ROHM Switching Regulator Solutions

Evaluation Board for ROHM's BD9G101G Buck Switching Regulator with Built-In Power MOSFET

BD9G101G-EVK-101 (5V | 0.5A Output)

AEY59-D1-0001

●Introduction

This user's guide will explain the steps necessary to operate and evaluate ROHM's BD9G101G step-down switching regulator using the BD9G101G evaluation board. Board layout recommendations, operating procedures, application data, and bill of materials are included.

●Description

This evaluation board has been specifically developed to evaluate the BD9G101G non-synchronous buck DC/DC converter with integrated 45V/800mΩ power MOSFET. Features include wide input (7.32V to 42V) and output of 5V and a switching frequency of 1.5MHz. Multiple protection functions are also built in, including a soft start circuit that prevents inrush current during startup, UVLO (Under Voltage Lock Out), TSD (Thermal Shutdown), and OCP (Overcurrent Protection). An EN pin allows for simple ON/OFF control to reduce standby current consumption. Also, output voltage can be set in the range of 1V to VCC x 0.7 by changing external resistors.

●Applications

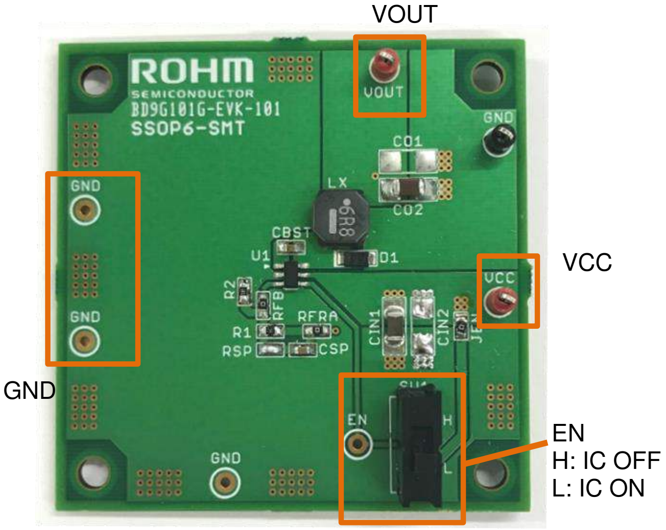
Industrial distributed power systems
Consumer electronics equipment

●Evaluation Board Operating Limits and Absolute Maximum Ratings

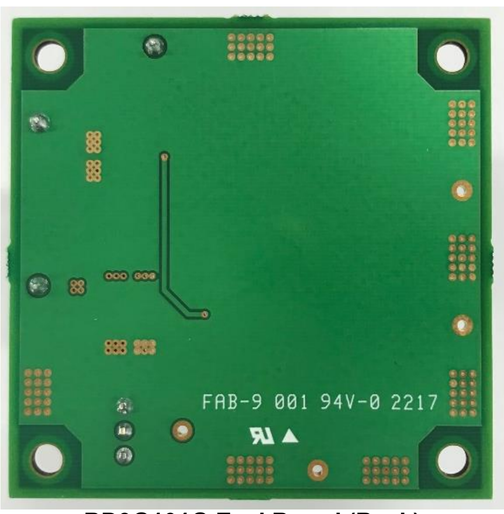
Parameter	Symbol	Type	Limit			Unit	Conditions
			MIN	TYP	MAX		
Supply Voltage	VCC	Maximum Rating	6	-	42	V	
		Recommended Range	7.32	-	42.0	V	
Output Voltage	VOUT	Recommended Range	-	5.05	-	V	* Set by R1 and R2.
Output Current	IOUT	Recommended Range	-	-	0.5	A	

●Evaluation Board

Below are images of the BD9G101G evaluation board. Component selection and board layout guidelines are provided in the BD9G101G datasheet.

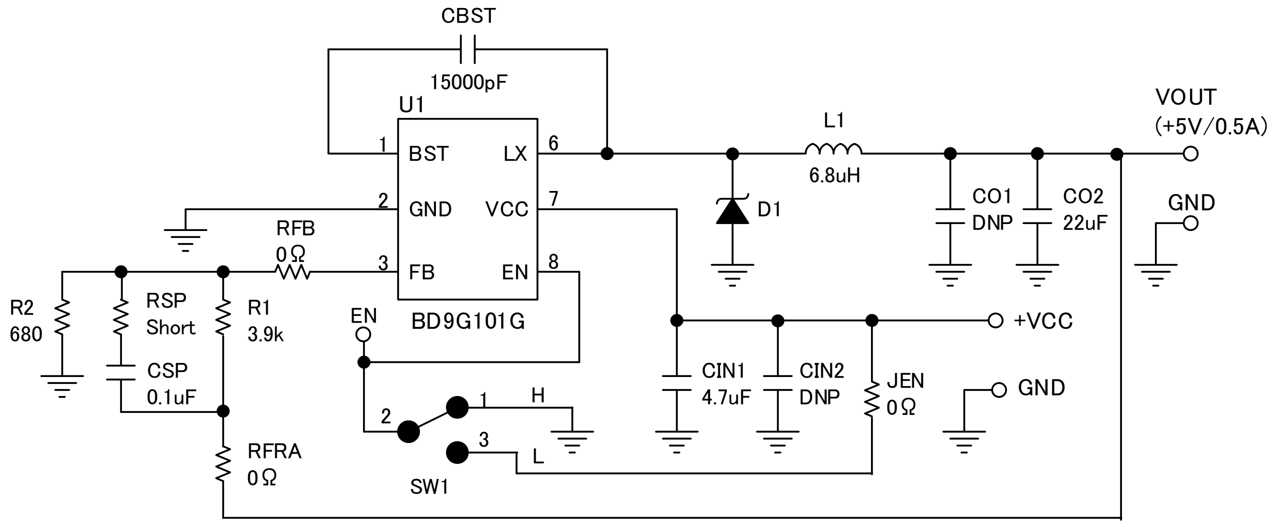


BD9G101G Eval Board (Front)



BD9G101G Eval Board (Back)

●**Board Schematic**



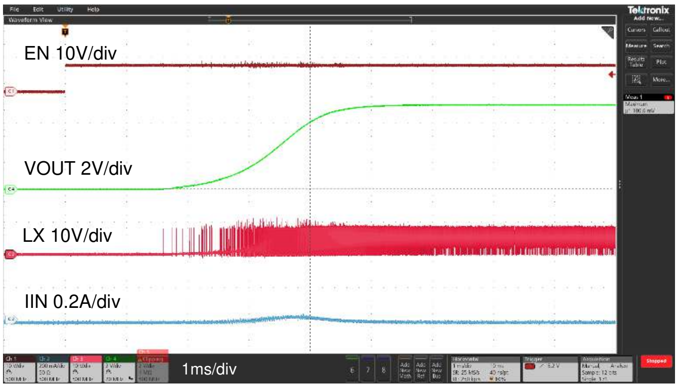
●**Operating Procedures**

1. Connect voltage source GND to the GND pin on the evaluation board.
2. Connect voltage source output (+) to the VCC pin on evaluation board.
3. The output voltage can be measured from the VOUT pin on the evaluation board. Output current can be measured with a proper load at VOUT.

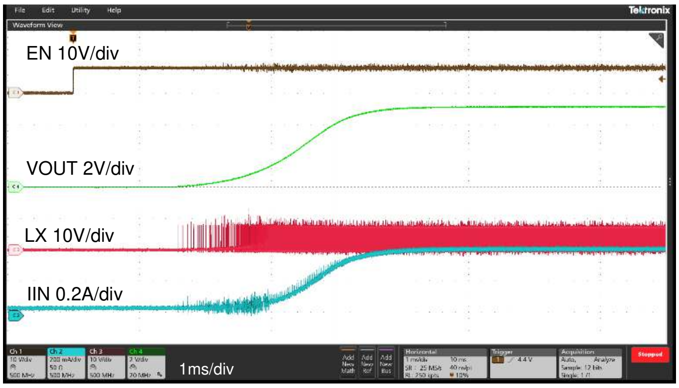
Note: The IC could be damaged if hot plugged. Therefore, make sure to power down the system before removing or connecting the BD9G101G-EVK-101.

●**Reference Application Data**

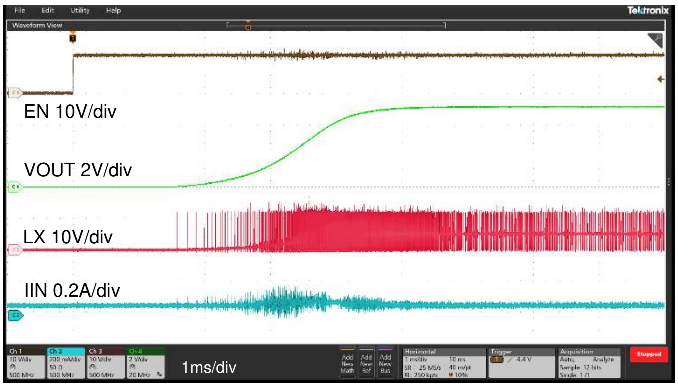
The below graphs show the efficiency, frequency response, and load characteristics of the BD9G101G eval board.



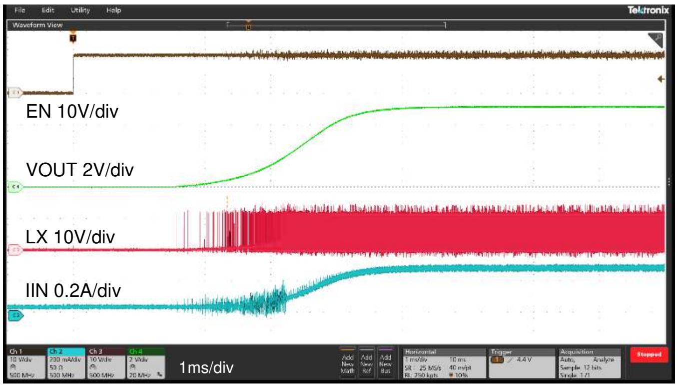
Start-up Characteristics
VCC=8V, VOUT-GND=Open, VOUT=5V



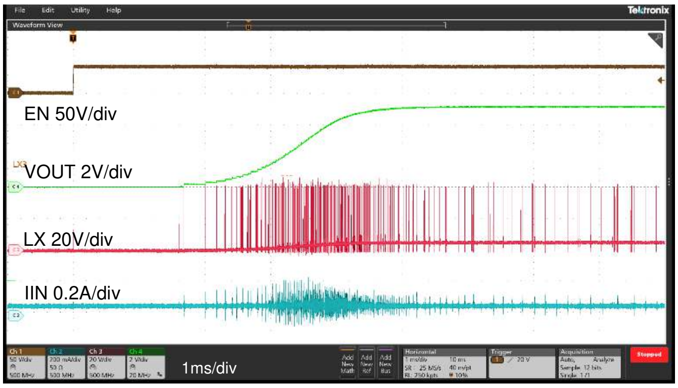
Start-up Characteristics
VCC=8V, VOUT-GND=10Ω, VOUT=5V



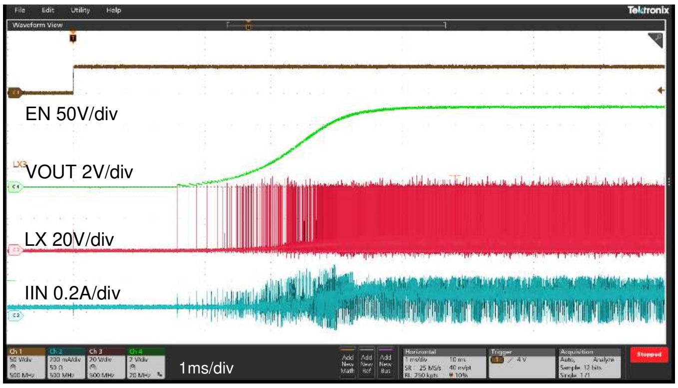
Start-up Characteristics
VCC=12V, VOUT-GND=Open, VOUT=5V



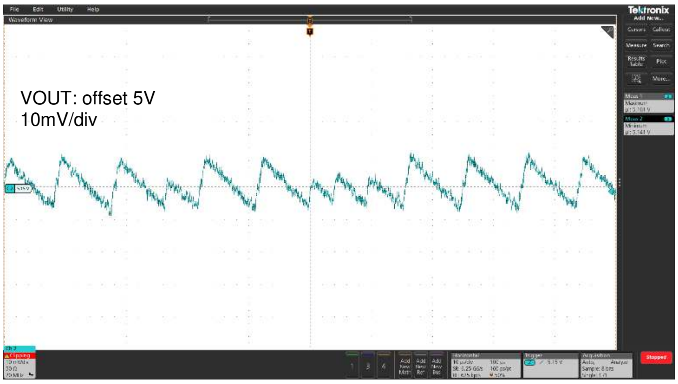
Start-up Characteristics
VCC=12V, VOUT-GND=10Ω, VOUT=5V



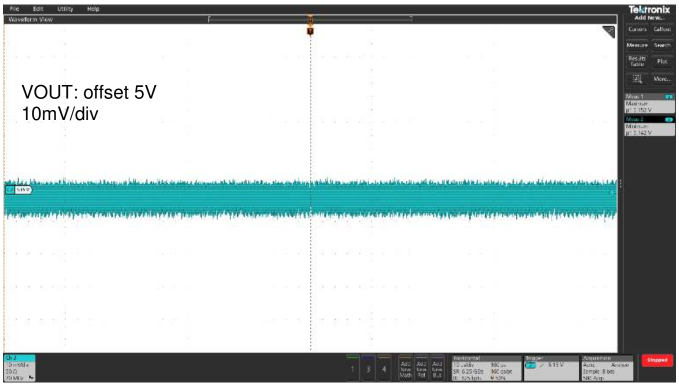
Start-up Characteristics
VCC=42V, VOUT-GND=Open, VOUT=5V



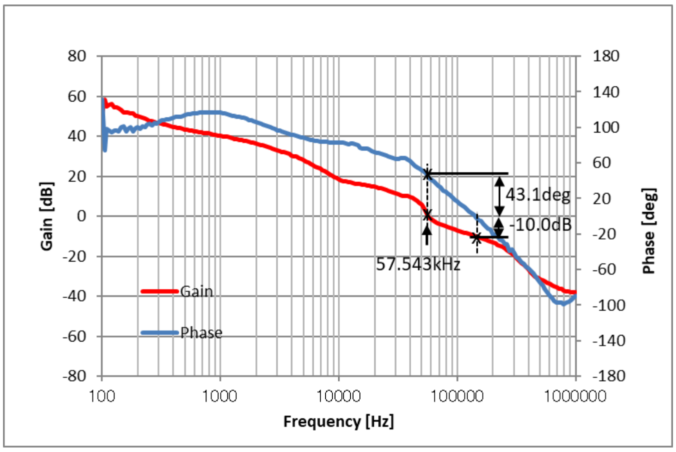
Start-up Characteristics
VCC=42V, VOUT-GND=10Ω, VOUT=5V



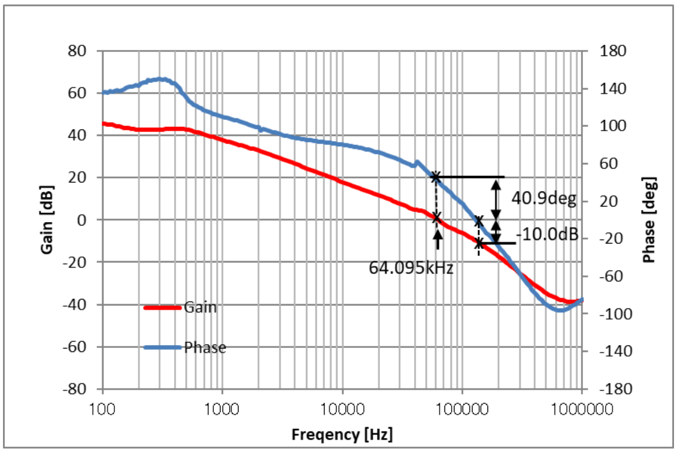
Output Ripple
VCC=24V, VOUT=5V, IOUT=20mA



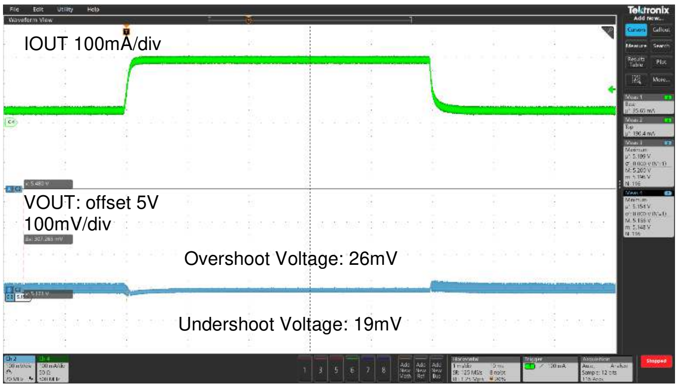
Output Ripple
VCC=24V, VOUT=5V, IOUT=200mA



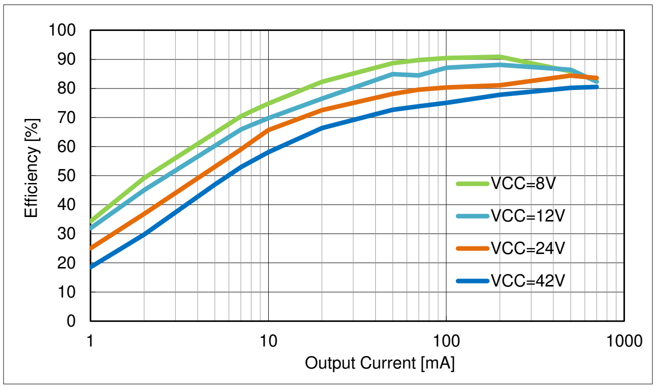
Frequency Response
VCC=24V, IOUT=150mA, VOUT=5V



Frequency Response
VCC=24V, IOUT=500mA, VOUT=5V



Load Response
VCC=24V, VOUT=5V, IOUT=50mA⇔200mA

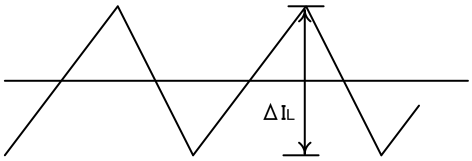


Electric Power Conversion Rate
IOUT=1mA-500mA, VOUT=5V

●Application Components Selection Method

(1) Inductor

A shield type with low DCR (DC resistance component) that satisfies the current rating (current value Ipeak below) is recommended.
The inductance value has a significant effect on the inductor ripple current, which becomes the source of output ripple.
As shown in the formula below, this ripple current can be made smaller by increasing the L value of the coil and/or the switching frequency.



Inductor Current

$$Ipeak = IOUT + \frac{\Delta IL}{2}\ [\mathrm{A}]$$

$$\Delta IL = \frac{VCC - VOUT}{L} \times \frac{VOUT}{VIN} \times \frac{1}{f}\ [\mathrm{A}]$$

(ΔIL: Output Ripple Current, f: Switching Frequency)
Please carry out inductor ripple design with a target of 20 to 50% of the maximum input current.
For the BD9G101G, the below inductors are recommended within the 4.7μH to 15μH range.
Recommended Inductor **Murata DEM4518C Series**
TAIYO YUDEN LSXND6060WKL Series

(2) Input Capacitor

To reduce input ripple voltage, please connect a low ESR ceramic capacitor near the VCC pin. For the BD9G101G, we recommend a capacitance less than 4.7μF. And in the event an electrolytic capacitor is used, mount a 1μF ceramic capacitor in parallel to prevent oscillation.

(3) Output Capacitor

To reduce output ripple, a low ESR ceramic capacitor is recommended. And in addition to taking into account DC bias characteristics, please provide sufficient margin with respect to the absolute maximum rated output voltage.

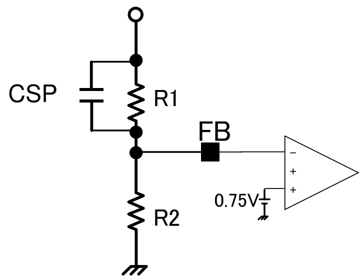
$$Vpp = \Delta IL \times \frac{1}{2\pi \times f \times Co} + \Delta IL \times R_{ESR}\ [\mathrm{V}]$$

Please design in a way that it is held within Capacity Ripple Voltage.
In the BD9G101G, it is recommended a ceramic capacitor over 10μF.

(4) Output voltage setting

The internal reference voltage of the ERROR AMP is 0.75V. The output voltage is determined from the following formula.

$$VOUT = \frac{R1 + R2}{R2} \times 0.75\ [\mathrm{V}]$$



Output Voltage Setting

However, in order to prevent BSTUVLO operation during reduced power and light loads, please ensure that the sum R1+R2 for the output resistance satisfies the following formula.

$$R1 + R2 \leq VOUT \times 10^3$$

Example output resistance settings: 5V output voltage → R1=3.9kΩ, R2=0.68kΩ
12V output voltage → R1=7.5kΩ, R2=0.51kΩ

(5) Feed-forward capacitor CSP
Please mount feed-forward capacitor in parallel to output resistance R1.
In order that a feed-forward capacitor may adjust the loop characteristic by adding the pair of a pole and zero to the loop characteristic. A phase margin is improved and transient response speed improves.
The feed-forward capacitor CSP should use the value near the following formulas

$$CSP = \frac{4.7\mathrm{k}}{R1} \times 0.15 \ \ [\mu\mathrm{F}]$$

Example CSP settings: 5V output voltage → R1=3.9kΩ, R2=0.68kΩ, CSP=0.1μF or 0.22μF
12V output voltage → R1=7.5kΩ, R2=0.51kΩ, CSP=0.1μF

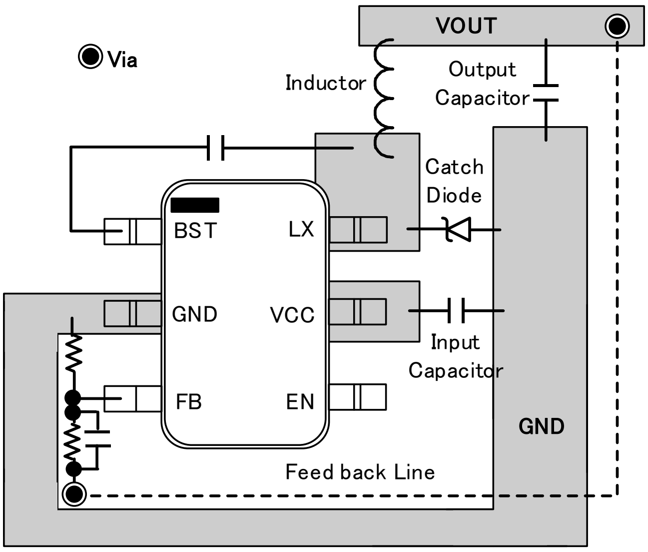
To prevent BSTUVLO operation during reduced power and light loads, we recommend connecting a feed-forward capacitor CSP in parallel with the output resister R1. The feed-forward capacitor improves phase margin and transient response by adding a zero-pole pair to the loop characteristics. This works to limit output fluctuation. For the feed-forward capacitor CSP, use an output resistance value near to the following formula.

Through the above measures, BSTUVLO will not activate under light loads and VIN-VOUT<3V.

(6) Bootstrap Capacitor
To prevent malfunction of the boot pin's internal circuit, connect a CBST=15000pF ceramic capacitor between the BST and LX pins.

(7) Catch Diode
Select a Schottky barrier diode that meets withstand voltage and rated current requirements.

●Evaluation Board Layout Guidelines



PCB layout is a critical portion of good power supply design. Some paths that conduct fast current / voltage change may cause noises and degrade the power supplying performance due to leakage flux or interaction with parasitic capacitance. To help reducing these problems, the VCC pin should be bypassed to ground with a low ESR ceramic capacitor. Also, the large current is generated especially on the following 2 loops; Bypass input capacitor -> Inductor -> Output capacitor or Catch diode -> Inductor -> Output capacitor. Therefore, the distance between the output capacitor and the catch diode, or the distance between the output capacitor and the bypass input capacitor on the GND pattern should be as short as possible.

The input bypass capacitor, the catch diode and the inductor should be located as close to the IC as possible. Please keep GND line on the top layer to avoid GND level fluctuation caused by external connection.

●Evaluation Board BOM

Below is a table showing the bill of materials. Part numbers and supplier references are also provided.

No.	Qty	Ref	Description	Manufacturer	Part Number	Digikey P/N
1	1	CIN1	CAP CER 4.7UF 50V Y5V 1206	Murata	GRM31CR71H475KA12	490-6521-1-ND
2	1	CIN2	No mount	-	-	-
3	1	CO1	No mount	-	-	-
4	1	CO2	CAP CER 22UF 25V 10% X6S 3216	Murata	GRM31CC81E226KE11L	490-14468-1-ND
5	1	CBST	CAP CER 0.015UF 50V 10% X7R 0603	Murata	GCD188R71H153KA01	490-GCD188R71H153KA01DCT-ND
6	1	CSP	CAP CER 0.1UF 50V 10% X7R 0402	Murata	GRM155R71H104KE14	490-13342-1-ND
7	1	D1	DIODE SCHOTTKY 60V 2A PMDU	ROHM	RBR2MM60B	RBR2MM60BCT-ND
8	1	SW1	SWITCH SLIDE SPDT 30V.2A PC MNT	E-Switch	EG1218	EG1903-ND
9	1	R1	※RES 3.9K OHM 1/8W 1% 0805 SMD	ROHM	MCR03EZPFX3901	RHM3.90KHCT-ND
10	1	R2	RES SMD 680 OHM 1% 1/10W 0603	ROHM	MCR03EZPFX6800	RHM680HTR-ND
11	1	RFRA	Solder short 0Ω	-	-	-
12	1	LX	INDUCT 6.8uH SOD-106	TAIYO YUDEN	LSXND6060WKL6R8NMG	587-LSXND6060WKL6R8NMGTR-ND
13	1	JEN	Solder short 0Ω	-	-	-
14	1	U1	5V, 0.5A Step-down SW Reg w/ FET	ROHM	BD9G101G	BD9G101G-CT-ND

Recommended parts are selected from those products and information available at the time this user's guide (Rev.003) was released. If supply conditions change and parts are not available, use similar parts please.

●Revision History

Date	Revision	Changes
1. May.2013	001	New Release
17.May.2016	002	Changed BOM (R1, R2, and CIN2). Added note to operation procedures.
28.Jul.2023	003	Changed the value of parts. Replaced waveform data with correct ones.

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