Functional Safety Information

THS4509-Q1
Functional Safety FIT Rate, FMD and Pin FMA

Table of Contents

List of Figures

List of Tables

Trademarks

1 Overview

This document contains information for THS4509-Q1 (RGT package) 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 (Pin FMA)

Figure 1-1 shows the device functional block diagram for reference.

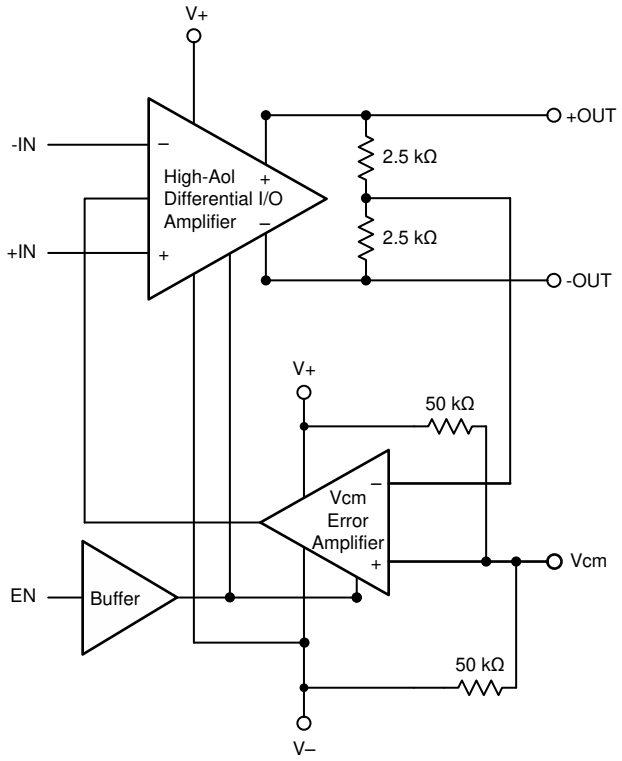

Figure 1-1. Functional Block Diagram

THS4509-Q1 was 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 THS4509-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)
Total Component FIT Rate	10
Die FIT Rate3	3
Package FIT Rate	7

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: 249 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
4	Bipolar Op Amp, Comparators, Voltage Monitors	12 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 THS4509-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 (%)
V_{OUT+}/V_{OUT-} open	20%
V_{OUT+}/V_{OUT-} to V_{S-}	20%
V_{OUT+}/V_{OUT-} to VS+	20%
V_{OUT+} or V_{OUT-} functional, not in specification	35%
Pin to pin short, any two pins	5%

4 Pin Failure Mode Analysis (Pin FMA)

This section provides a Failure Mode Analysis (FMA) for the pins of the THS4509-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 supply (see Table 4-5)

Table 4-2 through Table 4-5 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 THS4509-Q1 pin diagram. For a detailed description of the device pins please refer to the *Pin Configuration and Functions* section in the THS4509-Q1 data sheet.

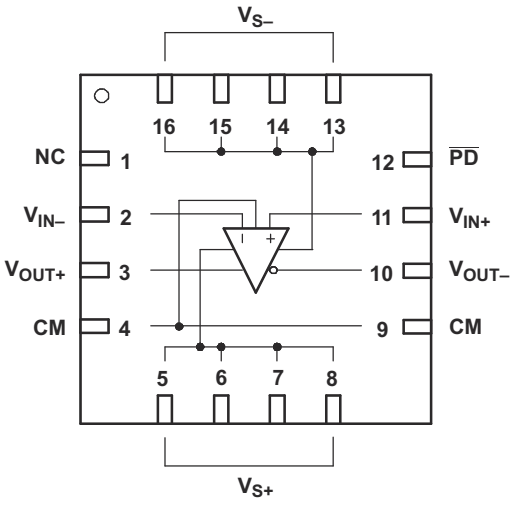

Figure 4-1. Pin Diagram

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

- Assumption – the device is running in the typical application, please refer to the *Simplified Schematic* on the first page of the THS4509-Q1 Wideband Low-Noise Low-Distortion Fully Differential Amplifier data sheet.
- Total supply voltage of 5 V with V+ connected to 2.5 V and V- connected to -2.5 V.
- Input and output pins biased to GND reference point.

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
NC	1	Normal operation. Pin has no internal connection.	D
V_{IN-}	2	Input at mid-supply (GND) is valid input; however, the application's desired result is unlikely.	C
V_{OUT+}	3	May cause device to overheat.	B
CM	4 and 9	Normal operation, unless single supply voltage was intended.	D
V_{S+}	5, 6, 7, and 8	Diodes from input to V_{S+} may turn on due to input signal and cause electrical overstress (EOS).	A

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

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
V_{OUT-}	10	May cause device to overheat.	B
V_{IN+}	11	Input at mid-supply (GND) is valid input; however, the application's desired result is unlikely.	C
$\overline{PD}$	12	Valid Input. Device will function normally with dual supplies and in low-power mode if single supply configuration is used.	D
V_{S-}	13, 14, 15, and 16	Diodes from input to V_{S-} may turn on due to input signal and cause electrical overstress (EOS). Normal Operation if single supply configuration is used.	A

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

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
NC	1	Normal operation. Pin has no internal connection.	D
V_{IN-}	2	Floating input, circuit will likely not function as expected.	C
V_{OUT+}	3	Output can be left open. There is no effect on the IC, but the output will not be measured.	C
CM	4 and 9	Normal operation. Output common-mode will be set to mid-supply.	D
V_{S+}	5, 6, 7, and 8	Highest voltage output pin will try to power the device's V_{S+} pin.	B
V_{OUT-}	10	Output can be left open. There is no effect on the IC, but the output will not be measured.	C
V_{IN+}	11	Floating input, circuit will likely not function as expected.	C
$\overline{PD}$	12	Power down pin can be left open for normal operation.	D
V_{S-}	13, 14, 15, and 16	Lowest voltage output pin will try to power the device's V_{S-}pin.	B

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
1	NC	V_{IN-}	Normal operation. NC pin has no internal connection.	D
2	V_{IN-}	V_{OUT+}	Tying input pin to an output pin is valid, however, the application's desired result is unlikely.	C
3	V_{OUT+}	CM	Tying output pin to CM pin is valid; however, the application's desired result is unlikely.	C
4	CM	V_{S+}	Tying output pin to V_{S+} pin is valid; however, the application's desired result is unlikely.	C
5, 6, and 7	V_{S+}	V_{S+}	Normal operation. Pins are connected internally.	D
8	V_{S+}	CM	Tying output pin to V_{S+} pin is valid; however, the application's desired result is unlikely.	C
9	CM	V_{OUT-}	Tying Output pin to CM pin is valid; however, the application's desired result is unlikely.	C
10	V_{OUT-}	V_{IN+}	Tying input pin to an output pin is valid; however, the application's desired result is unlikely.	C
11	V_{IN+}	$\overline{PD}$	Tying an input pin to the power-down pin is valid; however, the application's desired result is unlikely.	C
12	$\overline{PD}$	V_{S-}	Device will operate in low-power mode.	C
13, 14, and 15	V_{S-}	V_{S-}	Normal operation. Pins are connected internally.	D
16	V_{S-}	NC	Normal operation. NC pin has no internal connection.	D

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

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
NC	1	Normal operation. NC pin has no internal connection.	D
V_{IN-}	2	Input at V_{S+} is valid input; however, the application's desired result is unlikely.	C
V_{OUT+}	3	May cause device to overheat.	B
CM	4 and 9	CM pin at V_{S+} is valid input; however, the application's desired result is unlikely.	C
V_{S+}	5, 6, 7, and 8	Normal operation.	D
V_{OUT-}	10	May cause device to overheat.	B
V_{IN+}	11	Input at V_{S+} is valid input; however, the application's desired result is unlikely.	C
$\overline{PD}$	12	Normal operation.	D
V_{S-}	13, 14, 15, and 16	Diodes from input to V- may turn on due to input signal and cause electrical overstress (EOS).	A

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265