TPS2290x Ultra-Small Low-Input-Voltage Low r_{ON} Load Switch

1 Features

- Input Voltage: 1.1 V to 3.6 V
- Ultralow ON-State Resistance
  - r_{ON} = 66 mΩ at V_{IN} = 3.6 V
  - r_{ON} = 75 mΩ at V_{IN} = 2.5 V
  - r_{ON} = 90 mΩ at V_{IN} = 1.8 V
  - r_{ON} = 135 mΩ at V_{IN} = 1.2 V
- 500-mA Maximum Continuous Switch Current
- Quiescent Current < 1 µA
- Shutdown Current < 1 µA
- Low Control Input Threshold Enables Use of 1.2-V, 1.8-V, 2.5-V, and 3.3-V Logic
- Controlled Slew Rate (5 µs Maximum at 3.6 V)
- Quick Output Discharge (TPS22904 Only)
- ESD Performance Tested Per JESD 22
  - 2000-V Human Body Model (A114-B, Class II)
  - 1000-V Charged-Device Model (C101)
- 4-Terminal Wafer Chip-Scale Package (WCSP)
  - 0.8 mm × 0.8 mm, 0.4-mm Pitch, 0.5-mm Height

2 Applications

- PDAs
- Cell Phones
- GPS Devices
- MP3 Players
- Digital Cameras
- Peripheral Ports
- Portable Instrumentation

3 Description

The TPS22903 and TPS22904 are ultra-small, low r_{ON} single channel load switches with controlled turnon. The device contains a P-channel MOSFET that can operate over an input voltage range of 1.1 V to 3.6 V. The switch is controlled by an on and off input (ON), which is capable of interfacing directly with low-voltage control signals. In TPS22904, a 85-Ω on-chip load resistor is added for output quick discharge when switch is turned off.

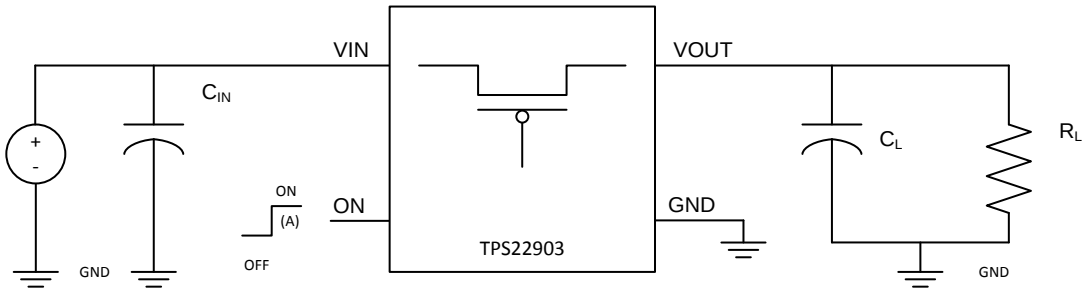
TPS22903 and TPS22904 are available in a space-saving 4-terminal WCSP 0.4-mm pitch (YFP). The devices are characterized for operation over the free-air temperature range of –40°C to 85°C.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TPS22903	DSBGA (4)	0.80 mm × 0.80 mm
TPS22904		

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

Simplified Schematic



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4 Revision History

Changes from Revision C (April 2010) to Revision D **Page**

- Added *Pin Configuration and Functions* section, *ESD Ratings* 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
- Removed *Ordering Information* table ... 1
- Renamed *Feature List* table to *Device Comparison* table ... 3

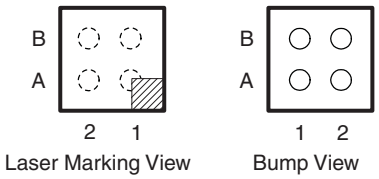
5 Device Comparison Table

DEVICE	r_{ON} TYPICAL AT 3.6 V	SLEW RATE AT 3.6 V	QUICK OUTPUT DISCHARGE(1)	MAXIMUM OUTPUT CURRENT	ENABLE
TPS22903	66 mΩ	5 µs max	No	500 mA	Active high
TPS22904	66 mΩ	5 µs max	Yes	500 mA	Active high

(1) This feature discharges the output of the switch to ground through a 85-Ω resistor, preventing the output from floating.

6 Pin Configuration and Functions

YFP Package
20-Pin DSBGA
Top View



Pin Functions

PIN		I/O	DESCRIPTION
BALL NO.	NAME		
A1	V_{IN}	I	Input of the switch, bypass this input with a ceramic capacitor to ground
A2	V_{OUT}	O	Output of the switch
B1	ON	I	Switch control input, active high, do not leave floating
B2	GND	—	Ground

7 Specifications

7.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
V_{IN}	Input voltage	–0.3	4	V
V_{OUT}	Output voltage		V_{IN} + 0.3	V
V_{ON}	Input voltage	–0.3	4	V
P_D	Power dissipation at T_A = 25°C		0.48	W
I_{MAX}	Maximum continuous switch current		0.5	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, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

7.2 ESD Ratings

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

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

7.3 Recommended Operating Conditions

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

		MIN	MAX	UNIT
V_{IN}	Input voltage	1.1	3.6	V
V_{OUT}	Output voltage		V_{IN}	V
V_{IH}	High-level input voltage, ON	0.85	3.6	V
V_{IL}	Low-level input voltage, ON		0.4	V
C_{IN}	Input capacitor	1		µF

7.4 Thermal Information

THERMAL METRIC (1)		TPS22903 YFP (DSBGA) 20 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	192.6	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	2.3	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	35.8	°C/W
ψ_{JT}	Junction-to-top characterization parameter	11.8	°C/W
ψ_{JB}	Junction-to-board characterization parameter	35.6	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	—	°C/W

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

7.5 Electrical Characteristics

V_{IN} = 1.1 V to 3.6 V, T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T_A	MIN	TYP (1)	MAX	UNIT
I_{IN}	Quiescent current	I_{OUT} = 0, V_{IN} = V_{ON}		Full			1	µA
$I_{IN(OFF)}$	OFF-state supply current	V_{ON} = GND, OUT = Open		Full			1	µA
$I_{IN(LEAKAGE)}$	OFF-state switch current	V_{ON} = GND, V_{OUT} = 0		Full			1	µA
r_{ON}	ON-state resistance	I_{OUT} = –200 mA	V_{IN} = 3.6 V	25°C		66	90	mΩ
				Full			95	
			V_{IN} = 2.5 V	25°C		75	95	
				Full			110	
			V_{IN} = 1.8 V	25°C		90	115	
				Full			125	
			V_{IN} = 1.2 V	25°C		135	175	
				Full			185	
			V_{IN} = 1.1 V	25°C		157	275	
				Full			300	
r_{PD}	Output pulldown resistance	V_{IN} = 3.3 V, V_{ON} = 0 (TPS22904 only), I_{OUT} = 30 mA				85	135	Ω
I_{ON}	ON-state input leakage current	V_{ON} = 1.1 V to 3.6 V or GND		Full			1	µA

(1) Typical values are at V_{IN} = 3.3 V and T_A = 25°C.

7.6 Switching Characteristics

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

PARAMETER		TEST CONDITIONS	TPS22903			TPS22904			UNIT
			MIN	TYP(1)	MAX	MIN	TYP(1)	MAX	
t_{ON}	Turnon time	I_{OUT} = 100 mA, C_L = 0.1 µF		0.9	1.5		0.9	1.5	µs
t_{OFF}	Turnoff time	I_{OUT} = 100 mA, C_L = 0.1 µF		5.8	8		5.3	7	µs
t_r	V_{OUT} rise time	I_{OUT} = 100 mA, C_L = 0.1 µF		0.80	5		0.8	5	µs
t_f	V_{OUT} fall time	I_{OUT} = 100 mA, C_L = 0.1 µF		8.3	10		5.8	7	µs

(1) Typical values are at T_A = 25°C.

7.7 Typical Characteristics

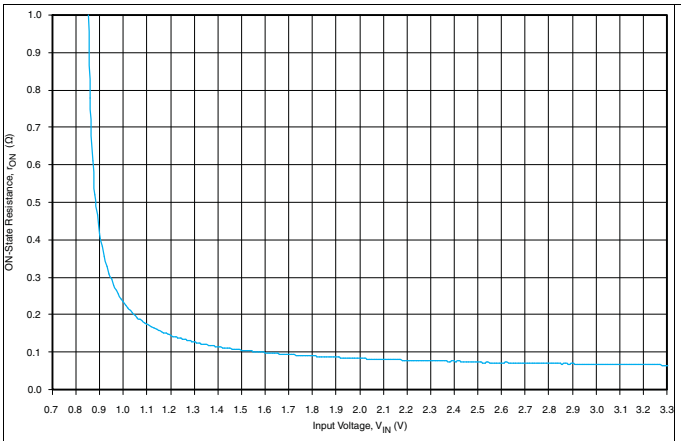


Figure 1. r_{ON} vs V_{IN}

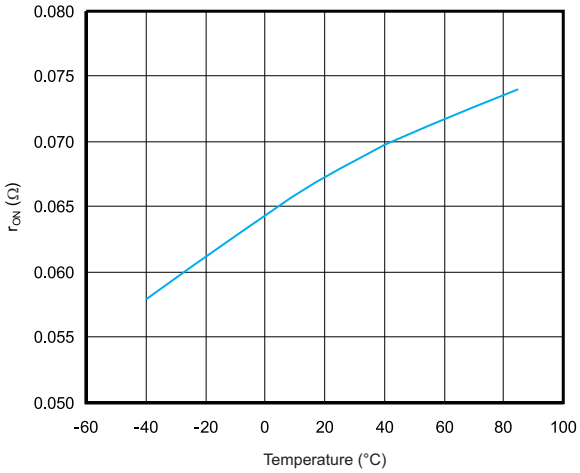


Figure 2. r_{ON} vs Temperature (V_{IN} = 3.3 V)

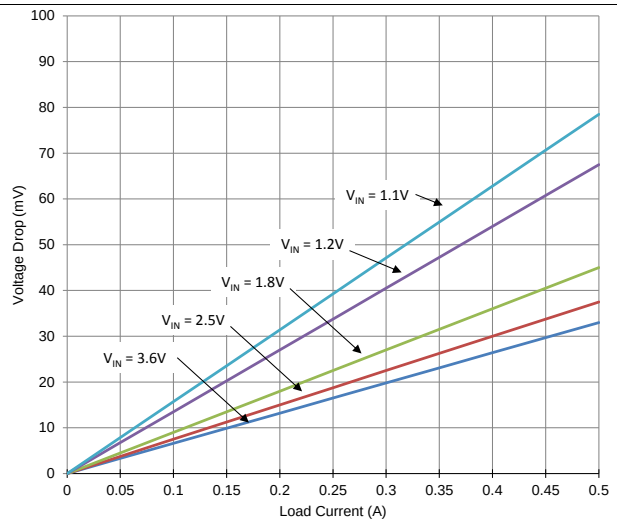


Figure 3. Voltage Drop vs Load Current

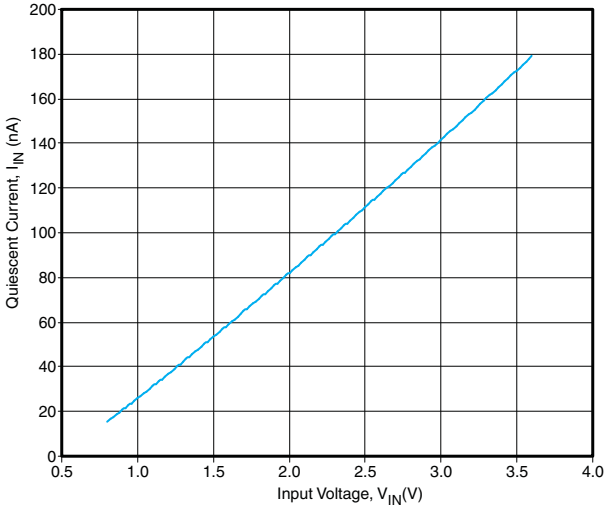


Figure 4. Quiescent Current vs V_{IN} (V_{ON} = V_{IN}, I_{OUT} = 0)

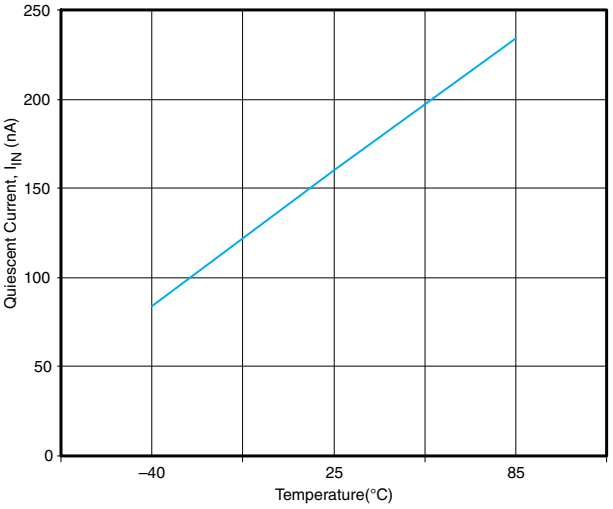


Figure 5. Quiescent Current vs Temperature (V_{IN} = 3.3 V, I_{OUT} = 0)

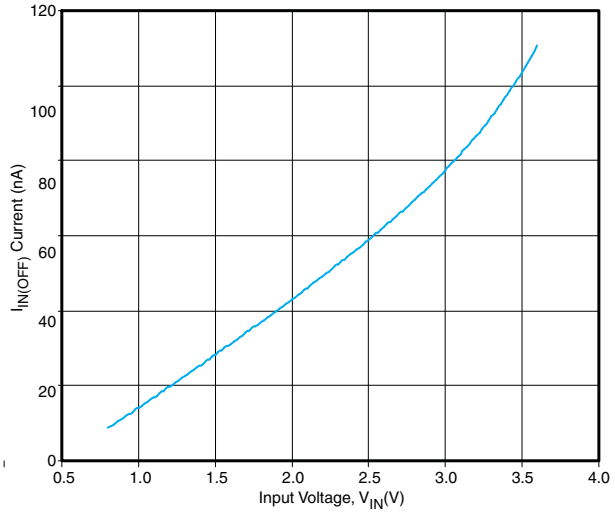


Figure 6. $I_{IN(OFF)}$ vs V_{IN} (V_{ON} = 0 V)

Typical Characteristics (continued)

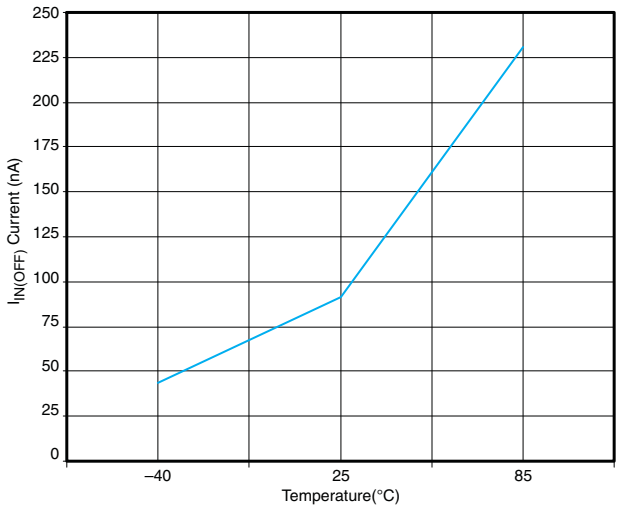


Figure 7. $I_{IN(OFF)}$ vs Temperature (V_{IN} = 3.3 V)

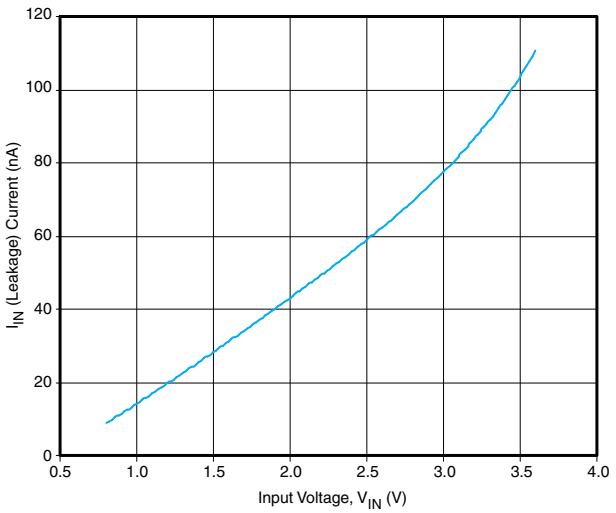


Figure 8. I_{IN}(Leakage) vs V_{IN} (I_{OUT} = 0)

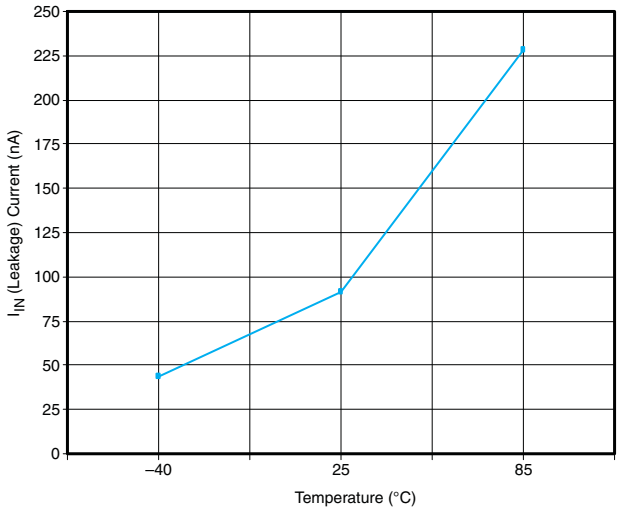


Figure 9. I_{IN} (Leakage) vs Temperature (V_{IN} = 3.3 V)

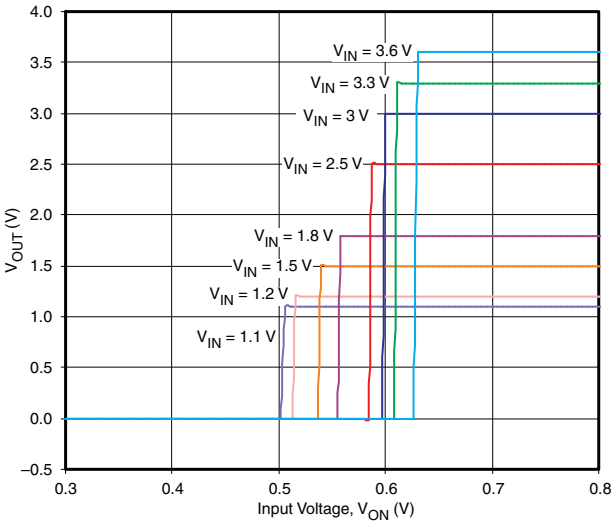


Figure 10. ON-Input Threshold

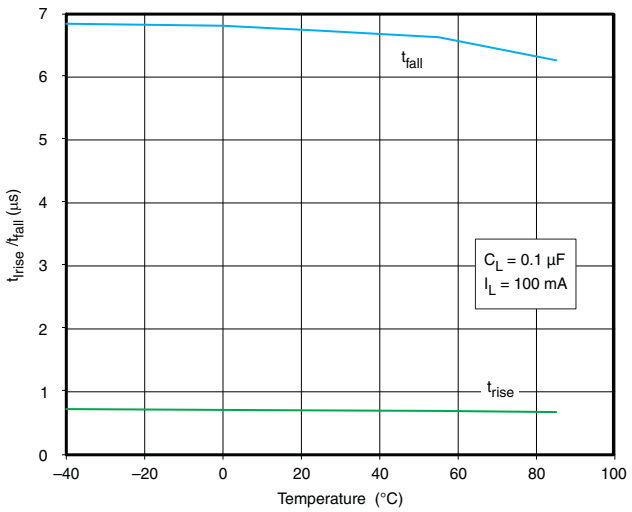


Figure 11. t_{rise} (TPS22903/4) / t_{fall} (TPS22903) vs Temperature (V_{IN} = 3.3 V)

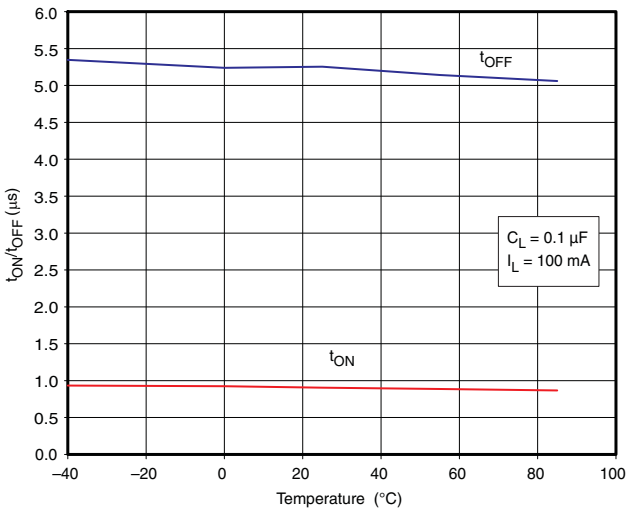


Figure 12. t_{ON} (TPS22903/4) / t_{OFF} (TPS22903) vs Temperature (V_{IN} = 3.3 V)

Typical Characteristics (continued)

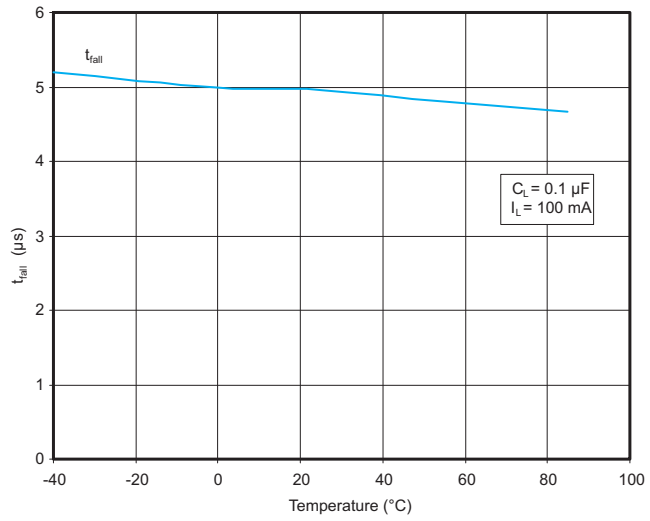


Figure 13. t_{fall} (TPS22904) vs Temperature (V_{IN} = 3.3 V)

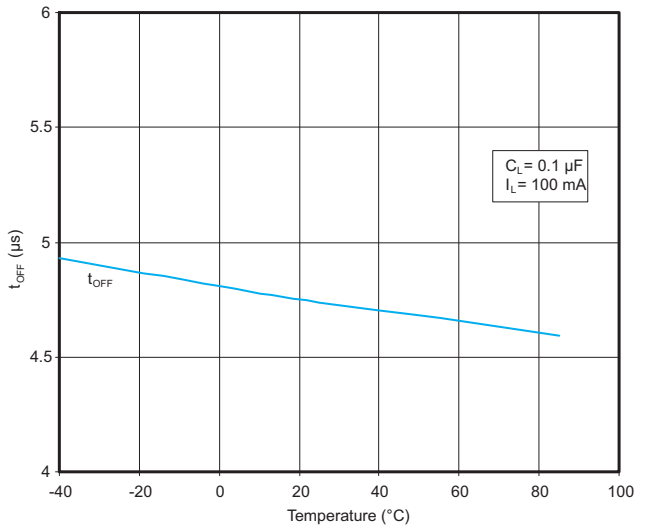


Figure 14. t_{OFF} (TPS22904) vs Temperature (V_{IN} = 3.3 V)

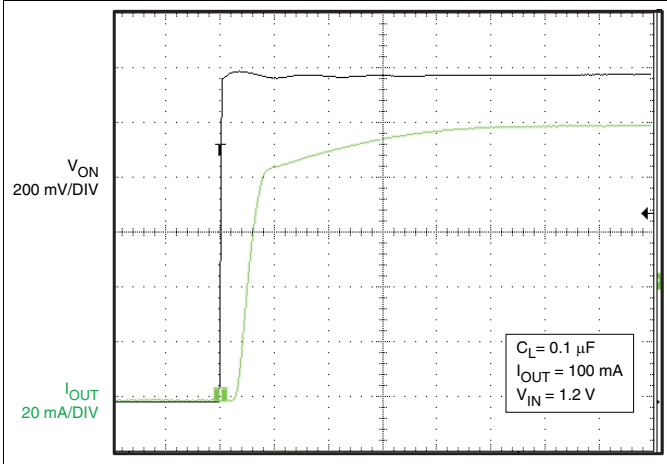


Figure 15. t_{ON} Response

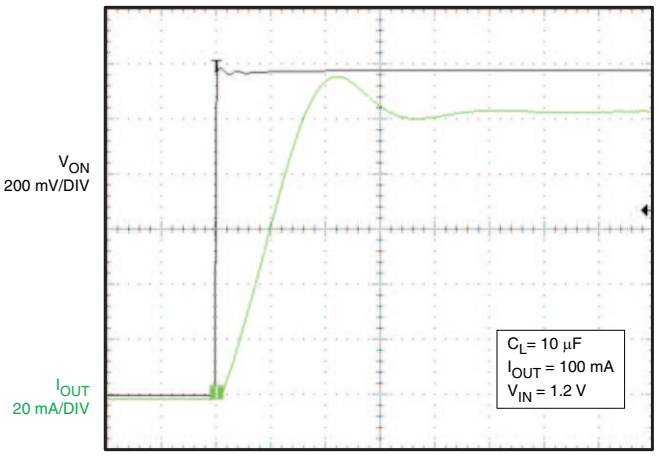


Figure 16. t_{ON} Response

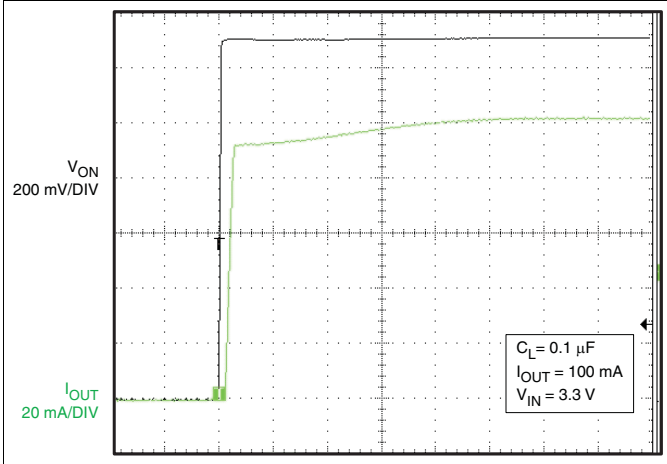


Figure 17. t_{ON} Response

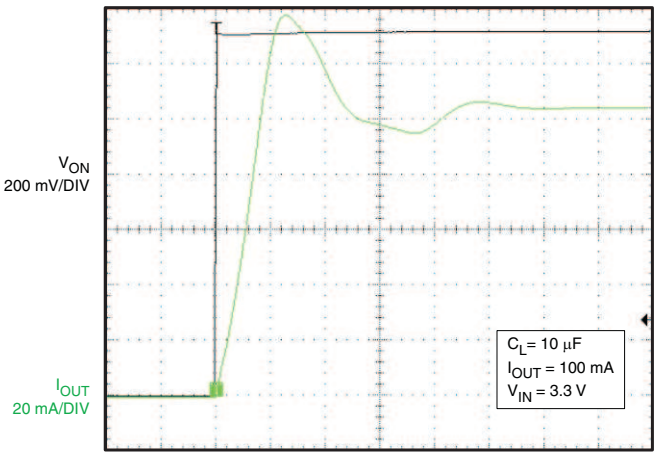


Figure 18. t_{ON} Response

Typical Characteristics (continued)

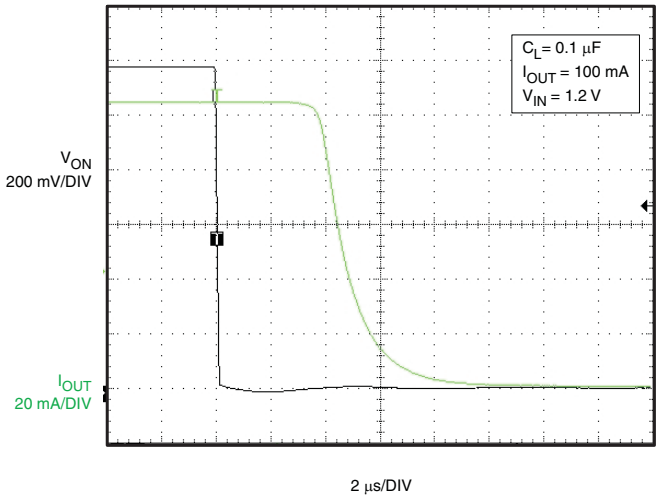


Figure 19. t_{OFF} Response (TPS22903)

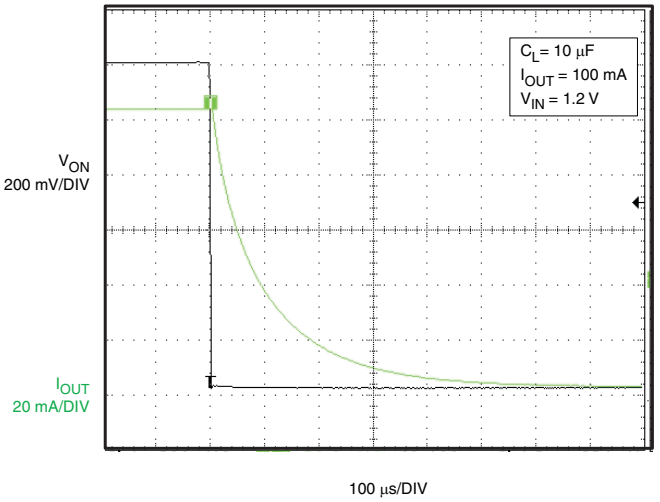


Figure 20. t_{OFF} Response (TPS22903)

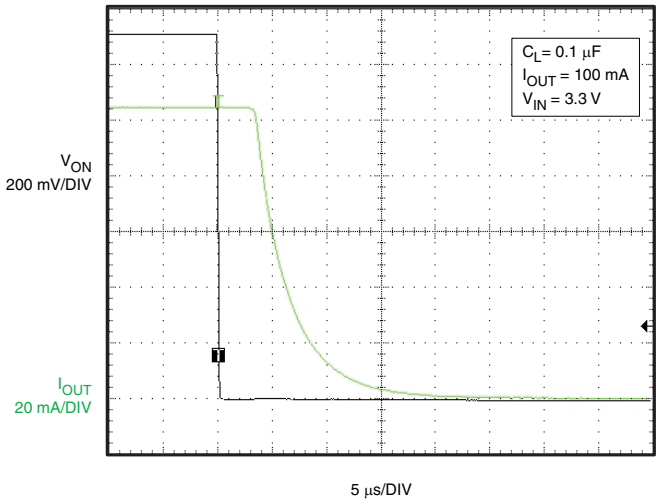


Figure 21. t_{OFF} Response (TPS22903)

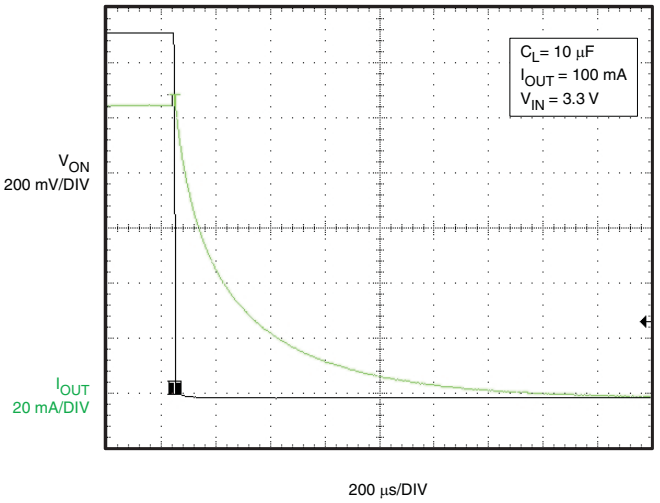


Figure 22. t_{OFF} Response (TPS22903)

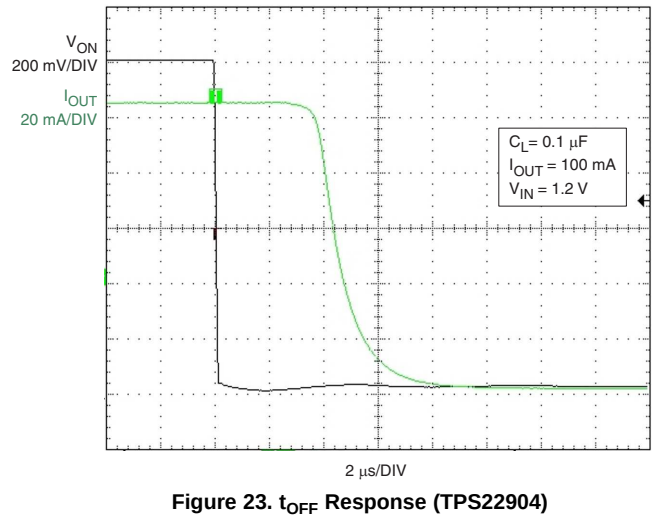


Figure 23. t_{OFF} Response (TPS22904)

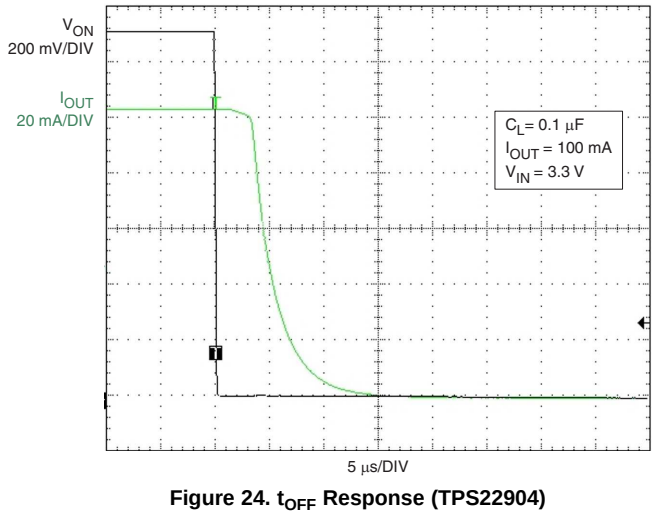


Figure 24. t_{OFF} Response (TPS22904)

Typical Characteristics (continued)

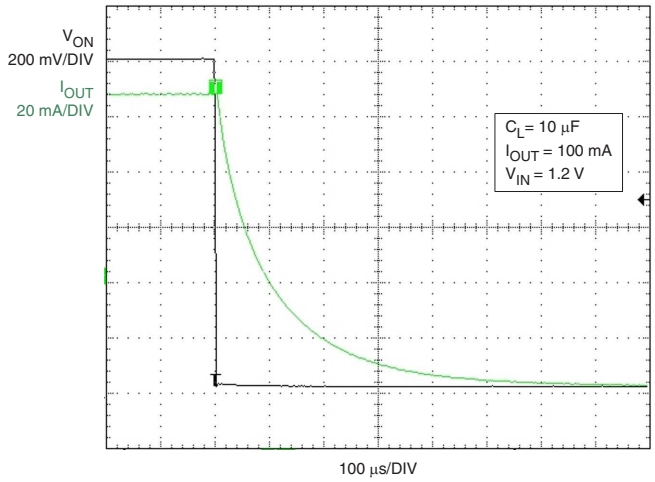


Figure 25. t_{OFF} Response (TPS22904)

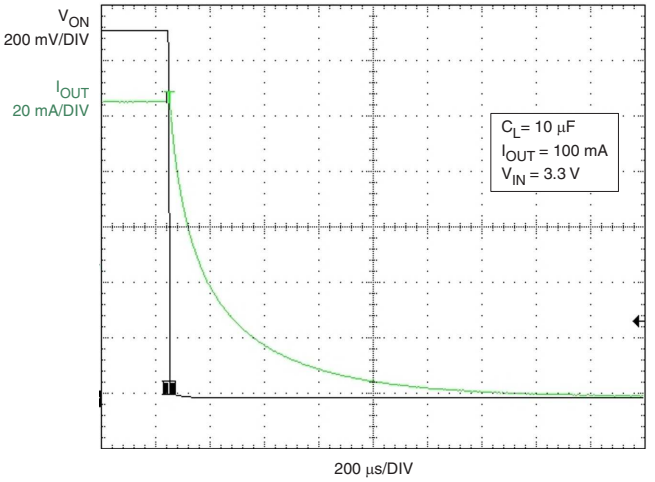
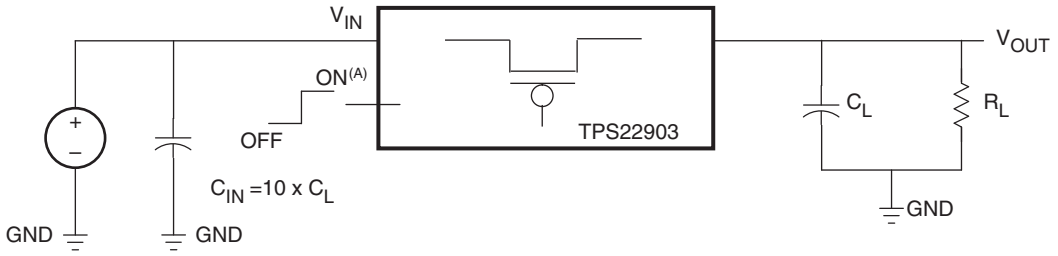
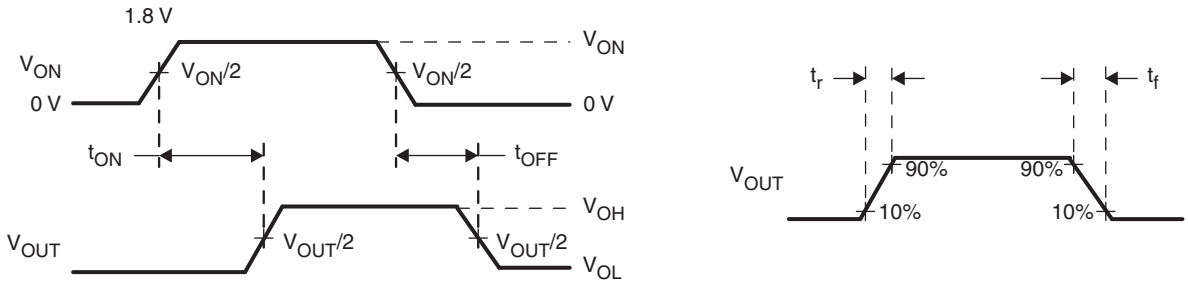


Figure 26. t_{OFF} Response (TPS22904)

8 Parameter Measurement Information



TEST CIRCUIT



t_{ON}/t_{OFF} WAVEFORMS

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

Figure 27. Test Circuit and t_{ON}/t_{OFF} Waveforms

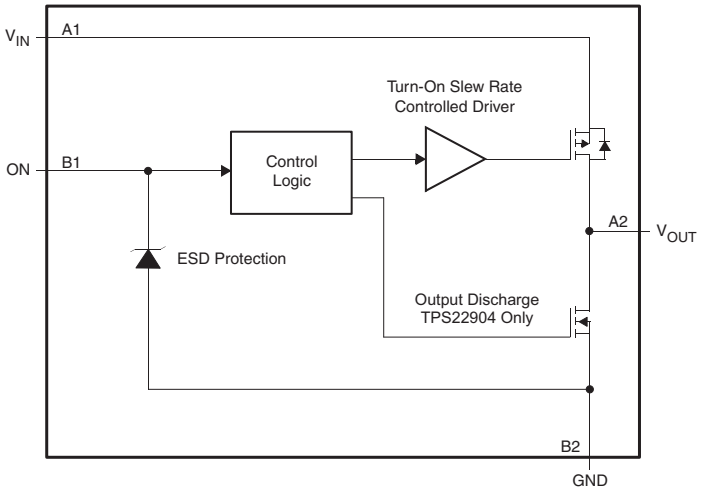
9 Detailed Description

9.1 Overview

The TPS22903 and TPS22904 are single-channel load switches with controlled turnon.

The devices contain a P-channel MOSFET that can operate over an input voltage range of 1.1 V to 3.6 V. The switch is controlled by an on and off input (ON), which is capable of interfacing directly with low-voltage control signals. In TPS22904, a 85-Ω on-chip load resistor is added for output quick discharge when switch is turned off. Both devices are available in a space-saving 4-terminal WCSP 0.4-mm pitch (YFP).

9.2 Functional Block Diagram



9.3 Feature Description

9.3.1 ON/OFF Control

The ON pin controls the state of the switch. Activating ON continuously holds the switch in the ON-state as there is no fault. 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 thresholds. It can be used with any microcontroller with 1.2-V, 1.8-V, 2.5-V, or 3.3-V GPIOs.

9.4 Device Functional Modes

Table 1 lists the VOUT pin connections as determined by the ON pin.

Table 1. Functional Table

ON (CONTROL INPUT)	V_{IN} TO V_{OUT}	V_{OUT} TO GND (TPS22904 ONLY)
L	OFF	ON
H	ON	OFF

10 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

10.1 Application Information

10.1.1 Input Capacitor (Optional)

To limit the voltage drop on the input supply caused by transient in-rush currents when the switch turns on into a discharged load capacitor or short-circuit, a capacitor needs to be placed between V_{IN} and GND. A 1-µF ceramic capacitor, C_{IN}, placed close to the pins, is usually sufficient. Higher values of C_{IN} can be used to further reduce the voltage drop during high-current application. When switching heavy loads, TI recommends to have an input capacitor about 10 times higher than the output capacitor to avoid excessive voltage drop.

10.1.2 Output Capacitor (Optional)

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}.

10.2 Typical Application

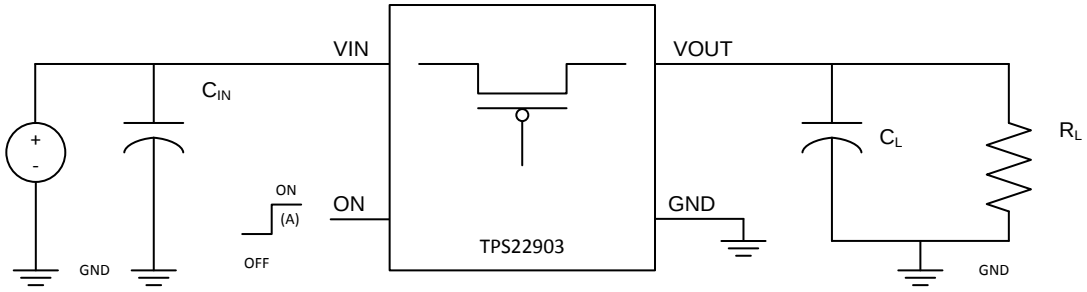


Figure 28. Typical Application Schematic

10.2.1 Design Requirements

Table 2 lists the design parameters for the TPS22903 device.

Table 2. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
VIN	1.8 V
Load Current	0.3 A
Ambient Temperature	25°C

10.2.2 Detailed Design Procedure

10.2.2.1 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. RON can be found in *Electrical Characteristics* and is dependent on temperature. When the value of RON is found, Equation 1 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 (1)

At VIN = 1.8 V, the TPS22903/4 has an RON value of 90 mΩ. Using this value and the defined load current, the above equation can be evaluated:

$$\Delta V = 0.30\ A \times 90\ m\Omega$$

where

- ΔV = 27 mV (2)

Therefore, the voltage drop across the device will be 27 mV.

10.2.3 Application Curve

Figure 29 shows the expected voltage drop across the device for different load currents and input voltages.

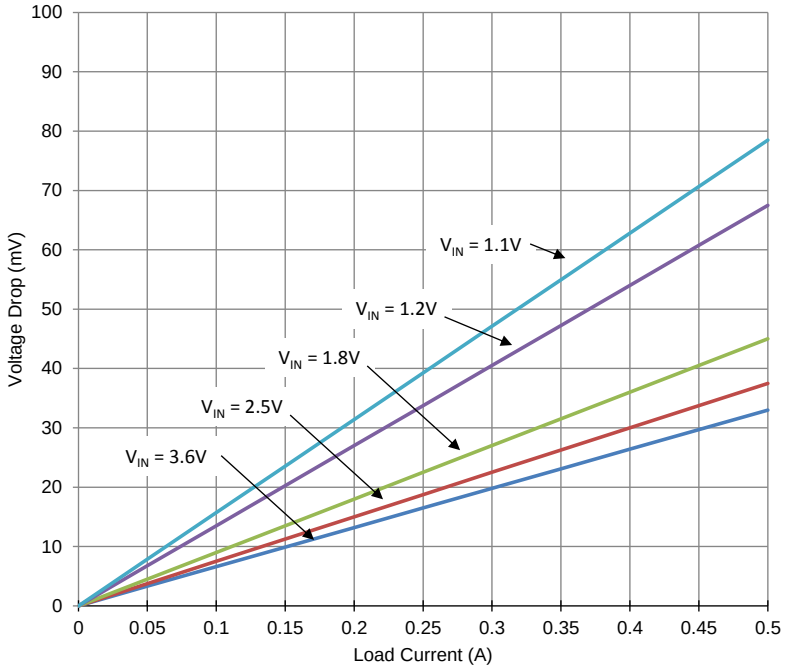


Figure 29. Voltage Drop vs Load Current

11 Power Supply Recommendations

The device is designed to operate with a VIN range of 1.1 V to 3.6 V. This supply must be well regulated and placed as close to the device terminals as possible. It must also be able to withstand all transient and load currents, using a recommended input capacitance of 1 µF if necessary. If the supply is more than a few inches from the device terminals, additional bulk capacitance may be required in addition to the ceramic bypass capacitors. If additional bulk capacitance is required, an electrolytic, tantalum, or ceramic capacitor of 10 µF may be sufficient.

12 Layout

12.1 Layout Guidelines

For best performance, all traces should be as short as possible. To be most effective, the input and output capacitors should be placed close to the device to minimize the effects that parasitic trace inductances may have on normal and short-circuit operation. Using wide traces for V_{IN}, V_{OUT}, and GND helps minimize the parasitic electrical effects along with minimizing the case-to-ambient thermal impedance.

12.2 Layout Example

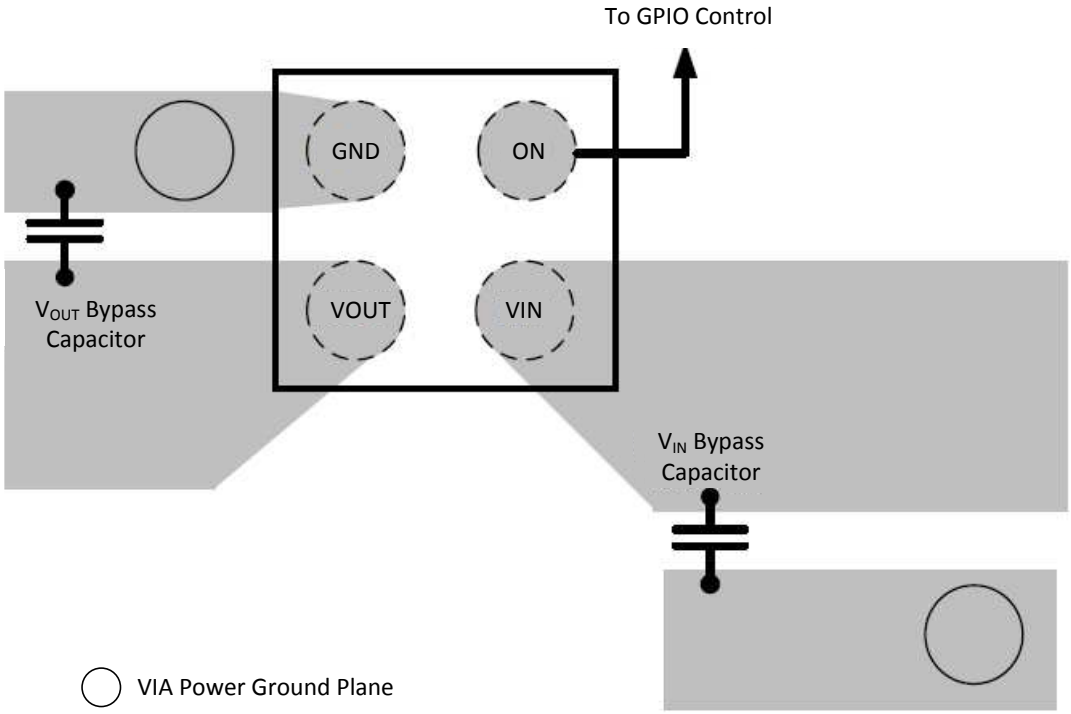


Figure 30. Layout Example Recommendation

13 Device and Documentation Support

13.1 Related Links

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

Table 3. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
TPS22903	Click here	Click here	Click here	Click here	Click here
TPS22904	Click here	Click here	Click here	Click here	Click here

13.2 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

TI E2E™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

13.3 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

13.4 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.

13.5 Glossary

SLYZ022 — *TI Glossary*.

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

14 Mechanical, Packaging, and Orderable Information

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

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TPS22904YFPR	Active	Production	DSBGA (YFP) | 4	3000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	4R (2, N)
TPS22904YFPR.B	Active	Production	DSBGA (YFP) | 4	3000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	4R (2, N)
TPS22904YFPT	Active	Production	DSBGA (YFP) | 4	250 | SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	4R (2, N)
TPS22904YFPT.B	Active	Production	DSBGA (YFP) | 4	250 | SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	4R (2, N)

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

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

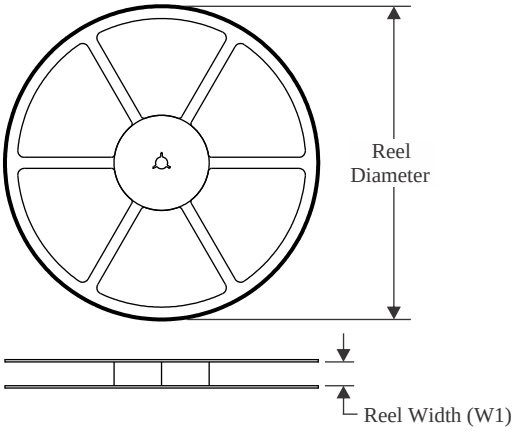
(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

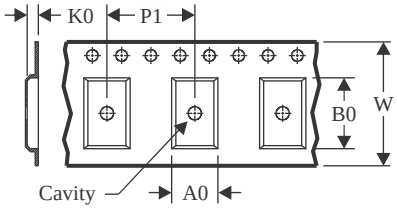
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

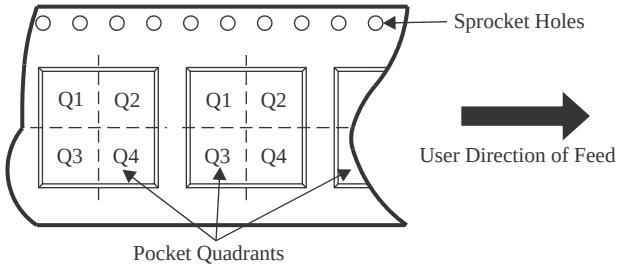


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

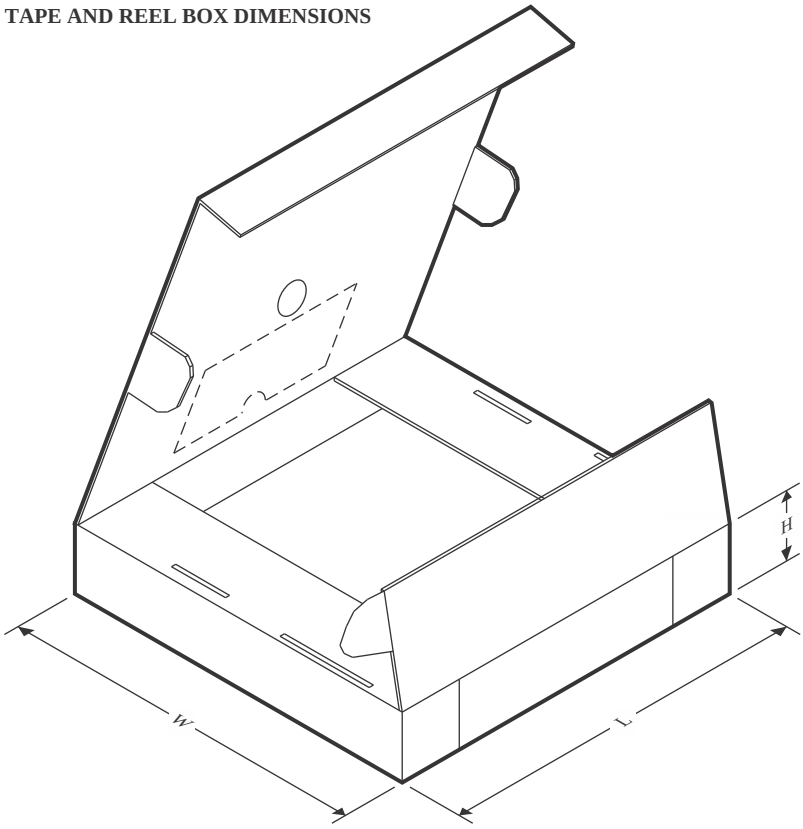
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TPS22904YFPR	DSBGA	YFP	4	3000	178.0	9.2	0.89	0.89	0.58	4.0	8.0	Q1
TPS22904YFPT	DSBGA	YFP	4	250	178.0	9.2	0.89	0.89	0.58	4.0	8.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

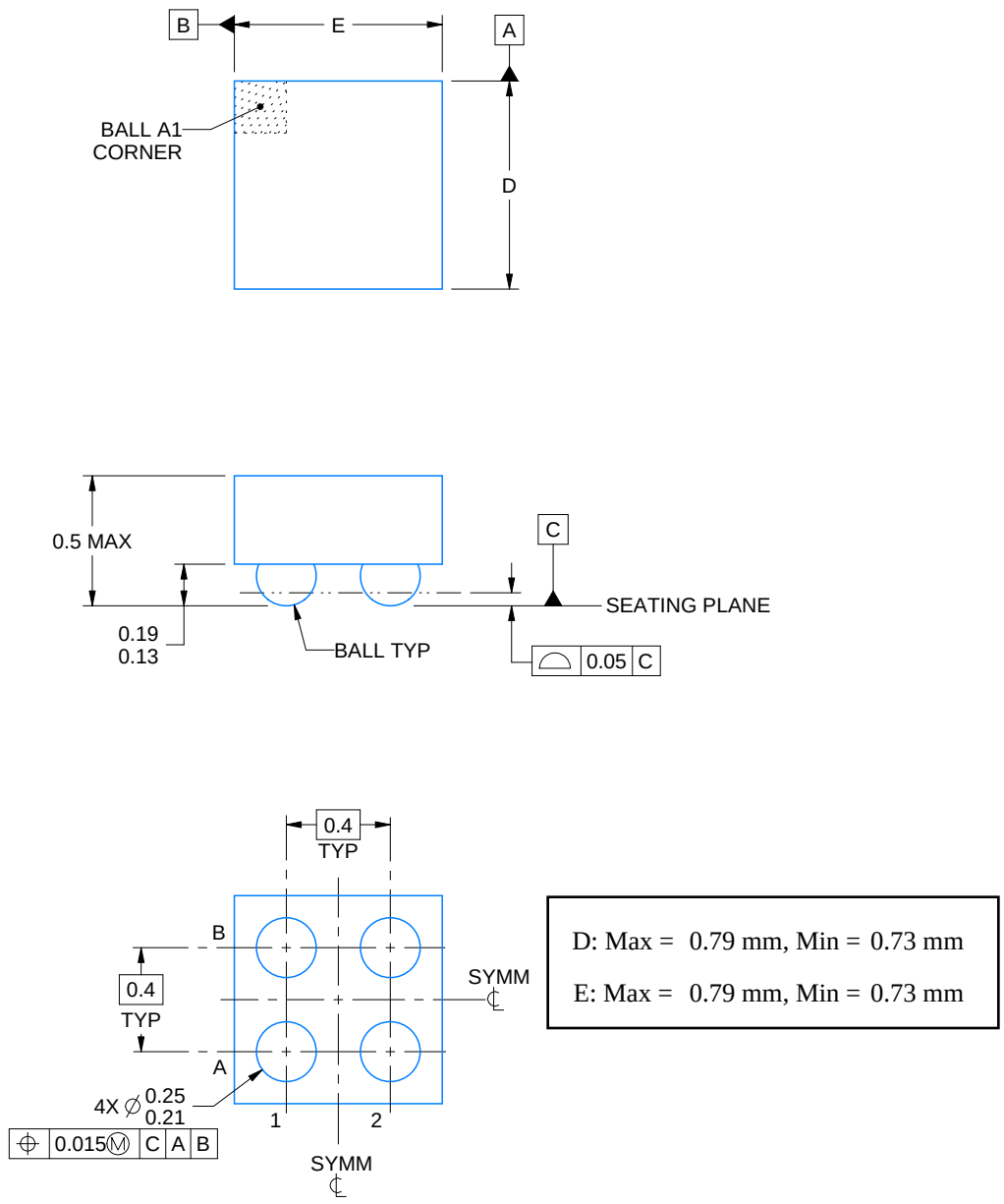
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS22904YFPR	DSBGA	YFP	4	3000	220.0	220.0	35.0
TPS22904YFPT	DSBGA	YFP	4	250	220.0	220.0	35.0

PACKAGE OUTLINE

YFP0004

DSBGA - 0.5 mm max height

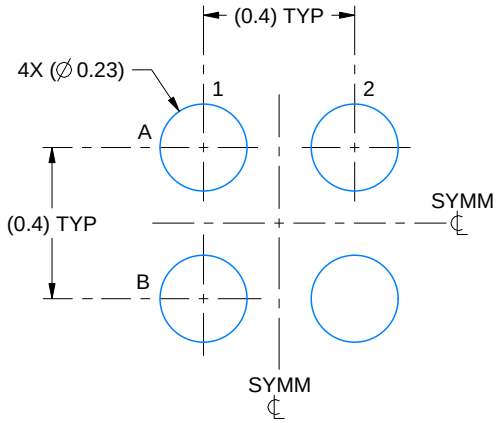
DIE SIZE BALL GRID ARRAY



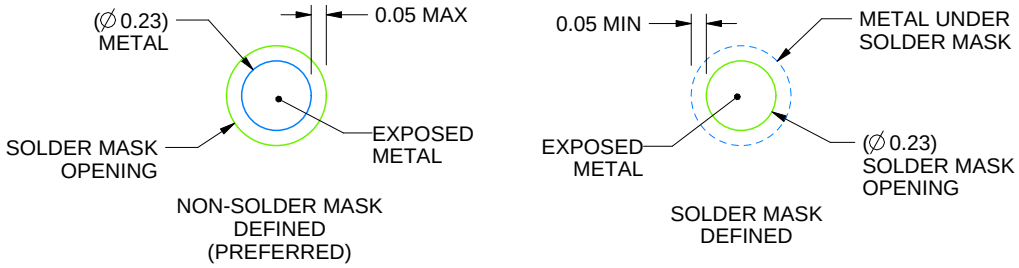
4223507/A 01/2017

NOTES:

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



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:50X



SOLDER MASK DETAILS
NOT TO SCALE

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NOTES: (continued)

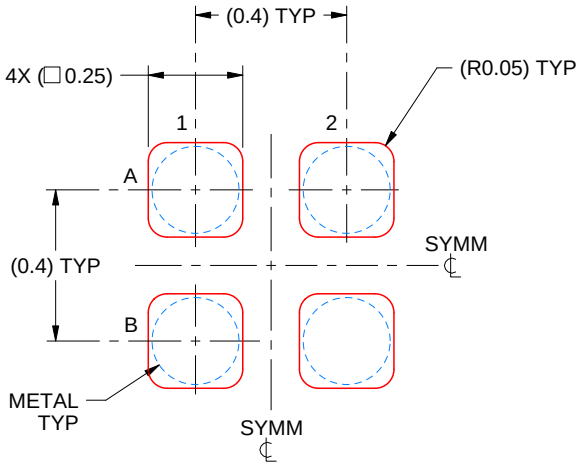
3. Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints.
For more information, see Texas Instruments literature number SNVA009 (www.ti.com/lit/snva009).

EXAMPLE STENCIL DESIGN

YFP0004

DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY



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

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NOTES: (continued)

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

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