

# ***High Performance Synchronous Buck EVM Using the TPS5210***

## *User's Guide*

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# Read This First

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### ***About This Manual***

This User's Guide describes how to connect and evaluate a synchronous buck regulator using a TI TPS5210 Programmable Synchronous Buck Regulator Controller.

The User's Guide describes the TPS5210EVM-119 Buck Converter Evaluation Module (SLVP119) that provides a convenient method for evaluating the performance of a synchronous buck converter using the TPS5210 Ripple Regulator Controller designed to meet or exceed the Intel VRM8.3 DC-DC converter electrical specifications. A complete designed and tested power supply is presented. Test results can be found in *Designing Fast Response Synchronous Buck Regulators Using the TPS5210* Application Report, Literature Number SLVA044

### ***How to Use This Manual***

This document contains the following chapters:

- Chapter 1 Introduction
- Chapter 2 Schematic
- Chapter 3 Physical Layouts
- Chapter 4 Bills of Material

### ***Related Documentation From Texas Instruments***

- Designing Fast Response Synchronous Buck Regulators Using the TPS5210* Application Report, Literature Number SLVA044.
- TPS5210 PROGRAMMABLE SYNCHRONOUS-BUCK REGULATOR CONTROLLER* Data Sheet, Literature Number SLVS171

### ***Related Documentation From Intel***

- VRM 8.3 DC-DC Converter Design Guidelines* Intel document Order number: 243870-001, June 1998.

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# Introduction

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This user's guide describes the TPS5210EVM-119 Synchronous Buck Converter Evaluation Module (SLVP119). The SLVP119 provides a convenient method for evaluating the performance of a synchronous buck converter using the TPS5210 Ripple Regulator Controller. The TPS5210 meets or exceeds the Intel VRM8.3 dc-dc converter electrical specifications. A complete designed and tested power supply is presented. The power supply is a programmable step-down dc-dc EVM that can deliver up to 20 A of continuous output current at a programmable output voltage from 1.3 V to 3.5 V determined by a 5 bit DAC code. The PWB board layout provides test points for viewing waveforms.

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## 1.1 Background

New high performance microprocessors may require from 40 to 80 watts of power for the CPU alone. Load current must be supplied with up to 30 A/ $\mu$ s slew rate while keeping the output voltage within tight regulation and response time tolerances. Parasitic interconnect impedances between the power supply and the processor must be kept to a minimum. Fast responding synchronous buck dc/dc converters controlled by the Texas Instruments TPS5210 hysteretic controller are ideally suited for microprocessor power applications requiring fast response and precise regulation to rapidly changing loads.

Conventional synchronous regulator control techniques include fixed frequency voltage-mode, fixed frequency current-mode, variable frequency current-mode, variable on-time, or variable off-time. CPU power supplies that are designed using these types of control methods require additional bulk storage capacitors on the output to maintain  $V_O$  within the regulation limits during the high di/dt load transients because of the limited bandwidth of the controller. Some controllers add a fast loop around the slower main control loop to improve the response time, but  $V_O$  must deviate outside a fixed tolerance band before the fast loop becomes active. The hysteretic control method employed by the TPS5210 offers superior performance with no requirements for additional output capacitance or difficult loop compensation design.

The TPS5210 controller was optimized for tight  $V_O$  regulation under static and dynamic load conditions for improved system efficiency. The TP5520 can operate in systems that derive main power from 12 V or 5 V.



## 1.2 Performance Specification Summary

This section summarizes the performance specifications of the SLVP119 converter. Table 1–1 gives the performance specifications of the converters.

Table 1–1. Performance Specification Summary

SPECIFICATION		TEST CONDITIONS	MIN	TYP	MAX	UNITS
Input voltage range	Main power ( $V_I$ )		4.5		13	V
	5-V input		4.5	5	5.5	V
	12-V input		11.4	12	13	V
Output voltage range		See Note 1	1.3	2	3.5	V
Static voltage tolerance		See Note 2	1.98	2	2.02	V
Line regulation		See Notes 1 and 3		±0.05%	±0.1%	
Load regulation		See Notes 4 and 5		±0.1%	±0.4%	
Transient response		See Note 6	±55			mV pk
			50			μsec
Output current range		See Note 3	0		20	A
Current limit		See Note 3	20			A
Output ripple		See Notes 3 and 5		35		mV
Soft-start risetime		See Note 4		10		ms
Operating frequency		See Notes 1 and 4		125		kHz
Efficiency, 10 A load		See Notes 2 and 4		90%		
Efficiency, 4 A load		See Notes 2 and 4		86%		

- Notes:**
- 1)  $I_O = 12$  A.
  - 2) VID inputs set for  $V_{REF} = 2$  V.
  - 3) Input voltage can be at any point over entire range.
  - 4) Input voltage adjusted to 12 Vdc.
  - 5)  $I_O$  can be at any point over entire range.
  - 6)  $I_O$  pulsed from 0 A to 16 A,  $di/dt = 30$  A/μs.

### 1.3 Voltage Identification Codes

The output voltage is programmed by driving the 5 VID inputs. The output voltage for a given VID input is shown in Table 1–2.

Table 1–2. Voltage Identification Codes

VID Terminals (0 = GND, 1 = floating or pull-up to 5 V)					VREF (Vdc)
VID4	VID3	VID2	VID1	VID0	
0	1	1	1	1	1.30
0	1	1	1	0	1.35
0	1	1	0	1	1.40
0	1	1	0	0	1.45
0	1	0	1	1	1.50
0	1	0	1	0	1.55
0	1	0	0	1	1.60
0	1	0	0	0	1.65
0	0	1	1	1	1.70
0	0	1	1	0	1.75
0	0	1	0	1	1.80
0	0	1	0	0	1.85
0	0	0	1	1	1.90
0	0	0	1	0	1.95
0	0	0	0	1	2.00
0	0	0	0	0	2.05
1	1	1	1	1	No CPU
1	1	1	1	0	2.10
1	1	1	0	1	2.20
1	1	1	0	0	2.30
1	1	0	1	1	2.40
1	1	0	1	0	2.50
1	1	0	0	1	2.60
1	1	0	0	0	2.70
1	0	1	1	1	2.80
1	0	1	1	0	2.90
1	0	1	0	1	3.00
1	0	1	0	0	3.10
1	0	0	1	1	3.20
1	0	0	1	0	3.30
1	0	0	0	1	3.40
1	0	0	0	0	3.50

# Schematic



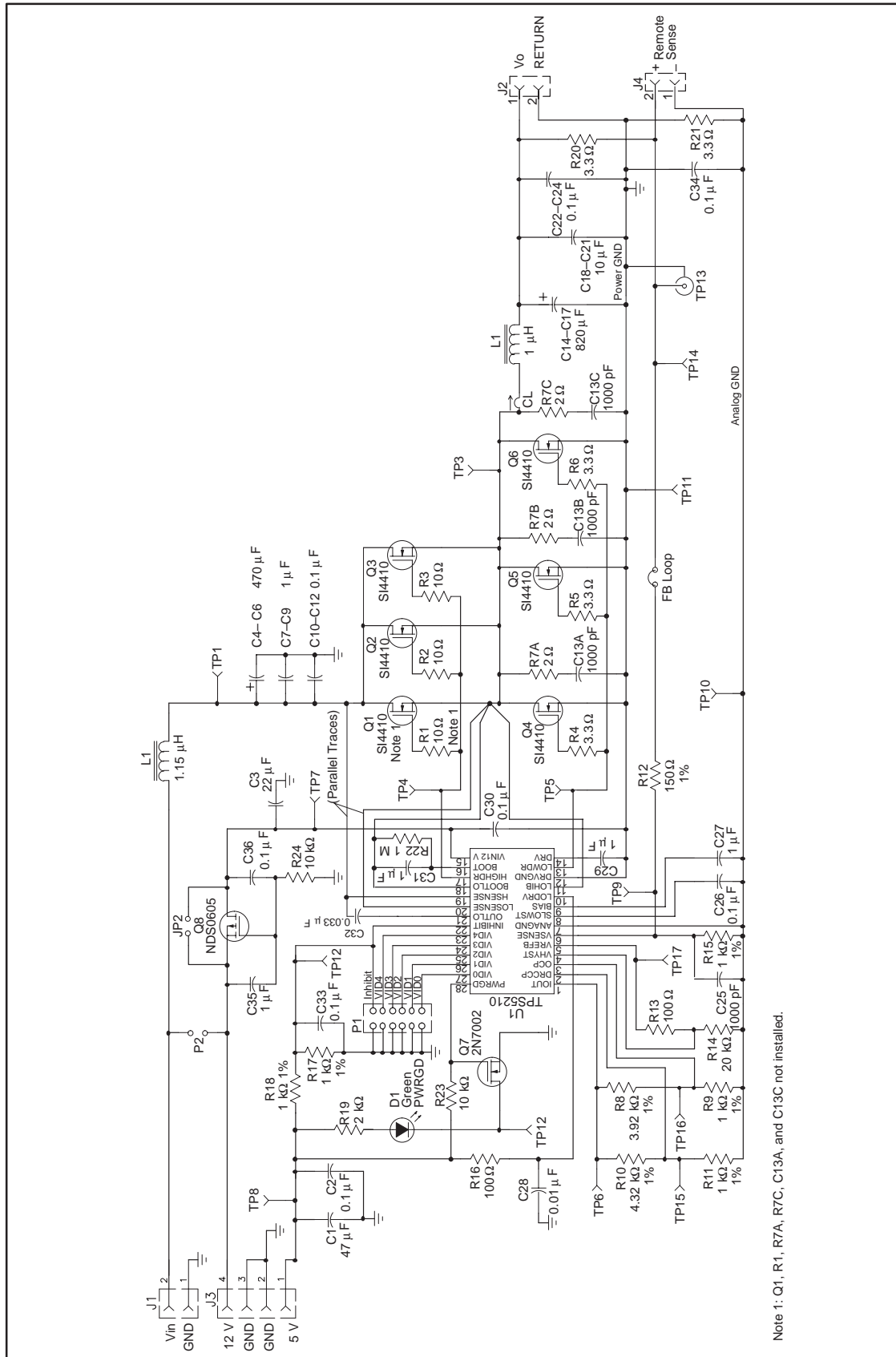
This chapter contains the schematic diagram for the SLVP119 EVM.

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## **2.1 Schematic Diagram**

Figure 2–1 shows the SLVP119 EVM schematic diagram.

Figure 2-1. SLVP119 Schematic Diagram



Note 1: Q1, R1, R7A, R7C, C13A, and C13C not installed.



# Physical Layouts

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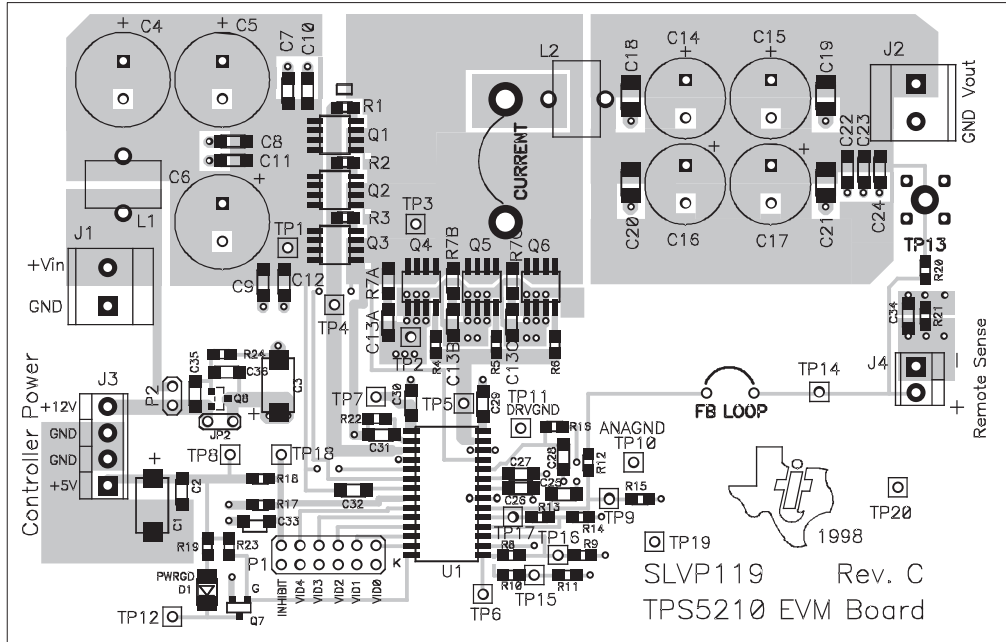
This chapter contains the board layout and I/O connection drawings for the SLVP119 EVM.

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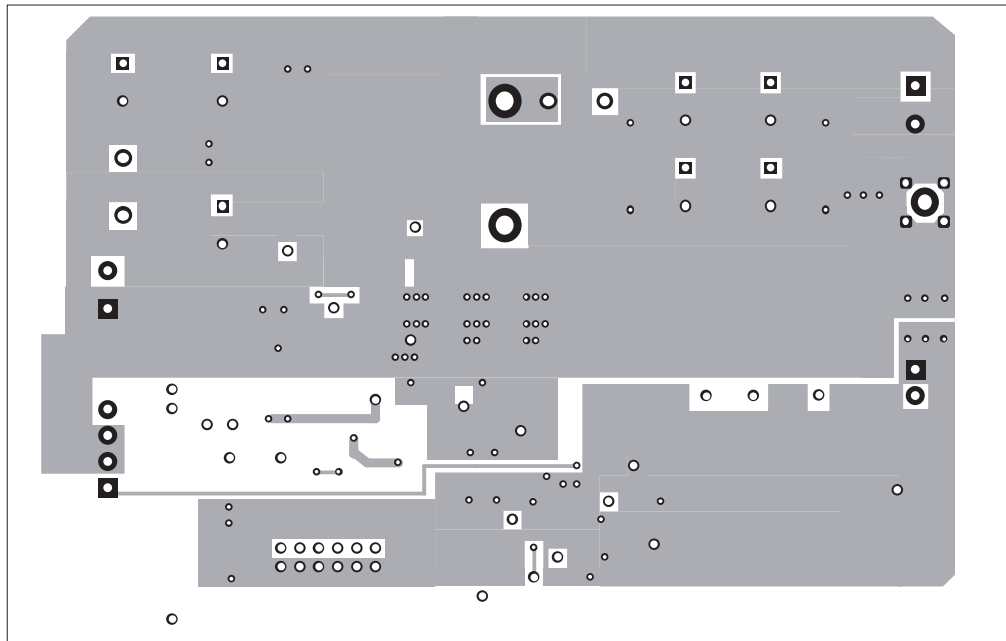
### 3.1 Board Layout

The power supply module consists of one PWB. The board layout includes many test points so that waveforms may be viewed during operation. Figure 3–1 shows the front view and back view of the SLVP119 EVM board.

Figure 3–1. SLVP119 Board Layout



Top Assembly



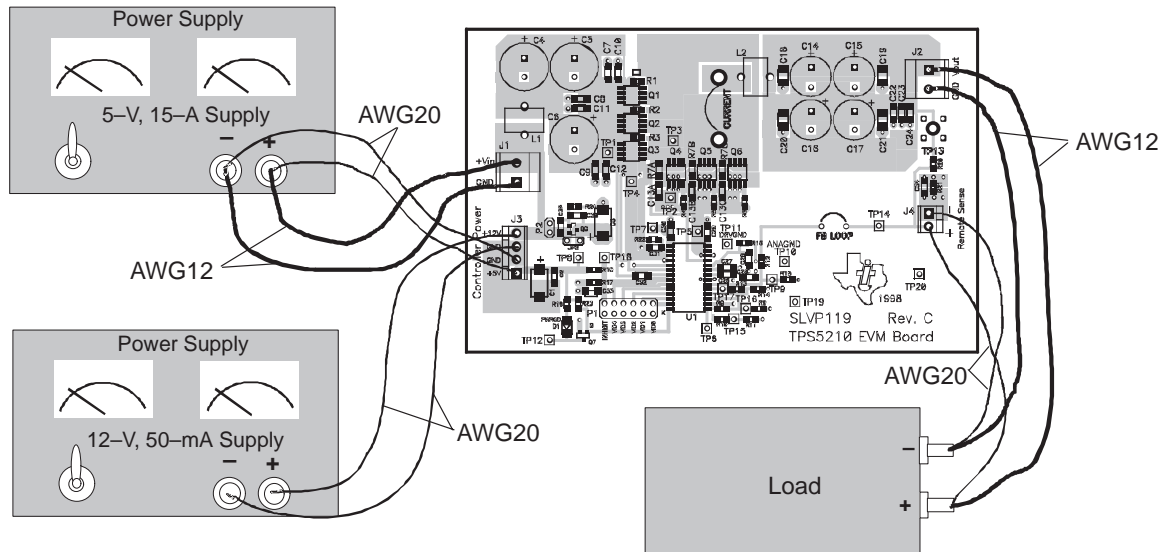
Bottom Layer (Top View)



### 3.2 Input/Output Connections

Figure 3–2 shows the input/output connections to the SLVP119.

Figure 3–2. SLVP119 Input/Output Connections



Note: All wire pairs should be twisted.



# Bill of Materials



This chapter contains the bill of materials required for the SLVP119EVM.

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## 4.1 Bill of Materials

Table 4–1 lists materials required for the SLVP119 EVM.

Table 4–1. SLVP119 Bill of Materials

REF DES	PART NUMBER	DESCRIPTION	MFG
C1	ECS–H1AD476R	Capacitor, Tantalum, 47 $\mu$ F, 10 V, 20%	Panasonic
C2	GRM42–6X7R104K050A	Capacitor, Ceramic, 0.1 $\mu$ F, 50 V, 10%, X7R	muRata
C3	ECS–H1CD226R	Capacitor, Tantalum, 22 $\mu$ F, 16 V, 20%	Panasonic
C4	16SA470M	Capacitor, Os–Con, 470 $\mu$ F, 16 V, 20%	Sanyo
C5	16SA470M	Capacitor, Os–Con, 470 $\mu$ F, 16 V, 20%	Sanyo
C6	16SA470M	Capacitor, Os–Con, 470 $\mu$ F, 16 V, 20%	Sanyo
C7	GRM42–6Y5V105Z025A	Capacitor, Ceramic, 1 $\mu$ F, 25 V, 80%–20%, Y5V	muRata
C8	GRM42–6Y5V105Z025A	Capacitor, Ceramic, 1 $\mu$ F, 25 V, 80%–20%, Y5V	muRata
C9	GRM42–6Y5V105Z025A	Capacitor, Ceramic, 1 $\mu$ F, 25 V, 80%–20%, Y5V	muRata
C10	GRM42–6X7R104K050A	Capacitor, Ceramic, 0.1 $\mu$ F, 50 V, 10%, X7R	muRata
C11	GRM42–6X7R104K050A	Capacitor, Ceramic, 0.1 $\mu$ F, 50 V, 10%, X7R	muRata
C12	GRM42–6X7R104K050A	Capacitor, Ceramic, 0.1 $\mu$ F, 50 V, 10%, X7R	muRata
C13A†	GRM42–6X7R102K050A	Capacitor, Ceramic, 1000 pF, 50 V, 10%, X7R	muRata
C13B	GRM42–6X7R102K050A	Capacitor, Ceramic, 1000 pF, 50 V, 10%, X7R	muRata
C13C†	GRM42–6X7R102K050A	Capacitor, Ceramic, 1000 pF, 50 V, 10%, X7R	muRata
C14	4SP820M	Capacitor, OS–Con, 820 $\mu$ F, 4 V, 20%	Sanyo
C15	4SP820M	Capacitor, OS–Con, 820 $\mu$ F, 4 V, 20%	Sanyo
C16	4SP820M	Capacitor, OS–Con, 820 $\mu$ F, 4 V, 20%	Sanyo
C17	4SP820M	Capacitor, OS–Con, 820 $\mu$ F, 4 V, 20%	Sanyo
C18	GRM235Y5V106Z016A	Capacitor, Ceramic, 10 $\mu$ F, 16 V, Y5V	TDK
C19	GRM235Y5V106Z016A	Capacitor, Ceramic, 10 $\mu$ F, 16 V, Y5V	TDK
C20	GRM235Y5V106Z016A	Capacitor, Ceramic, 10 $\mu$ F, 16 V, Y5V	TDK
C21	GRM235Y5V106Z016A	Capacitor, Ceramic, 10 $\mu$ F, 16 V, Y5V	TDK
C22	GRM42–6X7R104K050A	Capacitor, Ceramic, 0.1 $\mu$ F, 50 V, 10%, X7R	muRata
C23	GRM42–6X7R104K050A	Capacitor, Ceramic, 0.1 $\mu$ F, 50 V, 10%, X7R	muRata
C24	GRM42–6X7R104K050A	Capacitor, Ceramic, 0.1 $\mu$ F, 50 V, 10%, X7R	muRata
C25	GRM42–6X7R102K050A	Capacitor, Ceramic, 1000 pF, 50 V, 10%, X7R	muRata
C26	GRM42–6X7R104K050A	Capacitor, Ceramic, 0.1 $\mu$ F, 50 V, 10%, X7R	muRata

† C13A and C13C not installed.

Table 4–1. SLVP119 Bill of Materials (Continued)

REF DES	PART NUMBER	DESCRIPTION	MFG
C27	GRM42–6Y5V105Z025A	Capacitor, Ceramic, 1 $\mu$ F, 25 V, 80%–20%, Y5V	muRata
C28	GRM42–6X7R103K050A	Capacitor, Ceramic, 0.01 $\mu$ F, 50 V, 10%, X7R	muRata
C29	GRM42–6Y5V105Z025A	Capacitor, Ceramic, 1 $\mu$ F, 25 V, 80%–20%, Y5V	muRata
C30	GRM42–6X7R104K050A	Capacitor, Ceramic, 0.1 $\mu$ F, 50 V, 10%, X7R	muRata
C31	GRM42–6Y5V105Z025A	Capacitor, Ceramic, 1 $\mu$ F, 25 V, 80%–20%, Y5V	muRata
C32	GRM42–6X7R333Z050A	Capacitor, Ceramic, 0.033 $\mu$ F, 50 V, 10%, X7R	muRata
C33	GRM42–6X7R104K050A	Capacitor, Ceramic, 0.1 $\mu$ F, 50 V, 10%, X7R	muRata
C34	GRM42–6X7R104K050A	Capacitor, Ceramic, 0.1 $\mu$ F, 50 V, 10%, X7R	muRata
C35	GRM42–6Y5V105Z025A	Capacitor, Ceramic, 1 $\mu$ F, 25 V, 80%, –20%, Y5V	muRata
C36	GRM42–6X7R104K050A	Capacitor, Ceramic, 0.1 $\mu$ F, 50 V, 10%, X7R	muRata
D1	SML–LX2832GC–TR	Diode, LED, Green, 2.1 V, SM	Lumex
J2	MKDS3/2–5.08	Terminal Block, 2-Pin, 32A, 5.08 mm	Phoenix
J3	ED1516–ND	Terminal Block, 4-Pin, 6A, 3.5 mm	OST
J4	ED1514–ND	Terminal Block, 2-Pin, 6A, 3.5 mm	OST
L1		Inductor, Filter, 1.15 $\mu$ H, 11 A (8T #18 on T44–8/90 Core)	MicroMetals
L2		Inductor, Filter, 1 $\mu$ H, 25 A (7T #16 on T68–8/90 Core)	MicroMetals
P1	929836–09–36–ND	Header, Straight, 2x6, 0.1" (72-Pin cut down)	3M
P2	A19350–ND	Header, Straight, 1x2, 0.1" center	AMP
Q1†	Si4410DY	FET, N–ch, 30–V, 10–A, 13-m $\Omega$	Siliconix
Q2	Si4410DY	FET, N–ch, 30–V, 10–A, 13-m $\Omega$	Siliconix
Q3	Si4410DY	FET, N–ch, 30–V, 10–A, 13-m $\Omega$	Siliconix
Q4	Si4410DY	FET, N–ch, 30–V, 10–A, 13-m $\Omega$	Siliconix
Q5	Si4410DY	FET, N–ch, 30–V, 10–A, 13-m $\Omega$	Siliconix
Q6	Si4410DY	FET, N–ch, 30–V, 10–A, 13-m $\Omega$	Siliconix
Q7	SN7002	FET, N–ch, 60–V, 115 mA, 1.2- $\Omega$	Diodes Inc.
Q8	NDS0605	FET, N–ch, 60–V, 180 mA, 5- $\Omega$	Fairchild
R1†	Std	Resistor, Chip, Zero Ohm, 1/10 W, 5%	
R2	Std	Resistor, Chip, Zero Ohm, 1/10 W, 5%	
R3	Std	Resistor, Chip, Zero Ohm, 1/10 W, 5%	

† R1, Q1 not installed.

Table 4-1. SLVP119 Bill of Materials (Continued)

REF DES	PART NUMBER	DESCRIPTION	MFG
J1	MKDS3/2-5.08	Terminal Block, 2-Pin, 32A, 5.08 mm	Phoenix
R4	Std	Resistor, Chip, 3.3 $\Omega$ , 1/10 W, 5%	
R5	Std	Resistor, Chip, 3.3 $\Omega$ , 1/10 W, 5%	
R6	Std	Resistor, Chip, 3.3 $\Omega$ , 1/10 W, 5%	
R7A†	Std	Resistor, Chip, 2.7 $\Omega$ , 1/8 W, 5%	
R7B	Std	Resistor, Chip, 2.7 $\Omega$ , 1/8 W, 5%	
R7C†	Std	Resistor, Chip, 2.7 $\Omega$ , 1/8 W, 5%	
R8	Std	Resistor, Chip, 3.92 k $\Omega$ , 1/10 W, 1%	
R9	Std	Resistor, Chip, 1 k $\Omega$ , 1/10 W, 1%	
R10	Std	Resistor, Chip, 4.32 k $\Omega$ , 1/10 W, 1%	
R11	Std	Resistor, Chip, 1 k $\Omega$ , 1/10 W, 1%	
R12	Std	Resistor, Chip, 150 $\Omega$ , 1/10 W, 1%	
R13	Std	Resistor, Chip, 100 $\Omega$ , 1/10 W, 1%	
R14	Std	Resistor, Chip, 20 k $\Omega$ , 1/10 W, 1%	
R15	Std	Resistor, Chip, 10 k $\Omega$ , 1/10 W, 1%	
R16	Std	Resistor, Chip, 100 $\Omega$ , 1/10 W, 5%	
R17	Std	Resistor, Chip, 1 k $\Omega$ , 1/10 W, 1%	
R18	Std	Resistor, Chip, 1 k $\Omega$ , 1/10 W, 1%	
R19	Std	Resistor, Chip, 2 k $\Omega$ , 1/10 W, 5%	
R20	Std	Resistor, Chip, 3.3 $\Omega$ , 1/10 W, 5%	
R21	Std	Resistor, Chip, 3.3 $\Omega$ , 1/10 W, 5%	
R22	Std	Resistor, Chip, 1 M $\Omega$ , 1/10 W, 5%	
R23	Std	Resistor, Chip, 10 k $\Omega$ , 1/10 W, 5%	
R24	Std	Resistor, Chip, 10 k $\Omega$ , 1/10 W, 5%	
TP1-9, 12, 14-18	240-345	Test Point, Red	Farnell
TP10,11, 19,20	240-333	Test Point, Black	Farnell
TP13	131-4244-00	Adaptor, 3.5-mm probe clip ( or 131-5031-00)	Tektronix

† R7A, R7C not installed.

Table 4–1. SLVP119 Bill of Materials (Continued)

REF DES	PART NUMBER	DESCRIPTION	MFG
U1	TPS5210DW	IC, PWM Ripple Controller, Adjustable Output	TI
Current Jumper	9912	Wire, PVC, Stranded, 12AWG, 600 V, 1055C	Belden
FB Loop	8021	Wire, Bare, Solid, 22AWG	Belden
NA	929950–00–ND	Shunt, Jumper, 0.1" (for P1)	3M
NA	SLVP119	PCB, TPS5210 EVM Board	