

## LOW INPUT VOLTAGE, ULTRA-LOW $r_{ON}$ LOAD SWITCHES

### FEATURES

- **Input Voltage: 0.9 V to 3.6 V**
- **Ultra-Low ON Resistance**
  - $r_{ON} = 14\text{ m}\Omega$  at  $V_{IN} = 3.6\text{ V}$
  - $r_{ON} = 20\text{ m}\Omega$  at  $V_{IN} = 2.5\text{ V}$
  - $r_{ON} = 33\text{ m}\Omega$  at  $V_{IN} = 1.8\text{ V}$
  - $r_{ON} = 67\text{ m}\Omega$  at  $V_{IN} = 1.2\text{ V}$
  - $r_{ON} = 116\text{ m}\Omega$  at  $V_{IN} = 1.0\text{ V}$
- **2-A Maximum Continuous Switch Current**
- **Ultra-Low Quiescent Current: 78 nA at 1.8 V**
- **Ultra-Low Shutdown Current: 35 nA at 1.8 V**
- **Low Threshold Control Input Enable the use of 1.2V/1.8V/2.5V/3.3V Logic**
- **Controlled Slew Rate to Avoid Inrush Currents**
  - **TPS22921 and TPS22922: 30  $\mu$ S**
  - **TPS22922B: 200  $\mu$ S**
- **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 Package**
  - **0.9 mm  $\times$  1.4 mm, 0.5 mm Pitch, 0.5 mm Height**
  - **0.8 mm  $\times$  1.2 mm, 0.4 mm Pitch, 0.5 mm Height**

### APPLICATIONS

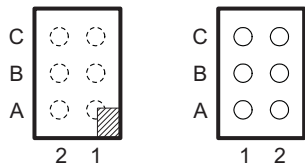
- PDAs
- Cell Phones
- GPS Devices
- MP3 Players
- Peripheral Ports
- Portable Media Players
- RF Modules

### DESCRIPTION

TPS22921, TPS22922, and TPS22922B are ultra-low  $r_{ON}$  load switches with controlled turn on. TPS22921/2/2B contain an ultra-low  $r_{ON}$  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 is capable of interfacing directly with low-voltage control signals. In TPS22922 and in TPS22922B, a 120- $\Omega$  on-chip load resistor is added for output quick discharge when 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  $\mu$ s rise time whereas TPS22922B is 200  $\mu$ s.

TPS22921, TPS22922, and TPS22922B feature ultra low quiescent and shutdown current and are available in space-saving 6-terminals wafer-chip-scale packages (WCSP: YZP with 0.5-mm pitch and YFP with 0.4-mm pitch) which make it ideal for portable electronics. The devices are characterized for operation over the free-air temperature range of  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

#### YFP, YZP, AND YZT PACKAGES



Laser Marking View      Bump View

#### TERMINAL ASSIGNMENTS

<b>C</b>	ON	GND
<b>B</b>	$V_{IN}$	$V_{OUT}$
<b>A</b>	$V_{IN}$	$V_{OUT}$
	<b>2</b>	<b>1</b>

	$r_{ON}$ AT 1.8 V (TYP)	SLEW RATE (TYP at 1.8V)	QUICK OUTPUT DISCHARGE <sup>(1)</sup>	MAX OUTPUT CURRENT	ENABLE
TPS22921	33 m $\Omega$	30 $\mu$ s		2 A	active high
TPS22922	33 m $\Omega$	30 $\mu$ s	Yes	2 A	active high
TPS22922B	33 m $\Omega$	200 $\mu$ s	Yes	2 A	active high

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



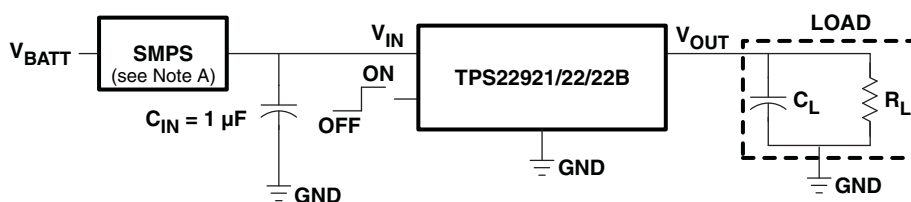
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**ORDERING INFORMATION**

T <sub>A</sub>	PACKAGE <sup>(1)(2)</sup>		ORDERABLE PART NUMBER	TOP-SIDE MARKING
-40°C to 85°C	WCSP – YFP (0.4 mm pitch)	Tape and reel	TPS22921YFPR	__3Y__
			TPS22922YFPR	__2Z__
			TPS22922BYFPR	PREVIEW
	WCSP – YZP (0.5 mm pitch)	Tape and reel	TPS22921YZPR	__3Y__
			TPS22922YZPR	__2Z__
			TPS22922BYZPR	__3Z__
WCSP – YZT (0.5 mm pitch)	Tape and reel	TPS22921YZTR	__3Y__	

- (1) Package drawings, thermal data, and symbolization are available at [www.ti.com/packaging](http://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](http://www.ti.com).

**TYPICAL APPLICATION**



A. Switched mode power supply

APPLICATION BLOCK DIAGRAM

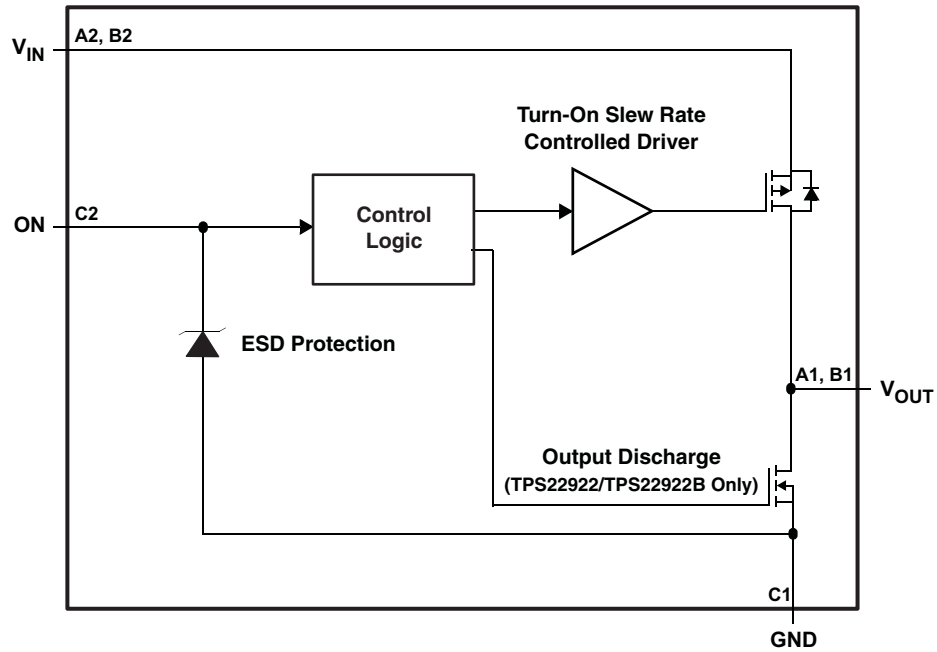


Figure 1. Functional Block Diagram

FUNCTION TABLE

ON	V <sub>IN</sub> TO V <sub>OUT</sub>	V <sub>OUT</sub> TO GND <sup>(1)</sup>
L	OFF	ON
H	ON	OFF

(1) TPS22922/TPS22922B only

TERMINAL FUNCTIONS

TERMINAL		DESCRIPTION
NO.	NAME	
A1, B1	V <sub>OUT</sub>	Switch output
A2, B2	V <sub>IN</sub>	Switch input
C1	GND	Ground
C2	ON	Switch control input, active high. Do not leave floating

**ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>**

		MIN	MAX	UNIT
V <sub>IN</sub>	Input voltage range	-0.3	4	V
V <sub>OUT</sub>	Output voltage range		V <sub>IN</sub> + 0.3	V
V <sub>ON</sub>	Input voltage range	-0.3	4	V
P	Power dissipation at T <sub>A</sub> = 25°C		0.645	W
I <sub>MAX</sub>	Maximum continuous switch current		2	A
T <sub>A</sub>	Operating free-air temperature range	-40	85	°C
T <sub>stg</sub>	Storage temperature range	-65	150	°C
T <sub>lead</sub>	Maximum lead temperature (10-s soldering time)		300	°C
ESD	Electrostatic discharge protection	Human-Body Model (HBM)	3000	V
		Charged Device Model (CDM)	1000	
		Machine Model (MM)	300	

(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 RATINGS**

			UNIT
θ <sub>JA</sub>	Package thermal impedance <sup>(1)</sup>	YFP package	155
		YZP/YZT package	123

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

**RECOMMENDED OPERATING CONDITIONS**

		MIN	MAX	UNIT
V <sub>IN</sub>	Input voltage range	0.9	3.6	V
V <sub>OUT</sub>	Output voltage range		V <sub>IN</sub>	
V <sub>IH</sub>	High-level input voltage, ON	0.85	3.6	V
V <sub>IL</sub>	Low-level input voltage, ON		0.4	V
C <sub>IN</sub>	Input capacitor	1 <sup>(1)</sup>		μF

(1) Refer to [Application Information](#).

**ELECTRICAL CHARACTERISTICS**
 $V_{IN} = 0.9\text{ V to }3.6\text{ V}$ ,  $T_A = -40^\circ\text{C to }85^\circ\text{C}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS		$T_A$	MIN	TYP <sup>(1)</sup>	MAX	UNIT
$I_{IN}$	Quiescent current	$I_{OUT} = 0$	$V_{IN} = 1\text{-V}$	Full	30	120	nA	
			$V_{IN} = 1.8\text{-V}$	Full	78	235		
			$V_{IN} = 3.6\text{-V}$	Full	200	880		
$I_{IN(OFF)}$	OFF-state supply current	$V_{ON} = \text{GND}, \text{OUT} = \text{Open}$	$V_{IN} = 1\text{-V}$	Full	10	210	nA	
			$V_{IN} = 1.8\text{-V}$	Full	35	260		
			$V_{IN} = 3.6\text{-V}$	Full	120	700		
$I_{IN(LEAKAGE)}$	OFF-state switch current	$V_{ON} = \text{GND}, V_{OUT} = 0$	$V_{IN} = 1\text{-V}$	Full	12	140	nA	
			$V_{IN} = 1.8\text{-V}$	Full	50	230		
			$V_{IN} = 3.6\text{-V}$	Full	130	610		
$r_{ON}$	ON-state resistance	$I_{OUT} = -200\text{ mA}$ ,	$V_{IN} = 3.6\text{ V}$	25°C	14	45	mΩ	
				Full		50		
			$V_{IN} = 2.5\text{ V}$	25°C	20	55		
				Full		60		
			$V_{IN} = 1.8\text{ V}$	25°C	33	65		
				Full		75		
			$V_{IN} = 1.2\text{ V}$	25°C	67	100		
				Full		120		
			$V_{IN} = 1.1\text{ V}$	25°C	82	150		
				Full		160		
			$V_{IN} = 1.0\text{ V}$	25°C	116	160		
				Full		170		
$r_{PD}$	Output pulldown resistance	$V_{IN} = 3.3\text{ V}, V_{ON} = 0, I_{OUT} = 30\text{ mA}$ (TPS22922/TPS22922B only)		25°C	65	120	Ω	
$I_{ON}$	ON input leakage current	$V_{ON} = 1.1\text{ V to }3.6\text{ V}$ or GND		Full		25	nA	

 (1) Typical values are at the specified  $V_{IN}$  and  $T_A = 25^\circ\text{C}$ .

**SWITCHING CHARACTERISTICS**
 $V_{IN} = 0.9\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS		TPS22921			TPS22922 <sup>(1)</sup>			TPS22922B <sup>(1)</sup>			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
$t_{ON}$	Turn-ON time	$R_L = 500\ \Omega$ ,	$C_L = 0.1\ \mu\text{F}$		121		121		638	μs		
			$C_L = 1\ \mu\text{F}$		160		160		712			
			$C_L = 3\ \mu\text{F}$		188		188		799			
$t_{OFF}$	Turn-OFF time	$R_L = 500\ \Omega$ ,	$C_L = 0.1\ \mu\text{F}$		46		40		40	μs		
			$C_L = 1\ \mu\text{F}$		308		279		279			
			$C_L = 3\ \mu\text{F}$		975		807		807			
$t_r$	$V_{OUT}$ rise time	$R_L = 500\ \Omega$ ,	$C_L = 0.1\ \mu\text{F}$		60		60		462	μs		
			$C_L = 1\ \mu\text{F}$		85		85		465			
			$C_L = 3\ \mu\text{F}$		107		107		507			
$t_f$	$V_{OUT}$ fall time	$R_L = 500\ \Omega$ ,	$C_L = 0.1\ \mu\text{F}$		119		51		51	μs		
			$C_L = 1\ \mu\text{F}$		969		434		434			
			$C_L = 3\ \mu\text{F}$		3174		1264		1264			

 (1)  $R_{L\_CHIP} = 120\ \Omega$

**SWITCHING CHARACTERISTICS**

V<sub>IN</sub> = 1.0 V, T<sub>A</sub> = 25°C (unless otherwise noted)

PARAMETER	TEST CONDITIONS		TPS22921			TPS22922 <sup>(1)</sup>			TPS22922B <sup>(1)</sup>			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t <sub>ON</sub> Turn-ON time	R <sub>L</sub> = 500 Ω,	C <sub>L</sub> = 0.1 μF	105			105			549			μs
		C <sub>L</sub> = 1 μF	136			136			613			
		C <sub>L</sub> = 3 μF	157			157			683			
t <sub>OFF</sub> Turn-OFF time	R <sub>L</sub> = 500 Ω,	C <sub>L</sub> = 0.1 μF	46			28			28			μs
		C <sub>L</sub> = 1 μF	309			186			186			
		C <sub>L</sub> = 3 μF	983			511			511			
t <sub>r</sub> V <sub>OUT</sub> rise time	R <sub>L</sub> = 500 Ω,	C <sub>L</sub> = 0.1 μF	51			51			386			μs
		C <sub>L</sub> = 1 μF	78			78			388			
		C <sub>L</sub> = 3 μF	88			88			419			
t <sub>f</sub> V <sub>OUT</sub> fall time	R <sub>L</sub> = 500 Ω,	C <sub>L</sub> = 0.1 μF	121			34			34			μs
		C <sub>L</sub> = 1 μF	986			306			306			
		C <sub>L</sub> = 3 μF	3300			908			908			

(1) R<sub>L</sub>\_CHIP = 120 Ω

**SWITCHING CHARACTERISTICS**

V<sub>IN</sub> = 1.1 V, T<sub>A</sub> = 25°C (unless otherwise noted)

PARAMETER	TEST CONDITIONS		TPS22921			TPS22922 <sup>(1)</sup>			TPS22922B <sup>(1)</sup>			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t <sub>ON</sub> Turn-ON time	R <sub>L</sub> = 500 Ω,	C <sub>L</sub> = 0.1 μF	91			93			484			μs
		C <sub>L</sub> = 1 μF	118			118			540			
		C <sub>L</sub> = 3 μF	137			137			599			
t <sub>OFF</sub> Turn-OFF time	R <sub>L</sub> = 500 Ω,	C <sub>L</sub> = 0.1 μF	44			21			21			μs
		C <sub>L</sub> = 1 μF	311			144			144			
		C <sub>L</sub> = 3 μF	99			383			383			
t <sub>r</sub> V <sub>OUT</sub> rise time	R <sub>L</sub> = 500 Ω,	C <sub>L</sub> = 0.1 μF	46			46			335			μs
		C <sub>L</sub> = 1 μF	60			60			336			
		C <sub>L</sub> = 3 μF	76			76			363			
t <sub>f</sub> V <sub>OUT</sub> fall time	R <sub>L</sub> = 500 Ω,	C <sub>L</sub> = 0.1 μF	122			29			29			μs
		C <sub>L</sub> = 1 μF	1000			224			224			
		C <sub>L</sub> = 3 μF	3300			732			732			

(1) R<sub>L</sub>\_CHIP = 120 Ω

**SWITCHING CHARACTERISTICS**
 $V_{IN} = 1.2\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS		TPS22921			TPS22922 <sup>(1)</sup>			TPS22922B <sup>(1)</sup>			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
$t_{ON}$ Turn-ON time	$R_L = 500\ \Omega$ ,	$C_L = 0.1\ \mu\text{F}$	83			83			435			$\mu\text{s}$
		$C_L = 1\ \mu\text{F}$	103			103			485			
		$C_L = 3\ \mu\text{F}$	122			122			536			
$t_{OFF}$ Turn-OFF time	$R_L = 500\ \Omega$ ,	$C_L = 0.1\ \mu\text{F}$	44			17			17			$\mu\text{s}$
		$C_L = 1\ \mu\text{F}$	312			117			117			
		$C_L = 3\ \mu\text{F}$	1000			319			319			
$t_r$ $V_{OUT}$ rise time	$R_L = 500\ \Omega$ ,	$C_L = 0.1\ \mu\text{F}$	41			41			301			$\mu\text{s}$
		$C_L = 1\ \mu\text{F}$	54			54			302			
		$C_L = 3\ \mu\text{F}$	67			67			325			
$t_f$ $V_{OUT}$ fall time	$R_L = 500\ \Omega$ ,	$C_L = 0.1\ \mu\text{F}$	123			25			25			$\mu\text{s}$
		$C_L = 1\ \mu\text{F}$	1000			214			214			
		$C_L = 3\ \mu\text{F}$	3400			632			632			

 (1)  $R_{L\_CHIP} = 120\ \Omega$ 
**SWITCHING CHARACTERISTICS**
 $V_{IN} = 1.8\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS		TPS22921			TPS22922 <sup>(1)</sup>			TPS22922B <sup>(1)</sup>			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
$t_{ON}$ Turn-ON time	$R_L = 500\ \Omega$ ,	$C_L = 0.1\ \mu\text{F}$	54			54			282			$\mu\text{s}$
		$C_L = 1\ \mu\text{F}$	67			67			314			
		$C_L = 3\ \mu\text{F}$	78			78			344			
$t_{OFF}$ Turn-OFF time	$R_L = 500\ \Omega$ ,	$C_L = 0.1\ \mu\text{F}$	41			10			10			$\mu\text{s}$
		$C_L = 1\ \mu\text{F}$	312			67			67			
		$C_L = 3\ \mu\text{F}$	1000			181			181			
$t_r$ $V_{OUT}$ rise time	$R_L = 500\ \Omega$ ,	$C_L = 0.1\ \mu\text{F}$	30			30			200			$\mu\text{s}$
		$C_L = 1\ \mu\text{F}$	37			37			202			
		$C_L = 3\ \mu\text{F}$	47			47			219			
$t_f$ $V_{OUT}$ fall time	$R_L = 500\ \Omega$ ,	$C_L = 0.1\ \mu\text{F}$	121			17			17			$\mu\text{s}$
		$C_L = 1\ \mu\text{F}$	1000			158			158			
		$C_L = 3\ \mu\text{F}$	3450			461			461			

 (1)  $R_{L\_CHIP} = 120\ \Omega$

**SWITCHING CHARACTERISTICS**

V<sub>IN</sub> = 2.5 V, T<sub>A</sub> = 25°C (unless otherwise noted)

PARAMETER	TEST CONDITIONS		TPS22921			TPS22922 <sup>(1)</sup>			TPS22922B <sup>(1)</sup>			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t <sub>ON</sub> Turn-ON time	R <sub>L</sub> = 500 Ω,	C <sub>L</sub> = 0.1 μF	40			40			211			μs
		C <sub>L</sub> = 1 μF	50			50			233			
		C <sub>L</sub> = 3 μF	59			59			256			
t <sub>OFF</sub> Turn-OFF time	R <sub>L</sub> = 500 Ω,	C <sub>L</sub> = 0.1 μF	41			10			10			μs
		C <sub>L</sub> = 1 μF	316			56			56			
		C <sub>L</sub> = 3 μF	1000			153			153			
t <sub>r</sub> V <sub>OUT</sub> rise time	R <sub>L</sub> = 500 Ω,	C <sub>L</sub> = 0.1 μF	23			23			164			μs
		C <sub>L</sub> = 1 μF	29			29			165			
		C <sub>L</sub> = 3 μF	38			38			177			
t <sub>f</sub> V <sub>OUT</sub> fall time	R <sub>L</sub> = 500 Ω,	C <sub>L</sub> = 0.1 μF	122			16			16			μs
		C <sub>L</sub> = 1 μF	1086			147			147			
		C <sub>L</sub> = 3 μF	3600			430			430			

(1) R<sub>L</sub>\_CHIP = 120 Ω

**SWITCHING CHARACTERISTICS**

V<sub>IN</sub> = 3 V, T<sub>A</sub> = 25°C (unless otherwise noted)

PARAMETER	TEST CONDITIONS		TPS22921			TPS22922 <sup>(1)</sup>			TPS22922B <sup>(1)</sup>			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t <sub>ON</sub> Turn-ON time	R <sub>L</sub> = 500 Ω,	C <sub>L</sub> = 0.1 μF	30			30			182			μs
		C <sub>L</sub> = 1 μF	38			38			201			
		C <sub>L</sub> = 3 μF	45			45			221			
t <sub>OFF</sub> Turn-OFF time	R <sub>L</sub> = 500 Ω,	C <sub>L</sub> = 0.1 μF	40			10			10			μs
		C <sub>L</sub> = 1 μF	353			51			51			
		C <sub>L</sub> = 3 μF	1036			139			139			
t <sub>r</sub> V <sub>OUT</sub> rise time	R <sub>L</sub> = 500 Ω,	C <sub>L</sub> = 0.1 μF	20			20			149			μs
		C <sub>L</sub> = 1 μF	25			25			150			
		C <sub>L</sub> = 3 μF	33			33			161			
t <sub>f</sub> V <sub>OUT</sub> fall time	R <sub>L</sub> = 500 Ω,	C <sub>L</sub> = 0.1 μF	104			15			15			μs
		C <sub>L</sub> = 1 μF	1030			143			143			
		C <sub>L</sub> = 3 μF	3230			419			419			

(1) R<sub>L</sub>\_CHIP = 120 Ω



**SWITCHING CHARACTERISTICS**
 $V_{IN} = 3.6\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS		TPS22921			TPS22922 <sup>(1)</sup>			TPS22922B <sup>(1)</sup>			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
$t_{ON}$ Turn-ON time	$R_L = 500\ \Omega$ ,	$C_L = 0.1\ \mu\text{F}$		30		30		159			$\mu\text{s}$	
		$C_L = 1\ \mu\text{F}$		38		38		175				
		$C_L = 3\ \mu\text{F}$		45		45		193				
$t_{OFF}$ Turn-OFF time	$R_L = 500\ \Omega$ ,	$C_L = 0.1\ \mu\text{F}$		42		10		10			$\mu\text{s}$	
		$C_L = 1\ \mu\text{F}$		310		51		51				
		$C_L = 3\ \mu\text{F}$		988		139		139				
$t_r$ $V_{OUT}$ rise time	$R_L = 500\ \Omega$ ,	$C_L = 0.1\ \mu\text{F}$		20		20		137			$\mu\text{s}$	
		$C_L = 1\ \mu\text{F}$		25		25		138				
		$C_L = 3\ \mu\text{F}$		33		33		148				
$t_f$ $V_{OUT}$ fall time	$R_L = 500\ \Omega$ ,	$C_L = 0.1\ \mu\text{F}$		120		15		15			$\mu\text{s}$	
		$C_L = 1\ \mu\text{F}$		1100		143		143				
		$C_L = 3\ \mu\text{F}$		3600		419		419				

 (1)  $R_{L\_CHIP} = 120\ \Omega$

TYPICAL CHARACTERISTICS

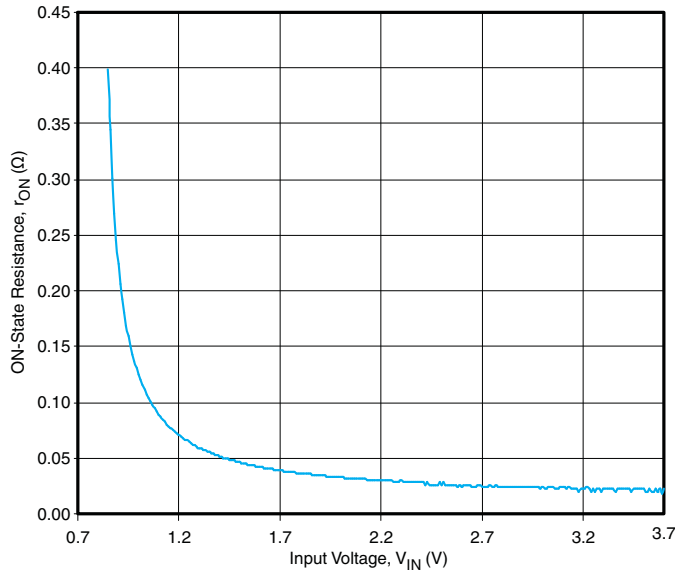


Figure 2.  $r_{ON}$  vs.  $V_{IN}$

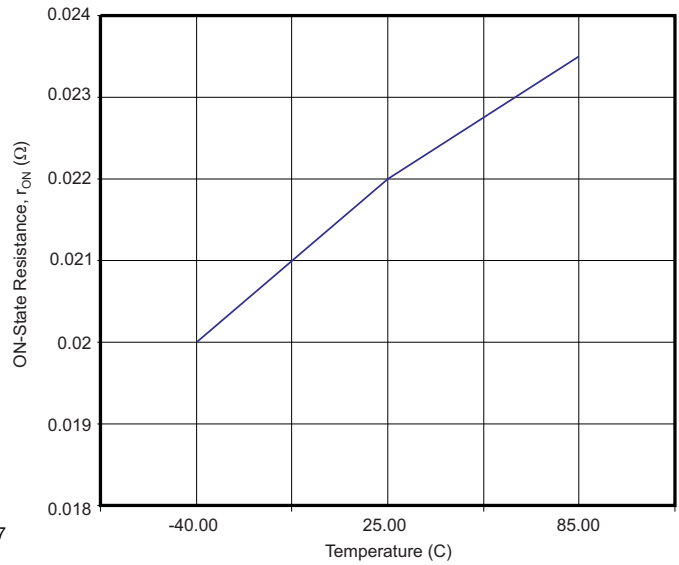


Figure 3.  $r_{ON}$  vs. Temperature ( $V_{IN} = 3.3\text{ V}$ )

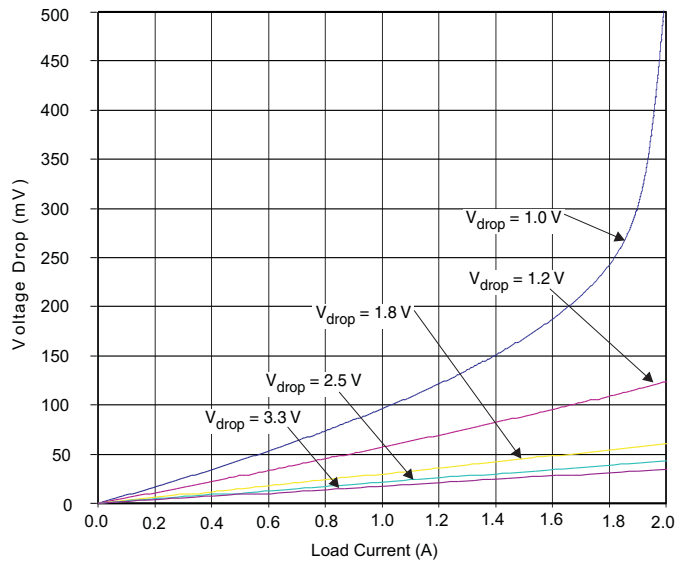


Figure 4. Voltage Drop vs Load Current

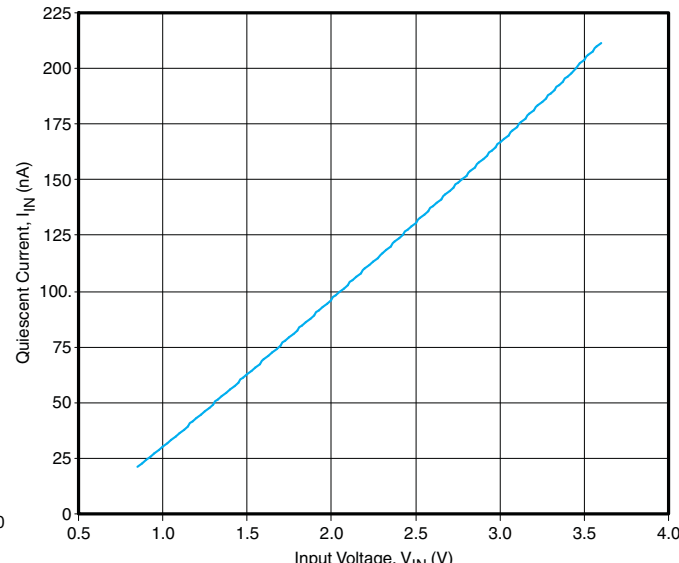


Figure 5. Quiescent Current vs.  $V_{IN}$  ( $V_{ON} = V_{IN}$ )

TYPICAL CHARACTERISTICS (continued)

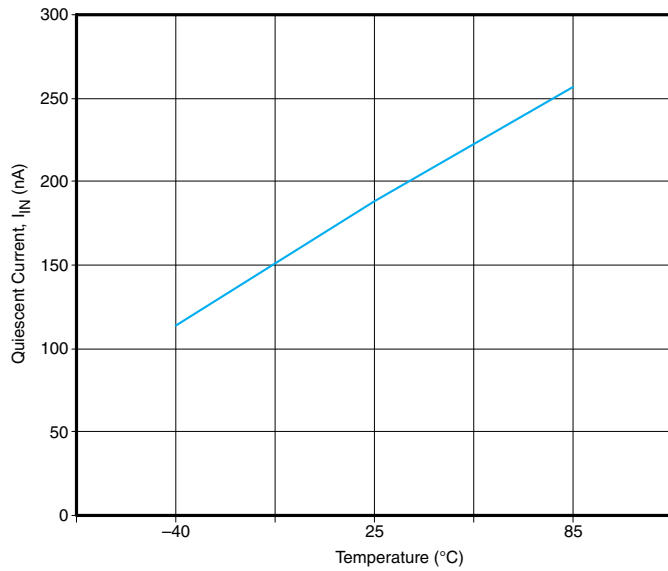


Figure 6. Quiescent Current vs. Temperature ( $V_{IN} = 3.3\text{ V}$ ,  $I_{OUT} = 0\text{ mA}$ )

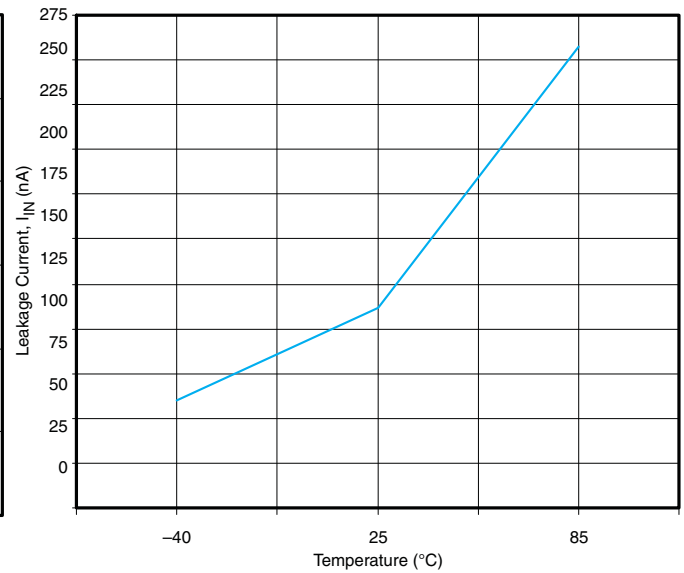


Figure 7.  $I_{IN}$  Leakage Current vs. Temperature ( $V_{IN} = 3.3\text{ V}$ )

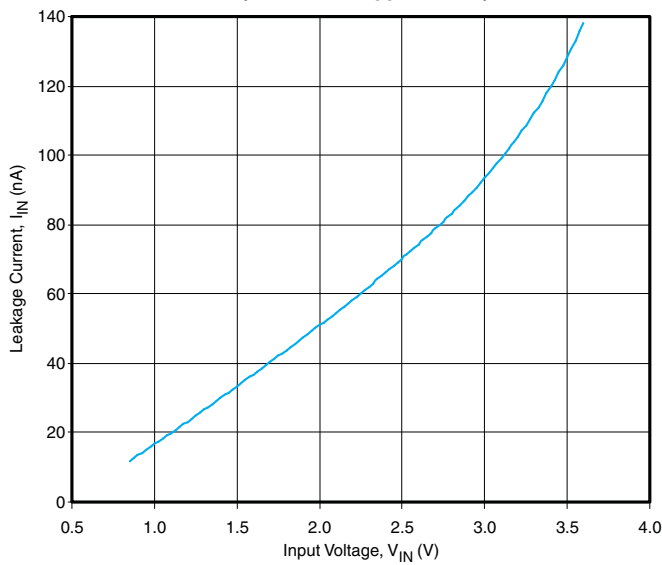


Figure 8. Leakage Current vs  $V_{IN}$

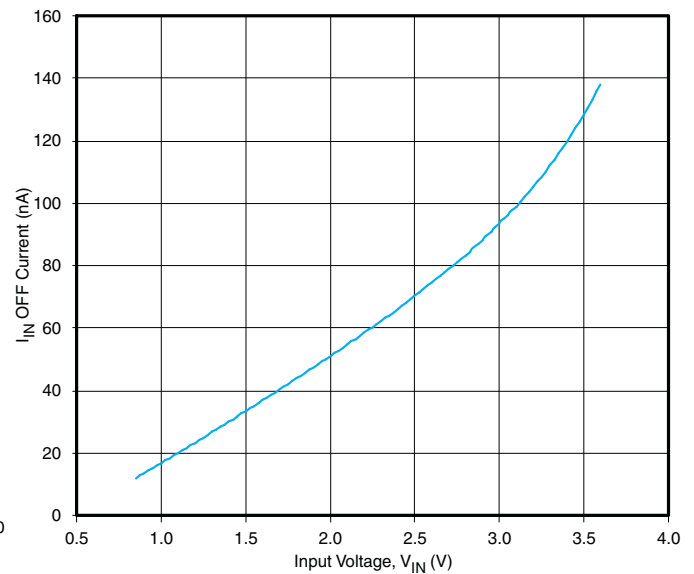


Figure 9.  $I_{IN}$  (OFF) vs  $V_{IN}$  ( $V_{ON} = 0\text{ V}$ )

TYPICAL CHARACTERISTICS (continued)

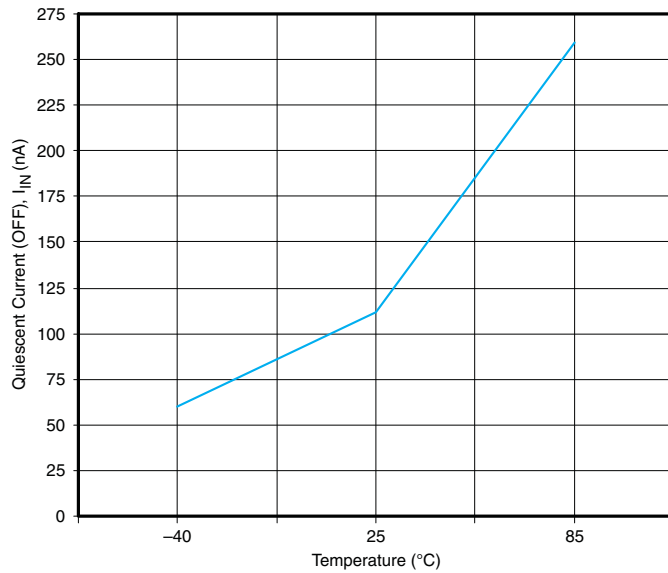


Figure 10. I<sub>IN</sub> (OFF) vs Temperature (V<sub>IN</sub> = 3.3 V)

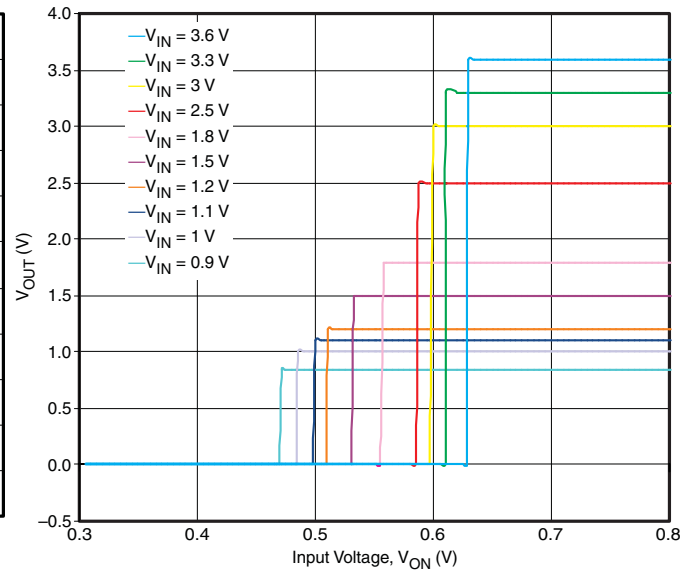


Figure 11. ON-Input Threshold

TPS22921

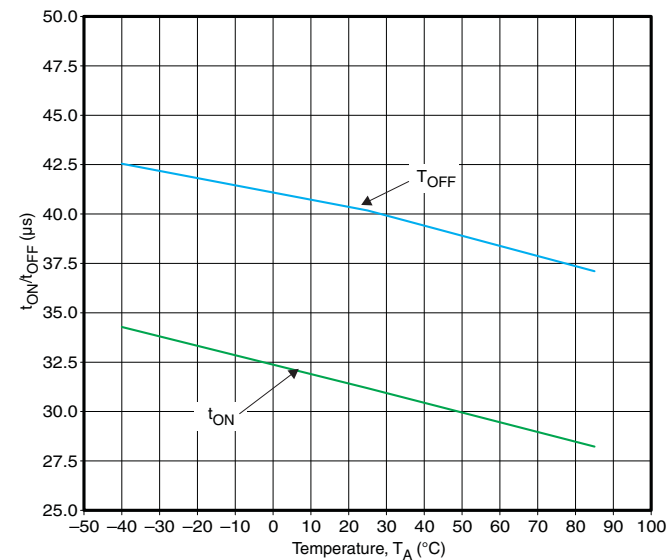


Figure 12. t<sub>ON</sub>/t<sub>OFF</sub> vs Temperature (V<sub>IN</sub> = 3.3 V)

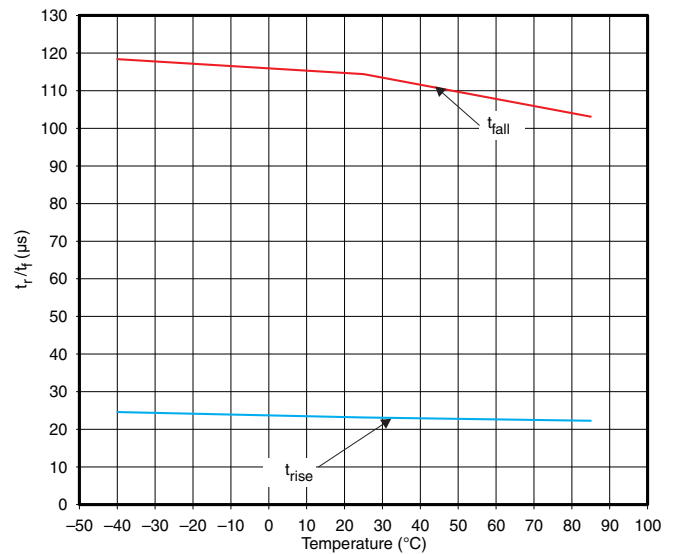


Figure 13. t<sub>rise</sub>/t<sub>fall</sub> vs Temperature (V<sub>IN</sub> = 3.3 V)

TYPICAL CHARACTERISTICS (continued)

TPS22922

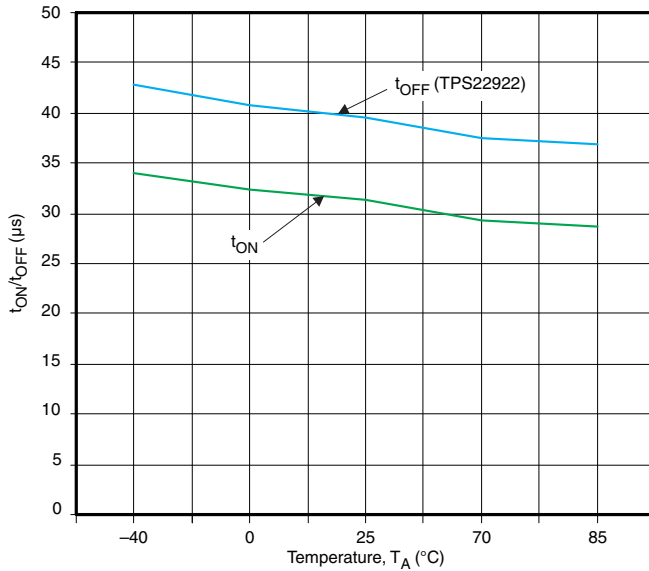


Figure 14.  $t_{ON}/t_{OFF}$  vs Temperature ( $V_{IN} = 3.3\text{ V}$ )

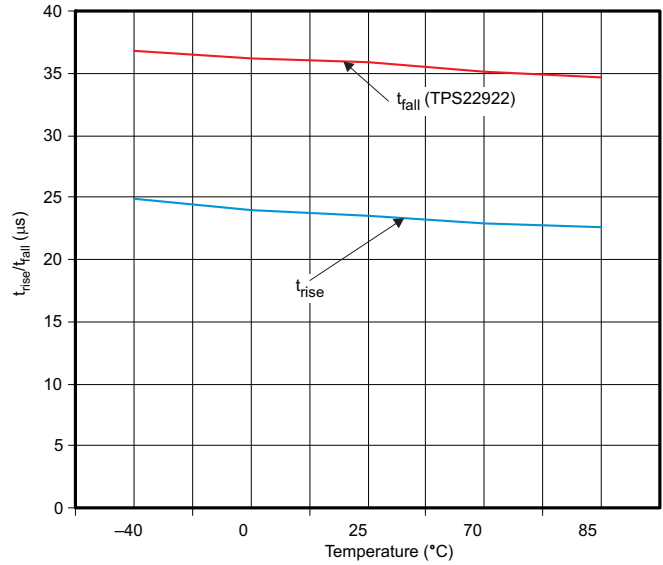


Figure 15.  $t_{rise}/t_{fall}$  vs Temperature ( $V_{IN} = 3.3\text{ V}$ )

TPS22922B

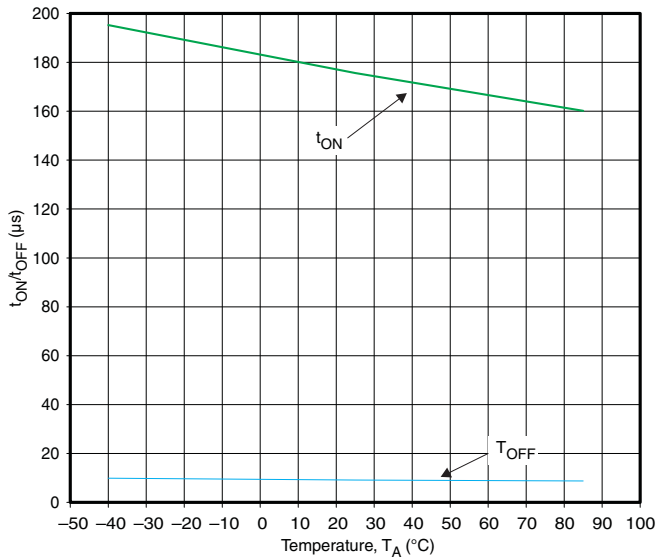


Figure 16.  $t_{ON}/t_{OFF}$  vs Temperature ( $V_{IN} = 3.3\text{ V}$ )

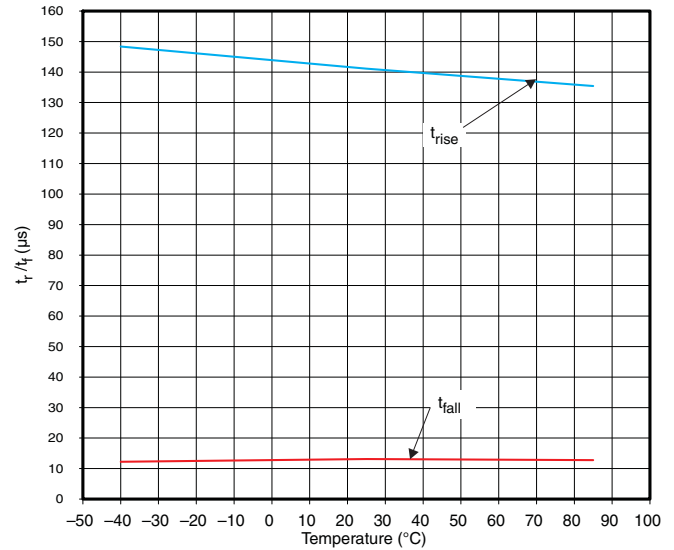


Figure 17.  $t_{rise}/t_{fall}$  vs Temperature ( $V_{IN} = 3.3\text{ V}$ )

TYPICAL CHARACTERISTICS (continued)

TPS22921 and TPS22922

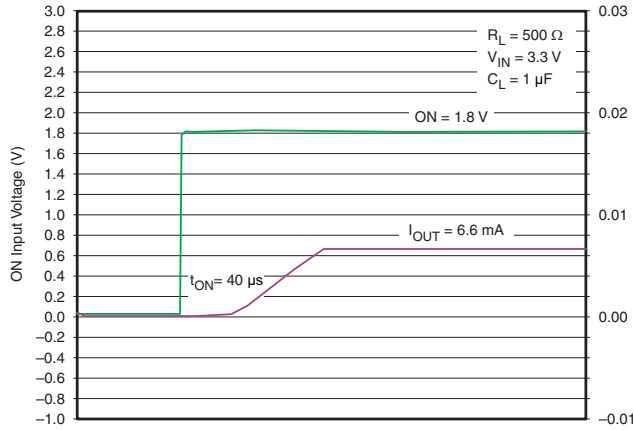


Figure 18.  $t_{ON}$  Response

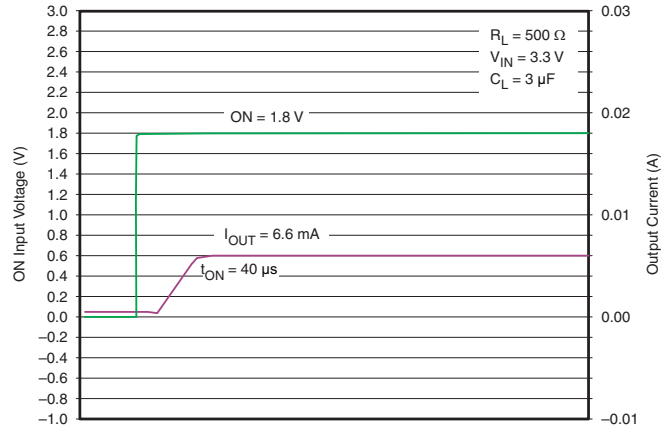


Figure 19.  $t_{ON}$  Response

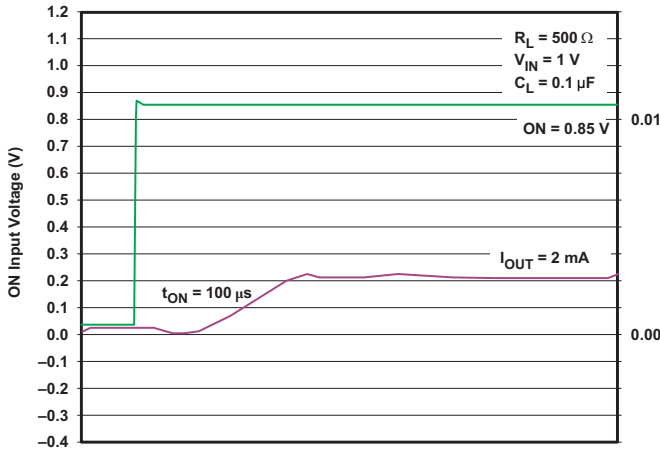


Figure 20.  $t_{ON}$  Response

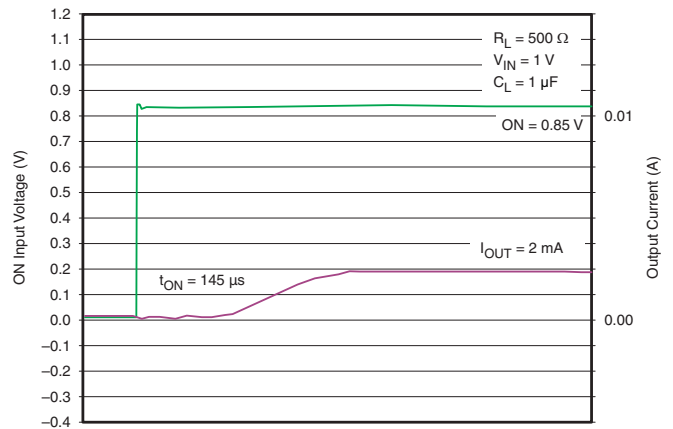


Figure 21.  $t_{ON}$  Response

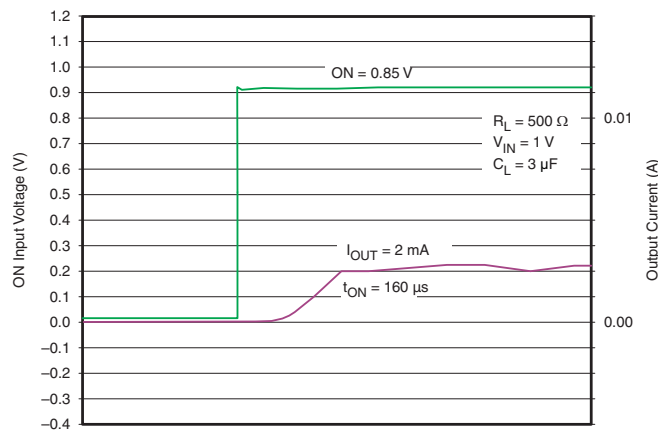


Figure 22.  $t_{ON}$  Response

TYPICAL CHARACTERISTICS (continued)

TPS22921

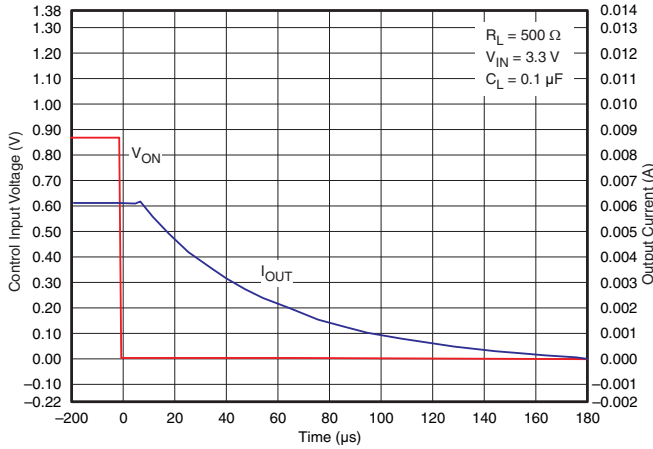


Figure 23.  $t_{OFF}$  Response

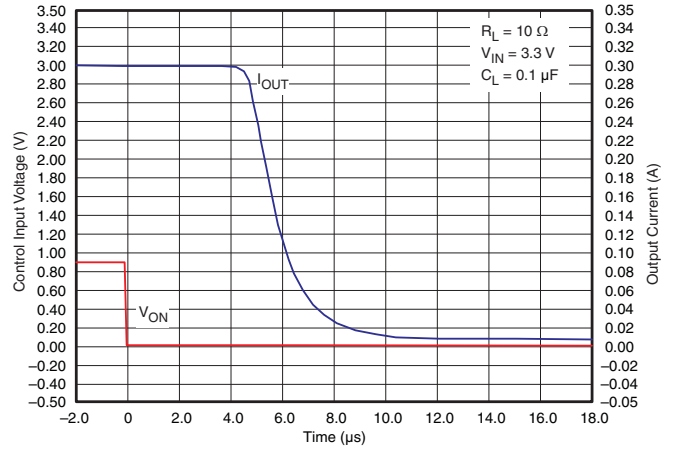


Figure 24.  $t_{OFF}$  Response

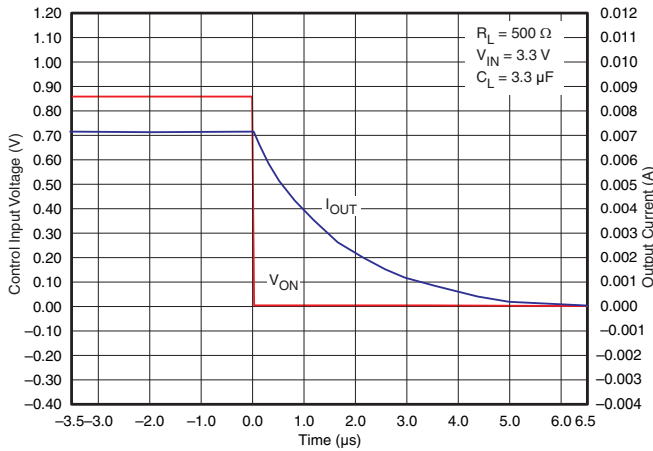


Figure 25.  $t_{OFF}$  Response

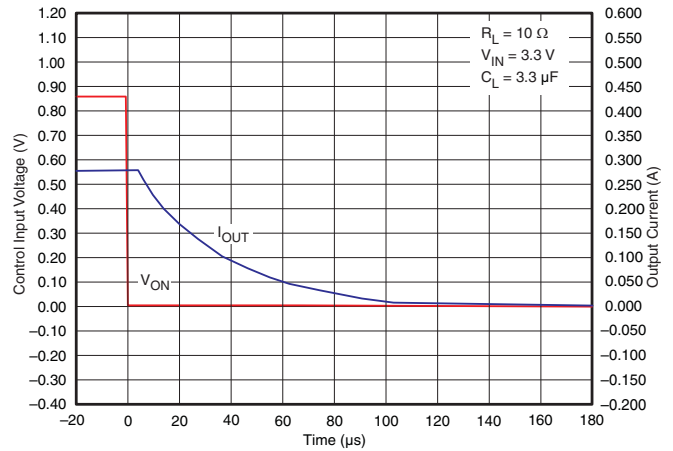


Figure 26.  $t_{OFF}$  Response

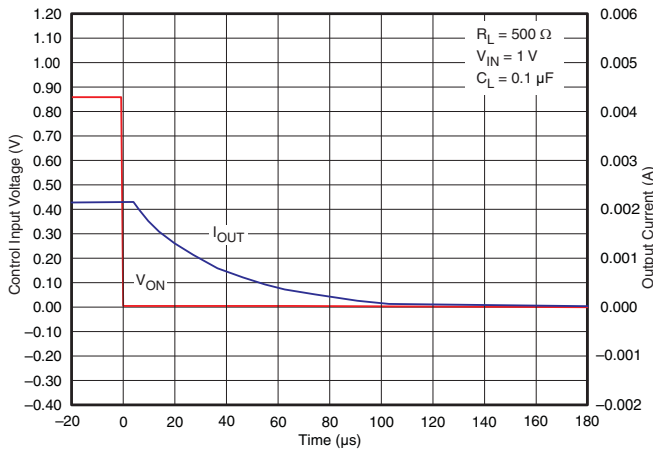


Figure 27.  $t_{OFF}$  Response

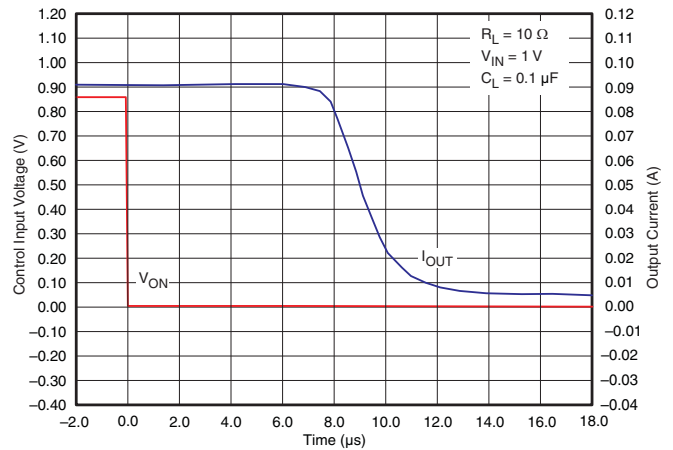


Figure 28.  $t_{OFF}$  Response

TYPICAL CHARACTERISTICS (continued)

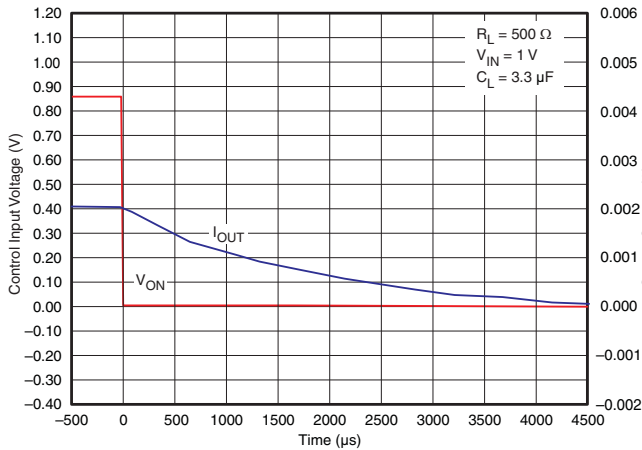


Figure 29.  $t_{OFF}$  Response

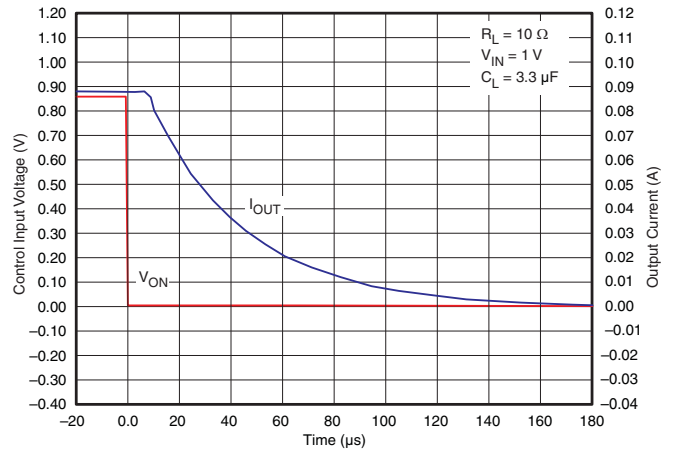


Figure 30.  $t_{OFF}$  Response

TPS22922

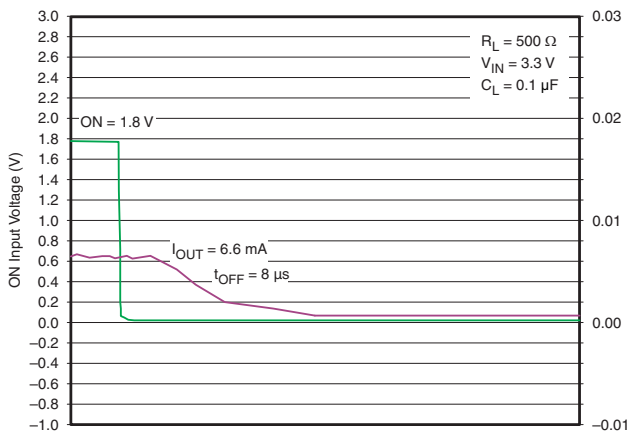


Figure 31.  $t_{OFF}$  Response

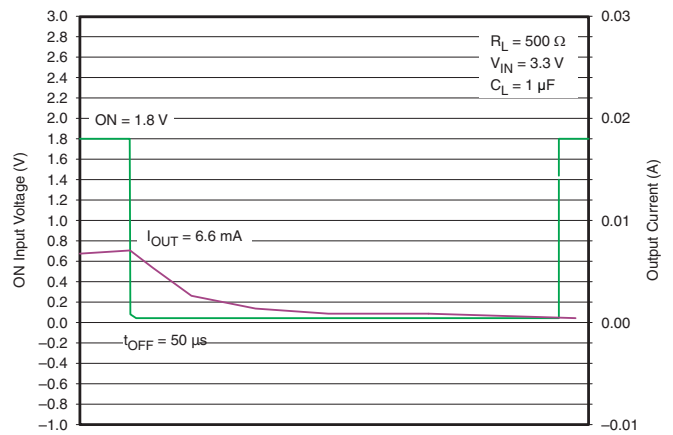


Figure 32.  $t_{OFF}$  Response

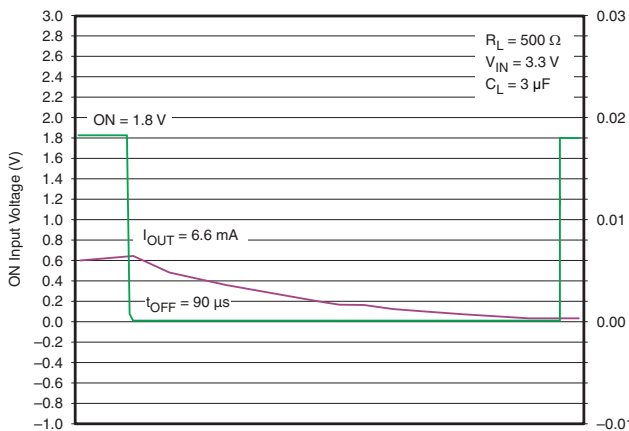


Figure 33.  $t_{OFF}$  Response

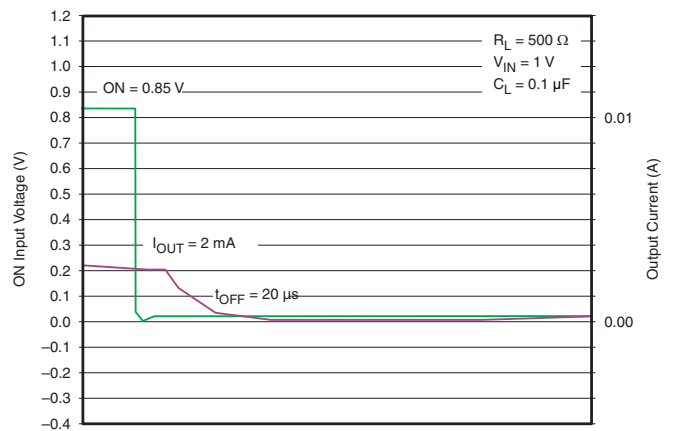


Figure 34.  $t_{OFF}$  Response



TYPICAL CHARACTERISTICS (continued)

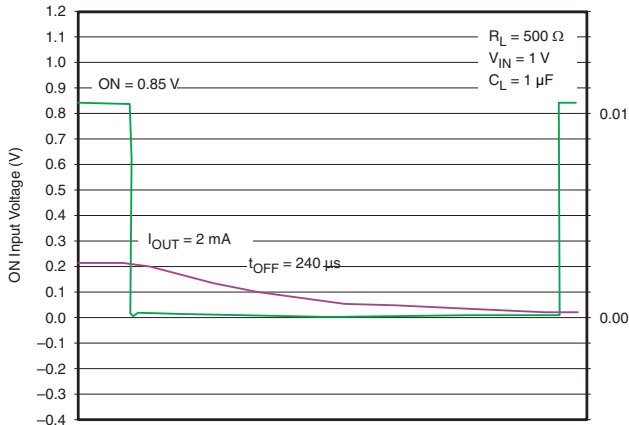


Figure 35.  $t_{OFF}$  Response

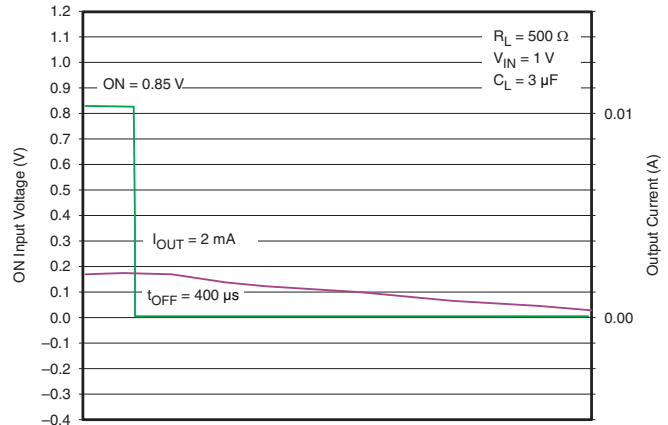


Figure 36.  $t_{OFF}$  Response

TPS22922B

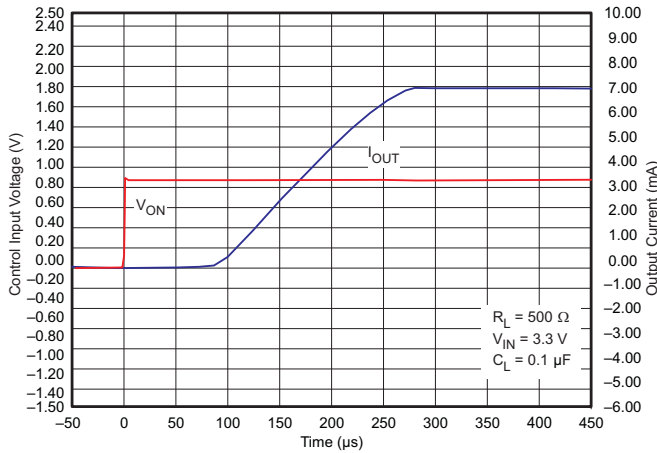


Figure 37.  $t_{ON}$  Response

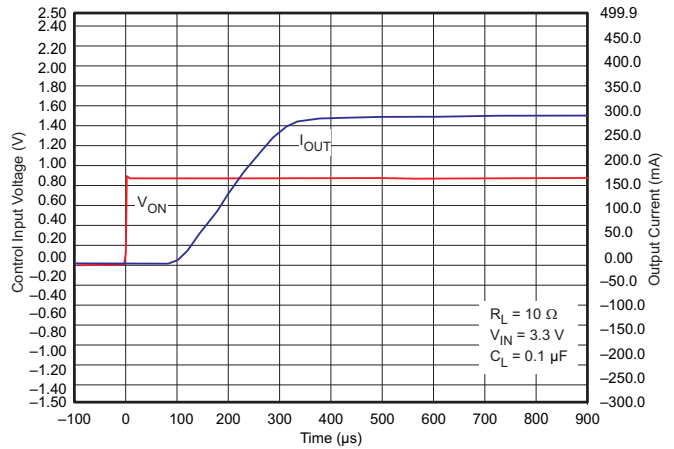


Figure 38.  $t_{ON}$  Response

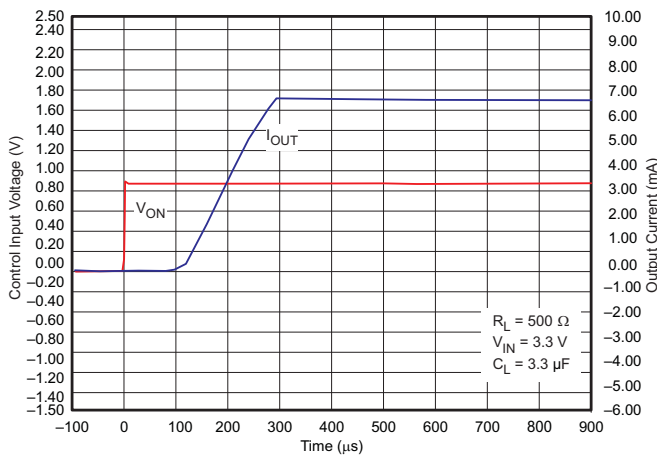


Figure 39.  $t_{ON}$  Response

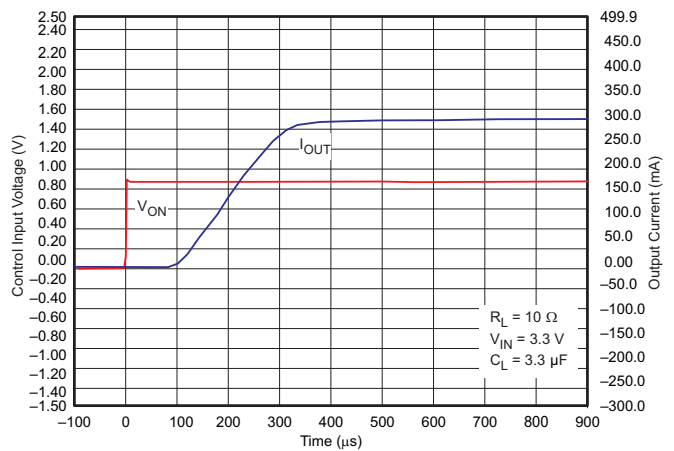


Figure 40.  $t_{ON}$  Response

TYPICAL CHARACTERISTICS (continued)

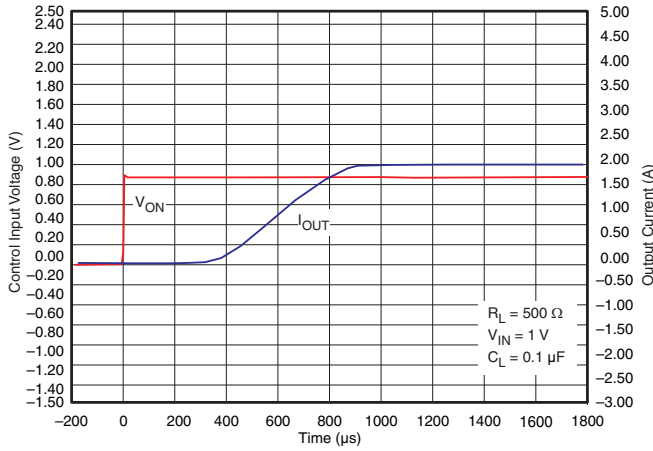


Figure 41. t<sub>ON</sub> Response

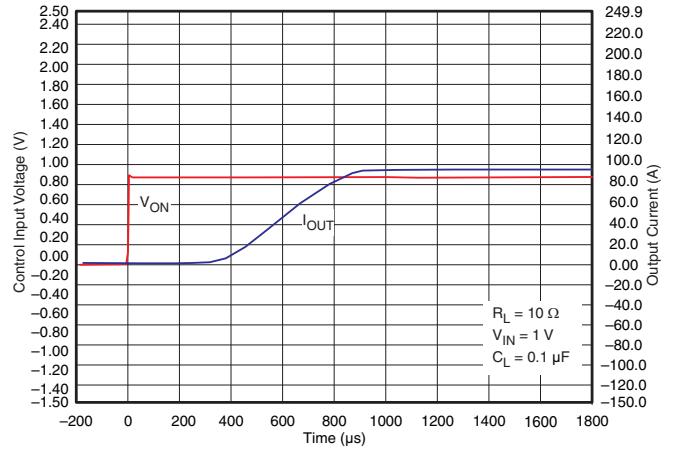


Figure 42. t<sub>ON</sub> Response

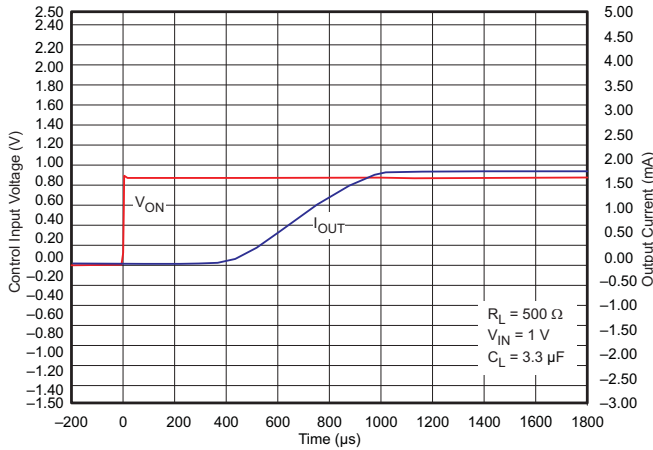


Figure 43. t<sub>ON</sub> Response

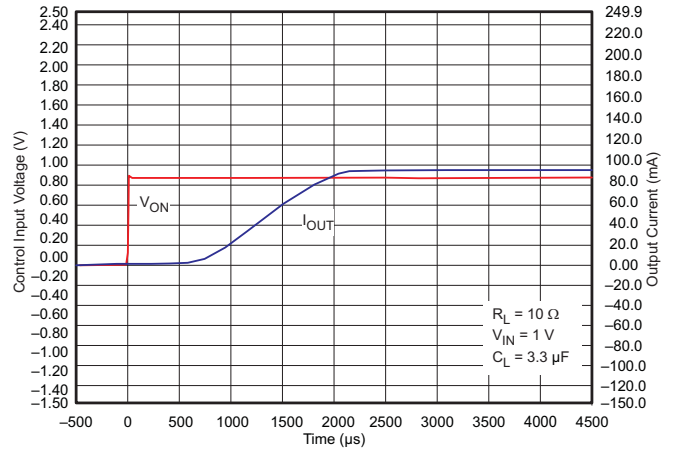


Figure 44. t<sub>ON</sub> Response

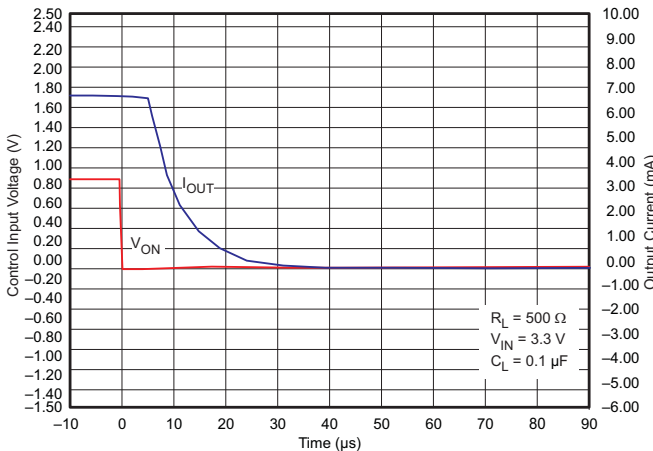


Figure 45. t<sub>OFF</sub> Response

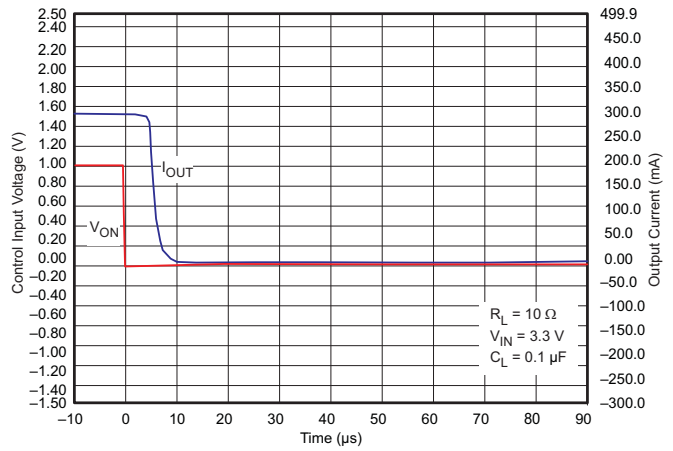


Figure 46. t<sub>OFF</sub> Response

TYPICAL CHARACTERISTICS (continued)

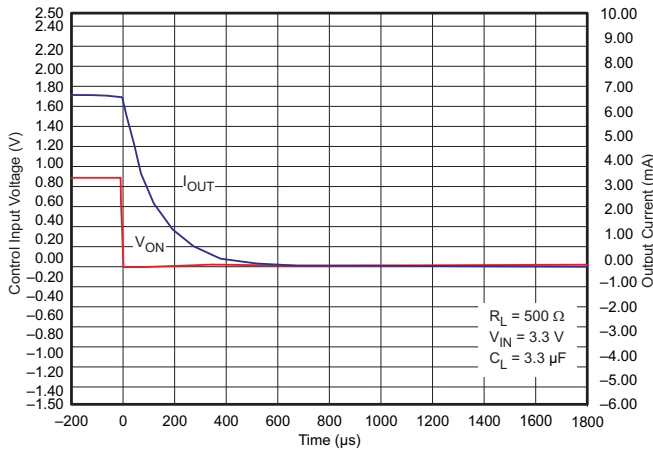


Figure 47.  $t_{OFF}$  Response

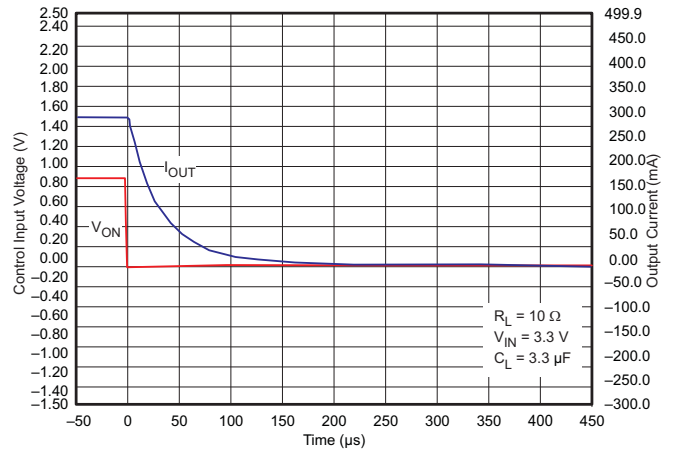


Figure 48.  $t_{OFF}$  Response

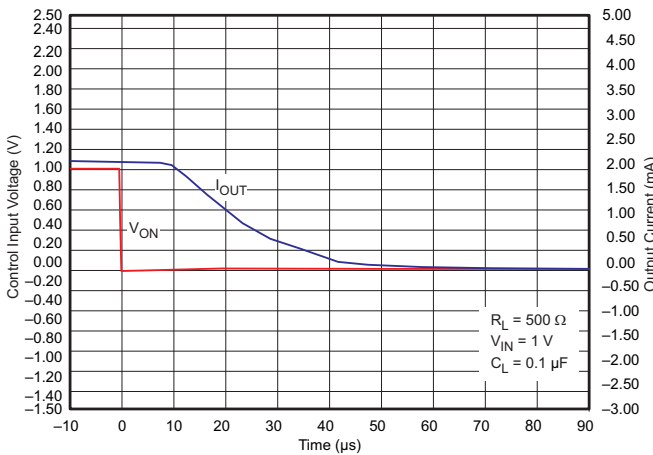


Figure 49.  $t_{OFF}$  Response

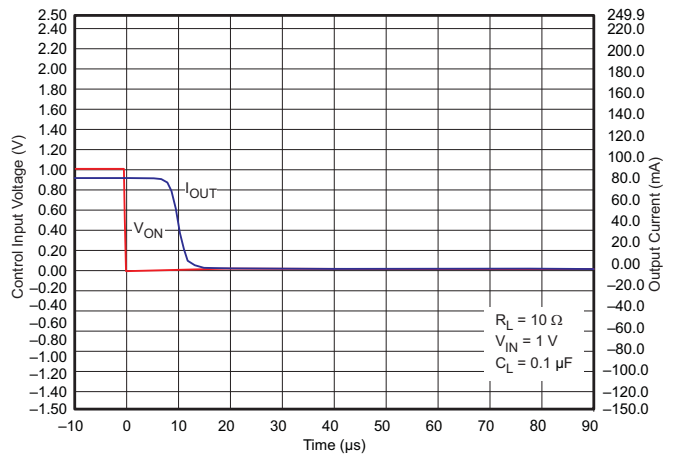


Figure 50.  $t_{OFF}$  Response

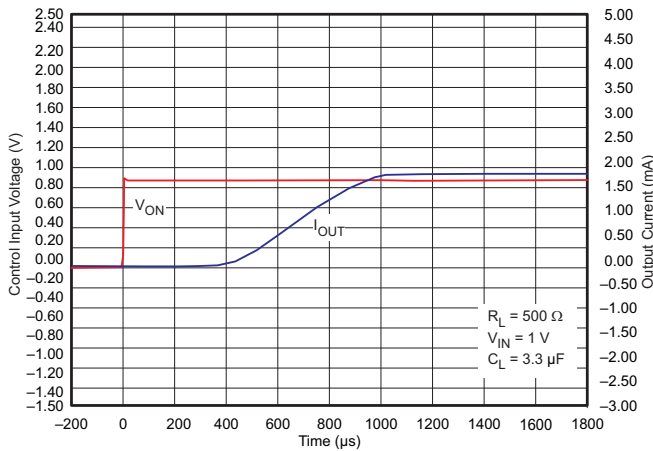


Figure 51.  $t_{OFF}$  Response

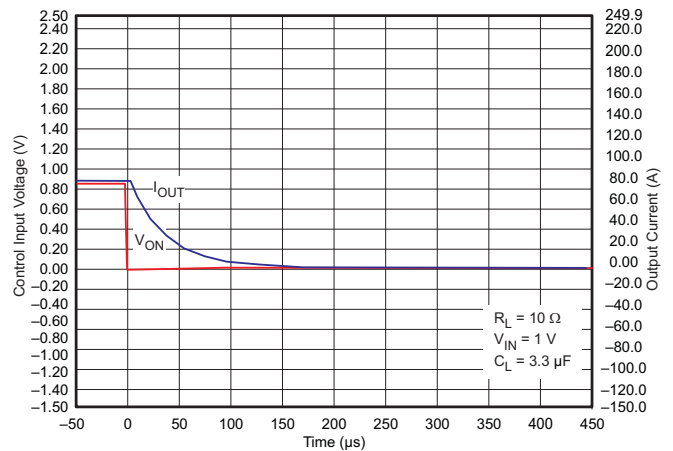
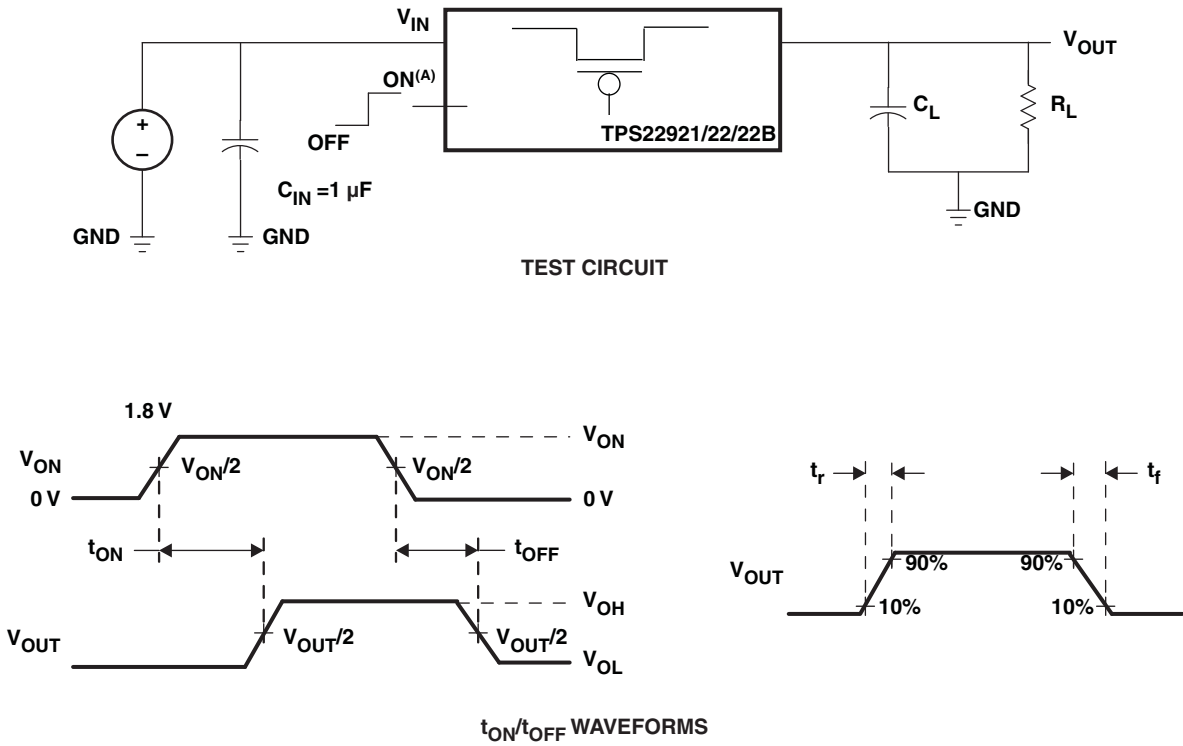


Figure 52.  $t_{OFF}$  Response

PARAMETER MEASUREMENT INFORMATION



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

Figure 53. 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 must be placed between  $V_{IN}$  and GND. A 1- $\mu$ F 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, it is recommended to have an input capacitor about 10 or more times higher than the output capacitor in order to avoid any supply 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 will help minimize the parasitic electrical effects along with minimizing the case to ambient thermal impedance.

**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
TPS22921YFPR	ACTIVE	DSBGA	YFP	6	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM
TPS22921YZPR	ACTIVE	DSBGA	YZP	6	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM
TPS22922BYFPR	ACTIVE	DSBGA	YFP	6	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM
TPS22922BYZPR	ACTIVE	DSBGA	YZP	6	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM
TPS22922YFPR	ACTIVE	DSBGA	YFP	6	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM
TPS22922YZPR	ACTIVE	DSBGA	YZP	6	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM

<sup>(1)</sup> 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.

<sup>(2)</sup> 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)

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

**Important Information and Disclaimer:**The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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

**TAPE AND REEL INFORMATION**

\*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	180.0	8.4	1.02	1.52	0.63	4.0	8.0	Q1
TPS22922BYFPR	DSBGA	YFP	6	3000	180.0	8.4	0.89	1.29	0.62	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	180.0	8.4	1.02	1.52	0.63	4.0	8.0	Q1

**TAPE AND REEL BOX DIMENSIONS**

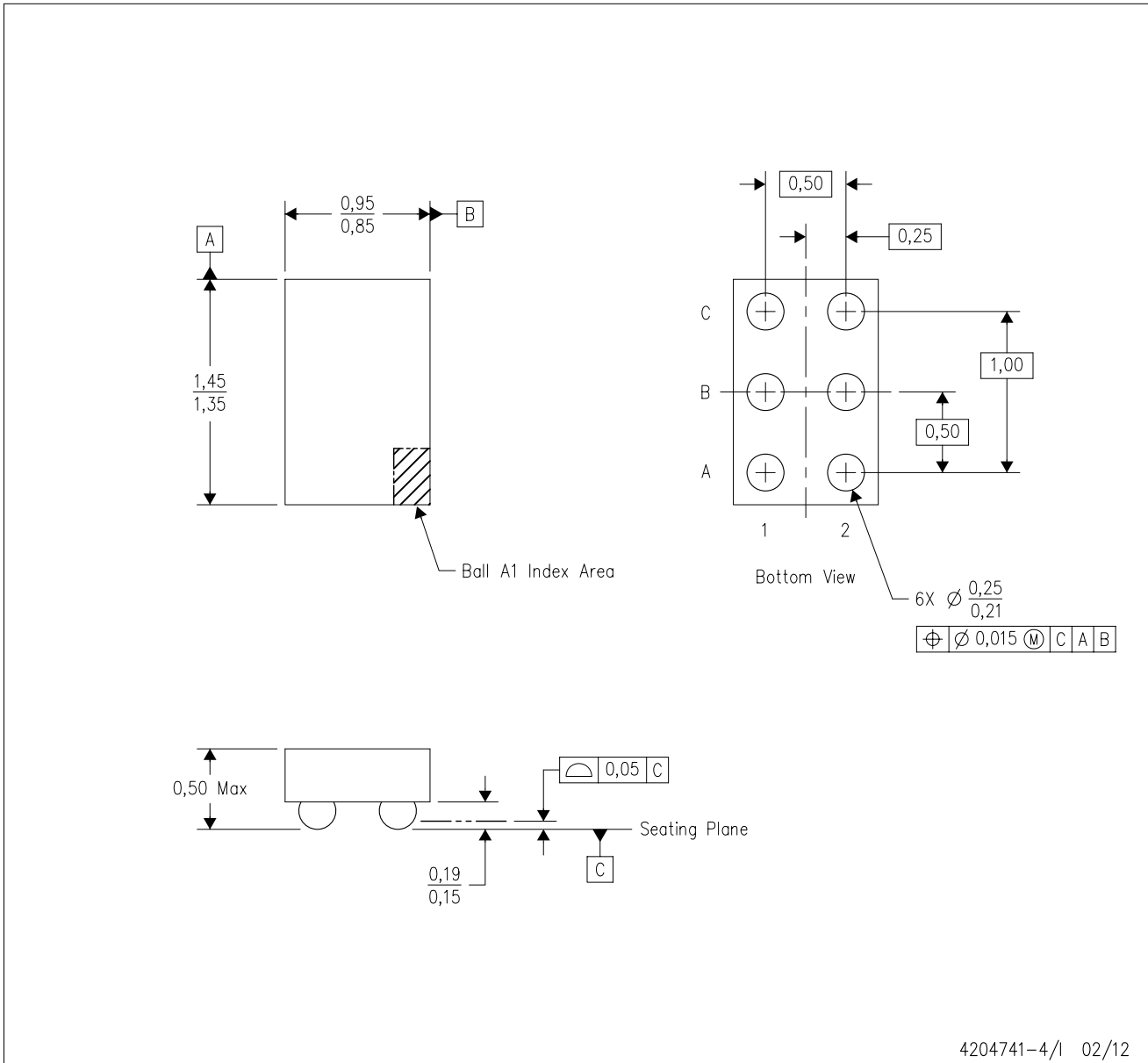

\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS22921YFPR	DSBGA	YFP	6	3000	210.0	185.0	35.0
TPS22921YZPR	DSBGA	YZP	6	3000	220.0	220.0	34.0
TPS22922BYFPR	DSBGA	YFP	6	3000	220.0	220.0	34.0
TPS22922BYZPR	DSBGA	YZP	6	3000	220.0	220.0	34.0
TPS22922YFPR	DSBGA	YFP	6	3000	210.0	185.0	35.0
TPS22922YZPR	DSBGA	YZP	6	3000	220.0	220.0	34.0



YZP (R-XBGA-N6)

DIE-SIZE BALL GRID ARRAY

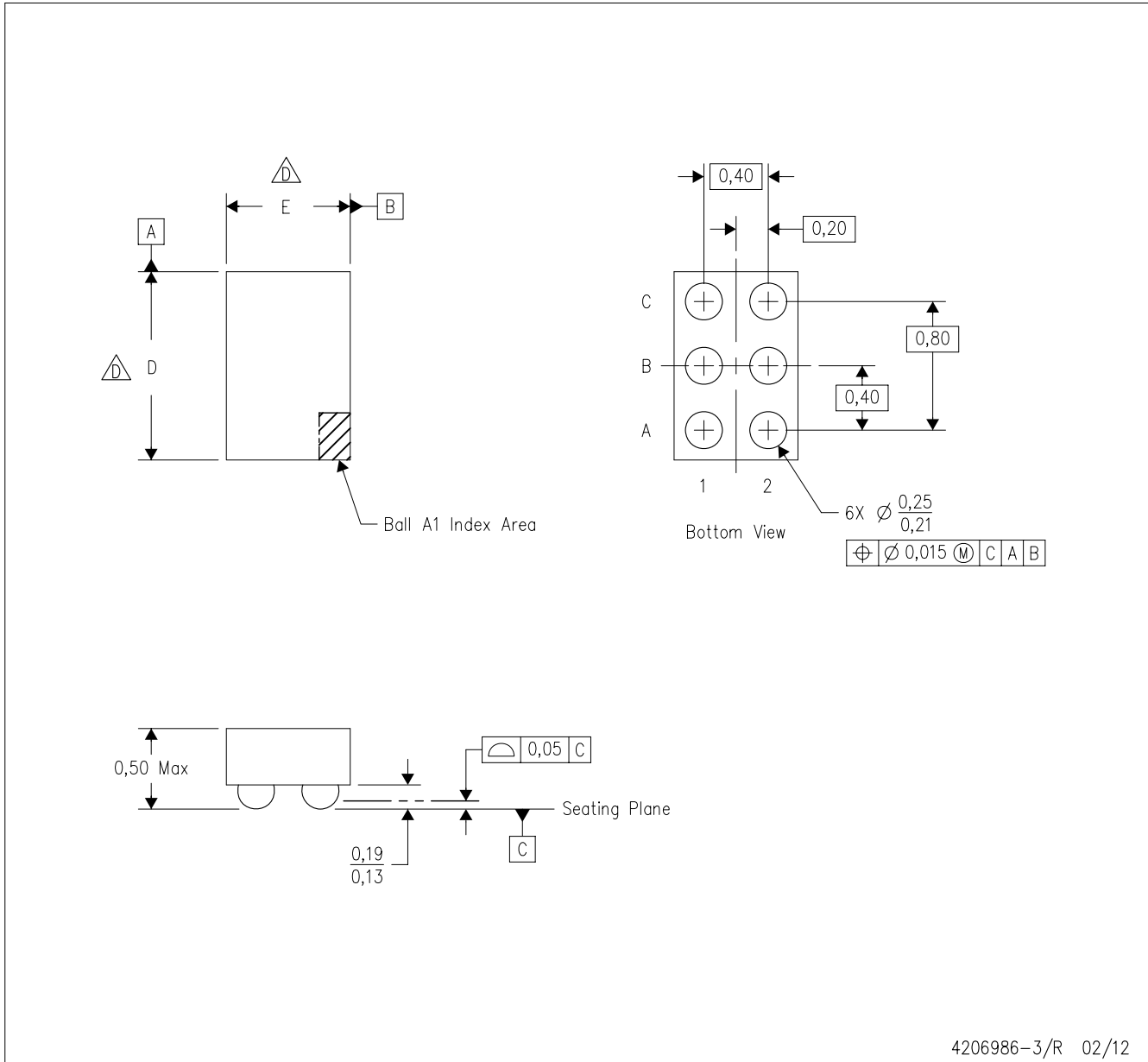


- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  - C. NanoFree™ package configuration.
  - D. This package is a Pb-free solder ball design. Refer to the 6 YEP package (drawing 4204725) for tin-lead (SnPb).

NanoFree is a trademark of Texas Instruments.

YFP (R-XBGA-N6)

DIE-SIZE BALL GRID ARRAY



4206986-3/R 02/12

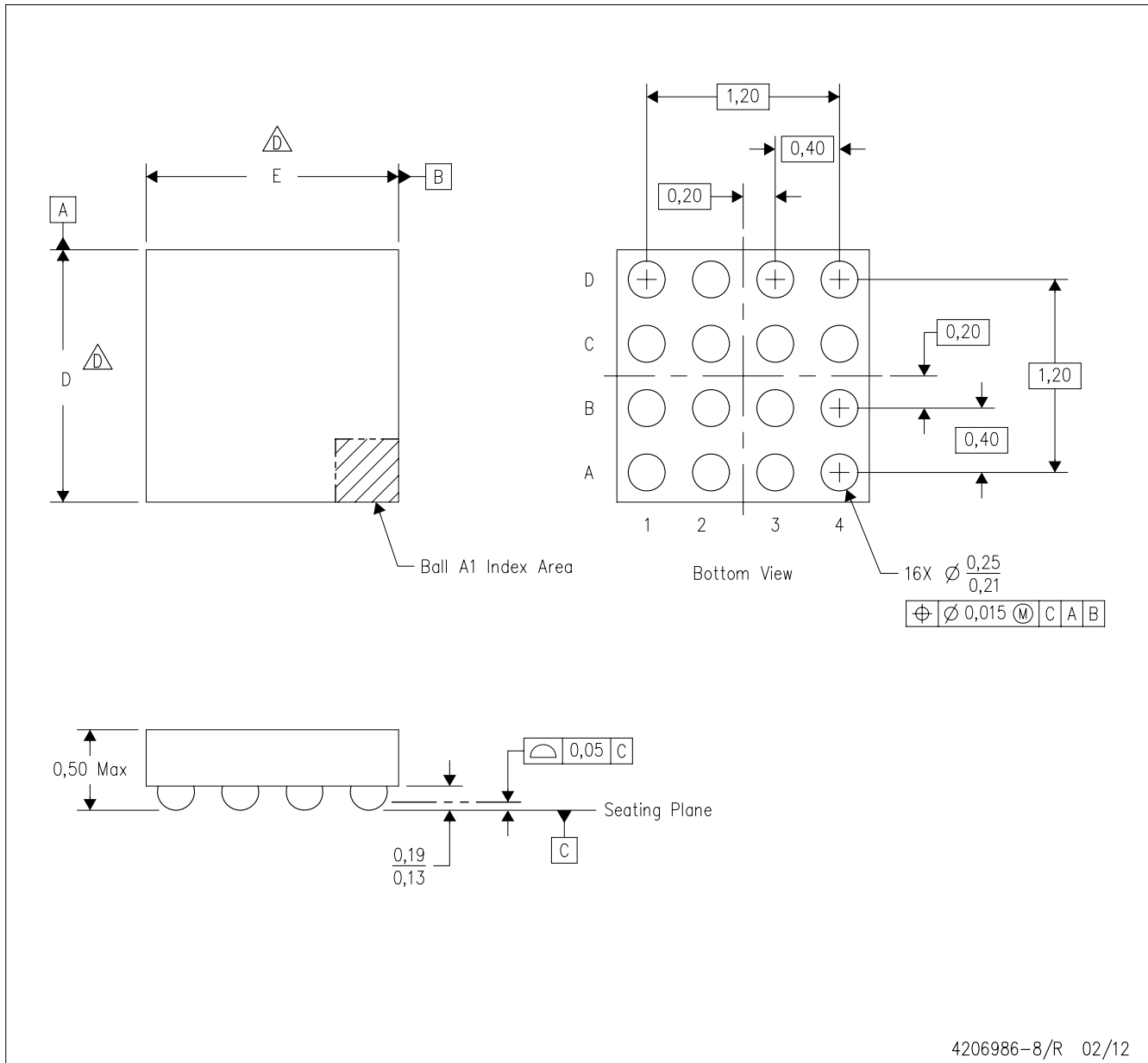
- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  - C. NanoFree™ package configuration.
  - $\triangle D$  The package size (Dimension D and E) of a particular device is specified in the device Product Data Sheet version of this drawing, in case it cannot be found in the product data sheet please contact a local TI representative.
  - E. Reference Product Data Sheet for array population.  
2 x 3 matrix pattern is shown for illustration only.
  - F. This package contains Pb-free balls.

NanoFree is a trademark of Texas Instruments

# MECHANICAL DATA

YFP (S-XBGA-N16)

DIE-SIZE BALL GRID ARRAY



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- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
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  - C. NanoFree™ package configuration.
  - $\triangle$  The package size (Dimension D and E) of a particular device is specified in the device Product Data Sheet version of this drawing, in case it cannot be found in the product data sheet please contact a local TI representative.
  - E. Reference Product Data Sheet for array population.  
4 x 4 matrix pattern is shown for illustration only.
  - F. This package contains Pb-free balls.

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