TPS2290x 3.6-V, 500-mA, 78-mΩ ON-Resistance Load Switch With Controlled Turnon

1 Features

- Integrated P-Channel Load Switch
- Low Input Voltage: 1 V to 3.6 V
- ON-Resistance (Typical Values)
  - r_{ON} = 78 mΩ at V_{IN} = 3.6 V
  - r_{ON} = 93 mΩ at V_{IN} = 2.5 V
  - r_{ON} = 109 mΩ at V_{IN} = 1.8 V
  - r_{ON} = 146 mΩ at V_{IN} = 1.2 V
- 500 mA Maximum Continuous Switch Current
- Quiescent Current: 82 nA at 1.8 V
- Shutdown Current: 44 nA at 1.8 V
- Low Control Input Thresholds Enable Use of 1.2-V, 1.8-V, 2.5-V, and 3.3-V Logic
- Controlled Slew Rate to Avoid Inrush Currents
  - t_r = 40 µs at V_{IN} = 1.8 V (TPS22901/2)
  - t_r = 220 µs at V_{IN} = 1.8 V (TPS22902B)
- Quick Output Discharge (TPS22902/2B)
- ESD Performance Tested Per JESD 22
  - 2000-V Human Body Model (A114-B, Class II)
  - 1000-V Charged-Device Model (C101)
- Four-Pin Wafer-Chip-Scale DSBGA Package
  - 0.8-mm × 0.8-mm, 0.4-mm Pitch, 0.5-mm Height (YFP)

2 Applications

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

3 Description

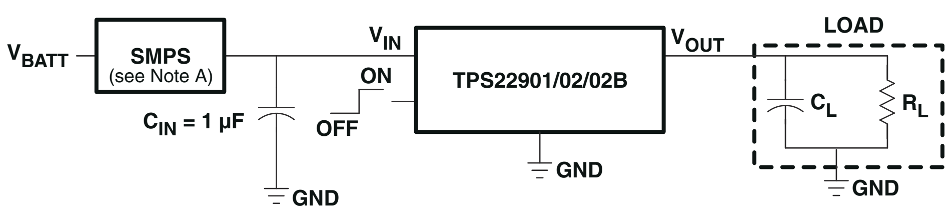
The TPS22901, TPS22902, and TPS22902B are small, low ON-resistance (r_{ON}) load switches with a controlled turnon. These devices contain a P-channel MOSFET that operates over an input voltage range of 1.0 V to 3.6 V. The switch is controlled by an on/off input (ON), which can interface directly with low-voltage control signals. In the TPS22902 and TPS22902B, an 88-Ω on-chip load resistor is added for output quick discharge when the switch is turned off.

The TPS22901, TPS22902, and TPS22902B are available in a space-saving 4-pin DSBGA (YFP) with 0.4-mm pitch. These devices are characterized for operation over the free-air temperature range of –40°C to 85°C.

Device Information

PART NUMBER	PACKAGE(1)	BODY SIZE (NOM)
TPS22901	DSBGA (4)	0.80 mm × 0.80 mm
TPS22902		
TPS22902B		

(1) For all available packages, see the orderable addendum at the end of the data sheet.



A. Switched-mode power supply

Typical Application Schematic

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4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision D (January 2015) to Revision E (September 2020) **Page**

- Updated the numbering format for tables, figures and cross-references throughout the document........1

Changes from Revision C (December 2012) to Revision D (January 2015) **Page**

- Added *ESD Rating* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section........1
- Deleted the *ORDERING INFORMATION* table........3

Changes from Revision B (March 2009) to Revision C (December 2012) **Page**

- Changed the *ORDERING INFORMATION* table........3

5 Device Comparison Table

	R_{ON} at 1.8 V (TYP)	RISE TIME (TYP at 1.8 V)	QUICK OUTPUT DISCHARGE(1)	MAX OUTPUT CURRENT	ENABLE
TPS22901		40 µs	No		
TPS22902	109 mΩ		Yes	500 mA	Active high
TPS22902B		220 µs	Yes		

(1) This feature discharges the output of the switch to ground through an 88 Ω resistor, preventing the output from floating.

6 Pin Configuration and Functions

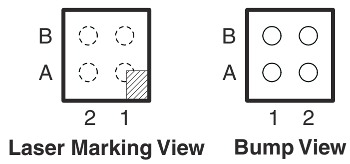


Figure 6-1. YFP Package 4-Pin DSBGA

Pin Assignments

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

Pin Functions

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

7 Specifications

7.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
V_{IN}	Input voltage	–0.3	4	V
V_{OUT}	Output voltage		V_{IN} + 0.3	V
V_{ON}	Input voltage	–0.3	4	V
P	Power dissipation at T_A = 25°C		0.48	W
I_{MAX}	Maximum continuous switch current		500	mA
T_A	Operating free-air temperature	–40	85	°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 *Section 7.3*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

7.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001[1]	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101[2]	±1000	

(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.

7.3 Recommended Operating Conditions

		MIN	MAX	UNIT
V_{IN}	Input voltage	1	3.6	V
V_{OUT}	Output voltage		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	See [1]		μF

(1) See *Section 10.1.1*.

7.4 Thermal Information

THERMAL METRIC[1]		TPS2290X YFP (DSBGA) 4 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	192.1	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	2.3	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	35.8	°C/W
ψ_{JT}	Junction-to-top characterization parameter	11.8	°C/W
ψ_{JB}	Junction-to-board characterization parameter	35.6	°C/W

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, SPRA953.

7.5 Electrical Characteristics

V_{IN} = 1.0 V to 3.6 V, T_A = –40°C to 85°C (unless otherwise noted). Typical values are for T_A = 25°C

PARAMETER		TEST CONDITIONS		T_A	MIN	TYP	MAX	UNIT
I_Q	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, V_{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	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		78	95	mΩ
				Full			95	
			V_{IN} = 2.5 V	25°C		93	110	
				Full			110	
			V_{IN} = 1.8 V	25°C		109	130	
				Full			130	
			V_{IN} = 1.2 V	25°C		146	200	
				Full			200	
			V_{IN} = 1.1 V	25°C		174	330	
				Full			330	
r_{PD}	Output pulldown resistance	V_{IN} = 3.3 V, V_{ON} = 0, I_{OUT} = 30 mA (TPS22902/TPS22902B only)		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

7.6 Switching Characteristics (V_{IN} = 1.1 V)

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

PARAMETER		TEST CONDITIONS		TPS22901			TPS22902[(1)]			TPS22902B[(1)]			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t_{ON}	Turn-ON time	R_L = 500 Ω	C_L = 0.1 µF		108			108			531		µs
			C_L = 1 µF		131			131			596		
			C_L = 3.3 µF		153			153			659		
t_{OFF}	Turn-OFF time	R_L = 500 Ω	C_L = 0.1 µF		39			11			11		µs
			C_L = 1 µF		317			69			67		
			C_L = 3.3 µF		1105			238			225		
t_r	V_{OUT} rise time	R_L = 500 Ω	C_L = 0.1 µF		70			70			365		µs
			C_L = 1 µF		78			78			367		
			C_L = 3.3 µF		92			92			395		
t_f	V_{OUT} fall time	R_L = 500 Ω	C_L = 0.1 µF		107			18			21		µs
			C_L = 1 µF		966			175			189		
			C_L = 3.3 µF		3532			632			565		

(1) Quick Output Discharge

7.7 Switching Characteristics (V_{IN} = 1.2 V)

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

PARAMETER		TEST CONDITIONS		TPS22901			TPS22902[(1)]			TPS22902B[(1)]			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t_{ON}	Turn-ON time	R_L = 500 Ω	C_L = 0.1 µF		96			96			471		µs
			C_L = 1 µF		116			116			527		
			C_L = 3.3 µF		135			135			587		
t_{OFF}	Turn-OFF time	R_L = 500 Ω	C_L = 0.1 µF		39			10			10		µs
			C_L = 1 µF		317			62			61		
			C_L = 3.3 µF		1110			210			199		
t_r	V_{OUT} rise time	R_L = 500 Ω	C_L = 0.1 µF		62			62			324		µs
			C_L = 1 µF		69			69			325		
			C_L = 3.3 µF		81			81			350		
t_f	V_{OUT} fall time	R_L = 500 Ω	C_L = 0.1 µF		109			17			20		µs
			C_L = 1 µF		995			163			175		
			C_L = 3.3 µF		3650			587			523		

(1) Quick Output Discharge

7.8 Switching Characteristics (V_{IN} = 1.8 V)

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

PARAMETER		TEST CONDITIONS		TPS22901			TPS22902(1)			TPS22902B(1)			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t_{ON}	Turn-ON time	R_L = 500 Ω	C_L = 0.1 µF		61			61			302		µs
			C_L = 1 µF		72			72			335		
			C_L = 3.3 µF		83			83			367		
t_{OFF}	Turn-OFF time	R_L = 500 Ω	C_L = 0.1 µF		38			8			8		µs
			C_L = 1 µF		317			49			49		
			C_L = 3.3 µF		1135			169			167		
t_r	V_{OUT} rise time	R_L = 500 Ω	C_L = 0.1 µF		40			40			220		µs
			C_L = 1 µF		45			45			220		
			C_L = 3.3 µF		53			53			235		
t_f	V_{OUT} fall time	R_L = 500 Ω	C_L = 0.1 µF		111			15			15		µs
			C_L = 1 µF		1020			140			159		
			C_L = 3.3 µF		3700			517			481		

(1) Quick Output Discharge

7.9 Switching Characteristics (V_{IN} = 2.5 V)

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

PARAMETER		TEST CONDITIONS		TPS22901			TPS22902(1)			TPS22902B(1)			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t_{ON}	Turn-ON time	R_L = 500 Ω	C_L = 0.1 µF		45			45			223		µs
			C_L = 1 µF		53			53			246		
			C_L = 3.3 µF		61			61			268		
t_{OFF}	Turn-OFF time	R_L = 500 Ω	C_L = 0.1 µF		38			7			7		µs
			C_L = 1 µF		314			46			47		
			C_L = 3.3 µF		1140			161			158		
t_r	V_{OUT} rise time	R_L = 500 Ω	C_L = 0.1 µF		32			32			175		µs
			C_L = 1 µF		35			35			175		
			C_L = 3.3 µF		41			41			187		
t_f	V_{OUT} fall time	R_L = 500 Ω	C_L = 0.1 µF		113			14			18		µs
			C_L = 1 µF		1040			139			185		
			C_L = 3.3 µF		3795			516			471		

(1) Quick Output Discharge

7.10 Switching Characteristics (V_{IN} = 3.0 V)

V_{IN} = 3.0 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		TPS22901			TPS22902[(1)]			TPS22902B[(1)]			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t_{ON}	Turn-ON time	R_L = 500 Ω	C_L = 0.1 µF		38			38			191		µs
			C_L = 1 µF		45			45			211		
			C_L = 3.3 µF		53			53			231		
t_{OFF}	Turn-OFF time	R_L = 500 Ω	C_L = 0.1 µF		38			7			7		µs
			C_L = 1 µF		320			46			46		
			C_L = 3.3 µF		1145			53			156		
t_r	V_{OUT} rise time	R_L = 500 Ω	C_L = 0.1 µF		28			28			159		µs
			C_L = 1 µF		31			31			160		
			C_L = 3.3 µF		37			37			170		
t_f	V_{OUT} fall time	R_L = 500 Ω	C_L = 0.1 µF		114			14			17		µs
			C_L = 1 µF		1045			139			160		
			C_L = 3.3 µF		3815			509			473		

(1) Quick Output Discharge

7.11 Switching Characteristics (V_{IN} = 3.6 V)

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

PARAMETER		TEST CONDITIONS		TPS22901			TPS22902[(1)]			TPS22902B[(1)]			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t_{ON}	Turn-ON time	R_L = 500 Ω	C_L = 0.1 µF		33			33			166		µs
			C_L = 1 µF		39			39			183		
			C_L = 3.3 µF		46			46			201		
t_{OFF}	Turn-OFF time	R_L = 500 Ω	C_L = 0.1 µF		38			7			7		µs
			C_L = 1 µF		322			46			45		
			C_L = 3.3 µF		1145			156			155		
t_r	V_{OUT} rise time	R_L = 500 Ω	C_L = 0.1 µF		25			25			146		µs
			C_L = 1 µF		28			28			146		
			C_L = 3.3 µF		34			34			156		
t_f	V_{OUT} fall time	R_L = 500 Ω	C_L = 0.1 µF		116			14			17		µs
			C_L = 1 µF		1060			139			161		
			C_L = 3.3 µF		3840			512			475		

(1) Quick Output Discharge

7.12 Typical Characteristics

7.12.1 Typical DC Characteristics

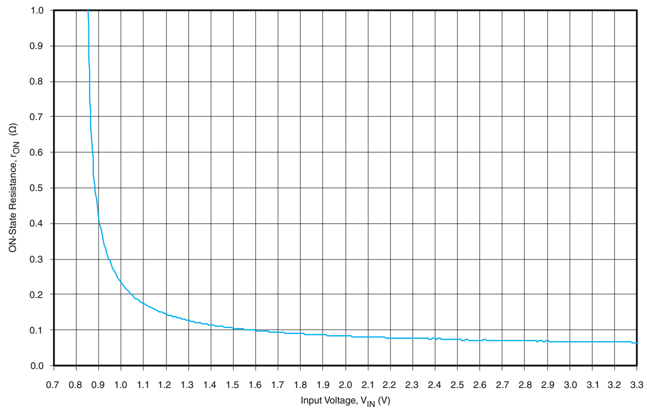


Figure 7-1. r_{ON} vs V_{IN}

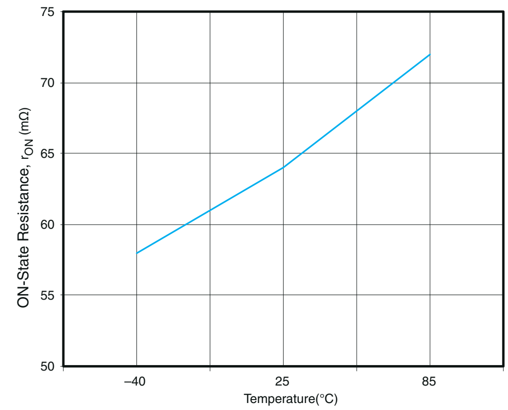


Figure 7-2. r_{ON} vs Temperature (V_{IN} = 3.3 V)

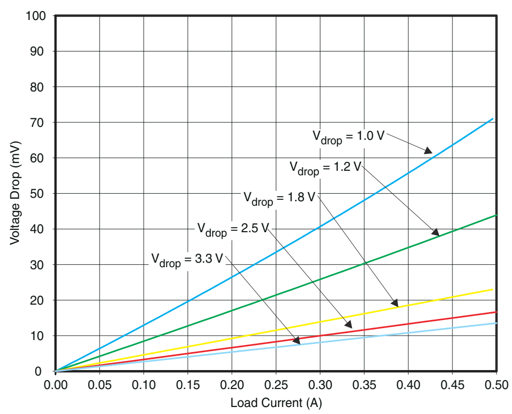


Figure 7-3. Voltage Drop vs. Load Current

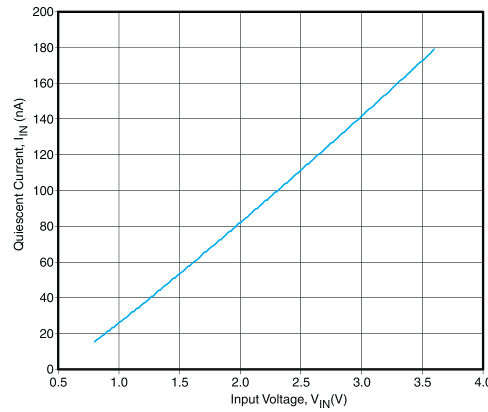


Figure 7-4. Quiescent Current vs V_{IN} (V_{ON} = V_{IN}, I_{OUT} = 0)

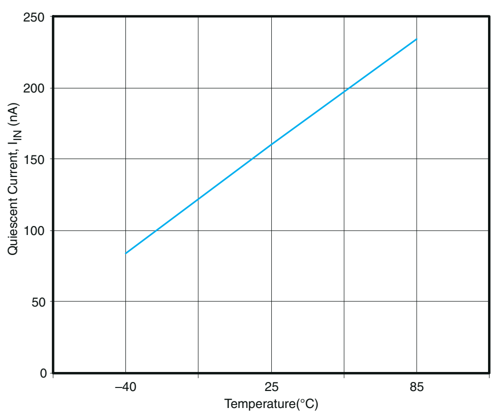


Figure 7-5. Quiescent Current vs Temperature (V_{IN} = 3.3 V, I_{OUT} = 0)

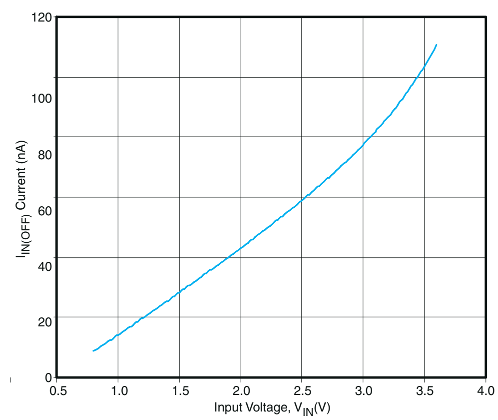


Figure 7-6. $I_{IN(OFF)}$ vs V_{IN} (V_{ON} = 0 V)

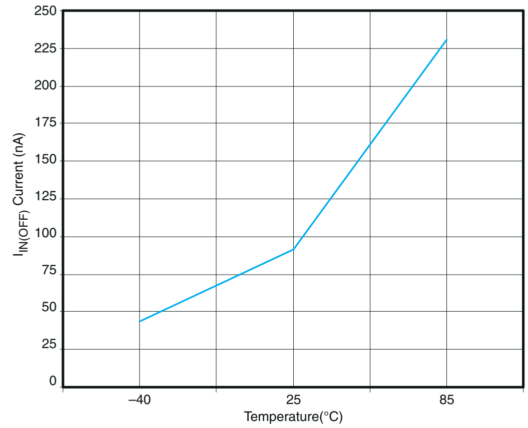


Figure 7-7. $I_{IN(OFF)}$ vs Temperature (V_{IN} = 3.3 V)

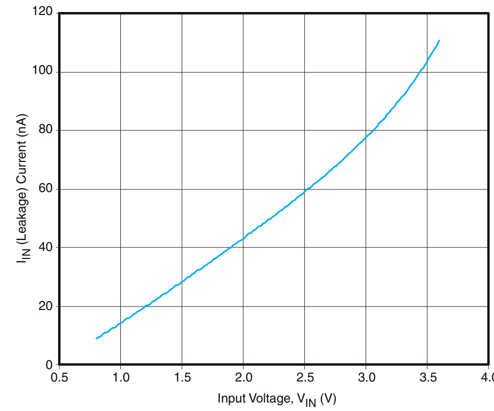


Figure 7-8. I_{IN}(Leakage) vs V_{IN} (I_{OUT} = 0)

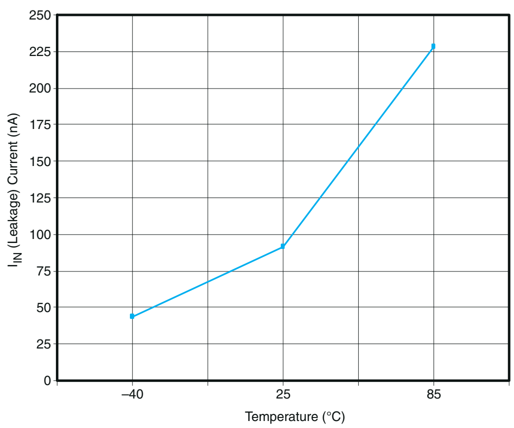


Figure 7-9. I_{IN} (Leakage) vs Temperature (V_{IN} = 3.3 V)

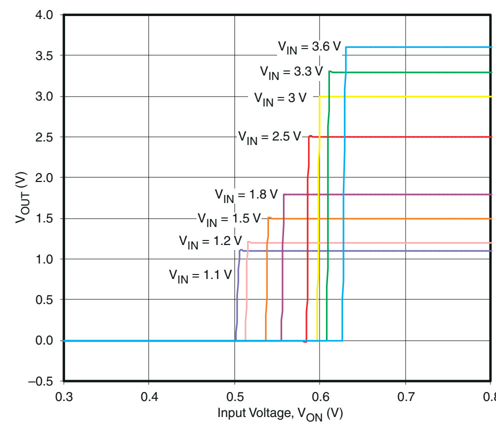


Figure 7-10. ON-Input Threshold

7.12.2 Typical AC Characteristics

7.12.2.1 TPS22901

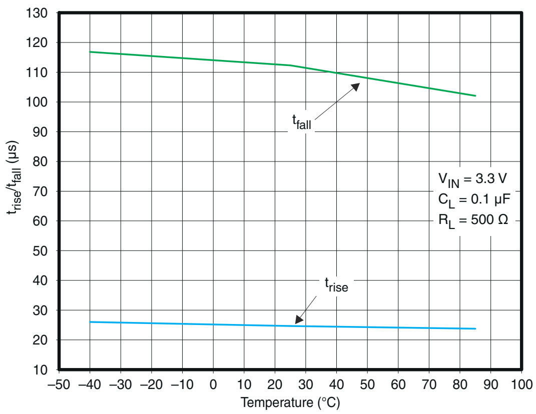


Figure 7-11. t_{rise}/t_{fall} vs Temperature

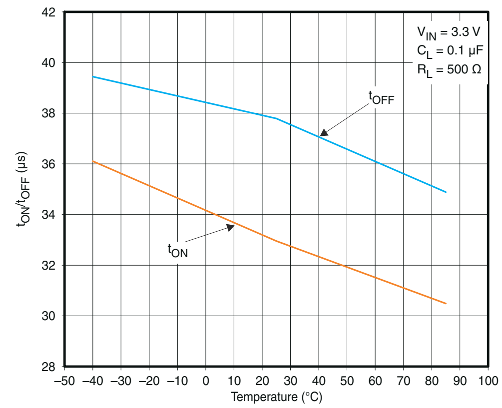


Figure 7-12. t_{ON}/t_{OFF} vs Temperature

7.12.2.2 TPS22902

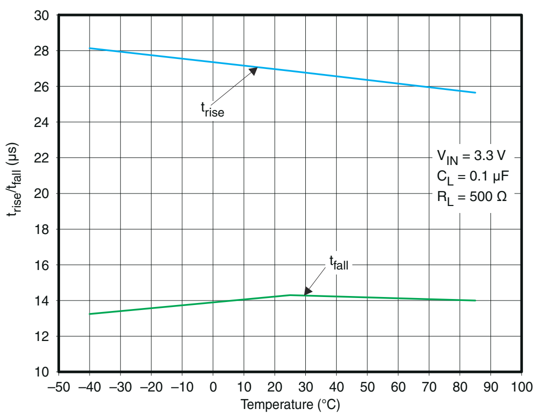


Figure 7-13. t_{rise}/t_{fall} vs Temperature

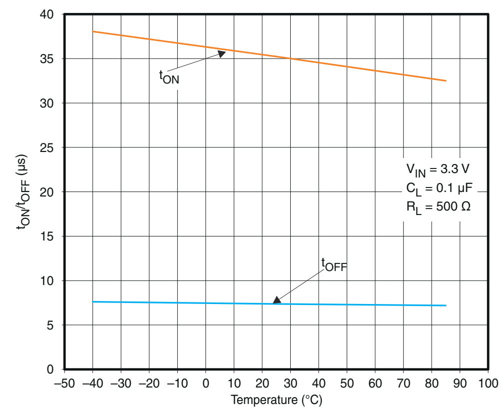


Figure 7-14. t_{ON}/t_{OFF} vs Temperature

7.12.2.3 TPS22902B

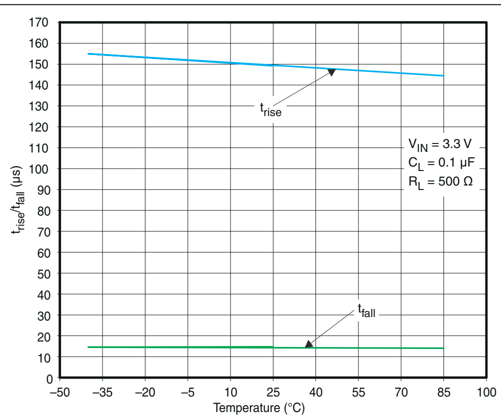


Figure 7-15. t_{rise}/t_{fall} vs Temperature

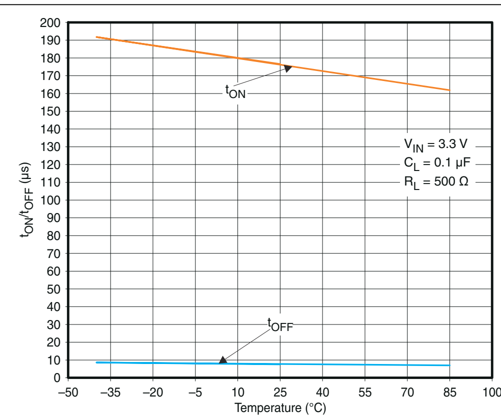


Figure 7-16. t_{ON}/t_{OFF} vs Temperature

7.12.2.4 TPS22901 and TPS22902

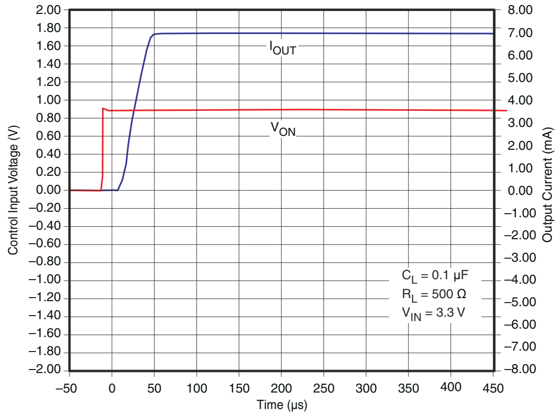


Figure 7-17. t_{ON} Response

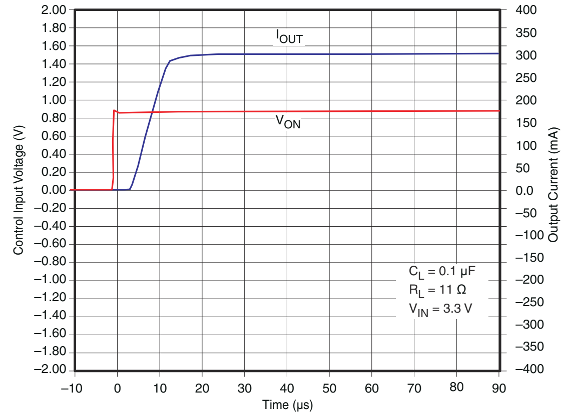


Figure 7-18. t_{ON} Response

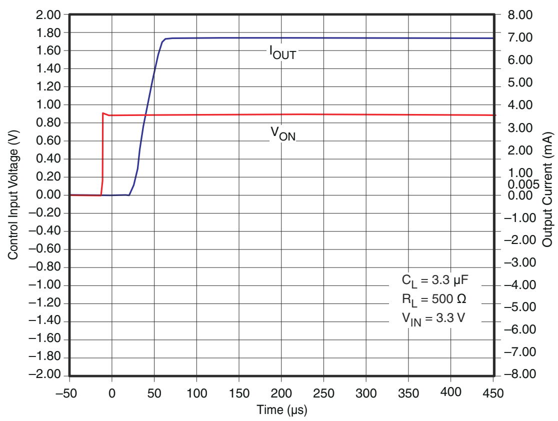


Figure 7-19. t_{ON} Response

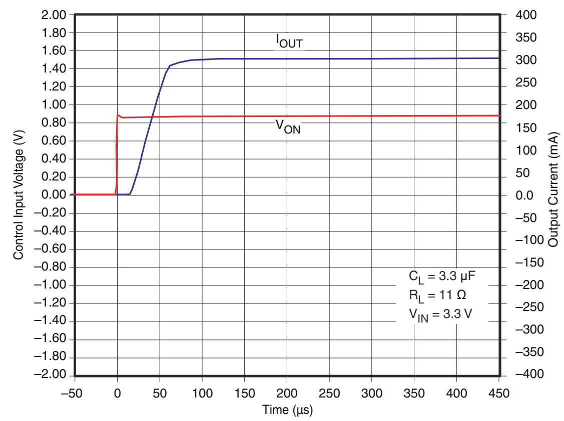


Figure 7-20. t_{ON} Response

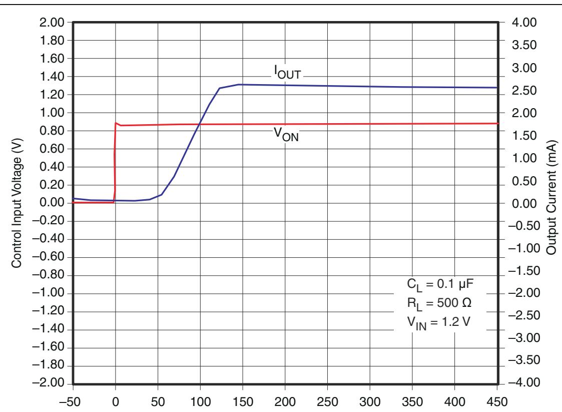


Figure 7-21. t_{ON} Response

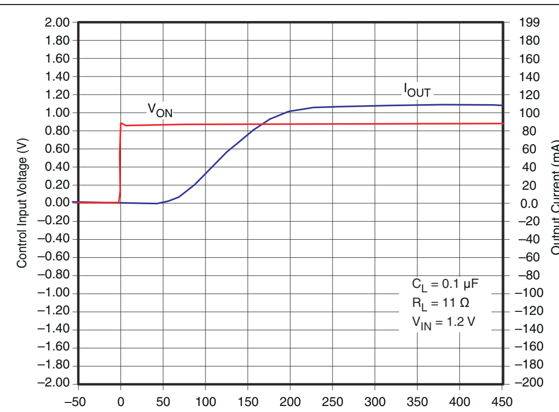


Figure 7-22. t_{ON} Response

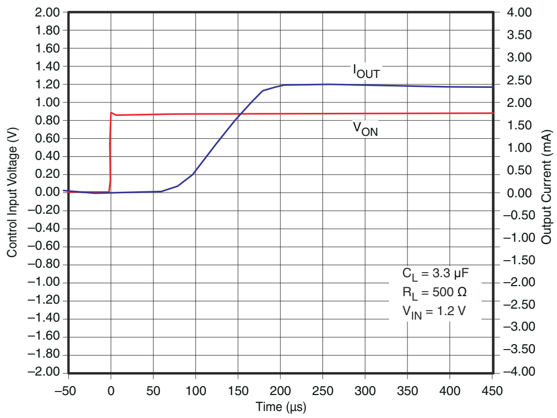


Figure 7-23. t_{ON} Response

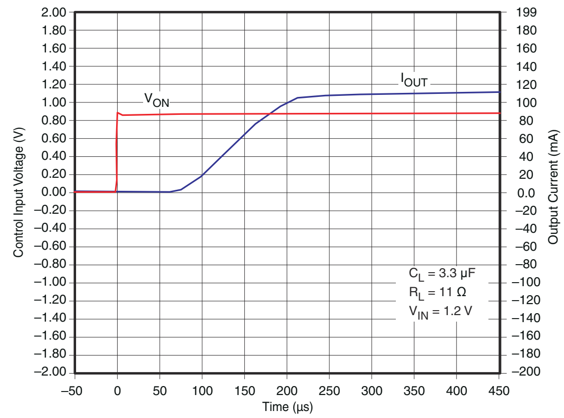


Figure 7-24. t_{ON} Response

7.12.2.5 TPS22901

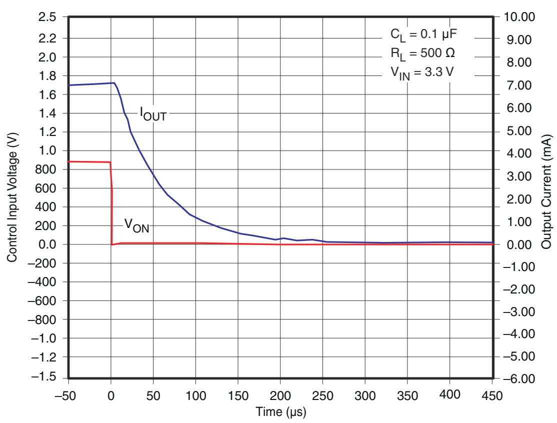


Figure 7-25. t_{OFF} Response

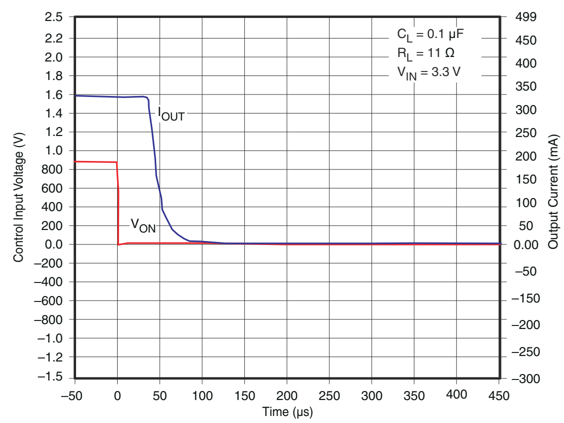


Figure 7-26. t_{OFF} Response

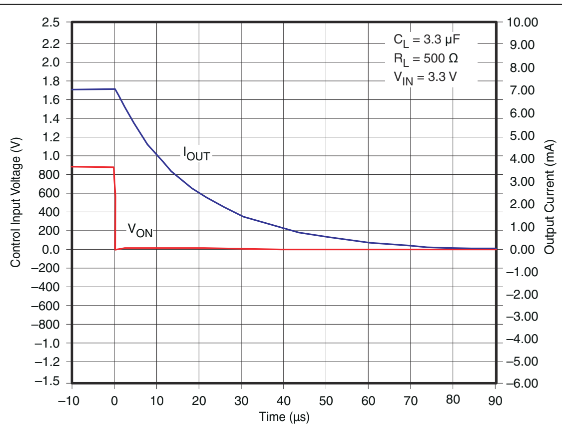


Figure 7-27. t_{OFF} Response

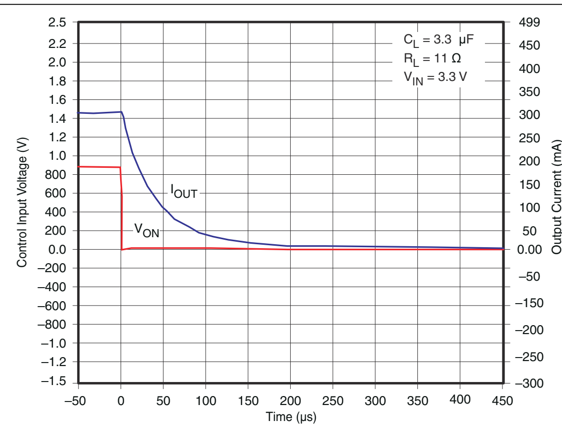


Figure 7-28. t_{OFF} Response

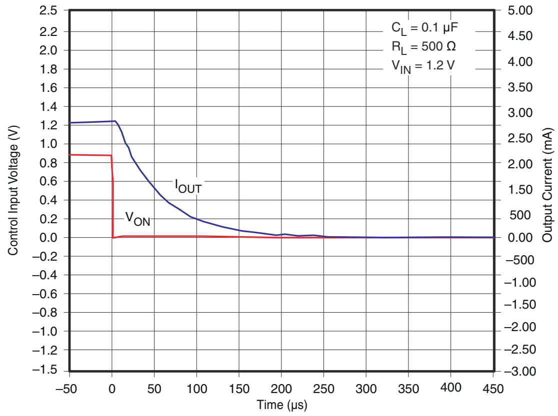


Figure 7-29. t_{OFF} Response

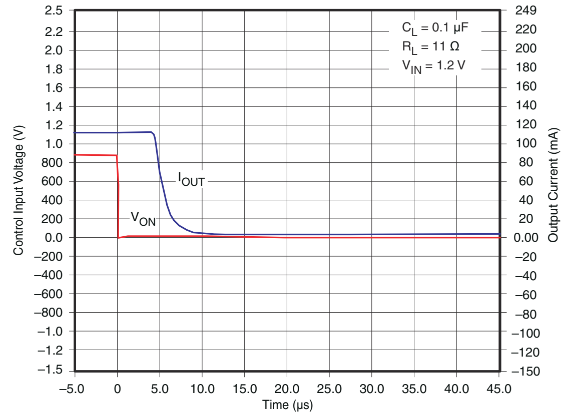


Figure 7-30. t_{OFF} Response

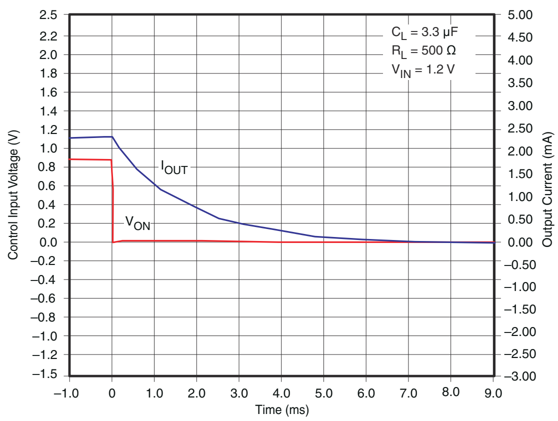


Figure 7-31. t_{OFF} Response

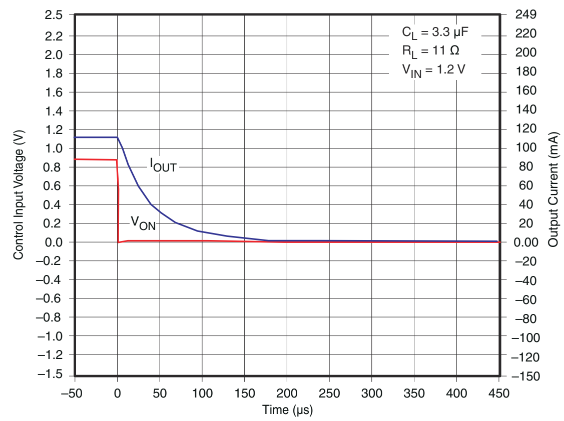


Figure 7-32. t_{OFF} Response

7.12.2.6 TPS22902

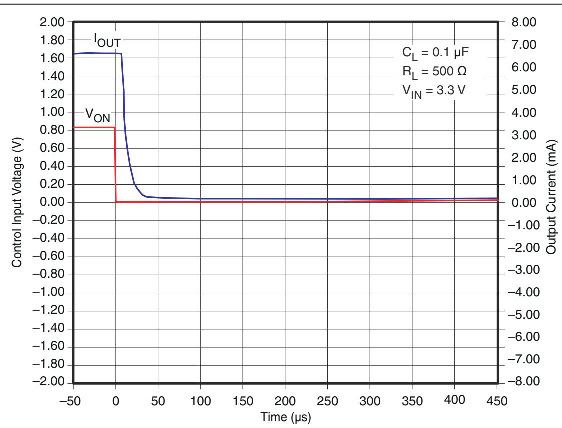


Figure 7-33. t_{OFF} Response

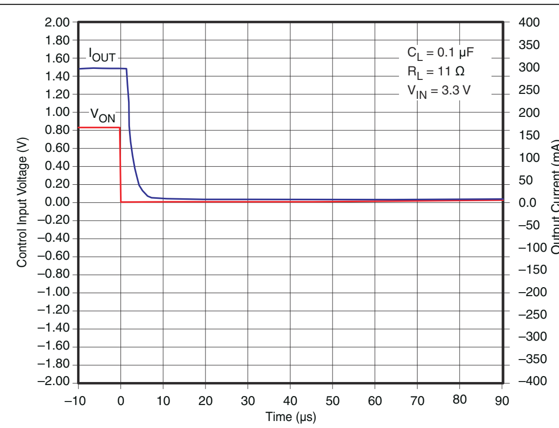


Figure 7-34. t_{OFF} Response

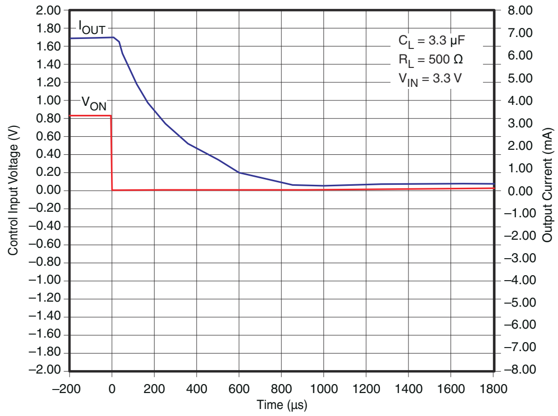


Figure 7-35. t_{OFF} Response

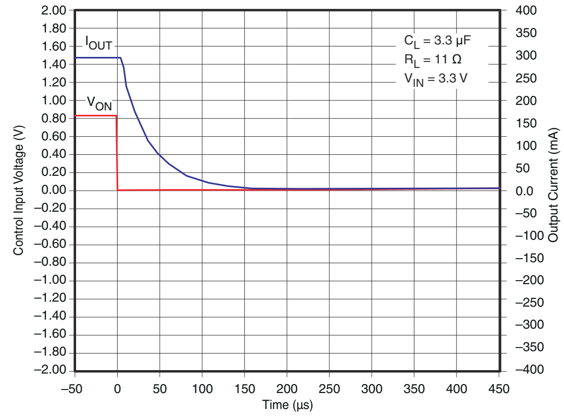


Figure 7-36. t_{OFF} Response

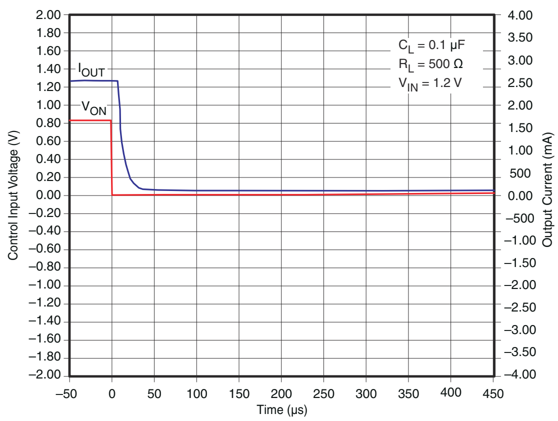


Figure 7-37. t_{OFF} Response

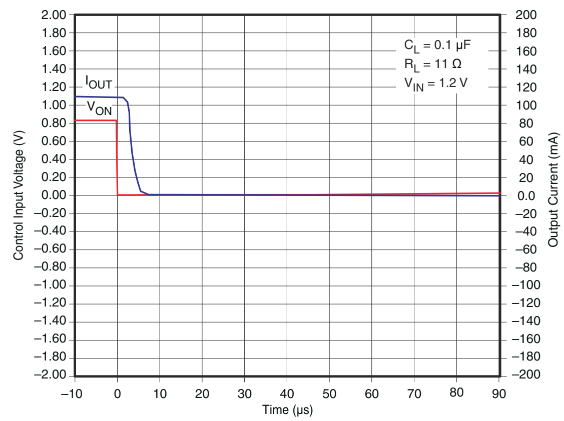


Figure 7-38. t_{OFF} Response

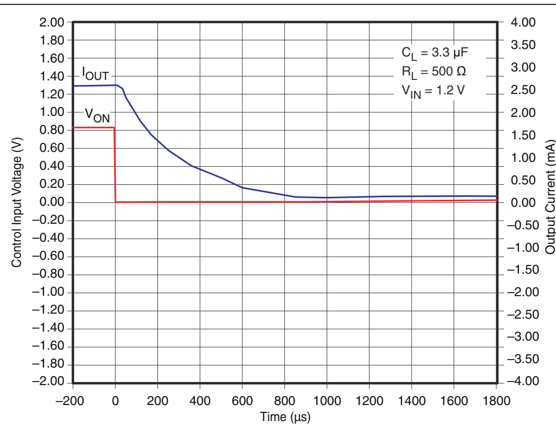


Figure 7-39. t_{OFF} Response

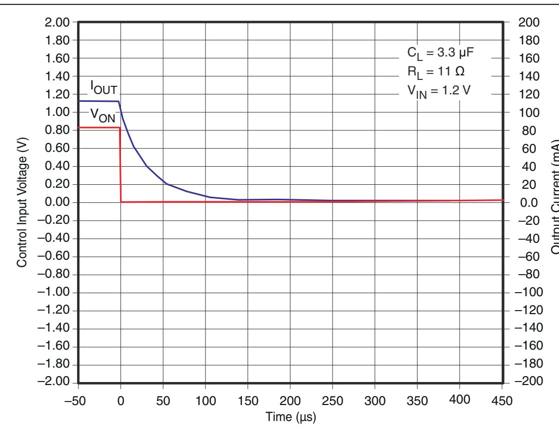


Figure 7-40. t_{OFF} Response

7.12.2.7 TPS22902B

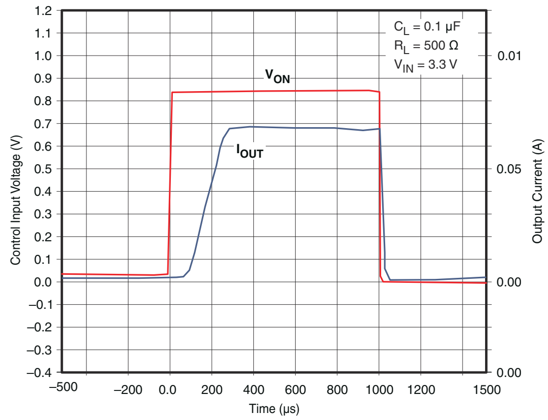


Figure 7-41. t_{ON} Response

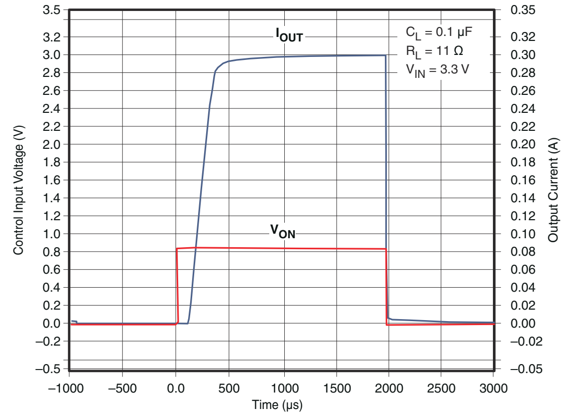


Figure 7-42. t_{ON} Response

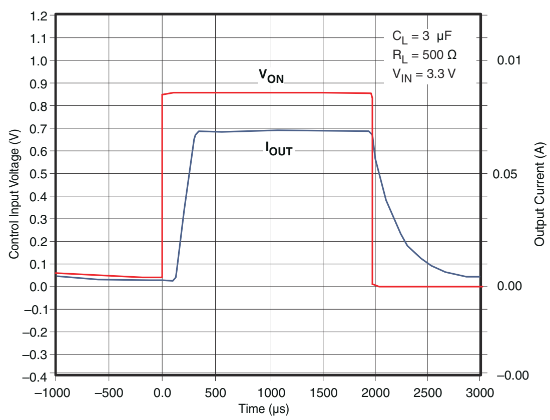


Figure 7-43. t_{ON} Response

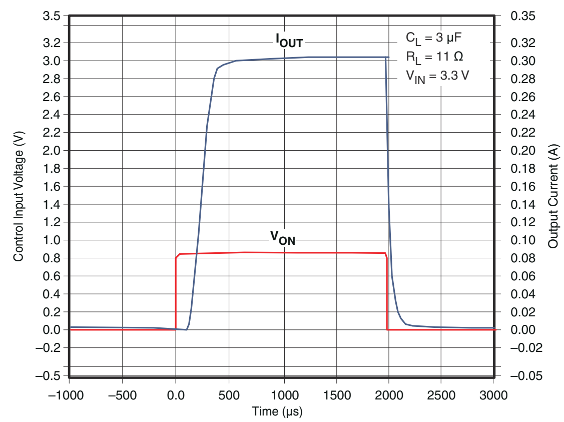


Figure 7-44. t_{ON} Response

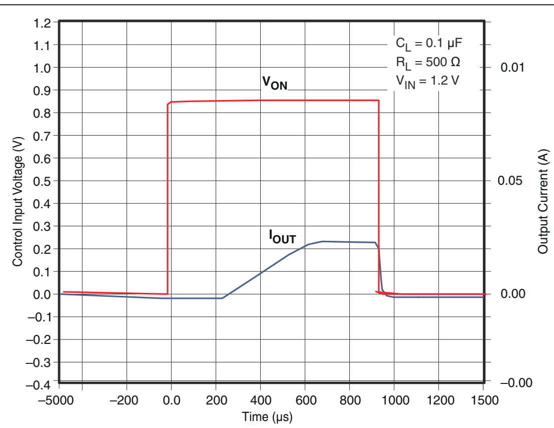


Figure 7-45. t_{ON} Response

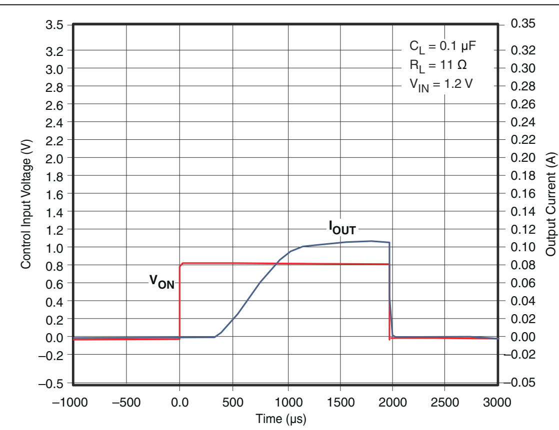


Figure 7-46. t_{ON} Response

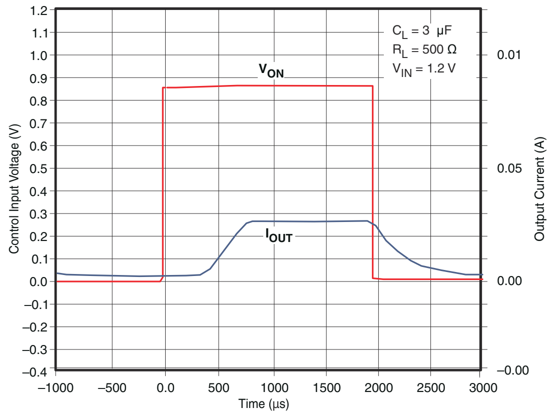


Figure 7-47. t_{ON} Response

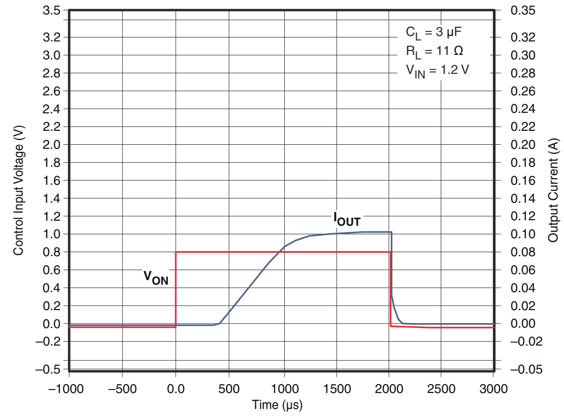


Figure 7-48. t_{ON} Response

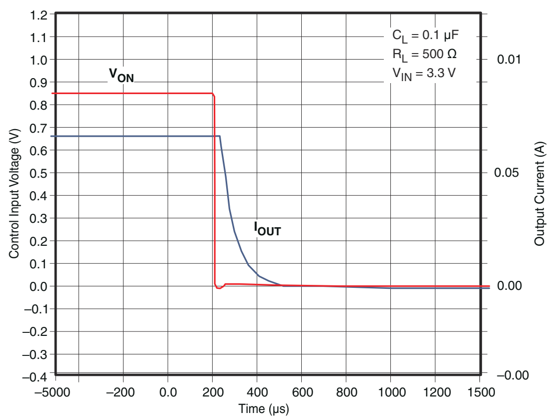


Figure 7-49. t_{OFF} Response

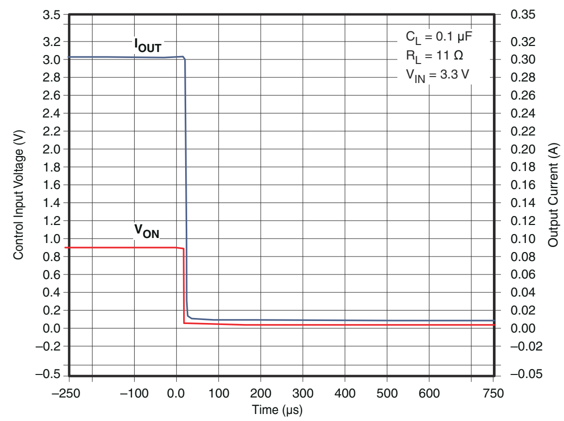


Figure 7-50. t_{OFF} Response

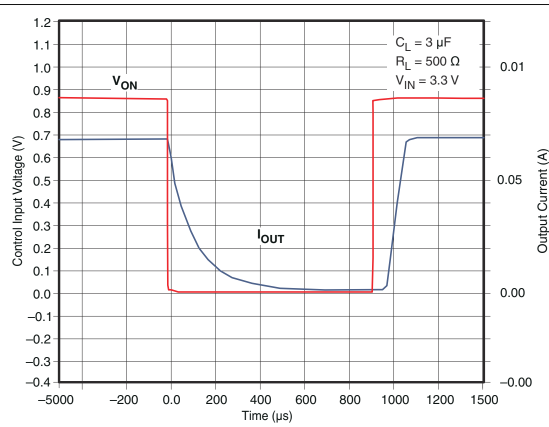


Figure 7-51. t_{OFF} Response

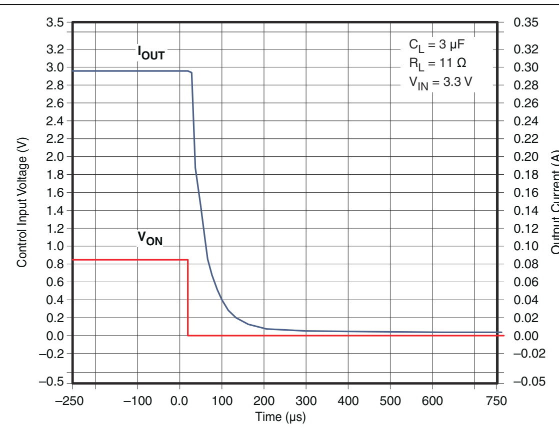


Figure 7-52. t_{OFF} Response

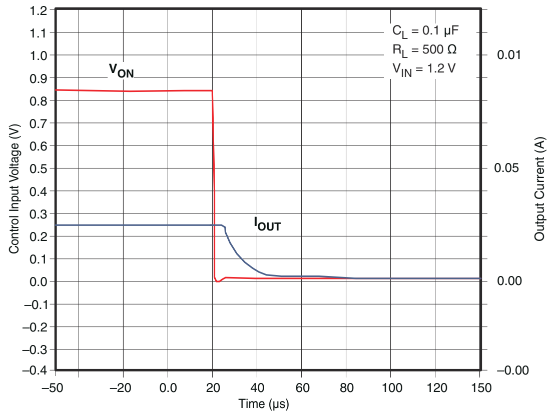


Figure 7-53. t_{OFF} Response

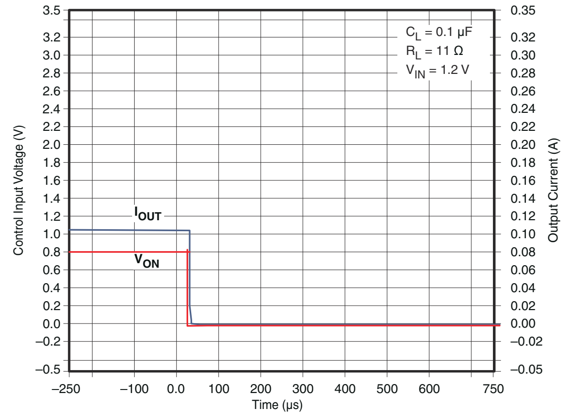


Figure 7-54. t_{OFF} Response

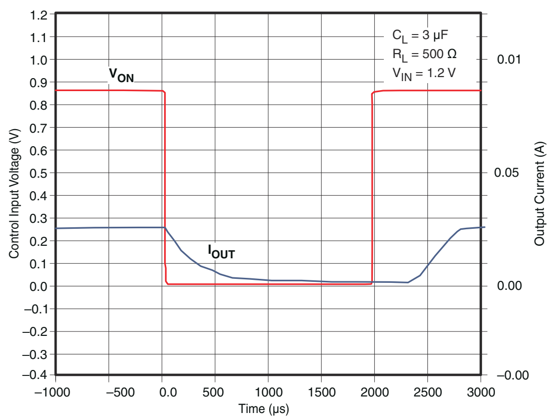


Figure 7-55. t_{OFF} Response

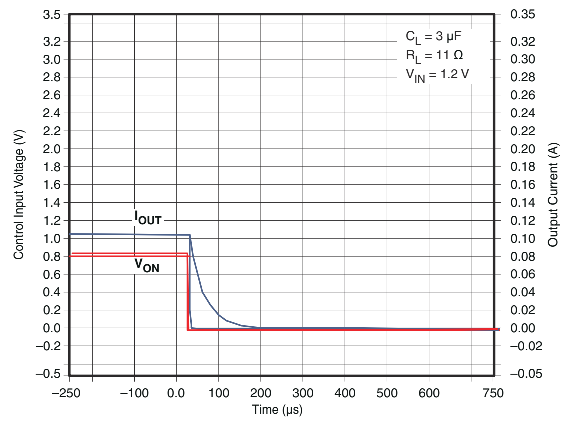
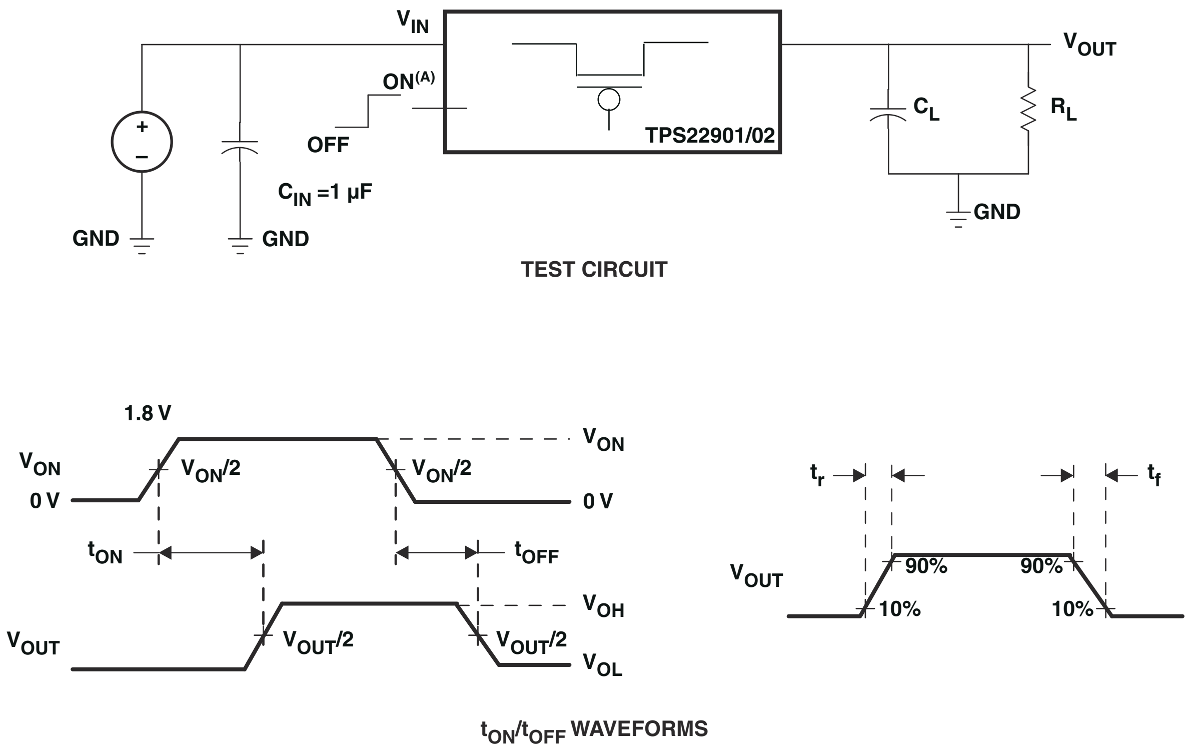


Figure 7-56. t_{OFF} Response

8 Parameter Measurement Information



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

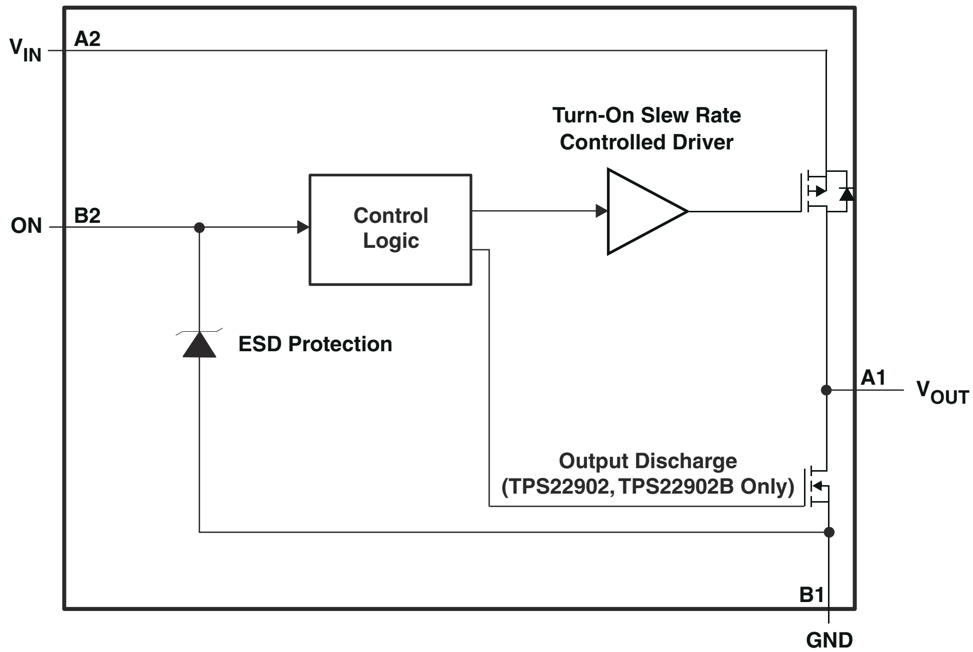
Figure 8-1. Test Circuit and t_{ON}/t_{OFF} Waveforms

9 Detailed Description

9.1 Overview

The TPS2290x and TPS22902B is a single channel, 500-mA load switch in a small, space-saving DSBGA-4 package. These devices implement a P-channel MOSFET to provide a low ON-resistance for a low voltage drop across the device. A controlled rise time is used in applications to limit the inrush current.

9.2 Functional Block Diagram



9.3 Feature Description

9.3.1 ON/OFF Control

The ON pin controls the state of the switch. Activating ON continuously holds the switch in the on state. 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, and it can be used with any microcontroller with 1.2 V, 1.8 V, 2.5 V or 3.3 V GPIOs.

9.3.2 Quick Output Discharge

The TPS2290x and TPS22902B includes the Quick Output Discharge (QOD) feature. When the switch is disabled, a discharge resistance with a typical value of 88 Ω is connected between the output and ground. This resistance pulls down the output and prevents it from floating when the device is disabled.

9.4 Device Functional Modes

Table 9-1 lists the VOUT pin connections for a particular device as determined by the ON pin.

Table 9-1. VOUT Function Table

ON (Control Input)	TPS22901	TPS22902/2B
L	Open	GND
H	VIN	VIN

10 Application and Implementation

Note

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.

10.1 Application Information

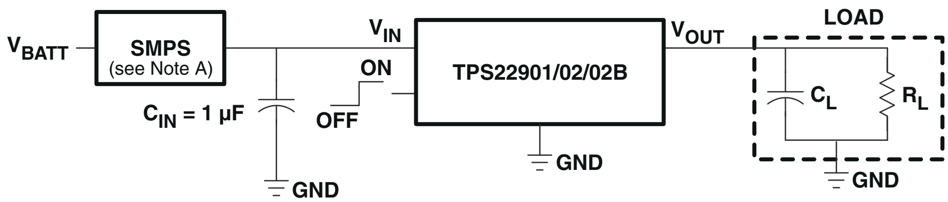
10.1.1 Input Capacitor (Optional)

To limit the voltage drop on the input supply caused by transient inrush currents when the switch turns on into a discharged load capacitor, a capacitor needs to be placed between V_{IN} and GND. A 1-µF ceramic capacitor, C_{IN}, placed 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, TI recommends using an input capacitor about 10 times higher than the output capacitor in order to avoid excessive voltage drop.

10.1.2 Output Capacitor (Optional)

Because of 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}.

10.2 Typical Application



A. Switched-mode power supply

Figure 10-1. Typical Application Schematic

10.2.1 Design Requirements

Table 10-1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
V_{IN}	1.8 V
C_L	4.7 µF
Load current	500 mA
Ambient Temperature	25 °C
Maximum inrush current	200 mA

10.2.2 Detailed Design Procedure

10.2.2.1 Managing Inrush Current

When the switch is enabled, the output capacitors must be charged up from 0 V to the set value (1.8 V in this example). This charge arrives in the form of inrush current. Inrush current can be calculated using the following equation:

$$I_{INRUSH} = C_L \times \frac{dV_{OUT}}{dt} \tag{1}$$

where:

- C_L = Output capacitance
- dV_{OUT} = Output voltage
- dt = Rise time

The TPS2290x and TPS22902B offers a controlled rise time for minimizing inrush current. This device can be selected based upon the minimum acceptable rise time which can be calculated using the design requirements and the inrush current equation. An output capacitance of 4.7 µF will be used since the amount of inrush current increases with output capacitance:

$$\begin{gathered} 200\ \text{mA} = 4.7\ \mu\text{F} \times 1.8\text{V} / dt \\ dt = 42.3\ \mu\text{s} \end{gathered} \tag{2}$$

To ensure an inrush current of less than 200 mA, a device with a rise time greater than 42.3 µs must be used. The TPS22902B has a typical rise time of 220 µs at 1.8 V which meets the above design requirements. The TPS22901/2 has a faster rise time of 40 µs at 1.8 V, and this would result in an inrush current larger than desired.

10.2.2.2 VIN to VOUT Voltage Drop

The voltage drop from VIN to VOUT is determined by the ON-resistance of the device and the load current. R_{ON} can be found in *Section 7.5* and is dependent on temperature. When the value of R_{ON} is found, the following equation can be used to calculate the voltage drop across the device:

$$\Delta V = I_{LOAD} \times R_{ON} \tag{3}$$

where:

- ΔV = Voltage drop across the device
- I_{LOAD} = Load current
- R_{ON} = ON-resistance of the device

At V_{IN} = 1.8 V, the TPS22901/2/2B has an R_{ON} value of 109 mΩ. Using this value and the defined load current, the above equation can be evaluated:

$$\begin{gathered} \Delta V = 500\ \text{mA} \times 109\ \text{m}\Omega \\ \Delta V = 54.5\ \text{mV} \end{gathered} \tag{4}$$

Therefore, the voltage drop across the device will be 54.5 mV.

10.2.3 Application Curve

Figure 10-2 shows the expected voltage drop across the device for different load currents and input voltages.

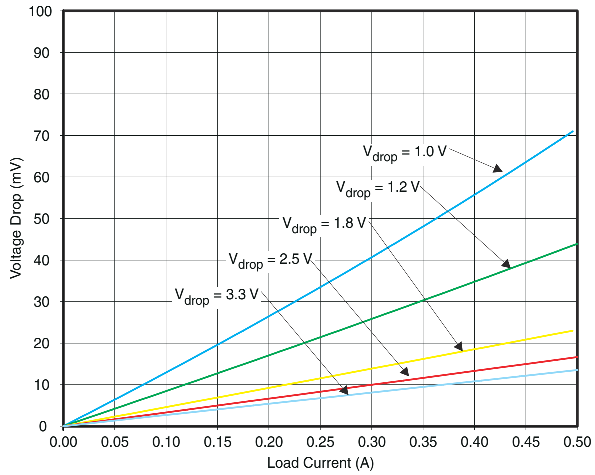


Figure 10-2. Voltage Drop vs Load Current

11 Power Supply Recommendations

The device is designed to operate with a VIN range of 1 V to 3.6 V. This supply must be well regulated and placed as close to the device terminals as possible. It must also be able to withstand all transient and load currents, using a recommended input capacitance of 1 µF if necessary. If the supply is located more than a few inches from the device terminals, additional bulk capacitance may be required in addition to the ceramic bypass capacitors. If additional bulk capacitance is required, an electrolytic, tantalum, or ceramic capacitor of 10 µF may be sufficient.

12 Layout

12.1 Layout Guidelines

For best performance, V_{IN}, V_{OUT}, and GND traces should be as short and wide as possible to help minimize the parasitic electrical effects. 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.

For higher reliability, the maximum IC junction temperature, $T_{J(max)}$, should be restricted to 125°C under normal operating conditions. Junction temperature is directly proportional to power dissipation in the device and the two are related by

$$T_J = T_A + \theta_{JA} \times P_D \quad (5)$$

where:

- T_J = Junction temperature of the device
- T_A = Ambient temperature
- P_D = Power dissipation inside the device
- θ_{JA} = Junction to ambient thermal resistance. See Thermal Information section of the datasheet. This parameter is highly dependent on board layout.

12.2 Layout Example

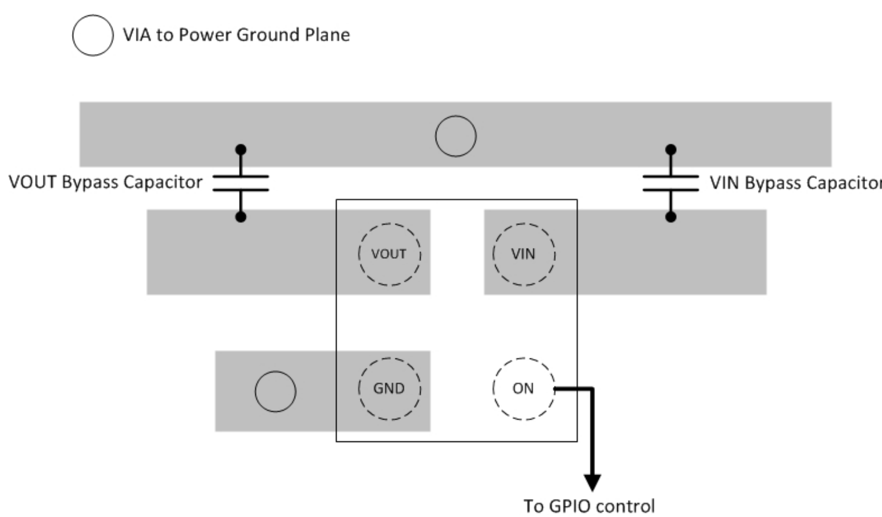


Figure 12-1. Layout Example Schematic

13 Device and Documentation Support

13.1 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 13-1. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
TPS22901	Click here	Click here	Click here	Click here	Click here
TPS22902	Click here	Click here	Click here	Click here	Click here
TPS22902B	Click here	Click here	Click here	Click here	Click here

13.2 Trademarks

All other trademarks are the property of their respective owners.

13.3 Electrostatic Discharge Caution

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.

13.4 Glossary

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

14 Mechanical, Packaging, and Orderable Information

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

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TPS22901YFPR	ACTIVE	DSBGA	YFP	4	3000	RoHS & Green	SNAGCU	Level-1-260C-UNLIM	-40 to 85	3P (3, 5)	Samples
TPS22902BYFPR	ACTIVE	DSBGA	YFP	4	3000	RoHS & Green	SNAGCU	Level-1-260C-UNLIM	-40 to 85	3S 3	Samples
TPS22902YFPR	ACTIVE	DSBGA	YFP	4	3000	RoHS & Green	SNAGCU	Level-1-260C-UNLIM	-40 to 85	3R	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 finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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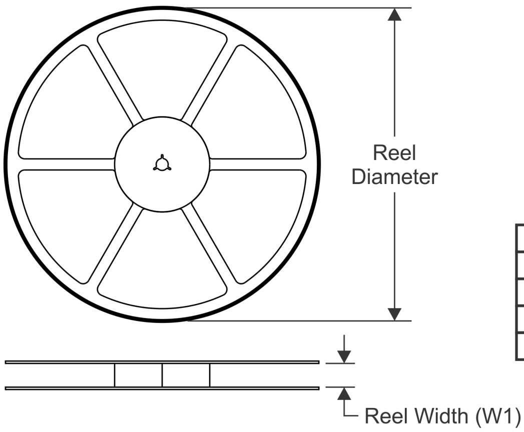
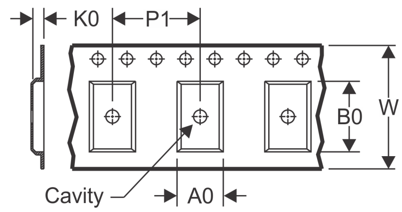
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

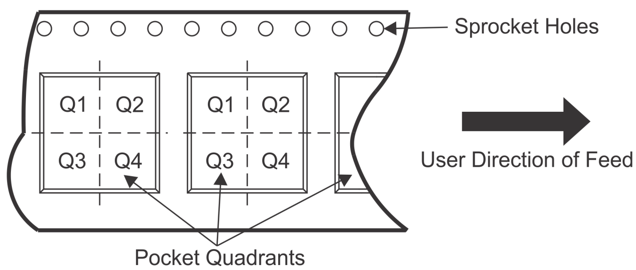


TAPE DIMENSIONS



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

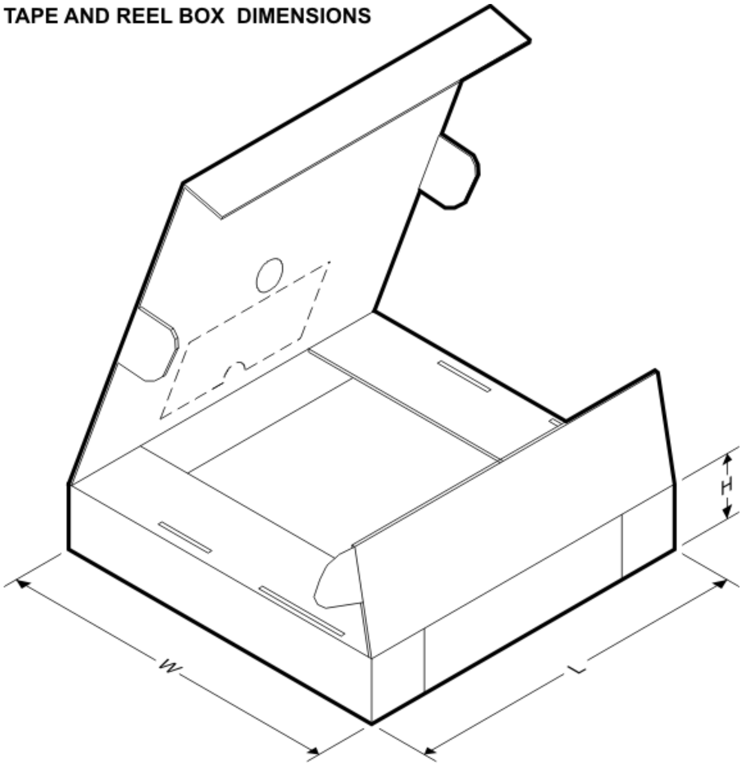
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

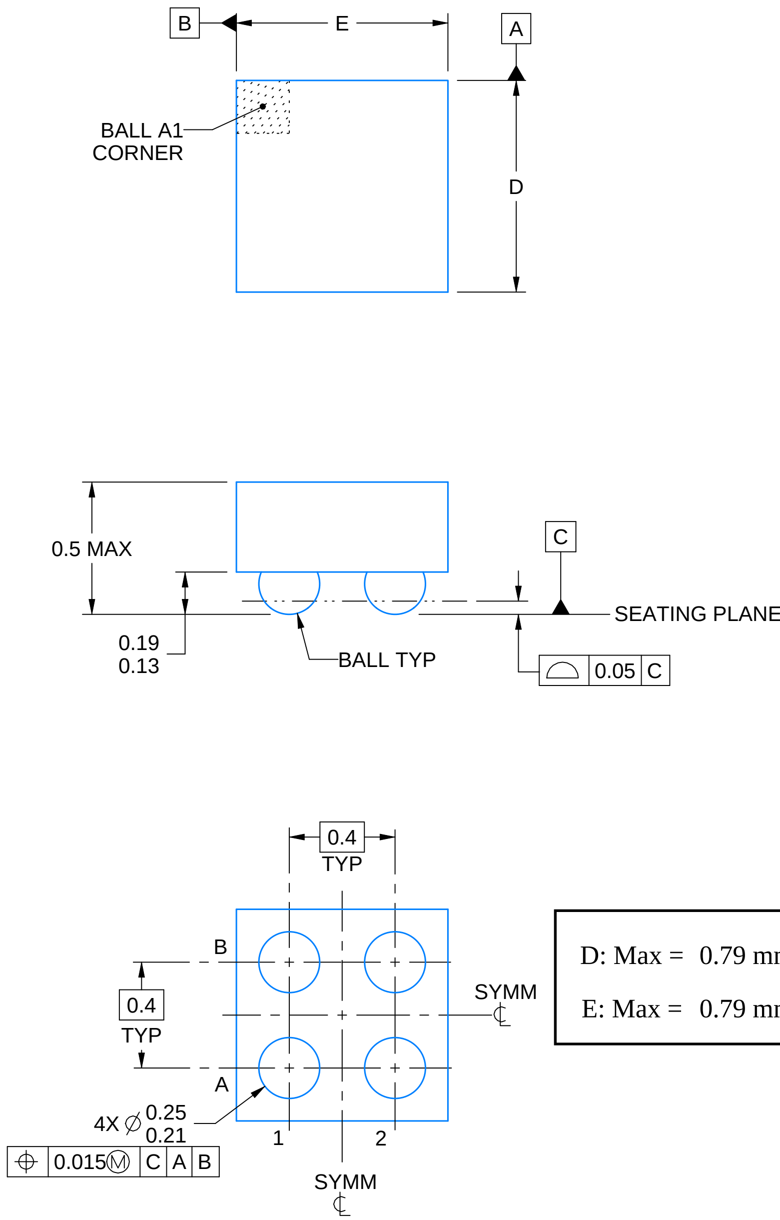
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TPS22901YFPR	DSBGA	YFP	4	3000	178.0	9.2	0.89	0.89	0.58	4.0	8.0	Q1
TPS22902BYFPR	DSBGA	YFP	4	3000	180.0	8.4	0.89	0.89	0.58	4.0	8.0	Q1
TPS22902YFPR	DSBGA	YFP	4	3000	178.0	9.2	0.89	0.89	0.58	4.0	8.0	Q1
TPS22902YFPR	DSBGA	YFP	4	3000	180.0	8.4	0.89	0.89	0.58	4.0	8.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

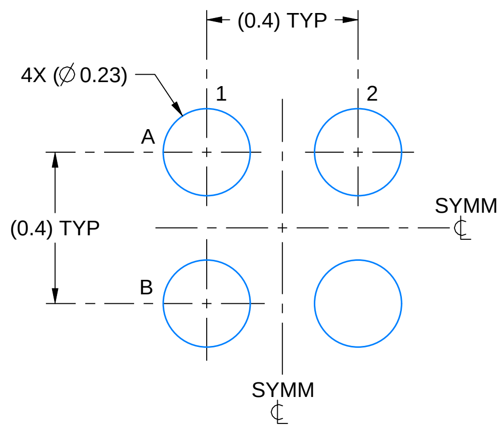
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS22901YFPR	DSBGA	YFP	4	3000	220.0	220.0	35.0
TPS22902BYFPR	DSBGA	YFP	4	3000	182.0	182.0	20.0
TPS22902YFPR	DSBGA	YFP	4	3000	270.0	225.0	227.0
TPS22902YFPR	DSBGA	YFP	4	3000	182.0	182.0	20.0



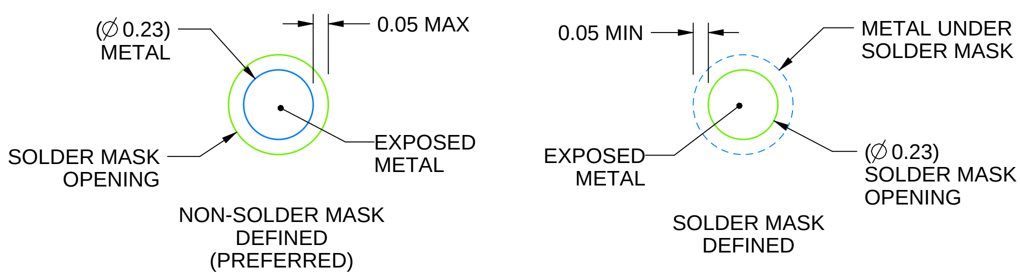
D: Max = 0.79 mm, Min = 0.73 mm	
E: Max = 0.79 mm, Min = 0.73 mm	

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.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:50X



SOLDER MASK DETAILS
NOT TO SCALE

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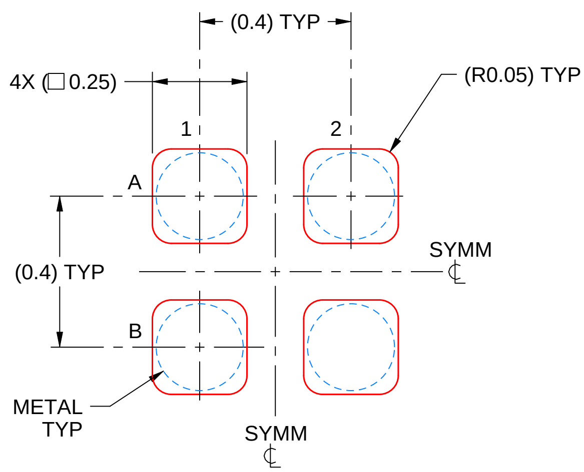
NOTES: (continued)

3. Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints.
For more information, see Texas Instruments literature number SNVA009 (www.ti.com/lit/snva009).



SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE:50X

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NOTES: (continued)

4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.