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1 Overview

This document contains information for the LM4040-N-Q1 (SOT-23 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.

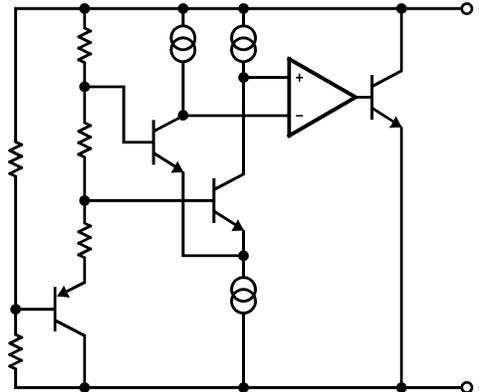


Figure 1-1. Functional Block Diagram

The LM4040-N-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 Functional Safety Failure In Time (FIT) Rates for Voltage Options ≤ 5V

This section provides functional safety failure in time (FIT) rates for the LM4040-N-Q1 (voltage options ≤ 5V) 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	3
Package FIT rate	1

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: 75mW
- 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, or 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 Functional Safety Failure In Time (FIT) Rates for 8.192V Voltage Option

This section provides functional safety failure in time (FIT) rates for the LM4040-N-Q1 (8.192V voltage option) 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 2-3. 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	7
Die FIT rate	6
Package FIT rate	1

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: 123mW
- 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, or 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.

2.3 Functional Safety Failure In Time (FIT) Rates for 10V Voltage Option

This section provides functional safety failure in time (FIT) rates for the LM4040-N-Q1 (10V voltage option) 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 2-5. 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	8
Die FIT rate	7
Package FIT rate	1

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: 150mW
- Climate type: World-wide table 8
- Package factor (lambda 3): Table 17b
- Substrate material: FR4
- EOS FIT rate assumed: 0 FIT

Table 2-6. 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	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.

3 Failure Mode Distribution (FMD)

The failure mode distribution estimation for the LM4040-N-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 (%)
VR voltage accuracy outside of the specifications	40
VR does not meet dynamic impedance specification	20
Minimum regulation current exceeds maximum value of the specification	40

4 Pin Failure Mode Analysis (Pin FMA)

This section provides a failure mode analysis (FMA) for the pins of the LM4040-N-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 LM4040-N-Q1 pin diagram. For a detailed description of the device pins, see the *Pin Configuration and Functions* section in the LM4040-N-Q1 data sheet.

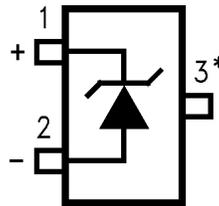


Figure 4-1. Pin Diagram

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

- $V_{dd}(\text{min}) < V_{dd} < V_{dd}(\text{max})$
- Cathode is connected to supply with a 100Ω resistor to keep the current in the operating range.

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

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
Cathode	1	The output does not regulate and the cathode pin is held low.	B
Anode	2	No effect to functionality; the device is operating as intended.	D
*	3	No effect to device functionality. Pin 3 must be left floating or connected to pin 2.	D

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

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
Cathode	1	The device is not powered.	B
Anode	2	The output does not regulate and follows the supply voltage.	B
*	3	No effect to device functionality. Pin 3 must be left floating or connected to pin 2.	D

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

Pin Name	Pin No.	Shorted to	Description of Potential Failure Effects	Failure Effect Class
Cathode	1	Anode	The output does not regulate and the cathode pin is held low.	B
Anode	2	*	No effect to device functionality. Pin 3 must be left floating or connected to pin 2.	D
*	3	Cathode	Not a recommended connection; Iq can increase.	C

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

Pin Name	Pin No.	Description of Potential Failure Effects	Failure Effect Class
Cathode	1	No effect to device functionality; the device is operating as intended.	D
Anode	2	The output does not regulate. The cathode pin is held low.	B
*	3	Not a recommended connection; Iq can increase	C

5 Revision History

Changes from Revision * (December 2018) to Revision A (November 2024)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document.....	2
• Added <i>Functional Safety Failure in Time (FIT) Rates</i> for different voltage options.....	3

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