Application Report
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TPS630250 Pin FMEA

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ABSTRACT

The TPS630250 is a high efficiency, low quiescent current buck-boost converter suitable for applications where the input voltage is higher or lower than the output. Output currents can go as high as 2 A in boost mode and as high as 4 A in buck mode. The maximum average current in the switches is limited to a typical value of 4 A. The TPS630250 regulates the output voltage over the complete input voltage range by automatically switching between buck or boost mode, depending on the input voltage ensuring a seamless transition between modes. The buck-boost converter is based on a fixed frequency, pulse-width-modulation (PWM) controller using synchronous rectification to obtain highest efficiency. At low load currents, the converter enters *Power Save Mode* to maintain high efficiency over the complete load current range. There is a PFM/PWM pin allowing the choice between automatic PFM/PWM mode operation and forced PWM operation. During PWM mode, a fixed-frequency of typically 2.5 MHz is used. 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 20-pin WCSP package measuring 1.766 mm x 2.086 mm and a 14-pin HotRod package measuring 2.5 mm x 3 mm.

1 Pin FMEA

This application note provides a *Failure Modes and Effects Analysis* (FMEA) for the device pins of the *TPS630250 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 TPS630250 V_{IN}
- Pin short-circuited to TPS630250 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 TPS630250 Pin Configurations and Functions

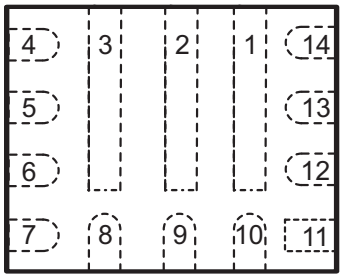

Figure 1. TPS630250 VQFN 14-pin RNC Package Pin-Out (Top View)

Pin Functions

Pin		I/O	Description
Name	RNC		
VOUT	12, 13, 14	PWR	Buck-boost converter output
FB	11	IN	Voltage feedback of adjustable version, must be connected to VOUT on fixed output voltage versions
L2	1	PWR	Connection for inductor
PFM/PWM	10	IN	Set low for PFM mode, set high for forced PWM mode. It must not be left floating
PGND	2	PWR	Power Ground
GND	9	PWR	Analog Ground
L1	3	PWR	Connection for inductor
EN	8	IN	Enable input. Set high to enable and low to disable. It must not be left floating.
VIN	4, 5, 6	PWR	Supply voltage for power stage
VINA	7	PWR	Supply voltage for control stage

3 FMEA Analysis

Table 1. Pin FMEA Analysis for Pin Short Circuit to Ground

Pin		Short to GND		
Number	Name	Damage	Functional	Comments
1	L2	NO	NO	Output voltage goes down to 0 V; high current consumption can affect long-term reliability
2	PGND	NO	YES	No effect
3	L1	YES	NO	Significant failure currents present
4	VIN	NO	YES	Device shuts down (UVLO) - equivalent to battery short
5	VIN	NO	YES	Device shuts down (UVLO) - equivalent to battery short
6	VIN	NO	YES	Device shuts down (UVLO) - equivalent to battery short
7	VINA	NO	NO	Device shuts down (UVLO) - equivalent to battery short - if VINA has an external power supply the device shuts down
8	EN	NO	NO	Device is disabled
9	GND	NO	YES	No effect
10	PFM/PWM	NO	NO	Device operates in PFM mode
11	FB	NO	YES	Device cannot regulate to the target voltage
12	VOUT	NO	NO	Short-circuit protection is triggered
13	VOUT	NO	NO	Short-circuit protection is triggered
14	VOUT	NO	NO	Short-circuit protection is triggered

Table 2. Pin FMEA Analysis for Pin Short Circuit to V_{IN}

Pin		Short to VIN		
Number	Name	Damage	Functional	Comments
1	L2	YES	NO	Significant failure currents present
2	PGND	NO	YES	Device shuts down (UVLO) - equivalent to battery short
3	L1	YES	NO	Current sensor shorted, no current regulation possible
4	VIN	NO	YES	No effect
5	VIN	NO	YES	No effect
6	VIN	NO	YES	No effect
7	VINA	NO	NO	No effect
8	EN	NO	NO	Device always enabled
9	GND	NO	YES	Device shuts down (UVLO) - equivalent to battery short
10	PFM/PWM	NO	NO	Device operates in PWM mode
11	FB	NO	YES	Device cannot regulate to the targeted voltage
12	VOUT	NO	NO	Depending on PFM/PWM, VIN and VOUT settings, the device operates in current limit or remains idle or keeps switching with no VOUT regulation
13	VOUT	NO	NO	Depending on PFM/PWM, VIN and VOUT settings, the device operates in current limit or remains idle or keeps switching with no VOUT regulation
14	VOUT	NO	NO	Depending on PFM/PWM, VIN and VOUT settings, the device operates in current limit or remains idle or keeps switching with no VOUT regulation

Table 3. Pin FMEA Analysis for Pin Short Circuit to V_{OUT}

Pin		Short to VOUT		
Number	Name	Damage	Functional	Comments
1	L2	NO	YES/NO	Significant failure currents present can affect long-term reliability; regulates in buck PWM mode
2	PGND	NO	NO	Short-circuit protection is triggered
3	L1	NO	NO	Significant failure currents present can affect long-term reliability
4	VIN	NO	NO	Depending on PFM/PWM, VIN and VOUT settings, the device operates in current limit or remains idle or keeps switching with no VOUT regulation
5	VIN	NO	NO	Depending on PFM/PWM, VIN and VOUT settings, the device operates in current limit or remains idle or keeps switching with no VOUT regulation
6	VIN	NO	NO	Depending on PFM/PWM, VIN and VOUT settings, the device operates in current limit or remains idle or keeps switching with no VOUT regulation
7	VINA	NO	NO	Depending on PFM/PWM, VIN and VOUT settings, the device operates in current limit or remains idle or keeps switching with no VOUT regulation
8	EN	NO	NO	Device cannot be started
9	GND	NO	NO	Short-circuit protection is triggered
10	PFM/PWM	NO	YES	Device operates in PWM mode
11	FB	NO	NO	Device cannot regulate to targeted voltage
12	VOUT	NO	NO	No effect
13	VOUT	NO	NO	No effect
14	VOUT	NO	NO	No effect

Table 4. Pin FMEA Analysis for Pin Short Circuit to an Adjacent Pin

Pin		Adjacent Pin		Short to Adjacent		
Number	Name			Damage	Functional	Comments
1	L2	2	PGND	NO	NO	Output voltage goes down to 0 V; high current consumption can affect long-term reliability
		12/13/14	VOUT	NO	Yes/NO	Significant failure currents present can affect long-term reliability; regulates in buck PWM mode
		10	PFM/PWM	NO	YES	Device operates in PWM mode
2	PGND	1	L2	NO	NO	Output voltage goes down to 0 V; high current consumption can affect long-term reliability
		3	L1	YES	NO	Significant failure currents present
		9	GND	NO	YES	No effect
3	L1	2	PGND	YES	NO	Significant failure currents present
		4/5/6	VIN	YES	NO	Current sensor shorted, no current regulation possible
		8	EN	NO	NO	Device cannot start
4	VIN	3	L1	YES	NO	Current sensor shorted, no current regulation possible
		5	VIN	NO	YES	No effect
5	VIN	4/6	VIN	NO	YES	No effect
		3	L1	YES	NO	Current sensor shorted, no current regulation possible
6	VIN	5	VIN	NO	YES	No effect
		7	VINA	NO	YES	No effect
		3	L1	YES	NO	Current sensor shorted, no current regulation possible
7	VINA	6	VIN	NO	NO	No effect
		8	EN	NO	YES	Device is enabled
8	EN	3	L1	NO	NO	Device cannot start
		7	VINA	NO	YES	Device is enabled
		9	GND	NO	NO	Device is disabled
9	GND	2	PGND	NO	YES	No effect
		8	EN	NO	NO	Device is disabled
		10	PFM/PWM	NO	Yes	Device operates in PFM mode
10	PFM/PWM	1	L2	NO	NO	Buck: operates in PWM mode; Boost: changes between PFM and PWM mode
		9	GND	NO	Yes	Device operates in PFM mode
		11	FB	YES	YES	Operates in PWM mode
11	FB	10	PFM/PWM	YES	YES	Operates in PWM mode
		12	VOUT	NO	NO	Device cannot regulate to targeted voltage
12	VOUT	1	L2	NO	Yes/NO	Significant failure currents present can affect long-term reliability; regulates in buck PWM mode
		11	FB	NO	NO	Device cannot regulate to targeted voltage
		13	VOUT	NO	YES	No effect
13	VOUT	1	L2	NO	Yes/NO	Significant failure currents present can affect long-term reliability; regulates in buck PWM mode
		12/14	VOUT	NO	YES	No effect
14	VOUT	1	L2	NO	Yes/NO	Significant failure currents present can affect long-term reliability; regulates in buck PWM mode
		13	VOUT	NO	YES	No effect

Table 5. Pin FMEA Analysis for Pin Open Circuit

Pin		Open Circuit		
Number	Name	Damage	Functional	Comments
1	L2	NO	NO	Open circuit, device not switching
2	PGND	NO	YES	Device is not functional as no PGND is present
3	L1	NO	NO	Open circuit, device not switching
4	VIN	NO	YES	No effect second connection present
5	VIN	NO	YES	No effect second connection present
6	VIN	NO	YES	No effect second connection present
7	VINA	NO	YES	Device suffers in noise performances
8	EN	NO	NO	Device enable cannot be controlled
9	GND	NO	NO	No VOUT regulation possible
10	PFM/PWM	NO	YES	PFM/PWM cannot be controlled
11	FB	NO	NO	No VOUT regulation possible, can affect long-term reliability
12	VOUT	NO	YES	No effect second connection present
13	VOUT	NO	YES	No effect second connection present
14	VOUT	NO	YES	No effect second connection present

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