

TPS2HB16-Q1

Functional Safety FIT Rate, FMD and Pin FMA



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1 Overview

This document contains information for TPS2HB16-Q1 (HTSSOP 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.

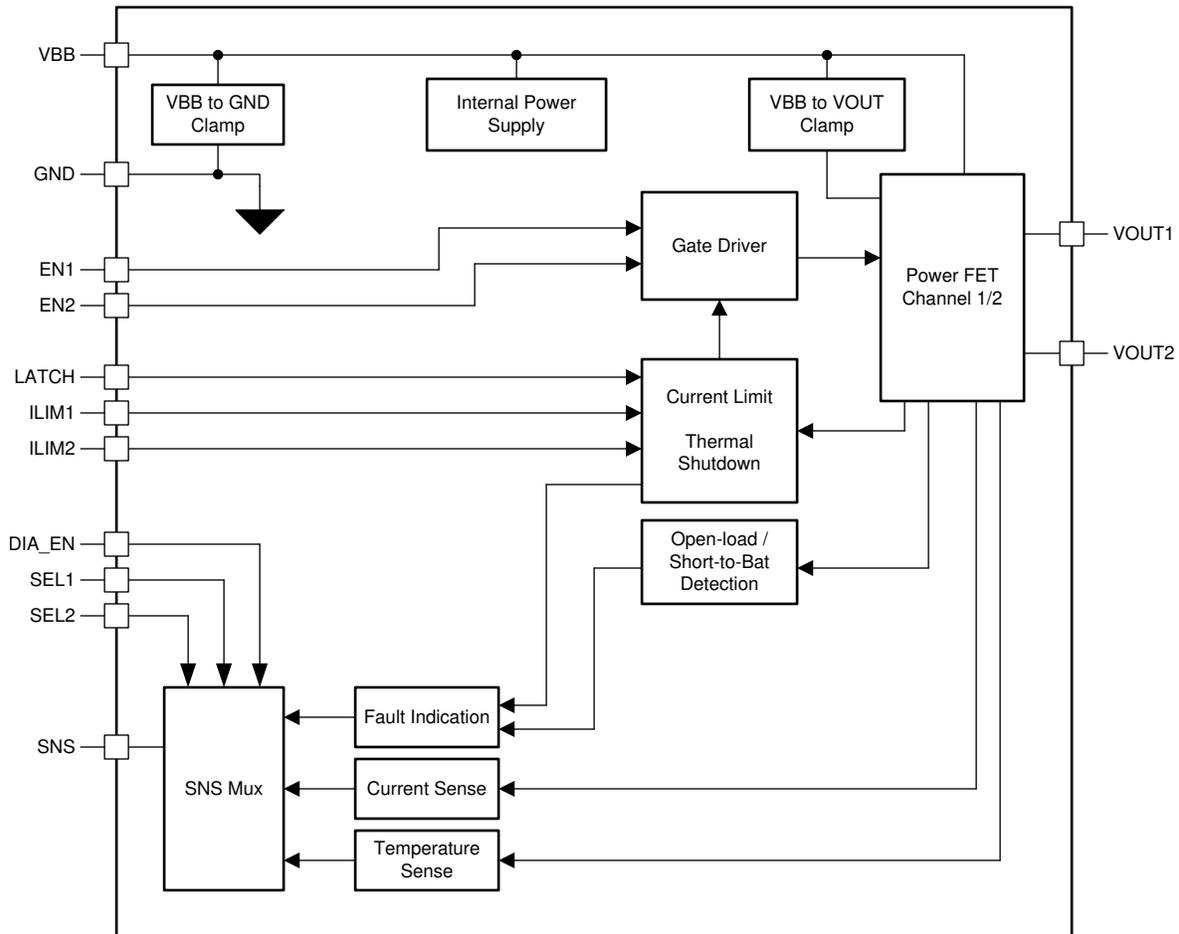


Figure 1-1. Functional Block Diagram

TPS2HB16-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 TPS2HB16-Q1 based on industry-wide used reliability standard:

- [Table 2-1](#) provides FIT rates based on IEC TR 62380 / ISO 26262 part 11

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	22
Die FIT Rate	12
Package FIT Rate	10

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: 750 mW
- Climate type: World-wide Table 8 IEC TR 62380
- Package factor (λ_3): Table 17b IEC TR 62380
- Substrate Material: FR4
- EOS FIT rate assumed: 0 FIT

3 Failure Mode Distribution (FMD)

The failure mode distribution estimation for TPS2HB16-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 (%)
VOUT open (HiZ)	20%
VOUT stuck on (VBB)	10%
VOUT functional, not in specification voltage or timing	45%
Diagnostics not in specification	10%
Protect functions fails to trip	10%
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 TPS2HB16-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 TPS2HB16-Q1 pin diagram. For a detailed description of the device pins please refer to the *Pin Configuration and Functions* section in the TPS2HB16-Q1 data sheet.

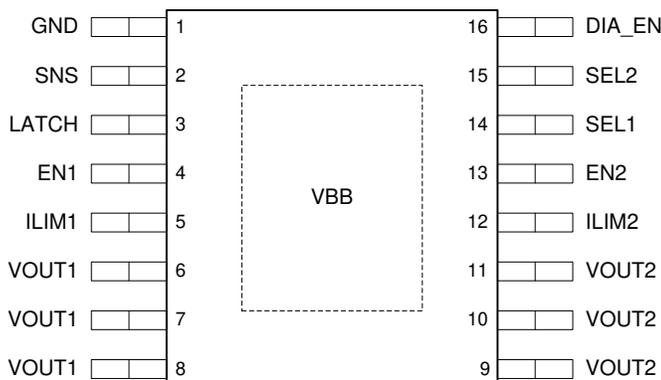


Figure 4-1. Pin Diagram Version A, B

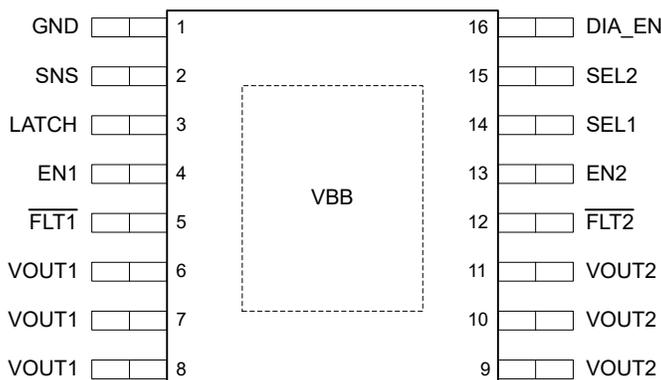


Figure 4-2. Pin Diagram Version F

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

- Follow data sheet recommendation for operating conditions, external component selection and PCB layout

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
GND	1	Resistor/diode network will be bypassed if present.	B
SNS	2	SNS current diagnostic not available.	B
LATCH	3	Normal operation. With device in auto-retry mode.	B
EN1	4	Normal operation with channel 1 output off (FET turned off).	B
ILIM1	5	Current Limit for channel 1 defaults to internal limit.	C
FLT1	5	Version F only. Channel 1 open drain fault diagnostics cannot be reported.	B
VOUT1	6,7,8	Short to GND protection kicks in to protect the device.	B
VOUT2	9,10,11	Short to GND protection kicks in to protect the device.	B
ILIM2	12	Current Limit for channel 2 defaults to internal limit.	C
FLT2	12	Version F only. Channel 2 open drain fault diagnostics cannot be reported.	B
EN2	13	Normal operation with channel 2 output off (FET turned off).	B
SEL1	14	Normal operation with diagnostics corresponding to SEL1=LOW.	B
SEL2	15	Normal operation with diagnostics corresponding to SEL2=LOW.	B
DIAG_EN	16	Normal operation with diagnostics function disabled.	B

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

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
GND	1	The output is off with the FET turned off.	B
SNS	2	SNS current diagnostic not available.	B
LATCH	3	Normal operation with device in auto-retry mode. Internal pull=down resistor will pull pin to GND.	B
EN1	4	Normal operation with channel 1 output off (FET turned off). Internal pull-down resistor will pull pin to GND.	B
ILIM1	5	Current Limit for channel 1 defaults to internal limit.	C
FLT1	5	Version F only. Channel 1 open drain fault diagnostics cannot be reported.	B
VOUT1	6,7,8	Channel 1 Output off. Open load detection will be triggered in off-state while in diagnostics state.	B
VOUT2	9,10,11	Channel 2 Output off. Open load detection will be triggered in off-state while in diagnostics state.	
ILIM2	12	Current Limit for channel 2 defaults to internal limit.	C
FLT2	12	Version F only. Channel 2 open drain fault diagnostics cannot be reported.	B
EN2	13	Normal operation with channel 2 output off (FET turned off). Internal pull-down resistor will pull pin to GND.	B
SEL1	14	Normal operation with diagnostics corresponding to SEL1=LOW. Internal pull-down resistor will pull pin to GND.	B
SEL2	15	Normal operation with diagnostics corresponding to SEL2=LOW. Internal pull-down resistor will pull pin to GND.	B
DIAG_EN	16	Normal operation with diagnostics function disabled. Internal pull-down resistor will pull pin to GND.	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
GND	1	2 (SNS)	SNS current diagnostic not available.	B
SNS	2	3 (LATCH)	Undefined device behavior and depends on pin voltage. Sense output may not be correct. Latch function may be enabled if pin voltage > VIH; latch function may be disabled if pin voltage < VIL.	B
LATCH	3	4 (EN)	Device behavior depends on pin voltage. Latch function may be enabled if pin voltage > VIH; Latch function may be disabled if pin voltage < VIL.	B

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

Pin Name	Pin No.	Shorted to	Description of Potential Failure Effect(s)	Failure Effect Class
EN1	4	5 (ILIM1)	Undefined device behavior. Channel may be enabled if pin voltage > VIH; channel may be disabled if pin voltage < VIL. Channel 1 current limit threshold will not be correct.	B
EN1	4	5 ($\overline{\text{FLT1}}$)	Version F only. Undefined device behavior. Channel may be enabled if pin voltage > VIH; channel may be disabled if pin voltage < VIL. Channel 1 open drain fault diagnostics cannot be reported.	B
ILIM1	5	6 (VOUT1)	Undefined device behavior. Current limit threshold (ch1) will not be correct or short circuit/overload protection may not function. VOUT of Ch1 behavior may not be correct.	B
$\overline{\text{FLT1}}$	5	6 (VOUT1)	Version F only. Channel 1 open drain fault diagnostics cannot be reported. VOUT of Ch1 behavior may not be correct.	B
VOUT1	6,7,8	5 (ILIM1)	Undefined device behavior. Current limit threshold (ch1) will not be correct or short circuit/overload protection may not function. VOUT of Ch1 behavior may not be correct.	A
VOUT1	6,7,8	5 ($\overline{\text{FLT1}}$)	Version F only. Channel 1 open drain fault diagnostics cannot be reported. VOUT of Ch1 behavior may not be correct.	B
VOUT2	9,10,11	12 (ILIM2)	Undefined device behavior. Current limit threshold (ch2) will not be correct or short circuit/overload protection may not function. VOUT of Ch2 behavior may not be correct.	A
VOUT2	9,10,11	12 ($\overline{\text{FLT2}}$)	Version F only. Undefined device behavior. Channel 1 open drain fault diagnostics cannot be reported. VOUT of Ch2 behavior may not be correct.	B
ILIM2	12	13 (EN2)	Undefined device behavior. Channel may be enabled if pin voltage > VIH; channel may be disabled if pin voltage < VIL. Channel 2 current limit threshold will not be correct.	B
$\overline{\text{FLT2}}$	12	13 (EN2)	Version F only. Undefined device behavior. Channel may be enabled if pin voltage > VIH; channel may be disabled if pin voltage < VIL. Channel 1 open drain fault diagnostics cannot be reported.	B
EN2	13	14 (SEL1)	Undefined device behavior. Ch2 may be enabled if pin voltage > VIH; Ch2 may be disabled if pin voltage < VIL.	B
SEL1	14	15 (SEL2)	Device behavior depends on adjacent pin voltage affecting diagnostic output.	B
SEL2	15	16 (DIAG_EN)	Device behavior depends on adjacent pin voltage affecting diagnostic output. Diagnostic function may be enabled if pin voltage > VIH; Diagnostic function may be disabled if pin voltage < VIL.	B
DIAG_EN	16	15 (SEL2)	Device behavior depends on adjacent pin voltage affecting diagnostic output. Diagnostic function may be enabled if pin voltage > VIH; Diagnostic function may be disabled if pin voltage < VIL.	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
GND	1	Supply power will be bypassed and device will not turn on.	B
SNS	2	Undefined device behavior; may cause device damage due to voltage breakdown on ESD circuit.	A
LATCH	3	If pin voltage exceeds the pin data sheet range, it may cause device damage due to voltage breakdown on ESD circuit. Device behavior depends on supply voltage.	A
EN1	4	Undefined device behavior; if pin voltage exceeds the pin data sheet range, it may cause device damage due to voltage breakdown on ESD circuit.	A
ILIM1	5	Normal operation but with ch1 higher current limit programmed with internal reference. No device damage.	C
$\overline{\text{FLT1}}$	5	Version F only. Channel 1 open drain fault diagnostics cannot be reported	B
VOUT	6,7,8,9,10,11	Output 1 stuck on to supply. Open load detection will be triggered in off-state in diagnostics state.	C
VOUT2	9,10,11	Output 2 stuck on to supply. Open load detection will be triggered in off-state in diagnostics state.	C
ILIM2	12	Normal operation but with ch2 higher current limit programmed with internal reference.	C
$\overline{\text{FLT2}}$	12	Version F only. Channel 2 open drain fault diagnostics cannot be reported.	B

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

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
EN2	13	Undefined device behavior; if pin voltage exceeds the pin data sheet range, it may cause device damage due to voltage breakdown on ESD circuit.	A
SEL1	14	Undefined device behavior; if pin voltage exceeds the pin data sheet range, it may cause device damage due to voltage breakdown on ESD circuit.	A
SEL2	15	Undefined device behavior; if pin voltage exceeds the pin data sheet range, it may cause device damage due to voltage breakdown on ESD circuit.	A
DIAG_EN	16	Undefined device behavior; if pin voltage exceeds the pin data sheet range, it may cause device damage due to voltage breakdown on ESD circuit.	A

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