

High Performance VRM Using the TPS5210

User's Guide

IMPORTANT NOTICE

Texas Instruments and its subsidiaries (TI) reserve the right to make changes to their products or to discontinue any product or service without notice, and advise customers to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current and complete. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgement, including those pertaining to warranty, patent infringement, and limitation of liability.

TI warrants performance of its semiconductor products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are utilized to the extent TI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

CERTAIN APPLICATIONS USING SEMICONDUCTOR PRODUCTS MAY INVOLVE POTENTIAL RISKS OF DEATH, PERSONAL INJURY, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE ("CRITICAL APPLICATIONS"). TI SEMICONDUCTOR PRODUCTS ARE NOT DESIGNED, AUTHORIZED, OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT DEVICES OR SYSTEMS OR OTHER CRITICAL APPLICATIONS. INCLUSION OF TI PRODUCTS IN SUCH APPLICATIONS IS UNDERSTOOD TO BE FULLY AT THE CUSTOMER'S RISK.

In order to minimize risks associated with the customer's applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance or customer product design. TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used. TI's publication of information regarding any third party's products or services does not constitute TI's approval, warranty or endorsement thereof.

Preface

Read This First

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. All the documentation that is required to reproduce this design is included to provide a total system solution.

How to Use This Manual

This document contains the following chapters:

- ☐ Chapter 1 Introduction
- ☐ Chapter 2 Schematics
- ☐ 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.

FCC Warning

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.

Trademarks

TI is a trademark of Texas Instruments Incorporated.

Contents

1	Introduction	1-1
1.1	Background	1-2
1.2	Performance Specification Summary	1-3
1.3	Voltage Identification Codes	1-4
2	Schematics	2-1
2.1	Main Board Schematic Diagram	2-2
2.2	Daughter Board Schematic Diagram	2-3
3	Physical Layouts	3-1
3.1	Assembly View	3-2
3.2	Assembly Details	3-3
3.3	Input/Output Connections	3-5
4	Bills of Material	4-1
4.1	Main Board Bill of Materials	4-2
4.2	Daughter Board Bill of Materials	4-4

Figures

2-1	Main Board Schematic Diagram	2-2
2-2	Daughter Board Schematic Diagram	2-3
3-1	Assembled Side View	3-2
3-2	Main Board Assembly	3-3
3-3	Daughter Board Assembly	3-4
3-4	Input/Output Connections	3-5

Tables

1-1	Performance Specification Summary	1-3
1-2	Voltage Identification Codes	1-4
4-1	Main Board Bill of Materials	4-2
4-2	Daughter Board Bill of Materials	4-4

Introduction

The TPS5210EVM-116 (SLVP116) Synchronous-Buck Converter VRM Evaluation Module provides a 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 and mechanical specifications. A complete system solution is presented and documented. The power supply is a programmable step-down dc-dc VRM that can deliver up to 16 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 power supply is configured on two PWBs, the main board containing the power and filtering components and the daughter board containing the TPS5210 controller and its associated components.

Topic	Page
1.1 Background	1-2
1.2 Performance Specification Summary	1-3
1.3 Voltage Identification Codes	1-4

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/ μ 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, and for operation 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 SLVP116 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	5-V Input		4.5	5	5.5	V
	12-V Input		11.4	12	13	
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		16	A
Current limit		See Note 3	16			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
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

Schematics

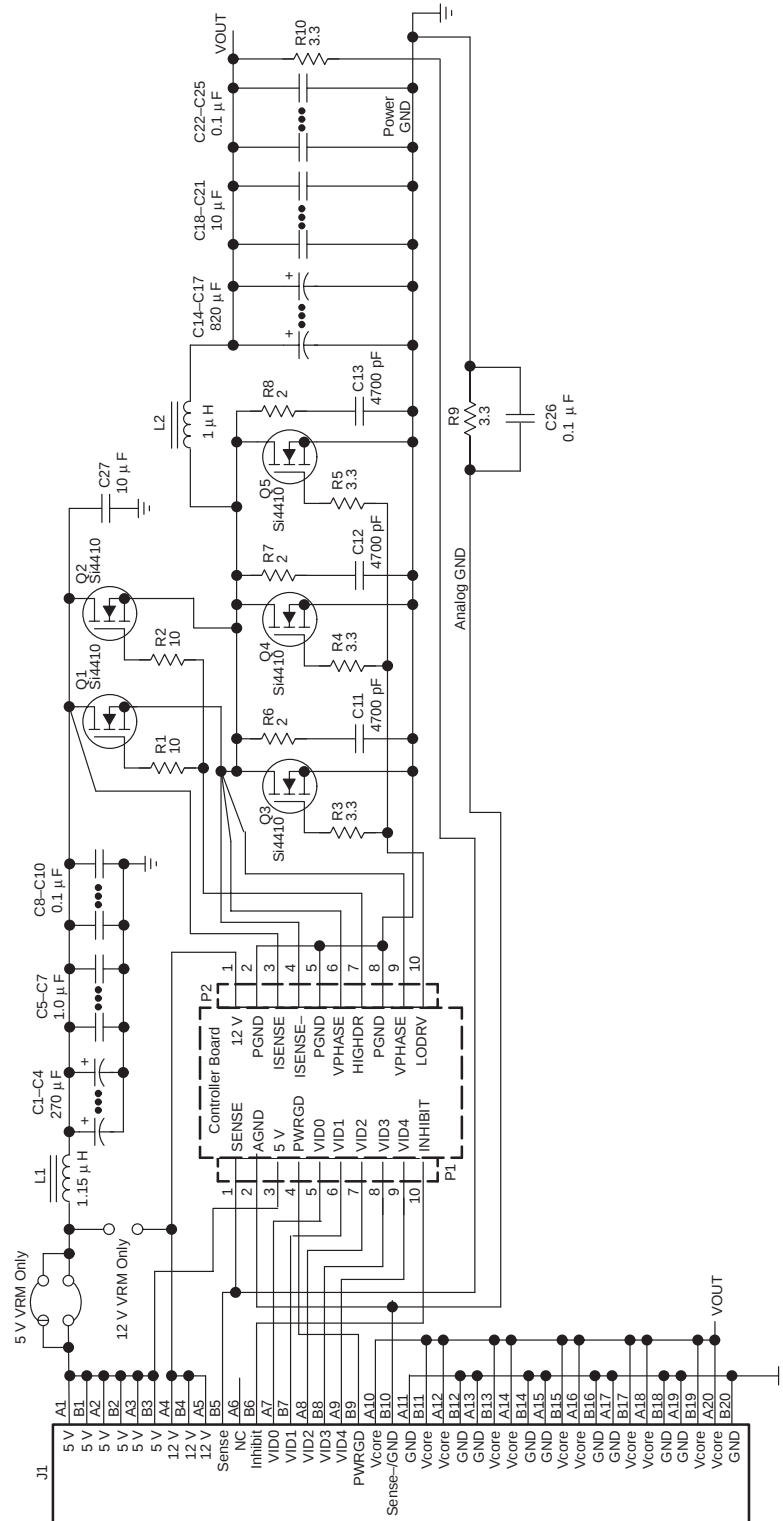
This chapter contains the schematic diagrams for the main board and the controller board.

Topic	Page
2.1 Main Board Schematic Diagram	2-2
2.2 Controller Board Schematic Diagram	2-3

2.1 Main Board Schematic Diagram

Figure 2–1 shows the SLVP116 VRM EVM main board schematic diagram.

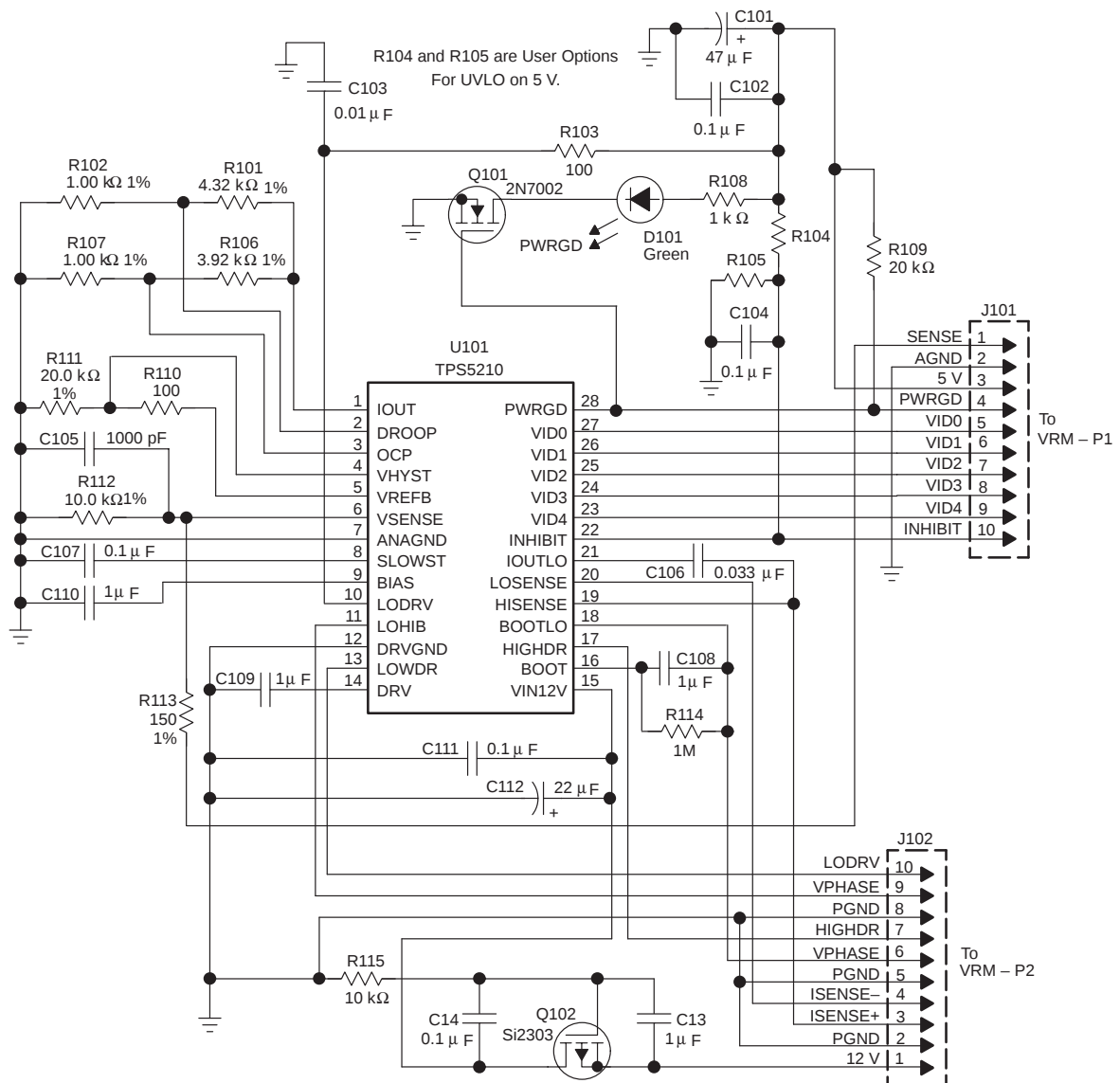
Figure 2–1. Main Board Schematic Diagram



2.2 Daughter Board Schematic Diagram

Figure 2–2 shows the SLVP116 VRM EVM daughter board (SLVP116DB) schematic diagram.

Figure 2–2. Daughter Board Schematic Diagram



Physical Layouts

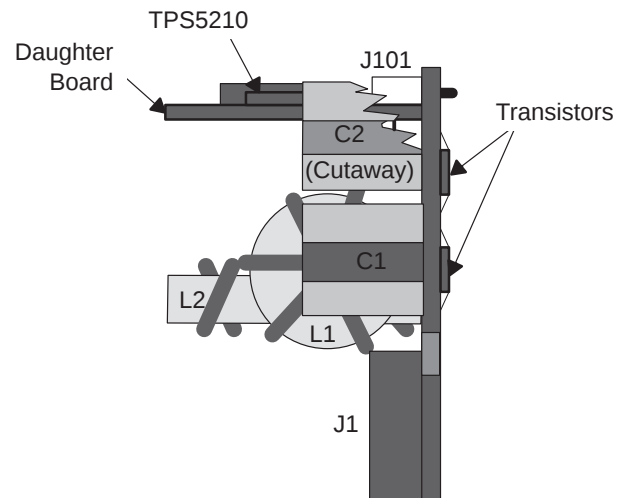
This chapter contains the assembly, physical layout, and I/O connection drawings for the main and daughter boards.

Topic	Page
3.1 Assembly View	3-2
3.2 Assembly Details	3-3
3.3 Input/Output Connections	3-5

3.1 Assembly View

Figure 3–1 shows the assembled side view of the SLVP116 VRM EVM.

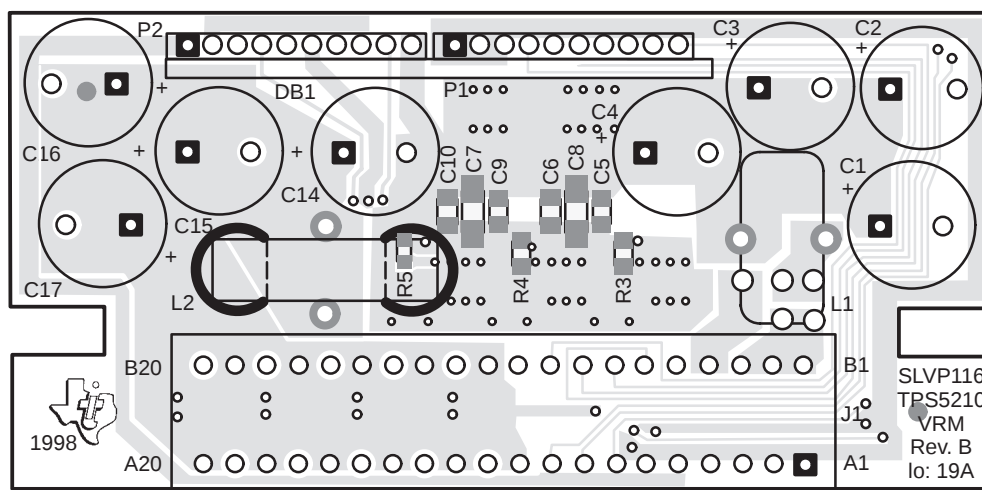
Figure 3–1. Assembled Side View



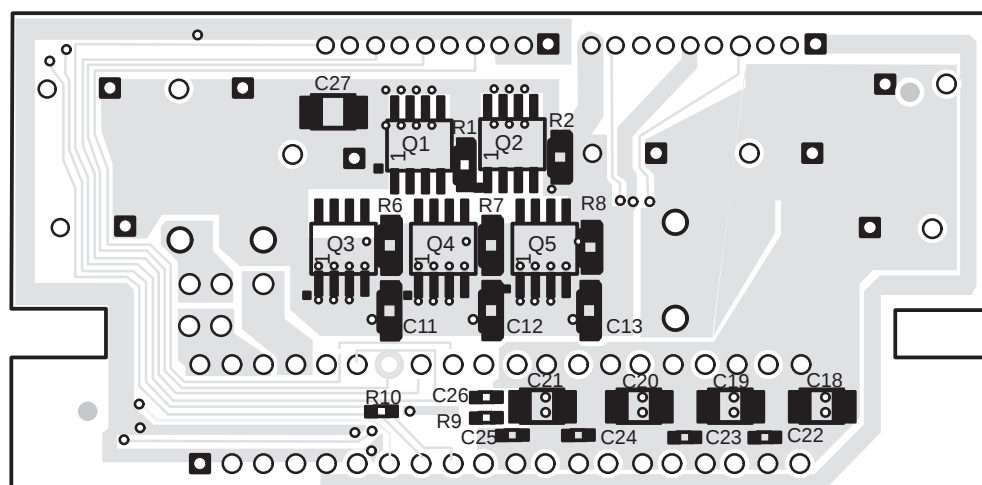
3.2 Assembly Details

The power supply module consists of two PWBs; the main board and the daughter board. Figure 3–2 shows the top view and bottom view of the SLVP116 main board. Figure 3–3 shows the front view and back view of the SLVP116 daughter board.

Figure 3–2. Main Board Assembly

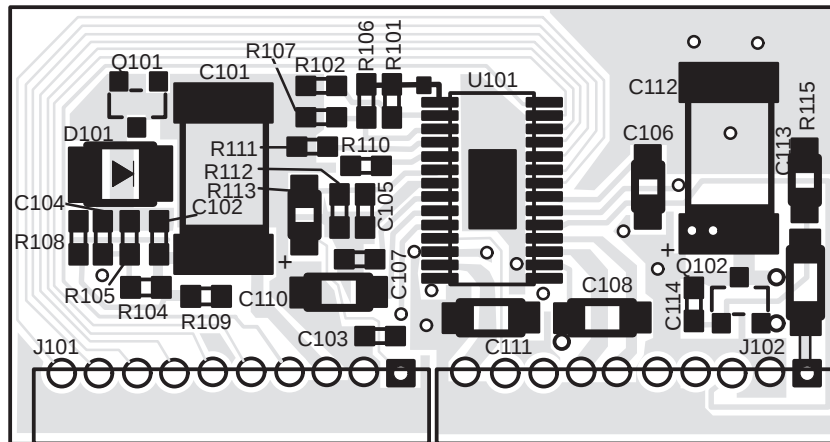


SLVP116 Top Assembly

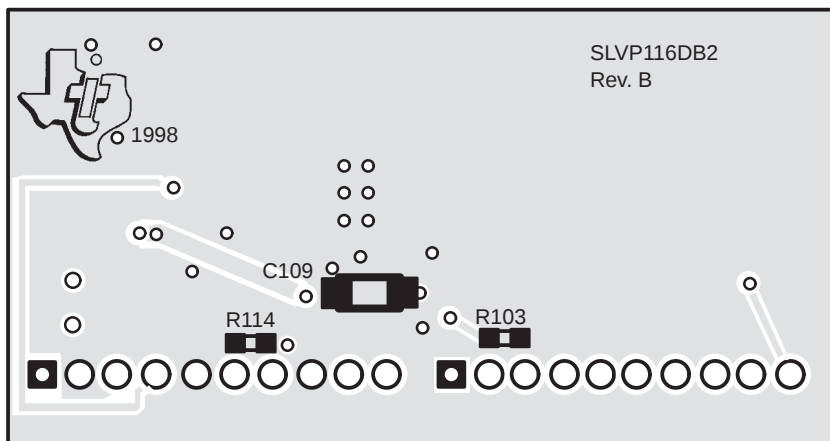


SLVP116 Bottom Assembly (Bottom View)

Figure 3–3. Daughter Board Assembly



SLVP116DB2 Top Assembly

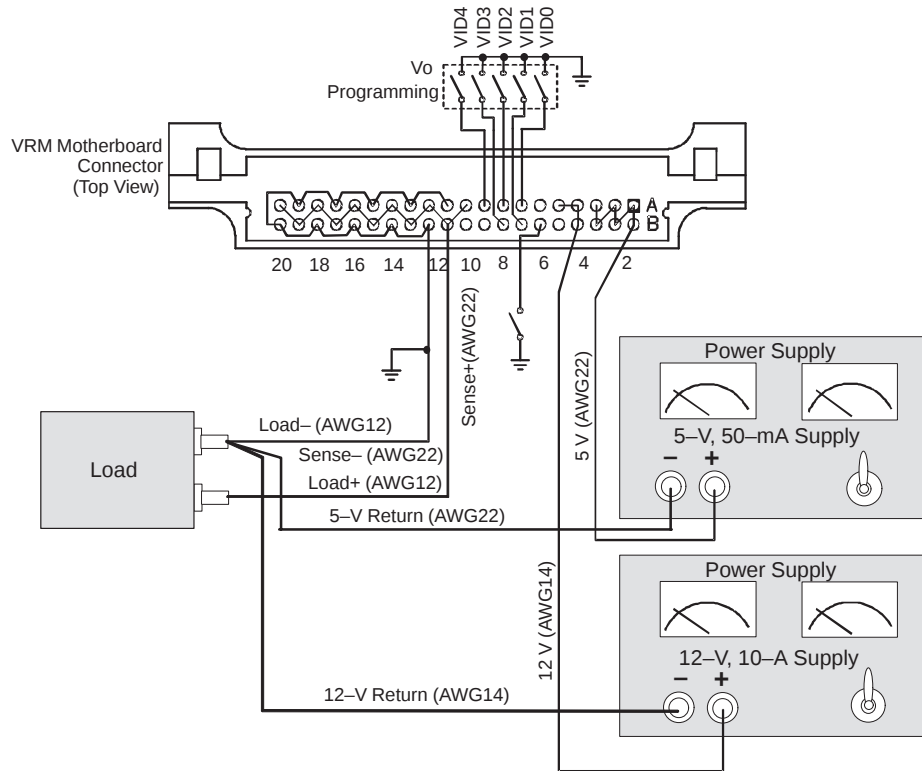


SLVP116DB2 Bottom Assembly (Bottom View)

3.3 Input/Output Connections

Figure 3–4 shows the input/output connections to the SLVP116.

Figure 3–4. Input/Output Connections





Bills of Material

This chapter contains the bills of material for the main and daughter boards.

Topic	Page
4.1 Main Board Bill of Materials	4-2
4.2 Daughter Board Bill of Materials	4-4

4.1 Main Board Bill of Materials

Table 4–1 lists materials required for the SLVP116 EVM, Main Board.

Table 4–1. Main Board Bill of Materials

REF DES	PART NUMBER	DESCRIPTION	MFG
C1	16SP270M	Capacitor, OS-Con, 270 μ F, 16 V, 20%	Sanyo
C2	16SP270M	Capacitor, OS-Con, 270 μ F, 16 V, 20%	Sanyo
C3	16SP270M	Capacitor, OS-Con, 270 μ F, 16 V, 20%	Sanyo
C4	16SP270M	Capacitor, OS-Con, 270 μ F, 16 V, 20%	Sanyo
C5	GRM42-6Y5V105Z025A	Capacitor, Ceramic, 1 μ F, 25 V, +80% –20%, Y5V	muRata
C6	GRM42-6Y5V105Z025A	Capacitor, Ceramic, 1 μ F, 25 V, +80% –20%, Y5V	muRata
C7	GRM42-6Y5V105Z025A	Capacitor, Ceramic, 1 μ F, 25 V, +80% –20%, Y5V	muRata
C8	GRM39X7R104K016A	Capacitor, Ceramic, 0.1 μ F, 16 V, 10%, X7R	muRata
C9	GRM39X7R104K016A	Capacitor, Ceramic, 0.1 μ F, 16 V, 10%, X7R	muRata
C10	GRM39X7R104K016A	Capacitor, Ceramic, 0.1 μ F, 16 V, 10%, X7R	muRata
C11	GRM42-6X7R472K050A	Capacitor, Ceramic, 4700 pF, 50 V, 10%, X7R	muRata
C12	GRM42-6X7R472K050A	Capacitor, Ceramic, 4700 pF, 50 V, 10%, X7R	muRata
C13	GRM42-6X7R472K050A	Capacitor, Ceramic, 4700 pF, 50 V, 10%, X7R	muRata
C14	4SP820M	Capacitor, OS-Con, 820 μ F, 4 V, 20%	Sanyo
C15	4SP820M	Capacitor, OS-Con, 820 μ F, 4 V, 20%	Sanyo
C16	4SP820M	Capacitor, OS-Con, 820 μ F, 4 V, 20%	Sanyo
C17	4SP820M	Capacitor, OS-Con, 820 μ F, 4 V, 20%	Sanyo
C18	GRM235Y5V106Z016A	Capacitor, Ceramic, 10 μ F, 16 V, Y5V	TDK
C19	GRM235Y5V106Z016A	Capacitor, Ceramic, 10 μ F, 16 V, Y5V	TDK
C20	GRM235Y5V106Z016A	Capacitor, Ceramic, 10 μ F, 16 V, Y5V	TDK
C21	GRM235Y5V106Z016A	Capacitor, Ceramic, 10 μ F, 16 V, Y5V	TDK
C22	GRM39X7R104K016A	Capacitor, Ceramic, 0.1 μ F, 16 V, 10%, X7R	muRata
C23	GRM39X7R104K016A	Capacitor, Ceramic, 0.1 μ F, 16 V, 10%, X7R	muRata
C24	GRM39X7R104K016A	Capacitor, Ceramic, 0.1 μ F, 16 V, 10%, X7R	muRata
C25	GRM39X7R104K016A	Capacitor, Ceramic, 0.1 μ F, 16 V, 10%, X7R	muRata
C26	GRM39X7R104K016A	Capacitor, Ceramic, 0.1 μ F, 16 V, 10%, X7R	muRata
C27	GRM235Y5V106Z016A	Capacitor, Ceramic, 10 μ F, 16 V, Y5V	TDK
J1	532956-7	Connector, AMPMODU, 40-pin	AMP

Table 4-1. Main Board Bill of Materials (Continued)

REF DES	PART NUMBER	DESCRIPTION	MFG
L1		Inductor, Filter, 1.15 μ H, 11 A (8T #18 on T44-8/90 Core)	Micro-Metals
L2		Inductor, Filter, 1 μ H, 25 A (7T #16 on T68-8/90 Core)	Micro-Metals
P1		For Ref only, Pads on board.	
P2		For Ref only, Pads on board	
Q1	Si4410DY	FET, N-ch, 30-V, 10-A, 13-milliohm	Siliconix
Q2	Si4410DY	FET, N-ch, 30-V, 10-A, 13-milliohm	Siliconix
Q3	Si4410DY	FET, N-ch, 30-V, 10-A, 13-milliohm	Siliconix
Q4	Si4410DY	FET, N-ch, 30-V, 10-A, 13-milliohm	Siliconix
Q5	Si4410DY	FET, N-ch, 30-V, 10-A, 13-milliohm	Siliconix
R1	Std	Resistor, Chip, 10 Ω 1/16 W, 5%	
R2	Std	Resistor, Chip, 10 Ω , 1/16 W, 5%	
R3	Std	Resistor, Chip, 3.3 Ω , 1/16 W, 5%	
R4	Std	Resistor, Chip, 3.3 Ω , 1/16 W, 5%	
R5	Std	Resistor, Chip, 3.3 Ω , 1/16 W, 5%	
R6	Std	Resistor, Chip, 2 Ω , 1/8 W, 5%	
R7	Std	Resistor, Chip, 2 Ω , 1/8 W, 5%	
R8	Std	Resistor, Chip, 2 Ω , 1/8 W, 5%	
R9	Std	Resistor, Chip, 3.3 Ω , 1/16 W, 5%	
R10	Std	Resistor, Chip, 3.3 Ω , 1/16 W, 5%	
DB1	SLVP116DB	PCB, VRM Controller Board (daughter board) 1.7" $\times$ 0.89" $\times$ 0.062", 2 layer, 2-oz copper	
DB1 (Alternate)	SLVP116DB2	PCB, VRM Controller Board (daughter board) 1.725" $\times$ 0.825" $\times$ 0.062", 2 layer, 2-oz copper	
NA	SLVP116	PCB, VRM Board, 3.1" $\times$ 1.5" $\times$ 0.062", 2-layer, 2-oz copper	

4.2 Daughter Board Bill of Materials

Table 4-2 lists materials required for the controller board, SLVP116 EVM.

Table 4–2. Daughter Board Bill of Materials

VRM Controller Board (SLVP116DB or SLVP116DB2)

REF DES	PART NUMBER	DESCRIPTION	MFG
C101	ECS-H1AD476R	Capacitor, Tantalum, 47 μ F, 10 V, 20%	Panasonic
C102	GRM39X7R104K016A	Capacitor, Ceramic, 0.1 μ F, 16 V, 10%, X7R	muRata
C103	GRM39X7R103K025A	Capacitor, Ceramic, 0.01 μ F, 25 V, 10%, X7R	muRata
C104	GRM39X7R104K016A	Capacitor, Ceramic, 0.1 μ F, 16 V, 10%, X7R	muRata
C105	GRM39X7R102K050A	Capacitor, Ceramic, 1000 pF, 50 V, 10%, X7R	muRata
C106	GRM40X7R333K025A	Capacitor, Ceramic, 0.033 μ F, 25 V, 10%, X7R	muRata
C107	GRM39X7R104K016A	Capacitor, Ceramic, 0.1 μ F, 16 V, 10%, X7R	muRata
C108	GRM42-6Y5V105Z025A	Capacitor, Ceramic, 1 μ F, 25 V, +80% –20%, Y5V	muRata
C109	GRM42-6Y5V105Z025A	Capacitor, Ceramic, 1 μ F, 25 V, +80% –20%, Y5V	muRata
C110	GRM42-6Y5V105Z025A	Capacitor, Ceramic, 1 μ F, 25 V, +80% –20%, Y5V	muRata
C111	GRM42-6X7R104K025A	Capacitor, Ceramic, 0.1 μ F, 25 V, 10%, X7R	muRata
C112	ECS-H1CD226R	Capacitor, Tantalum, 22 μ F, 16 V, 20%	Panasonic
C113	GRM42-6Y5V105Z025A	Capacitor, Ceramic, 1 μ F, 25 V, +80% –20%, Y5V	muRata
C114	GRM39X7R104K016A	Capacitor, Ceramic, 0.1 μ F, 16 V, 10%, X7R	muRata
D101	SML-LX2832GC-TR	Diode, LED, Green, 2.1 V, SM	Lumex
J101	2163R-10-ND	Header, 2 mm, Single row, right angle, 10 pin	NorComp
J102	2163R-10-ND	Header, 2 mm, Single row, right angle, 10 pin	NorComp
Q101	2N7002DICT-ND	MOSFET, N-ch, 60 V, 115 mA, 1.2 Ω	Diodes, Inc.
Q102	Si2303DS	MOSFET, P-ch, –30 V, –1.7 A, 0.24 Ω	Siliconix
R101	Std	Resistor, Chip, 4.32 k Ω , 1/16 W, 1%	
R102	Std	Resistor, Chip, 1.00 k Ω , 1/16 W, 1%	
R103	Std	Resistor, Chip, 100 Ω , 1/16 W, 5%	
R104	Std	Resistor, Chip, 10.0 k Ω , 1/16 W, 1%	
R105	Std	Resistor, Chip, 11.0 k Ω , 1/16 W, 1%	
R106	Std	Resistor, Chip, 3.92 k Ω , 1/16 W, 1%	
R107	Std	Resistor, Chip, 1.00 k Ω , 1/16 W, 1%	

Table 4-2. Daughter Board Bill of Materials (Continued)

REF DES	PART NUMBER	DESCRIPTION	MFG
R108	Std	Resistor, Chip, 1 k Ω , 1/16 W, 5%	
R109	Std	Resistor, Chip, 20 k Ω , 1/16 W, 5%	
R110	Std	Resistor, Chip, 100 Ω , 1/16 W, 1%	
R111	Std	Resistor, Chip, 20.0 k Ω , 1/16 W, 1%	
R112	Std	Resistor, Chip, 10.0 k Ω , 1/16 W, 1%	
R113	Std	Resistor, Chip, 150 Ω , 1/16 W, 1%	
R114	Std	Resistor, Chip, 1 M Ω , 1/16 W, 5%	
R115	Std	Resistor, Chip, 10 k Ω , 1/16 W, 5%	
(SLVP116DB only)			
U101	TPS5210DW	IC, PWM Ripple Controller, Adjustable Output	TI
	SLVP116DB	PCB, VRM Controller Board (daughter board) 1.7" $\times$ 0.89" $\times$ 0.062", 2 layer, 2-oz copper	
(SLVP116DB2 only)			
U101	TPS5210PWP	IC, PWM Ripple Controller, Adjustable Output	TI
	SLVP116DB2	PCB, VRM Controller Board (daughter board) 1.725" $\times$ 0.825" $\times$ 0.062", 2 layer, 2-oz copper	