# Dual Power-Distribution Switch with Fault-Blanking

## DESCRIPTION

The EUP3546 incorporates dual 95mΩ P-channel MOSFET power switches for power-distribution systems that require multiple power switches in a single package. Each switch is controlled by a logic enable input.

When either output load exceeds the current-limit threshold or a short is present, the device limits the outputs current to a safe level by switching into a constant-current limit mode with fold back, pulling the over-current (OCB(s)) logic output low. When continuous heavy overloads or short-circuits increase the power dissipation in the switches, causing the junction temperature to raise, a thermal protection circuit shutdown the switches to prevent damage. Internal Under Voltage Lock-Out (UVLO) circuitry ensures that the switches remain off until valid input voltage is present. Each power switch is designed to set current limit at 1A typically.

OCB(s) are open-drain outputs which are asserted when over-current occurs. A 8ms fault-blanking feature enables the circuit to ignore momentary faults, such as those caused when hot-swapping a capacitive load, preventing false alarms to the host system. The EUP3546 eliminates any reversed current flow across each switch when it is powered off.

The EUP3546 is available in 8-pin SOP package, operates over the extended (-40℃to +85℃) temperature range.

## FEATURES

- Dual 95mΩ High-Side MOSFET
- 1A (EUP3546) Current Limits with Fold-back
- 1.5A (EUP3546-15) Current Limits with Fold-back
- Operating Range:2.7V to 5.5V
- 300μS Typical Rise Time
- Under voltage Lockout
- 15μA Quiescent Supply Current
- 1μA Shutdown Supply Current
- Logic Level Enable Pin, Available with Active-Low Version
- No Reverse Current when Power Off
- Open-Drain Over-Current Flag Outputs with fault-blanking
- Available in SOP-8 and SOP-8 (EP) Packages
- RoHS Compliant and 100% Lead(Pb)-Free Halogen-Free

## APPLICATIONS

- High-Side Power Protection Switch
- USB Power Management
- USB Host and Self-Powered Bubs
- USB Bus-Powered Hubs
- Hot Plug-In Power Supplies
- Battery-Charger Circuits
- Short-Circuit Protections

## Typical Application Circuit

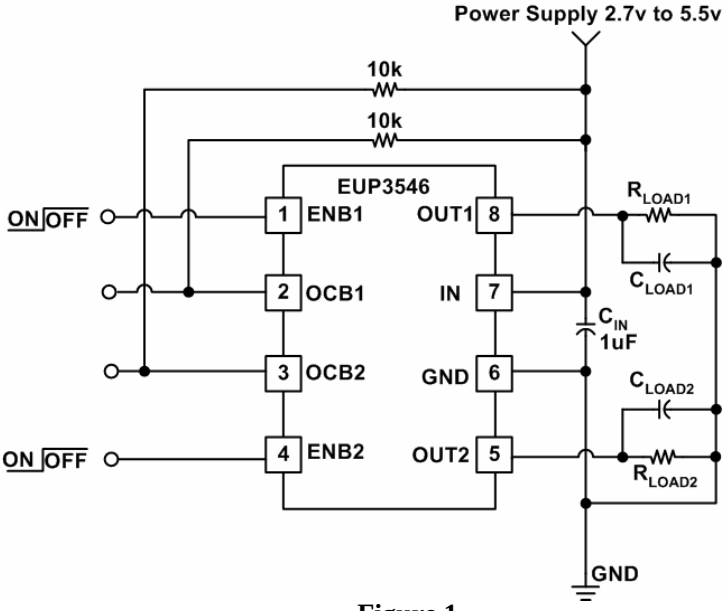



**Figure 1.**

## Block Diagram

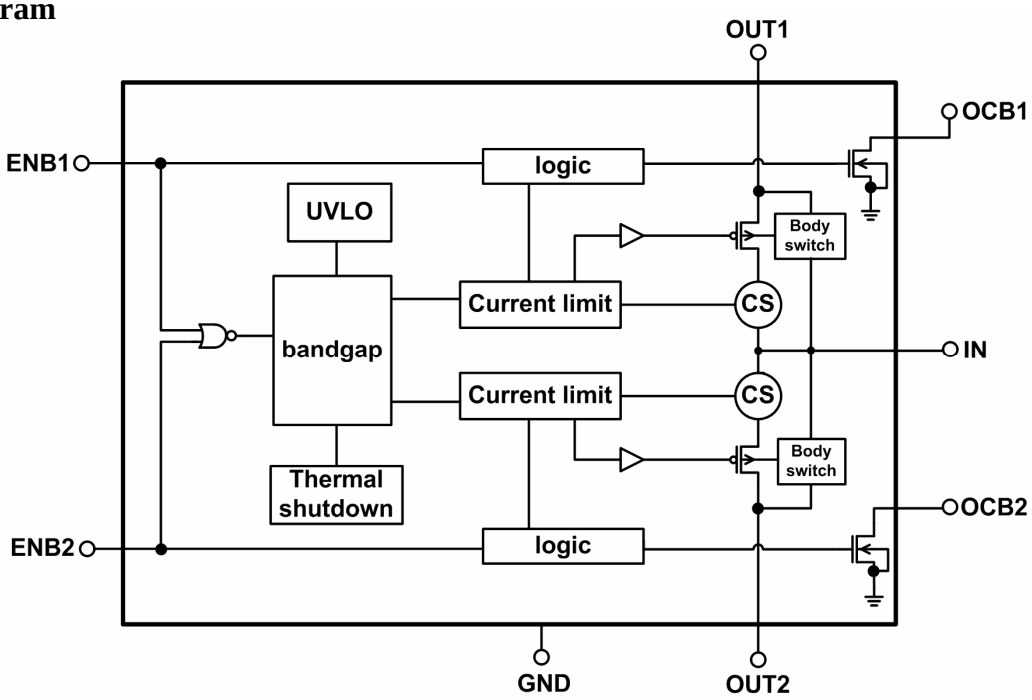
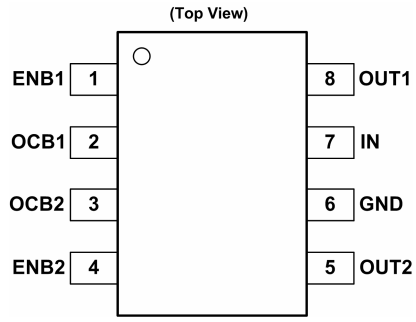
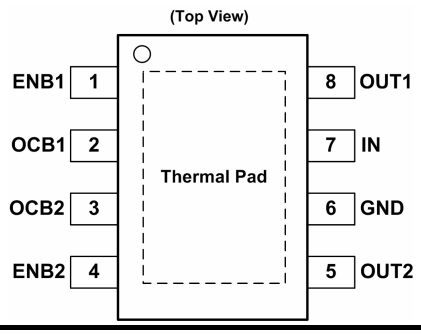



**Figure 2.**

## Pin Configurations

| Package Type | Pin Configurations | Package Type | Pin Configurations |
|---|---|---|---|
| EUP3546<br>SOP-8 |  | EUP3546-15<br>SOP-8 (EP) |  |





## Pin Description

| PIN | NAME | DESCRIPTION |
|---|---|---|
| 1 | ENB1 | **Enable:** Logic level enable input of switch 1.<br>Make sure ENB1 pin never floating. |
| 2 | OCB1 | **Over-Current:** Over-Current Flag of switch 1, open-drain output. |
| 3 | OCB2 | **Over-Current:** Over-Current Flag of switch 2, open-drain output. |
| 4 | ENB2 | **Enable:** Logic level enable input of switch 2<br>Make sure ENB2 pin never floating. |
| 5 | OUT2 | **Switch Output:** Output MOSFET Drain of switch 2.<br>Typically connect to switched side of load. |
| 6 | GND | **Ground** |
| 7 | IN | **Input Supply:** Output MOSEFT Source, which also supplies IC's internal circuitry.<br>Connect to positive supply. |
| 8 | OUT1 | **Switch Output:** Output MOSFET Drain of switch 1.<br>Typically connect to switched side of load. |

## Ordering Information

| Order Number | Package Type | Marking | Operating Temperature Range |
|---|---|---|---|
| EUP3546DIR1 | SOP-8 | xxxxx<br>EUP3546 | -40 °C to +85°C |
| EUP3546-15DIR1 | SOP-8 (EP) | xxxxx<br>EUP3546<br>1C | -40 °C to +85°C |

EUP3546 □□ □ □ □ □

Lead Free Code
1: Lead Free, Halogen Free 0: Lead

Packing
R: Tape & Reel

Operating temperature range
I: Industry Standard

Package Type
D: SOP

Output Current Rating
--: 1A
15: 1.5A

## Absolute Maximum Ratings (1)

- Supply Voltage ($V_{IN}$) ---------- 6V
- Output Voltages ($V_{OUT}$) ---------- 6V
- Output Current ($I_{OUT}$) ---------- Internally Limited
- Continuous Load Current (Dual Channel) ---------- 1.5A
- Enable Input ($V_{ENB}$) ---------- -0.3V to +6V
- Storage Temperature ($T_S$) ---------- -65°C to +150°C
- Reflow Temperature (soldering,10sec) ---------- 260°C
- Thermal Resistance $\theta_{JA}$ (SOP-8) ---------- 125°C/W
- Thermal Resistance $\theta_{JA}$ (SOP-8_EP) ---------- 60°C/W
- ESD protection ---------- 4kV

## Recommend Operating Conditions (2)

- Supply Voltage ($V_{IN}$) ---------- 2.7V to 5.5V
- Operating Temperature ($T_A$) ---------- -40°C to +85°C

*Note (1): Stress beyond those listed under "Absolute Maximum Ratings" may damage the device.*
*Note (2): The device is not guaranteed to function outside the recommended operating conditions.*

## Electrical Characteristics

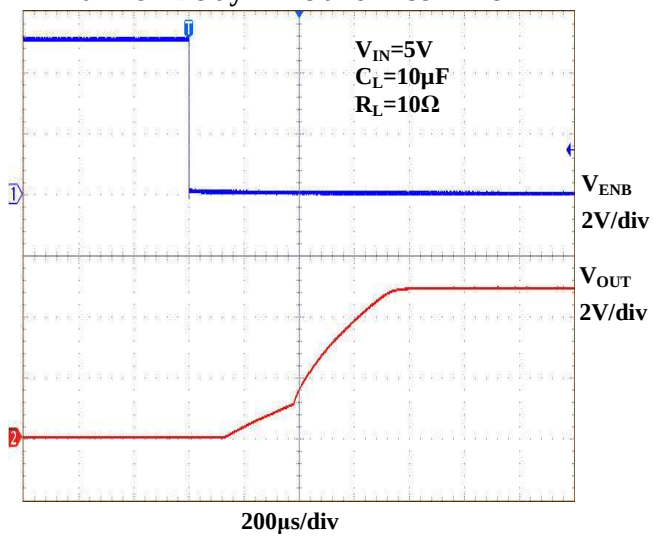
Unless otherwise specified, $V_{IN}$=5V, $C_{IN}$=1µF, $C_{OUT}$=1µF, $R_L$=10Ω, $T_A$=+25°C.

| Parameter | Conditions | | EUP3546 | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| Input Voltage Rage | | | 2.7 | - | 5.5 | V |
| Output MOS $R_{DS(ON)}$ | $I_{OUT}$ = 0.5A | | - | 95 | 150 | mΩ |
| Supply Current | | | - | 13 | 20 | µA |
| Output Turn-on Rising Time | $R_L$=10Ω, 90% Setting | EUP3546 | - | 300 | - | µs |
| | | EUP3546-15 | - | 150 | - | |
| Current Limit Threshold | $V_{OUT}$ = 4V | EUP3546 | 0.7 | 1 | 1.4 | A |
| | | EUP3546-15 | 1.8 | 2.5 | 3.2 | |
| Short-circuit Current | $V_{OUT}$ <1V | EUP3546 | 0.2 | 0.6 | 1 | A |
| | | EUP3546-15 | 1 | 1.5 | 2 | |
| ENB Input Threshold | ENB Falling | | 1.35 | 1.4 | 1.55 | V |
| | ENB Rising | | 1.5 | 1.6 | 1.7 | V |
| Shutdown Supply Current | | | - | - | 2 | µA |
| Output Leakage Current | ENB=5V, $V_{OUT}$ = 0V | | - | 0.5 | 1 | µA |
| VIN Under Voltage Lockout | VIN=Falling | | 1.9 | 2.15 | 2.5 | V |
| VIN Under Voltage Hysteresis | | | - | 200 | - | mV |
| Thermal Limit | | | - | 135 | - | °C |
| Thermal Limit Hysteresis | | | - | 20 | - | °C |
| OCB Deglitch | OCB assertion or deassertion | | 5 | 8 | 15 | ms |
| OCB Output Low Voltage | $I_{OCB}$= 10mA, $V_{IN}$ = 5V | | - | - | 0.2 | V |
| OCB Off-State Current | $V_{OCB}$= 5V | | - | - | 1 | µA |

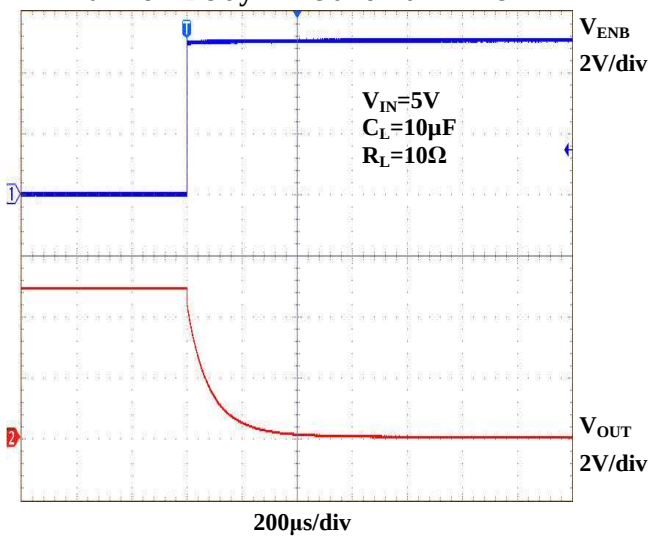
## Typical Operating Characteristics

($V_{IN}$=5V, $C_{IN}$=1μF, $C_{OUT}$=1μF, $V_{ENB}$=0V, $T_A$=+25°C, unless otherwise noted.)

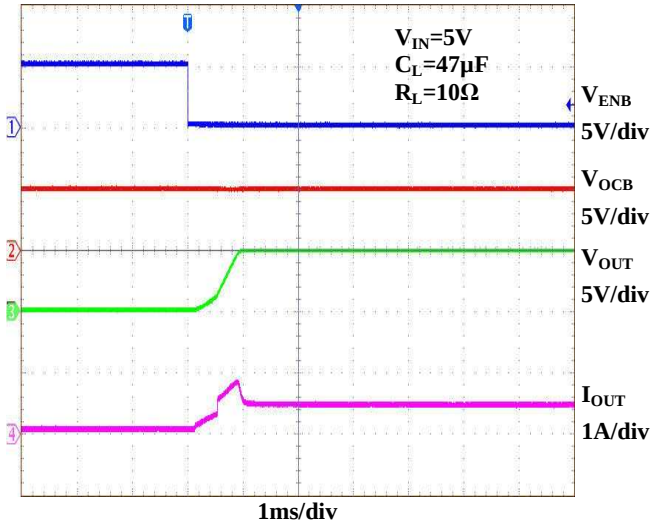
### Turn on Delay Time and Rise Time



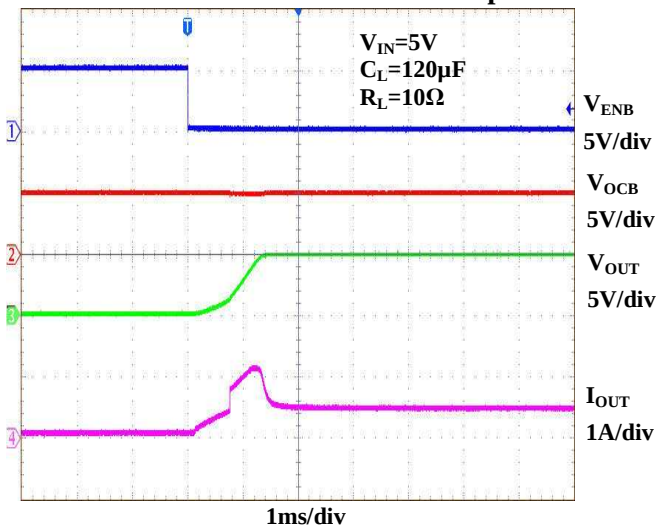

### Turn off Delay Time and Fall Time



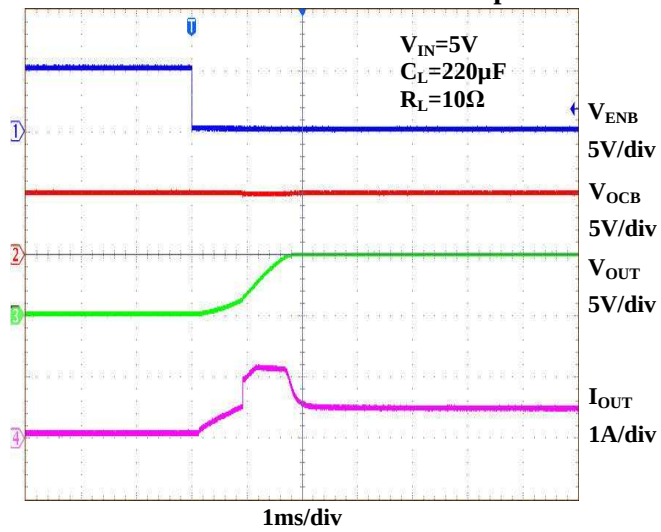

### Inrush Current with Different Load Capacitance



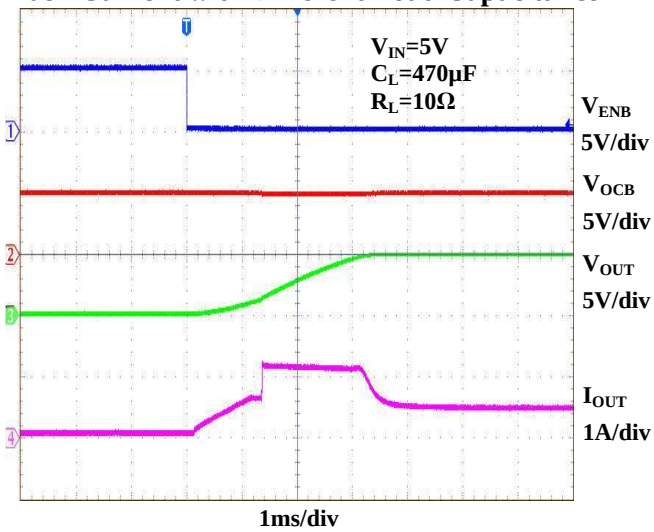

### Inrush Current with Different Load Capacitance



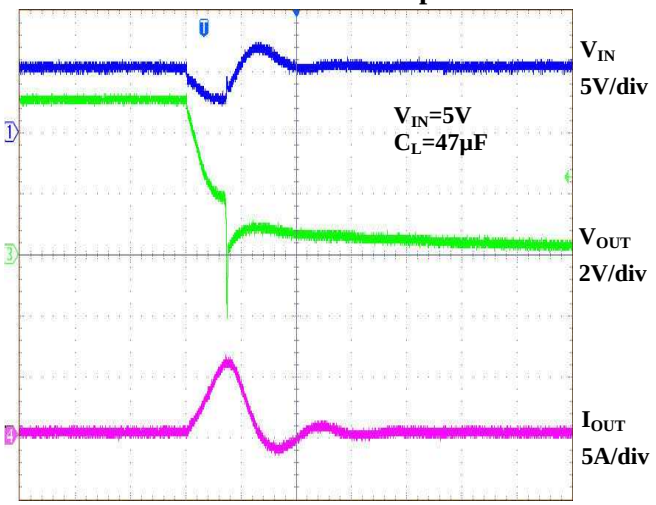

### Inrush Current with Different Load Capacitance



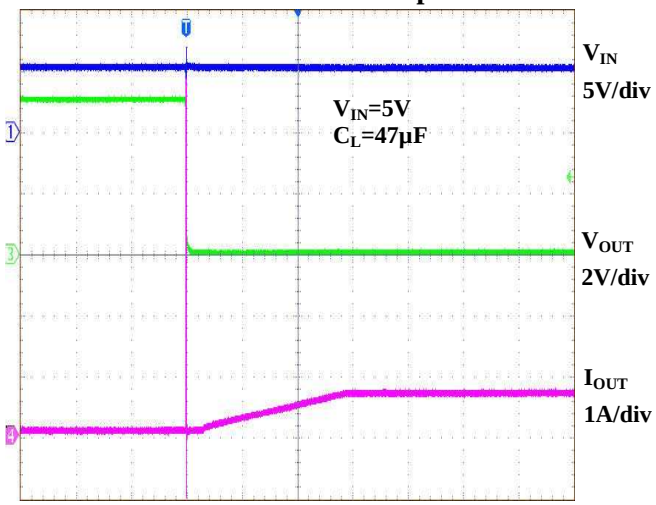

### Inrush Current with Different Load Capacitance



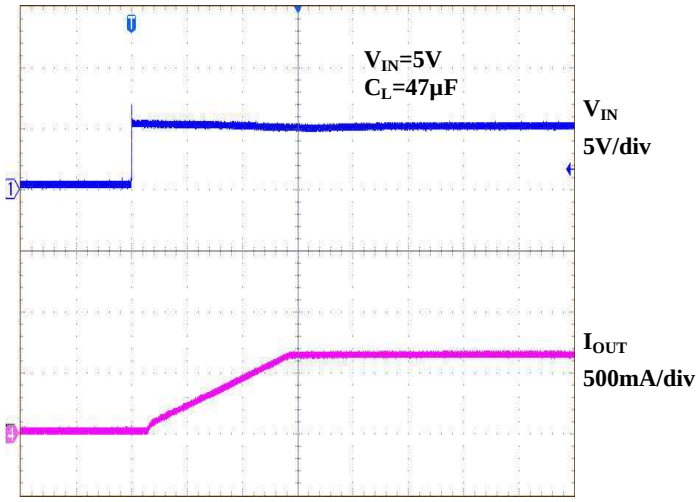
**Inrush Short Circuit Response**



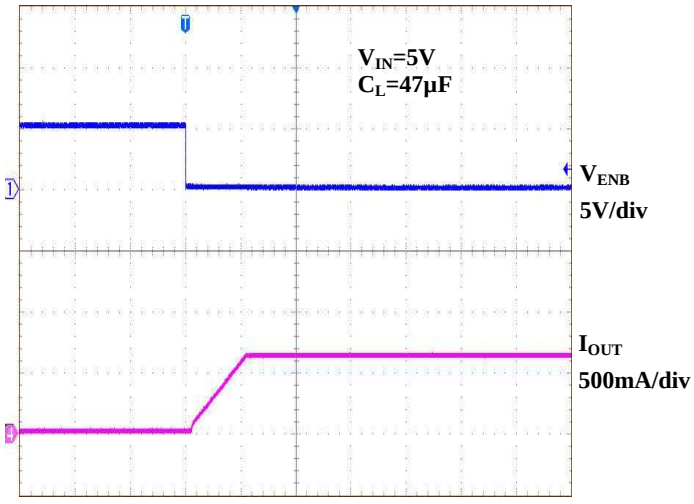

**Inrush Short Circuit Response**



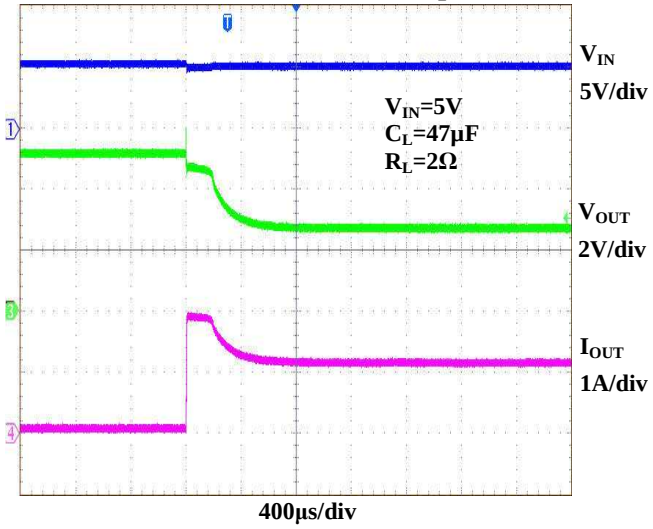

**Short Circuit Response at Start Up**



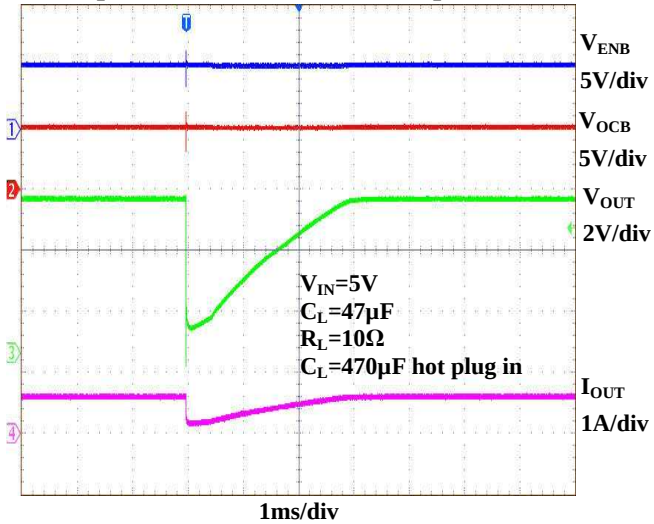

**Short Circuit Current, Device Enable into Short**



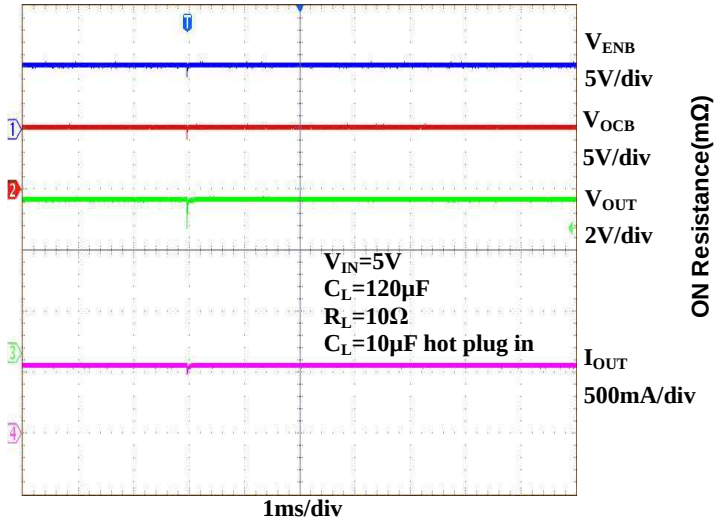

**Resistance Load Inrush Response**



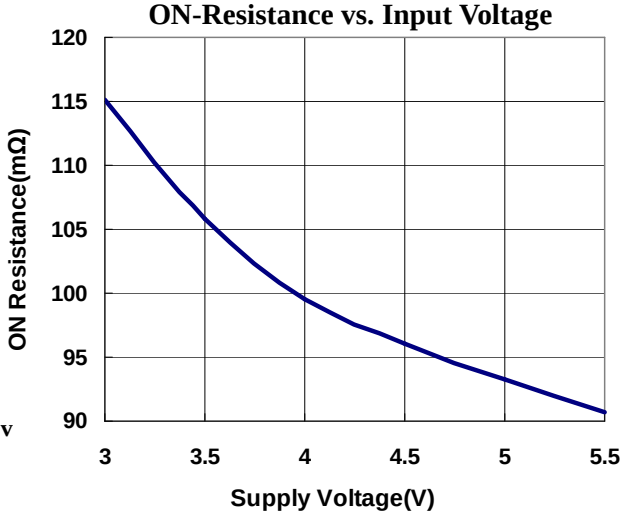

**Capacitance Load Inrush Response**



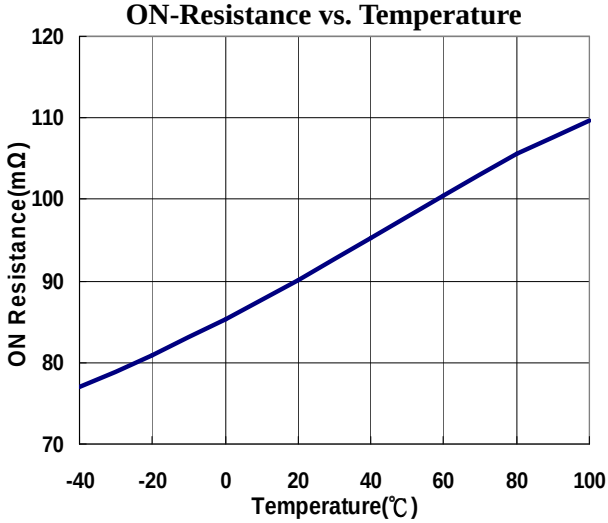
### Capacitance Load Inrush Response



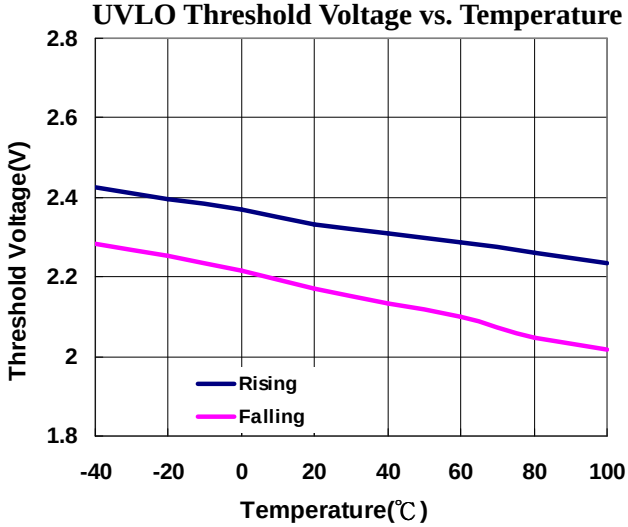

### ON-Resistance vs. Input Voltage



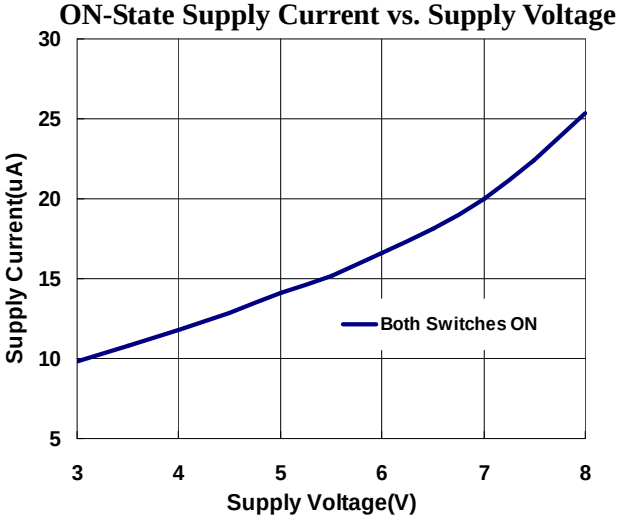

### ON-Resistance vs. Temperature



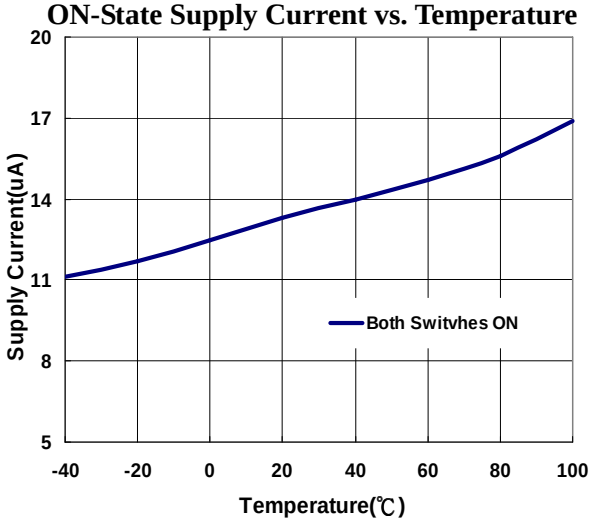

### UVLO Threshold Voltage vs. Temperature

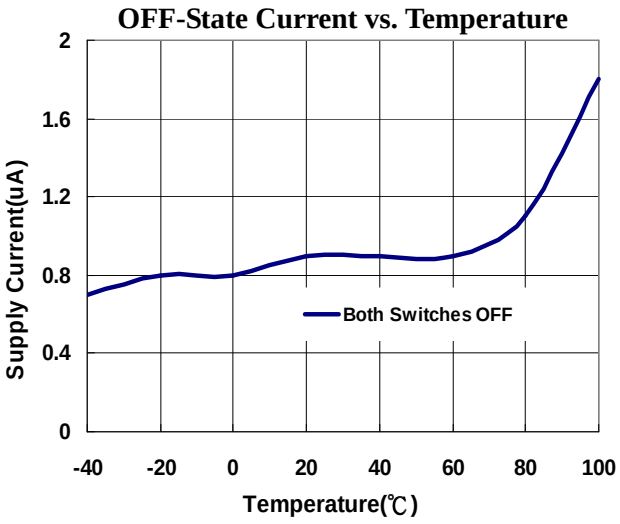


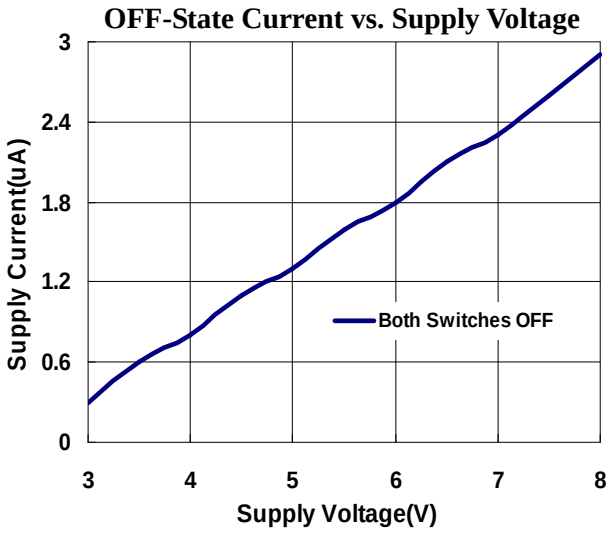

### ON-State Supply Current vs. Supply Voltage

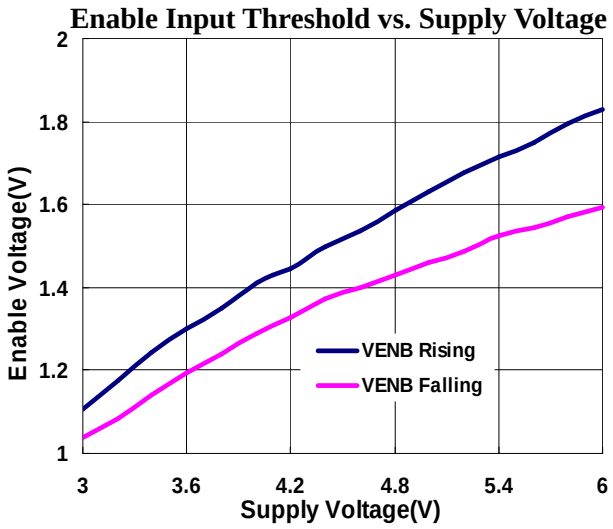


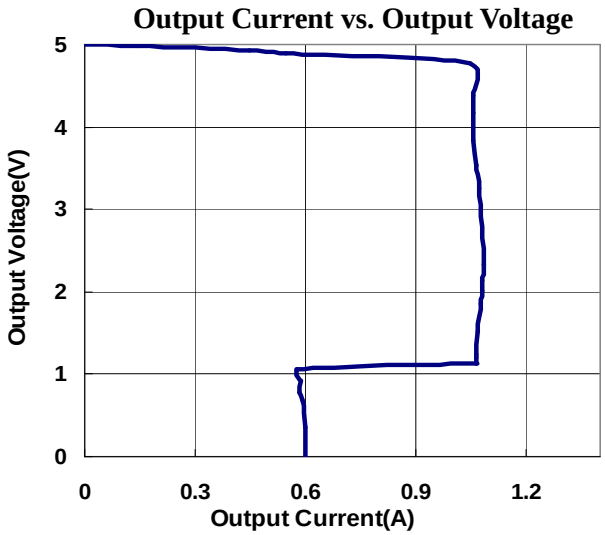

### ON-State Supply Current vs. Temperature




OFF-State Current vs. Temperature
Supply Current(uA)
2
1.6
1.2
0.8
0.4
0
-40
-20
0
20
40
60
80
100
Temperature(℃)
Both Switches OFF


OFF-State Current vs. Supply Voltage
Supply Current(uA)
3
2.4
1.8
1.2
0.6
0
3
4
5
6
7
8
Supply Voltage(V)
Both Switches OFF


Enable Input Threshold vs. Supply Voltage
Enable Voltage(V)
2
1.8
1.6
1.4
1.2
1
3
3.6
4.2
4.8
5.4
6
Supply Voltage(V)
VENB Rising
VENB Falling


Output Current vs. Output Voltage
Output Voltage(V)
5
4
3
2
1
0
0
0.3
0.6
0.9
1.2
Output Current(A)

## Functional Description

### Input and Output

IN (input) is the power supply connection to the logic circuitry and the source of the power MOSFETs. OUT1 and OUT2 (outputs) are the drain of the power MOSFETs. In a typical application, current flows through the switch from IN to OUT toward the load.

### Current Limiting

With the present of a sense FET, over-current conditions can be detected without increasing the series resistance of the current path. Under over-current condition, the device maintains a constant output current and reduces the output voltage accordingly. Complete shutdown occurs only if the fault is presented long enough to activate thermal limiting. There are several possible over-current conditions can occur.

- The each output has been shorted before the device is enabled or before IN has been applied, the device senses the short and immediately switches into a constant-current limit mode.
- A short or an overload occurs at each output while the device is enabled. At the instant the overload occurs, high currents may flow for a short period of time before the current-limit circuit can react. After the current limit circuit has tripped (reached the over-current trip threshold), the device switches into constant current mode.
- The each output load has been gradually increased beyond the recommended operating current. The current is permitted to rise until the current limit threshold is reached or until the thermal limit of the device is exceeded. The EUP3546 is capable of delivering current up to the current limit threshold without damaging the device. Once the threshold has been reached, the device switches into its constant current mode.

The typical current limit value of EUP3546 is 1A, There is a fold-back of current limit to 0.6A when OUT(s) < 1V. (*See Typical Operating Characteristics*).

### Thermal Shutdown

Thermal shutdown protects EUP3546 from excessive power dissipation. If the die temperature exceeds 135°C, the power switches are shut off. 20°C of hystersis prevents the switch from turning on until the die temperature drops to 115°C. Thermal shutdown circuit functions when either of the switches is enabled.

### Under-Voltage Lockout

Whenever the input voltage falls below approximately 2.1V, the power switch is quickly turned off. This facilitates the design of hot-insertion systems where it is not possible to turn off the power switch before input power is removed. The UVLO also keeps the switches from being turned on until the power supply has reached at least 2.3V, even if both switches are enabled.

### OCB Function

The OCB(s) open-drain output are asserted (active low) when an over current condition is encountered after a 8ms fault-blanking timeout (to eliminate false over-current reporting). This feature allows the device to handle USB loads that might not be fully compliant with USB specifications. The EUP3546 successfully powers USB loads with additional bypass capacitance and/or large startup currents while protecting the upstream power source. No fault is reported if the switches bring up the load within the 8ms blanking period.

## Application Information

### Input Power Supply and Capacitance

Pin IN power the internal control circuitry. A 1µF bypass capacitor from IN to GND, located near the EUP3546, is strongly recommended to control supply transients. When driving inductive loads or operating from inductive sources, which may occur when the EUP3546 is powered by long leads or PC traces, larger input bypass capacitance is required to prevent voltage spikes from exceeding the EUP3546's absolute maximum ratings ($V_{INMAX}$ = 6V) during short-circuit events.

### Output Capacitor

Bypass each OUT to GND with a 1uF ceramic capacitor for local decoupling. Placing a high-value electrolytic capacitor on the output pin(s) is recommended when the output load is heavy. This precaution reduces power-supply transients that may cause ringing on the input and reduces output voltage transients under dynamic load conditions. Using output capacitors greater than 470uF might assert OCB(s) if the current limit cannot charge the output capacitor within the 8ms fault-blanking period.

### ENB(s), the Enable Logic Input

ENB(s) must be driven logic low for a clearly defined input. Floating the input may cause unpredictable operation. ENB(s) should not be allowed to go negative with respect to GND.

### Driving Inductive Loads

A wide variety of devices (mice, keyboards, cameras, and printers) typically connect to the USB port with cables, which might add an inductive component to the load. This inductance causes the output voltage at the USB port to oscillate during a load step. The EUP3546 drives inductive loads, but avoid exceeding the device's absolute maximum ratings. Usually, the load inductance is relatively small, and the EUP3546's input includes a substantial bulk capacitance from an upstream regulator as well as local bypass capacitors, limiting overshoot.

**Layout and Thermal Dissipation**

Keep all traces as short as possible to reduce the effect of undesirable parasitic inductance and optimize the switch response time to output short circuit conditions. Place input and output capacitors no more than 5mm from device leads. Connect IN and OUT(s) to the power bus with short traces. Wide power bus planes at IN and OUT(s) provide superior heat dissipation as well.

An active switch dissipates little power with minimal change in package temperature. Calculate the power dissipation for this condition as follows:

$$P = I_{OUT}^2 \times R_{(DS)ON}$$

At the normal operating current ($I_{OUT}$ = 0.5A) and the maximum on resistance of the switch (150m Ω), the power dissipation is:

$$P = 2 \times (0.5A)^2 \times 0.15\Omega = 75mW$$

The worst-case power dissipation occurs when the output current is just below the current limit threshold (1.5A max) with a low output voltage 1V, for example. For a 5V input, the power dissipated is the voltage drop across the switch multiplied by the current limit:

$$P = 2 \times I_{LIM} \times (V_{IN} - V_{OUT})$$

$$= 2 \times 1.4A \times (5V - 1V) = 11.2W$$

In this case, the EUP3546 die temperature exceeds the 135℃ thermal shutdown threshold, and the switch output shuts down until the junction temperature cools by 20℃. The duty cycle and period are strong functions of the ambient temperature and the PC board layout (see the Thermal Shutdown section). If the output current exceeds the current limit threshold, the EUP3546 asserts a fault state after 8ms.

**Test Circuit**

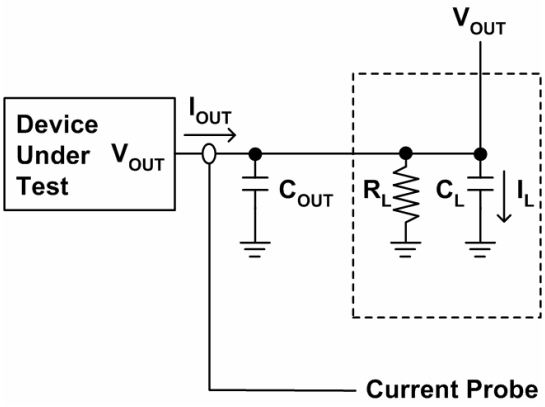



**Figure 3.**

**Timing Diagrams**

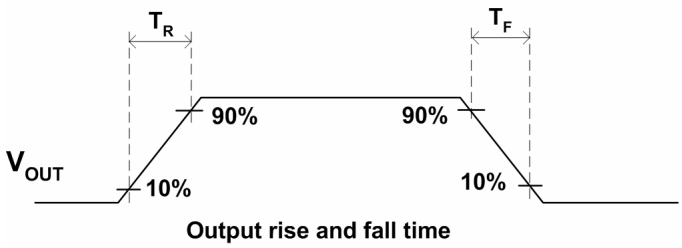



**Figure 4.**

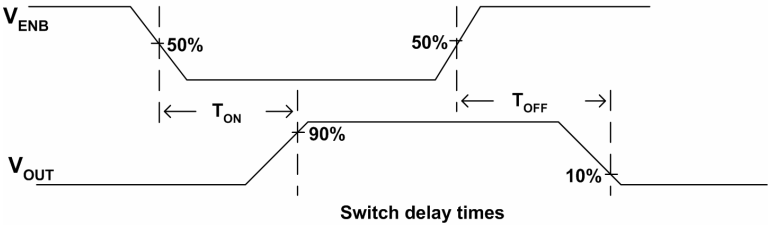
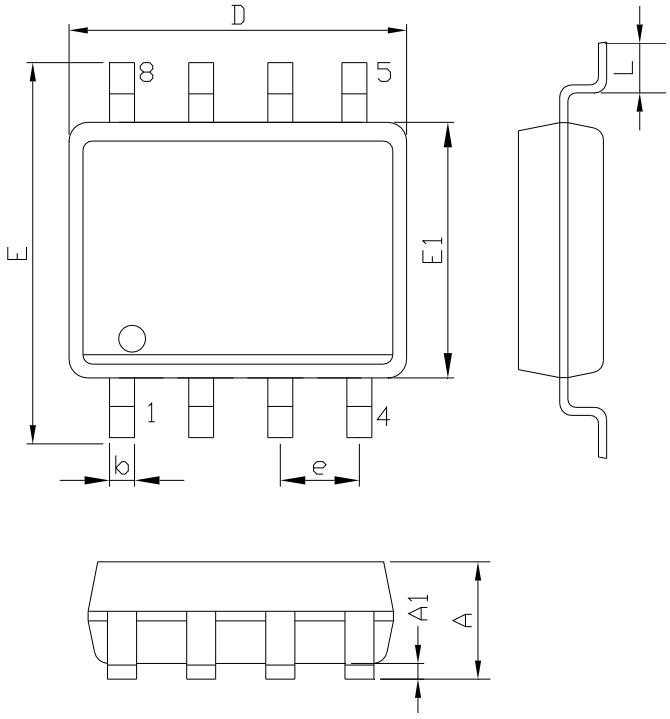



**Figure 5.**

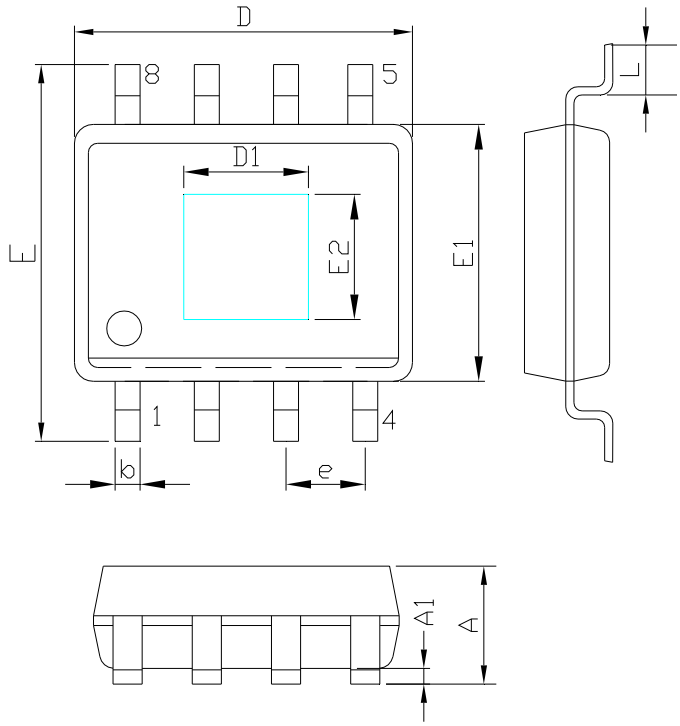
## Packaging Information

**SOP-8**




| SYMBOLS | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| | MIN. | MAX. | MIN. | MAX. |
| A | 1.35 | 1.75 | 0.053 | 0.069 |
| A1 | 0.10 | 0.25 | 0.004 | 0.010 |
| D | 4.90 | | 0.193 | |
| E | 5.80 | 6.20 | 0.228 | 0.244 |
| E1 | 3.90 | | 0.153 | |
| L | 0.40 | 1.27 | 0.016 | 0.050 |
| b | 0.31 | 0.51 | 0.012 | 0.020 |
| e | 1.27 | | 0.050 | |

**SOP-8 (EP)**




| SYMBOLS | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| | MIN. | MAX. | MIN. | MAX. |
| A | 1.35 | 1.75 | 0.053 | 0.069 |
| A1 | 0.10 | 0.25 | 0.004 | 0.010 |
| D | 4.90 | | 0.193 | |
| E1 | 3.90 | | 0.153 | |
| D1 | 2.00 | | 0.081 | |
| E2 | 2.00 | | 0.081 | |
| E | 5.80 | 6.20 | 0.228 | 0.244 |
| L | 0.40 | 1.27 | 0.016 | 0.050 |
| b | 0.31 | 0.51 | 0.012 | 0.020 |
| e | 1.27 | | 0.050 | |