Functional Safety Information

TPS3700-Q1
Functional Safety FIT Rate, FMD and Pin FMA

Table of Contents

Trademarks

1 Overview

This document contains information for TPS3700-Q1 (DDC and DSE 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.

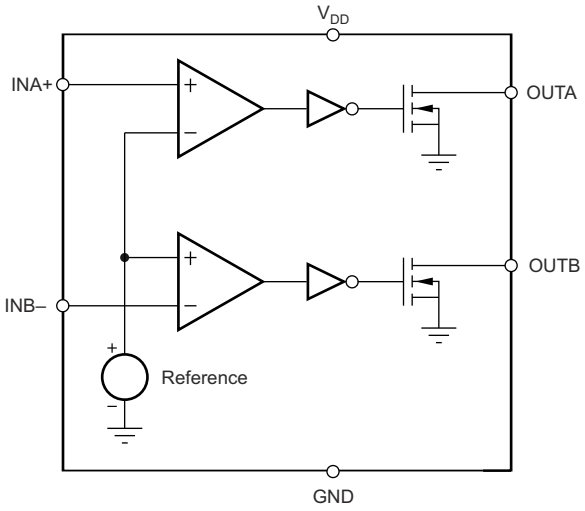

Figure 1-1. Functional Block Diagram

TPS3700-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

2.1 DDC Package

This section provides Functional Safety Failure In Time (FIT) rates for DDC package of TPS3700-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: 6 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	20 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.

2.2 DSE Package

This section provides Functional Safety Failure In Time (FIT) rates for the DSE package of TPS3700-Q1 based on two different industry-wide used reliability standards:

- Table 2-3 provides FIT rates based on IEC TR 62380 / ISO 26262 part 11
- Table 2-4 provides FIT rates based on the Siemens Norm SN 29500-2

Table 2-3. 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 2-3 comes from the Reliability data handbook IEC TR 62380 / ISO 26262 part 11:

- Mission Profile: Motor Control from Table 11
- Power dissipation: 6 mW
- Climate type: World-wide Table 8
- Package factor (lambda 3): Table 17b
- Substrate Material: FR4
- EOS FIT rate assumed: 0 FIT

Table 2-4. Component Failure Rates per Siemens Norm SN 29500-2

Table	Category	Reference FIT Rate	Reference Virtual T_J
5	CMOS, BICMOS Digital, analog / mixed	20 FIT	55°C

The Reference FIT Rate and Reference Virtual T_J (junction temperature) in Table 2-4 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 TPS3700-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 (%)
Output HiZ	30%
Output stuck low	30%
Output operating outside of specification	40%

4 Pin Failure Mode Analysis (Pin FMA)

This section provides a Failure Mode Analysis (FMA) for the pins of the TPS3700-Q1 (DDC and DSE package). The failure modes covered in this document include the typical pin-by-pin failure scenarios:

- Pin short-circuited to Ground (see Table 4-2 and Table 4-6.)
- Pin open-circuited (seeTable 4-3 and Table 4-7)
- Pin short-circuited to an adjacent pin (see Table 4-4 and Table 4-8)
- Pin short-circuited to VDD (see Table 4-5 and Table 4-9)

Table 4-2 through Table 4-9 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

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

- Unless otherwise specified, it is assumed that the voltages applied to all the pins are within the Recommended Operating Range specified in the TPS3700-Q1 data sheet.
- VDD = 5 V
- OUTA and OUTB pulled-up to VDD unless stated otherwise.

4.1 DDC Package

Figure 4-1 shows the TPS3700-Q1 pin diagram for the DDC package. For a detailed description of the device pins please refer to the *Pin Configuration and Functions* section in the TPS3700-Q1 data sheet.

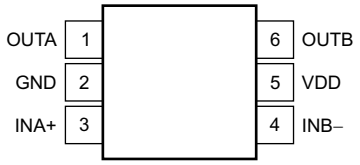

Figure 4-1. Pin Diagram (DDC) Package)
SOT-6
Top View

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
OUTA	1	No damage to device, undervoltage output pin nonfunctional, OUTA indicates an undervoltage fault, increase in system current due to current through OUTA pull-up resistor	B
GND	2	Normal operation.	D
INA+	3	No damage to device, undervoltage sense input pin nonfunctional, OUTA indicates undervoltage fault, increase in system current due to current through OUTA pull-up resistor	B
INB-	4	No damage to device, overvoltage sense input pin nonfunctional, OUTB indicates no overvoltage fault.	B
VDD	5	No damage to device, but device is unpowered. Device is nonfunctional.	B
OUTB	6	No damage to device, overvoltage output pin nonfunctional, OUTB indicates an overvoltage fault, increase in system current due to current through OUTB pull-up resistor	B

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

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
OUTA	1	Open-drain output requires pull-up resistor to pull-up voltage for correct functionality.	B
GND	2	No damage to device, but device is unpowered. Device is nonfunctional.	B
INA+	3	No damage to device, undervoltage sense input pin nonfunctional, OUTA indicates undervoltage fault.	B
INB-	4	No damage to device, overvoltage sense input pin nonfunctional, OUTB indicates no overvoltage fault.	B
VDD	5	No damage to device, but device is unpowered. Device is nonfunctional.	B
OUTB	6	Open-drain output requires pull-up resistor to pull-up voltage for correct functionality.	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
OUTA	1	GND	No damage to device, undervoltage output pin nonfunctional, OUTA indicates an undervoltage fault, increase in system current due to current through OUTA pull-up resistor	B
GND	2	INA+	No damage to device, undervoltage sense input pin nonfunctional, OUTA indicates undervoltage fault, increase in system current due to current through OUTA pull-up resistor	B
INA+	3	INB-	No damage to device, device monitors a single input for both undervoltage and overvoltage	C
INB-	4	VDD	No damage to device, overvoltage sense input pin nonfunctional, OUTB indicates overvoltage fault.	B
VDD	5	OUTB	Open-drain output requires pull-up resistor to pull-up voltage for correct functionality. OUTB indicates no overvoltage fault. OUTB shorted to VDD can violate the output current ABS MAX rating and cause damage if INB- is below V_IT-	A
OUTB	6	OUTA	No damage to device, device outputs a single signal for both undervoltage and overvoltage window monitoring. OUTA and OUTB indicate a fault if either undervoltage or overvoltage condition occurs	C

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

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
OUTA	1	Open-drain output requires pull-up resistor to pull-up voltage for correct functionality. OUTA indicates no undervoltage fault. OUTA shorted to VDD can violate the output current ABS MAX rating and cause damage if INA+ is below V_IT-	A
GND	2	No damage to device, but device is unpowered. Device is nonfunctional.	B
INA+	3	No damage to device, undervoltage sense input pin nonfunctional, OUTA indicates no undervoltage fault.	B
INB-	4	No damage to device, overvoltage sense input pin nonfunctional, OUTB indicates overvoltage fault.	B
VDD	5	Normal operation.	D
OUTB	6	Open-drain output requires pull-up resistor to pull-up voltage for correct functionality. OUTB indicates no overvoltage fault. OUTB shorted to VDD can violate the output current ABS MAX rating and cause damage if INB- is below V_IT-	A

4.2 DSE Package

Figure 4-2 shows the TPS3700-Q1 pin diagram for the DSE package. For a detailed description of the device pins please refer to the *Pin Configuration and Functions* section in the TPS3700-Q1 data sheet.

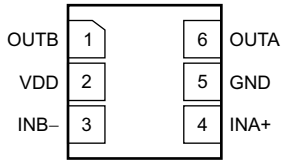

Figure 4-2. Pin Diagram (DSE Package)
WSON-6
Top View

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

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
OUTB	1	No damage to device, overvoltage output pin nonfunctional, OUTB indicates an overvoltage fault, increase in system current due to current through OUTB pull-up resistor	B
VDD	2	No damage to device, but device is unpowered. Device is nonfunctional.	B
INB-	3	No damage to device, overvoltage sense input pin nonfunctional, OUTB indicates no overvoltage fault.	B
INA+	4	No damage to device, undervoltage sense input pin nonfunctional, OUTA indicates undervoltage fault, increase in system current due to current through OUTA pull-up resistor	B
GND	5	Normal Operation.	D
OUTA	6	No damage to device, undervoltage output pin nonfunctional, OUTA indicates an undervoltage fault, increase in system current due to current through OUTA pull-up resistor	B

Table 4-7. Pin FMA for Device Pins Open-Circuited

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
OUTB	1	Open-drain output requires pull-up resistor to pull-up voltage for correct functionality.	B
VDD	2	No damage to device, but device is unpowered. Device is nonfunctional.	B
INB-	3	No damage to device, overvoltage sense input pin nonfunctional, OUTB indicates no overvoltage fault.	B
INA+	4	No damage to device, undervoltage sense input pin nonfunctional, OUTA indicates undervoltage fault.	B
GND	5	No damage to device, but device is unpowered. Device is nonfunctional.	B
OUTA	6	Open-drain output requires pull-up resistor to pull-up voltage for correct functionality.	B

Table 4-8. 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
OUTB	1	VDD	Open-drain output requires pull-up resistor to pull-up voltage for correct functionality. OUTB indicates no overvoltage fault. OUTB shorted to VDD can violate the output current ABS MAX rating and cause damage if INB- is below V_IT-	A
VDD	2	INB-	No damage to device, overvoltage sense input pin nonfunctional, OUTB indicates overvoltage fault.	B
INB-	3	INA+	No damage to device, device monitors a single input for both undervoltage and overvoltage	C
INA+	4	GND	No damage to device, undervoltage sense input pin nonfunctional, OUTA indicates undervoltage fault, increase in system current due to current through OUTA pull-up resistor	B
GND	5	OUTA	No damage to device, undervoltage output pin nonfunctional, OUTA indicates an undervoltage fault, increase in system current due to current through OUTA pull-up resistor	B
OUTA	6	OUTB	No damage to device, device outputs a single signal for both undervoltage and overvoltage window monitoring. OUTA and OUTB indicate a fault if either undervoltage or overvoltage condition occurs	C

Table 4-9. Pin FMA for Device Pins Short-Circuited to VDD

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
OUTB	1	Open-drain output requires pull-up resistor to pull-up voltage for correct functionality. OUTB indicates no overvoltage fault. OUTB shorted to VDD can violate the output current ABS MAX rating and cause damage if INB- is below V_IT-	A
VDD	2	Normal operation.	D
INB-	3	No damage to device, overvoltage sense input pin nonfunctional, OUTB indicates overvoltage fault.	B
INA+	4	No damage to device, undervoltage sense input pin nonfunctional, OUTA indicates no undervoltage fault.	B
GND	5	No damage to device, but device is unpowered. Device is nonfunctional.	B
OUTA	6	Open-drain output requires pull-up resistor to pull-up voltage for correct functionality. OUTA indicates no undervoltage fault. OUTA shorted to VDD can violate the output current ABS MAX rating and cause damage if INA+ is below V_IT-	A

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