60mΩ Adjustable Current Limited Power Switches

General Description

The ET2016C are current limited P-channel MOSFET power switch designed for high-side load switching applications. This switch operates with inputs ranging from 2.5V to 5.5V, making it ideal for both 3.3V and 5V systems. An integrated current-limiting circuit protects the input supply against large currents which may cause the supply to fall out of regulation. The ET2016C is also protected from thermal overload which limits power dissipation and junction temperatures. It can be used to control loads that require from 0.2A to 2.1A. Current limit threshold is programmed with a resistor from SET to ground. The quiescent supply current in active mode is only 25µA. In shutdown mode, the supply current decreases to less than 1µA.

The ET2016C is available in Pb-free packages and is specified over the -40℃ to +85℃ ambient temperature range.

Features

- Input Voltage Range from 2.5V to 5.5V
- Programmable Current Limit
- Reverse Current Blocking
- Short-Circuit Response is 2us Typical
- Very Low Quiescent Current is 25µA Typical
- 1µA Max Shutdown Supply Current
- Under-Voltage Lockout
- Thermal Shutdown
- 4kV ESD Rating
- Ambient Temperature Range: -40°C to +85°C
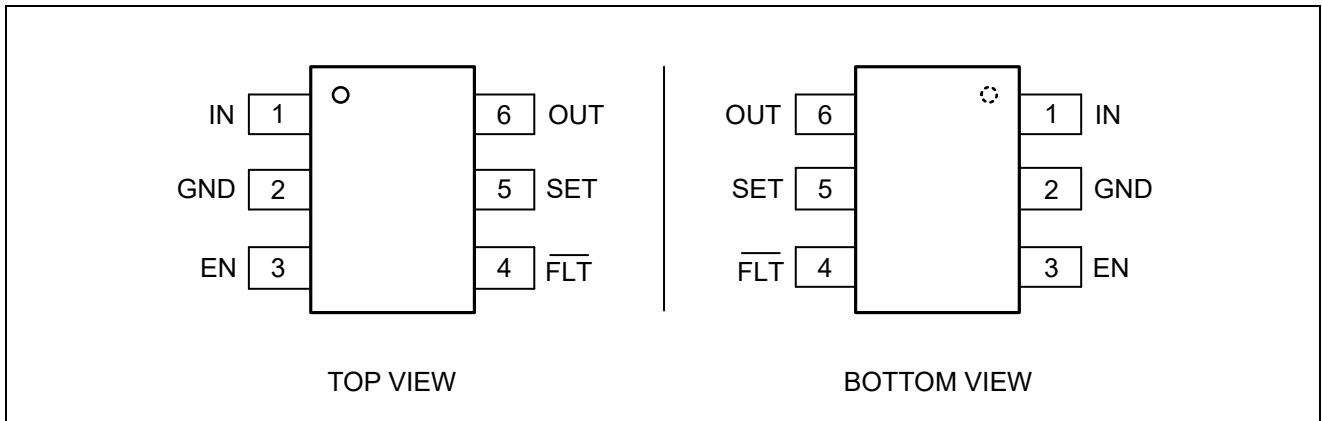- Part No. and Package

Part No.	Package
ET2016C	SOT23-6

Applications

- Laptop/Desktop Computers and NetBooks
- LCD TVs and Monitors
- Portable Game Players
- Portable Media Players and MIDs
- USB Keyboards
- USB Hard Disk Drives
- USB Memory Drives
- USB Hubs

ET2016C

Pin Configuration

TOP VIEW

BOTTOM VIEW

Pin Function

Pin No.	Pin Name	Pin Function
1	IN	Power supply input pin. Must be closely decoupled to GND pins with a 1µF or greater ceramic capacitor.
2	GND	Ground pin.
3	EN	Enable input pin.
4	$\overline{\text{FLT}}$	Over-current, reverse-voltage and over-temperature fault reporting signal output pin, active low with 6ms blanking time for over-current.
5	SET	Current limit programming pin.
6	OUT	Power output pin.

Block Diagram
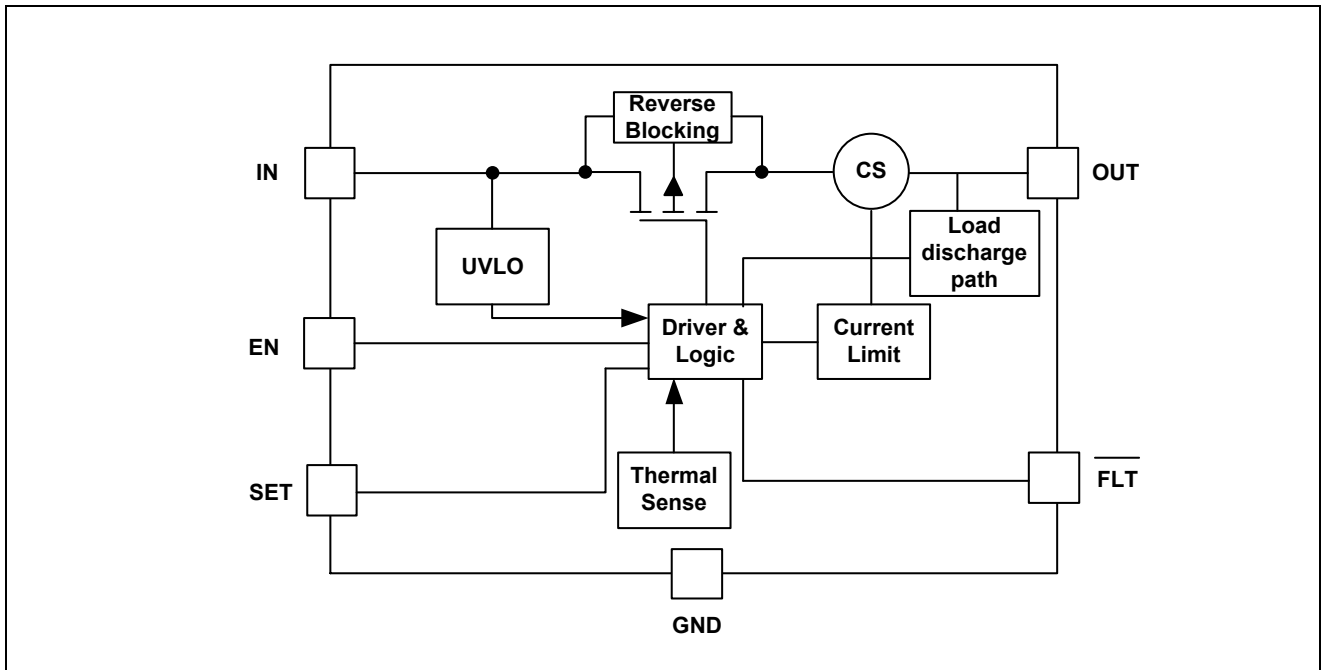
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Functional Description

ET2016C is an integrated power switch with a low $R_{DS(ON)}$ P-channel MOSFET internal gate rive circuit, programmable current limiting. When the ET2016C turns on, it can deliver up to 2.1A continuous current to load. When the device is active, if there is no load, the device only consumes 25uA supply current, which makes the device suitable for battery powered applications.

Power Supply Considerations

A 0.01µF to 0.1µF ceramic bypass capacitor between IN and GND, close to the device, is recommended.

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 minimize the input voltage droops. Additionally, bypassing the output with a 0.01µF to 0.1µF ceramic capacitor improves the immunity of the device to short-circuit transients.

Power Dissipation and Junction Temperature

The low on-resistance on the P-channel MOSFET allows the small surface-mount packages to pass large currents. It is good design practice to check power dissipation and junction temperature for each application. Begin by determining the $R_{DS(ON)}$ of the P-channel MOSFET relative to the input voltage and operating temperature. Using the highest operating ambient temperature of interest and $R_{DS(ON)}$, the power dissipation per switch can be calculated by:

$$P_D = R_{DS(ON)} \times I_{OUT}^2 \qquad\qquad (1)$$

Finally, calculate the junction temperature:

$$T_J = P_D \times R_{\theta JA} + T_A \qquad\qquad (2)$$

Where:

    T_A = Ambient temperature

    $R_{\theta JA}$ = Thermal resistance

    P_D = Total power dissipation

Compare the calculated junction temperature with the maximum junction temperature which is 150°C. If they are within degrees, either the maximum load current needs to be reduced or another package option will be required.

Over Current

A sense FET is employed to check for over-current conditions. When an over-current condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. ET2016C will limit the current until the overload condition is removed or the device begins to thermal cycle.

Three possible overload conditions can occur. In the first condition, the output has been shorted before the device is enabled or before V_{IN} has been applied. The ET2016C senses the short and immediately switches into a constant-current output.

In the second condition, 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 reached the over-current trip threshold, the device switches into constant-current mode.

In the third condition, 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 ET2016C 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.

FLT Output

The FAULT Flag ($\overline{FLT}$) is provided to alert the system if a ET2016C load is not receiving sufficient voltage to operate properly. If current limiting circuit is active for more than approximately 6ms, the FAULT Flag is pulled to ground through an approximately 100Ω resistor. The filtering of voltage or current transients of less than 6ms prevents capacitive loads connected to the ET2016C output from activating the FAULT Flag when they are initially attached. However, if the device is entering over-temperature conditions, the $\overline{FLT}$ will be pulled low without delay or deglitch. Pull-up resistance of 1kΩ to 100kΩ on $\overline{FLT}$ pin is recommended. Since $\overline{FLT}$ is an open drain terminal, it may be pulled up to any unrelated voltage less than the maximum operating voltage of 5.5V, allowing for level shifting between circuits.

Thermal Protection

Thermal protection prevents damage to the IC when heavy-overload or short-circuit faults are present for extended periods of time. The ET2016C implements a thermal sensing to monitor the operating junction temperature of the power distribution switch. In an over-current or short-circuit condition, the junction temperature rises due to excessive power dissipation. Once the die temperature rises to approximately 155°C due to over-current conditions, the internal thermal sense circuitry turns the power switch off, thus preventing the power switch from damage. Hysteresis is built into the thermal sense circuit, and after the device has cooled approximately 25°C, the switch turns back on. The switch continues to cycle in this manner until the load fault or input power is removed.

Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
V_{IN} , V_{IO}	IN, EN , $\overline{FLT}$ Voltage	-0.3 to 6.0	V
V_{OUT}	OUT Voltage	-0.3 to V_{IN} + 0.3	V
I_{MAX}	OUT Current	Adjustable Limited	A
P_D	Power Dissipation	300	mW
θ_{JA}	Package Thermal Resistance	250	°C/W
T_J	Operating Junction Temperature	-40 to 150	°C
T_{STG}	Storage Temperature	-65 to 150	°C
T_L	Lead Temperature (Soldering, 10 sec)	300	°C

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Recommended Operating Conditions

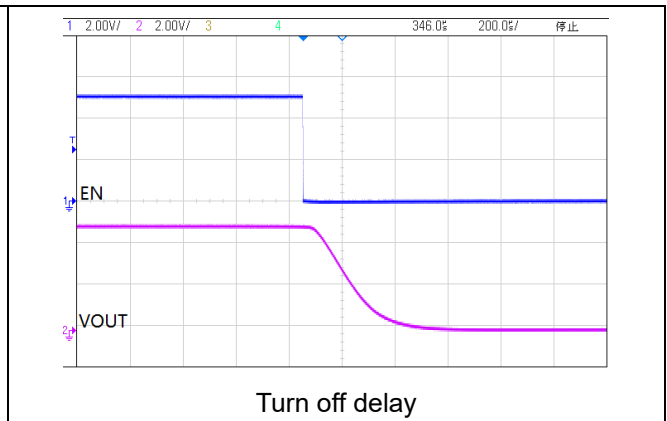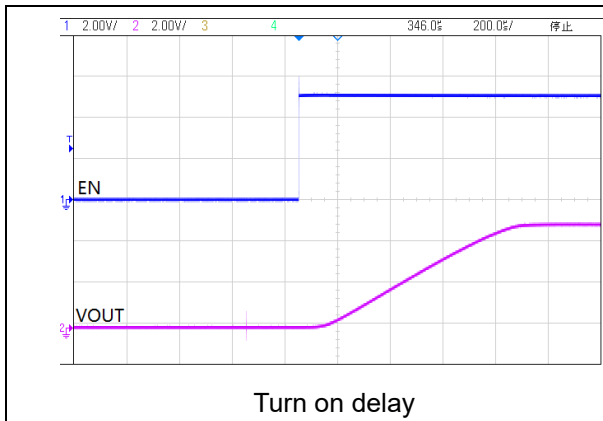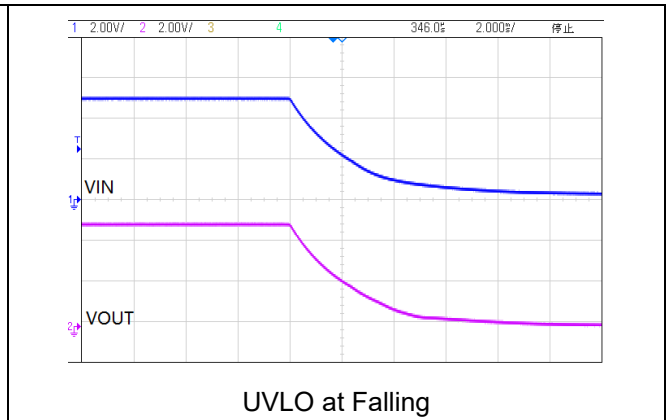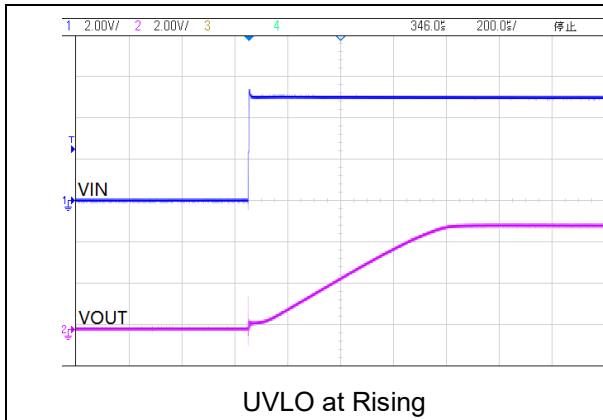| Symbol	Parameter	Min	Max	Unit
V_{IN}	DC Input Voltage	2.5	5.5	V
I_{LMT}	DC Output Current Limit	0.2	2.1	A
T_A	Operating Temperature Range	-40	+85	°C

Electrical Characteristics

(V_{IN} = 5.0V, V_{EN}=0V or V_{EN}=V_{IN} ,T_A = -40°C to 85°C, typical values at T_A=25°C, unless otherwise stated)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{IN}	Input Voltage Range		2.5		5.5	V
V_{UVLO}	Input UVLO		1.4	1.8	2.3	V
V_{UVLO_HYS}	UVLO Hysteresis			0.25		V
I_{SHDN}	Input Shutdown Quiescent Current	Disabled, OUT floating or shorted to ground		0.1	1	uA
I_Q	Input Quiescent Current /Channel	Enabled, I_{OUT}=0		25	60	uA
$R_{DS(ON)}$	Switch On-resistance	V_{IN}=5V, I_{OUT}=0.6A		60	120	mΩ
I_{LMT}	Current Limit	V_{IN}=5V ,R_{SET}=20K, T_A=25°C	1.453	1.55	1.674	A
I_{LMT_MIN}				0.2		A
V_{IL}	EN Input Logic Low Voltage				0.8	V
V_{IH}	EN Input Logic High Voltage		2			V
I_{SINK}	EN Input Leakage	V_{EN} = 5V		0.01	1	uA
t_{ON}	Output Turn-on Delay Time	V_{IN} =5V, C_L=1uF, R_{LOAD}=100Ω	0.2	0.6	1	ms
t_R	Output Turn-on Rise Time	V_{IN} =5V, C_L=1uF, R_{LOAD}=100Ω	0.2	0.5	0.8	ms
t_{OFF}	Output Turn-off Delay Time	V_{IN} =5V, C_L=1uF, R_{LOAD}=100Ω	0.1	0.3	0.5	ms
t_F	Output Turn-off Fall Time	V_{IN} =5V, C_L=1uF, R_{LOAD}=100Ω	50	120	200	us
t_{FLT_BLANK}	FLT Blanking Time		2	6	15	ms
V_{FLT_LO}	FLT Logic Low Voltage	$I_{FLT(SINK)}$ =1mA			0.2	V
I_{FLT}	FLT Leakage Current	V_{FLT} =5V, Enabled, No Fault Conditions		0.1	1	uA
R_{DIS}	Output Discharge FET R_{DSON}	Disabled, V_{IN} =5V, V_{OUT}=5V	200	400	800	Ω
I_{REV}	Reverse Leakage Current	V_{OUT} =5V , V_{IN} =0V measure I_{VOUT}	0.1	1	3	uA
T_{SHDN}	Thermal Shutdown Threshold	V_{IN} = 5V	140	155	165	°C
T_{HYS}	Thermal Shutdown Hysteresis	V_{IN} = 5V		25		°C

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Typical Performance Characteristics

UVLO at Rising

UVLO at Falling

Turn on delay

Turn off delay

Short circuit response and Thermal shutdown

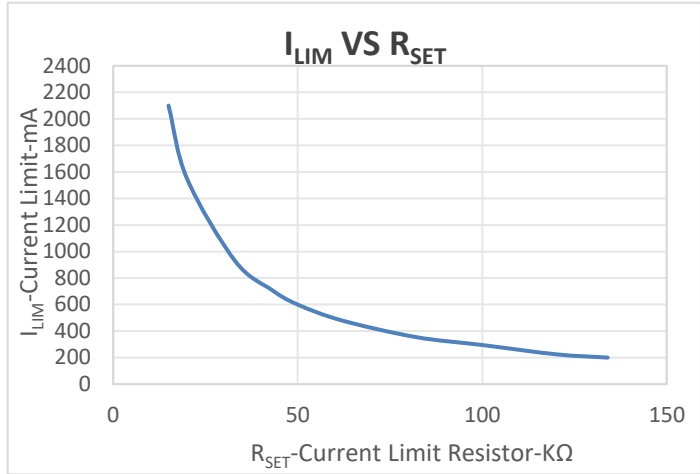
Over load response VS FLT
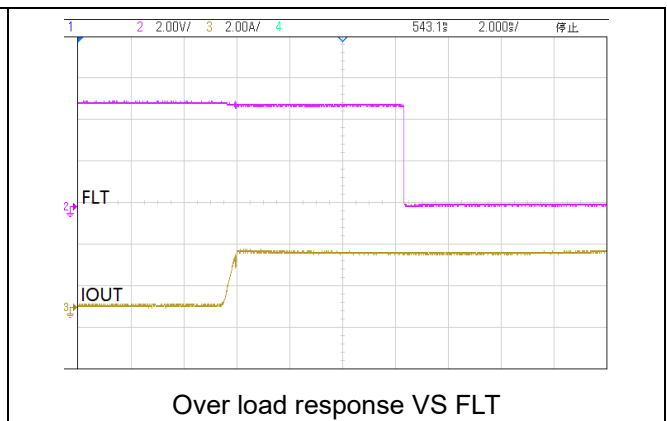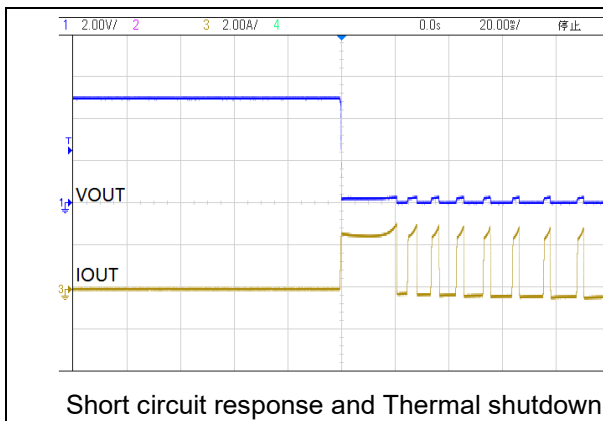
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Current Limiting Setting

Current limit is programmable to protect the power source from over current and short circuit conditions. Connect a resistor R_{SET} from SET pin to GND to program the current limit:

R_{SET} (KΩ)	I_{LMT} (mA) (Typ.)
15	2100
20	1550
33	930
43	710
50	600
62	480
82	355
100	295
120	225
134	200

PCB Layout Guide

PCB layout is very important to achieve stable operation. It is highly recommended to duplicate EVB layout for optimum performance. If change is necessary, please follow these guidelines for reference.

1) Keep the path of current short and minimize the loop area formed by Input and output capacitor.

2) Output capacitor and IC must be on the same side. The distance of out pin and output capacitor <3mm is recommended.
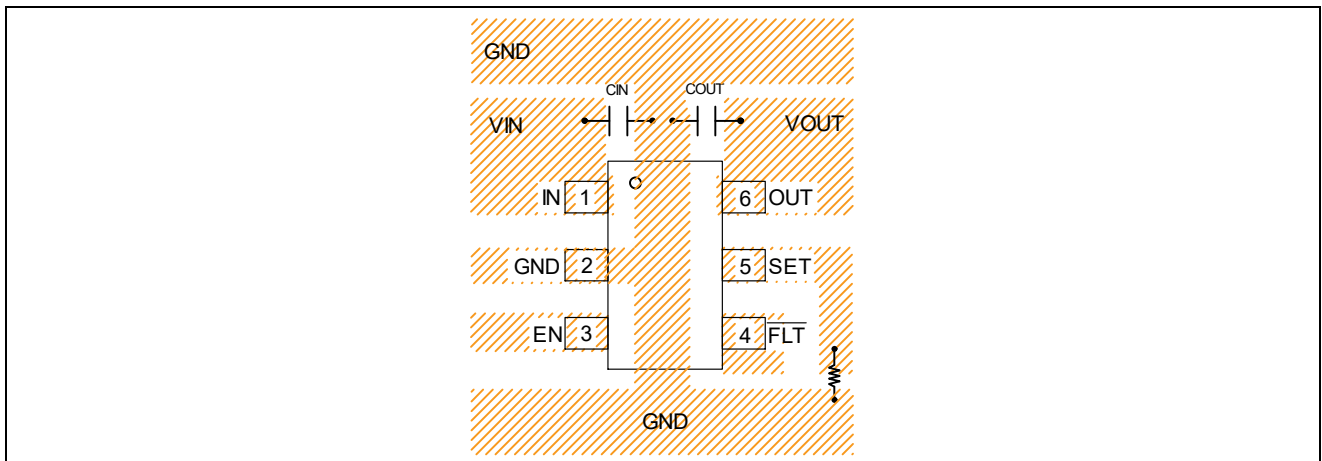
3) Bypass ceramic capacitors are suggested to be put close to the IN Pin.

4) Connect IN, OUT, and especially GND respectively to a large copper area to cool the chip to improve thermal performance and long-term reliability.
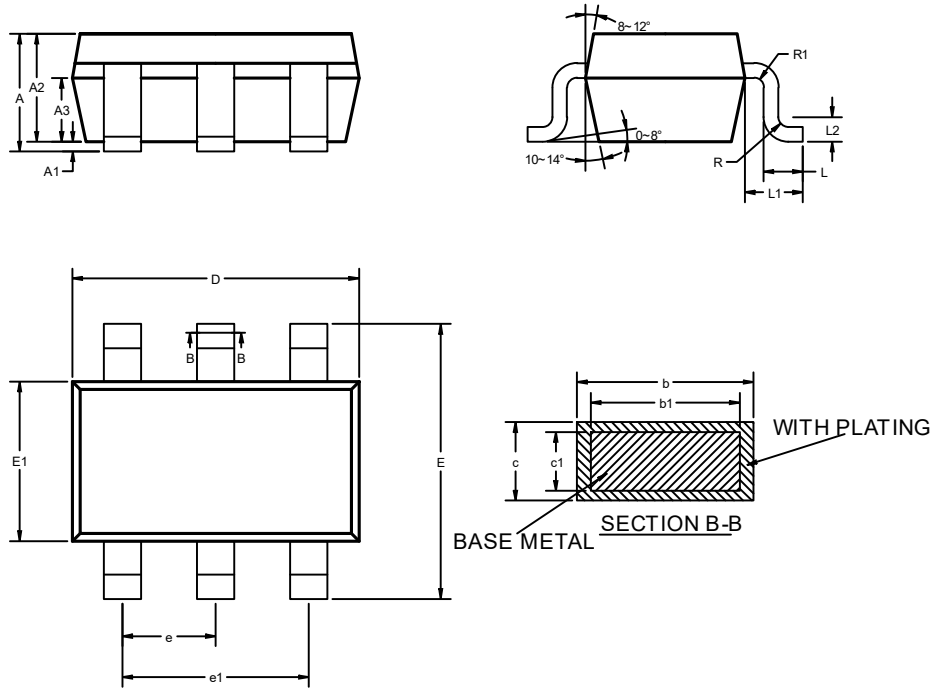
Application Circuits
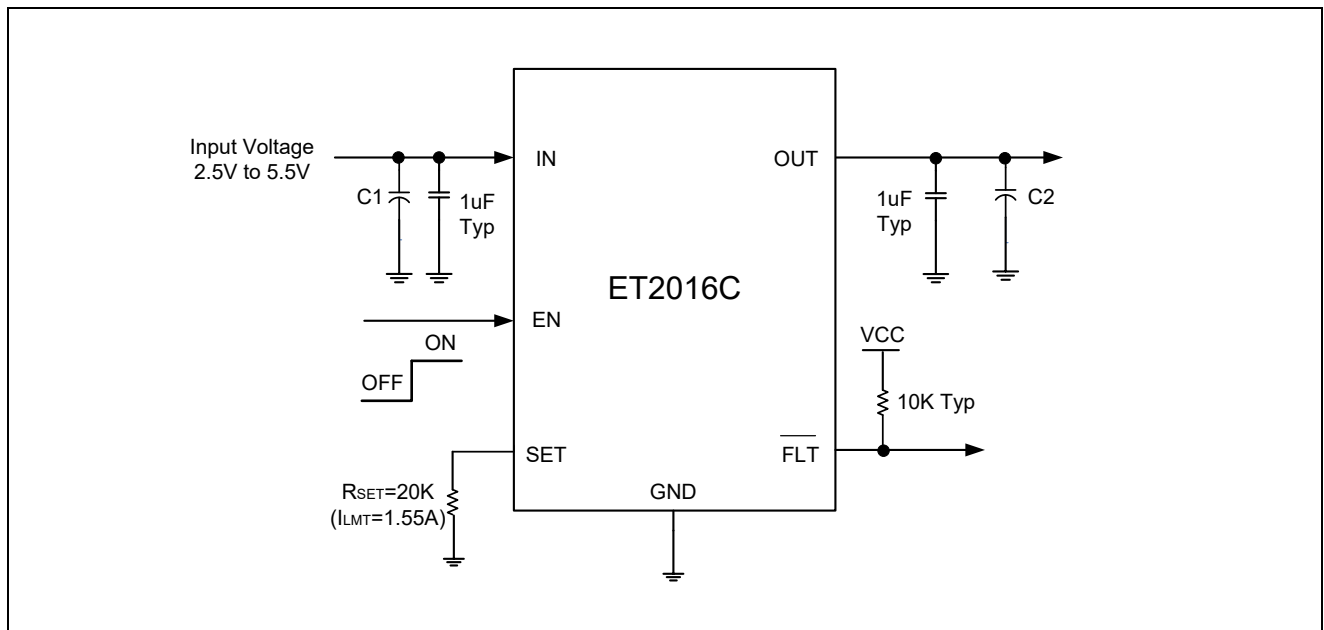
Note:

Tantalum or Aluminum Electrolytic capacitors (C1 and C2) may be required for USB applications.

Package Dimension

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Dimensions Table (Units:mm)

Symbol	Min	Typ	Max
A	—	—	1.250
A1	0	—	0.150
A2	0.750	—	1.200
A3	0.350	0.650	0.700
b	0.360	—	0.460
b1	0.350	0.380	0.430
c	0.130	—	0.200
c1	0.120	0.150	0.160
D	2.820	2.926	3.026
E	2.600	2.800	3.000
E1	1.500	1.626	1.726
e	0.900	0.950	1.000
e1	1.800	1.900	2.000
L	0.300	0.400	0.500
L1	0.590 REF		
L2	0.250 BSC		
R	0.050	—	0.200
R1	0.050	—	0.200

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Revision History and Checking Table

Version	Date	Revision Item	Modifier	Function & Spec Checking	Package & Tape Checking
0.0	2023-04-03	Preliminary version	Zou Chaomin	Liu Yi Guo	Liujy
1.0	2023-12-15	Initial Version	Zoucm	Shibo	Shibo