80mΩ USB Power-Distribution Switch with Programmable Current Limit

DESCRIPTION

The EUP3551 is an incorporated power-distribution switch for USB applications and the 80mΩ P-channel MOSFET realized in this IC.

The EUP3551 integrates several protection features to prevent catastrophic switch failure caused by increasing power dissipation. The current-limit threshold is programmed with an external resistor from ILIM pin to ground ， When the output load exceeds the current-limit threshold or a short is present, the system limits the output current by switching into a constant-current limit mode and pulls the OCB logic output low. An internal reverse voltage comparator disables the power switch when the output voltage is driven higher than the input to protect devices on the input side of switch.

OCB is open-drain output which is asserted when over-current or short circuit occurs. A 7ms 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 EUP3551 eliminates any reversed current flow across the switch when it is powered off.

The EUP3551 is available in SOT23-6 packages, operates over the extended (-40°C to +85°C) temperature range.

FEATURES

- 80mΩ(typ.) Power MOSFET
- Adjustable current limit: 125mA to 1.5A
- Operating Range : 2.7V to 5.5V
- Under Voltage Lockout
- 100μA Quiescent Current
- 1μA Maximum Shutdown Current
- No Reverse Current when Power Off
- Fault Blanking Open-Drain limit-Current Flag Output OCB
- Enable Active-High or Active-Low
- Available in SOT23-6 Packages
- RoHS Compliant and 100% Lead(Pb)-Free Halogen-Free

APPLICATIONS

- USB Ports and Hubs
- TV
- Set-Top Boxes

Typical Application Circuit

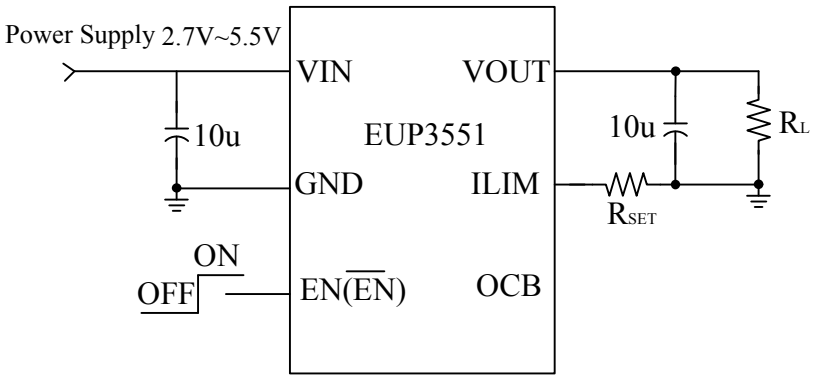
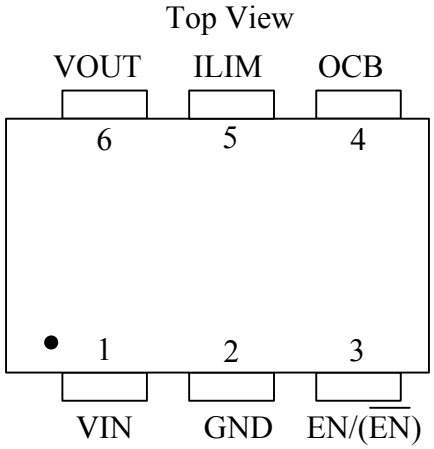


Figure 1.

Pin Configurations

Package Type	Pin Configurations
SOT23-6	

Pin Description

NAME	SOT23-6	DESCRIPTION
VIN	1	Power Input. Connect all VIN inputs together and bypass with a 10uF or greater ceramic capacitor to GND. Load conditions might require additional bulk capacitance to prevent pulling VIN down.
GND	2	Ground. The exposed pad must be soldered to a large PCB and connected to GND for maximum power dissipation.
EN/ ($\overline{EN}$)	3	Enable: Logic level enable input. Make sure EN/($\overline{EN}$) pin never floating. EN : Logic high turns on power switch. $\overline{EN}$: Logic low turns on power switch.
OCB	4	Fault Indicator Output. Open-drain output asserts low when enters thermal shutdown, or a sustained (7ms typical) current-limit or short-circuit condition.
ILIM	5	Current-Limit Set Input. Connect a resistor R_{SET} from ILIM to ground to set the current limit for the switch.
VOUT	6	Power Output. Bypass VOUT to GND with a 1uF ceramic capacitor. Load conditions might require additional bulk capacitance.

Ordering Information

Order Number	Package Type	Marking	Enable	OCB Output	Quantity per Reel	Operating Temperature Range
EUP3551AVIR1	SOT23-6	xxxxx Bp00	Active High	YES	3000	-40 °C to +85°C
EUP3551BVIR1	SOT23-6	xxxxx Bq00	Active Low	YES	3000	-40 °C to +85°C

EUP3551 □ □ □ □ □

- Lead Free Code
  1: Lead Free, Halogen Free
- Packing
  R: Tape & Reel
- Operating temperature range
  I: Industry Standard
- Package Type
  V: SOT23
- A: Enable high, B: Enable low

Block Diagram

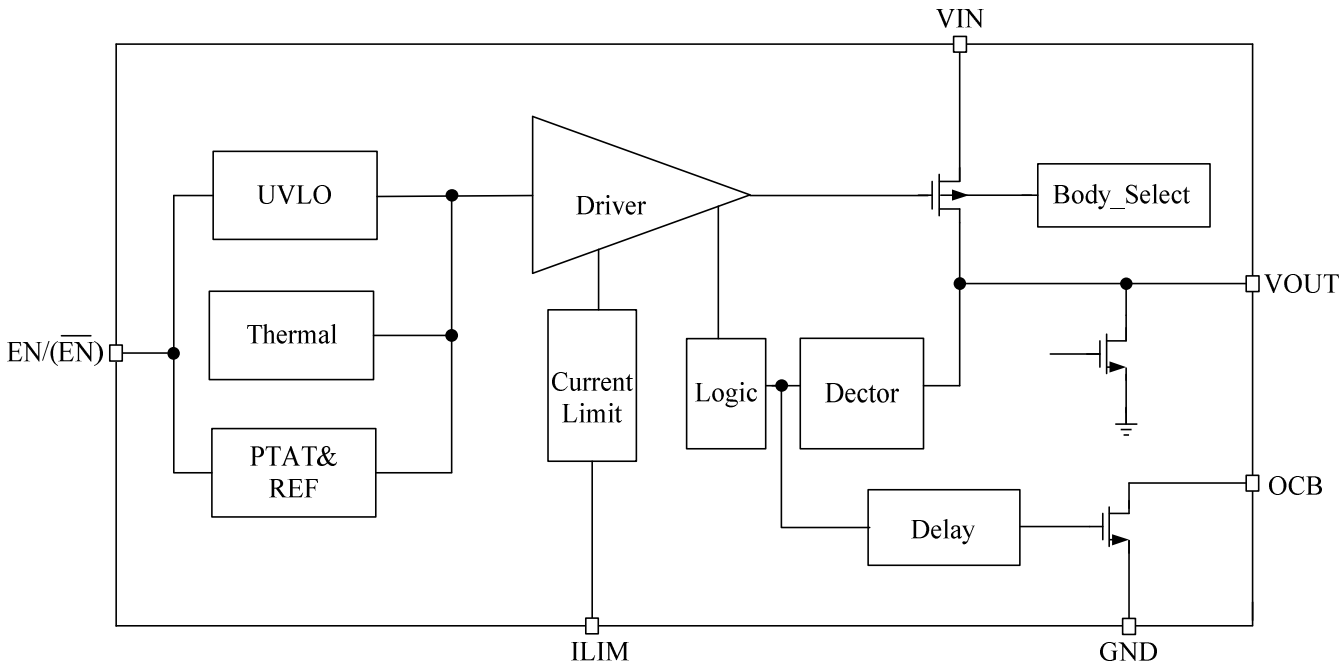


Figure 2.

Absolute Maximum Ratings (1)

- Supply Voltage (VIN) ---------- 6V
- Output Voltages (VOUT) ---------- 6V
- Enable Input (V_{EN}) ---------- -0.3V to 6V
- Storage Temperature (T_S) ---------- -65°C to 150°C
- Reflow Temperature (soldering,10sec) ---------- 260°C
- Thermal Resistance θ_{JA} (SOT23-6) ---------- 205°C /W
- HBM ESD protection ---------- 8kV

Recommend Operating Conditions (2)

- Supply Voltage (VIN) ---------- 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

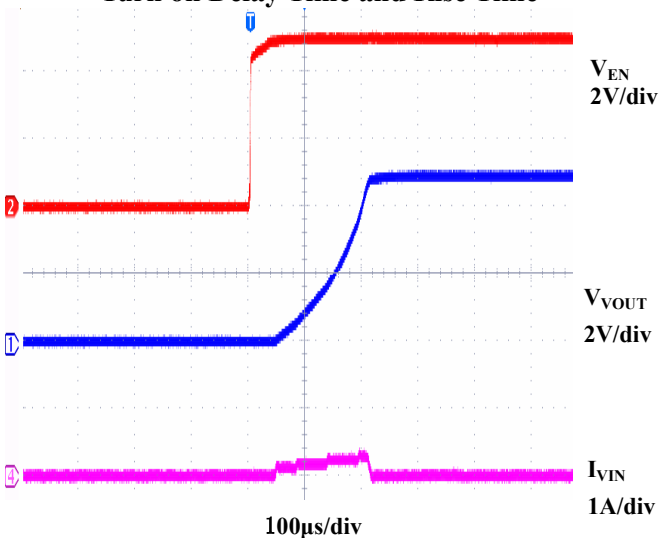
Unless otherwise specified, VIN =5V, C_{IN}=C_{OUT}=10μF, T_A=+25°C

Symbol	Parameter	Conditions	EUP3551			Units
			Min.	Typ.	Max.	
V_{IN}	Operating Voltage		2.7		5.5	V
R_{ON}	Output MOS $R_{DS(ON)}$	IC Enable， R_{SET}=1K， I_{OUT}=0.6A		80		mΩ
I_Q	Supply Current	IC Enable，R_{SET}=10K		100	140	μA
T_{RISE}	Output Turn-on Rising Time	R_L=10Ω，R_{SET}=1K		350		us
I_{LIMIT}	Current Limit Threshold	R_{SET}=10K	0.1	0.13	0.16	A
		R_{SET}=1.5K	0.9	1	1.1	
		R_{SET}=1K	1.35	1.5	1.65	
I_{SHORT}	Short-Circuit Current	R_{SET}=10K，VOUT =0V		0.125		A
		R_{SET}=1K，VOUT =0V		1.35		A
V_{IL}	Low-Level Input Voltage				0.7	V
V_{IH}	High-Level Input Voltage		1.4			V
I_{SHDN}	Shutdown Supply Current	IC Disable		0.4	1	μA
I_{LEAK}	Output Leakage Current	IC Disable, VOUT =0V		0	1	μA
V_{UVLO}	V_{IN} Under Voltage Lockout		1.8	2.05	2.2	V
$V_{UVLO-Hys}$	V_{IN} Under Voltage Hysteresis			150		mV
T_{OCB}	OCB Deglitch		5	7	9	ms
V_{OCB}	OCB Output Low Voltage	IOCB= 5mA			0.3	V
I_{OCB}	OC Off-State Current	V_{OC} = 5V			1	μA
T_{OTP}	Thermal Limit			145		°C
T_{SDH}	Thermal Limit Hysteresis			20		°C

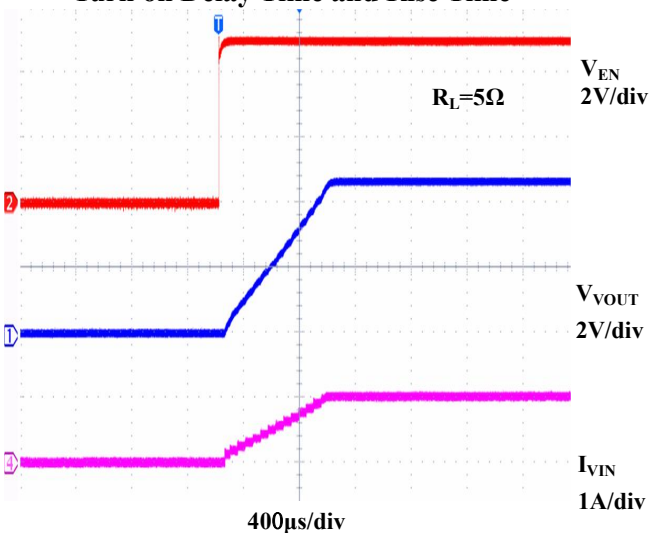
Typical Operating Characteristics

(VIN =5V, C_{IN}=10µF, C_{OUT}=10µF, V_{EN} =5V, R_{SET}=1K, T_A=+25°C, unless otherwise noted.)

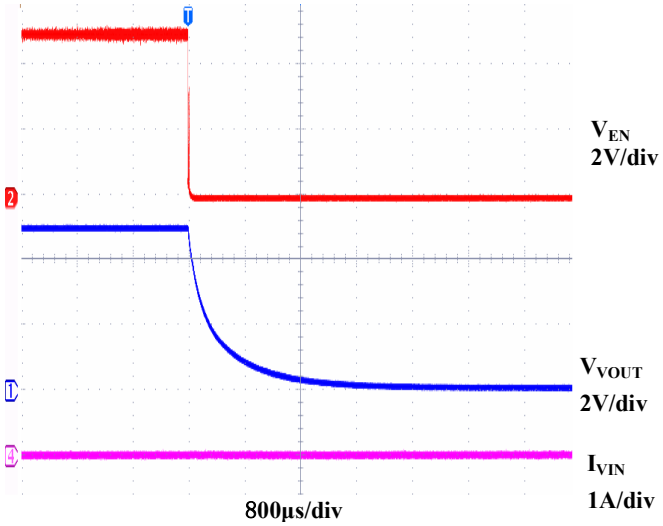
Turn on Delay Time and Rise Time



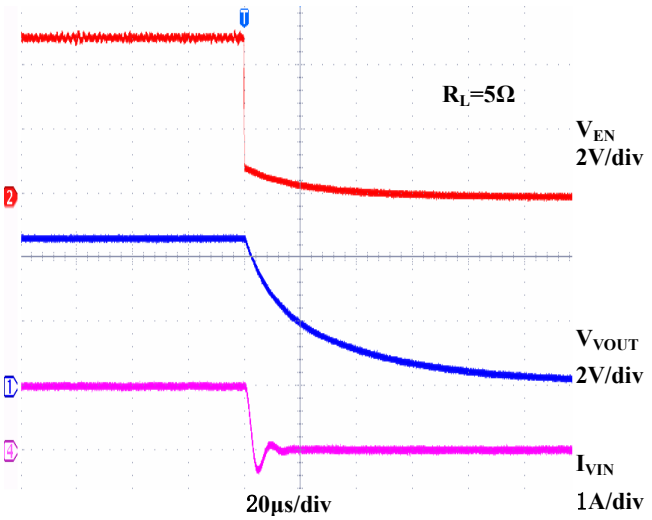
Turn on Delay Time and Rise Time



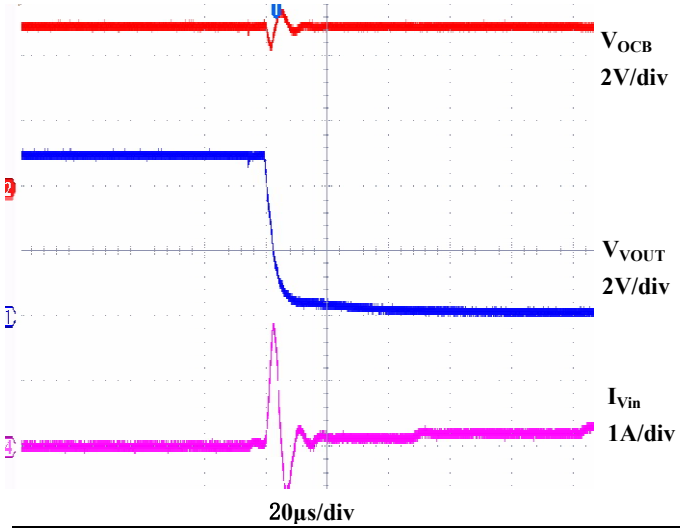
Turn off Delay Time and Fall Time



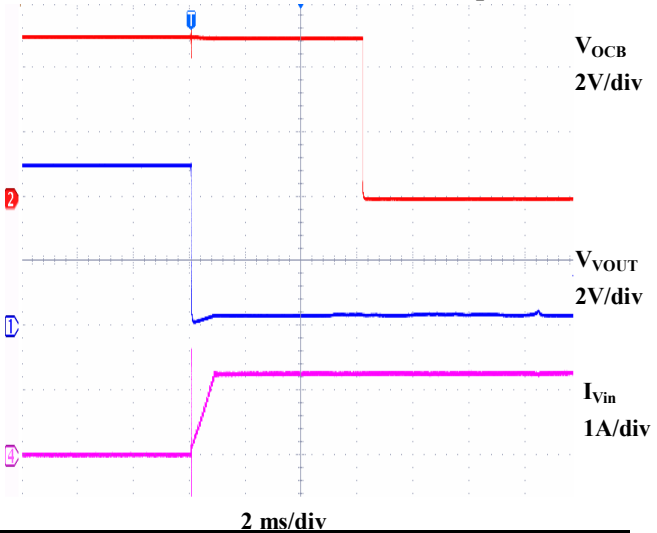
Turn on Delay Time and Rise Time



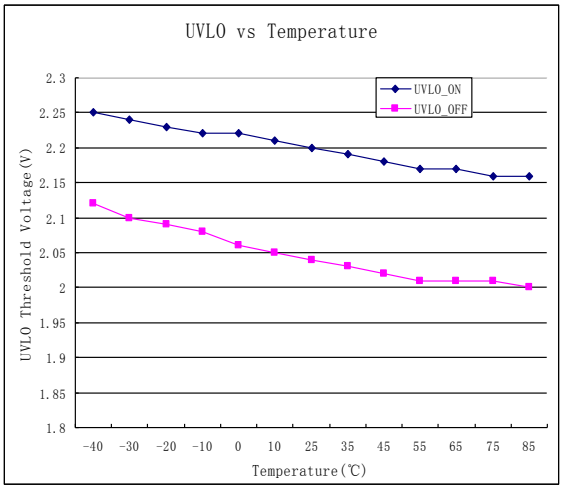
Inrush Short Circuit Response



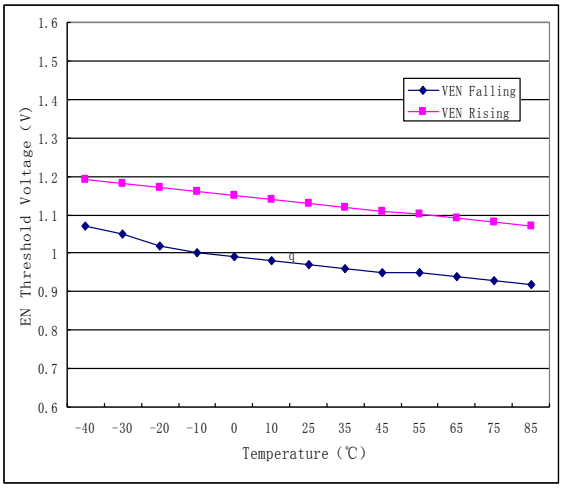
Short Circuit OCB Protector Response



UVLO Voltage vs. Temperature



EN Threshold vs. Temperature



Functional Description

Input and Output

VIN (input) is the power supply connection to the logic circuitry and the source of the power MOSFET. VOUT (output) is the drain of the power MOSFET. In a typical application, current flows through the switch from VIN to VOUT toward the load. All VOUT pins must connect together to the load.

Current Limiting

The EUP3551 continuously monitors the output current for over-current protection to protect the system power, the power switch, and the load from damage during output short circuit .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 output has been shorted before the device is enabled or before VIN has been applied, the EUP3551 senses the short immediately switches into a constant-current limit mode.
- A short or an overload occurs 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 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 EUP3551 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 current limit value refers to typical operating characteristics.

Thermal Shutdown

Thermal shutdown protector is built in EUP3551. When the die temperature exceeds 145°C, the MOSFETS switch is shut off. 20°C of hysteresis prevents the switch from turning on until the die temperature drops to 125°C. Thermal shutdown circuit functions only when the switch is enabled.

Under-Voltage Lockout

A voltage-sense circuit monitors the input voltage. When the input voltage falls below approximately 2.05V, the power switch is quickly turned off. The UVLO also keeps the switch from being turned on until the power supply has reached at least 2.2V, even if the switch is enabled.

OCB Function

The OCB open-drain output is pull low voltage, when an over current condition is encountered over approximately 7ms 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 EUP3551 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 switch brings up the load within the 7ms blanking period.

Setting the Current Limit Level

The current limit circuitry prevents damage to the MOSFET switch but can deliver load current up to the current limit threshold through the switch. EUP3551 provides adjustable current limit threshold between 0.12~1.55A through an external resistor. The current limit threshold (Typ.) and R_{SET} curve is show below:

Current Limit R_{SET} Values

Design Current Limit(mA)	Ideal R_{SET} Value (kΩ)	Real R_{SET} (kΩ)	Actual Limits(mA)
125	10	10	126
200	6.25	6.2	205
300	4.55	4.57	296
400	3.57	3.54	434
500	2.94	3	508
600	2.50	2.54	601
700	2.17	2.1	726
800	1.85	1.87	816
900	1.67	1.67	912
1000	1.52	1.51	1011
1100	1.39	1.33	1147
1200	1.28	1.24	1230
1300	1.19	1.2	1286
1400	1.11	1.1	1387
1500	1.04	1.04	1467
1550	1.00	1	1500

Application Information

Input Power Supply and Capacitance

A 10μF bypass capacitor from VIN to GND, located near the EUP3551, is strongly recommended to prevent the input voltage dropping during hot-plug events. When the devices is powered by long leads or PC traces ,it is quit to driver inductive loads or operate from inductive sources, larger input bypass capacitance is required to prevent voltage spikes from exceeding the EUP3551's absolute maximum ratings (VIN_{MAX} = 6V) during short-circuit events.

Output Capacitor

A ceramic capacitor greater than 10uF between，VOUT and GND is recommended to reduce the voltage drop, 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 470μF might assert OCB if the current limit cannot charge the output capacitor within the 7ms fault-blanking period.

EN, the Enable Logic Input

EN must be driven logic low or logic high for a clearly defined input. Floating the input may cause unpredictable operation. EN should not be allowed to go negative with respect to GND.

Driving Inductive Loads

To the USB port with cables is typically connected A wide variety of devices (mice, keyboards, cameras, and printers), 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 EUP3551 drives inductive loads, but avoid exceeding the device's absolute maximum ratings. Usually, the load inductance is relatively small, and the EUP3551'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 VIN and VOUT to the power bus with short traces. Wide power bus planes at VIN and VOUT 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} = 1.5A) and the maximum on resistance of the switch (80mΩ), the power dissipation is:

$$P = (1.5A)^2 \times 0.08\Omega = 180mW$$

The worst-case power dissipation occurs when the output current is just below the current limit threshold (ex. 1.5A) with a low output voltage 0V, for example. For a 5V input, the power dissipated is the voltage drop across the switch multiplied by the current limit:

$$P = I_{LIM} \times (V_{IN} - V_{OUT}) = 1.5A \times 5V = 7.5W$$

In this case, the EUP3551 die temperature exceeds the 145°C thermal shutdown threshold，and the switch output shuts down until the junction temperature cools by 20°C. 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 EUP3551 asserts a fault state after 7ms.

Test Circuit

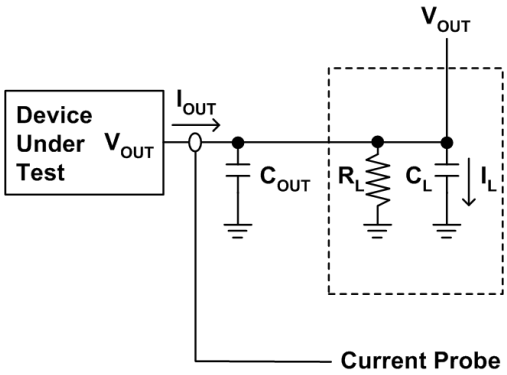


Figure 3.

Timing Diagrams

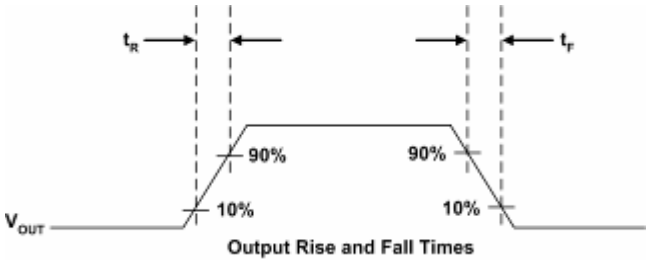
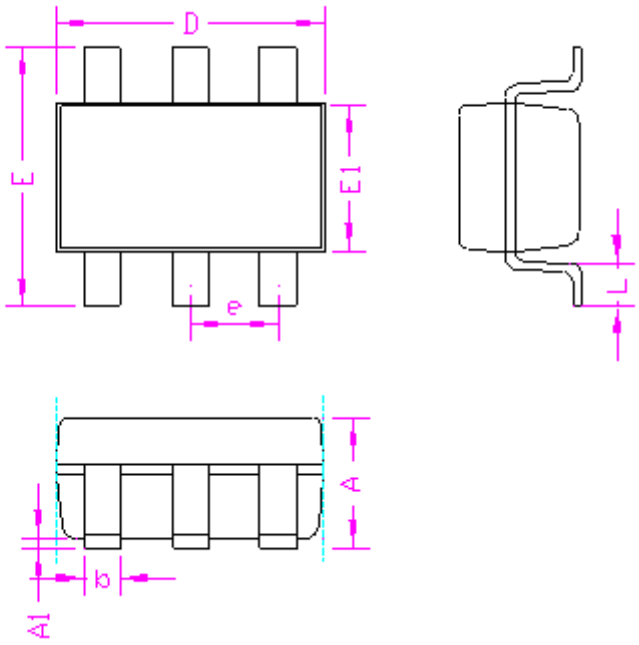


Figure 4.

Packaging Information

SOT23-6



SYMBOLS	MILLIMETERS			INCHES		
	MIN.	Normal	MAX.	MIN.	Normal	MAX.
A	1.00	-	1.45	0.039	-	0.057
A1	0.00	-	0.15	0.000	-	0.006
b	0.30	-	0.50	0.012	-	0.020
D	2.70	2.90	3.10	0.106	0.114	0.122
E1	1.45	1.60	1.75	0.057	0.063	0.069
e	0.95 REF			0.037 REF		
E	2.60	2.80	3.00	0.102	0.110	0.118
L	0.30	-	0.60	0.012	-	0.024