Functional Safety Information

BQ24078
Functional Safety FIT Rate and Pin FMA

TEXAS INSTRUMENTS

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1 Overview

This document contains information for the BQ24078 (VQFN (16) 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
*   Pin failure mode analysis (pin FMA)

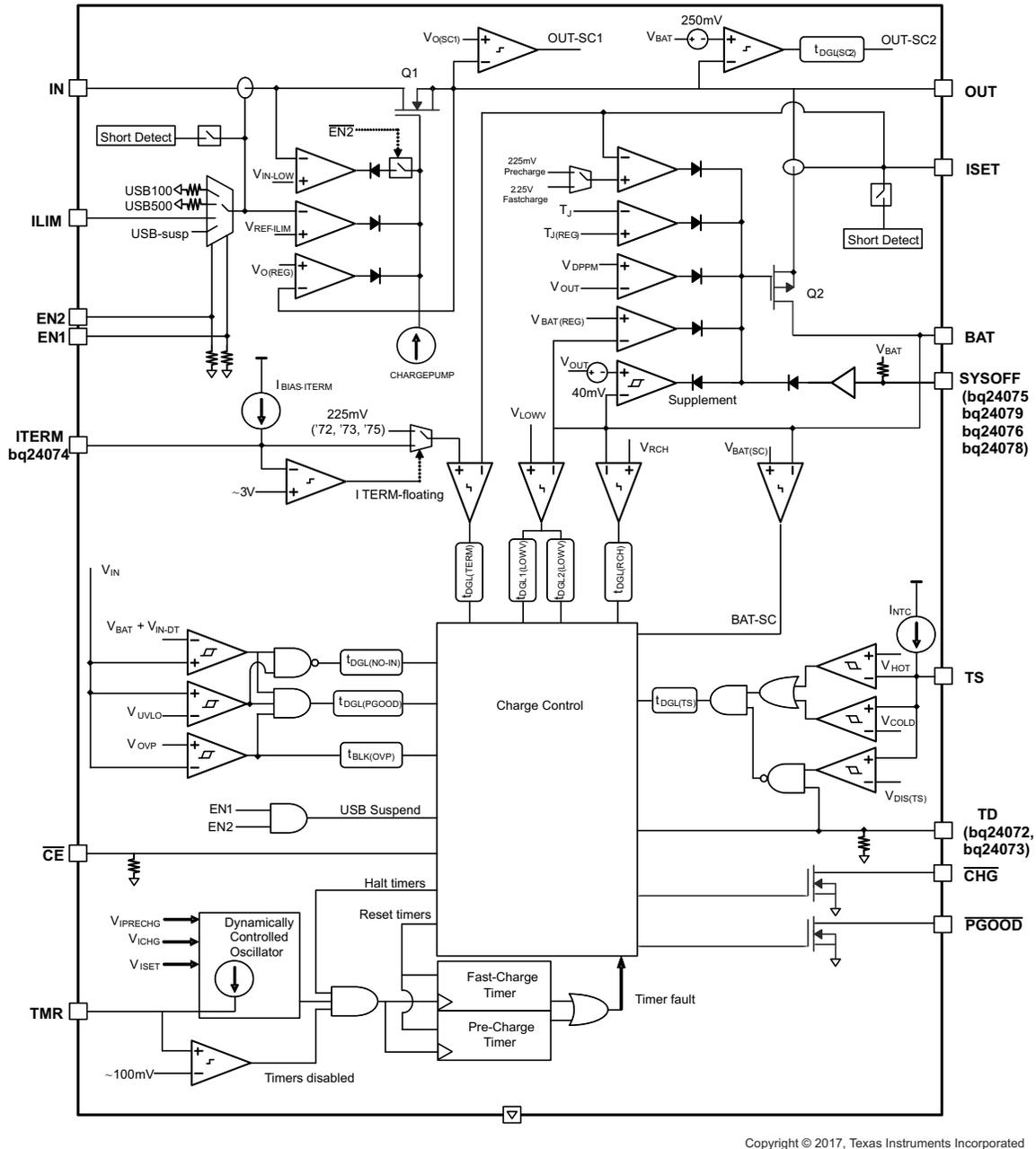Figure 1-1 shows the device functional block diagram for reference.

Figure 1-1. Functional Block Diagram

The BQ24078 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 BQ24078 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	23
Die FIT rate	4
Package FIT rate	19

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: 250mW
- 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	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 Pin Failure Mode Analysis (Pin FMA)

This section provides a failure mode analysis (FMA) for the pins of the BQ24078. The failure modes covered in this document include the typical pin-by-pin failure scenarios:

- Pin short-circuited to ground (see Table 3-2)
- Pin open-circuited (see Table 3-3)
- Pin short-circuited to an adjacent pin (see Table 3-4)
- Pin short-circuited to supply (see Table 3-5)

Table 3-2 through Table 3-5 also indicate how these pin conditions can affect the device as per the failure effects classification in Table 3-1.

Table 3-1. 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 3-1 shows the BQ24078 pin diagram. For a detailed description of the device pins, see the *Pin Configuration and Functions* section in the BQ24078 datasheet.
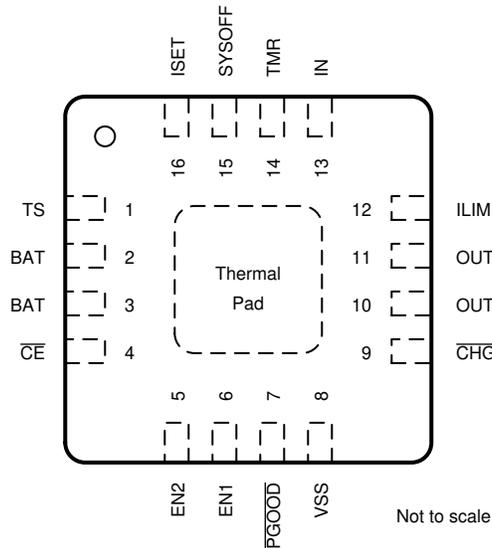

Figure 3-1. Pin Diagram

Table 3-2. Pin FMA for Device Pins Short-Circuited to Ground

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
TS	1	The charger in the hot region of the TS pin stops charging.	B
BAT	2	The device stops charging when the battery voltage is below the VBAT(SC) short-circuit protection. There is uncontrolled current from the battery to the ground.	B
	3		
$\overline{CE}$	4	The charger is active.	D
EN2	5	The input current limit is set to either USB100 or USB500 mode. Refer to the *EN1/EN2 Settings* table in the *Pin Configuration and Functions* section of the datasheet.	C
EN1	6	The input current limit is set to either USB100 or ILIM mode. Refer to the *EN1/EN2 Settings* table in the *Pin Configuration and Functions* section of the datasheet.	C
$\overline{PGOOD}$	7	The $\overline{PGOOD}$ LED is always on. An incorrect $\overline{PGOOD}$ status is reported. The charge function of the device is still functional.	C

Table 3-2. Pin FMA for Device Pins Short-Circuited to Ground (continued)

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
VSS	8	The VSS pin is GND.	D
$\overline{\text{CHG}}$	9	The $\overline{\text{CHG}}$ LED is always on. An incorrect charger status is reported. The charge function of the device is still functional.	C
OUT	10	OUT short-circuit recovery is active when VOUT < VO(SC1). The input current is limited to 100mA.	B
	11		
ILIM	12	The input current is not limited when the ILIM pin is shorted to ground after start-up. The pin is potentially damaged if fault conditions exceed the absolute maximum ratings in the datasheet for the device. When the short is removed, the device operates as normal. When a short occurs before start-up, the device does not charge.	A
IN	13	The input FET is turned off. The output is powered by the battery. There is uncontrolled current from the input supply.	B
TMR	14	The safety timer is disabled. The charge function of the device is still functional.	C
SYSOFF	15	The BATFET (battery field-effect transistor) operates normally.	D
ISET	16	The charging function is disabled. The device resumes charging when the short is removed.	D

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

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
TS	1	The charging function is disabled. The voltage of the TS pin pulls high due to the 75µA current source, which puts the voltage of the TS pin outside the charge range.	B
BAT	2	The device stops charging. The charger goes into battery-detect mode. The OUT pin is powered by the IN pin.	D
	3		
$\overline{\text{CE}}$	4	There is 285kΩ of internal pulldown on the $\overline{\text{CE}}$ pin. The device is enabled and charging occurs.	D
EN2	5	There is 285kΩ of internal pulldown on the EN2 pin. The input current limit is dependent on the EN1 and EN2 pins, according to the *EN1/EN2 Settings* table in the *Pin Configuration and Functions* section of the datasheet.	C
EN1	6	There is 285kΩ of internal pulldown on the EN1 pin. The input current limit is dependent on the EN1 and EN2 pins, according to the *EN1/EN2 Settings* table in the *Pin Configuration and Functions* section of the datasheet.	C
$\overline{\text{PGOOD}}$	7	There is an open-drain output. There is no $\overline{\text{PGOOD}}$ indication. The charger functions normally.	D
VSS	8	The device is off and inactive.	B
$\overline{\text{CHG}}$	9	This pin is an open-drain output. There is no charge status indication. The charger functions normally.	D
OUT	10	There is no load on the OUT pin. The charger functions normally.	D
	11		
ILIM	12	The input FET is turned off. The OUT pin is powered by the BAT pin.	B
IN	13	There is no input. The OUT pin is powered by the battery.	D
TMR	14	The safety timer is set to default values. The device stops charging after the timer expires.	D
SYSOFF	15	The BATFET is off. The SYSOFF pin is internally pulled up to VBAT through a large resistor (approximately 5MΩ), and the BATFET turns off when the SYSOFF pin is high.	C
ISET	16	The charging current is set to 0mA. The OUT pin is powered by the input or battery.	B

Table 3-4. Pin FMA for Device Pins Short-Circuited to Adjacent Pin

Pin Name	Pin No.	Shorted to	Description of Potential Failure Effects	Failure Effect Class
TS	1	BAT	The device stops charging. The voltage of the TS pin is outside the charging range.	B
BAT	3	$\overline{\text{CE}}$	The $\overline{\text{CE}}$ pin is pulled high, and charging is disabled.	B

Table 3-4. Pin FMA for Device Pins Short-Circuited to Adjacent Pin (continued)

Pin Name	Pin No.	Shorted to	Description of Potential Failure Effects	Failure Effect Class
EN2	5	EN1	The input current limit is set to either USB100 mode (if both pins are pulled low) or USB suspend mode (if both pins are pulled high as stated in the *EN1/EN2 Settings* table in the *Pin Configuration and Functions* section of the data sheet).	C
EN1	6	$\overline{PGOOD}$	The EN1 pin is pulled low when VIN is present. The *EN1/EN2 Settings* table in the *Pin Configuration and Functions* section of the datasheet states the state of the input current limit.	C
$\overline{PGOOD}$	7	VSS	The $\overline{PGOOD}$ LED is always on. The incorrect $\overline{PGOOD}$ status is reported. The charge function is still functional.	C
$\overline{CHG}$	9	OUT	There is an increase in the observed input current when the OUT pin is shorted to the $\overline{CHG}$ pin with VIN present. The charger is still functional. The pin is potentially damaged if fault conditions exceed the absolute maximum ratings in the datasheet for the device.	A
OUT	11	ILIM	The input FET is turned off and charging stops until the short to the OUT pin is removed. The battery powers the output.	B
IN	13	TMR	The device stops charging after the default timer limit is reached. The pin is potentially damaged if fault conditions exceed the absolute maximum ratings in the datasheet for the device.	A
TMR	14	SYSOFF	If the SYSOFF pin is high when shorted to the TMR pin, the device stops charging after the default safety timer duration. If the SYSOFF pin is low when shorted to the TMR pin, the safety timers are disabled.	C
SYSOFF	15	ISET	The ISET pin sets the charge current, so the charge current setting is affected by the SYSOFF pin voltage when these pins are shorted together.	C

Table 3-5. Pin FMA for Device Pins Short-Circuited to Supply

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
TS	1	The device stops charging in the cold region of the TS pin. The pin is potentially damaged if fault conditions exceed the absolute maximum ratings in the datasheet for the device.	A
BAT	2	The battery and BAT pin are potentially damaged due to an unregulated current path and an exceedance of the absolute maximum rating of the pin. The device resumes charging when the short is removed. The pin is potentially damaged if fault conditions exceed the absolute maximum ratings in the datasheet for the device.	A
	3		
$\overline{CE}$	4	The charging function is disabled. The pin is potentially damaged if fault conditions exceed the absolute maximum ratings in the datasheet for the device.	A
EN2	5	The ILIM pin is in either ILIM mode or standby mode. Refer to the *EN1/EN2 Settings* table in the *Pin Configuration and Functions* section of the datasheet. The pin is potentially damaged if fault conditions exceed the absolute maximum ratings in the datasheet for the device.	A
EN1	6	The EN1 pin is high. The device is in either USB500 mode or standby mode. Refer to the *EN1/EN2 Settings* table in the *Pin Configuration and Functions* section of the datasheet. The pin is potentially damaged if fault conditions exceed the absolute maximum ratings in the datasheet for the device.	A
$\overline{PGOOD}$	7	The input current increases. There is no $\overline{PGOOD}$ indicator function. The pin is potentially damaged if fault conditions exceed the absolute maximum ratings in the datasheet for the device.	A
VSS	8	The input supply is shorted to ground with possible damage to the input if short protection is not present. The current of the system is supplied by the battery but charging does not occur.	A
$\overline{CHG}$	9	The input current increases. The pin is potentially damaged if fault conditions exceed the absolute maximum ratings in the datasheet for the device.	A
OUT	10	There is unregulated current from the supply to output. There is pin damage. Downstream devices are potentially damaged. The pin is potentially damaged if fault conditions exceed the absolute maximum ratings in the datasheet for the device.	A
	11		
ILIM	12	The input FET is turned off and the device stops charging until the short to the supply is removed. The battery powers the output. The pin is potentially damaged if fault conditions exceed the absolute maximum ratings in the datasheet for the device.	A
IN	13	N/A	D

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Table 3-5. Pin FMA for Device Pins Short-Circuited to Supply (continued)

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
TMR	14	The device stops charging after the default timer limit is reached. The pin is potentially damaged if fault conditions exceed the absolute maximum ratings in the datasheet for the device.	A
SYSOFF	15	The BATFET is off since the SYSOFF pin is high. The pin is potentially damaged if fault conditions exceed the absolute maximum ratings in the datasheet for the device.	A
ISET	16	The device stops charging. The pin is potentially damaged if fault conditions exceed the absolute maximum ratings in the datasheet for the device.	A

4 Revision History

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

DATE	REVISION	NOTES
March 2026	*	Initial Release

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