

## TPS63020-Q1 Pin FMEA

---

---

---

Florian Feckl

### ABSTRACT

The TPS63020-Q1 device provides a power-supply solution for products powered by either a two-cell or three-cell alkaline NiCd or NiMH battery, or a one-cell Li-Ion or Li-polymer battery. Output currents can go as high as 3 A while using a single-cell Li-Ion or Li-Polymer Battery, and discharge it down to 2.5 V or lower. The buck-boost converter is based on a fixed frequency, pulse-width-modulation (PWM) controller using synchronous rectification to obtain maximum efficiency. At low load currents, the converter enters *Power Save* mode to maintain high efficiency over a wide load current range. The Power Save mode can be disabled, forcing the converter to operate at a fixed switching frequency. The maximum average current in the switches is limited to a typical value of 4 A. The output voltage is programmable using an external resistor divider, or is fixed internally on the chip. The converter can be disabled to minimize battery drain. During shutdown, the load is disconnected from the battery. The device is packaged in a 14-pin VSON TM package measuring 3 mm × 4 mm (DSJ).

### 1 Pin FMEA

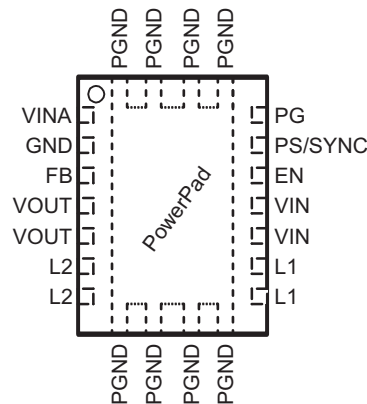
This application note provides a Failure Modes and Effects Analysis (FMEA) for the device pins of the TPS63020-Q1 Buck-Boost Converter. The failure conditions covered in this document include the typical pin-by-pin failure scenarios:

- Pin short-circuited to Ground
- Pin short-circuited to TPS63020-Q1  $V_{IN}$
- Pin short-circuited to TPS63020-Q1  $V_{OUT}$
- Pin short-circuited to an adjacent pin
- Pin is open circuited

This application note also details how these pin conditions affect the device:

- Does the pin condition cause permanent damage?
- Is the device functional under the pin condition?
- How does the particular pin condition affect the device operation?

## 2 TPS63020-Q1 Pin Configurations and Functions



**Figure 1. TPS63020-Q1 DSJ Package Pin-Out (Top View)**

**Table 1. Pin Functions**

Pin		I/O	Description
Number	Name		
1	VINA	I	Supply voltage for control stage
2	GND	–	Control/logic ground
3	FB	I	Voltage feedback of adjustable versions, must be connected to VOUT on fixed output voltage versions
4	VOUT	O	Buck-boost converter output
5	VOUT	O	Buck-boost converter output
6	L2	I	Connection for inductor
7	L2	I	Connection for inductor
8	L1	I	Connection for inductor
9	L1	I	Connection for inductor
10	VIN	I	Supply voltage for power stage
11	VIN	I	Supply voltage for power stage
12	EN	I	Enable input (1 enabled, 0 disabled) , must not be left open
13	PS/SYNC	I	Enable/disable power save mode (1 disabled, 0 enabled, clock signal for synchronization), must not be left open
14	PG	O	Output power good (1 good, 0 failure; open drain)
PowerPAD™	PGND	-	Power ground
	PowerPAD	-	Must be connected to PGND. Must be soldered to achieve appropriate power dissipation.

### 3 FMEA Analysis

**Table 2. Pin FMEA Analysis for Pin Short Circuit to Ground**

Pin		Short to GND		
Number	Name	Damage	Functional	Comments
1	VINA	NO	NO	Device shuts down; leakage current from VIN to VINA
2	GND	NO	YES	No effect
3	FB	NO	NO	Device cannot regulate to the target voltage
4	VOUT	NO	NO	Device operates in current limit
5	VOUT	NO	NO	Device operates in current limit
6	L2	NO	NO	Significant failure currents present, can affect long-term reliability
7	L2	NO	NO	Significant failure currents present, can affect long-term reliability
8	L1	NO	NO	Significant failure currents present, can affect long-term reliability
9	L1	NO	NO	Significant failure currents present, can affect long-term reliability
10	VIN	NO	NO	Device will shut down; if VINA is connected to additional power source, leakage current from VINA to VIN
11	VIN	NO	NO	Device will shut down; if VINA is connected to additional power source, leakage current from VINA to VIN
12	EN	NO	NO	Device is shutdown
13	PS/SYNC	NO	YES	Power Safe Mode enabled
14	PG	NO	YES	No Power Good indication
PowerPAD	PGND	NO	YES	No effect
	PowerPAD	NO	YES	No effect

**Table 3. Pin FMEA Analysis for Pin Short Circuit to  $V_{IN}$** 

Pin		Short to $V_{IN}$		
Number	Name	Damage	Functional	Comments
1	VINA	NO	YES	No effect
2	GND	YES	NO	High current from GND to PGND
3	FB	NO	NO	Device cannot regulate to the target voltage
4	VOUT	NO	NO	Depending on PS/SYNC and VOUT setting, the device operates in current limit or remains idle
5	VOUT	NO	NO	Depending on PS/SYNC and VOUT setting, the device operates in current limit or remains idle
6	L2	NO	NO	Significant failure currents present, can affect long-term reliability
7	L2	NO	NO	Significant failure currents present, can affect long-term reliability
8	L1	NO	NO	Significant failure currents present, can affect long-term reliability
9	L1	NO	NO	Significant failure currents present, can affect long-term reliability
10	VIN	NO	YES	No effect
11	VIN	NO	YES	No effect
12	EN	NO	YES	Device is enabled
13	PS/SYNC	NO	YES	Device operates in FPWM
14	PG	NO	YES	No Power Good indicator; leakage current from PG to GND when PG = low
PowerPAD	PGND	YES	NO	High current from PGND to GND
	PowerPAD	YES	NO	High current from PGND to GND

**Table 4. Pin FMEA Analysis for Pin Short Circuit to  $V_{OUT}$** 

Pin		Short to $V_{OUT}$		
Number	Name	Damage	Functional	Comments
1	VINA	NO	NO	Device cannot regulate to the target voltage
2	GND	NO	NO	Significant failure currents present, can affect long-term reliability
3	FB	NO	NO	Device cannot regulate to the target voltage
4	VOUT	NO	YES	No effect
5	VOUT	NO	YES	No effect
6	L2	NO	NO	Significant failure currents present, can affect long-term reliability
7	L2	NO	NO	Significant failure currents present, can affect long-term reliability
8	L1	NO	NO	Significant failure currents present, can affect long-term reliability
9	L1	NO	NO	Significant failure currents present, can affect long-term reliability
10	VIN	NO	YES	Depending on PS/SYNC and VOUT setting, the device operates in current limit or remains idle
11	VIN	NO	YES	Depending on PS/SYNC and VOUT setting, the device operates in current limit or remains idle
12	EN	NO	NO	Device will remain enabled. Device cannot be started.
13	PS/SYNC	NO	YES	Power Safe Mode disabled
14	PG	NO	YES	No Power Good indicator; leakage current from PG to GND when PG = low
PowerPAD	PGND	NO	YES	Device operates in current limit
	PowerPAD	NO	YES	Device operates in current limit

**Table 5. Pin FMEA Analysis for Pin Short Circuit to an Adjacent Pin**

Pin		Short to Adjacent Pin		
Number	Name	Damage	Functional	Comments
1	VINA	NO	NO	Device shuts down, leakage current from VINA to GND/PGND
2	GND	NO	NO	Device shuts down, leakage current from VINA to GND/PGND, no regulated output voltage
3	FB	NO	NO	Device cannot regulate to the target voltage
4	VOOUT	NO	NO	Device cannot regulate to the target voltage once connected to FB. No effect once shorted to pin 5.
5	VOOUT	NO	NO	No effect once shorted to pin 4. Once shorted to pin 6, significant failure currents present - can affect long-term reliability.
6	L2	NO	NO	No effect once shorted to pin 7. Once shorted to pin 5, significant failure currents present - can affect long-term reliability.
7	L2	NO	NO	No effect once shorted to pin 6. Not operational once shorted to pin 8.
8	L1	NO	NO	No effect once shorted to pin 9. Not operational once shorted to pin 7.
9	L1	NO	NO	No effect once shorted to pin 8. Once shorted to pin 10, significant failure currents present - can affect long-term reliability.
10	VIN	NO	NO	No effect once shorted to pin 11. Once shorted to pin 9, significant failure currents present - can affect long-term reliability.
11	VIN	NO	YES	No effect once shorted to pin 10. Device is always enabled by short to pin 12.
12	EN	NO	YES	Device is always enabled by short to pin 12. Device enable/disable follows signal at pin 13.
13	PS/SYNC	NO	YES	Power Safe Mode enable/disable follows signals present at adjacent pins
14	PG	NO	YES	No Power Good indication. Potential leakage current when Power Good = Low.
PowerPAD	PGND	NO	NO	See <a href="#">Table 2</a> as PowerPAD is adjacent to every pin
	PowerPAD	NO	NO	See <a href="#">Table 2</a> as PowerPAD is adjacent to every pin

**Table 6. Pin FMEA Analysis for Pin Open Circuit**

Pin		Pin Open		
Number	Name	Damage	Functional	Comments
1	VINA	NO	YES	Device suffers in noise performance
2	GND	NO	YES	Bad DC regulation and noise performance
3	FB	NO	NO	No VOUT regulation possible
4	VOUT	NO	YES	No effect, 2nd connection present
5	VOUT	NO	YES	No effect, 2nd connection present
6	L2	NO	YES	No effect, 2nd connection present
7	L2	NO	YES	No effect, 2nd connection present
8	L1	NO	YES	No effect, 2nd connection present
9	L1	NO	YES	No effect, 2nd connection present
10	VIN	NO	YES	No effect, 2nd connection present
11	VIN	NO	YES	No effect, 2nd connection present
12	EN	NO	NO	Device enable cannot be controlled
13	PS/SYNC	NO	YES	PFM/PWM cannot be controlled
14	PG	NO	YES	No PG indication
PowerPAD	PGND	NO	NO	Device not functional as no GND present
	PowerPAD	NO	NO	Device not functional as no GND present

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

### Products

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Applications Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

### Applications

Automotive and Transportation	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

### TI E2E Community

[e2e.ti.com](http://e2e.ti.com)