

# TPS53355 Step-Down Converter Evaluation Module User's Guide



## ABSTRACT

The TPS53355EVM-743 evaluation module (EVM) allows users to evaluate the TPS53355. The TPS53355 is a D-CAP™ mode, 30-A synchronous buck converter with integrated MOSFETs. It provides a fixed 1.5-V output at up to 30 A from a 12-V input bus.

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### Trademarks

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## 1 Description

The TPS53355EVM-743 is designed to use a regulated 12-V bus to produce a regulated 1.5-V output at up to 30 A of load current. The TPS53355EVM-743 is designed to demonstrate the TPS53355 in a typical, low-voltage application while providing a number of test points to evaluate the performance of the TPS53355.

### 1.1 Typical Applications

- Server/storage
- Workstations and desktops
- Telecommunication infrastructure

### 1.2 Features

The TPS53355EVM-743 features:

- 30-A<sub>DC</sub>, steady-state output current
- Supports prebias output voltage start-up
- J5 for selectable switching frequency setting
- J4 for selectable soft-start time
- J2 for enable function
- J6 for auto-skip and forced CCM selection
- Convenient test points for probing critical waveforms

## 2 Electrical Performance Specifications

**Table 2-1. TPS53355EVM-743 Electrical Performance Specifications**

| Parameters                     | Test Conditions  | Min | Typ   | Max | Units |
|--------------------------------|--|-----|-------|-----|-------|
| <b>Input Characteristics</b>   |  |     |       |     |       |
| Voltage range                  | $V_{IN}$   | 8   | 12    | 14  | V     |
| Maximum input current          | $V_{IN} = 8\text{ V}, I_O = 30\text{ A}$                                   |     | 6.3   |     | A     |
| No load input current          | $V_{IN} = 14\text{ V}, I_O = 0\text{ A}$ with auto-skip mode               |     | 1     |     | mA    |
| <b>Output Characteristics</b>  |  |     |       |     |       |
| Output voltage $V_{OUT}$       |  |     | 1.5   |     | V     |
| Output voltage regulation      | Line regulation ( $V_{IN} = 8\text{ V} - 14\text{ V}$ )                    |     | 0.1   |     | %     |
|                                | Load regulation ( $V_{IN} = 12\text{ V}, I_O = 0\text{ A} - 30\text{ A}$ ) |     | 1     |     | %     |
| Output voltage ripple          | $V_{IN} = 12\text{ V}, I_O = 30\text{ A}$                                  |     | 20    |     | mVpp  |
| Output load current            |  | 0   |       | 30  | A     |
| Output overcurrent             |  |     | 34    |     | A     |
| <b>Systems Characteristics</b> |  |     |       |     |       |
| Switching frequency            |  |     | 500   |     | kHz   |
| Peak efficiency                | $V_{IN} = 12\text{ V}, 1.5\text{ V}/10\text{ A}$                           |     | 91.87 |     | %     |
| Ful-load efficiency            | $V_{IN} = 12\text{ V}, 1.5\text{ V}/30\text{ A}$                           |     | 89.46 |     | %     |
| Operating temperature          |  |     | 25    |     | °C    |

### Note

Jumpers are set to default locations; see [Section 5](#) of this user's guide.

### 3 Schematic

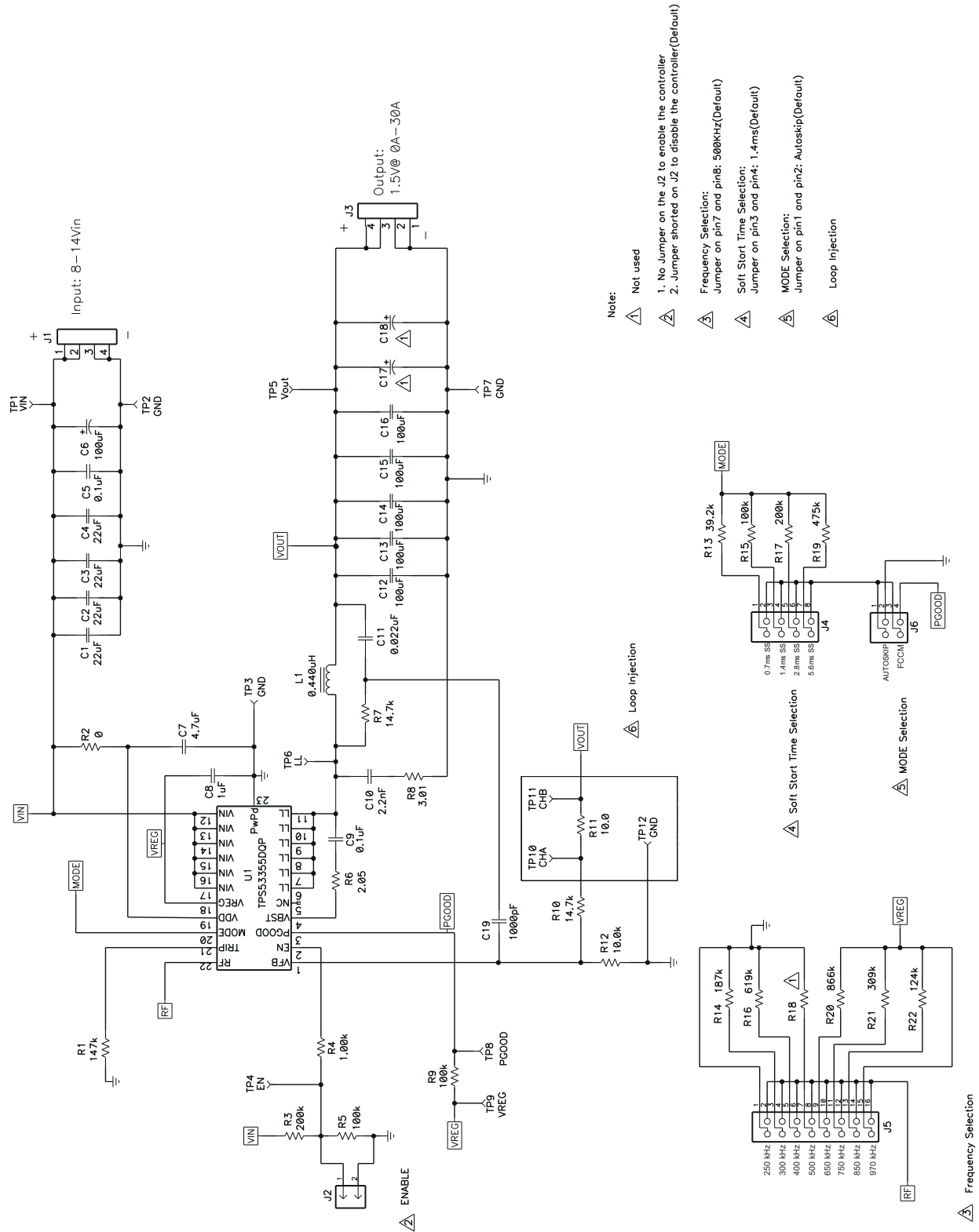


Figure 3-1. TPS53355EVM-743 Schematic

## 4 Test Setup

### 4.1 Test Equipment

**Voltage Source:** The input voltage source  $V_{IN}$  must be a 0-V to 14-V variable DC source capable of supplying 10 A<sub>DC</sub>. Connect  $V_{IN}$  to J1 as shown in [Figure 4-2](#).

Multimeters:

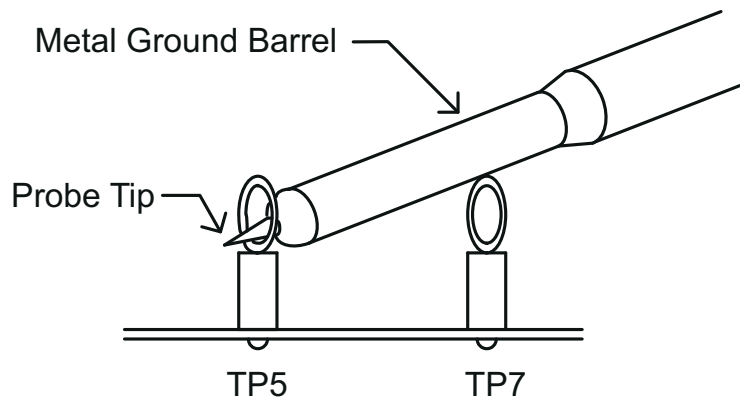
- V1:  $V_{IN}$  at TP1 ( $V_{IN}$ ) and TP2 (GND).
- V2:  $V_{OUT}$  at TP5 ( $V_{OUT}$ ) and TP7 (GND).
- A1:  $V_{IN}$  input current

**Output Load:** The output load must be an electronic constant resistance mode load capable of 0 Adc to 30 Adc at 1.5 V.

**Oscilloscope:** A digital or analog oscilloscope can be used to measure the output ripple. The oscilloscope must be set for the following:

- 1-M $\Omega$  impedance
- 20-MHz bandwidth
- AC coupling
- 2- $\mu$ s/division horizontal resolution
- 50-mV/division vertical resolution

Test points TP5 and TP7 can be used to measure the output ripple voltage by placing the oscilloscope probe tip through TP5 and holding the ground barrel on TP7 as shown in [Figure 4-1](#). Using a leaded ground connection may induce additional noise due to the large ground loop.



**Figure 4-1. Tip and Barrel Measurement for V<sub>OUT</sub> Ripple**

**Fan:** Some of the components in this EVM can approach temperatures of 60°C during operation. A small fan capable of 200–400 LFM is recommended to reduce component temperatures while the EVM is operating. Only probe the EVM when the fan is running.

#### Recommended Wire Gauge:

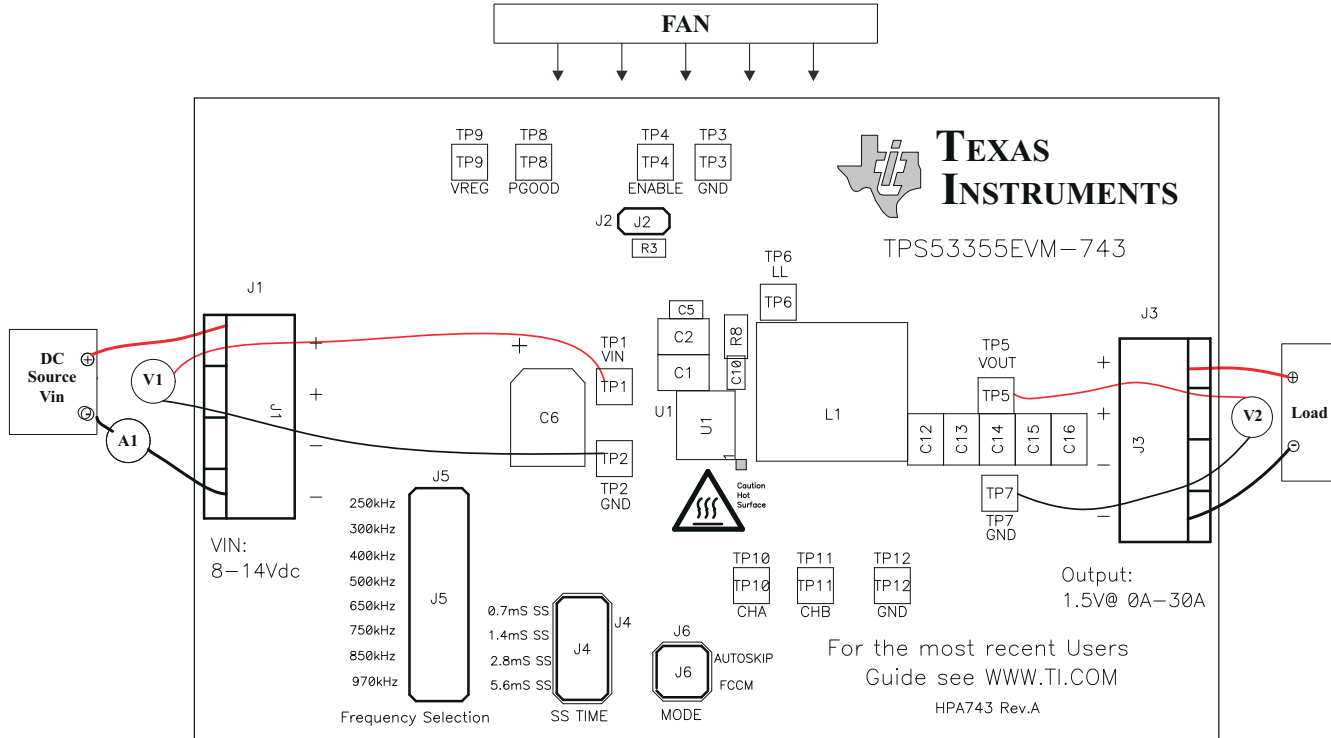
1.  $V_{IN}$  to J1 (12-V input):

The recommended wire size is 1× AWG 14 per input connection, with the total length of wire less than four feet (2-foot input, 2-foot return).

2. J3 to LOAD:

The minimum recommended wire size is 2× AWG 14, with the total length of wire less than four feet (2-foot output, 2-foot return)

## 4.2 Recommended Test Setup



**Figure 4-2. TPS53355EVM-743 Recommended Test Setup**

Figure 4-2 is the recommended test setup to evaluate the TPS53355EVM-743. Working at an ESD workstation, ensure that any wrist straps, bootstraps, or mats are connected referencing the user to earth ground before power is applied to the EVM.

### Input Connections:

1. Prior to connecting the dc input source  $V_{IN}$ , it is advisable to limit the source current from  $V_{IN}$  to 10 A maximum. Ensure that  $V_{IN}$  is initially set to 0 V and connected as shown in Figure 4-2.
2. Connect a voltmeter V1 at TP1 ( $V_{IN}$ ) and TP2 (GND) to measure the input voltage.
3. Connect a current meter A1 to measure the input current.

### Output Connections:

1. Connect the load to J3, and set Load to constant resistance mode to sink 0  $A_{DC}$  before  $V_{IN}$  is applied.
2. Connect a voltmeter V2 at TP5 (VOUT) and TP7 (GND) to measure the output voltage.

### Other Connections:

Place a fan as shown in Figure 4-2, and turn it on, making sure that air is flowing across the EVM.

## 5 Configurations

All jumper selections must be made prior to applying power to the EVM. Users can configure this EVM per the following configurations.

### 5.1 Switching Frequency Selection

The switching frequency can be set by J5.

**Default setting: 500 kHz**

**Table 5-1. Switching Frequency Selection**

| Jumper Set to                   | Resistor (RF) Connections (kΩ) | Switching Frequency (kHz) |
|---------------------------------|--------------------------------|---------------------------|
| Top (1–2 pin shorted)           | 0                              | 250                       |
| Second (3–4 pin shorted)        | 187                            | 300                       |
| Third (5–6 pin shorted)         | 619                            | 400                       |
| <b>Fourth (7–8 pin shorted)</b> | <b>Open</b>                    | <b>500</b>                |
| Fifth (9–10 pin shorted)        | 866                            | 650                       |
| Sixth (11–12 pin shorted)       | 309                            | 750                       |
| Seventh (13–14 pin shorted)     | 124                            | 850                       |
| Bottom (15–16 pin shorted)      | 0                              | 970                       |

### 5.2 Soft-Start Selection

The soft-start time can be set by J4.

**Default setting: 1.4 ms**

**Table 5-2. Soft-Start Time Selection**

| Jumper Set to                   | R <sub>MODE</sub> Connections (kΩ) | Soft-Start Time (ms) |
|---------------------------------|------------------------------------|----------------------|
| Top (1–2 pin shorted)           | 39.2                               | 0.7                  |
| <b>Second (3–4 pin shorted)</b> | <b>100</b>                         | <b>1.4</b>           |
| Third (5–6 pin shorted)         | 200                                | 2.8                  |
| Bottom (7–8 pin shorted)        | 475                                | 5.6                  |

### 5.3 Mode Selection

The MODE can be set by J6.

**Default setting: Auto Skip**

**Table 5-3. MODE Selection**

| Jumper Set to                | MODE Selection   |
|------------------------------|------------------|
| <b>Top (1–2 pin shorted)</b> | <b>Auto Skip</b> |
| Bottom (7–8 pin shorted)     | Forced CCM       |

## 5.4 Enable Selection

The controller can be enabled and disabled by J2.

**Default setting: Jumper shorts on J2 to disable the controller**

**Table 5-4. Enable Selection**

| Jumper Set to          | Enable Selection       |
|------------------------|------------------------|
| Jumper shorts on J2    | Disable the controller |
| No jumper shorts on J2 | Enable the controller  |

## 6 Test Procedure

### 6.1 Line/Load Regulation and Efficiency Measurement Procedure

1. Set up the EVM as described in [Section 4](#) and [Figure 4-2](#).
2. Ensure the load is set to constant resistance mode and to sink 0 A<sub>DC</sub>.
3. Ensure that all jumpers configuration settings are per [Section 5](#).
4. Ensure that the jumper provided in the EVM shorts on J2 before V<sub>IN</sub> is applied.
5. Increase V<sub>IN</sub> from 0 V to 12 V. Use V1 to measure input voltage.
6. Remove the jumper on J2 to enable the controller.
7. Use V2 to measure V<sub>OUT</sub> voltage.
8. Vary the load from 0 A<sub>DC</sub> to 30 A<sub>DC</sub>; V<sub>OUT</sub> must remain in load regulation.
9. Vary V<sub>IN</sub> from 8 V to 14 V; V<sub>OUT</sub> must remain in line regulation.
10. Put the jumper on J2 to disable the controller.
11. Decrease the load to 0 A.
12. Decrease V<sub>IN</sub> to 0 V.

### 6.2 Control Loop Gain and Phase Measurement Procedure

The TPS53355EVM-743 contains a 10-Ω series resistor in the feedback loop for loop response analysis.

1. Set up the EVM as described in [Section 4](#) and [Figure 4-2](#).
2. Connect isolation transformer to test points marked TP10 and TP11.
3. Connect input signal amplitude measurement probe (channel A) to TP10. Connect output signal amplitude measurement probe (channel B) to TP11.
4. Connect ground lead of channel A and channel B to TP12.
5. Inject an approximate 40-mV or less signal through the isolation transformer.
6. Sweep the frequency from 100 Hz to 1 MHz with 10-Hz or lower post filter. The control loop gain and phase margin can be measured.
7. Disconnect isolation transformer from bode-plot test points before making other measurements (Signal injection into feedback can interfere with accuracy of other measurements).



## 6.3 Test Point List

**Table 6-1. Test Point Functions**

| Test Points | Name  | Description                |
|-------------|-------|----------------------------|
| TP1         | VIN   | Controller input           |
| TP2         | GND   | Ground                     |
| TP3         | GND   | Ground                     |
| TP4         | EN    | Enable                     |
| TP5         | VOUT  | Output voltage             |
| TP6         | LL    | Switching node             |
| TP7         | GND   | Ground                     |
| TP8         | PGOOD | Power Good                 |
| TP9         | VREG  | 5-V LDO output             |
| TP10        | CHA   | Input A for loop injection |
| TP11        | CHB   | Input B for loop injection |
| TP12        | GND   | GND                        |

## 6.4 Equipment Shutdown

1. Shut down Load.
2. Shut down Load.
3. Shut down fan.

## 7 Performance Data and Typical Characteristic Curves

Figure 7-1 through Figure 7-15 present typical performance curves for TPS53355EVM-743.

### 7.1 Efficiency

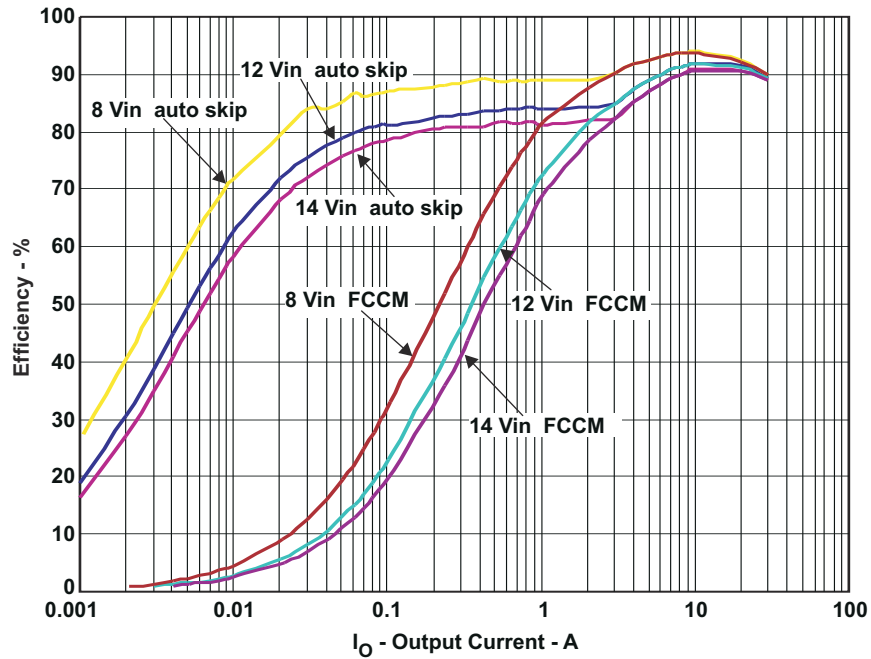


Figure 7-1. Efficiency

### 7.2 Load Regulation

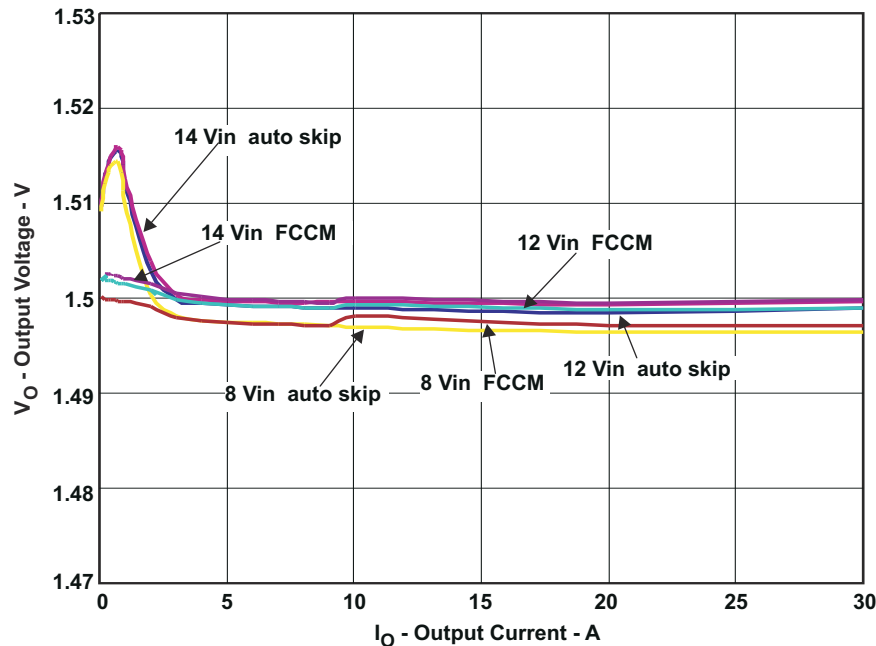


Figure 7-2. Load Regulation

### 7.3 Line Regulation

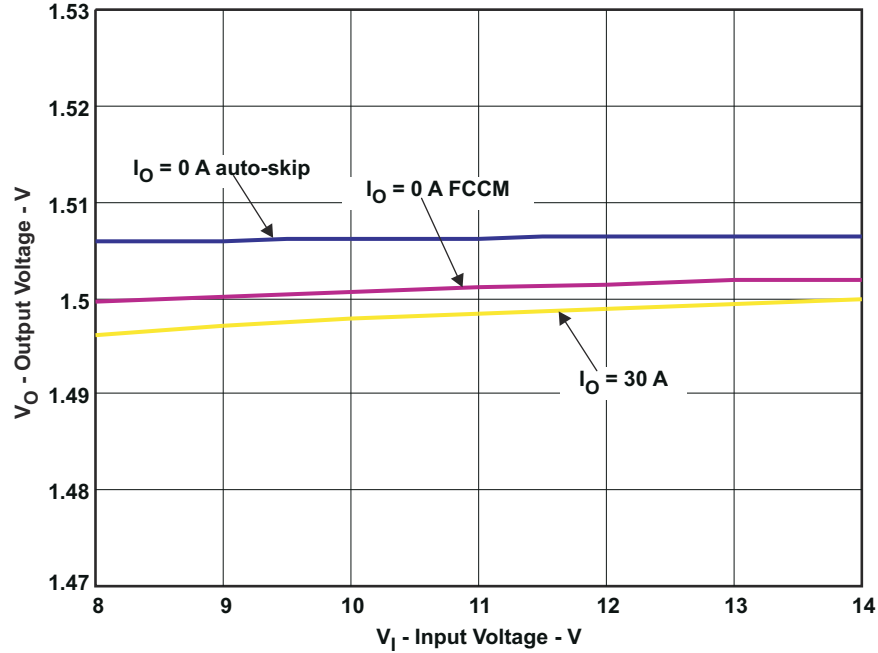


Figure 7-3. Line Regulation

### 7.4 Enable Turn-On/Turn-Off

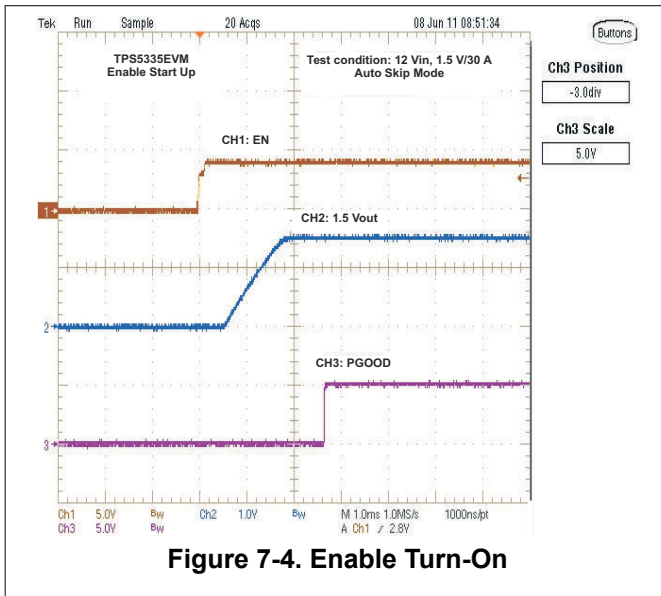


Figure 7-4. Enable Turn-On

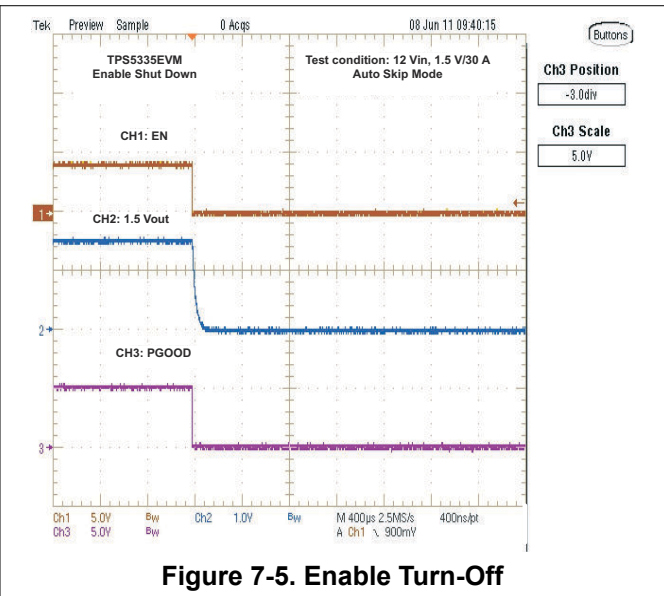


Figure 7-5. Enable Turn-Off

## 7.5 Output Ripple

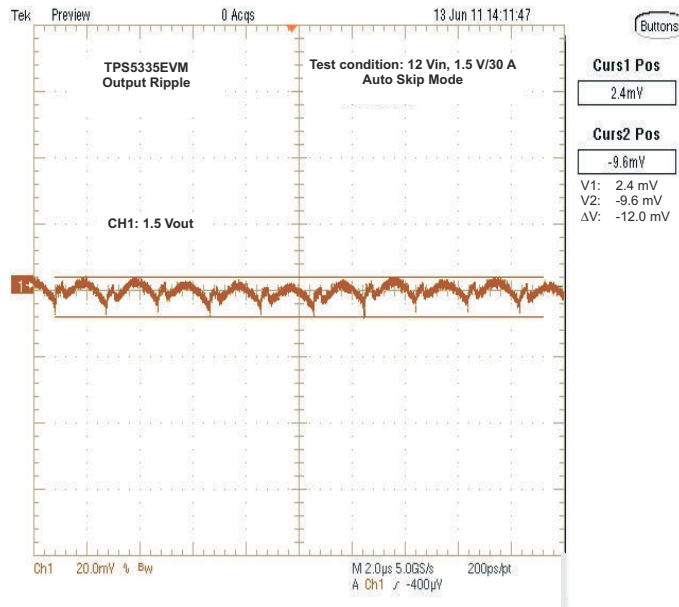


Figure 7-6. Output Ripple

## 7.6 Switching Node

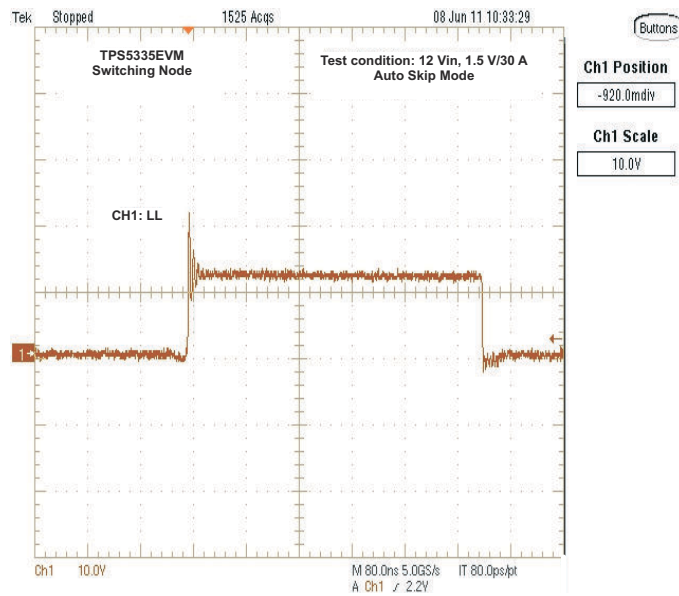


Figure 7-7. Switching Node

### 7.7 Output Transient With Auto-Skip Mode

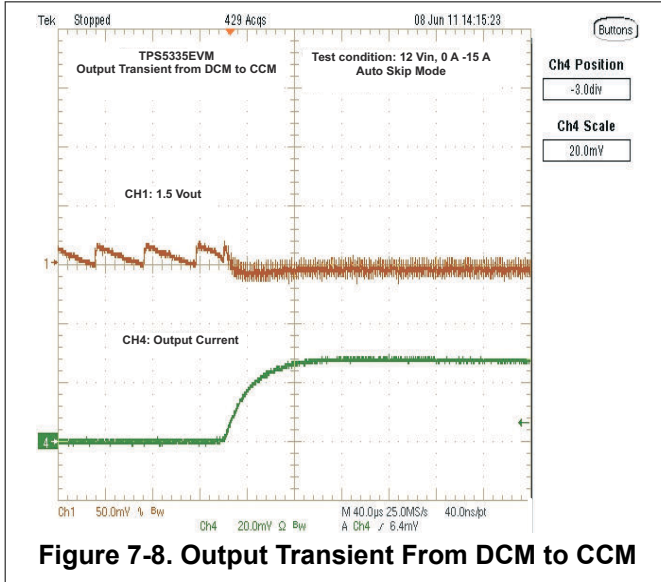


Figure 7-8. Output Transient From DCM to CCM

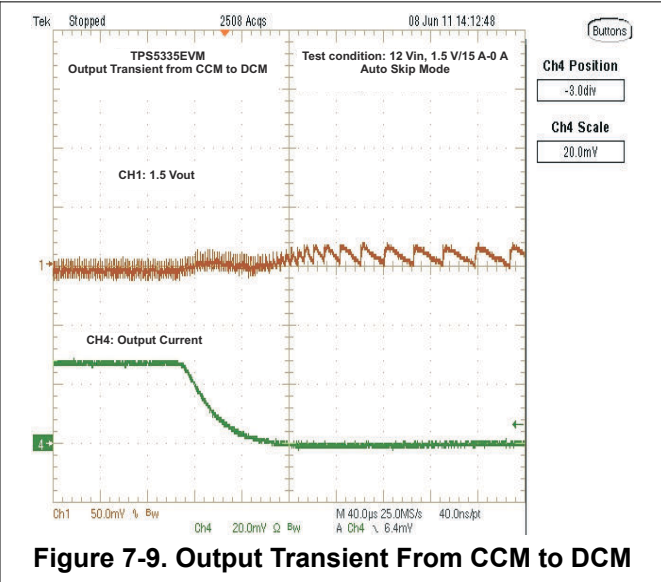


Figure 7-9. Output Transient From CCM to DCM

### 7.8 Output Transient With FCCM Mode

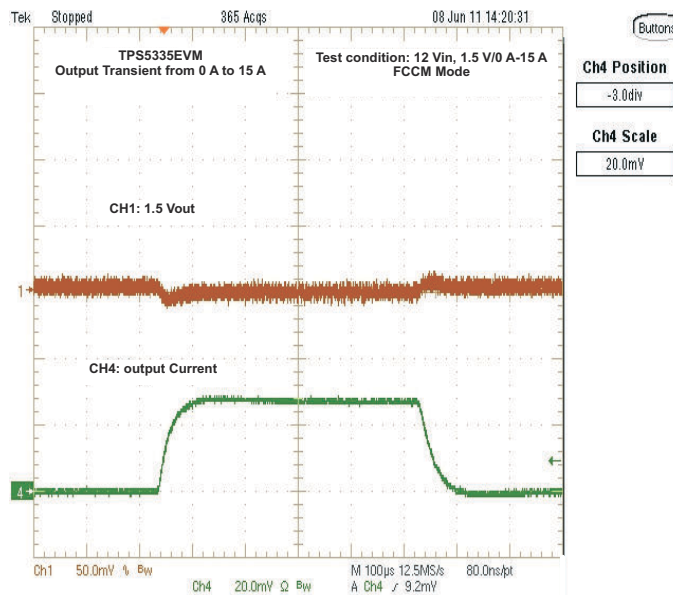


Figure 7-10. Output Transient With FCCM Mode

### 7.9 Output 0.75-V Prebias Turn-On

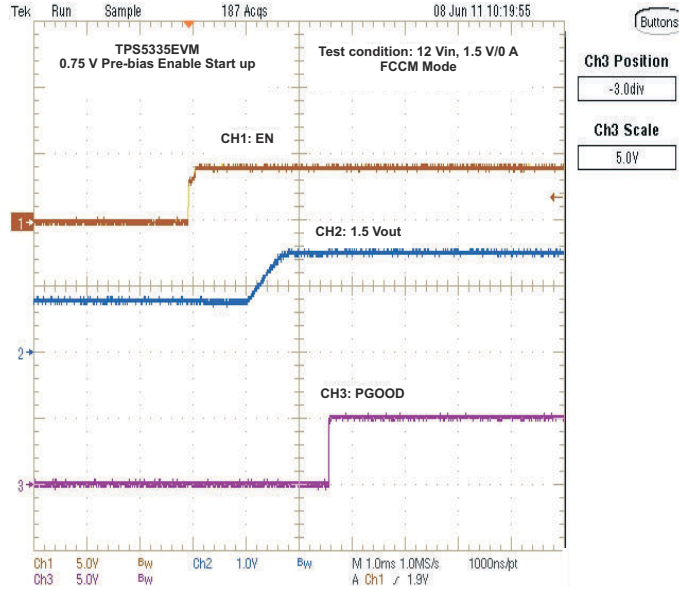


Figure 7-11. Output 0.75-V Prebias Turn-On

### 7.10 Output Overcurrent and Short-Circuit Protection

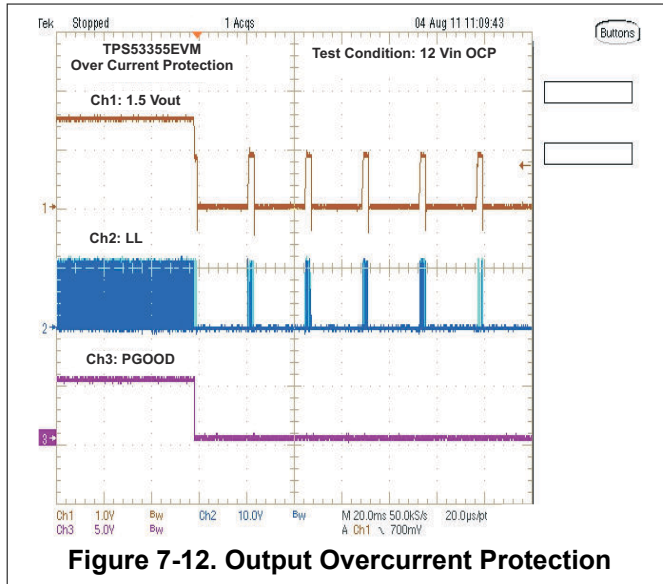


Figure 7-12. Output Overcurrent Protection

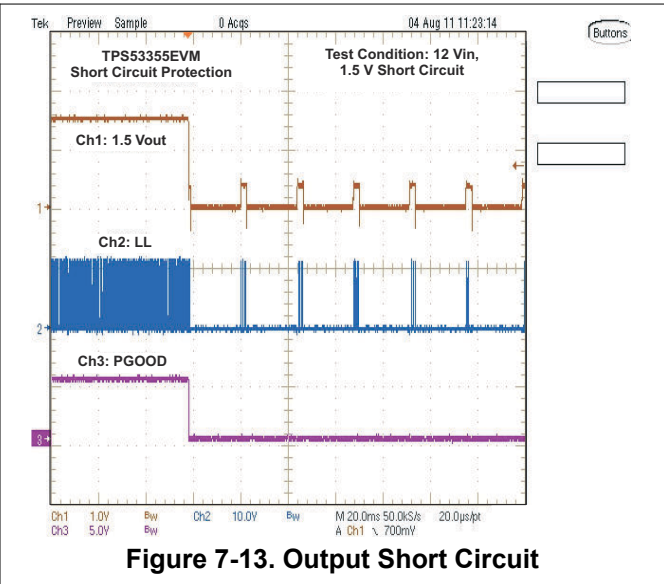


Figure 7-13. Output Short Circuit

## 7.11 Bode Plot

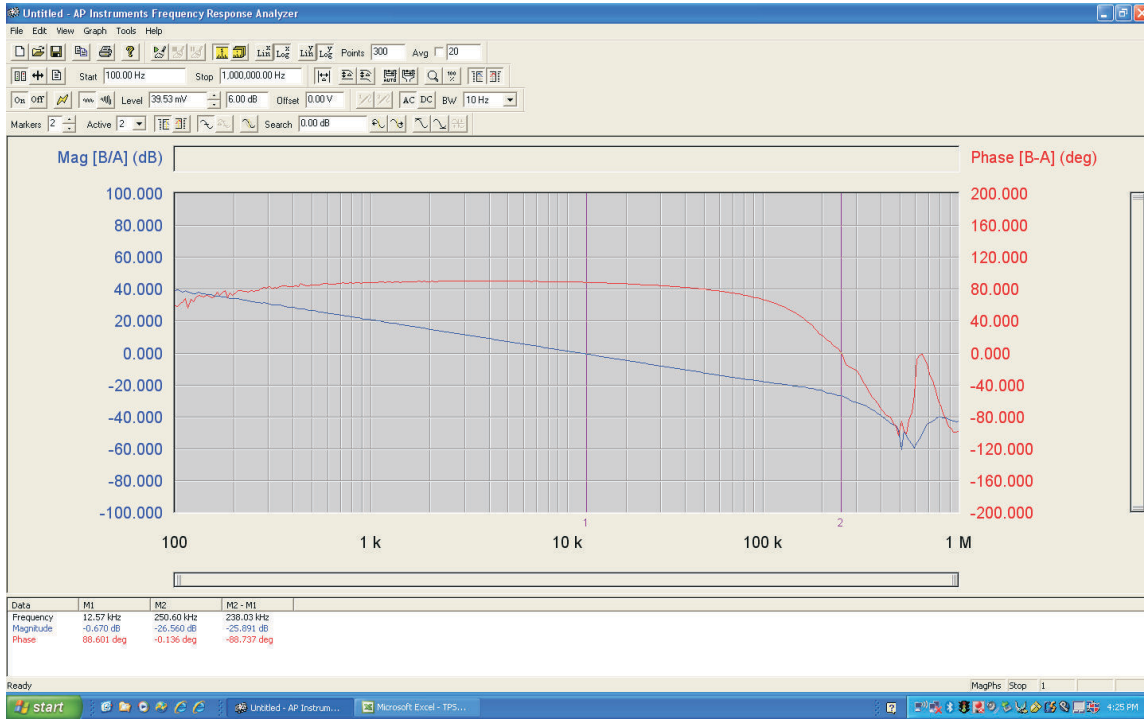


Figure 7-14. Bode Plot at 12 V<sub>IN</sub>, 1.5 V/30 A

## 7.12 Thermal Image

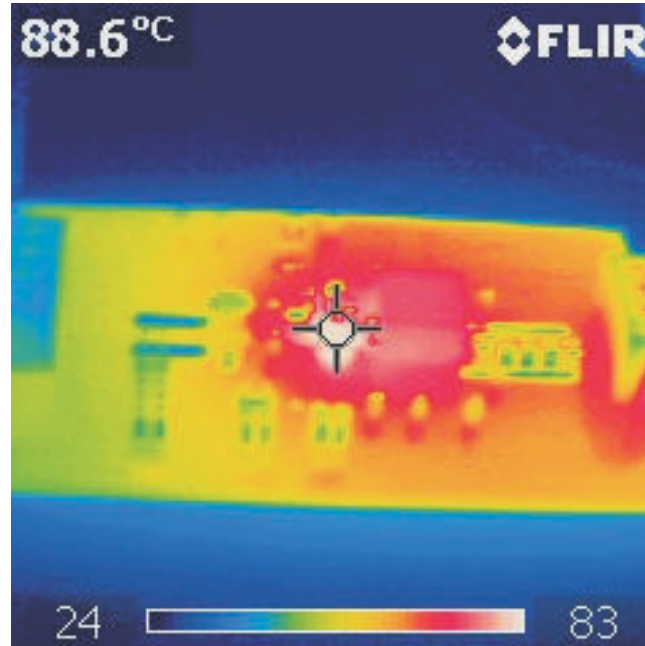
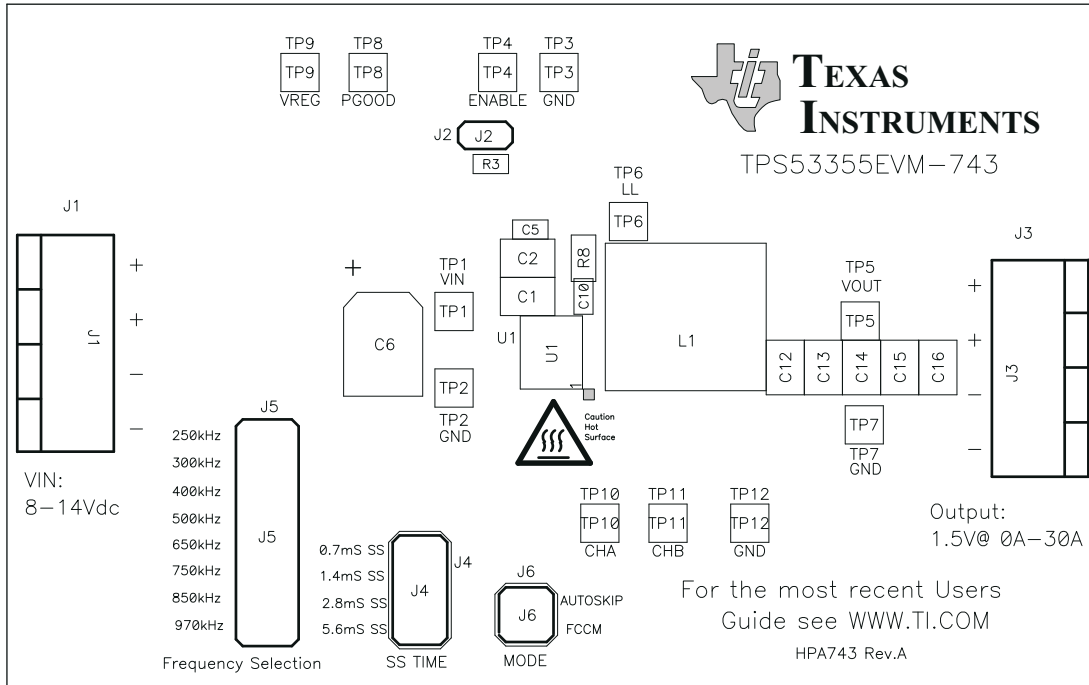


Figure 7-15. Top Board at 12 V<sub>IN</sub>, 1.5 V/30 A, 25°C Ambient Temperature Without Airflow

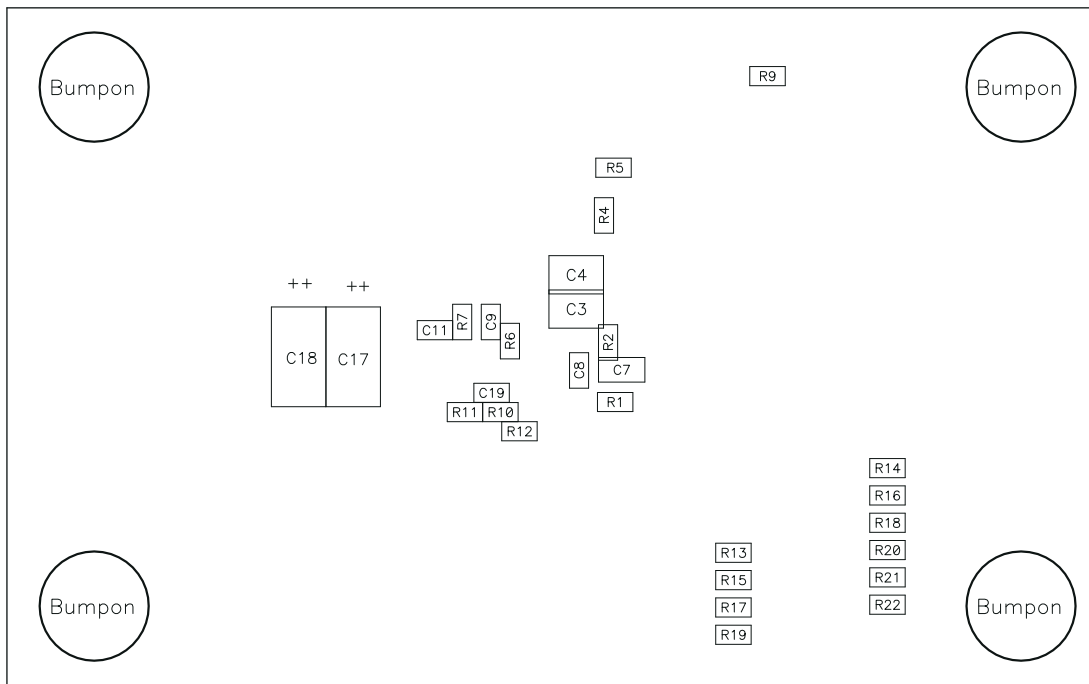


## 8 EVM Assembly Drawing and PCB Layout

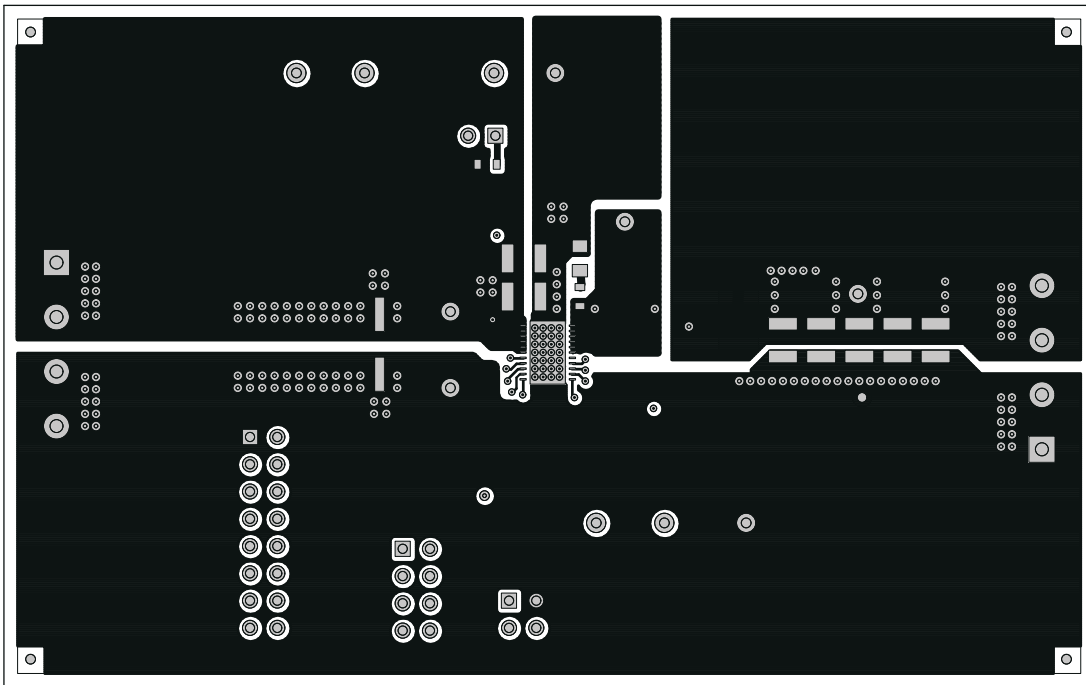
The following illustrations (Figure 8-1 through Figure 8-8) show the design of the TPS53355EVM-743 printed-circuit board. The EVM was designed using a 6-layer, 2-oz copper circuit board.



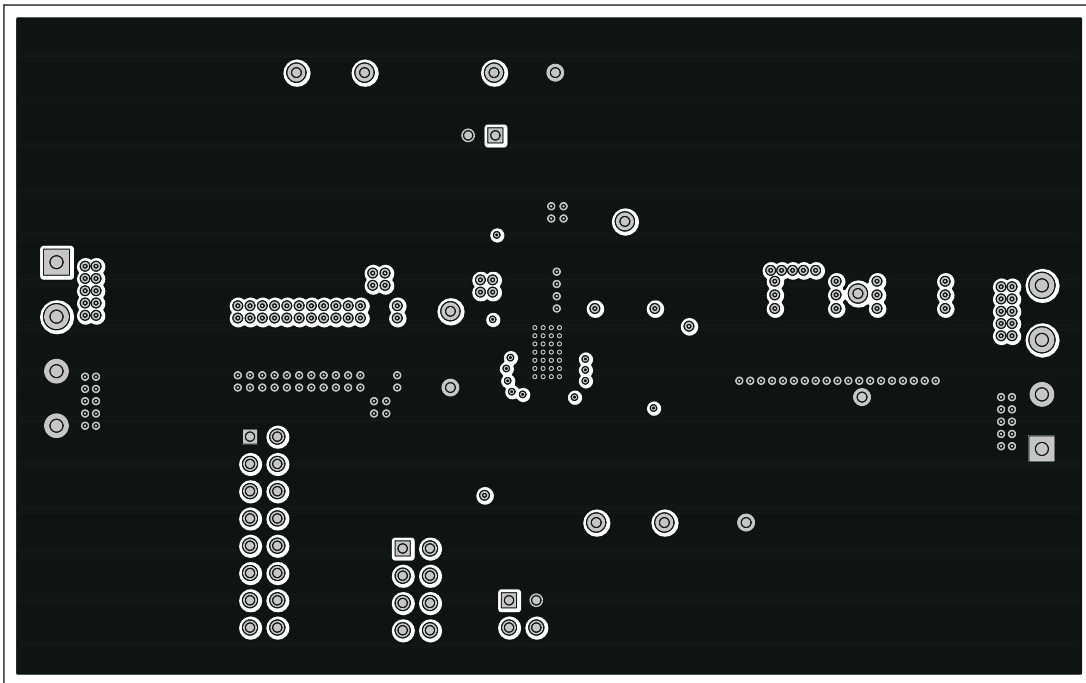
**Figure 8-1. TPS53355EVM-743 Top Layer Assembly Drawing**



**Figure 8-2. TPS53355EVM-743 Bottom Assembly Drawing**



**Figure 8-3. TPS53355EVM-743 Top Copper**



**Figure 8-4. TPS53355EVM-743 Layer-2 Copper**

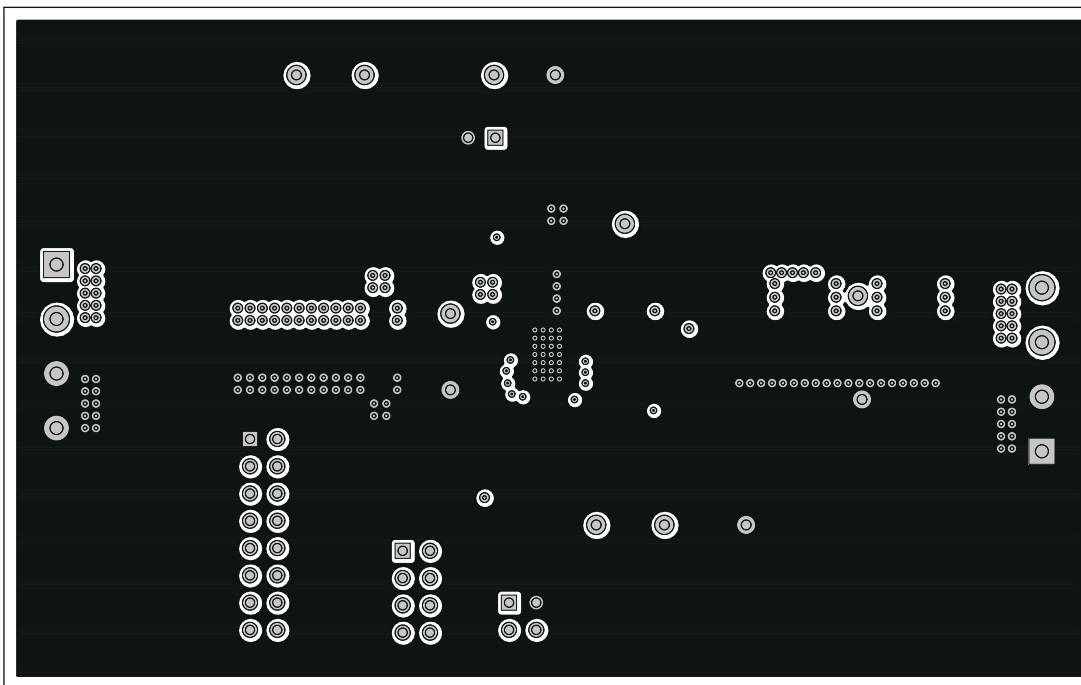


Figure 8-5. TPS53355EVM-743 Layer-3 Copper

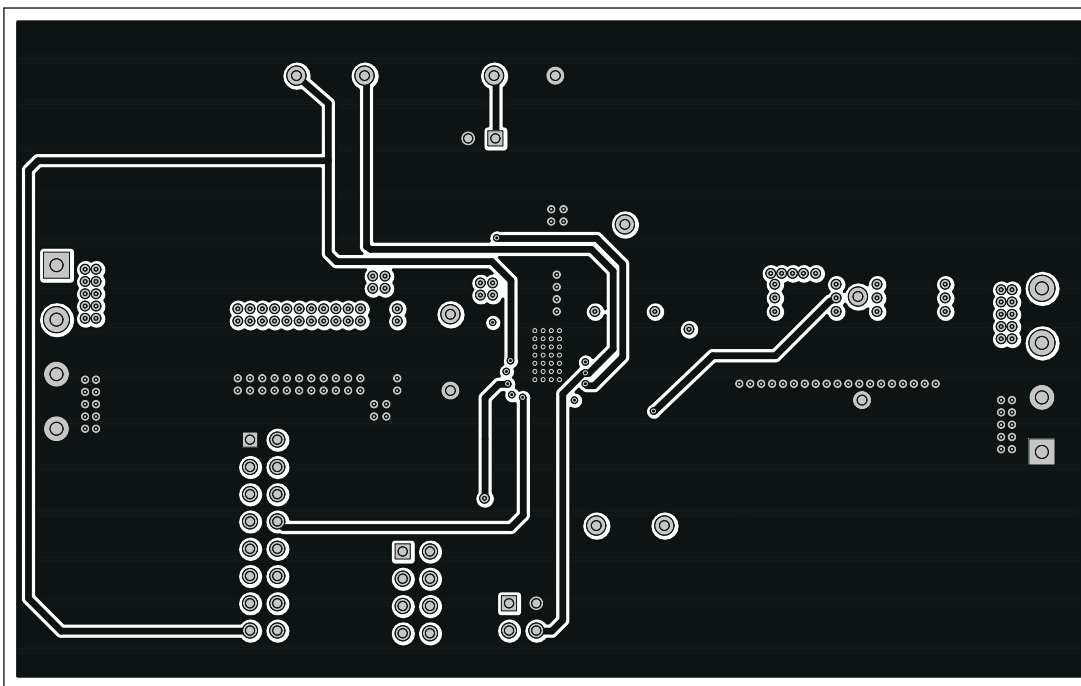
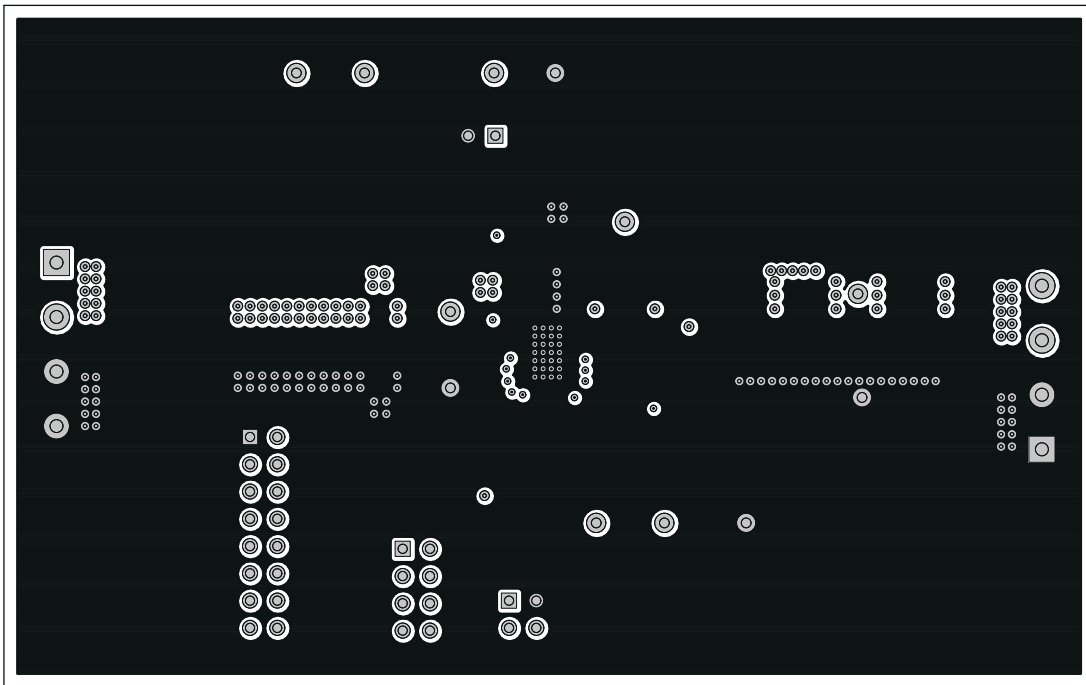
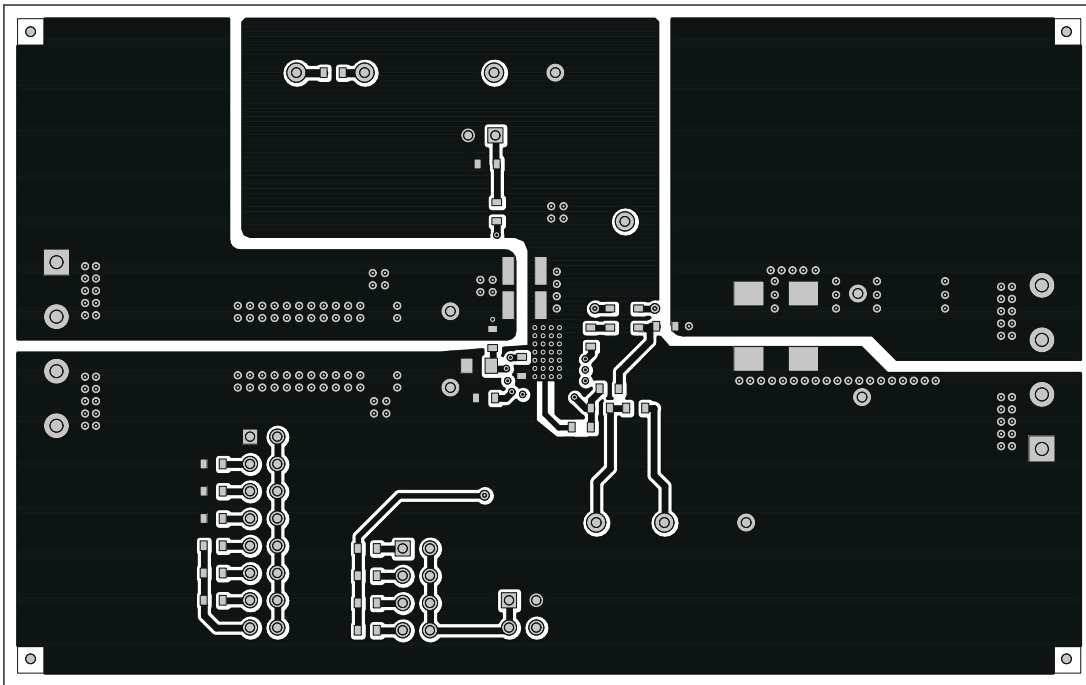


Figure 8-6. TPS53355EVM-743 Layer-4 Copper



**Figure 8-7. TPS53355EVM-743 Layer-5 Copper**



**Figure 8-8. TPS53355EVM-743 Bottom Layer Copper**

## 9 Bill of Materials

**Table 9-1. The EVM Components List According to the Schematic Shown in Figure 3-1**

| QTY | REFDES                  | DESCRIPTION   | MFR       | PART NUMBER        |
|-----|-------------------------|---|-----------|--------------------|
| 4   | C1, C2, C3, C4          | Capacitor, Ceramic, 22 $\mu$ F, 16 V, X5R, 20%, 1210                                | MURATA    | GRM32ER61C226KE20L |
| 5   | C12, C13, C14, C15, C16 | Capacitor, Ceramic, 100 $\mu$ F, 6.3 V, X5R, 20%, 1210                              | MURATA    | GRM32ER60J107ME20L |
| 1   | C10                     | Capacitor, Ceramic, 2.2 nF, 50 V, X7R, 20%, 0603                                    | STD       | STD                |
| 1   | C11                     | Capacitor, Ceramic, 0.022 $\mu$ F, 50 V, X7R, 20%, 0603                             | STD       | STD                |
| 1   | C19                     | Capacitor, Ceramic, 1000 pF, 50 V, X7R, 20%, 0603                                   | STD       | STD                |
| 2   | C5, C9                  | Capacitor, Ceramic, 0.1 $\mu$ F, 50 V, X7R, 20%, 0603                               | STD       | STD                |
| 1   | C6                      | Capacitor, Aluminum, 100 $\mu$ F, 16 VDC, 20%, Code D8                              | Panasonic | EEEEFP1C101AP      |
| 1   | C7                      | Capacitor, Ceramic, 4.7 $\mu$ F, 25 V, X5R, 20%, 0805                               | STD       | STD                |
| 1   | C8                      | Capacitor, Ceramic, 1 $\mu$ F, 50 V, X7R, 20%, 0603                                 | STD       | STD                |
| 1   | L1                      | Inductor, SMT, 0.44 $\mu$ H, 30 A, 0.0032 $\Omega$ , 0.530 inch $\times$ 0.510 inch | Pulse     | PA0513-441NLT      |
| 1   | R1                      | Resistor, Chip, 147 k, 1/16W, 1%, 0603  | STD       | STD                |
| 1   | R11                     | Resistor, Chip, 10, 1/16W, 1%, 0603   | STD       | STD                |
| 1   | R12                     | Resistor, Chip, 10.0 k, 1/16W, 1%, 0603   | STD       | STD                |
| 1   | R13                     | Resistor, Chip, 39.2 k, 1/16W, 1%, 0603   | STD       | STD                |
| 1   | R14                     | Resistor, Chip, 187 k, 1/16W, 1%, 0603  | STD       | STD                |
| 1   | R16                     | Resistor, Chip, 619 k, 1/16W, 1%, 0603  | STD       | STD                |
| 1   | R19                     | Resistor, Chip, 475 k, 1/16W, 1%, 0603  | STD       | STD                |
| 1   | R2                      | Resistor, Chip, 0, 1/16W, 1%, 0603  | STD       | STD                |
| 1   | R20                     | Resistor, Chip, 866 k, 1/16W, 1%, 0603  | STD       | STD                |
| 1   | R21                     | Resistor, Chip, 309 k, 1/16W, 1%, 0603  | STD       | STD                |
| 1   | R22                     | Resistor, Chip, 124 k, 1/16W, 1%, 0603  | STD       | STD                |
| 2   | R3, R1                  | Resistor, Chip, 200 k, 1/16W, 1%, 0603  | STD       | STD                |
| 3   | 7 R5, R9, R15           | Resistor, Chip, 100 k, 1/16W, 5%, 0603  | STD       | STD                |
| 1   | R4                      | Resistor, Chip, 1.00 k, 1/16W, 1%, 0603   | STD       | STD                |
| 1   | R6                      | Resistor, Chip, 2.05, 1/16W, 1%, 0603   | STD       | STD                |
| 2   | R7, R10                 | Resistor, Chip, 14.7k, 1/16W, 1%, 0603  | STD       | STD                |
| 1   | R8                      | Resistor, Chip, 3.01, 1/16W, 1%, 0805   | STD       | STD                |
| 1   | U1                      | IC, 30-A Synchronous Buck converter with integrated MOSFETs, DQP-22                 | TI        | TPS53355DQP        |

## 10 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| Changes from Revision * (August 2011) to Revision A (January 2022)                                     | Page |
|--|------|
| • Updated the numbering format for tables, figures, and cross-references throughout the document. .... | 3    |
| • Updated the user's guide title.....  | 3    |

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