MAX6762:
Safety Application Note

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

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Contents

1| Overview

The scope of this document is to provide information to support integrating the MAX6762 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 MAX6762 is a low-power window detector designed to monitor system voltages for undervoltage (UV) and overvoltage (OV) conditions. It can monitor dual-voltage systems and offers adjustable thresholds from 0.9V to 5V with a selectable ±5%, ±10%, or ±15% window voltage for precise monitoring.

Additional features include delay timing options (20µs, typ or 100ms, min), a latched overvoltage output function for enhance protection, and a manual reset input. This device is available in TDFN 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
MAX6762	Low-power window detector	Monitor whether VCC or VCC2 falls below a certain threshold (UV) and, if so, assert $\overline{\text{UV}}$. Additionally, monitor if VCC or VCC2 exceeds a certain threshold (OV) and, if so, assert $\overline{\text{OV}}$.

Figure 1-1 shows the product specific block diagram of MAX6762.

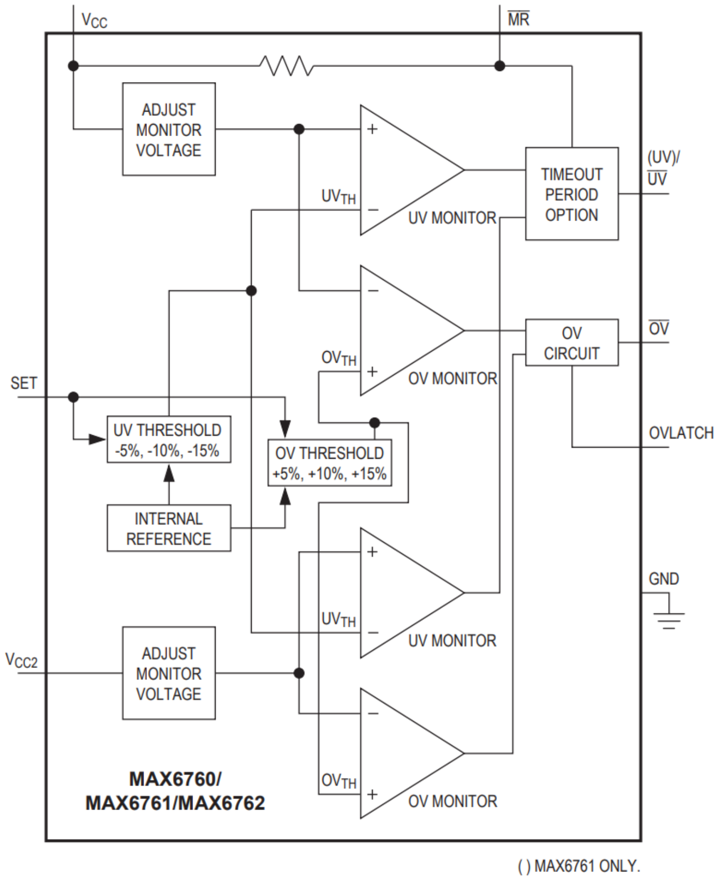

Figure 1-1 MAX6762 Block Diagram

The MAX6762 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.

Table 1-2 Applicable Assumptions

The following assumptions were made in deriving the FMD and Pin FMEA.

Case	Assumption	Description
1	SET Pin Connected to GND	±5% OV/UV window tolerance
2	SET Pin Connected to VCC	±10% OV/UV window tolerance
3	SET Pin Connected to VCC/2	±15% OV/UV window tolerance

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

This section offers specific details on the base functional safety failure-in-time (FIT) for MAX6762, 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 MAX6762 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	40.01

- Mission Profile: 20 years constant operation at 55°C temperature
- Operating Voltage (max): 6V
- Power Dissipation: 0.18mW
- Theta-JA: 41°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 MAX6762 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	5.85
Die FIT	5.46
Package FIT	0.39

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: 2003
- Integration Density: 50-5k
- Climate type: World-wide (Table 8)
- IEC 62380 part and section for package FIT: Table 17b, Peripheral Connection Packages
- Package type: TDFN 8 pins, length: 3mm, width: 3mm, pitch: 0.65mm
- Technology Structure: Bipolar BiCMOS (Low Voltage)
- Substrate Material: Epoxy Glass (FR4, G-10)
- EOS FIT assumed: 0 FIT

The FIT of MAX6762 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 to Table 3-3 show the failure mode distribution estimation for MAX6762 as derived from the component die area ratio and complexity, and from engineering expertise. Refer to Table 1-2 for the applicable assumptions.

System Function

- Monitor whether VCC or VCC2 falls below a certain threshold (UV) and, if so, assert $\overline{\text{UV}}$. Additionally, monitor if VCC or VCC2 exceeds a certain threshold (OV) and, if so, assert $\overline{\text{OV}}$.

Table 3-1 Case 1: Failure Mode Distribution

Failure Modes	Failure Mode Distribution
Part stuck with UV asserted	11%
Part stuck with OV asserted	10%
Part does not assert UV	26%
Part does not assert OV	25%
UV triggered early	4%
OV triggered early	4%
UV triggered late	2%
OV triggered late	2%
No effect	16%

Table 3-2 Case 2: Failure Mode Distribution

Failure Modes	Failure Mode Distribution
Part stuck with UV asserted	11%
Part stuck with OV asserted	7%
Part does not assert UV	25%
Part does not assert OV	26%
UV triggered early	4%
OV triggered early	4%
UV triggered late	2%
OV triggered late	2%
No effect	19%

Table 3-1 Case 3: Failure Mode Distribution

Failure Modes	Failure Mode Distribution
Part stuck with UV asserted	11%
Part stuck with OV asserted	8%
Part does not assert UV	24%
Part does not assert OV	25%
UV triggered early	6%
OV triggered early	6%
UV triggered late	2%
OV triggered late	2%
No effect	16%

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

This section presents the Pin Failure Mode and Effects Analysis (Pin FMEA) for MAX6762. The failure modes discussed in this section encompass the common pin-by-pin failure scenarios:

Case 1 - SET pin connected to GND:

- 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)

Case 2 - SET pin connected to VCC:

- Pin short-circuited to supply (see Table 4-5)
- Pin short-circuited to GND (see Table 4-6)
- Pin open-circuited (see Table 4-7)
- Pin short-circuited to adjacent pins (see Table 4-8)

Case 3 - SET pin connected to VCC/2:

- Pin short-circuited to supply (see Table 4-9)
- Pin short-circuited to GND (see Table 4-10)
- Pin open-circuited (see Table 4-11)
- Pin short-circuited to adjacent pins (see Table 4-12)

Figure 4-1 illustrates the pin diagram for MAX6762. Refer to the product datasheet for a detailed description of each pin's function.

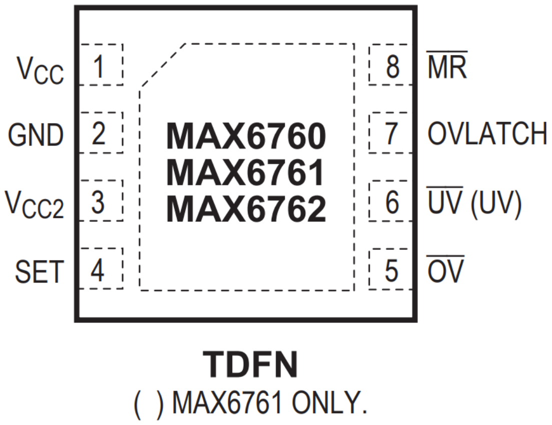

Figure 4-1. MAX6762 Pin Diagram

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

- The $\overline{\text{UV}}$ and $\overline{\text{OV}}$ pins are active-low reset output available in open-drain configuration.
- The $\overline{\text{UV}}$ and $\overline{\text{OV}}$ pins are connected to a 10kΩ pull-up resistor.
- The operating voltage range (VCC) is from 1.0V to 6.0V, and the operating temperature range (T_A) is from -40°C to +125°C.
- Typical values are measured at VCC = 1.0V to 6.0V, VCC2 = 0 to 6.0V, and TA = +25°C.
- The monitoring inputs, VCC and VCC2 are not equal.
- OVLATCH pin is connected HIGH, latching $\overline{\text{OV}}$ after assertion.

Table 4-1 Case 1: Pin FMEA for MAX6762 Pins Short-Circuited to Supply

Pin no.	Pin Name	Effect of Failure Mode
1	VCC	No effect
2	GND	Part not functional
3	VCC2	VCC and VCC2 shorted. Part not functional
4	SET	VCC shorted to GND. Part not functional
5	$\overline{OV}$	$\overline{OV}$ always high
6	$\overline{UV}$	$\overline{UV}$ always high
7	OVLATCH	No effect
8	$\overline{MR}$	Part does not respond to $\overline{MR}$ assertion but can still detect supply UV

Table 4-2 Case 1: Pin FMEA for MAX6762 Pins Short-Circuited to GND

Pin no.	Pin Name	Effect of Failure Mode
1	VCC	Part not functional
2	GND	No effect
3	VCC2	Part not functional
4	SET	No effect
5	$\overline{OV}$	$\overline{OV}$ always low
6	$\overline{UV}$	$\overline{UV}$ always low
7	OVLATCH	Cannot latch OV output
8	$\overline{MR}$	$\overline{UV}$ always low

Table 4-3 Case 1: Pin FMEA for MAX6762 Pins Open-Circuited

Pin no.	Pin Name	Effect of Failure Mode
1	VCC	No monitoring function for VCC rail
2	GND	Loss of monitoring function
3	VCC2	No monitoring function for VCC2 rail
4	SET	Indeterminate OV and UV thresholds. Unreliable $\overline{UV}$ and $\overline{OV}$ outputs
5	$\overline{OV}$	Unreliable $\overline{OV}$ output
6	$\overline{UV}$	Unreliable $\overline{UV}$ output
7	OVLATCH	Indeterminate whether $\overline{OV}$ should be latched or not
8	$\overline{MR}$	Part does not respond to $\overline{MR}$ assertion but can still detect supply UV

Table 4-4 Case 1: Pin FMEA for MAX6762 Pins Short-Circuited to Adjacent Pins

Pin no.	Pin Name	Shorted to	Effect of Failure Mode
1	VCC	GND	Part not functional
2	GND	VCC2	VCC2 shorted to GND. Part not functional
3	VCC2	SET	VCC2 shorted to GND. Part not functional
4	SET	$\overline{OV}$	$\overline{OV}$ always low
5	$\overline{OV}$	$\overline{UV}$	$\overline{UV}$ and $\overline{OV}$ output assertion in OR logic
6	$\overline{UV}$	OVLATCH	$\overline{UV}$ always high
7	OVLATCH	$\overline{MR}$	When $\overline{MR}$ is high, no effect. When $\overline{MR}$ is low, part not functional
8	$\overline{MR}$	VCC	Part does not respond to $\overline{MR}$ assertion but can still detect supply UV

Table 4-5 Case 2: Pin FMEA for MAX6762 Pins Short-Circuited to Supply

Pin no.	Pin Name	Effect of Failure Mode
1	VCC	No effect
2	GND	Part not functional
3	VCC2	Part not functional
4	SET	No effect
5	$\overline{\text{OV}}$	$\overline{\text{OV}}$ always high
6	$\overline{\text{UV}}$	$\overline{\text{UV}}$ always high
7	OVLATCH	No effect
8	$\overline{\text{MR}}$	Part does not respond to $\overline{\text{MR}}$ assertion but can still detect supply UV

Table 4-6 Case 2: Pin FMEA for MAX6762 Pins Short-Circuited to GND

Pin no.	Pin Name	Effect of Failure Mode
1	VCC	Part not functional
2	GND	No effect
3	VCC2	Part not functional
4	SET	VCC shorted to GND. Part not functional
5	$\overline{\text{OV}}$	$\overline{\text{OV}}$ always low
6	$\overline{\text{UV}}$	$\overline{\text{UV}}$ always low
7	OVLATCH	Cannot latch $\overline{\text{OV}}$ output
8	$\overline{\text{MR}}$	$\overline{\text{UV}}$ always low

Table 4-7 Case 3: Pin FMEA for MAX6762 Pins Open-Circuited

Pin no.	Pin Name	Effect of Failure Mode
1	VCC	No monitoring function for VCC rail
2	GND	Loss of monitoring function
3	VCC2	No monitoring function for VCC2 rail
4	SET	Indeterminate OV and UV thresholds. Unreliable $\overline{\text{UV}}$ and $\overline{\text{OV}}$ outputs
5	$\overline{\text{OV}}$	Unreliable $\overline{\text{OV}}$ output
6	$\overline{\text{UV}}$	Unreliable $\overline{\text{UV}}$ output
7	OVLATCH	Indeterminate whether $\overline{\text{OV}}$ should be latched or not
8	$\overline{\text{MR}}$	Part does not respond to $\overline{\text{MR}}$ assertion but can still detect supply UV

Table 4-8 Case 4: Pin FMEA for MAX6762 Pins Short-Circuited to Adjacent Pins

Pin no.	Pin Name	Shorted to	Effect of Failure Mode
1	VCC	GND	Part not functional
2	GND	VCC2	VCC2 shorted to gnd. Part not functional
3	VCC2	SET	No effect
4	SET	$\overline{\text{OV}}$	$\overline{\text{OV}}$ always high
5	$\overline{\text{OV}}$	$\overline{\text{UV}}$	$\overline{\text{UV}}$ and $\overline{\text{OV}}$ output assertion in OR logic
6	$\overline{\text{UV}}$	OVLATCH	$\overline{\text{UV}}$ always high
7	OVLATCH	$\overline{\text{MR}}$	When $\overline{\text{MR}}$ is high, no effect. When $\overline{\text{MR}}$ is low, part not functional
8	$\overline{\text{MR}}$	VCC	Part does not respond to $\overline{\text{MR}}$ assertion but can still detect supply UV

Table 4-9 Case 3: Pin FMEA for MAX6762 Pins Short-Circuited to Supply

Pin no.	Pin Name	Effect of Failure Mode
1	VCC	No effect
2	GND	Part not functional
3	VCC2	Part not functional
4	SET	OV threshold always 10%, UV threshold always -10%
5	$\overline{\text{OV}}$	$\overline{\text{OV}}$ always high
6	$\overline{\text{UV}}$	$\overline{\text{UV}}$ always high
7	OVLATCH	No effect
8	$\overline{\text{MR}}$	Part does not respond to $\overline{\text{MR}}$ assertion but can still detect supply UV

Table 4-10 Case 3: Pin FMEA for MAX6762 Pins Short-Circuited to GND

Pin no.	Pin Name	Effect of Failure Mode
1	VCC	Part not functional
2	GND	No effect
3	VCC2	Part not functional
4	SET	OV threshold always 5%, UV threshold always -5%
5	$\overline{\text{OV}}$	$\overline{\text{OV}}$ always low
6	$\overline{\text{UV}}$	$\overline{\text{UV}}$ always low
7	OVLATCH	Cannot latch $\overline{\text{OV}}$ output
8	$\overline{\text{MR}}$	$\overline{\text{UV}}$ always low

Table 4-11 Case 3: Pin FMEA for MAX6762 Pins Open-Circuited

Pin no.	Pin Name	Effect of Failure Mode
1	VCC	No monitoring function for VCC rail
2	GND	Loss of monitoring function
3	VCC2	No monitoring function for VCC2 rail
4	SET	Indeterminate OV and UV thresholds. Unreliable $\overline{\text{UV}}$ and $\overline{\text{OV}}$ outputs
5	$\overline{\text{OV}}$	Unreliable $\overline{\text{OV}}$ output
6	$\overline{\text{UV}}$	Unreliable $\overline{\text{UV}}$ output
7	OVLATCH	Indeterminate whether $\overline{\text{OV}}$ should be latched or not
8	$\overline{\text{MR}}$	Part does not respond to $\overline{\text{MR}}$ assertion but can still detect supply UV

Table 4-12 Case 3: Pin FMEA for MAX6762 Pins Short-Circuited to Adjacent Pins

Pin no.	Pin Name	Shorted to	Effect of Failure Mode
1	VCC	GND	Part not functional
2	GND	VCC2	VCC2 shorted to GND. Part not functional
3	VCC2	SET	UV threshold always 10%, OV threshold always 10%
4	SET	$\overline{\text{OV}}$	$\overline{\text{OV}}$ stuck at VCC/2. Indeterminate $\overline{\text{OV}}$ output
5	$\overline{\text{OV}}$	$\overline{\text{UV}}$	$\overline{\text{UV}}$ and $\overline{\text{OV}}$ output assertion in OR logic
6	$\overline{\text{UV}}$	OVLATCH	$\overline{\text{UV}}$ always high
7	OVLATCH	$\overline{\text{MR}}$	When $\overline{\text{MR}}$ is high, no effect. When $\overline{\text{MR}}$ is low, part not functional
8	$\overline{\text{MR}}$	VCC	Part does not respond to $\overline{\text{MR}}$ assertion but can still detect supply UV

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.

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