

LM3525

Single Port USB Power Switch and Over-Current Protection

General Description

The LM3525 provides Universal Serial Bus standard power switch and over-current protection for all host port applications. The single port device is ideal for Notebook PC and Handheld PC applications that supply power to one port.

A 1 ms delay on fault flag output prevents erroneous over-current reporting caused by inrush currents during the hot-plug events.

The LM3525 accepts an input voltage between 2.7V and 5.5V allowing use as a device-based inrush current limiter for 3.3V USB peripherals, as well as Root and Self-Powered Hubs at 5.5V. The Enable input accepts both 3.3V and 5.0V logic thresholds.

The small size, low R_{ON} , and 1 ms fault flag delay make the LM3525 a good choice for root hubs as well as ganged power control in space-critical self-powered hubs.

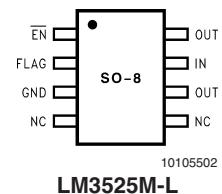
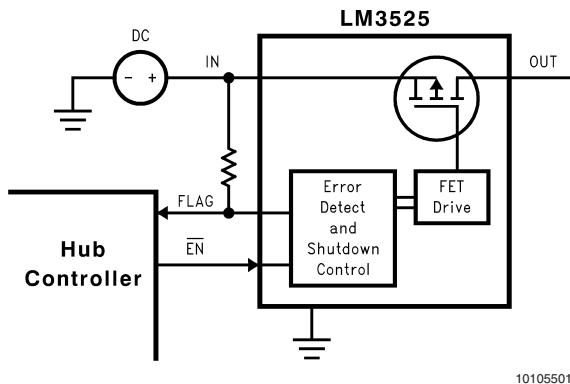
Features

- Compatible with USB1.1 and USB 2.0
- 1 ms Fault Flag Delay During Hot-Plug Events
- Smooth Turn-On Eliminates Inrush Induced Voltage Drop
- UL Recognized Component: REF # 205202
- 1A Nominal Short Circuit Output Current Protects Notebook PC Power Supplies
- Thermal Shutdown Protects Device in Direct Short Condition
- 500mA Minimum Continuous Load Current
- Small SO-8 Package Minimizes Board Space
- 2.7V to 5.5V Input Voltage Range
- Switch Resistance $\leq 120 \text{ m}\Omega$ Max. at $V_{IN} = 5\text{V}$
- 1 μA Max Standby Current
- 100 μA Max Operating Current
- Undervoltage Lockout (UVLO)

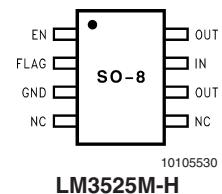
Applications

- Universal Serial Bus (USB) Root Hubs including Desktop and Notebook PC
- USB Monitor Hubs
- Other Self-Powered USB Hub Devices
- High Power USB Devices Requiring Inrush Limiting
- General Purpose High Side Switch Applications

Typical Operating Circuit and Connection Diagram




 UL Recognized Component
 10105531



Ordering Information

Part Number	Enable, Delivery Option	Package Type
LM3525M-H	Active High Enable, 95 units per rail	SO-8, NS Package Number M08A
LM3525M-L	Active Low Enable, 95 units per rail	
LM3525MX-H	Active High Enable, 2500 units per reel	
LM3525MX-L	Active Low Enable, 2500 units per reel	

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Supply Voltage	-0.3V to 6.0V
Output Voltage	-0.3V to 6.0V
Voltage at All Other Pins	-0.3V to 5.5V
Power Dissipation ($T_A = 25^\circ\text{C}$) (Note 2)	700 mW
T_{JMAX} (Note 2)	150°C

Operating Ratings

Supply Voltage Range	2.7 to 5.5V
Operating Ambient Range	-40°C to +85°C
Operating Junction Temperature Range	-40°C to +125°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 5 seconds)	260°C
ESD Rating (Note 3)	2 kV

DC Electrical Characteristics

Limits in standard typeface are for $T_J = 25^\circ\text{C}$, and limits in **boldface** type apply over the full operating temperature range. Unless otherwise specified: $V_{IN} = 5.0\text{V}$, $\bar{EN} = 0\text{V}$ (LM3525-L) or $EN = V_{IN}$ (LM3525-H).

Symbol	Parameter	Conditions	Min	Typ	Max	Units
R_{ON}	On-Resistance	IN to Out pins $V_{IN} = 5\text{V}$ $V_{IN} = 2.7\text{V}$		80 120	120 160	$\text{m}\Omega$
I_{OUT}	OUT pins continuous output current		0.5			A
I_{SC}	Short Circuit Output Current	(Note 4)	0.5	1.0	1.5	A
I_{LEAK}	OUT pins Output Leakage Current	$\bar{EN} = V_{IN}$ (LM3525-L) or $EN = GND$ (LM3525-H),		0.15	10	μA
OC_{THRESH}	Over-current Threshold			2.25	3.2	A
R_{FO}	FLAG Output Resistance	$I_{FO} = 10\text{ mA}$, $V_{IN} = 5\text{V}$		6	25	Ω
		$I_{FO} = 10\text{ mA}$, $V_{IN} = 2.7\text{V}$		8	40	
I_{EN}	\bar{EN}/EN Leakage Current	$\bar{EN}/EN = 0\text{V}$ or $\bar{EN}/EN = V_{IN}$	-0.5		0.5	μA
V_{IH}	\bar{EN}/EN Input Voltage	(Note 5)	2.4	1.9		V
V_{IL}	\bar{EN}/EN Input Voltage	(Note 5)		1.7	0.8	V
V_{UVLO}	Under-Voltage Lockout	$V_{IN} = \text{Increasing}$ $V_{IN} = \text{Decreasing}$		1.9 1.8		V
I_{DDOFF}	Supply Current	Switch OFF		0.05	1	μA
I_{DDON}	Supply Current	Switch ON		65	100	μA
Th_{SD}	Overtemperature Shutdown Threshold (Note 4)	T_J Increasing		135		$^\circ\text{C}$
		T_J Decreasing		125		$^\circ\text{C}$
I_{FH}	Error Flag Leakage Current	$V_{FLAG} = 5\text{V}$		0.1	1	μA

AC Electrical Characteristics

Limits in standard typeface are for $T_J = 25^\circ\text{C}$, and limits in **boldface** type apply over the full operating temperature range. Unless otherwise specified: $V_{IN} = 5.0\text{V}$.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_r	OUT Rise Time	$R_L = 10\Omega$		200		μs
t_f	OUT Fall Time	$R_L = 10\Omega$		20		μs
t_{ON}	Turn on Delay, $\overline{\text{EN}}$ to OUT	$R_L = 10\Omega$		200		μs
t_{OFF}	Turn off Delay, $\overline{\text{EN}}$ to OUT	$R_L = 10\Omega$		20		μs
t_{OC}	Over Current Flag Delay	$R_L = 0$		1		ms

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Electrical specifications do not apply when operating the device beyond its rated operating conditions. Products are not tested under negative Absolute Maximum conditions.

Note 2: The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{JMAX} (maximum junction temperature), θ_{JA} (junction to ambient thermal resistance), and T_A (ambient temperature). The maximum allowable power dissipation at any temperature is $P_{DMAX} = (T_{JMAX} - T_A)/\theta_{JA}$ or the number given in the Absolute Maximum Ratings, whichever is lower. The thermal resistance θ_{JA} of the LM3525 in the SO-8 package is $150^\circ\text{C}/\text{W}$.

Note 3: The human body model is a 100 pF capacitor discharged through a $1.5\text{ k}\Omega$ resistor into each pin.

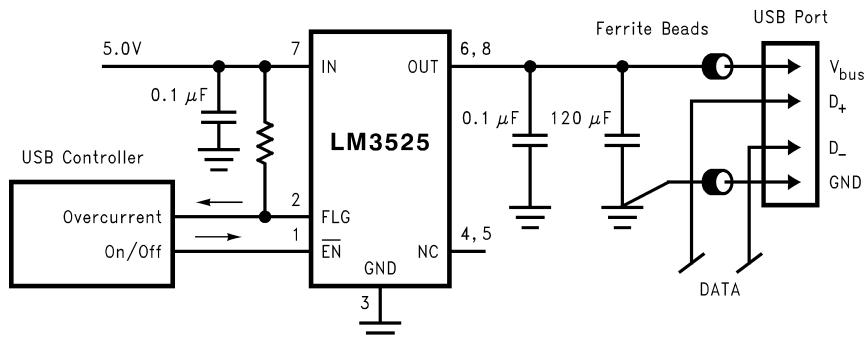
Note 4: Thermal shutdown will protect the device from permanent damage.

Note 5: For the LM3525-L, OFF is $\overline{\text{EN}} \geq 2.4\text{V}$ and ON is $\overline{\text{EN}} \leq 0.8\text{V}$. For the LM3525-H, OFF is $\text{EN} \leq 0.8\text{V}$ and ON is $\text{EN} \geq 2.4\text{V}$

Pin Description

Pin Number	Pin Name	Pin Function
1	$\overline{\text{EN}}$ (LM3525-L) EN (LM3525-H)	Enable (Input): Logic-compatible enable input.
2	FLG	Fault Flag (Output): Active-low, open-drain output. Indicates overcurrent, UVLO and thermal shutdown.
3	GND	Ground
4, 5	NC	Not internally connected.
7	IN	Supply Input: This pin is the input to the power switch and the supply voltage for the IC.
6, 8	OUT	Switch Output: This pin is the output of the high side switch. Pins 6 & 8 must be tied together.

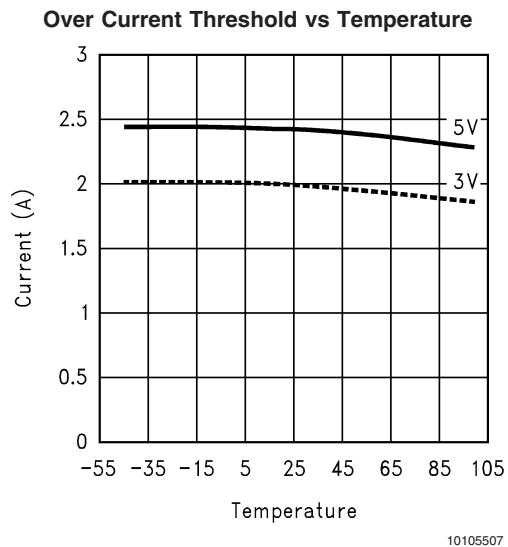
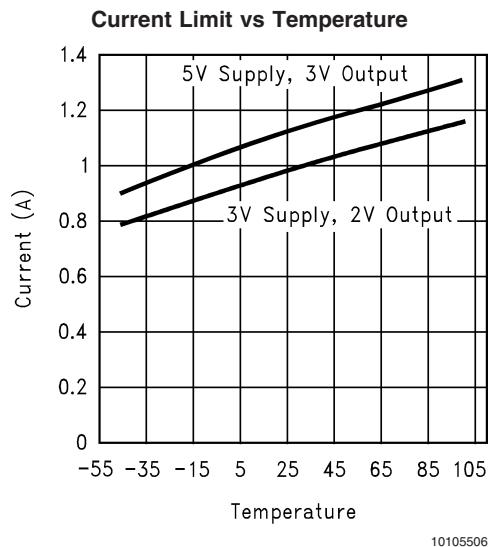
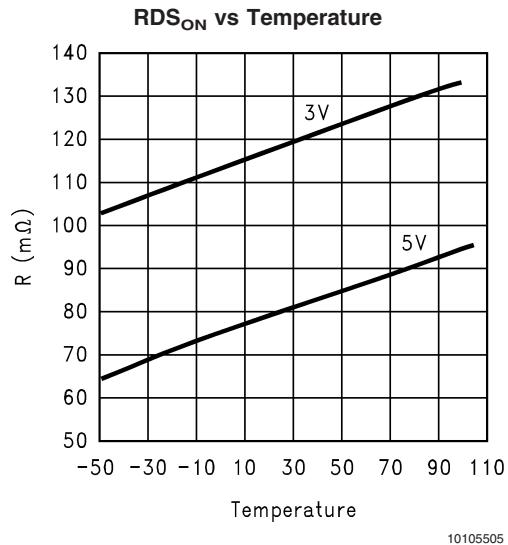
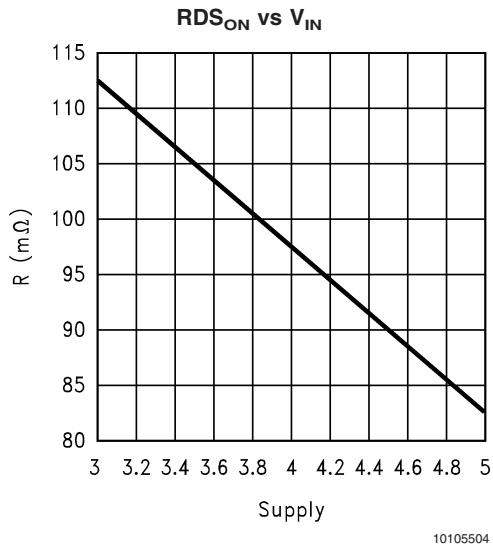
Typical Application Circuit



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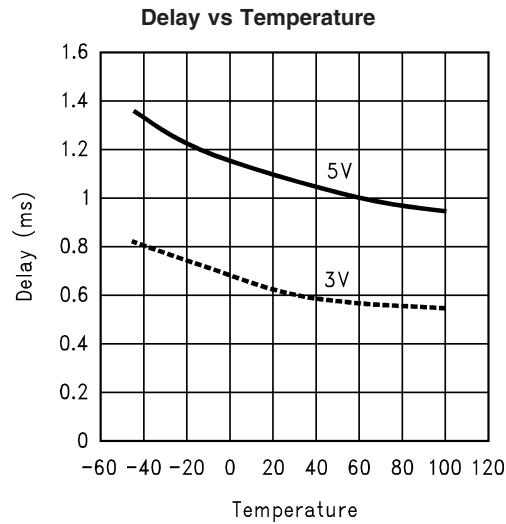
Typical Performance Characteristics

$V_{IN} = 5.0V$, $I_L = 500$ mA, $T_A = 25^\circ C$ unless otherwise specified.

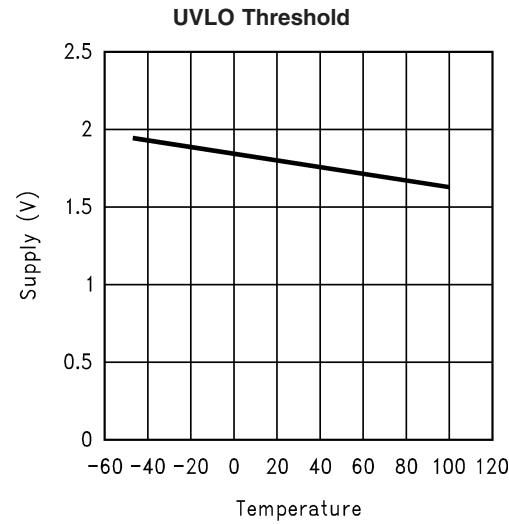


Typical Performance Characteristics

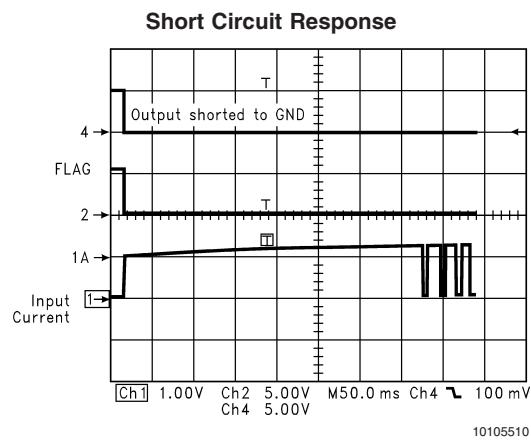
$V_{IN} = 5.0V$, $I_L = 500$ mA, $T_A = 25^\circ C$ unless otherwise specified. (Continued)



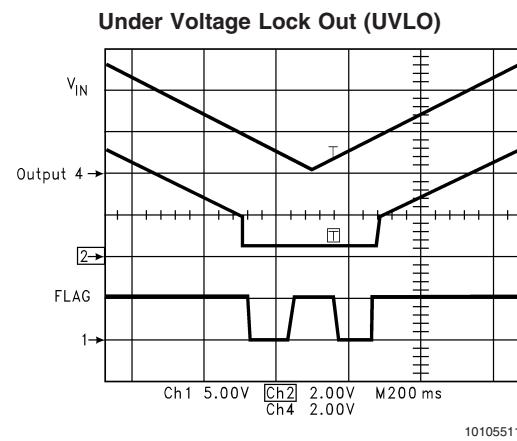
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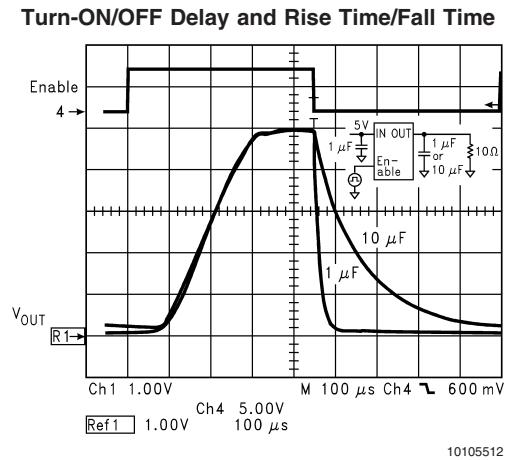
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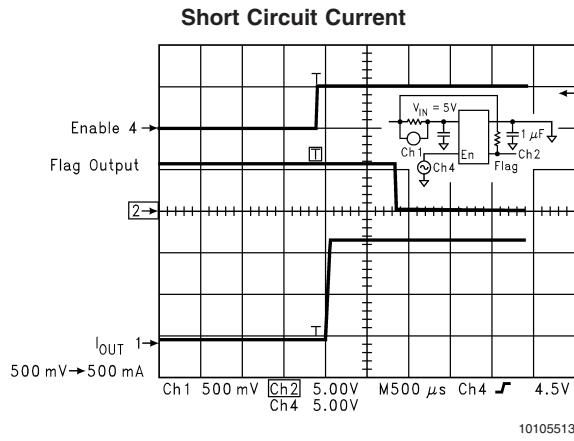
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10105512



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Application Information (Continued)

- Place the switch as close to the USB connector as possible. Keep all V_{bus} traces as short as possible and use at least 50-mil, 1 ounce copper for all V_{bus} traces. Solder plating the traces will reduce the trace resistance.
- Avoid vias as much as possible. If vias are used, use multiple vias in parallel and/or make them as large as possible.

- Place the output capacitor and ferrite beads as close to the USB connector as possible.
- If ferrite beads are used, use wires with minimum resistance and large solder pads to minimize connection resistance.

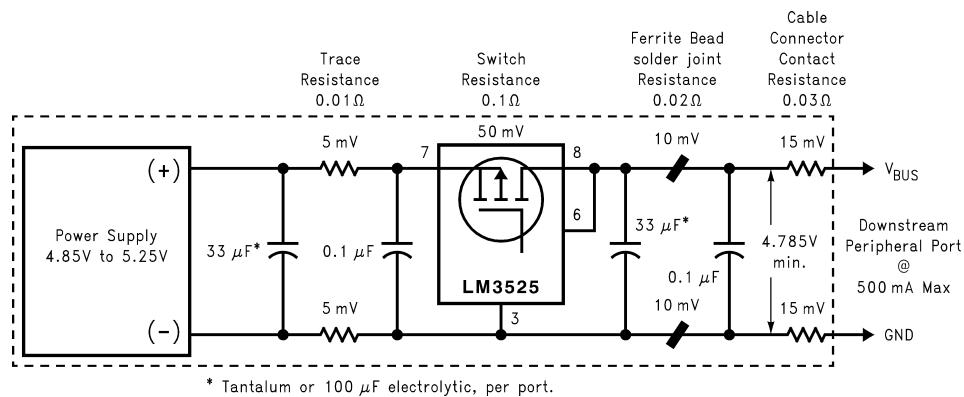


FIGURE 2. Self-Powered Hub Per-Port Voltage Drop

Typical Applications

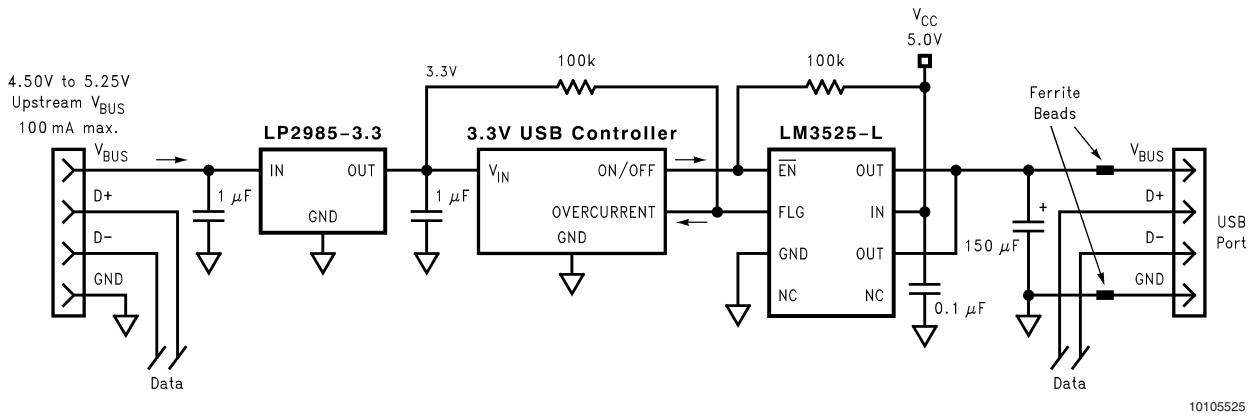


FIGURE 3. Single-Port USB Self-Powered Hub

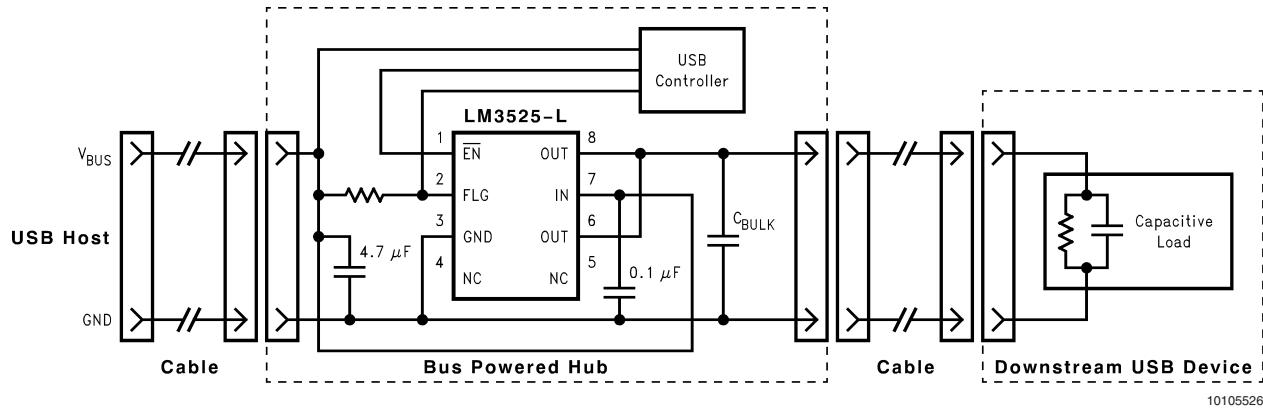


FIGURE 4. Soft-Start Application

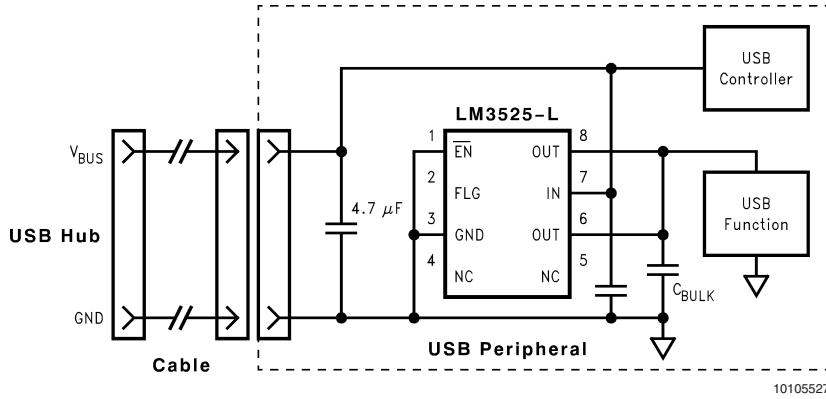
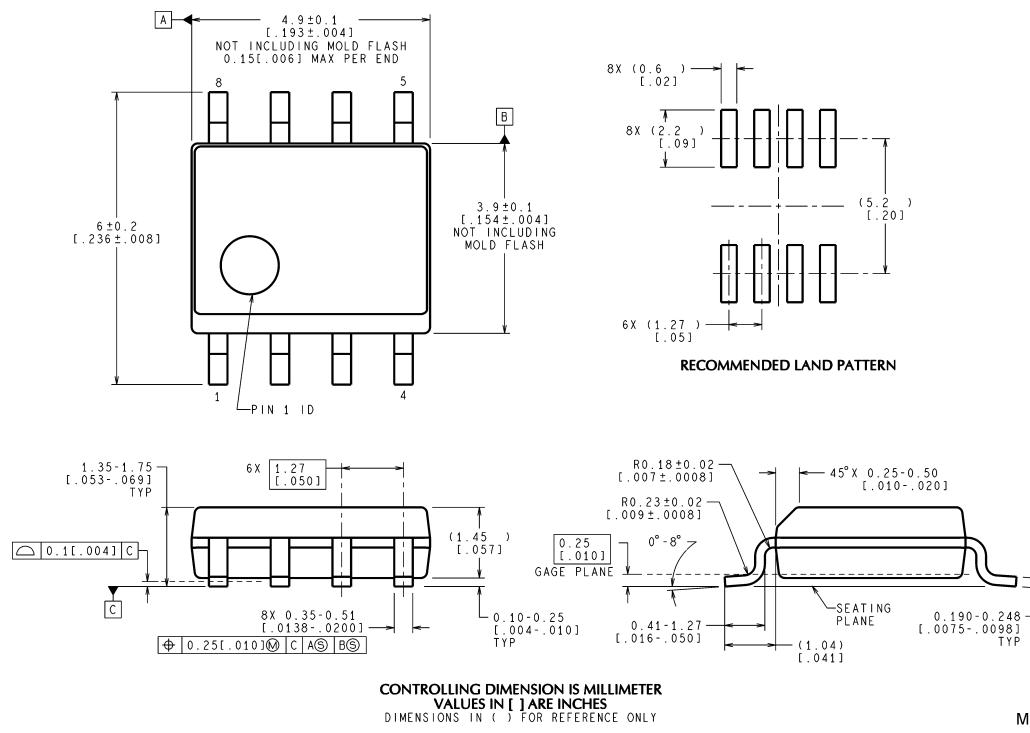


FIGURE 5. Inrush Current-limit Application

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Physical Dimensions inches (millimeters) unless otherwise noted



For Order Numbers , see Ordering Information Table
NS Package Number M08A

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