Texas Instruments

Using the TPS51020 High-Performance Synchronous Buck

User's Guide

EVM IMPORTANT NOTICE (CATEGORY B)

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DYNAMIC WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the maximum input voltage ranges specified in Table 4.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than 50°C. The EVM is designed to operate properly with certain components above 50°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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Using the TPS51020 High-Performance Buck Controller Evaluation Module

Portable Power Products

CONTENTS

1 Introduction

The TPS51020 is a multi-function dual-synchronous step-down controller. The part is specifically designed for high performance, high-efficiency applications where the loss associated with a current sense resistor is unacceptable. The TPS51020 uses feed-forward voltage mode control to improve the line response. Efficiency at light load conditions can be maintained high as well by incorporating auto-skip operation. The TPS51020 can be used in notebook computer system bus and I/O, DDR I or DDR II termination applications, distributed power and point-of-load regulation for DSPs, FPGAs, ASICs, etc. in servers, base stations, and broadband, networking or optical communications systems.

TPS51020EVM−001 evaluation module (EVM) is a high-efficiency, dual synchronous buck converter providing 5 V at 6.0 A and 3.3 V at 6.0 A from an 8.0 V to 20 V input. The TPS51020 operates at 300 kHz with a peak efficiency of 94.8% with both channels enabled. This user’s guide describes the TPS51020EVM−001 performance in dual mode.

2 Electrical Performance Specifications

A summary of performance specifications for TPS51020EVM−001 is provided in Table 1.

2.1 Performance Specification Summary

Table 1. Performance Specification Summary(1)

SPECIFICATION	TEST CONDITIONS	MIN	TYP	MAX	UNIT
GENERAL					
Input voltage range, $V_{IN(DC)}$		8	12	20	V
Operating frequency			300		kHz
Input ripple voltage (RMS value)	V_{IN} = 12 V, I_{OUT1} = 6 A, I_{OUT2} = 6 A		194		mV
CHANNEL1 (V_{O1}, GND)					
Maximum output current	8 V ≤ V_{IN} ≤ 20 V,	6			A
Output voltage		4.85	5.00	5.13	V
Line regulation	I_{OUT1} = 6 A, 8 V ≤ V_{IN} ≤ 20 V			0.1%	
Load regulation	V_{IN} = 12 V, 0 A ≤ I_{OUT1} ≤ 6 A			0.1%	
Load transient response voltage change	I_{OUT1} rising from 0 A to 5 A		30		mV_{P-P}
	I_{OUT1} falling from 5 A to 0 A		60		
Load transient response recovery time	I_{OUT1} rising from 0 A to 5 A			500	µs
	I_{OUT1} falling from 5 A to 0 A			500	
Loop bandwidth	I_{OUT1} = 6 A, V_{IN} = 12 V		14		kHz
Phase margin	I_{OUT1} = 6 A, V_{IN} = 12 V		32		°
Output ripple voltage	I_{OUT1} = 6 A, V_{IN} = 12 V		36	60	mV_{P-P}
Output rise time	I_{OUT1} = 6 A, V_{IN} = 12 V, V_{O1} = 5 V		4.6		ms
Full load efficiency	I_{OUT1} = 6 A, I_{OUT2} = 0 A, V_{IN} = 12 V, V_{O1} = 5 V		93.9%		
CHANNEL2 (V_{O2}, GND)					
Maximum output current	8 V ≤ V_{IN} ≤ 20 V,	6			A
Output voltage		3.21	3.30	3.38	V
Line regulation	I_{OUT2} = 6 A, 8 V ≤ V_{IN} ≤ 20 V			0.1%	
Load regulation	V_{IN} = 12 V, 0 A ≤ I_{OUT2} ≤ 6 A			0.2%	
Load transient response voltage change	I_{OUT2} rising from 0 A to 5 A		50		mV_{P-P}
	I_{OUT2} falling from 5 A to 0 A		50		
Load transient response recovery time	I_{OUT2} rising from 0 A to 5 A			500	µs
	I_{OUT2} falling from 5 A to 0 A			500	
Loop bandwidth	I_{OUT2} = 6 A, V_{IN} = 12 V		15		kHz
Phase margin	I_{OUT2} = 6 A, V_{IN} = 12 V		41		°
Output ripple voltage	I_{OUT2} = 6 A, V_{IN} = 12 V		34	60	mV_{P-P}
Output rise time	I_{OUT2} = 6 A, V_{IN} = 12 V, V_{O2} = 3.3 V		4.72		ms
Full load efficiency	I_{OUT1} = 0 A, I_{OUT2} = 6 A, V_{IN} = 12 V, V_{O2} = 3.3 V		91.3%		

3 TPS51020EVM−001 Circuit Module Schematic

Figure 1 shows the TPS51020EVM−001 circuit module schematic diagram.

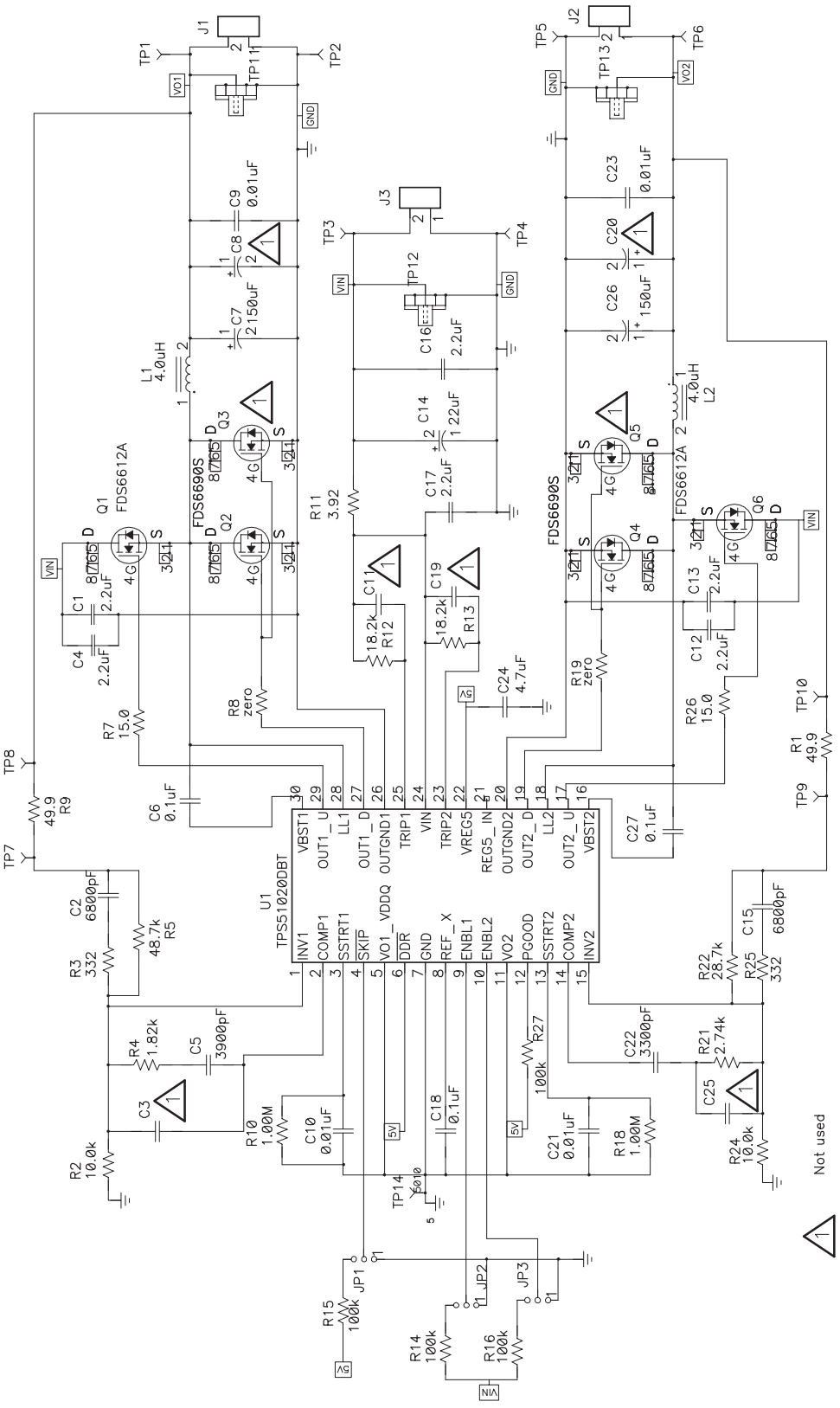

Figure 1. TPS51020EVM−001 Schematic

4 Test Setup and Results

4.1 Test Setup

The HPA064 has the following input/output connections: 12-V input through J3 (VIN and GND), 5.0-V output through J1 (VO1 and GND), 3.3-V output through J2 (VO2 and GND). A diagram showing the connection points is shown in Figure 2. A power supply capable of supplying 6 A should be connected to VIN and GND through a pair of 16 AWG wires. The 5.0-V and 3.3-V loads should be connected respectively to VO1, GND and VO2, GND2 through pairs of 16 AWG wires. Wire lengths should be minimized to reduce losses in the wires.

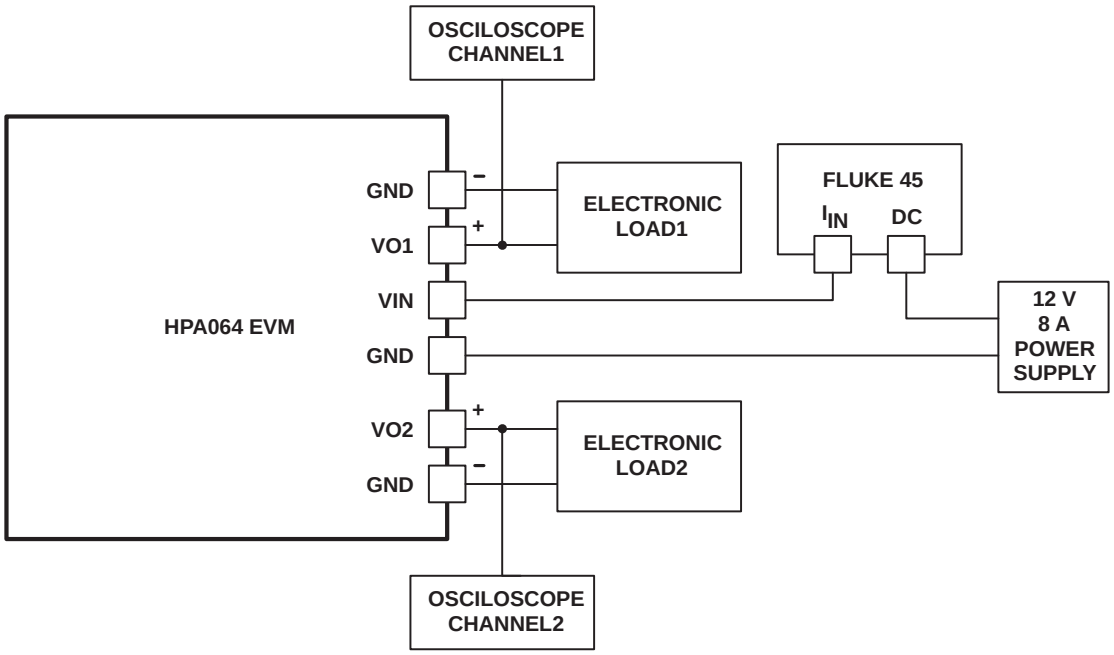

Figure 2. TPS51020EVM−001 Schematic

4.2 Power-Up and Power-Down

Figures 3 and 4 show the power-up and power-down waveforms. The powergood (PGOOD) pin jumps to high after both outputs have started and have been in regulation for 2048 clock pulses (6.8 ms).

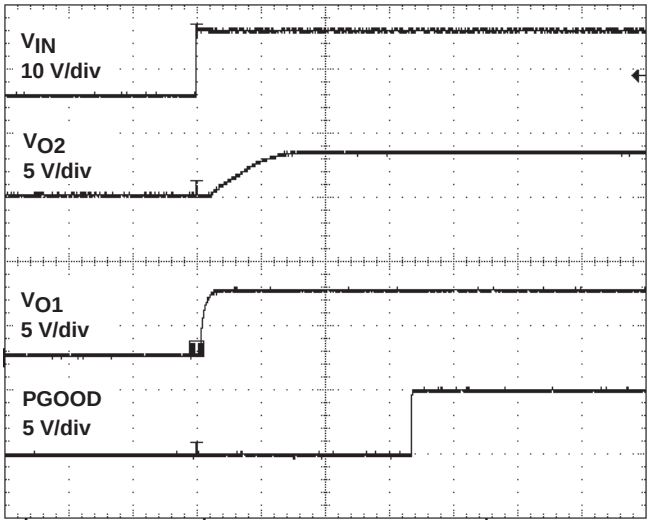

Figure 3. Power-Up Waveform

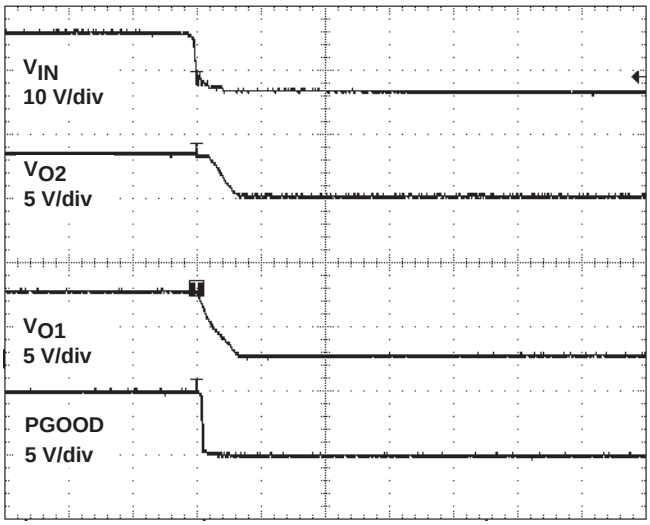

Figure 4. Power-Down Waveform

4.3 Efficiency and Power Loss

Figures 5 and 6 show the test efficiency and power losses vs. load current at different conditions. The maximum efficiency is approximately 94.8% when both channels are enabled. The total power loss is 3.5 W when both channels are on and deliverying 6.0 A.

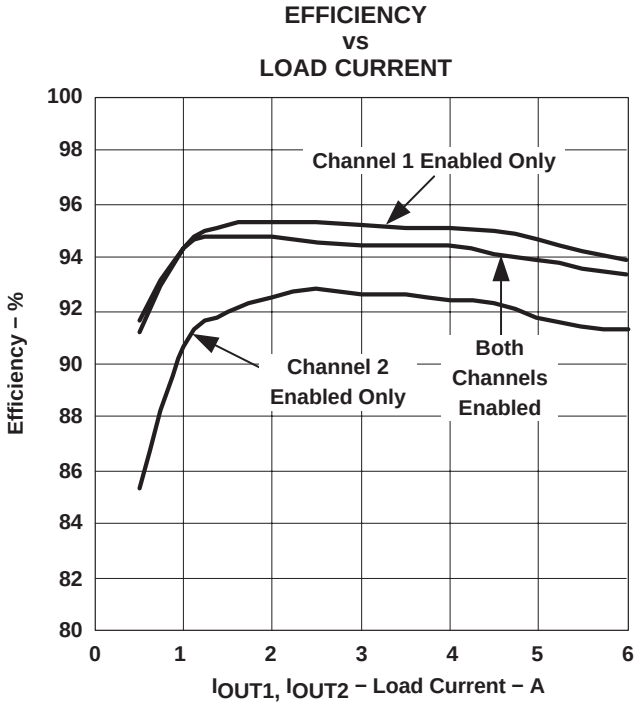

Figure 5.

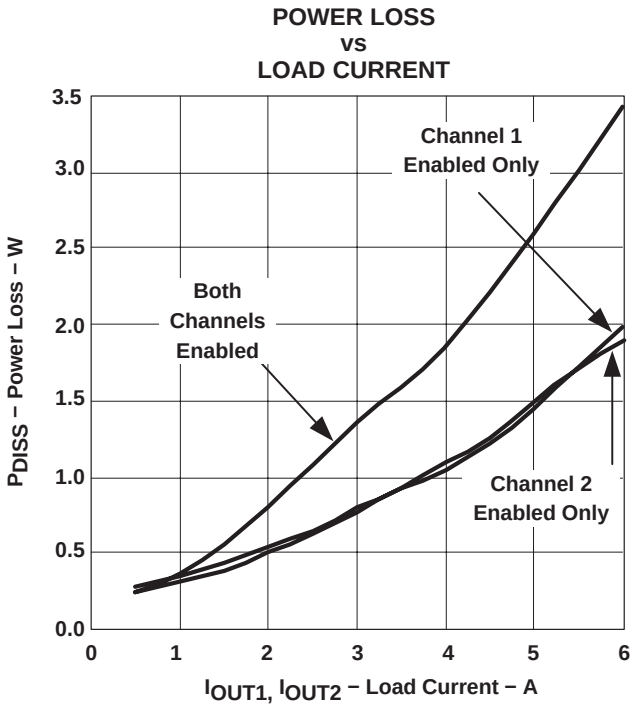

Figure 6.

4.4 Output Ripple

In Figure 7 the output ripple waveform shows that two channels are running at 180º phase shift. The peak-to-peak ripple voltage is less than 40 mV in each channel.

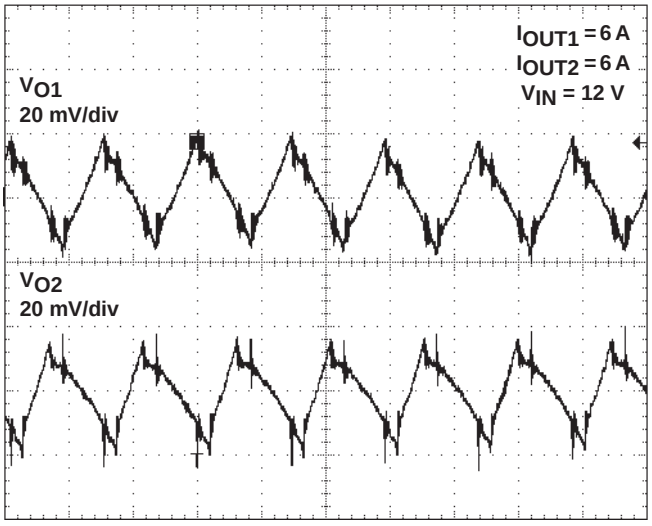

Figure 7. Output Ripple

4.5 Load Transient

Figures 8 and 9 show the load transient waveforms for each channel. When load is stepped from 0 A to 5 A, the undershoot voltage is less than 60 mV and the settling time is less than 30 μs. When load is stepped down from 5 A to 0 A, the overshoot voltage is less than 50 mV and the settling time is less than 50 μs.

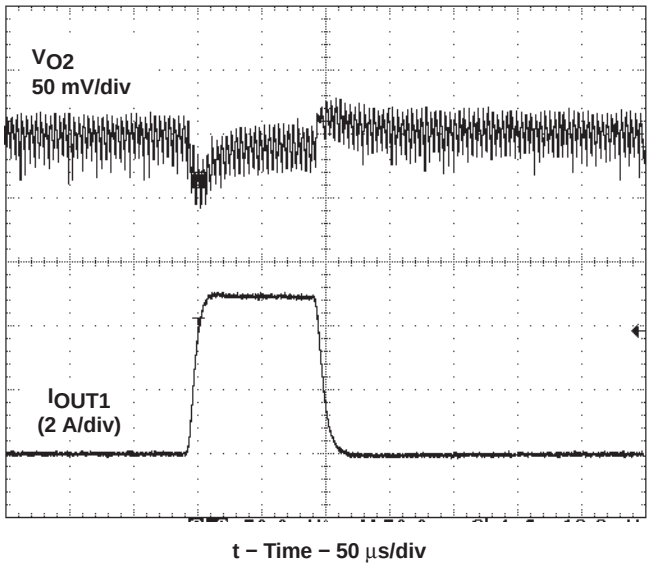

Figure 8. Channel 1 Load Transient Waveform

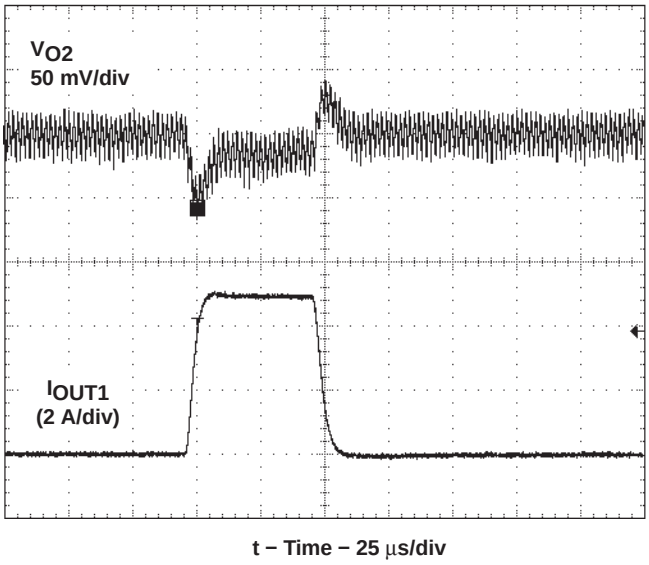

Figure 9. Channel 2 Load Transient Waveform

4.6 Loop Characteristics

Figures 10 and 11 show the bode plot of each channel. The crossover frequency is approximately 14 kHz and the phase margin is 32° for Channel 1 when the output is 5 V and 6 A. Channel 2 shows a 15-kHz crossover frequency and a 41° phase margin.

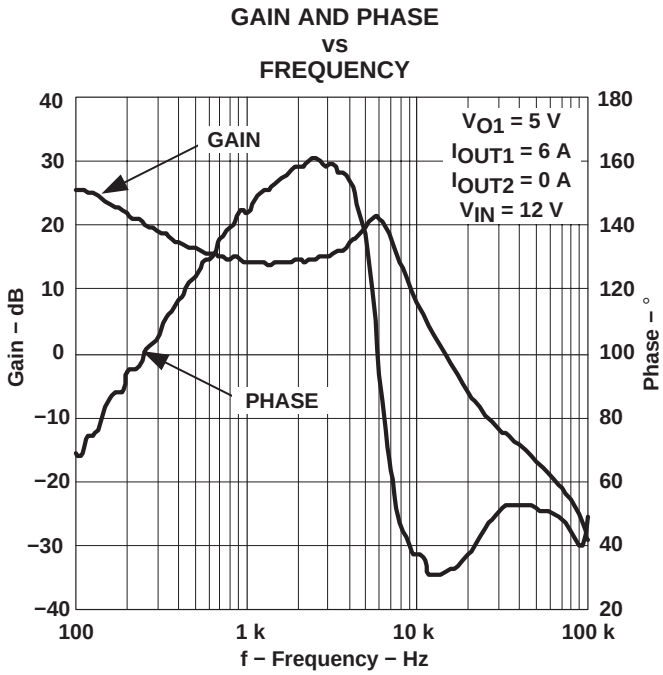

Figure 10. Channel 1 Bode Plot

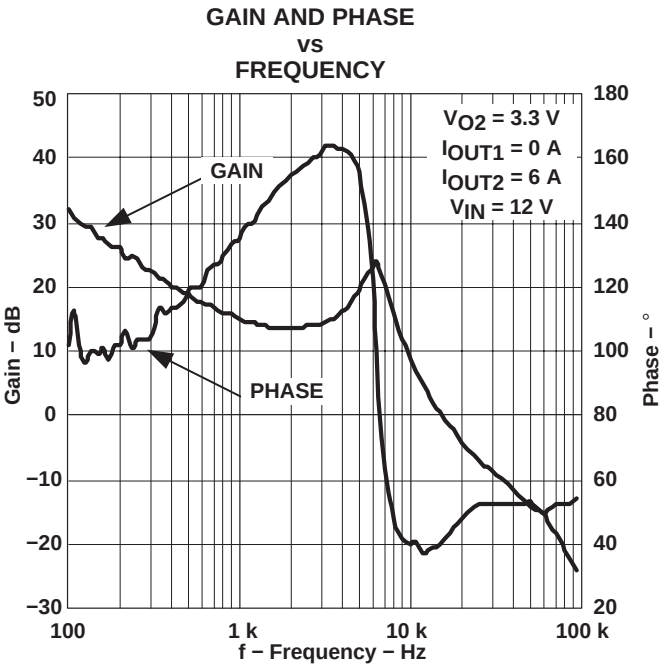

Figure 11. Channel 2 Bode Plot

5 TPS51020EVM−001 Assembly Drawing and PCB Layout

Figures 12 through 16 show the assembly drawing and each layer.

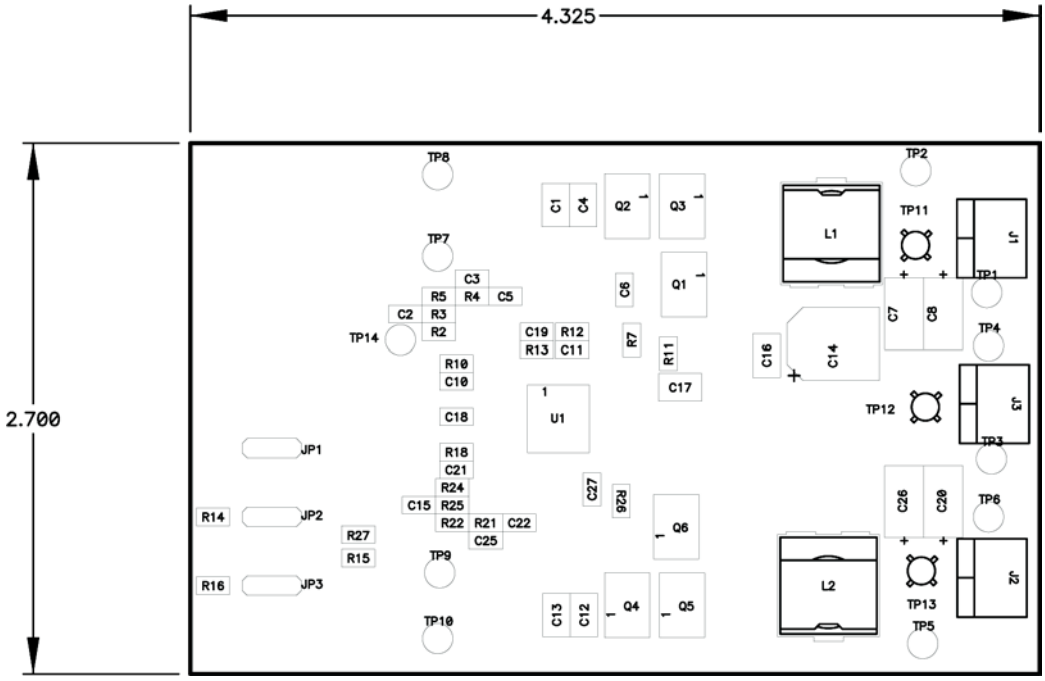

Figure 12. Top Assembly

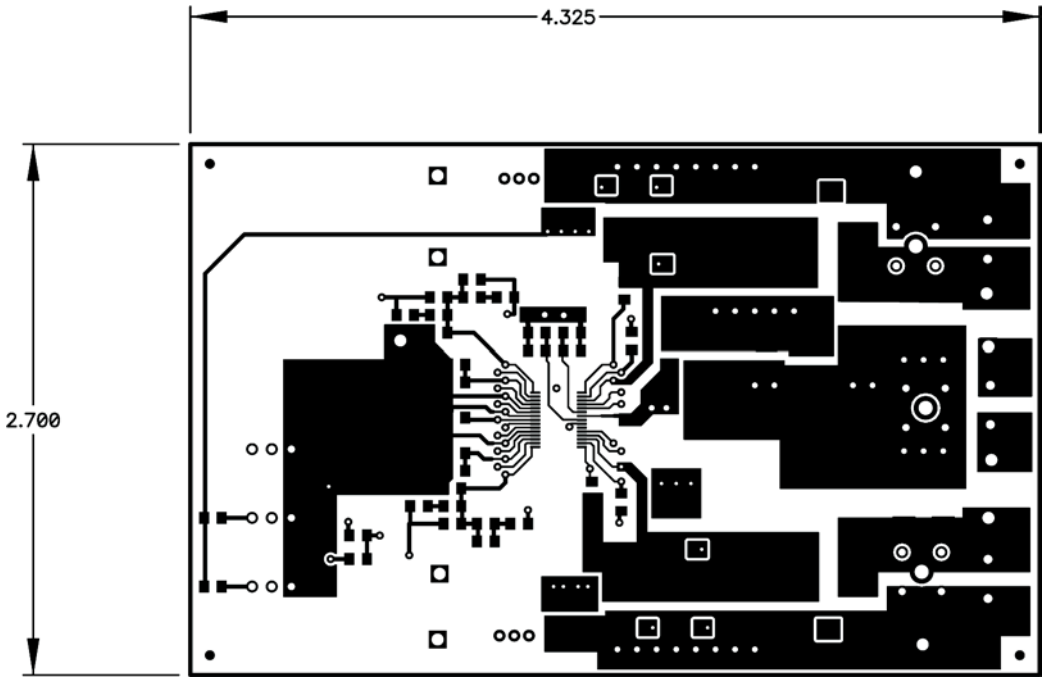

Figure 13. Top Layer

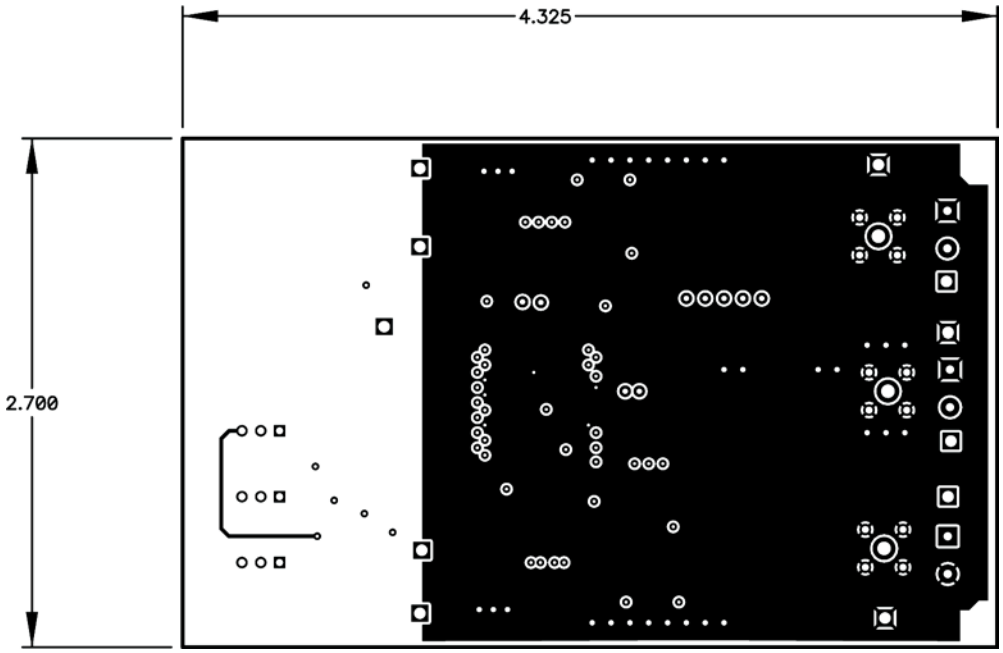

Figure 14. Inner Layer 1

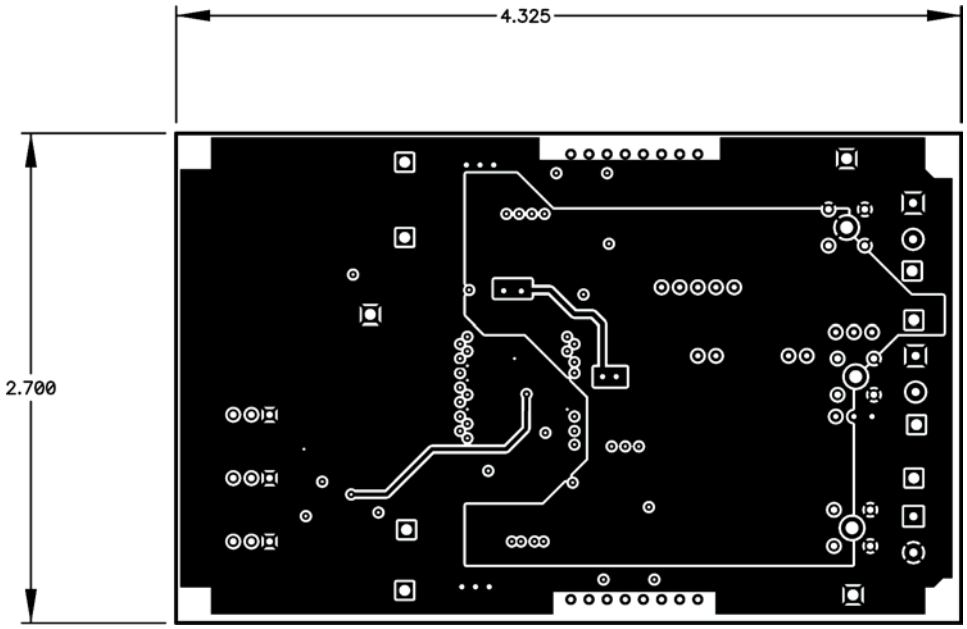

Figure 15. Inner Layer 2

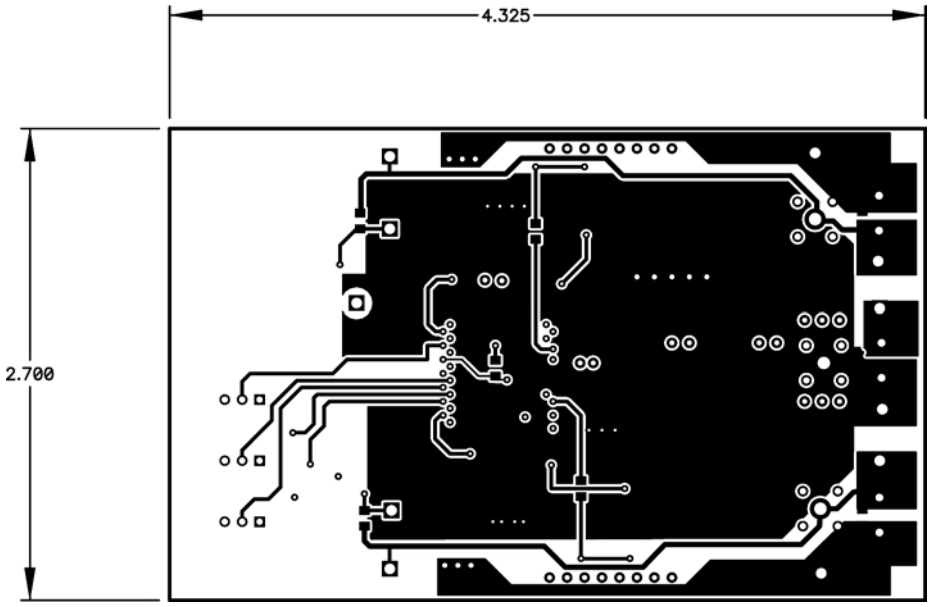

Figure 16. Bottom Layer

6 TPS51020EVM−001 Circuit Module List of Materials

List of materials required for the TPS51020EVM−001.

Table 2. List of Materials

RERERENCE DESIGNATOR	QTY	DESCRIPTION	SIZE	MFR	PART NUMBER
C1, C4, C12, C13, C16, C17	6	Capacitor, ceramic, 2.2 μF, 25 V, X5R, 10%	1210	Panasonic	ECJ−4YB1E225K
C2, C15	2	Capacitor, ceramic, 6800 pF, 25 V, X7R, 10%	805	Std	Std
C3, C11, C19, C25	0	Capacitor, ceramic, TBD	805	Std	Std
C24	1	Capacitor, ceramic, 4.7 μF, 25 V, X5R, 10%	805	Panasonic	ECJ−2FB1E475M
C22	1	Capacitor, ceramic, 3300 pF, 25 V, X7R, 5%	805	Std	Std
C14	1	Capacitor, aluminum solid cap, with conductive polymer 22 μF, 35 V, 20%	8.3m (E7)	Sanyo	35SVPD22M
C5	1	Capacitor, ceramic, 3900 pF, 25 V, X7R, 5%	805	Std	Std
C6, C18, C27	3	Capacitor, ceramic, 0.1 μF, 25 V, X7R, 10%	805	Std	Std
C7, C26	2	Capacitor, aluminum, 150 μF, 6.3 V, 20% (UE Series)	7343	Panasonic	EEF−UE0J151R
C8, C20	0	Capacitor, aluminum, 150 μF, 6.3 V, 20% (UE Series)	7343	Panasonic	EEF−UE0J151R
C9, C10, C21, C23	4	Capacitor, ceramic, 0.01 μF, 25 V, X7R, 10%	805	Std	Std
L1, L2	2	Inductor, SMT, 4.0 μH, 10.3 A, 8.0 mΩ	0.492 sq”	Sumida	CEP125(H)−4R0
Shorts Jumper	3	STC02SYAN	Shorts Jumper	Sullins	N/A
JP, JP2, JP3	3	Header, 3 pin, 100mil spacing, (36 pin strip)	0.100 × 3	Sullins	PTC36SAAN
R1, R9	2	Resistor, chip, 49.9 Ω, 1/10−W, 1%	805	Vishay	Std
R10, R18	2	Resistor, chip, 1M Ω, 1/10W, 1%	805	Vishay	Std
R4	1	Resistor, chip, 1.82 kΩ, 1/10W, 1%	805	Vishay	Std
R21	1	Resistor, chip, 2.74 kΩ, 1/10W, 1%	805	Vishay	Std
R11	1	Resistor, chip, 3.92 kΩ, 1/10W, 1%	805	Vishay	Std
R2, R24	2	Resistor, chip, 10.0 kΩ, 1/10W, 1%	805	Vishay	Std
R7, R26	2	Resistor, chip, 15 Ω, 1/10W, 1%	805	Vishay	Std
R12, R13	2	Resistor, chip, 18.2 kΩ, 1/10W, 1%	805	Vishay	Std
R22	1	Resistor, chip, 28.7 kΩs, 1/10W, 1%	805	Vishay	Std
R5	1	Resistor, chip, 48.7 kΩs, 1/10W, 1%	805	Vishay	Std
R14, R15, R16, R27	4	Resistor, chip, 100 kΩ, 1/10W, 1%	805	Vishay	Std
R3, R25	2	Resistor, chip, 332 Ω, 1/10W, 1%	805	Vishay	Std
R8, R19	2	Resistor, chip, 0 Ω, 1/10W, 1%	805	Vishay	Std
J1, J2, J3	3	Terminal block, 2 pin, 15 A, 5.1mm	0.40 × 0.35	OST	ED1609
TP1, TP3, TP6, TP8, TP10	5	Test point, 0.062 hole, red	0.25	Keystone	5011
TP2, TP4, TP5, TP7, TP9, TP14	6	Test point, 0.062 hole, black	0.25	Keystone	5010
U1	1	Dual voltage mode, DDR selectable, syncronous, step-down controller for notebook	TSSOP30	TI	TPS51020DBT
TP11, T12, TP13	3	Adaptor, 3.5 mm probe clip (or 131−5031−00)	0.2	Tektronix	131−4244−00
Q1, Q6	2	Transistor, MOSFET, N-channel, 30 V, 8.4 A, Rds 22 mΩ	SO−8	Fairchild	FDS6612A
Q2, Q4	2	Transistor, MOSFET, N-channel, 30 V, 10 A, Rds 16 mΩ	SO−8	Fairchild	FDS6690S
Q3, Q5	0	Transistor, MOSFET, N-channel, 30 V, 10 A, Rds 16 mΩ	SO−8	Fairchild	FDS6690S

7 References

1. TPS51020 Datasheet, Dual, Voltage Mode, DDR Selectable, Synchronous, Step−down Controller for Notebook System (SLUS564B)

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