# 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 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**
- **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 µS**
  - **TPS22922B: 200 µS**
- **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 × 1.4 mm, 0.5 mm Pitch, 0.5 mm Height**
  - **0.8 mm × 1.2 mm, 0.4 mm Pitch, 0.5 mm Height**

## APPLICATIONS

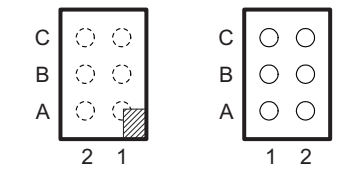
- **PDAs**
- **Cell Phones**
- **GPS Devices**
- **MP3 Players**
- **Peripheral Ports**
- **Portable Media Players**
- **RF Modules**

## 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-Ω 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 µs rise time whereas TPS22922B is 200 µs.

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°C to 85°C.

**YFP, YZP, AND YZT PACKAGES**




**Laser Marking View** **Bump View**

**TERMINAL ASSIGNMENTS**

| | | |
|---|---|---|
| **C** | ON | GND |
| **B** | $V_{IN}$ | $V_{OUT}$ |
| **A** | $V_{IN}$ | $V_{OUT}$ |
| | **2** | 1 |

| | $r_{ON}$ AT 1.8 V (TYP) | SLEW RATE (TYP at 1.8V) | QUICK OUTPUT DISCHARGE(1) | MAX OUTPUT CURRENT | ENABLE |
|---|---|---|---|---|---|
| TPS22921 | 33 mΩ | 30 µs | | 2 A | active high |
| TPS22922 | 33 mΩ | 30 µs | Yes | 2 A | active high |
| TPS22922B | 33 mΩ | 200 µs | Yes | 2 A | active high |

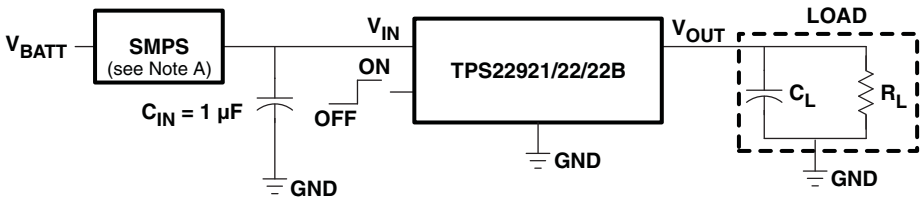
(1) This feature discharges the output of the switch to ground through a 120-Ω resistor, preventing the output from floating.

## ORDERING INFORMATION

| $T_A$ | PACKAGE(1)(2) | | 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.
(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.

## TYPICAL APPLICATION




A. Switched mode power supply

## APPLICATION BLOCK DIAGRAM

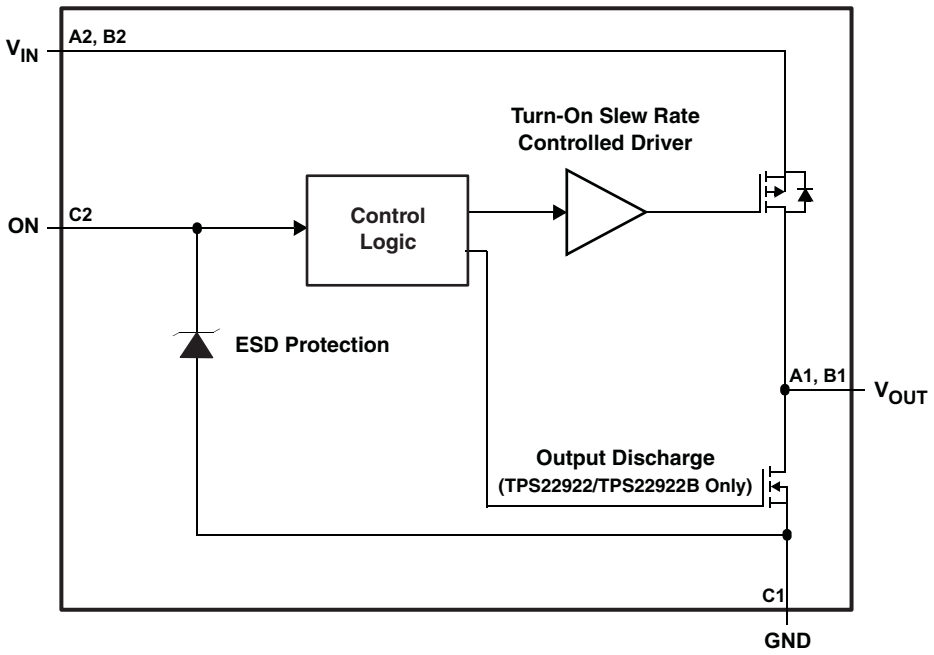



**Figure 1. Functional Block Diagram**

## FUNCTION TABLE

| ON | $V_{IN}$ TO $V_{OUT}$ | $V_{OUT}$ TO GND(1) |
|---|---|---|
| L | OFF | ON |
| H | ON | OFF |

(1) TPS22922/TPS22922B only

## TERMINAL FUNCTIONS

| TERMINAL | | DESCRIPTION |
|---|---|---|
| NO. | NAME | |
| A1, B1 | $V_{OUT}$ | Switch output |
| A2, B2 | $V_{IN}$ | Switch input |
| C1 | GND | Ground |
| C2 | ON | Switch control input, active high. Do not leave floating |

## ABSOLUTE MAXIMUM RATINGS(1)

| | | | MIN | MAX | UNIT |
|---|---|---|---|---|---|
| $V_{IN}$ | Input voltage range | | –0.3 | 4 | V |
| $V_{OUT}$ | Output voltage range | | | $V_{IN}$ + 0.3 | V |
| $V_{ON}$ | Input voltage range | | –0.3 | 4 | V |
| P | Power dissipation at $T_A$ = 25°C | | | 0.645 | W |
| $I_{MAX}$ | Maximum continuous switch current | | | 2 | A |
| $T_A$ | Operating free-air temperature range | | –40 | 85 | °C |
| $T_{stg}$ | Storage temperature range | | –65 | 150 | °C |
| $T_{lead}$ | Maximum lead temperature (10-s soldering time) | | | 300 | °C |
| ESD | Electrostatic discharge protection | Human-Body Model (HBM) | | 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 |
|---|---|---|---|---|
| $\theta_{JA}$ | Package thermal impedance(1) | YFP package | 155 | °C/W |
| | | YZP/YZT package | 123 | |

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

## RECOMMENDED OPERATING CONDITIONS

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| $V_{IN}$ | Input voltage range | 0.9 | 3.6 | V |
| $V_{OUT}$ | Output voltage range | | $V_{IN}$ | |
| $V_{IH}$ | 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.

## 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 |
|---|---|---|---|---|---|---|---|---|
| $I_{IN}$ | Quiescent current | $I_{OUT}$ = 0 | $V_{IN}$ = 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 | $V_{IN}$ = 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 | |
| | | | $V_{IN}$ = 1.0 V | 25°C | | 116 | 160 | |
| | | | | Full | | | 170 | |
| $r_{PD}$ | Output pulldown resistance | $V_{IN}$ = 3.3 V, $V_{ON}$ = 0, $I_{OUT}$ = 30 mA (TPS22922/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.

## SWITCHING CHARACTERISTICS

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

| PARAMETER | | TEST CONDITIONS | | TPS22921 | | | TPS22922[1] | | | TPS22922B[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 | | 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 | | |

(1) RL_CHIP = 120 Ω

## SWITCHING CHARACTERISTICS

$V_{IN}$ = 1.0 V, $T_A$ = 25°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | TPS22921 | | | TPS22922(1) | | | TPS22922B(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 | | 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 | | |

(1) RL_CHIP = 120 Ω

## SWITCHING CHARACTERISTICS

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

| PARAMETER | | TEST CONDITIONS | | TPS22921 | | | TPS22922(1) | | | TPS22922B(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 | | 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 | | |

(1) RL_CHIP = 120 Ω

## SWITCHING CHARACTERISTICS

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

| PARAMETER | | TEST CONDITIONS | | TPS22921 | | | TPS22922(1) | | | TPS22922B(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 | | 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 | | |

(1) RL_CHIP = 120 Ω

## SWITCHING CHARACTERISTICS

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

| PARAMETER | | TEST CONDITIONS | | TPS22921 | | | TPS22922(1) | | | TPS22922B(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 | | 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 | | |

(1) RL_CHIP = 120 Ω

## SWITCHING CHARACTERISTICS

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

| PARAMETER | | TEST CONDITIONS | | TPS22921 | | | TPS22922(1) | | | TPS22922B(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 | | 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 | | |

(1) RL_CHIP = 120 Ω

## SWITCHING CHARACTERISTICS

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

| PARAMETER | | TEST CONDITIONS | | TPS22921 | | | TPS22922(1) | | | TPS22922B(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 | | 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 | | |

(1) RL_CHIP = 120 Ω

## SWITCHING CHARACTERISTICS

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

| PARAMETER | | TEST CONDITIONS | | TPS22921 | | | TPS22922[1] | | | TPS22922B[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 | | 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 | | |

(1) RL_CHIP = 120 Ω

## TYPICAL CHARACTERISTICS

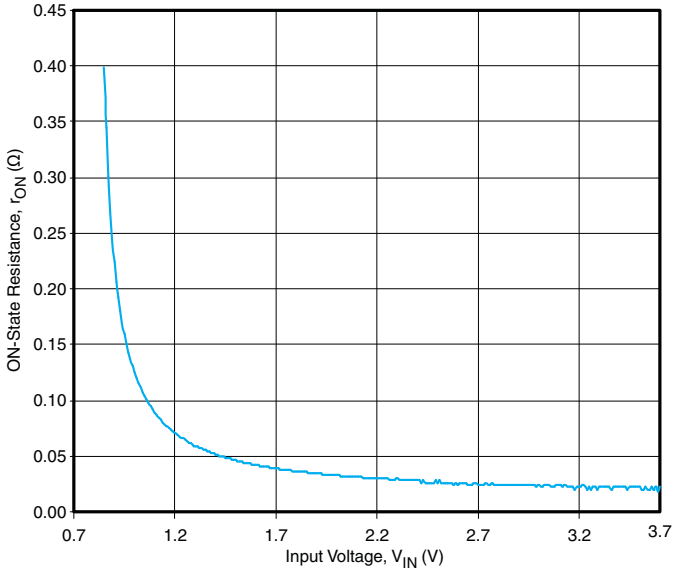



**Figure 2. $r_{ON}$ vs. $V_{IN}$**

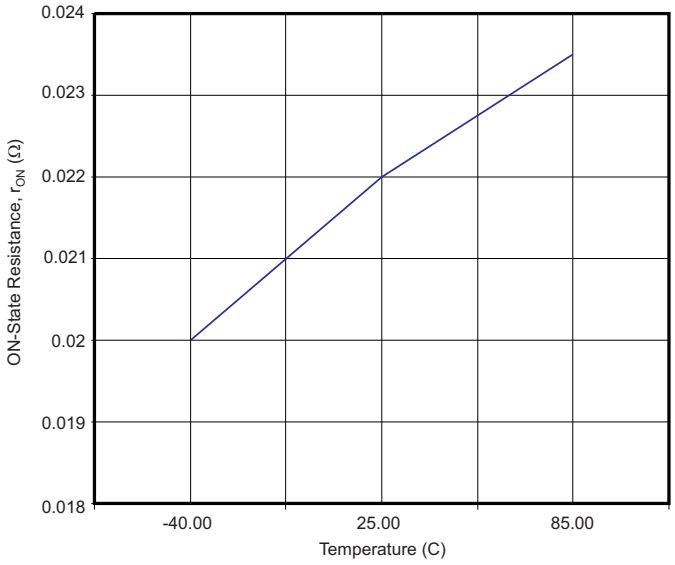



**Figure 3. $r_{ON}$ vs. Temperature ($V_{IN}$ = 3.3 V)**

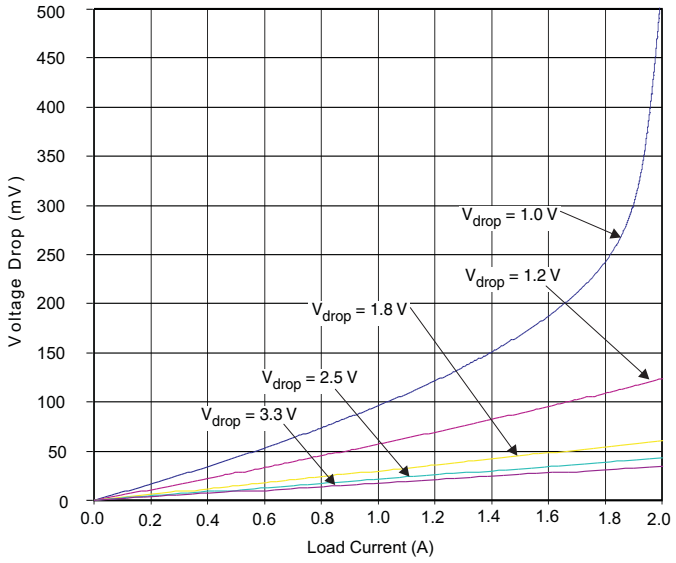



**Figure 4. Voltage Drop vs Load Current**

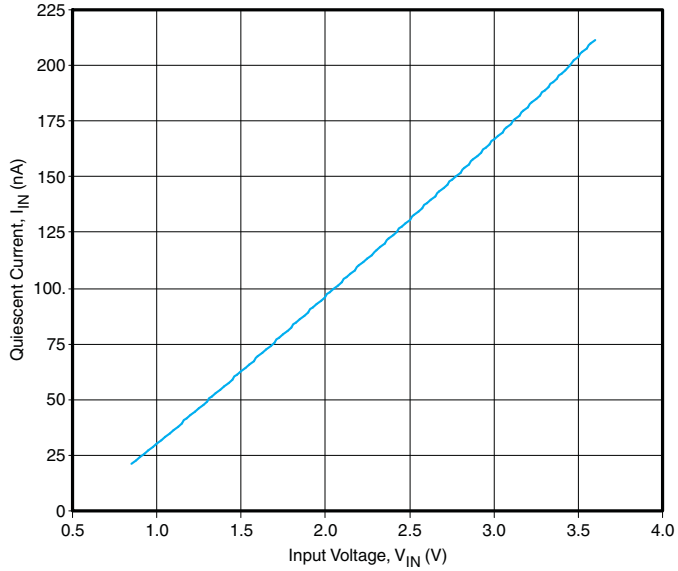



**Figure 5. Quiescent Current vs. $V_{IN}$ ($V_{ON}$ = $V_{IN}$)**

## TYPICAL CHARACTERISTICS (continued)

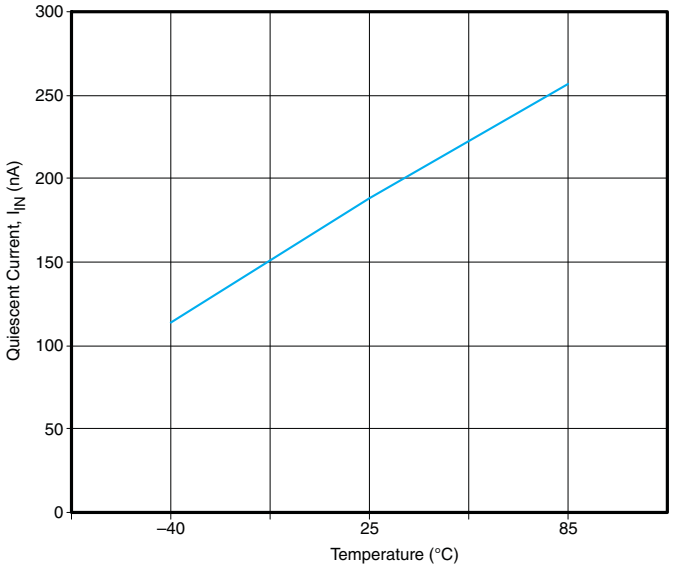



**Figure 6. Quiescent Current vs. Temperature ($V_{IN}$ = 3.3 V, $I_{OUT}$ = 0 mA)**

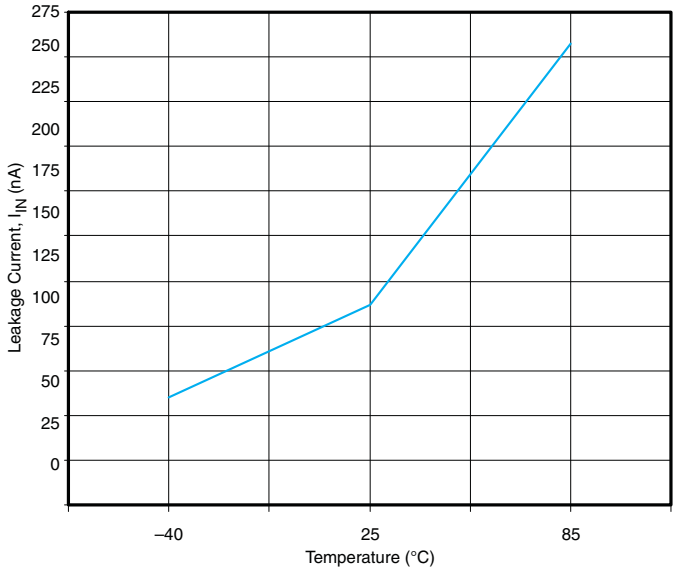



**Figure 7. $I_{IN}$ Leakage Current vs. Temperature ($V_{IN}$ = 3.3 V)**

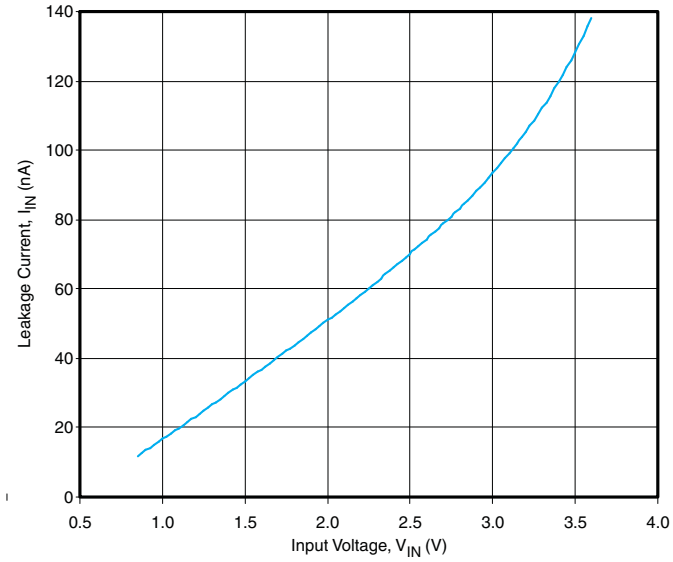



**Figure 8. Leakage Current vs $V_{IN}$**

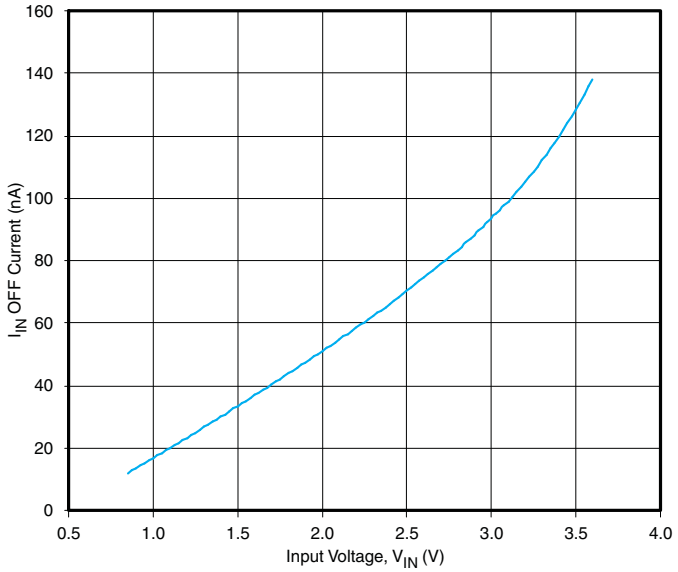



**Figure 9. $I_{IN}$ (OFF) vs $V_{IN}$ ($V_{ON}$ = 0 V)**

## TYPICAL CHARACTERISTICS (continued)

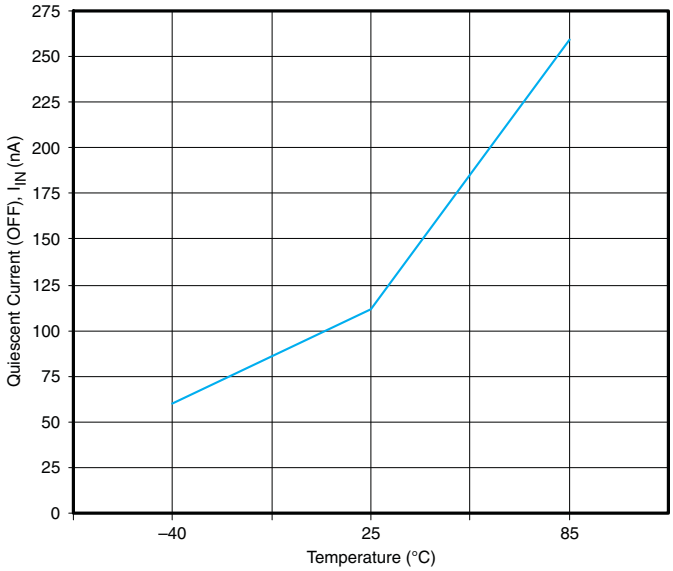



Figure 10. $I_{IN}$ (OFF) vs Temperature ($V_{IN}$ = 3.3 V)

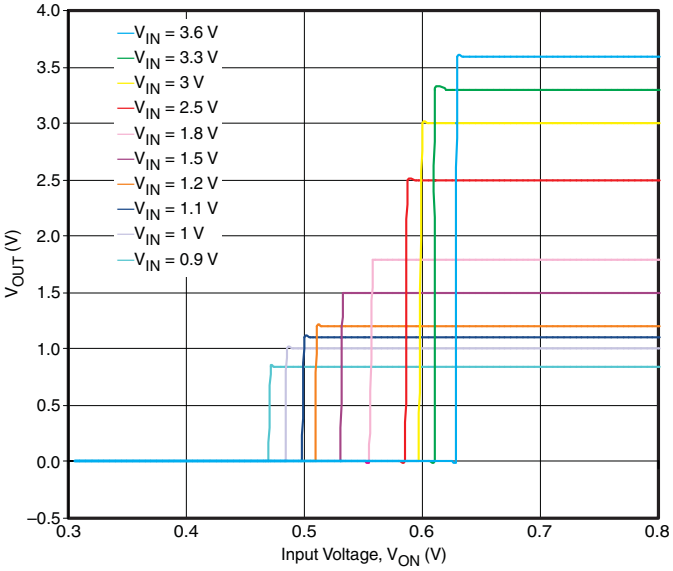



Figure 11. ON-Input Threshold

## TPS22921

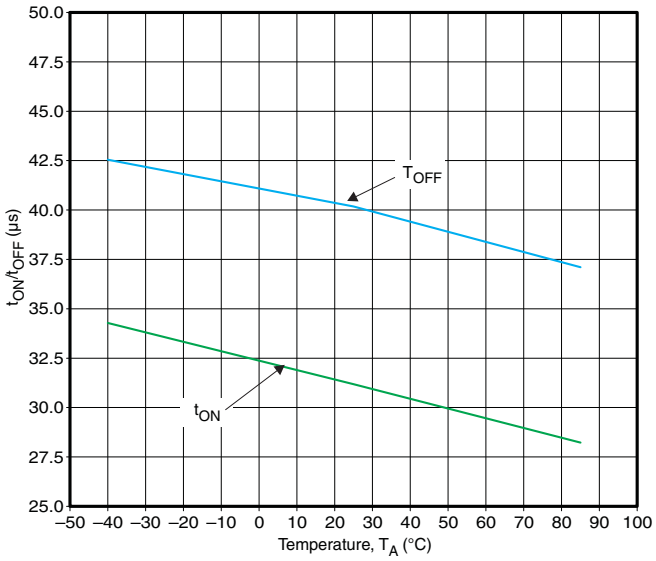



Figure 12. $t_{ON}/t_{OFF}$ vs Temperature ($V_{IN}$ = 3.3 V)

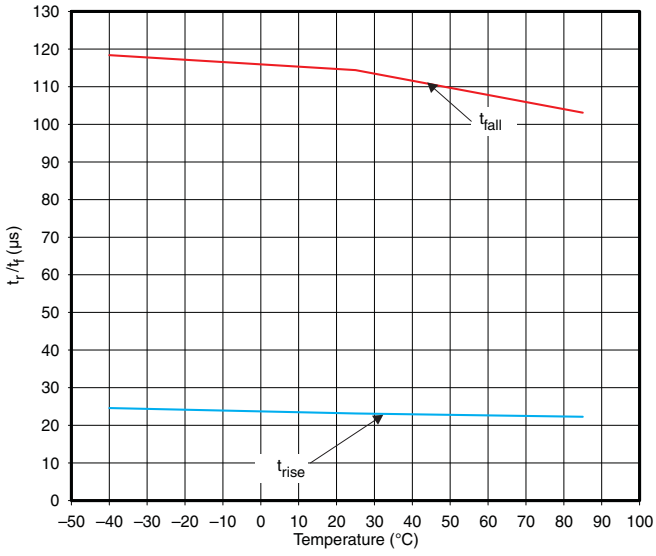



Figure 13. $t_{rise}/t_{fall}$ vs Temperature ($V_{IN}$ = 3.3 V)

## TYPICAL CHARACTERISTICS (continued)

### TPS22922

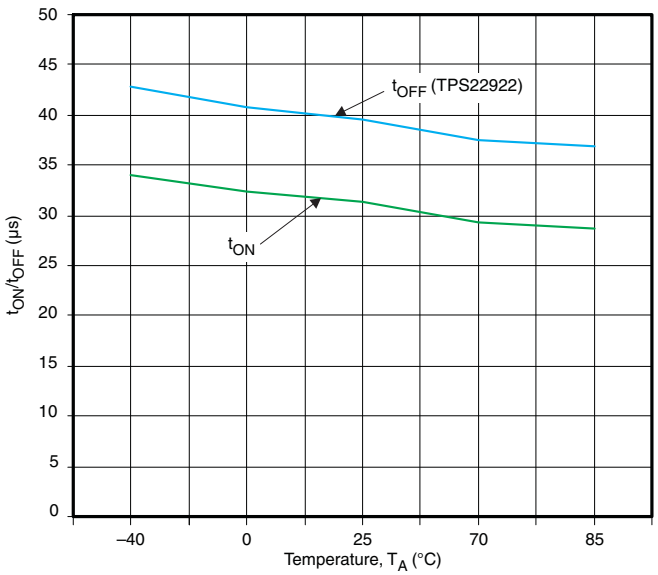



**Figure 14. $t_{ON}/t_{OFF}$ vs Temperature ($V_{IN}$ = 3.3 V)**

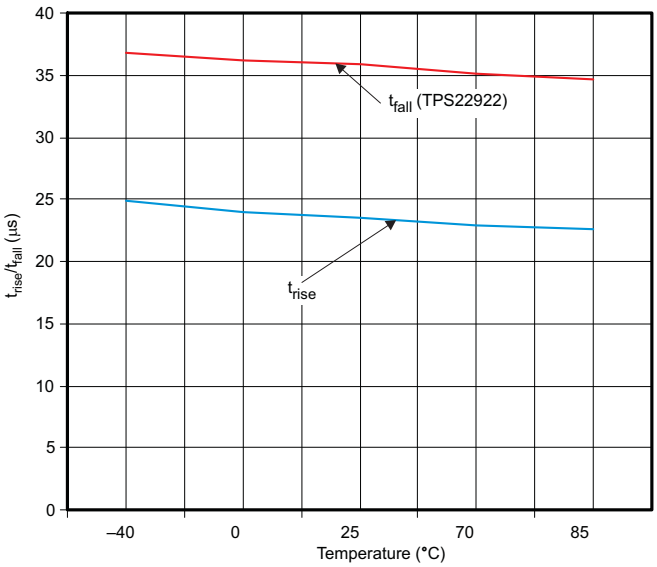



**Figure 15. $t_{rise}/t_{fall}$ vs Temperature ($V_{IN}$ = 3.3 V)**

### TPS22922B

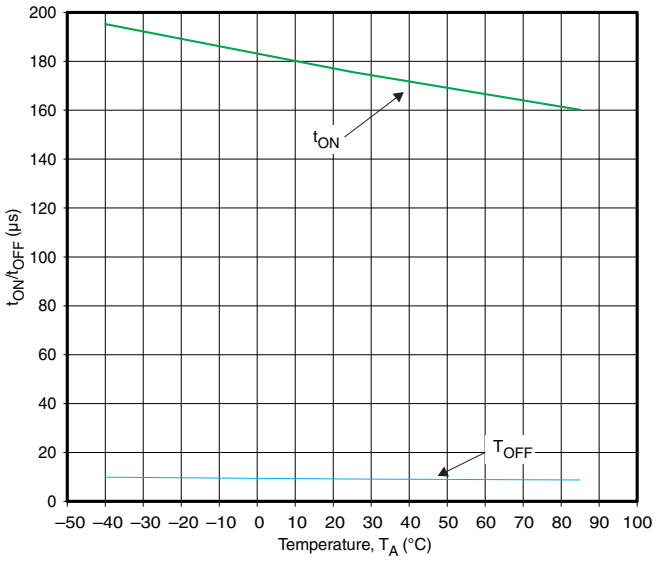



**Figure 16. $t_{ON}/t_{OFF}$ vs Temperature ($V_{IN}$ = 3.3 V)**

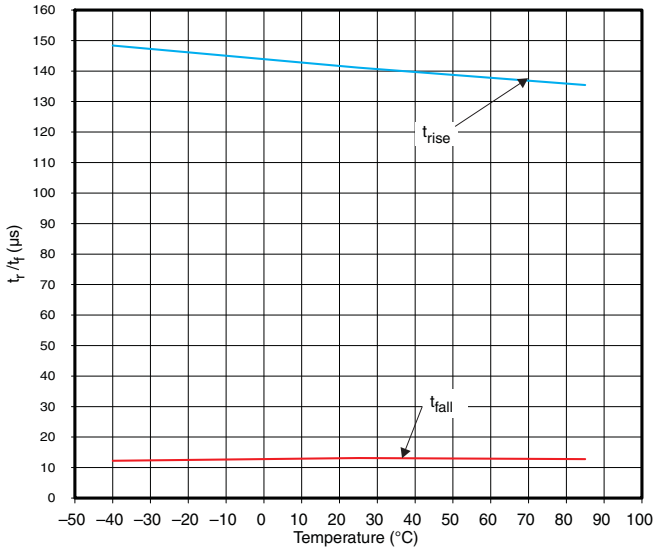



**Figure 17. $t_{rise}/t_{fall}$ vs Temperature ($V_{IN}$ = 3.3 V)**

## TYPICAL CHARACTERISTICS (continued)

### TPS22921 and TPS22922

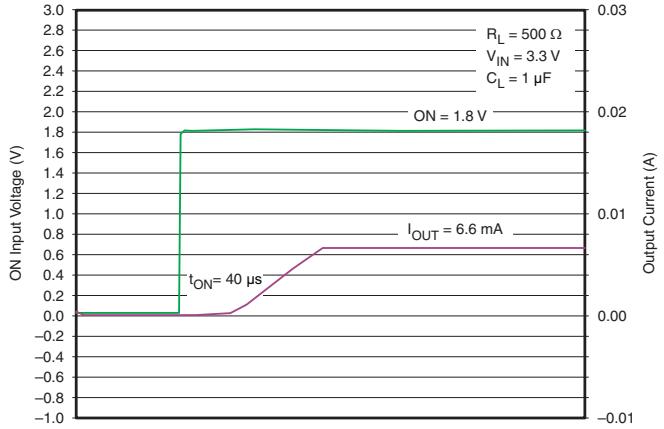



**Figure 18. $t_{ON}$ Response**

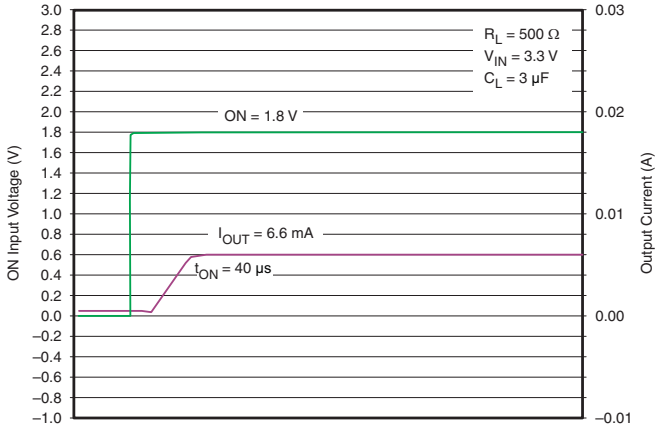



**Figure 19. $t_{ON}$ Response**

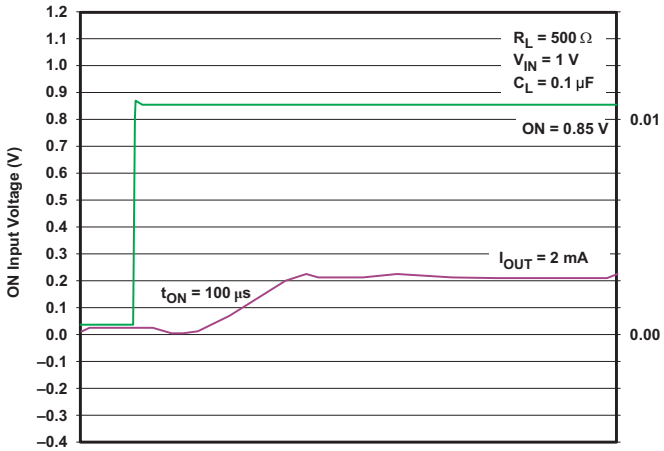



**Figure 20. $t_{ON}$ Response**

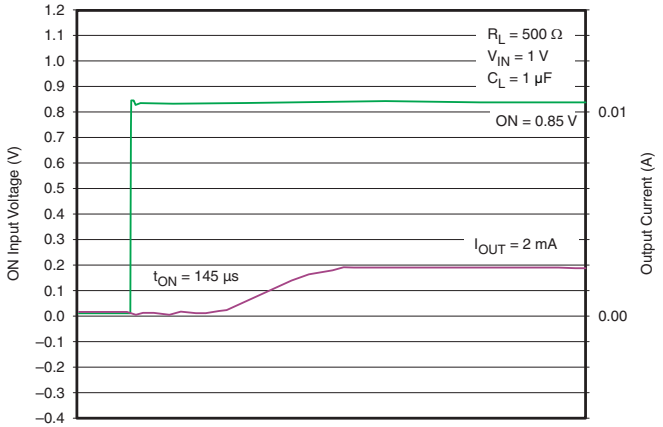



**Figure 21. $t_{ON}$ Response**

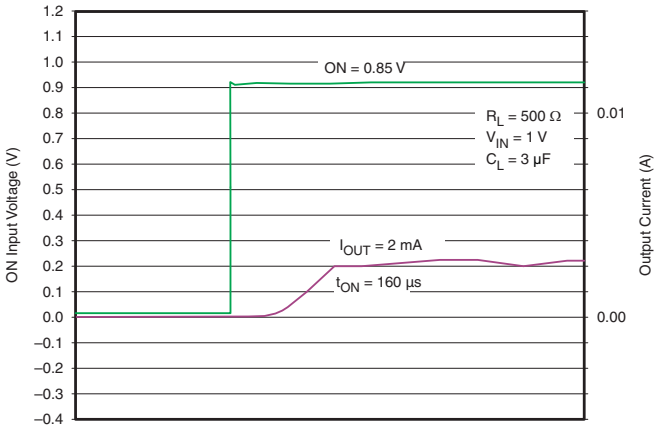



**Figure 22. $t_{ON}$ Response**

## TYPICAL CHARACTERISTICS (continued)

### TPS22921

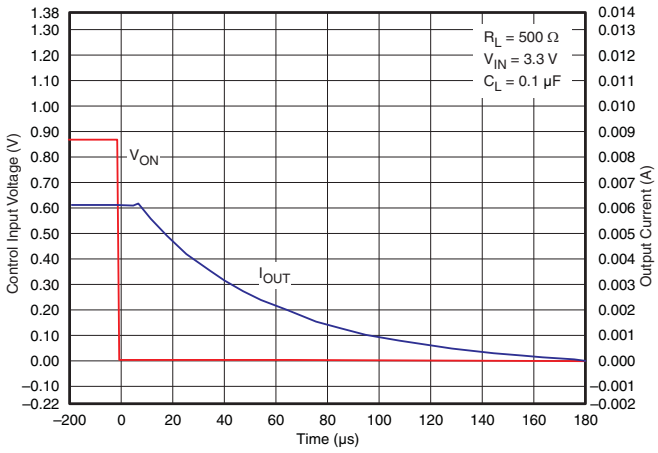



**Figure 23. $t_{OFF}$ Response**

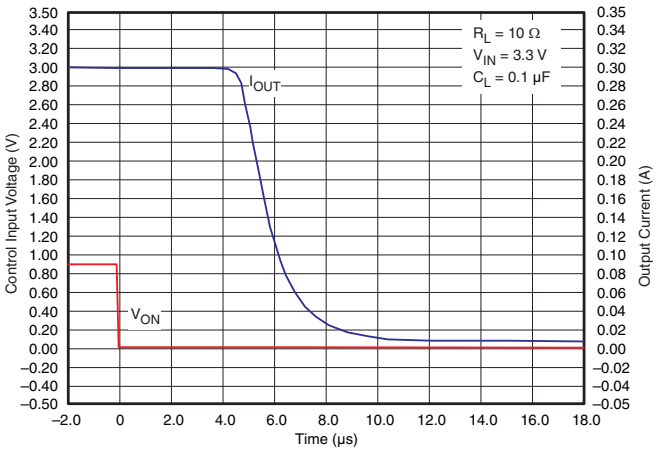



**Figure 24. $t_{OFF}$ Response**

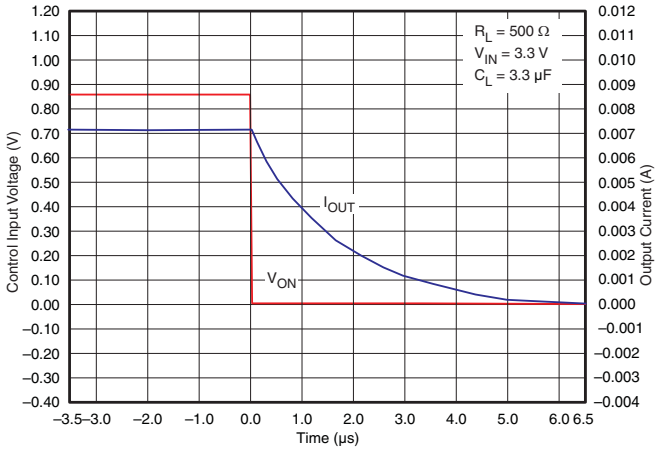



**Figure 25. $t_{OFF}$ Response**

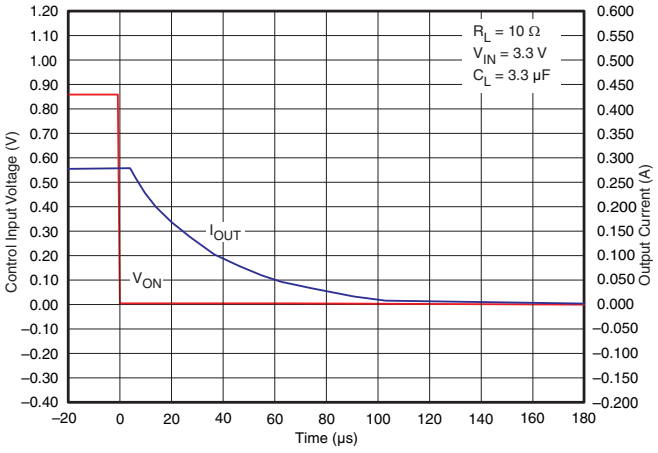



**Figure 26. $t_{OFF}$ Response**

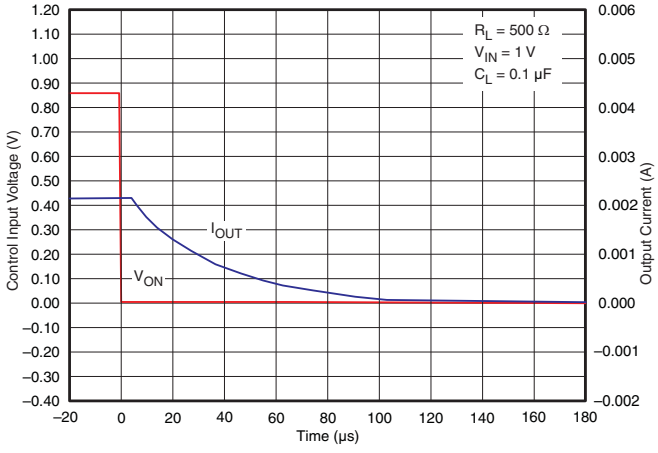



**Figure 27. $t_{OFF}$ Response**

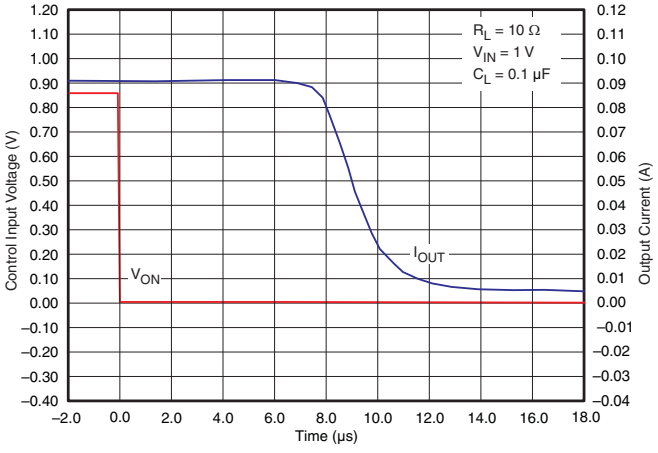



**Figure 28. $t_{OFF}$ Response**

## TYPICAL CHARACTERISTICS (continued)

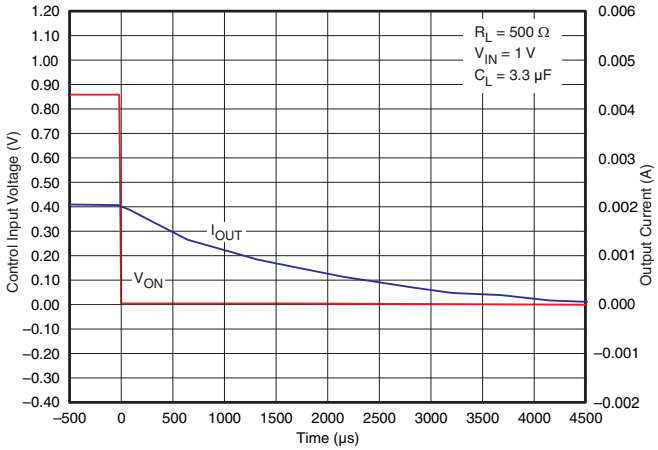



**Figure 29. $t_{OFF}$ Response**

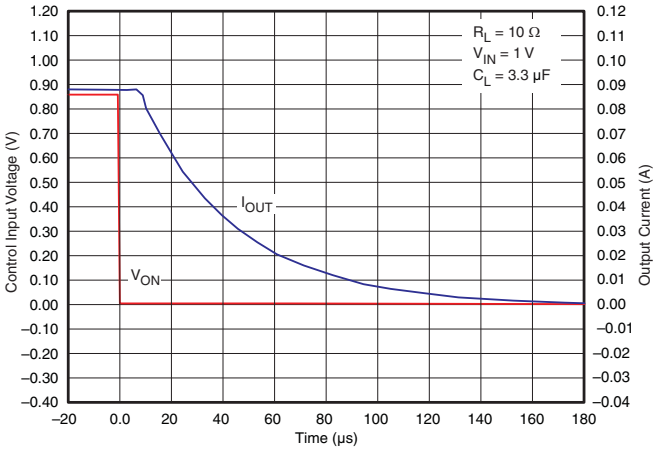



**Figure 30. $t_{OFF}$ Response**

## TPS22922

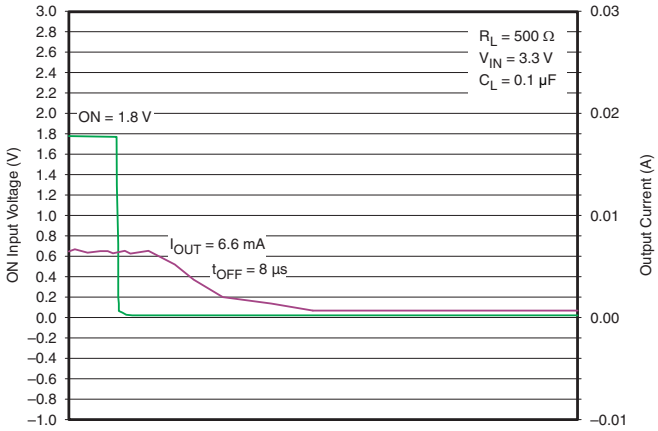



**Figure 31. $t_{OFF}$ Response**

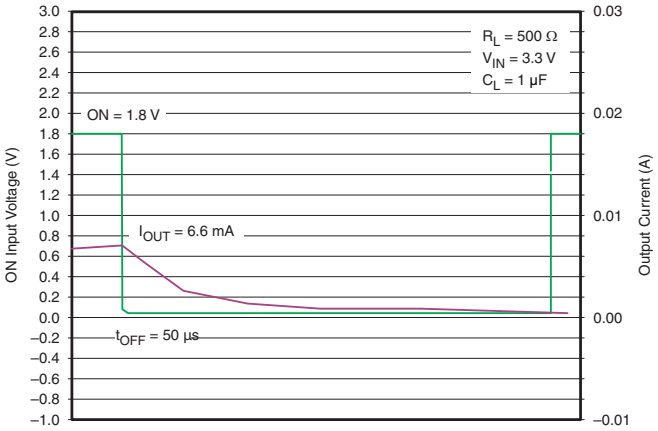



**Figure 32. $t_{OFF}$ Response**

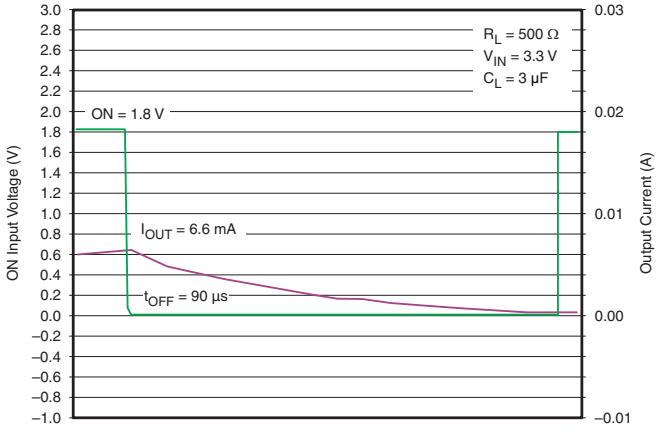



**Figure 33. $t_{OFF}$ Response**

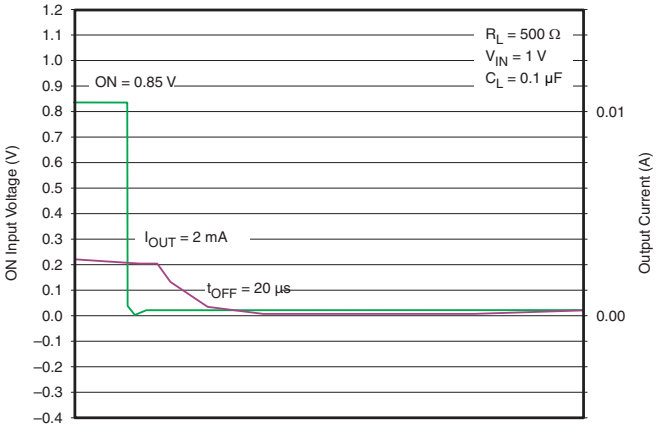



**Figure 34. $t_{OFF}$ Response**

## TYPICAL CHARACTERISTICS (continued)

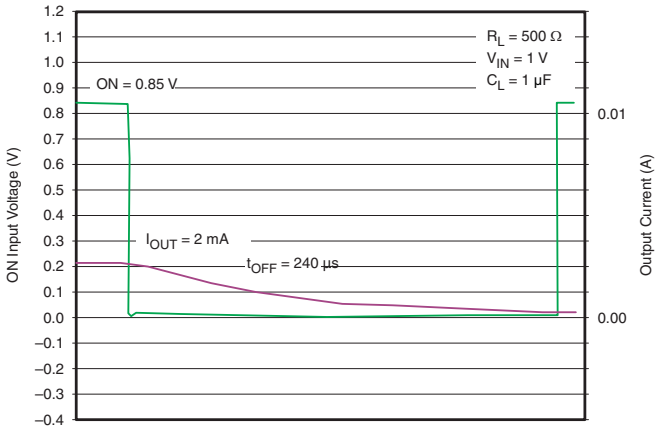



**Figure 35. $t_{OFF}$ Response**

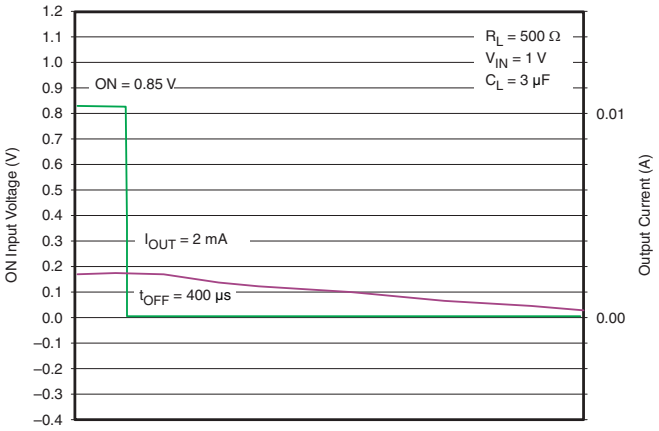



**Figure 36. $t_{OFF}$ Response**

## TPS22922B

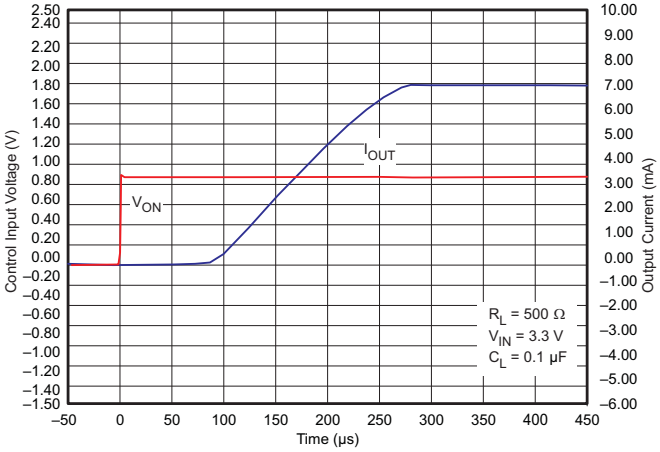



**Figure 37. $t_{ON}$ Response**

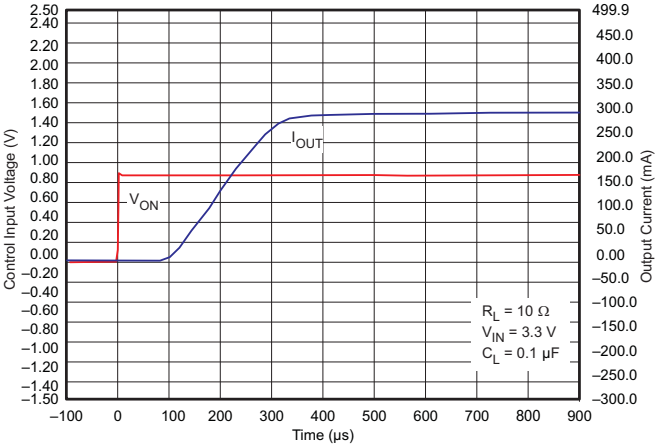



**Figure 38. $t_{ON}$ Response**

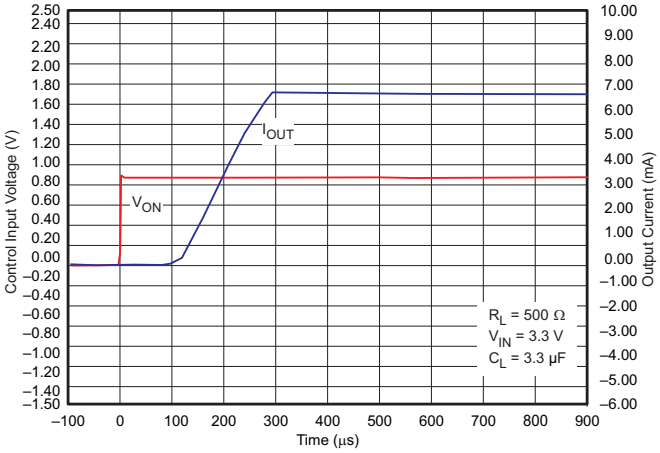



**Figure 39. $t_{ON}$ Response**

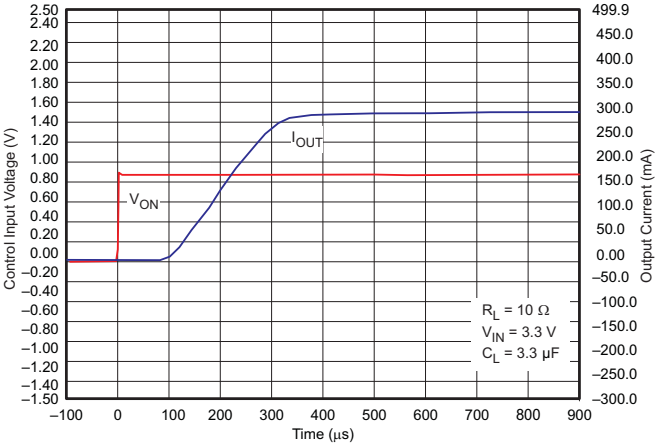



**Figure 40. $t_{ON}$ Response**

## TYPICAL CHARACTERISTICS (continued)

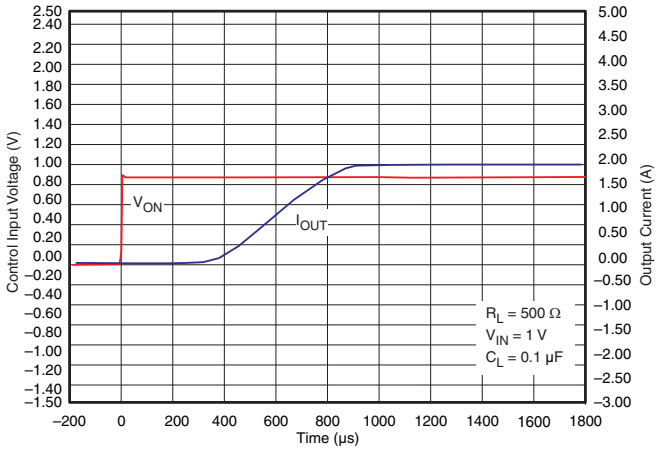



**Figure 41. $t_{ON}$ Response**

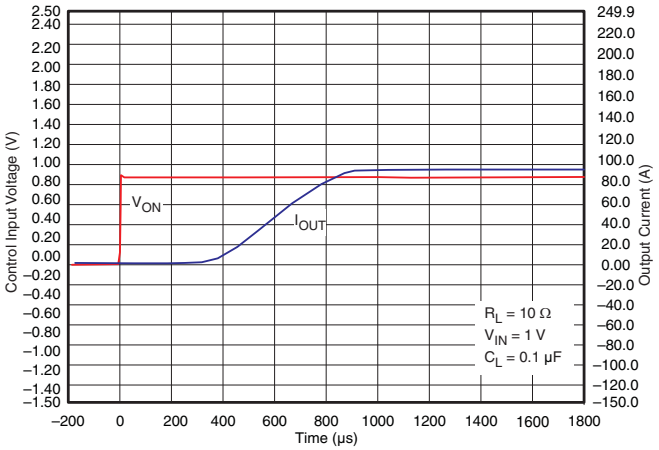



**Figure 42. $t_{ON}$ Response**

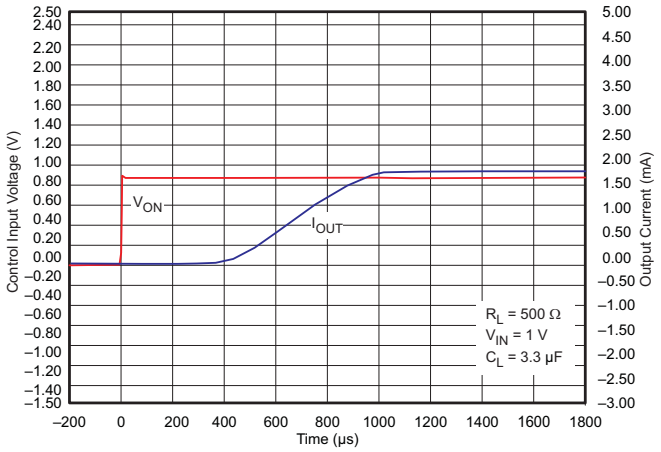



**Figure 43. $t_{ON}$ Response**

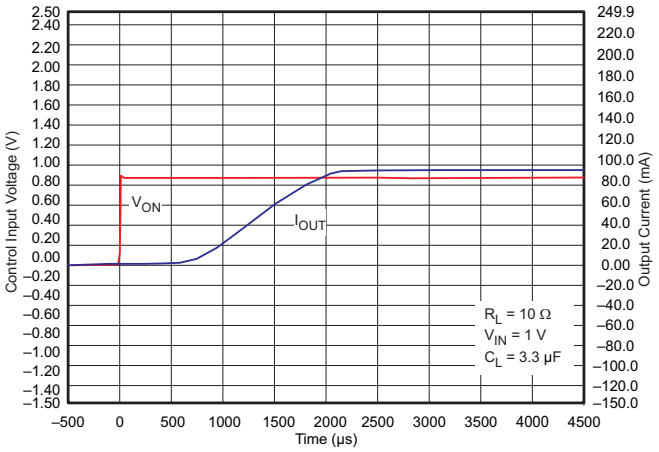



**Figure 44. $t_{ON}$ Response**

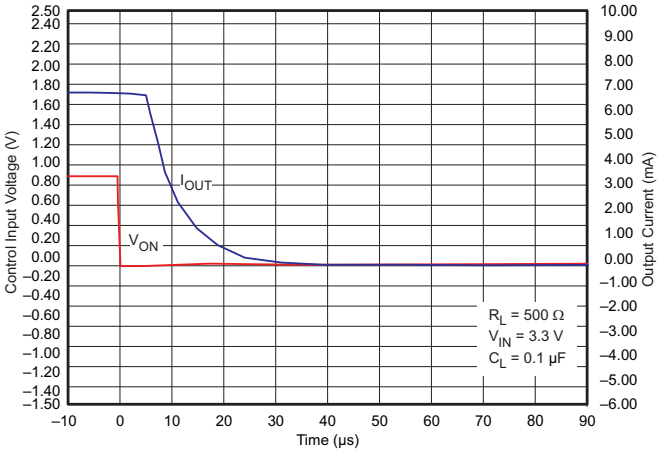



**Figure 45. $t_{OFF}$ Response**

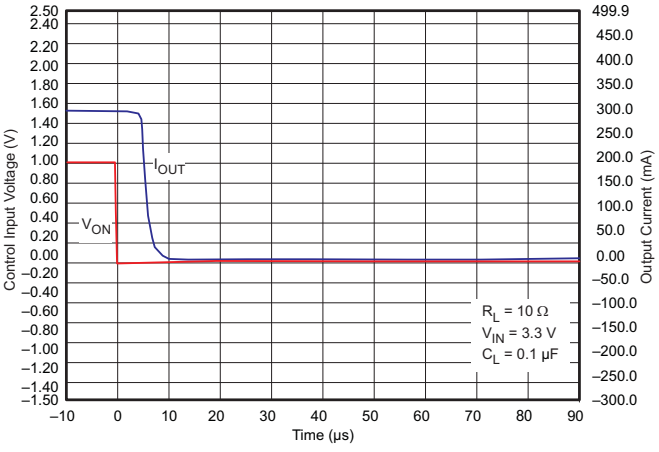



**Figure 46. $t_{OFF}$ Response**

## TYPICAL CHARACTERISTICS (continued)

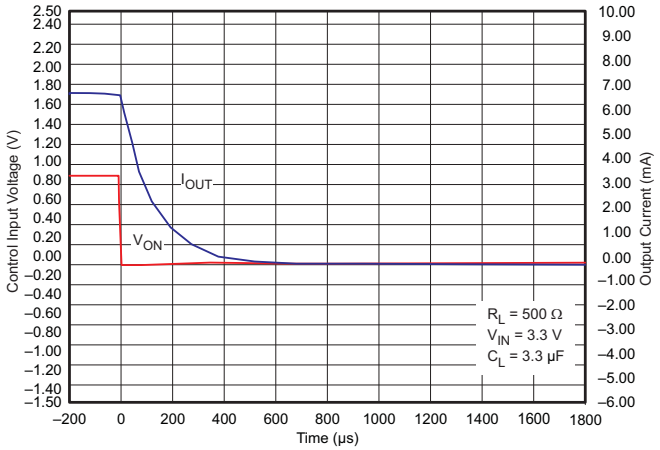



**Figure 47. $t_{OFF}$ Response**

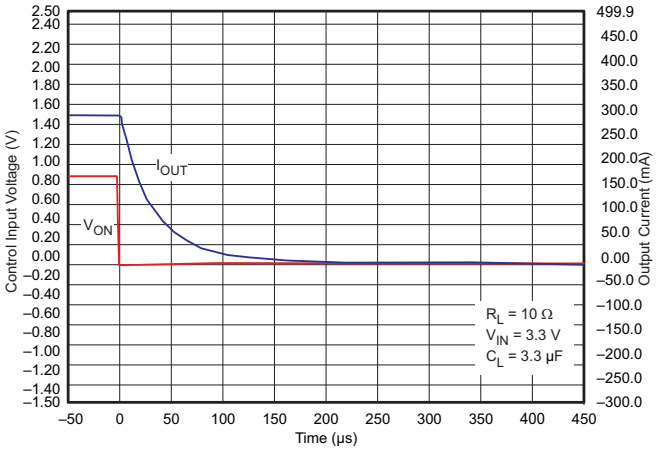



**Figure 48. $t_{OFF}$ Response**

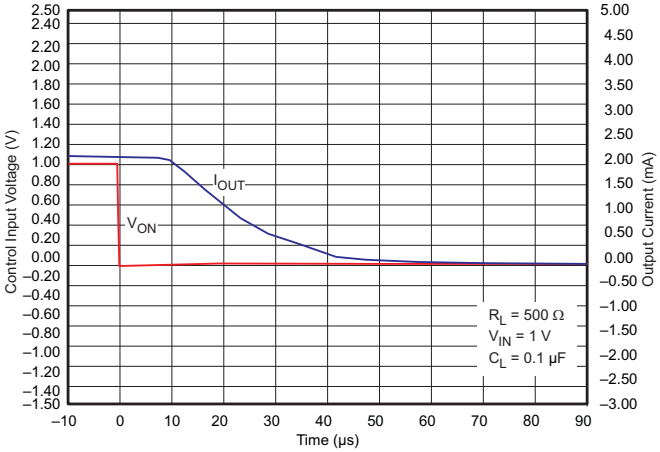



**Figure 49. $t_{OFF}$ Response**

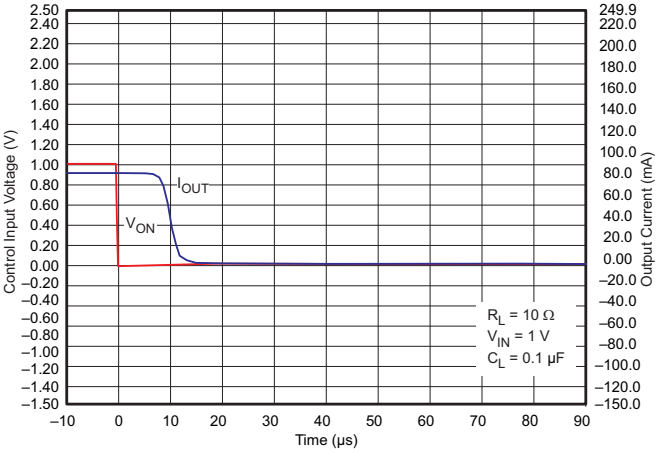



**Figure 50. $t_{OFF}$ Response**

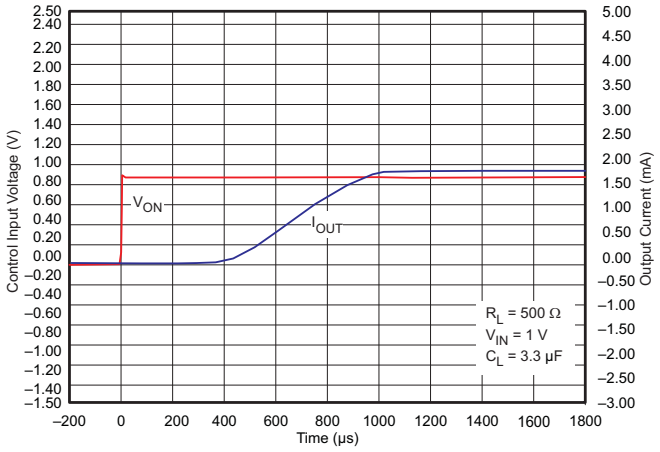



**Figure 51. $t_{OFF}$ Response**

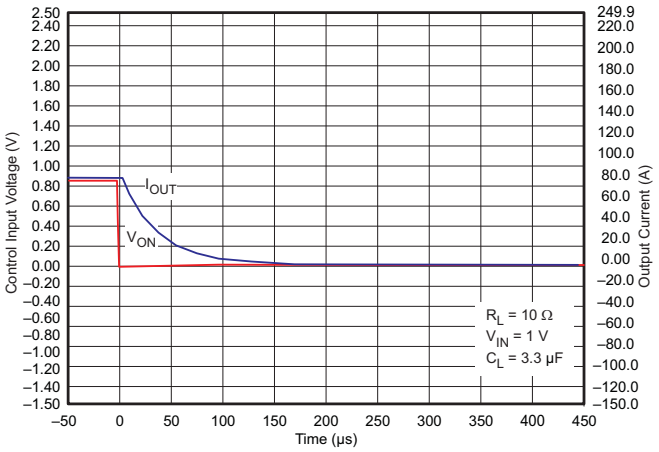
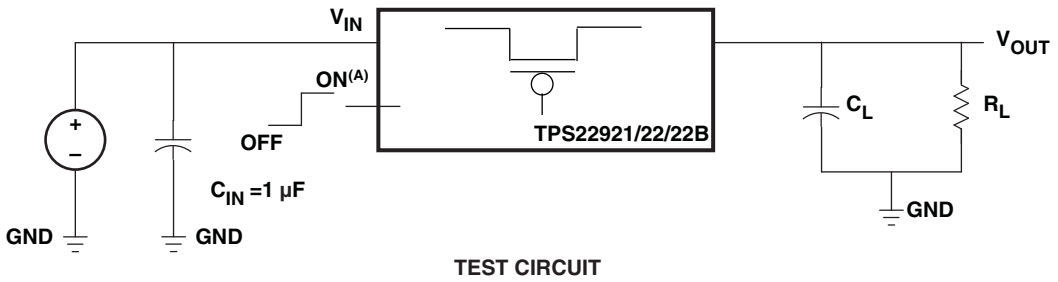
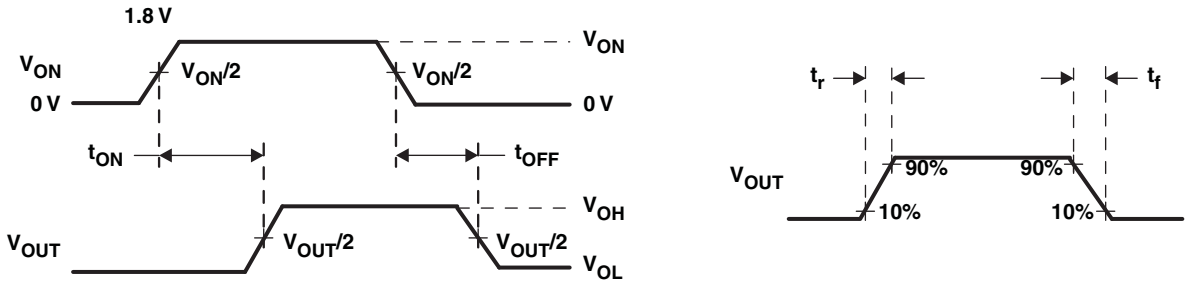



**Figure 52. $t_{OFF}$ Response**

## PARAMETER MEASURMENT INFORMATION




TEST CIRCUIT




$t_{ON}/t_{OFF}$ WAVEFORMS

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-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, 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 (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) |
|---|---|---|---|---|---|---|---|---|
| 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 |

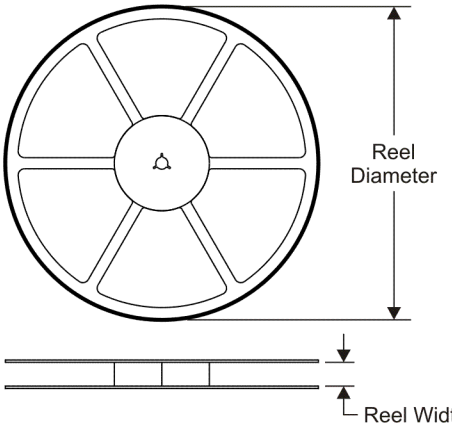
(1) The marketing status values are defined as follows:
**ACTIVE:** Product device recommended for new designs.
**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
**NRND:** Not recommended for new designs. Device is in production to support existing 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)

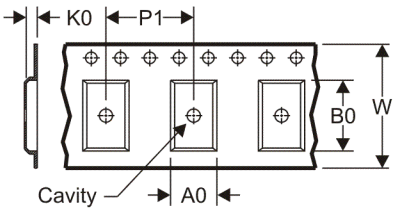
(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

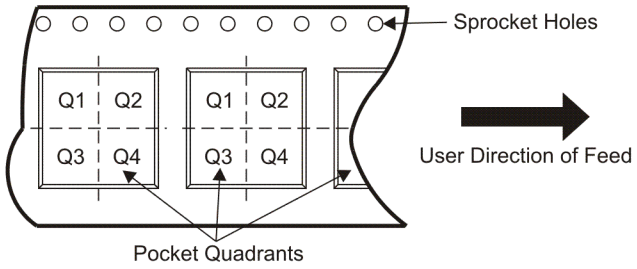



**TAPE DIMENSIONS**




| | |
|---|---|
| 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 |

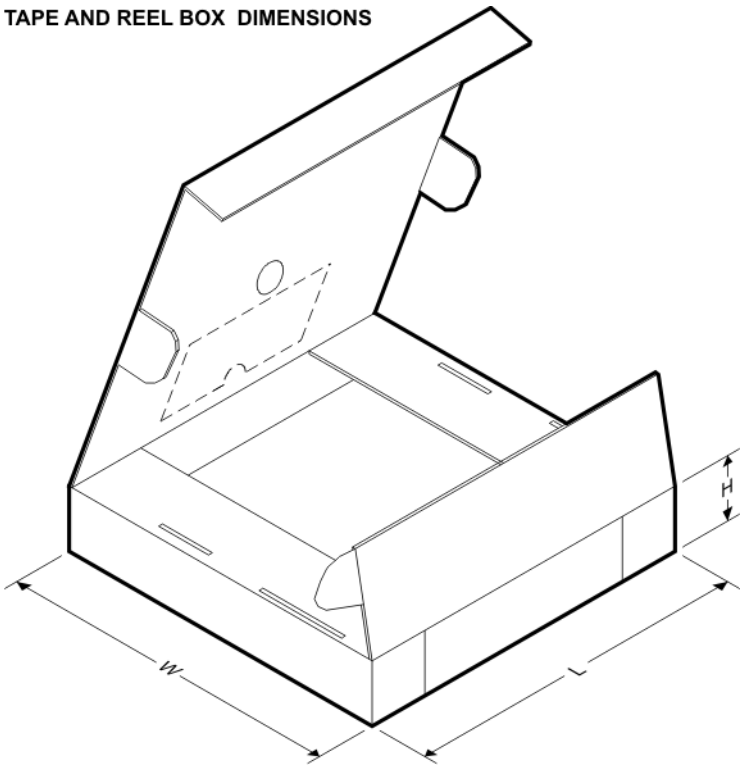
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*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 | 180.0 | 8.4 | 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 |
| TPS22922YZPR | DSBGA | YZP | 6 | 3000 | 180.0 | 8.4 | 1.02 | 1.52 | 0.63 | 4.0 | 8.0 | Q1 |

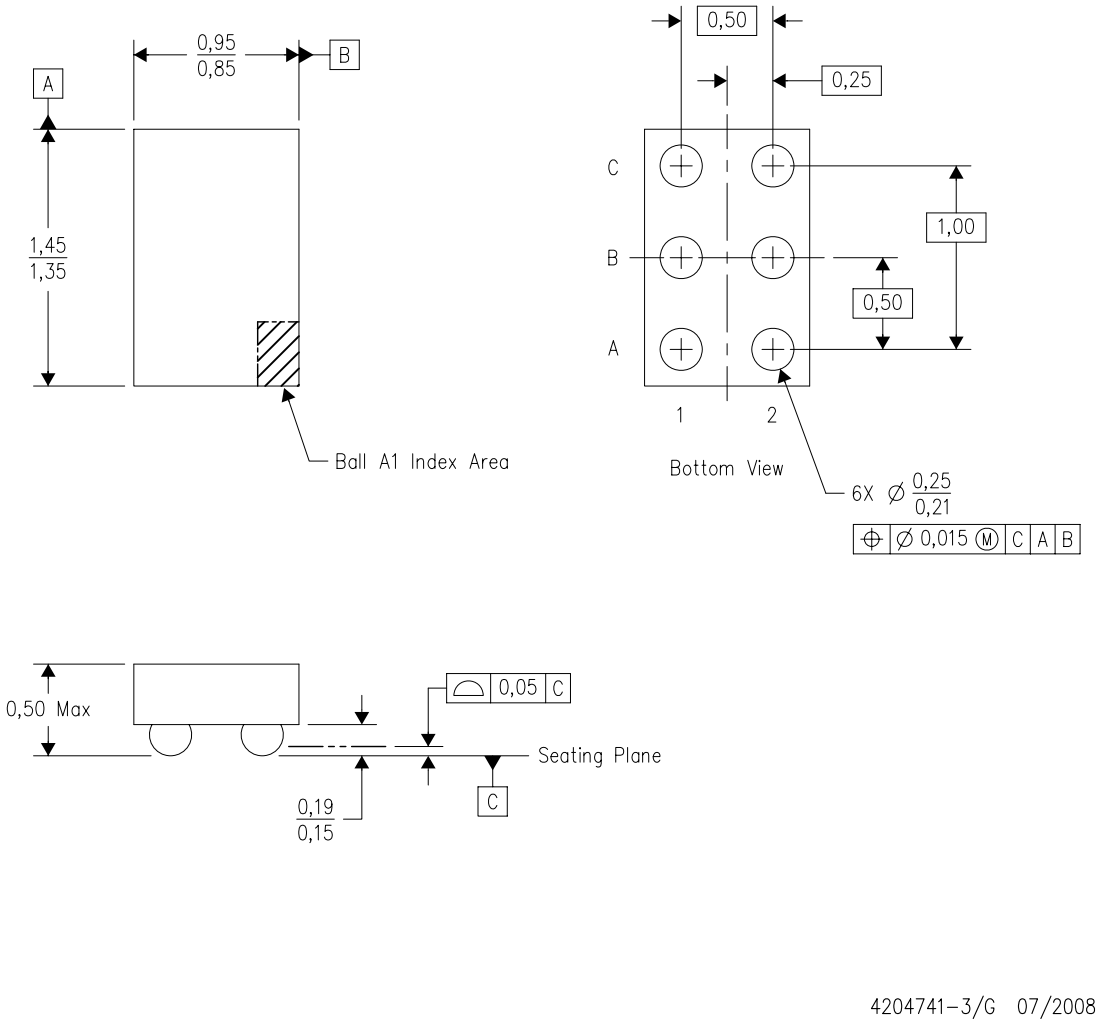
TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| TPS22921YFPR | DSBGA | YFP | 6 | 3000 | 190.5 | 212.7 | 31.8 |
| TPS22921YZPR | DSBGA | YZP | 6 | 3000 | 220.0 | 220.0 | 34.0 |
| TPS22922BYZPR | DSBGA | YZP | 6 | 3000 | 220.0 | 220.0 | 34.0 |
| TPS22922YZPR | DSBGA | YZP | 6 | 3000 | 220.0 | 220.0 | 34.0 |

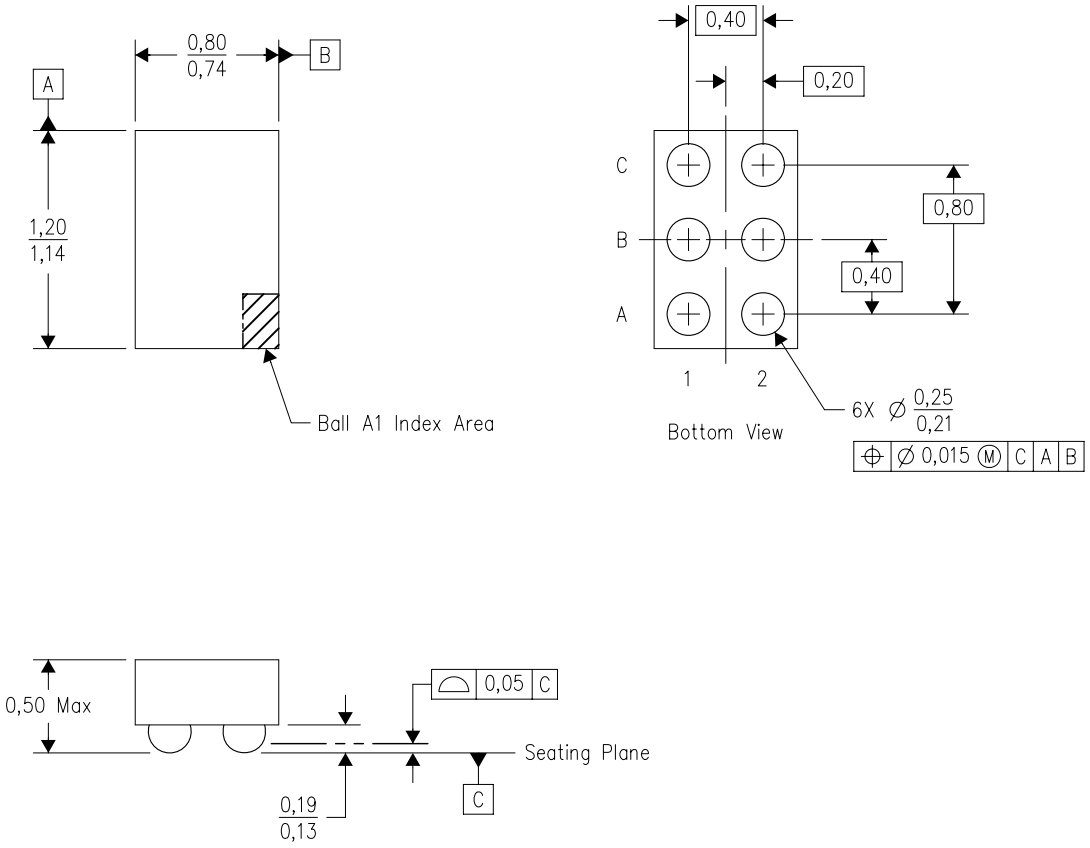
YZP (R–XBGA–N6) DIE–SIZE BALL GRID ARRAY




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 lead–free. 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/P 04/2010

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 is a Pb–free solder ball design.

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