

MAX16134:

Safety Application Note

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

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1 | Overview

The scope of this document is to provide information to support integrating the MAX16134 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 MAX16134 is a low-voltage, $\pm 1\%$ accurate, triple-voltage μP supervisor that monitor up to 3 system-supply voltages for undervoltage (UV) and overvoltage (OV) faults. It detects undervoltage and overvoltage conditions, triggering a reset output when its corresponding input falls outside the factory-trimmed OV and UV window threshold from $\pm 4\%$ to $\pm 11\%$, with $\pm 1\%$ resolution and 0.25% or 0.50% hysteresis. The reset outputs are active-low, open-drain.

The MAX16134 is available in a small 8-pin SOT23 package and specified over the temperature range of -40°C to $+125^{\circ}\text{C}$.

Table 1-1 Product Description

Part Number	Primary Function	System Function
MAX16134	Low-voltage, $\pm 1\%$ accurate, triple-voltage μP supervisor	Monitor if a System Supply Voltage is out-of-range (OV/UV) and assert corresponding $\overline{\text{RESET}}$ output

Figure 1-1 shows the product specific block diagram of MAX16134.

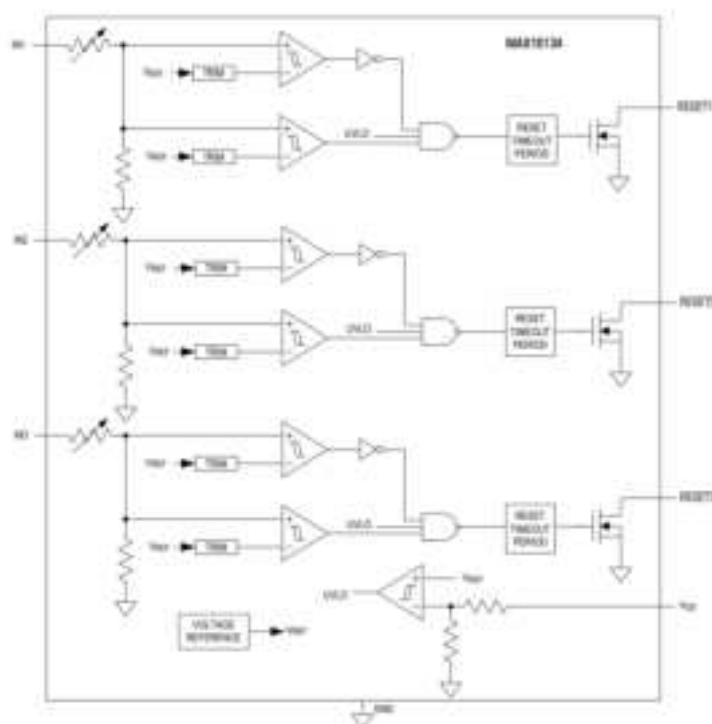


Figure 1-1 MAX16134 Block Diagram

The MAX16134 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 MAX16134, 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 MAX16134 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	50.06

- Mission Profile: 20 years constant operation at 55°C temperature
- Operating Voltage (max): 5.5V
- Power Dissipation: 0.165mW
- Theta-JA: 196°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: 5k-50k
- Part is sensitive to drift

The FIT of MAX16134 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	4.48
Die FIT	4.34
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 for die FIT: 2019
- Integration Density: 5k-50k
- Climate type: World-wide (Table 8)
- IEC 62380 part and section for package FIT: Table 17b, Two rows connections packages
- Package type: SOT23 8 pins, length: 2.9mm, width: 1.62mm, pitch: 0.65mm
- Technology Structure: MOS BiCMOS (Low Voltage)
- Substrate Material: Epoxy Glass (FR4, G-10)
- EOS FIT assumed: 0 FIT

The FIT of MAX16134 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%	0.27
90%	0.51
95%	0.67
99%	1.03

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: 83,375
- Number of Failures: 0
- Activation Energy: 0.7eV
- Raw Device Hours: 58,309,140
- Accelerated Temperature: 55°C
- Equivalent Accelerated Device Hours: 4,489,980,576

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 MAX16134 as derived from the component die area ratio and complexity, and from engineering expertise.

Since some failures had no effect and do not contribute to any failure mode, the total percentage of the Failure Mode Distribution would not add up to 100%. A Correction factor (CF) was applied to the distribution to account for failures with no effect on the system.

System Function

- Monitor if a System Supply Voltage is out-of-range (OV/UV) and assert corresponding $\overline{\text{RESET}}$ output.

Table 3-1 Failure Mode Distribution (CF = 1.23)

Failure Modes	Failure Mode Distribution
RESET1 always asserted	15%
RESET1 never asserts	15%
RESET1 asserts early	3%
RESET1 asserts late	1%
RESET2 always asserted	15%
RESET2 never asserts	14%
RESET2 asserts early	3%
RESET2 asserts late	1%
RESET3 always asserted	15%
RESET3 never asserts	14%
RESET3 asserts early	3%
RESET3 asserts late	1%

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

This section presents the Pin Failure Mode and Effects Analysis (Pin FMEA) for MAX16134. 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 MAX16134. Refer to the product datasheet for a detailed description of each pin's function.

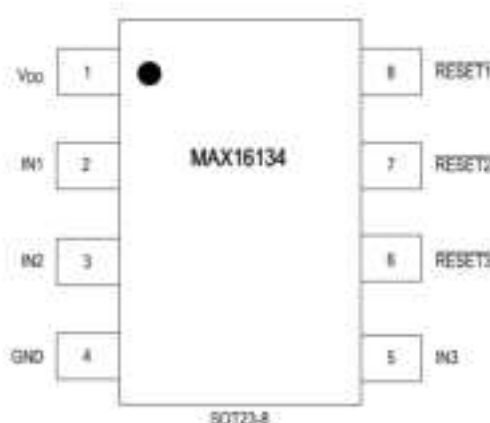


Figure 4-1. MAX16134 Pin Diagram

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

- The $\overline{\text{RESET1}}$, $\overline{\text{RESET2}}$, and $\overline{\text{RESET3}}$ pins are active-low reset output available in open-drain configuration.
- The $\overline{\text{RESET1}}$, $\overline{\text{RESET2}}$, and $\overline{\text{RESET3}}$ pins are connected to a 10k Ω pull-up resistor.
- The operating voltage range (VDD) is from 1.71V to 5.5V, and the operating temperature range ($T_A = T_J$) is from -40°C to +125°C.
- Typical values are measured at VDD = 5V, and $T_A = +25^\circ\text{C}$.

Table 4-1 Pin FMEA for MAX16134 Pins Short-Circuited to Supply

Pin no.	Pin Name	Effect of Failure Mode
1	VDD	No effect
2	IN1	VDD>OV,th: Always OV on IN1. $\overline{\text{RESET1}}$ always low VDD<UV,th: Always UV on IN1. $\overline{\text{RESET1}}$ always low VDD within IN1 range: No effect
3	IN2	VDD>OV,th: Always OV on IN1. $\overline{\text{RESET2}}$ always low VDD<UV,th: Always UV on IN1. $\overline{\text{RESET2}}$ always low VDD within IN2 range: No effect
4	GND	Part not functional
5	IN3	VDD>OV,th: Always OV on IN1. $\overline{\text{RESET3}}$ always low VDD<UV,th: Always UV on IN1. $\overline{\text{RESET3}}$ always low VDD within IN3 range: No effect
6	$\overline{\text{RESET3}}$	$\overline{\text{RESET3}}$ always high
7	$\overline{\text{RESET2}}$	$\overline{\text{RESET2}}$ always high
8	$\overline{\text{RESET1}}$	$\overline{\text{RESET1}}$ always high

Table 4-2 Pin FMEA for MAX16134 Pins Short-Circuited to GND

Pin no.	Pin Name	Effect of Failure Mode
1	VDD	Part not functional
2	IN1	Always UV on IN1. $\overline{\text{RESET1}}$ always low
3	IN2	Always UV on IN2. $\overline{\text{RESET2}}$ always low
4	GND	No effect
5	IN3	Always UV on IN3. $\overline{\text{RESET3}}$ always low
6	$\overline{\text{RESET3}}$	$\overline{\text{RESET3}}$ always low
7	$\overline{\text{RESET2}}$	$\overline{\text{RESET2}}$ always low
8	$\overline{\text{RESET1}}$	$\overline{\text{RESET1}}$ always low

Table 4-3 Pin FMEA for MAX16134 Pins Open-Circuited

Pin no.	Pin Name	Effect of Failure Mode
1	VDD	Part has no Power. Part not functional
2	IN1	Always UV on IN1. $\overline{\text{RESET1}}$ always low
3	IN2	Always UV on IN2. $\overline{\text{RESET2}}$ always low
4	GND	Part not functional
5	IN3	Always UV on IN3. $\overline{\text{RESET3}}$ always low
6	$\overline{\text{RESET3}}$	Unreliable $\overline{\text{RESET3}}$
7	$\overline{\text{RESET2}}$	Unreliable $\overline{\text{RESET2}}$
8	$\overline{\text{RESET1}}$	Unreliable $\overline{\text{RESET1}}$

Table 4-4 Pin FMEA for MAX16134 Pins Short-Circuited to Adjacent Pins

Pin no.	Pin Name	Shorted to	Effect of Failure Mode
1	VDD	IN1	VDD>OV,th: Always OV on IN1. RESET1 always low VDD<UV,th: Always UV on IN1. RESET1 always low VDD within IN1 range: No effect
2	IN1	IN2	IN2 may trigger RESET1 depending on IN1 thresholds (or IN1 triggers RESET2). Unreliable RESET1/2 output
3	IN2	GND	Always UV on IN2. RESET2 always low
4	GND	IN3	Always UV on IN3. RESET3 always low
5	IN3	RESET3	Unreliable RESET3
6	RESET3	RESET2	RESET2, RESET3 or-ing output
7	RESET2	RESET1	RESET2, RESET1 or-ing output
8	RESET1	VDD	RESET1 always high

5 | Revision History

Revision	Revision Date	Description
A	September 2024	Initial Release
B	July 2025	Updated <i>Overview</i> and <i>Functional Safety Failure-In-Time (FIT)</i> . Corrected typographical errors and Notes.

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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