SC5826
HotSwitch™ Dual USB Power Distribution Switch With Enable

Description

USB power distribution switches are high-side N-channel MOSFET switches with built-in overcurrent protection and low on-state resistance. The SC5826 switch is designed to meet the USB requirements for power switching and maintenance-free fault protection for self-powered and bus-powered hub applications.

The SC5826 features low on-state resistance to meet the USB requirement for voltage drop and regulation. The switch is controlled by an enable input that is compatible with 3V and 5V logic. The enable input is available with an active high (EN, SC5826-1) or active low (SHDN, SC5826-2) input for maximum design flexibility.

The device provides short circuit current limiting at a value of less than 1.5A, well below the USB limit of 5A. During an overcurrent condition the device provides a fault notification to signal the USB controller. An integrated thermal protection circuit automatically shuts the switches off when the junction temperature reaches its thermal limit. The switches remain off until the junction temperature drops approximately 5°C. The switches will continue to cycle on and off until the fault is removed.

Inrush current limiting prevents the voltage drop on an upstream port when the switches are enabled. An undervoltage lockout circuit guarantees the switches are initially off during start-up.

The SC5826 is available in the popoular SO-8 surface mount package.

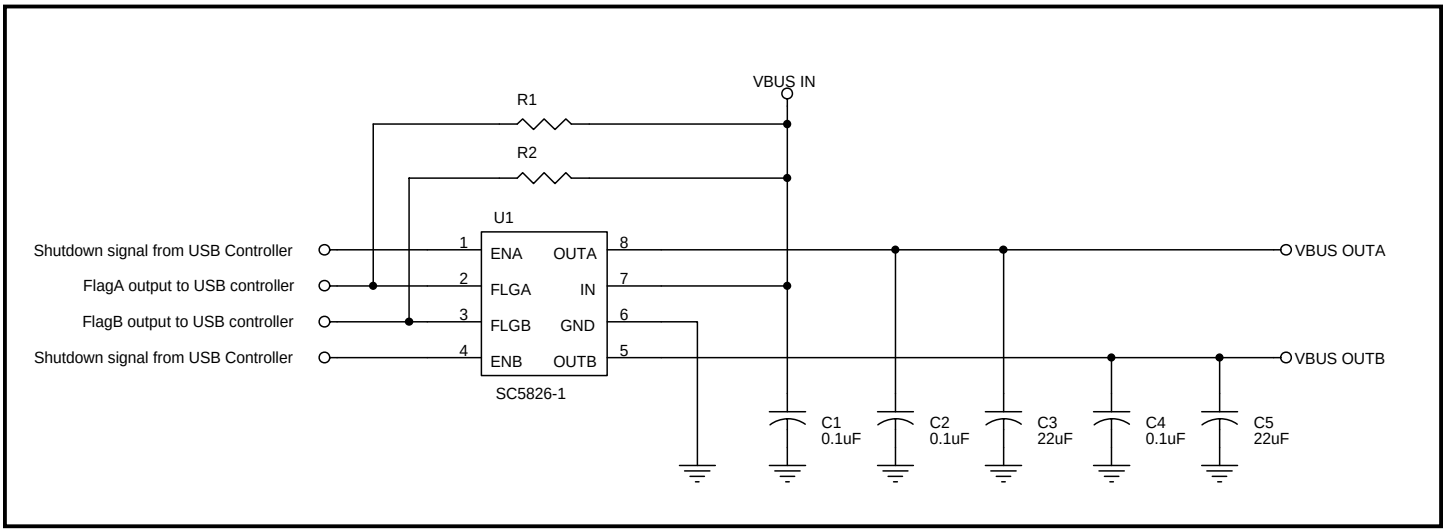
Features

- Designed to meet USB specification revisions 1.1 and 2.0 power management requirements
- UL recognized
- 500mA continuous load current
- High-side MOSFET switches with low $R_{DS(ON)}$
- Short-circuit current protection
- Internal thermal shutdown
- Undervoltage lockout
- Open drain fault output
- Soft start circuit with slow turn-on time
- Wide supply voltage range: 2.8V to 5.5V
- Full industrial temperature range
- SO-8 surface mount package

Applications

- Universal Serial Bus (USB) power management
- Self-powered or bus-powered USB hubs
- Root hubs in desktop PCs and servers
- Notebook PCs
- Peripherals

Typical Application Circuit



Absolute Maximum Ratings

Parameter	Symbol	Maximum	Units
Input Voltage Range	V_{IN}	-0.3 to +7	V
Output Voltage Range`	V_{OUT}	-0.3 to +7	V
Enable Input	V_{EN}	-0.3 to +7	V
Flag Output	V_{FLG}	-0.3 to (V_{IN} + 0.3)	V
Continuous Output Current	I_{OUT}	Internally Limited	mA
Thermal Impedance Junction to Ambient	θ_{JA}	163	°C/W
Thermal Impedance Junction to Case	θ_{JC}	39	°C/W
Operating Ambient Temperature Range	T_A	-40 to +85	°C
Operating Junction Temperature Range	T_J	-40 to +125	°C
Storage Temperature Range	T_{STG}	-65 to +150	°C
Lead Temperature (Soldering) 10 seconds	T_L	300	°C

Electrical Characteristics(1)

Unless specified: T_A = 25°C, V_{IN} = 5V, V_{EN} = 5V (SC5826-1), V_{SHDN} = 0V (SC5826-2), I_{OUTA} = I_{OUTB} = 500mA. Values in **bold** apply over the full operating temperature range.

Parameter	Symbol	Conditions	Min	Typ	Max	Units
IN						
Supply Voltage Range	V_{IN}		**2.8**		**5.5**	**V**
Supply Current	I_Q	V_{IN} = 3.3V		80	115	µA
					150	
		V_{IN} = 5.0V		100	130	µA
					200	
		V_{IN} = 5.5V, both outputs OFF(2)		0.02	**10**	µA
Power Switch						
On Resistance	r_{ON}	V_{IN} = 3.3V		110	150	mΩ
					200	
		V_{IN} = 5.0V		100	140	mΩ
					190	
OUT						
Output Leakage Current	$I_{L(OFF)}$	V_{IN} = 5.5V, both outputs OFF(2), V_{OUT} = 0V		0.02	**20**	µA
Output Turn On Delay(3)	$t_{d(ON)}$	R_{OUT} = 10Ω, C_{OUT} = 1µF		0.25		ms

Electrical Characteristics(1)

Unless specified: T_A = 25°C, V_{IN} = 5V, V_{EN} = 5V (SC5826-1), V_{SHDN} = 0V (SC5826-2), I_{OUTA} = I_{OUTB} = 500mA. Values in **bold** apply over the full operating temperature range.

Parameter	Symbol	Conditions	Min	Typ	Max	Units
OUT (Cont.)						
Output Turn On Rise Time(3)	t_r	R_{OUT} = 10Ω, C_{OUT} = 1µF		0.55		ms
Output Turn Off Delay(3)	$t_{d(OFF)}$	R_{OUT} = 10Ω, C_{OUT} = 1µF		35		µs
Output Turn Off Fall Time(3)	t_f	R_{OUT} = 10Ω, C_{OUT} = 1µF		0.1		ms
Current Limit						
Short Circuit Current Limit	I_{CL}	V_{OUT} = 0V	**0.50**	0.85	**1.50**	A
Current Limit Trip Threshold	$I_{TH(CL)}$			1.5		A
EN/SHDN						
High Level Input Voltage	V_{IH}	2.8V ≤ V_{IN} ≤ 5.5V	**2.4**			V
Low Level Input Voltage	V_{IL}	2.8V ≤ V_{IN} ≤ 5.5V			**0.8**	V
Input Current	I_{EN}, I_{SHDN}	V_{IN} = 5.5V, V_{OUT} = OPEN, 0V ≤ (V_{EN} or V_{SHDN}) ≤ V_{IN}	**-1**		**1**	µA
Undervoltage Lockout						
UVLO Threshold	V_{UVLO}	V_{IN} rising	**2.3**	2.5	**2.7**	V
UVLO Hysteresis	V_{HYST}	V_{IN} falling		125		mV
FLG						
Output Resistance	r_{FLG}	I_{FLG} = 10mA, V_{OUT} = 0V			**50**	Ω
Leakage Current (OFF)(2)	I_{FLG}	V_{FLG} = 5.0V, both outputs OFF			**1**	µA
Over Temperature Protection						
High Trip Level	T_{HI}			160		°C
Hysteresis	T_{HYST}			5		°C

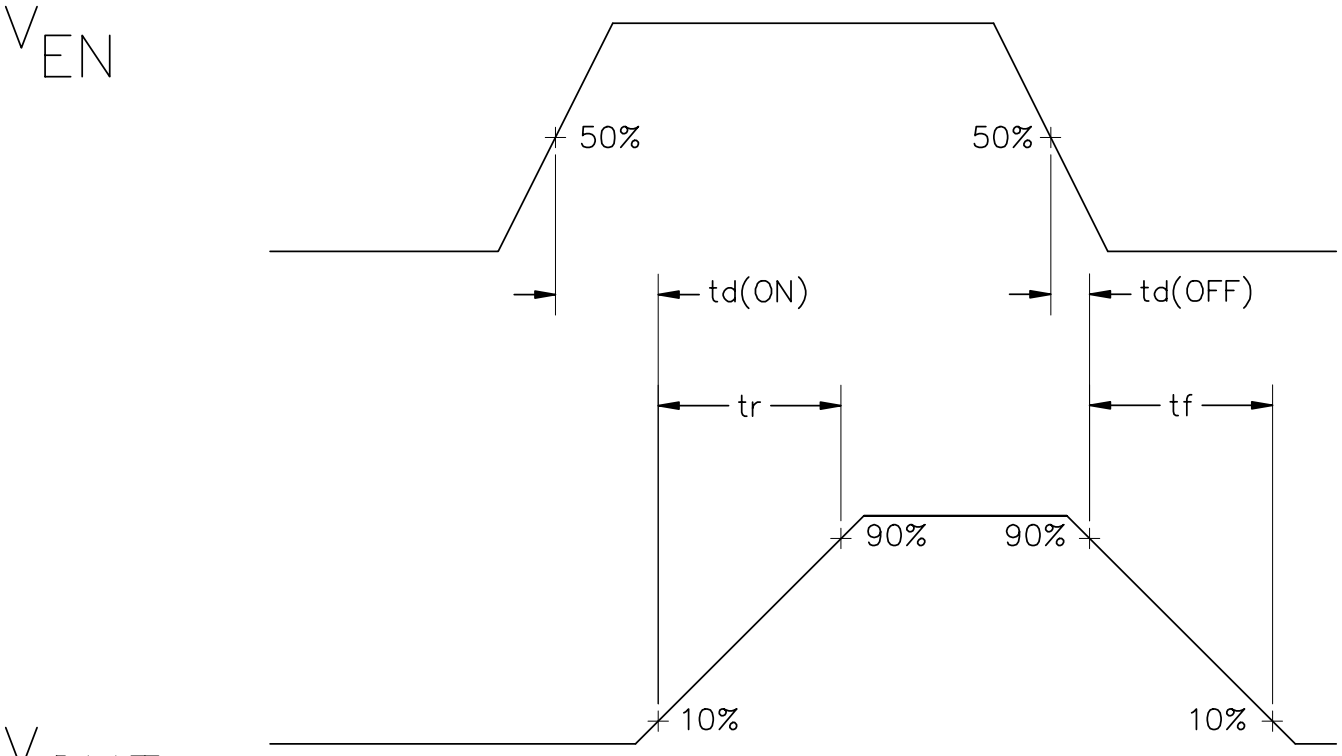
Notes:

(1) This device is ESD sensitive. Use of standard ESD handling precautions is required.

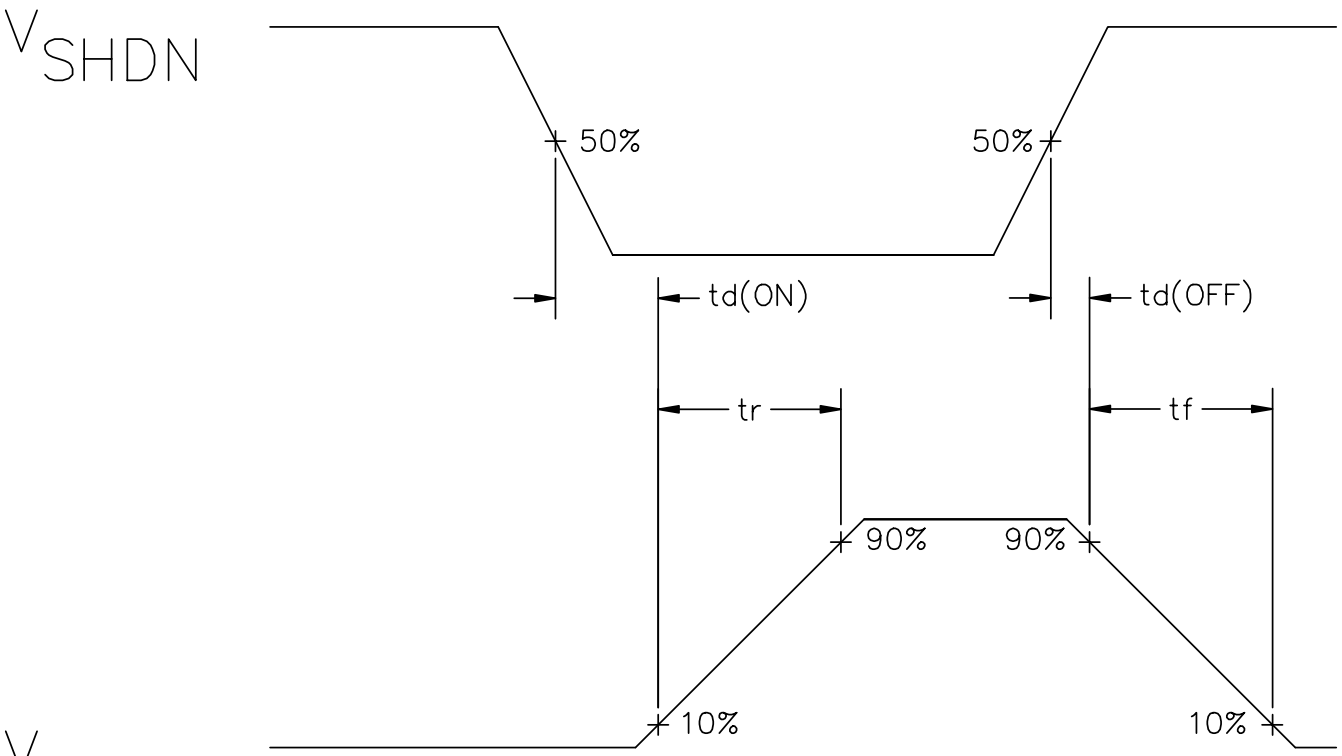
(2) Both outputs are OFF when V_{EN} = 0V (SC5826-1) or V_{SHDN} = V_{IN} (SC5826-2).

(3) See Timing Diagrams on page 4.

Timing Diagrams

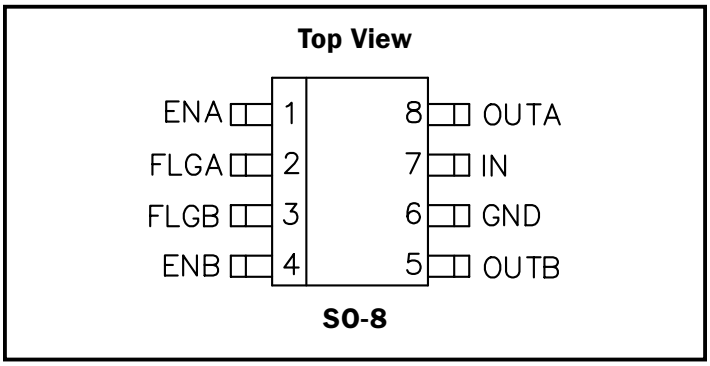


SC5826-1



SC5826-2

Pin Configuration



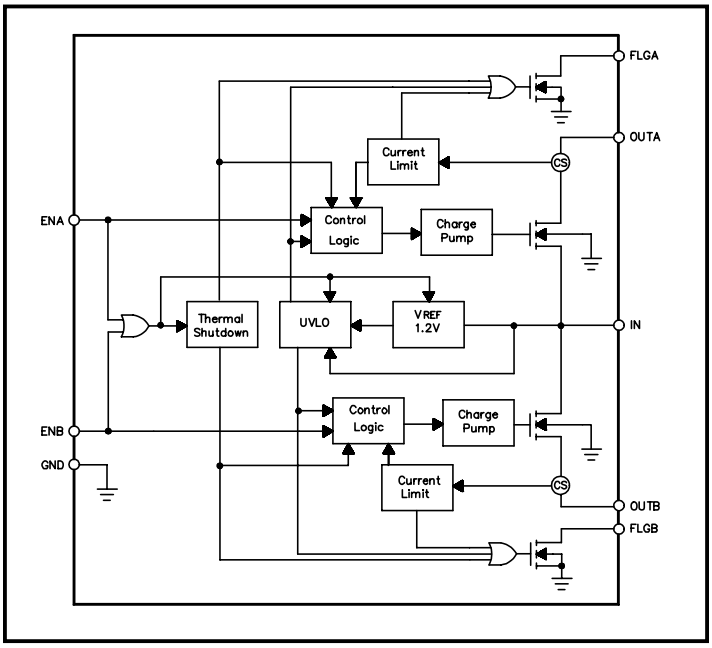
Note for Pin Configuration and Block Diagram:
(1) SC5826-1 shown. For SC5826-2, pins 1 and 4 are SHDNA and SHDNB.

Ordering Information

Device[1]	Enable/Shutdown	Package
SC5826-1CS.TR	Enable (Active High)	SO-8
SC5826-2CS.TR	Shutdown (Active Low)	SO-8

Note:
(1) Only available in tape and reel packaging. A reel contains 2500 devices.

Block Diagram

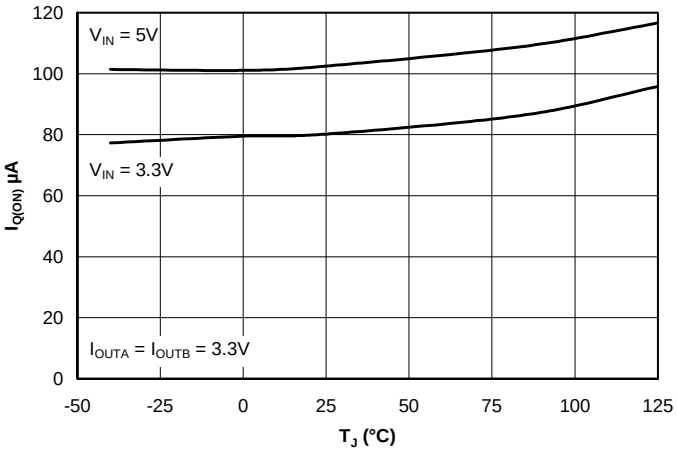


Pin Descriptions

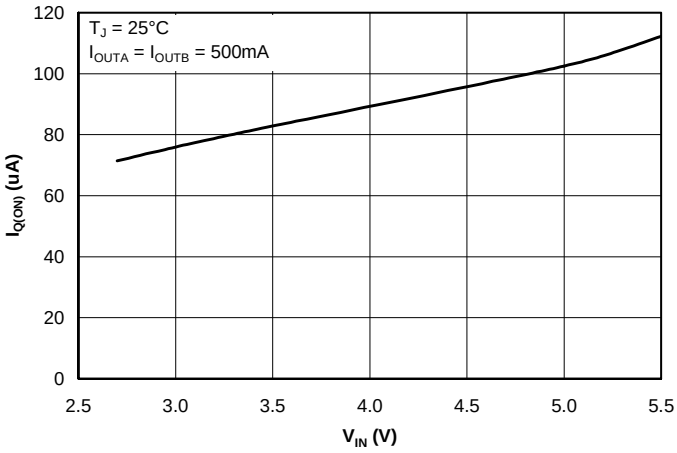
Pin	Pin Name	Pin Function
1, 4	ENA/B (SC5826-1) SHDNA/B (SC5826-2)	Enable inputs: TTL compatible. OUTA/B N-channel power MOSFETs are turned on when these pins are pulled high. Shutdown inputs: TTL compatible. OUTA/B N-channel power MOSFETs are turned on when these pins are pulled low.
2, 3	FLGA/B	Error flag outputs: FLG is asserted active low during a fault condition (overcurrent, input undervoltage or thermal shutdown).
6	GND	Ground.
7	IN	Input voltage: drain of N-channel power MOSFETs. Connect to supply voltage.
5, 8	OUTA/B	Power switch output: source of N-channel power MOSFETs. Connect to load.

Typical Characteristics

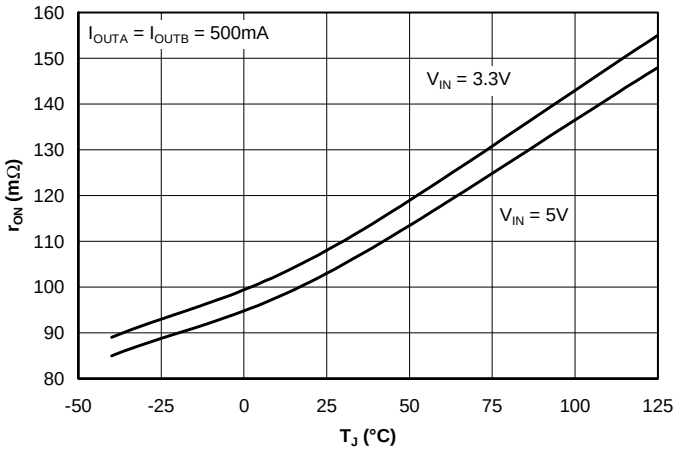
On-State Quiescent Current vs. Junction Temperature vs. Input Voltage



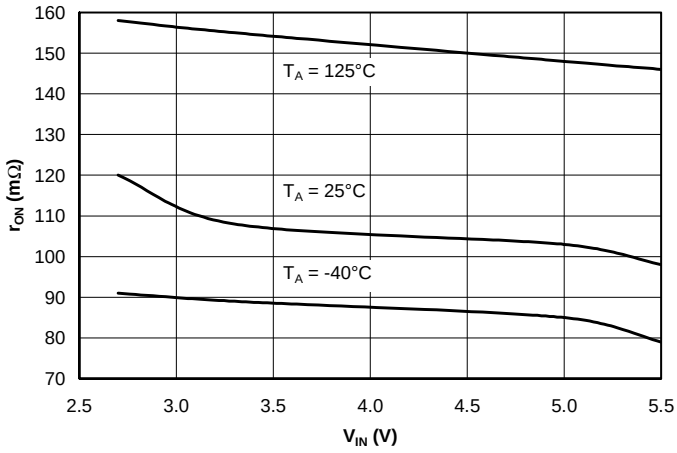
On-State Quiescent Current vs. Input Voltage



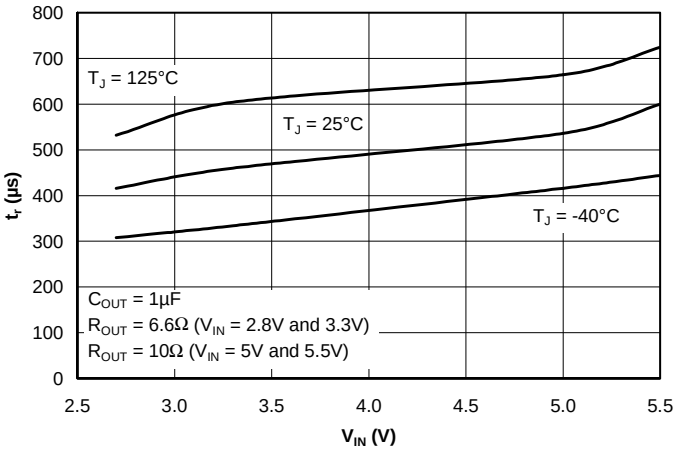
Power Switch On Resistance vs. Junction Temperature vs. Input Voltage



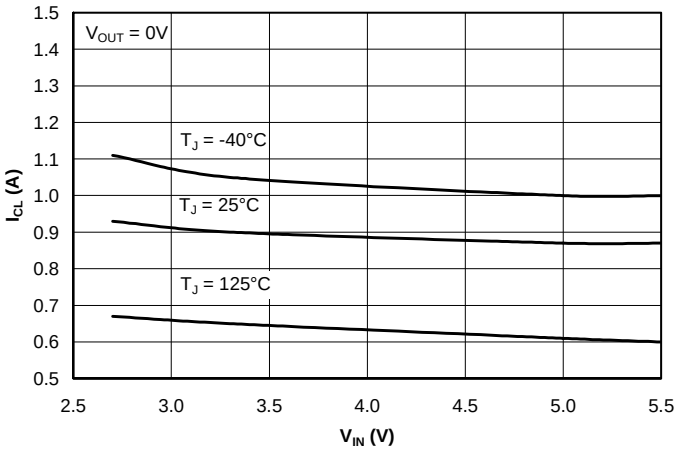
Power Switch On Resistance vs. Input Voltage vs. Junction Temperature



Output Turn-On Rise Time vs. Input Voltage vs. Junction Temperature

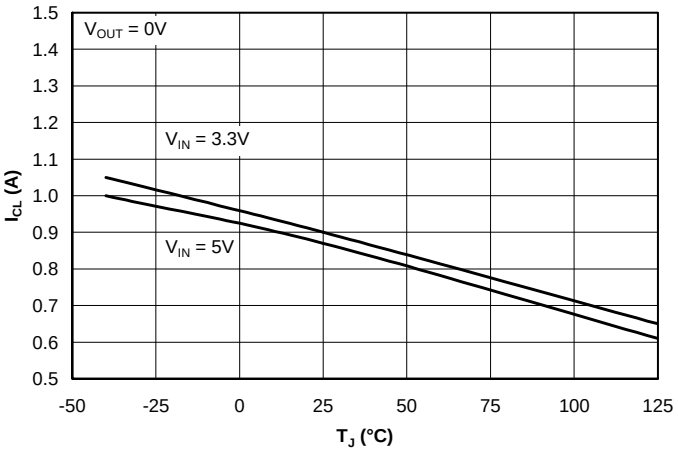


Short Circuit Current Limit vs. Input Voltage vs. Junction Temperature

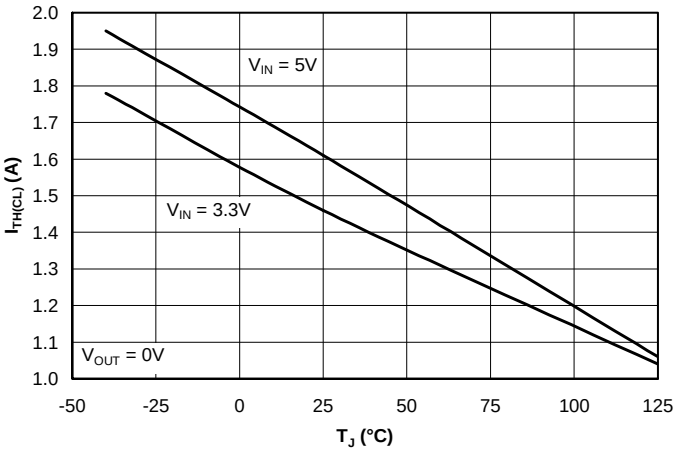


Typical Characteristics (Cont.)

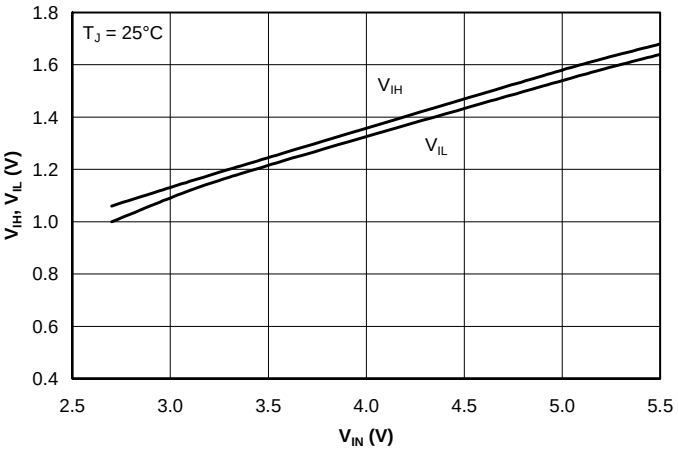
Short Circuit Current Limit vs. Junction Temperature vs. Input Voltage



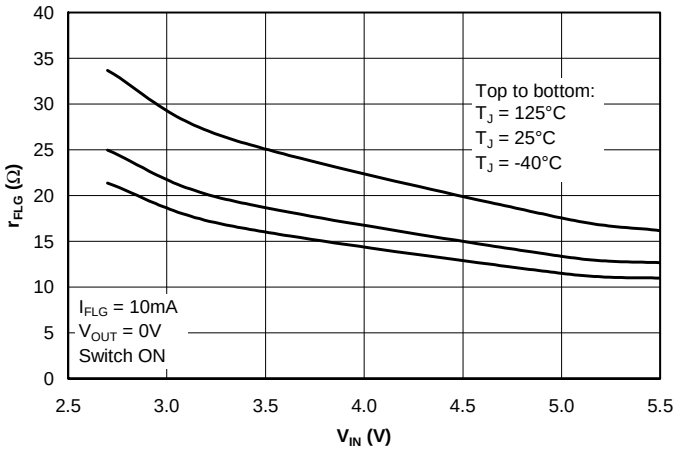
Current Limit Trip Threshold vs. Junction Temperature vs. Input Voltage



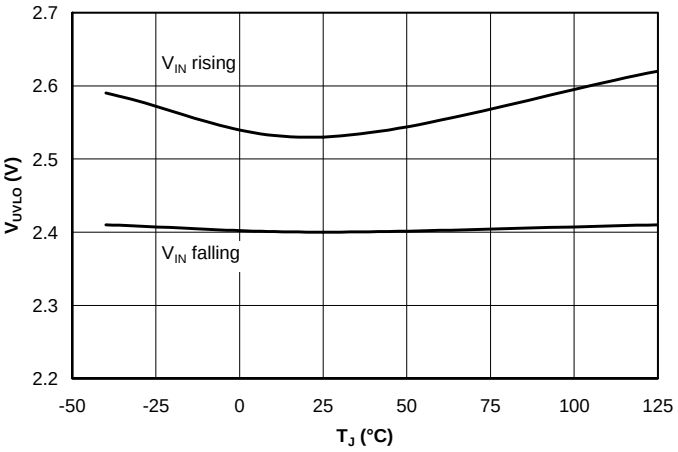
Enable/Shutdown Threshold vs. Input Voltage



Error Flag Output Resistance vs. Input Voltage vs. Junction Temperature

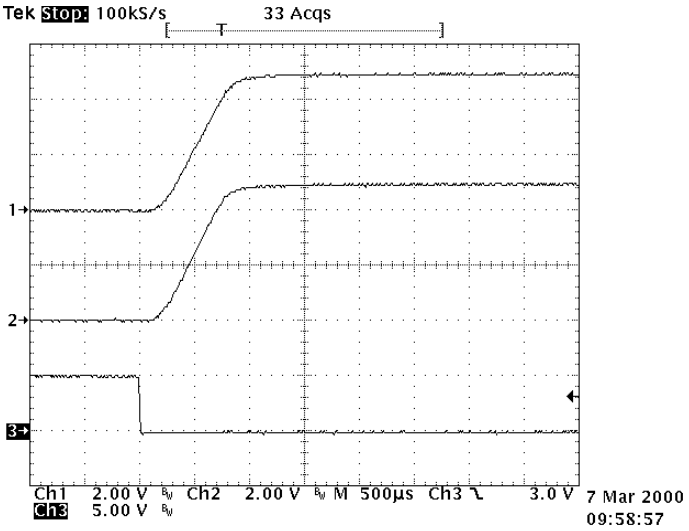


Undervoltage Lockout vs. Junction Temperature



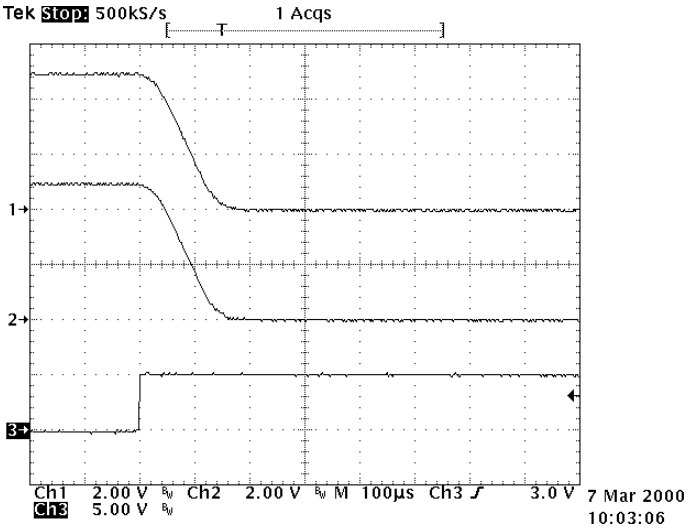
Typical Characteristics (Cont.)

Figure 1: Output Turn On Delay and Rise Time with 1µF Output Capacitor and 10Ω Load



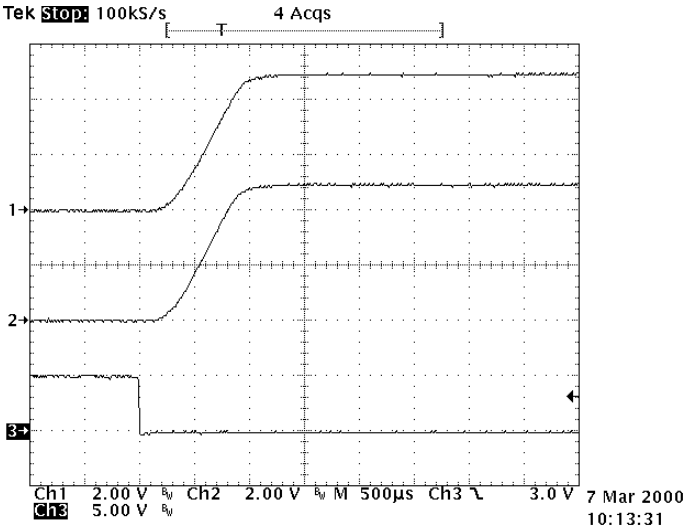
Trace 1: V_{OUTA}, 2V/div.
Trace 2: V_{OUTB}, 2V/div.
Trace 3: $V_{SHDNA/B}$, 5V/div.
Timebase: 500µs/div.
SC5826-2 shown.

Figure 2: Output Turn Off Delay and Fall Time with 1µF Output Capacitor and 10Ω Load



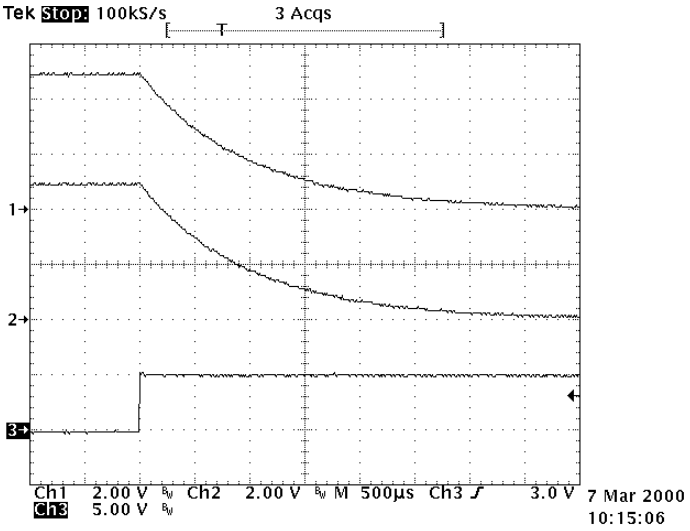
Trace 1: V_{OUTA}, 2V/div.
Trace 2: V_{OUTB}, 2V/div.
Trace 3: $V_{SHDNA/B}$, 5V/div.
Timebase: 100µs/div.
SC5826-2 shown.

Figure 3: Output Turn On Delay and Rise Time with 100µF Output Capacitor and 10Ω Load



Trace 1: V_{OUTA}, 2V/div.
Trace 2: V_{OUTB}, 2V/div.
Trace 3: $V_{SHDNA/B}$, 5V/div.
Timebase: 500µs/div.
SC5826-2 shown.

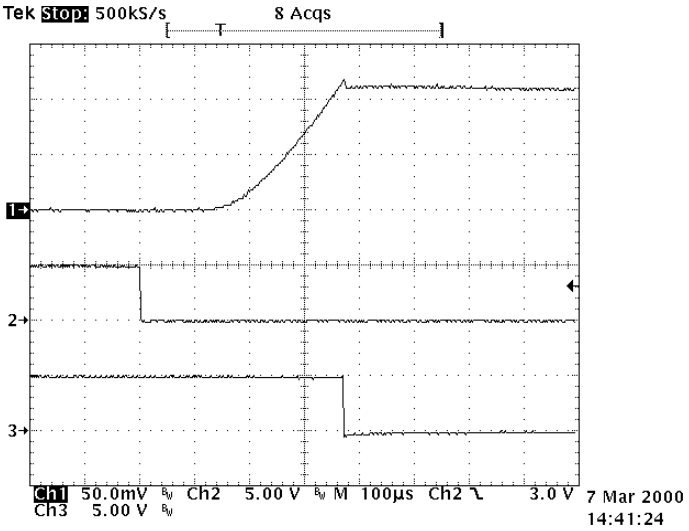
Figure 4: Output Turn Off Delay and Fall Time with 100µF Output Capacitor and 10Ω Load



Trace 1: V_{OUTA}, 2V/div.
Trace 2: V_{OUTB}, 2V/div.
Trace 3: $V_{SHDNA/B}$, 5V/div.
Timebase: 500µs/div.
SC5826-2 shown.

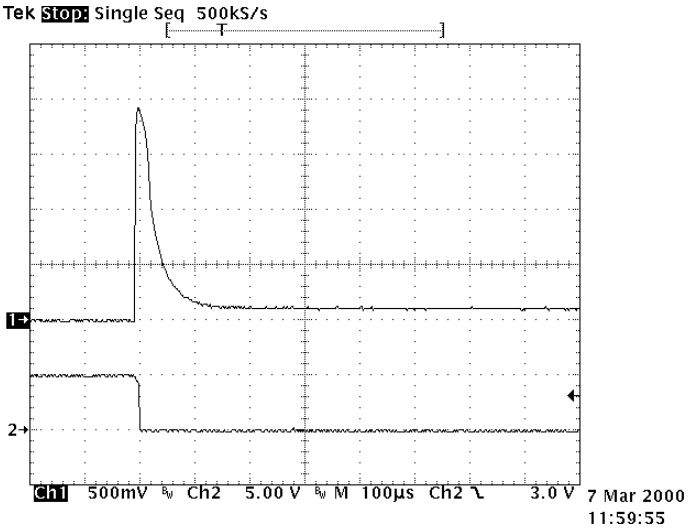
Typical Characteristics (Cont.)

Figure 5: Short Circuit Current, Output Enabled Into Short



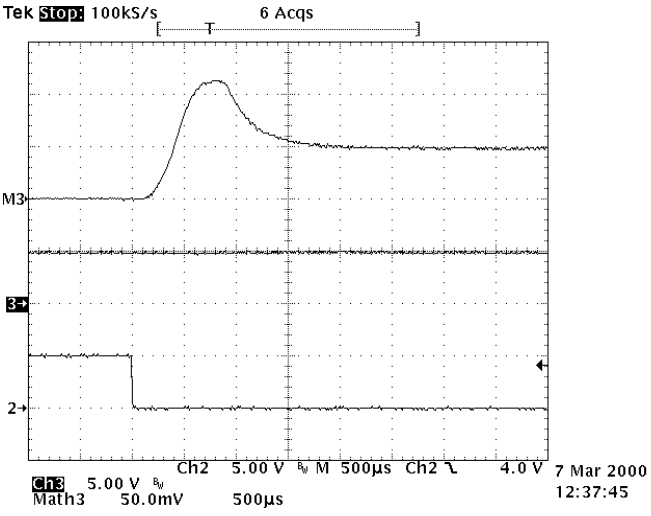
Trace 1: $I_{OUTA/B}$, 0.5A/div.
Trace 2: $V_{SHDNA/B}$, 5V/div.
Trace 3: $V_{FLGA/B}$, 5V/div.
Timebase: 100µs/div.
SC5826-2 shown.

Figure 6: Short Circuit Current, Short Applied to Enabled Device (C_{OUT} = 100µF)



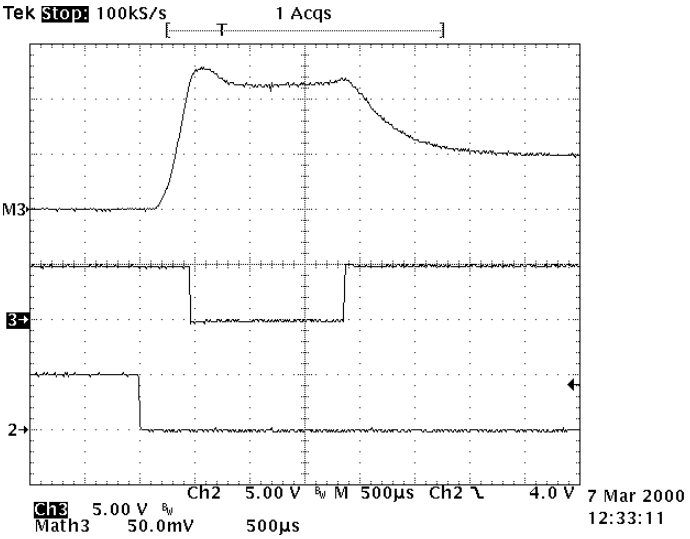
Trace 1: $I_{OUTA/B}$, 5A/div.
Trace 2: $V_{SHDNA/B}$, 5V/div.
Timebase: 100µs/div.
Note: initial peak current supplied by output capacitor.
SC5826-2 shown.

Figure 7: Inrush Current, Device Enabled Into 100µF Output Capacitor and 10Ω Load



Trace M3: $I_{OUTA/B}$, 0.5A/div.
Trace 3: $V_{FLGA/B}$, 5V/div.
Trace 2: $V_{SHDNA/B}$, 5V/div.
Timebase: 500µs/div.
SC5826-2 shown.

Figure 8: Inrush Current, Device Enabled Into 330µF Output Capacitor and 10Ω Load



Trace M3: $I_{OUTA/B}$, 0.5A/div.
Trace 3: $V_{FLGA/B}$, 5V/div.
Trace 2: $V_{SHDNA/B}$, 5V/div.
Timebase: 500µs/div.
SC5826-2 shown.

Applications Information

Theory Of Operation

The SC5826 contains dual current limited 100mΩ power switches with error reporting and enable features. The power switches are N-channel MOSFETs with their gates driven by an internal charge pump. The switches have been designed to turn on slowly (0.55ms typical) to minimize inrush currents at turn-on.

The Shutdown pins (SHDNA/B for SC5826-2) are compatible with 3V or 5V logic, and when pulled high, shut off the related power switches. When both are shut down, the device enters a very low power shutdown mode, where it will draw less than 10µA from the supply. While enabled, the SC5826 draws only 100µA from the supply. The SC5826-1 has active high Enable pins for each output (ENA/B).

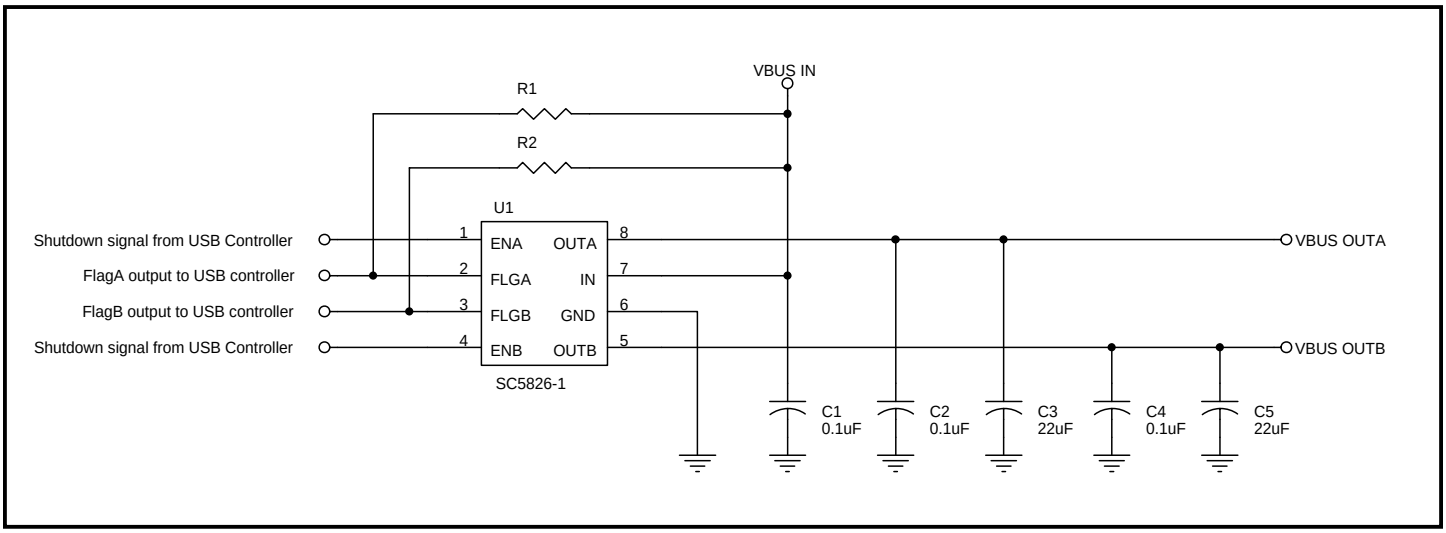
The power switches have current limit detection circuitry which will limit the current through the switch to 0.85A (typical) and reduce the output voltage accordingly. When current limit is entered, the open drain Flag pin (FLGA/B) is asserted low, indicating a fault condition. If an overcurrent or short condition is continuous, the power dissipation in the switch will cause the junction temperature to rise, triggering the thermal protection circuitry to shut the switch down (at T_j = 160°C typical). This will shut off the output current altogether, and also cause the Flag pin to be asserted low. Once the junction temperature has dropped by 5°C (typical), the device will start up once more in a controlled manner.

The SC5826 will operate from supply voltages as low as 2.8V, and internal undervoltage lockout circuitry ensures that the power switches will be turned off at power-up, even if the device is enabled. Once the UVLO threshold voltage (2.5V typical) is reached, the switches will turn on (if enabled) and slowly ramp up the outputs.

The SC5826 has been designed for use in USB applications such as:
1) **hosts** or **self-powered hubs** that need to current limit downstream ports and report overcurrent conditions;
2) **bus powered hubs** that need to be able to switch power to downstream ports, limit inrush currents at power-up (to less than a 44Ω resistor in parallel with a 10µF capacitor) and power-up and draw less than 100mA;
3) **bus powered functions** that need to limit inrush currents at power-up (to less than a 44Ω resistor in parallel with a 10µF capacitor) and power-up and draw less than 100mA.

Component Selection - General

A 0.1µF or greater ceramic bypass capacitor is recommended at the device input. This should be placed close to the input pin (IN) and routed directly to ground. A low ESR electrolytic capacitor is recommended at each output, higher values should be used for heavy loads to reduce ringing at the output (and hence input). Bypass the output with a 0.1µF to 1µF ceramic capacitor to improve immunity to short circuit transients.



Enable/Shutdown

The shutdown pins (SHDN) are active-low (enable pins

Applications Information (Cont.)

are active high) and compatible with 3V or 5V logic. Pulling the shutdown pins high shuts down the power switches and the SC5826 will draw < 10µA from the supply. Pulling these pins low will enable the device. For the enable pins the device will be shutdown if pulled low.

Error Flags

The error flag (FLG) outputs are open drain N-channel MOSFETs. Each output is pulled low during overcurrent, input undervoltage and thermal shutdown conditions. Connection of high capacitance loads to the output can cause momentary overcurrent conditions due to inrush current and trigger false error flag assertion. This can be reduced by using low ESR output capacitors to provide a low impedance source for hot-plug events. The addition of an RC filter between FLG and the USB controller can resolve this easily. These pins also require a pull-up resistor for a high signal when not asserted.

Overcurrent

There are three overcurrent situations to be considered:

1) the output is already short before the device is enabled or power is applied. In this case, the SC5826 immediately detects the short, and the output current will slowly ramp up to the current limit value, and FLG will assert low. Refer to Figure 5 on Page 9.

2) a short occurs while the device is enabled. In this case, very high current may flow initially while the overcurrent circuitry reacts. Once the current limit circuitry trips, the current is limited to 0.85A (typ.) and FLG is asserted low. Refer to Figure 6 on Page 9.

3) the load gradually increases beyond 500mA. In this case, the current will be allowed to rise until it reaches the Current Limit Trip Threshold, at which point the current will drop back to 0.85A and FLG will assert low.

Thermal Sensing

An internal thermal shutdown circuit turns off the power switch when the die temperature exceeds 160°C (typical). The FLG pin asserts low signaling a fault condition. Built-in hysteresis prevents the switch from turning back on until the die temperature has cooled approximately 5°C. The switch will continue to cycle on and off until the fault condition is removed. The thermal sense circuit functions only when the switches are enabled.

Undervoltage Lockout

An undervoltage lockout circuit monitors the input voltage and prevents the power switches from turning on until the input voltage (IN) exceeds 2.5V (typical). If the input voltage falls and drops below 2.375V (typical), the undervoltage circuitry turns off the power switches and the FLG pins assert low. The undervoltage lockout functions only when the switches are enabled.

Thermal Considerations

Since the on-resistance of the power switch is so low, the SC5826 can pass large currents without requiring a large package to dissipate the heat. The worst-case power dissipation (under normal operating conditions) is given by:

$$P_{D(MAX)} = (I_{OUTA})^2 \bullet r_{ONA(MAX)} + (I_{OUTB})^2 \bullet r_{ONB(MAX)}$$

So for $I_{OUTA} = I_{OUTB} = 500mA$ and $r_{ON(MAX)} = 200m\Omega$ (at $V_{IN} = 3.3V$), the maximum power dissipation is:

$$P_{D(MAX)} = 2 \bullet (0.5)^2 \bullet 0.2 = 100mW$$

The junction temperature can be calculated using the following equation:

$$T_J = T_A + \theta_{JA} \bullet P_{D(MAX)}$$

Inserting $T_A = 85°C$, $\theta_{JA} = 163°C/W$ (package thermal impedance for minimum line widths and no internal power planes) and $P_{D(MAX)} = 100mW$, we calculate the worst-case T_J to be:

$$T_J = 85 + 163 \bullet 0.1 = 101°C$$

Thus it can be seen that this device does not require any additional copper area for heatsinking under normal operating conditions. Sustained overcurrents or short circuits will rapidly heat $T_J > 160°C$, thus activating the thermal shutdown circuitry.

Layout Considerations

The ceramic bypass capacitors for IN and OUT should be connected as close to the relevant device pins as possible.

The bulk output capacitors required by the USB specification should be placed close to the USB connector to provide a low impedance source for hot plug purposes.

Ferrite beads should be placed on the V_{BUS} and Ground pins of the downstream connectors to reduce the droop on adjacent ports during hot plug events.

Typical Applications Circuits

Self-Powered Hub, Individual Port Power Management

A self-powered hub must supply a continuous 500mA of current to each downstream port. Since an internal power supply is used to supply the power, self-powered hubs are required to implement overcurrent protection for safety. The self-powered hub must also have a method to detect and report fault conditions to the USB controller. The circuit in Figure 9 below utilizes the SC5826 to provide individual port overcurrent protection & power switching for maximum port protection.

Under fault conditions, the SC5826 provides the short-circuit current limiting function and has a fault flag logic output for notifying the hub controller. The USB hub can use the SC5826 to remove power from the faulty port, allowing the other ports to operate normally. Each SC5826 can control the power to two ports.

Since USB is a hot insertion and removal system, USB ports are subject to electrostatic discharge (ESD). The SRDA05-4 provides ESD protection on the downstream data and power lines. Each device will protect two USB ports. With proper layout the port is hardened to greater than 15kV, meeting the requirements of IEC 1000-4-2. The SC5205 LDO regulator is used to power the hub controller from the hub's 5V power supply.

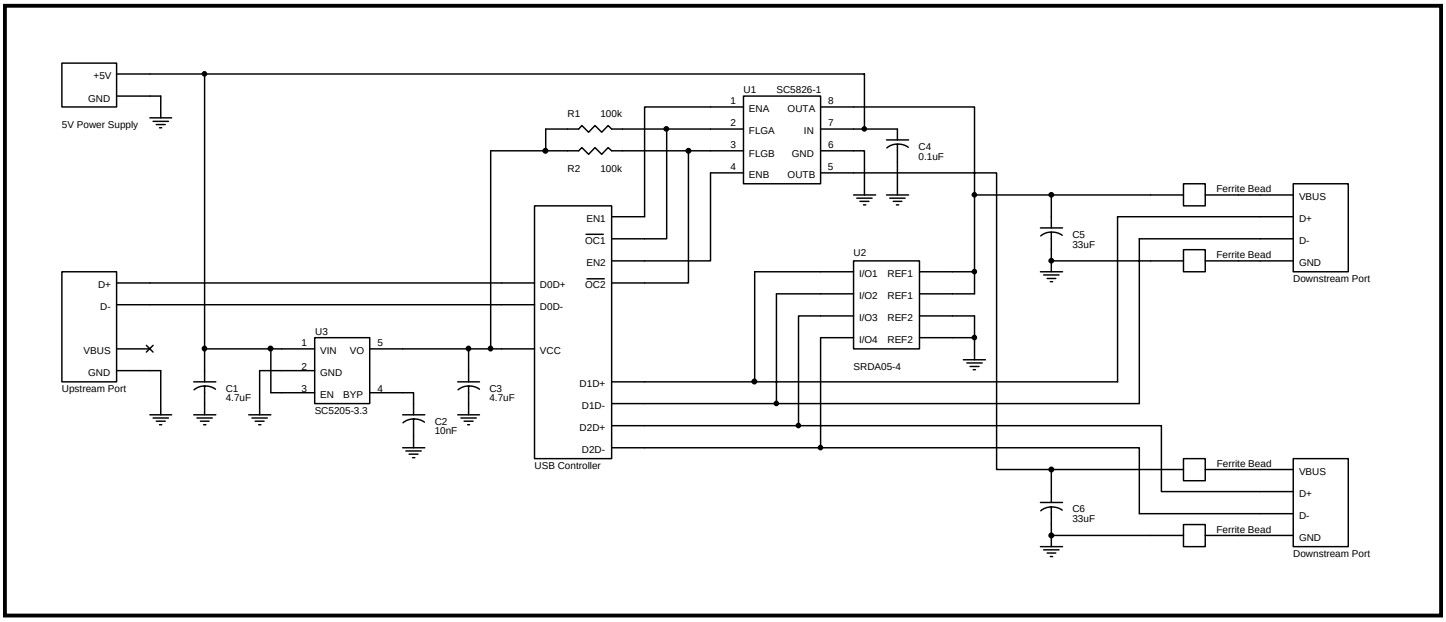


Figure 9: Self-Powered Hub

Notes:

(1) Two ports only shown for simplicity.

(2) 33µF output capacitor assumes four downstream ports for this hub, therefore meeting the USB specification requirement of 120µF minimum capacitance per hub.

Typical Applications Circuits (Cont.)

Bus Powered Hub, Ganged-Port Power Management

A bus-powered hub distributes power and data from an input port to downstream ports. It must supply a continuous 100mA of current to each downstream port. A bus-powered hub must be able to switch power to downstream ports to prevent illegal device hook-up. Inrush current limiting is also required to prevent power supply drooping. The circuit in Figure 10 below utilizes the SC5826 to provide ganged port power switching, inrush current limiting and overcurrent protection for maximum port protection. In a ganged switch configuration, all ports are switched simultaneously.

Under fault conditions, the USB controller will remove power to all of the ganged ports. For individual port management, one extra SC5826 may be used.

Since USB is a hot insertion and removal system, USB ports are subject to electrostatic discharge (ESD). The SRDA05-4 provides ESD protection on the downstream data and power lines. Each device will protect two USB ports. With proper layout the port is hardened to greater than 15kV, meeting the requirements of IEC 1000-4-2. On the upstream port, the SR05 provides ESD protection to the above levels for one line pair. The SC5205 LDO regulator is used to power the hub controller from the upstream bus.

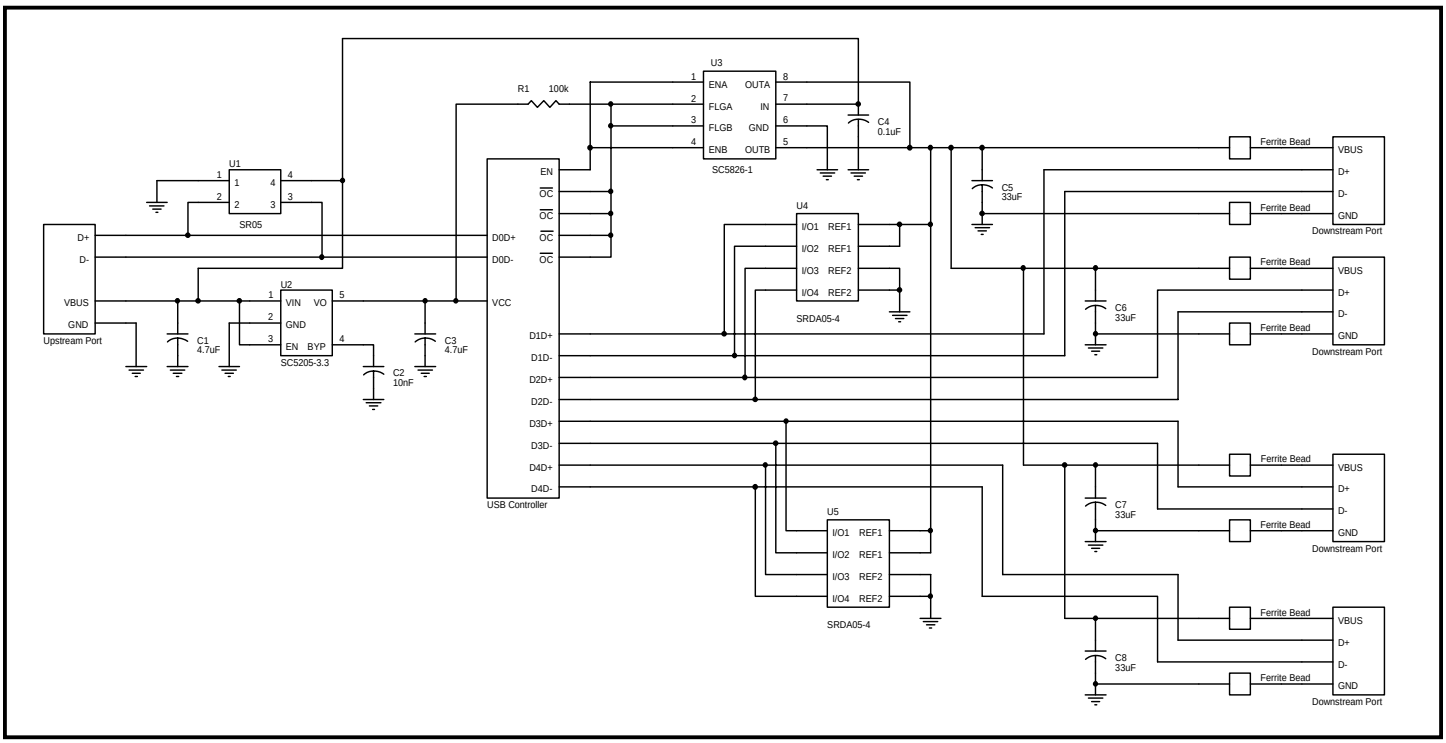


Figure 10: Bus Powered Hub

Note:

(1) 33µF output capacitor per port meets the USB specification minimum capacitance requirement of 120µF per hub.

Typical Applications Circuits (Cont.)

High-Power or Low-Power Bus-Powered Functions

Both low-power and high-power bus-powered functions must draw less than 100mA at startup. At this time, they must also present a load of less than the parallel combination of a 44Ω resistor and a 10µF capacitor. After startup, high powered functions may then draw up to 500mA. The circuit in figure 11 below utilizes the SC5826 to provide inrush current limiting and power switching for two internal functions.

Since USB is a hot insertion and removal system, USB ports are subject to electrostatic discharge (ESD). The SR05 provides ESD protection on the upstream data and power lines. With proper layout the port is hardened to greater than 15kV, meeting the requirements of IEC 1000-4-2. The SC5205 LDO regulator is used to power the USB controller from the upstream bus.

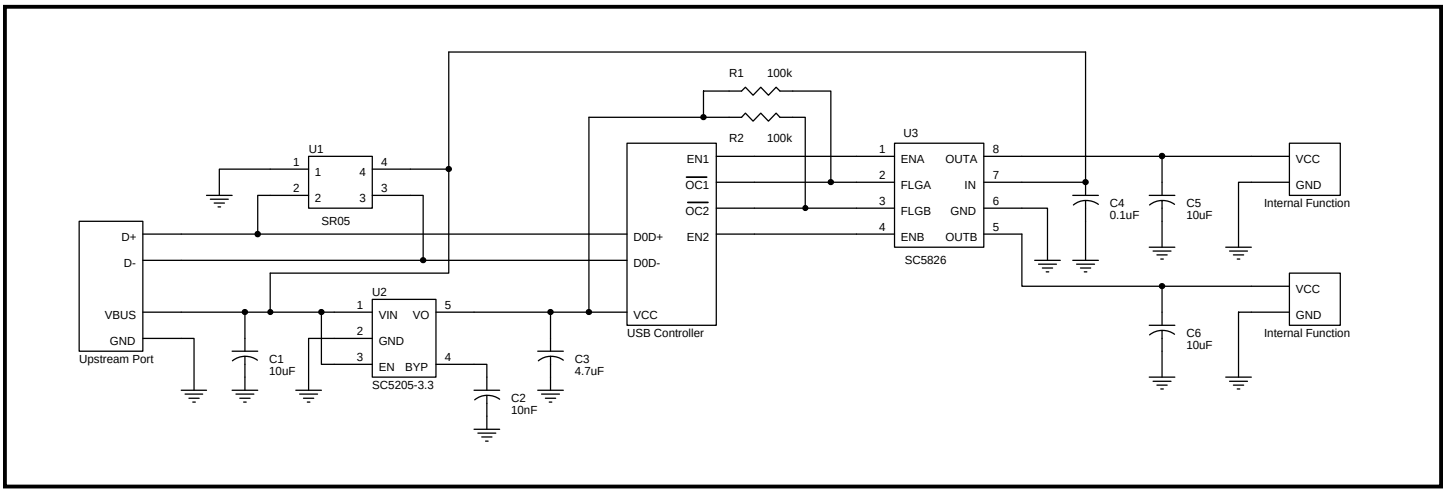
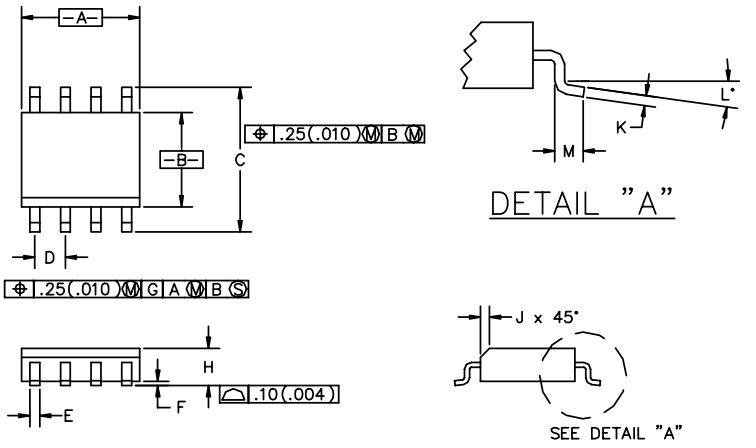


Figure 11: High-Power or Low-Power Bus-Powered Functions

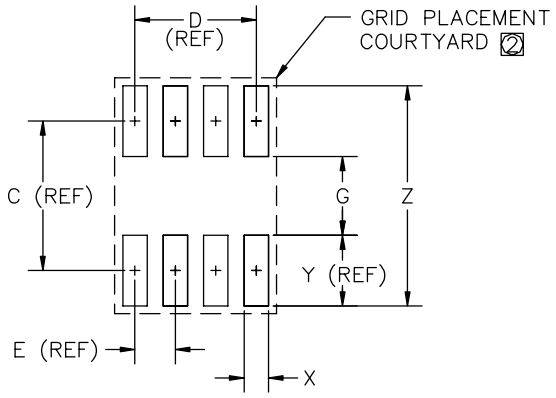
Outline Drawing - SO-8



JEDEC REF: MS-012AA

DIMENSIONS					
DIM	INCHES		MM		NOTE
	MIN	MAX	MIN	MAX	
A	.188	.197	4.80	5.00	
B	.149	.158	3.80	4.00	
C	.228	.244	5.80	6.20	
D	.050 BSC		1.27 BSC		
E	.013	.020	0.33	0.51	
F	.004	.010	0.10	0.25	
H	.053	.069	1.35	1.75	
J	.011	.019	0.28	0.48	
K	.007	.010	.19	.25	
L	0°	8°	0°	8°	
M	.016	.050	0.40	1.27	

Land Pattern - SO-8



DIMENSIONS (1)					
DIM	INCHES		MM		NOTE
	MIN	MAX	MIN	MAX	
C	–	.19	–	5.00	–
D	–	.15	–	3.81	–
E	–	.05	–	1.27	–
G	.10	.11	2.60	2.80	–
X	.02	.03	.60	.80	–
Y	–	.09	–	2.40	–
Z	–	.29	7.20	7.40	–

(2) GRID PLACEMENT COURTYARD IS 12x16 ELEMENTS (6 mm X 8mm) IN ACCORDANCE WITH THE INTERNATIONAL GRID DETAILED IN IEC PUBLICATION 97.

(1) CONTROLLING DIMENSION: MILLIMETERS

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