Functional Safety Information

ALM2403-Q1

Functional Safety FIT Rate, FMD and Pin FMA

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Trademarks

1 Overview

This document contains information for ALM2403-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.

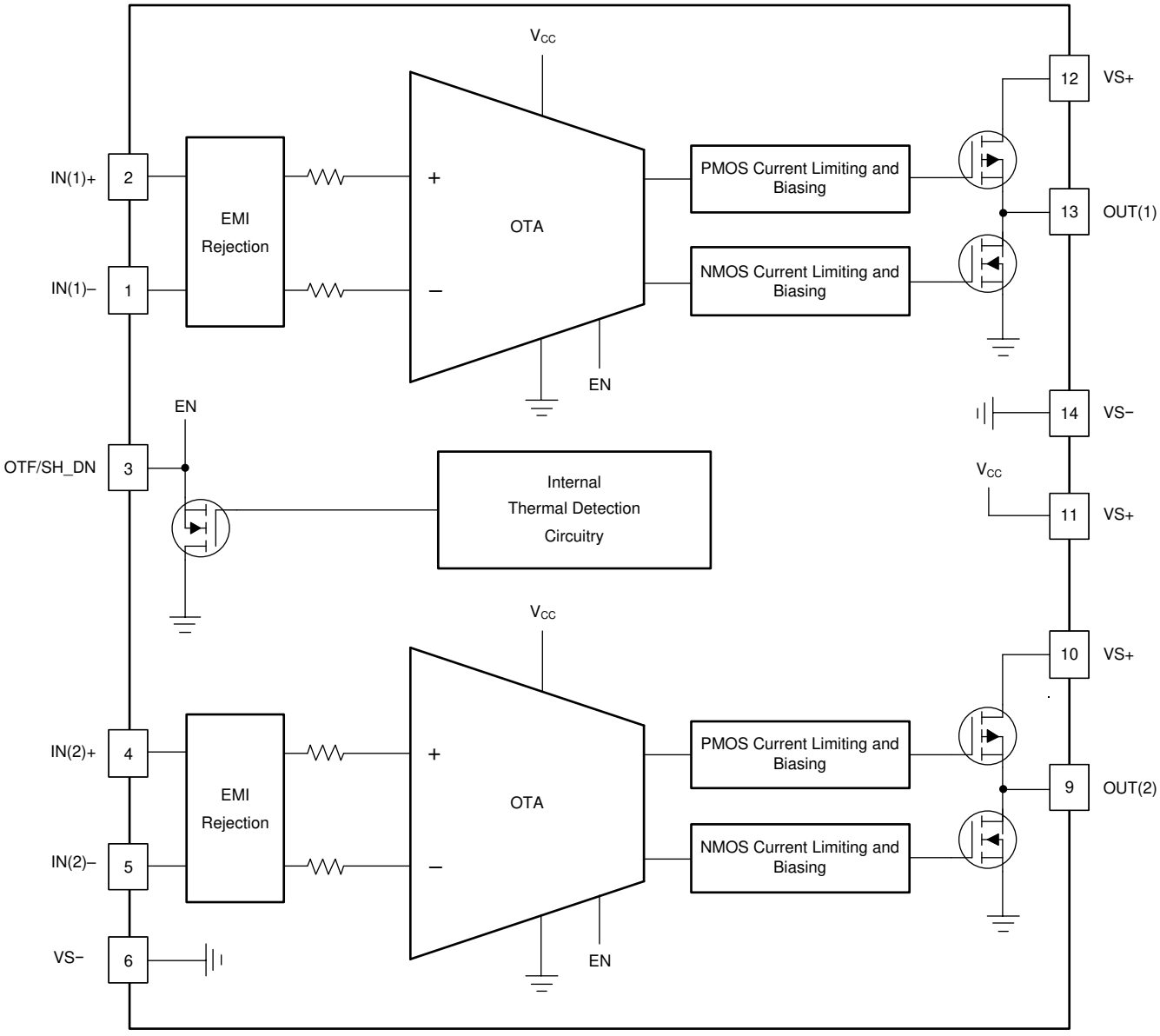

Figure 1-1. Functional Block Diagram

ALM2403-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 ALM2403-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	12
Die FIT Rate	4
Package FIT Rate	8

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: 300mW
- 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
4	BiCMOS Op Amp, Comparators, Voltage Monitors	8 FIT	45°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 ALM2403-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 open (Hi-Z)	20%
Output saturated high	25%
Output saturated low	25%
Output functional, out of specification voltage or timing	30%

4 Pin Failure Mode Analysis (Pin FMA)

This section provides a Failure Mode Analysis (FMA) for the pins of the ALM2403-Q1 (HTSSOP). 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 ALM2403-Q1 pin diagram. For a detailed description of the device pins please refer to the '*Pin Configuration and Functions*' section in the ALM2403-Q1 datasheet.

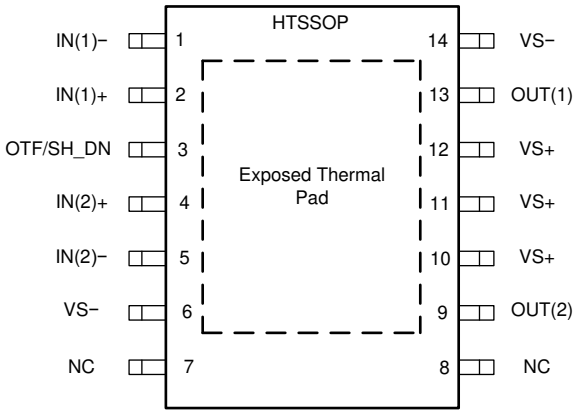

Figure 4-1. Pin Diagram

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

- 'Short circuit to Supply or Power' means short to VS+
- 'Short to GND' means short to VS–
- VS+ is equivalent to VCC and VS– equivalent to VEE
- OTF/SH_DN pin is configured in such a state as to enable the amplifier

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
IN1–	1	Negative feedback not present to device. Depending on circuit configuration, output will most likely move to negative supply.	B
IN+	2	Device common–mode tied to negative rail. Depending on circuit configuration, output will likely not respond due to the device being put in an invalid common–mode condition.	C
OTF	3	GND pin will be likely be driven to OTF voltage. the device will turn off. No damage to device.	B
INA2+	4	Device common–mode tied to negative rail. Depending on circuit configuration, output will likely not respond due to the device being put in an invalid common–mode condition.	C
IN2–	5	Negative feedback not present to device. Depending on circuit configuration, output will most likely move to negative supply.	B
NC	7	NC pin internally disconnected, no effect.	D
NC	8	NC pin internally disconnected, no effect.	D
OUT2	9	Depending on circuit configuration, device will likely be forced into short circuit condition with OUT2 voltage ultimately forced to GND voltage. Prolonged exposure to short circuit conditions could result in long term reliability issues.	A
VCC	10	Op–Amp supplies will be shorted together leaving VCC pin at some voltage between VCC and GND sources (depending on source impedance).	A
VCC	11	Op–Amp supplies will be shorted together leaving VCC pin at some voltage between VCC and GND sources (depending on source impedance).	A
VCC	12	Op–Amp supplies will be shorted together leaving VCC pin at some voltage between VCC and GND sources (depending on source impedance).	A
OUT1	13	Depending on circuit configuration, device will likely be forced into short circuit condition with OUT1 voltage ultimately forced to GND voltage. Prolonged exposure to short circuit conditions could result in long term reliability issues.	A

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

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
IN1–	1	Inverting pin of Op–Amp left floating. Negative feedback will not be provided to device, likely resulting in device output moving between positive and negative rail. IN1– pin voltage will likely end up at positive or negative rail due to leakage on ESD diodes.	B
IN+	2	Input common–mode left floating. Op–Amp will not be provided with common–mode bias, device output will likely end up at positive or negative rail. IN1+ pin voltage will likely end up at positive or negative rail due to leakage on ESD diodes.	B
OTF	3	No damage to device, but OTF pin will be vulnerable to capacitive coupling and potential switching between shutdown and non-shutdown states.	B
IN2+	4	Input common–mode left floating. Op–Amp will not be provided with common–mode bias, device output will likely end up at positive or negative rail. IN2+ pin voltage will likely end up at positive or negative rail due to leakage on ESD diodes.	B
IN2–	5	Inverting pin of Op–Amp left floating. Negative feedback will not be provided to device, likely resulting in device output moving between positive and negative rail. IN2– pin voltage will likely end up at positive or negative rail due to leakage on ESD diodes.	B
GND	6	Negative supply left floating. Op–Amp will cease to function as no current can source/sink to the device.	B
NC	7	NC pin internally disconnected, no effect.	D
NC	8	NC pin internally disconnected, no effect.	D
OUT2	9	No negative feedback or ability for OUT2 to drive application.	B
VCC	10	Positive supply left floating. Op–Amp will cease to function as no current can source/sink to the device.	A
VCC	11	Positive supply left floating. Op–Amp will cease to function as no current can source/sink to the device.	A
VCC	12	Positive supply left floating. Op–Amp will cease to function as no current can source/sink to the device.	A
OUT1	13	No negative feedback or ability for OUT1 to drive application.	B
GND	14	Negative supply left floating. Op–Amp will cease to function as no current can source/sink to the device.	A

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
IN1–	1	2	Both inputs will be tied together. Depending on the offset of the device, this will likely move the output voltage near mid supply.	D
IN1+	2	3	Device will toggle between shutdown or non-shutdown depending on OTF voltage. This is a 3.3V logic gate, so exceeding the ABS max ratings for current or voltage could damage the device.	A
OTF	3	4	Device will toggle between shutdown or non-shutdown depending on OTF voltage. This is a 3.3V logic gate, so exceeding the ABS max ratings for current or voltage could damage the device.	A
IN2+	4	5	Both inputs will be tied together. Depending on the offset of the device, this will likely move the output voltage near mid supply.	D
IN2–	5	6	Negative feedback not present to device. Depending on circuit configuration, output will most likely move to negative supply.	B
GND	6	7	NC pin internally disconnected, no effect.	D
NC	8	9	NC pin internally disconnected, no effect.	D
OUT2	9	10	Depending on circuit configuration, device will likely be forced into short circuit condition with OUT2 voltage ultimately forced to VCC voltage. Prolonged exposure to short circuit conditions could result in long term reliability issues.	A
VCC	12	13	Depending on circuit configuration, device will likely be forced into short circuit condition with VCC voltage ultimately forced to OUT1 voltage. Prolonged exposure to short circuit conditions could result in long term reliability issues.	A
OUT1	13	14	Depending on circuit configuration, device will likely be forced into short circuit condition with OUT1 voltage ultimately forced to GND voltage. Prolonged exposure to short circuit conditions could result in long term reliability issues.	A
GND	14	1	Negative feedback not present to device. Depending on circuit configuration, output will most likely move to negative supply.	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
IN1–	1	Negative feedback not present to device. Depending on non–inverting input voltage and circuit configuration, output will most likely move to negative supply.	B
IN1+	2	Depending on circuit configuration, application will likely not function due to the device common–mode being connected to IN1+.	B
OTF	3	Device will be likely be enabled. This is a 3.3V logic gate, so exceeding the ABS max ratings for current or voltage could damage the device.	A
IN2+	4	Depending on circuit configuration, application will likely not function due to the device common–mode being connected to IN2+.	B
IN2–	5	Negative feedback not present to device. Depending on non–inverting input voltage and circuit configuration, output will most likely move to negative supply.	B
GND	6	Op–Amp supplies will be shorted together leaving GND pin at some voltage between GND and VCC sources (depending on source impedance).	A
NC	7	NC pin internally disconnected, no effect.	D
NC	8	NC pin internally disconnected, no effect.	D
OUT2	9	Depending on circuit configuration, device will likely be forced into short circuit condition with OUT2 voltage ultimately forced to VCC voltage. Prolonged exposure to short circuit conditions could result in long term reliability issues.	A
OUT1	13	Depending on circuit configuration, device will likely be forced into short circuit condition with OUT1 voltage ultimately forced to VCC voltage. Prolonged exposure to short circuit conditions could result in long term reliability issues.	A
GND	14	Op–Amp supplies will be shorted together leaving GND pin at some voltage between GND and VCC sources (depending on source impedance).	A

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