

TPS65580EVM-575 1.5-A, 2.5-A, 1.5-A Triple Synchronous Regulator Evaluation Module

This user's guide contains information for the TPS65580 as well as support documentation for the TPS65580EVM-575 evaluation module. Included are the performance specifications, board layouts, schematic, and the bill of materials of the TPS65580EVM-575.

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1 Introduction

The TPS65580 is a triple output, advanced D-CAP2™-mode, synchronous buck converter requiring a very low external component count. The advanced D-CAP2 control circuit is optimized for low-ESR output capacitors such as POSCAP, SP-CAP, or ceramic types and features fast transient response with no external compensation. The switching frequency is internally set at a nominal 700 kHz. The high-side and low-side switching MOSFETs are incorporated inside the TPS65580 package along with the gate-drive circuitry. The low drain-to-source on resistance of the MOSFETs allows the TPS65580 to achieve high efficiencies and helps keep the junction temperature low at high output currents. The TPS65580 dc/dc synchronous converter is designed to provide up to 1.5-A, 2.5-A and 1.5-A output for each of 3 channels from an input voltage source of 4.5 V to 18 V. The output voltage range is from 0.76 V to 6.5 V. Rated input voltage, output voltage and output current ranges for the evaluation module are given in [Table 1](#). This user's guide describes the TPS65580EVM-575 performance.

Table 1. Input Voltage, Output Voltage and Output Current Summary

| EVM | Input Voltage Range | Channel | Output Voltage | Output Current Range |
|-----------------|---|---------|----------------|----------------------|
| TPS65580EVM-575 | $V_{IN} = 4.5 \text{ V to } 18 \text{ V}$ | CH1 | 3.3 V | 0-A to 1.5-A |
| | | CH2 | 1.2 V | 0-A to 2.5-A |
| | | CH3 | 1.5 V | 0-A to 1.5-A |

2 Performance Specification Summary

A summary of the TPS65580EVM-575 performance specifications is provided in [Table 2](#). Specifications are given for an input voltage of $V_{IN} = 12 \text{ V}$ and $T_a = 25^\circ\text{C}$ unless otherwise noted.

Table 2. TPS65580EVM-575 Performance Specifications Summary

| Specifications | | Test Conditions | Min | Typ | Max | Unit |
|----------------------------------|-----------------------|--|-----|-----|-----|------------------|
| Input voltage range (V_{IN}) | | | 4.5 | 12 | 18 | V |
| Operating frequency | | | | 700 | | kHz |
| CH1 | Output voltage | | | 3.3 | | V |
| | Output current range | | 0 | | 1.5 | A |
| | Over current limit | $V_{IN} = 12 \text{ V}, L_O = 3.3 \mu\text{H}$ | | 2.0 | | A |
| | Output ripple voltage | $V_{IN} = 12 \text{ V}, I_O = 1.5 \text{ A}$ | | 10 | | mV _{PP} |
| CH1 | Output voltage | | | 1.2 | | V |
| | Output current range | | 0 | | 2.5 | A |
| | Over current limit | $V_{IN} = 12 \text{ V}, L_O = 2.2 \mu\text{H}$ | | 3.5 | | A |
| | Output ripple voltage | $V_{IN} = 12 \text{ V}, I_O = 2.5 \text{ A}$ | | 10 | | mV _{PP} |
| CH1 | Output voltage | | | 1.5 | | V |
| | Output current range | | 0 | | 1.5 | A |
| | Over current limit | $V_{IN} = 12 \text{ V}, L_O = 2.2 \mu\text{H}$ | | 2.0 | | A |
| | Output ripple voltage | $V_{IN} = 12 \text{ V}, I_O = 1.5 \text{ A}$ | | 10 | | mV _{PP} |

3 Modifications

These evaluation modules are designed to provide access to the features of the TPS65580. Some modifications can be made to this module.

3.1 Output Voltage Setpoint

To change the output voltage of the EVMs, it is necessary to change the value of the top resistor in the voltage set point divider network (R9, R13, and R17). Changing the value of R_{TOP} can change the output voltage above 0.765 V. The value of R_{TOP} for a specific output voltage can be calculated using [Equation 1](#).

$$R_{TOP} = R_{BOT} \times \left(\frac{V_{OUT}}{0.764V} - 1 \right) \quad (1)$$

[Table 3](#) lists the R_{TOP} values for some common output voltages. A feed-forward capacitor (C_{FF}) may be optionally used to improve phase margin. Pads for this component (C12, C18, and C24) are provided on the printed-circuit board. Note that the values given in [Table 3](#) are standard values and not the exact value calculated using [Equation 1](#).

Table 3. Output Voltages

| Output Voltage (V) | R_{TOP} (k Ω) | R_{BOT} (k Ω) | C_{FF} (pF) | L_{OUT} (μ H) | | | C_{OUT} (μ F) |
|--------------------|-------------------------|-------------------------|---------------|----------------------|-----|-----|----------------------|
| | | | | Min | Typ | Max | |
| 1.0 | .681 | 2.21 | 220 - 680 | 1.5 | 2.2 | 3.3 | 22 - 68 |
| 1.05 | .825 | 2.21 | 100 - 680 | 1.5 | 2.2 | 3.3 | 22 - 68 |
| 1.2 | 1.27 | 2.21 | 68 - 680 | 1.5 | 2.2 | 3.3 | 22 - 68 |
| 1.5 | 2.10 | 2.21 | 68 - 330 | 1.5 | 2.2 | 3.3 | 22 - 68 |
| 1.8 | 3.01 | 2.21 | 5 - 68 | 1.5 | 2.2 | 3.3 | 22 - 68 |
| 2.5 | 4.99 | 2.21 | 5 - 22 | 2.2 | 3.3 | 4.7 | 22 - 68 |
| 3.3 | 7.32 | 2.21 | 5 - 22 | 2.2 | 3.3 | 4.7 | 22 - 68 |
| 5.0 | 12.4 | 2.21 | 5 - 22 | 2.2 | 3.3 | 4.7 | 22 - 68 |
| 6.5 | 16.5 | 2.21 | 5 - 22 | 2.2 | 3.3 | 4.7 | 22 - 68 |

4 Test Setup and Results

This section describes how to properly connect, set up, and use the TPS65580EVM-575. The section also includes test results typical for the evaluation modules and efficiency, output load regulation, output line regulation, load transient response, output voltage ripple, input voltage ripple, start-up, and switching frequency.

4.1 Input/Output Connections

The TPS65580EVM-575 is provided with input/output connectors and test points as shown in Table 4. A power supply capable of supplying 5 A must be connected to J1 through a pair of 20-AWG wires. The loads must be connected to J2, J3 and J4 through pairs of 20-AWG wires. The maximum load current capability is for each channel is shown in Table 1. Wire lengths must be minimized to reduce losses in the wires. Test point TP1 provides a place to monitor the V_{IN} input voltages with TP2 providing a convenient ground reference. Test points TP11, TP15 and TP19 are used to monitor the output voltage for each of the three channels. Test points TP12, TP18 and TP20 are used as the ground reference for each of the three channels.

Table 4. Connections and Test Points

| Reference Designator | Function |
|----------------------|--|
| J1 | V_{IN} (see Table 1 for V_{IN} range) |
| J2 | CH1 V_{OUT} , 3.3 V at 1.5-A maximum |
| J3 | CH2 V_{OUT} , 1.2 V at 2.5-A maximum |
| J4 | CH3 V_{OUT} , 1.5 V at 1.5-A maximum |
| JP1 | CH1 EN control. Jumper JP1-2 to JP1-3 to disable, jumper JP1-2 to JP1-1 to enable. |
| JP2 | CH2 EN control. Jumper JP2-2 to JP2-3 to disable, jumper JP2-2 to JP2-1 to enable. |
| JP3 | CH3 EN control. Jumper JP3-2 to JP3-3 to disable, jumper JP3-2 to JP3-1 to enable. |
| TP1 | V_{IN} test point at V_{IN} connector |
| TP2 | GND test point at V_{IN} |
| TP3 | CH1 EN test point |
| TP4 | CH2 EN test point |
| TP5 | CH3 EN test point |
| TP6 | Power good test point |
| TP7 | Power ground test point |
| TP8 | Analog ground test point |
| TP9 | CH1 switch node test point |
| TP10 | CH1 loop response test point |
| TP11 | CH1 output voltage test point |
| TP12 | CH1 ground test point at output connector |
| TP13 | CH2 switch node test point |
| TP14 | CH2 loop response test point |
| TP15 | CH2 output voltage test point |
| TP16 | CH2 ground test point at output connector |
| TP17 | CH3 switch node test point |
| TP18 | CH3 loop response test point |
| TP19 | CH3 output voltage test point |
| TP20 | CH3 ground test point at output connector |

4.2 Start-Up Procedure

1. Ensure that the jumpers at JP1 (CH1 Enable control), JP2 (CH2 Enable control) and JP3 (CH3 Enable control) is set from ON to OFF
2. Apply appropriate V_{IN} voltage to VIN and GND terminals at J1
3. Set the jumpers at JP1 (CH1 Enable control), JP2 (CH2 Enable control) and JP3 (CH3 Enable control) to ON. The EVM enables the output voltages for each of the three channels.

4.3 Efficiency

Figure 1 shows the efficiency for the TPS65580EVM-575 CH1.

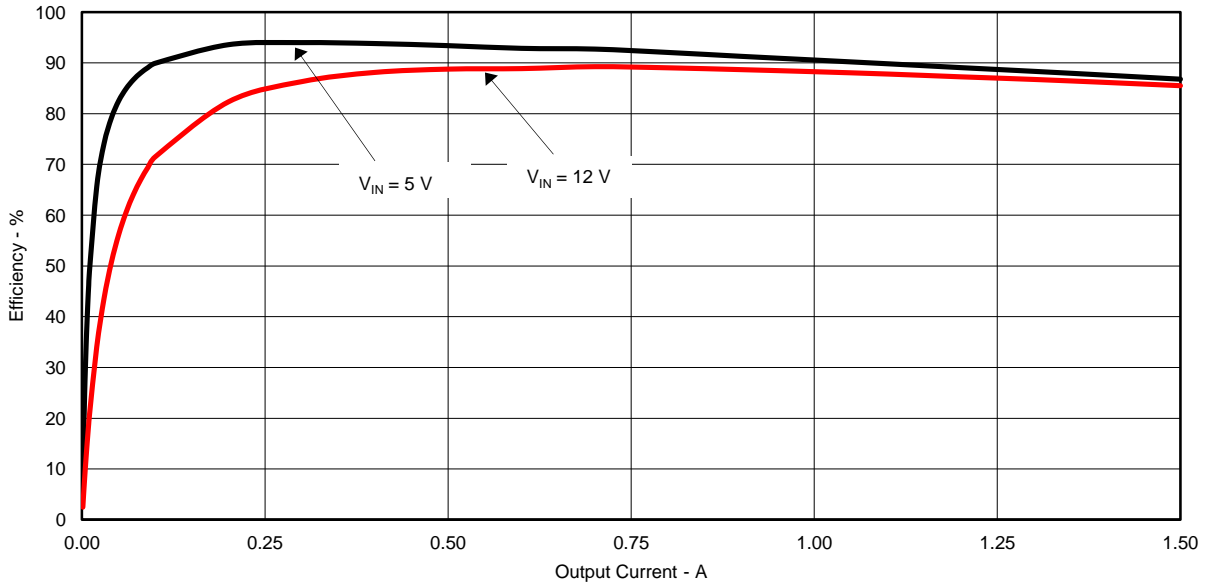


Figure 1. TPS65580EVM-575 CH1 Efficiency

Figure 2 shows the efficiency at light loads for the TPS65580EVM-575 CH1.

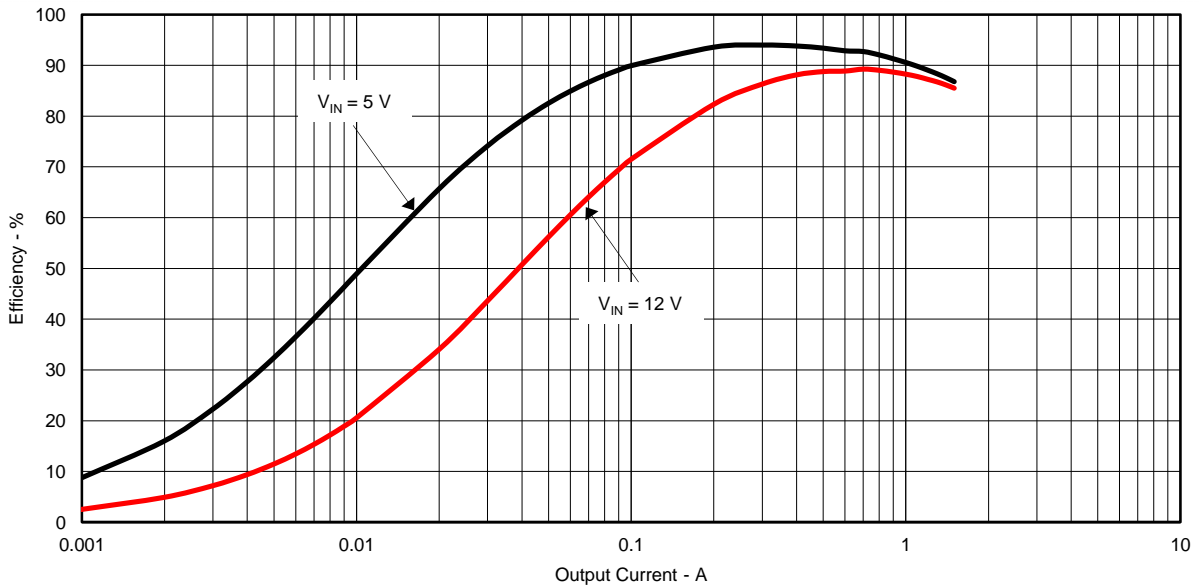


Figure 2. TPS65580EVM-575 Light CH1 Load Efficiency

Figure 3 shows the efficiency for the TPS65580EVM-575 CH2.

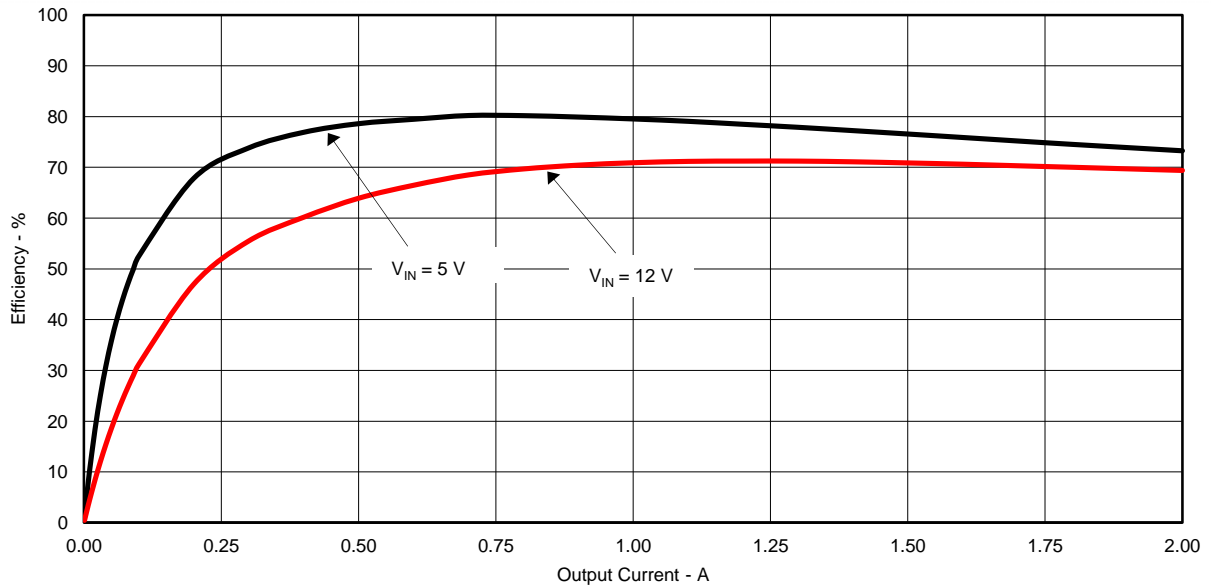


Figure 3. TPS65580EVM-575 CH2 Efficiency

Figure 4 shows the efficiency at light loads for the TPS65580EVM-575 CH2.

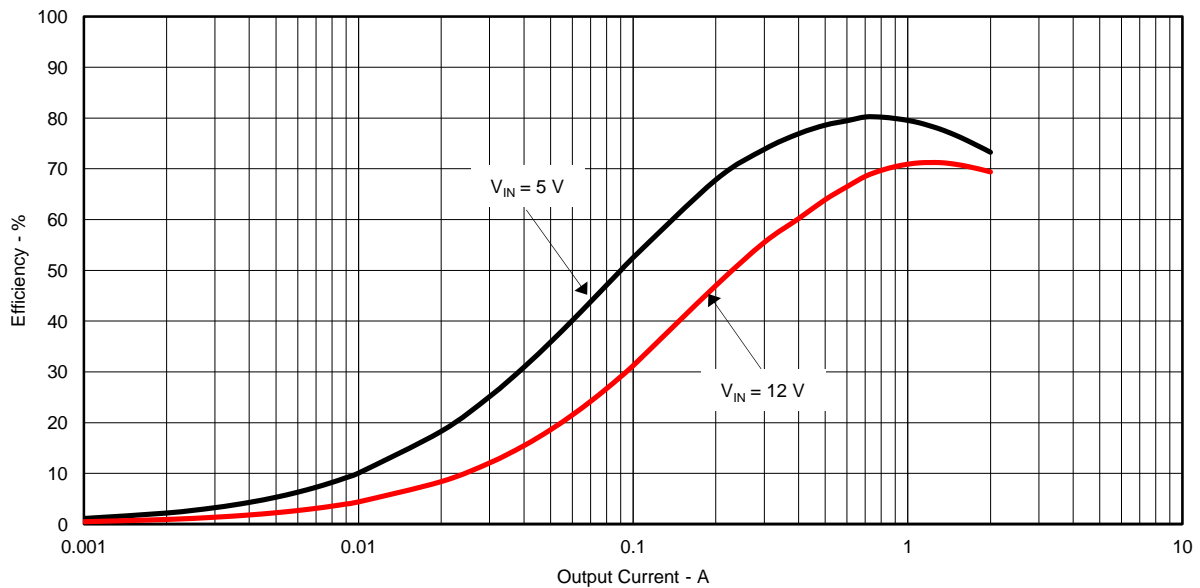


Figure 4. TPS65580EVM-575 Light CH2 Load Efficiency

Figure 5 shows the efficiency for the TPS65580EVM-575 CH3.

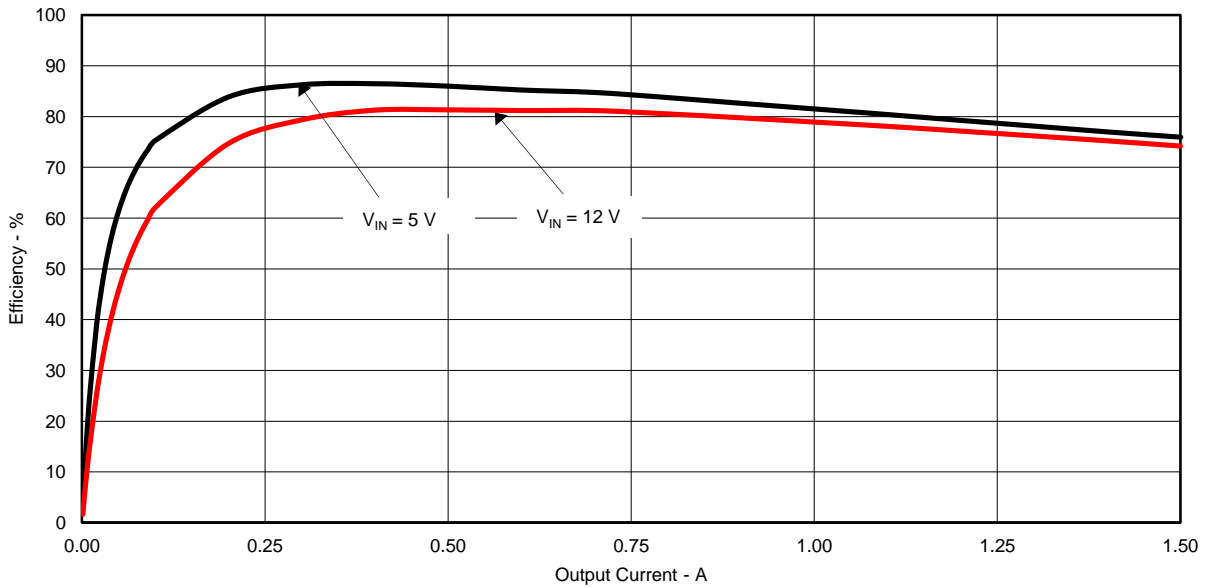


Figure 5. TPS65580EVM-575 CH3 Efficiency

Figure 6 shows the efficiency at light loads for the TPS65580EVM-575 CH3.

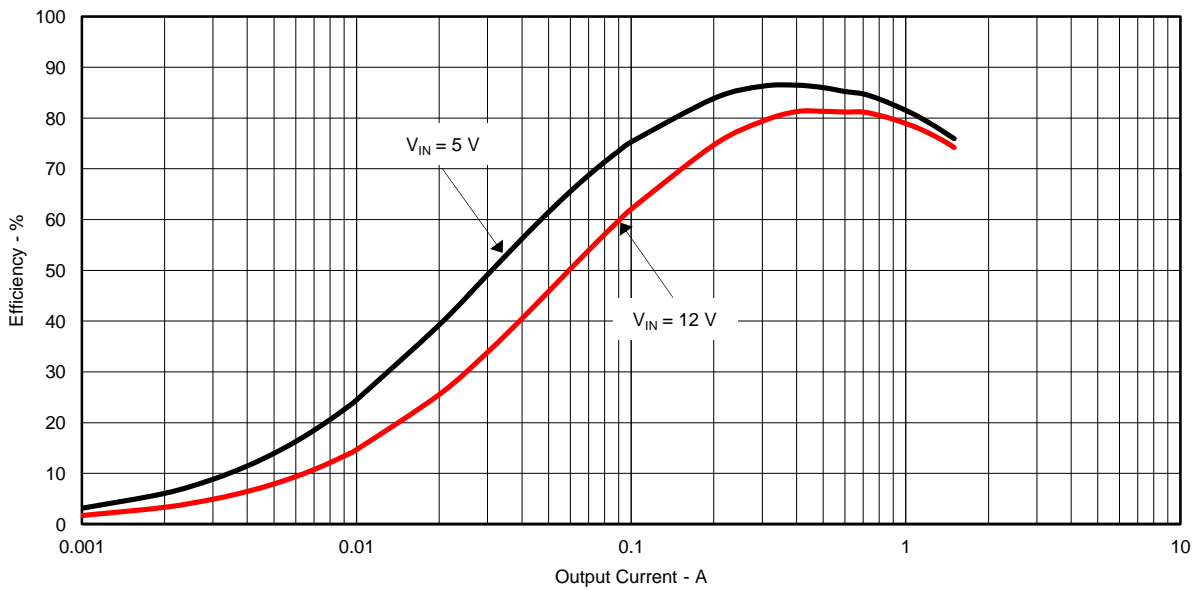


Figure 6. TPS65580EVM-575 Light CH3 Load Efficiency

4.4 Load Regulation

The load regulation for the TPS65580EVM-575 CH1 is shown in Figure 7. The load regulation for CH2 and CH3 is similar and is not shown.

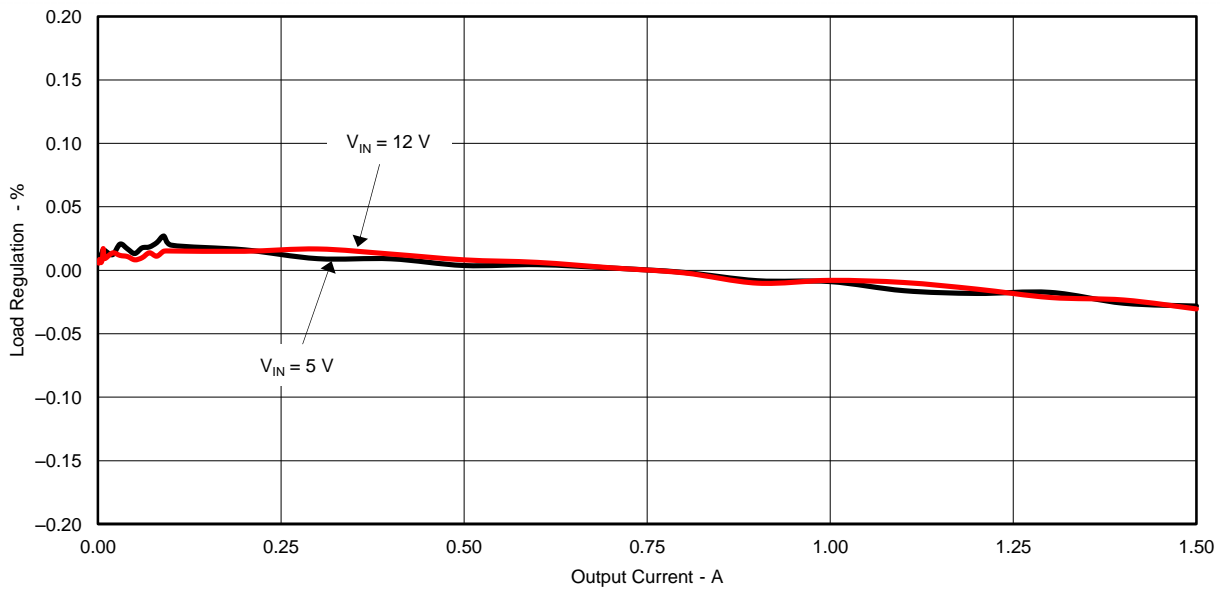


Figure 7. TPS65580EVM-575 CH1 Load Regulation

4.5 Line Regulation

The line regulation for the TPS65580EVM-575 CH1, CH2, and CH3 is shown in Figure 8. Note that the CH1 output voltage is 3.3 V and the line regulation is lessened as V_{IN} approaches V_{OUT} .

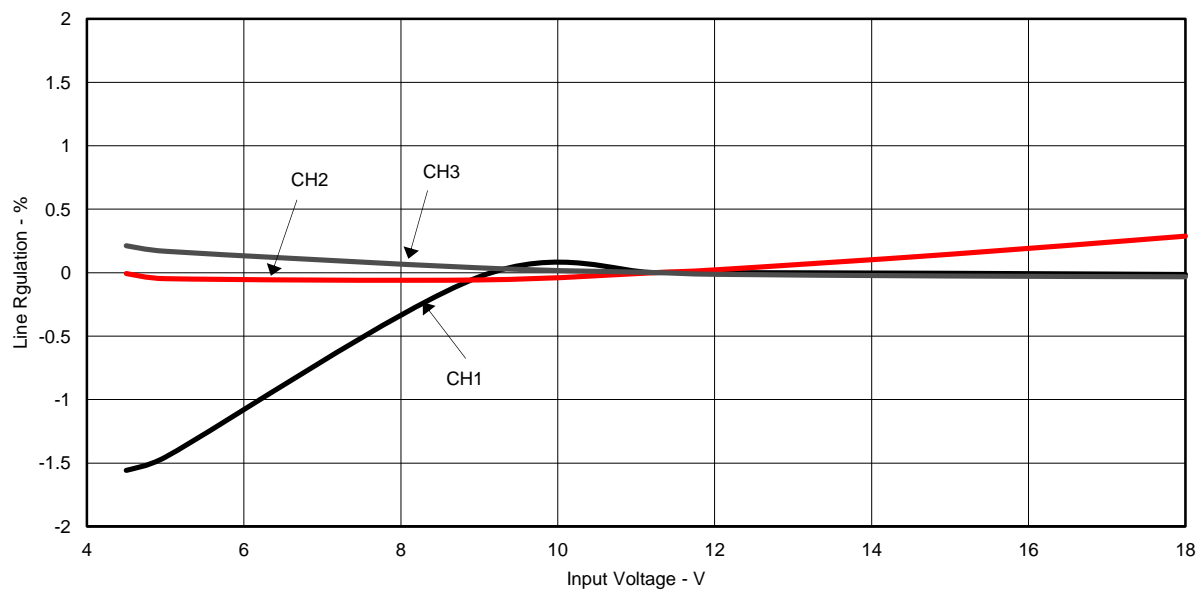


Figure 8. TPS65580EVM-575 Line Regulation

4.6 Load Transient Response

The TPS65580EVM-575 CH1 response to load transients is shown in Figure 9. The current steps and slew rates are indicated in the figures. Total peak-to-peak voltage variation is as shown. The transient response for CH2 and CH3 is similar and is not shown.

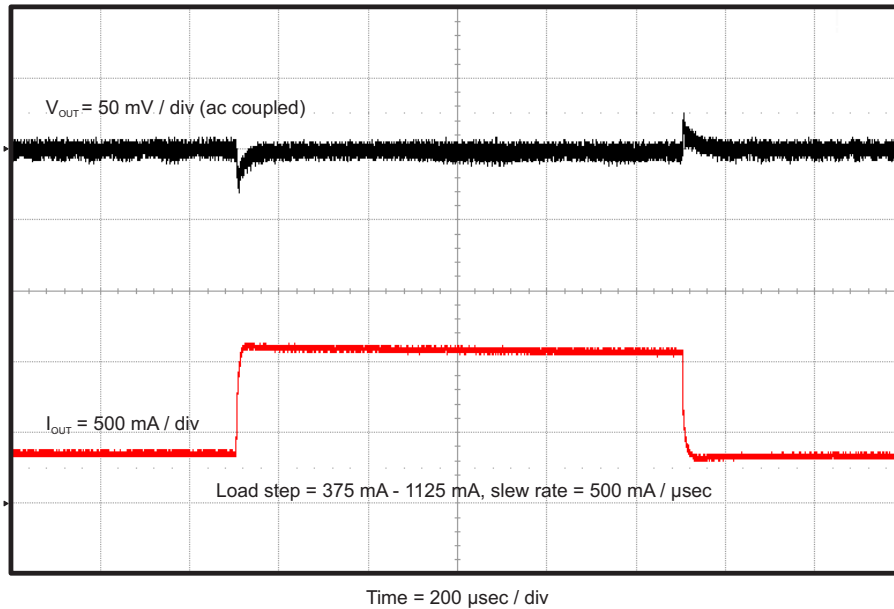


Figure 9. TPS65580EVM-575 CH1 Load Transient Response, 25% to 75% Load Step

4.7 Input Voltage Ripple

The TPS65580EVM-575 input voltage ripple is shown in Figure 10. The output current for each channel is the full rated load of 1.5-A, 2.5-A and 1.5-A. Note that the switching waveforms for each channel are out of phase to reduce input ripple.

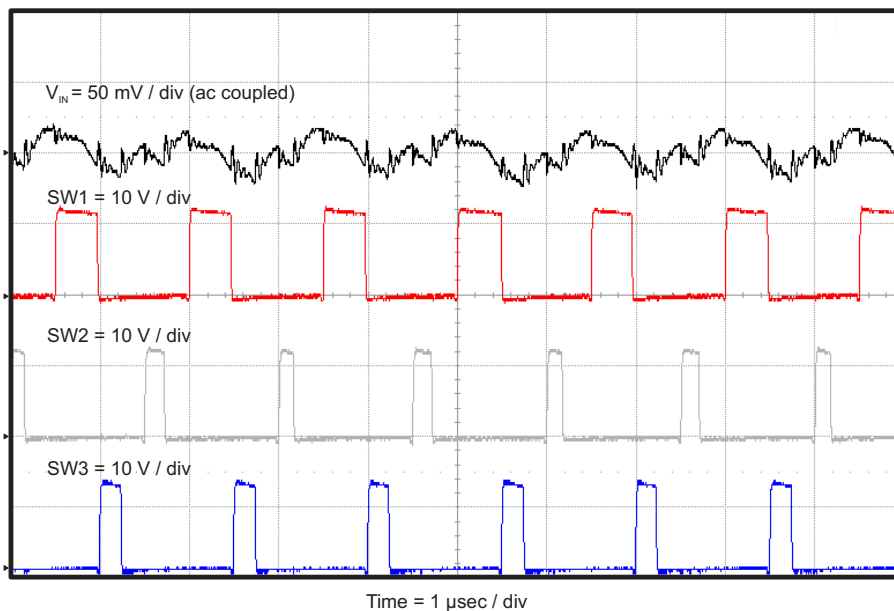


Figure 10. TPS65580EVM-575 Input Voltage Ripple

4.8 Start-Up

The TPS65580EVM-575 start-up waveform for CH1 relative to V_{IN} is shown in Figure 11. Load = 4 Ω resistive. The start up waveforms for CH2 and CH3 are similar and not shown.

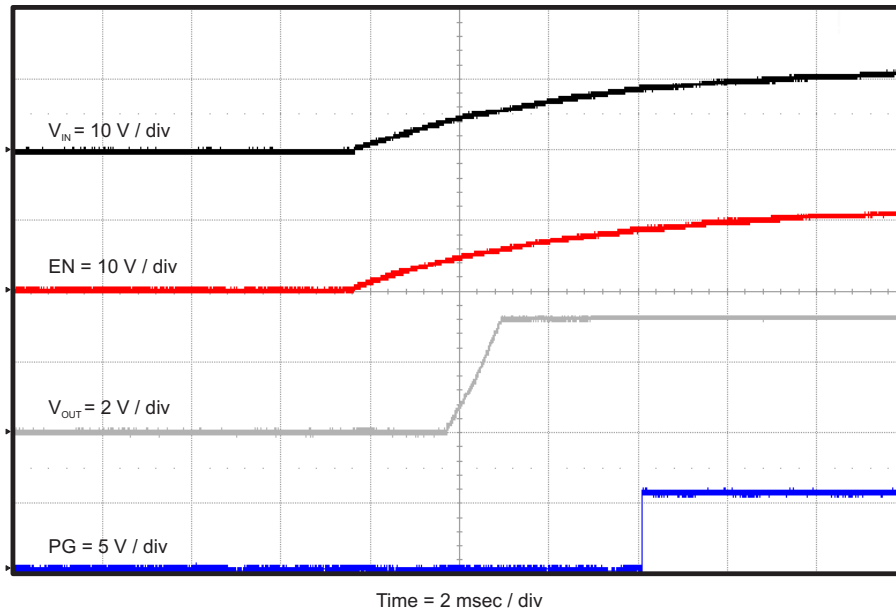


Figure 11. TPS65580EVM-575 CH1 Start-Up Relative to V_{IN}

The TPS65580EVM-575 start-up waveform for CH1 relative to enable (EN) is shown in Figure 12. Load = 4 Ω resistive. The start up waveforms for CH2 and CH3 are similar and not shown.

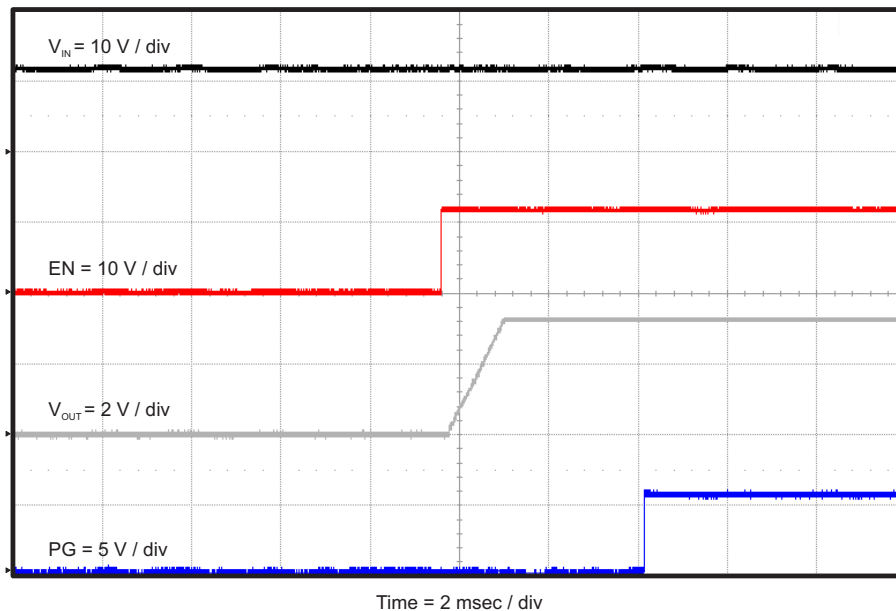


Figure 12. TPS65580EVM-575 CH1 Start-Up Relative to EN

5 Board Layout

This section provides a description of the TPS65580EVM-575, board layout, and layer illustrations.

5.1 Layout

The board layout for the TPS65580EVM-575 is shown in [Figure 13](#) through [Figure 17](#).

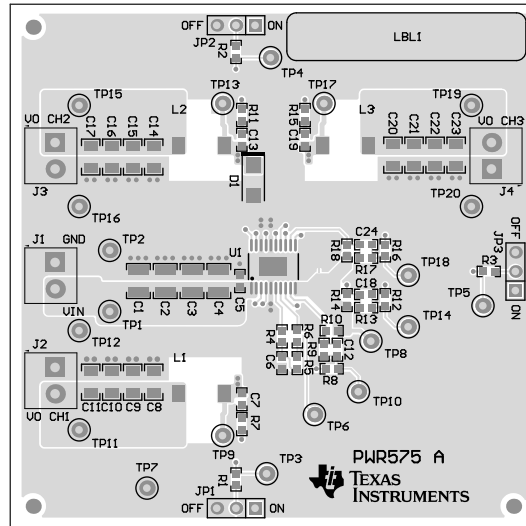


Figure 13. Top Assembly

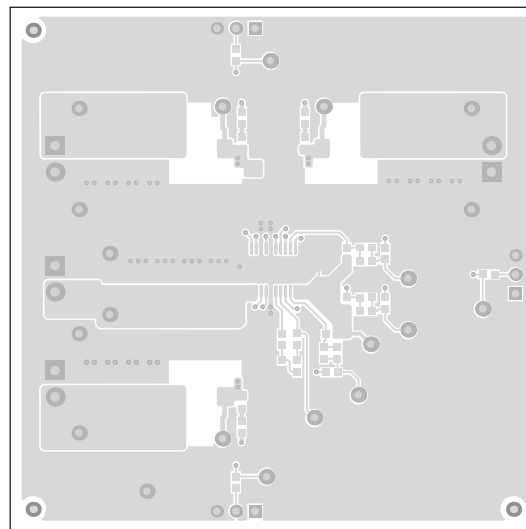


Figure 14. Top Layer

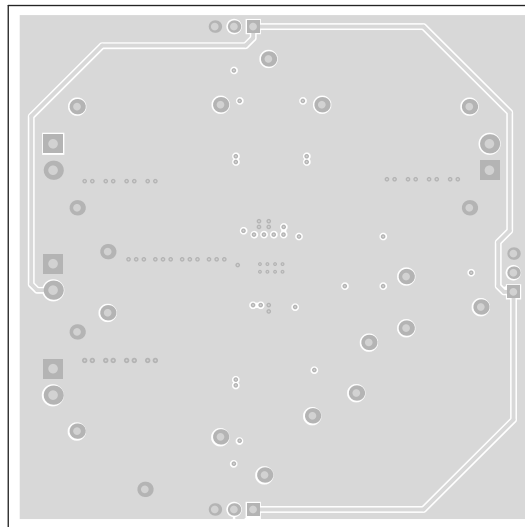


Figure 15. Internal Layer 1

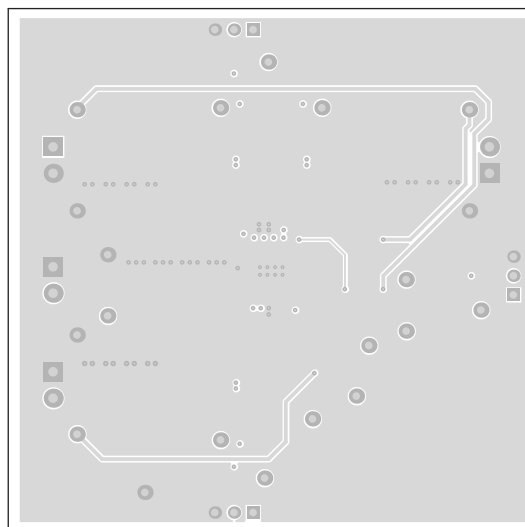


Figure 16. Internal Layer 2

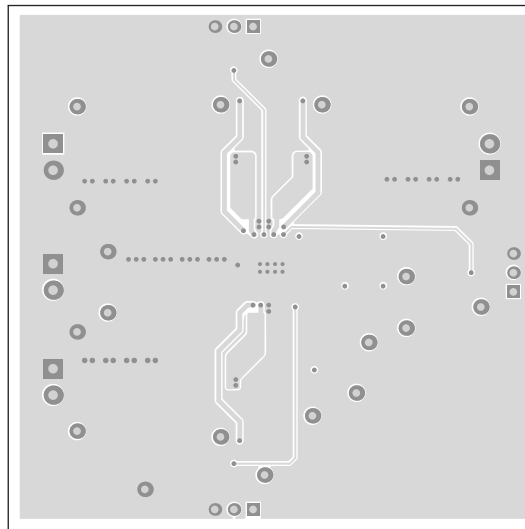


Figure 17. Bottom Layer

6 Schematic, Bill of Materials, and Reference

6.1 Schematic

Figure 18 is the schematic for the TPS65580EVM-575.

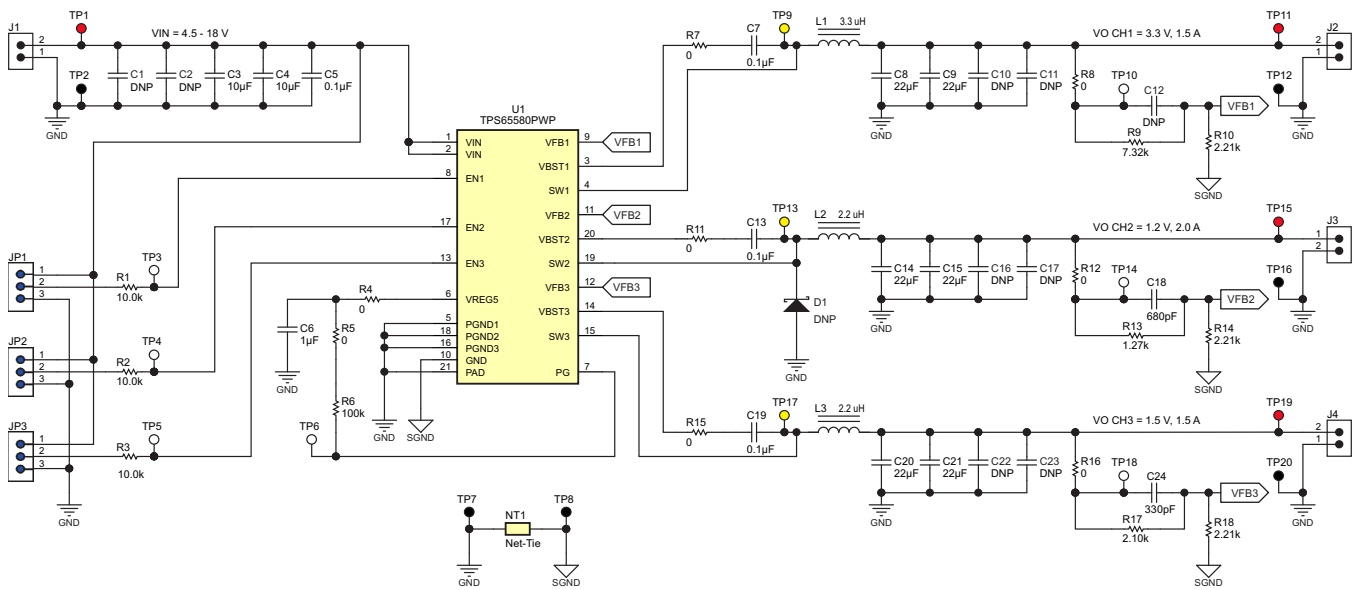


Figure 18. TPS65580EVM-575 Schematic Diagram

6.2 Bill of Materials

Table 5. Bill of Materials

| Designator | Quantity | Value | Description | Package Reference | Part Number | Manufacturer |
|--------------------------------------|----------|-------------|---|----------------------------|--------------------|-----------------------------|
| PCB1 | 1 | | Printed Circuit Board | | PWR575 | Any |
| C3, C4 | 2 | 10 μ F | CAP, CERM, 10uF, 25V, +/-10%, X5R, 1210 | 1210 | GRM32DR61E106KA12L | MuRata |
| C5, C7, C13, C19 | 4 | 0.1 μ F | CAP, CERM, 0.1uF, 25V, +/-10%, X5R, 0603 | 0603 | GRM188R61E104KA01D | MuRata |
| C6 | 1 | 1 μ F | CAP, CERM, 1uF, 10V, +/-10%, X5R, 0603 | 0603 | GRM185R61A105KE36D | MuRata |
| C8, C9, C14, C15, C20, C21 | 6 | 22 μ F | CAP, CERM, 22uF, 10V, +/-10%, X5R, 1206 | 1206 | GRM31CR61A226KE19L | MuRata |
| C18 | 1 | 680 pF | CAP, CERM, 680pF, 50V, +/-10%, X7R, 0603 | 0603 | GRM188R71H681KA01D | MuRata |
| C24 | 1 | 330 pF | CAP, CERM, 330pF, 50V, +/-10%, X7R, 0603 | 0603 | GRM188R71H331KA01D | MuRata |
| J1, J2, J3, J4 | 4 | | Terminal Block, 6A, 3.5mm Pitch, 2-Pos, TH | 7.0x8.2x6.5mm | ED555/2DS | On-Shore Technology, Inc. |
| JP1, JP2, JP3 | 3 | 1x3 | Header, TH, 100mil, 1x3, Gold plated, 230 mil above insulator | PBC03SAAN | PBC03SAAN | Sullins Connector Solutions |
| L1 | 1 | 3.3 μ H | Inductor, Power Line, Magnetic Shielded, \pm 30% | 6.9x7.2 mm | CLF7045T-3R3N | TDK |
| L2, L3 | 2 | 2.2 μ H | Inductor, Power Line, Magnetic Shielded, \pm 30% | 6.9x7.2 mm | CLF7045T-2R2N | TDK |
| R1, R2, R3 | 3 | 10.0k | RES, 10.0k ohm, 1%, 0.1W, 0603 | 0603 | CRCW060310K0FKEA | Vishay-Dale |
| R4, R5, R7, R8, R11, R12, R15, R16 | 8 | 0 | RES, 0 ohm, 5%, 0.1W, 0603 | 0603 | CRCW06030000Z0EA | Vishay-Dale |
| R6 | 1 | 100k | RES, 100k ohm, 1%, 0.1W, 0603 | 0603 | CRCW0603100KFKEA | Vishay-Dale |
| R9 | 1 | 7.32k | RES, 7.32k ohm, 1%, 0.1W, 0603 | 0603 | CRCW06037K32FKEA | Vishay-Dale |
| R10, R14, R18 | 3 | 2.21k | RES, 2.21k ohm, 1%, 0.1W, 0603 | 0603 | CRCW06032K21FKEA | Vishay-Dale |
| R13 | 1 | 1.27k | RES, 1.27k ohm, 1%, 0.1W, 0603 | 0603 | CRCW06031K27FKEA | Vishay-Dale |
| R17 | 1 | 2.10k | RES, 2.10k ohm, 1%, 0.1W, 0603 | 0603 | CRCW06032K10FKEA | Vishay-Dale |
| SH-JP1, SH-JP2, SH-JP3 | 3 | 1x2 | Shunt, 100mil, Gold plated, Black | Shunt | 969102-0000-DA | 3M |
| TP1, TP11, TP15, TP19 | 4 | Red | Test Point, Miniature, Red, TH | Red Miniature Testpoint | 5000 | Keystone |
| TP2, TP7, TP8, TP12, TP16, TP20 | 6 | Black | Test Point, Miniature, Black, TH | Black Miniature Testpoint | 5001 | Keystone |
| TP3, TP4, TP5, TP6, TP10, TP14, TP18 | 7 | White | Test Point, Miniature, White, TH | White Miniature Testpoint | 5002 | Keystone |
| TP9, TP13, TP17 | 3 | Yellow | Test Point, Miniature, Yellow, TH | Yellow Miniature Testpoint | 5004 | Keystone |
| U1 | 1 | | 4.5V to 18V Input 1.5A/2A/1.5A Triple Synchronous Step-Down SWIFT Converter, PWP0020B | PWP0020B | TPS65580PWP | Texas Instruments |
| C1, C2 | 0 | 10uF | CAP, CERM, 10uF, 25V, +/-10%, X5R, 1210 | 1210 | GRM32DR61E106KA12L | MuRata |
| C10, C11, C16, C17, C22, C23 | 0 | 22uF | CAP, CERM, 22uF, 10V, +/-10%, X5R, 1206 | 1206 | GRM31CR61A226KE19L | MuRata |
| C12 | 0 | | CAP, CERM, | | Used in BOM report | Used in BOM report |
| D1 | 0 | 30V | Diode, Schottky, 30V, 3A, SMA | SMA | B330A-13-F | Diodes Inc. |

6.3 Reference

TPS65580: 4.5V to 18V Input 1.5A, 2.5A, 1.5A Triple Synchronous Step-Down Converter data sheet ([SLVSC29](#))

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