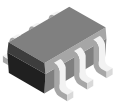
Adjustable Current Limited Power Distribution Switch TPS2553D

FEATURES

- 2.8V to 5.5V Operating Range
- Adjustable Current Limit : 200 mA to 2.25 A
- Fold-back Short Circuit Protection
- 90 μA Typical On-State Supply Current
- 5.0 μA Maximum Standby Supply Current
- Independent Open-drain Fault Flag Pin
- Reverse Current Protection
- Thermal Shutdown Protection
- Under Voltage Lockout (UVLO)
- Output Auto Discharge Function

APPLICATIONS

- USB Peripherals
- General Purpose Power Switching
- ACPI Power Distribution
- Notebook PCs
- PDAs
- Hot Plug-in Power Supplies



SOT-23-6L

ORDERING INFORMATION

Device	Package
TPS2553DSF6	SOT-23-6L

DESCRIPTION

The TPS2553D is single-channel High-Side MOSFET switch optimized for adjustable current limited power distribution requiring circuit protection. The TPS2553D support the following USB requirements. The TPS2553D supply up to 2.25A as required by USB downstream devices. Maximum continuous current can be different on the types of package and ambient temperature. Switch's low on-resistance meets USB voltage drop requirement. Flag output indicates fault condition to the local USB controller. Soft-start prevents the transient voltage drop on the upstream port that can occur when the switch is enabled in bus-powered applications. Under voltage lockout (UVLO) feature disables the output switches until a valid input voltage. Auto discharge function quickly lowers the VOUT to the ground level when the TPS2553D turns off. Also the TPS2553D includes thermal shutdown to prevent switch failure from high-current loads and reverse current protection circuit to prevent the reverse current from VOUT pin to VIN pin.

ABSOLUTE MAXIMUM RATINGS (Note 1)

CHARACTERISTIC	SYMBOL	MIN	MAX	UNIT
Input Supply Voltage	V_{IN}	−0.3	6.5	V
Enable Input Voltage	V_{EN}	−0.3	V_{IN} + 0.3	V
Output Voltage	V_{OUT}	-	6.5	V
Flag Voltage	V_{FLAG}	-	6.5	V
Flag Current	I_{FLAG}	-	10	mA
Output Current	I_{OUT}	-	Internally Limited	
Operating Junction Temperature Range	T_{JOPR}	−40	125	°C
Storage Temperature Range	T_{STG}	−65	150	°C
Package Thermal Resistance*	$\Theta_{JA\text{-}SOT\text{-}23\text{-}5}$	250		°C/W
	$\Theta_{JC\text{-}SOT\text{-}23\text{-}5}$	130		°C/W

* Calculated from package in still air, mounted to minimum foot print 2 layer PCB without thermal via per JESD51 standards.

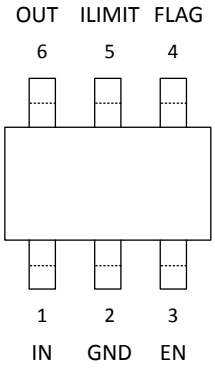
RECOMMENDED OPERATING RATINGS (Note 2)

CHARACTERISTIC	SYMBOL	MIN	MAX	UNIT
Input Supply Voltage	V_{IN}	2.8	5.5	V
Enable Input Voltage	V_{EN}	0	V_{IN}	V
Operating Junction Temperature Range	T_J	−40	125	°C
Ambient Temperature Range	T_A	−40	85	°C

ORDERING INFORMATION

Package	Order No.	Description	Supplied As	Status
SOT-23-6L	TPS2553DSF6	Adjustable Current, Enable	Tape & Reel	Active

PIN CONFIGURATION

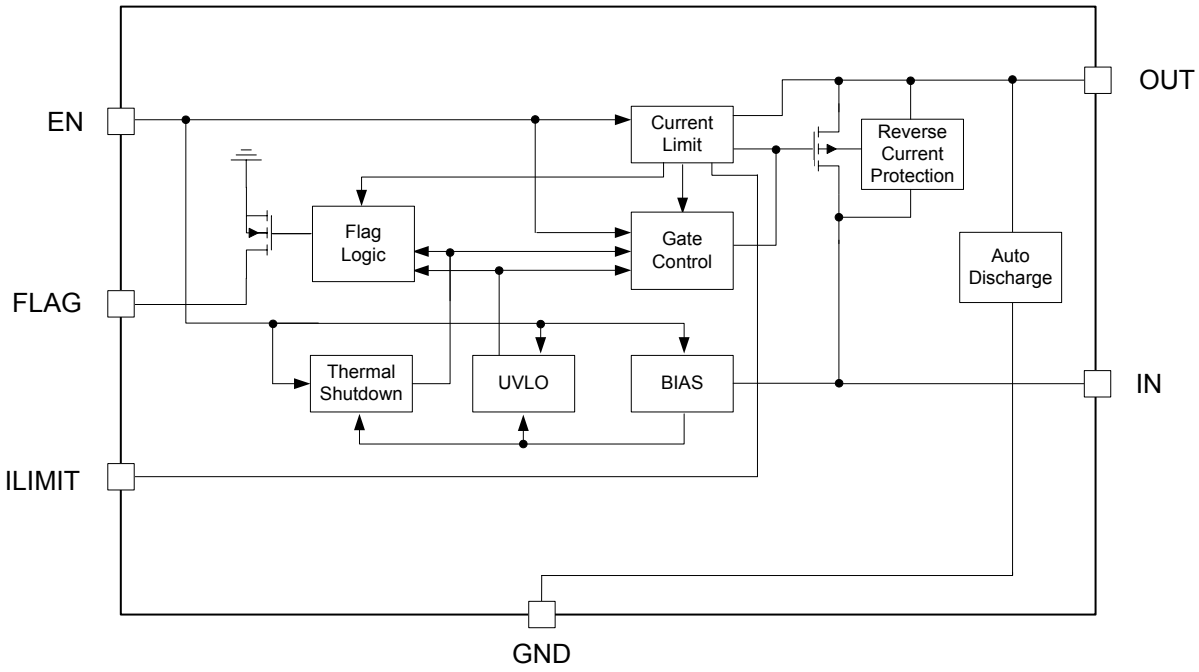


SOT-23-6L

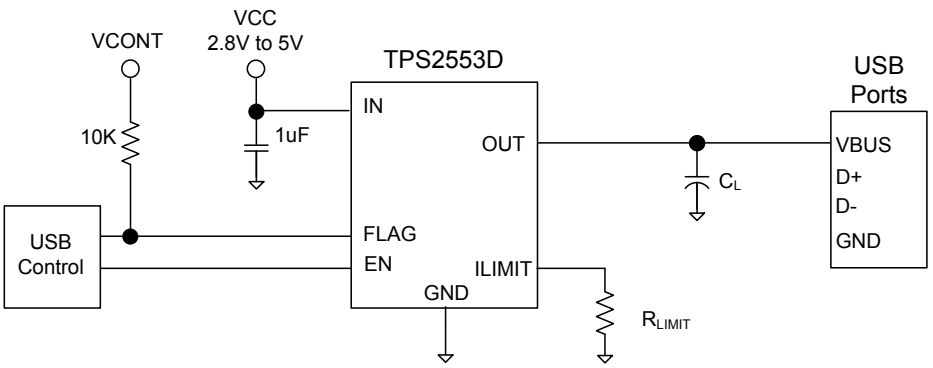
PIN DESCRIPTION

Pin No.	Pin Name	Pin Function
1	IN	Input Voltage. Power Switch Input. Also supply IC's internal circuitry. Connect to positive supply.
2	GND	Ground.
3	EN	Chip Enable. Logic High turns on Power Switch. Do Not Float.
4	FLAG	Fault Flag. Active-low open-drain output. Asserted during Over-current, Over-temperature conditions..
5	ILIMIT	Setting Current Limit Threshold using External Resistor
6	OUT	Power Switch Output. Typically connect to side of load.

BLOCK DIAGRAM



TYPICAL APPLICATION CIRCUIT



ELECTRICAL CHARACTERISTICS

Under the conditions of V_{IN} = 5V and T_A = 25ºC

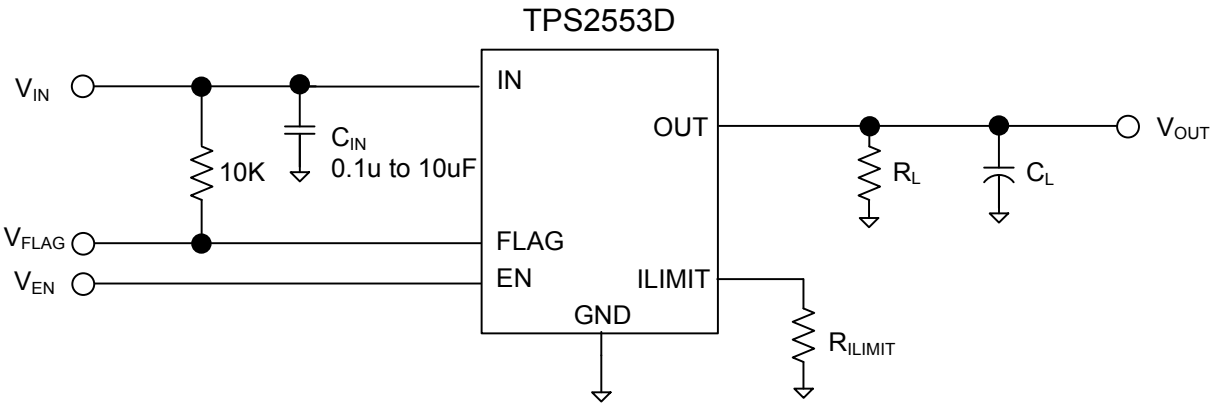
PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Operating Voltage Range	V_{IN}		2.8	-	5.5	V
Supply Current	I_{CC}	Enable off, OUT = Open	-	1.0	5	μA
		Enable on, OUT = Open	-	90	130	μA
Enable Input Threshold	V_{ENL}	Output = Low	-	-	0.8	V
	V_{ENH}	Output = High	2.0	-	-	V
Enable Input Current	I_{EN}	V_{EN} = 0V to 5.5V	−1.0	0.01	1.0	μA
Enable Input Capacitance	C_{EN}		-	1.0	-	pF
Switch Resistance	$R_{DS(ON)}$	V_{IN} = 5V, I_{OUT}=0.5A	-	100	120	mΩ
Output Turn-On Delay	T_{DON}	R_L = 5Ω each output, C_L = 1μF, R_{ILIMIT} = 8kΩ	-	0.5	5.0	ms
Output Turn-On Rise Time	T_R	R_L = 5Ω each output, C_L = 1μF, R_{ILIMIT} = 8kΩ	-	2.5	5.0	ms
Output Turn-Off Delay	T_{DOFF}	R_L = 5Ω each output, C_L = 1μF, R_{ILIMIT} = 8kΩ	-	5.0	150	μs
Output Turn-Off Fall Time	T_F	R_L = 5Ω each output, C_L = 1μF, R_{ILIMIT} = 8kΩ	-	10	100	μs
Output Leakage Current	I_{LEAK}	V_{EN} ≤ 0.8V	-	0.01	5.0	μA
Current Limit Threshold (Note 3)	I_{LIM}	R_{ILIMIT} = 80kΩ	-	200	-	mA
		R_{ILIMIT} = 16kΩ	-	1033	-	mA
		R_{ILIMIT} = 8kΩ	-	2095	-	mA
Short Circuit Current Limit	I_{SC}	R_{ILIMIT} = 80kΩ, V_{OUT} = 0V	-	112	-	mA
		R_{ILIMIT} = 16kΩ, V_{OUT} = 0V	-	578	-	mA
		R_{ILIMIT} = 8kΩ, V_{OUT} = 0V	-	1173	-	mA
Recommended Maximum Continuous Current (Note 4)		SOT-23-6L package	-	1.5	-	A
Thermal Shutdown Temperature	T_{SD}	(Note 5)	-	150	-	ºC
Thermal Shutdown Hysteresis	T_{HYS}	(Note 5)	-	20	-	ºC
Error Flag Output Resistance	R_{FO}	V_{IN} = 5V, I_L = 10mA	-	20	-	Ω
Error Flag Off Current	I_{FOH}	V_{FLAG} = 5V	-	0.01	10	μA
Output Discharge Resistance	R_{DISC}	V_{IN} = 5V, V_{EN} = 0V	-	100	-	Ω
UVLO Threshold	UVLO	V_{IN} = Increasing	2.25	2.4	2.55	V
		V_{IN} = Decreasing	2.1	2.25	2.4	V
Overcurrent Flag Response Delay	T_{DFOV}	V_{IN} = 5V, apply V_{OUT} = 0V until FLAG low	-	7.0	15	ms
Current Limit Response Time	T_{LIM}	(Note 6)	-	1.0	-	μs

Note 1. Exceeding the absolute maximum ratings may damage the device.
Note 2. The device is not guaranteed to function outside its operating ratings.

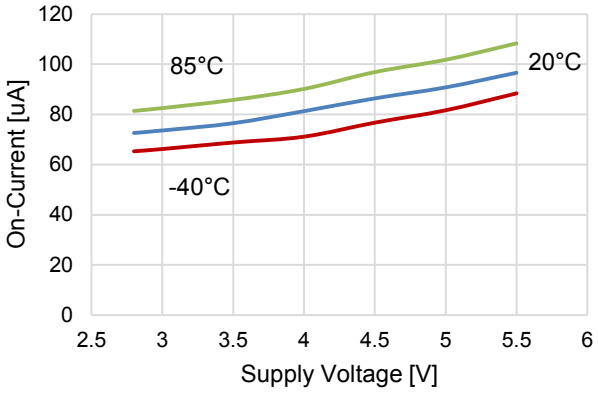
Note 3. It is recommended that current limit level set to 1.5 times more than constant current for a stable power.
Note 4. Maximum Continuous Current depends on device junction temperature and system level considerations, such as power dissipation, thermal resistance of PKG and board layout.
Note 5. Guaranteed by design. Not tested.
Note 6. T_{LIM} is the response time to operate current limit when the peak value of the current is increased more than set limit value.

TYPICAL OPERATING CHARACTERISTICS

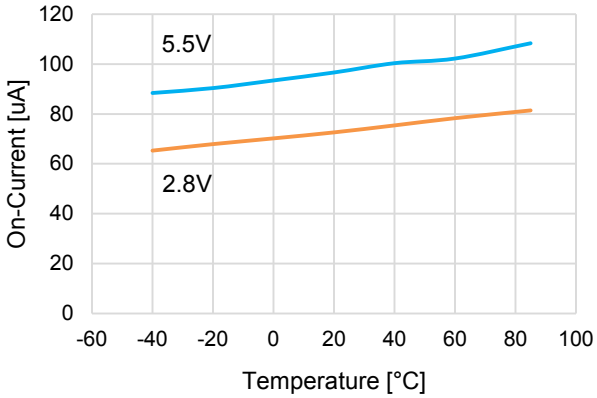
TEST CIRCUIT



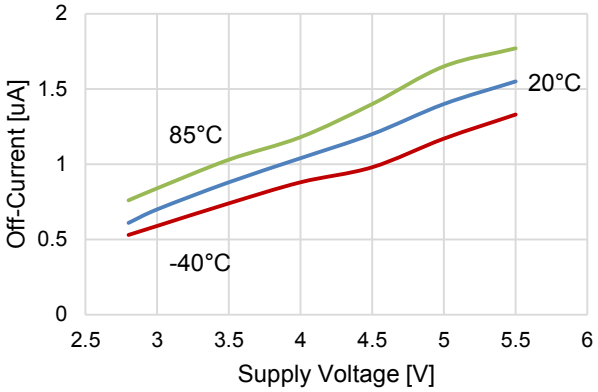
V_{IN} = 5V, V_{EN} = 5V, T_A = 25ºC, R_{ILIMIT} = 10 kΩ, C_{IN} = 1.0 µF, C_L = 10 µF, No Load, unless otherwise noted.



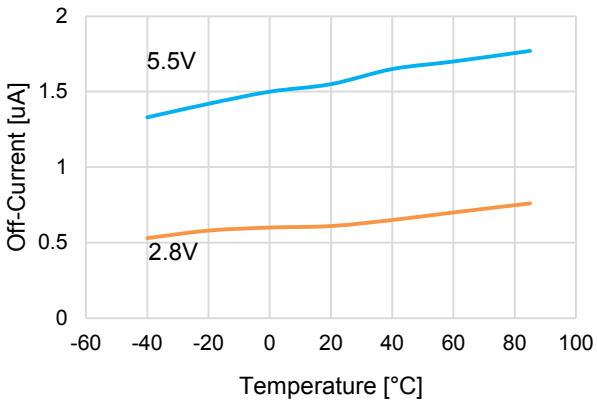
On-Current vs. Supply Voltage



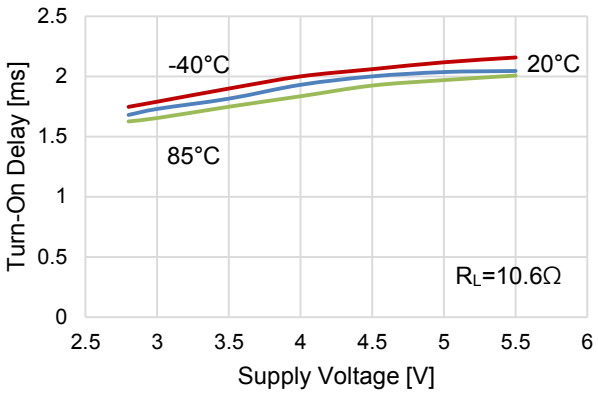
On-Current vs. Temperature



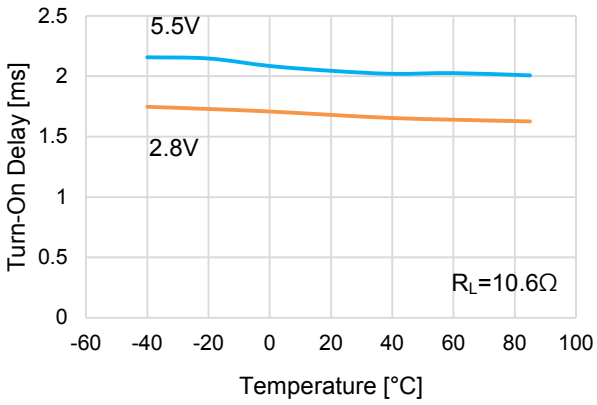
Off-Current vs. Supply Voltage



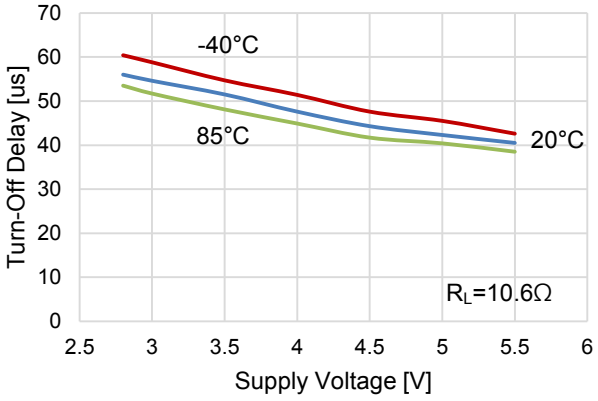
Off-Current vs. Temperature



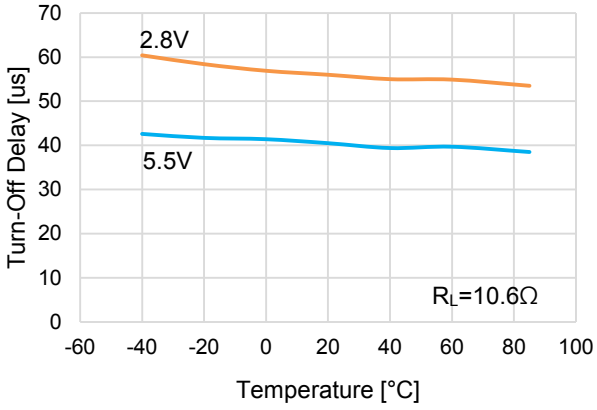
Turn On Delay Time vs. Supply Voltage



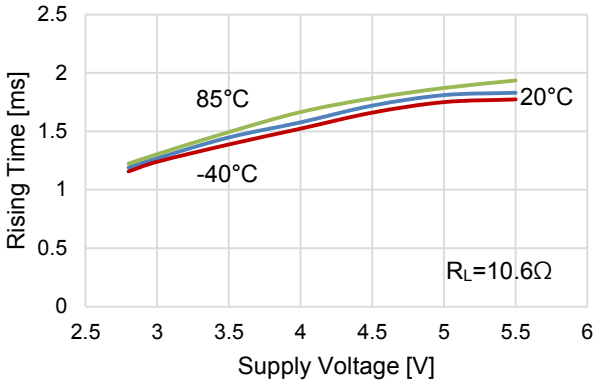
Turn On Delay Time vs. Temperature



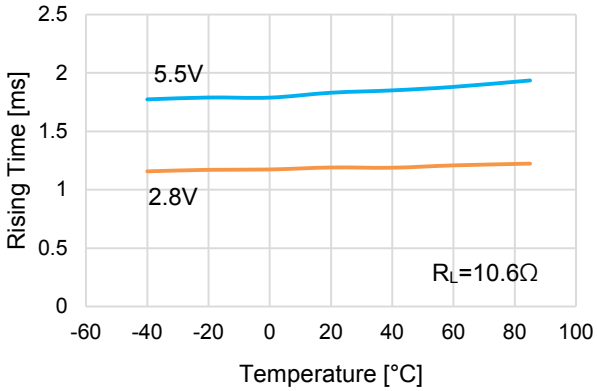
Turn Off Delay Time vs. Supply Voltage



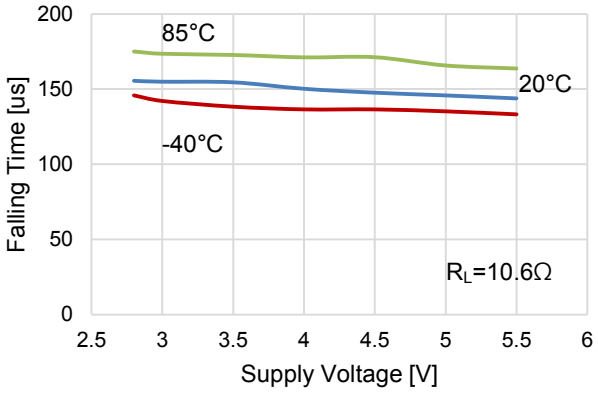
Turn Off Delay Time vs. Temperature



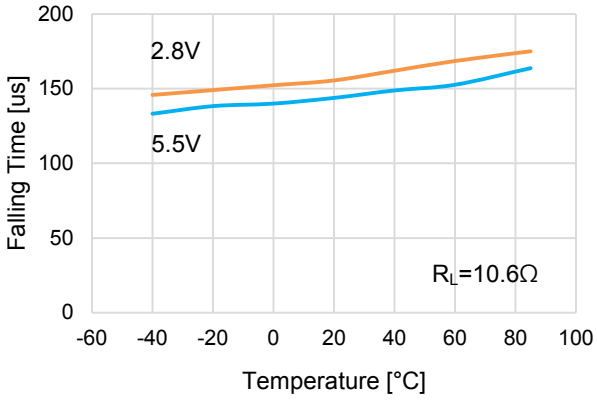
Rising Time vs. Supply Voltage



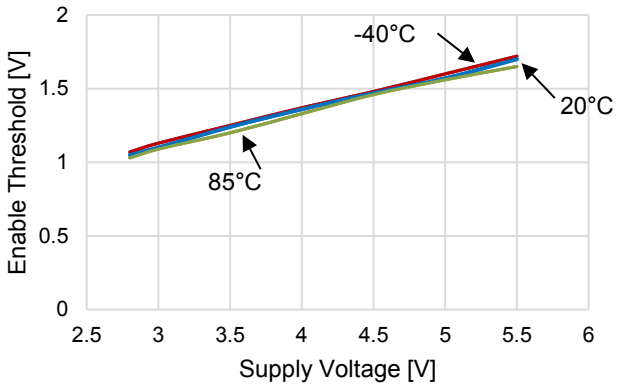
Rising Time vs. Temperature



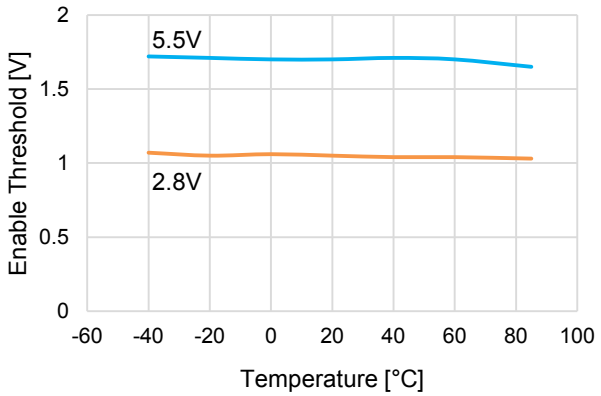
Falling Time vs. Supply Voltage



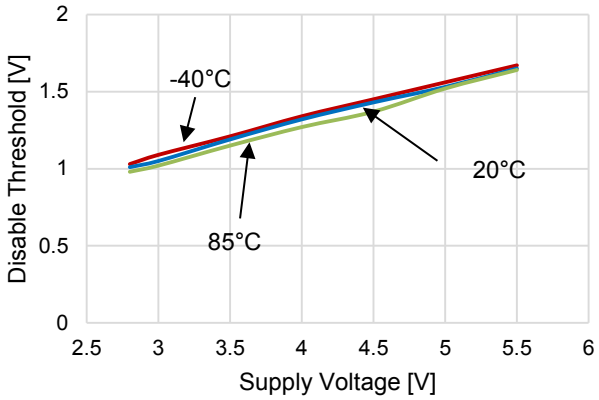
Falling Time vs. Temperature



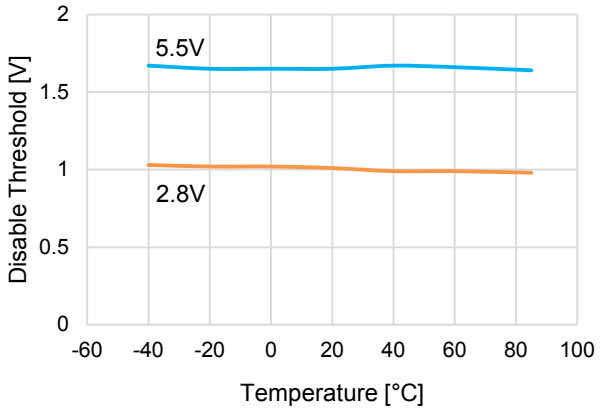
Enable Threshold vs. Supply Voltage



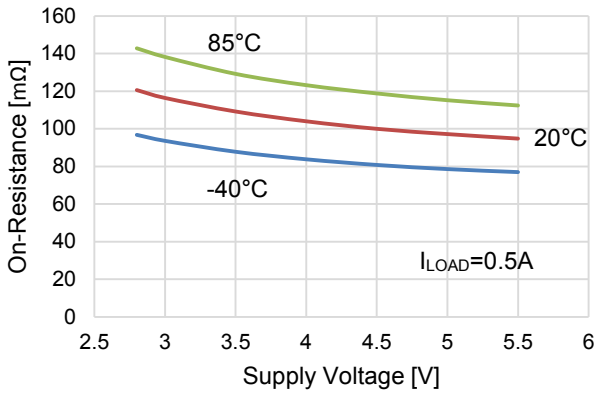
Enable Threshold vs. Temperature



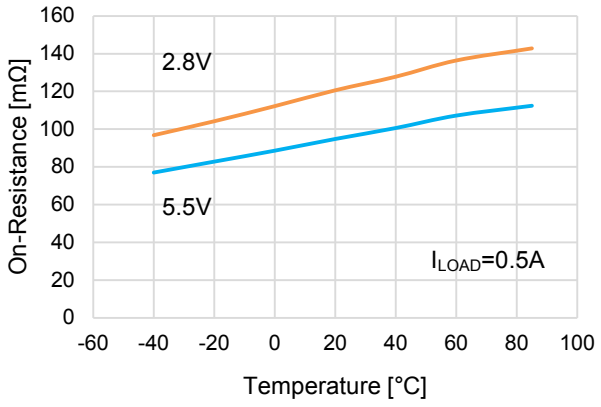
Disable Threshold vs. Supply Voltage



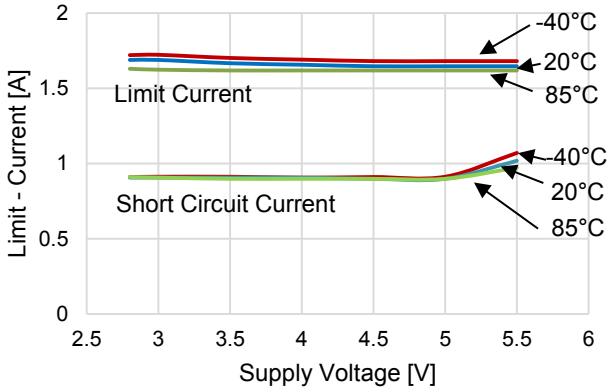
Disable Threshold vs. Temperature



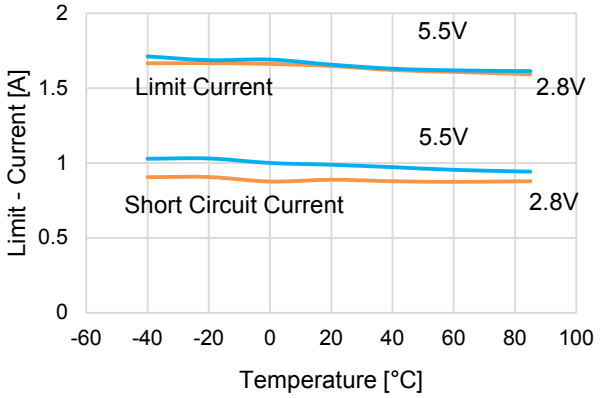
On-Resistance vs. Supply Voltage



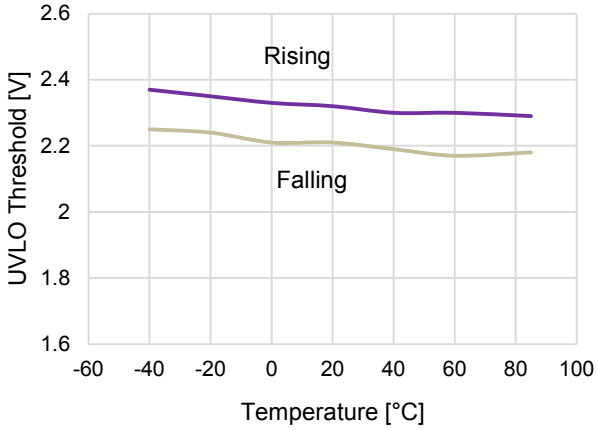
On-Resistance vs. Temperature



Current Limit & I_{SC} vs. Supply Voltage

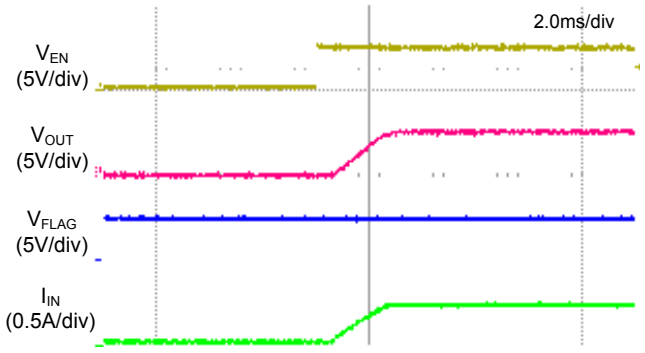


Current Limit & I_{SC} vs. Temperature

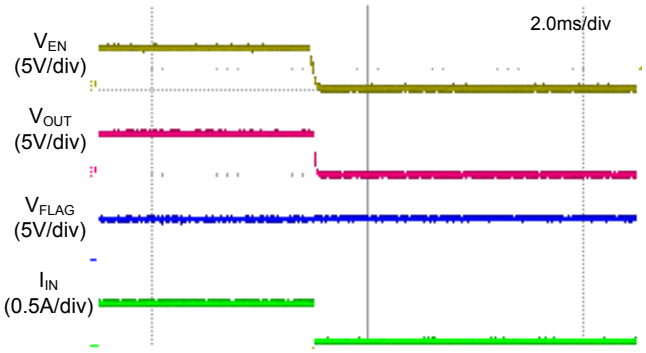


UVLO Threshold vs. Temperature

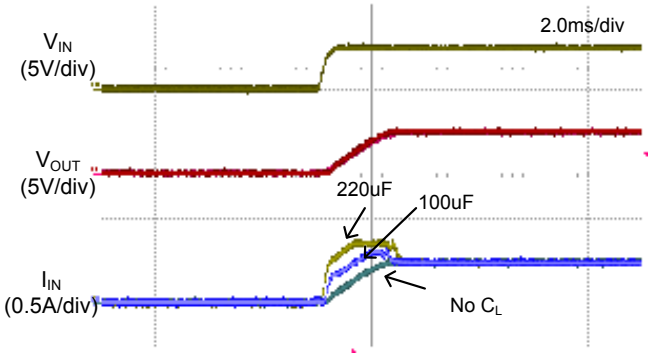
V_{IN} = 5V, V_{EN} = 5V, T_A = 25ºC, R_{ILIMIT} = 12 kΩ, C_{IN} = 1.0 µF, C_L = 10 µF, unless otherwise noted.



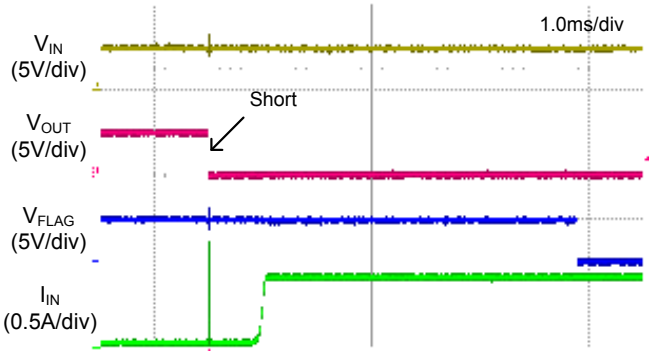
Turn ON



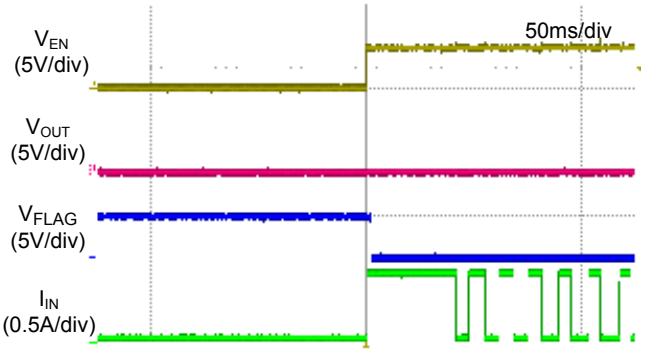
Turn OFF



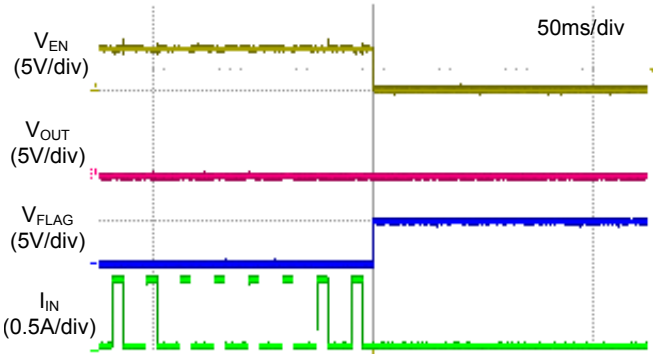
Inrush Current Response



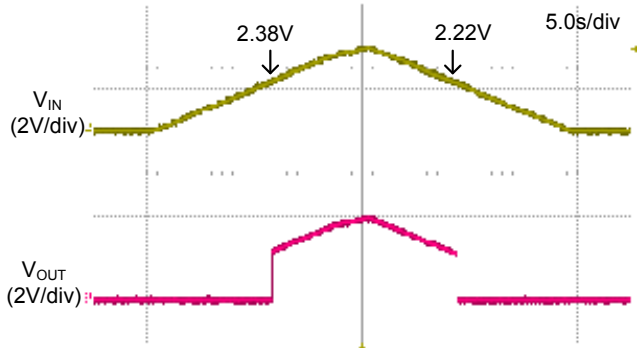
Short Circuit Response



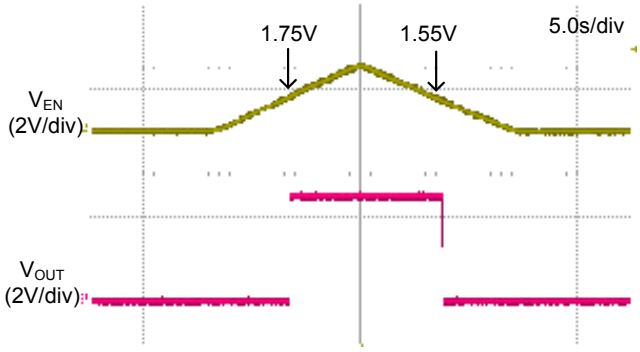
Enable into Short Circuit



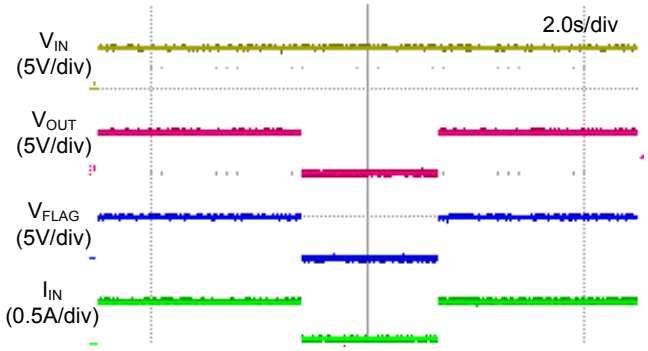
Disable from Short Circuit



UVLO



Enable Threshold



Thermal Shutdown

APPLICATION INFORMATION

SUPPLY FILTERING

A 0.1 μF to 10 μF bypass capacitor from IN pin to GND pin is recommended to control power supply transients. Recommend X5R or X7R dielectrics when using ceramic capacitors for input/output. Without this bypass capacitor, an output short can cause ringing from supply lead inductance on the input and damage the internal control circuitry.
Input or output transients must not exceed the absolute maximum supply voltage ($V_{IN(MAX)}$ = 6.5V).

POWER DISSIPATION

The device's junction temperature depends on several factors such as the load, PCB layout, ambient temperature, and package type. Equations that can be used to calculate power dissipation of each channel and junction temperature are found below:

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

Total power dissipation of the device will be the summation of P_D for both channels. To relate this to junction temperature, the following equation can be used:

$$T_J = P_D \times \theta_{JA} + T_A$$

Where:

T_J = Junction temperature
T_A = Ambient temperature
θ_{JA} = Thermal resistance of the package

ENABLE

The EN control pin must be driven to a logic high or logic low for a clearly defined signal input. Floating these control lines may cause unpredictable operation.

FAULT FLAG

The FLAG signal is open-drained output of N-channel MOSFET, the FLAG output is pulled low to signal the following fault conditions: output short to GND and thermal shutdown.

SOFT-START CONDITION

The TPS2553D has high impedance when off, which gradually shifts to low impedance as the chip turns on. This prevents an inrush current from causing voltage drops that result from charging a capacitive load and can pull the USB voltage bus below specified levels. This satisfies the USB voltage drop requirements for bus-powered applications.
The TPS2553D can provide inrush current limiting for applications with large load capacitances where C_L > 10 μF.

CURRENT SENSE

A sense MOSFET monitors the current supplied to the load. The sense MOSFET measures current more efficiently than conventional resistance methods. When an overload or short circuit is encountered, the current-sense circuitry sends a control signal to the driver. The driver in turn reduces the gate-source voltage and drives the power MOSFET into its saturation region, which switches the output into a constant-current mode and holds the current constant while varying the voltage on the load. When operating region of power MOSFET is close to saturation region, ON resistance of power MOSFET is made significantly increase. It can cause the operation of thermal protection before reaching to current limit level.

OVER-CURRENT AND SHORT-CIRCUIT PROTECTION

The TPS2553D features an over-current protection circuitry to protect the device against overload conditions.
The current limit threshold is user programmable via an external resistor. The TPS2553D provides an adjustable current limit threshold between 200 mA and 2.25 A (typ). The recommended 1% resistor range for R_{ILIMIT} is 7.46 kΩ to 80.06 kΩ. It protects the output MOSFET switch from damage due to undesirable short circuit conditions of excess inrush current often encountered during hot plug-in. Also the TPS2553D is including a fold back current limiting function for short-circuit protection. In the event of an output short-circuit condition, the current flowing through the switch is about 40~50% smaller than the current limit threshold (I_{LIM}). A short circuit current limit condition will signal the error flag. These features can protect the load system effectively at any accidental circumstances.
The following equations can be used to calculate the resulting current limit threshold and short circuit current for determining external resistor value (R_{ILIMIT}). However, in the equation do not consider tolerance factors like that processing variation from part to part, as well as variations in the voltage at IN and OUT, plus the operating temperature. Therefore current limit may be operated more than the calculated value.
When input voltage oscillates by external factors, input current also oscillates. It can cause the malfunction to current limit operation. In case of the peak value of current is increased more than set limit value, the current limit function of TPS2553D operates. Then the RMS value of the current limit may operate lower than a targeted level.

Equations for current limit:

$$I_{LIM(TYP)} = 17479.6 \times R_{ILIMIT}[k\Omega]^{-1.02}$$

$$I_{LIM(MIN)} = I_{LIM(TYP)}[mA] \times 0.98 - 90$$

$$I_{LIM(MAX)} = I_{LIM(TYP)}[mA] \times 1.02 + 90$$

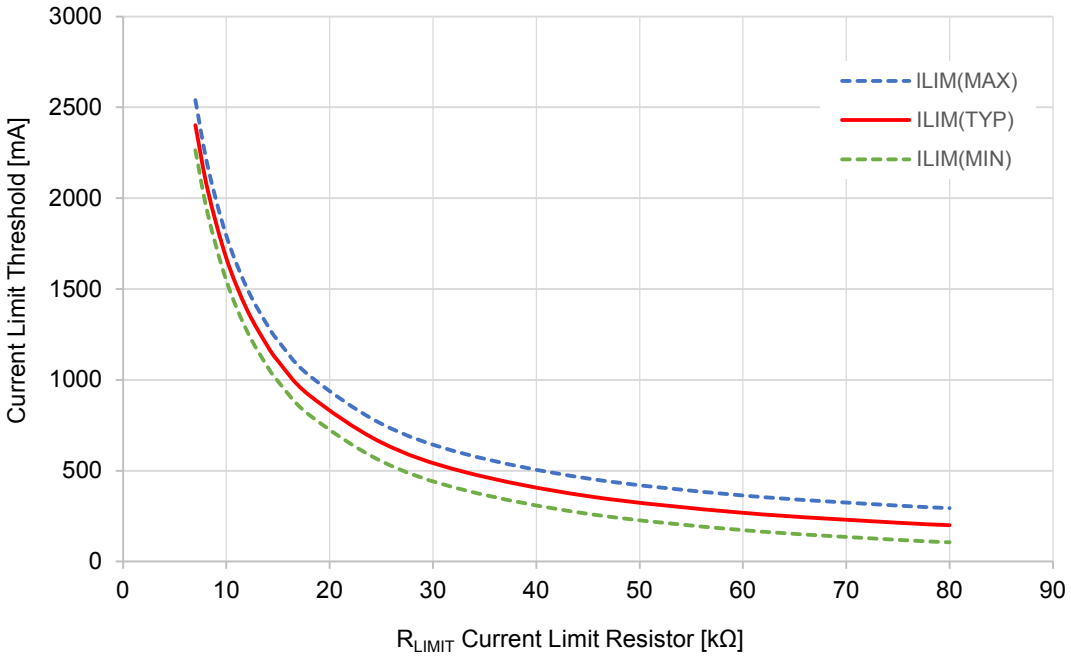


Table 1. Recommended R_{ILIMIT} Resistor Selections

R_{ILIMIT} [kΩ]	I_{LIM} [mA]			$I_{SC(TYP)}$ [mA]
	MIN	TYP	MAX	
80.06	106	200	294	112
53.80	204	300	396	168
40.58	302	400	498	224
32.61	400	500	600	280
27.27	498	600	702	336
23.44	596	700	804	392
20.57	694	800	906	448
18.32	792	900	1008	504
16.53	890	1000	1110	560
15.05	988	1100	1212	616
13.82	1086	1200	1314	672
12.78	1184	1300	1416	728
11.88	1282	1400	1518	784
11.11	1380	1500	1620	840
10.42	1478	1600	1722	896
9.82	1576	1700	1824	952
9.29	1674	1800	1926	1008
8.81	1772	1900	2028	1064
8.38	1870	2000	2130	1120
7.98	1968	2100	2232	1176
7.63	2066	2200	2334	1232
7.46	2115	2250	2385	1260

OVER TEMPERATURE PROTECTION

Thermal shutdown limits the TPS2553D junction temperature and protects the device from damage as a result of overheated.

Thermal protection turns off when the TPS2553D's junction temperature 150°C reached, allowing it to cool down until 130°C. The TPS2553D is reactivated when a junction temperature drops to approximately 130°C. It depends on the power dissipation, thermal resistance, and ambient temperature.

UNDERVOLTAGE LOCKOUT

Under Voltage Lockout (UVLO) prevents the output MOSFET from turning on until V_{IN} exceeds approximately 2.4V. After the switch turns on, if the voltage drops below 2.25V typically, UVLO shuts off the output MOSFET. Under voltage detection functions only works when the switch is enabled.

AUTO DISCHARGE FUNCTION

When the switch turns off from disable control input, UVLO or OTP, auto discharge function turns on. The auto-discharge function quickly lowers the V_{OUT} to the ground level by releasing the electrical charge accumulated in the external capacitor.

REVERSE CURRENT PROTECTION

The Reverse Current Protection circuit prevents the reverse current from V_{OUT} pin to V_{IN} pin when V_{OUT} becomes higher than V_{IN}.

PCB LAYOUT

The power circuitry of USB printed circuit boards requires a customized layout to maximize thermal dissipation and to minimize voltage drop and EMI.

REVISION NOTICE

The description in this datasheet is subject to change without any notice to describe its electrical characteristics properly.