CURRENT-LIMITED, POWER-DISTRIBUTION SWITCH

Check for Samples: TPS2066-Q1

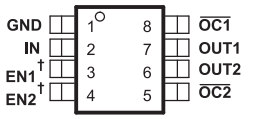
FEATURES

- **Qualified for Automotive Applications**
- **70-mΩ High-Side MOSFET**
- **1-A Continuous Current**
- **Thermal and Short-Circuit Protection**
- **Accurate Current Limit (1.1 A min, 1.9 A max)**
- **Operating Range: 2.7 V to 5.5 V**
- **0.6-ms Typical Rise Time**
- **Undervoltage Lockout**
- **Deglitched Fault Report ($\overline{OC}$)**
- **No $\overline{OC}$ Glitch During Power Up**
- **1-µA Maximum Standby Supply Current**
- **Bidirectional Switch**
- **Ambient Temperature Range: -40°C to 105°C**
- **Built-in Soft-Start**
- **UL Listed - File No. E169910**

APPLICATIONS

- **Heavy Capacitive Loads**
- **Short-Circuit Protections**

DGN PACKAGE (TOP VIEW)



†All enable inputs are active high

DESCRIPTION

The TPS2066-Q1 power-distribution switch is intended for applications where heavy capacitive loads and short-circuits are likely to be encountered. This device incorporates 70-mΩ N-channel MOSFET power switches for power-distribution systems that require multiple power switches in a single package. Each switch is controlled by a logic enable input. Gate drive is provided by an internal charge pump designed to control the power-switch rise times and fall times to minimize current surges during switching. The charge pump requires no external components and allows operation from supplies as low as 2.7 V.

When the output load exceeds the current-limit threshold or a short is present, the device limits the output current to a safe level by switching into a constant-current mode, pulling the overcurrent (OCx) logic output low. When continuous heavy overloads and short-circuits increase the power dissipation in the switch, causing the junction temperature to rise, a thermal protection circuit shuts off the switch to prevent damage. Recovery from a thermal shutdown is automatic once the device has cooled sufficiently. Internal circuitry ensures that the switch remains off until valid input voltage is present. This power-distribution switch is designed to set current limit at 1.5 A typically.

Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PowerPAD is a trademark of Texas Instruments.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of the Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

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This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

ORDERING INFORMATION(1)

T_A	PACKAGE		ORDERABLE PART NUMBER	TOP-SIDE MARKING
-40°C to 105°C	8-Pin VSSOP - DGN	Reel of 2500	TPS2066TDGNRQ1	2066Q

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.

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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, $V_{I(EN)}$, $V_{I(EN)}$, $V_{I(ENx)}$, $V_{I(EN)}$		-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
Continuous total power dissipation		See Dissipation Rating Table
Operating junction temperature range, T_J		-40°C to 150°C
Electrostatic discharge (ESD) protection	Human body model (HBM)	2 kV
	Charge device model (CDM)	1000 V
	Machine model (MM)	100V

(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.

DISSIPATING RATING TABLE

PACKAGE	$T_A \le 25°C$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25°C$	$T_A = 70°C$ POWER RATING	$T_A = 85°C$ POWER RATING	$T_A = 105°C$ POWER RATING
DGN-8(1)	1712.3 mW	17.123 mW/°C	941.78 mW	684.33 mW	341 mW

(1) Power ratings are based on the high-k board (2 signal, 2 plane) with PowerPAD™ vias to the internal ground plane.

RECOMMENDED OPERATING CONDITIONS

	MIN	MAX	UNIT
Input voltage, $V_{I(IN)}$	2.7	5.5	V
Input voltage, $V_{I(EN)}$, $V_{I(EN)}$, $V_{I(ENx)}$, $V_{I(EN)}$	0	5.5	V
Continuous output current, $I_{O(OUT)}$, $I_{O(OUTx)}$	0	1	A
Operating ambient temperature, T_A	-40	105	°C

ELECTRICAL CHARACTERISTICS

over recommended operating ambient temperature range T_A = -40°C to 105°C (unless otherwise noted), $V_{I(IN)}$ = 5.5 V, I_O = 1 A, $V_{I(ENx)}$ = 0 V, or $V_{I(ENx)}$ = 5.5 V

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°C ≤ T_A ≤ 105°C			70	135	mΩ
	Static drain-source on-state resistance, 2.7-V operation	$V_{I(IN)}$ = 2.7 V, I_O = 1 A, -40°C ≤ T_A ≤ 105°C			75	150	mΩ
t_r	Rise time, output	$V_{I(IN)}$ = 5.5 V	C_L = 1 µF, R_L = 5 Ω, T_A = 25°C		0.6	1.5	ms
		$V_{I(IN)}$ = 2.7 V			0.4	1	
t_f	Fall time, output	$V_{I(IN)}$ = 5.5 V		0.05		0.5	
		$V_{I(IN)}$ = 2.7 V		0.05		0.5	

(1) Pulse-testing techniques maintain junction temperature close to ambient temperature; thermal effects must be taken into account separately.

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ELECTRICAL CHARACTERISTICS (continued)

over recommended operating ambient temperature range T_A = -40°C to 105°C (unless otherwise noted), $V_{I(IN)}$ = 5.5 V, I_O = 1 A, $V_{I(ENx)}$ = 0 V, or $V_{I(ENx)}$ = 5.5 V

PARAMETER		TEST CONDITIONS[1]		MIN	TYP	MAX	UNIT
ENABLE INPUT $\overline{EN}$ OR EN							
V_{IH}	High-level input voltage	2.7 V ≤ $V_{I(IN)}$ ≤ 5.5 V		2			V
V_{IL}	Low-level input voltage	2.7 V ≤ $V_{I(IN)}$ ≤ 5.5 V				0.8	V
I_I	Input current	$V_{I(ENx)}$ = 0 V or 5.5 V, $V_{I(ENx)}$ = 0 V or 5.5 V		-0.5		0.5	µA
t_{on}	Turnon time	C_L = 100 µF, R_L = 5 Ω				3	ms
t_{off}	Turnoff time	C_L = 100 µF, R_L = 5 Ω				10	ms
CURRENT LIMIT							
I_{OS}	Short-circuit output current	$V_{I(IN)}$ = 5 V, OUT connected to GND, device enabled into short-circuit	T_A = 25°C	1.1	1.5	1.9	A
			-40°C ≤ T_A ≤ 105°C	1.1	1.5	2.1	A
I_{OC_TRIP}	Overcurrent trip threshold	$V_{I(IN)}$ = 5 V, current ramp (≤ 100 A/s) on OUT		1.6	2.3	2.9	A
SUPPLY CURRENT							
Supply current, low-level output		No load on OUT, $V_{I(ENx)}$ = 0 V	T_A = 25°C		0.5	1	µA
			-40°C ≤ T_A ≤ 105°C		0.5	5	µA
Supply current, high-level output		No load on OUT, $V_{I(ENx)}$ = 5.5 V	T_A = 25°C		50	70	µA
			-40°C ≤ T_A ≤ 105°C		50	90	µA
Leakage current		OUT connected to ground, $V_{I(ENx)}$ = 0 V	-40°C ≤ T_A ≤ 105°C		1		µA
Reverse leakage current		$V_{I(OUTx)}$ = 5.5 V, IN = ground	T_A = 25°C		0.2		µA
UNDERVOLTAGE LOCKOUT							
Low-level input voltage, IN				2		2.5	V
Hysteresis, IN		T_A = 25°C			75		mV
OVERCURRENT $\overline{OC1}$ and $\overline{OC2}$							
Output low voltage, $V_{OL(OCx)}$		$I_{O(\overline{OCx})}$ = 5 mA				0.4	V
Off-state current		$V_{O(\overline{OCx})}$ = 5 V or 3.3 V				1	µA
$\overline{OC}$ deglitch		$\overline{OCx}$ assertion or deassertion		4	8	15	ms
THERMAL SHUTDOWN[2]							
Thermal shutdown threshold				135			°C
Recovery from thermal shutdown				125			°C
Hysteresis					10		°C

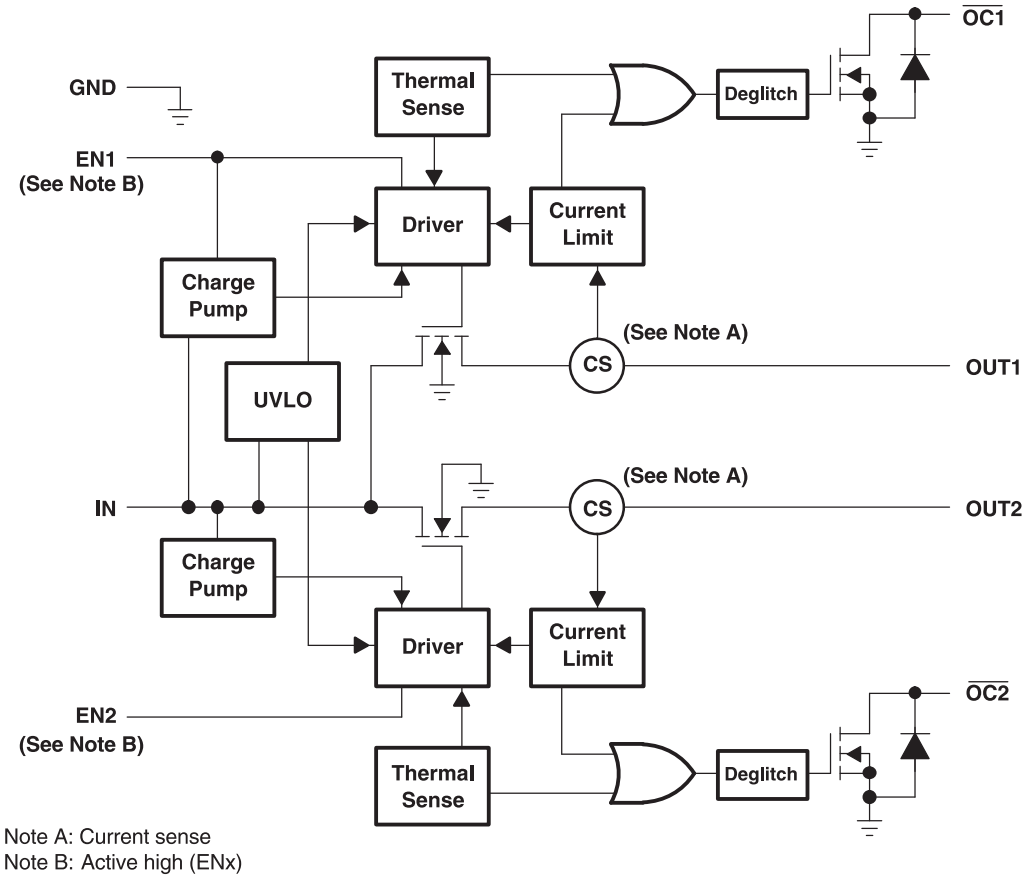
(2) The thermal shutdown only reacts under overcurrent conditions.

PIN FUNCTIONS

PINS		I/O	DESCRIPTION
NAME	NO.		
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		Ground
IN	2	I	Input voltage
$\overline{OC1}$	8	O	Overcurrent, open-drain output, active low, IN-OUT1
$\overline{OC2}$	5	O	Overcurrent, open-drain output, active low, IN-OUT2
OUT1	7	O	Power-switch output, IN-OUT1
OUT2	6	O	Power-switch output, IN-OUT2
PowerPAD™	-		Internally connected to GND; used to heat-sink the part to the circuit board traces. Should be connected to GND pin.

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Functional Block Diagram



Note A: Current sense
Note B: Active high (ENx)

PARAMETER MEASUREMENT INFORMATION

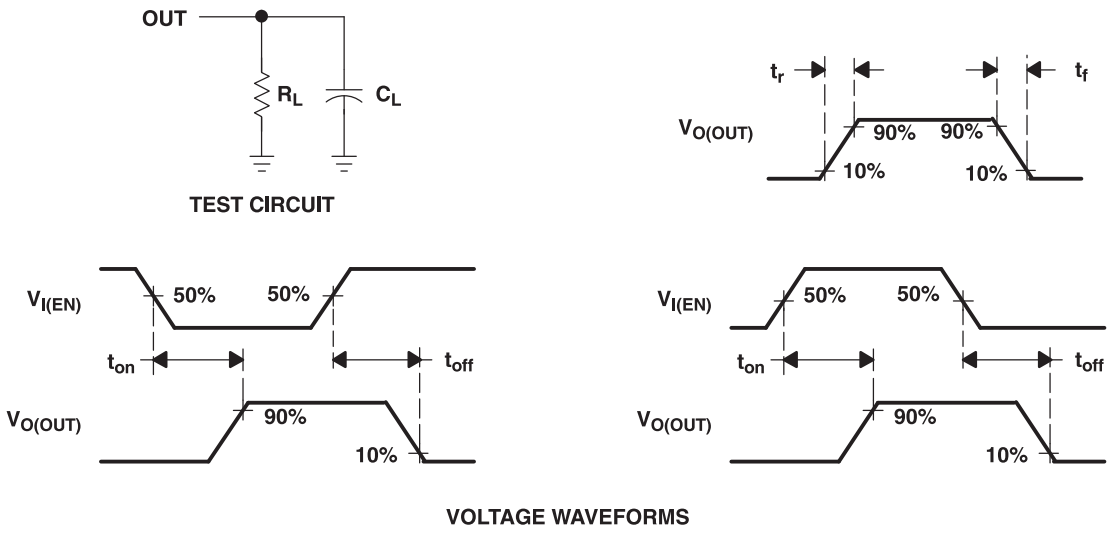


Figure 1. Test Circuit and Voltage Waveforms

PARAMETER MEASUREMENT INFORMATION (continued)

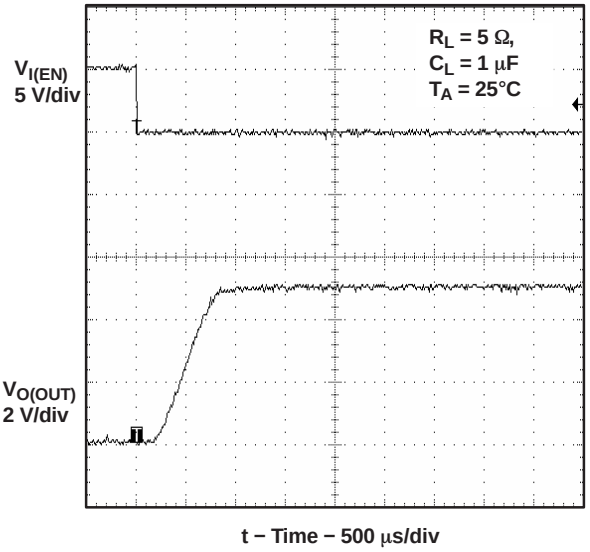


Figure 2. Turnon Delay and Rise Time With 1-μF Load

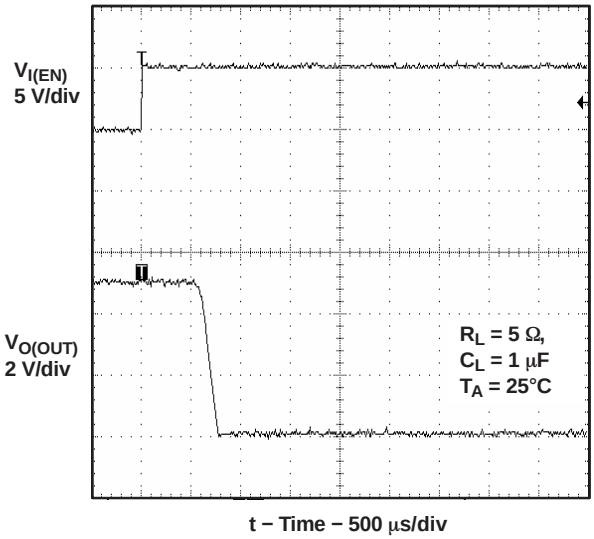


Figure 3. Turnoff Delay and Fall Time With 1-μF Load

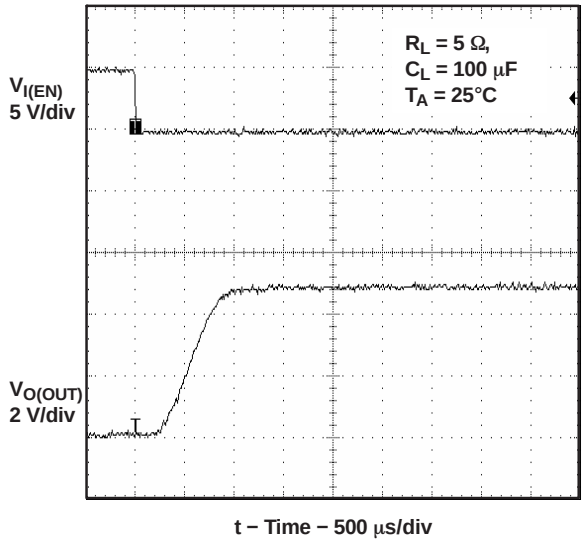


Figure 4. Turnon Delay and Rise Time With 100-μF Load

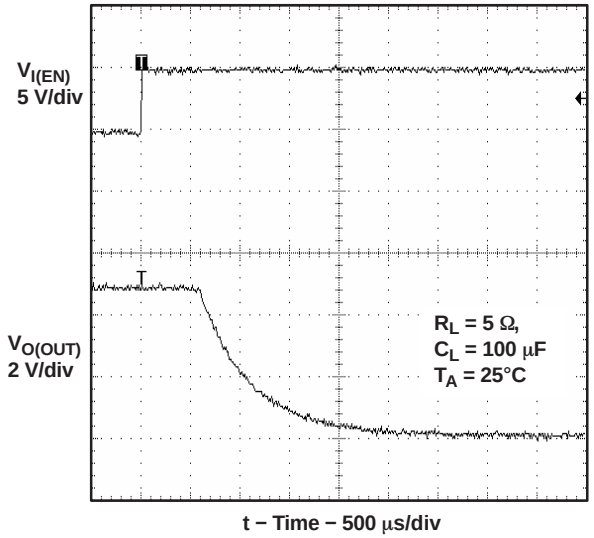


Figure 5. Turnoff Delay and Fall Time With 100-μF Load

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PARAMETER MEASUREMENT INFORMATION (continued)

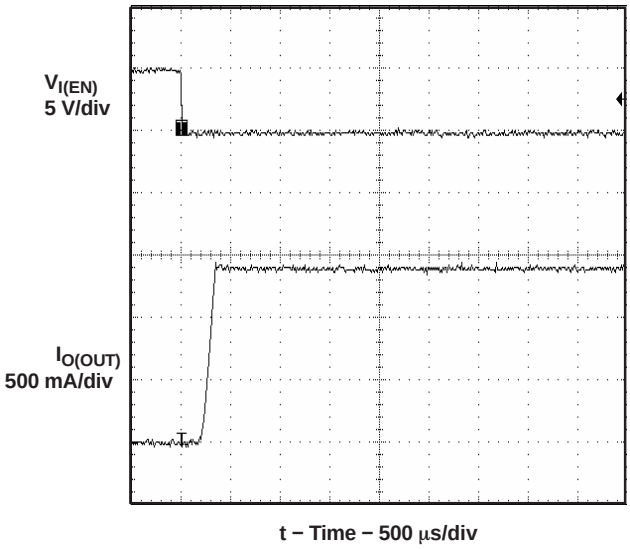


Figure 6. Short-Circuit Current, Device Enabled Into Short

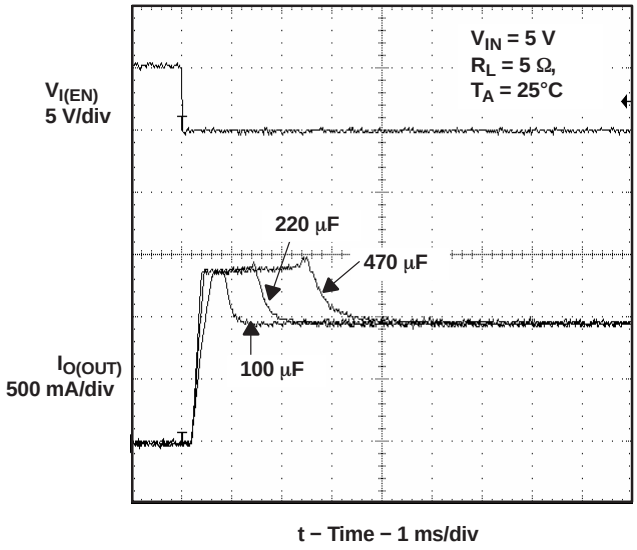


Figure 7. Inrush Current With Different Load Capacitance

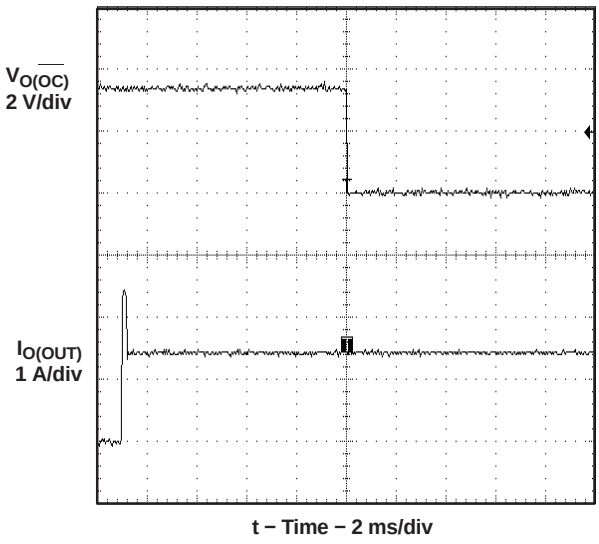


Figure 8. 2-Ω Load Connected to Enabled Device

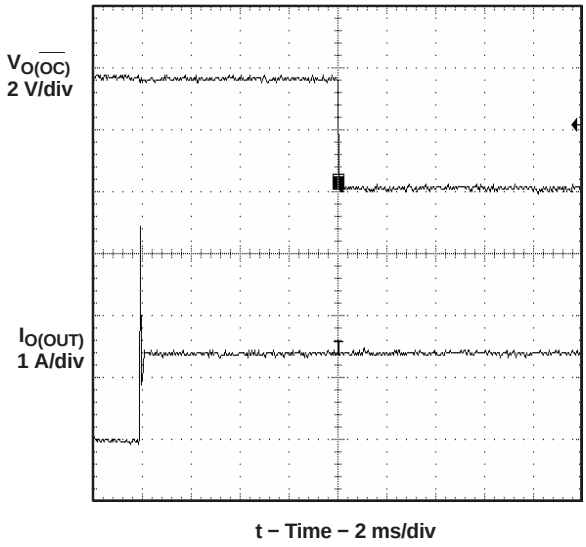


Figure 9. 1-Ω Load Connected to Enabled Device

TYPICAL CHARACTERISTICS

TURN-ON TIME vs INPUT VOLTAGE

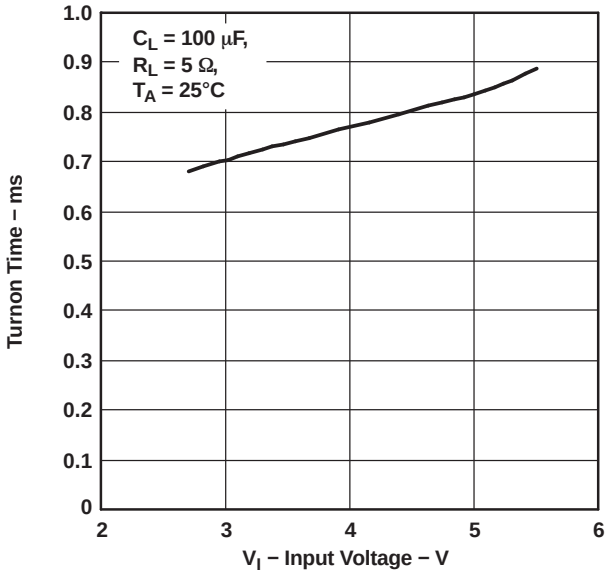


Figure 10.

TURN-OFF TIME vs INPUT VOLTAGE

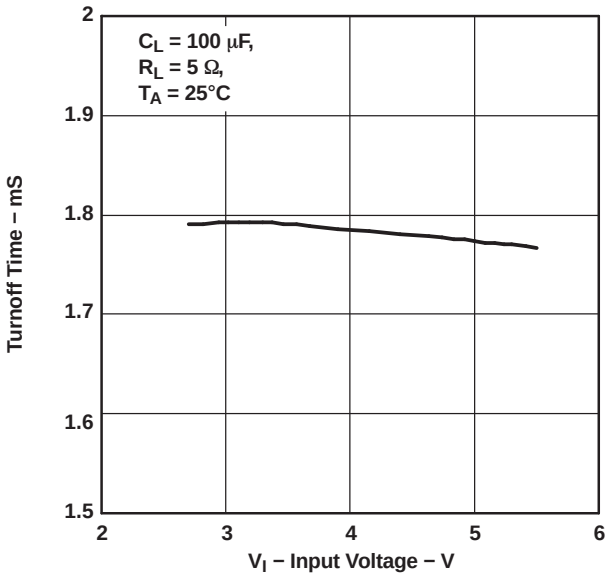


Figure 11.

RISE TIME vs INPUT VOLTAGE

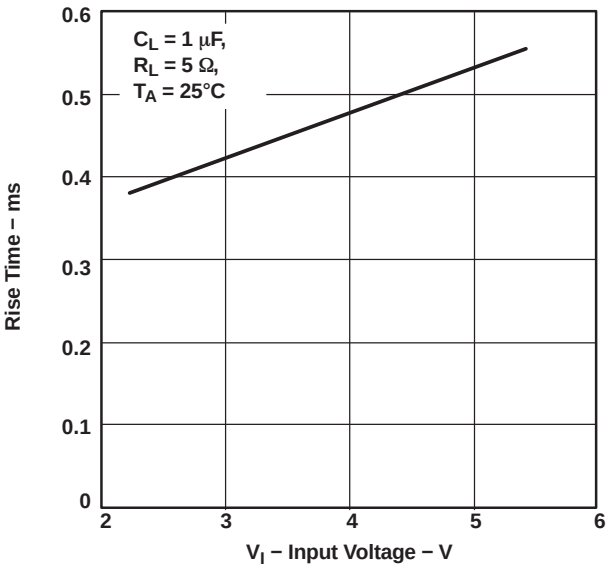


Figure 12.

FALL TIME vs INPUT VOLTAGE

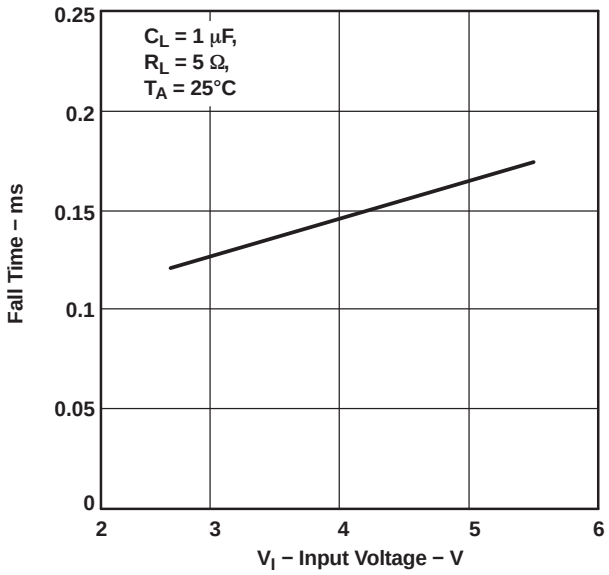


Figure 13.

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TYPICAL CHARACTERISTICS (continued)

SUPPLY CURRENT, OUTPUT ENABLED vs JUNCTION TEMPERATURE

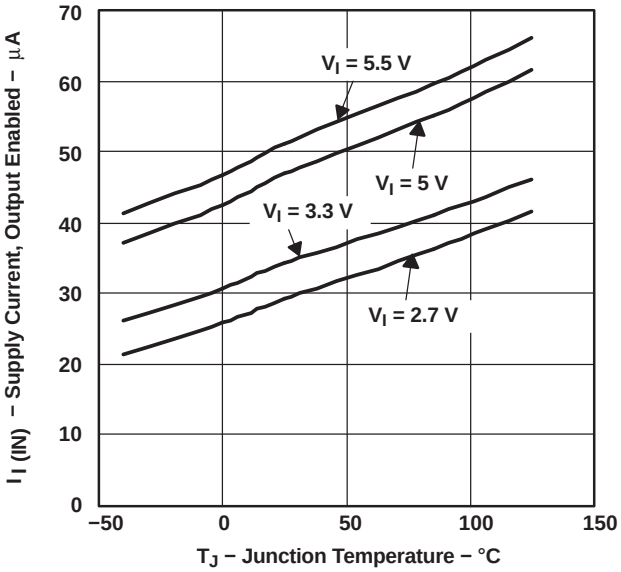


Figure 14.

SUPPLY CURRENT, OUTPUT DISABLED vs JUNCTION TEMPERATURE

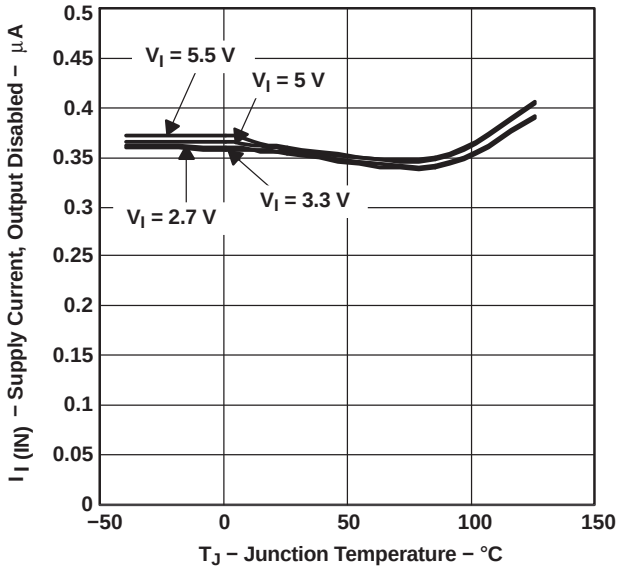


Figure 15.

STATIC DRAIN-SOURCE ON-STATE RESISTANCE vs JUNCTION TEMPERATURE

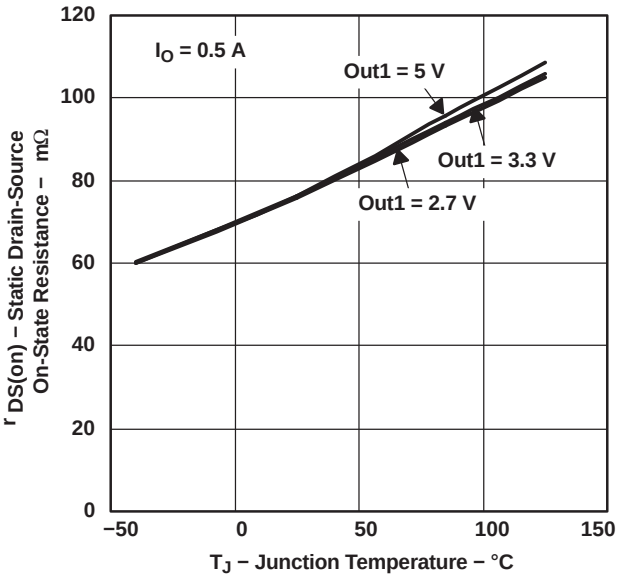


Figure 16.

SHORT-CIRCUIT OUTPUT CURRENT vs JUNCTION TEMPERATURE

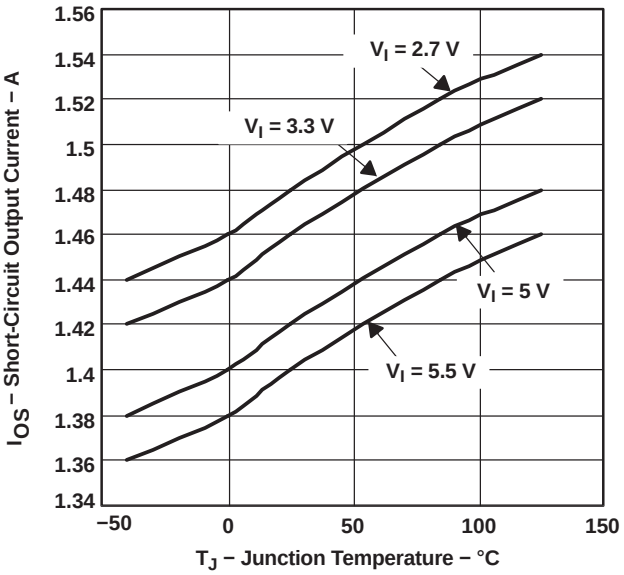


Figure 17.

TYPICAL CHARACTERISTICS (continued)

THRESHOLD TRIP CURRENT
vs
INPUT VOLTAGE

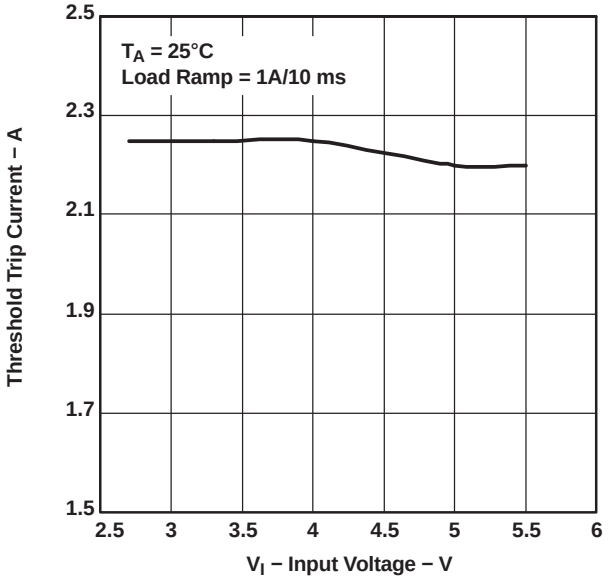


Figure 18.

UNDERVOLTAGE LOCKOUT
vs
JUNCTION TEMPERATURE

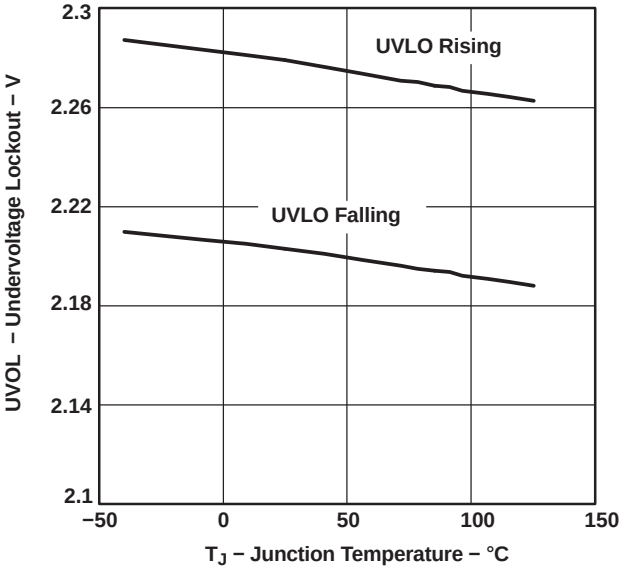


Figure 19.

CURRENT-LIMIT RESPONSE
vs
PEAK CURRENT

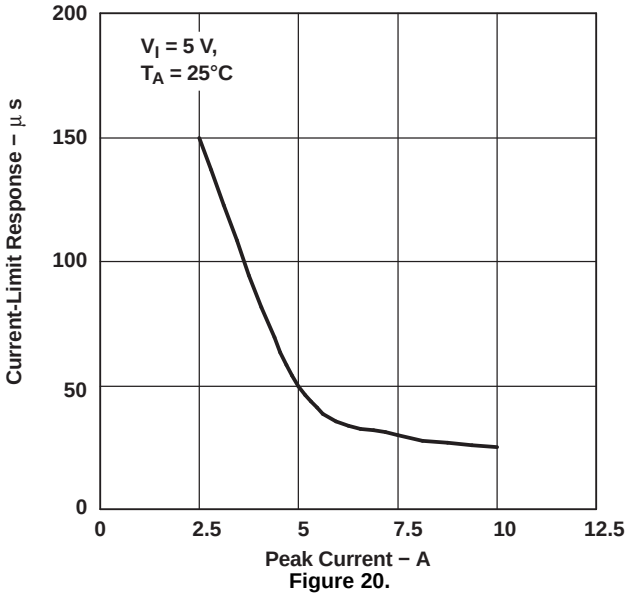


Figure 20.

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APPLICATION INFORMATION

POWER-SUPPLY CONSIDERATIONS

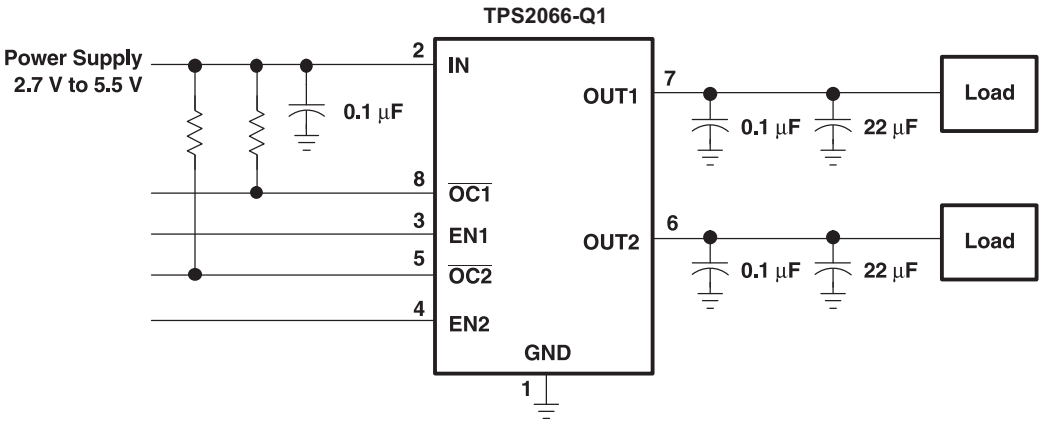


Figure 21. Typical Application

A 0.01-µF to 0.1-µF 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-µF to 0.1-µF ceramic capacitor improves the immunity of the device to short-circuit transients.

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.

Three possible overload conditions can occur. In the first condition, the output has been shorted before the device is enabled or before $V_{I(IN)}$ has been applied (see Figure 14). The TPS2066-Q1 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), the device switches into constant-current mode.

In the third condition, the load has been gradually increased beyond the recommended operating current. The current is permitted to rise until the current-limit threshold is reached or until the thermal limit of the device is exceeded (see Figure 15). The TPS2066-Q1 is capable of delivering current up to the current-limit threshold without damaging the device. Once the threshold has been reached, the device switches into its constant-current mode.

$\overline{\text{OC}}$ RESPONSE

The $\overline{\text{OCx}}$ 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 $\overline{\text{OCx}}$ occurs due to the 10-ms deglitch circuit. The TPS2066-Q1 is designed to eliminate false overcurrent reporting. The internal overcurrent deglitch eliminates the need for external components to remove unwanted pulses. $\overline{\text{OCx}}$ is not deglitched when the switch is turned off due to an overtemperature shutdown.

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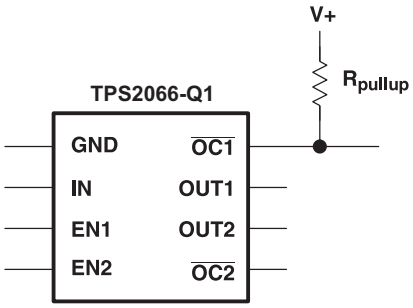


Figure 22. Typical Circuit for the $\overline{OC}$ Pin

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 16. 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 / (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.

THERMAL PROTECTION

Thermal protection prevents damage to the IC when heavy-overload or short-circuit faults are present for extended periods of time. The TPS2066-Q1 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.

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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. This 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.

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 (e.g., 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 TPS2066-Q1 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.

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 23). 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.

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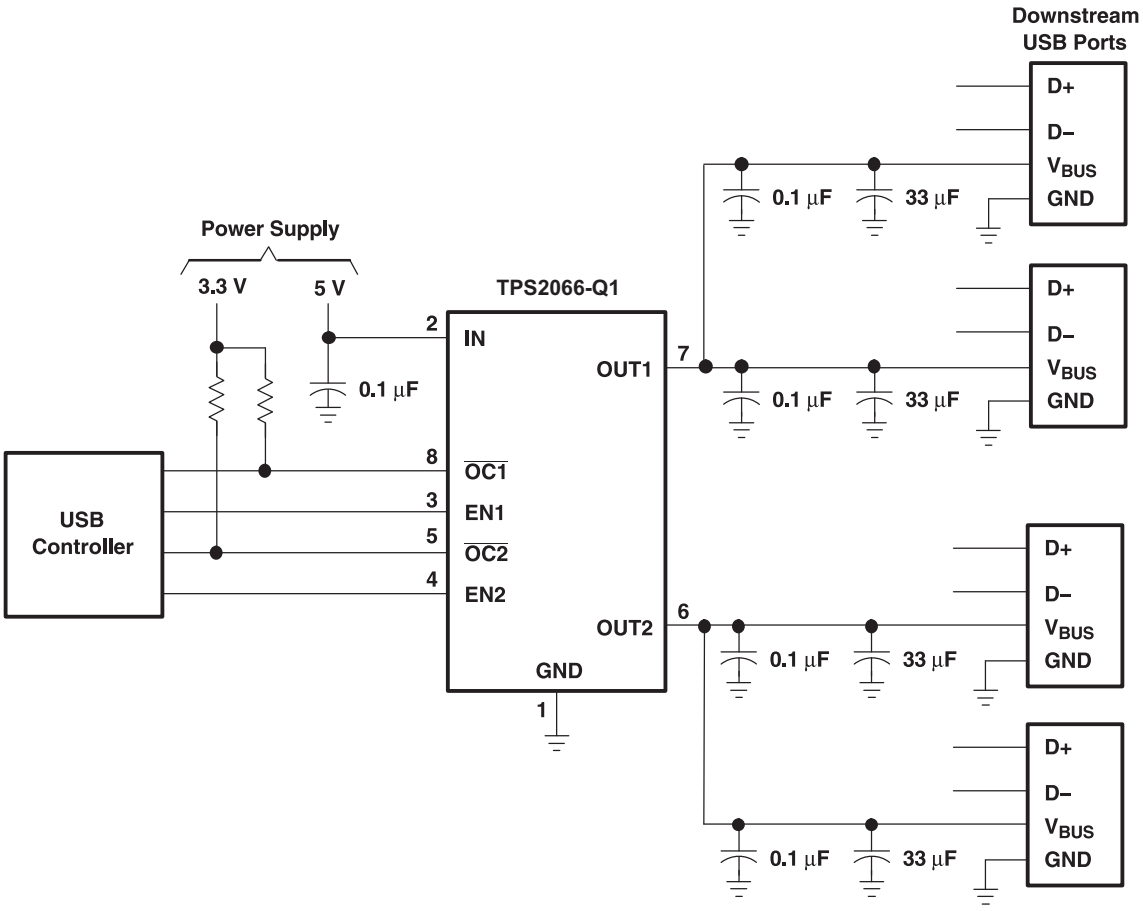


Figure 23. Typical Four-Port USB Host / Self-Powered Hub

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.

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 24). With TPS2066-Q1, the internal functions could draw more than 500 mA, which fits the needs of some applications such as motor driving circuits.

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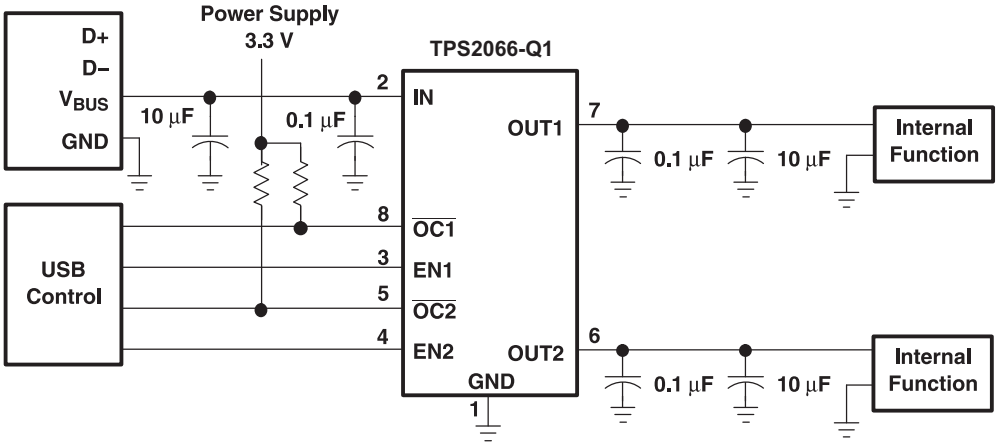


Figure 24. High-Power Bus-Powered Function

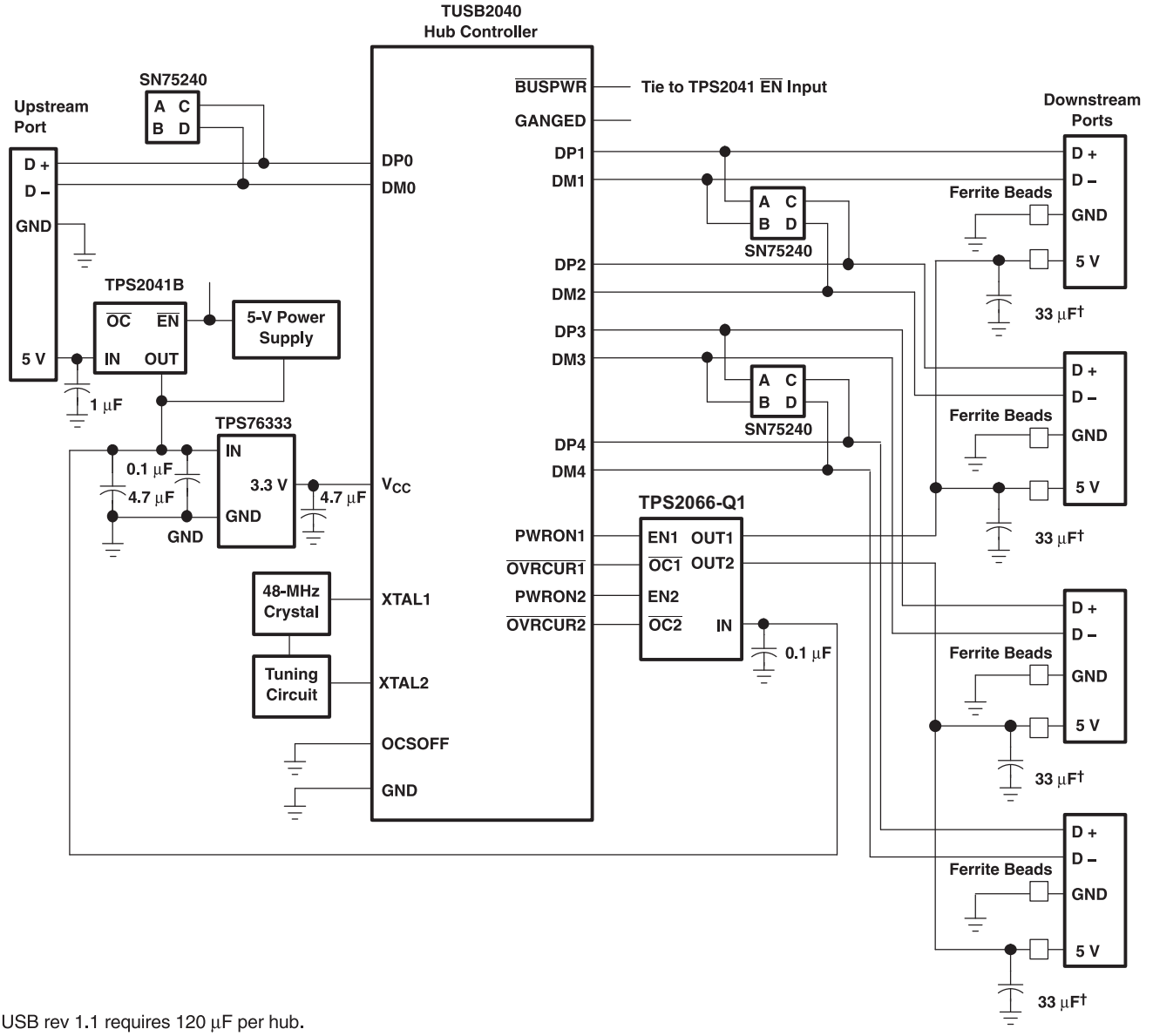
USB POWER-DISTRIBUTION REQUIREMENTS

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 TPS2066-Q1 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 25).

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† USB rev 1.1 requires 120 µF per hub.

Figure 25. Hybrid Self / Bus-Powered Hub Implementation

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 TPS2066-Q1, 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 TPS2066-Q1 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.

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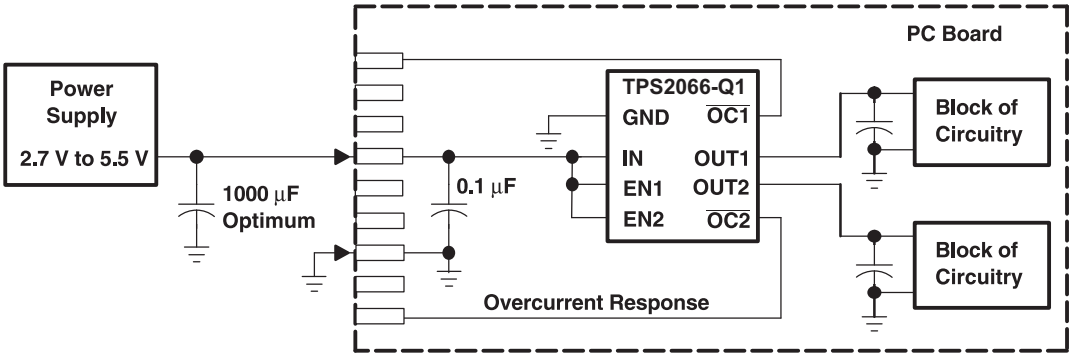


Figure 26. Typical Hot-Plug Implementation

By placing the TPS2066-Q1 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.

DETAILED DESCRIPTION

Power Switch

The power switch is an N-channel MOSFET with a low on-state resistance. Configured as a high-side switch, the power switch prevents current flow from OUT to IN and IN to OUT when disabled. The power switch supplies a minimum current of 1 A.

Charge Pump

An internal charge pump supplies power to the driver circuit and provides the necessary voltage to pull the gate of the MOSFET above the source. The charge pump operates from input voltages as low as 2.7 V and requires little supply current.

Driver

The driver controls the gate voltage of the power switch. To limit large current surges and reduce the associated electromagnetic interference (EMI) produced, the driver incorporates circuitry that controls the rise times and fall times of the output voltage.

Enable ($\overline{ENx}$ 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 $\overline{ENx}$, or when a logic low is present on ENx. A logic zero input on $\overline{ENx}$, 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.

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.

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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.

Thermal Sense

The TPS2066-Q1 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 ($\overline{OC}$x) is asserted (active low) when an overtemperature shutdown or overcurrent occurs.

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.

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PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TPS2066TDGNRQ1	ACTIVE	HVSSOP	DGN	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	2066Q	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 <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm 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/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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OTHER QUALIFIED VERSIONS OF TPS2066-Q1 :

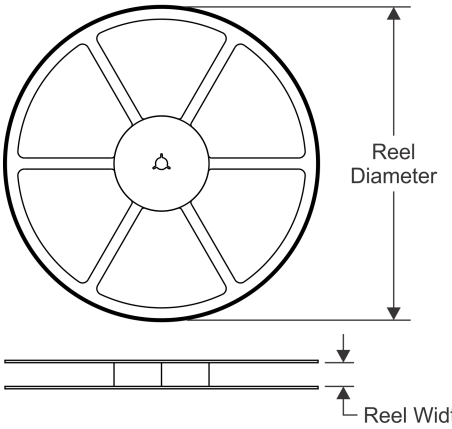
- Catalog: TPS2066

NOTE: Qualified Version Definitions:

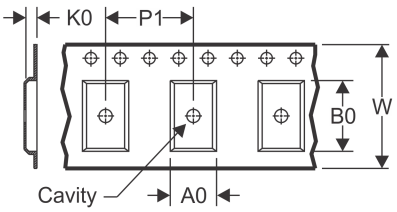
- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION

REEL DIMENSIONS

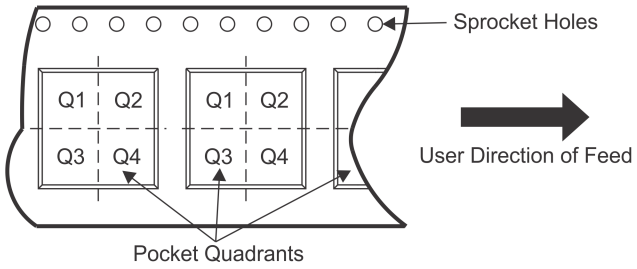


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

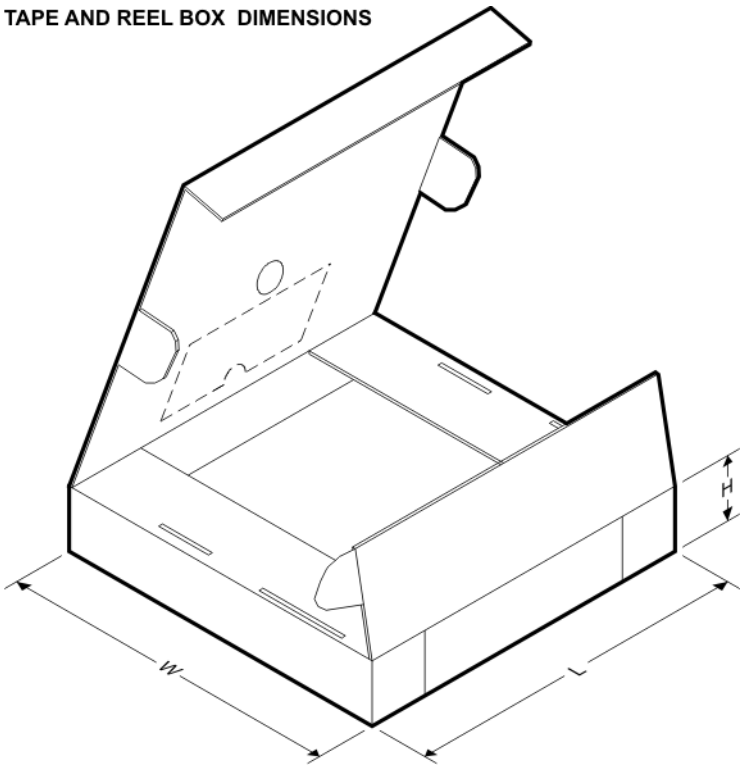
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TPS2066TDGNRQ1	HVSSOP	DGN	8	2500	330.0	12.4	5.3	3.3	1.3	8.0	12.0	Q1

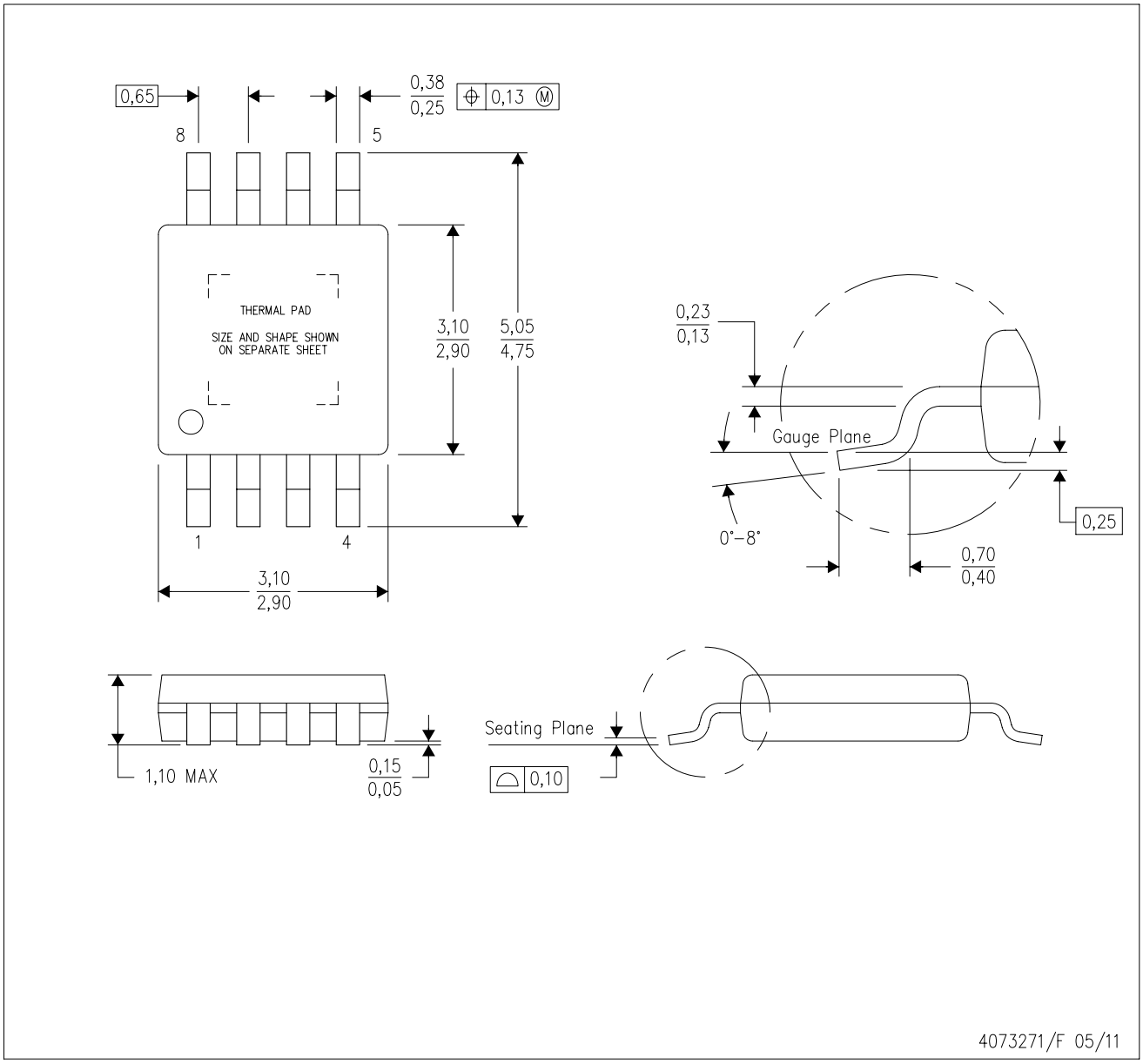
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS2066TDGNRQ1	HVSSOP	DGN	8	2500	370.0	355.0	55.0

DGN (S–PDSO–G8) PowerPAD™ PLASTIC SMALL OUTLINE

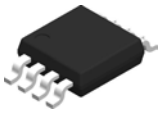


NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion.
D. This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPad Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 for information regarding recommended board layout. This document is available at www.ti.com <http://www.ti.com>.
E. See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
F. Falls within JEDEC MO–187 variation AA–T

PowerPAD is a trademark of Texas Instruments.

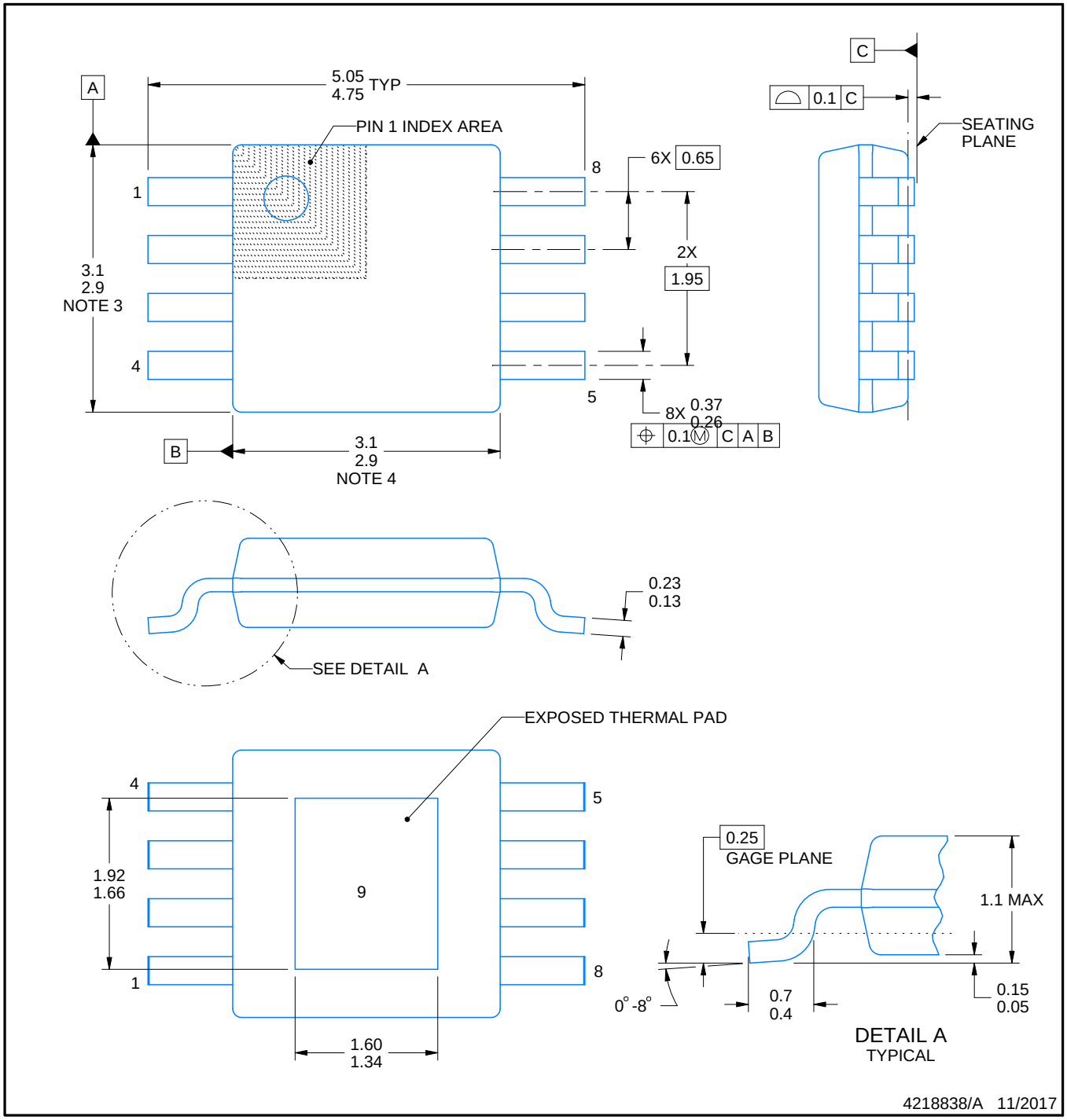
PACKAGE OUTLINE

DGN0008C



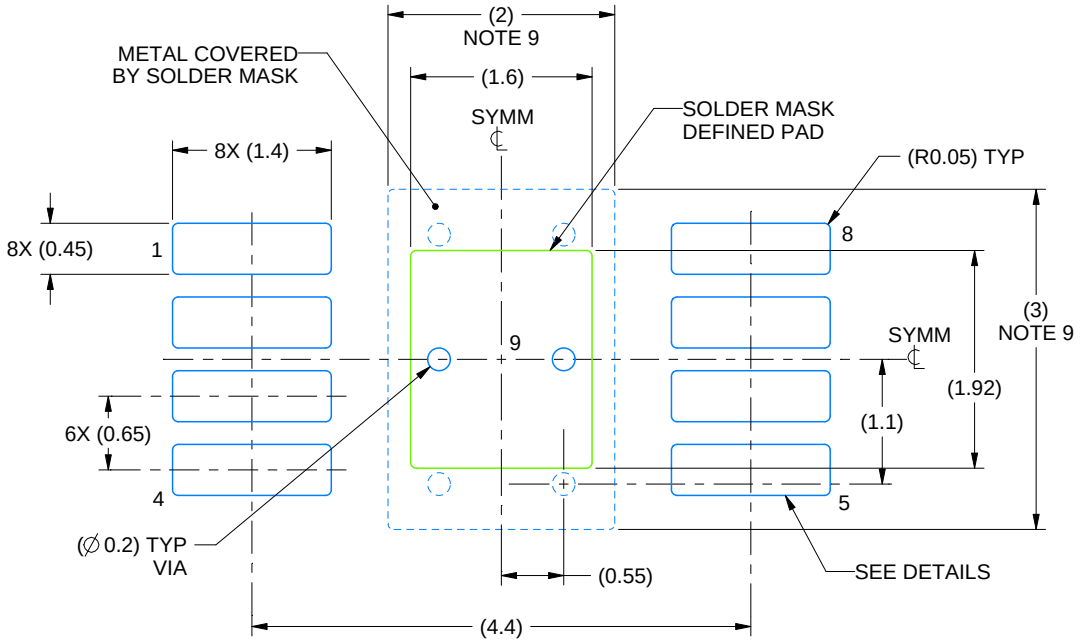
HVSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE

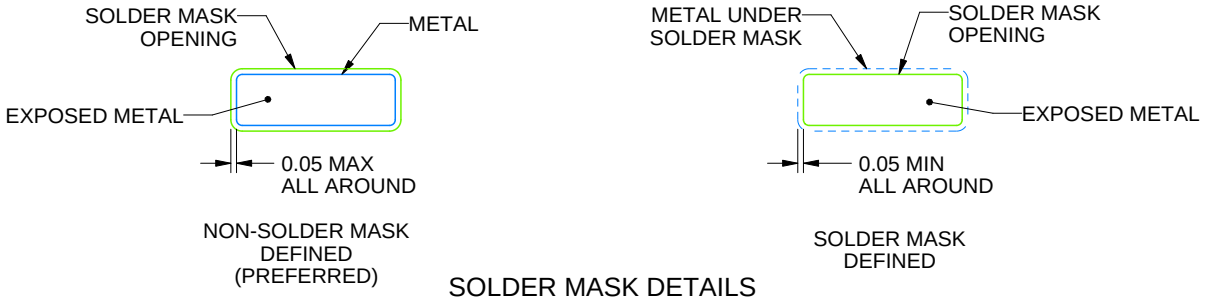


NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-187.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 15X

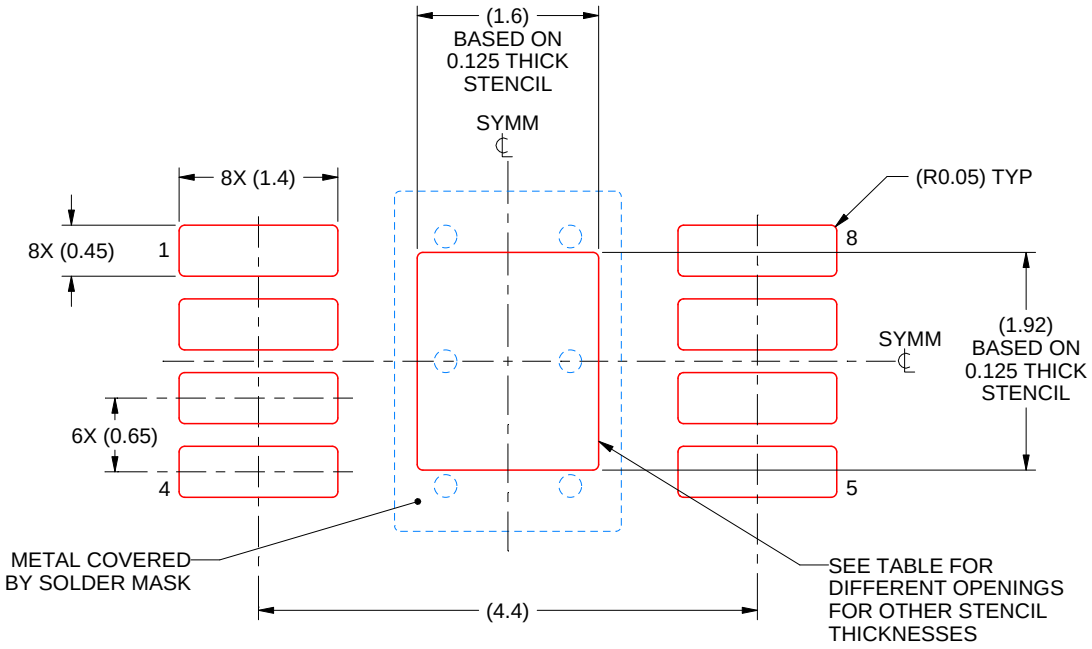


SOLDER MASK DETAILS

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NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.
9. Size of metal pad may vary due to creepage requirement.



SOLDER PASTE EXAMPLE
EXPOSED PAD 9:
100% PRINTED SOLDER COVERAGE BY AREA
SCALE: 15X

STENCIL THICKNESS	SOLDER STENCIL OPENING
0.1	1.79 X 2.15
0.125	1.60 X 1.92 (SHOWN)
0.15	1.46 X 1.75
0.175	1.35 X 1.62

4218838/A 11/2017

NOTES: (continued)

10. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
11. Board assembly site may have different recommendations for stencil design.

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