MAX6459:
Safety Application Note

Failure-In-Time, Failure Mode Distribution and Pin Failure Mode and Effects Analysis

SEPTEMBER 2025

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1 | Overview

The scope of this document is to provide information to support integrating the MAX6459 into functional safety designs. This contains:

- Failure-In-Time (FIT) of the component calculated in accordance with the industry reliability standards
- Failure Mode Distribution of the device (FMD)
- Pin Failure Mode and Effects Analysis (Pin FMEA)

General Description

The MAX6459 is a high supply voltage, low-power voltage monitor capable of detecting both overvoltage (OV) and undervoltage (UV) conditions. It operates on a supply voltage ranging from 4V to 28V and includes key features like a precision bandgap reference, two independent comparator outputs, and internal hysteresis options (0.5%, 5%, and 8.3%).

External resistors set the voltage threshold for monitoring. The device offers a fixed 50µs timeout period and is housed in a compact SOT23 package, designed for use over the extended temperature range of -40°C to +125°C.

Table 1-1 Product Description

Part Number	Primary Function	System Function
MAX6459	High supply voltage, low-power voltage monitor	Monitor the System Supply Voltage and assert OUTA if it is below a certain threshold (UV), or assert OUTB if it is above a certain threshold (OV).

Figure 1-1 shows the product specific block diagram of MAX6459.

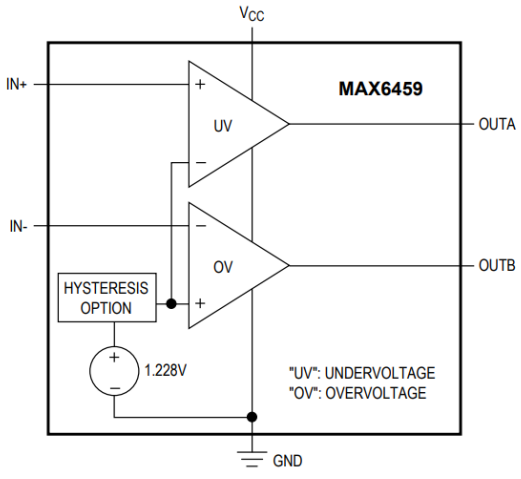

Figure 1-1 MAX6459 Block Diagram

The MAX6459 was developed following a quality-managed development process in compliance with the ISO 9001 quality management system standard but was not developed in compliance with the IEC61508 safety standard. The associated certificates are available on Quality Certificates | Analog Devices.

2 | Functional Safety Failure-In-Time (FIT)

This section offers specific details on the base functional safety failure-in-time (FIT) for MAX6459, according to SN 29500, IEC 62380 and accelerated testing conditions of HTOL. It also identifies the relevant component category for each standard, allowing customers to compute their own failure rates.

- Table 2-1 provides FIT according to SN 29500
- Table 2-2 provides FIT according to IEC 62380
- Table 2-3 provides FIT according to HTOL

The FIT of MAX6459 based on SN 29500 for a specific industrial mission profile is detailed below:

Table 2-1 Functional Safety Component FIT According to SN 29500

SN 29500 Industrial Mission Profile	FIT (Failures Per 10^9 Hours)
Predicted Component FIT	29.94

- Mission Profile: 20 years constant operation at 55°C temperature
- Operating Voltage (max): 28V
- Power Dissipation: 0.35mW
- Theta-JA: 115°C/W

Note 1: For applications requiring a different mission profile, the following information can be used to calculate the base FIT based on SN 29500.

- SN 29500 part: Part 2 Table 5 under ASICs
- Sub-category: CMOS, BiCMOS
- Integration Density: 50-5k
- Part is sensitive to drift

The FIT of MAX6459 based on IEC 62380 for a specific industrial mission profile is detailed below:

Table 2-2 Functional Safety Component FIT According to IEC 62380

IEC 62380 Industrial Mission Profile	FIT (Failures Per 10^9 Hours)
Total Component FIT	6.28
Die FIT	6.14
Package FIT	0.14

Note 2: For applications requiring a different mission profile, the following information can be used to calculate the base FIT based on IEC 62380.

- FIT calculation model: Section 7.3.1, refer to Mathematical Model
- IEC 62380 part and section for die FIT: Table 16, MOS ASIC circuits, Full Custom
- Production year: 2002
- Integration Density: 50-5k
- Climate type: World-wide (Table 8)
- IEC 62380 part and section for package FIT: Table 17b, Two rows connections packages
- Package type: SOT23 6 pins, length: 2.9mm, width: 1.62mm, pitch: 0.95mm
- Technology Structure: Bipolar BiCMOS (High Voltage)
- Substrate Material: Epoxy Glass (FR4, G-10)
- EOS FIT assumed: 0 FIT

The FIT of MAX6459 based on accelerated testing conditions of HTOL is detailed below:

Table 2-3 Functional Safety Component FIT According to HTOL Testing

Confidence Level	FIT (Failures Per 10^9 Hours)
70%	2.21
90%	4.24
95%	5.51
99%	8.47

Note 3: The FIT for various confidence levels were determined through HTOL reliability studies, utilizing the Arrhenius equation for acceleration assuming a chi-square distribution using the following test parameters:

- Sample size: 7,563
- Number of Failures: 0
- Activation Energy: 0.7eV
- Raw Device Hours: 7,059,016
- Accelerated Temperature: 55°C
- Equivalent Accelerated Device Hours: 543,565,635

3 | Failure Mode Distribution (FMD)

The failure mode distribution includes all relevant failure modes of the product function as defined in the product description.

Table 3-1 shows the failure mode distribution estimation for MAX6459 as derived from the component die area ratio and complexity, and from engineering expertise.

System Function

- Monitor the System Supply Voltage and assert OUTA if it is below a certain threshold (UV), or assert OUTB if it is above a certain threshold (OV).

Table 3-1 Failure Mode Distribution

Failure Modes	Failure Mode Distribution
Part stuck with OUTA (UV) asserted	12%
Part stuck with OUTB (OV) asserted	8%
Part does not assert OUTA (UV)	22%
Part does not assert OUTB (OV)	24%
OUTA (UV) triggered early	8%
OUTB (OV) triggered early	6%
OUTA (UV) triggered late	4%
OUTB (OV) triggered late	4%
No effect	12%

4 | Pin Failure Mode and Effects Analysis (Pin FMEA)

This section presents the Pin Failure Mode and Effects Analysis (Pin FMEA) for MAX6459. The failure modes discussed in this section encompass the common pin-by-pin failure scenarios:

- Pin short-circuited to supply (see Table 4-1)
- Pin short-circuited to GND (see Table 4-2)
- Pin open-circuited (see Table 4-3)
- Pin short-circuited to adjacent pins (see Table 4-4)

Figure 4-1 illustrates the pin diagram for MAX6459. Refer to the product datasheet for a detailed description of each pin's function.

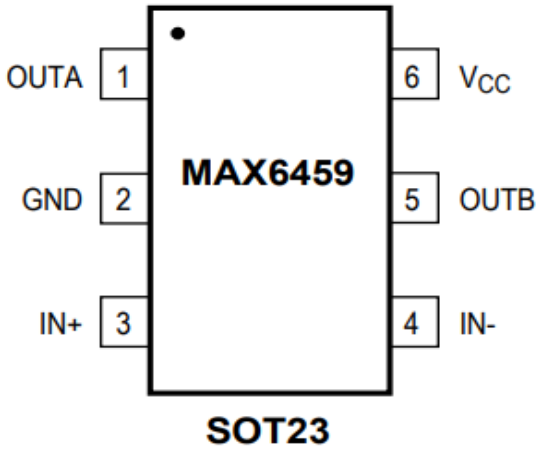

Figure 4-1. MAX6459 Pin Diagram

Below are the usage assumptions and device configuration considered for the Pin FMEA, based on the Typical Application Circuit, unless otherwise noted:

- The OUTA and OUTB pins are active-low output available in open-drain configuration.
- The OUTA and OUTB pins are connected to a 10kΩ pull-up resistor.
- MAX6459 operates as a window supervisor. Input resistors, R1 = 3.9MΩ, R2 = 36kΩ, and R3 = 220kΩ
- The operating voltage range (VCC) is from 4V to, and the operating temperature range (T_A) is from -40°C to +125°C.
- Values are measured at VCC = 21V, $V_{TRIPHIGH}$ = 23.1V, $V_{TRIPLOW}$ = 18.9V, and T_A = +25°C.

Table 4-1 Pin FMEA for MAX6459 Pins Short-Circuited to Supply

Pin no.	Pin Name	Effect of Failure Mode
1	OUTA	OUTA always high
2	GND	Part not functional
3	IN+	OUTA always high
4	IN-	OV on OUTB is triggered
5	OUTB	OUTB always high
6	VCC	No effect

Table 4-2 Pin FMEA for MAX6459 Pins Short-Circuited to GND

Pin no.	Pin Name	Effect of Failure Mode
1	OUTA	OUTA always low
2	GND	No effect
3	IN+	UV on OUTA is triggered
4	IN-	OUTB always high
5	OUTB	OUTB always low
6	VCC	Part not functional

Table 4-3 Pin FMEA for MAX6459 Pins Open-Circuited

Pin no.	Pin Name	Effect of Failure Mode
1	OUTA	Unreliable UV output
2	GND	Failure of OV and UV monitoring functions
3	IN+	OUTA unreliable output
4	IN-	OUTB unreliable output
5	OUTB	Unreliable OV output
6	VCC	Part is non-functional

Table 4-4 Pin FMEA for MAX6459 Pins Short-Circuited to Adjacent Pins

Pin no.	Pin Name	Shorted to	Effect of Failure Mode
1	OUTA	GND	OUTA always low
2	GND	IN+	UV on OUTA is triggered
3	IN+	IN-	UV triggered early
4	IN-	OUTB	OUTB unreliable output
5	OUTB	VCC	OUTB always high
6	VCC	OUTA	OUTA always high

5 | Revision History

Revision	Revision Date	Description
A	September 2024	Initial Release
B	July 2025	Updated *Overview* and *Functional Safety Failure-In-Time (FIT)*. Corrected typographical errors and Notes.
C	September 2025	Updated the FMD section to remove correction factor. Corrected minor typographical errors.

IMPORTANT NOTES AND DISCLAIMER

PLEASE BE AWARE THAT THE PRODUCT IN QUESTION HAS NOT BEEN DEVELOPED IN ACORDANCE WITH INDUSTRIAL SAFETY STANDARDS AND IS NOT RECOMMENDED FOR SUCH APPLICATIONS AS PER THE SPECIFIC DATA SHEET. THIS REPORT IS INTENDED SOLELY TO PROVIDE THE CUSTOMER WITH DETAILED INFORMATION ON FAILURE MODES AND THEIR DISTRIBUTION ACCORDING TO IEC61508, RELATED TO THE POTENTIAL USE OF QUALITY-MANAGED PARTS FOR SPECIFIC HARDWARE EVALUATION CLASS AS DESCRIBED IN THIS STANDARD.

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