Functional Safety Information

TPS4HC120-Q1
Functional Safety FIT Rate, FMD and Pin FMA

Table of Contents

Trademarks

1 Overview

This document contains information for the TPS4HC120-Q1 (DGQ | 28-pin HVSSOP 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 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.

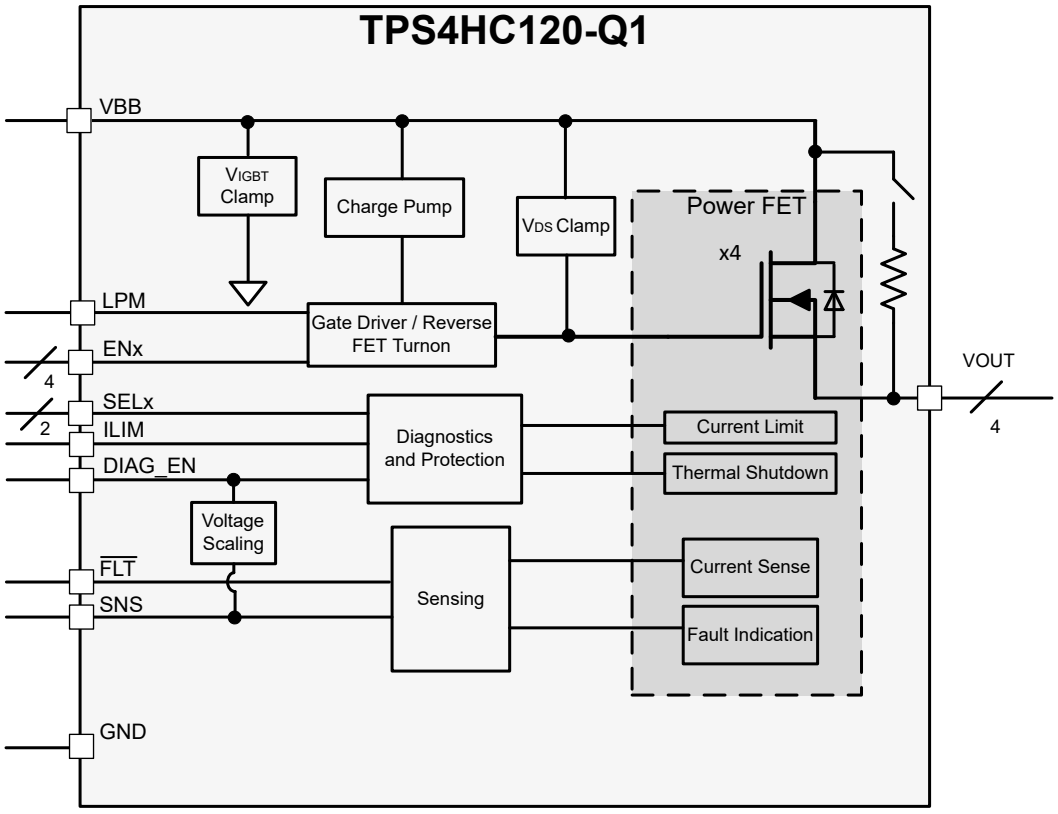

Figure 1-1. Functional Block Diagram

The TPS4HC120-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 the TPS4HC120-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	19
Die FIT rate	7
Package FIT rate	12

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 or figure 16
- Power dissipation: 1000mW
- Climate type: World-wide table 8 or figure 13
- Package factor (lambda 3): From table 17b or figure 15
- 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, or mixed	60 FIT	70°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 the TPS4HC120-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 (%)
VOUT open (Hi-Z)	20
VOUT stuck on (VBB)	10
VOUT functional, not within specification (voltage or timing)	50
Diagnostics not within specification	10
Protection function fails to trip	10

4 Pin Failure Mode Analysis (Pin FMA)

This section provides a failure mode analysis (FMA) for the pins of the TPS4HC120-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 TPS4HC120-Q1 pin diagram. For a detailed description of the device pins, see the *Pin Configuration and Functions* section in the TPS4HC120-Q1 data sheet.

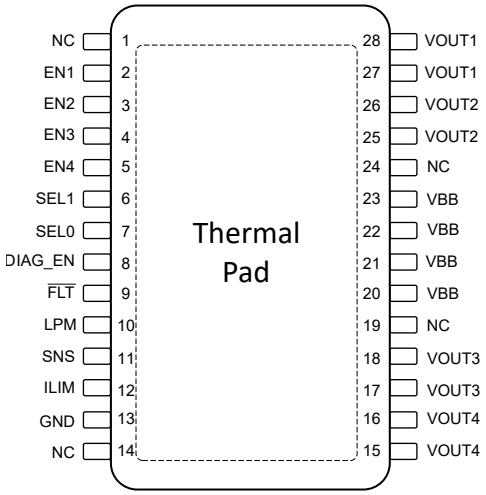

Figure 4-1. Pin Diagram

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

- The device is used with external components consistent with the values described in the external component table of the data sheet.

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

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
NC	1	No effect.	D
EN1	2	The corresponding channel shuts down.	B
EN2	3	The corresponding channel shuts down.	B
EN3	4	The corresponding channel shuts down.	B
EN4	5	The corresponding channel shuts down.	B
SEL1	6	The sense function is activated for only channel 1 or 3.	B
SEL0	7	The sense function is activated for only channel 1 or 2.	B

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

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
DIAG_EN	8	The diagnostics are disabled.	B
FLT_	9	The status reported is potentially erroneous.	B
LPM	10	The LPM status reported is potentially erroneous.	B
SNS	11	The sense current is not valid from the SNS pin.	B
ILIM	12	The device defaults to 2.25A current limit.	C
GND	13	The resistor or diode network is bypassed, if present.	B
NC	14	No effect.	D
VOUT4	15	The current limit of the device engages.	B
VOUT4	16	The current limit of the device engages.	B
VOUT3	17	The current limit of the device engages.	B
VOUT3	18	The current limit of the device engages.	B
NC	19	No effect.	D
VBB	20	The device has no input supply, and therefore, does not function.	B
VBB	21	The device has no input supply, and therefore, does not function.	B
VBB	22	The device has no input supply, and therefore, does not function.	B
VBB	23	The device has no input supply, and therefore, does not function.	B
NC	24	No effect.	D
VOUT2	25	The current limit of the device engages.	B
VOUT2	26	The current limit of the device engages.	B
VOUT1	27	The current limit of the device engages.	B
VOUT1	28	The current limit of the device engages.	B

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

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
NC	1	No effect.	D
EN1	2	Channel 1 shuts down, EN is pulled down internally.	B
EN2	3	Channel 2 shuts down, EN is pulled down internally.	B
EN3	4	Channel 3 shuts down, EN is pulled down internally.	B
EN4	5	Channel 4 shuts down, EN is pulled down internally.	B
SEL1	6	Internally pulled down. The sense function is activated for only channel 1 or 3	B
SEL0	7	Internally pulled down. The sense function is activated for only channel 1 or 2.	B
DIAG_EN	8	Internally pulled down. The diagnostics are disabled.	B
FLT_	9	The fault signal is not reported.	B
LPM	10	The LPM signal is not reported.	B
SNS	11	The correct sense current cannot be read.	B
ILIM	12	The device defaults to 5A current limit.	C
GND	13	Loss of ground detection engages and the device shuts off.	B
NC	14	No effect.	D
VOUT4	15	No effect. If configured, open-load detection triggers.	B
VOUT4	16	No effect. If configured, open-load detection triggers.	B
VOUT3	17	No effect. If configured, open-load detection triggers.	B
VOUT3	18	No effect. If configured, open-load detection triggers.	B
NC	19	No effect.	D
VBB	20	The device has no input supply, and therefore, does not function.	B

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

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
VBB	21	The device has no input supply, and therefore, does not function.	B
VBB	22	The device has no input supply, and therefore, does not function.	B
VBB	23	The device has no input supply, and therefore, does not function.	B
NC	24	No effect.	D
VOUT2	25	No effect. If configured, open-load detection triggers.	B
VOUT2	26	No effect. If configured, open-load detection triggers.	B
VOUT1	27	No effect. If configured, open-load detection triggers.	B
VOUT1	28	No effect. If configured, open-load detection triggers.	B

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

Pin Name	Pin No.	Shorted to Pin No.	Description of Potential Failure Effects	Failure Effect Class
NC	1	2	No effect.	D
EN1	2	3	The EN1 signal affects the EN2 signal, and the EN2 signal affects the EN1 signal.	B
EN2	3	4	The EN2 signal affects the EN3 signal, and the EN3 signal affects the EN2 signal.	B
EN3	4	5	The EN3 signal affects the EN4 signal, and the EN4 signal affects the EN3 signal.	B
EN4	5	6	The EN4 signal affects the SEL1 signal, and the SEL1 signal affects the EN4 signal.	B
SEL1	6	7	The SEL1 signal affects the SEL0 signal, and the SEL0 signal affects the SEL1 signal.	B
SEL0	7	8	The SEL0 signal affects the DIAG_EN signal, and the DIAG_EN signal affects the SEL0 signal.	B
DIAG_EN	8	9	Fault reporting is erroneous, diagnostics are enabled if the FLT_ pin is high.	B
FLT_	9	10	The reports of Fault and LPM are potentially erroneous.	B
LPM	10	11	The reports of current sensing and LPM are potentially erroneous.	B
SNS	11	12	The outputs of current limit and current sensing are incorrect.	B
ILIM	12	13	The device defaults to 2.25A current limit.	B
GND	13	14	No effect.	D
VOUT4	15	16	No effect.	D
VOUT4	16	17	There is a potential loss of load control on channels 3 and 4.	B
VOUT3	17	18	No effect.	D
VOUT3	18	19	No effect.	D
NC	19	20	No effect.	D
VBB	20	21	No effect.	D
VBB	21	22	No effect.	D
VBB	22	23	No effect.	D
VBB	23	24	No effect.	D
NC	24	25	No effect.	D
VOUT2	25	26	No effect.	D
VOUT2	26	27	There is a potential loss of load control on channels 1 and 2.	B
VOUT1	27	28	No effect.	D

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

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
NC	1	No effect.	D
EN1	2	There is a violation of the absolute maximum rating of the pin. A breakdown of the ESD cell is possible.	A
EN2	3	There is a violation of the absolute maximum rating of the pin. A breakdown of the ESD cell is possible.	A
EN3	4	There is a violation of the absolute maximum rating of the pin. A breakdown of the ESD cell is possible.	A
EN4	5	There is a violation of the absolute maximum rating of the pin. A breakdown of the ESD cell is possible.	A
SEL1	6	There is a violation of the absolute maximum rating of the pin. A breakdown of the ESD cell is possible.	A
SEL0	7	There is a violation of the absolute maximum rating of the pin. A breakdown of the ESD cell is possible.	A
DIAG_EN	8	There is a violation of the absolute maximum rating of the pin. A breakdown of the ESD cell is possible.	A
FLT_	9	There is a violation of the absolute maximum rating of the pin. A breakdown of the ESD cell is possible.	A
LPM	10	There is a violation of the absolute maximum rating of the pin. A breakdown of the ESD cell is possible.	A
SNS	11	There is a violation of the absolute maximum rating of the pin. A breakdown of the ESD cell is possible.	A
ILIM	12	There is a violation of the absolute maximum rating of the pin. A breakdown of the ESD cell is possible.	A
GND	13	The supply power is bypassed and the device does not turn on.	B
NC	14	No effect.	D
VOUT4	15	The output is pulled to supply; a short-to-battery triggers, if configured.	D
VOUT4	16	The output is pulled to supply; a short-to-battery triggers, if configured.	B
VOUT3	17	The output is pulled to supply; a short-to-battery triggers, if configured.	B
VOUT3	18	The output is pulled to supply; a short-to-battery triggers, if configured.	B
NC	19	No effect.	D
VBB	20	Intended operation.	D
VBB	21	Intended operation.	D
VBB	22	Intended operation.	D
VBB	23	Intended operation.	D
NC	24	No effect.	D
VOUT2	25	The output is pulled to supply; a short-to-battery triggers, if configured.	B
VOUT2	26	The output is pulled to supply; a short-to-battery triggers, if configured.	B
VOUT1	27	The output is pulled to supply; a short-to-battery triggers, if configured.	B
VOUT1	28	The output is pulled to supply; a short-to-battery triggers, if configured.	B

5 Revision History

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

DATE	REVISION	NOTES
June 2025	*	Initial Release

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