



# Current-Limited Switch for Two USB Ports

MAX1930

## General Description

The MAX1930 current-limited 70mΩ switch with built-in fault blanking provides an accurate, preset 1.2A to 2.3A current limit, making it ideal for dual USB applications. Its low quiescent supply current (16μA) and standby current (1μA) conserve battery power in portable applications. The MAX1930 operates with inputs from 2.7V to 5.5V, making it ideal for both 3V and 5V systems.

The MAX1930 has several safety features to ensure that the USB port is protected. Built-in thermal-overload protection limits power dissipation and junction temperature. The device also has accurate internal current-limiting circuitry to protect the input supply against overload.

The MAX1930 is offered in a space-saving 8-pin SO package and operates over the extended (-40°C to +85°C) temperature range.

## Features

- ◆ Pin Compatible with TPS2010–TPS2013
- ◆ Accurate Current Limit (1.2A min, 2.3A max)
- ◆ 125mΩ (max) High-Side MOSFET
- ◆ Short-Circuit and Thermal Protection
- ◆ Undervoltage Lockout
- ◆ 16μA Quiescent Supply Current
- ◆ 1μA (max) Standby Supply Current
- ◆ 2.7V to 5.5V Supply Range
- ◆ UL Recognized: UL# E211395

## Applications

Notebook Computers

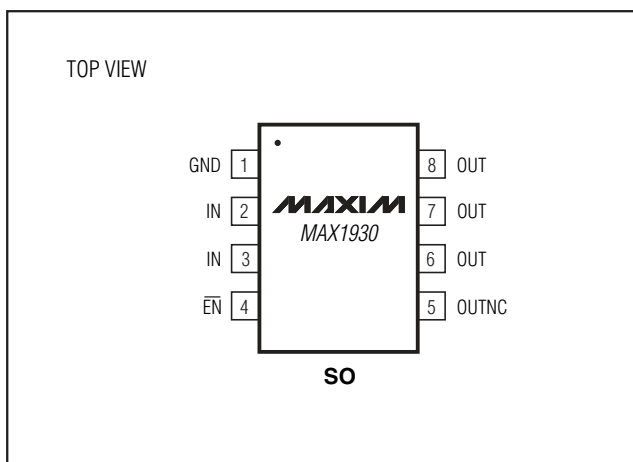
USB Ports and Hubs

Docking Stations

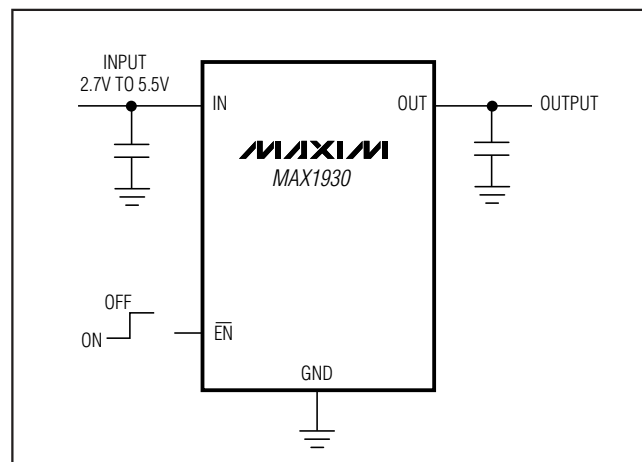
## Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX1930ESA	-40°C to +85°C	8 SO

## Pin Configuration



## Typical Operating Circuit



Maxim Integrated Products 1

For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at [www.maxim-ic.com](http://www.maxim-ic.com).

# Current-Limited Switch for Two USB Ports

## ABSOLUTE MAXIMUM RATINGS

IN,  $\overline{\text{EN}}$  to GND .....-0.3V to +6V  
 OUT to GND .....-0.3V to ( $V_{\text{IN}} + 0.3\text{V}$ )  
 Maximum Switch Current.....2.3A (internally limited)  
 OUT Short Circuit to GND .....Continuous

Continuous Power Dissipation ( $T_A = +70^\circ\text{C}$ )  
 8-Pin SO (derate 5.88mW/ $^\circ\text{C}$  above  $+70^\circ\text{C}$ ).....471mW  
 Operating Temperature Range (extended)..... $-40^\circ\text{C}$  to  $+85^\circ\text{C}$   
 Storage Temperature Range ..... $-65^\circ\text{C}$  to  $+150^\circ\text{C}$   
 Lead Temperature (soldering, 10s) ..... $+300^\circ\text{C}$

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS

( $V_{\text{IN}} = 5\text{V}$ ,  $T_A = 0^\circ\text{C}$  to  $+85^\circ\text{C}$ , unless otherwise noted. Typical values are at  $T_A = +25^\circ\text{C}$ .)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS	
<b>OPERATING CONDITION</b>							
Input Voltage	$V_{\text{IN}}$		2.7		5.5	V	
<b>POWER SWITCH</b>							
Switch Static Drain-Source On-Resistance	$R_{\text{DS(ON)}}$	$T_A = +25^\circ\text{C}$	$V_{\text{IN}} = 4.4\text{V}$ to $5.5\text{V}$		70	100	m $\Omega$
		$T_A = 0^\circ\text{C}$ to $+85^\circ\text{C}$	$V_{\text{IN}} = 4.4\text{V}$ to $5.5\text{V}$			125	
			$V_{\text{IN}} = 3\text{V}$		72	150	
Switch Turn-On Time	$t_{\text{ON}}$	$I_{\text{LOAD}} = 400\text{mA}$		80	200	$\mu\text{s}$	
Switch Turn-Off Time	$t_{\text{OFF}}$	$I_{\text{LOAD}} = 400\text{mA}$	3	6	20	$\mu\text{s}$	
<b>ENABLE INPUT (<math>\overline{\text{EN}}</math>)</b>							
$\overline{\text{EN}}$ High-Level Input Voltage	$V_{\text{IH}}$	$V_{\text{IN}} = 2.7\text{V}$ to $3.6\text{V}$	2.0			V	
		$V_{\text{IN}} = 3.7\text{V}$ to $5.5\text{V}$	2.4				
$\overline{\text{EN}}$ Low-Level Input Voltage	$V_{\text{IL}}$	$V_{\text{IN}} = 2.7\text{V}$ to $5.5\text{V}$			0.8	V	
$\overline{\text{EN}}$ Input Current		$V_{\overline{\text{EN}}} = V_{\text{IN}}$ or GND	-1		+1	$\mu\text{A}$	
Startup Time		$V_{\text{IN}} = 5\text{V}$ , $C_{\text{OUT}} = 150\mu\text{F}$ from $\overline{\text{EN}}$ driven low to 50% full $V_{\text{OUT}}$		1		ms	
<b>CURRENT LIMIT</b>							
Overload Output Current	$I_{\text{LIMIT}}$	Force $V_{\text{OUT}}$ to 4.5V	1.2	1.75	2.3	A	
Short-Circuit Output Current	$I_{\text{SC}}$	OUT shorted to GND		1	1.5	A	
<b>SUPPLY CURRENT</b>							
Supply Current, Low-Level Input		$V_{\overline{\text{EN}}} = V_{\text{IN}} = V_{\text{OUT}} = 5.5\text{V}$		0.002	1	$\mu\text{A}$	
Supply Current, High-Level Input	$I_{\text{Q}}$	$V_{\overline{\text{EN}}} = 0$ , $I_{\text{OUT}} = 0$	Timer not running	16	25	$\mu\text{A}$	
			Timer running	35			
Supply Leakage Current		$V_{\overline{\text{EN}}} = V_{\text{IN}} = 5.5\text{V}$ , $V_{\text{OUT}} = 0$	$T_A = +25^\circ\text{C}$	0.01	2	$\mu\text{A}$	
			$T_A = 0^\circ\text{C}$ to $+85^\circ\text{C}$	15			
<b>UNDERVOLTAGE LOCKOUT</b>							
Undervoltage Lockout	UVLO	Rising edge, 100mV hysteresis	2.0	2.4	2.6	V	
<b>THERMAL SHUTDOWN</b>							
Thermal-Shutdown Threshold				165		$^\circ\text{C}$	

# Current-Limited Switch for Two USB Ports

MAX1930

## ELECTRICAL CHARACTERISTICS

( $V_{IN} = 5V$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ , unless otherwise noted.) (Note 1)

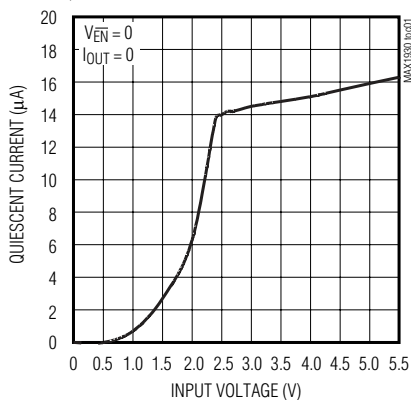
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>OPERATING CONDITION</b>						
Input Voltage	$V_{IN}$		3.0		5.5	V
<b>POWER SWITCH</b>						
Switch Static Drain-Source On-Resistance	$R_{DS(ON)}$	$V_{IN} = 4.4V$ to $5.5V$			125	m $\Omega$
		$V_{IN} = 3V$			150	
Switch Turn-On Time	$t_{ON}$	$I_{LOAD} = 400mA$			200	$\mu s$
Switch Turn-Off Time	$t_{OFF}$	$I_{LOAD} = 400mA$	1		20	$\mu s$
<b>ENABLE INPUT (<math>\overline{EN}</math>)</b>						
$\overline{EN}$ High-Level Input Voltage	$V_{IH}$	$V_{IN} = 3V$ to $3.6V$	2.0			V
		$V_{IN} = 3.7V$ to $5.5V$	2.4			
$\overline{EN}$ Low-Level Input Voltage	$V_{IL}$	$V_{IN} = 3V$ to $5.5V$			0.8	V
$\overline{EN}$ Input Current		$V_{\overline{EN}} = V_{IN}$ or GND	-1		+1	$\mu A$
<b>CURRENT LIMIT</b>						
Overload Output Current	$I_{LIMIT}$	Force $V_{OUT}$ to $4.5V$	1.2		2.3	A
Short-Circuit Output Current	$I_{SC}$	OUT shorted to GND			1.5	A
<b>SUPPLY CURRENT</b>						
Supply Current, Low-Level Input		$V_{\overline{EN}} = V_{IN} = V_{OUT} = 5.5V$			2	$\mu A$
Supply Current, High-Level Input	$I_Q$	$V_{\overline{EN}} = GND$ , $I_{OUT} = 0$ , timer not running			25	$\mu A$
Supply Leakage Current		$V_{\overline{EN}} = V_{IN} = 5.5V$ , $V_{OUT} = GND$			15	$\mu A$
<b>UNDERVOLTAGE LOCKOUT</b>						
Undervoltage Lockout	UVLO	Rising edge, 100mV hysteresis	2.0		2.9	V

**Note 1:** Specifications to  $-40^{\circ}C$  are guaranteed by design, not production tested.

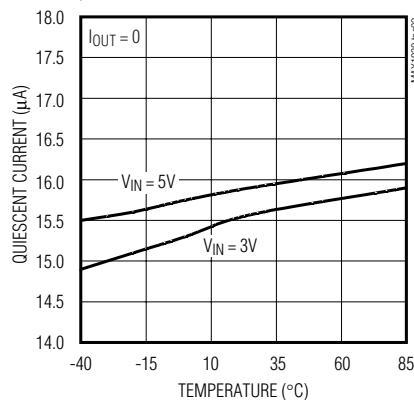
## Typical Operating Characteristics

(Circuit of Figure 2,  $V_{IN} = 5V$ ,  $T_A = +25^{\circ}C$ , unless otherwise noted.)

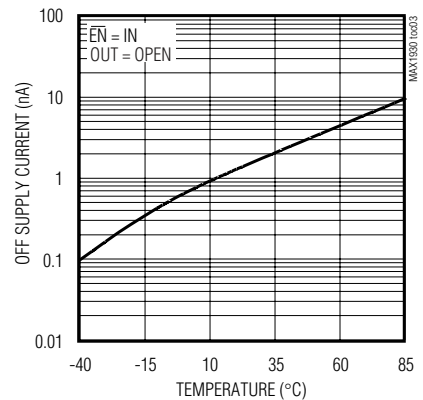
**QUIESCENT CURRENT vs. INPUT VOLTAGE**



**QUIESCENT CURRENT vs. TEMPERATURE**



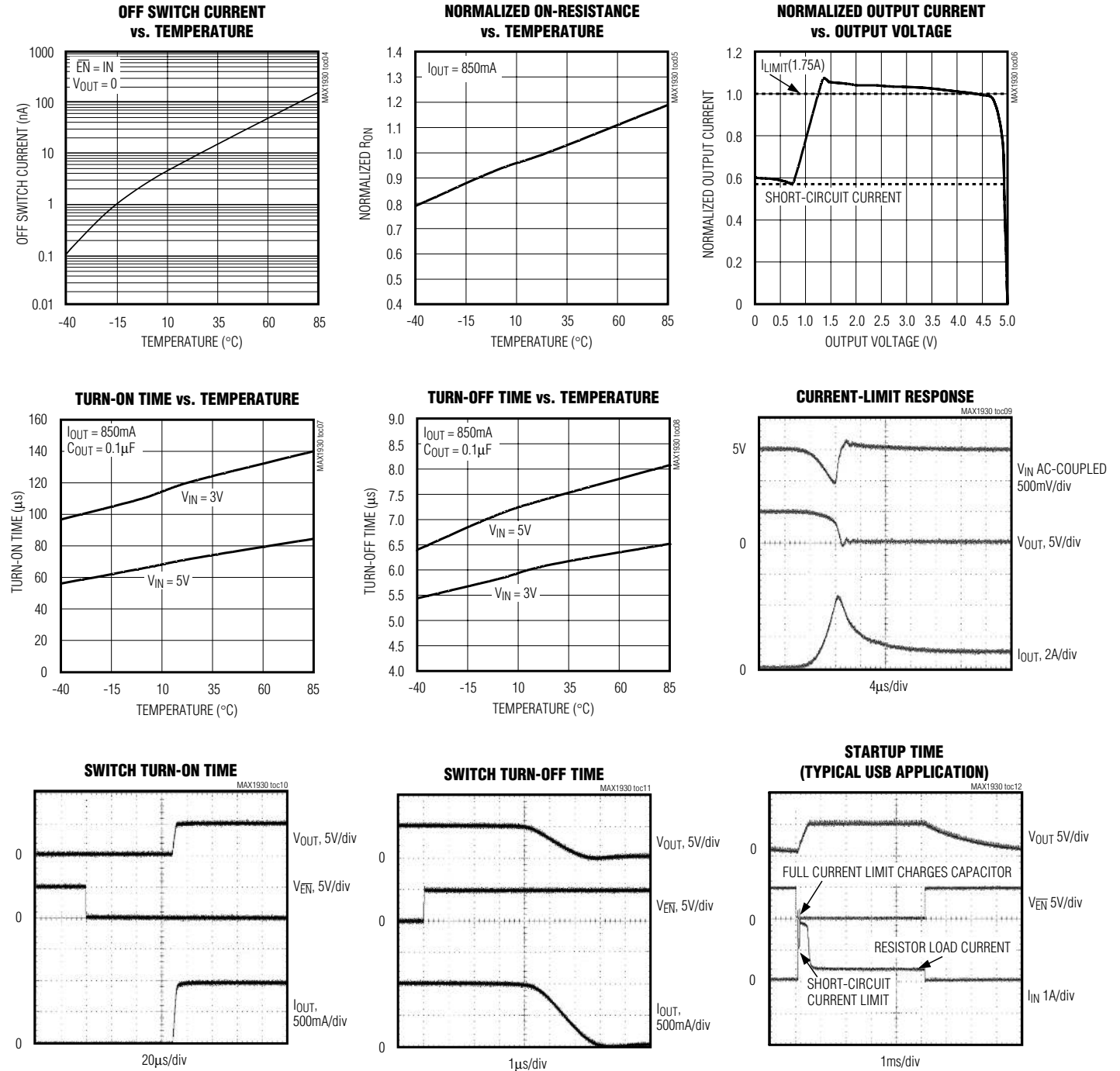
**OFF SUPPLY CURRENT vs. TEMPERATURE**



# Current-Limited Switch for Two USB Ports

## Typical Operating Characteristics (continued)

(Circuit of Figure 2,  $V_{IN} = 5V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



# Current-Limited Switch for Two USB Ports

MAX1930

## Pin Description

PIN	NAME	FUNCTION
1	GND	Ground
2, 3	IN	Input. P-channel MOSFET source—connect all IN pins together and bypass with a 1μF capacitor to ground.
4	$\overline{\text{EN}}$	Active-Low Switch Enable Input. A logic low turns on the switch.
5	OUTNC	No Connection. This pin is not internally connected and can be connected to OUT.
6, 7, 8	OUT	Switch Output. P-channel MOSFET drain—connect all OUT pins together and bypass with a 0.1μF capacitor to ground.

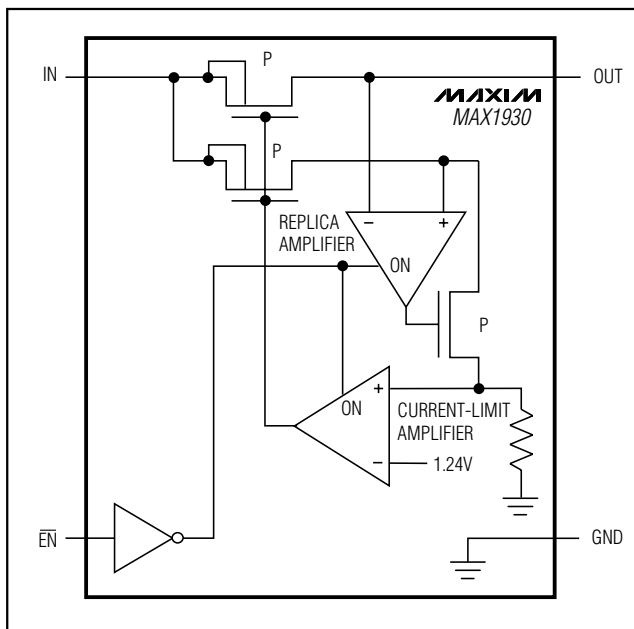


Figure 1. Functional Diagram

## Detailed Description

The MAX1930 P-channel MOSFET power switch limits output current to 1.2A (min) and 2.3A (max). When the output current increases beyond the current limit ( $I_{LIMIT}$ ), the current also increases through the replica switch ( $I_{OUT} / 13,000$ ). The current-limit error amplifier compares the voltage to the internal 1.24V reference and regulates the current back to the  $I_{LIMIT}$  (Figure 1).

These switches are not bidirectional. As a result, the input voltage must be higher than the output voltage.

### Continuous Short-Circuit Protection

The MAX1930 is a short-circuit protected switch. In the event of an output short-circuit condition, the current through the switch is foldback-current-limited to 1A continuous.

## Thermal Shutdown

The MAX1930 has a thermal shutdown feature. The switch turns off when the junction temperature exceeds +165°C. When the MAX1930 cools 20°C, the switch turns back on. If the fault short-circuit condition is not removed, the switch cycles on and off, resulting in a pulsed output.

## Applications Information

### Input Capacitor

To limit the input voltage drop during momentary output short-circuit conditions, connect a capacitor from IN to GND. A 1μF ceramic capacitor is adequate for most applications; however, higher capacitor values further reduce the voltage drop at the input (Figure 2).

### Output Capacitor

Connect a 0.1μF capacitor from OUT to GND. This capacitor helps to prevent inductive parasitics from pulling OUT negative during turn-off.

## Layout and Thermal Dissipation

It is important to optimize the switch response time to output short-circuit conditions by keeping all traces as short as possible to reduce the effect of undesirable parasitic inductance. Place input and output capacitors as close as possible to the device (no more than 5mm away). All IN and OUT pins must be connected with short traces to the power bus. Wide power-bus planes provide superior heat dissipation through the MAX1930's IN and OUT pins.

Under normal operating conditions, the package can dissipate and channel heat away. Calculate the maximum power dissipation as follows:

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

where  $I_{LIMIT}$  is the preset current limit (2.3A max) and  $R_{ON}$  is the on-resistance of the switch (125mΩ max).

When the output is short circuited, foldback-current-limiting activates and the voltage drop across the switch equals the input supply voltage. The power dissipated across the switch increases, as does the die tempera-

## Current-Limited Switch for Two USB Ports

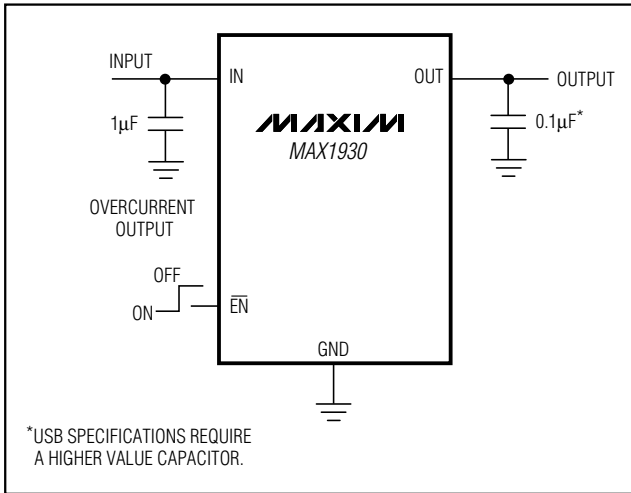


Figure 2. Typical Application Circuit

ture. If the fault condition is not removed, the thermal-overload protection circuitry activates (see the *Thermal Shutdown* section). Wide power-bus planes connected to IN and OUT and a ground plane in contact with the device help dissipate additional heat.

### Driving Inductive Loads

A wide variety of devices (mice, keyboards, cameras, and printers) can load the USB port. These devices commonly connect to the port with cables, which can add an inductive component to the load. This inductance causes the output voltage at the USB port to ring during a load step. The MAX1930 is capable of driving inductive loads, but avoid exceeding the device's absolute maximum ratings. Usually the load inductance is relatively small, and the MAX1930's input includes a substantial bulk capacitance from an upstream regulator, as well as local bypass capacitors, limiting overshoot. If severe ringing occurs due to large load inductance, clamp the MAX1930 output below 6V and above -0.3V.

### Chip Information

TRANSISTOR COUNT: 715

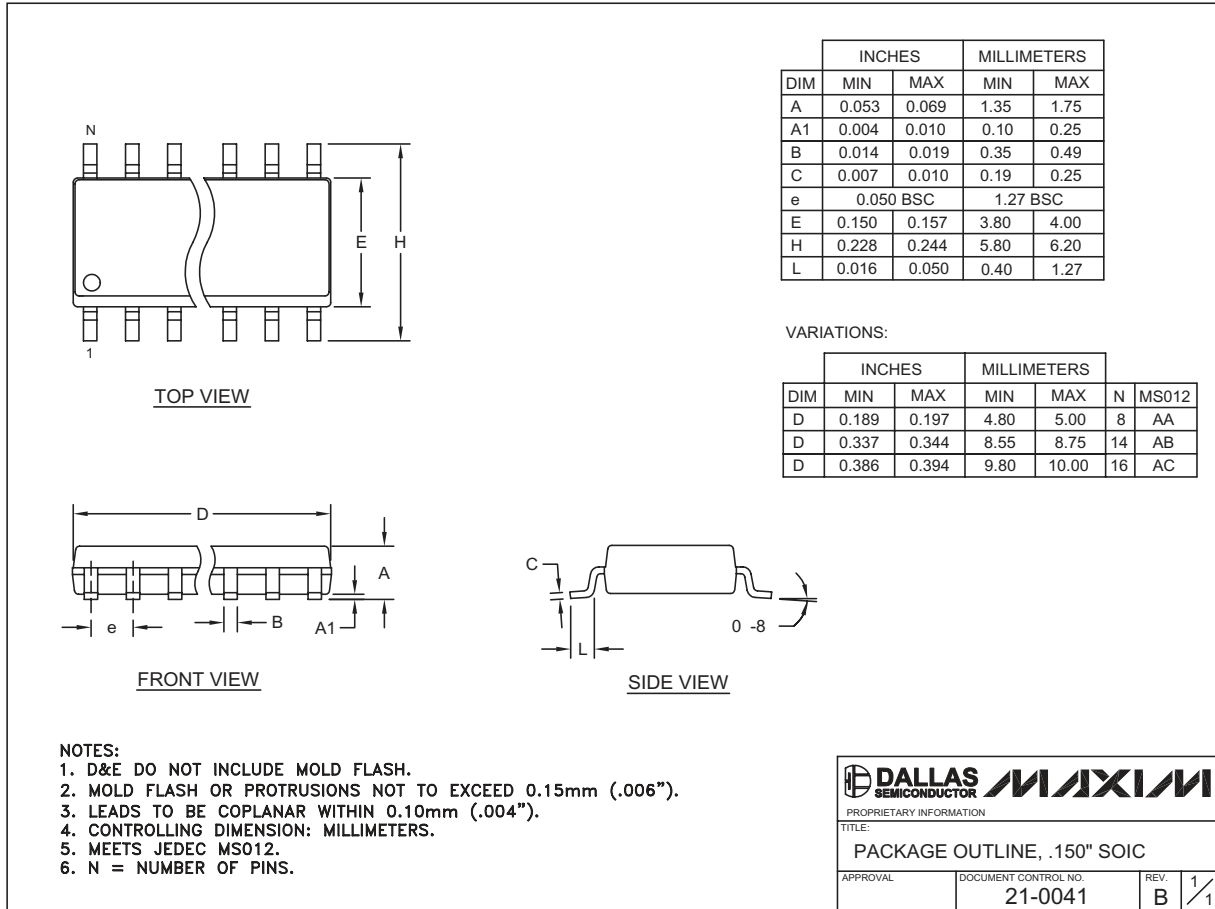
PROCESS: BiCMOS

# Current-Limited Switch for Two USB Ports

## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)

**MAX1930**



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