MAX6764:
Safety Application Note

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

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Contents

1 | Overview 2
2 | Functional Safety Failure-In-Time (FIT) Rates 3
3 | Failure Mode Distribution (FMD) 5
4 | Pin Failure Mode and Effects Analysis (Pin FMEA) 6
5 | Revision History 8

1 | Overview

The scope of this document is to provide a report on MAX6764 to support in functional safety designs. This contains:

- Failure-In-Time (FIT) rates 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 MAX6764 is a low-power window detector designed to monitor system voltages for undervoltage (UV) and overvoltage (OV) conditions. It provides independent undervoltage and overvoltage outputs available in open-drain configuration, and allow for externally adjustable thresholds.

This device is available in SOT23 package, and is specified over the extended temperature range of -40°C to +125°C.

Table 1-1 Product Description

Part Number	Primary Function	System Function
MAX6764	Low-power window detector	Monitor the System Supply Voltage and assert $\overline{UV}$ if it is below a certain threshold (UV), or assert $\overline{OV}$ if it is above a certain threshold (OV).

Figure 1-1 shows the product specific block diagram of MAX6764.

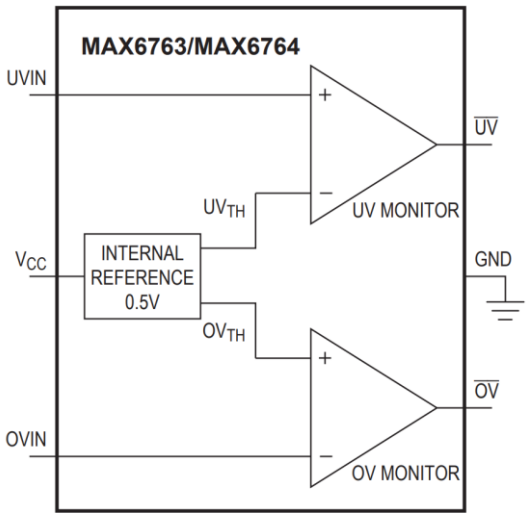

Figure 1-1 MAX6764 Block Diagram

MAX6764 was developed following a quality-managed development process in compliance with ISO 9001 quality management system standards but was not developed in compliance with IEC61508 safety standard. The associated certificates are available on Quality Certificates | Analog Devices.

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

This section offers specific details on the base functional safety failure-in-time (FIT) rates for MAX6764, according to SN29500, 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 rates according to SN29500
- Table 2-2 provides FIT rates according to IEC 62380
- Table 2-3 provides FIT rates according to HTOL

The FIT rates of MAX6764 based on SN29500 for a specific industrial mission profile is detailed below:

Table 2-1 Functional Safety Component FIT Rate According to SN29500

SN29500 Industrial Mission Profile	FIT (Failures Per 10^9 Hours)
Predicted Component FIT Rate	40.03

- Mission Profile: 20 years constant operation at 55°C temperature
- Climate type: World-wide (Table 8)
- Operating Voltage (max): 6V
- Power Dissipation: 0.138mW
- Theta-JA: 115°C/W
- Substrate Material: FR4
- EOS FIT rate assumed: 0 FIT
- Part is sensitive to drift

Note 1: For applications requiring a different mission profile, the following information can be used to calculate the base FIT rate based on SN29500.

- SN29500 part and section: Part 2/Section 5 and ASICs
- Sub-category: CMOS, BiCMOS
- Integration Density: 50-5k

The FIT rates of MAX6764 based on IEC62380 for a specific industrial mission profile is detailed below:

Table 2-2 Functional Safety Component FIT Rates According to IEC62380

IEC62380 Industrial Mission Profile	FIT (Failures Per 10^9 Hours)
Total Component FIT Rate	5.26
Die FIT Rate	5.12
Package FIT Rate	0.14

Note 2: For applications requiring a different mission profile, the following information can be used to calculate the base FIT rate based on IEC62380.

- FIT rate calculation model: Section 7.3.1, refer to Mathematical Model
- IEC62380 part and section for die FIT rate: Table 16, MOS ASIC circuits, Full Custom
- Production year for die FIT rate: 2004
- Integration Density: 50-5k
- IEC62380 part and section for package FIT rate: Table 17b, Two rows connections packages
- Package type: SOT23 6 pins, length: 2.9mm, width: 1.62mm, pitch: 0.95mm
- Interface device (EOS relevant): No

The FIT rates of MAX6764 based on accelerated testing conditions of HTOL is detailed below:

Table 2-3 Functional Safety Component FIT Rates 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 rates 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 MAX6764 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 the System Supply Voltage and assert $\overline{UV}$ if it is below a certain threshold, or assert $\overline{OV}$ if it is above a certain threshold.

Table 3-1 Failure Mode Distribution (CF = 1.53)

Failure Modes	Failure Mode Distribution
Part stuck with UV asserted	14%
Part stuck with OV asserted	14%
Part does not assert UV	31%
Part does not assert OV	31%
UV triggered early	3%
OV triggered early	3%
UV triggered late	2%
OV triggered late	2%

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

This section presents the Pin Failure Mode and Effects Analysis (Pin FMEA) for MAX6764. 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 MAX6764. Refer to the product datasheet for a detailed description of each pin's function.

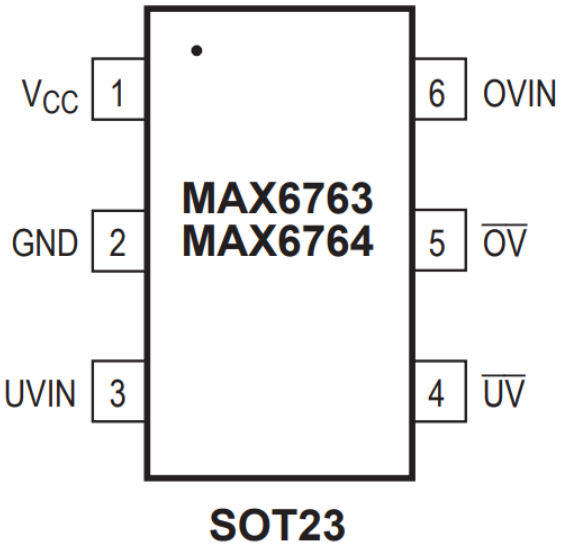

Figure 4-1. MAX6764 Pin Diagram

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

- The $\overline{OV}$ and $\overline{UV}$ pins are active-low reset output available in open-drain configurations.
- The $\overline{OV}$ and $\overline{UV}$ pin are connected to a 10kΩ pull-up resistor.
- The operating voltage range (VCC) is from 1.4V to 6V, and the operating temperature range (T_A) is from -40°C to +125°C.

Table 4-1 Pin FMEA for MAX6764 Pins Short-Circuited to Supply

Pin no.	Pin Name	Effect of Failure Mode
1	VCC	No effect
2	GND	Part not functional
3	UVIN	$\overline{UV}$ always high
4	$\overline{UV}$	$\overline{UV}$ always high
5	$\overline{OV}$	$\overline{OV}$ always high
6	OVIN	$\overline{OV}$ always low

Table 4-2 Pin FMEA for MAX6764 Pins Short-Circuited to GND

Pin no.	Pin Name	Effect of Failure Mode
1	VCC	Part not functional
2	GND	No effect
3	UVIN	$\overline{UV}$ always low
4	$\overline{UV}$	$\overline{UV}$ always low
5	$\overline{OV}$	$\overline{OV}$ always low
6	OVIN	$\overline{OV}$ always high

Table 4-3 Pin FMEA for MAX6764 Pins Open-Circuited

Pin no.	Pin Name	Effect of Failure Mode
1	VCC	Part not functional. No power
2	GND	Part not functional
3	UVIN	Unreliable $\overline{UV}$ output
4	$\overline{UV}$	Unreliable $\overline{UV}$ output
5	$\overline{OV}$	Unreliable $\overline{OV}$ output
6	OVIN	Unreliable $\overline{OV}$ output

Table 4-4 Pin FMEA for MAX6764 Pins Short-Circuited to Adjacent Pins

Pin no.	Pin Name	Shorted to	Effect of Failure Mode
1	VCC	GND	Part not functional
2	GND	UVIN	$\overline{UV}$ always low
3	UVIN	$\overline{UV}$	Unreliable $\overline{UV}$ output
4	$\overline{UV}$	$\overline{OV}$	UV and OV output assertion in OR logic
5	$\overline{OV}$	OVIN	Unreliable $\overline{OV}$ output
6	OVIN	VCC	$\overline{OV}$ always low

5 | Revision History

Revision	Revision Date	Description
A	September 2024	Initial Release

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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