Si9118/9 Demonstration Board

FEATURES

- Fixed Telecom Input Voltage Range: 36 V to 72 V
- 5-V Output Voltage, 5-A Max.
- Total 25-W Continuous Power
- High Efficiency 500-kHz Switching Frequency
- Integrated Start-up Circuitry
- Single switch Forward Converter With Self Resonant Reset
- Current Mode Control With Slope Compensation
- Optional Pulse Skipping Mode For Light Load Efficiency

DESCRIPTION

Included in this document are the Bill-of-Materials, Demo Board Schematic, and PCB layout.

The demonstration board layout is available in Gerber file format. Please contact your Vishay Siliconix sales representative or distributor for a copy.

ORDERING INFORMATION: PART NUMBER Si9118/9119DB

POWER-UP CHECK LIST

This demonstration board is a complete single switch forward converter design for telecom application. The converter is optimized for 25-W continuous output power.

1. P1 and P2 are input power connector.
2. P5 and P6 are output power connector.
3. P3 is signal ground and is connected on the board to the input power ground at a single point. Use P3 as reference ground connection when probing the control circuitry.
4. P4 is SYNC pin for clock synchronous operation (Si9119DB only).
5. JP1 is used for selecting PWM (pulse width modulated) mode or PSM (pulse skipping mode). To configure the converter to run in PWM mode, connect JP1 across pin 1 and 2. To configure PSM, connect JP1 across pin 2 and 3.
6. TP1 is used for measuring the converter loop gain. This pin is referred to the output ground (P6).

TYPICAL WAVEFORMS AND PERFORMANCE

The demo converter is designed on a double sided surface mount FR4 board. All components are surface mount except the electrolytic capacitors. The schematic, bill of materials and board layout artworks are included at the end of this demo board note. Following are typical waveforms and converter performance.

EFFICIENCY

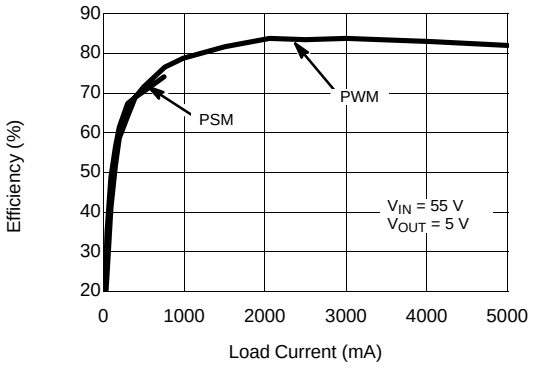


FIGURE 1. PSM and PWM Efficiency vs. Load Current

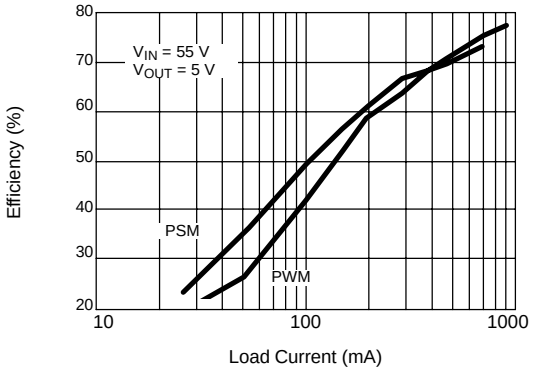


FIGURE 2. PSM and PWM Efficiency vs. Load Current

OUTPUT REGULATION

Figure 3 shows typical output voltage at various input voltage and load condition and in both PWM/PSM operation. Load and line regulation is a quarter of a percent for both PWM and PSM mode of operation.

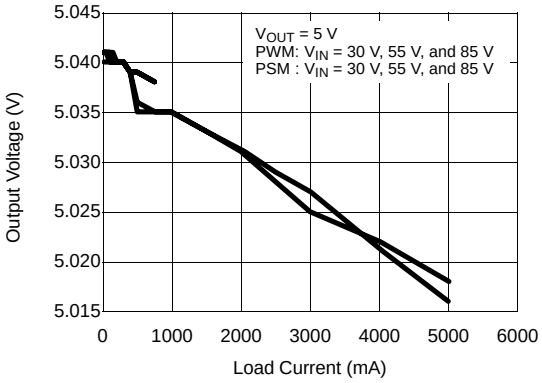
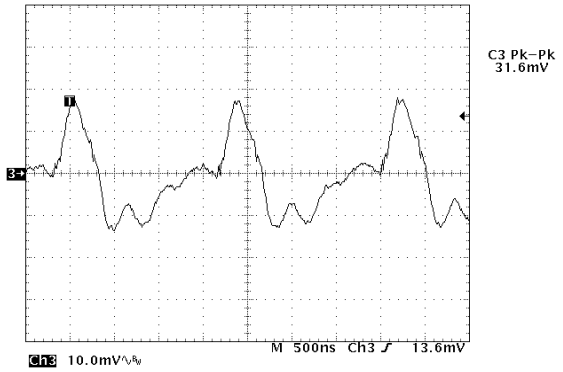


FIGURE 3. Output Regulation vs. Load

V_O minimum = 5.016 V, V_O maximum = 5.041 V, V_O mean = 5.029 V, V_O tolerance = ±0.25%

OUTPUT RIPPLE VOLTAGE

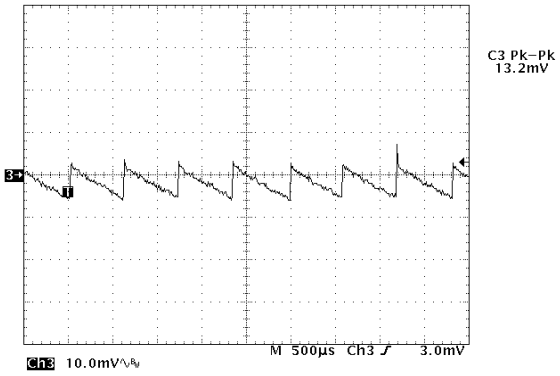
Typical output ripple voltage in PWM mode.



Operating Condition: V_{IN} = 80 V, I_O = 5 A, 20 MHz BWL

FIGURE 4. Typical Output Ripple Voltage in PWM Mode

Typical output ripple voltage during PSM

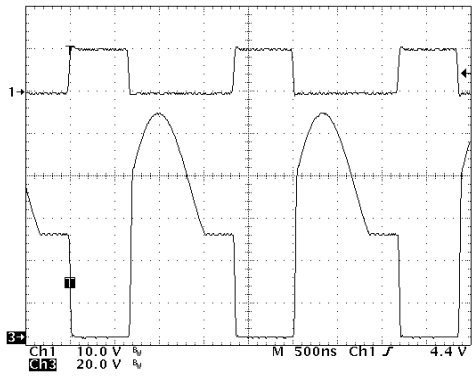


Operating Condition: V_{IN} = 80 V, I_O = 0 A, 20 MHz BWL

FIGURE 5. Output Ripple Voltage During PSM

V_{DS} RESONANT VOLTAGE

Figure 6 shows the drain to source voltage, V_{DS}, of the main power MOSFET switch. V_{DS} is measured with differential probe TEK P5205 x 50. The primary magnetizing inductance current is fully reset when the V_{DS} is reset back to V_I. At this point, all of the magnetizing energy is fully recovered.

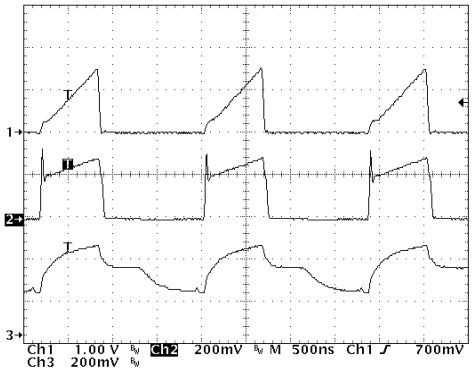


Ch1: Gate-Source Voltage
Ch3: Drain-Source Voltage
Operating Condition: V_{IN} = 48 V, I_O = 2.5 A

FIGURE 6.

MISC WAVEFORMS

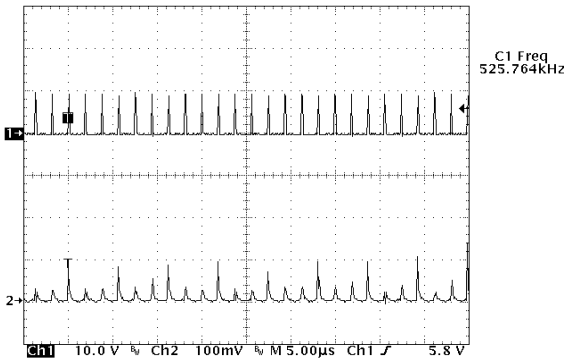
Figure 7 shows typical voltage waveforms at the V_{SC}, I_{LIM}, and the I_{CS} pins. Notice that I_{CS} voltage is not a direct addition of I_{LIM} and V_{SC}. I_{CS} is an input of a high speed current comparator. This comparator sources a non linear current out off I_{CS} pin. In order to provide optimum slope compensation value for the current signal, the equation mentioned in the slope compensation section must be used.



Ch1: V_{SC}
Ch2: I_{LIM}
Ch3: I_{CS}
Operating Condition: V_{IN} = 48 V, I_O = 2.5 A

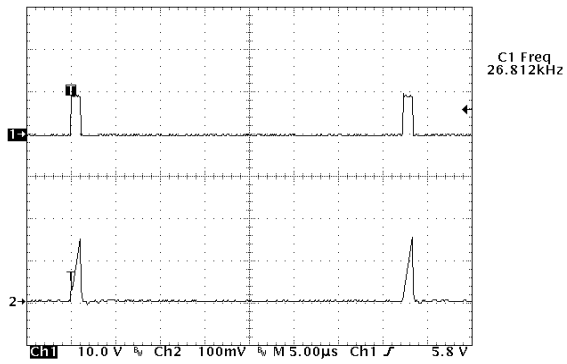
FIGURE 7.

Figures 8 and 9 demonstrate the operation of PWM versus PSM mode. During PSM mode, at V_I = 55 V, I_O = 50 mA, the frequency is fold back to 23.3 kHz from 522 kHz. The switching losses is reduced to $^1/_{22}$ times that of the PWM operation.



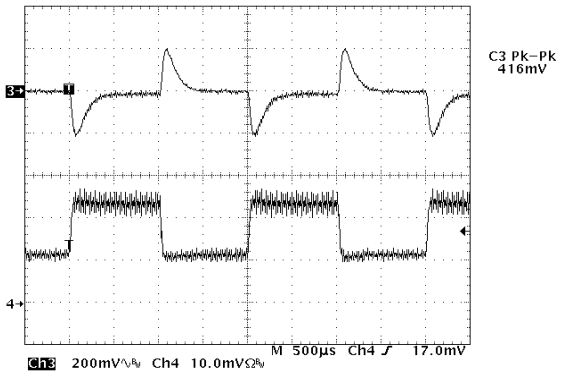
Ch1: Gate-Drive Voltage
Ch2: I_{LIM}
Operating Condition: PSM Mode, V_{IN} = 48 V, I_O = 50 mA

FIGURE 8.



Ch1: Gate-Drive Voltage
Ch2: I_{LIM}
Operating Condition: PSM Mode, V_{IN} = 48 V, I_O = 50 mA

FIGURE 9.



Ch4: Load Step Current, 2A/div
Ch3: Output Voltage Load Step Response
Operating Condition: PSM Mode, V_{IN} = 48 V
I_O steps between 2.5 A – 5.0 A, $T_r = t_f$ = 50 µS, f_C = 8 kHz

FIGURE 10.

LOAD STEP RESPONSE

Figure 10 shows output voltage response to a load step condition. This converter has the voltage loop gain cross over frequency of 8 kHz. Worst case output voltage deviation is 230-mV nominal to peak, a 4.6% deviation from nominal output voltage. The voltage recovers nicely within 300uS. The load step response performance can be improved further with a higher loop gain cross over frequency. Higher cross over frequency exceeding 40 kHz can be done in non isolated design or with the use of faster opto-coupler.

SCHEMATIC, BILL-OF-MATERIAL AND PCB LAYOUT

This section contains the schematic, bill of material, PCB layout artwork for the demo board. The Gerber file for the artwork is also available. Please contact Vishay Siliconix application department for more information.

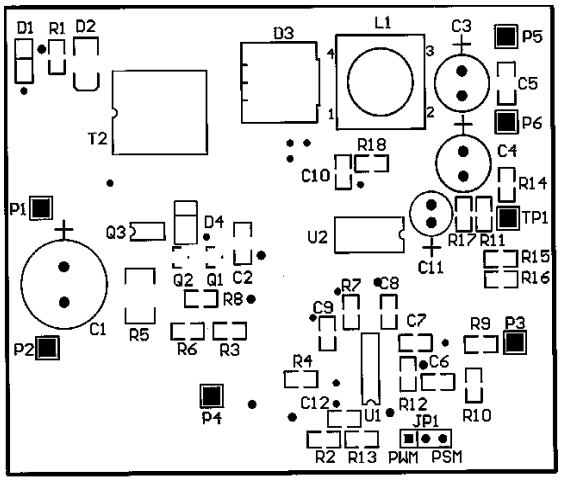


FIGURE 11.

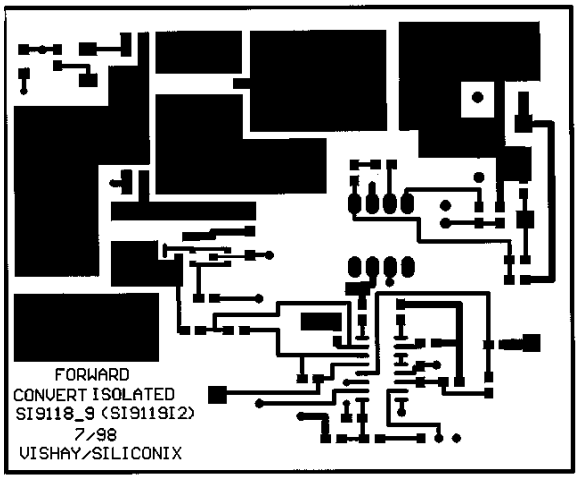


FIGURE 12.

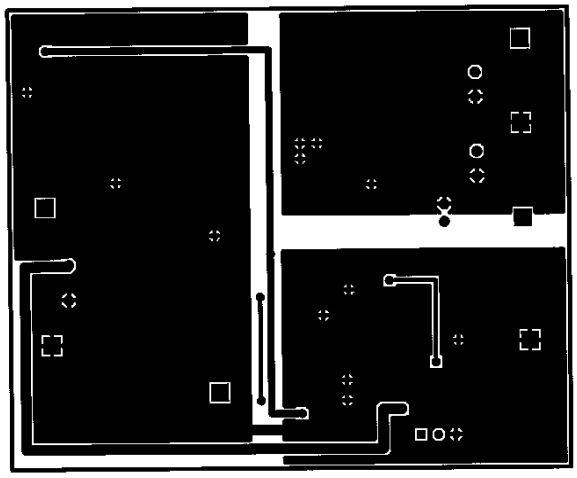


FIGURE 13.

APPLICATIONS CIRCUIT

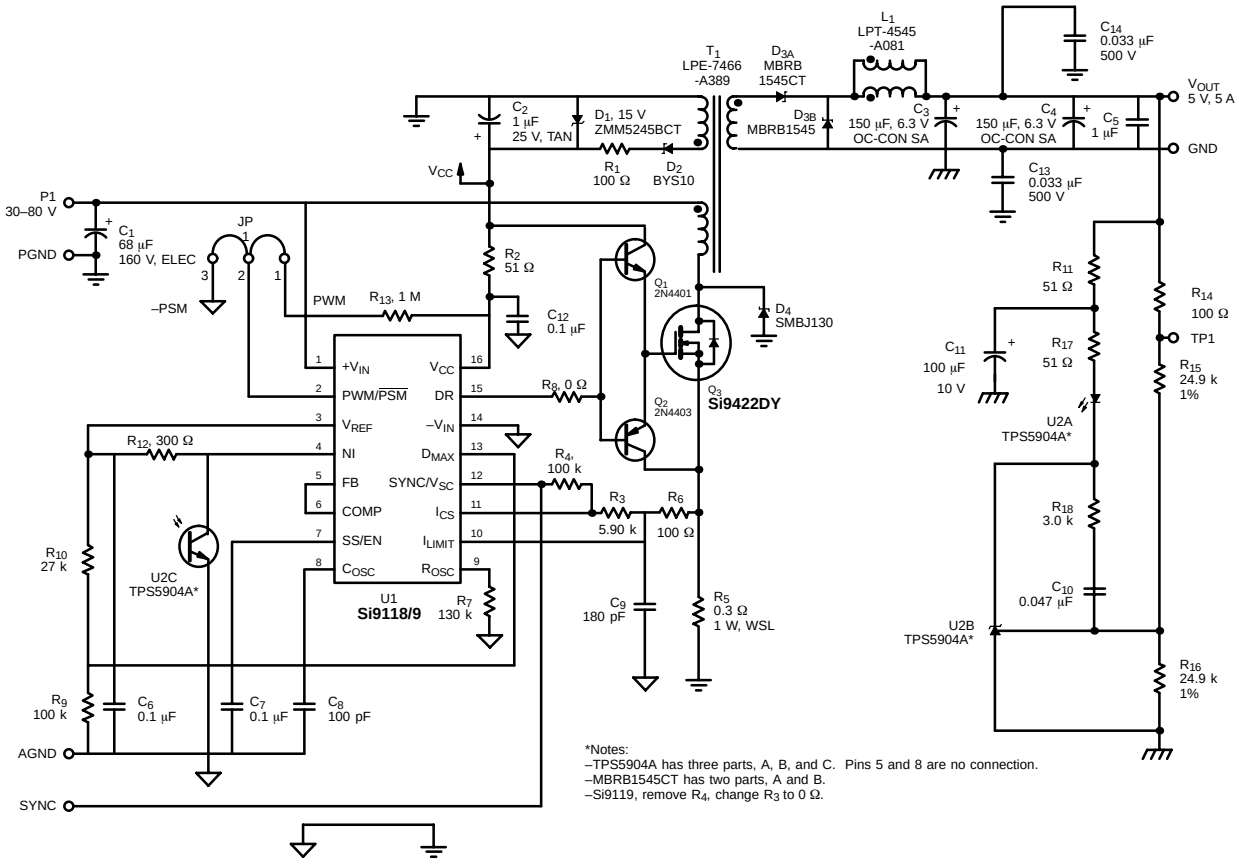


FIGURE 14. Forward Converter Isolated

TABLE 1. BILL-OF-MATERIAL

Item	Qty	Designator	Part Type	Description	Footprint	Part Number	Manufacturer
1	3	R_1, R_6, R_{14}	100	Resistor, 5%, $^1/_8$ W	0805	CRCW0805101JRT1	Vishay Dale
2	3	R_2, R_{11}, R_{17}	51	Resistor, 5%, $^1/_8$ W	0805	CRCW0805510JRT1	Vishay Dale
3	1	R_3	5.90 k	Resistor, 5%, $^1/_8$ W	0805	CRCW0805592JRT1	Vishay Dale
4	2	R_4, R_9	100 k	Resistor, 5%, $^1/_8$ W	0805	CRCW0805104JRT1	Vishay Dale
5	1	R_5	0.3	Resistor, 1%, 1.0 W	2512A	WSL-2512	Vishay Dale
6	1	R_7	130 k	Resistor, 5%, $^1/_8$ W	0805	CRCW0805134JRT1	Vishay Dale
7	1	R_8	0	Jumper Resistor, $^1/_8$ W	0805	CRCW0805000JRT1	Vishay Dale
8	1	R_{10}	27 k	Resistor, 5%, $^1/_8$ W	0805	CRCW0805273JRT1	Vishay Dale
9	1	R_{12}	300	Resistor, 5%, $^1/_8$ W	0805	CRCW0805301JRT1	Vishay Dale
10	1	R_{13}	1 M	Resistor, 5%, $^1/_8$ W	0805	CRCW0805105JRT1	Vishay Dale
11	2	R_{15}, R_{16}	24.9 k	Resistor, 1%, $^1/_8$ W	0805	CRCW08052492FRT1	Vishay Dale
12	1	R_{18}	3.0 k	Resistor, 5%, $^1/_8$ W	0805	CRCW0805302JFT1	Vishay Dale
13	1	C_1	68 µF	Capacitor, Elec., 160 V	RB.2/.5	EEU-EB2C680	Panasonic
14	1	C_2	1 µF	Capacitor, Ceramic., 25 V	1206	VJ1206Y105KXXAT	Vishay Sprague
15	2	C_3, C_4	150 µF	Capacitor, Elec., 6.3 V	RB.14/.3	OS-CON_E, SA Series	Sanyo
16	1	C_5	1 µF	Capacitor, Ceramic, 10 V	1206	Y5V Dielectric	AVX
17	3	C_6, C_7, C_{12}	0.1 µF	Capacitor, Ceramic, 10 V	0805	VJ0805410KXXXAT	Vishay Vitramon
18	1	C_8	100 pF	Capacitor, Ceramic, 10 V	0805	VJ0805410KXXXAT	Vishay Vitramon
19	1	C_9	180 pF	Capacitor, Ceramic, 10 V	0805	VJ0805181KXXXAT	Vishay Vitramon
20	1	C_{10}	0.047 µF	Capacitor, Ceramic, 10 V	0805	VJ0805473KXXXAT	Vishay Vitramon
21	1	C_{11}	100 µF	Capacitor, Elec., 10 V	RB.1/.25	ECE-A1AFS101	Panasonic
21B	1	C_{13}, C_{14}	0.033 µF	Capacitor, Ceramic, 500 V	1812	VJ1812Y333MXEAT	Vishay Vitramon
22	1	Q_1	2N4401	NPN Transistor	SOT-23N	2N4401	Multi-Source
23	1	Q_2	2N4403	NPN Transistor	SOT-23N	2N4403	Multi-Source
24	1	Q_3	Si9422DY	N-Channel MOSFET	SOIC-8	Si9422DY	Vishay Siliconix
25	1	D_1	ZMM524BCT	Diode, Zener, 15 V, 8.5 mA	DL-35	ZMM5245BCT	Liteon
26	1	D_2	BYS10	Diode, Schottky, 45 V, 1 A	BYS10	BYS10-45	Vishay Telefunken
27	1	D_3	MBRB	Diode, Schottky, 45 V, 15 A	DD-PAC	MBRB1545CT	Liteon
28	1	D_4	SMBJ130	Transient, 600 W, 130 V	SMB	SMBJ130A	Liteon
29	1	U_1	Si9118/9	Powerr IC	SOIC-16	Si9118/9	Vishay Siliconix
30	1	U_2	TPS5904A	Optoisolated-FB AMP	SMT8	TPS5904A	Texas Instrument
31	1	L_1	L_LPT4545	10-µH Inductor	L_LPT4545	LPT-4545-A081	Vishay Dale
32	1	T_1	SFMR_LP7466	Custom-Made	XFMR_LPE7466	LPE-7466-A389	Vishay Dale
33	1	JP_1	Header	3-Pin Header, 0.1” spacing	SIP_3	SIP Header	Multi-Source
34	6	P_1 to P_6	Header Strips	1-Pin Header, 0.1” spacing	TP_1	SIP Header	Multi-Source
35	1	TP_1	Header Strips	1-Pin Header, 0.1” spacing	TP_1	SIP Header	Multi-Source

TABLE 2. ALTERNATE PARTS FOR DIFFERENT POWER LEVELS DESIRED						
Item	**Reference Designator**	**Description**	**Manufacturer**	**Part Number**	**Pkg**	**Qty**
Power Lever: 12.5 W						
Power Transformer	T_1	Custom Transformer	Vishay Dale	LPE-7466-XXX	LPE	1
Output Inductor	L_1	Custom Inductor	Vishay Dale	LPT-4545-XXX	LPT	1
Input Power Switch	Q_3	MOSFET, 200 V, 1.0 Ω	Vishay Siliconix	Si9420DY	SOIC-8	1
Input Capacitor	C_1	Capacitor 22 μF, 160 V	Panasonic	EEU-EB2C220S	10 x 20	1
Output Capacitor	C_4	Capacitor 150 μF, 6.3 V, OSCON	Sanyo	6SA150M	8 x 10.5	1
Output Rectifying Diodes	D_3	Schottky, 5 A, 40 V	Vishay Liteon	B540C	SMC	2
Output Limiting Resistor	R_5	Resistor, 0.6 Ω, 0.5 W	Vishay Dale	WSL-1206-R600F	1206	1
Power Level: 25 W						
Power Transformer	T_1	Custom Transformer	Vishay Dale	LPE-7466-A389	LPE	1
Output Inductor	L_1	Custom Inductor	Vishay Dale	LPT-4545-A081	LPT	1
Input Power Switch	Q_3	MOSFET, 200 V, 0.42 Ω	Vishay Siliconix	Si9422DY	SOIC-8	1
Input Capacitor	C_1	Capacitor 68 μF, 160 V	Panasonic	EEU-EB2C680S	12.5 x 20	1
Output Capacitor	C_4	Capacitor 150 μF, 6.3 V, OSCON	Sanyo	6SA150M	8 x 10.5	2
Output Rectifying Diodes	D_3	Schottky, 15 A, 45 V	Vishay Liteon	MBRB1545PT	D^2PAK	1
Output Limiting Resistor	R_5	Resistor, 0.3 Ω, 1 W	Vishay Dale	WSL-2512-R300F	2512	1
Power Level: 50 W						
Power Transformer	T_1	Custom Transformer	Vishay Dale	LPE-7466-XXX	LPE	1
Output Inductor	L_1	Custom Inductor	Vishay Dale	LPT-4545-XXX	LPT	1
Input Power Switch	Q_3	MOSFET, 200 V, 0.42 Ω	Vishay Siliconix	Si9422DY	SOIC-8	3
Input Capacitor	C_1	Capacitor 100 μF, 160 V	Panasonic	EEU-EB2C101S	18 x 20	1
Output Capacitor	C_4	Capacitor 150 μF, 6.3 V, OSCON	Sanyo	6SA150M	8 x 10.5	4
Output Rectifying Diodes	D_3	Schottky, 20 A, 45 V	Vishay Liteon	SLB2045PT	TO-220AB	1
Output Limiting Resistor	R_5	Resistor, 0.15 Ω, 2 W	Vishay Dale	WSR2-R150F	WSR2	1