# BLL2453

**16V, 3A, 500KHz COT Synchronous Step-Down DC/DC Converter**

## DESCRIPTION

The BLL2453 is a fully integrated synchronous rectified step-down converter that provides wide 4.2V to 16V input voltage range and 3A continuous load current capability. The BLL2453 can achieve high efficiency and reduce power loss at light load. In shutdown mode, the maximum supply current is about 3µA.

The BLL2453 protection function includes cycle-by-cycle current limit, UVLO and thermal shutdown. Besides, internal soft-start prevents inrush current at fast power-on. This device uses Constant On-Time (COT) control mode which provides fast load transient response. Internal loop compensation function reduces the external compensator components and simplifies the design process.

The BLL2453 requires a minimum number of readily available standard external components and is available in tiny SOT563 and SOT23-6 packages.

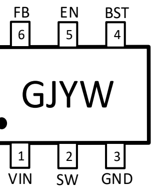
## FEATURES

- Wide input voltage range: 4.2V to 16V
- 3A output current
- 0.8V reference voltage
- Low $R_{DS(ON)}$ integrated power MOSFET (80/50mΩ)
- 3µA(Max) shutdown current
- Integrated internal compensation
- High efficiency at light load
- Internal 1ms soft-start
- Cycle-by-cycle current limit
- Over-temperature protection with auto recovery
- Under voltage lockout (UVLO)
- Hiccup short circuit protection
- Available in tiny SOT563 and SOT23-6 packages
- RoHS compliant

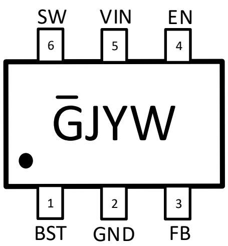
## APPLICATIONS

- Distributed power system
- Flat Panel television and monitors
- STB (Set-top-box)
- Networking, XDSL modem

## PIN OUT & MARKING




SOT563



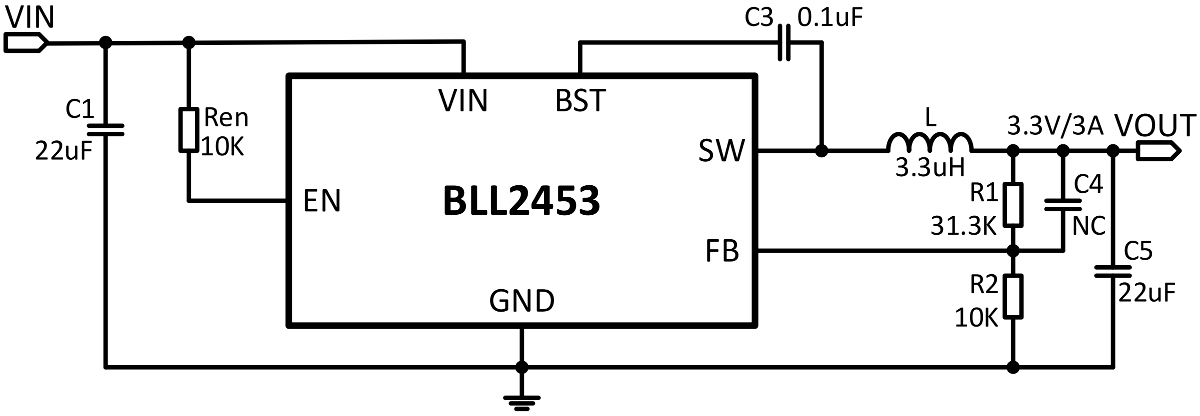

SOT23-6

*GJ/ḠJ: Product Code*
*YW: Date code (Year & Week)*

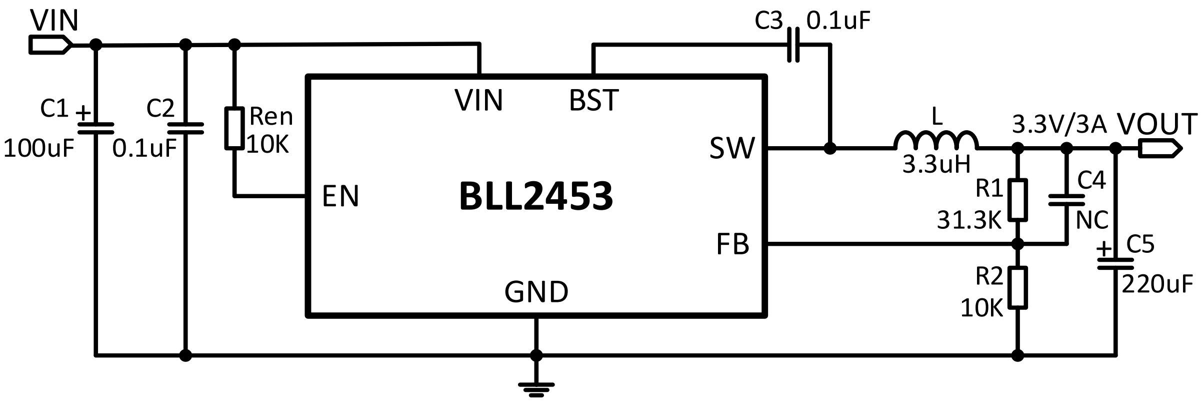
## ORDERING INFORMATION

| Part No. | BLL2453CU6TR |
|---|---|
| Package | SOT563 |
| Tape&Reel | 5000/reel |
| Part No. | BLL2453CB6TR |
| Package | SOT23-6 |
| Tape&Reel | 3000/reel |

## TYPICAL APPLICATION




$C_{IN}$ &$C_{OUT}$ use Ceramic Capacitors Application Circuit




$C_{IN}$ &$C_{OUT}$ use Electrolytic Capacitors Application Circuit

Table1. Recommended Component Values

$V_{IN}$=12V, the recommended BOM list is shown as below.

| $V_{OUT}$ | C1 | C2 | L | R1 | R2 | C5 |
|---|---|---|---|---|---|---|
| 5V | 10uF/MLCC | - | 4.7uH-10uH | 52.5K | 10K | 22uF/MLCC |
| 3.3V | | | 3.3uH-4.7uH | 31.3K | 10K | |
| 1.8V | | | 1.0uH-2.2uH | 12.5K | 10K | |
| 1.5V | | | 1.0uH-2.2uH | 8.8K | 10K | |
| 1.2V | | | 1.0uH-2.2uH | 5K | 10K | |
| 0.9V | | | 1.0uH-2.2uH | 1.25K | 10K | |
| 5V | 100uF/25V/ECL | 0.1uF/MLCC | 4.7uH-10uH | 52.5K | 10K | 220uF/6.3V/ECL |
| 3.3V | | | 3.3uH-4.7uH | 31.3K | 10K | |
| 1.8V | | | 1.0uH-2.2uH | 12.5K | 10K | |
| 1.5V | | | 1.0uH-2.2uH | 8.8K | 10K | |
| 1.2V | | | 1.0uH-2.2uH | 5K | 10K | |
| 0.9V | | | 1.0uH-2.2uH | 1.25K | 10K | |

## PIN DESCRIPTION

| Pin# | | Name | Description |
|---|---|---|---|
| SOT563 | SOT23-6 | | |
| 1 | 5 | VIN | Power input. Bypass with a 22uF ceramic capacitor to GND. |
| 2 | 6 | SW | Power switching node to connect inductor. |
| 3 | 2 | GND | Ground. |
| 4 | 1 | BST | High-side power transistor gate drive boost input. |
| 5 | 4 | EN | Enable input. Set this pin to high level to enable the part, low level to disable. |
| 6 | 3 | FB | Feedback input with reference voltage set to 0.8V. |

## ABSOLUTE MAXIMUM RATING

| Parameter | | Value |
|---|---|---|
| Supply voltage $V_{IN}$ | | -0.3V to 18V |
| Switch node voltage $V_{SW}$ | | -0.3V to ($V_{IN}$+0.5V) |
| Boost voltage $V_{BST}$ | | ($V_{SW}$-0.3V) to ($V_{SW}$+5V) |
| Enable voltage $V_{EN}$ | | -0.3V to 18V |
| All other pins | | -0.3V to 6V |
| Package thermal resistance ($\theta_{JA}$) [1,2] | SOT563 | 200°C/W |
| | SOT23-6 | 200°C/W |
| Operating temperature range | | -40°C to 85°C |
| Storage temperature range | | -65°C to 150°C |
| Lead temperature (Soldering, 10s) | | 260°C |

***Note:***

*1) The value of $R_{\vartheta JA}$ is simulated on a standard JEDEC board. They do not represent the performance obtained in an actual application.*

*2) The real $R_{\vartheta JA}$ on DEMO board is about 70℃/W(SOT563) and 78℃/W(SOT23-6).*

*3) Exceed these limits to damage to the device. Exposure to absolute maximum rating conditions may affect device reliability.*

## ELECTRICAL CHARACTERISTICS

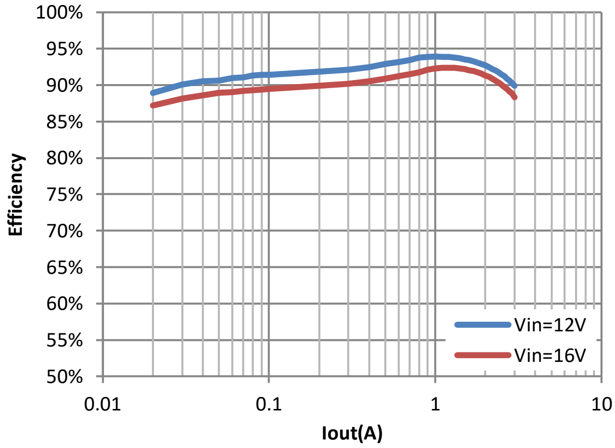
$V_{IN}$ =12V, $T_A$=25°C, unless otherwise stated.

| Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Input voltage range | | 4.2 | | 16 | V |
| UVLO threshold | $V_{IN}$ rising | | 3.8 | | V |
| UVLO hysteresis | $V_{IN}$ falling | | 300 | | mV |
| Supply current in operation | $V_{EN}$ = 5V, $V_{FB}$ = 1V | | 150 | | uA |
| Supply current in shutdown | $V_{EN}$ = 0V | | 1 | | uA |
| Regulated feedback voltage | $V_{IN}$ = 12V, $V_{EN}$ = 5V | 0.784 | 0.8 | 0.816 | V |
| High-side switch on resistance | $V_{BST-SW}$ = 5V | | 80 | | mΩ |
| Low-side switch on resistance | $V_{IN}$ = 5V | | 50 | | mΩ |
| High-side switch leakage current | $V_{EN}$ = 0V, $V_{SW}$ = 0V | | 0.1 | 1 | uA |
| Peak current limit | | | 5 | | A |
| Valley current limit | | | 4 | | A |
| Oscillation frequency | $V_{OUT}$ = 1.2V, $I_{OUT}$ = 1A | | 500 | | KHz |
| Maximum duty cycle | | | 80 | | % |
| Minimum duty cycle | | | 5 | | % |
| Minimum on time | | | 100 | | ns |
| Minimum off time | | | 250 | | ns |
| EN input voltage “H” | | 1.5 | | | V |
| EN input voltage “L” | | | | 0.4 | V |
| Soft-start period | | | 0.7 | | ms |
| Input OVP | $I_{OUT}$ = 0.1A, $V_{IN}$ rising | | 19.5 | | V |
| Input OVP hysteresis | $I_{OUT}$ = 0.1A, $V_{IN}$ rising | | 2 | | V |
| Thermal shutdown | | | 160 | | °C |
| Thermal hysteresis | | | 30 | | °C |

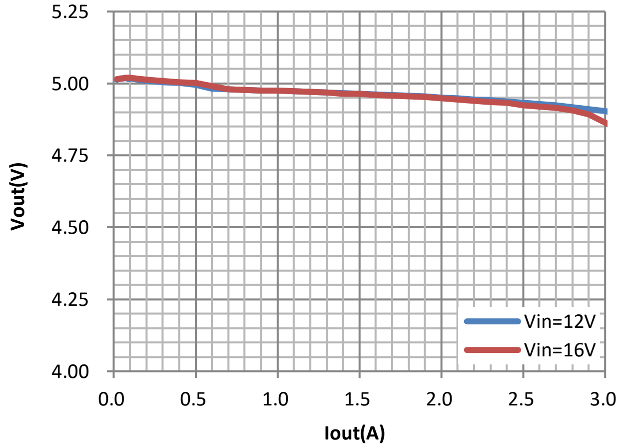
## ELECTRICAL PERFORMANCE

*Tested under $T_A$=25°C*, unless otherwise specified.

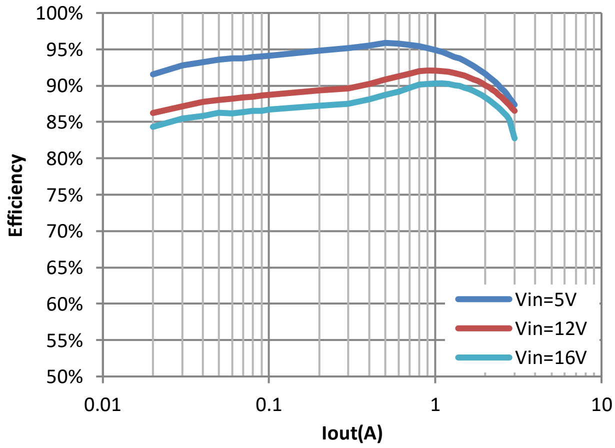
**Efficiency vs. Iout**
**(Vout=5.0V)**



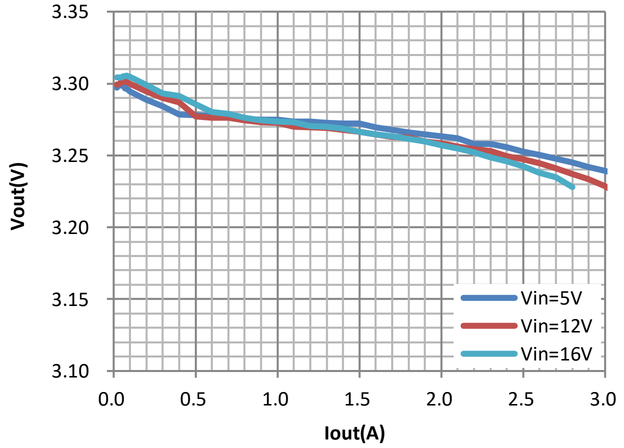

**Load Regulation**
**(Vout=5.0V)**



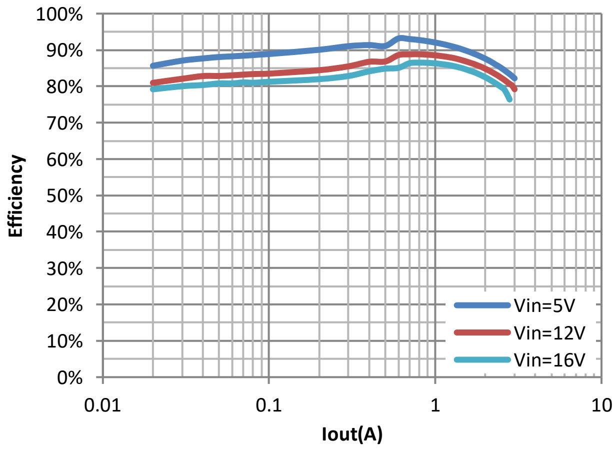

**Efficiency vs. Iout**
**(Vout=3.3V)**



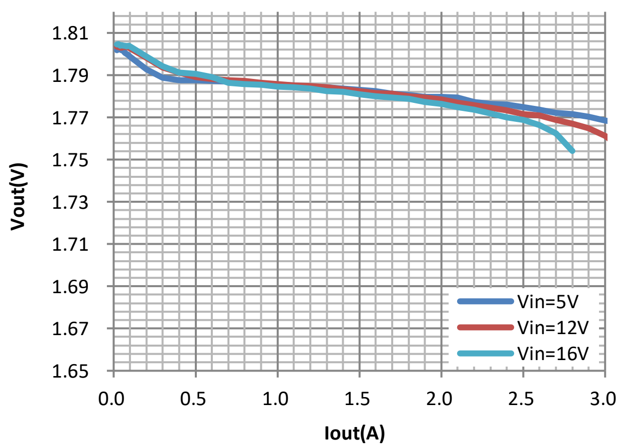

**Load Regulation**
**(Vout=3.3V)**



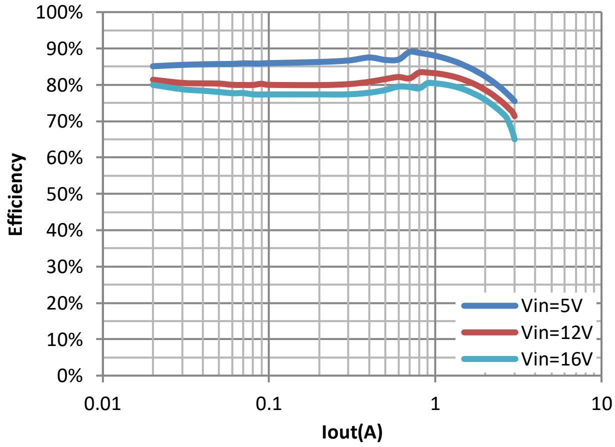

**Efficiency vs. Iout**
**(Vout=1.8V)**



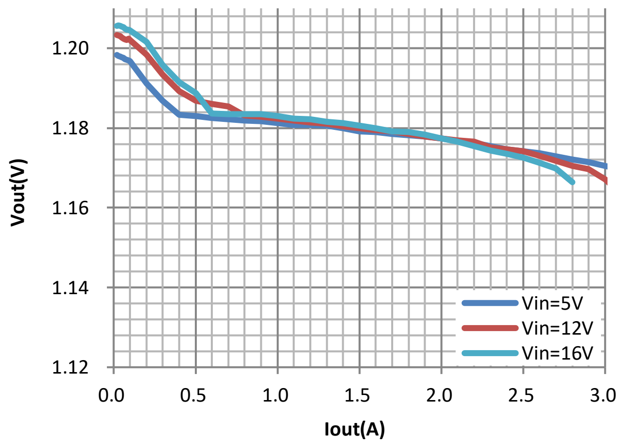

**Load Regulation**
**(Vout=1.8V)**



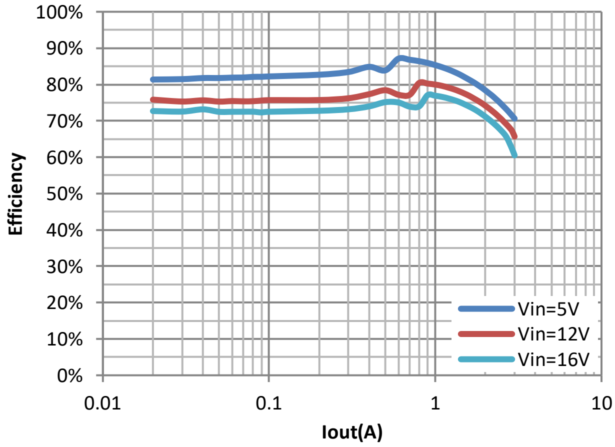
**Efficiency vs. Iout**
**(Vout=1.2V)**



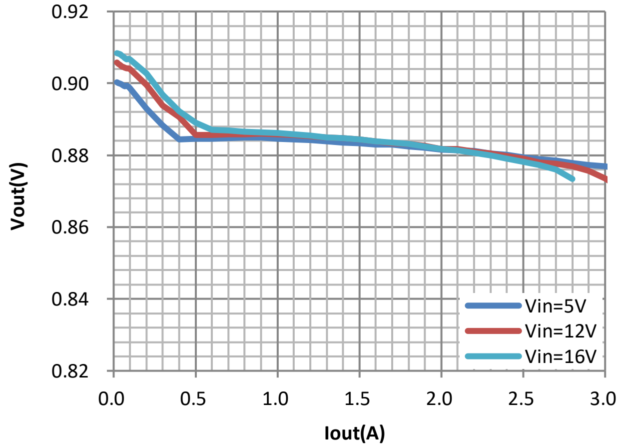

**Load Regulation**
**(Vout=1.2V)**



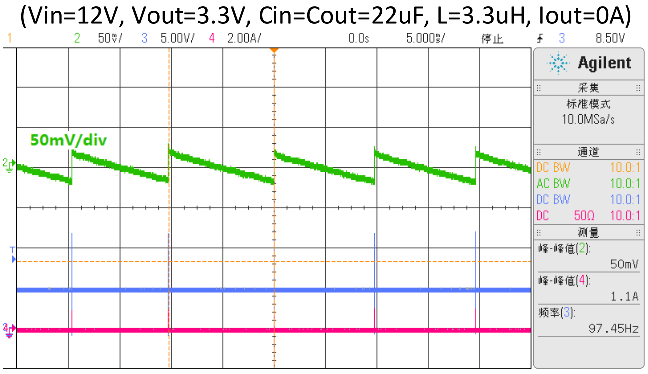

**Efficiency vs. Iout**
**(Vout=0.9V)**




**Load Regulation**
**(Vout=0.9V)**

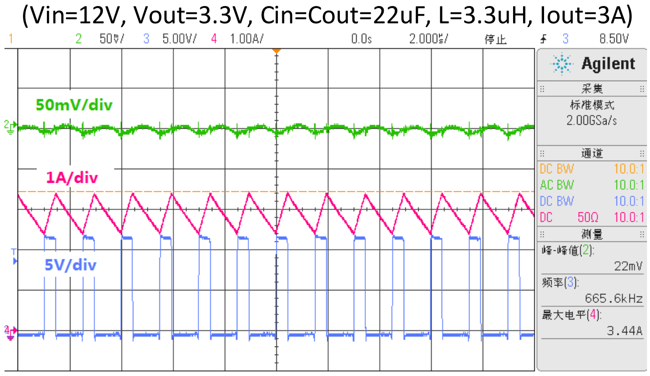



**Steady State Waveform**
(Vin=12V, Vout=3.3V, Cin=Cout=22uF, L=3.3uH, Iout=0A)




Ch2: Vout, Ch3: Vsw, Ch4: Isw

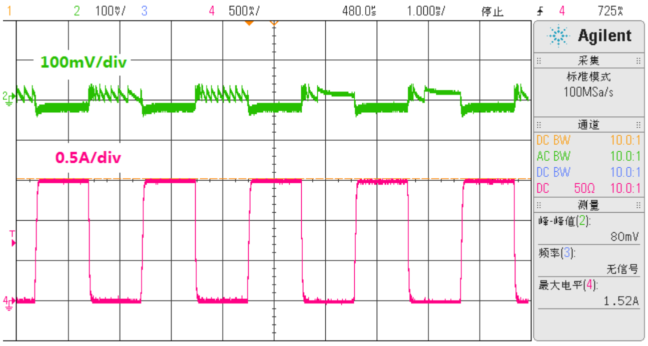
**Steady State Waveform**
(Vin=12V, Vout=3.3V, Cin=Cout=22uF, L=3.3uH, Iout=3A)




Ch2: Vout, Ch3: Vsw, Ch4: Isw

**Load Transient**

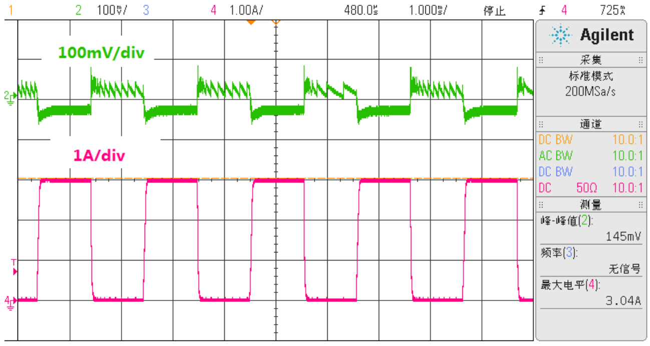
(Vin=12V, Vout=3.3V, Iout=0.01-1.5A)




Ch2: Vout, Ch4: Iout

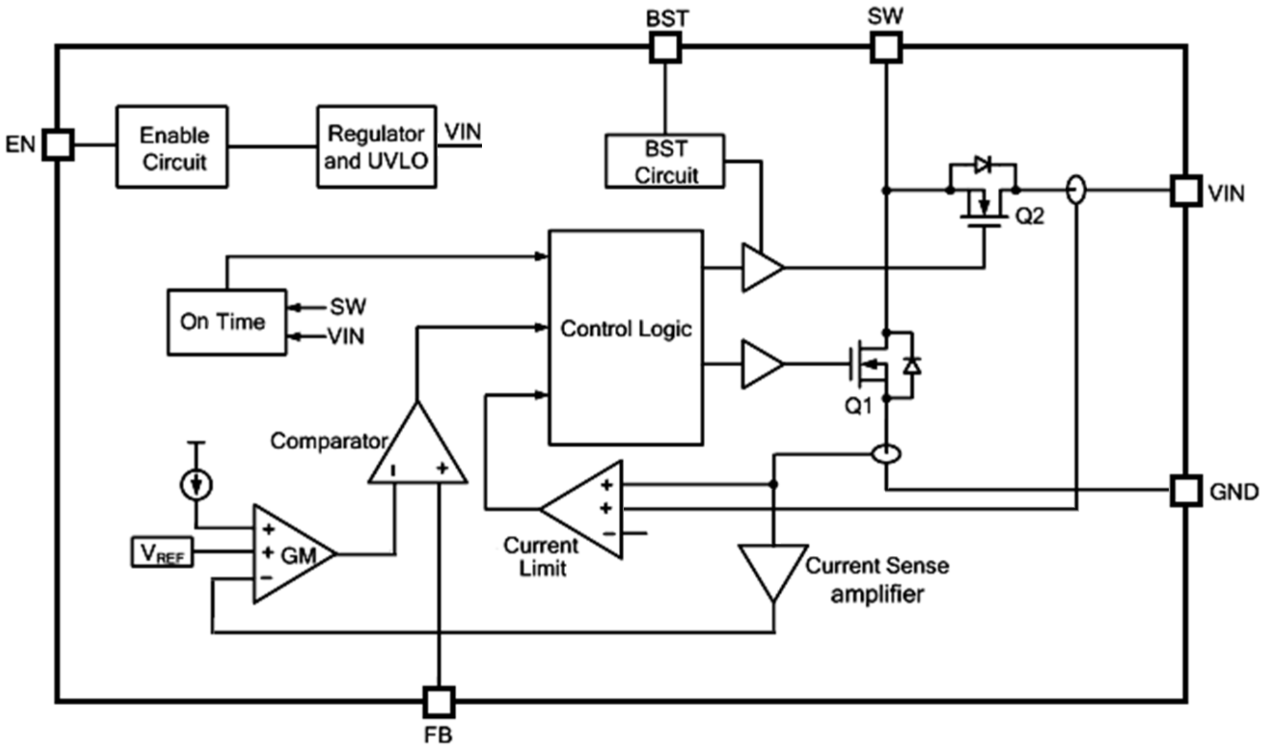
**Load Transient**

(Vin=12V, Vout=3.3V, Iout=0.01-3A)




Ch2: Vout, Ch4: Iout

## BLOCK DIAGRAM



## FUNCTIONAL DECRIPTIONS

### *Loop operation*

The BLL2453 is a wide input range, high-efficiency, DC-to-DC step-down switching regulator, capable of delivering up to 3A of output current, integrated with a 80/50mΩ synchronous MOSFET pair, eliminating the need for external diode. It uses Constant On-Time control mode scheme. An error amplifier integrates error between the FB signal and the internal reference voltage. The output of the integrator is then compared to the sum of a current-sense signal and the slope compensation ramp. This operation generates a PWM signal that modulates the duty cycle of the power MOSFETs to achieve regulation for output voltage.

### *Internal soft-start*

The soft-start is important for many applications because it eliminates power-up initialization problems. The controlled voltage ramp of the output also reduces peak inrush current during start-up, minimizing start-up transient events to the input power bus.

### *Over-current-protection and hiccup*

The BLL2453 has a cycle-by-cycle over-current limit for when the inductor current peak value exceeds the set current-limit threshold. First, when the output voltage drops until FB falls below the Under-Voltage (UV) threshold (typically 200mV) to trigger a UV event, the BLL2453 enters hiccup mode to periodically restart the part. This protection mode is especially useful when the output is dead-shorted to ground. This greatly reduces the average short-circuit current to alleviate thermal issues and to protect the regulator. The BLL2453 exits hiccup mode once the overcurrent condition is removed.

### *Startup and shutdown*

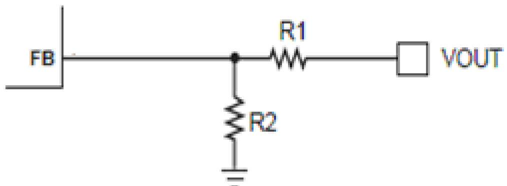
If both VIN and EN are higher than their appropriate thresholds, the chip starts. The reference block starts first, generating stable reference voltage and currents, and then the internal regulator is enabled. The regulator provides stable supply for the remaining circuitries. Three events can shut down the chip: EN low, VIN low and thermal shutdown. In the shutdown procedure, the signaling path is first blocked to avoid any fault triggering. The COMP voltage and the internal supply rail are then pulled down. The floating driver is not subject to this shutdown command.

## APPLICATIONS INFORMATION

### *Setting the output voltage*

The external resistor divider is used to set the output voltage. The feedback resistor R1 also sets the feedback loop bandwidth with the internal compensation capacitor. R2 is then given by:

$$R_2 = \frac{R_1}{V_{out}/V_{FB} - 1}$$




### *Selecting the inductor*

Use a 1μH-to-6.8μH inductor with a DC current rating of at least 25% higher than the maximum load current for most applications. For most designs, derive the inductance value from the following equation:

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

Where $\Delta I_L$ is the inductor ripple current. Choose an inductor current approximately 30% of the maximum load current. The maximum inductor peak current is:

$$I_{L(MAX)} = I_{LOAD} + \frac{\Delta I_L}{2}$$

Under light-load conditions (below 100mA), use a larger inductor to improve efficiency.

### *Selecting the output capacitor*

The output capacitor maintains the DC output voltage. Use ceramic, tantalum, or low-ESR electrolytic capacitors. Use low ESR capacitors to limit the output voltage ripple. Estimate the output voltage ripple with:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \times L} \times \left[1 - \frac{V_{OUT}}{V_{IN}}\right] \times \left[R_{ESR} + \frac{1}{8 \times f_S \times C_2}\right]$$

Where L is the inductor value and $R_{ESR}$ is the equivalent series resistance (ESR) of the output capacitor.

For ceramic capacitors, the capacitance dominates the impedance at the switching frequency and causes most of the output voltage ripple. For simplification, estimate the output voltage ripple with:

$$\Delta V_{OUT} = \frac{V_{OUT}}{8 \times f_s^2 \times L \times C_2} \times \left[1 - \frac{V_{OUT}}{V_{IN}}\right]$$

For tantalum or electrolytic capacitors, the ESR dominates the impedance at the switching frequency. For simplification, the output ripple can be approximated with:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \times L} \times \left[1 - \frac{V_{OUT}}{V_{IN}}\right] \times R_{ESR}$$

The characteristics of the output capacitor also affect the stability of the regulation system. The BLL2453 can be optimized for a wide range of capacitance and ESR values.

## PCB LAYOUT RECOMMENDATION

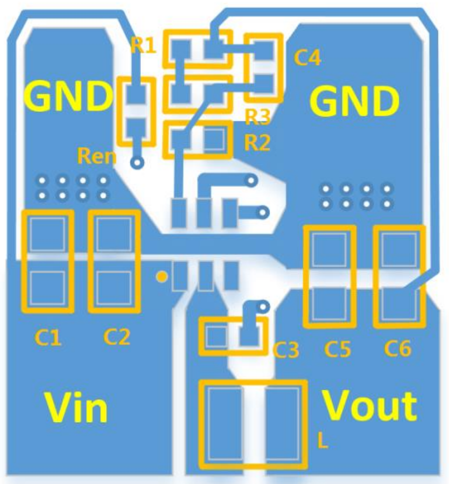
The device's performance and stability are dramatically affected by PCB layout. It is recommended to follow these general guidelines shown as below:

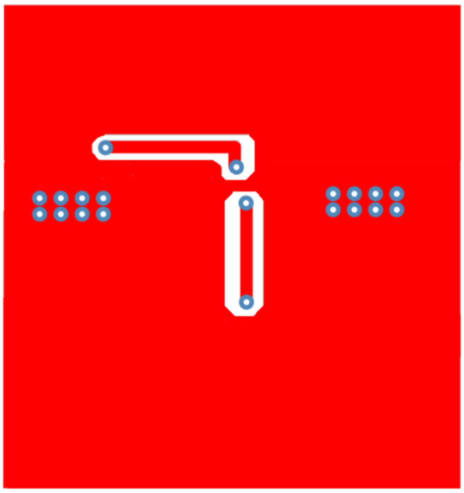
1. Place the input capacitors and output capacitors as close to the device as possible. The traces which connect to these capacitors should be as short and wide as possible to minimize parasitic inductance and resistance.

2. Place feedback resistors close to the FB pin.

3. Keep the sensitive signal (FB) away from the switching signal (SW).

4. Multi-layer PCB design is recommended.

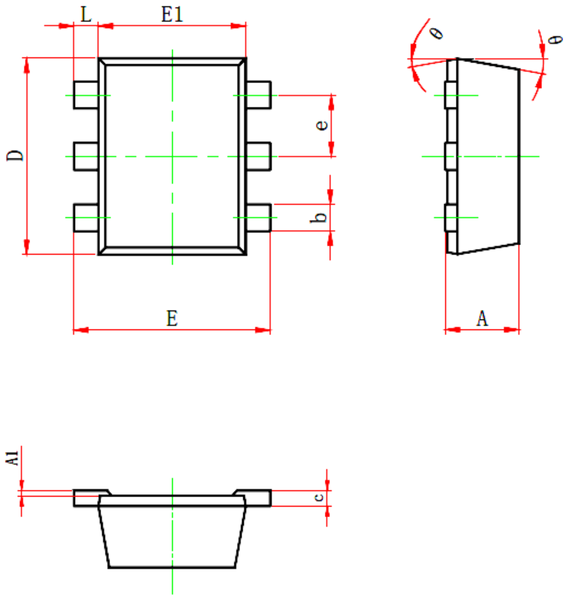


## PACKAGE OUTLINE

| Package | SOT563 | Devices per reel | 5000pcs |
|---|---|---|---|

Package dimension:

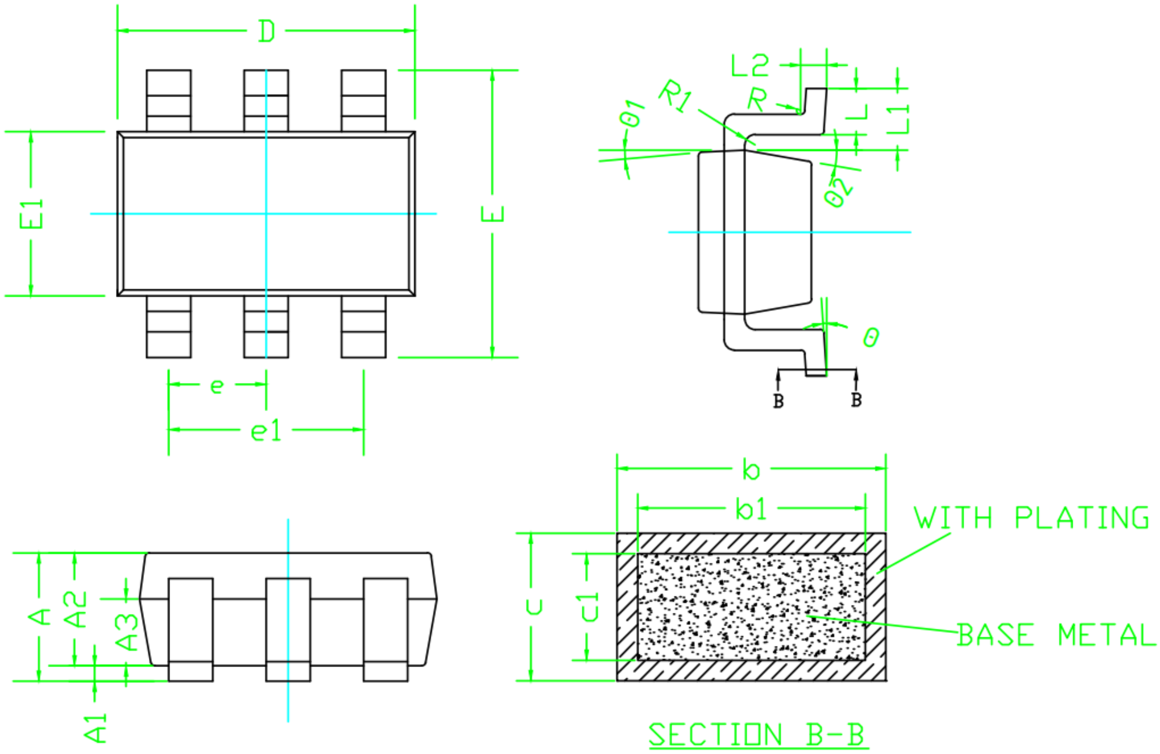



| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min. | Max. | Min. | Max. |
| A | 0.525 | 0.600 | 0.021 | 0.024 |
| A1 | 0.000 | 0.050 | 0.000 | 0.002 |
| e | 0.450 | 0.550 | 0.018 | 0.022 |
| c | 0.090 | 0.180 | 0.004 | 0.007 |
| D | 1.500 | 1.700 | 0.059 | 0.067 |
| b | 0.170 | 0.270 | 0.007 | 0.011 |
| E1 | 1.100 | 1.300 | 0.043 | 0.051 |
| E | 1.500 | 1.700 | 0.059 | 0.067 |
| L | 0.100 | 0.300 | 0.004 | 0.012 |
| L1 | 0.200 | 0.400 | 0.008 | 0.016 |
| θ | 9° REF. | | 9° REF. | |

Unit: mm

| Package | SOT23-6 | Devices per reel | 3000pcs |
|---|---|---|---|

Package dimension:




| | COMMON DIMENSION (MM) | | | DIMENSION In Inches | | |
|---|---|---|---|---|---|---|
| PKG | SOT23-6L | | | SOT23-6L | | |
| REF. | MIN. | NOM. | MAX | MIN. | NOM. | MAX |
| A | – | – | 1.250 | – | – | 0.049 |
| A1 | 0.000 | – | 0.150 | 0.000 | – | 0.006 |
| A2 | 1.000 | 1.100 | 1.200 | 0.039 | 0.043 | 0.047 |
| A3 | 0.600 | 0.650 | 0.700 | 0.024 | 0.026 | 0.028 |
| b | 0.360 | – | 0.500 | 0.014 | – | 0.020 |
| b1 | 0.360 | 0.380 | 0.450 | 0.014 | 0.015 | 0.018 |
| c | 0.140 | – | 0.200 | 0.006 | – | 0.008 |
| c1 | 0.140 | 0.150 | 0.160 | 0.006 | 0.006 | 0.006 |
| D | 2.826 | 2.926 | 3.026 | 0.111 | 0.115 | 0.119 |
| E | 2.600 | 2.800 | 3.000 | 0.102 | 0.110 | 0.118 |
| E1 | 1.526 | 1.626 | 1.726 | 0.060 | 0.064 | 0.068 |
| e | 0.900 | 0.950 | 1.000 | 0.035 | 0.037 | 0.039 |
| e1 | 1.800 | 1.900 | 2.000 | 0.071 | 0.075 | 0.079 |
| L | 0.350 | 0.450 | 0.600 | 0.014 | 0.018 | 0.024 |
| L1 | 0.590REF | | | 0.023REF | | |
| L2 | 0.250BSC | | | 0.010BSC | | |
| R | 0.050 | – | – | 0.002 | – | – |
| R1 | 0.050 | – | 0.200 | 0.002 | – | 0.008 |
| θ | 0° | – | 8° | 0° | – | 8° |
| θ1 | 3° | 5° | 7° | 3° | 5° | 7° |
| θ2 | 6° | – | 14° | 6° | – | 14° |

Unit: mm