

電流制限付き配電スイッチ

1 特長

- 70mΩ ハイサイド MOSFET
- 1A の連続電流
- 過熱および短絡保護
- 正確な電流制限 (最小 1.1A、最大 1.9A)
- 動作範囲: 2.7V~5.5V
- 0.6ms の立ち上がり時間 (代表値)
- 低電圧誤動作防止
- デグリッチ フォルトレポート (\overline{OC})
- 電源投入時の \overline{OC} グリッチなし
- スタンバイ時電源電流: 最大 1μA
- 双方向スイッチ
- 周囲温度範囲: -40°C~85°C
- ソフトスタート機能内蔵
- UL 認定済み: ファイル番号 E169910

2 アプリケーション

- 大きな容量性負荷
- 短絡保護

3 概要

TPS206x 配電スイッチは、大きな容量性負荷と短絡が発生しやすいアプリケーションを対象としています。このデバイスは、複数のパワー スイッチを 1 つのパッケージに搭載する必要があるパワー ディストリビューション システム向けに、70mΩ N チャネル MOSFET パワー スイッチを内蔵しています。各スイッチは、ロジック イネーブル入力によって制御されます。ゲートドライブは、スイッチング中の電流サーージを最小限に抑えるためにパワー スイッチの立ち上がり時間と立ち下がり時間を制御するように設計された、内部チャージポンプによって提供されています。チャージポンプには外付け部品が不要で、最低 2.7V の電源で動作できます。

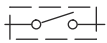
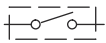
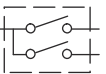
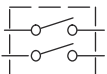
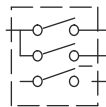
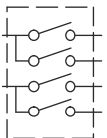
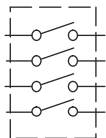
GENERAL SWITCH CATALOG						
33 mΩ, Single	80 mΩ, Single	80 mΩ, Dual	80 mΩ, Dual	80 mΩ, Triple	80 mΩ, Quad	80 mΩ, Quad
						
TPS201xA 0.2 A to 2 A TPS202x 0.2 A to 2 A TPS203x 0.2 A to 2 A	TPS2014 600 mA TPS2015 1 A TPS2041B 500 mA TPS2051B 500 mA TPS2045A 250 mA TPS2049 100 mA TPS2055A 250 mA TPS2061 1 A TPS2065 1 A TPS2068 1.5 A TPS2069 1.5 A	TPS2042B 500 mA TPS2052B 500 mA TPS2046B 250 mA TPS2056 250 mA TPS2062 1 A TPS2066 1 A TPS2060 1.5 A TPS2064 1.5 A	TPS2080 500 mA TPS2081 500 mA TPS2082 500 mA TPS2090 250 mA TPS2091 250 mA TPS2092 250 mA	TPS2043B 500 mA TPS2053B 500 mA TPS2047B 250 mA TPS2057A 250 mA TPS2063 1 A TPS2067 1 A	TPS2044B 500 mA TPS2054B 500 mA TPS2048A 250 mA TPS2058 250 mA	TPS2085 500 mA TPS2086 500 mA TPS2087 500 mA TPS2095 250 mA TPS2096 250 mA TPS2097 250 mA



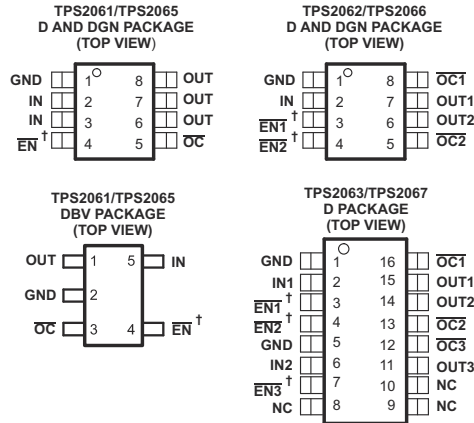
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4 概要 (続き)

出力負荷が電流制限スレッシュホールドを超えた場合、または短絡が存在する場合、デバイスは定電流モードに切り替えて過電流 (OCx) ロジック出力を **Low** にすることで、出力電流を安全なレベルに制限します。連続的に大きな過負荷と短絡が発生すると、スイッチの電力散逸が増加し、接合部温度が上昇すると、熱保護回路によってスイッチがシャットオフされ、損傷を防止します。デバイスの温度が十分に低下すると、自動的にサーマル・シャットダウンからの回復が行われます。内部回路により、有効な入力電圧が印加されるまでスイッチがオフに維持されます。この配電スイッチは、電流制限を **1.5A** (代表値) に設定するように設計されています。

5 Pin Configuration and Functions



† All Enable Inputs Are Active High For TPS2065, TPS2066, and TPS2067

表 5-1. Pin Functions (TPS2061 and TPS2065)

NAME	PINS		I/O	DESCRIPTION
	D or DGN Package	DBV Package		
	TPS2061	TPS2065		
EN	4	-	I	Enable input, logic low turns on power switch
EN	-	4	I	Enable input, logic high turns on power switch
GND	1	1		Ground
IN	2, 3	2,3	I	Input voltage
OC	5	5	O	Overcurrent, open-drain output, active-low
OUT	6, 7, 8	6, 7, 8	O	Power-switch output
PowerPAD™	-	-		Internally connected to GND; used to heat-sink the part to the circuit board traces. Must be connected to GND pin.

表 5-2. Pin Functions (TPS2062 and TPS2066)

NAME	PINS		I/O	DESCRIPTION
	NO.			
	TPS2062	TPS2066		
EN1	3	-	I	Enable input, logic low turns on power switch IN-OUT1
EN2	4	-	I	Enable input, logic low turns on power switch IN-OUT2
EN1	-	3	I	Enable input, logic high turns on power switch IN-OUT1
EN2	-	4	I	Enable input, logic high turns on power switch IN-OUT2
GND	1	1		Ground
IN	2	2	I	Input voltage
OC1	8	8	O	Overcurrent, open-drain output, active low, IN-OUT1
OC2	5	5	O	Overcurrent, open-drain output, active low, IN-OUT2
OUT1	7	7	O	Power-switch output, IN-OUT1
OUT2	6	6	O	Power-switch output, IN-OUT2
PowerPAD™	-	-		Internally connected to GND; used to heat-sink the part to the circuit board traces. Must be connected to GND pin.

表 5-3. Pin Functions (TPS2063 and TPS2067)

NAME	PINS		I/O	DESCRIPTION
	TPS2063	TPS2067		
EN1	3	–	I	Enable input, logic low turns on power switch IN1-OUT1
EN2	4	–	I	Enable input, logic low turns on power switch IN1-OUT2
EN3	7	–	I	Enable input, logic low turns on power switch IN2-OUT3
EN1	–	3	I	Enable input, logic high turns on power switch IN1-OUT1
EN2	–	4	I	Enable input, logic high turns on power switch IN1-OUT2
EN3	–	7	I	Enable input, logic high turns on power switch IN2-OUT3
GND	1, 5	1, 5		Ground
IN1	2	2	I	Input voltage for OUT1 and OUT2
IN2	6	6	I	Input voltage for OUT3
NC	8, 9, 10	8, 9, 10		No connection
$\overline{OC1}$	16	16	O	Overcurrent, open-drain output, active low, IN1-OUT1
$\overline{OC2}$	13	13	O	Overcurrent, open-drain output, active low, IN1-OUT2
$\overline{OC3}$	12	12	O	Overcurrent, open-drain output, active low, IN2-OUT3
OUT1	15	15	O	Power-switch output, IN1-OUT1
OUT2	14	14	O	Power-switch output, IN1-OUT2
OUT3	11	11	O	Power-switch output, IN2-OUT3

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range unless otherwise noted⁽¹⁾

		UNIT
Input voltage range, $V_{I(IN)}$ ⁽²⁾		-0.3 V to 6 V
Output voltage range, $V_{O(OUT)}$ ⁽²⁾ , $V_{O(OUTx)}$		-0.3 V to 6 V
Input voltage range, $V_{I(EN)}$, $V_{I(ENx)}$, $V_{I(EN\bar{x})}$, $V_{I(ENx)}$		-0.3 V to 6 V
Voltage range, $V_{I(\overline{OC})}$, $V_{I(\overline{OCx})}$		-0.3 V to 6 V
Continuous output current, $I_{O(OUT)}$, $I_{O(OUTx)}$		Internally limited
Operating virtual junction temperature range, T_J		-40°C to 150°C
Electrostatic discharge (ESD) protection	Human body model	2 kV
	Charge device model (CDM)	500 V

- (1) 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 under *recommended operating conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltages are with respect to GND.

6.2 Recommended Operating Conditions

	MIN	MAX	UNIT
Input voltage, $V_{I(IN)}$	2.7	5.5	V
Input voltage, $V_{I(EN)}$, $V_{I(ENx)}$, $V_{I(EN\bar{x})}$, $V_{I(ENx)}$	0	5.5	V
Continuous output current, $I_{O(OUT)}$, $I_{O(OUTx)}$	0	1	A
Operating virtual junction temperature, T_J	-40	125	°C

6.3 Thermal Information

THERMAL METRIC ⁽¹⁾		D (SOIC)		DBV (SOT-23)	DGN (HVSSOP)	UNIT
		8 PINS	16 PINS	5 PINS	8 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	119.3	81.6	208.6	53.6	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	67.6	42.7	122.9	58.7	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	59.6	39.1	37.8	35.5	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	20.3	10.4	14.6	2.7	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	59.1	38.8	36.9	35.3	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	N/A	N/A	6.7	°C/W

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

6.4 Electrical Characteristics

over recommended operating junction temperature range, $V_{I(IN)} = 5.5$ V, $I_O = 1$ A, $V_{I(EN\bar{x})} = 0$ V, or $V_{I(ENx)} = 5.5$ V (unless otherwise noted)

PARAMETER		TEST CONDITIONS ⁽¹⁾		MIN	TYP	MAX	UNIT
POWER SWITCH							
$r_{DS(on)}$	Static drain-source on-state resistance, 5-V operation and 3.3-V operation	$V_{I(IN)} = 5$ V or 3.3 V, $I_O = 1$ A, $-40^\circ\text{C} \leq T_J \leq 125^\circ\text{C}$	D and DGN packages	70	135	mΩ	
			DBV package	95	140		
	Static drain-source on-state resistance, 2.7-V operation	$V_{I(IN)} = 2.7$ V, $I_O = 1$ A, $-40^\circ\text{C} \leq T_J \leq 125^\circ\text{C}$	D and DGN packages	75	150	mΩ	

6.4 Electrical Characteristics (続き)

over recommended operating junction temperature range, $V_{I(IN)} = 5.5\text{ V}$, $I_O = 1\text{ A}$, $V_{I(EN\bar{x})} = 0\text{ V}$, or $V_{I(ENx)} = 5.5\text{ V}$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS ⁽¹⁾		MIN	TYP	MAX	UNIT
t_r	Rise time, output	$V_{I(IN)} = 5.5\text{ V}$	$C_L = 1\text{ }\mu\text{F}$, $R_L = 5\text{ }\Omega$, $T_J = 25^\circ\text{C}$	0.6	1.5	ms	
		$V_{I(IN)} = 2.7\text{ V}$		0.4	1		
t_f	Fall time, output	$V_{I(IN)} = 5.5\text{ V}$		0.05	0.5		
		$V_{I(IN)} = 2.7\text{ V}$		0.05	0.5		
ENABLE INPUT $\bar{E}N$ OR EN							
V_{IH}	High-level input voltage	$2.7\text{ V} \leq V_{I(IN)} \leq 5.5\text{ V}$		2			V
V_{IL}	Low-level input voltage	$2.7\text{ V} \leq V_{I(IN)} \leq 5.5\text{ V}$				0.8	V
I_I	Input current	$V_{I(EN\bar{x})} = 0\text{ V}$ or 5.5 V , $V_{I(ENx)} = 0\text{ V}$ or 5.5 V		-0.5		0.5	μA
t_{on}	Turnon time	$C_L = 100\text{ }\mu\text{F}$, $R_L = 5\text{ }\Omega$				3	ms
t_{off}	Turnoff time	$C_L = 100\text{ }\mu\text{F}$, $R_L = 5\text{ }\Omega$				10	
CURRENT LIMIT							
I_{OS}	Short-circuit output current	$V_{I(IN)} = 5\text{ V}$, OUT connected to GND, device enabled into short-circuit	$T_J = 25^\circ\text{C}$	1.1	1.5	1.9	A
				$-40^\circ\text{C} \leq T_J \leq 125^\circ\text{C}$			
$I_{OC}^{(2)}$	Overcurrent trip threshold	$V_{I(IN)} = 5\text{ V}$, current ramp ($\leq 100\text{ A/s}$) on OUT	TPS2063, TPS2067	1.6	2.4	3.0	A
SUPPLY CURRENT (TPS2061, TPS2065)							
Supply current, low-level output	No load on OUT, $V_{I(EN\bar{x})} = 5.5\text{ V}$, or $V_{I(ENx)} = 0\text{ V}$	$T_J = 25^\circ\text{C}$	TPS2061 TPS2065	0.5	1	μA	
				$-40^\circ\text{C} \leq T_J \leq 125^\circ\text{C}$			0.5
Supply current, high-level output	No load on OUT, $V_{I(EN\bar{x})} = 0\text{ V}$, or $V_{I(ENx)} = 5.5\text{ V}$	$T_J = 25^\circ\text{C}$	TPS2061 TPS2065	75	95	μA	
				$-40^\circ\text{C} \leq T_J \leq 125^\circ\text{C}$			75
Leakage current	OUT connected to ground, $V_{I(EN)} = 5.5\text{ V}$, or $V_{I(EN)} = 0\text{ V}$	$-40^\circ\text{C} \leq T_J \leq 125^\circ\text{C}$		1		μA	
Reverse leakage current	$V_{I(OUTx)} = 5.5\text{ V}$, IN = ground	$T_J = 25^\circ\text{C}$		0		μA	
SUPPLY CURRENT (TPS2062, TPS2066)							
Supply current, low-level output	No load on OUT, $V_{I(EN\bar{x})} = 5.5\text{ V}$, or $V_{I(ENx)} = 0\text{ V}$	$T_J = 25^\circ\text{C}$		0.5	1	μA	
				$-40^\circ\text{C} \leq T_J \leq 125^\circ\text{C}$			0.5
Supply current, high-level output	No load on OUT, $V_{I(EN\bar{x})} = 0\text{ V}$, or $V_{I(ENx)} = 5.5\text{ V}$	$T_J = 25^\circ\text{C}$		95	120	μA	
				$-40^\circ\text{C} \leq T_J \leq 125^\circ\text{C}$			95
Leakage current	OUT connected to ground, $V_{I(ENx)} = 5.5\text{ V}$, or $V_{I(ENx)} = 0\text{ V}$	$-40^\circ\text{C} \leq T_J \leq 125^\circ\text{C}$		1		μA	
Reverse leakage current	$V_{I(OUTx)} = 5.5\text{ V}$, IN = ground	$T_J = 25^\circ\text{C}$		0.2		μA	
SUPPLY CURRENT (TPS2063, TPS2067)							
Supply current, low-level output	No load on OUT, $V_{I(EN\bar{x})} = 0\text{ V}$	$T_J = 25^\circ\text{C}$		0.5	2	μA	
				$-40^\circ\text{C} \leq T_J \leq 125^\circ\text{C}$			0.5
Supply current, high-level output	No load on OUT, $V_{I(EN\bar{x})} = 5.5\text{ V}$	$T_J = 25^\circ\text{C}$		65	90	μA	
				$-40^\circ\text{C} \leq T_J \leq 125^\circ\text{C}$			65
Leakage current	OUT connected to ground, $V_{I(EN\bar{x})} = 5.5\text{ V}$, or $V_{I(ENx)} = 0\text{ V}$	$-40^\circ\text{C} \leq T_J \leq 125^\circ\text{C}$		1		μA	
Reverse leakage current	$V_{I(OUTx)} = 5.5\text{ V}$, INx = ground	$T_J = 25^\circ\text{C}$		0.2		μA	
UNDERVOLTAGE LOCKOUT (TPS2063, TPS2067)							
Low-level input voltage, IN				2		2.5	V
Hysteresis, IN				$T_J = 25^\circ\text{C}$		75	mV
UNDERVOLTAGE LOCKOUT (TPS2061, TPS2062, TPS2065, TPS2066)							
Low-level input voltage, IN				2		2.6	V
Hysteresis, IN				$T_J = 25^\circ\text{C}$		75	mV
OVERCURRENT $\bar{OC}1$ and $\bar{OC}2$							
Output low voltage, $V_{OL(OCx)}$		$I_{O(\bar{OC}x)} = 5\text{ mA}$				0.4	V
Off-state current		$V_{O(\bar{OC}x)} = 5\text{ V}$ or 3.3 V				1	μA

6.4 Electrical Characteristics (続き)

over recommended operating junction temperature range, $V_{I(IN)} = 5.5\text{ V}$, $I_O = 1\text{ A}$, $V_{I(EN\bar{X})} = 0\text{ V}$, or $V_{I(ENx)} = 5.5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS ⁽¹⁾	MIN	TYP	MAX	UNIT
OC deglitch	OCX assertion or deassertion	4	8	15	ms
THERMAL SHUTDOWN⁽³⁾					
Thermal shutdown threshold		135			°C
Recovery from thermal shutdown		125			°C
Hysteresis			10		°C

- (1) Pulse-testing techniques maintain junction temperature close to ambient temperature; thermal effects must be taken into account separately.
- (2) TPS2061, TSP2062, TPS2065, and TPS2066 do not have overcurrent trip threshold. Current is limited to I_{OS} under different test condition. Check [セクション 8.7](#) for more details.
- (3) The thermal shutdown only reacts under overcurrent conditions.

6.5 Typical Characteristics (TPS2061, TPS2062, TPS2065, and TPS2066)

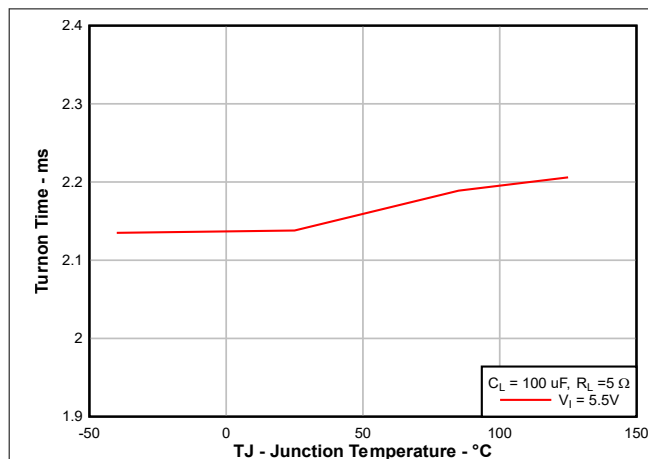


図 6-1. Turnon Time vs Junction Temperature

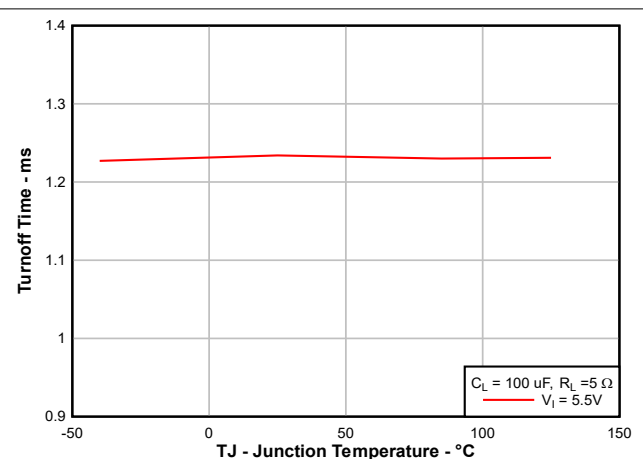


図 6-2. Turnoff Time vs Junction Temperature

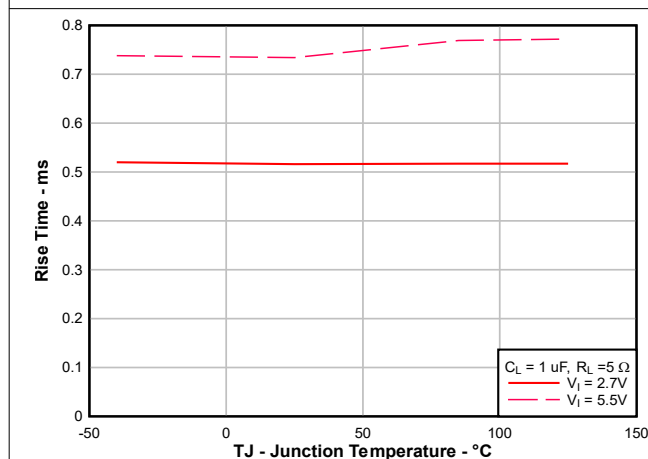


図 6-3. Rise Time vs Junction Temperature

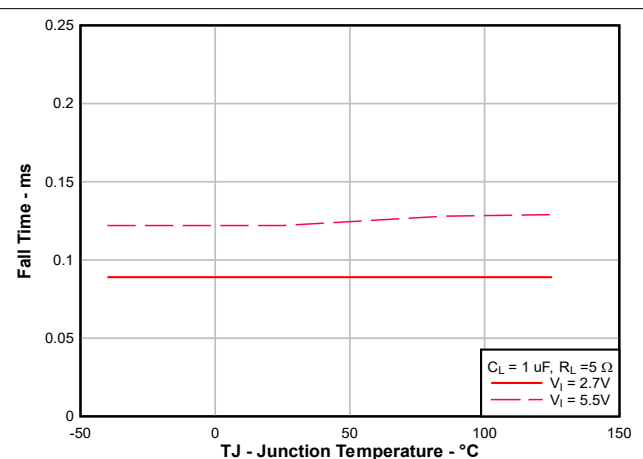


図 6-4. Fall Time vs Junction Temperature

6.5 Typical Characteristics (TPS2061, TPS2062, TPS2065, and TPS2066) (continued)

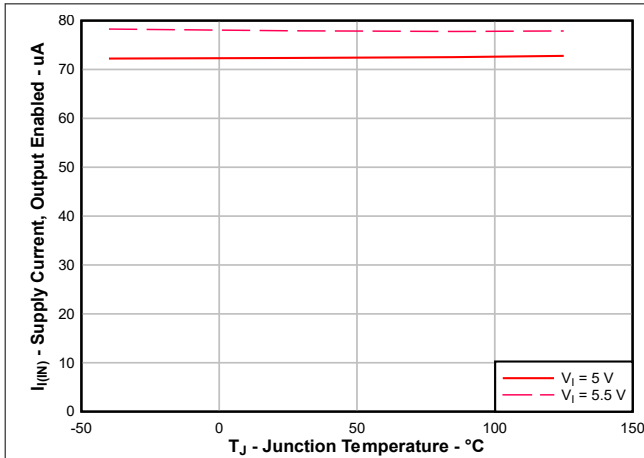


图 6-5. TPS2065DBV Supply Current, Output Enabled vs Junction Temperature

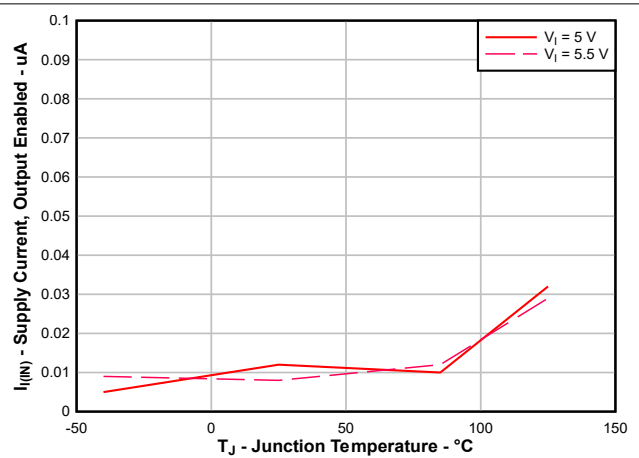


图 6-6. TPS2065DBV Supply Current, Output Disabled vs Junction Temperature

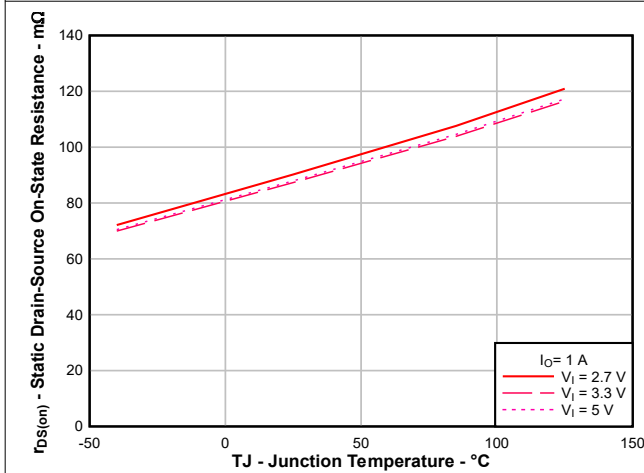


图 6-7. DBV Package Static Drain-Source on-State Resistance vs Junction Temperature

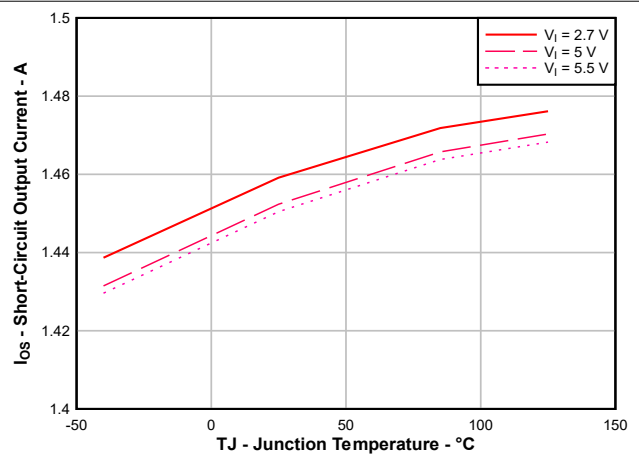


图 6-8. Short-Circuit Output Current vs Junction Temperature

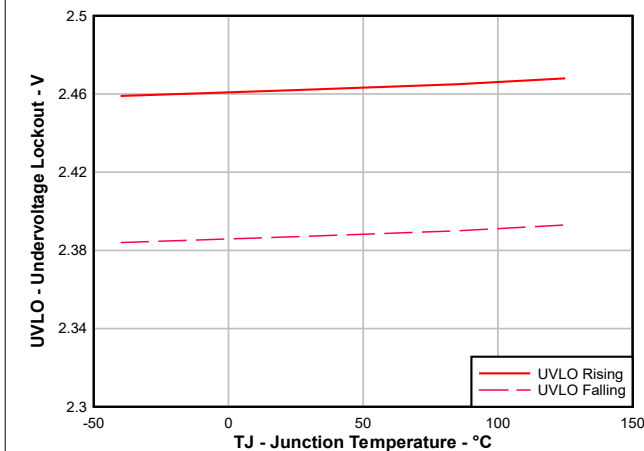


图 6-9. Undervoltage Lockout vs Junction Temperature

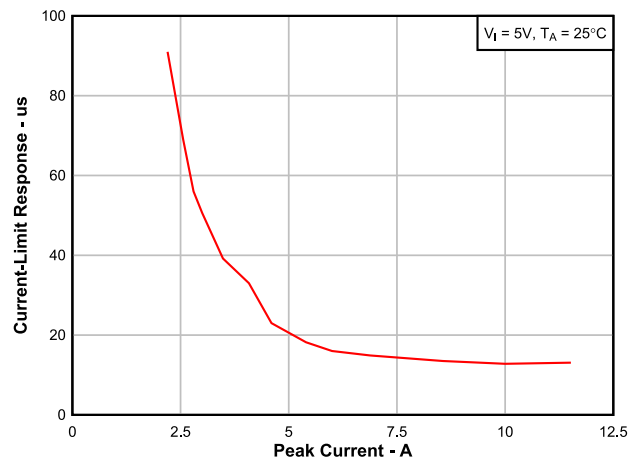


图 6-10. Current-Limit Response vs Peak Current

6.5 Typical Characteristics (TPS2061, TPS2062, TPS2065, and TPS2066) (continued)

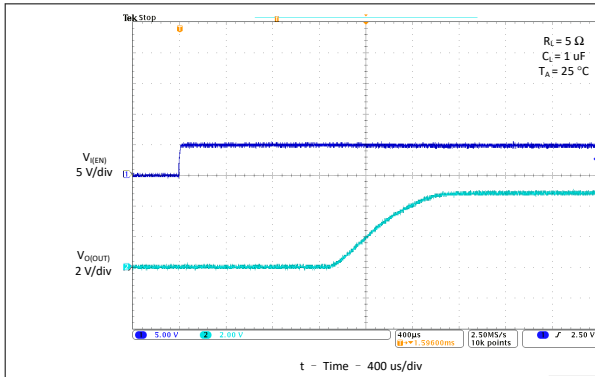


图 6-11. Turnon Delay and Rise Time With 1-µF Load

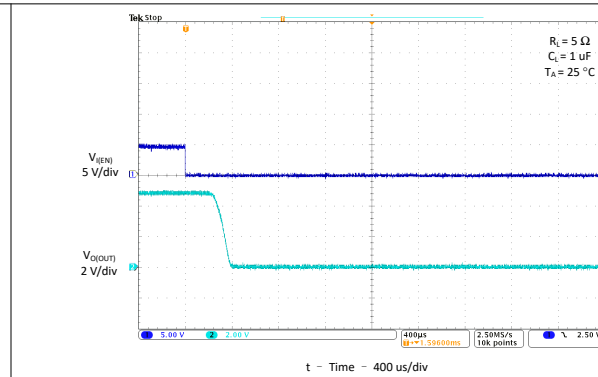


图 6-12. Turnoff Delay and Fall Time With 1-µF Load

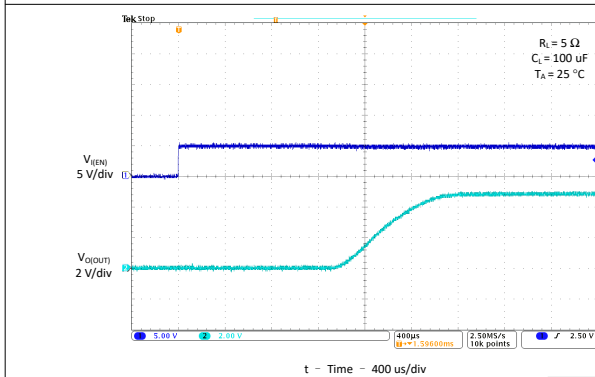


图 6-13. Turnon Delay and Rise Time With 100-µF Load

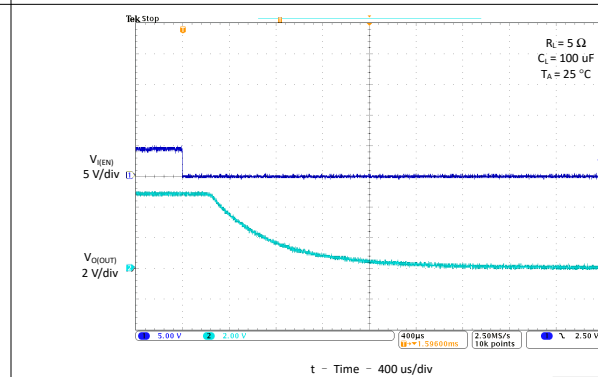


图 6-14. Turnoff Delay and Fall Time With 100-µF Load

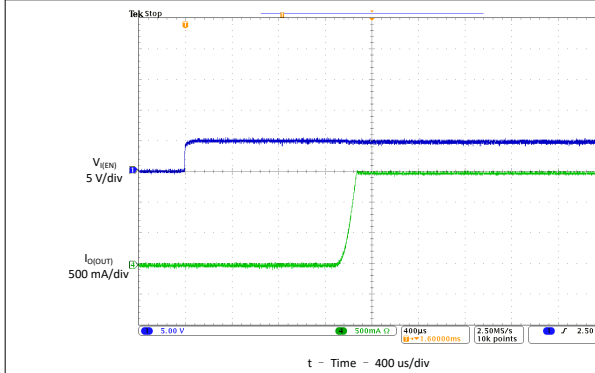


图 6-15. Short-Circuit Current, Device Enabled Into Short

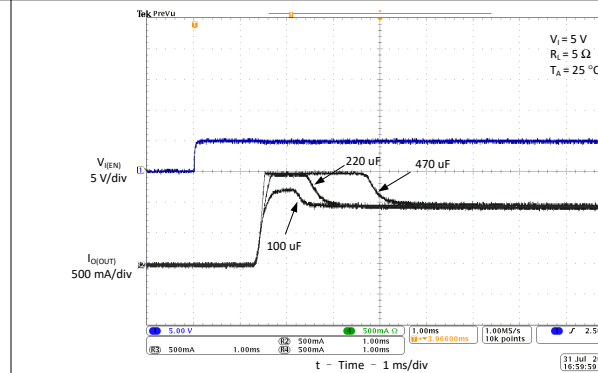


图 6-16. Inrush Current With Different Load Capacitance

6.5 Typical Characteristics (TPS2061, TPS2062, TPS2065, and TPS2066) (continued)

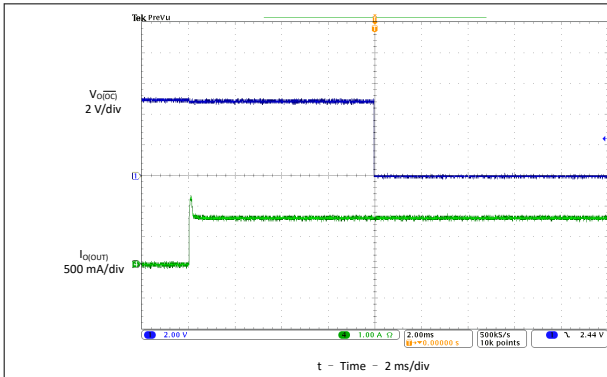


図 6-17. 3-Ω Load Connected to Enabled Device

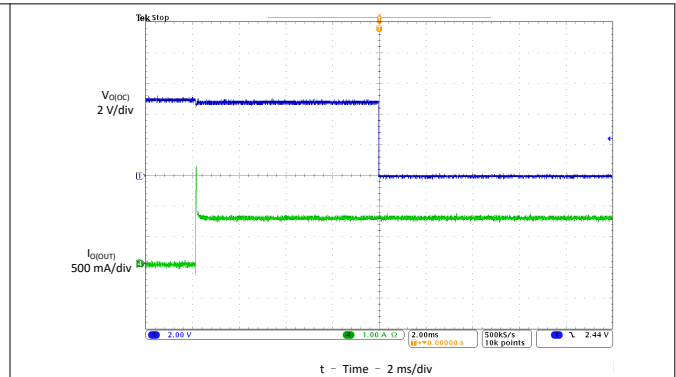


図 6-18. 2-Ω Load Connected to Enabled Device

6.6 Typical Characteristics (TPS2063 & TPS2067)

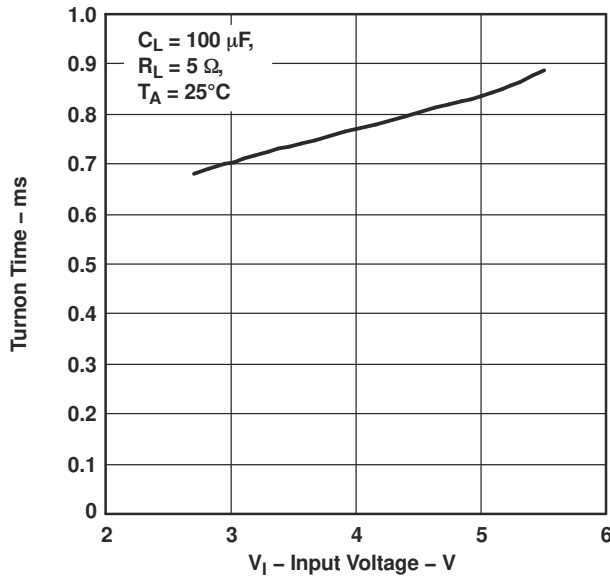


図 6-19. TURNON TIME vs INPUT VOLTAGE

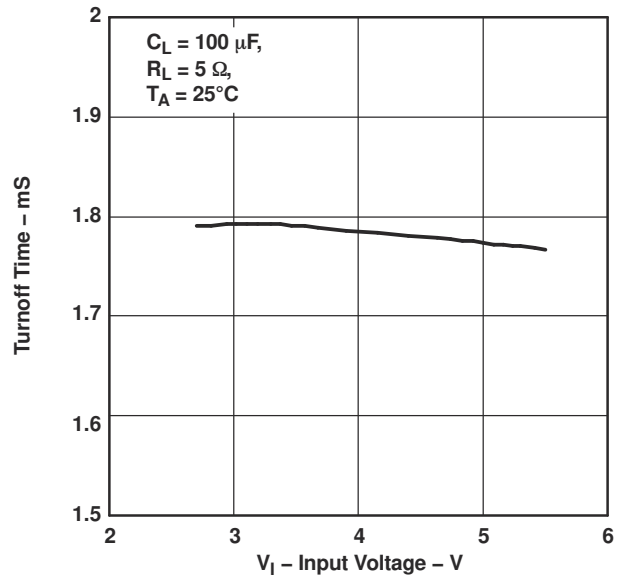


図 6-20. TURNOFF TIME vs INPUT VOLTAGE

6.6 Typical Characteristics (TPS2063 & TPS2067) (continued)

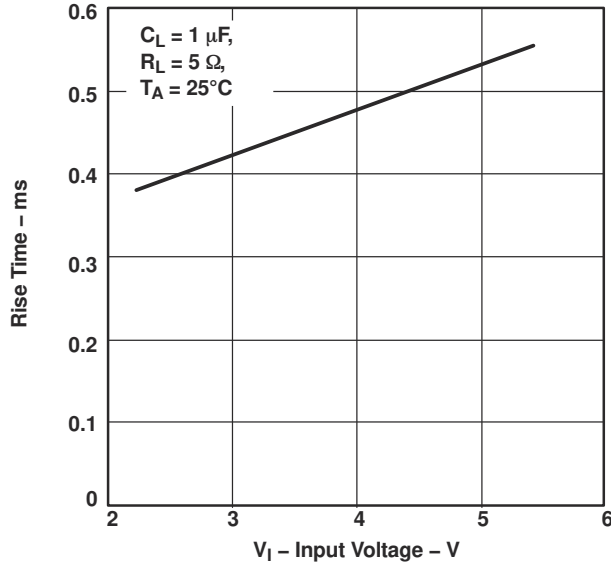


图 6-21. RISE TIME vs INPUT VOLTAGE

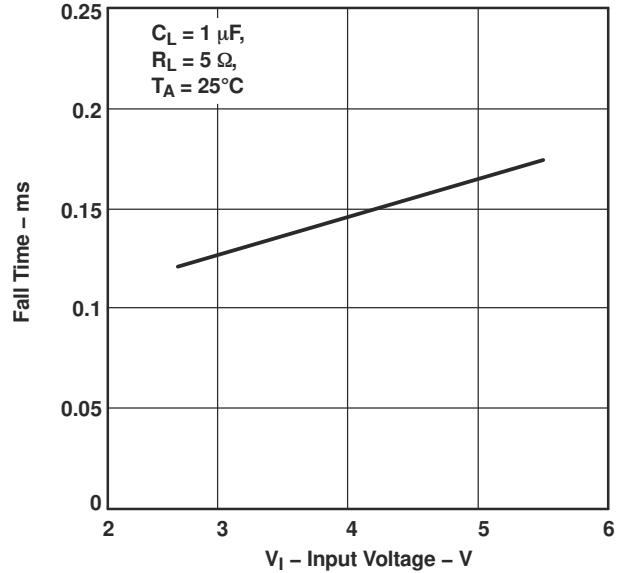


图 6-22. FALL TIME vs INPUT VOLTAGE

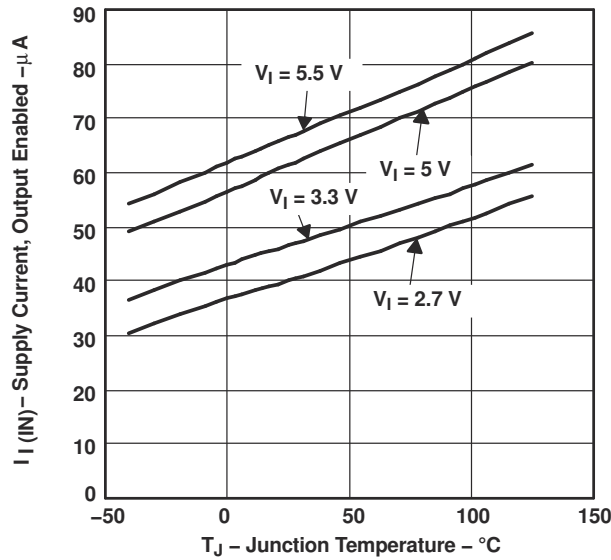


图 6-23. TPS2063, TPS2067 SUPPLY CURRENT, OUTPUT ENABLED vs JUNCTION TEMPERATURE

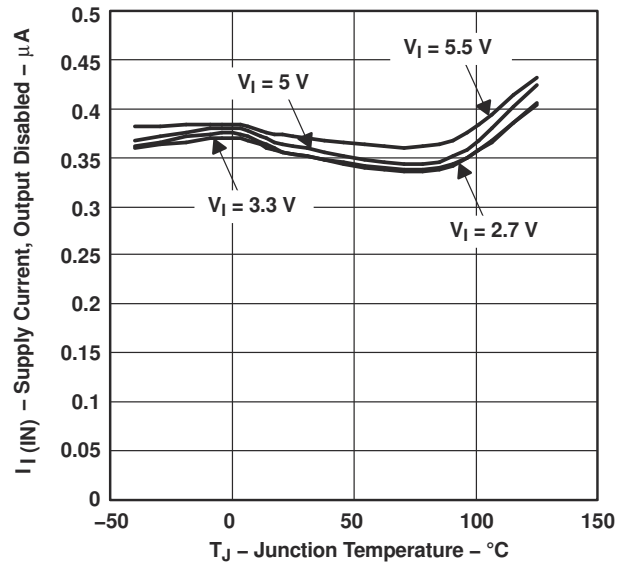
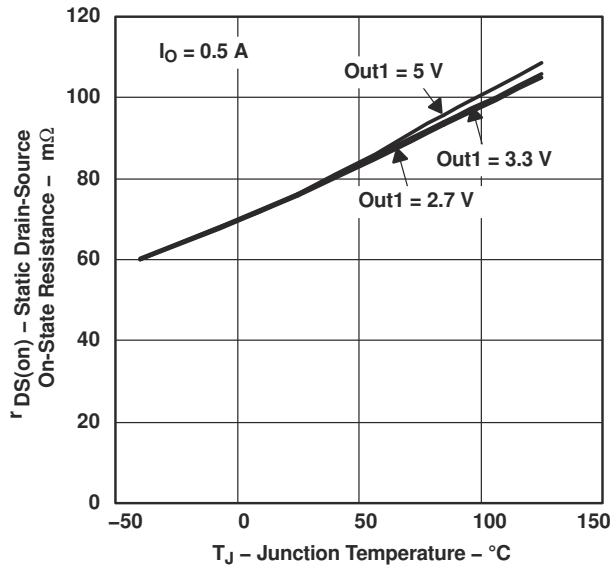
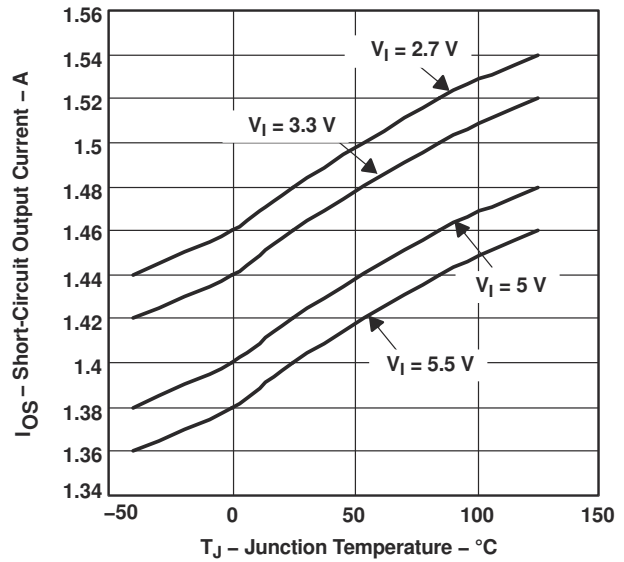


图 6-24. TPS2063, TPS2067 SUPPLY CURRENT, OUTPUT DISABLED vs JUNCTION TEMPERATURE

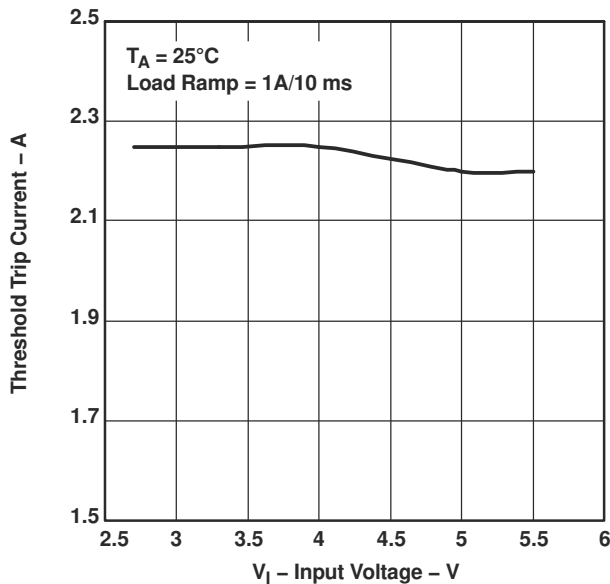
6.6 Typical Characteristics (TPS2063 & TPS2067) (continued)



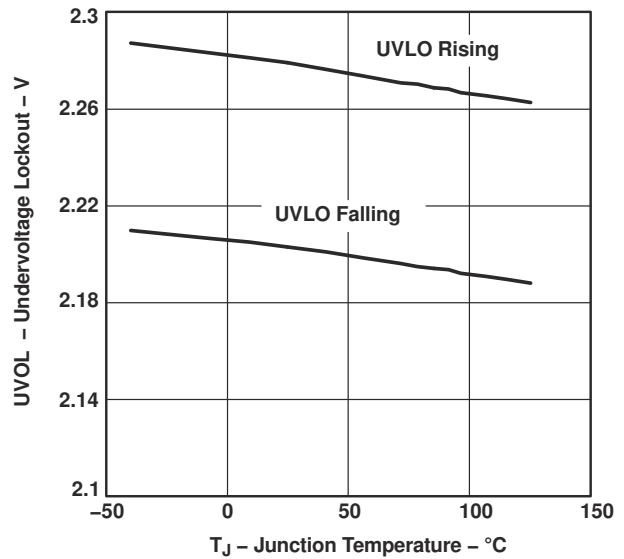
6-25. STATIC DRAIN-SOURCE ON-STATE RESISTANCE vs JUNCTION TEMPERATURE



6-26. SHORT-CIRCUIT OUTPUT CURRENT vs JUNCTION TEMPERATURE



6-27. THRESHOLD TRIP CURRENT vs INPUT VOLTAGE



6-28. UNDERVOLTAGE LOCKOUT vs JUNCTION TEMPERATURE

6.6 Typical Characteristics (TPS2063 & TPS2067) (continued)

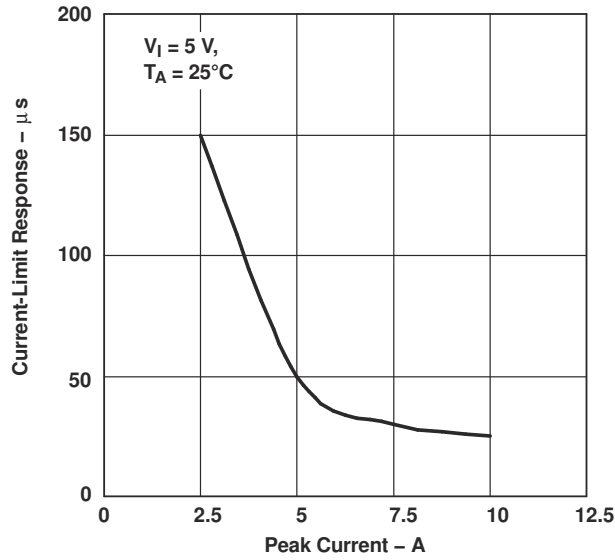


図 6-29. CURRENT-LIMIT RESPONSE vs PEAK CURRENT

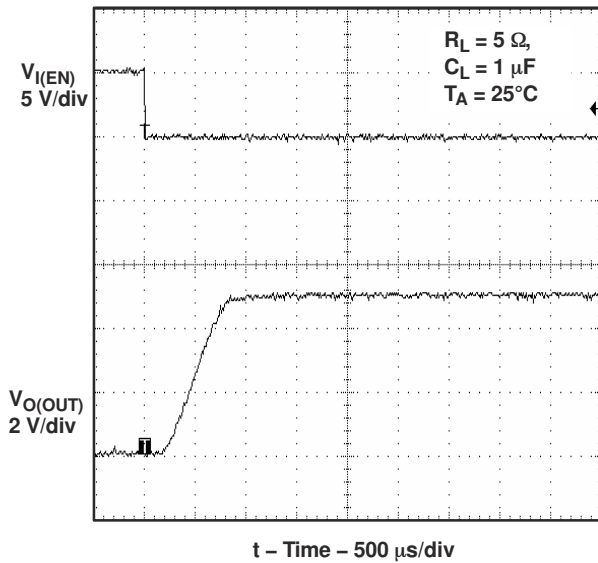


図 6-30. Turnon Delay and Rise Time With 1-μF Load

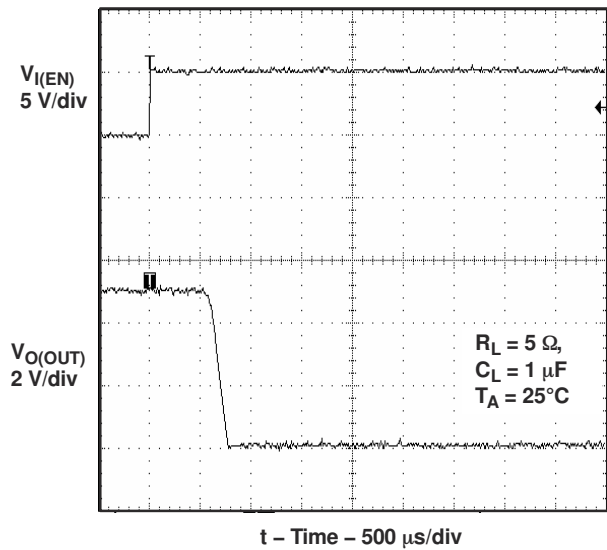


図 6-31. Turnoff Delay and Fall Time With 1-μF Load

6.6 Typical Characteristics (TPS2063 & TPS2067) (continued)

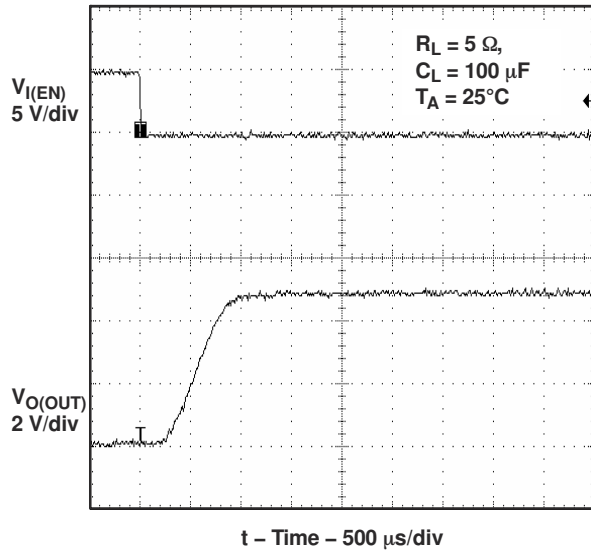


图 6-32. Turnon Delay and Rise Time With 100- μF Load

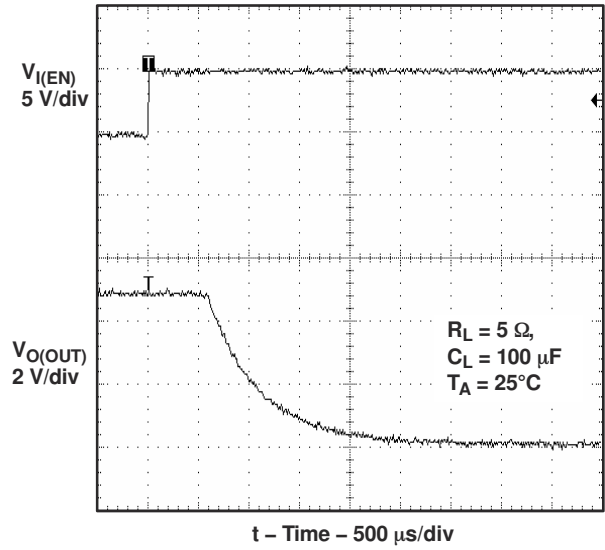


图 6-33. Turnoff Delay and Fall Time With 100- μF Load

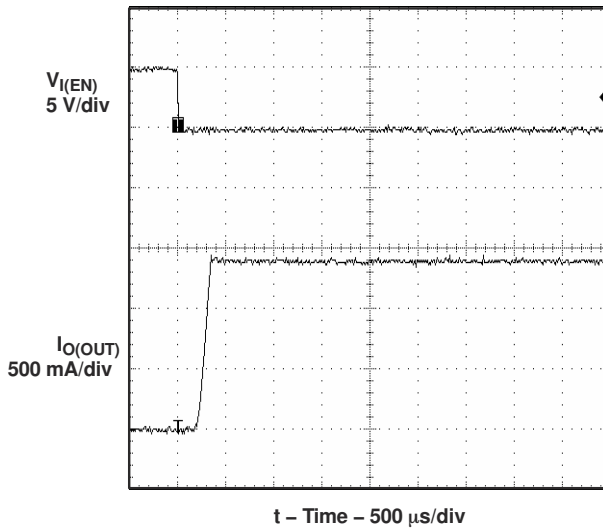


图 6-34. Short-Circuit Current, Device Enabled Into Short

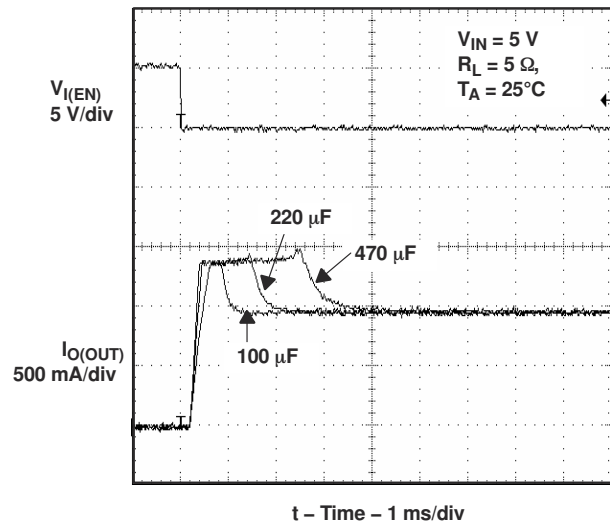


图 6-35. Inrush Current With Different Load Capacitance

6.6 Typical Characteristics (TPS2063 & TPS2067) (continued)

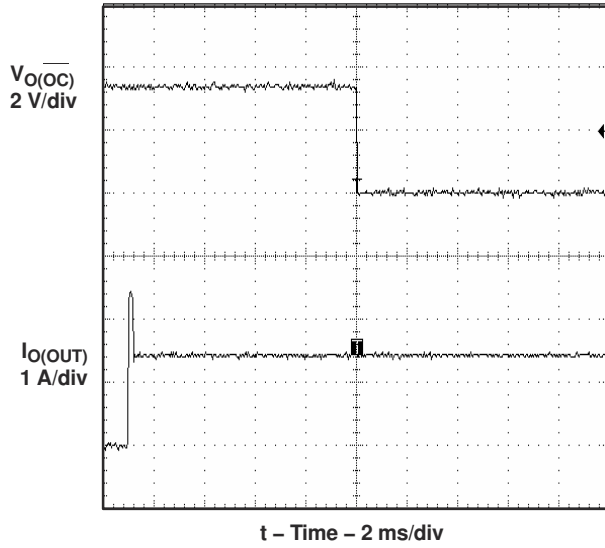


図 6-36. 2-Ω Load Connected to Enabled Device

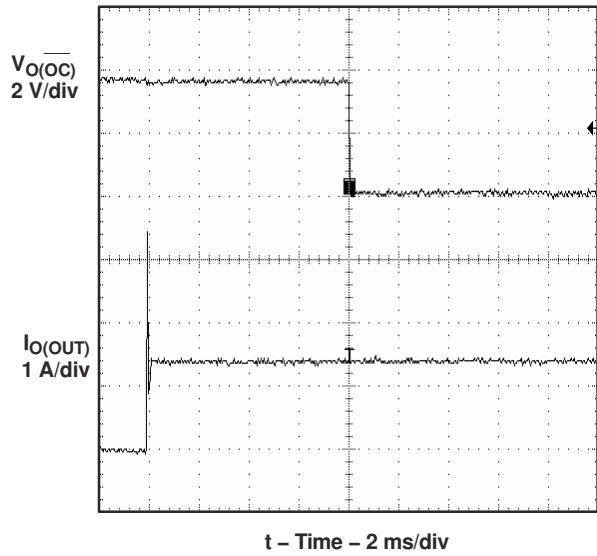
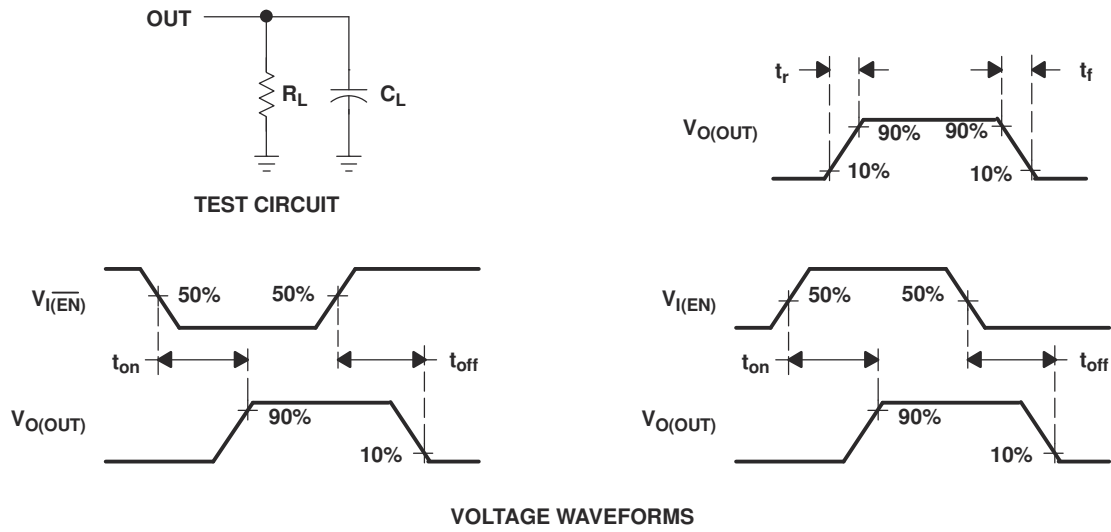


図 6-37. 1-Ω Load Connected to Enabled Device

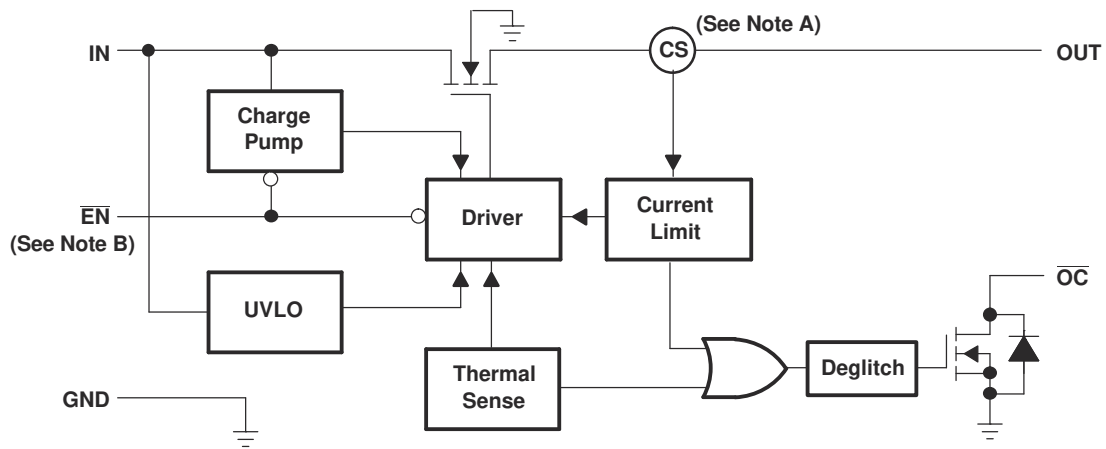
7 Parameter Measurement Information



7-1. Test Circuit and Voltage Waveforms

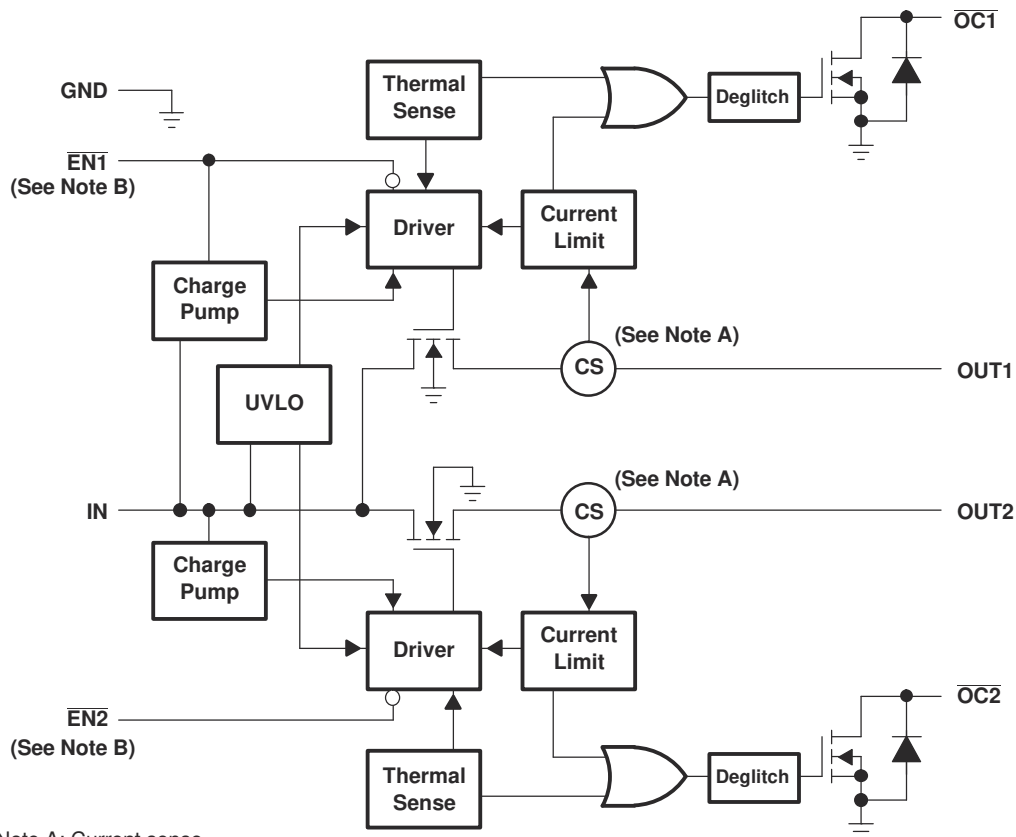
8 Detailed Description

8.1 Functional Block Diagram



Note A: Current sense
 Note B: Active low ($\overline{\text{EN}}$) for TPS2061. Active high (EN) for TPS2065.

図 8-1. TPS2061 and TPS2065



Note A: Current sense
 Note B: Active low ($\overline{\text{ENx}}$) for TPS2062. Active high (ENx) for TPS2066.

図 8-2. TPS2062 and TPS2066

8.5 Enable ($\overline{\text{ENx}}$ or ENx)

The logic enable disables the power switch and the bias for the charge pump, driver, and other circuitry to reduce the supply current. The supply current is reduced to less than 1 μA when a logic high is present on $\overline{\text{ENx}}$, or when a logic low is present on ENx. A logic zero input on $\overline{\text{ENx}}$, or a logic high input on ENx restores bias to the drive and control circuits and turns the switch on. The enable input is compatible with both TTL and CMOS logic levels.

8.6 Current Sense

A sense FET monitors the current supplied to the load. The sense FET 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 voltage and drives the power FET 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.

8.7 Overcurrent

A sense FET is employed to check for overcurrent conditions. Unlike current-sense resistors, sense FETs do not increase the series resistance of the current path. When an overcurrent condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. Complete shutdown occurs only if the fault is present long enough to activate thermal limiting.

There are two kinds of current limit profiles for the TPS20xx family of devices.

The TPS2063 and TPS2067 have an output I vs V characteristic similar to the plot labeled **Current Limit with Peaking** in [Figure 8-4](#). This type of limiting can be characterized by two parameters, the overcurrent trip threshold (I_{OC}), and the short-circuit output current threshold (I_{OS}).

The TPS2061, TPS2062, TPS2065, and TPS2066 have an output I vs V characteristic similar to the plot labeled **Flat Current Limit** in [Figure 8-4](#). This type of limiting can be characterized by one parameter, the short circuit current (I_{OS}).

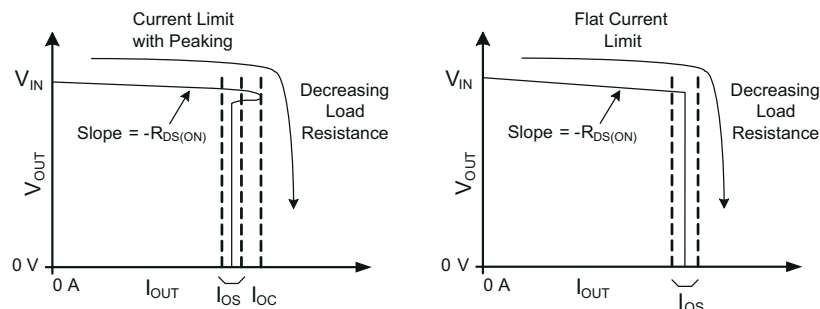


Figure 8-4. Current Limit Profiles

8.7.1 Overcurrent Conditions (TPS2063 and TPS2067)

Three possible overload conditions can occur for the TPS2063 and TPS2067. In the first condition, the output has been shorted before the device is enabled or before $V_{I(IN)}$ has been applied (see [Figure 6-34](#) through [Figure 6-36](#)). The TPS2063 and TPS2067 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 has tripped (reached the overcurrent trip threshold (I_{OC})), the device switches into constant-current mode and current is limited at the short-circuit output current threshold (I_{OS}).

In the third condition, the load has been gradually increased beyond the recommended operating current. The current is permitted to rise until the overcurrent trip threshold (I_{OC}) is reached or until the thermal limit of the device is exceeded. The TPS2063 and TPS2067 are capable of delivering current up to the current-limit

threshold without damaging the device. Once the overcurrent trip threshold (I_{OC}) has been reached, the device switches into its constant-current mode current is limited at the short-circuit output current threshold (I_{OS}).

8.7.2 Overcurrent Conditions (TPS2061, TPS2062, TPS2065, and TPS2066)

Three possible overload conditions can occur for the TPS2061, TPS2062, TPS2065 and TPS2066. In the first condition, the output has been shorted before the device is enabled or before $V_{I(IN)}$ has been applied (see [Figure 6-15](#) through [Figure 6-18](#)). The TPS20xx 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 short-circuit output current threshold (I_{OS}) is reached, the device switches into constant-current mode.

In the third condition, the load has been gradually increased beyond the recommended operating current. After the short-circuit output current threshold (I_{OS}) is reached, the device switches into constant-current mode.

8.8 Overcurrent (\overline{OCx})

The \overline{OCx} open-drain output is asserted (active low) when an overcurrent or overtemperature condition is encountered. The output remains asserted until the overcurrent or overtemperature condition is removed. A 10-ms deglitch circuit prevents the \overline{OCx} signal from oscillation or false triggering. If an overtemperature shutdown occurs, the \overline{OCx} is asserted instantaneously.

8.9 Thermal Sense

The TPS206x implements a thermal sensing to monitor the operating temperature of the power distribution switch. In an overcurrent or short-circuit condition the junction temperature rises. When the die temperature rises to approximately 140°C due to overcurrent conditions, the internal thermal sense circuitry turns off the switch, thus preventing the device from damage. Hysteresis is built into the thermal sense, and after the device has cooled approximately 10 degrees, the switch turns back on. The switch continues to cycle off and on until the fault is removed. The open-drain false reporting output (\overline{OCx}) is asserted (active low) when an overtemperature shutdown or overcurrent occurs.

8.10 Undervoltage Lockout

A voltage sense circuit monitors the input voltage. When the input voltage is below approximately 2 V, a control signal turns off the power switch.

9 Application and Implementation

注

以下のアプリケーション情報は、TI の製品仕様に含まれるものではなく、TI ではその正確性または完全性を保証いたしません。個々の目的に対する製品の適合性については、お客様の責任で判断していただくこととなります。お客様は自身の設計実装を検証しテストすることで、システムの機能を確認する必要があります。

9.1 Application Information

9.1.1 Power-supply Considerations

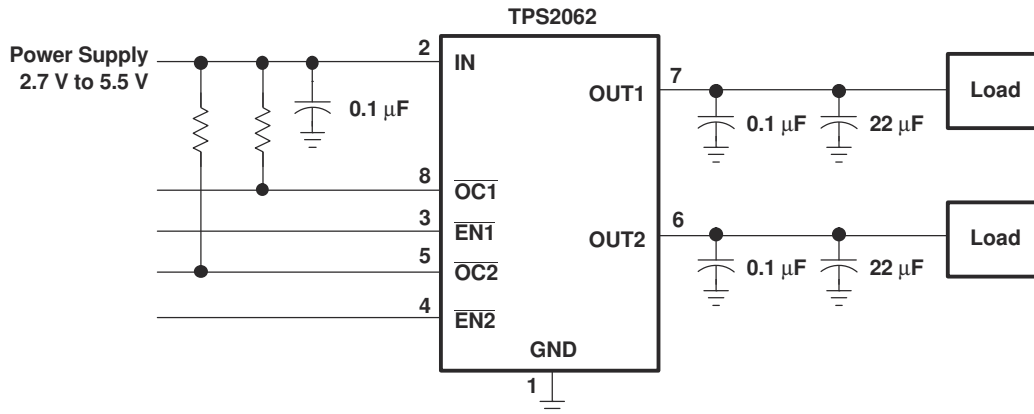


図 9-1. Typical Application

A 0.01- μ F to 0.1- μ F 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. Additionally, bypassing the output with a 0.01- μ F to 0.1- μ F ceramic capacitor improves the immunity of the device to short-circuit transients.

9.1.2 \overline{OC} Response

The \overline{OCx} open-drain output is asserted (active low) when an overcurrent or overtemperature shutdown condition is encountered after a 10-ms deglitch timeout. The output remains asserted until the overcurrent or overtemperature condition is removed. Connecting a heavy capacitive load to an enabled device can cause a momentary overcurrent condition; however, no false reporting on \overline{OCx} occurs due to the 10-ms deglitch circuit. The TPS206x is designed to eliminate false overcurrent reporting. The internal overcurrent deglitch eliminates the need for external components to remove unwanted pulses. \overline{OCx} is not deglitched when the switch is turned off due to an overtemperature shutdown.

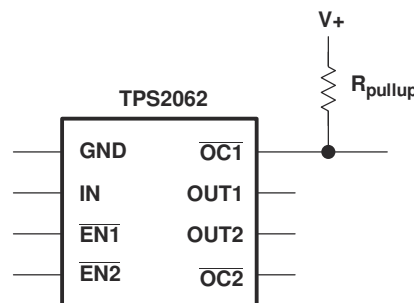


図 9-2. Typical Circuit for the \overline{OC} Pin

9.1.3 Power Dissipation and Junction Temperature

The low on-resistance on the N-channel MOSFET allows the small surface-mount packages to pass large currents. The thermal resistances of these packages are high compared to those of power packages; it is good design practice to check power dissipation and junction temperature. Begin by determining the $r_{DS(on)}$ of the N-channel MOSFET relative to the input voltage and operating temperature. As an initial estimate, use the highest operating ambient temperature of interest and read $r_{DS(on)}$ from [Figure 6-25](#). Using this value, the power dissipation per switch can be calculated by:

- $P_D = r_{DS(on)} \times I^2$

Multiply this number by the number of switches being used. This step renders the total power dissipation from the N-channel MOSFETs.

The thermal resistance, $R_{\theta JA} = 1 / (\text{DERATING FACTOR})$, where DERATING FACTOR is obtained from the Dissipation Ratings Table. Thermal resistance is a strong function of the printed circuit board construction, and the copper trace area connecting the integrated circuit.

Finally, calculate the junction temperature:

- $T_J = P_D \times R_{\theta JA} + T_A$

Where:

- T_A = Ambient temperature °C
- $R_{\theta JA}$ = Thermal resistance
- P_D = Total power dissipation based on number of switches being used.

Compare the calculated junction temperature with the initial estimate. If they do not agree within a few degrees, repeat the calculation, using the calculated value as the new estimate. Two or three iterations are generally sufficient to get a reasonable answer.

9.1.4 Thermal Protection

Thermal protection prevents damage to the IC when heavy-overload or short-circuit faults are present for extended periods of time. The TPS206x implements a thermal sensing to monitor the operating junction temperature of the power distribution switch. In an overcurrent or short-circuit condition, the junction temperature rises due to excessive power dissipation. Once the die temperature rises above a minimum of 135°C due to overcurrent 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 10°C, the switch turns back on. The switch continues to cycle in this manner until the load fault or input power is removed. The \overline{OCx} open-drain output is asserted (active low) when an overtemperature shutdown or overcurrent occurs.

9.1.5 Undervoltage Lockout (UVLO)

An undervoltage lockout ensures that the power switch is in the off state at power up. Whenever the input voltage falls below approximately 2 V, the power switch is quickly turned off. The UVLO facilitates the design of hot-insertion systems where it is not possible to turn off the power switch before input power is removed. The UVLO also keeps the switch from being turned on until the power supply has reached at least 2 V, even if the switch is enabled. On reinsertion, the power switch is turned on, with a controlled rise time to reduce EMI and voltage overshoots.

9.1.6 Universal Serial Bus (USB) Applications

The universal serial bus (USB) interface is a 12-Mb/s, or 1.5-Mb/s, multiplexed serial bus designed for low-to-medium bandwidth PC peripherals (for example, keyboards, printers, scanners, and mice). The four-wire USB interface is conceived for dynamic attach-detach (hot plug-unplug) of peripherals. Two lines are provided for differential data, and two lines are provided for 5-V power distribution.

USB data is a 3.3-V level signal, but power is distributed at 5 V to allow for voltage drops in cases where power is distributed through more than one hub across long cables. Each function must provide its own regulated 3.3 V from the 5-V input or its own internal power supply.

The USB specification defines the following five classes of devices, each differentiated by power-consumption requirements:

- Hosts/self-powered hubs (SPH)
- Bus-powered hubs (BPH)
- Low-power, bus-powered functions
- High-power, bus-powered functions
- Self-powered functions

SPHs and BPHs distribute data and power to downstream functions. The TPS206x has higher current capability than required by one USB port; so, it can be used on the host side and supplies power to multiple downstream ports or functions.

9.1.7 Host/Self-Powered and Bus-powered Hubs

Hosts and SPHs have a local power supply that powers the embedded functions and the downstream ports (see [Figure 9-3](#)). This power supply must provide from 5.25 V to 4.75 V to the board side of the downstream connection under full-load and no-load conditions. Hosts and SPHs are required to have current-limit protection and must report overcurrent conditions to the USB controller. Typical SPHs are desktop PCs, monitors, printers, and stand-alone hubs.

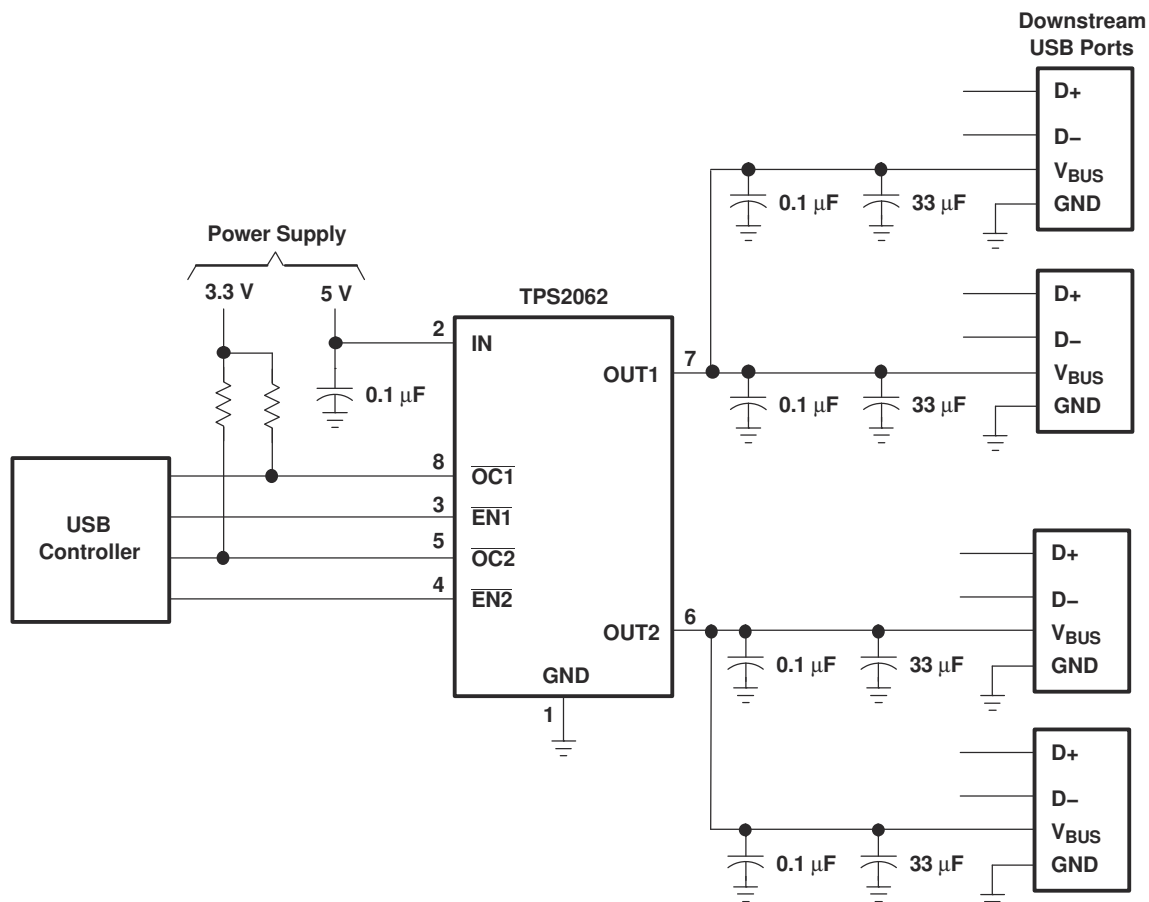


Figure 9-3. Typical Four-Port USB Host / Self-Powered Hub

BPHs obtain all power from upstream ports and often contain an embedded function. The hubs are required to power up with less than one unit load. The BPH usually has one embedded function, and power is always available to the controller of the hub. If the embedded function and hub require more than 100 mA on power up, the power to the embedded function may need to be kept off until enumeration is completed. This can be accomplished by removing power or by shutting off the clock to the embedded function. Power switching the embedded function is not necessary if the aggregate power draw for the function and controller is less than one unit load. The total current drawn by the bus-powered device is the sum of the current to the controller, the embedded function, and the downstream ports, and it is limited to 500 mA from an upstream port.

9.1.8 Low-power Bus-powered and High-Power Bus-Powered Functions

Both low-power and high-power bus-powered functions obtain all power from upstream ports; low-power functions always draw less than 100 mA; high-power functions must draw less than 100 mA at power up and can draw up to 500 mA after enumeration. If the load of the function is more than the parallel combination of 44 Ω and 10 μF at power up, the device must implement inrush current limiting (see [Figure 9-4](#)). With TPS206x, the internal functions can draw more than 500 mA, which fits the needs of some applications such as motor driving circuits.

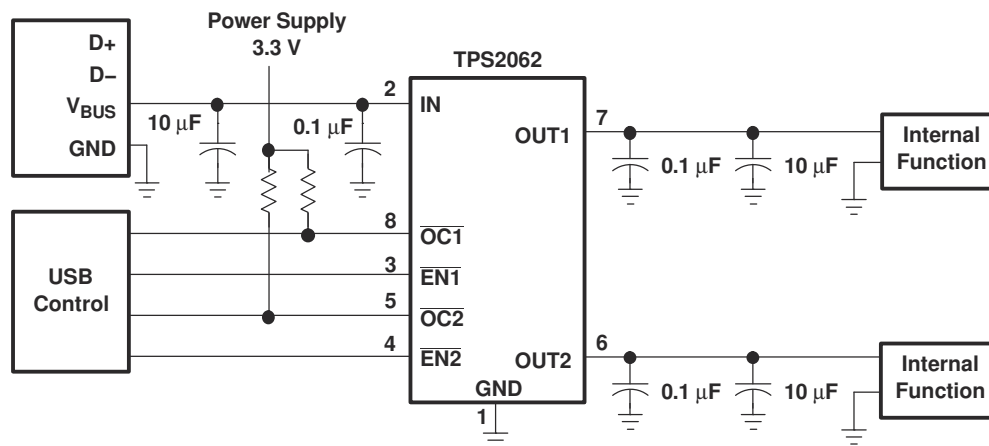


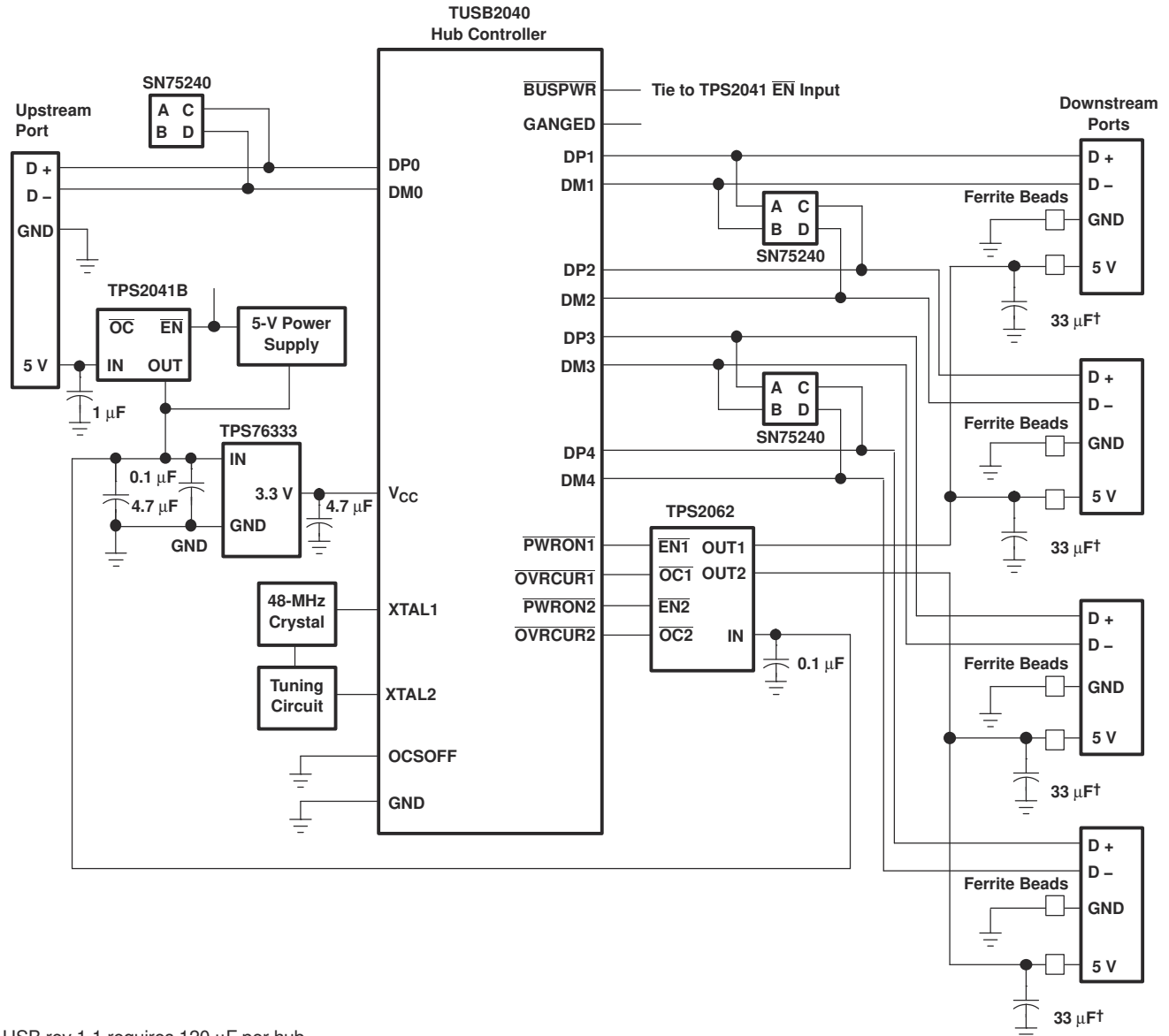
Figure 9-4. High-Power Bus-Powered Function

9.1.9 USB Power-distribution Requirements

USB can be implemented in several ways, and, regardless of the type of USB device being developed, several power-distribution features must be implemented.

- Hosts/SPHs must:
 - Current-limit downstream ports
 - Report overcurrent conditions on USB V_{BUS}
- BPHs must:
 - Enable/disable power to downstream ports
 - Power up at <100 mA
 - Limit inrush current (<44 Ω and 10 μF)
- Functions must:
 - Limit inrush currents
 - Power up at <100 mA

The feature set of the TPS206x allows them to meet each of these requirements. The integrated current-limiting and overcurrent reporting is required by hosts and self-powered hubs. The logic-level enable and controlled rise times meet the need of both input and output ports on bus-powered hubs, as well as the input ports for bus-powered functions (see [Figure 9-5](#)).



† USB rev 1.1 requires 120 µF per hub.

図 9-5. Hybrid Self / Bus-Powered Hub Implementation

9.1.10 Generic Hot-Plug Applications

In many applications it may be necessary to remove modules or pc boards while the main unit is still operating. These are considered hot-plug applications. Such implementations require the control of current surges seen by the main power supply and the card being inserted. The most effective way to control these surges is to limit and slowly ramp the current and voltage being applied to the card, similar to the way in which a power supply normally turns on. Due to the controlled rise times and fall times of the TPS206x, these devices can be used to provide a softer start-up to devices being hot-plugged into a powered system. The UVLO feature of the TPS206x also ensures that the switch is off after the card has been removed, and that the switch is off during the next insertion. The UVLO feature insures a soft start with a controlled rise time for every insertion of the card or module.

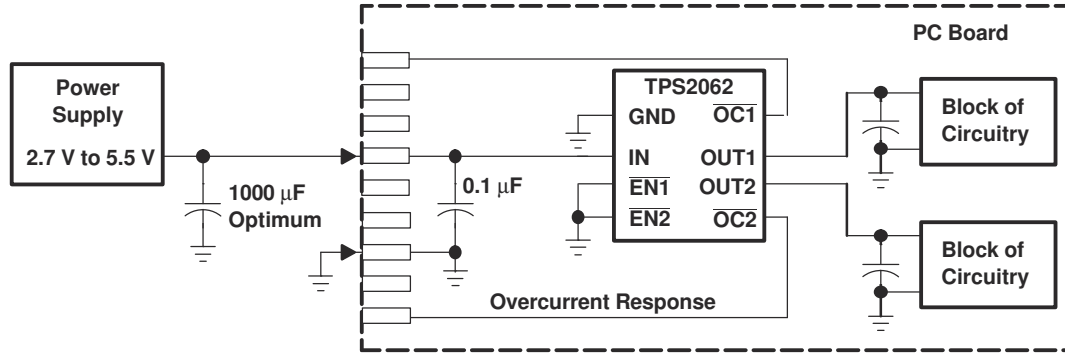


図 9-6. Typical Hot-Plug Implementation

By placing the TPS206x between the V_{CC} input and the rest of the circuitry, the input power reaches these devices first after insertion. The typical rise time of the switch is approximately 1 ms, providing a slow voltage ramp at the output of the device. This implementation controls system surge currents and provides a hot-plugging mechanism for any device.

10 Device and Documentation Support

TI offers an extensive line of development tools. Tools and software to evaluate the performance of the device, generate code, and develop solutions are listed below.

10.1 Device Support

10.2 Documentation Support

10.3 ドキュメントの更新通知を受け取る方法

ドキュメントの更新についての通知を受け取るには、www.tij.co.jp のデバイス製品フォルダを開いてください。[通知] をクリックして登録すると、変更されたすべての製品情報に関するダイジェストを毎週受け取ることができます。変更の詳細については、改訂されたドキュメントに含まれている改訂履歴をご覧ください。

10.4 サポート・リソース

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10.7 用語集

[テキサス・インスツルメンツ用語集](#) この用語集には、用語や略語の一覧および定義が記載されています。

11 Revision History

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

Changes from Revision J (August 2023) to Revision K (June 2024)	Page
• 「消費電力定格」表を削除.....	1
• Added セクション 6.3	6
• Updated TPS2061, TPS2062, TPS2065, TPS2066 electrical characteristics, including overcurrent trip threshold, high-level output supply current and undervoltage lockout.....	6
• Updated TPS2061, TPS2062, TPS2065, TPS2066 Typical Characteristics.....	8
• Updated TPS2061, TPS2062, TPS2065, TPS2066 overcurrent description.....	20
• Updated セクション 8.7.1	20
• Updated セクション 8.7.2	21

Changes from Revision I (October 2009) to Revision J (August 2023)	Page
• ドキュメント全体にわたって表、図、相互参照の採番方法を更新.....	1

- Added $r_{DS(on)}$ for DBV package..... 6
- Updated TPS2065DBV electrical characteristics, including overcurrent trip threshold, high-level output supply current and undervoltage lockout..... 6
- Updated TPS2065DBV Typical Characteristics..... 8
- Moved overcurrent description from Application and Implementation section to Detailed Description section..... 20
- Added TPS2065DBV overcurrent description..... 20

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

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PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TPS2061D	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2061	Samples
TPS2061DBVR	ACTIVE	SOT-23	DBV	5	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 125	2061	Samples
TPS2061DBVT	ACTIVE	SOT-23	DBV	5	250	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 125	2061	Samples
TPS2061DG4	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2061	Samples
TPS2061DGN	ACTIVE	HVSSOP	DGN	8	80	RoHS & Green	NIPDAU NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	2061	Samples
TPS2061DGNR	ACTIVE	HVSSOP	DGN	8	2500	RoHS & Green	NIPDAU NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	2061	Samples
TPS2061DGNRG4	ACTIVE	HVSSOP	DGN	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2061	Samples
TPS2061DR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2061	Samples
TPS2062D	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2062	Samples
TPS2062DG4	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2062	Samples
TPS2062DGN	ACTIVE	HVSSOP	DGN	8	80	RoHS & Green	NIPDAU NIPDAUAG	Level-1-260C-UNLIM	-40 to 85	2062	Samples
TPS2062DGNG4	ACTIVE	HVSSOP	DGN	8	80	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2062	Samples
TPS2062DGNR	ACTIVE	HVSSOP	DGN	8	2500	RoHS & Green	NIPDAU NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	2062	Samples
TPS2062DR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2062	Samples
TPS2062DRG4	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2062	Samples
TPS2063D	ACTIVE	SOIC	D	16	40	TBD	Call TI	Call TI	-40 to 125	2063	Samples
TPS2063DR	ACTIVE	SOIC	D	16	2500	TBD	Call TI	Call TI	-40 to 125	2063	Samples
TPS2063DRG4	ACTIVE	SOIC	D	16	2500	TBD	Call TI	Call TI	-40 to 125	2063	Samples
TPS2065D	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2065	Samples
TPS2065DBVR	ACTIVE	SOT-23	DBV	5	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2065	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TPS2065DBVT	OBSOLETE	SOT-23	DBV	5		TBD	Call TI	Call TI	-40 to 125	2065	
TPS2065DG4	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2065	Samples
TPS2065DGN	ACTIVE	HVSSOP	DGN	8	80	RoHS & Green	NIPDAU NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	2065	Samples
TPS2065DGNR	ACTIVE	HVSSOP	DGN	8	2500	RoHS & Green	NIPDAU NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	2065	Samples
TPS2065DR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2065	Samples
TPS2066D	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2066	Samples
TPS2066DGN	ACTIVE	HVSSOP	DGN	8	80	RoHS & Green	NIPDAU NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	2066	Samples
TPS2066DGNG4	ACTIVE	HVSSOP	DGN	8	80	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2066	Samples
TPS2066DGNR	ACTIVE	HVSSOP	DGN	8	2500	RoHS & Green	NIPDAU NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	2066	Samples
TPS2066DGNRG4	ACTIVE	HVSSOP	DGN	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2066	Samples
TPS2066DR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2066	Samples
TPS2066DRG4	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2066	Samples
TPS2067D	ACTIVE	SOIC	D	16	40	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2067	Samples
TPS2067DR	ACTIVE	SOIC	D	16	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2067	Samples
TPS2067DRG4	ACTIVE	SOIC	D	16	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2067	Samples

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of ≤ 1000 ppm threshold. Antimony trioxide based flame retardants must also meet the ≤ 1000 ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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OTHER QUALIFIED VERSIONS OF TPS2062, TPS2065, TPS2066 :

- Automotive : [TPS2062-Q1](#), [TPS2065-Q1](#), [TPS2066-Q1](#)

NOTE: Qualified Version Definitions:

- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

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