Functional Safety Information

TCAN1042-Q1 and TCAN1042V-Q1 Functional Safety FIT Rate, FMD, and Pin FMA

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Trademarks

1 Overview

This document contains information for TCAN1042-Q1 and TCAN1042V-Q1 (as well as the TCAN1042H-Q1, TCAN1042G-Q1, TCAN1042HV-Q1, TCAN1042GV-Q1, TCAN1042HG-Q1 and TCAN1042HGV-Q1). These are Controller Area Network (CAN) transceivers in the SOIC (D) and VSON (DRB) 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 TCAN1042-Q1 and TCAN1042V-Q1

Figure 1-1 shows the device functional block diagram for reference. TCAN1042V-Q1 has the VIO input at pin 5, while TCAN1042-Q1 has a no connect (NC) at pin 5.

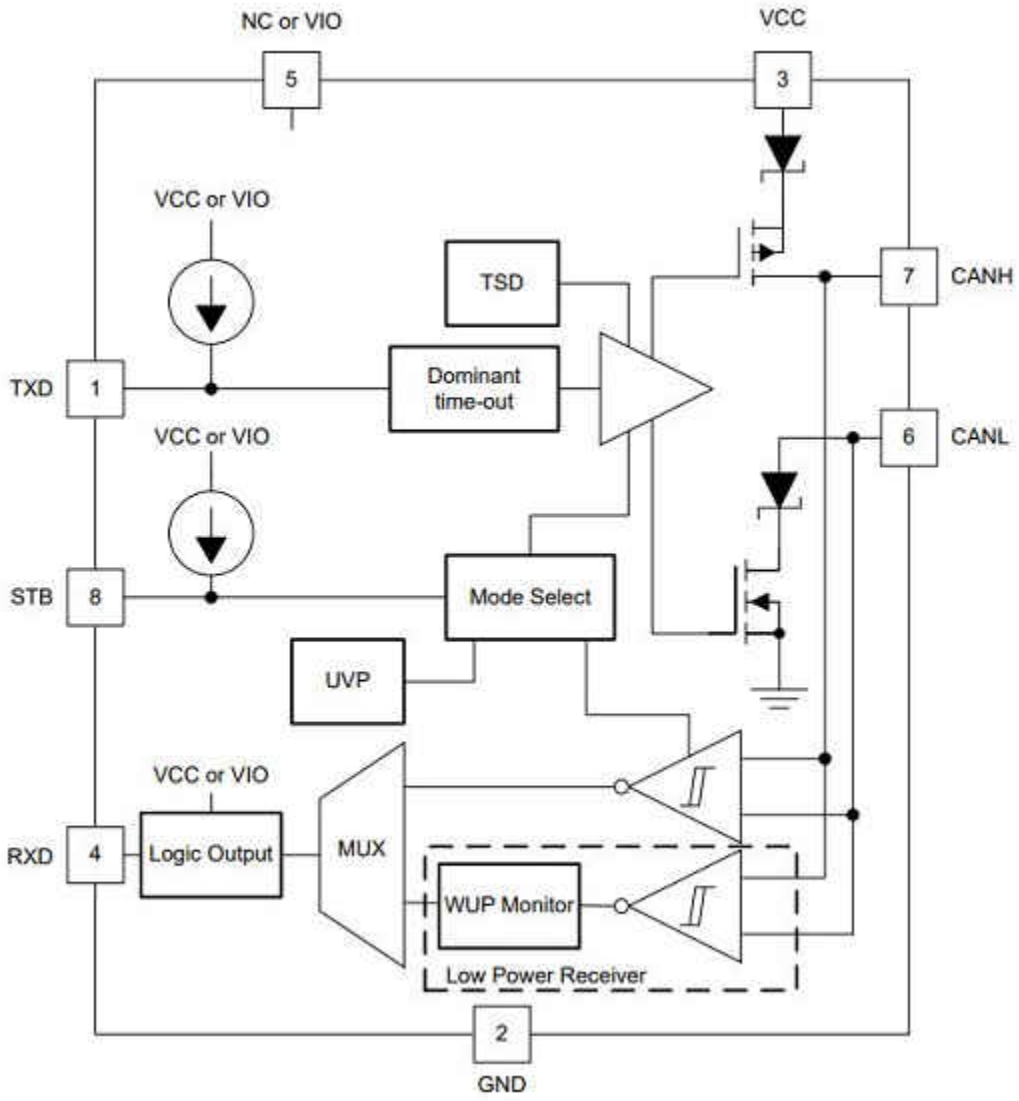

Figure 1-1. TCAN1042-Q1/TCAN1042V-Q1 Functional Block Diagram

TCAN1042-Q1 and TCAN1042V-Q1 were developed using a quality-managed development process, but was 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 TCAN1042-Q1 and TCAN1042V-Q1 (as well as the TCAN1042H-Q1, TCAN1042G-Q1, TCAN1042HV-Q1, TCAN1042GV-Q1, TCAN1042HG-Q1 and TCAN1042HGV-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 VSON (DRB)
Total Component FIT Rate	12	6
Die FIT Rate	4	2
Package FIT Rate	8	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: 124 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 & Mixed =<50V supply	20 FIT	55C

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 TCAN1042-Q1 and TCAN1042V-Q1 (as well as the TCAN1042H-Q1, TCAN1042G-Q1, TCAN1042HV-Q1, TCAN1042GV-Q1, TCAN1042HG-Q1 and TCAN1042HGV-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 due to misuse or overstress.

Table 3-1. Die Failure Modes and Distribution

Die Failure Modes	Failure Mode Distribution (%)
Receiver fail	45%
Transmitter fail	45%
CANL or CANH driver stuck dominant	5%
Short circuitry any two pins	5%

4 Pin Failure Mode Analysis (Pin FMA)

This section provides a Failure Mode Analysis (FMA) for the pins of the TCAN1042-Q1 and TCAN1042V-Q1 (as well as the TCAN1042H-Q1, TCAN1042G-Q1, TCAN1042HV-Q1, TCAN1042GV-Q1, TCAN1042HG-Q1 and TCAN1042HGV-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 VCC (see Table 4-5)
- Pin short-circuited to VBAT (see Table 4-6)
- Pin short-circuited to VIO (see 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.

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 TCAN1042-Q1/TCAN1042V-Q1 SOIC pin diagram. Figure 4-2 shows the TCAN1042-Q1/TCAN1042V-Q1 VSON pin diagram. For a detailed description of the device pins please refer to the *Pin Configuration and Functions* section in the TCAN1042-Q1/TCAN1042V-Q1 data sheet.

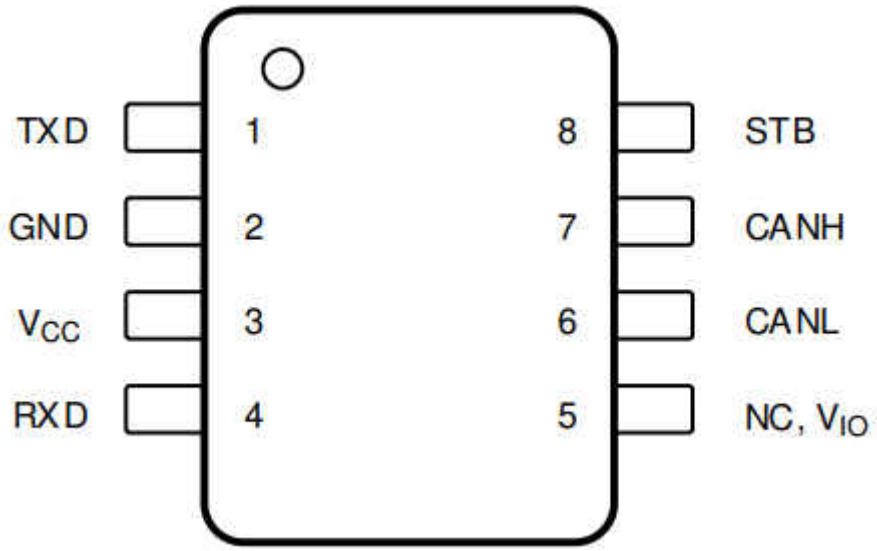

Figure 4-1. SOIC Pin Diagram

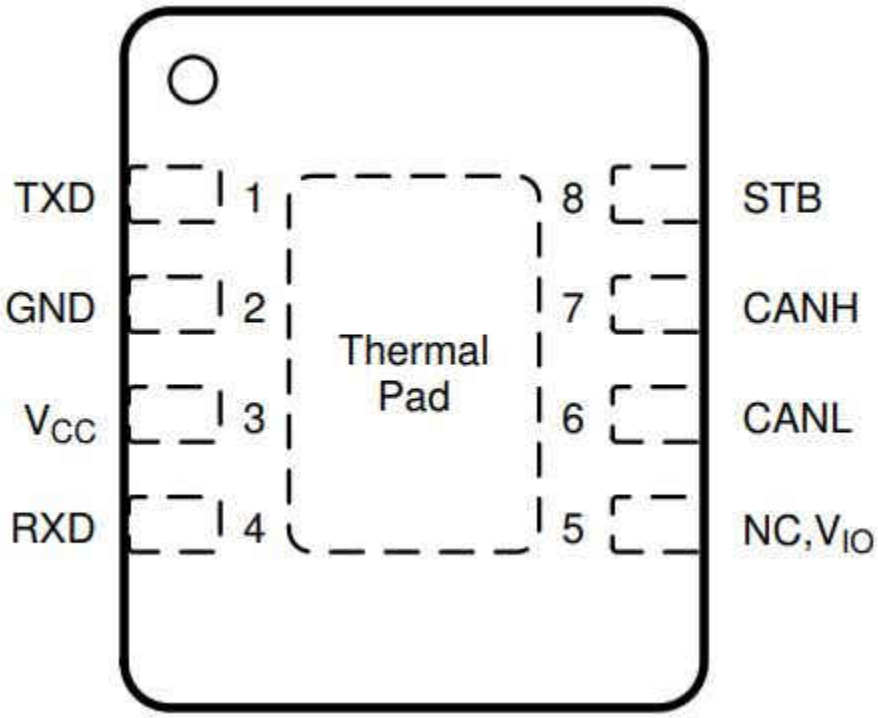

Figure 4-2. VSON Pin Diagram

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

- VCC = 4.5 to 5.5V
- VBAT = 6 to 24V
- VIO = 3 to 5.5V

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

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
TXD	1	Device will enter dominant time out mode. Unable to transmit data.	B
GND	2	None	D
VCC	3	Device unpowered, high I_{CC} current.	B
RXD	4	Transceiver output biased dominant, unable to receive data from the CAN bus. Internal damage possible.	B
NC	5	None	D
VIO	5	Device will be in protected mode. Transceiver passive on bus.	B
CANL	6	$V_{O(REC)}$ spec violated. Degraded EMC performance.	C
CANH	7	Device cannot drive dominant to the bus, no communication possible.	B
STB	8	STB stuck low, transceiver 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 Effect(s)	Failure Effect Class
TXD	1	TXD pin defaults high, device always recessive and unable to transmit data.	B
GND	2	Device unpowered.	B
VCC	3	Device unpowered.	B
RXD	4	No RXD output, unable to receive data.	B
NC	5	None	D
VIO	5	Device will be 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 Effect(s)	Failure Effect Class
TXD	1	GND	Device will enter dominant time out mode. Unable to transmit data.	B
GND	2	VCC	Device unpowered, high I_{CC} current.	B
VCC	3	RXD	RXD output stuck high, unable to receive data.	B
NC	5	CANL	None	D
VIO	5	CANL	Bus stuck recessive, no communication possible. I_{OS} current may be reached on CANL.	B
CANL	6	CANH	Bus stuck recessive, no communication possible. I_{OS} current may 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.

Table 4-5. Pin FMA for Device Pins Short-Circuited to VCC

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
TXD	1	TXD stuck high, unable to transmit data.	B
GND	2	Device unpowered, high I_{CC} current.	B
VCC	3	None	D
RXD	4	RXD pin stuck high, unable to receive data.	B
NC	5	None	D
VIO	5	IO pins will operate as 5V input/outputs. Microcontroller may be damaged if VCC > VIO.	C
CANL	6	RXD always recessive, no communication possible. I_{OS} current may be reached.	B
CANH	7	$V_{O(REC)}$ spec violated, degraded EMC performance.	C
STB	8	STB stuck high, transceiver always in standby mode.	B

Table 4-6. Pin FMA for Device Pins Short-Circuited to VBAT

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
TXD	1	Absolute maximum violation, transceiver may be damaged. Unable to transmit data.	A
GND	2	Device unpowered, high I_{BAT}current	B
VCC	3	Absolute maximum violation, transceiver may be damaged. Bus may be unable to communicate.	A
RXD	4	Absolute maximum violation, transceiver may be damaged. Unable to receive data.	A
NC	5	None	D
VIO	5	Absolute maximum violation, transceiver may be damaged.	A
CANL	6	RXD always recessive, no communication possible. I_{OS}current may be reached.	B
CANH	7	$V_{O(REC)}$ spec violated, degraded EMC performance.	C
STB	8	Absolute maximum violation, transceiver may be damaged. Transceiver stuck in low-power mode.	A

Table 4-7. Pin FMA for Device Pins Short-Circuited to VIO

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
TXD	1	TXD stuck high, unable to transmit data.	B
GND	2	Device unpowered, high I_{IO} current.	B
VCC	3	IO pins will operate as 5V input/outputs. Microcontroller may be damaged if VCC > VIO.	C
RXD	4	RXD pin stuck high, unable to receive data.	B
NC	5	None	D
VIO	5	None	D
CANL	6	RXD always recessive, no communication possible. I_{OS} current may be reached if VIO ≥ 3.3V.	B
CANH	7	$V_{O(REC)}$ spec violated if, degraded EMC performance.	C
STB	8	STB stuck high, transceiver always in standby mode.	B

Note

Table 4-7 is only applicable to the TCAN1042V-Q1 device.

5 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision * (October 2020) to Revision A (December 2021)	Page
• Added references to the document for TCAN1042H-Q1, TCAN1042G-Q1, TCAN1042HV-Q1, TCAN1042GV-Q1, TCAN1042HG-Q1 and TCAN1042HGV-Q1	2
• Changed the RXD pin description in the *Pin FMA Short-Circuited to Ground* table	5

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