Functional Safety Information

TCAN3403-Q1 and TCAN3404-Q1 Functional Safety FIT Rate, FMD, and Pin FMA

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Trademarks

1 Overview

This document contains information for the TCAN340x-Q1, which are 3.3V controller area network (CAN) transceivers. The TCAN340x-Q1 comes in the SOIC (D), VSON (DRB), and SOT (DDF) packages to aid in a functional safety system design. Information provided are:

- Functional safety failure in time (FIT) rates of the semiconductor component estimated by the application of industry reliability standards
- Component failure modes and their distribution (FMD) based on the primary function of the device
- Pin failure mode analysis (FMA) for the device pins of TCAN340x-Q1

Figure 1-1 shows the device functional block diagram for reference. TCAN3403-Q1 has the low voltage I/O support at pin 5, while TCAN3404-Q1 has the ultra-low power shutdown mode at pin 5.

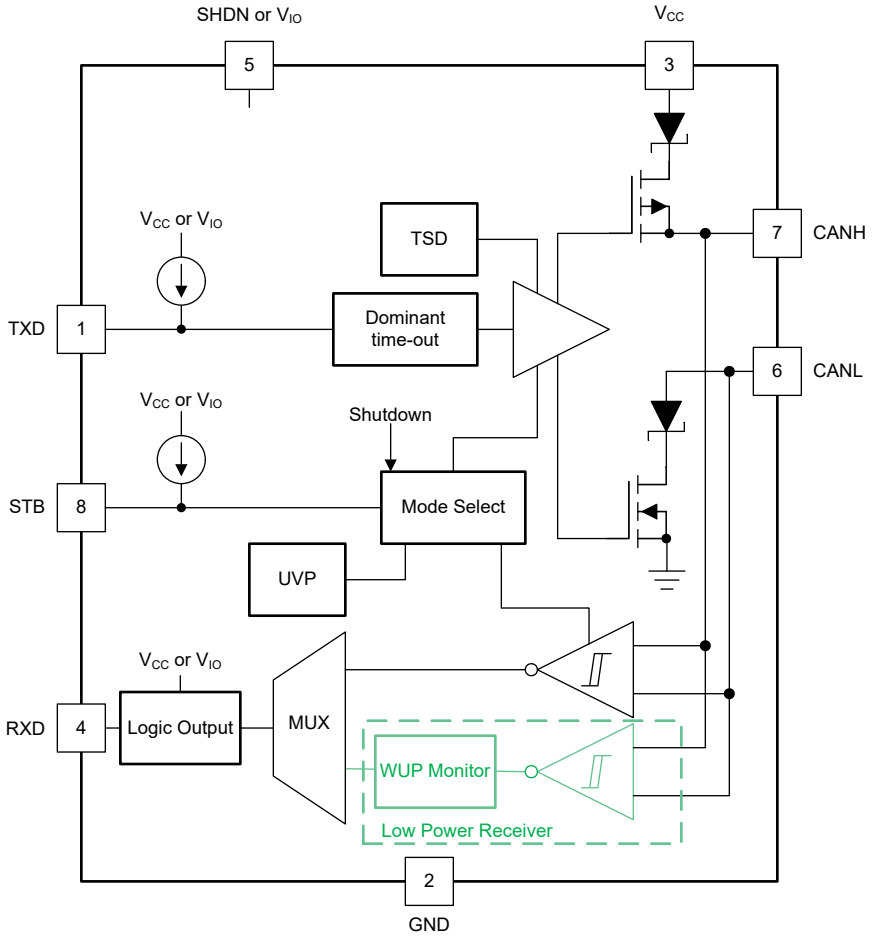

Figure 1-1. TCAN3403-Q1 and TCAN3404-Q1 Functional Block Diagram

The TCAN340x-Q1 were developed using a quality-managed development process, but were not developed in accordance with the IEC 61508 or ISO 26262 standards.

2 Functional Safety Failure In Time (FIT) Rates

This section provides functional safety failure in time (FIT) rates for the TCAN340x-Q1 based on two different industry-wide used reliability standards:

- Table 2-1 provides FIT rates based on IEC TR 62380 / ISO 26262 part 11
- Table 2-2 provides FIT rates based on the Siemens Norm SN 29500-2

Table 2-1. Component Failure Rates per IEC TR 62380 / ISO 26262 Part 11

FIT IEC TR 62380 / ISO 26262	FIT (Failures Per 10^9 Hours) 8-pin SOIC (D)	FIT (Failures Per 10^9 Hours) 8-pin SOT (DDF)	FIT (Failures Per 10^9 Hours) 8-pin VSON (DRB)
Total component FIT rate	9	4	6
Die FIT rate	2	2	2
Package FIT rate	7	2	4

The failure rate and mission profile information in Table 2-1 comes from the reliability data handbook IEC TR 62380 / ISO 26262 part 11:

- Mission profile: Motor control from Table 11
- Power dissipation: 57 mW
- Climate type: World-wide Table 8
- Package factor (lambda 3): Table 17b
- Substrate material: FR4
- EOS FIT rate assumed: 0 FIT

Table 2-2. Component Failure Rates per Siemens Norm SN 29500-2

Table	Category	Reference FIT Rate	Reference Virtual T_J
5	CMOS/BICMOS ASICs analog and mixed = < 50V supply	25 FIT	55°C

The reference FIT rate and reference virtual T_J (junction temperature) in Table 2-2 come from the Siemens Norm SN 29500-2 tables 1 through 5. Failure rates under operating conditions are calculated from the reference failure rate and virtual junction temperature using conversion information in SN 29500-2 section 4.

3 Failure Mode Distribution (FMD)

The failure mode distribution estimation for TCAN340x-Q1 in Table 3-1 comes from the combination of common failure modes listed in standards such as IEC 61508 and ISO 26262, the ratio of sub-circuit function size and complexity, and from best engineering judgment.

The failure modes listed in this section reflect random failure events and do not include failures resulting from misuse or overstress.

Table 3-1. Die Failure Modes and Distribution

Die Failure Modes	Failure Mode Distribution (%)
Transmitter Fail	62
Receiver Fail	16
Power management or state control fail	10
Input/output buffer fail	12

4 Pin Failure Mode Analysis (Pin FMA)

This section provides a failure mode analysis (FMA) for the pins of the TCAN340x-Q1. The failure modes covered in this document include the typical pin-by-pin failure scenarios:

- Pin short-circuited to ground (see Table 4-2)
- Pin open-circuited (see Table 4-3)
- Pin short-circuited to an adjacent pin (see Table 4-4)
- Pin short-circuited to V_{CC} (see Table 4-5)
- Pin short-circuited to V_{BAT} (see Table 4-6)
- Pin short-circuited to V_{IO} (Table 4-7)

Table 4-2 through Table 4-7 also indicate how these pin conditions can affect the device as per the failure effects classification in Table 4-1.

Following are the assumptions of use and the device configuration assumed for the pin FMA in this section:

- V_{CC} = 3V to 3.6V
- V_{BAT} = 6V to 24V
- V_{IO} = 1.7V to 3.6V
- The VSON thermal pad is not connected to device GND and is only for thermal purposes.
- No bus fault condition is considered while evaluating pin shorts.

Table 4-1. TI Classification of Failure Effects

Class	Failure Effects
A	Potential device damage that affects functionality.
B	No device damage, but loss of functionality.
C	No device damage, but performance degradation.
D	No device damage, no impact to functionality or performance.

Figure 4-1 shows the TCAN340x-Q1 SOIC pin diagram. Figure 4-2 shows the TCAN340x-Q1 VSON pin diagram. Figure 4-3 shows the TCAN340x-Q1 SOT pin diagram. For a detailed description of the device pins, see the *Pin Configuration and Functions* section in the TCAN340x-Q1 data sheets.

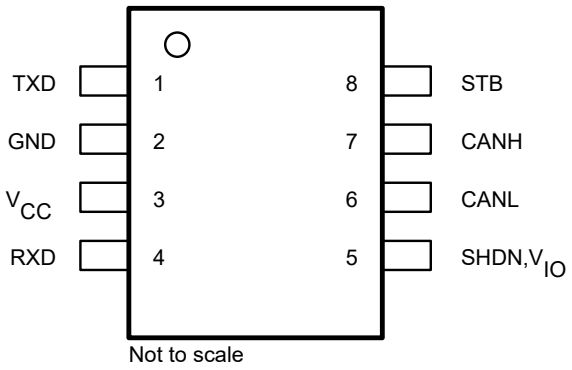

Figure 4-1. SOIC Pin Diagram

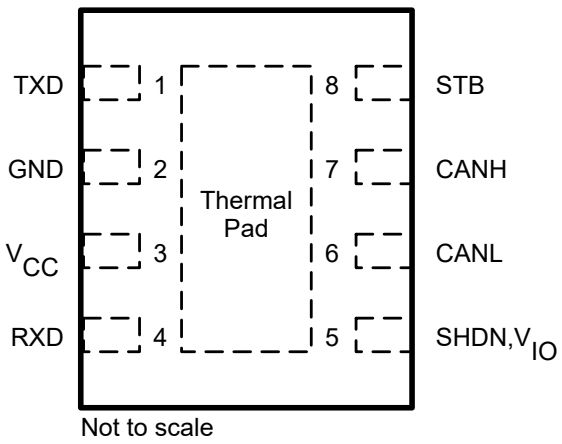

Figure 4-2. VSON Pin Diagram

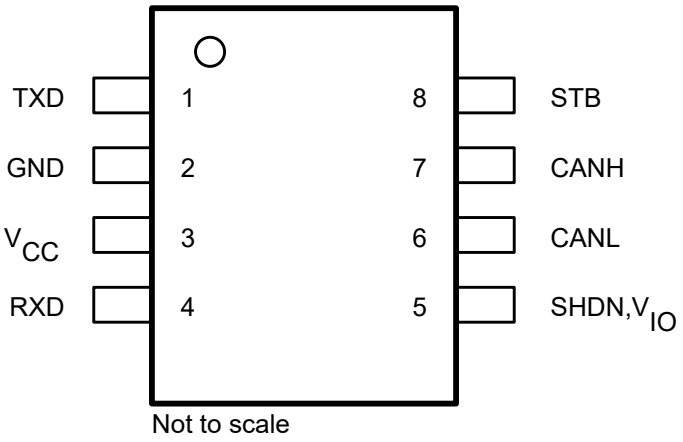

Figure 4-3. SOT Pin Diagram

Table 4-2. Pin FMA for Device Pins Short-Circuited to Ground

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
TXD	1	Device enters dominant time out mode. Unable to transmit data.	B
GND	2	None.	D
V_{CC}	3	Device not powered, high I_{CC} current.	B
RXD	4	RXD default is high-side FET ON, with pin short to ground, forms direct path between supply and ground causing high current.	A
SHDN	5	Device is unable to enter ultra-low power shutdown mode.	B
V_{IO}	5	Device is in protected mode. Transceiver passive on bus.	B
CANL	6	$V_{O(REC)}$ specification violated. Degraded EMC performance.	C
CANH	7	Device cannot drive dominant to the bus, no communication is possible.	B
STB	8	STB stuck low, transceiver is unable to enter low-power mode.	B
Thermal Pad	-	None.	D

Note

The VSON package includes a thermal pad.

Table 4-3. Pin FMA for Device Pins Open-Circuited

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
TXD	1	TXD pin defaults high, device is always recessive and unable to transmit data.	B
GND	2	Device not powered.	B
V_{CC}	3	Device not powered.	B
RXD	4	No RXD output, unable to receive data.	B
SHDN	5	Device remains in active mode due to integrated pull-down.	B
V_{IO}	5	Device is in protected mode. Transceiver passive on bus.	B
CANL	6	Device cannot drive dominant on the bus, unable to communicate.	B
CANH	7	Device cannot drive dominant on the bus, unable to communicate.	B
STB	8	STB pin defaults high, transceiver stuck in low-power mode.	B
Thermal Pad	-	None.	D

Note

The VSON package includes a thermal pad.

Table 4-4. Pin FMA for Device Pins Short-Circuited to Adjacent Pin

Pin Name	Pin No.	Shorted to	Description of Potential Failure Effects	Failure Effect Class
TXD	1	GND	Device enters dominant time out mode. Unable to transmit data.	B
GND	2	V_{CC}	High current can flow through GND pin, transceiver can be damaged.	A
V_{CC}	3	RXD	RXD output stuck high, unable to receive data.	B
SHDN	5	CANL	Device experiences disrupted CAN communication and there is potential for unintended shutdown behavior.	B
V_{IO}	5	CANL	Bus stuck recessive, no communication is possible. I_{OS} current can be reached on CANL.	B
CANL	6	CANH	Bus stuck recessive, no communication possible. I_{OS} current can be reached on CANH/CANL.	B
CANH	7	STB	Driver and receiver turn off when a dominant is driven. May not enter normal mode.	B

Note

- The VSON package includes a thermal pad. All device pins are adjacent to the thermal pad. The device behavior, when pins are shorted to the thermal pad, depends on which net is connected to the thermal pad.
- For a GND shorted to V_{CC} scenario, the device can be damaged if:
  - V_{CC} is shorted to GND
  - V_{CC} pin is soldered to V_{CC} route with supply ON
  - The GND pin is not soldered to system ground
  - The SHDN or STB pins are soldered to system GND

Table 4-5. Pin FMA for Device Pins Short-Circuited to V_{CC}

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
TXD	1	TXD stuck high, unable to transmit data.	B
GND	2	High current can flow through GND pin, transceiver can be damaged.	A
V_{CC}	3	None.	D
RXD	4	RXD pin stuck high, unable to receive data.	B

Table 4-5. Pin FMA for Device Pins Short-Circuited to V_{CC} (continued)

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
SHDN	5	Device enters ultra-low power shutdown mode.	B
V_{IO}	5	IO pins operate as 3.3V input/outputs. Microcontroller can be damaged if $V_{CC} > V_{IO}$.	C
CANL	6	RXD is always recessive, no communication is possible. I_{OS} current can be reached.	B
CANH	7	$V_{O(REC)}$ specification is violated, degraded EMC performance.	C
STB	8	STB stuck high, transceiver is always in standby mode.	B

Table 4-6. Pin FMA for Device Pins Short-Circuited to V_{BAT}

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
TXD	1	Absolute maximum violation, transceiver can be damaged. Unable to transmit data.	A
GND	2	Device not powered, high I_{BAT} current.	B
V_{CC}	3	Absolute maximum violation, transceiver can be damaged. Bus can be unable to communicate.	A
RXD	4	Absolute maximum violation, transceiver can be damaged. Unable to receive data.	A
SHDN	5	Absolute maximum violation, transceiver can be damaged.	A
V_{IO}	5	Absolute maximum violation, transceiver can be damaged.	A
CANL	6	RXD is always recessive, no communication is possible. I_{OS} current can be reached.	B
CANH	7	$V_{O(REC)}$ specification violated, degraded EMC performance.	C
STB	8	Absolute maximum violation, transceiver can be damaged. Transceiver stuck in low-power mode.	A

Table 4-7. Pin FMA for Device Pins Short-Circuited to V_{IO}

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
TXD	1	TXD stuck high, unable to transmit data.	B
GND	2	High current can flow through GND pin, transceiver can be damaged.	A
V_{CC}	3	IO pins operate as 5V input/outputs. Microcontroller can be damaged if $V_{CC} > V_{IO}$.	C
RXD	4	RXD pin stuck high, unable to receive data.	B
SHDN	5	None, as there is not a V_{IO} pin for the device having an SHDN pin.	D
V_{IO}	5	None.	D
CANL	6	RXD is always recessive, no communication is possible. I_{OS} current can be reached if $V_{IO} \geq 3.3V$.	B
CANH	7	$V_{O(REC)}$ specification is violated if $V_{IO} \geq 3.3V$, degraded EMC performance.	C
STB	8	STB stuck high, transceiver is always in standby mode.	B

Note

Table 4-7 is only applicable to the TCAN3403-Q1 device.

- For a GND shorted to V_{IO} scenario, the device can be damaged if:
  - V_{IO} is shorted to GND
  - V_{IO} pin is soldered to V_{IO} route with supply ON
  - The GND pin is not soldered to system ground
  - The STB pins are soldered to system GND

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