TPS630250 Pin FMEA

Sabrina Ramalingam

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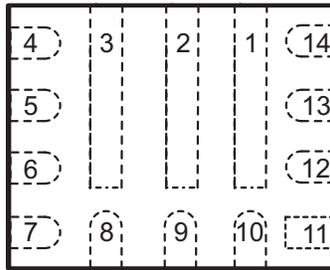
Figure 1. TPS630250 VQFN 14-pin RNC Package Pin-Out (Top View)

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

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		Applications	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		