TEXAS INSTRUMENTS

Synchronous Buck EVM Using the TPS5211

User's Guide

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Mixed-Signal Products

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Preface

Read This First

About This Manual

This user's guide describes how to connect and evaluate a synchronous-buck regulator using a TI TPS5211 high-frequency programmable-hysteretic regulator controller.

The user's guide describes the TPS5211EVM-154 synchronous-buck converter evaluation module (SLVP154) that provides a convenient method for evaluating the performance of a synchronous-buck converter using the TPS5211 high-frequency programmable-hysteretic regulator controller designed to meet or exceed the Intel VRM8.2, VRM8.3, and VRM8.4 dc-dc converter electrical specifications. A complete designed and tested power supply is presented.

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 Materials

Related Documentation From Texas Instruments

- ❑ *TPS5211 HIGH FREQUENCY PROGRAMMABLE HYSTERETIC REGULATOR CONTROLLER* Data Sheet, Literature Number SLVS243
- ❑ R. Miftakhutdinov and P. Rogers, *Low-Cost Minimum Size Solution for Powering . . .*, Analog Applications Journal, May 2000, pp. 14 – 18, Literature Number SLYT015

Related Documentation From Intel

- *VRM 8.3 DC-DC Converter Design Guidelines* Intel document Order number: 243870–001, June 1998.
- *VRM 8.4 DC-DC Converter Design Guidelines* Intel document Order number: 245335–001, November 1999.

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This equipment is intended for use in a laboratory test environment only. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to subpart J of part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

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Chapter 1

Introduction

This user's guide describes the TPS5211EVM-154 synchronous-buck converter evaluation module (SLVP154). The SLVP154 provides a convenient method for evaluating the performance of a synchronous-buck converter using the TPS5211 high-frequency programmable-hysteretic regulator controller. The TPS5211 meets or exceeds the Intel VRM8.3 and VRM8.4 dc-dc converter electrical specifications. A completely designed and tested power supply is presented. The power supply is a 5-V to 1.65-V step-down dc-dc EVM that can deliver up to 22 A of continuous output current and 26 A of peak transient current. Also included onboard is a 370-pin Celeron™ microprocessor socket and a transient load generator. 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/µs 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 TPS5211 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 TPS5211 offers superior performance with no requirements for additional output capacitance or difficult loop compensation design.

The TPS5211 controller was optimized for tight V_O regulation under static and dynamic load conditions for improved system efficiency. The TP5211 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 SLVP154 converter. Table 1–1 gives the performance specifications of the converters.

Table 1–1. Performance Specification Summary (see Note 1)

SPECIFICATION		TEST CONDITIONS	MIN	TYP	MAX	UNITS
Input voltage range	Main power (V_I)	See Note 2	4.5		13	V
	5-V input		4.5	5	5.5	V
	12-V input		11.4	12	13	V
Static voltage tolerance		See Note 3	1.57	1.65	1.69	V
Line regulation		See Note 4		±0.05%	±0.1%	
Load regulation		See Note 5				
Transient response		See Note 6	–130		80	mV pk
				50		µsec
Output current range		See Note 4	0		26	A
Current limit		See Note 4	27			A
Output ripple		See Notes 4 and 7		24		mV
Soft-start risetime		See Note 8		10		ms
Operating frequency			120	125	145	kHz
Efficiency, 22-A load		See Note 3		84%		
Efficiency, 0.5-A load		See Note 3		53.8%		

Notes:

1) Designed to meet Intel VRM8.4 requirements for future Celeron processors in the PGA-370 package.
2) The module is optimized for 5-V input. It can be modified to any voltage within the 4.5 V – 13 V range.
3) VID inputs set for V_{REF} = 1.65 V.
4) Input voltage can be at any point over entire range.
5) Droop compensation keeps the voltage within static tolerances with a minimum number of output capacitors.
6) I_O pulsed from 2.2 A to 26 A, di/dt = 30 A/µs.
7) I_O can be at any point over entire range.
8) Input voltage adjusted to 5 Vdc.

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 pullup to 5 V)					VREF
VID4	VID3	VID2	VID1	VID0	(Vdc)
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

Chapter 2

Schematic

This chapter contains the schematic diagram for the SLVP154 EVM.

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2.1 Schematic Diagram

Figure 2–1 shows the SLVP154 EVM schematic diagram.

Figure 2–1. SLVP154 EVM Schematic Diagram

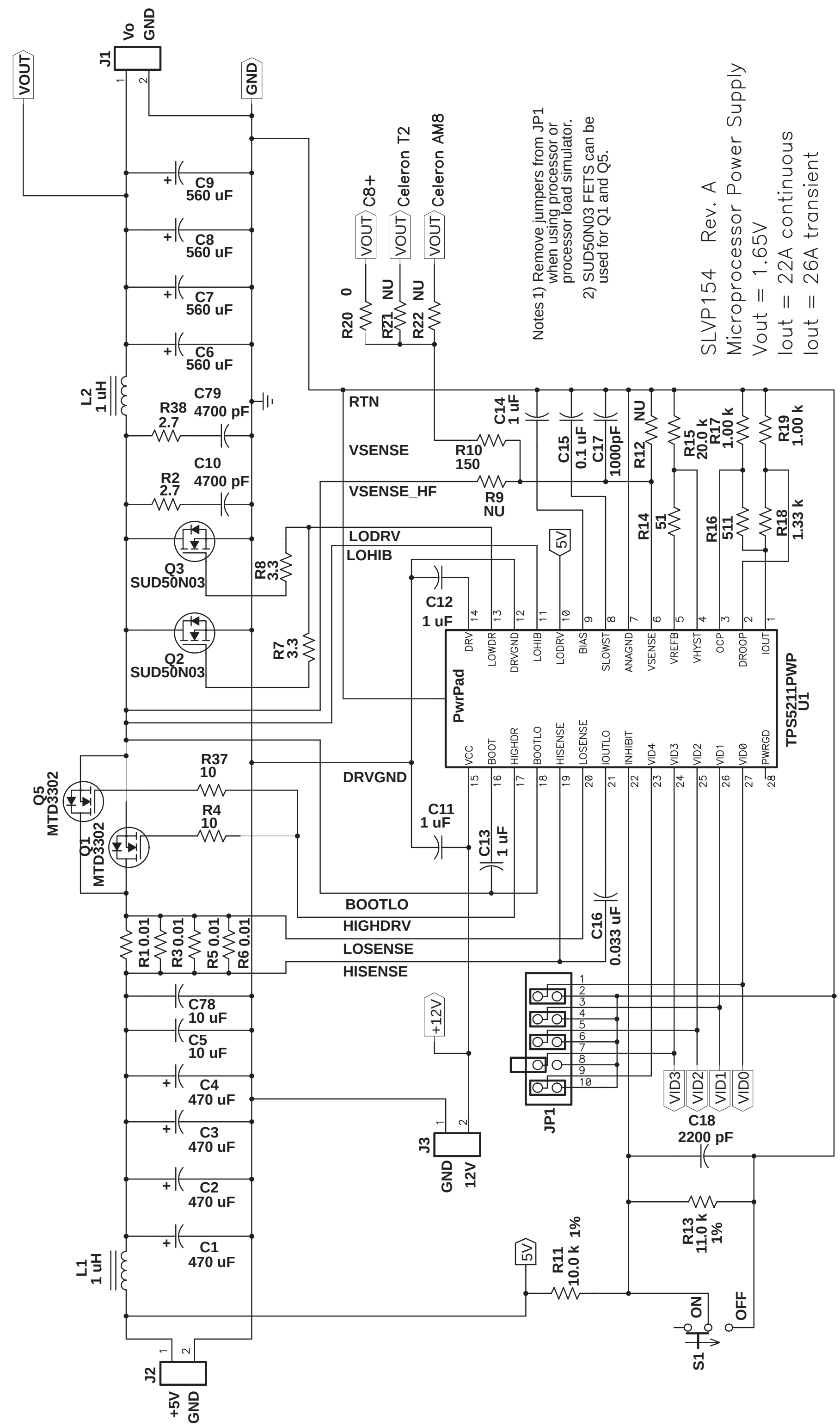


Figure 2–1. SLVP154 EVM Schematic Diagram *(Continued)*

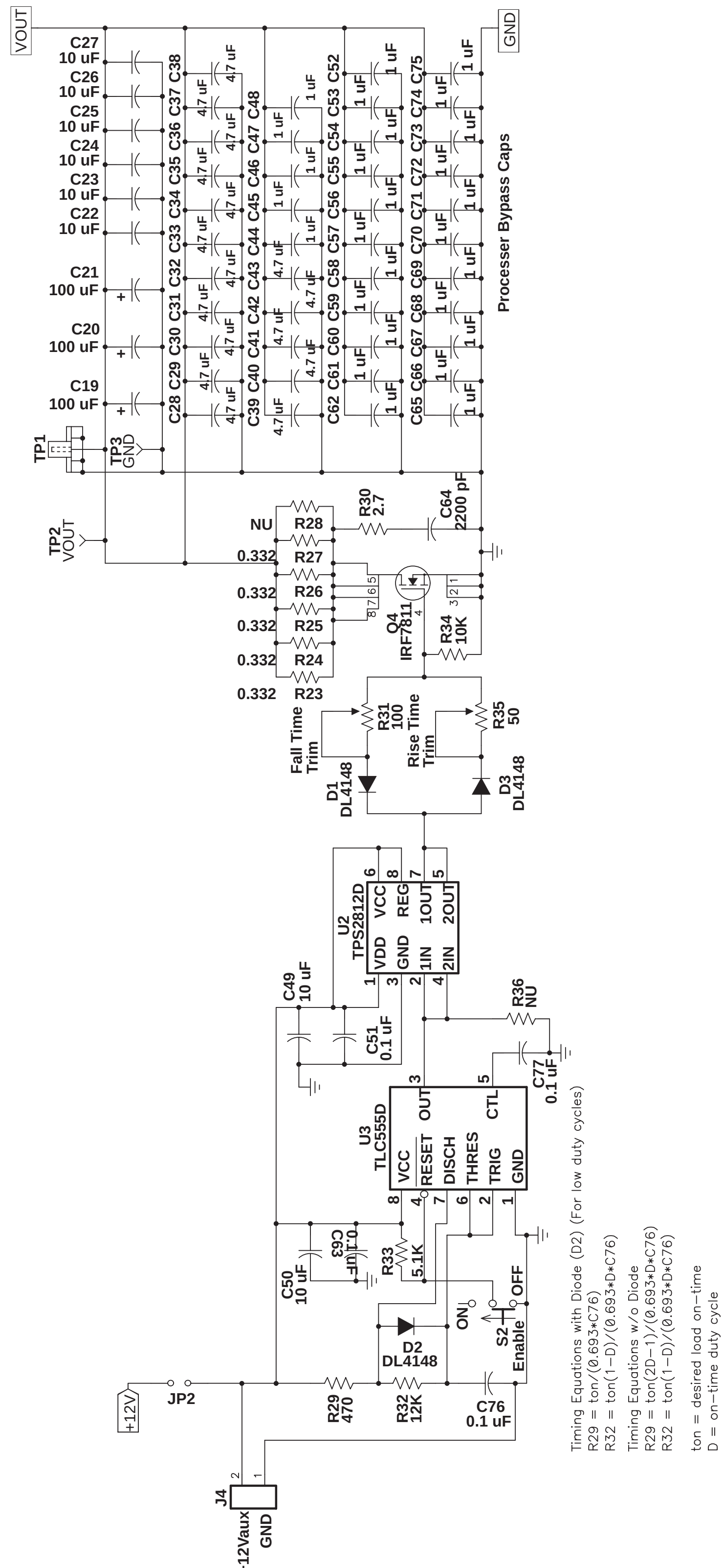
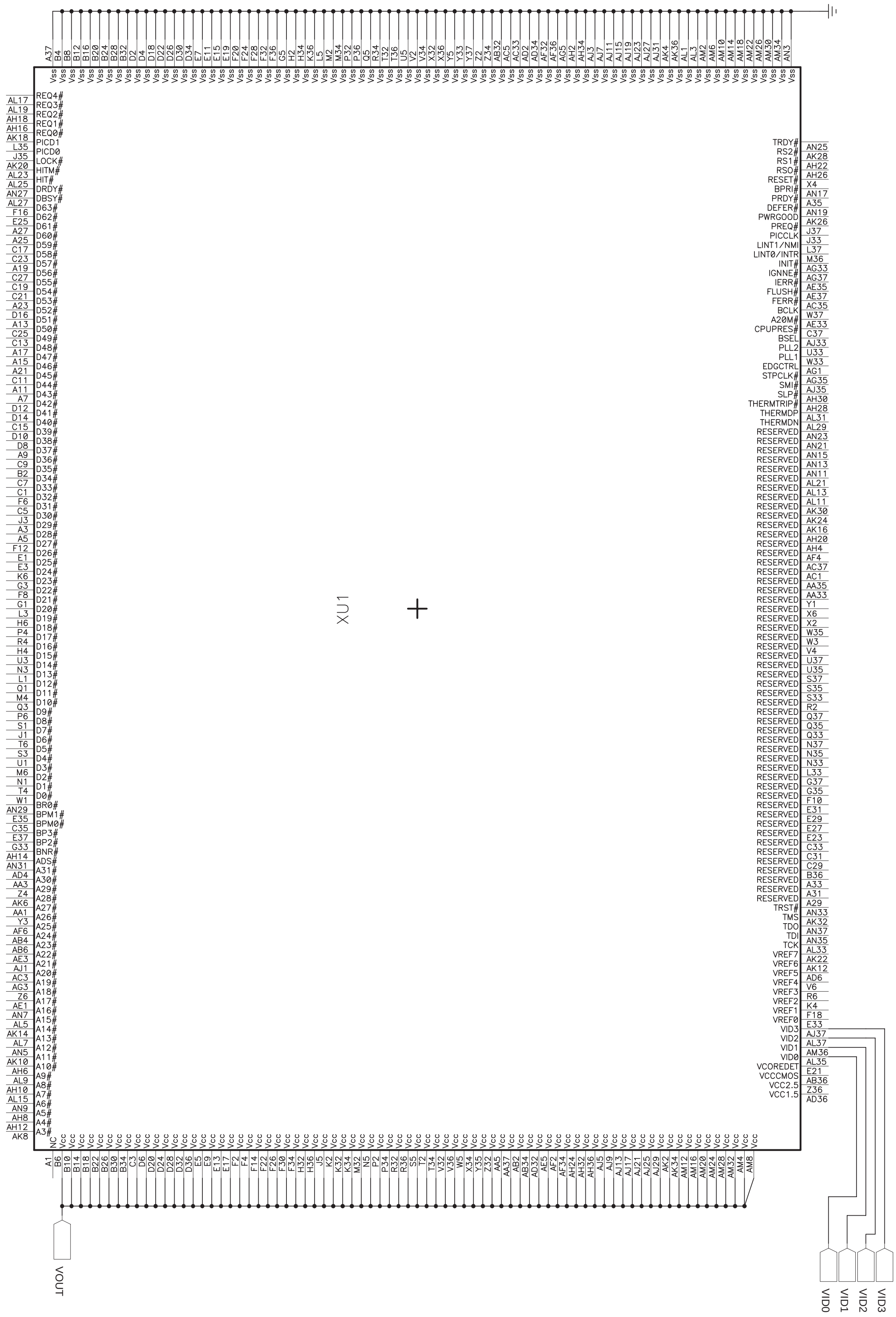


Figure 2–1. SLVP154 EVM Schematic Diagram *(Continued)*



Chapter 3

Physical Layouts

This chapter contains the board layout and I/O connection drawings for the SLVP154 EVM.

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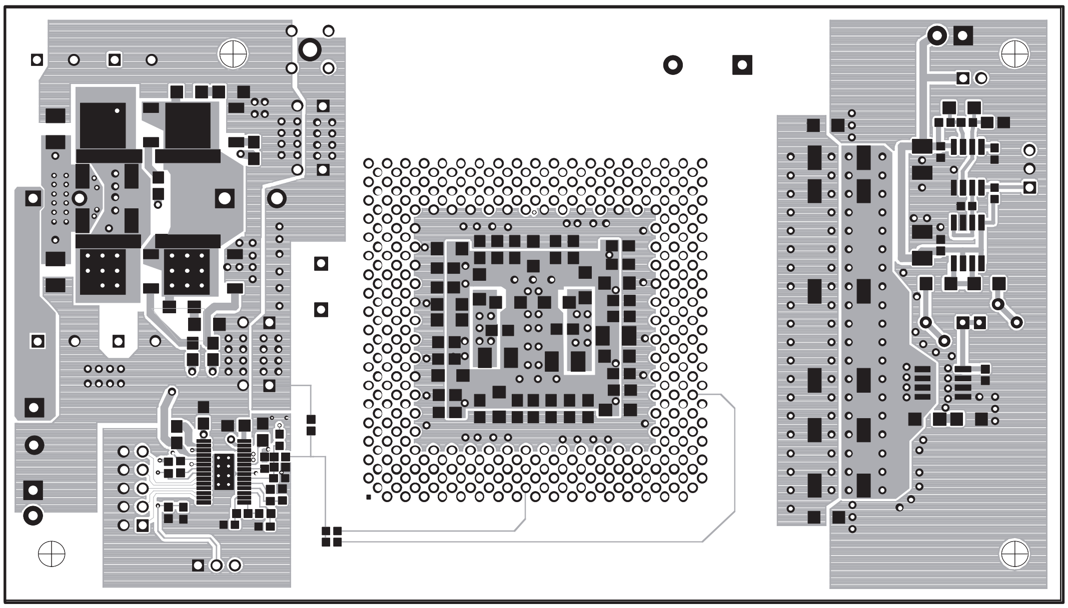
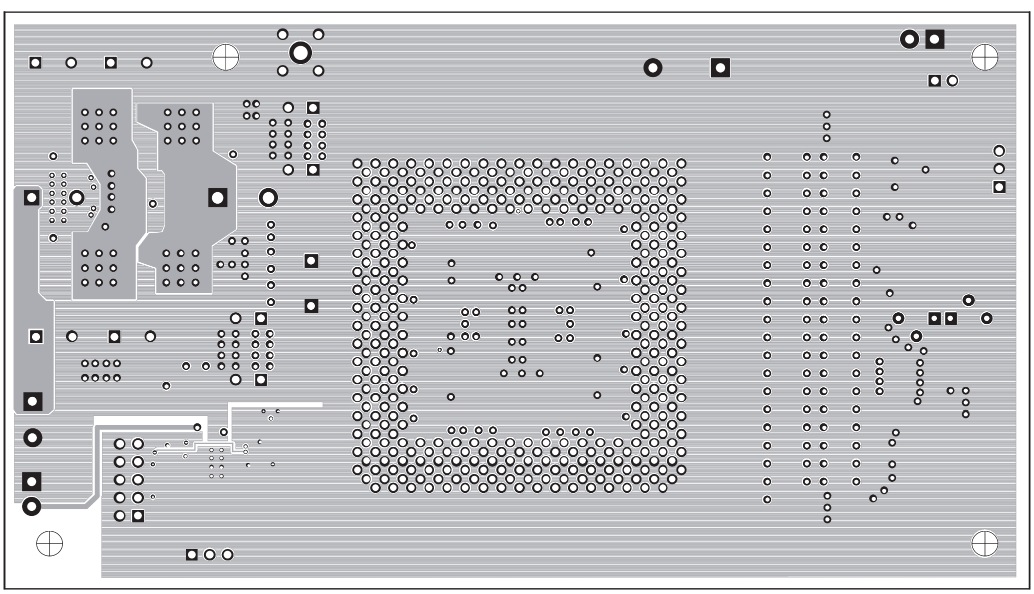
3.1 Board Layout

The power supply module consists of one PWB. The 4-layer board is designed as the power supply section of a motherboard. This allows the EVM to be as close as possible to the actual application conditions. Figure 3–1 shows the four layers of the SLVP154 EVM board.

Figure 3–1. SLVP154 Board Layout

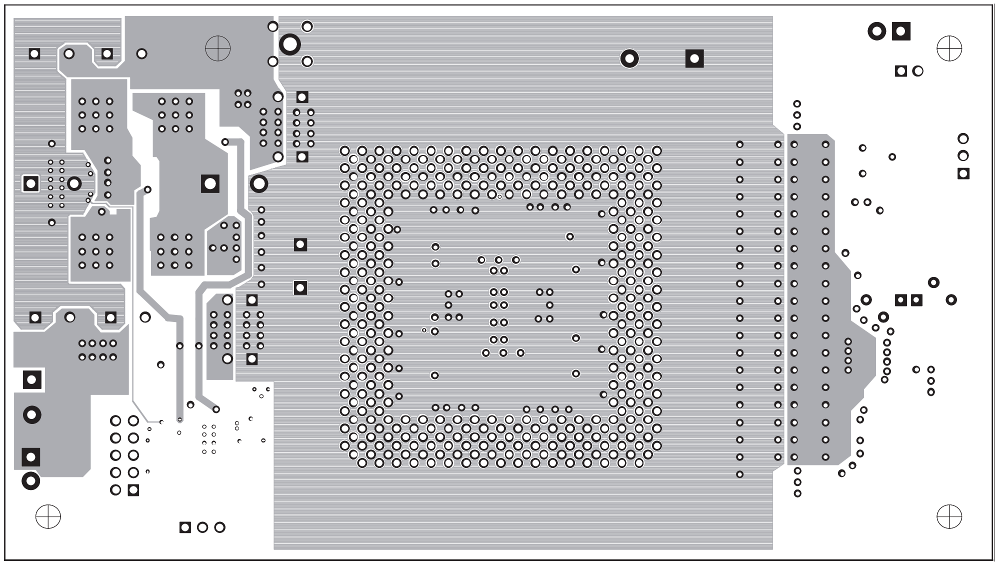


Top Layer (Top View)

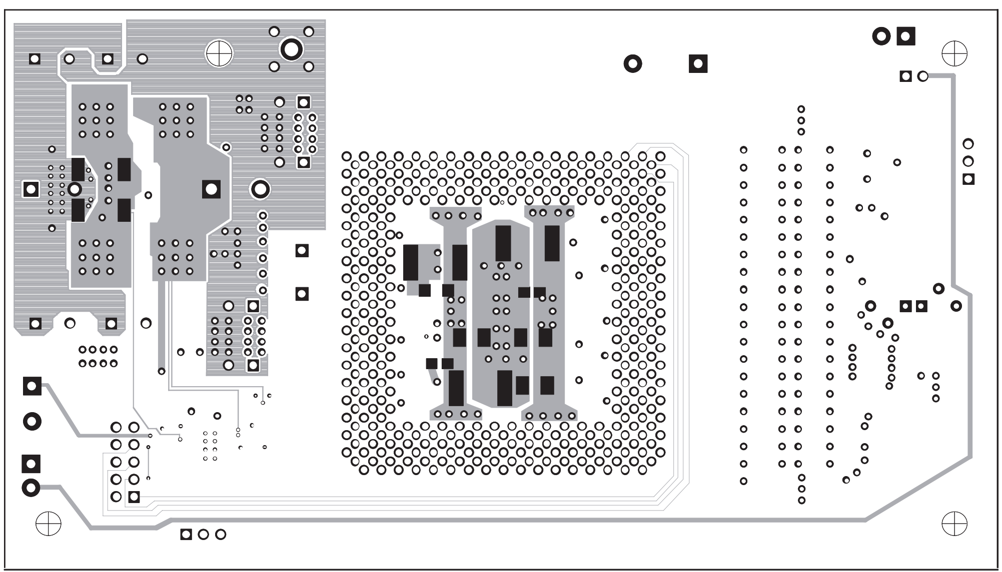


Layer 2, Ground (Top View)

Figure 3–1. SLVP154 Board Layout (Continued)

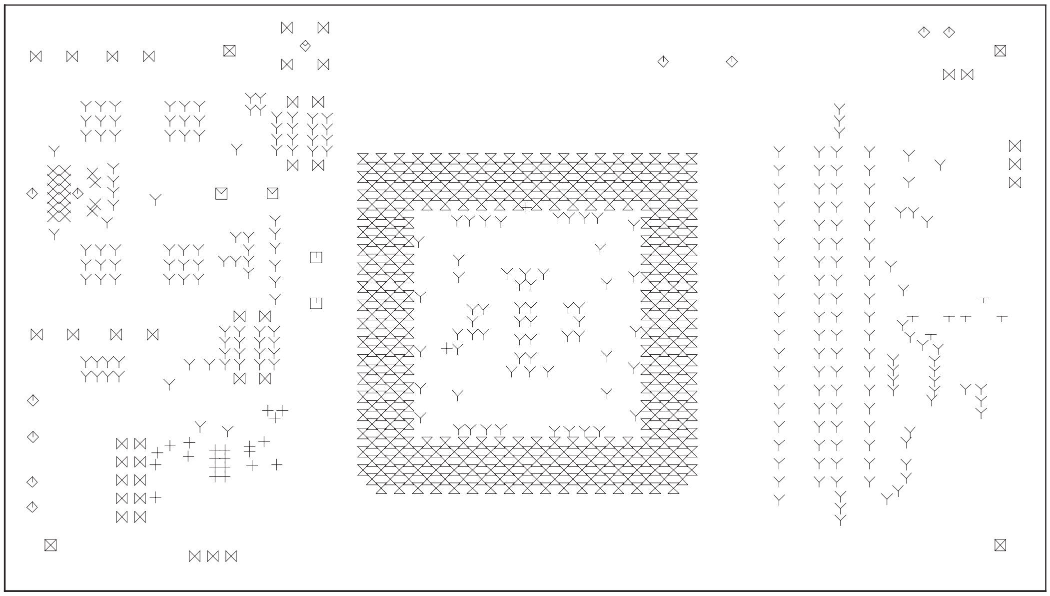


Layer 3, Core Voltage (Top View)



Bottom Layer (Top View)

Figure 3–1. SLVP154 Board Layout (Continued)



Drill Drawing (Top View)

Table 3–1. Drill Table

Drill Table			
Hole Dia (inch)	Symbol	Quantity	Plated
0.010	+	24	Yes
0.012	×	16	Yes
0.018	Y	282	Yes
0.028	⊤	6	Yes
0.032	⧗	370	Yes
0.038	⋈	38	Yes
0.040	◫	2	Yes
0.046	◇	10	Yes
0.060	⊠	2	Yes
0.073	◈	1	Yes
0.140	⊠	4	Yes

3.2 Assembly Drawings

Figure 3–2. Assembly Drawings

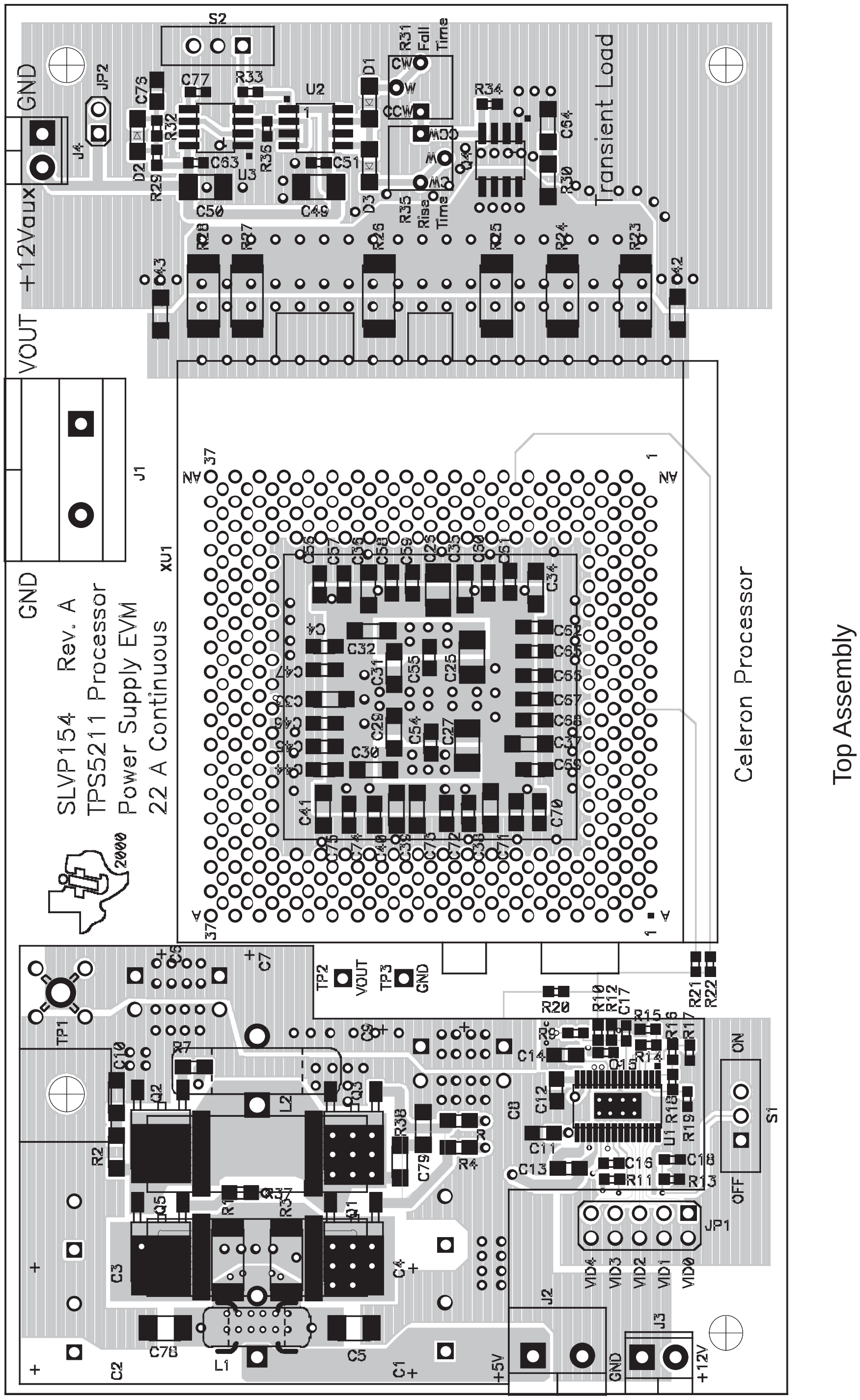
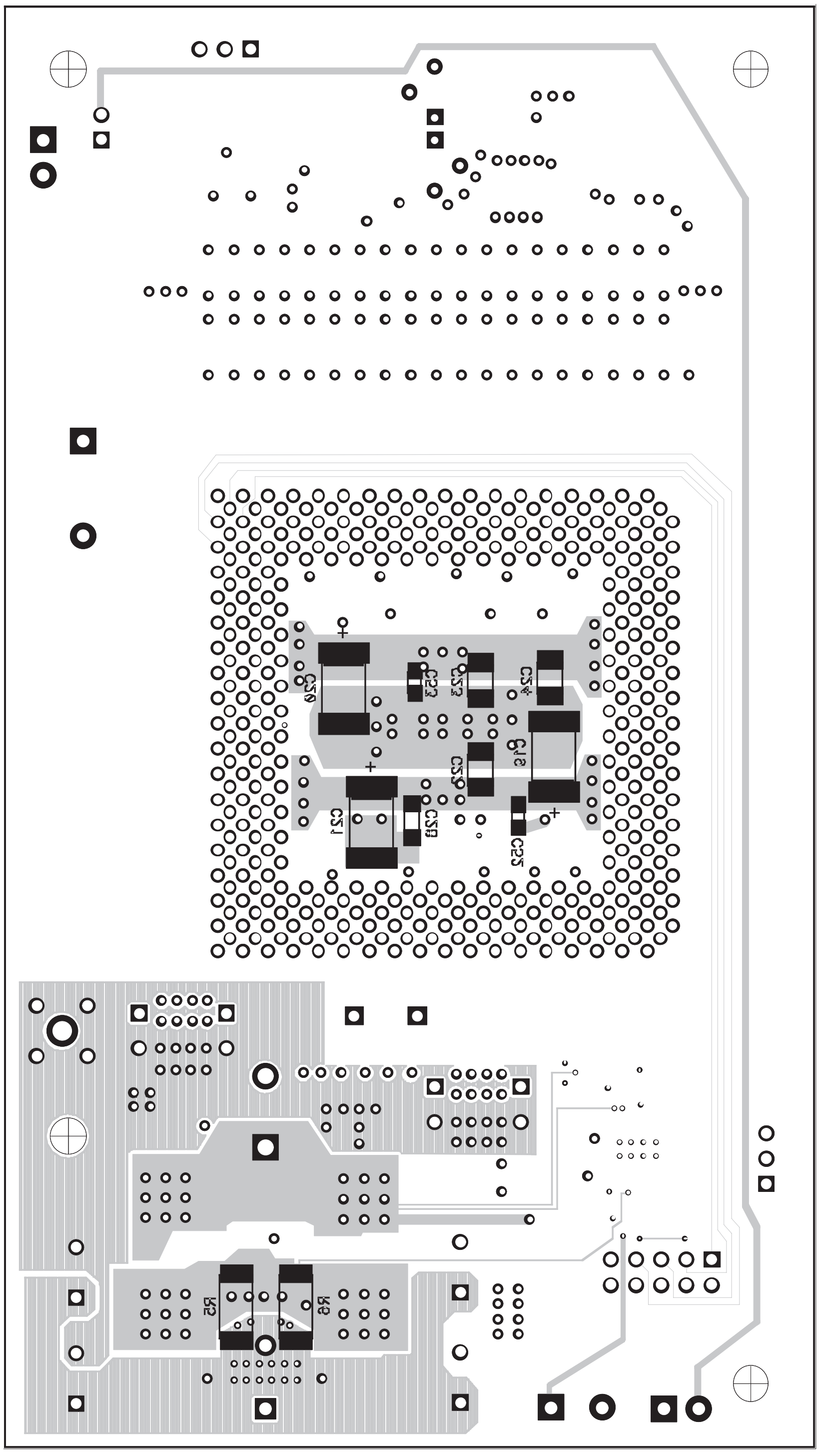


Figure 3–2. Assembly Drawings (Continued)

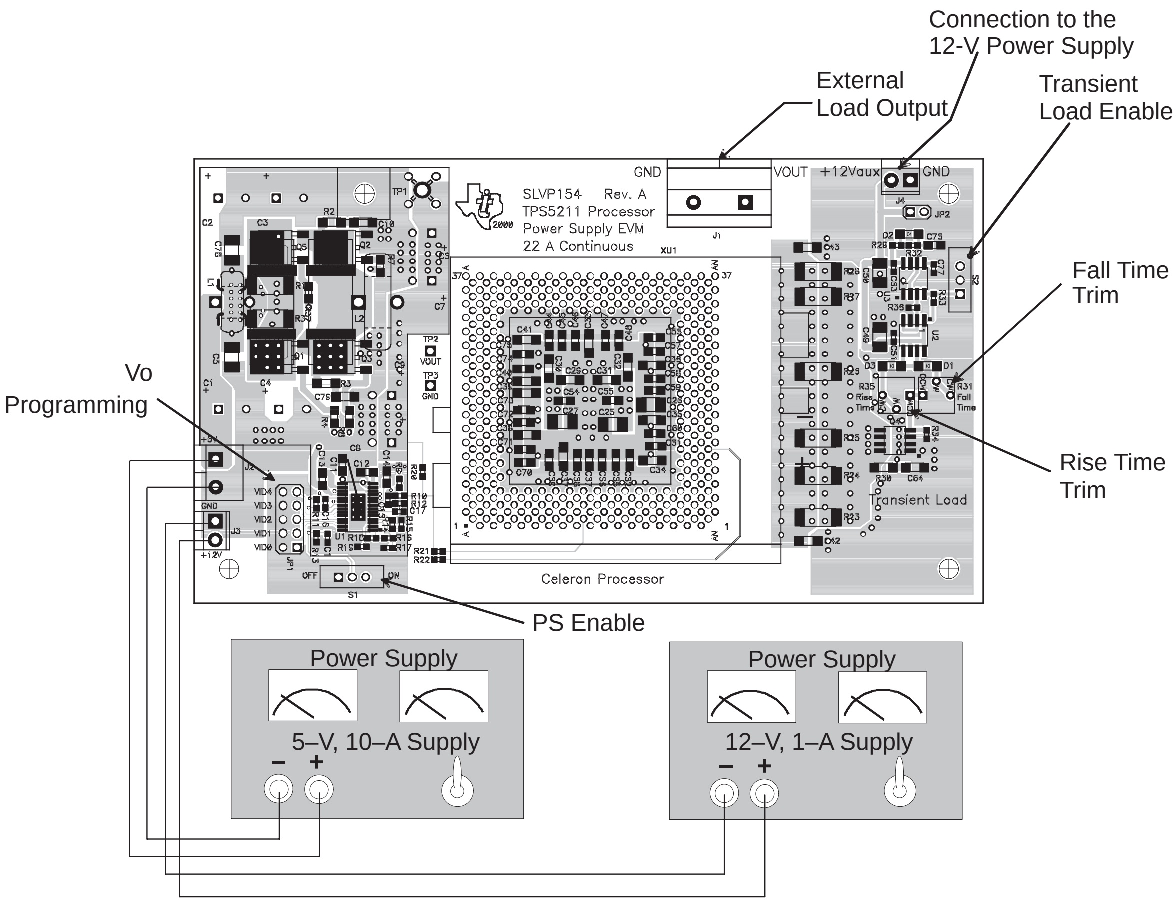


Bottom Assembly

3.3 Input/Output Connections

Figure 3–2 shows the input/output connections to the SLVP154.

Figure 3–3. SLVP154 Input/Output Connections



All wire pairs should be twisted.

Notes:

1) Output voltage can be programmed using the V_O programming jumpers and the VID Codes.
2) R20, R21, and R22 are sensing resistors that allow the user to select the desired V_O sense point. Only one of these 0-Ω resistors should be inserted at a time.
3) The frequency and duty cycle of the onboard transient generator can be changed as desired along with the resistor loading. Care should be taken to insure that the load resistors and/or power supply do not dissipate excessive power.
4) The EVM board has been designed with the same characteristics (layer thicknesses and copper weight) as a typical motherboard to approximate actual noise and thermal conditions.
5) To use a single 12-V power supply for both the transient load and the converter input, jumper JP2 must be shorted.

Chapter 4

Bill of Materials

This chapter contains the bill of materials required for the SLVP154 EVM.

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4.1 Bill of Materials

Table 4–1 lists materials required for the SLVP154 EVM.

Table 4–1. SLVP154 Bill of Materials

Ref Des	Qty	Part Number	Description	MFG	Size
Power Supply Section					
C1,C2, C3,C4	4	10SP470M	Capacitor, OS-CON, 470μF, 10V, 20%	Sanyo	F-case
C5, C78	2	GRM235Y5V106Z016A	Capacitor, Ceramic, 10 μF, 16V, Y5V	muRata	1210
C6,C7, C8,C9	4	4SP560M	Capacitor, OS-CON, 560μF, 4V, 20%	Sanyo	E-case
C11,C12, C13,C14	4		Capacitor, Ceramic, 1.0 μF, 16V, +80%–20%, Y5V	Std	805
C15	1		Capacitor, Ceramic, 0.1 μF, 16V, 10%, X7R	Std	603
C16	1		Capacitor, Ceramic, 0.033 μF, 50V, 10%, X7R	Std	603
C17	1		Capacitor, Ceramic, 1000 pF, 50V, 10%, X7R	Std	603
C18	1		Capacitor, Ceramic, 2200 pF, 50V, 10%, X7R	Std	603
C10, C79	2		Capacitor, Ceramic, 4700 pF, 50V, 10%, X7R	Std	1206
L1	1		Inductor, 12A, 1 μH T44–8/90 Core, 8-turns, 18AWG Wire	Core-Micrometals	T44
L2	1		Inductor, 28A, 1 μH T68–8/90 Core, 7-turns, 16AWG Wire	Core-Micrometals	T68
Q1,Q5	2	SUD50N03	MOSFET, N-ch, 30-V, 20-A, 7-milliohm	Vishay-Siliconix	DPAK
Q2,Q3	2	SUD50N03	MOSFET, N-ch, 30-V, 20-A, 7-milliohm	Vishay-Siliconix	DPAK
HS1,HS2	0	573100, see Note 1	Heatsink, D-PAK (One for both high-side FETs and one for both low-side FETs)	AAVID	.355x.35
R1,R3, R5,R6	4	WSL–2512–0.010–1%	Resistor, Chip, 0.010 Ohms, 1W, 1%	Dale	2512
R2, R38	2		Resistor, Chip, 2.7 Ohms, 1/8W, 5%	Std	1206
R4,R37	2		Resistor, Chip, 3.3 Ohms, 1/10W, 5%	Std	805
R7,R8	2		Resistor, Chip, 3.3 Ohms, 1/10W, 5%	Std	805
R9	0		NU		603
R10	1		Resistor, Chip, 150 Ohms, 1/16W, 1%	Std	603
R11	1		Resistor, Chip, 10.0k Ohms, 1/16W, 1%	Std	603
R12	0		NU		603
R13	1		Resistor, Chip, 11.0k Ohms, 1/16W, 1%	Std	603
R14	1		Resistor, Chip, 51 Ohms, 1/16W, 5%	Std	603
R15	1		Resistor, Chip, 20.0k Ohms, 1/16W, 1%	Std	603
R16	1		Resistor, Chip, 511 Ohms, 1/16W, 1%	Std	603
R18	1		Resistor, Chip, 1.33k Ohms, 1/16W, 1%	Std	603
R17,R19	2		Resistor, Chip, 1.00k Ohms, 1/16W, 1%	Std	603
U1	1	TPS5211PWP	IC, Hysteretic Controller, Synchronous	TI	PWP28

Note:

1) The heatsink is optional. However, it should be used if long time load current exceeds 22 A.

Table 4–1. SLVP154 Bill of Materials (Continued)

Ref Des	Qty	Part Number	Description	MFG	Size
Celeron, Transient Load, and Auxiliary sections					
C28–C43	16	ECJ–3YB0J475K	Capacitor, Ceramic, 4.7µF, 6.3V, 10%	Panasonic	1206
C44–C48 C52–C62 C65–C75	27	ECJ–2VF1C105Z	Capacitor, Ceramic, 1.0 µF, 16V, +80%–20%, Y5V	Panasonic	805
C22–C27 C49–C50	8	GRM235Y5V106Z016A	Capacitor, Ceramic, 10 µF, 16V, Y5V	muRata	1210
C51,C63, C76,C77	4	GRM39X7R104K016A	Capacitor, Ceramic, 0.1 µF, 16V, 10%, X7R	muRata	603
C64	1	ECU–V1H222KBM	Capacitor, Ceramic, 2200 pF, 50V, 10%, X7R	Panasonic	1206
C19–C21	3	TPSD107M010R100	Capacitor, Tantalum, 100µF, 10V, 20%	AVX	D
D1–D3	3	DL4148	Diode, Signal, 75V, 200mA	Diodes, Inc	DL–35
J1	1	ED1981	Terminal Block, 32A, 9.5mm, 2-Terminals	OST	9.5mm
J2	1	ED1609	Terminal Block, 15A, 5.1mm, 2-Terminals	OST	5.1mm
J3–J4	2	ED1514	Terminal Block, 6A, 3.5mm, 2-Terminals	OST	3.5mm
JP1	1		Header, 2x5 Pins, 0.025” Sq pins	Std	0.1”
JP2	1		Header, 1x2 Pins, 0.025” Sq pins	Std	0.1”
Q4	1	IRF7811	FET, N-ch, 30-V, 10-A, 11-milliohm	IR	SO-8
R20	1	Std	Resistor, Chip, 0 Ohms, 1/16W, 5%	Std	603
R21–R22	0		Not used	Std	603
R23–R27	5	WSL–2512–R332–1%	Resistor, Chip, 0.332 Ohms, 1W, 1%	Dale	2512
R28			User Option, Not Installed	Dale	2512
R29	1	Std	Resistor, Chip, 470 Ohms, 1/16W, 5%	Std	603
R30	1	Std	Resistor, Chip, 2.7 Ohms, 1/8W, 1%	Std	1206
R31	1	3323P–101	Trim Pot, Cermet, 100 Ohms, 1/2W, 10%	Bourns	3/8”
R32	1	Std	Resistor, Chip, 12k Ohms, 1/16W, 5%	Std	603
R33	1	Std	Resistor, Chip, 5.1k Ohms, 1/16W, 5%	Std	603
R34	1	Std	Resistor, Chip, 10k Ohms, 1/16W, 5%	Std	603
R35	1	3323P–500	Trim Pot, Cermet, 50 Ohms, 1/2W, 10%	Bourns	3/8”
R36			User Option, Not Installed	Std	603
S1–S2	2	EG1218	Switch, Slide, 1P2T, 200mA	E-Switch	0.1”
TP1	1	131–4244–00	Adaptor, 3.5-mm probe clip (or 131–5031–00)	Tektronix	
TP2	1	240–345	Test Point, Red, 1mm	Farnell	
TP3	1	240–333	Test Point, Black, 1mm	Farnell	
U2	1	TPS2812D	IC, MOSFET Driver, 2-Ch, Buffer, 2A	TI	SO-8
U3	1	TLC555CD	IC, Timer	TI	SO-8
XU1	1	PGA370	Socket, 370-Pin	AMP	