Application Note

ROHM Switching Regulator Solutions

Evaluation Board: Synchronous Buck Converter Integrated FET

BU90002GWZEVK-101 (3.3V | 1A Output)

No.000000000

- **Introduction**

This application note will provide the steps necessary to operate and evaluate ROHM's synchronous buck DC/DC converter using the BU90002GWZ evaluation boards. Component selection, board layout recommendations, operation procedures and application data is provided.

- **Description**

This evaluation board has been developed for ROHM's synchronous buck DC/DC converter customers evaluating BU90002GWZ. While accepting a power supply of 4.0-5.5V, an output of 3.3V can be produced. The IC has internal 250mOhm high-side P-channel MOSFET and 220mOhm low-side N-channel MOSFET and a synchronization frequency range of 5.4MHz to 6.6MHz. A fixed Soft Start circuit prevents in-rush current during startup along with UVLO (low voltage error prevention circuit) and TSD (thermal shutdown detection) protection circuits. An EN pin allows for simple ON/OFF control of the IC to reduce standby current consumption. A MODE pin allows the user to select Forced PWM (Pulse Width Modulation) mode or PFM (Pulse Frequency Modulation) and PWM auto change mode utilized power save operation at light load current.

- **Applications**

Smart phones, Cell phones, Portable applications and Micro DC/DC modules, USB accessories

- **Evaluation Board Operating Limits and Absolute Maximum Ratings**

Parameter		Symbol	Limit			Unit	Conditions
			MIN	TYP	MAX		
Supply Voltage							
	BU90002GWZ	V_{CC}	4.0	-	5.5	V	
Output Voltage / Current							
	BU90002GWZ	V_{OUT}	-	3.300	-	V	
		I_{OUT}	-	-	1	A	

- **Evaluation Board**

Below is evaluation board with the BU90002GWZ.

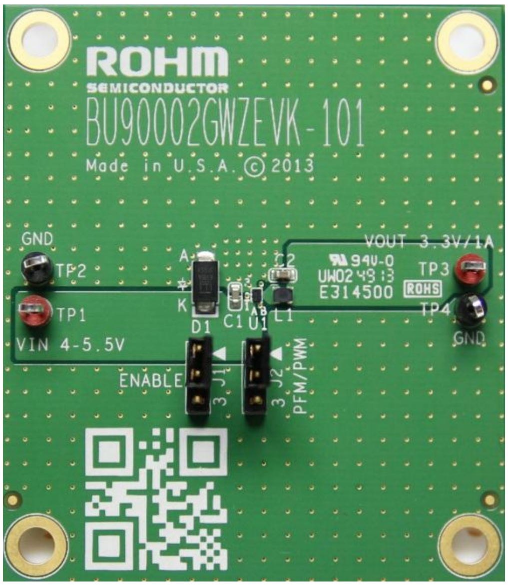
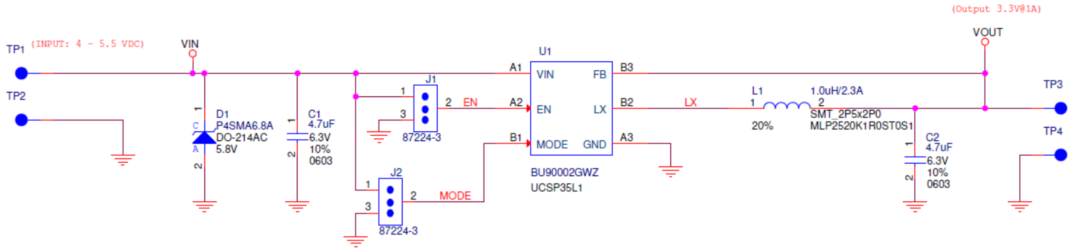


Fig 1: BU90002GWZ Evaluation Board

- **Evaluation Board Schematic**

Below is evaluation board schematic for BU90002GWZ.



BU90002GWZ EVM Jumper Positions		
Reference Designator	Position	Description
J1	2 - 1	Jumper to enable U1. Active Mode
	2 - 3	Jumper to disable U1. standby Mode
J2	2 - 1	Jumper to select Forced PWM Mode
	2 - 3	Jumper to select Automatic PFM/PWM Mode

Fig 2: BU90002GWZ Evaluation Board Schematic

- **Evaluation Board I/O**

Below is reference application circuit that shows the inputs (V_{IN}, EN and MODE) and the output (V_{OUT}).

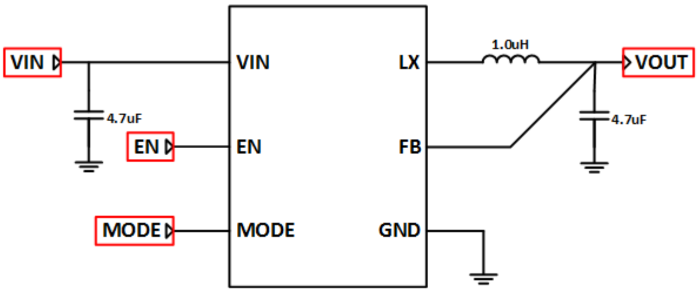


Fig 3: BU90002GWZ Evaluation Board I/O

- **Evaluation Board Operation Procedures**

Below is the procedure to operate the evaluation board.

1. Connect power supply's GND terminal to GND test point TP2 on the evaluation board.
2. Connect power supply's V_{CC} terminal to V_{IN} test point TP1 on the evaluation board. This will provide V_{IN} to the IC U1. Please note that the V_{CC} should be in range of 4.0V to 5.5V.
3. Set operation mode of IC by set position of shunt jumper of J2 (If Pin2 connect to Pin1, MODE pin of IC U1 will be pulled high and IC U1 will operate in Forced PWM mode, else MODE pin of IC U1 will be pulled low and IC U1 will operate in Automatic PFM/PWM mode).
4. Check if shunt jumper of J1 is at position ON (Pin2 connect to Pin1, EN pin of IC U1 is pulled high).
5. Connect electronic load to TP3 and TP4. Do not turn on load (electronic load is off power).
6. Turn on power supply. The output voltage V_{OUT} (+3.3V) can be measured at the test point TP3. Now turn on the load. The load can be increased up to 1A MAX.

Notes:

In some cases that the evaluation board is not operated following the above power up sequence, the output current spike can exceed the current limitation 1A with electronic load 1A setting as shown in fig.4. Then the integrated OCP (Over Current Protection) will be active to protect the IC and the output voltage is about 0.3V instead of 3.3V as expected. In order to get the IC out of OCP, turn off any output loads and power down the input voltage. Then, follow the operating procedure listed above for normal operation of this IC.

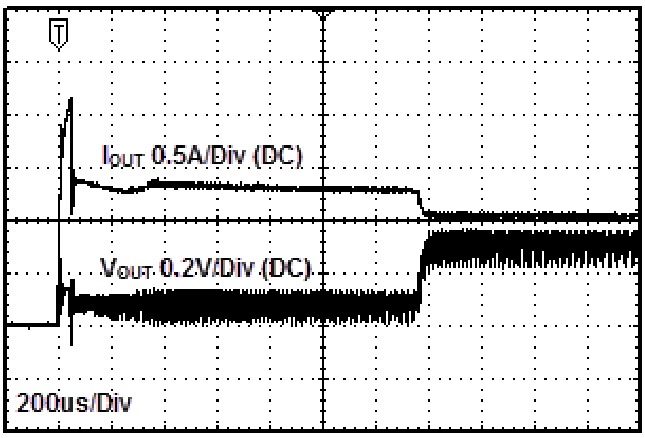


Fig 4: I_{OUT} vs. V_{OUT} when OCP active

- **Reference Application Data for BU90002GWZEVK-101**

  Following graphs show hot plugging test, quiescent current, efficiency, load response, output voltage ripple response of the BU90002GWZ evaluation board.

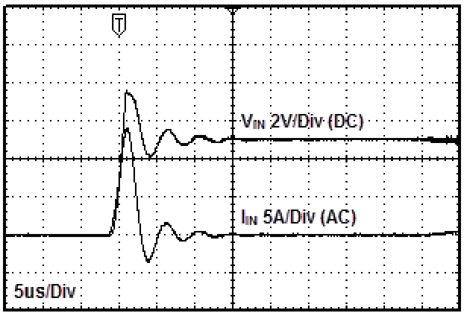


Fig 5: Hot Plug-in Test with Zener Diode P4SMA6.8A, V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=0.6A, Automatic PFM/PWM Mode

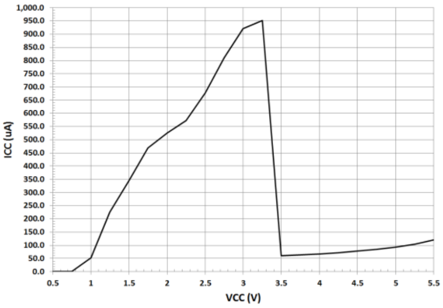


Fig 6: Circuit Current vs. Power supply Voltage Characteristics (Temp=25^{o}C, Automatic PFM/PWM Mode)

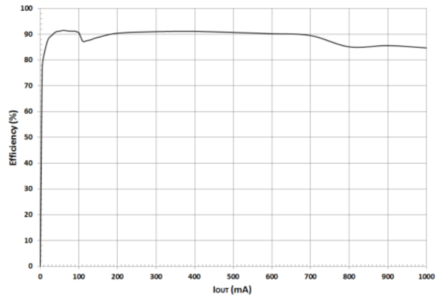


Fig 7: Electric Power Conversion Rate (V_{OUT}=3.3V, Automatic PFM/PWM Mode)

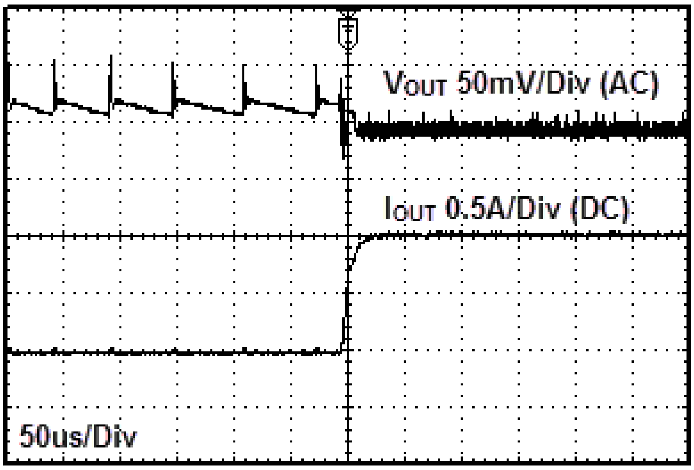


Fig 8: Load Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, L=1.0uH, C_{OUT}=4.7uF, I_{OUT}=0A→1A, Automatic PFM/PWM Mode)

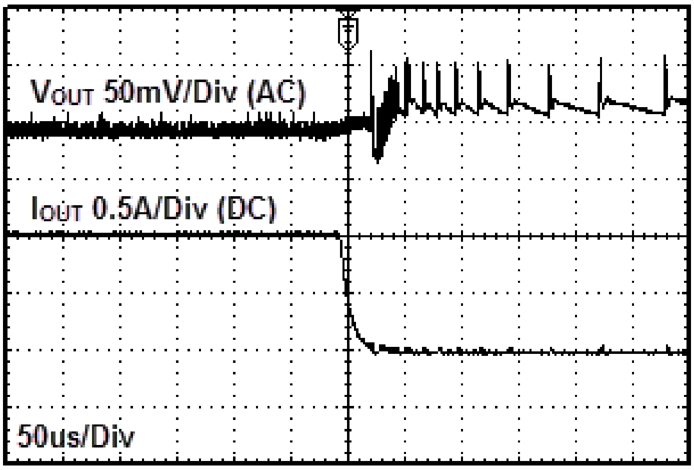


Fig 9: Load Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, L=1.0uH, C_{OUT}=4.7uF, I_{OUT}=1A→0A, Automatic PFM/PWM Mode)

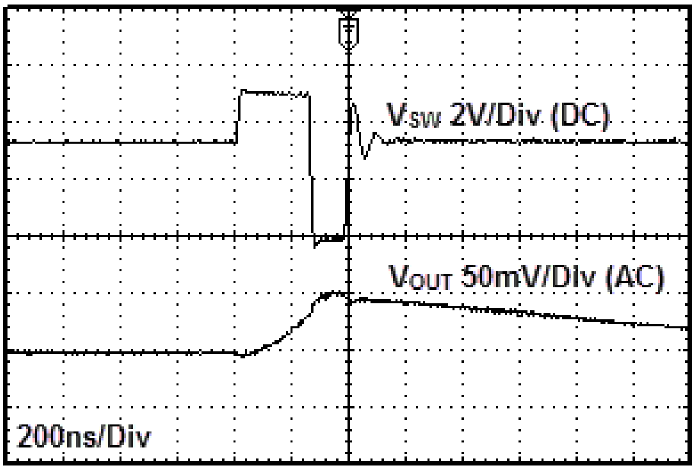


Fig 10: Output Voltage Ripple Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, L=1.0uH, C_{OUT}=4.7uF, I_{OUT}=0A, Automatic PFM/PWM Mode)

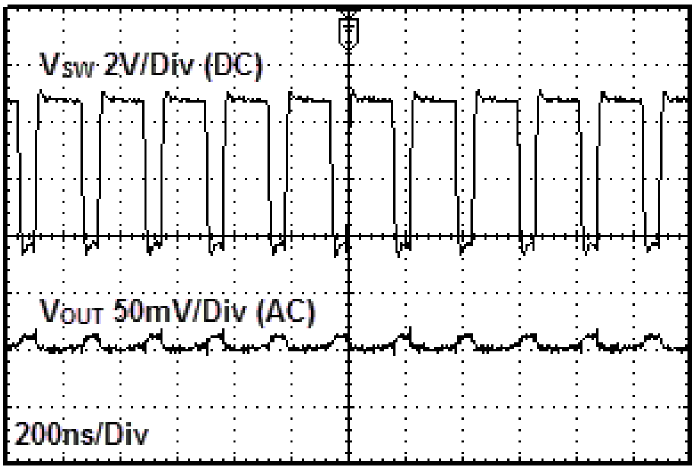


Fig 11: Output Voltage Ripple Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, L=1.0uH, C_{OUT}=4.7uF, I_{OUT}=1A, Automatic PFM/PWM Mode)

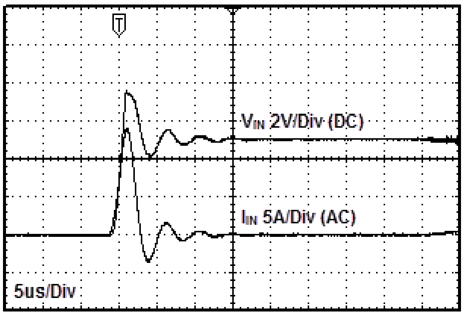


Fig 12: Hot Plug-in Test with Zener Diode P4SMA6.8A, V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=0.6A, Forced PWM Mode

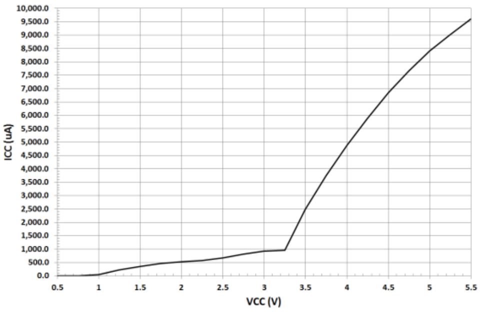


Fig 13: Circuit Current vs. Power supply Voltage Characteristics (Temp=25^{o}C, Forced PWM Mode)

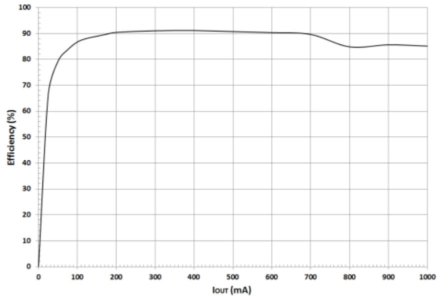


Fig 14: Electric Power Conversion Rate (V_{OUT}=3.3V, Forced PWM Mode)

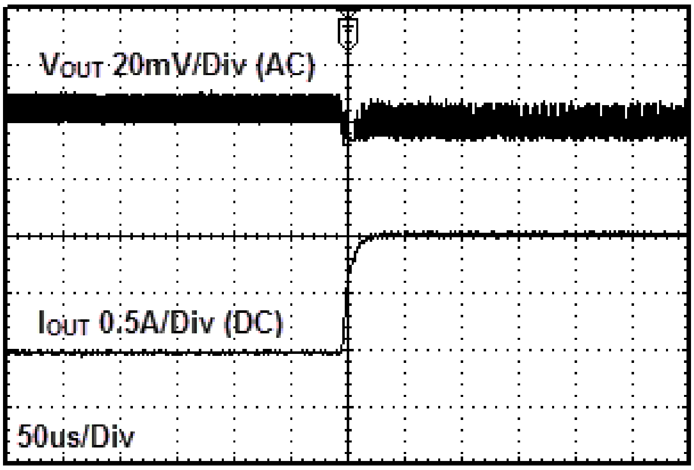


Fig 15: Load Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, L=1.0uH, C_{OUT}=4.7uF, I_{OUT}=0A→1A, Forced PWM Mode)

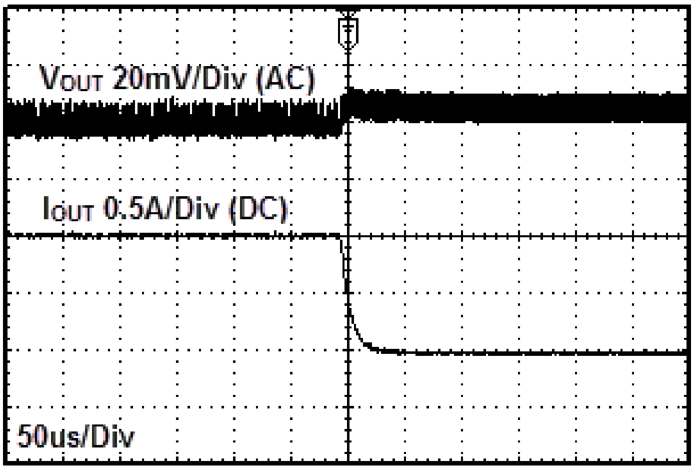


Fig 16: Load Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, L=1.0uH, C_{OUT}=4.7uF, I_{OUT}=1A→0A, Forced PWM Mode)

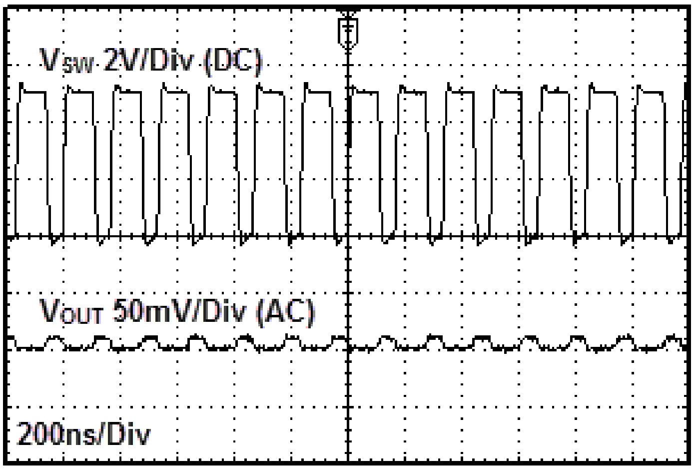


Fig 17: Output Voltage Ripple Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, L=1.0uH, C_{OUT}=4.7uF, I_{OUT}=0A, Forced PWM Mode)

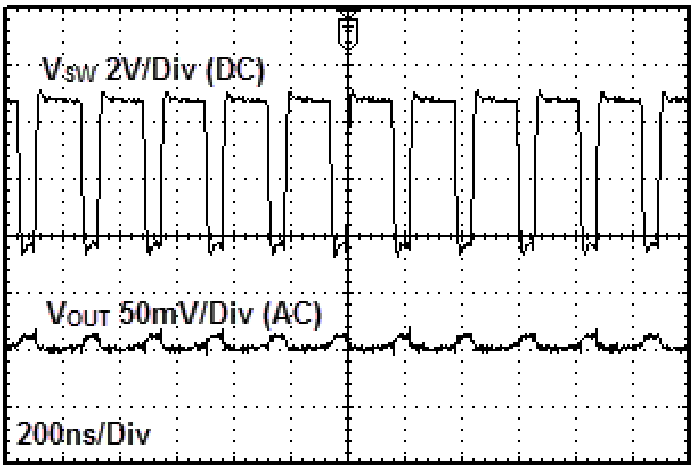


Fig 18: Output Voltage Ripple Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, L=1.0uH, C_{OUT}=4.7uF, I_{OUT}=1A, Forced PWM Mode)

- **Evaluation Board Layout Guidelines**

  Below are the guidelines that have been followed and recommended for BU90002GWZ designs.

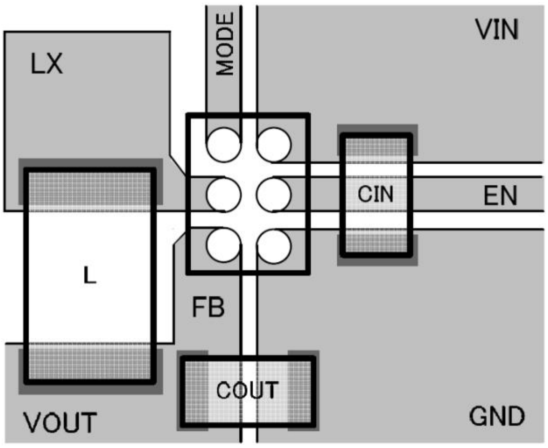


Fig 19: BU90002GWZ PCB Layout

① The input capacitor C_{IN} should be connect as closely possible to V_{IN} pin and GND pin.
② From the output voltage to the FB pin line should be as separate as possible.
③ C_{OUT} and L should be connected as closely as possible. The connection of L to the LX pin should be as short as possible.

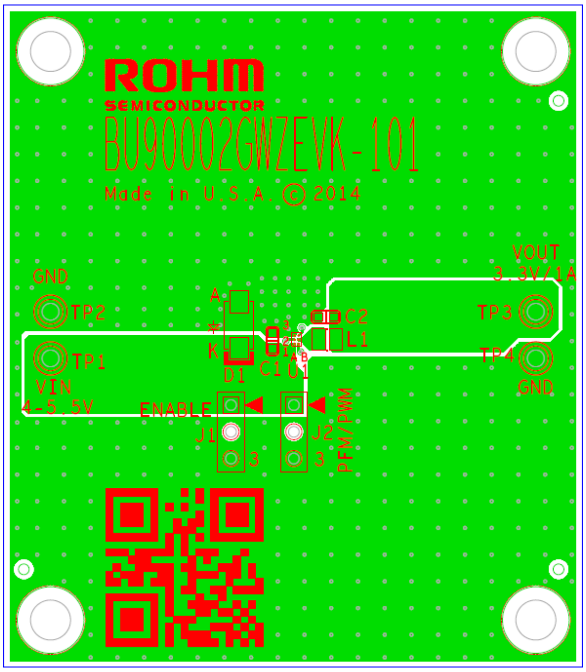


Fig 20: BU90002GWZEVK Board PCB layout

- **Calculation of Application Circuit Components**

  Selection of inductor (L)

  The inductance significantly depends on output ripple current. As shown by following equation, the ripple current decreases as the inductor and/or switching frequency increase.

$$\Delta I_L = \frac{(V_{IN} - V_{OUT}) \times V_{OUT}}{L \times V_{IN} \times f}$$

f: switching frequency, L: inductance, ΔI_L: inductor current ripple

As a minimum requirement, the DC current rating of the inductor should be equal to the maximum load current plus half of the inductor current ripples as shown by the following equation.

$$I_{LPEAK} = I_{OUTMAX} + \frac{\Delta I_L}{2}$$

- **Evaluation Board BOM**
  Below is a table with the build of materials. Part numbers and supplier references are provided.

Item	Qty.	Ref	Description	Manufacturer	Part Number
1	2	C1,C2	CAP CER 4.7UF 6.3V 10% X5R 0603	Murata	GRM188R60J475KE19D
2	1	D1	DIODE TVS 400W 6.8V UNI 5% SMD	Littelfuse	P4SMA6.8A
3	2	J1,J2	CONN HEADER VERT .100 3POS 15AU	TE Connectivity	87224-3
4	1	L1	INDUCTOR POWER 1.0UH 2.3A SMD	TDK	MLP2520K1R0ST0S1
5	2	TP1,TP3	TEST POINT PC MULTI PURPOSE RED	Keystone Electronics	5010
6	2	TP2,TP4	TEST POINT PC MULTI PURPOSE BLK	Keystone Electronics	5011
7	1	U1	IC REG BUCK SYNC 3.3V 1A 6WLCSP	ROHM	BU90002GWZ-E2
8	2		Shunt jumper for header J1, J2	TE Connectivity	881545-1

Notes

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