Application Report
SLVA736–October 2015

TPS63020-Q1 Pin FMEA

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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?

PowerPAD is a trademark of Texas Instruments.

2 TPS63020-Q1 Pin Configurations and Functions

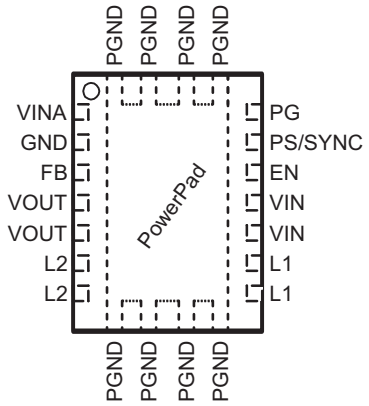

Figure 1. TPS63020-Q1 DSJ Package Pin-Out (Top View)

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	VOUT	NO	NO	Device cannot regulate to the target voltage once connected to FB. No effect once shorted to pin 5.
5	VOUT	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 Table 2 as PowerPAD is adjacent to every pin
	PowerPAD	NO	NO	See Table 2 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

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