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1 Overview

This document contains information for LMR36015S (VQFN-HR package) 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.

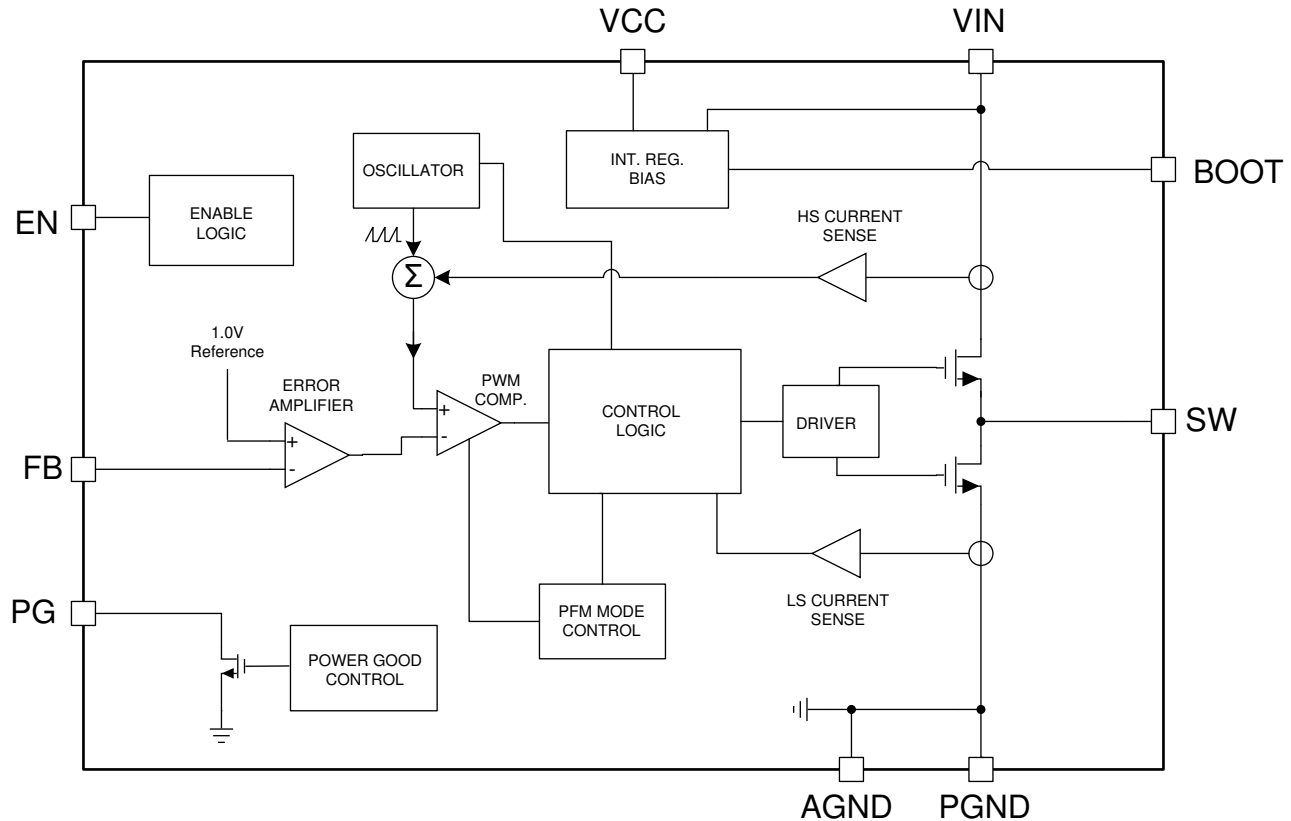


Figure 1-1. Functional Block Diagram

LMR36015S 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

This section provides Functional Safety Failure In Time (FIT) rates for LMR36015S based on two different 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 ⁹ Hours)
Total Component FIT Rate	13
Die FIT Rate	9
Package FIT Rate	4

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: 500 mW
- Climate type: World-wide Table 8
- Package factor (λ_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 _J
5	CMOS, BICMOS Digital, analog / mixed	25 FIT	55°C

The Reference FIT Rate and Reference Virtual T_J (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.

3 Failure Mode Distribution (FMD)

The failure mode distribution estimation for LMR36015S 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 (%)
SW no output	35%
SW output not in specification – voltage or timing	45%
SW driver FET stuck on	10%
PG false trip or fails to trip	5%
Short circuit any two pins	5%

The FMD in [Table 3-1](#) excludes short circuit faults across the isolation barrier. Faults for short circuit across the isolation barrier can be excluded according to ISO 61800-5-2:2016 if the following requirements are fulfilled:

1. The signal isolation component is OVC III according to IEC 61800-5-1. If a SELV/PELV power supply is used, pollution degree 2/OVC II applies. All requirements of IEC 61800-5-1:2007, 4.3.6 apply.
2. Measures are taken to ensure that an internal failure of the signal isolation component cannot result in excessive temperature of its insulating material.

Creepage and clearance requirements should be applied according to the specific equipment isolation standards of an application. Care should be taken to maintain the creepage and clearance distance of a board design to ensure that the mounting pads of the isolator on the printed-circuit board do not reduce this distance.

4 Pin Failure Mode Analysis (Pin FMA)

This section provides a Failure Mode Analysis (FMA) for the pins of the LMR36015S. The failure modes covered in this document include the typical pin-by-pin failure scenarios:

- Pin short-circuited to Ground (see [Table 4-2](#))
- Pin open-circuited (see [Table 4-3](#))
- Pin short-circuited to an adjacent pin (see [Table 4-4](#))
- Pin short-circuited to supply (see [Table 4-5](#))

[Table 4-2](#) through [Table 4-5](#) 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

[Figure 4-1](#) shows the LMR36015S pin diagram. For a detailed description of the device pins please refer to the *Pin Configuration and Functions* section in the LMR36015S data sheet.

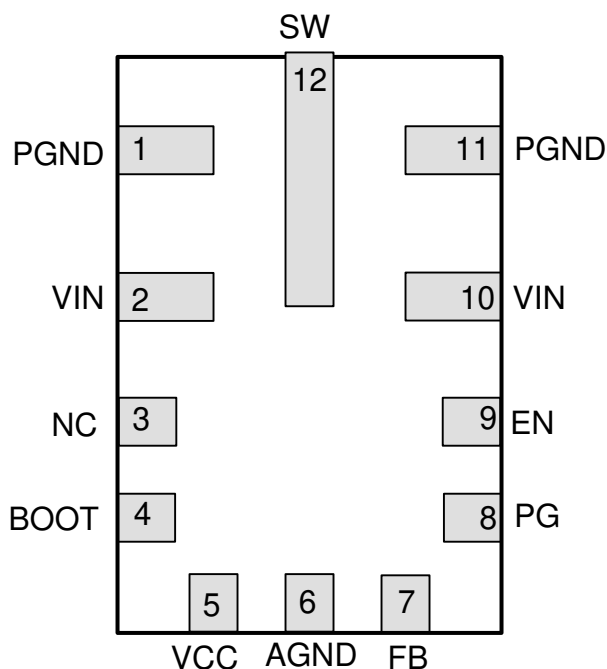


Figure 4-1. Pin Diagram

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

- Application circuit, as per the [LMR36015-Q1 data sheet](#) is used.

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
PGND	1,11	This is the ground pin, no effect.	D
VIN	2,10	No output voltage will be generated. Possible damage to customer input supply, PCB can occur unless customer provides protection, or both. Reverse current from the SW pin to VIN pin, due to discharge of output capacitors, can damage regulator.	B
N/C	3	No connection when it is NOT used for SW to BOOT connection	D
		When used for SW to BOOT connection, as recommended, the effect is the same as for pin SW (12).	A
BOOT	4	Driver supply to high side MOSFET will be lost. Output voltage will not be regulated. Possible damage to internal regulator and Cboot charging circuit.	A
VCC	5	Internal circuits will be disabled. No output voltage will be generated. Possible increase in input current and possible damage to internal LDO.	A
AGND	6	This is the ground pin, no effect.	D
FB	7	The regulator will operate at maximum duty cycle. Output voltage will rise to nearly the input voltage level. Possible damage to customer load, output stage components can occur, or both.	D
PG	8	This is a valid connection for the PG output. PG functionality will be lost. Damage to customer components connected to PG input can occur.	D
EN	9	This is a valid connection for the EN input. Enable functionality will be lost; the device will remain off with no output voltage generated. Damage to customer components connected to EN input can occur.	B
SW	12	Shorting the SW pin to ground will result in large currents through the device and subsequent damage. No output voltage will be produced.	A

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

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
PGND	1,11	Erratic operation; probable loss of regulation. Possible output voltage increase and damage to customer load	B
VIN	2,11	Loss of output voltage	B
N/C	3	No connection when it is NOT used for SW to BOOT connection.	D
		When used for SW to BOOT connection, as recommended, the effect is the same as for pin BOOT (4).	B
BOOT	4	Driver supply to high side MOSFET will be lost. Output voltage will not be regulated. Low or no output voltage; erratic switching behavior	B
VCC	5	Internal LDO may oscillate. VCC voltage will not be stable. Internal circuits will not function correctly. Output voltage may not be regulated.	B
AGND	6	Erratic operation; probable loss of regulation. Possible output voltage increase and damage to customer load	B
FB	7	Device will not regulate. Output voltage can rise or fall. Damage to customer load, output stage components is probable, or both.	B
PG	8	This is a valid connection for the PG output. PG functionality will be lost.	B
EN	9	Loss of enable functionality. Erratic operation; probable loss of regulation	B
SW	12	Loss of output voltage	B

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
PGND	1	VIN	No output voltage will be generated. Possible damage to customer input supply, PCB can occur unless customer provides protection, or both. Reverse current from the SW pin to VIN pin, due to discharge of output capacitors, can damage the regulator.	B
VIN	2	N/C	No connection when NOT used for SW to BOOT connection. When used for SW to BOOT connection, as recommended, the output voltage will rise to the level of VIN. Customer load will be damaged.	D B
N/C	3	BOOT	No connection, when NOT used for SW to BOOT connection. When used for SW to BOOT connection, as recommended, large currents will flow through internal circuits. Possible damage to internal regulator and CBOOT charging circuits. No output voltage will be produced.	D A
BOOT	4	VCC	Damage to VCC regulator, other internal circuits, or both. Output voltage can be affected.	A
VCC	5	AGND	Internal circuits will be disabled. No output voltage will be generated. Possible increase in input current and possible damage to internal LDO	A
AGND	6	FB	The regulator will operate at maximum duty cycle. Output voltage will rise to nearly the input voltage level. Possible damage to customer load, output stage components can occur, or both.	B
FB	7	PG	Erratic operation; probable loss of regulation. Possible output voltage increase and damage to customer load	B
PG	8	EN	Erratic operation; probable loss of regulation. Possible damage to customer circuits connected to these pins	B
EN	9	VIN	This is a valid connection for the EN input. Enable functionality will be lost; the device will remain on. Damage to customer components connected to EN input can occur.	D
VIN	10	PGND	No output voltage will be generated. Possible damage to customer input supply, PCB can occur unless customer provides protection, or both. Reverse current from SW pin to VIN pin, due to discharge of output capacitors, can damage the regulator.	B
PGND	11	SW	Shorting the SW pin to ground will result in large currents through the device and subsequent damage. No output voltage will be produced.	A

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

Pin Name	Pin No.	Description of Potential Failure Effect(s)	Failure Effect Class
PGND	1,11	VOUT = 0 V. Damage to low-side circuitry if PGND >> AGND	A
VIN	2,10	Normal operation	D
N/C	3	Normal operation when NOT used for SW to BOOT connection Damage to LS FET when used for SW to BOOT connection as recommended.	D A
BOOT	4	VOUT = 0 V. CBOOT ESD clamp will run current to destruction.	A
VCC	5	If VIN exceeds 5.5 V, damage will occur.	A
AGND	6	VOUT = 0 V. Damage to other pins referred to GND.	A
FB	7	If VIN exceeds 16 V, damage will occur. VOUT = 0 V.	A
PG	8	PGOOD ESD clamp will run current to destruction	A
EN	9	Normal operation	D
SW	12	Damage to LS FET	A

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