ULTRA-SMALL, LOW-INPUT VOLTAGE, LOW r_{ON} LOAD SWITCH

FEATURES

- **Low Input Voltage: 1.0 V to 3.6 V**
- **Ultra-Low ON-State Resistance**
  - **r_{ON} = 90 mΩ at V_{IN} = 3.6 V**
  - **r_{ON} = 100 mΩ at V_{IN} = 2.5 V**
  - **r_{ON} = 114 mΩ at V_{IN} = 1.8 V**
  - **r_{ON} = 172 mΩ at V_{IN} = 1.2 V**
- **500-mA Maximum Continuous Switch Current**
- **Ultra Low Quiescent Current: 82 nA at 1.8 V**
- **Ultra Low Shutdown Current: 44 nA at 1.8 V**
- **Low Control Input Thresholds Enable Use of 1.2-V/1.8-V/2.5-V/3.3-V Logic**
- **Controlled Slew Rate to Avoid Inrush Current: 220 µs t_r**
- **ESD Performance Tested Per JESD 22**
  - **2000-V Human-Body Model (A114-B, Class II)**
  - **1000-V Charged-Device Model (C101)**
- **Four-Terminal Wafer-Chip-Scale Package (WCSP)**
  - **0.9 mm × 0.9 mm, 0.5-mm Pitch, 0.5-mm Height**

APPLICATIONS

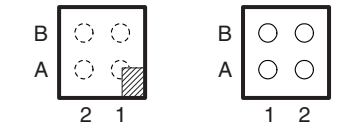
- **Personal Digital Assistants (PDAs)**
- **Cellular Phones**
- **GPS Devices**
- **MP3 Players**
- **Digital Cameras**
- **Peripheral Ports**
- **Portable Instrumentation**
- **RF Modules**

DESCRIPTION

TPS22906 is an ultra-small, low ON-state resistance (r_{ON}) load switch with controlled turn on. The device contains a P-channel MOSFET that operates over an input voltage range of 1.0 V to 3.6 V. The switch is controlled by an on/off input (ON), which is capable of interfacing directly with low-voltage control signals. A 120-Ω on-chip load resistor is added for output quick discharge when the switch is turned off.

TPS22906 is available in a space-saving 4-terminal WCSP with 0.5-mm pitch (YZV). The device is characterized for operation over the free-air temperature range of –40°C to 85°C.

YZV PACKAGE



Laser Marking View Bump View

TERMINAL ASSIGNMENTS

B	ON	GND
A	V_{IN}	V_{OUT}
	2	**1**

DEVICE	r_{ON} at 1.8 V (TYP)	SLEW RATE (TYP at 1.8 V)	QUICK OUTPUT DISCHARGE(1)	MAX OUTPUT CURRENT	ENABLE
TPS22906	114 mΩ	220 µs	Yes	500 mA	Active high

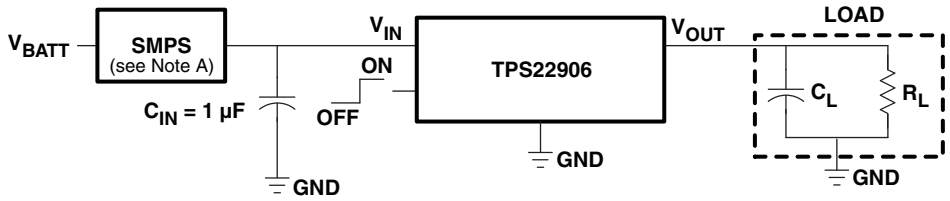
(1) This feature discharges the output of the switch to ground through a 120-Ω resistor, preventing the output from floating.

ORDERING INFORMATION

T_A	PACKAGE(1)(2)		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	WCSP – YZV (0.5-mm pitch)	Tape and reel	TPS22906YZVR	_ _ _ 5D_ (3)

(1) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.
(2) 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.
(3) The actual top-side marking has three preceding characters to denote year, month, and sequence code, and one following character to designate the wafer fab/assembly site. Pin 1 identifier indicates solder-bump composition (1 = SnPb, • = Pb-free).

TYPICAL APPLICATION



A. Switched mode power supply

APPLICATION BLOCK DIAGRAM

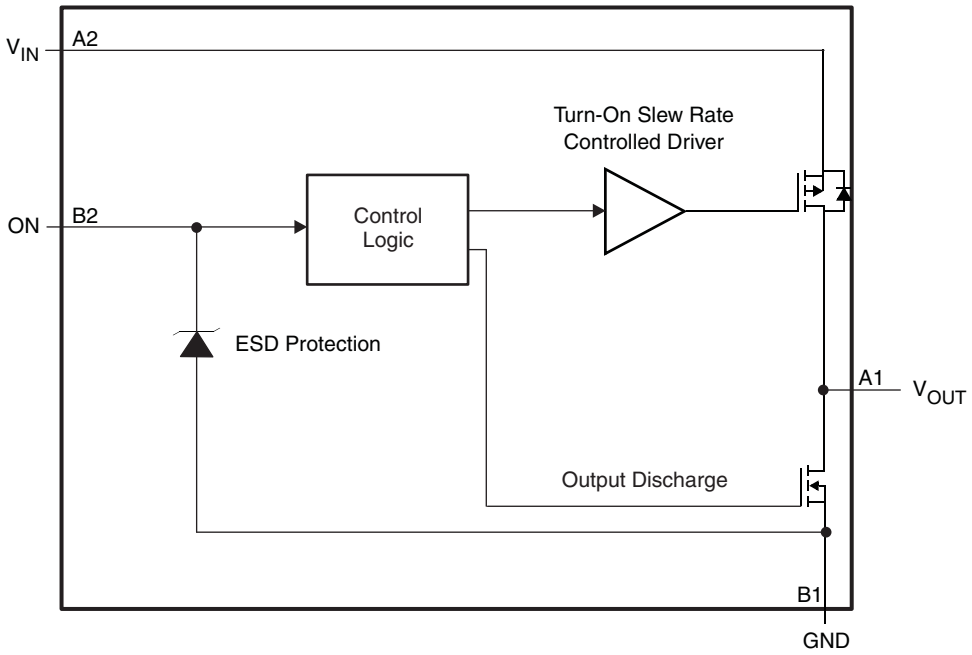


Figure 1. Functional Block Diagram

FUNCTION TABLE

ON (Control Input)	V_{IN} to V_{OUT}	V_{OUT} to GND
L	OFF	ON
H	ON	OFF

TERMINAL FUNCTIONS

TERMINAL		DESCRIPTION
BALL NO.	NAME	
A1	V_{OUT}	Switch output
A2	V_{IN}	Switch input, bypass this input with a ceramic capacitor to ground
B1	GND	Ground
B2	ON	Switch control input, active high

ABSOLUTE MAXIMUM RATINGS(1)

			MIN	MAX	UNIT
V_{IN}	Input voltage range		–0.3	4	V
V_{OUT}	Output voltage range			V_{IN} + 0.3	V
V_{ON}	Input voltage range		–0.3	4	V
P_D	Power dissipation at T_A = 25°C			0.48	W
I_{MAX}	Maximum continuous switch current			500	mA
T_A	Operating free-air temperature range		–40	85	°C
T_{stg}	Storage temperature range		–65	150	°C
T_{lead}	Maximum lead temperature (10-s soldering time)			300	°C
ESD	Electrostatic discharge protection	Human-Body Model (HBM)		2000	V
		Charged-Device Model (CDM)		1000	

(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.

THERMAL IMPEDANCE RATING

				UNIT
θ_{JA}	Package thermal impedance(1)	YZV package	123	°C/W

(1) The package thermal impedance is calculated in accordance with JESD 51-7.

RECOMMENDED OPERATING CONDITIONS

		MIN	MAX	UNIT
V_{IN}	Input voltage range	1	3.6	V
V_{OUT}	Output voltage range		V_{IN}	V
V_{IH}	High-level input voltage, ON	0.85	3.6	V
V_{IL}	Low-level input voltage, ON		0.4	V
C_{IN}	Input capacitor	1(1)		µF

(1) See Application Information.

ELECTRICAL CHARACTERISTICS

V_{IN} = 1.0 V to 3.6 V, T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T_A	MIN	TYP[1]	MAX	UNIT
I_{IN}	Quiescent current	I_{OUT} = 0, V_{IN} = V_{ON}	V_{IN} = 1.1 V	Full		37	120	nA
			V_{IN} = 1.8 V	Full		82	235	
			V_{IN} = 3.6 V	Full		204	880	
$I_{IN(OFF)}$	OFF-state supply current	V_{ON} = GND, OUT = Open	V_{IN} = 1.1 V	Full		22	210	nA
			V_{IN} = 1.8 V	Full		44	260	
			V_{IN} = 3.6 V	Full		137	700	
$I_{IN(LEAKAGE)}$	OFF-state switch current	V_{ON} = GND, V_{OUT} = 0	V_{IN} = 1.1 V	Full		22	140	nA
			V_{IN} = 1.8 V	Full		45	230	
			V_{IN} = 3.6 V	Full		137	610	
r_{ON}	ON-state resistance	I_{OUT} = - 200 mA	V_{IN} = 3.6 V	25°C		90	108	mΩ
				Full			125	
			V_{IN} = 2.5 V	25°C		100	120	
				Full			140	
			V_{IN} = 1.8 V	25°C		114	138	
				Full			160	
			V_{IN} = 1.2 V	25°C		172	210	
				Full			235	
			V_{IN} = 1.1 V	25°C		204	330	
				Full			330	
r_{PD}	Output pulldown resistance	V_{IN} = 3.3 V, V_{ON} = 0, I_{OUT} = 30 mA		25°C		88	120	Ω
I_{ON}	ON input leakage current	V_{ON} = 1.1 V to 3.6 V or GND		Full			25	nA

(1) Typical values are at the specified V_{IN} and T_A = 25°C.

SWITCHING CHARACTERISTICS

V_{IN} = 1.1 V, T_A = 25°C , RL_CHIP = 120 Ω (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
t_{ON}	Turn-ON time	R_L = 500 Ω	C_L = 0.1 µF		531		µs
			C_L = 1 µF		596		
			C_L = 3.3 µF		659		
t_{OFF}	Turn-OFF time	R_L = 500 Ω	C_L = 0.1 µF		11		µs
			C_L = 1 µF		67		
			C_L = 3.3 µF		225		
t_r	V_{OUT} rise time	R_L = 500 Ω	C_L = 0.1 µF		365		µs
			C_L = 1 µF		367		
			C_L = 3.3 µF		395		
t_f	V_{OUT} fall time	R_L = 500 Ω	C_L = 0.1 µF		21		µs
			C_L = 1 µF		189		
			C_L = 3.3 µF		565		

SWITCHING CHARACTERISTICS

V_{IN} = 1.2 V, T_A = 25°C , RL_CHIP = 120 Ω (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
t_{ON}	Turn-ON time	R_L = 500 Ω	C_L = 0.1 µF		471		µs
			C_L = 1 µF		527		
			C_L = 3.3 µF		587		
t_{OFF}	Turn-OFF time	R_L = 500 Ω	C_L = 0.1 µF		10		µs
			C_L = 1 µF		61		
			C_L = 3.3 µF		199		
t_r	V_{OUT} rise time	R_L = 500 Ω	C_L = 0.1 µF		324		µs
			C_L = 1 µF		325		
			C_L = 3.3 µF		350		
t_f	V_{OUT} fall time	R_L = 500 Ω	C_L = 0.1 µF		20		µs
			C_L = 1 µF		175		
			C_L = 3.3 µF		523		

SWITCHING CHARACTERISTICS

V_{IN} = 1.8 V, T_A = 25°C , RL_CHIP = 120 Ω (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
t_{ON}	Turn-ON time	R_L = 500 Ω	C_L = 0.1 µF		302		µs
			C_L = 1 µF		335		
			C_L = 3.3 µF		367		
t_{OFF}	Turn-OFF time	R_L = 500 Ω	C_L = 0.1 µF		8		µs
			C_L = 1 µF		49		
			C_L = 3.3 µF		167		
t_r	V_{OUT} rise time	R_L = 500 Ω	C_L = 0.1 µF		220		µs
			C_L = 1 µF		220		
			C_L = 3.3 µF		235		
t_f	V_{OUT} fall time	R_L = 500 Ω	C_L = 0.1 µF		15		µs
			C_L = 1 µF		159		
			C_L = 3.3 µF		481		

SWITCHING CHARACTERISTICS

V_{IN} = 2.5 V, T_A = 25°C , RL_CHIP = 120 Ω (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
t_{ON}	Turn-ON time	R_L = 500 Ω	C_L = 0.1 µF		223		µs
			C_L = 1 µF		246		
			C_L = 3.3 µF		268		
t_{OFF}	Turn-OFF time	R_L = 500 Ω	C_L = 0.1 µF		7		µs
			C_L = 1 µF		47		
			C_L = 3.3 µF		158		
t_r	V_{OUT} rise time	R_L = 500 Ω	C_L = 0.1 µF		175		µs
			C_L = 1 µF		175		
			C_L = 3.3 µF		187		
t_f	V_{OUT} fall time	R_L = 500 Ω	C_L = 0.1 µF		18		µs
			C_L = 1 µF		185		
			C_L = 3.3 µF		471		

SWITCHING CHARACTERISTICS

V_{IN} = 3 V, T_A = 25°C , RL_CHIP = 120 Ω (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
t_{ON}	Turn-ON time	R_L = 500 Ω	C_L = 0.1 µF		191		µs
			C_L = 1 µF		211		
			C_L = 3.3 µF		231		
t_{OFF}	Turn-OFF time	R_L = 500 Ω	C_L = 0.1 µF		7		µs
			C_L = 1 µF		46		
			C_L = 3.3 µF		156		
t_r	V_{OUT} rise time	R_L = 500 Ω	C_L = 0.1 µF		159		µs
			C_L = 1 µF		160		
			C_L = 3.3 µF		170		
t_f	V_{OUT} fall time	R_L = 500 Ω	C_L = 0.1 µF		17		µs
			C_L = 1 µF		160		
			C_L = 3.3 µF		473		

SWITCHING CHARACTERISTICS

V_{IN} = 3.6 V, T_A = 25°C , RL_CHIP = 120 Ω (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
t_{ON}	Turn-ON time	R_L = 500 Ω	C_L = 0.1 µF		166		µs
			C_L = 1 µF		183		
			C_L = 3.3 µF		201		
t_{OFF}	Turn-OFF time	R_L = 500 Ω	C_L = 0.1 µF		7		µs
			C_L = 1 µF		45		
			C_L = 3.3 µF		155		
t_r	V_{OUT} rise time	R_L = 500 Ω	C_L = 0.1 µF		146		µs
			C_L = 1 µF		146		
			C_L = 3.3 µF		156		
t_f	V_{OUT} fall time	R_L = 500 Ω	C_L = 0.1 µF		17		µs
			C_L = 1 µF		161		
			C_L = 3.3 µF		475		

TYPICAL CHARACTERISTICS

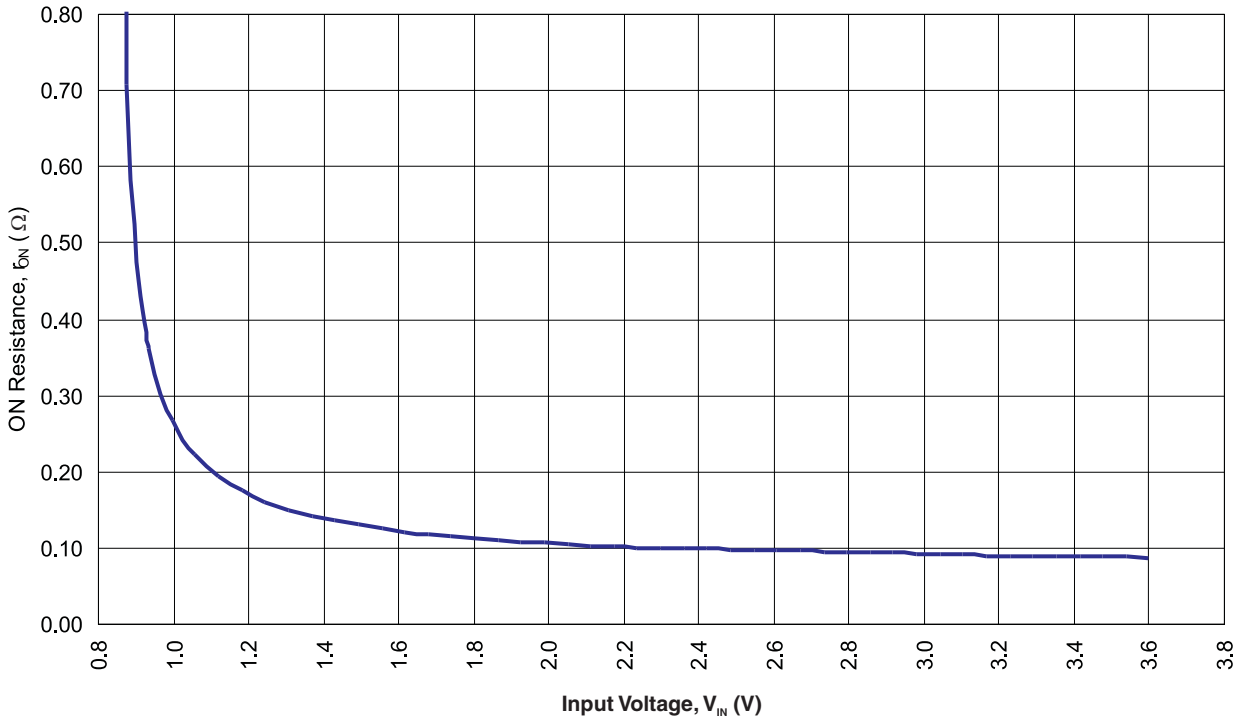


Figure 2. r_{ON} vs V_{IN}

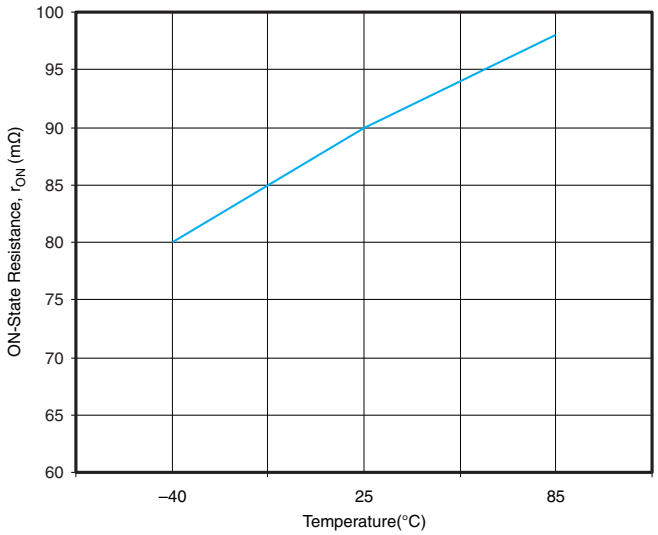


Figure 3. r_{ON} vs Temperature (V_{IN} = 3.3 V)

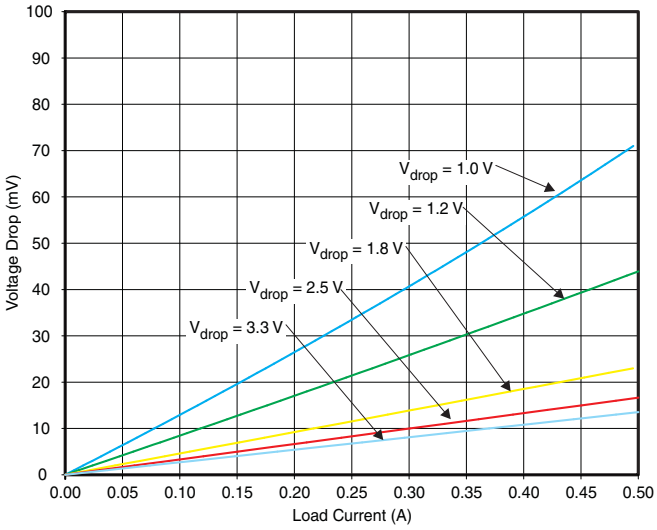


Figure 4. Voltage Drop vs. Load Current

TYPICAL CHARACTERISTICS (continued)

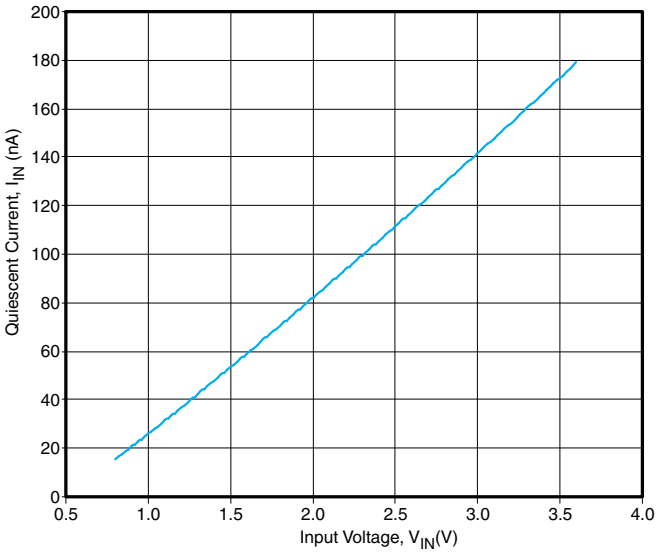


Figure 5. Quiescent Current vs V_{IN} (V_{ON} = V_{IN}, I_{OUT} = 0)

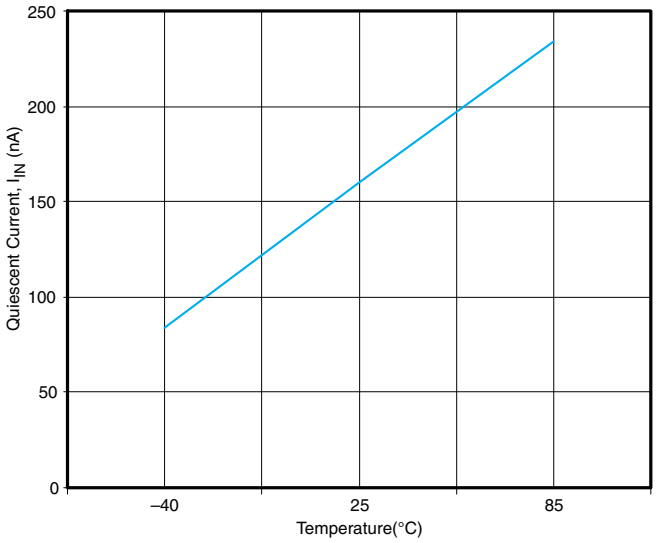


Figure 6. Quiescent Current vs Temperature (V_{IN} = 3.3 V, I_{OUT} = 0)

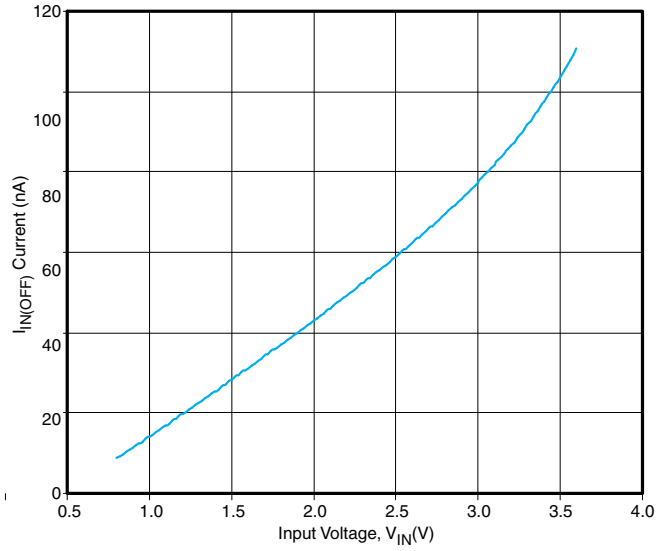


Figure 7. $I_{IN(OFF)}$ vs V_{IN} (V_{ON} = 0 V)

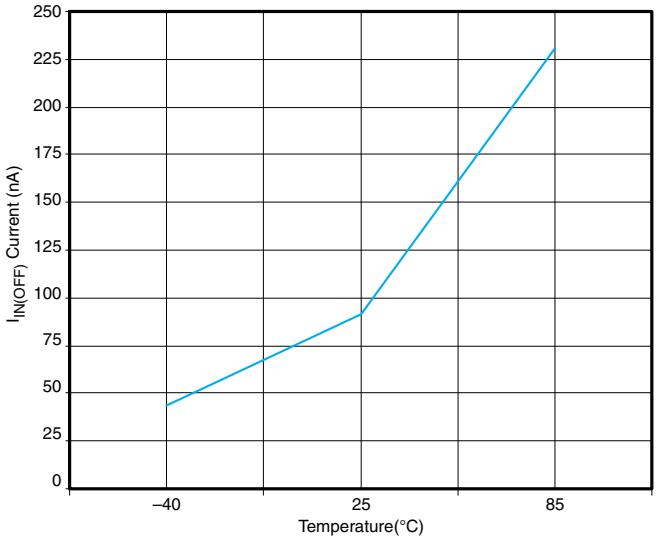


Figure 8. $I_{IN(OFF)}$ vs Temperature (V_{IN} = 3.3 V)

TYPICAL CHARACTERISTICS (continued)

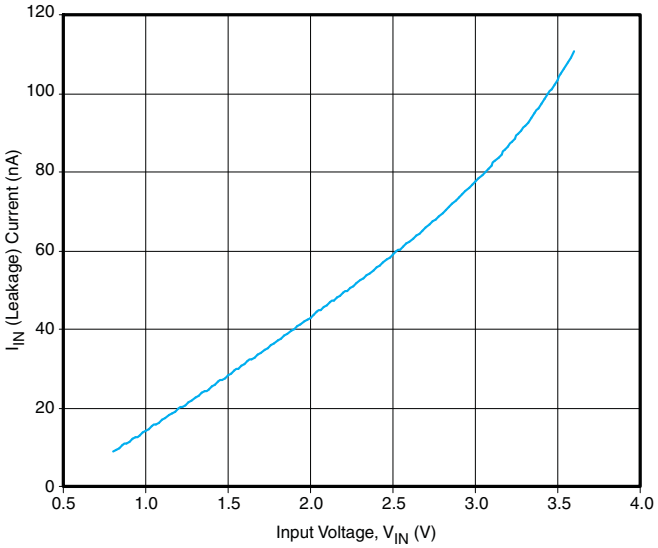


Figure 9. I_{IN}(Leakage) vs V_{IN} (I_{OUT} = 0)

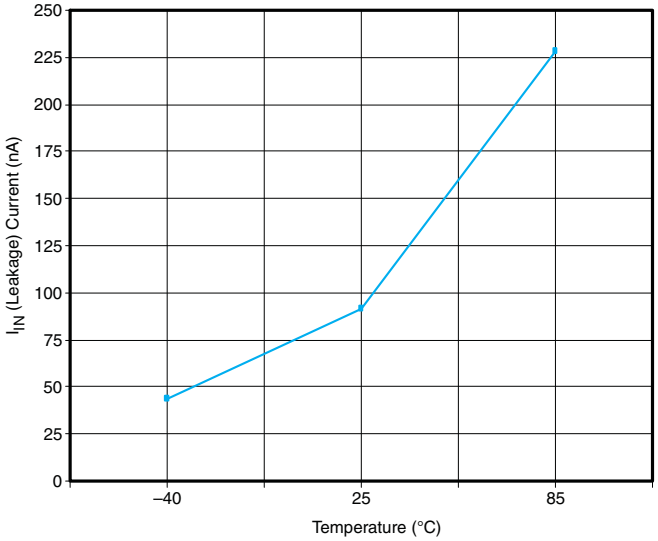


Figure 10. I_{IN} (Leakage) vs Temperature (V_{IN} = 3.3 V)

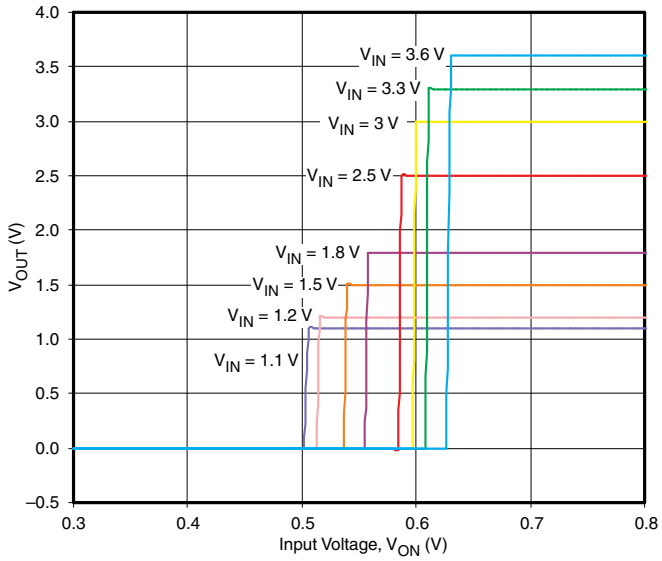


Figure 11. ON-Input Threshold

TYPICAL CHARACTERISTICS (continued)

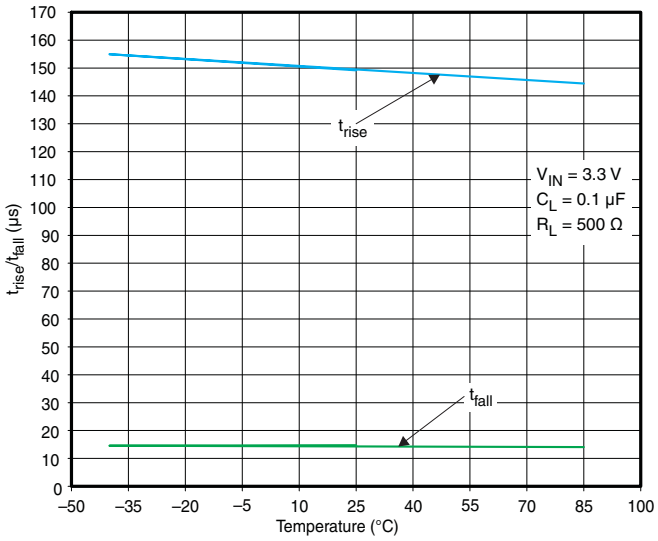


Figure 12. t_{rise}/t_{fall} vs Temperature

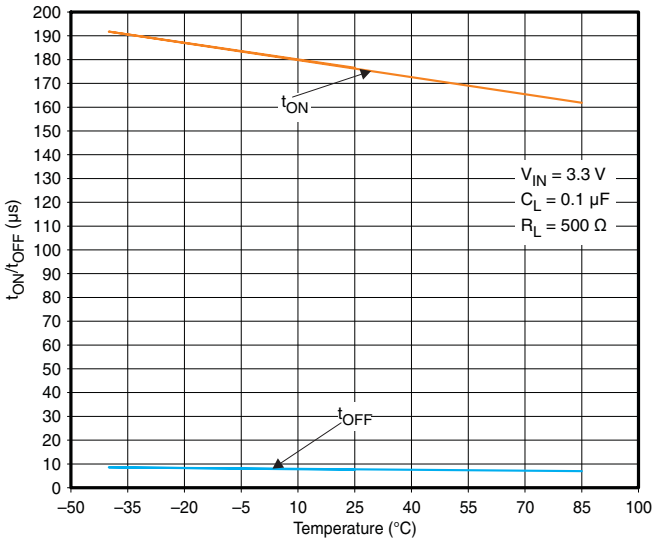


Figure 13. t_{ON}/t_{OFF} vs Temperature

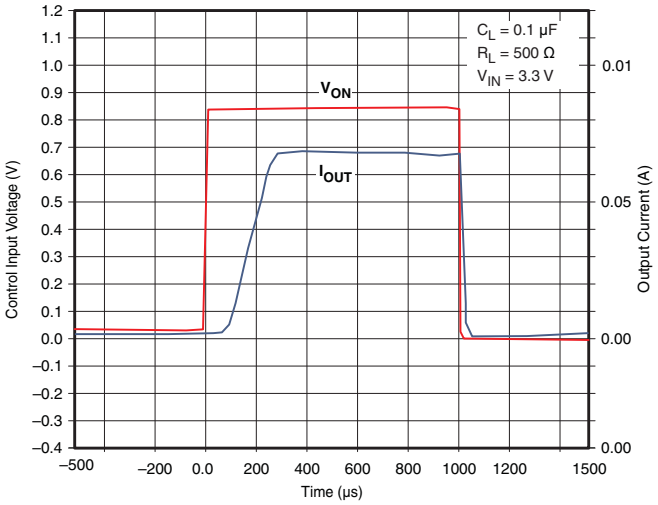


Figure 14. t_{ON} Response

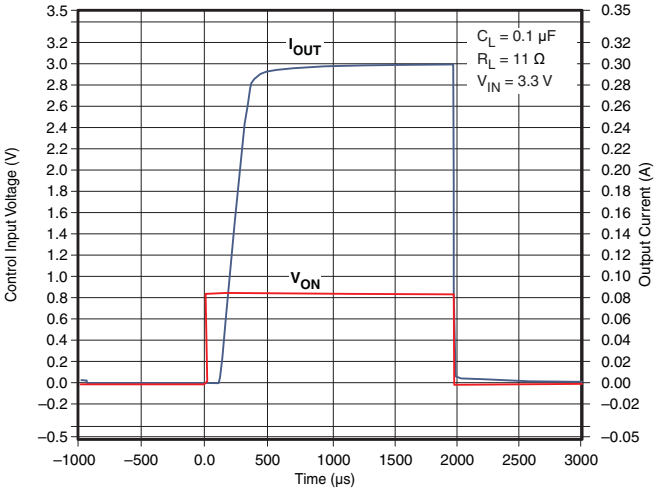


Figure 15. t_{ON} Response

TYPICAL CHARACTERISTICS (continued)

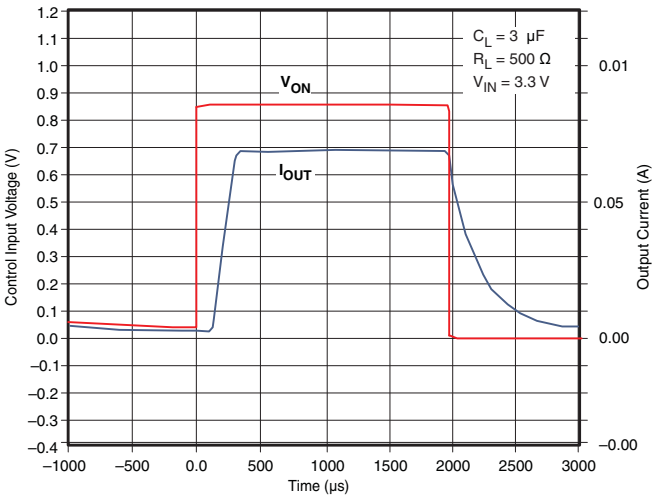


Figure 16. t_{ON} Response

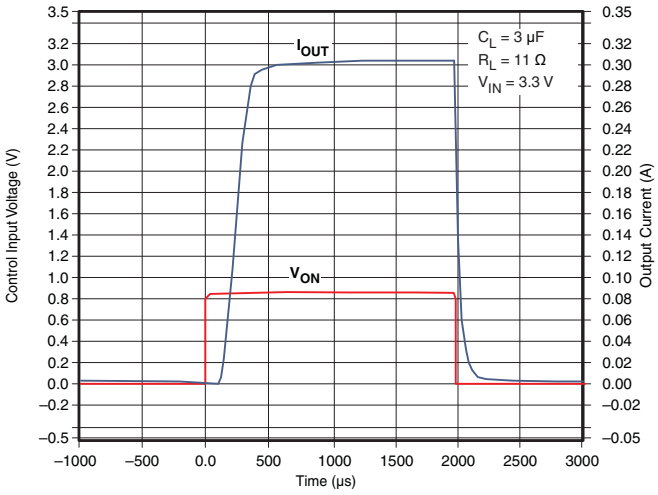


Figure 17. t_{ON} Response

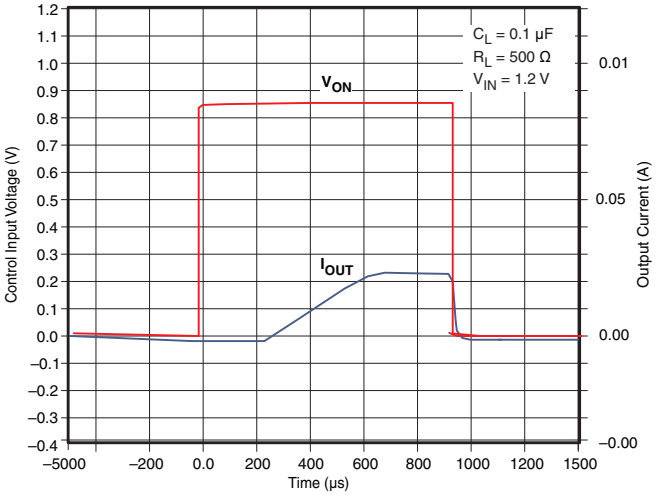


Figure 18. t_{ON} Response

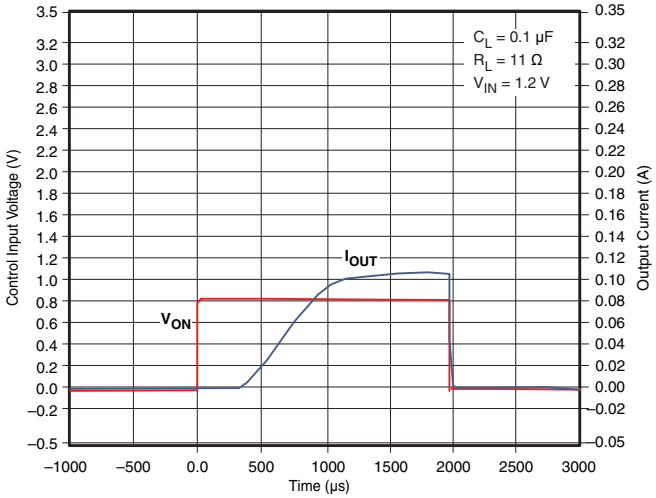


Figure 19. t_{ON} Response

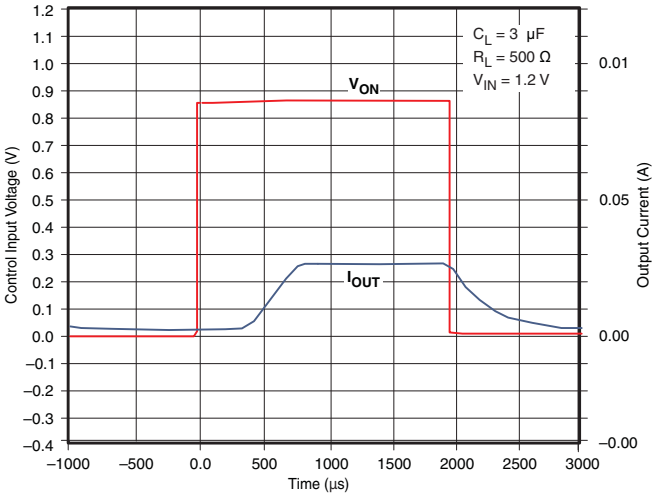


Figure 20. t_{ON} Response

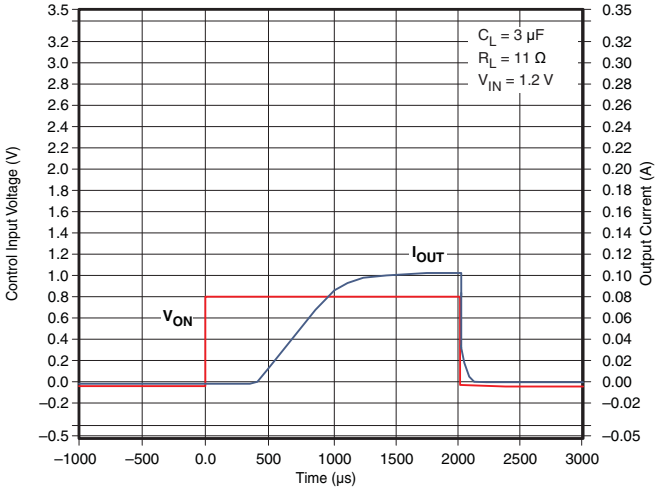


Figure 21. t_{ON} Response

TYPICAL CHARACTERISTICS (continued)

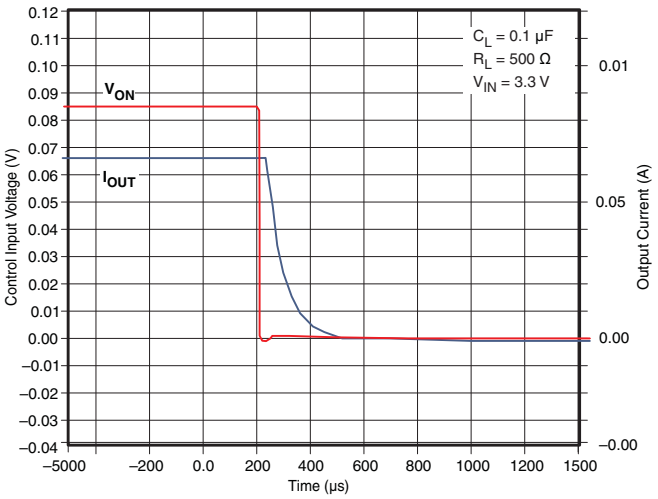


Figure 22. t_{OFF} Response

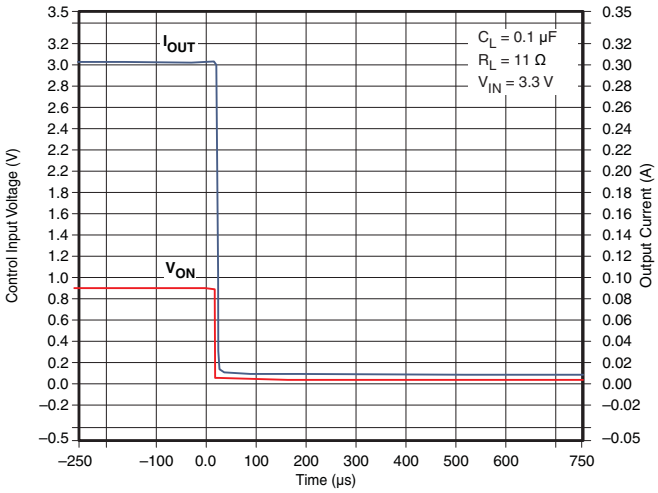


Figure 23. t_{OFF} Response

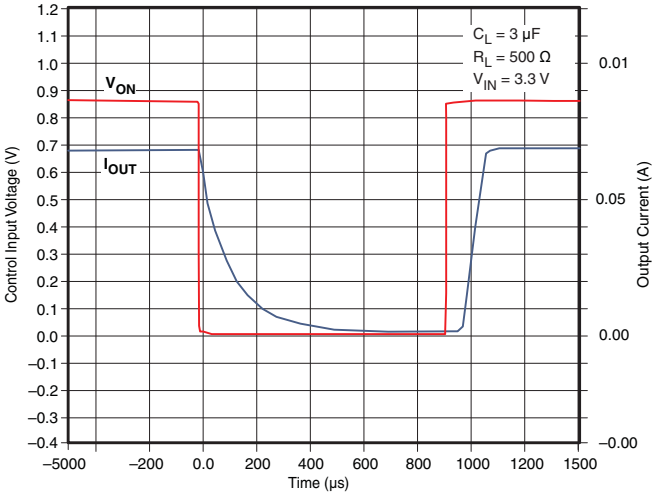


Figure 24. t_{OFF} Response

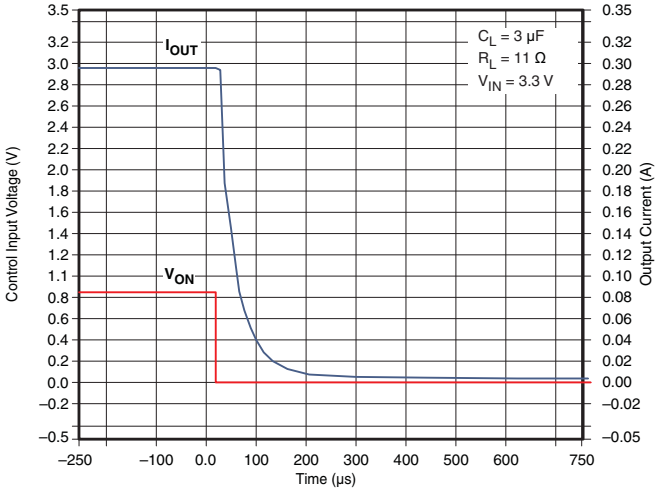


Figure 25. t_{OFF} Response

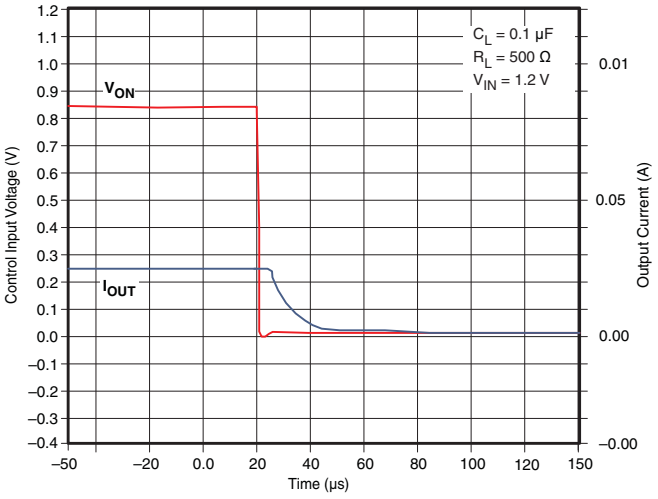


Figure 26. t_{OFF} Response

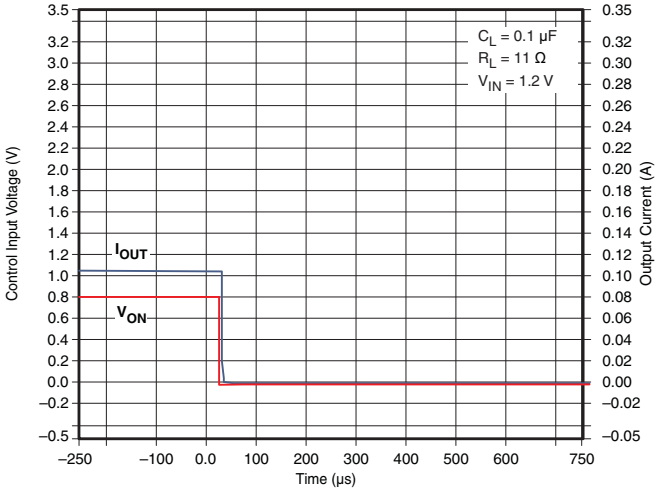


Figure 27. t_{OFF} Response

TYPICAL CHARACTERISTICS (continued)

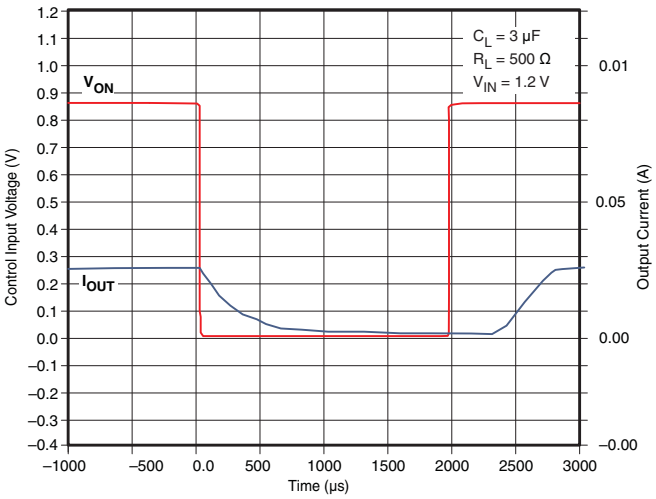


Figure 28. t_{OFF} Response

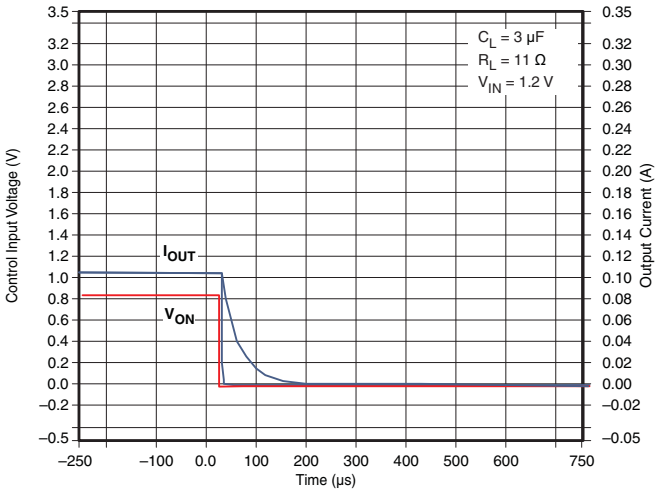
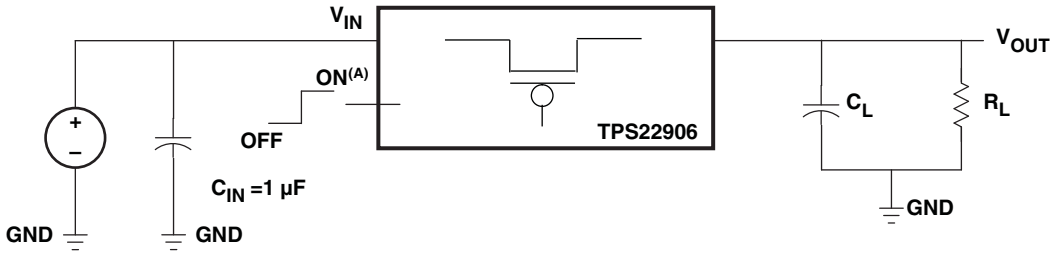
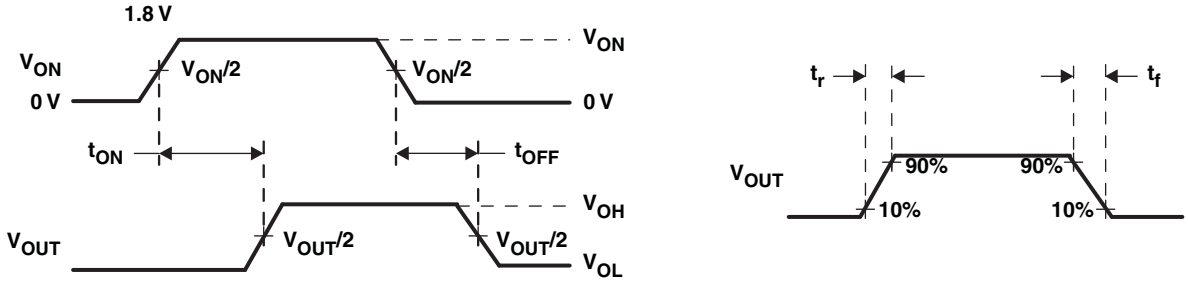


Figure 29. t_{OFF} Response

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



t_{ON}/t_{OFF} WAVEFORMS

A. t_{rise} and t_{fall} of the control signal is 100 ns.

Figure 30. Test Circuit and t_{ON}/t_{OFF} Waveforms

APPLICATION INFORMATION

ON/OFF Control

The ON pin controls the state of the switch. Activating ON continuously holds the switch in the on state so long as there is no fault. ON is active HI 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, 1.8-V, 2.5-V, or 3.3-V GPIOs.

Input Capacitor

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 or short-circuit, a capacitor needs to be placed between V_{IN} and GND. A 1-µF ceramic capacitor, C_{IN}, place close to the pins is usually sufficient. Higher values of C_{IN} can be use to further reduce the voltage drop during high current application. When switching heavy loads, it is recommended to have an input capacitor approximately 10 times higher than the output capacitor to avoid excessive voltage drop.

Output Capacitor

Due to the integral body diode in the PMOS 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 V_{OUT} to V_{IN}.

Board Layout

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 and short-circuit operation. Using wide traces for V_{IN}, V_{OUT}, and GND helps minimize the parasitic electrical effects along with minimizing the case to ambient thermal impedance.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
TPS22906YZVR	ACTIVE	DSBGA	YZV	4	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 85	5D 3	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.

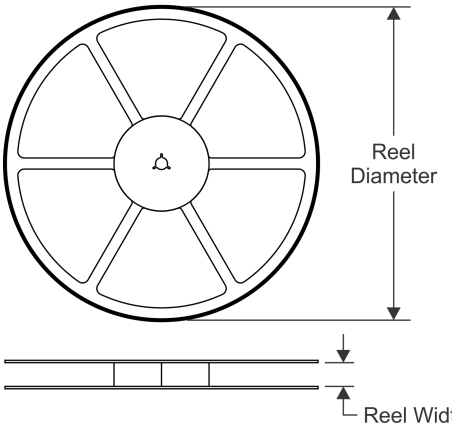
(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

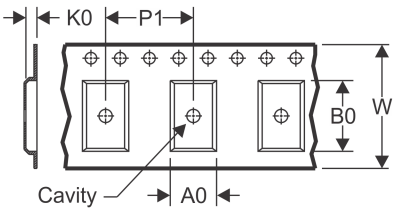
(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Top-Side Marking for that device.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

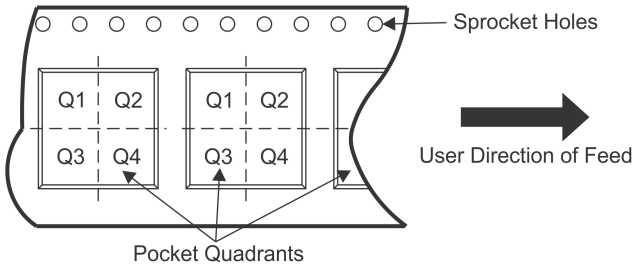


TAPE DIMENSIONS



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

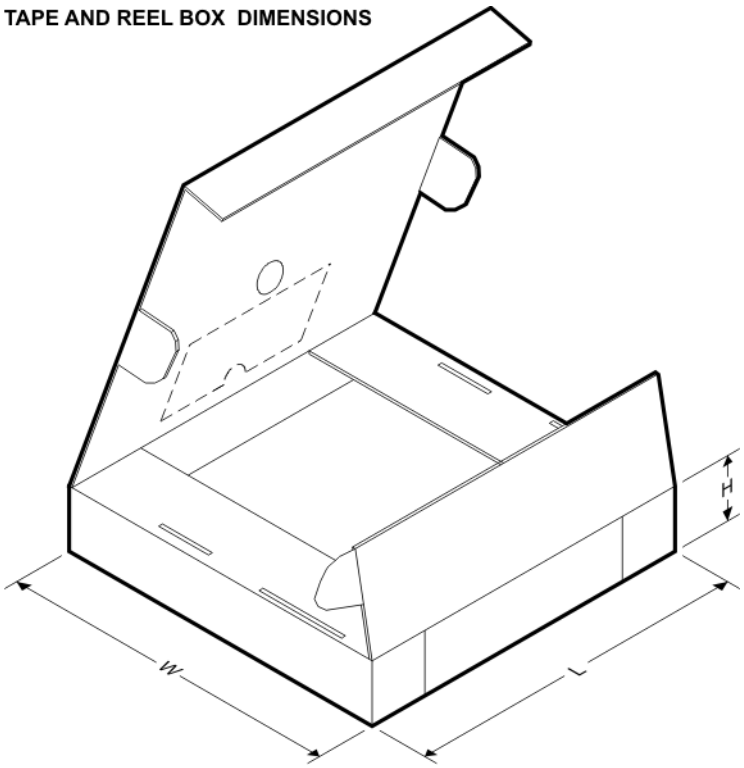
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TPS22906YZVR	DSBGA	YZV	4	3000	180.0	8.4	1.0	1.0	0.63	4.0	8.0	Q1

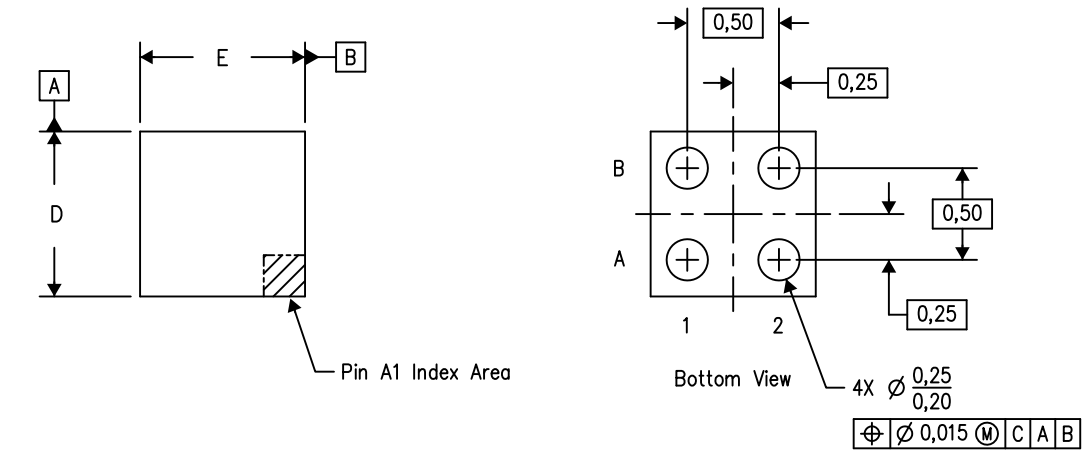
TAPE AND REEL BOX DIMENSIONS

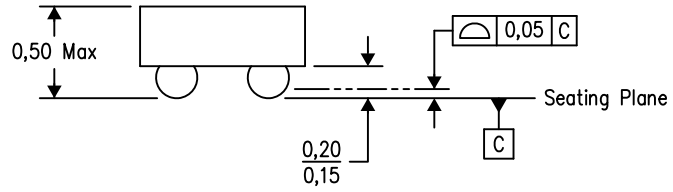


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS22906YZVR	DSBGA	YZV	4	3000	220.0	220.0	34.0

YZV (S–XBGA–N4) DIE–SIZE BALL GRID ARRAY





D: Max = 0.918 mm, Min =0.858 mm

E: Max = 0.918 mm, Min =0.858 mm

4206083/C 07/13

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. NanoFree™ package configuration.

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