



**Table of Contents**

<b>1 Overview</b> .....	<b>2</b>
<b>2 Functional Safety Failure In Time (FIT) Rates</b> .....	<b>3</b>
2.1 HTSSOP Package.....	3
2.2 WSON Package.....	4
<b>3 Failure Mode Distribution (FMD)</b> .....	<b>5</b>
<b>4 Pin Failure Mode Analysis (Pin FMA)</b> .....	<b>6</b>
4.1 HTSSOP Package.....	7
4.2 WSON Package.....	11
<b>5 Revision History</b> .....	<b>15</b>

## 1 Overview

This document contains information for LM63635-Q1 (HTSSOP and WSON packages) 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.

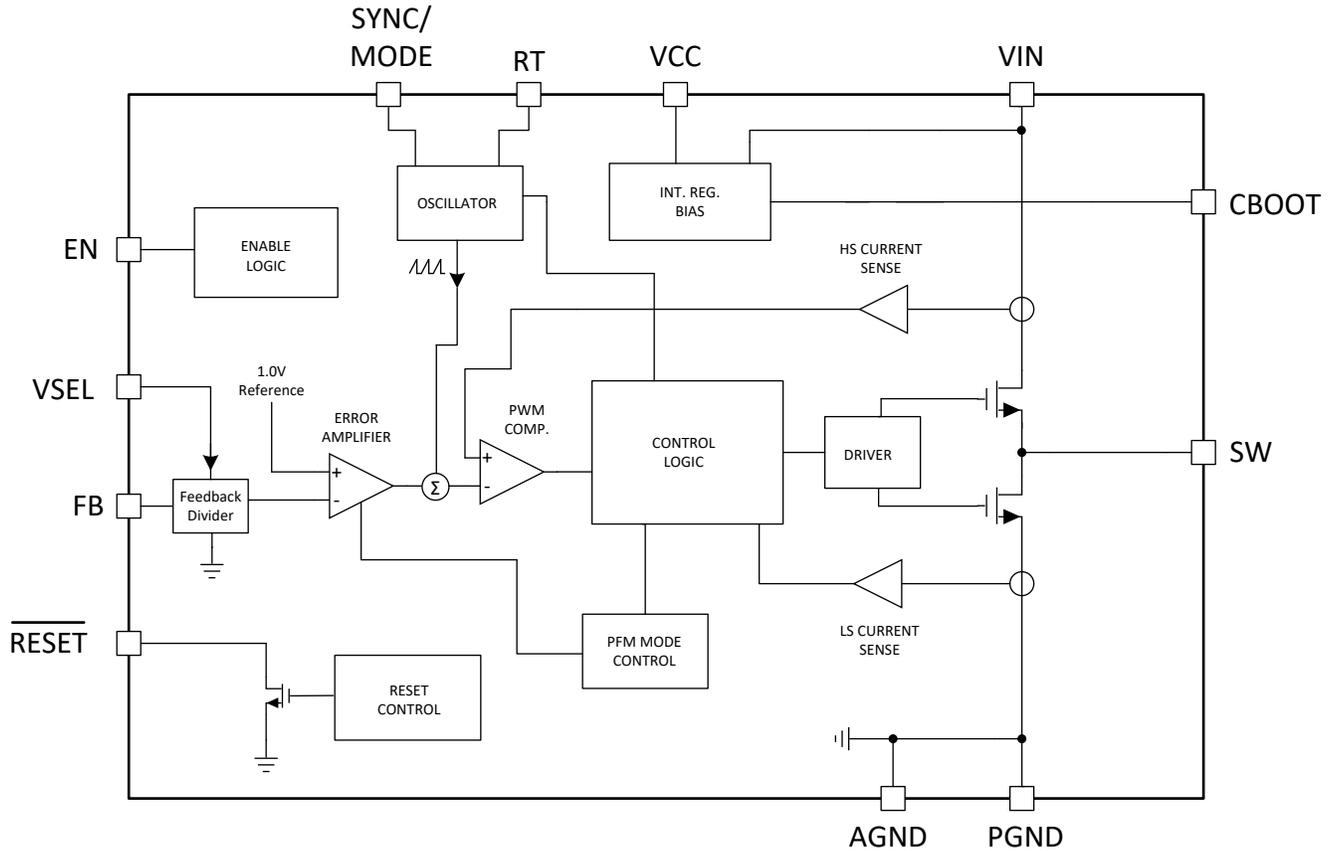


Figure 1-1. Functional Block Diagram

LM63635-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 HTSSOP Package

This section provides Functional Safety Failure In Time (FIT) rates for the HTSSOP package of LM63635-Q1 based on the following 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 <sup>9</sup> Hours)
Total Component FIT Rate	17
Die FIT Rate	7
Package FIT Rate	10

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: 600 mW
- 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 <sub>J</sub>
5	CMOS, BICMOS Digital, analog / mixed	25 FIT	55°C

The Reference FIT Rate and Reference Virtual T<sub>J</sub> (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 WSON Package

This section provides Functional Safety Failure In Time (FIT) rates for the WSON package of LM63635-Q1 based on the following industry-wide used reliability standards:

- [Table 2-3](#) provides FIT rates based on IEC TR 62380 / ISO 26262 part 11
- [Table 2-4](#) 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 <sup>9</sup> Hours)
Total Component FIT Rate	12
Die FIT Rate	7
Package FIT Rate	5

The failure rate and mission profile information in [Table 2-3](#) comes from the Reliability data handbook IEC TR 62380 / ISO 26262 part 11:

- Mission Profile: Motor Control from Table 11
- Power dissipation: 600 mW
- 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 <sub>J</sub>
5	CMOS, BICMOS Digital, analog / mixed	25 FIT	55°C

The Reference FIT Rate and Reference Virtual T<sub>J</sub> (junction temperature) in [Table 2-4](#) 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 LM63635-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 due to misuse or overstress.

**Table 3-1. Die Failure Modes and Distribution**

Die Failure Modes	Failure Mode Distribution (%)
No output voltage	35%
Output not in specification -- voltage or timing	45%
SW driver FET stuck on	10%
RESET false trip or fails to trip	5%
Short circuit any two pins	5%

## 4 Pin Failure Mode Analysis (Pin FMA)

This section provides a Failure Mode Analysis (FMA) for the pins of the LM63635-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](#) and [Table 4-6](#))
- Pin open-circuited (see [Table 4-3](#) and [Table 4-7](#))
- Pin short-circuited to an adjacent pin (see [Table 4-4](#) and [Table 4-8](#))
- Pin short-circuited to VIN (see [Table 4-5](#) and [Table 4-9](#))

These tables 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**

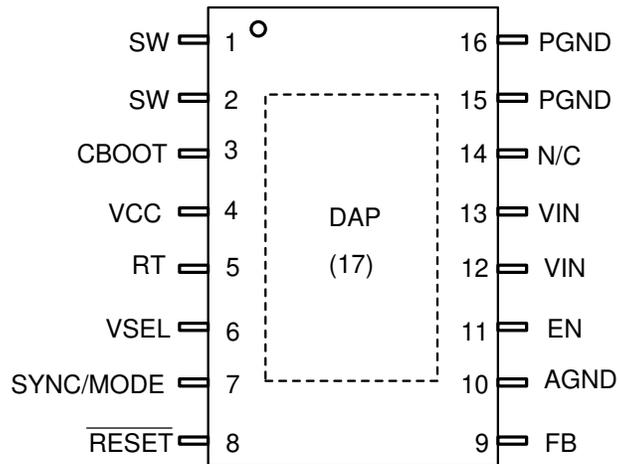
Class	Failure Effects
A	Potential device damage that affects functionality
B	No device damage, but loss of functionality
C	No device damage, but performance degradation
D	No device damage, no impact to functionality or performance

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

- Device used within the *Recommended Operating Conditions* and the *Absolute Maximum Ratings* found in the [LM63635](#) data sheet.
- Configuration as shown in the *Example Application Circuit* found in the [LM63635](#) data sheet.

## 4.1 HTSSOP Package

Figure 4-1 shows the LM63635-Q1 pin diagram for the HTSSOP package. For a detailed description of the device pins, please refer to the *Pin Configuration and Functions* section in the [LM63635](#) data sheet.



**Figure 4-1. Pin Diagram for HTSSOP**

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

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
SW	1,2	Damage to internal power FET(s) and other internal circuits	A
BOOT	3	Damage to internal circuits	A
VCC	4	Fault mode will shut device off	B
RT	5	Depends on exact application configuration. For application circuit as shown in the <i>Example Application Circuit</i> in the device data sheet, no effect will be produced. If an RT resistor is used the frequency will be set to 2.1MHz. If a 0Ω jumper is used to connect the RT input to VCC, then the VCC output will be pulled to ground; see <i>short to ground on pin 4</i> .	B
VSEL	6	Depends on exact application configuration. For an application circuit as shown in the <i>Example Application Circuit</i> in the device data sheet, VCC will be shorted to ground; see <i>short to ground on pin 4</i> . If a VSEL resistor is used, or if the VSEL input is pulled to ground with a 0Ω jumper, then the output voltage will be set to 3.3V, before power-up. No effect after power-up.	B
SYNC/MODE	7	Depends on exact application configuration. For an application circuit as shown in the <i>Example Application Circuit</i> in the device data sheet, no effect will be produced. If a 0Ω jumper is used to connect the SYNC/MODE input to VCC, then the VCC output will be pulled to ground; see <i>short to ground on pin 4</i> .	B
RESET	8	RESET functionality will be lost.	B
FB	9	The regulator will operate at maximum duty cycle. Output voltage will rise to nearly the input voltage (VIN) level. Possible damage to customer load and output stage components may occur. No effect on device.	B
AGND	10	No effect	D
EN	11	Loss of ENABLE functionality Device will remain in shut-down mode.	B
VIN	12,13	Device will not operate. No output voltage will be generated. Output capacitors will discharge through input short. Large reverse current may damage device.	A
N/C	14	No effect	D
PGND	15,16	No effect	D

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

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
SW	1,2	With both pins open, there can be a loss of output voltage. With one pin open, there can be some loss of device performance.	B
BOOT	3	Loss of output voltage regulation; low or no output voltage.	B
VCC	4	VCC LDO will be unstable. Loss of output voltage regulation and possible damage to internal circuits.	A
RT	5	Device switching frequency will drop to zero or become erratic. Loss of output voltage.	B
VSEL	6	Device will enter ADJ mode when EN or VIN is cycled. Incorrect output voltage if fixed VOUT mode was intended. No effect after power-up.	C
SYNC/MODE	7	Internal pull-down will place device in AUTO mode.	B
RESET	8	RESET functionality will be lost.	B
FB	9	Loss of output voltage regulation. Output voltage may rise or fall outside of intended regulation window.	B
AGND	10	Loss of output voltage regulation. Possible damage to internal circuits.	A
EN	11	Loss of ENABLE functionality. Erratic operation; probable loss of regulation.	B
VIN	12,13	With both pins open: loss of output voltage. With one pin open: possible device damage.	A
N/C	14	No effect	D
PGND	15,16	With either one or both pins open, possible device damage.	A

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

Pin Name	Pin No.	Shorted to	Description of Potential Failure Effect(s)	Failure Effect Class
SW	1	SW	No effect	D
SW	2	BOOT	Loss of output regulation, possible damage to internal circuits	A
BOOT	3	VCC	Loss of output regulation, possible damage to internal circuits	A
VCC	4	RT	Depends on exact application configuration. For an application circuit as shown in the <i>Example Application Circuit</i> in the device data sheet, VCC will be shorted to ground; see <i>short to ground on pin 4</i> . For all other configurations, the effect will either be no change or erratic switching frequency with possible damage to device internal circuits.	A
RT	5	VSEL	Depends on exact application configuration. For an application circuit as shown in the <i>Example Application Circuit</i> in the device data sheet, VCC will be shorted to ground; see <i>short to ground on pin 4</i> . For all other configurations, the effect will either be no change or erratic output voltage and switching frequency with possible damage to device internal circuits.	A
VSEL	6	SYNC/MODE	Depends on exact application configuration. For an application circuit as shown in the <i>Example Application Circuit</i> in the device data sheet, VCC will be shorted to ground; see <i>short to ground on pin 4</i> . For all other configurations, the effect will either be no change or erratic operation and switching frequency with possible damage to device internal circuits.	A
SYNC/MODE	7	RESET	Depends on exact application configuration. For an application circuit as shown in the <i>Example Application Circuit</i> in the device data sheet, RESET will be shorted to ground; see <i>short to ground on pin 8</i> . For all other configurations, the effect will either be no change or erratic operation and loss of RESET and/or SYNC/MODE functionality with possible damage to device internal circuits.	A
FB	9	AGND	See <i>short to ground on pin 9</i>	B
AGND	10	EN	See <i>short to ground on pin 11</i>	B
EN	11	VIN	See <i>short to VIN on pin 11</i>	B
VIN	12,13	N/C	No effect	D
N/C	14	PGND	No effect	D

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

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
SW	1,2	Damage to internal power FET(s) and other internal circuits	A
BOOT	3	Damage to internal circuits	A
VCC	4	Damage to internal circuits for VIN >5.5V	A
RT	5	Depends on exact application configuration. For an application circuit as shown in the <i>Example Application Circuit</i> in the device data sheet, no damage will occur. For all other configurations, damage to internal circuits will occur for VIN >5.5V.	A
VSEL	6	Damage to internal circuits for VIN >5.5V	A
SYNC/MODE	7	Depends on exact application configuration. For an application circuit as shown in the <i>Example Application Circuit</i> in the device data sheet, no damage will occur. For all other configurations, damage to internal circuits will occur for VIN >5.5V.	A
RESET	8	Damage to internal circuits.	A
FB	9	Depends on exact application configuration. For an application circuit as shown in the <i>Example Application Circuit</i> in the device data sheet, damage to internal circuits will occur for VIN >16V. For operation in the ADJ mode, damage to internal circuits will occur for VIN >5.5V.	A
AGND	10	Possible damage to internal circuits or package	A
EN	11	No damage to device. Loss of ENABLE functionality.	B
VIN	12,13	No effect.	D
N/C	14	No effect.	D
PGND	15,16	Possible damage to internal circuits or package	A



**Table 4-6. Pin FMA for Device Pins Short-Circuited to Ground**

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
SW	1	Damage to internal power FET(s) and other internal circuits	A
BOOT	2	Damage to internal circuits	A
VCC	3	Fault mode will shut device off	B
RT	4	Depends on exact application configuration. For an application circuit as shown in the <i>Example Application Circuit</i> in the device data sheet, no effect will be produced. If an RT resistor is used the frequency will be set to 2.1MHz. If a 0Ω jumper is used to connect the RT input to VCC, then the VCC output will be pulled to ground; see <i>short to ground on pin 3</i> .	B
VSEL	5	Depends on exact application configuration. For application circuit as shown in the <i>Example Application Circuit</i> in the device data sheet, VCC will be shorted to ground; see <i>short to ground on pin 3</i> . If a VSEL resistor is used, or if the VSEL input is pulled to ground with a 0Ω jumper, then the output voltage will be set to 3.3V, before power-up. No effect after power-up.	B
SYNC/MODE	6	Depends on exact application configuration. For application circuit as shown in the <i>Example Application Circuit</i> in the device data sheet, no effect will be produced. If a 0Ω jumper is used to connect the SYNC/MODE input to VCC, then the VCC output will be pulled to ground; see <i>short to ground on pin 3</i> .	B
RESET	7	RESET functionality will be lost.	B
FB	8	The regulator will operate at maximum duty cycle. Output voltage will rise to nearly the input voltage (VIN) level. Possible damage to customer load and output stage components may occur. No effect on device.	B
AGND	9	No effect	D
EN	10	Loss of ENABLE functionality Device will remain in shutdown mode.	B
VIN	12	Device will not operate. No output voltage will be generated. Output capacitors will discharge through input short. Large reverse current may damage device.	A
N/C	11	No effect	D
PGND	13	No effect	D

**Table 4-7. Pin FMA for Device Pins Open-Circuited**

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
SW	1	With both pins open, there can be a loss of output voltage. With one pin open, there can be some loss of device performance.	B
BOOT	2	Loss of output voltage regulation; low or no output voltage.	B
VCC	3	VCC LDO will be unstable. Loss of output voltage regulation and possible damage to internal circuits.	A
RT	4	Device switching frequency will drop to zero or become erratic. Loss of output voltage.	B
VSEL	5	Device will enter ADJ mode when EN or VIN is cycled. Incorrect output voltage if fixed VOUT mode was intended. No effect after power-up.	C
SYNC/MODE	6	Internal pull-down will place device in AUTO mode.	B
RESET	7	RESET functionality will be lost.	B
FB	8	Loss of output voltage regulation. Output voltage may rise or fall outside of intended regulation window.	B
AGND	9	Loss of output voltage regulation. Possible damage to internal circuits.	A
EN	10	Loss of ENABLE functionality. Erratic operation; probable loss of regulation.	B
VIN	12	With both pins open, there can be a loss of output voltage. With one pin open, there can be possible device damage.	A
N/C	11	No effect	D
PGND	13	With either one or both pins open, there can be possible device damage.	A

**Table 4-8. Pin FMA for Device Pins Short-Circuited to Adjacent Pin**

Pin Name	Pin No.	Shorted to	Description of Potential Failure Effect(s)	Failure Effect Class
SW	1	BOOT	Loss of output regulation, possible damage to internal circuits	A
BOOT	2	VCC	Loss of output regulation, possible damage to internal circuits	A
VCC	3	RT	Depends on exact application configuration. For an application circuit as shown in the <i>Example Application Circuit</i> in the device data sheet, VCC will be shorted to ground; see <i>short to ground on pin 3</i> . For all other configurations, the effect will either be no change or erratic switching frequency with possible damage to device internal circuits.	A
RT	4	VSEL	Depends on exact application configuration. For an application circuit as shown in the <i>Example Application Circuit</i> in the device data sheet, VCC will be shorted to ground; see <i>short to ground on pin 3</i> . For all other configurations, the effect will either be no change or erratic output voltage and switching frequency with possible damage to device internal circuits.	A
VSEL	5	SYNC/MODE	Depends on exact application configuration. For an application circuit as shown in the <i>Example Application Circuit</i> in the device data sheet, VCC will be shorted to ground; see <i>short to ground on pin 3</i> . For all other configurations, the effect will either be no change or erratic operation and switching frequency with possible damage to device internal circuits.	A
RESET	7	FB	Loss of regulation. Output voltage unstable. Possible damage to device.	A
FB	8	AGND	See <i>short to ground on pin 8</i>	B
AGND	9	EN	See <i>short to ground on pin 10</i>	B
EN	10	N/C	No effect	D
N/C	11	VIN	No effect	D

**Table 4-9. Pin FMA for Device Pins Short-Circuited to VIN**

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
SW	1	Damage to internal power FETs and other internal circuits	A
BOOT	2	Damage to internal circuits	A
VCC	3	Damage to internal circuits for VIN > 5.5V	A
RT	4	Depends on exact application configuration. For an application circuit as shown in the <i>Example Application Circuit</i> in the device data sheet, no damage will occur. For all other configurations, damage to internal circuits will occur for VIN > 5.5V.	A
VSEL	5	Damage to internal circuits for VIN > 5.5V	A
SYNC/MODE	6	Depends on exact application configuration. For an application circuit as shown in the <i>Example Application Circuit</i> in the device data sheet, no damage will occur. For all other configurations, damage to internal circuits will occur for VIN > 5.5V.	A
RESET	7	Damage to internal circuits.	A
FB	8	Depends on exact application configuration. For an application circuit as shown in the <i>Example Application Circuit</i> in the device data sheet, damage to internal circuits will occur for VIN > 16V. For operation in the ADJ mode, damage to internal circuits will occur for VIN > 5.5V.	A
AGND	9	Possible damage to internal circuits or package	A
EN	10	No damage to device. Loss of ENABLE functionality.	B
VIN	12	No effect.	D
N/C	11	No effect.	D
PGND	13	Possible damage to internal circuits or package	A

## 5 Revision History

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**Changes from Revision B (October 2020) to Revision C (March 2024)** **Page**

- Updated formatting throughout document..... 2
  - Changed *SW Output* to *No output voltage* ..... 5
  - Changed *SW output not in specification* to *Output not in specification* ..... 5
  - Corrected typo..... 5
- 

**Changes from Revision A (April 2020) to Revision B (October 2020)** **Page**

- Added Component Failure Rates per Siemens Norm SN 29500-2 tables..... 3
- 

**Changes from Revision \* (April 2020) to Revision A (April 2020)** **Page**

- Added pin FMEA information..... 6
-

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