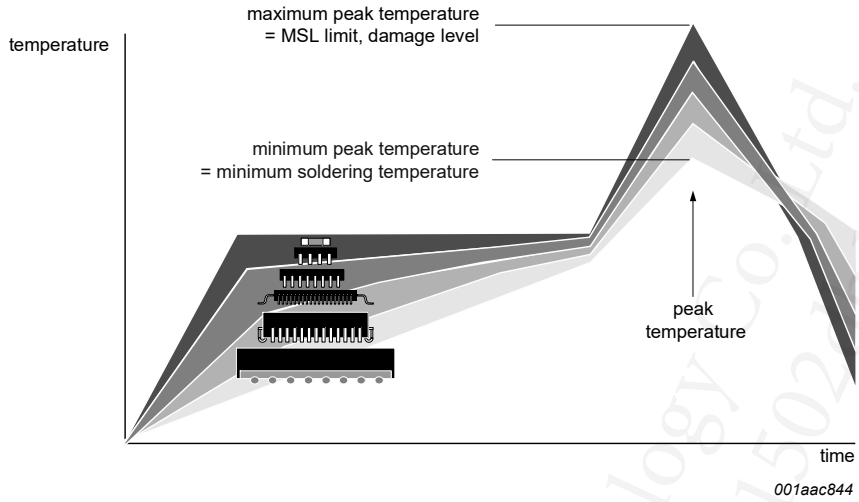
Package thickness (mm)	Package reflow temperature (°C)	
	Volume (mm^3)	
	< 350	≥ 350
< 2.5	235	220
≥ 2.5	220	220

Table 50. Lead-free process (from J-STD-020D)

Package thickness (mm)	Package reflow temperature (°C)		
	Volume (mm^3)		
	< 350	350 to 2000	> 2000
< 1.6	260	260	260
1.6 to 2.5	260	250	245
> 2.5	250	245	245

Moisture sensitivity precautions, as indicated on the packing, must be respected at all times.

Studies have shown that small packages reach higher temperatures during reflow soldering, see Figure 22.



MSL: Moisture Sensitivity Level

Figure 22. Temperature profiles for large and small components

For further information on temperature profiles, refer to Application Note *AN10365 "Surface mount reflow soldering description"*.

16 Appendix: ISO 11898-2:2016 parameter cross-reference lists

Table 51. ISO 11898-2:2016 to NXP data sheet parameter conversion

ISO 11898-2:2016		NXP data sheet	
Parameter	**Notation**	**Symbol**	**Parameter**
HS-PMA dominant output characteristics			
Single ended voltage on CAN_H	V_{CAN_H}	$V_{O(dom)}$	dominant output voltage
Single ended voltage on CAN_L	V_{CAN_L}		
Differential voltage on normal bus load	V_{Diff}	$V_{O(dif)}$	differential output voltage
Differential voltage on effective resistance during arbitration			
Optional: Differential voltage on extended bus load range			
HS-PMA driver symmetry			
Driver symmetry	V_{SYM}	V_{TXsym}	transmitter voltage symmetry
Maximum HS-PMA driver output current			
Absolute current on CAN_H	I_{CAN_H}	$I_{O(sc)}$	short-circuit output current
Absolute current on CAN_L	I_{CAN_L}		
HS-PMA recessive output characteristics, bus biasing active/inactive			
Single ended output voltage on CAN_H	V_{CAN_H}	$V_{O(rec)}$	recessive output voltage
Single ended output voltage on CAN_L	V_{CAN_L}		
Differential output voltage	V_{Diff}	$V_{O(dif)}$	differential output voltage
Optional HS-PMA transmit dominant time-out			
Transmit dominant time-out, long	t_{dom}	$t_{to(dom)TXD}$	TXD dominant time-out time
Transmit dominant time-out, short			
HS-PMA static receiver input characteristics, bus biasing active/inactive			
Recessive state differential input voltage range Dominant state differential input voltage range	V_{Diff}	$V_{th(RX)dif}$	differential receiver threshold voltage
		$V_{rec(RX)}$	receiver recessive voltage
		$V_{dom(RX)}$	receiver dominant voltage
HS-PMA receiver input resistance (matching)			
Differential internal resistance	R_{Diff}	$R_{i(dif)}$	differential input resistance
Single ended internal resistance	R_{CAN_H} R_{CAN_L}	R_i	input resistance
Matching of internal resistance	MR	ΔR_i	input resistance deviation
HS-PMA implementation loop delay requirement			
Loop delay	t_{Loop}	$t_{d(TXDH-RXDH)}$	delay time from TXD HIGH to RXD HIGH
		$t_{d(TXDL-RXDL)}$	delay time from TXD LOW to RXD LOW

Table 51. ISO 11898-2:2016 to NXP data sheet parameter conversion_...continued_

ISO 11898-2:2016		NXP data sheet	
Parameter	**Notation**	**Symbol**	**Parameter**
Optional HS-PMA implementation data signal timing requirements for use with bit rates above 1 Mbit/s up to 2 Mbit/s and above 2 Mbit/s up to 5 Mbit/s			
Transmitted recessive bit width @ 2 Mbit/s / @ 5 Mbit/s, intended	$t_{Bit(Bus)}$	$t_{bit(bus)}$	transmitted recessive bit width
Received recessive bit width @ 2 Mbit/s / @ 5 Mbit/s	$t_{Bit(RXD)}$	$t_{bit(RXD)}$	bit time on pin RXD
Receiver timing symmetry @ 2 Mbit/s / @ 5 Mbit/s	Δt_{Rec}	Δt_{rec}	receiver timing symmetry
HS-PMA maximum ratings of V_{CAN_H}, V_{CAN_L} and V_{Diff}			
Maximum rating V_{Diff}	V_{Diff}	$V_{(CANH-CANL)}$	voltage between pin CANH and pin CANL
General maximum rating V_{CAN_H} and V_{CAN_L}	V_{CAN_H} V_{CAN_L}	V_x	voltage on pin x
Optional: Extended maximum rating VCAN_H and VCAN_L			
HS-PMA maximum leakage currents on CAN_H and CAN_L, unpowered			
Leakage current on CAN_H, CAN_L	I_{CAN_H} I_{CAN_L}	I_L	leakage current
HS-PMA bus biasing control timings			
CAN activity filter time, long	t_{Filter}	$t_{wake(busdom)}$ [1] $t_{wake(busrec)}$	bus dominant wake-up time bus recessive wake-up time
CAN activity filter time, short			
Wake-up time-out, short	t_{Wake}	$t_{to(wake)bus}$	bus wake-up time-out time
Wake-up time-out, long			

[1] $t_{fltr(wake)bus}$ - bus wake-up filter time, in devices with basic wake-up functionality

17 Revision history

Table 52. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
TJA1445 v.1	<tbd>	Product data sheet	-	-

18 Legal information

18.1 Data sheet status

Document status[1][2]	Product status[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.
[2] The term 'short data sheet' is explained in section "Definitions".
[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL http://www.nxp.com.

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