Application Report
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TPS54372-Q1 Pin Open and Short Test Results

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ABSTRACT

As a member of the SWIFT™ family of DC/DC regulators, the TPS54372-Q1 is an automotive-qualified, low-input voltage, high-output current, synchronous-buck PWM converter integrating all required active components. Included on the substrate with the listed features is a true, high-performance, voltage-error amplifier enabling maximum performance under transient conditions and flexibility in choosing the output filter L and C components. The part is also equipped with an undervoltage lock out circuit to prevent start-up until the input voltage reaches 3 V, an internally and externally set slow-start circuit to limit in-rush current, and a status output to indicate valid operating conditions.

The TPS54372-Q1 is available in a thermally enhanced 20-pin TSSOP (PWP) PowerPAD™ package, which eliminates bulky heat sinks. Texas Instruments provides evaluation modules and the SWIFT designer software tool to aid in quickly achieving high-performance power supply designs to meet aggressive equipment development cycles.

Test Results

This application note provides test results for the device pins of the TPS54372-Q1 output tracking and termination synchronous PWM switcher. The failure conditions covered in this document include typical failure scenarios, such as short-circuit to GND, short-circuit to supply, short-circuit to a neighboring pin, or if the pin is left open. It also details how these conditions affect the device. The first effect considered is whether the condition damages the pin in question, or the device itself. The second effect considered is whether the device is functional under the condition. Lastly, the analysis includes a comments section that discusses how the particular condition affects the device operation.

NOTE: Values in green indicate normal device operation. Values in red indicate damage to the device.

Table 1. Analysis for Pin Short-Circuit to GND

Pin		Short to GND		
Number	**Name**	**Damage**	**Functionality**	**Comments**
1	AGND	NO	YES	Appropriate connection. **Normal operation**
2	VSENSE	YES	NO	Device is at maximum duty cycle, so it goes into overcurrent mode. **Unregulated output and potential damage to load.**
3	COMP	YES	NO	**No switching and output voltage is 0 V. Also, possible violation of absolute maximum rating for source current on COMP pin.**
4	STATUS	NO	YES	**Information carried by STATUS signal is lost**
5	BOOT	YES	NO	Boot capacitor cannot charge. **Possible damage to BOOT pin**
6	PH	YES	NO	Output is at 0 V. **No operation**
7	PH	YES	NO	Output is at 0 V. **No operation**
8	PH	YES	NO	Output is at 0 V. **No operation**
9	PH	YES	NO	Output is at 0 V. **No operation**
10	PH	YES	NO	Output is at 0 V. **No operation**
11	PGND	NO	YES	Appropriate connection. **Normal operation**
12	PGND	NO	YES	Appropriate connection. **Normal operation**
13	PGND	NO	YES	Appropriate connection. **Normal operation**
14	VIN	YES	NO	**Supply shorted to GND**
15	VIN	YES	NO	**Supply shorted to GND**
16	VIN	YES	NO	**Supply shorted to GND**
17	VBIAS	YES	NO	Internal supply rail shorted to GND. **No output. Violation of absolute maximum rating for source current from V_{BIAS} pin.**
18	REFIN	NO	NO	Output voltage is at 0 V. **No operation**
19	ENA	NO	NO	Device is always disabled. **No output**
20	RT	NO	NO	Device does not switch. **No output**

Table 2. Analysis for Pin Left Open

Pin		Open		
Number	Name	Damage	Functionality	Comments
1	AGND	NO	NO	AGND and PGND are not connected internally. **The device does not operate.**
2	VSENSE	NO	NO	Device is in open loop and there is a great potential for instability. **Unstable operation**
3	COMP	NO	NO	Output becomes unstable because E/A is operating at open loop gain. **Unstable operation**
4	STATUS	NO	YES	**Loss of transmission of STATUS signal**
5	BOOT	NO	NO	Boot capacitor cannot charge. **No output**
6	PH	NO	YES	The other same function pins takes care of it. It might degrade efficiency. **Normal operation**
7	PH	NO	YES	The other same function pins takes care of it. It might degrade efficiency. **Normal operation**
8	PH	NO	YES	The other same function pins takes care of it. It might degrade efficiency. **Normal operation**
9	PH	NO	YES	The other same function pins takes care of it. It might degrade efficiency. **Normal operation**
10	PH	NO	YES	The other same function pins takes care of it. It might degrade efficiency. **Normal operation**
11	PGND	NO	YES	Other PGND connections should be sufficient. **Normal operation may occur** (may have noisy switching waveform).
12	PGND	NO	YES	Other PGND connections should be sufficient. **Normal operation may occur** (may have noisy switching waveform).
13	PGND	NO	YES	Other PGND connections should be sufficient. **Normal operation may occur** (may have noisy switching waveform).
14	VIN	NO	YES	The other V_{IN} pins should be sufficient although efficiency might be degraded. **Normal operation**
15	VIN	NO	YES	The other V_{IN} pins should be sufficient although efficiency might be degraded. **Normal operation**
16	VIN	NO	YES	The other V_{IN} pins should be sufficient although efficiency might be degraded. **Normal operation**
17	VBIAS	NO	NO	V_{BIAS} output may be unstable causing internal control circuitry to not work properly. **Unregulated output**
18	REFIN	NO	YES	Internal bandgap reference is used. **Normal operation**
19	ENA	NO	NO	**Device is in off state.**
20	RT	NO	YES	Device switches at the internally programmed frequency of 350 kHz typical. **Normal operation**

Table 3. Analysis for Pin Short-Circuit to Supply Voltage

Pin		Short to Supply		
Number	Name	Damage	Functionality	Comments
1	AGND	YES	NO	**Supply shorted to GND**
2	VSENSE	YES	NO	V_{SENSE} voltage may exceed the absolute maximum rating. **Potential Damage to V_{SENSE} pin.** Also, no switching because E/A output is low. **No device operation**
3	COMP	YES	NO	Device is at maximum duty cycle, so it goes into overcurrent mode. **Unregulated output and potential damage to load. Also, in violation of absolute maximum rating for sink current on the COMP pin.**
4	STATUS	YES	NO	STATUS signal is low at power up, so there is potential for damage. **Supply shorted to GND**
5	BOOT	NO	NO	BOOT level is around 2 × V_{IN} in normal operation. **BOOT cap cannot charge and no output.**
6	PH	YES	NO	**Violation of absolute maximum rating of PH pin if supply voltage > 6 V. Possible damage to lower transistor.**
7	PH	YES	NO	**Violation of absolute maximum rating of PH pin if supply voltage > 6 V. Possible damage to lower transistor.**
8	PH	YES	NO	**Violation of absolute maximum rating of PH pin if supply voltage > 6 V. Possible damage to lower transistor.**
9	PH	YES	NO	**Violation of absolute maximum rating of PH pin if supply voltage > 6 V. Possible damage to lower transistor.**
10	PH	YES	NO	**Violation of absolute maximum rating of PH pin if supply voltage > 6 V. Possible damage to lower transistor.**
11	PGND	YES	NO	**Supply shorted to GND**
12	PGND	YES	NO	**Supply shorted to GND**
13	PGND	YES	NO	**Supply shorted to GND**
14	VIN	NO	YES	Appropriate connection. **Normal operation**
15	VIN	NO	YES	Appropriate connection. **Normal operation**
16	VIN	NO	YES	Appropriate connection. **Normal operation**
17	VBIAS	NO	NO	V_{BIAS} supplies the internal circuitry and internal functions. Shorting it to the supply causes the device to not function properly. **Improper operation**
18	REFIN	YES	NO	**Potential damage to REFIN pin if supply voltage > 4 V.**
19	ENA	NO	YES	Device is always enabled when V_{supply} > 3 V typical. **Normal operation**
20	RT	YES	NO	V_{supply} voltage at RT pin causes incorrect switching frequency or no switching depending on the supply voltage. **Incorrect switching frequency or no switching. Violation of absolute maximum rating of RT pin if supply voltage > 6 V.**

Table 4. Analysis for Pin Short-Circuit to Neighboring Pin

Pin		Short to Neighboring Pin		
Number	Name	Damage	Functionality	Comments
1	AGND	YES	NO	(1 – 2) Device is at maximum duty cycle, so it goes into overcurrent mode. **Unregulated output and potential damage to load.**
2	VSENSE	NO	NO	(2 – 3) Error amplifier output connected to V_{SENSE} causes the output to become unregulated. **Unregulated output**
3	COMP	NO	NO	(3 – 4) STATUS signal is low at power-up so COMP is driven low and stays low. **No switching and output voltage is 0 V.**
4	STATUS	NO	NO	(4 – 5) STATUS signal is low at power up so BOOT is driven low and stays low. **No switching and output voltage is 0 V.**
5	BOOT	NO	NO	(5 – 6) Boot capacitor cannot charge. **No output**
6	PH	NO	YES	(6 – 7) They are the same pins internally tied together. **Normal operation**
7	PH	NO	YES	(7 – 8) They are the same pins internally tied together. **Normal operation**
8	PH	NO	YES	(8 – 9) They are the same pins internally tied together. **Normal operation**
9	PH	NO	YES	(9 – 10) They are the same pins internally tied together. **Normal operation**
10	PH	N/A	N/A	(10 – 11) N/A
11	PGND	NO	YES	(11 – 12) They are the same pins internally tied together. **Normal operation**
12	PGND	NO	YES	(12 – 13) They are the same pins internally tied together. **Normal operation**
13	PGND	YES	NO	(13 – 14) **Supply shorted to GND**
14	VIN	NO	YES	(14 – 15) They are the same pins internally tied together. **Normal operation**
15	VIN	NO	YES	(14 – 15) They are the same pins internally tied together. **Normal operation**
16	VIN	NO	NO	(16 – 17) V_{BIAS} supplies the internal circuitry and internal functions. Shorting it to V_{IN} causes the device to not function properly. **Improper operation**
17	VBIAS	NO	NO	(17 – 18) **Output voltage is forced to internal bandgap reference voltage.**
18	REFIN	No	NO	(18 – 19) **Output voltage is forced to externally-provided ENA level if ENA < 1.75 V. If ENA > 1.75 V, then output is forced to internal bandgap reference voltage.**
19	ENA	NO	NO	(19 – 20) ENA voltage at RT pin causes incorrect switching frequency or no switching depending on the ENA voltage. **Incorrect switching frequency or no switching.**
20	RT	N/A	N/A	(20 – 1) N/A

Revision History

Changes from Original (April 2013) to A Revision	Page
• Changed document title and Pin FMEA to test results throughout document	1
• Deleted Pin FMEA from table titles	2

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- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
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