



Si9167 Demonstration Board

FEATURES

- Voltage Mode Control
- Fully Integrated MOSFET Switches
- 600-mA Load Capability
- 5- to 10-V Input Voltage Range for V_{DD} and V_{IN}
- Programmable PWM/PSM Control
- Up to 2-MHz Switching Frequency in PWM
- Synchronous Rectification in PWM as well as in PSM
- 200- μ A I_{DD} in PSM
- Output Power Good Signal
- Integrated UVLO and POR
- Integrated Soft-Start
- Synchronization
- Shutdown Current $<1 \mu$ A
- Wide Bandwidth Feedback Amplifier
- 2-Cell Li+ and 6-Cell NiCd or NiMH Operation

DESCRIPTION

The Si9167DB, a Buck Regulator Demonstration Board, includes all the components needed to fully demonstrate the capability of the Si9167 in a buck conversion application. It provides 3.6-V output with up to 600-mA load. The output voltage and output PWR_Good threshold can be easily adjusted by changing the resistor values. The input source can be a 2-cell Li+, 6-cell NiCd/NiMH battery pack or a dc supply. The set frequency in PWM is 850 kHz and can be increased up to 2 MHz. The efficiency is 94% at 5-V input and at 400-mA load current (Figure 9).

The demonstration board uses all surface mount components

and is fully assembled and tested for quick evaluation. Jumpers and Test points are provided for the easy selection of operating mode and to observe waveforms.

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

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 Si9167DB

POWER-UP CHECK LIST AND OPERATION

Follow these steps to verify the board operation.

7. Visually inspect the PCB to be sure that all the components are intact and no foreign substance is lying on it.
8. Reduce the source voltage to zero and connect it through the dc ammeter at P1 and P2 with positive at P1 and ground at P2.
9. Position the jumper JP1 to ENABLE and JP2 to PWM.
10. Connect the load through the dc ammeter at P7 and P8, with positive at P7 and ground at P8. Keep the load at 200 mA.
11. Connect the voltmeters exactly at P1 and P2 for input voltage and P7 and P8 for output voltage measurement. Connect the oscilloscope ground to the input ground and the probe at coil (pin 20) to observe the switching waveform.
12. Slowly increase the input voltage while monitoring the output voltage and and coil waveform. Set the input voltage to 7.2 V and increase the load slowly up to 600 mA.
13. To test the demo board in PSM, adjust the load to 50 mA. Then change the jumper JP2 setting to PSM. Notice the reduction of the input current.

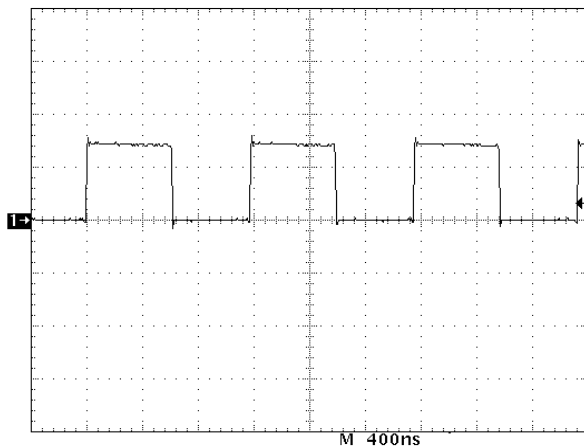
PCB LAYOUT AND ACTUAL WAVEFORMS

Typical Waveforms and Performance

The Demo Board output voltage is adjustable from 1.3 V to 10 V and is set at 3.6 V. The converter is optimized to deliver up to 600 mA in PWM and 150 mA in PSM mode.

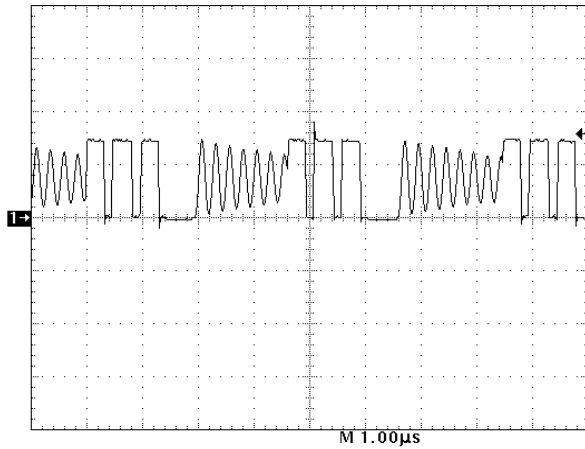
Coil Waveforms

The typical coil waveforms, in PWM and PSM mode of operation is shown in Figure 1 and Figure 2. As can be seen, there is very little spike over the high coil voltage, during the cross-over.



Ch1: Coil/pin 20 (5 V/div)
 $V_{IN} = 7.2\text{ V}$
 $V_{OUT} = 3.6\text{ V}$
 $I_{OUT} = 600\text{ mA}$

FIGURE 1. Coil Waveform—PWM



Ch1: Coil/pin 20 (5 V/div)
 $V_{IN} = 7.2\text{ V}$
 $V_{OUT} = 3.6\text{ V}$
 $I_{OUT} = 150\text{ mA}$

FIGURE 2. Coil Waveform—PSM

PWM/PSM Output Ripple and Noise

Special care is required to correctly measure the ripple performance. A well shielded probe and 100-MHz oscilloscope bandwidth are recommended to avoid any

pick-up through the oscilloscope and falls reading. Precise connection of the probe across the output test points, P7 and P8, is also recommended (Figure 3). Figures 4 and 5 show the output ripple and noise waveforms in PWM and PSM operation.

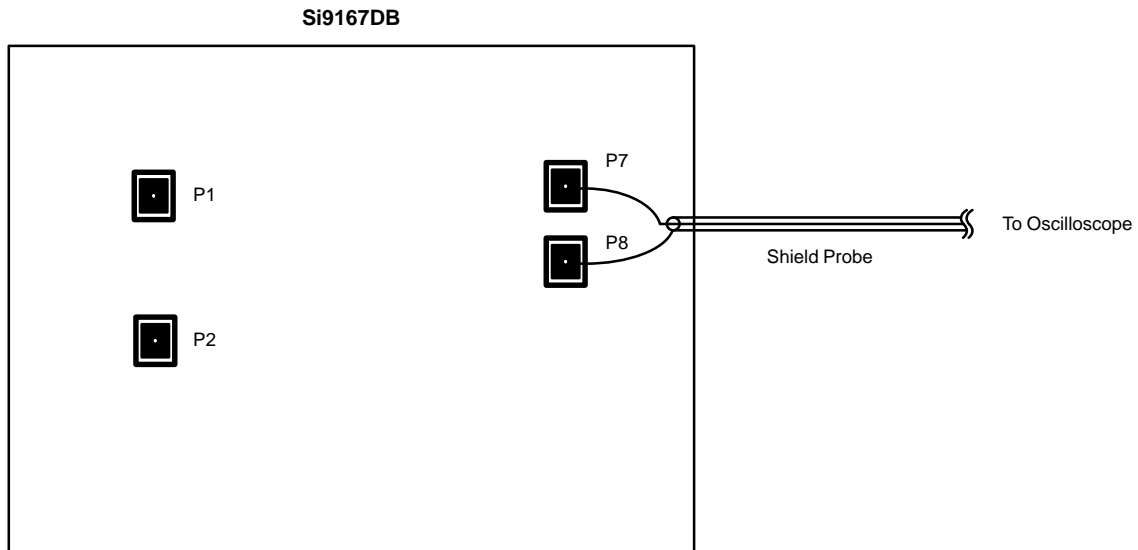
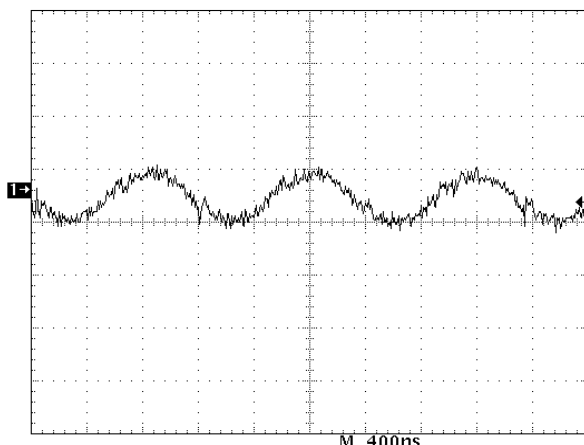
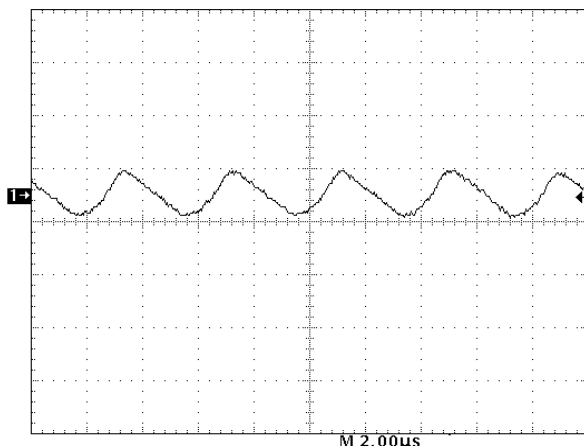


FIGURE 3. Ripple and Noise Measurement



Ch1: V_{OUT} (10 mV/div)
 $V_{IN} = 7.2\text{ V}$
 $V_{OUT} = 3.6\text{ V}$
 $I_{OUT} = 600\text{ mA}$

FIGURE 4. Output Ripple—PWM



Ch1: V_{OUT} (50 mV/div)
 $V_{IN} = 7.2\text{ V}$
 $V_{OUT} = 3.6\text{ V}$
 $I_{OUT} = 150\text{ mA}$

FIGURE 5. Output Ripple—PSM

Synchronization

The synchronization of the Si9167 with an external source or even in a master-slave configuration is possible without using any extra components. To verify the sync function in master-slave configuration:

1. Connect two Si9167 Demo boards with the twisted pair of wires as shown in Figure 6.
2. Set the slave oscillator frequency 30% lower than the master oscillator frequency.
3. Connect the oscilloscope grounds to P6(GND) and the probes to P5(CLK) of both converters.
4. Power up both demo boards with 7.2-V input and keep 200-mA nominal load at the outputs.
5. Observe the waveforms with and without the twisted wire connection.

The master can be replaced with the signal generator to verify the synchronization by external frequency source. Figures 7 and 8 demonstrate the clock waveforms of master and slave with and without synchronization. Refer the Application note AN727 for the behavior of the synchronized converters, when operated in PSM mode.

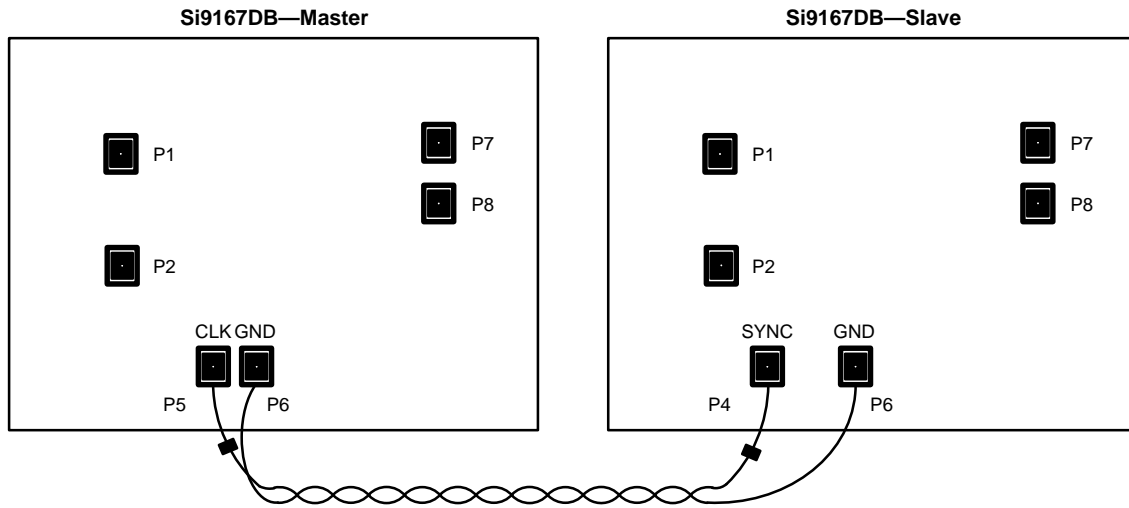
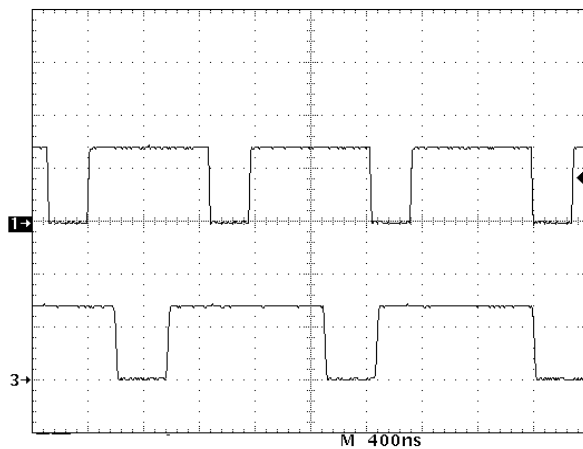
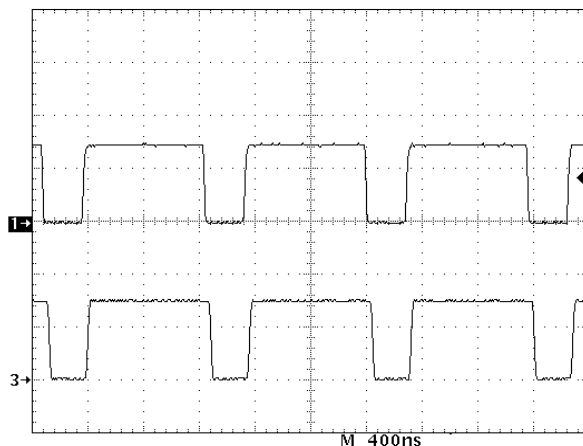


FIGURE 6. Synchronization



Ch1: CLK_Master (5 V/div)
 Ch3: CLK_Slave (5 V/div)
 Si9167DB Master: $V_{IN} = 7.2\text{ V}$
 $V_{OUT} = 3.6\text{ V}$
 $I_{OUT} = 200\text{ mA}$
 Si9167DB Slave: $V_{IN} = 7.2\text{ V}$
 $V_{OUT} = 2.7\text{ V}$
 $I_{OUT} = 200\text{ mA}$

FIGURE 7. No Synchronization



Ch1: CLK_Master (5 V/div)
 Ch3: CLK_Slave (5 V/div)
 Si9167DB Master: $V_{IN} = 7.2\text{ V}$
 $V_{OUT} = 3.6\text{ V}$
 $I_{OUT} = 200\text{ mA}$
 Si9167DB Slave: $V_{IN} = 7.2\text{ V}$
 $V_{OUT} = 2.7\text{ V}$
 $I_{OUT} = 200\text{ mA}$

FIGURE 8. With Synchronization

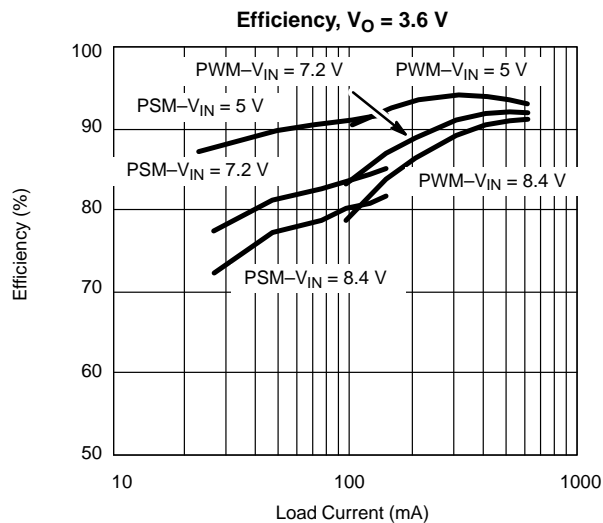


FIGURE 9.

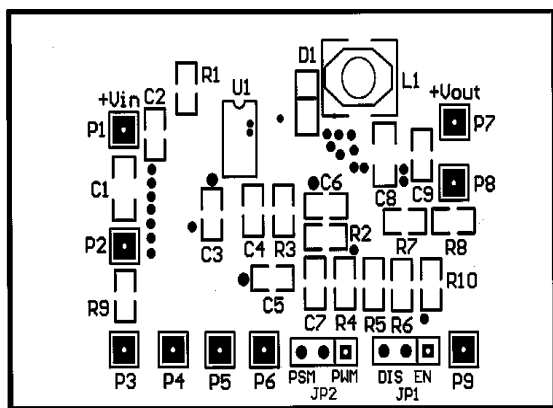


FIGURE 10. Silk Screen

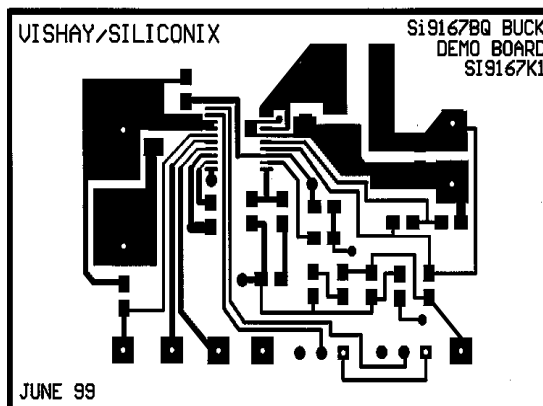


FIGURE 11. Top Layer

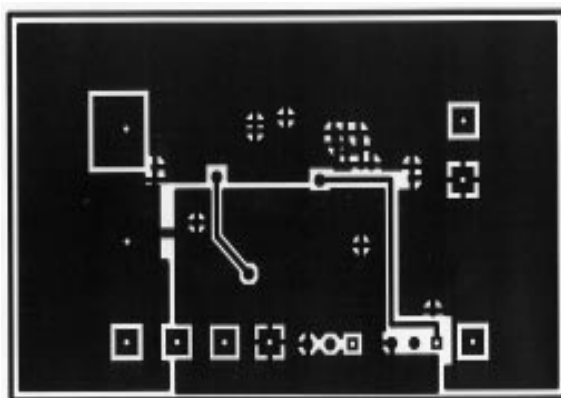


FIGURE 12. Bottom Layer

Si9167DB APPLICATION CIRCUIT

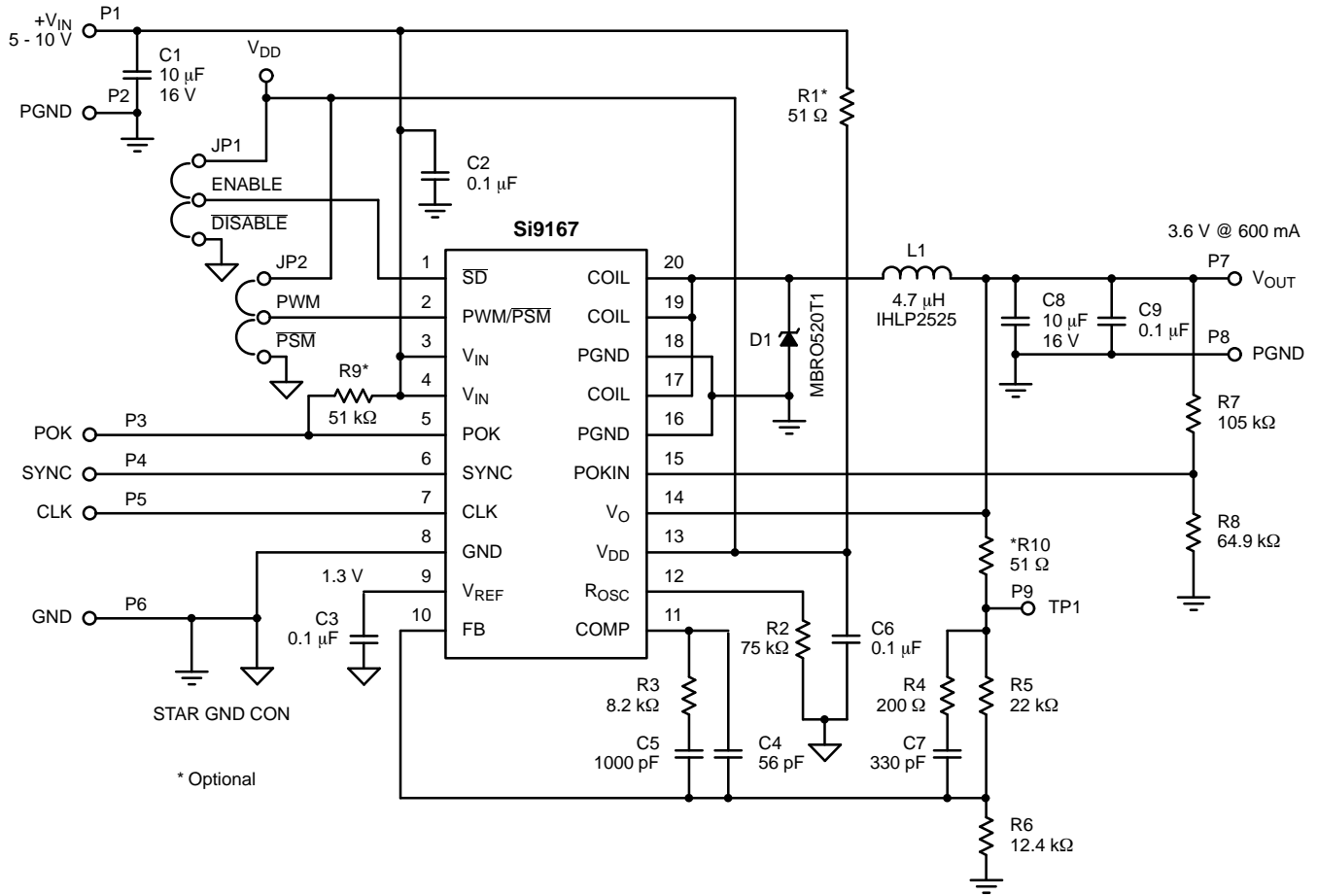


FIGURE 13. Typical Application Circuit—Buck

**TABLE 2. Buck Demo Board Bill-of-Material (V_{OUT} = 3.6 V @ 600 mA)**

Item	Qty	Designator	Part Type	Description	Vendor #	Footprint	Manufacturer
1	2	R1, R10	51 Ω	Resistor, 1/8 W, 5%	CRCW0805510JRT1	0805	Vishay Dale
2	1	R2	75 kΩ	Resistor, 1/8 W, 1%	CRCW08057502FRT1	0805	Vishay Dale
3	1	R3	8.2 kΩ	Resistor, 1/8 W, 1%	CRCW08058201FRT1	0805	Vishay Dale
4	1	R4	200 Ω	Resistor, 1/8 W, 1%	CRCW08052000FRT1	0805	Vishay Dale
5	1	R5	22 kΩ	Resistor, 1/8 W, 1%	CRCW08052202FRT1	0805	Vishay Dale
6	1	R6	12.4 kΩ	Resistor, 1/8 W, 1%	CRCW08051242FRT1	0805	Vishay Dale
7	1	R7	105 kΩ	Resistor, 1/8 W, 1%	CRCW08051053FRT1	0805	Vishay Dale
8	1	R8	64.9 kΩ	Resistor, 1/8 W, 1%	CRCW08056492FRT1	0805	Vishay Dale
9	1	R9	51 kΩ	Resistor, 1/8 W, 5%	CRCW08055102JRT1	0805	Vishay Dale
10	2	C1, C8	10 μF	Capacitor, Ceramic, 16 V	C25Y5U1C106ZP	1210	Tokin
11	4	C2, C3, C6, C9	0.1 μF	Capacitor, Ceramic, 25 V	VJ0805Y104KXXAT	0805	Vishay Vitramon
12	1	C4	56 pF	Capacitor, Ceramic, 25 V	VJ0805Y560KXXAT	0805	Vishay Vitramon
13	1	C5	1000 pF	Capacitor, Ceramic, 25 V	VJ0805Y102KXXAT	0805	Vishay Vitramon
14	1	C7	330 pF	Capacitor, Ceramic, 25 V	VJ0805Y331KXXAT	0805	Vishay Vitramon
15	1	D1	MBR0520T1	Schottky Diode	MBR0520T1	SOD-123	Motorola
16	1	L1	4.7 μH	4.7 μH Inductor	IHLP2525-4.7	IHLP2525	Vishay Dale
17	1	U1	Si9167	Power IC	Si9167BQ-T1	TSSOP-20	Vishay Siliconix
18	2	JP1, JP2	Jumpers	3-Pin Headers		SIP3	Multi-Source
19	9	PT to P9	Power, GND, TP	1-Pin Headers		TP1	Multi-Source