Functional Safety Information

TMP112-Q1
Functional Safety FIT Rate, FMD and Pin FMA

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Trademarks

1 Overview

This document contains information for TMP112-Q1 (SOT563-6 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.

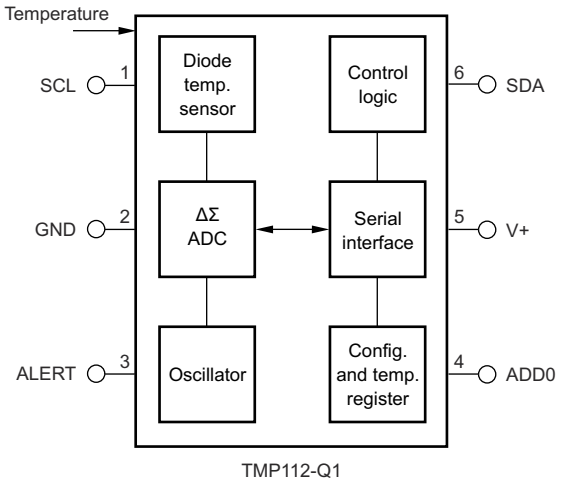

Figure 1-1. Functional Block Diagram

TMP112-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 TMP112-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	4
Die FIT Rate	2
Package FIT Rate	2

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: 1.0 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 Digital, analog / mixed	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 TMP112-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 (%)
Serial Communication Error	15%
ADC offset out of specification	20%
ADC gain out of specification	25%
ADC conversion output code bit error	15%
ADC incorrect input channel selected	5%
Register bank data bit error	15%
Alert false trip, fails to trip	5%

The FMD in Table 3-1 excludes short circuit faults across the isolation barrier. Faults for short circuit across the isolation barrier can be excluded according to ISO 61800-5-2:2016 if the following requirements are fulfilled:

1. The signal isolation component is OVC III according to IEC 61800-5-1. If a SELV/PELV power supply is used, pollution degree 2/OVC II applies. All requirements of IEC 61800-5-1:2007, 4.3.6 apply.
2. Measures are taken to ensure that an internal failure of the signal isolation component cannot result in excessive temperature of its insulating material.

Creepage and clearance requirements should be applied according to the specific equipment isolation standards of an application. Care should be taken to maintain the creepage and clearance distance of a board design to ensure that the mounting pads of the isolator on the printed-circuit board do not reduce this distance.

4 Pin Failure Mode Analysis (Pin FMA)

This section provides a Failure Mode Analysis (FMA) for the pins of the TMP112-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 TMP112-Q1 pin diagram. For a detailed description of the device pins please refer to the *Pin Configuration and Functions* section in the TMP112-Q1 data sheet.

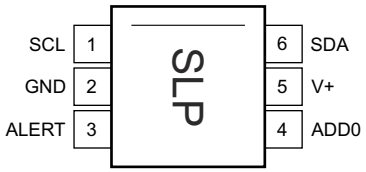

Figure 4-1. Pin Diagram

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

- Device is the only slave on the I2C bus
- External pull-up resistor on SCL/SDA pins

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
SCL	1	SCL stuck low. No I2C communication with device possible.	B
GND	2	No effect. Normal operation.	D
ALERT	3	ALERT stuck low. Non-functionable. False thermal limit will be triggered.	B
ADD0	4	Limited address selection. Communication could be corrupted.	B
V+	5	Device unpowered. Device not functional. Observe that the absolute maximum ratings for all pins of the device are met, otherwise device damage may be plausible.	A
SDA	6	SDA stuck low. No I2C communication with device possible.	B

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

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
SCL	1	State of SCL undetermined. No I2C communication with device possible.	B
GND	2	Device functionality undetermined. Device may be unpowered or connect to ground internally through alternate pin ESD diode and power up.	B
ALERT	3	State of ALERT undetermined. False thermal limit can be triggered.	B

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

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
ADD0	4	Limited address selection. Communication could be corrupted.	B
V+	5	Device functionality undetermined. Device unpowered if all external analog and digital pins are held low. Device may power up through internal ESD diodes to V+ if voltages above the device's power-on reset threshold are present on any of the analog or digital pins.	B
SDA	6	State of SDA undetermined. No I2C communication with device possible.	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
SCL	1	GND	SCL stuck low. No I2C communication with device possible.	B
GND	2	ALERT	If ALERT is low then normal operation. If ALERT is high then device functionality undetermined. Observe that the absolute maximum ratings for all pins of the device are met, otherwise device damage may be plausible.	A
ALERT	3	GND	ALERT stuck low. Non-functionable. False thermal limit will be triggered.	B
SDA	4	V+	SDA stuck high. No I2C communication with device possible.	B
V+	5	ADD0	If ADD0 is intended to be connected to V+ then normal operation. If ADD0 is connected to SDA or SCL then functionality is undetermined. If ADD0 is connected to GND then device unpowered. Device not functional. Observe that the absolute maximum ratings for all pins of the device are met, otherwise device damage may be plausible.	A
ADD0	6	V+	Limited address selection. Communication could be corrupted.	B

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

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
SCL	1	SCL stuck high. No I2C communication with device possible.	B
GND	2	Device functionality undetermined. Observe that the absolute maximum ratings for all pins of the device are met, otherwise device damage may be plausible.	A
ALERT	3	ALERT stuck high. Non-functionable. Thermal limit will not be triggered.	B
ADD0	4	Limited address selection. Communication could be corrupted.	B
V+	5	No effect. Normal operation.	D
SDA	6	SDA stuck high. No I2C communication with device possible.	B

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