TPS22966-Q1 双通道、超低电阻负载开关

1 特性

- 符合汽车类应用 要求
- 具有符合 AEC-Q100 标准的下列特性：
  - 器件温度等级 2：-40°C 至 105°C 的环境工作温度范围
  - 器件人体放电模式 (HBM) 静电放电 (ESD) 分类等级 H1C
  - 器件组件充电模式 (CDM) ESD 分类等级 C6
- 集成双通道负载开关
- 输入电压范围：0V 至 5.5V
- 超低导通电阻 (R_{ON})
  - V_{IN} = 5V (V_{BIAS} = 5V) 时，R_{ON} = 16mΩ
  - V_{IN} = 3.3V (V_{BIAS} = 5V) 时，R_{ON} = 16mΩ
  - V_{IN} = 1.8V (V_{BIAS} = 5V) 时，R_{ON} = 16mΩ
- 每通道最大 4A 持续开关电流
- 低静态电流
  - 80µA（两个通道）
  - 80µA（单通道）
- 低控制输入阈值支持使用 1.2V、1.8V、2.5V 和 3.3V 逻辑器件
- 可配置的上升时间
- 快速输出放电 (QOD)
- 带有散热焊盘的 SON 14 引脚封装

2 应用

- 信息娱乐
- ADAS（高级驾驶辅助系统）

3 说明

TPS22966-Q1 器件是一款上升时间可调节的小型、超低 R_{ON} 双通道负载开关。此器件包含两个可在 0V 至 5.5V 输入电压范围内工作的 N 沟道 MOSFET，并且每通道支持最大 4A 的连续电流。每个开关由一个导通/关断输入（ON1 和 ON2）单独控制，此输入可与低电压控制信号直接连接。TPS22966-Q1 包含一个 230Ω 片上电阻，用于在开关关闭时快速输出放电。

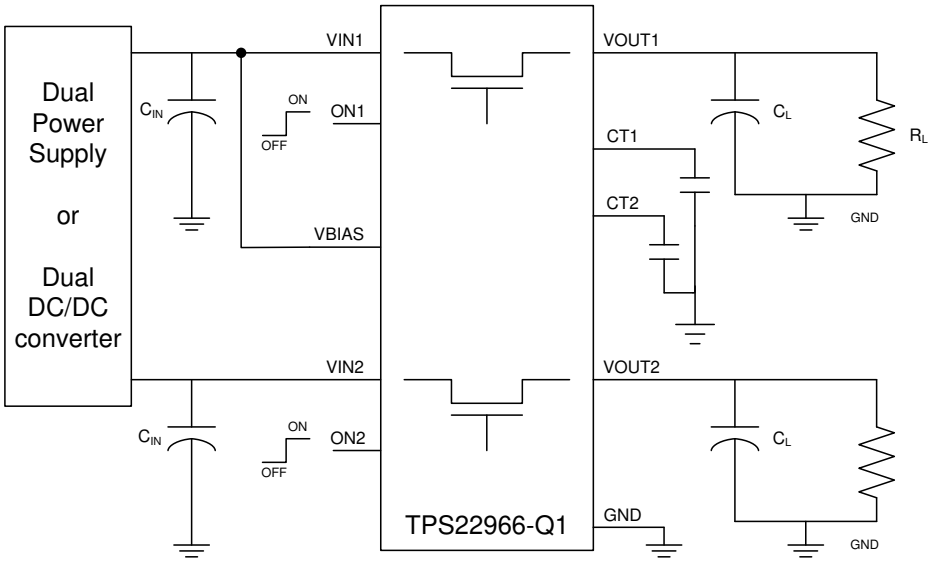
TPS22966-Q1 采用节省空间的 2mm × 3mm 14-SON 小型封装 (DPU)，带有集成散热焊盘，可实现较高的功率耗散。器件在自然通风环境下的额定运行温度范围为 –40°C 至 105℃。

器件信息(1)

器件型号	封装	封装尺寸（标称值）
TPS22966-Q1	WSON (14)	3.00mm × 2.00mm

(1) 如需了解所有可用封装，请见数据表末尾的可订购产品附录。

典型应用原理图



本文档旨在为方便起见，提供有关 TI 产品中文版本的信息，以确认产品的概要。 有关适用的官方英文版本的最新信息，请访问 www.ti.com，其内容始终优先。 TI 不保证翻译的准确性和有效性。 在实际设计之前，请务必参考最新版本的英文版本。

目录

1 特性 ... 1
2 应用 ... 1
3 说明 ... 1
4 修订历史记录 ... 2
5 **Pin Configuration and Functions** ... 3
6 **Specifications** ... 4
6.1 Absolute Maximum Ratings ... 4
6.2 ESD Ratings ... 4
6.3 Recommended Operating Conditions ... 4
6.4 Thermal Information ... 5
6.5 Electrical Characteristics: V_{BIAS} = 5 V ... 5
6.6 Electrical Characteristics: V_{BIAS} = 2.5 V ... 6
6.7 Switching Characteristics ... 7
6.8 Typical Characteristics ... 8
7 **Parameter Measurement Information** ... 13
8 **Detailed Description** ... 14
8.1 Overview ... 14
8.2 Functional Block Diagram ... 14
8.3 Feature Description ... 15
8.4 Device Functional Modes ... 15
9 **Application and Implementation** ... 16
9.1 Application Information ... 16
9.2 Typical Application ... 18
10 **Power Supply Recommendations** ... 20
11 **Layout** ... 20
11.1 Layout Guidelines ... 20
11.2 Layout Example ... 21
12 器件和文档支持 ... 22
12.1 商标 ... 22
12.2 静电放电警告 ... 22
12.3 Glossary ... 22
12.4 接收文档更新通知 ... 22
12.5 支持资源 ... 22
13 机械、封装和可订购信息 ... 22

4 修订历史记录

Changes from Revision A (March 2015) to Revision B **Page**

- Changed Input voltage range from 0.8 V to 0 V in the *Recommended Operating Conditions* table ... 4

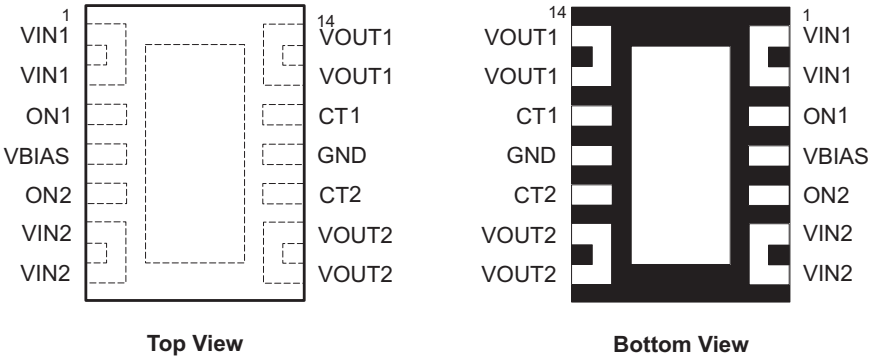
Changes from Original (December 2013) to Revision A **Page**

- 已添加 添加了*引脚配置和功能* 部分、*ESD 额定值* 表、*特性* *说明* 部分、*器件功能模式*、*应用和实施* 部分、*电源建议* 部分、*布局* 部分、*器件和文档支持* 部分以及*机械、封装和可订购信息* 部分 ... 1

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5 Pin Configuration and Functions

DPU Package
14-Pin WSON



Pin Functions

PIN		I/O	DESCRIPTION
NO.	NAME		
1	VIN1	I	Switch 1 input. Place an optional decoupling capacitor between this pin and GND for reduce VIN dip during turnon of the channel. See Application Information section for more information.
2	VIN1	I	Switch 1 input. Place an optional decoupling capacitor between this pin and GND for reduce VIN dip during turnon of the channel. See *Application Information*for more information.
3	ON1	I	Active high switch 1 control input. Do not leave floating.
4	VBIAS	I	Bias voltage. Power supply to the device. See *Application Information* for more information.
5	ON2	I	Active high switch 2 control input. Do not leave floating.
6	VIN2	I	Switch 2 input. Place an optional decoupling capacitor between this pin and GND for reduce VIN dip during turnon of the channel. See *Application Information* for more information.
7	VIN2	I	Switch 2 input. Place an optional decoupling capacitor between this pin and GND for reduce VIN dip during turnon of the channel. See *Application Information* for more information.
8	VOUT2	O	Switch 2 output.
9	VOUT2	O	Switch 2 output.
10	CT2	O	Switch 2 slew rate control. Can be left floating. Capacitor used on this pin should be rated for a minimum of 25 V for desired rise time performance.
11	GND	–	Ground
12	CT1	O	Switch 1 slew rate control. Can be left floating. Capacitor used on this pin should be rated for a minimum of 25 V for desired rise time performance.
13	VOUT1	O	Switch 1 output.
14	VOUT1	O	Switch 1 output.
15	Thermal Pad	O	Thermal pad (exposed center pad) to alleviate thermal stress. Tie to GND. See *Layout Guidelines* for layout guidelines.

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6 Specifications

6.1 Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted)(1) (2)

		MIN	MAX	UNIT
$V_{IN1,2}$	Input voltage	–0.3	6	V
$V_{OUT1,2}$	Output voltage	–0.3	6	V
$V_{ON1,2}$	ON-pin voltage	–0.3	6	V
V_{BIAS}	VBIAS voltage	–0.3	6	V
I_{MAX}	Maximum continuous switch current per channel		4	A
I_{PLS}	Maximum pulsed switch current per channel, pulse <300 µs, 2% duty cycle		6	A
T_J	Maximum junction temperature		150	°C
T_{LEAD}	Maximum lead temperature (10-s soldering time)		300	°C
T_{STG}	Storage temperature	–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) All voltage values are with respect to network ground terminal.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±4000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101(2)	±1500	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

			MIN	MAX	UNIT
$V_{IN1,2}$	Input voltage range		0	V_{BIAS}	V
V_{BIAS}	Bias voltage range		2.5	5.5	V
$V_{ON1,2}$	ON voltage range		0	5.5	V
$V_{OUT1,2}$	Output voltage range			V_{IN}	V
V_{IH}	High-level input voltage, ON	V_{BIAS} = 2.5 V to 5.5 V	1.2	5.5	V
V_{IL}	Low-level input voltage, ON	V_{BIAS} = 2.5 V to 5.5 V	0	0.5	V
$C_{IN1,2}$	Input capacitor		1(1)		µF
T_A	Operating free-air temperature(2)		–40	105	°C

(1) Refer to *Application Information*.
(2) In applications where high power dissipation and/or poor package thermal resistance is present, the maximum ambient temperature may have to be derated. Maximum ambient temperature [$T_{A(max)}$] is dependent on the maximum operating junction temperature [$T_{J(max)}$], the maximum power dissipation of the device in the application [$P_{D(max)}$], and the junction-to-ambient thermal resistance of the part/package in the application (θ_{JA}), as given by the following equation: $T_{A(max)} = T_{J(max)} - (\theta_{JA} \times P_{D(max)})$

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6.4 Thermal Information

THERMAL METRIC(1)		TPS22966-Q1 DPU (WSON) 14 PINS	UNIT
θ_{JA}	Junction-to-ambient thermal resistance	52.3	°C/W
θ_{JCtop}	Junction-to-case (top) thermal resistance	45.9	
θ_{JB}	Junction-to-board thermal resistance	11.5	
ψ_{JT}	Junction-to-top characterization parameter	0.8	
ψ_{JB}	Junction-to-board characterization parameter	11.4	
θ_{JCbot}	Junction-to-case (bottom) thermal resistance	6.9	

(1) 有关传统和新热指标的更多信息，请参见应用报告《*半导体和 IC 封装热指标*》（文献编号：SPRA953）。

6.5 Electrical Characteristics: V_{BIAS} = 5 V

Unless otherwise noted, the specifications apply over the operating ambient temperature, –40°C ≤ T_A ≤ 105°C (full) and V_{BIAS} = 5 V. Typical values are for T_A = 25°C (unless otherwise noted).

PARAMETER		TEST CONDITIONS		T_A	MIN	TYP	MAX	UNIT
POWER SUPPLIES AND CURRENTS								
$I_{IN(VBIAS-ON)}$	V_{BIAS} quiescent current (both channels)	I_{OUT1} = I_{OUT2} = 0 mA, $V_{IN1,2}$ = $V_{ON1,2}$ = V_{BIAS} = 5 V		–40°C to 105°C		80	120	µA
$I_{IN(VBIAS-ON)}$	V_{BIAS} quiescent current (single channel)	I_{OUT1} = I_{OUT2} = 0 mA, V_{ON2} = 0 V $V_{IN1,2}$ = V_{ON1} = V_{BIAS} = 5 V		–40°C to 105°C		80	120	µA
$I_{IN(VBIAS-OFF)}$	V_{BIAS} shutdown current	$V_{ON1,2}$ = 0 V, $V_{OUT1,2}$ = 0 V		–40°C to 105°C			2	µA
$I_{IN(VIN-OFF)}$	$V_{IN1,2}$ off-state supply current (per channel)	$V_{ON1,2}$ = 0 V, $V_{OUT1,2}$ = 0 V	$V_{IN1,2}$ = 5 V	–40°C to 105°C		0.5	8	µA
			$V_{IN1,2}$ = 3.3 V			0.1	3	
			$V_{IN1,2}$ = 1.8 V			0.07	2	
			$V_{IN1,2}$ = 0.8 V			0.04	1	
I_{ON}	ON pin input leakage current	V_{ON} = 5.5 V		–40°C to 105°C			1	µA
RESISTANCE CHARACTERISTICS								
R_{ON}	ON-state resistance (per channel)	I_{OUT} = –200 mA, V_{BIAS} = 5 V	V_{IN} = 5 V	25°C		16	19	mΩ
				–40°C to 85°C			21	
				–40°C to 105°C			23	
			V_{IN} = 3.3 V	25°C		16	19	
				–40°C to 85°C			21	
				–40°C to 105°C			23	
			V_{IN} = 1.8 V	25°C		16	19	
				–40°C to 85°C			21	
				–40°C to 105°C			23	
			V_{IN} = 1.5 V	25°C		16	19	
				–40°C to 85°C			21	
				–40°C to 105°C			23	
			V_{IN} = 1.2 V	25°C		16	19	
				–40°C to 85°C			21	
				–40°C to 105°C			23	
			V_{IN} = 0.8 V	25°C		16	19	
				–40°C to 85°C			21	
				–40°C to 105°C			23	
R_{PD}	Output pulldown resistance	V_{IN} = 5.0 V, V_{ON} = 0 V, I_{OUT} = 15 mA		–40°C to 105°C		230	330	Ω

6.6 Electrical Characteristics: V_{BIAS} = 2.5 V

Unless otherwise noted, the specifications apply over the operating ambient temperature –40°C ≤ T_A ≤ 105°C (full) and V_{BIAS} = 2.5 V. Typical values are for T_A = 25°C (unless otherwise noted).

PARAMETER		TEST CONDITIONS		T_A	MIN	TYP	MAX	UNIT
POWER SUPPLIES AND CURRENTS								
$I_{IN(VBIAS-ON)}$	V_{BIAS} quiescent current (both channels)	I_{OUT1} = I_{OUT2} = 0 mA, $V_{IN1,2}$ = $V_{ON1,2}$ = V_{BIAS} = 2.5 V		–40°C to 105°C		32	40	µA
$I_{IN(VBIAS-ON)}$	V_{BIAS} quiescent current (single channel)	I_{OUT1} = I_{OUT2} = 0 mA, V_{ON2} = 0 V $V_{IN1,2}$ = V_{ON1} = V_{BIAS} = 2.5 V		–40°C to 105°C		32	40	µA
$I_{IN(VBIAS-OFF)}$	V_{BIAS} shutdown current	$V_{ON1,2}$ = 0 V, $V_{OUT1,2}$ = 0 V		–40°C to 105°C			2	µA
$I_{IN(VIN-OFF)}$	$V_{IN1,2}$ off-state supply current (per channel)	$V_{ON1,2}$ = 0 V, $V_{OUT1,2}$ = 0 V	$V_{IN1,2}$ = 2.5 V	–40°C to 105°C		0.13	3	µA
			$V_{IN1,2}$ = 1.8 V			0.07	2	
			$V_{IN1,2}$ = 1.2 V			0.05	2	
			$V_{IN1,2}$ = 0.8 V			0.04	1	
I_{ON}	ON pin input leakage current	V_{ON} = 5.5 V		–40°C to 105°C			1	µA
RESISTANCE CHARACTERISTICS								
R_{ON}	ON-state resistance	I_{OUT} = –200 mA, V_{BIAS} = 2.5 V	V_{IN} = 2.5 V	25°C		21	24	mΩ
				–40°C to 85°C			27	
				–40°C to 105°C			29	
			V_{IN} = 1.8 V	25°C		19	22	
				–40°C to 85°C			25	
				–40°C to 105°C			27	
			V_{IN} = 1.5 V	25°C		18	21	
				–40°C to 85°C			24	
				–40°C to 105°C			26	
			V_{IN} = 1.2 V	25°C		18	21	
				–40°C to 85°C			24	
				–40°C to 105°C			26	
			V_{IN} = 0.8 V	25°C		17	20	
				–40°C to 85°C			23	
				–40°C to 105°C			25	
R_{PD}	Output pulldown resistance	V_{IN} = 2.5 V, V_{ON} = 0 V, I_{OUT} = 1 mA		Full		280	330	Ω

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6.7 Switching Characteristics

PARAMETER		TEST CONDITION	MIN	TYP	MAX	UNIT
V_{IN} = V_{ON} = V_{BIAS} = 5 V, T_A = 25ºC (unless otherwise noted)						
t_{ON}	Turnon time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF		1559		µs
t_{OFF}	Turnoff time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF		6		
t_R	V_{OUT} rise time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF		1991		
t_F	V_{OUT} fall time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF		2		
t_D	ON delay time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF		665		
V_{IN} = 0.8 V, V_{ON} = V_{BIAS} = 5 V, T_A = 25ºC (unless otherwise noted)						
t_{ON}	Turnon time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF		732		µs
t_{OFF}	Turnoff time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF		161		
t_R	V_{OUT} rise time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF		371		
t_F	V_{OUT} fall time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF		14		
t_D	ON delay time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF		544		
V_{IN} = 2.5 V, V_{ON} = 5 V, V_{BIAS} = 2.5 V, T_A = 25ºC (unless otherwise noted)						
t_{ON}	Turnon time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF		2410		µs
t_{OFF}	Turnoff time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF		7		
t_R	V_{OUT} rise time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF		2412		
t_F	V_{OUT} fall time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF		2		
t_D	ON delay time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF		1181		
V_{IN} = 0.8 V, V_{ON} = 5 V, V_{BIAS} = 2.5 V, T_A = 25ºC (unless otherwise noted)						
t_{ON}	Turnon time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF		1575		µs
t_{OFF}	Turnoff time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF		124		
t_R	V_{OUT} rise time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF		927		
t_F	V_{OUT} fall time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF		14		
t_D	ON delay time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF		1089		

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6.8 Typical Characteristics

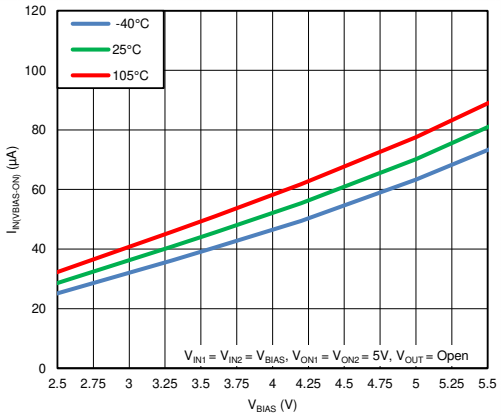


图 1. Quiescent Current vs. V_{BIAS} (Both Channels)

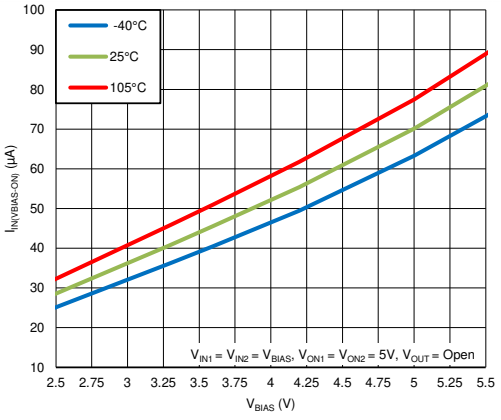


图 2. Quiescent Current vs. V_{BIAS} (Single Channel)

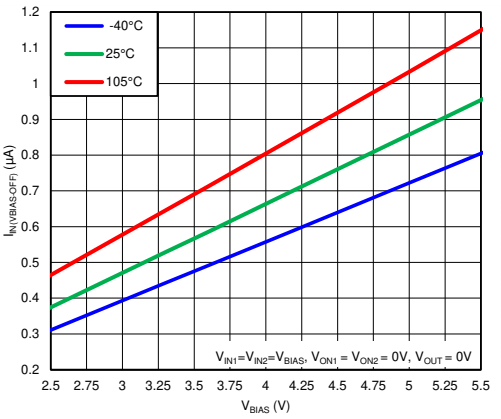


图 3. Shutdown Current vs. V_{BIAS} (Both Channels)

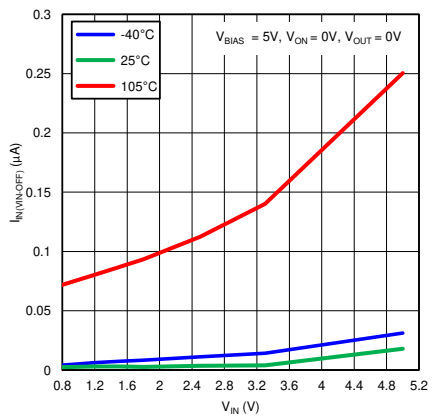


图 4. Off-State VIN Current vs. V_{IN} (Single Channel)

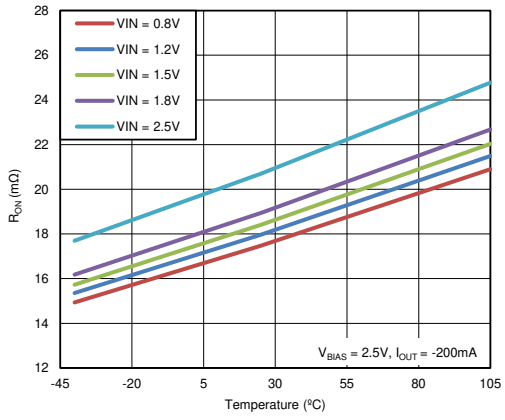


图 5. R_{ON} vs. Temperature (V_{BIAS} = 2.5 V, Single Channel)

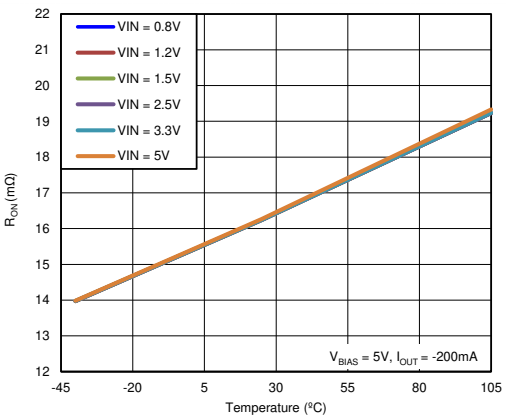


图 6. R_{ON} vs. Temperature (V_{BIAS} = 5 V, Single Channel)

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Typical Characteristics (接下页)

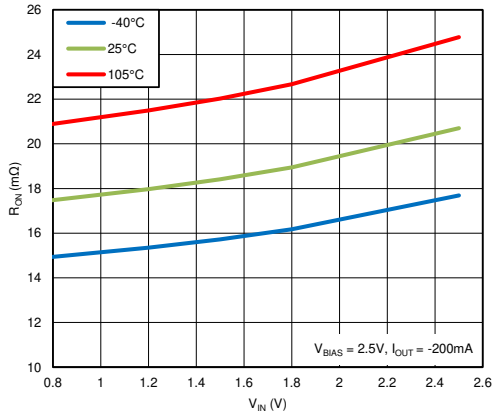


图 7. R_{ON} vs. V_{IN} (V_{BIAS} = 2.5 V, Single Channel)

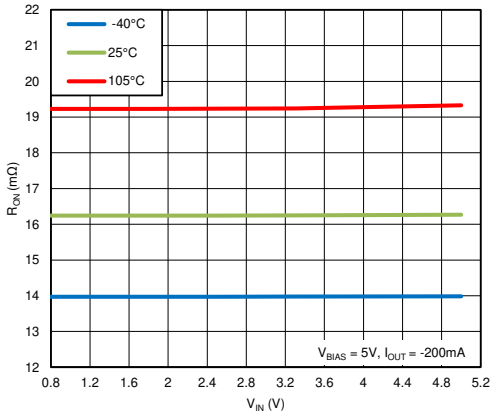


图 8. R_{ON} vs. V_{IN} (V_{BIAS} = 5 V, Single Channel)

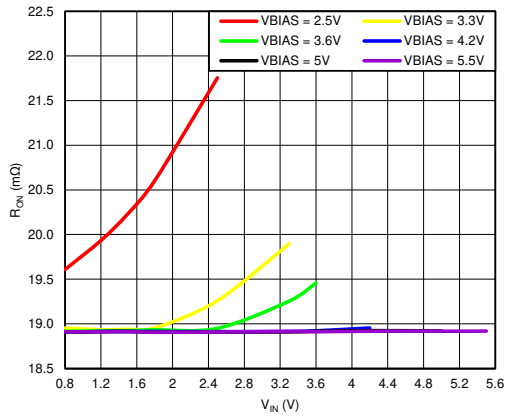


图 9. R_{ON} vs. V_{IN} (T_A = 25°C, Single Channel)

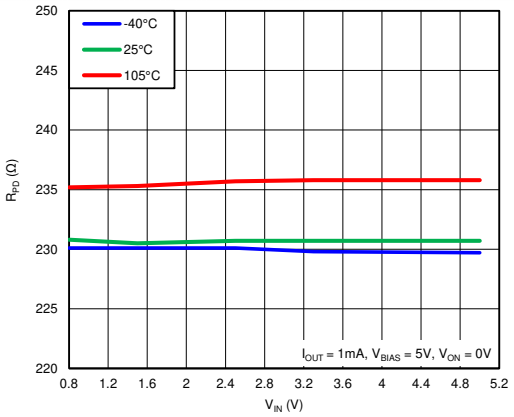


图 10. R_{PD} vs. V_{IN} (V_{BIAS} = 5 V, Single Channel)

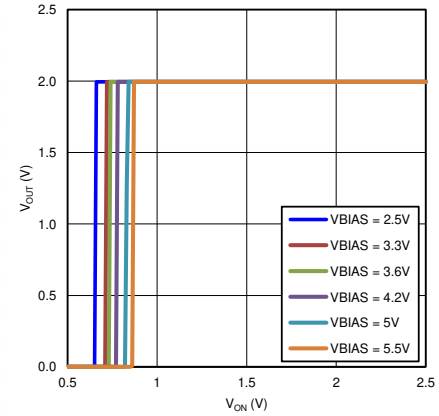


图 11. V_{OUT} vs. V_{ON} (T_A = 25°C, Single Channel)

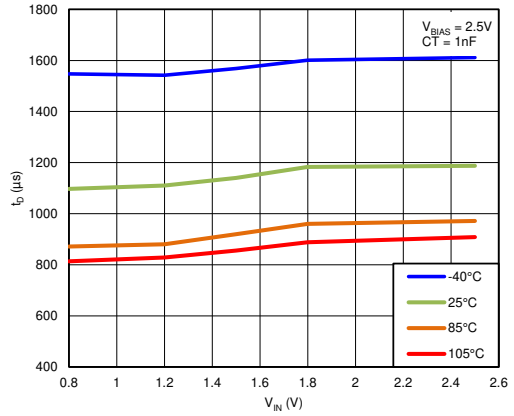


图 12. t_D vs. V_{IN} (V_{BIAS} = 2.5 V, CT = 1 nF)

Typical Characteristics (接下页)

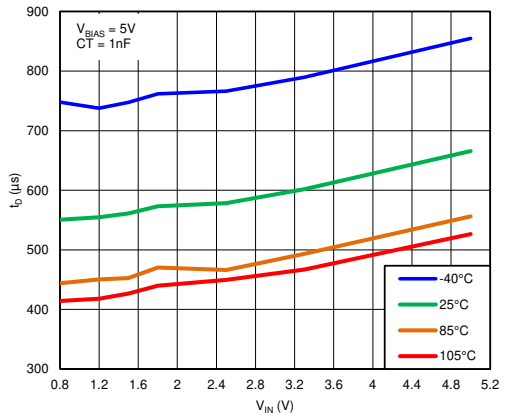


图 13. t_D vs. V_{IN} (V_{BIAS} = 5 V, CT = 1 nF)

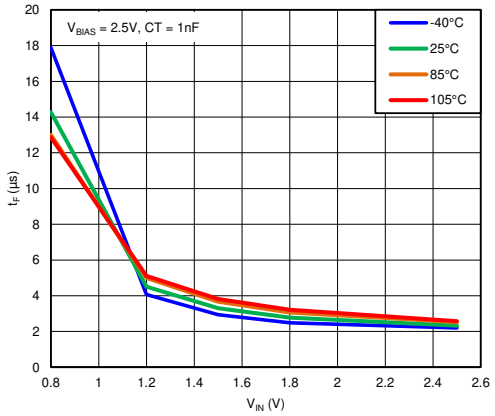


图 14. t_F vs. V_{IN} (V_{BIAS} = 2.5 V, CT = 1 nF)

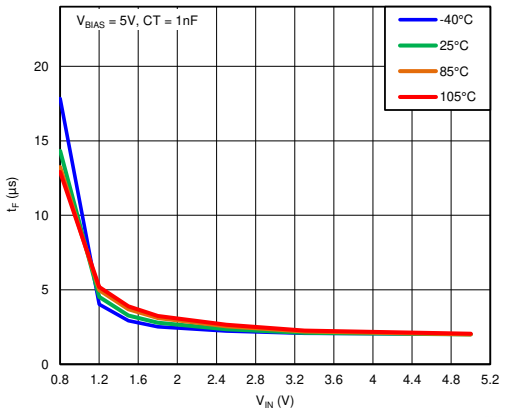


图 15. t_F vs. V_{IN} (V_{BIAS} = 5 V, CT = 1 nF)

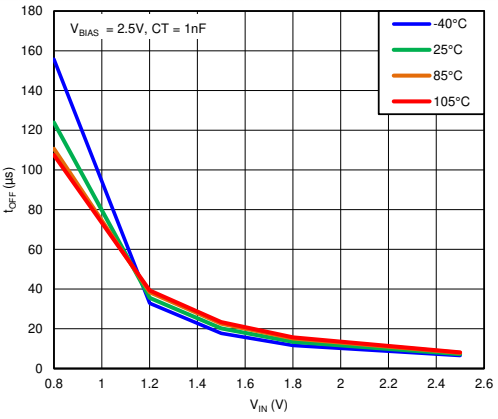


图 16. t_{OFF} vs. V_{IN} (V_{BIAS} = 2.5 V, CT = 1 nF)

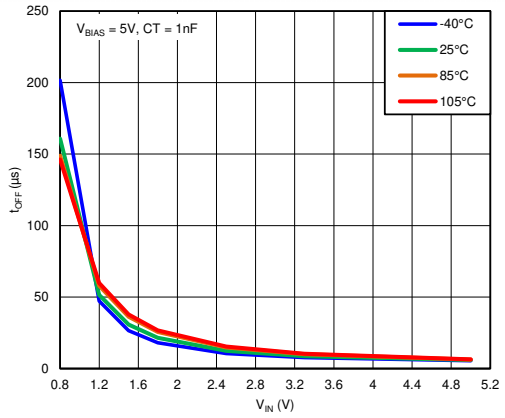


图 17. t_{OFF} vs. V_{IN} (V_{BIAS} = 5 V, CT = 1 nF)

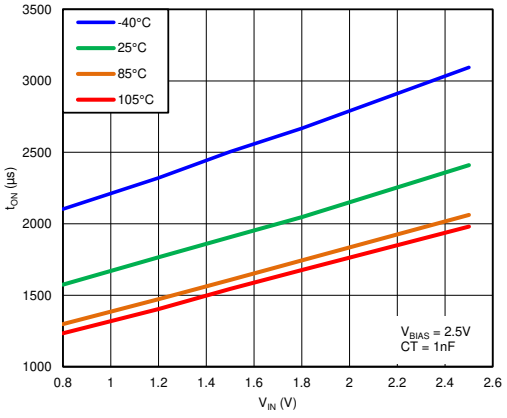


图 18. t_{ON} vs. V_{IN} (V_{BIAS} = 2.5 V, CT = 1 nF)

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Typical Characteristics (接下页)

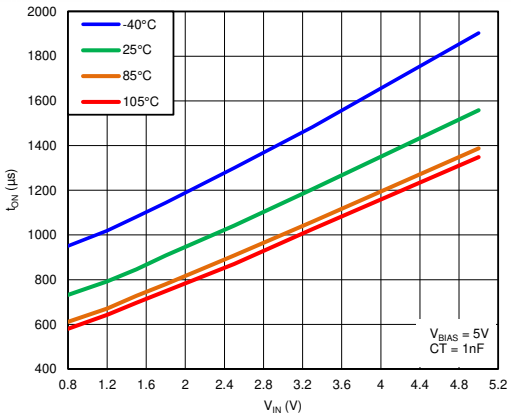


图 19. t_{ON} vs. V_{IN} (V_{BIAS} = 5 V, CT = 1 nF)

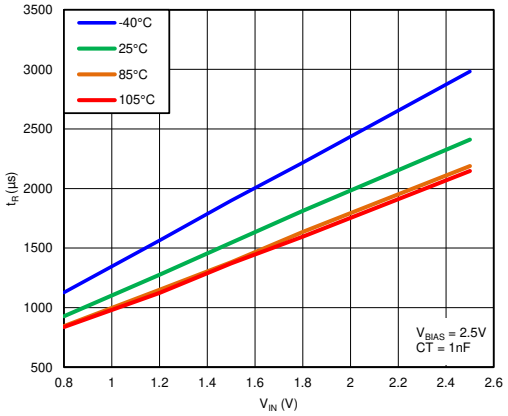


图 20. t_R vs. V_{IN} (V_{BIAS} = 2.5 V, CT = 1 nF)

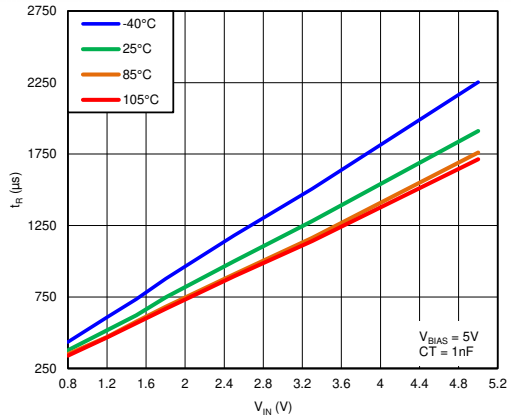


图 21. t_R vs. V_{IN} (V_{BIAS} = 5 V, CT = 1 nF)

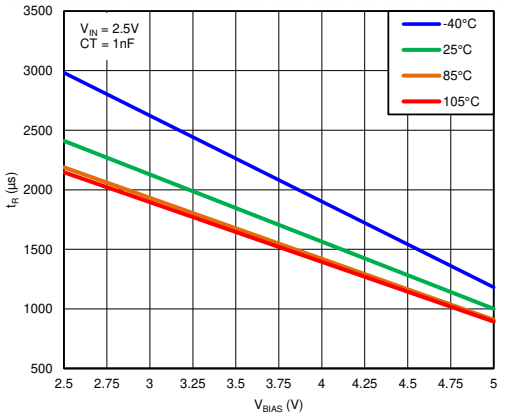


图 22. t_R vs. V_{BIAS} (V_{IN} = 2.5 V, CT = 1 nF)

6.8.1 Typical AC Scope Captures at T_A = 25ºC, CT = 1 nF

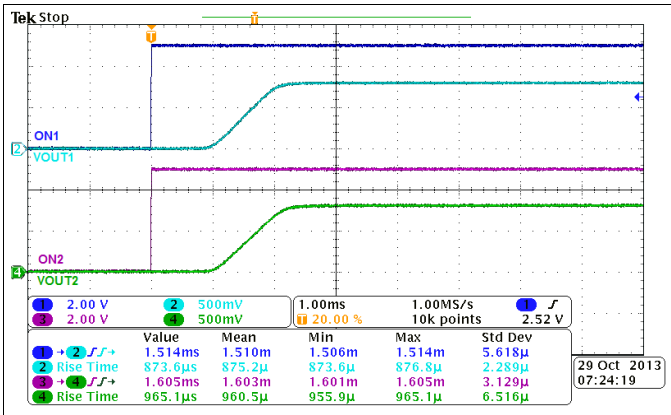


图 23. Turnon Response Time (V_{IN} = 0.8 V, V_{BIAS} = 2.5 V, C_{IN} = 1 µF, C_L = 0.1 µF, R_L = 10 Ω)

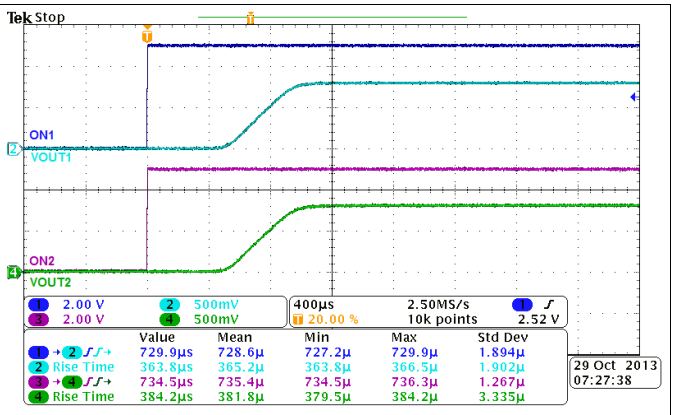


图 24. Turnon Response Time (V_{IN} = 0.8 V, V_{BIAS} = 5 V, C_{IN} = 1 µF, C_L = 0.1 µF, R_L = 10 Ω)

Typical AC Scope Captures at T_A = 25°C, CT = 1 nF (接下页)

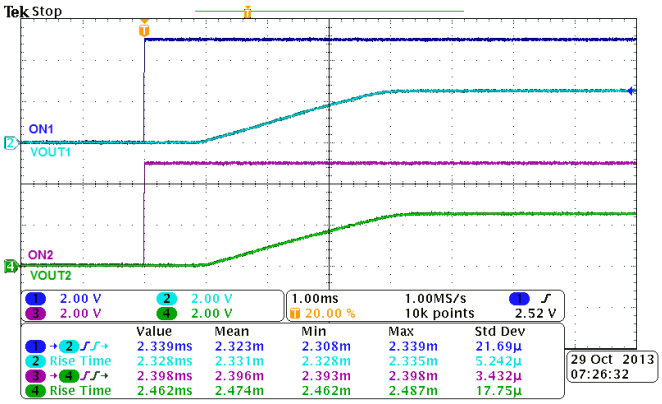


图 25. Turnon Response Time (V_{IN} = 2.5 V, V_{BIAS} = 2.5 V, C_{IN} = 1 µF, C_L = 0.1 µF, R_L = 10 Ω)

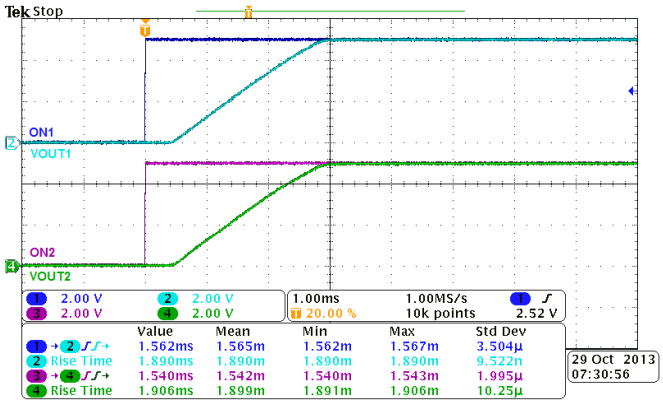


图 26. Turnon Response Time (V_{IN} = 5 V, V_{BIAS} = 5 V, C_{IN} = 1 µF, C_L = 0.1 µF, R_L = 10 Ω)

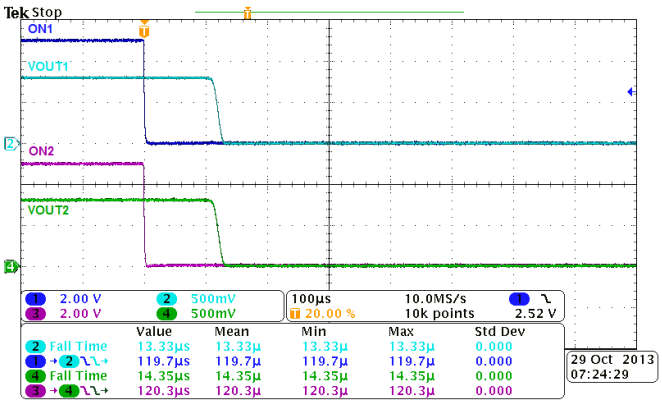


图 27. Turnoff Response Time (V_{IN} = 0.8 V, V_{BIAS} = 2.5 V, C_{IN} = 1 µF, C_L = 0.1 µF, R_L = 10 Ω)

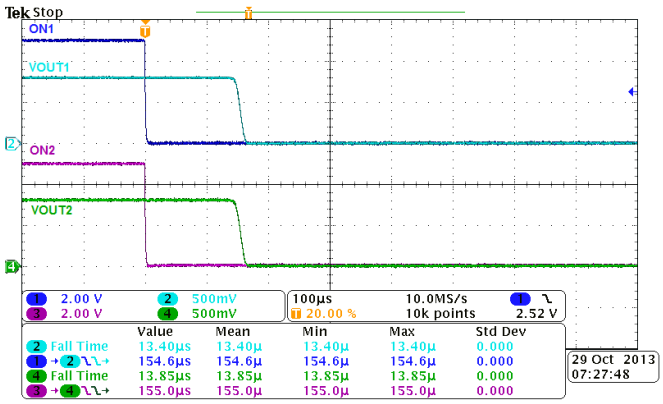


图 28. Turnoff Response Time (V_{IN} = 0.8 V, V_{BIAS} = 5 V, C_{IN} = 1 µF, C_L = 0.1 µF, R_L = 10 Ω)

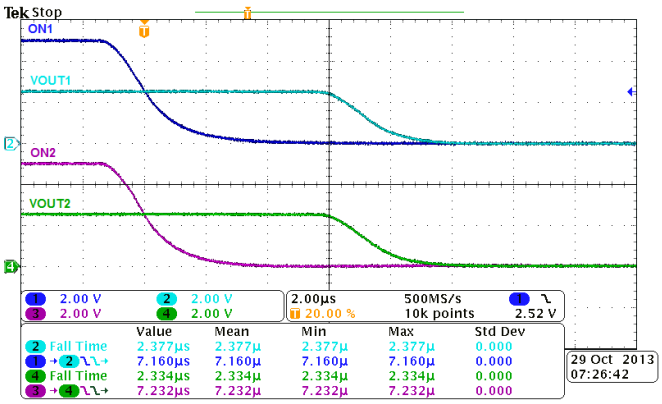


图 29. Turnoff Response Time (V_{IN} = 2.5 V, V_{BIAS} = 2.5 V, C_{IN} = 1 µF, C_L = 0.1 µF, R_L = 10 Ω)

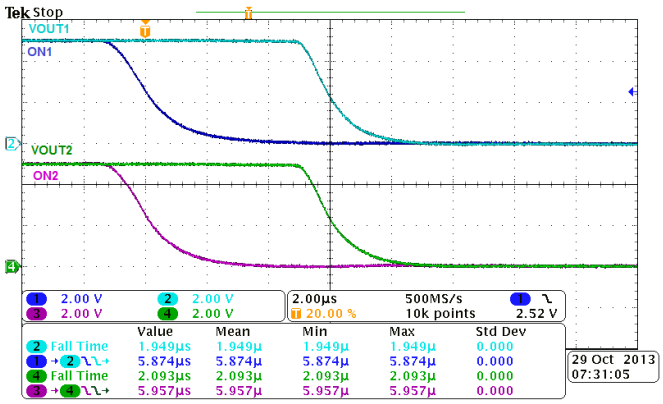
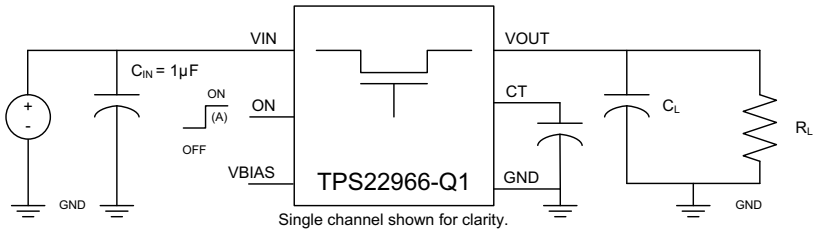


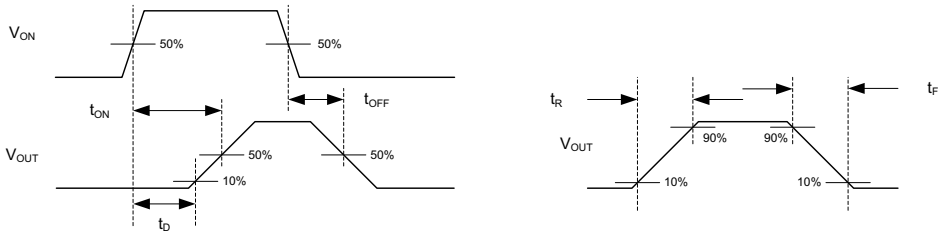
图 30. Turnoff Response Time (V_{IN} = 5 V, V_{BIAS} = 5 V, C_{IN} = 1 µF, C_L = 0.1 µF, R_L = 10 Ω)

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7 Parameter Measurement Information



TEST CIRCUIT



TIMING WAVEFORMS

(A) Control signal rise and fall times are 100 ns.

图 31. Test Circuit and Timing Waveforms

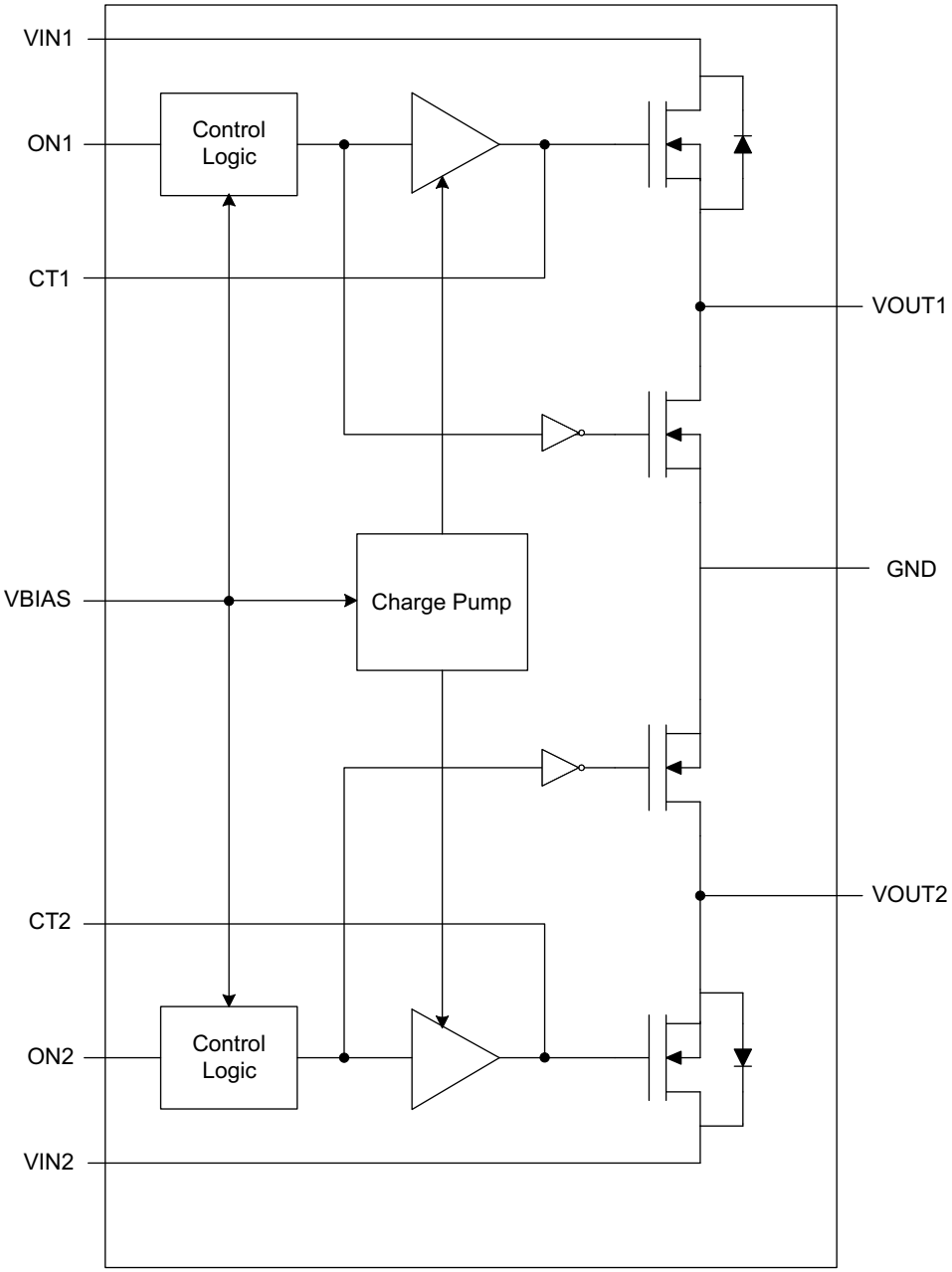
8 Detailed Description

8.1 Overview

The device is a dual-channel, 4-A automotive load switch in a 14-pin SON package. To reduce the voltage drop in high current rails, the device implements a low-resistance N-channel MOSFET.

The device has a programmable slew rate for applications that require specific rise-time. The device has very low leakage current during off state. This prevents downstream circuits from pulling high standby current from the supply. Integrated control logic, driver, power supply, and output discharge FET eliminates the need for any external components, which reduces solution size and bill of materials (BOM) count.

8.2 Functional Block Diagram



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8.3 Feature Description

8.3.1 Quick Output Discharge

Each channel of the TPS22966-Q1 includes a Quick Output Discharge (QOD) feature. When the switch is disabled, a discharge resistor is connected between VOUT and GND. This resistor has a typical value of 230-Ω and prevents the output from floating while the switch is disabled.

8.3.2 ON/OFF Control

The ON pins control the state of the switch. Asserting ON high enables the switch. ON is active high and has a low threshold, making it capable of interfacing with low-voltage signals. The ON pin is compatible with standard GPIO logic threshold. It can be used with any microcontroller with 1.2-V or higher GPIO voltage. This pin cannot be left floating and must be tied either high or low for proper functionality.

8.3.3 Adjustable Rise Time

A capacitor to GND on the CTx pins sets the slew rate for each channel. To ensure desired performance, a capacitor with a minimum voltage rating of 25 V should be used on the CTx pin. An approximate formula for the relationship between CTx and slew rate is (the equation below accounts for 10% to 90% measurement on V_{OUT} and does **NOT** apply for CTx = 0 pF. Use 表 1 to determine rise times for when CTx = 0 pF):

$$SR = 0.32 \times CT + 13.7 \quad (1)$$

where

- SR = slew rate (in µs/V)
- CT = the capacitance value on the CTx pin (in pF)
- The units for the constant 13.7 is in µs/V.

Rise time can be calculated by multiplying the input voltage by the slew rate. 表 1 shows rise time values measured on a typical device. Rise times shown below are only valid for the power-up sequence where V_{IN} and V_{BIAS} are already in steady state condition, and the ON pin is asserted high.

表 1. Rise Time Values

CTx (pF)	RISE TIME (µs) 10% - 90%, C_L = 0.1µF, C_{IN} = 1µF, R_L = 10Ω TYPICAL VALUES at 25°C, V_{BIAS} = 5V, 25V X7R 10% CERAMIC CAP						
	5V	3.3V	1.8V	1.5V	1.2V	1.05V	0.8V
0	124	88	63	60	53	49	42
220	481	323	193	166	143	133	109
470	855	603	348	299	251	228	175
1000	1724	1185	670	570	469	411	342
2200	3328	2240	1308	1088	893	808	650
4700	7459	4950	2820	2429	1920	1748	1411
10000	16059	10835	6040	5055	4230	3770	3033

8.4 Device Functional Modes

表 2. Functional Table

ONx	VINx to VOUTx	VOUTx to GND
L	Off	On
H	On	Off

9 Application and Implementation

注

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

9.1 Application Information

9.1.1 Input Capacitor (Optional)

To limit the voltage drop on the input supply caused by transient in-rush currents when the switch turns on into a discharged load capacitor, a capacitor needs to be placed between VIN and GND. A 1-µF ceramic capacitor, C_{IN}, placed close to the pins, is usually sufficient. Higher values of C_{IN} can be used to further reduce the voltage drop in high-current application. When switching heavy loads, it is recommended to have an input capacitor about 10 times higher than the output capacitor to avoid excessive voltage drop.

9.1.2 Output Capacitor (Optional)

Due to the integrated body diode in the NMOS switch, a C_{IN} greater than C_L is highly recommended. A C_L greater than C_{IN} can cause V_{OUT} to exceed V_{IN} when the system supply is removed. This could result in current flow through the body diode from VOUT to VIN. A C_{IN} to C_L ratio of 10 to 1 is recommended for minimizing V_{IN} dip caused by inrush currents during start-up, however a 10 to 1 ratio for capacitance is not required for proper functionality of the device. A ratio smaller than 10 to 1 (such as 1 to 1) could cause slightly more V_{IN} dip upon turnon due to inrush currents. This can be mitigated by increasing the capacitance on the CT pin for a longer rise time (see *Adjustable Rise Time*).

9.1.3 V_{IN} and V_{BIAS} Voltage Range

For optimal R_{ON} performance, make sure $V_{IN} \leq V_{BIAS}$. The device will still be functional if $V_{IN} > V_{BIAS}$ but it will exhibit R_{ON} greater than what is listed in *Electrical Characteristics*. See 图 32 for an example of a typical device. Notice the increasing R_{ON} as V_{IN} exceeds V_{BIAS} voltage.

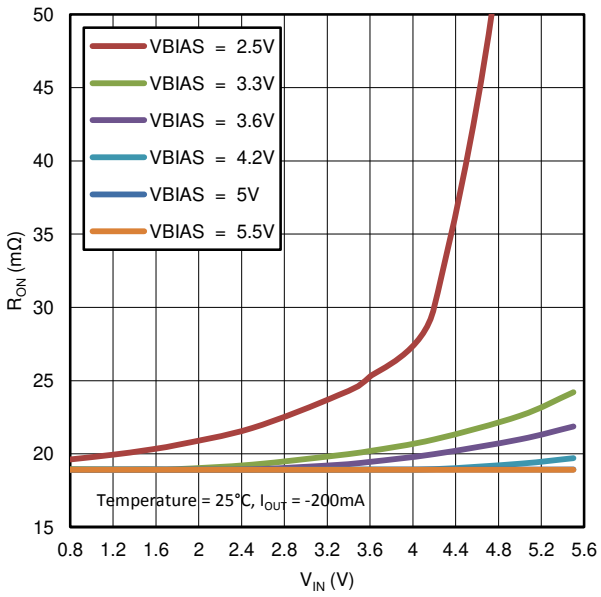


图 32. R_{ON} vs. V_{IN} (Single Channel)

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Application Information (接下页)

9.1.4 Safe Operating Area (SOA)

The SOA curves in 图 33 show the continuous current carrying capability of the device versus ambient temperature (T_A) to ensure reliable operation over 100,000 hours of device lifetime. Each curve represents a specific percent of time that the switch is on.

The 100% curve represents use for a full 24 hours in a day. The 75% curve indicates 18 hours of use in a day while the 12.5% curve shows 3 hours of use per day.

Examples on how to use this plot:

- The application has an ambient temperature of 60°C and the switch will be on 100% of the time. The maximum continuous current that can be applied is approximately 2.1 A.
- The application requires the switch to be on 12.5% of the time and the current while on will be 3 A. The maximum ambient temperature is approximately 100°C.
- The application requires 2 A and will be operated at 70°C. The switch can be on for a maximum of 75% of the time.
- It is expected that most applications will not have specific use cases as defined in the examples above. Different use cases can be combined to generate a more complete view of a specific application. This example shows use under various conditions simplified to an average use case. The application requires operation at 4 A for 25% of the time, 1 A for 25% of the time and is off the remaining 50% of the time. Ambient temperature will vary from 25°C to 50°C. Will there be any limitations? The average current can be calculated as (4 A × 25% + 1 A * 25% + 0 A * 50%). The average current calculates to be 1.25 A. Assuming worst case temperature of 50°C, the resulting application is within the safe operating area.

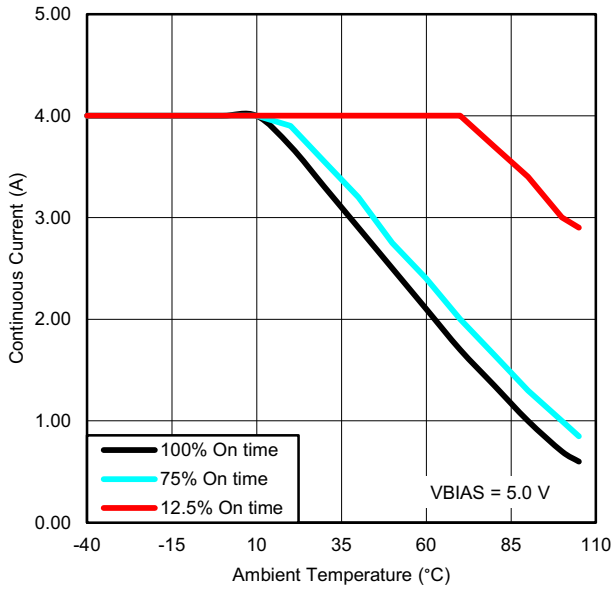


图 33. Safe Operating Area

9.2 Typical Application

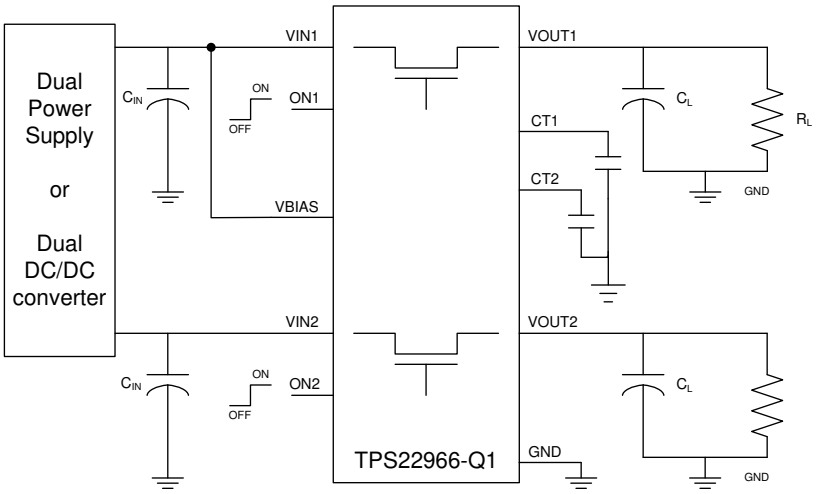


图 34. Typical Application Schematic

9.2.1 Design Requirements

For this design example, use the parameters listed in 表 3 as the input parameters.

表 3. Design Parameters

DESIGN PARAMETER	VALUE
Input voltage	3.3 V
Bias voltage	5 V
Load capacitance (C_L)	22 µF
Maximum acceptable inrush current	400 mA

9.2.2 Detailed Design Procedure

When the switch is enabled, the output capacitors must be charged up from 0 V to the set value (3.3 V in this example). This charge arrives in the form of inrush current. Inrush current can be calculated using 公式 2:

Inrush Current = C × dV/dt

where

- C = output capacitance
- dV = output voltage
- dt = rise time (2)

The TPS22966-Q1 offers adjustable rise time for VOUT. This feature allows the user to control the inrush current during turnon. The appropriate rise time can be calculated using 表 3 and the inrush current equation.

400 mA = 22 µF × 3.3 V/dt (3)

dt = 181.5 µs (4)

To ensure an inrush current of less than 400 mA, choose a CT value that will yield a rise time of more than 181.5 µs. See the oscilloscope captures in for an example of how the CT capacitor can be used to reduce inrush current.

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9.2.3 Application Curves

V_{BIAS} = 5 V ; V_{IN} = 3.3 V ; C_L = 22 µF

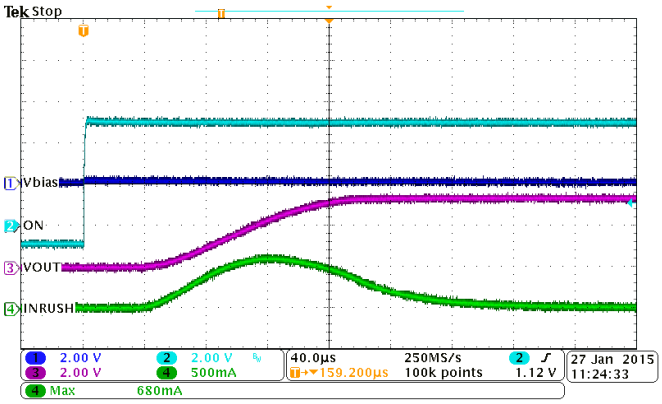


图 35. Inrush Current With CT = 0 pF

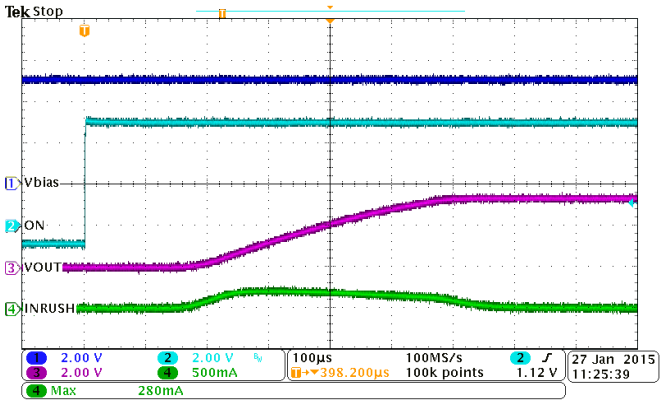


图 36. Inrush Current With CT = 220 pF

10 Power Supply Recommendations

The device is designed to operate from a VBIAS range of 2.5 V to 5.5 V and a VIN voltage range of 0 V to 5.5 V. The power supply should be well regulated and placed as close to the device terminals as possible. It must be able to withstand all transient and load current steps. In most situations, using an input capacitance of 1 uF is sufficient to prevent the supply voltage from dipping when the switch is turned on. In cases where the power supply is slow to respond to a large transient current or large load current step, additional bulk capacitance may be required on the input.

The requirements for larger input capacitance can be mitigated by adding additional capacitance to the CT pin. This will cause the load switch to turn on more slowly. Not only will this reduce transient inrush current, but it will also give the power supply more time to respond to the load current step.

11 Layout

11.1 Layout Guidelines

For best performance, all traces should be as short as possible. To be most effective, the input and output capacitors should be placed close to the device to minimize the effects that parasitic trace inductances may have on normal operation. Using wide traces for VIN, VOUT, and GND helps minimize the parasitic electrical effects along with minimizing the case to ambient thermal impedance.

The maximum IC junction temperature should be restricted to 150°C under normal operating conditions. To calculate the maximum allowable power dissipation, $P_{D(max)}$ for a given output current and ambient temperature, use the following equation:

$$P_{D(max)} = \frac{T_{J(max)} - T_A}{\theta_{JA}} \quad (5)$$

where

- $P_{D(max)}$ = maximum allowable power dissipation
- $T_{J(max)}$ = maximum allowable junction temperature (150°C for the TPS22966-Q1)
- T_A = ambient temperature
- Θ_{JA} = junction to air thermal impedance. See Thermal Information section. This parameter is highly dependent upon board layout.

图 37 shows an example of a layout. Notice the thermal vias located under the exposed thermal pad of the device. This allows for thermal diffusion away from the device.

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11.2 Layout Example

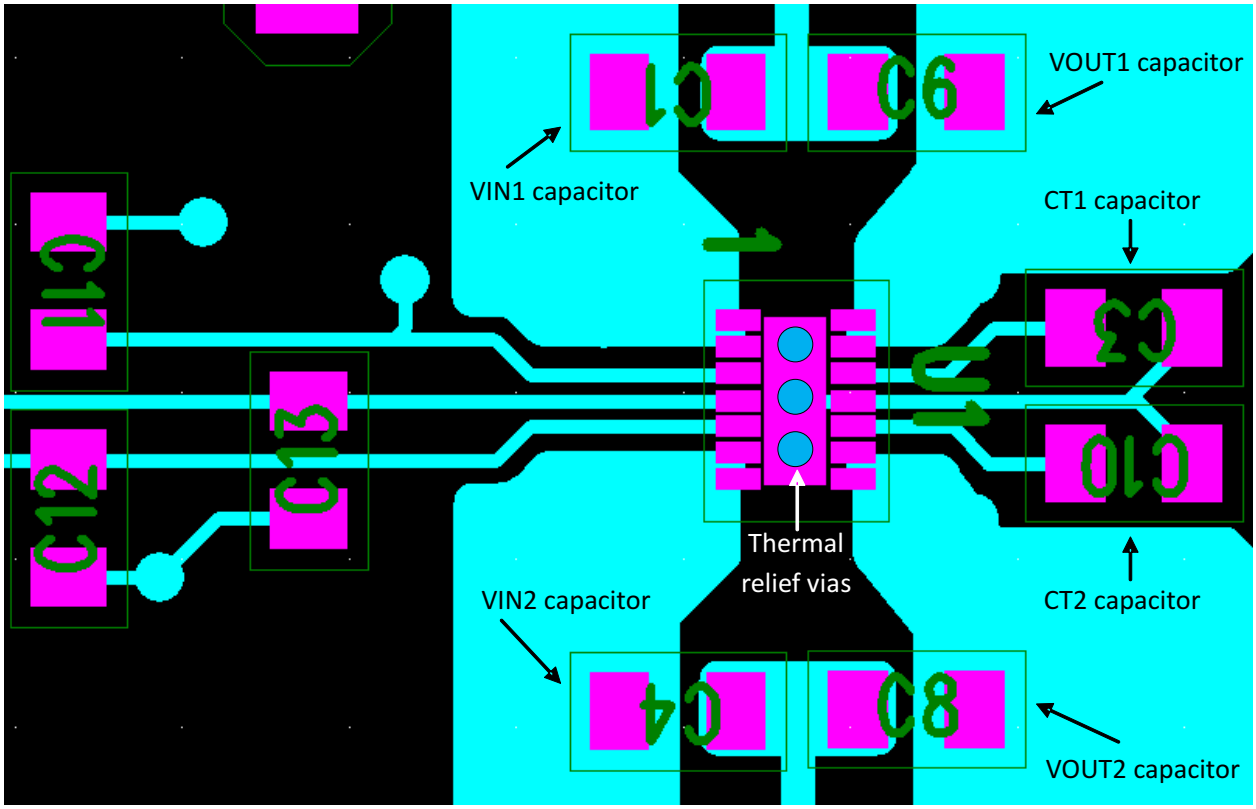


图 37. Layout Example

12 器件和文档支持

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12.2 静电放电警告



这些装置包含有限的内置 ESD 保护。 存储或装卸时，应将导线一起截短或将装置放置于导电泡棉中，以防止 MOS 门极遭受静电损伤。

12.3 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

12.4 接收文档更新通知

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13 机械、封装和可订购信息

以下页面包含机械、封装和可订购信息。这些信息是指定器件的最新可用数据。数据如有变更，恕不另行通知，且不会对此文档进行修订。如需获取此数据表的浏览器版本，请查阅左侧的导航栏。

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PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TPS22966TDPURQ1	Active	Production	WSON (DPU) | 14	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 105	966TQ1
TPS22966TDPURQ1.A	Active	Production	WSON (DPU) | 14	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 105	966TQ1
TPS22966TDPUTQ1	Active	Production	WSON (DPU) | 14	250 | SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 105	966TQ1
TPS22966TDPUTQ1.A	Active	Production	WSON (DPU) | 14	250 | SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 105	966TQ1

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts 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.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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OTHER QUALIFIED VERSIONS OF TPS22966-Q1 :

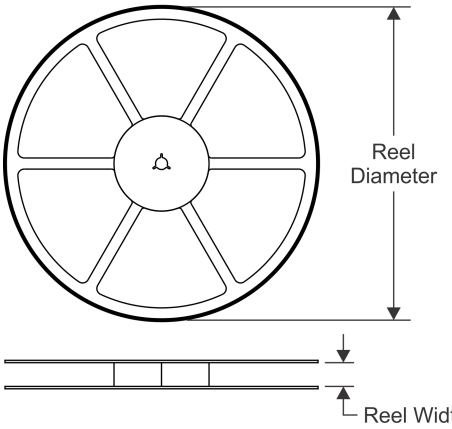
- Catalog : TPS22966

NOTE: Qualified Version Definitions:

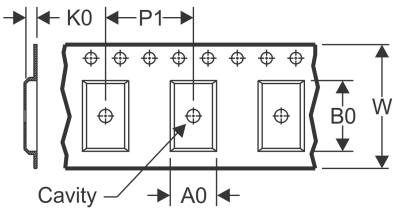
- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION

REEL DIMENSIONS

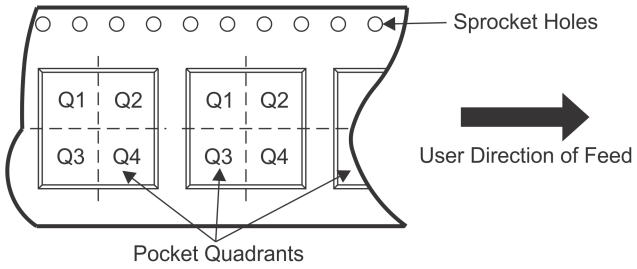


TAPE DIMENSIONS



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

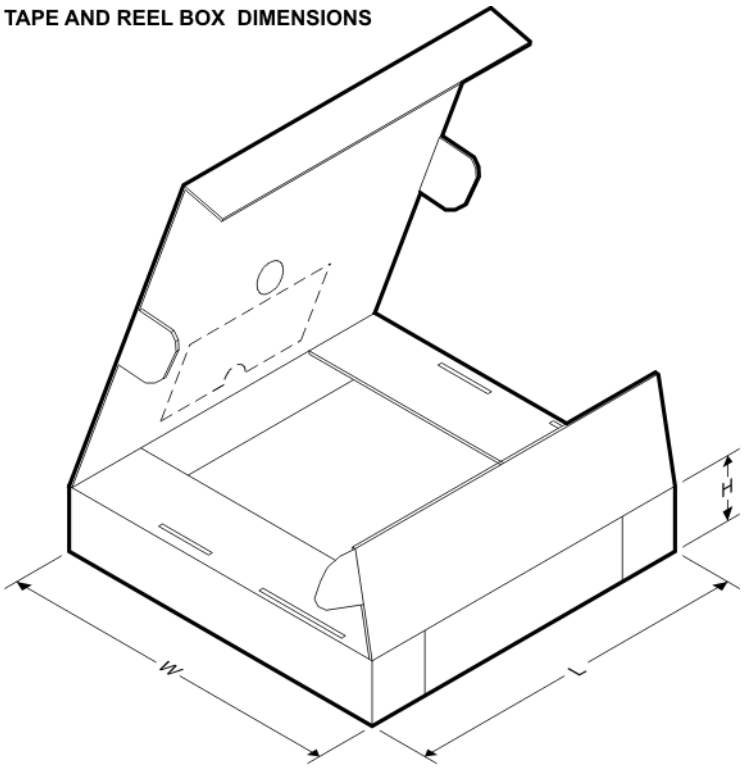
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TPS22966TDPURQ1	WSON	DPU	14	3000	180.0	8.4	2.25	3.25	1.05	4.0	8.0	Q1
TPS22966TDPUTQ1	WSON	DPU	14	250	180.0	8.4	2.25	3.25	1.05	4.0	8.0	Q1

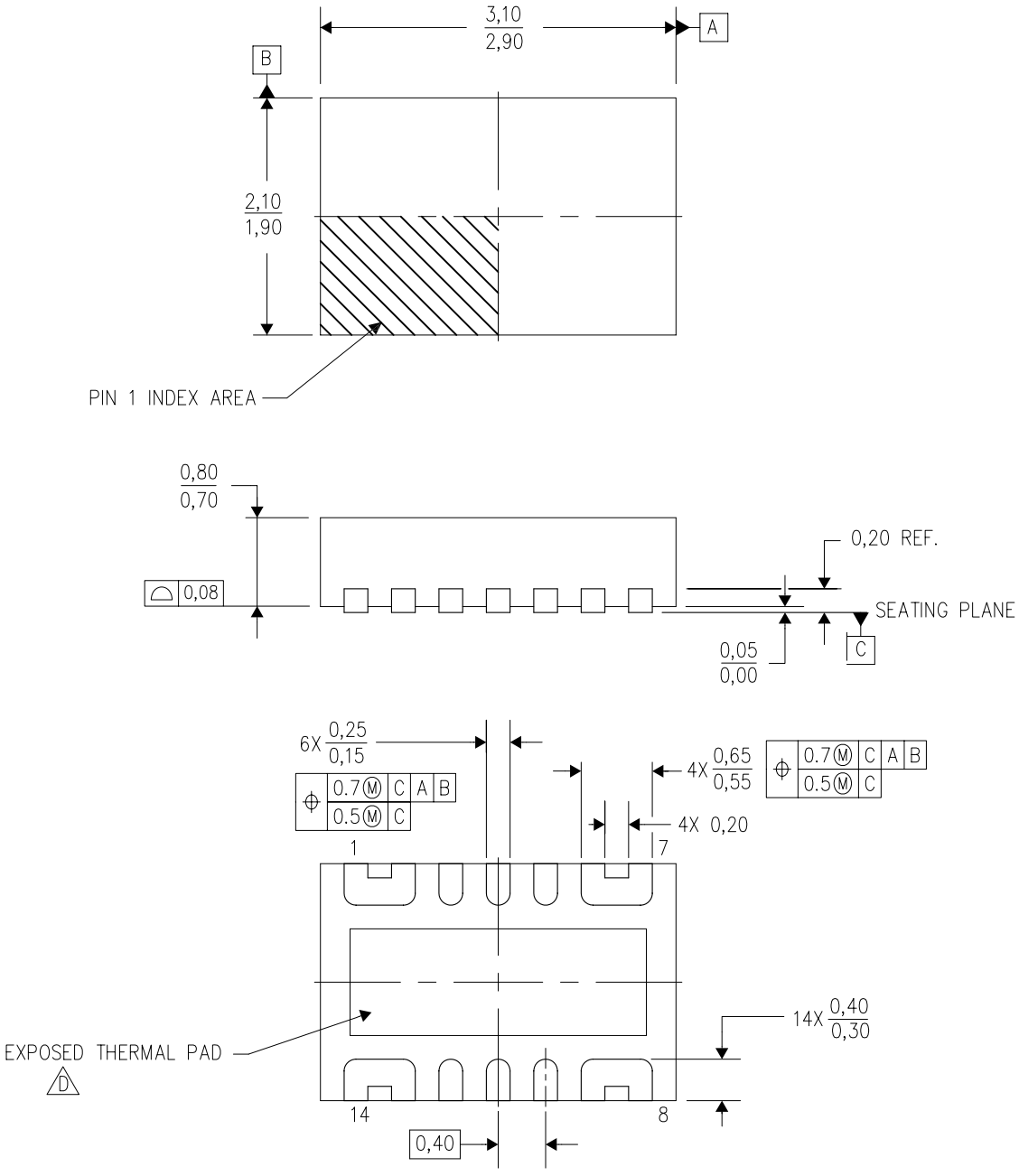
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS22966TDPURQ1	WSON	DPU	14	3000	210.0	185.0	35.0
TPS22966TDPUTQ1	WSON	DPU	14	250	210.0	185.0	35.0

DPU (R–PWSON–N14) PLASTIC SMALL OUTLINE NO–LEAD



4211321/B 11/10

NOTES:
A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
B. This drawing is subject to change without notice.
C. Small Outline No–Lead (SON) package configuration.
D. The package thermal pad must be soldered to the board for thermal and mechanical performance. See the Product Data Sheet for details regarding the exposed thermal pad dimensions.
E. This package is Pb–free.

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