TPS2292x 3.6-V, 2-A, 14-mΩ ON-Resistance Load Switch With Controlled Turnon

1 Features

- Integrated P-Channel Load Switch
- Input Voltage: 0.9 V to 3.6 V
- ON-Resistance (Typical Values)
  - r_{ON} = 14 mΩ at V_{IN} = 3.6 V
  - r_{ON} = 20 mΩ at V_{IN} = 2.5 V
  - r_{ON} = 33 mΩ at V_{IN} = 1.8 V
  - r_{ON} = 67 mΩ at V_{IN} = 1.2 V
  - r_{ON} = 116 mΩ at V_{IN} = 1.0 V
- 2-A Maximum Continuous Switch Current
- Quiescent Current:
  - Typical 78 nA at 1.8 V
- Shutdown Current:
  - Typical 35 nA at 1.8 V
- Low Threshold Control Input Enable the use of 1.2 V, 1.8 V, 2.5 V, or 3.3 V Logic
- Controlled Slew Rate to Avoid Inrush Currents
  - t_R = 30 µs at V_{IN} = 1.8 V (TPS22921/2)
  - t_R = 200 µs at V_{IN} = 1.8 V (TPS22922B)
- Quick Output Discharge (TPS22922/2B)
- ESD Performance Tested Per JESD 22
  - 3000-V Human Body Model (A114-B, Class II)
  - 1000-V Charged-Device Model (C101)
- Six Terminal Wafer-Chip-Scale DSBGA Package (nominal dimensions shown - see *Mechanical, Packaging, and Orderable Information* for details)
  - 0.9-mm × 1.4-mm, 0.5-mm Pitch, 0.5 mm Height (YZP)
  - 0.9-mm × 1.4-mm, 0.5-mm Pitch, 0.625 mm Height (YZT)
  - 0.8-mm × 1.2-mm, 0.4-mm Pitch, 0.5-mm Height (YFP)

2 Applications

- PDAs
- Cell Phones
- GPS Devices
- MP3 Players
- Peripheral Ports
- Portable Media Players
- RF Modules

3 Description

TPS22921, TPS22922, and TPS22922B are small, low r_{ON} load switches with controlled turnon. The TPS22921/2/2B contains a P-channel MOSFET that can operate over an input voltage range of 0.9 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 TPS22922 and in TPS22922B, a 65-Ω on-chip load resistor is added for output quick discharge when the switch is turned off. The rise time (slew rate) of the device is internally controlled in order to avoid inrush current: TPS22921 and TPS22922 feature a 30-µs rise time, whereas TPS22922B is 200 µs.

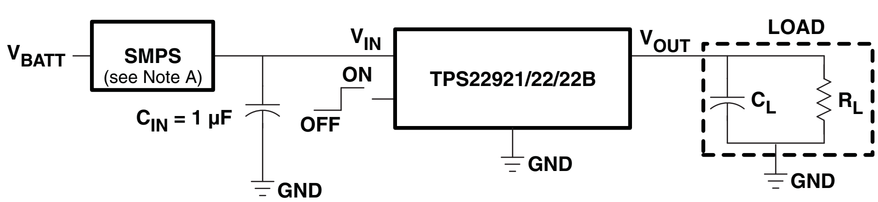
TPS22921, TPS22922, and TPS22922B feature low quiescent and shutdown currents and are available in space-saving 6-pin wafer-chip-scale packages DSBGA (WCSP: YZP and YZT with 0.5-mm pitch and YFP with 0.4-mm pitch) which make them ideal for portable electronics. The devices are characterized for operation over the free-air temperature range of –40°C to 85°C.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TPS22921(1)	YZT	0.9 mm × 1.4 mm
	YZP	
	YFP	0.8 mm × 1.2 mm
TPS22922 TPS22922B	YZP	0.9 mm × 1.4 mm
	YFP	0.8 mm × 1.2 mm

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

4 Typical Application



A. Switched-mode power supply

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5 Revision History

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

Changes from Revision B (May 2012) to Revision C — **Page**

- Added *Pin Configuration and Functions* section, *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

Changes from Revision A (December 2008) to Revision B — **Page**

- Changed Feature From: Ultra-Low Quiescent Current: 78 nA at 1.8 V To: Ultra-Low Quiescent Current: Typical 78 nA at 1.8 V 1
- Changed Feature From: Typical 78 nA at 1.8 V To: Ultra-Low Shutdown Current: Typical 35 nA at 1.8 V 1
- Changed Feature From: Six Terminal Wafer-Chip-Scale Package To: Six Terminal Wafer-Chip-Scale Package (nominal dimensions shown - see addendum for details 1
- Changed Feature From: 0.5-mm Height To: 0.5-mm Height (YFP) 1
- Changed TPS22921 QUICK OUTPUT DISCHARGE From: - To: No 3
- Changed the format of the ELECTRICAL CHARACTERISTICS Test Conditions From: V_{IN} = 1-V to V_{IN} = 1 V 5
- Deleted Note 1 - RL_CHIP = 120 Ω from all SWITCHING CHARACTERISTICS tables 6
- Changed Figure 50 title From: t_{OFF} Response To: t_{ON} Response 17

Changes from Original (November 2008) to Revision A — **Page**

- Added Note A to the TYPICAL APPLICATION circuit 1

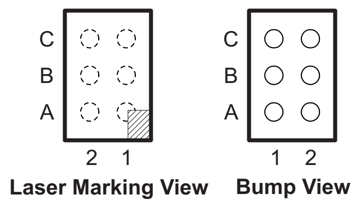
6 Device Comparison Table

	R_{ON} AT 1.8 V (TYP)	RISE TIME (TYP at 1.8 V)	QUICK OUTPUT DISCHARGE(1)	MAX OUTPUT CURRENT	ENABLE
TPS22921	33 mΩ	30 µs	No	2 A	Active high
TPS22922	33 mΩ	30 µs	Yes	2 A	Active high
TPS22922B	33 mΩ	200 µs	Yes	2 A	Active high

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

7 Pin Configuration and Functions

YFP, YZP, AND YZT PACKAGES



Pin Assignments

C	ON	GND
B	V_{IN}	V_{OUT}
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. Use a bypass capacitor to ground (ceramic)
B1	V_{OUT}	O	Switch output
B2	V_{IN}	I	Switch input. Use a bypass capacitor to ground (ceramic)
C1	GND	–	Ground
C2	ON	I	Switch control input, active high. Do not leave floating

8 Specifications

8.1 Absolute Maximum Ratings[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		0.645	W
I_{MAX}	Maximum continuous switch current		2	A
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, 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.

8.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001[1]	±3000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101[2]	±1000	
		Machine model (MM)	±300	

(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.

8.3 Recommended Operating Conditions

		MIN	MAX	UNIT
V_{IN}	Input voltage range	0.9	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) Refer to *Application Information*.

8.4 Thermal Information

THERMAL METRIC[1]		TPS22921, TPS22922, TPS22922B		TPS22921	UNIT
		YFP	YZP	YZT	
		6 PINS			
$R_{\theta JA}$	Junction-to-ambient thermal resistance	125.1	131	120.7	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	1.4	1.3	2.1	
$R_{\theta JB}$	Junction-to-board thermal resistance	26	22.6	26.4	
ψ_{JT}	Junction-to-top characterization parameter	0.3	5.2	3.7	
ψ_{JB}	Junction-to-board characterization parameter	26	22.6	26.4	

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

8.5 Electrical Characteristics

V_{IN} = 0.9 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_Q	Quiescent current	I_{OUT} = 0 mA	V_{IN} = 1 V	Full		30	120	nA
			V_{IN} = 1.8 V	Full		78	235	
			V_{IN} = 3.6 V	Full		200	880	
$I_{IN(OFF)}$	OFF-state supply current	V_{ON} = GND, OUT = Open	V_{IN} = 1 V	Full		10	210	nA
			V_{IN} = 1.8 V	Full		35	260	
			V_{IN} = 3.6 V	Full		120	700	
$I_{IN(LEAKAGE)}$	OFF-state switch current	V_{ON} = GND, V_{OUT} = 0 V	V_{IN} = 1 V	Full		12	140	nA
			V_{IN} = 1.8 V	Full		50	230	
			V_{IN} = 3.6 V	Full		130	610	
r_{ON}	ON-state resistance	I_{OUT} = –200 mA	V_{IN} = 3.6 V	25°C		14	45	mΩ
				Full			50	
			V_{IN} = 2.5 V	25°C		20	55	
				Full			60	
			V_{IN} = 1.8 V	25°C		33	65	
				Full			75	
			V_{IN} = 1.2 V	25°C		67	100	
				Full			120	
			V_{IN} = 1.1 V	25°C		82	150	
				Full			160	
			V_{IN} = 1 V	25°C		116	160	
				Full			170	
r_{PD}	Output pulldown resistance	V_{IN} = 3.3 V, V_{ON} = 0 V, I_{OUT} = 30 mA (TPS22922 and TPS22922B only)		25°C		65	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.

8.6 Switching Characteristics: V_{IN} = 0.9 V

V_{IN} = 0.9 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		TPS22921			TPS22922			TPS22922B			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t_{ON}	Turn-ON time	R_L = 500 Ω	C_L = 0.1 µF		121			121			638		µs
			C_L = 1 µF		160			160			712		
			C_L = 3 µF		188			188			799		
t_{OFF}	Turn-OFF time	R_L = 500 Ω	C_L = 0.1 µF		46			40			40		µs
			C_L = 1 µF		308			279			279		
			C_L = 3 µF		975			807			807		
t_r	V_{OUT} rise time	R_L = 500 Ω	C_L = 0.1 µF		60			60			462		µs
			C_L = 1 µF		85			85			465		
			C_L = 3 µF		107			107			507		
t_f	V_{OUT} fall time	R_L = 500 Ω	C_L = 0.1 µF		119			51			51		µs
			C_L = 1 µF		969			434			434		
			C_L = 3 µF		3174			1264			1264		

8.7 Switching Characteristics: V_{IN} = 1 V

V_{IN} = 1 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		TPS22921			TPS22922			TPS22922B			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t_{ON}	Turn-ON time	R_L = 500 Ω	C_L = 0.1 µF		105			105			549		µs
			C_L = 1 µF		136			136			613		
			C_L = 3 µF		157			157			683		
t_{OFF}	Turn-OFF time	R_L = 500 Ω	C_L = 0.1 µF		46			28			28		µs
			C_L = 1 µF		309			186			186		
			C_L = 3 µF		983			511			511		
t_r	V_{OUT} rise time	R_L = 500 Ω	C_L = 0.1 µF		51			51			386		µs
			C_L = 1 µF		78			78			388		
			C_L = 3 µF		88			88			419		
t_f	V_{OUT} fall time	R_L = 500 Ω	C_L = 0.1 µF		121			34			34		µs
			C_L = 1 µF		986			306			306		
			C_L = 3 µF		3300			908			908		

8.8 Switching Characteristics: V_{IN} = 1.1 V

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

PARAMETER		TEST CONDITIONS		TPS22921			TPS22922			TPS22922B			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t_{ON}	Turn-ON time	R_L = 500 Ω	C_L = 0.1 µF		91			93			484		µs
			C_L = 1 µF		118			118			540		
			C_L = 3 µF		137			137			599		
t_{OFF}	Turn-OFF time	R_L = 500 Ω	C_L = 0.1 µF		44			21			21		µs
			C_L = 1 µF		311			144			144		
			C_L = 3 µF		99			383			383		
t_r	V_{OUT} rise time	R_L = 500 Ω	C_L = 0.1 µF		46			46			335		µs
			C_L = 1 µF		60			60			336		
			C_L = 3 µF		76			76			363		
t_f	V_{OUT} fall time	R_L = 500 Ω	C_L = 0.1 µF		122			29			29		µs
			C_L = 1 µF		1000			224			224		
			C_L = 3 µF		3300			732			732		

8.9 Switching Characteristics: V_{IN} = 1.2 V

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

PARAMETER		TEST CONDITIONS		TPS22921			TPS22922			TPS22922B			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t_{ON}	Turn-ON time	R_L = 500 Ω	C_L = 0.1 µF		83			83			435		µs
			C_L = 1 µF		103			103			485		
			C_L = 3 µF		122			122			536		
t_{OFF}	Turn-OFF time	R_L = 500 Ω	C_L = 0.1 µF		44			17			17		µs
			C_L = 1 µF		312			117			117		
			C_L = 3 µF		1000			319			319		
t_r	V_{OUT} rise time	R_L = 500 Ω	C_L = 0.1 µF		41			41			301		µs
			C_L = 1 µF		54			54			302		
			C_L = 3 µF		67			67			325		
t_f	V_{OUT} fall time	R_L = 500 Ω	C_L = 0.1 µF		123			25			25		µs
			C_L = 1 µF		1000			214			214		
			C_L = 3 µF		3400			632			632		

8.10 Switching Characteristics: V_{IN} = 1.8 V

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

PARAMETER		TEST CONDITIONS		TPS22921			TPS22922			TPS22922B			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t_{ON}	Turn-ON time	R_L = 500 Ω	C_L = 0.1 µF		54			54			282		µs
			C_L = 1 µF		67			67			314		
			C_L = 3 µF		78			78			344		
t_{OFF}	Turn-OFF time	R_L = 500 Ω	C_L = 0.1 µF		41			10			10		µs
			C_L = 1 µF		312			67			67		
			C_L = 3 µF		1000			181			181		
t_r	V_{OUT} rise time	R_L = 500 Ω	C_L = 0.1 µF		30			30			200		µs
			C_L = 1 µF		37			37			202		
			C_L = 3 µF		47			47			219		
t_f	V_{OUT} fall time	R_L = 500 Ω	C_L = 0.1 µF		121			17			17		µs
			C_L = 1 µF		1000			158			158		
			C_L = 3 µF		3450			461			461		

8.11 Switching Characteristics: V_{IN} = 2.5 V

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

PARAMETER		TEST CONDITIONS		TPS22921			TPS22922			TPS22922B			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t_{ON}	Turn-ON time	R_L = 500 Ω	C_L = 0.1 µF		40			40			211		µs
			C_L = 1 µF		50			50			233		
			C_L = 3 µF		59			59			256		
t_{OFF}	Turn-OFF time	R_L = 500 Ω	C_L = 0.1 µF		41			10			10		µs
			C_L = 1 µF		316			56			56		
			C_L = 3 µF		1000			153			153		
t_r	V_{OUT} rise time	R_L = 500 Ω	C_L = 0.1 µF		23			23			164		µs
			C_L = 1 µF		29			29			165		
			C_L = 3 µF		38			38			177		
t_f	V_{OUT} fall time	R_L = 500 Ω	C_L = 0.1 µF		122			16			16		µs
			C_L = 1 µF		1086			147			147		
			C_L = 3 µF		3600			430			430		

8.12 Switching Characteristics: V_{IN} = 3 V

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

PARAMETER		TEST CONDITIONS		TPS22921			TPS22922			TPS22922B			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t_{ON}	Turn-ON time	R_L = 500 Ω	C_L = 0.1 μF		30			30			182		μs
			C_L = 1 μF		38			38			201		
			C_L = 3 μF		45			45			221		
t_{OFF}	Turn-OFF time	R_L = 500 Ω	C_L = 0.1 μF		40			10			10		μs
			C_L = 1 μF		353			51			51		
			C_L = 3 μF		1036			139			139		
t_r	V_{OUT} rise time	R_L = 500 Ω	C_L = 0.1 μF		20			20			149		μs
			C_L = 1 μF		25			25			150		
			C_L = 3 μF		33			33			161		
t_f	V_{OUT} fall time	R_L = 500 Ω	C_L = 0.1 μF		104			15			15		μs
			C_L = 1 μF		1030			143			143		
			C_L = 3 μF		3230			419			419		

8.13 Switching Characteristics: V_{IN} = 3.6 V

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

PARAMETER		TEST CONDITIONS		TPS22921			TPS22922			TPS22922B			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t_{ON}	Turn-ON time	R_L = 500 Ω	C_L = 0.1 μF		30			30			159		μs
			C_L = 1 μF		38			38			175		
			C_L = 3 μF		45			45			193		
t_{OFF}	Turn-OFF time	R_L = 500 Ω	C_L = 0.1 μF		42			10			10		μs
			C_L = 1 μF		310			51			51		
			C_L = 3 μF		988			139			139		
t_r	V_{OUT} rise time	R_L = 500 Ω	C_L = 0.1 μF		20			20			137		μs
			C_L = 1 μF		25			25			138		
			C_L = 3 μF		33			33			148		
t_f	V_{OUT} fall time	R_L = 500 Ω	C_L = 0.1 μF		120			15			15		μs
			C_L = 1 μF		1100			143			143		
			C_L = 3 μF		3600			419			419		

8.14 Typical Characteristics

8.14.1 Typical DC Characteristics

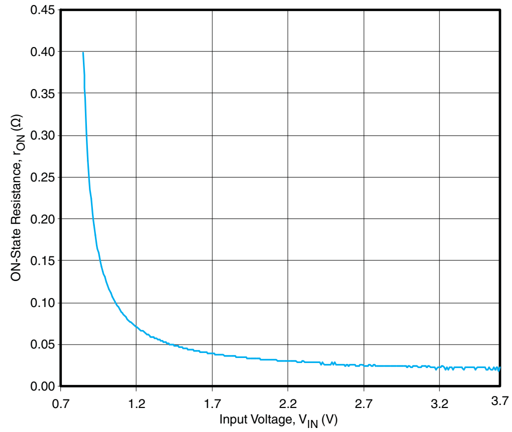


Figure 1. r_{ON} vs V_{IN}

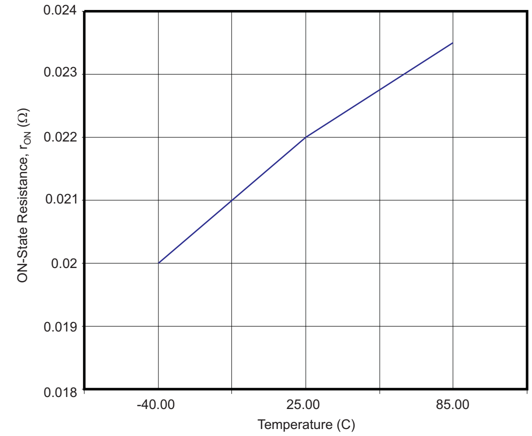


Figure 2. r_{ON} vs Temperature (V_{IN} = 3.3 V)

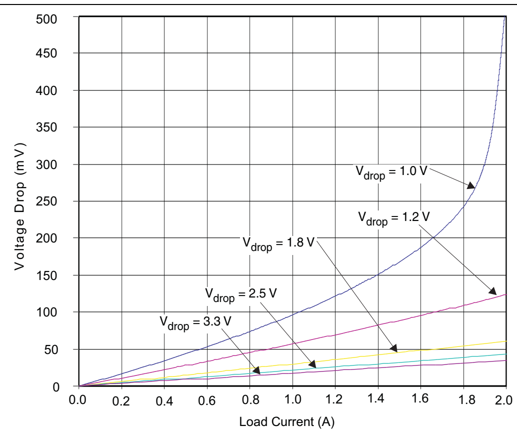


Figure 3. Voltage Drop vs Load Current

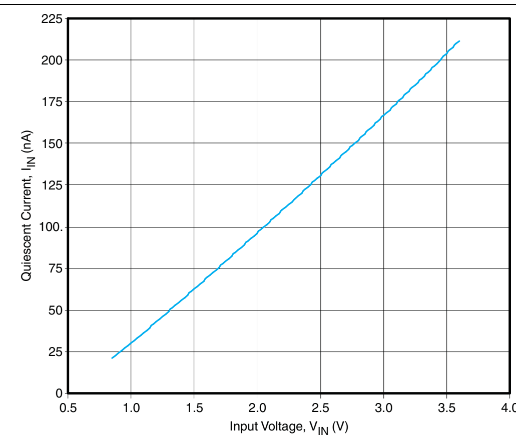


Figure 4. Quiescent Current vs V_{IN} (V_{ON} = V_{IN})

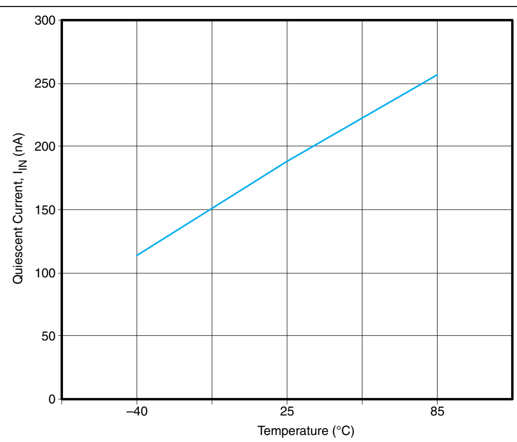


Figure 5. Quiescent Current vs Temperature (V_{IN} = 3.3 V, I_{OUT} = 0 mA)

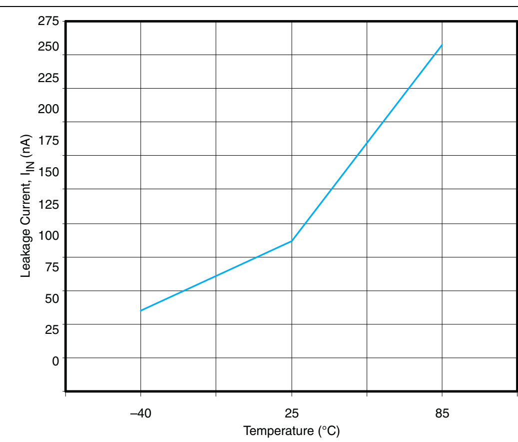


Figure 6. I_{IN} Leakage Current vs Temperature (V_{IN} = 3.3 V)

Typical DC Characteristics (continued)

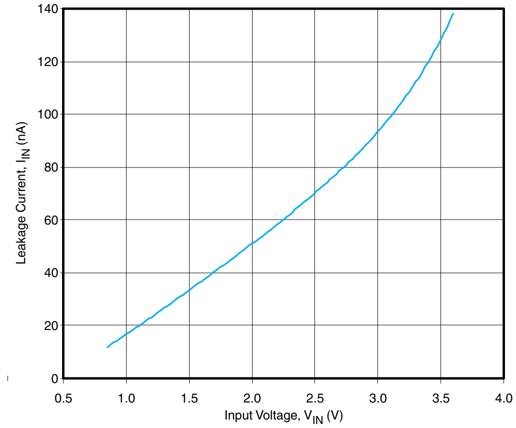


Figure 7. Leakage Current vs V_{IN}

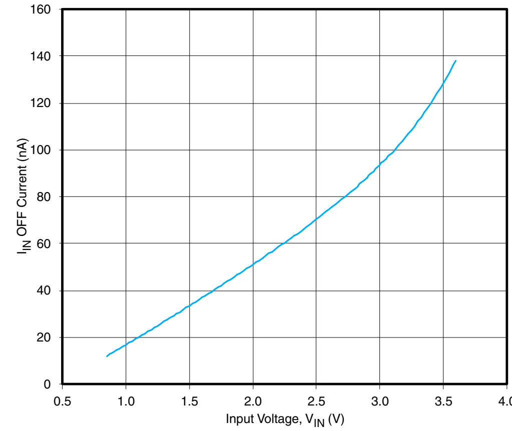


Figure 8. I_{IN} (OFF) vs V_{IN} (V_{ON} = 0 V)

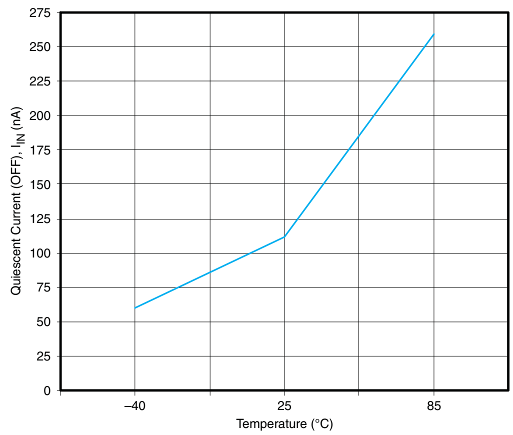


Figure 9. I_{IN} (OFF) vs Temperature (V_{IN} = 3.3 V)

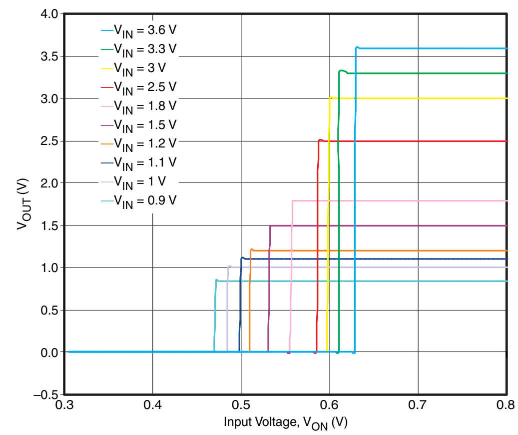


Figure 10. ON-Input Threshold

8.14.2 Typical AC Characteristics (TPS22921)

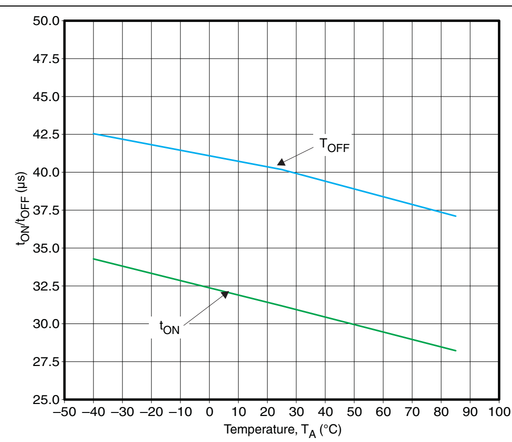


Figure 11. t_{ON}/t_{OFF} vs Temperature (V_{IN} = 3.3 V)

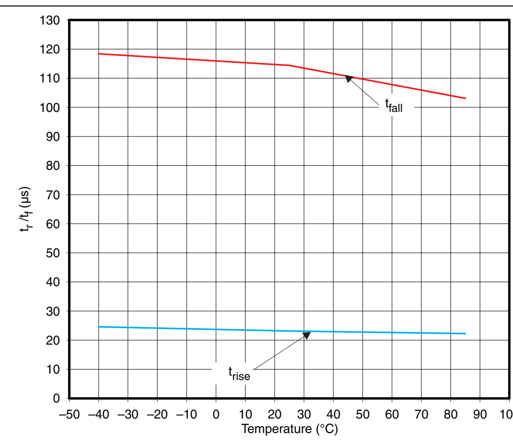


Figure 12. t_{rise}/t_{fall} vs Temperature (V_{IN} = 3.3 V)

8.14.3 Typical AC Characteristics (TPS22922)

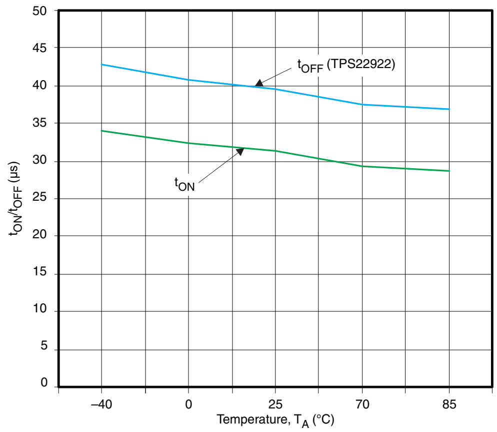


Figure 13. t_{ON}/t_{OFF} vs Temperature (V_{IN} = 3.3 V)

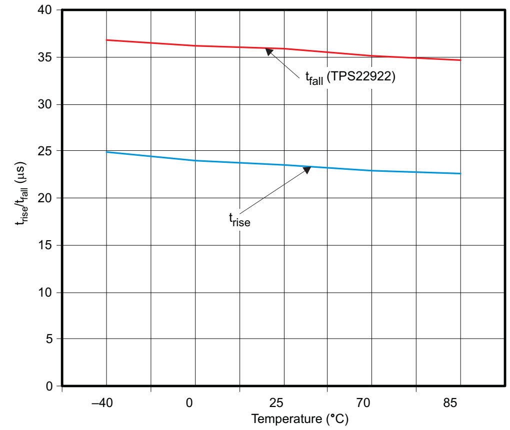


Figure 14. t_{rise}/t_{fall} vs Temperature (V_{IN} = 3.3 V)

8.14.4 Typical AC Characteristics (TPS22922B)

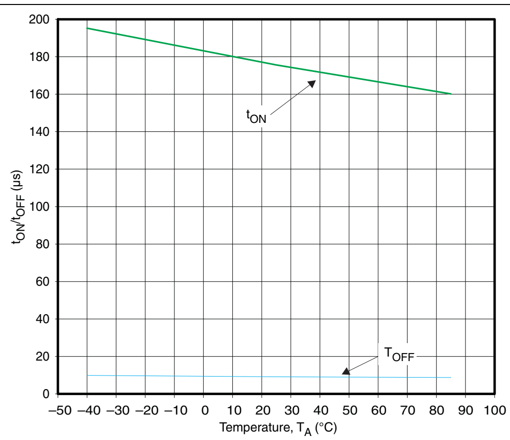


Figure 15. t_{ON}/t_{OFF} vs Temperature (V_{IN} = 3.3 V)

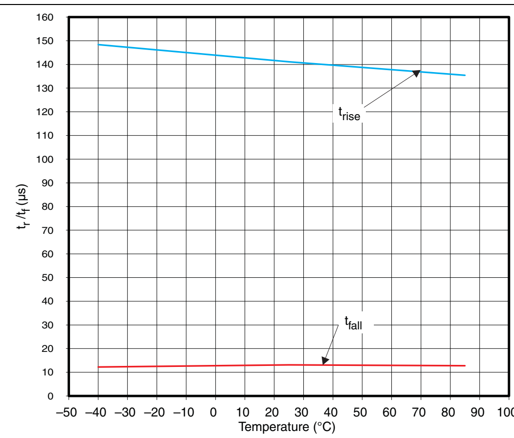


Figure 16. t_{rise}/t_{fall} vs Temperature (V_{IN} = 3.3 V)

8.14.5 Typical AC Characteristics (TPS22921 and TPS22922)

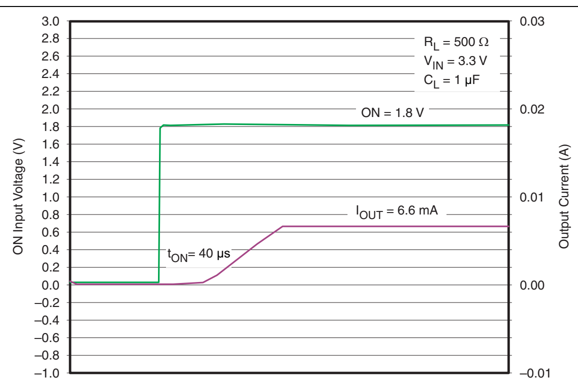


Figure 17. t_{ON} Response

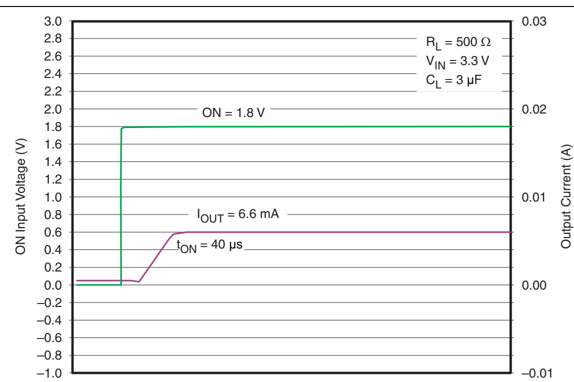


Figure 18. t_{ON} Response

Typical AC Characteristics (TPS22921 and TPS22922) (continued)

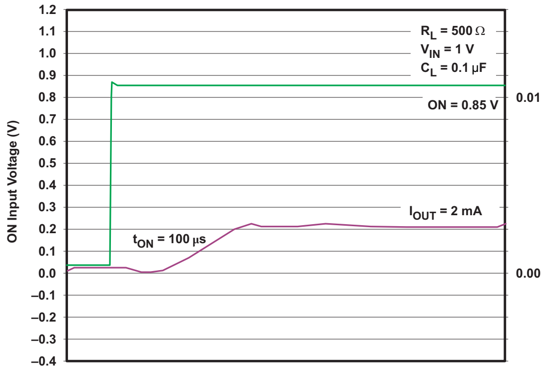


Figure 19. t_{ON} Response

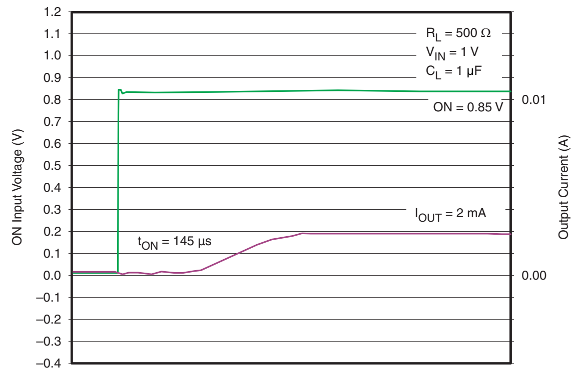


Figure 20. t_{ON} Response

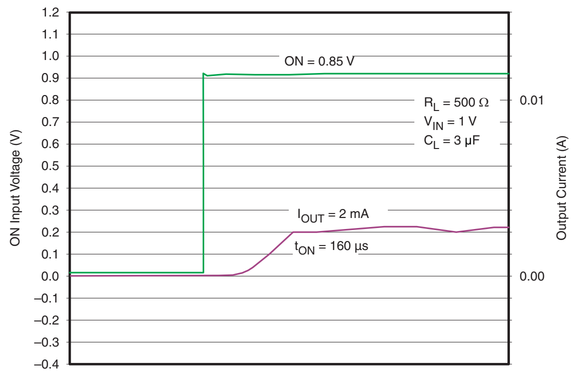


Figure 21. t_{ON} Response

8.14.6 Typical AC Characteristics (TPS22921)

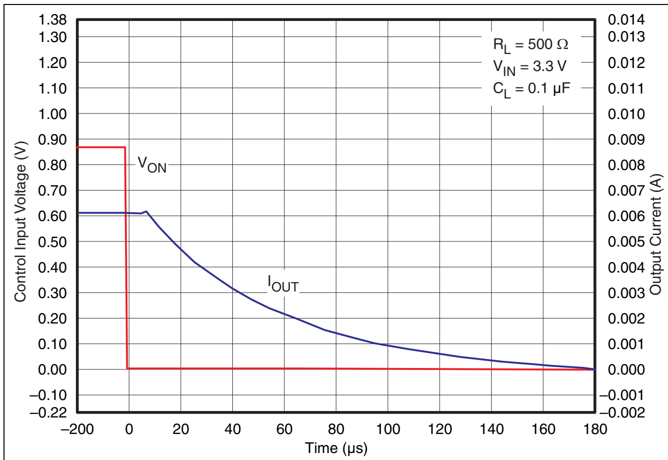


Figure 22. t_{OFF} Response

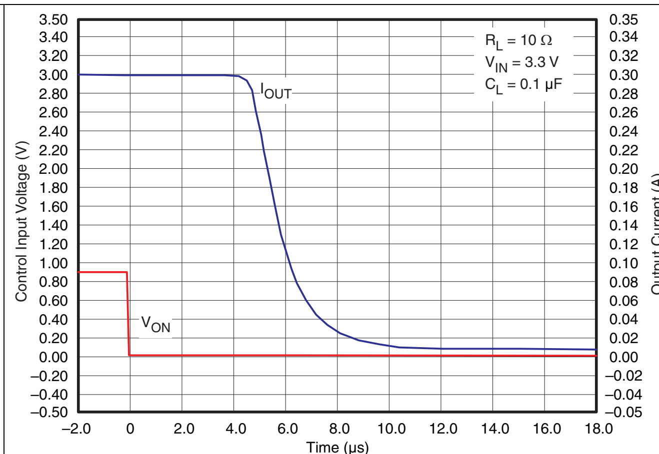


Figure 23. t_{OFF} Response

Typical AC Characteristics (TPS22921) (continued)

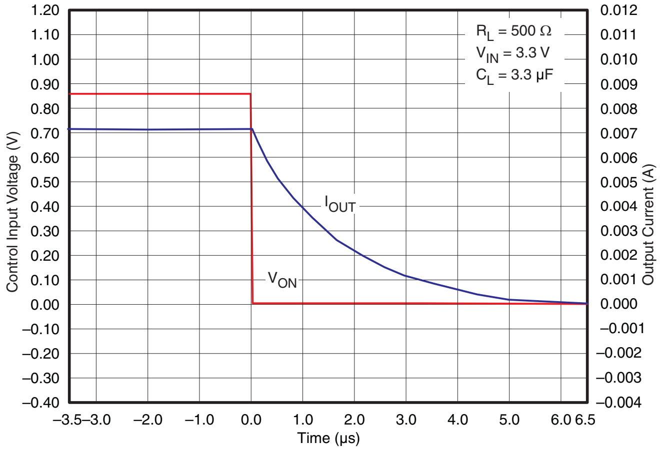


Figure 24. t_{OFF} Response

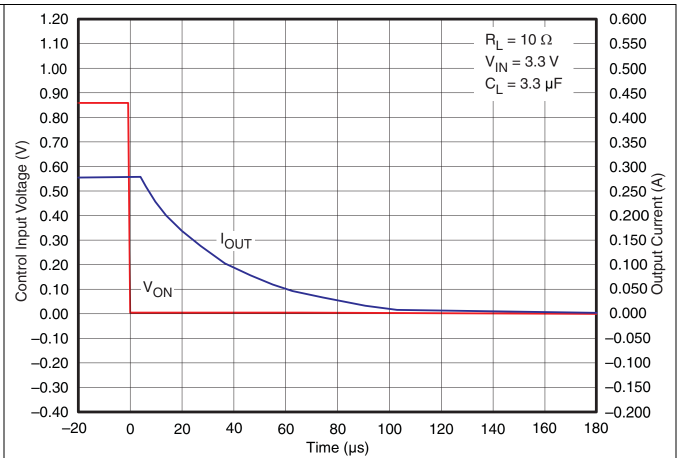


Figure 25. t_{OFF} Response

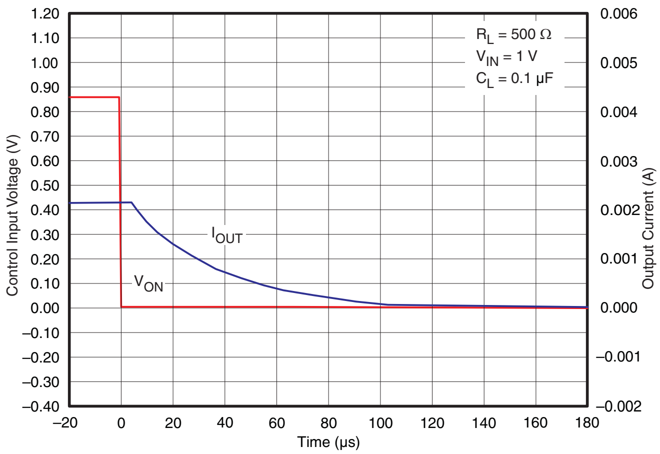


Figure 26. t_{OFF} Response

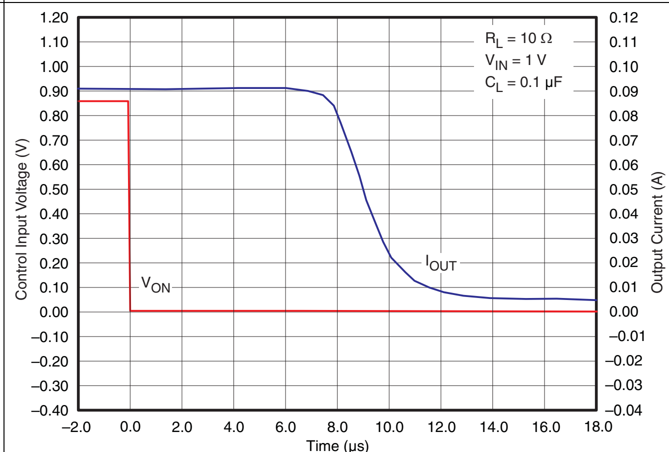


Figure 27. t_{OFF} Response

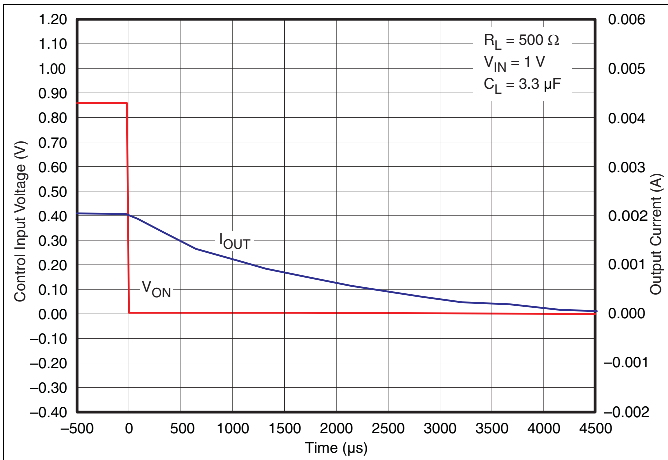


Figure 28. t_{OFF} Response

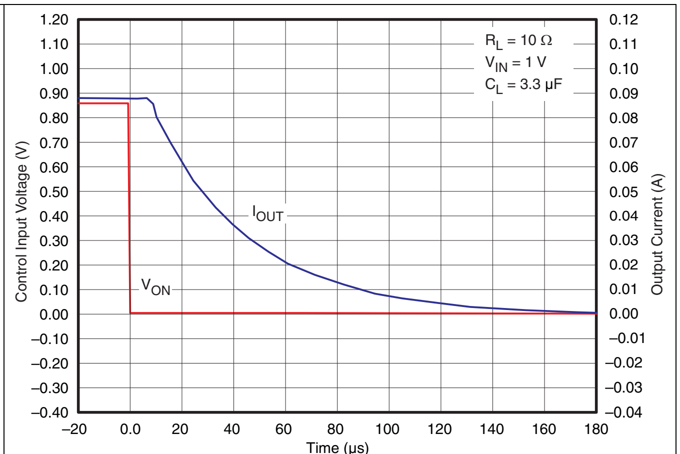


Figure 29. t_{OFF} Response

8.14.7 Typical AC Characteristics (TPS22922)

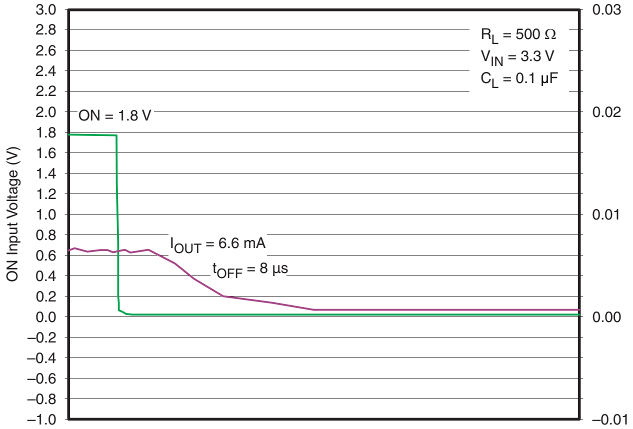


Figure 30. t_{OFF} Response

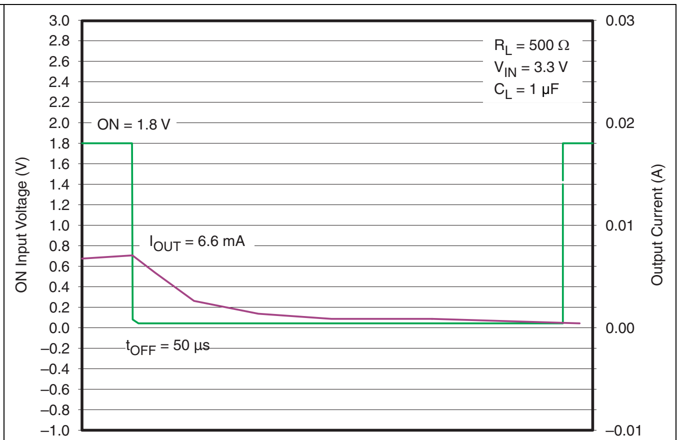


Figure 31. t_{OFF} Response

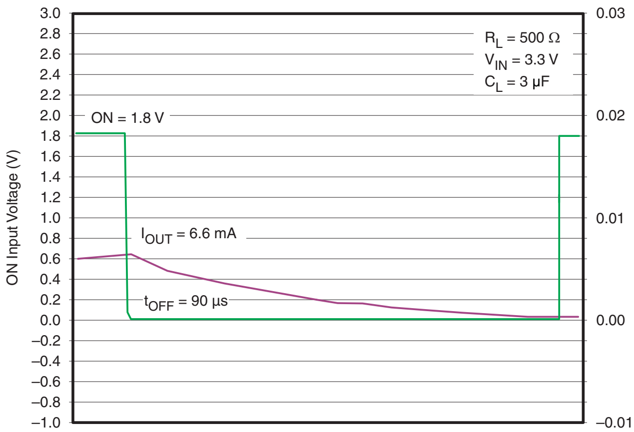


Figure 32. t_{OFF} Response

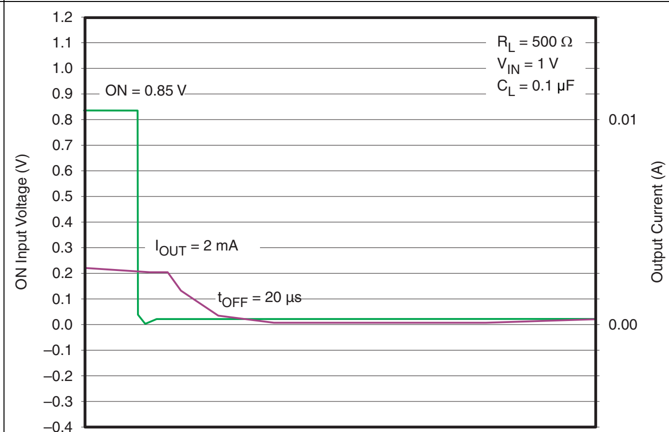


Figure 33. t_{OFF} Response

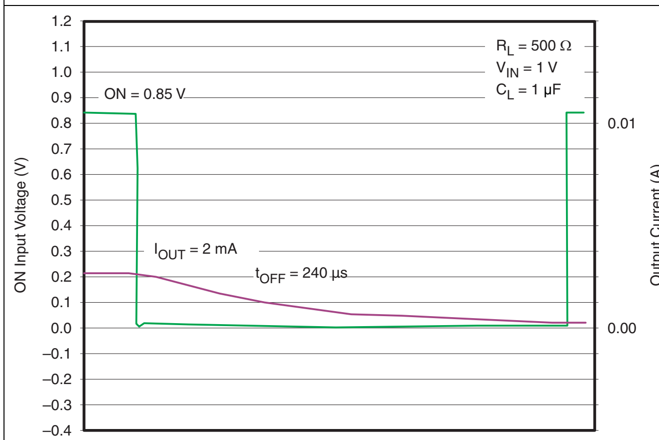


Figure 34. t_{OFF} Response

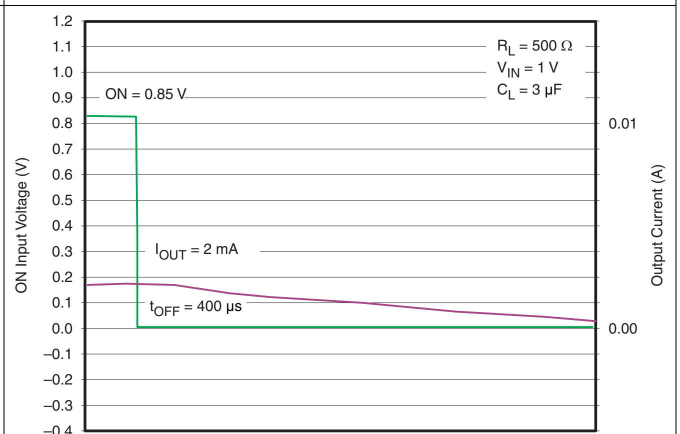


Figure 35. t_{OFF} Response

8.14.8 Typical AC Characteristics (TPS22922B)

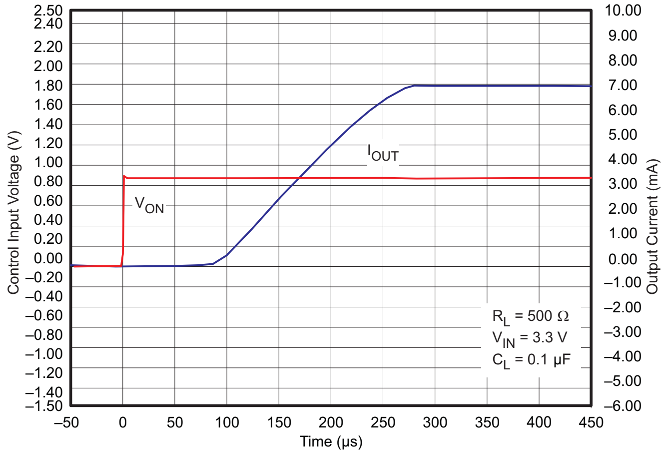


Figure 36. t_{ON} Response

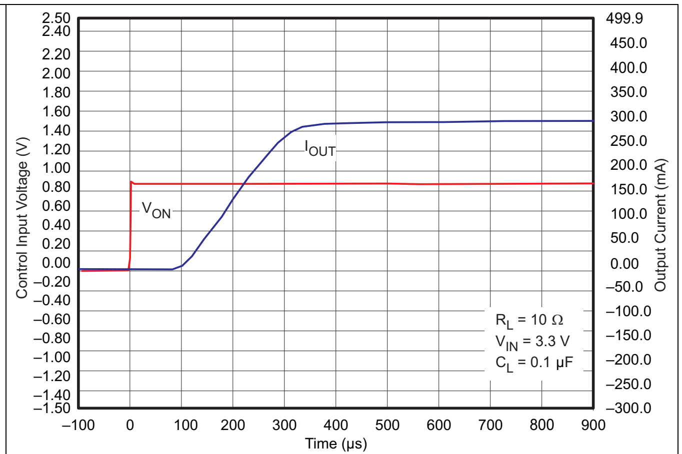


Figure 37. t_{ON} Response

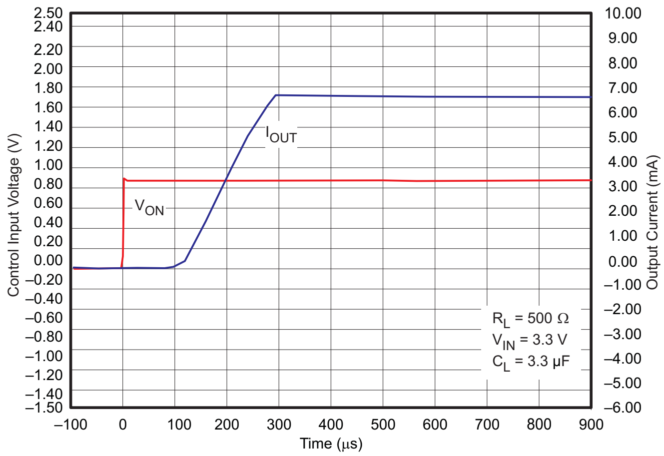


Figure 38. t_{ON} Response

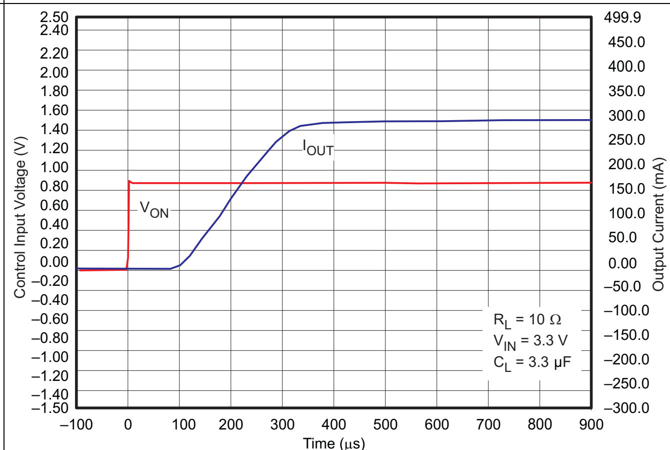


Figure 39. t_{ON} Response

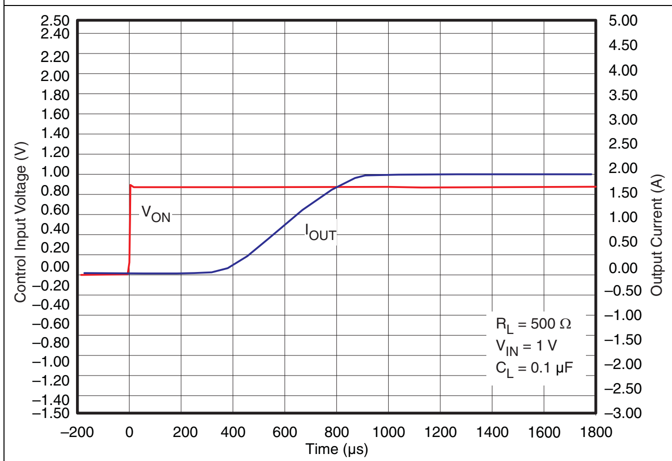


Figure 40. t_{ON} Response

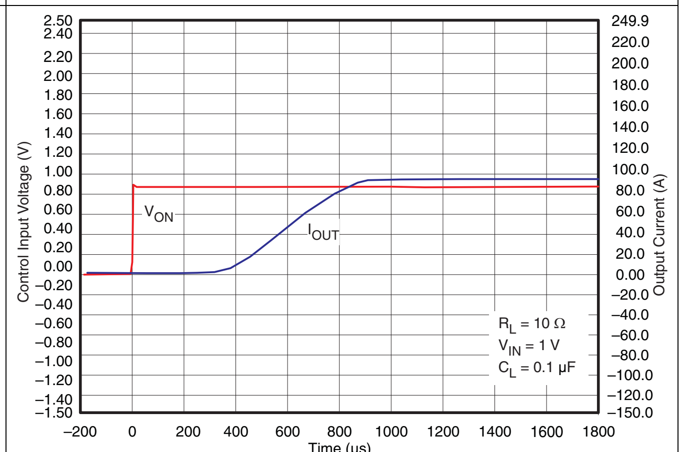


Figure 41. t_{ON} Response

Typical AC Characteristics (TPS22922B) (continued)

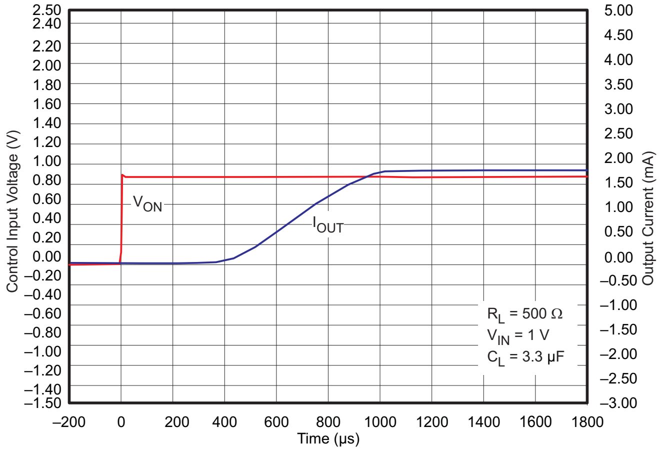


Figure 42. t_{ON} Response

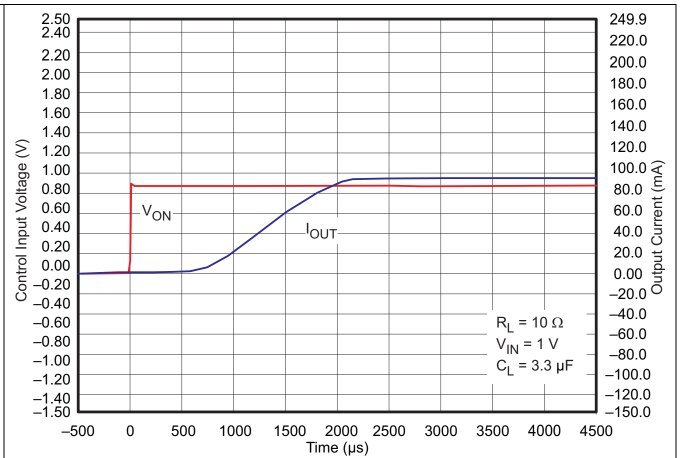


Figure 43. t_{ON} Response

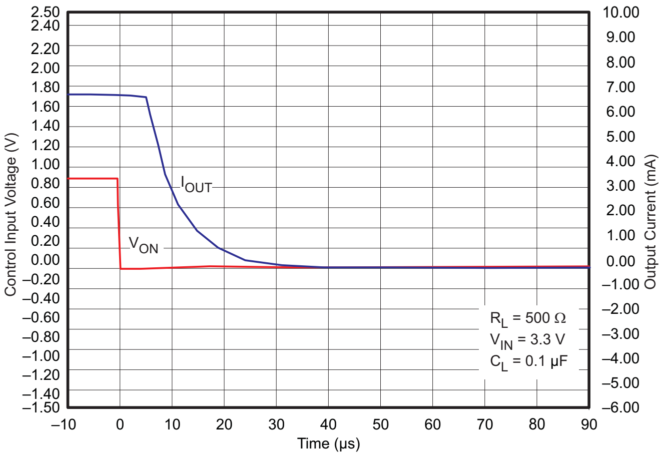


Figure 44. t_{OFF} Response

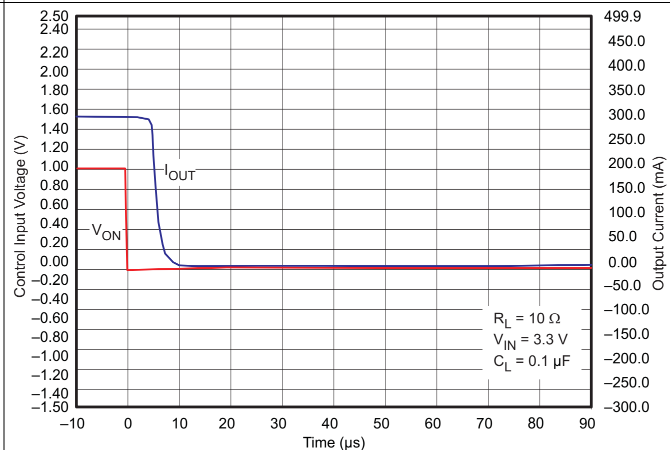


Figure 45. t_{OFF} Response

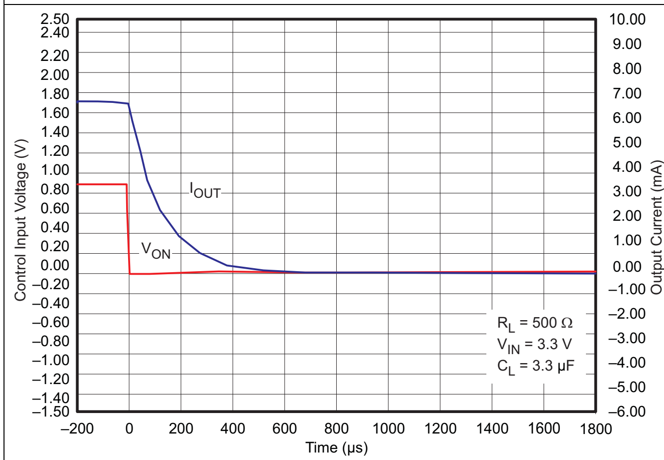


Figure 46. t_{OFF} Response

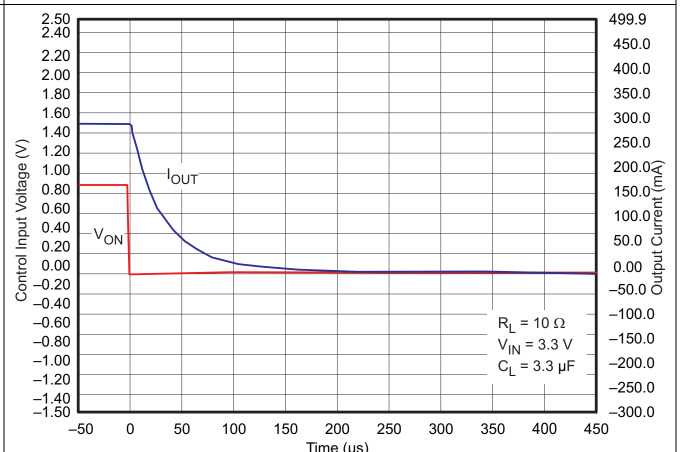


Figure 47. t_{OFF} Response

Typical AC Characteristics (TPS22922B) (continued)

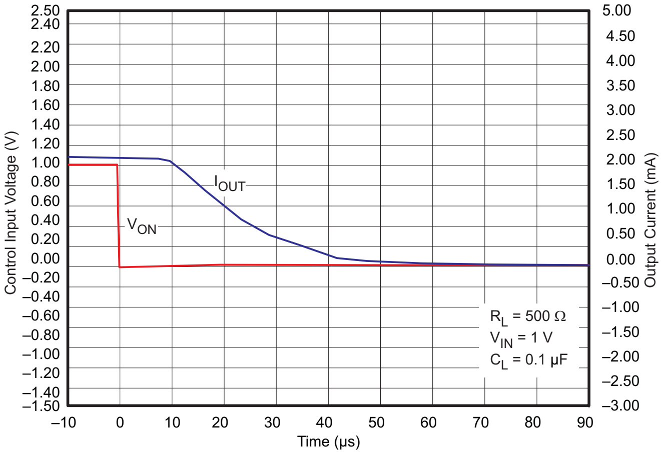


Figure 48. t_{OFF} Response

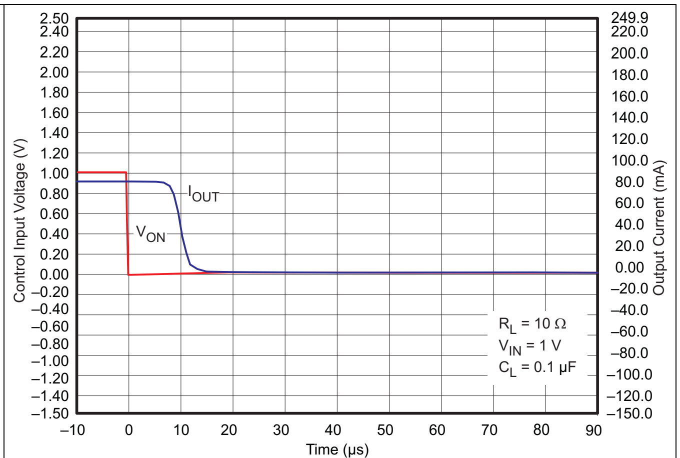


Figure 49. t_{OFF} Response

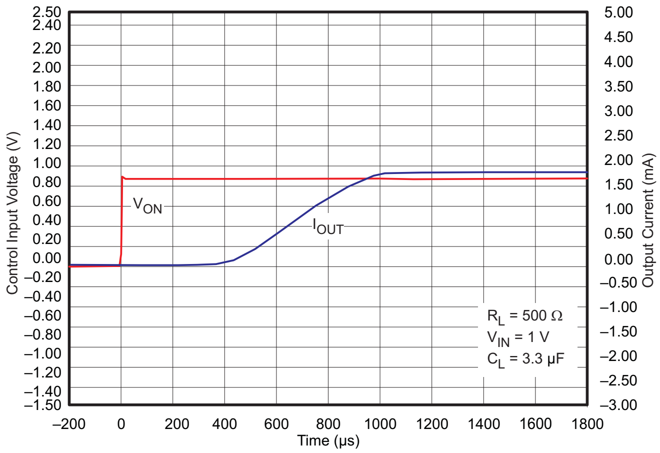


Figure 50. t_{ON} Response

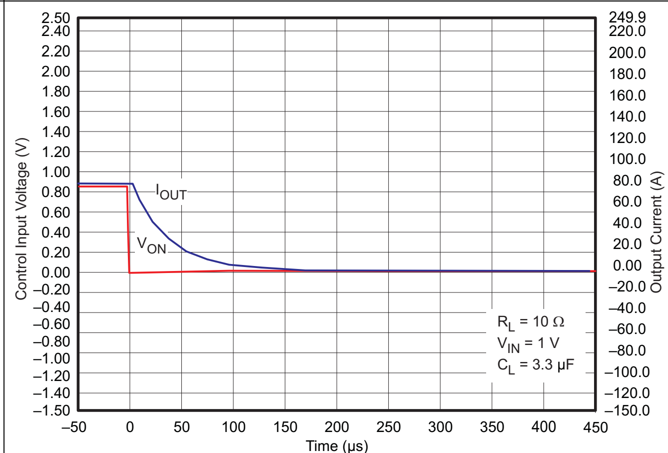
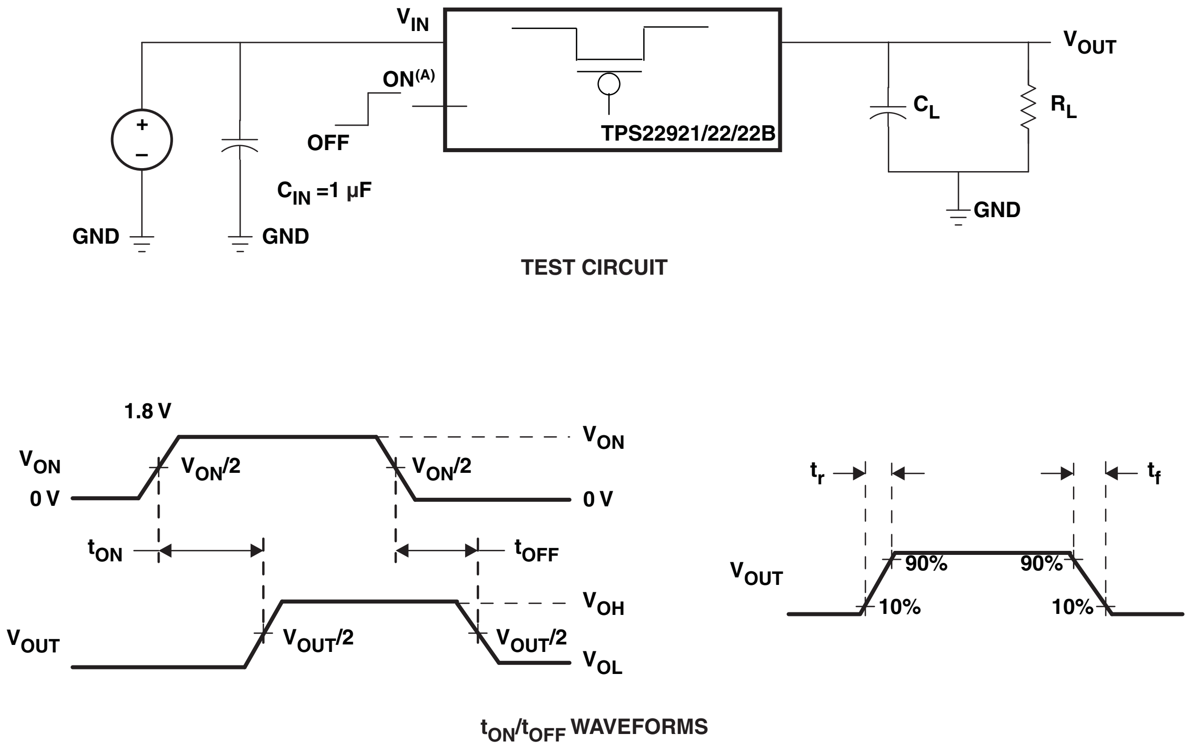


Figure 51. t_{OFF} Response

9 Parameter Measurement Information



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

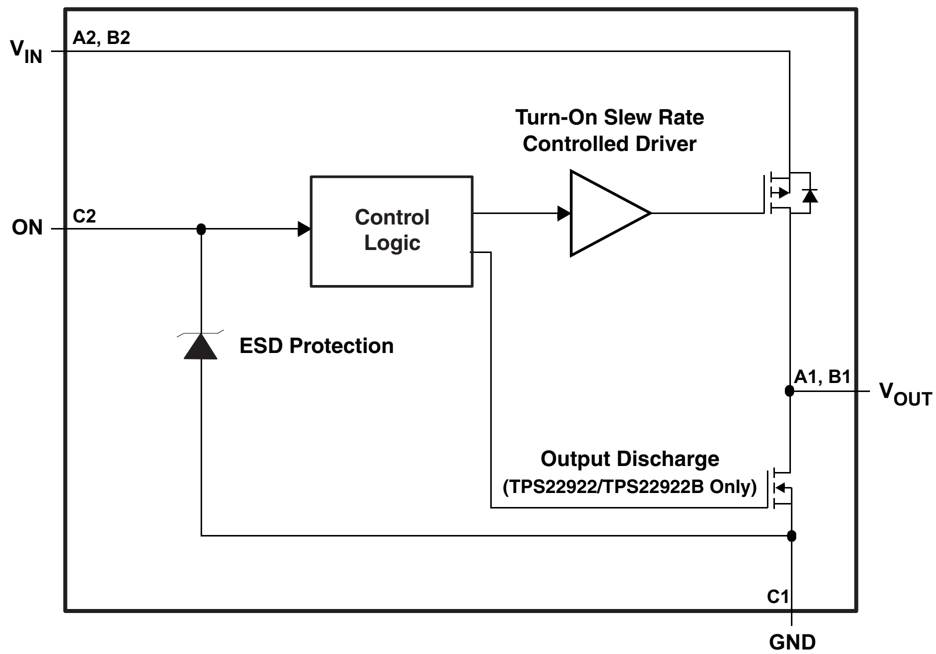
Figure 52. Test Circuit and t_{ON}/t_{OFF} Waveforms

10 Detailed Description

10.1 Overview

The TPS2292x is a single-channel, 2-A load switch in a small, space-saving CSP-6 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.

10.2 Functional Block Diagram



10.3 Feature Description

10.3.1 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.

10.3.2 Quick Output Discharge

The TPS22922 and TPS22922B includes the Quick Output Discharge (QOD) feature. When the switch is disabled, a discharge resistance with a typical value of 65 Ω is connected between the output and ground. This resistance pulls down the output and prevents it from floating when the device is disabled.

10.4 Device Functional Modes

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

Table 1. VOUT Function Table

ON	TPS22921	TPS22922/2B
L	Open	GND
H	VIN	VIN

11 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.

11.1 Application Information

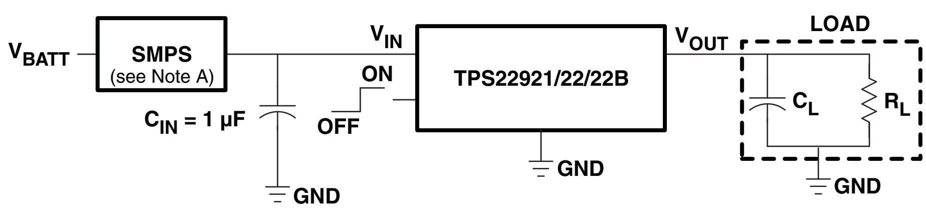
11.1.1 Input Capacitor (Optional)

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 must 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 used to further reduce the voltage drop during higher current application. When switching a heavy load, TI recommends using an input capacitor about 10 or more times higher than the output capacitor in order to avoid any supply drop.

11.1.2 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}.

11.2 Typical Application



A. Switched-mode power supply

Figure 53. Typical Application

11.2.1 Design Requirements

Table 2. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
V_{IN}	1.8 V
C_L	4.7 µF
Load current	2 A
Ambient Temperature	25 °C
Maximum inrush current	200 mA

11.2.2 Detailed Design Procedure

11.2.2.1 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:

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

where

- C_L = Output capacitance
- dV_{OUT} = Output voltage
- dt = Rise time (1)

The TPS22921/2/2B 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 because the amount of inrush current increases with output capacitance:

200 mA = 4.7 µF × 1.8V / dt

where

- dt = 42.3 µs (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 TPS22922B has a typical rise time of 200 µs at 1.8 V which meets the above design requirements. The TPS22921/2 has a faster rise time of 30 µs at 1.8 V, and this would result in an inrush current larger than desired.

11.2.2.2 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 *Electrical Characteristics* 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:

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

where

- ΔV = Voltage drop across the device
- I_{LOAD} = Load current
- R_{ON} = ON-resistance of the device (3)

At V_{IN} = 1.8 V, the TPS22921/2/2B has an R_{ON} value of 33 mΩ. Using this value and the defined load current, the above equation can be evaluated:

ΔV = 2 A × 33 mΩ

where

- ΔV = 66 mV (4)

Therefore, the voltage drop across the device will be 66 mV.

11.2.3 Application Curve

Figure 54 shows the expected voltage drop across the device for different load currents and input voltages.

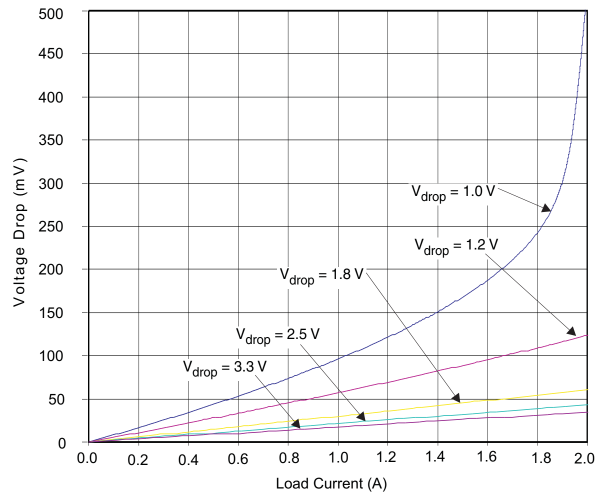


Figure 54. Voltage Drop vs Load Current

12 Power Supply Recommendations

The device is designed to operate with a VIN range of 0.9 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.

13 Layout

13.1 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 data sheet. This parameter is highly dependent on board layout.

13.2 Layout Example

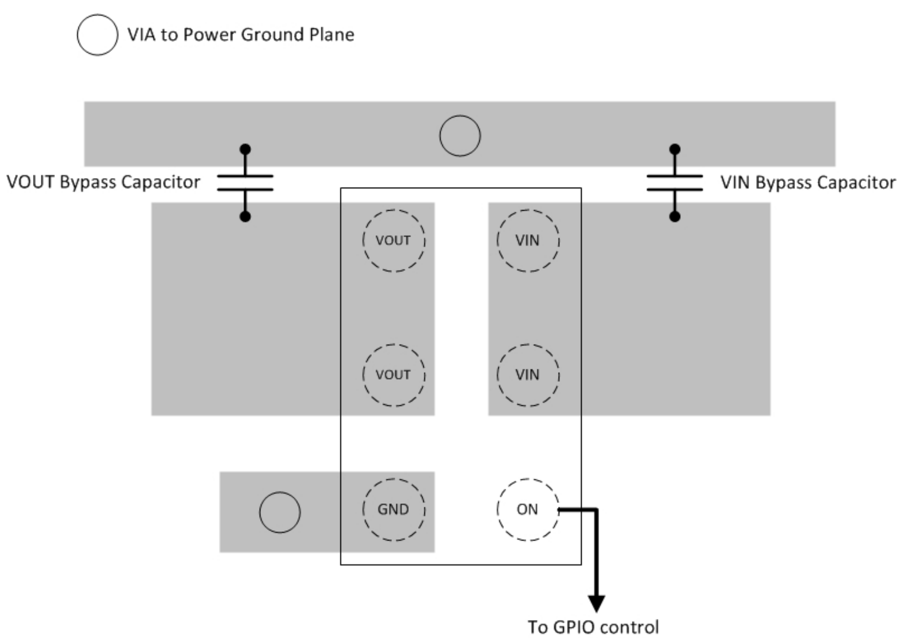


Figure 55. Layout Recommendation

14 Device and Documentation Support

14.1 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 3. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
TPS22921	Click here	Click here	Click here	Click here	Click here
TPS22922	Click here	Click here	Click here	Click here	Click here
TPS22922B	Click here	Click here	Click here	Click here	Click here

14.2 Trademarks

All trademarks are the property of their respective owners.

14.3 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

14.4 Glossary

SLYZ022 — *TI Glossary*.

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

15 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/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TPS22921YFPR	ACTIVE	DSBGA	YFP	6	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 85	(3Y ~ 3Y3)	Samples
TPS22921YZPR	ACTIVE	DSBGA	YZP	6	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 85	(3Y3 ~ 3Y5)	Samples
TPS22921YZTR	ACTIVE	DSBGA	YZT	6	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 85	(3Y3 ~ 3Y5)	Samples
TPS22922BYFPR	ACTIVE	DSBGA	YFP	6	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM		(3Z ~ 3Z3)	Samples
TPS22922BYZPR	ACTIVE	DSBGA	YZP	6	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 85	(3Z ~ 3Z3)	Samples
TPS22922YFPR	ACTIVE	DSBGA	YFP	6	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM		(2Z ~ 2Z3)	Samples
TPS22922YZPR	ACTIVE	DSBGA	YZP	6	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 85	(2Z ~ 2Z3)	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) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

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

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

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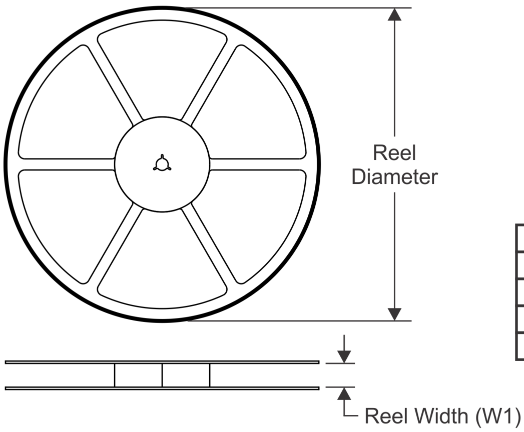
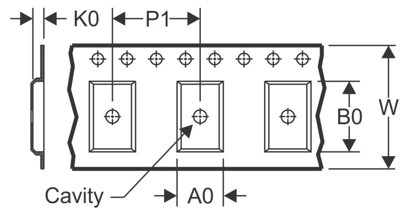
TAPE AND REEL INFORMATION

REEL DIMENSIONS

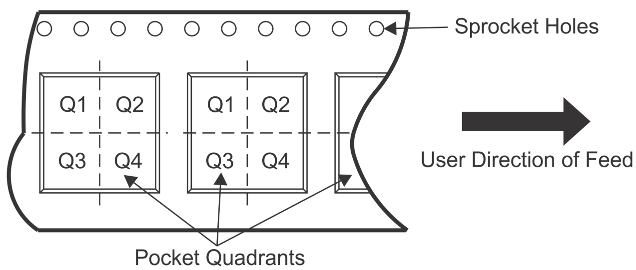


TAPE DIMENSIONS



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

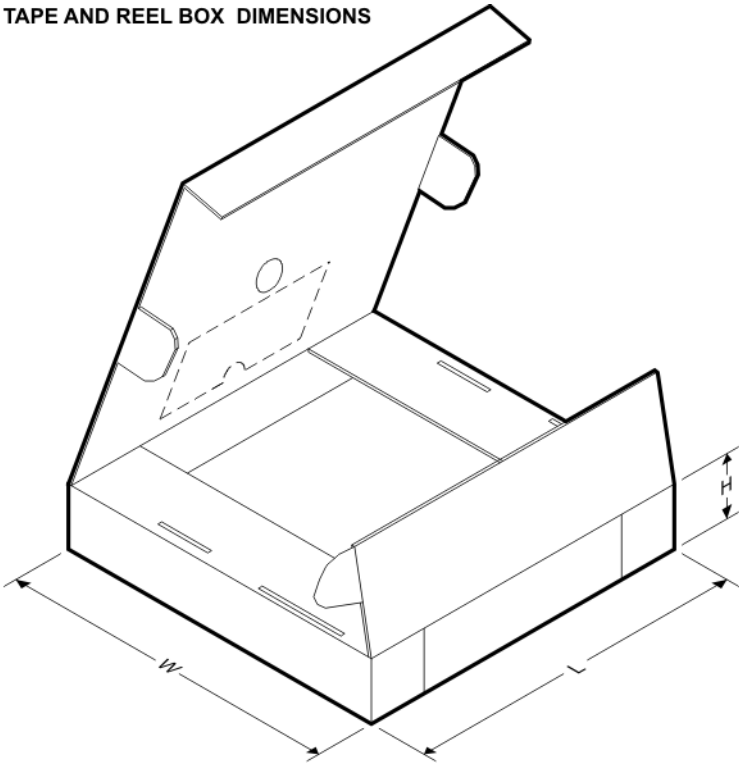
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TPS22921YFPR	DSBGA	YFP	6	3000	180.0	8.4	0.89	1.29	0.62	4.0	8.0	Q1
TPS22921YZPR	DSBGA	YZP	6	3000	178.0	9.2	1.02	1.52	0.63	4.0	8.0	Q1
TPS22921YZTR	DSBGA	YZT	6	3000	178.0	9.2	1.02	1.52	0.75	4.0	8.0	Q1
TPS22922BYFPR	DSBGA	YFP	6	3000	178.0	9.2	0.89	1.29	0.62	4.0	8.0	Q1
TPS22922BYZPR	DSBGA	YZP	6	3000	178.0	9.2	1.02	1.52	0.63	4.0	8.0	Q1
TPS22922BYZPR	DSBGA	YZP	6	3000	180.0	8.4	1.02	1.52	0.63	4.0	8.0	Q1
TPS22922YFPR	DSBGA	YFP	6	3000	180.0	8.4	0.89	1.29	0.62	4.0	8.0	Q1
TPS22922YZPR	DSBGA	YZP	6	3000	178.0	9.2	1.02	1.52	0.63	4.0	8.0	Q1

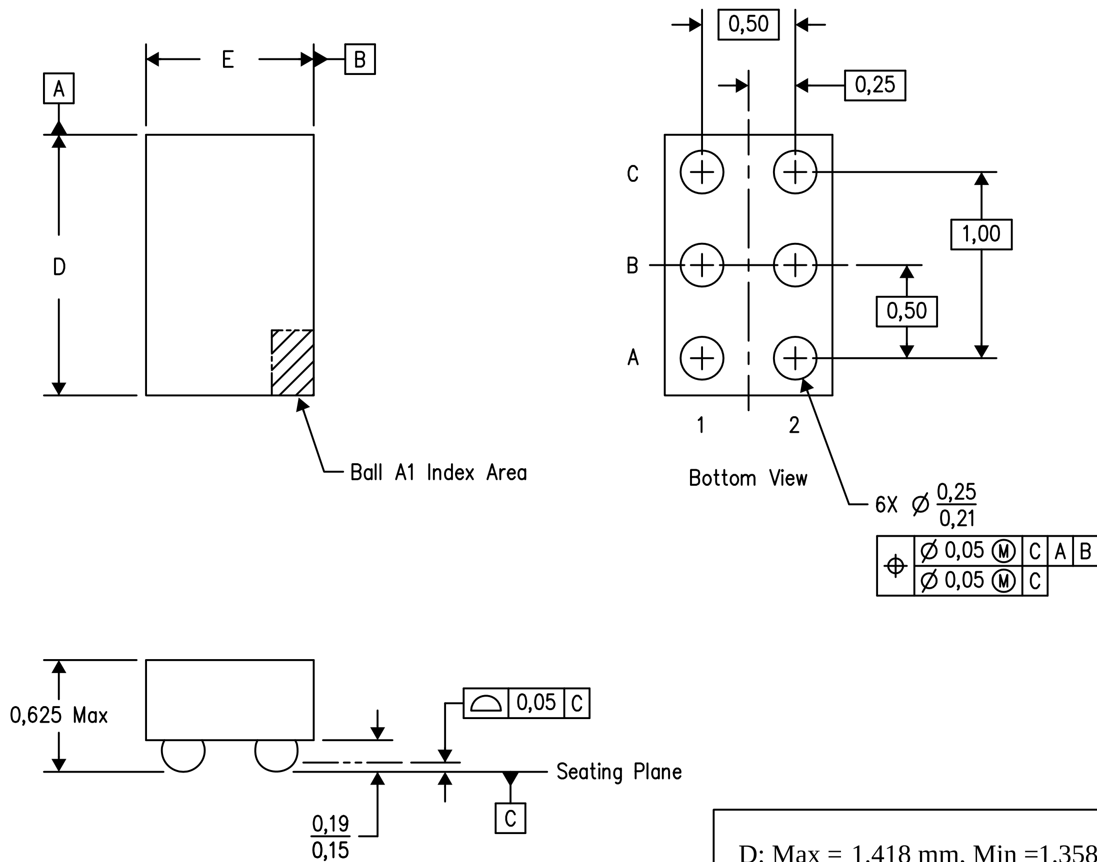
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS22921YFPR	DSBGA	YFP	6	3000	182.0	182.0	20.0
TPS22921YZPR	DSBGA	YZP	6	3000	220.0	220.0	35.0
TPS22921YZTR	DSBGA	YZT	6	3000	220.0	220.0	35.0
TPS22922BYFPR	DSBGA	YFP	6	3000	220.0	220.0	35.0
TPS22922BYZPR	DSBGA	YZP	6	3000	220.0	220.0	35.0
TPS22922BYZPR	DSBGA	YZP	6	3000	220.0	220.0	34.0
TPS22922YFPR	DSBGA	YFP	6	3000	182.0	182.0	20.0
TPS22922YZPR	DSBGA	YZP	6	3000	220.0	220.0	35.0

YZT (R–XBGA–N6) DIE–SIZE BALL GRID ARRAY



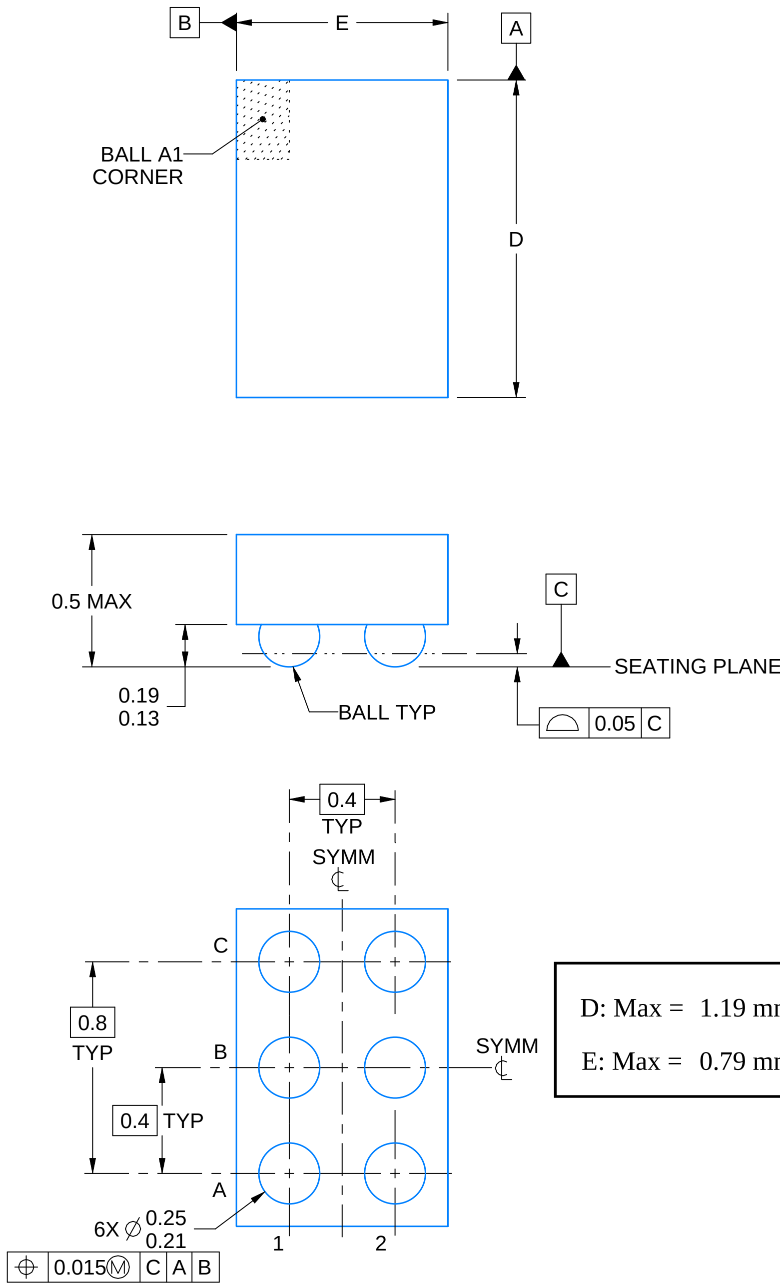
D: Max = 1.418 mm, Min =1.358 mm

E: Max = 0.918 mm, Min =0.858 mm

4205418–4/H 05/13

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.

NanoFree is a trademark of Texas Instruments.

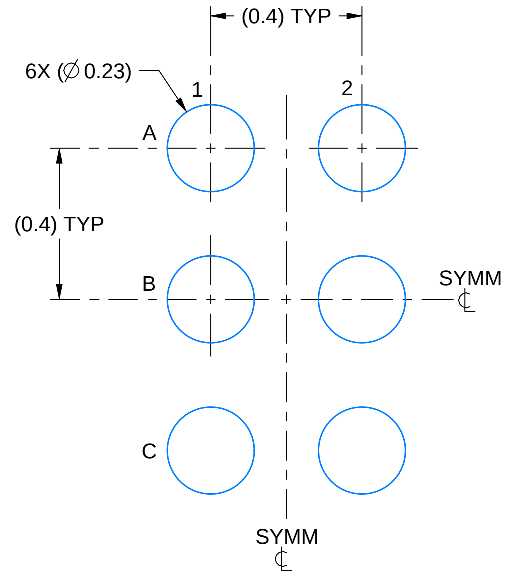


D: Max = 1.19 mm, Min = 1.13 mm	
E: Max = 0.79 mm, Min = 0.73 mm	

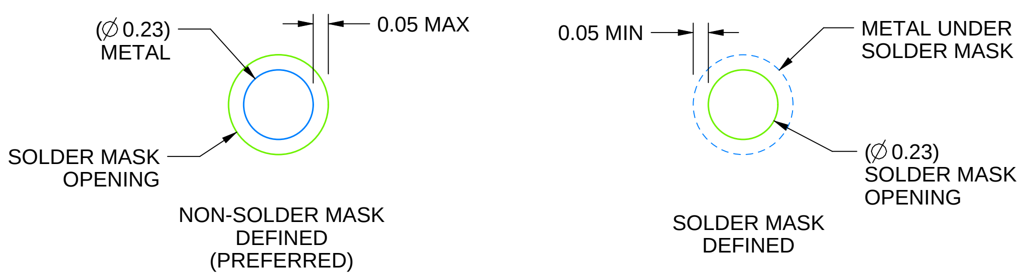
4223410/A 11/2016

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
SCALE:50X

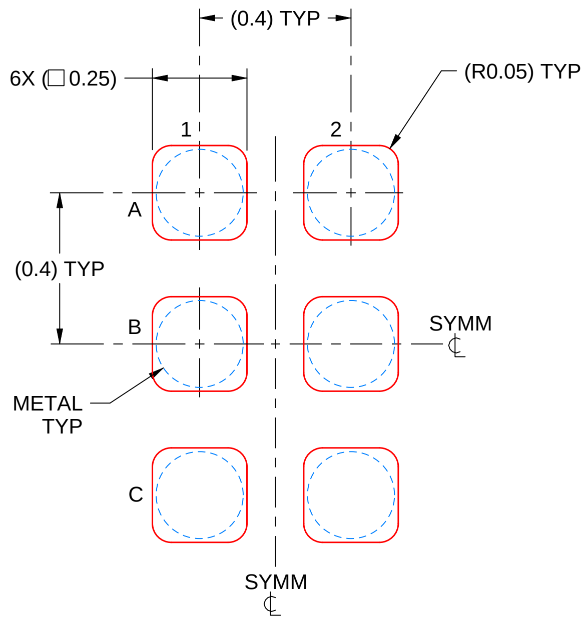


SOLDER MASK DETAILS
NOT TO SCALE

4223410/A 11/2016

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

4223410/A 11/2016

NOTES: (continued)

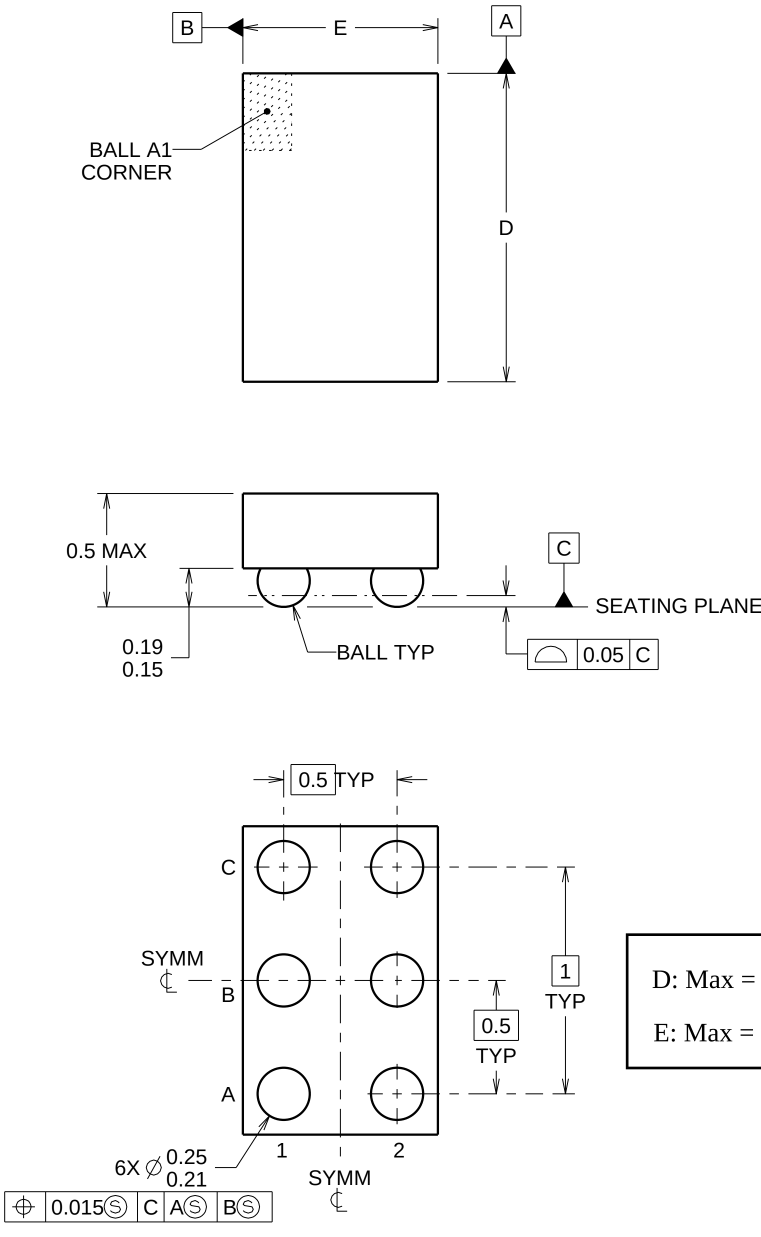
4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.

PACKAGE OUTLINE

YZP0006

DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY



D: Max = 1.418 mm, Min =1.358 mm

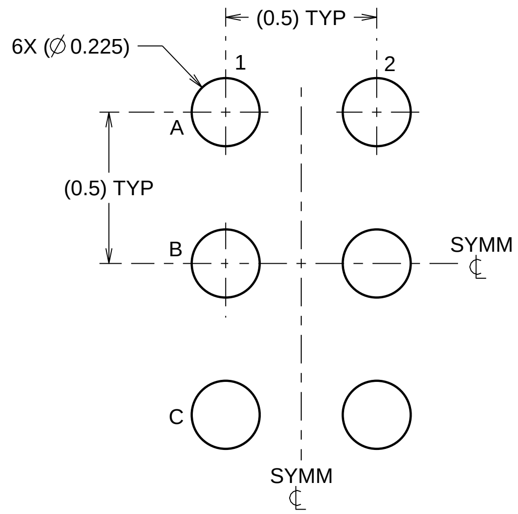
E: Max = 0.918 mm, Min =0.858 mm

4219524/A 06/2014

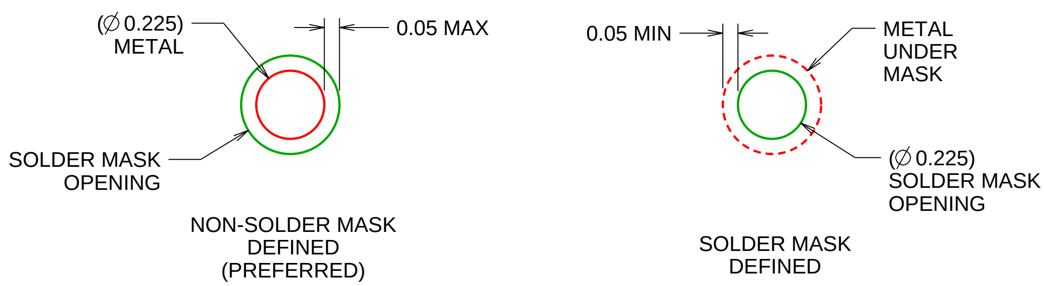
NOTES:

NanoFree Is a trademark of Texas Instruments.

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. NanoFree™ package configuration.



LAND PATTERN EXAMPLE
SCALE:40X

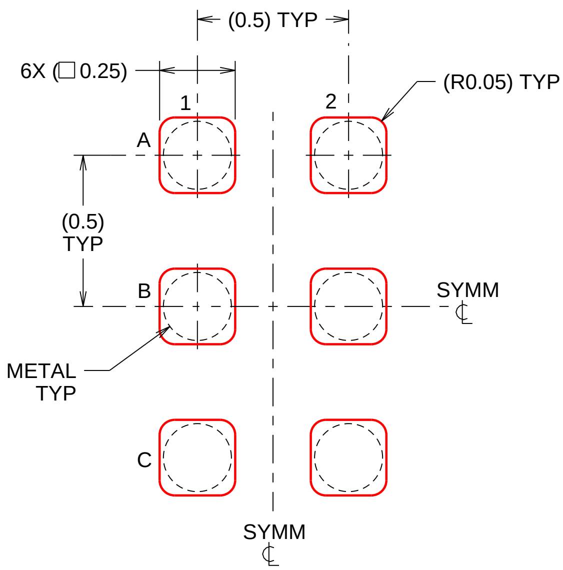


SOLDER MASK DETAILS
NOT TO SCALE

4219524/A 06/2014

NOTES: (continued)

4. Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints. For more information, see Texas Instruments literature number SBVA017 (www.ti.com/lit/sbva017).



SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE:40X

4219524/A 06/2014

NOTES: (continued)

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

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