ULTRA-SMALL, LOW-INPUT-VOLTAGE, LOW R_{ON} LOAD SWITCH

Check for Samples: TPS22924D

FEATURES

- **Integrated Single Load Switch**
- **Input Voltage: 0.75 V to 3.6 V**
- **Ultra-Low ON Resistance**
  - **r_{ON} = 18.3 mΩ at V_{IN} = 3.6 V**
  - **r_{ON} = 18.5 mΩ at V_{IN} = 2.5 V**
  - **r_{ON} = 19.6 mΩ at V_{IN} = 1.8 V**
  - **r_{ON} = 19.4 mΩ at V_{IN} = 1.2 V**
  - **r_{ON} = 20.3 mΩ at V_{IN} = 1.0 V**
  - **r_{ON} = 22.7 mΩ at V_{IN} = 0.75 V**
- **Ultra Small CSP-6 package 0.9 mm x 1.4 mm, 0.5-mm Pitch**
- **2-A Maximum Continuous Switch Current**
- **Low Shutdown Current**
- **Low Threshold Control Input**
- **Controlled Slew Rate to Avoid Inrush Currents**
- **Quick Output Discharge Transistor**
- **ESD Performance Tested Per JESD 22**
  - **5000-V Human-Body Model (A114-B, Class II)**
  - **1000-V Charged-Device Model (C101)**

APPLICATIONS

- **Battery Powered Equipment**
- **Portable Industrial Equipment**
- **Portable Medical Equipment**
- **Portable Media Players**
- **Point Of Sales Terminal**
- **GPS Devices**
- **Digital Cameras**
- **Notebooks / Tablet PCs / eReaders**
- **Smartphones**

DESCRIPTION

The TPS22924D is a small, ultra-low R_{ON} load switch with controlled turn on. The device contains a N-channel MOSFET that can operate over an input voltage range of 0.75 V to 3.6 V. An integrated charge pump biases the NMOS switch to achieve a minimum switch ON resistance. The switch is controlled by an on/off input (ON), which is capable of interfacing directly with low-voltage control signals.

A 1250-Ω on-chip load resistor is added for output quick discharge when the switch is turned off. The rise time of the device is internally controlled to avoid inrush current. The TPS22924D features a rise time of 6200 µs at 3.6 V.

The TPS22924D is available in an ultra-small space-saving 6-pin CSP package and is characterized for operation over the free-air temperature range of –40ºC to 85ºC.

Figure 1. TYPICAL APPLICATION

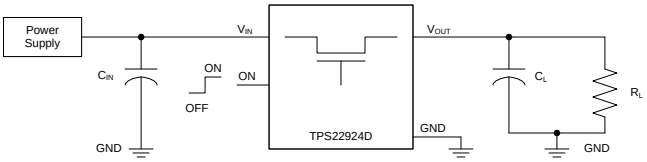


Table 1. FEATURE LIST

	r_{ON} (TYP) AT 3.6 V	SLEW RATE (TYP) AT 3.6 V	QUICK OUTPUT DISCHARGE(1)	MAXIMUM OUTPUT CURRENT	ENABLE
TPS22924D	18.3 mΩ	6200 µs	Yes	2 A	Active high

(1) This feature discharges the output of the switch to ground through a 1250-Ω resistor, preventing the output from floating. See the *Output Pulldown* section in Application Information.

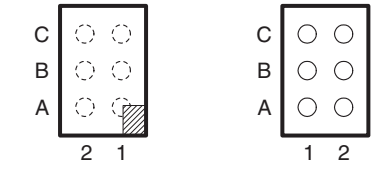
This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

ORDERING INFORMATION

For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com

YZP PACKAGE



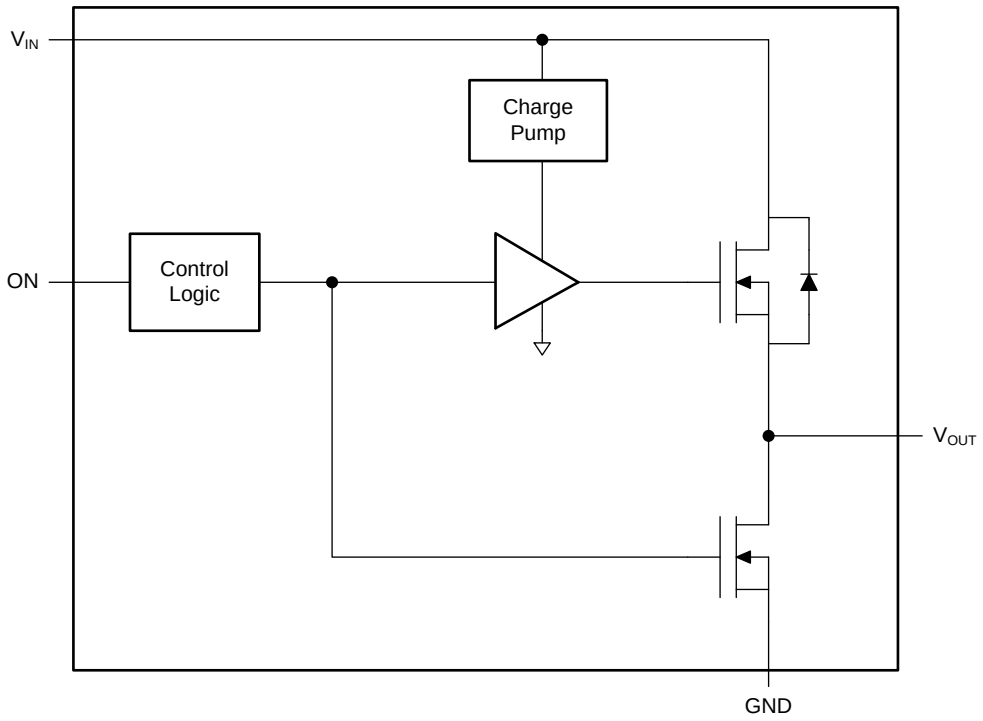
TERMINALS ASSIGNMENTS (YZP PACKAGE)

C	GND	ON
B	VOUT	VIN
A	VOUT	VIN
	1	2

TERMINAL FUNCTIONS

NO.	NAME	DESCRIPTION
C1	GND	Ground
C2	ON	Switch control input, active high. Do not leave floating
A1, B1	VOUT	Switch output
A2, B2	VIN	Switch input. Place a decoupling capacitor from VIN to GND. See Application Information section for details about input capacitors.

BLOCK DIAGRAM



FUNCTION TABLE

ON (Control Signal)	VIN to VOUT	VOUT to GND(1)
L	OFF	ON
H	ON	OFF

(1) See application section *Output Pulldown*.

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}	ON pin voltage range		–0.3	4	V
I_{MAX}	Maximum continuous switch current, T_A = -40°C to 85°C			2	A
I_{PLS}	Maximum pulsed switch current, 100-µs pulse, 2% duty cycle, T_A = -40°C to 85°C			4	A
T_A	Operating free-air temperature range		–40	85	°C
T_{stg}	Storage temperature range		–65	150	°C
ESD	Electrostatic discharge protection	Human-Body Model (HBM)		5000	V
		Charged-Device Model (CDM)		1000	

(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.

DISSIPATION RATINGS

BOARD	PACKAGE	$R_{\theta JC}$	$R_{\theta JA}$	DERATING FACTOR ABOVE T_A = 25°C	T_A < 25°C	T_A = 70°C	T_A = 85°C
High-K(1)	YZP	17.6°C/W	123.36°C/W	- 8.1063 mW/°C	810.63 mW	445.84 mW	324.25 mW

(1) The JEDEC high-K (2s2p) board used to derive this data was a 3- × 3-inch, multilayer board with 1-ounce internal power and ground planes and 2-ounce copper traces on top and bottom of the board.

RECOMMENDED OPERATING CONDITIONS

			MIN	MAX	UNIT
V_{IN}	Input voltage		0.75	3.6	V
V_{OUT}	Output voltage			V_{IN}	V
V_{IH}	High-level input voltage, ON	V_{IN} = 2.5 V to 3.6 V	1.2	3.6	V
		V_{IN} = 0.75 V to 2.5 V	0.9	3.6	
V_{IL}	Low-level input voltage, ON	V_{IN} = 2.5 V to 3.6 V		0.6	V
		V_{IN} = 0.75 V to 2.49 V		0.4	
C_{IN}	Input capacitance		1(1)		µF

(1) See the *Input Capacitor* section in Application Information.

ELECTRICAL CHARACTERISTICS

V_{IN} = 0.75 V to 3.6 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T_A	MIN	TYP(1)	MAX	UNIT
$I_{Q, VIN}$	Quiescent current	VOUT = open, V_{IN} = V_{ON}	V_{IN} = 3.6 V	Full		75	160	µA
			V_{IN} = 2.5 V			42	100	
			V_{IN} = 1.8 V			50	350	
			V_{IN} = 1.2 V			95	200	
			V_{IN} = 1.0 V			65	120	
			V_{IN} = 0.75 V			35	80	
$I_{SD, VIN}$	Shutdown current	V_{ON} = GND, VOUT = 0V		Full			4.0	µA
R_{ON}	ON-state resistance	I_{OUT} = -200 mA	V_{IN} = 3.6 V	25°C		18.3	22.8	mΩ
				Full			26.8	
			V_{IN} = 2.5 V	25°C		18.5	23.0	
				Full			27.2	
			V_{IN} = 1.8 V	25°C		19.6	24.1	
				Full			28.1	
			V_{IN} = 1.2 V	25°C		19.4	23.9	
				Full			28.0	
			V_{IN} = 1.0 V	25°C		20.3	24.8	
				Full			29.0	
			V_{IN} = 0.75 V	25°C		22.7	27.2	
				Full			34.8	
R_{PD}	Output pulldown resistance(2)	V_{IN} = 3.3 V, V_{ON} = 0, I_{OUT} = 1 mA		25°C	450		1400	Ω
I_{ON}	ON-pin input leakage current	V_{ON} = 0.9 V to 3.6 V or GND		Full			0.1	µA

(1) Typical values are at V_{IN} = 3.3 V and T_A = 25°C.
(2) See Output Pulldown in *Application Information*.

SWITCHING CHARACTERISTICS

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

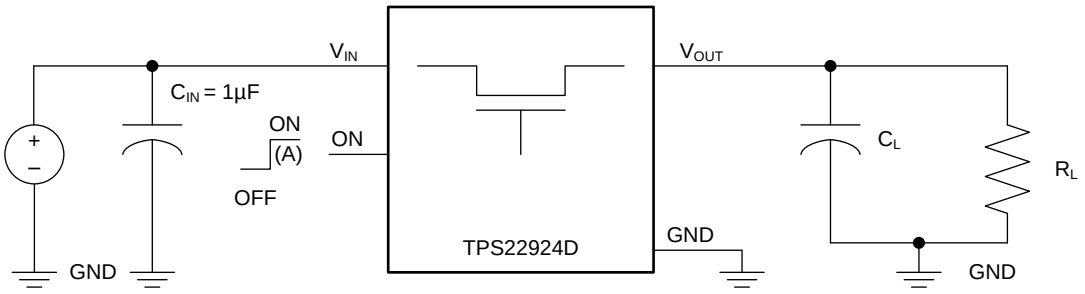
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{ON}	Turn-ON time	R_L = 10 Ω, C_L = 0.1 µF, V_{IN} = 3.6V		7400		µs
t_{OFF}	Turn-OFF time	R_L = 10 Ω, C_L = 0.1 µF, V_{IN} = 3.6V		2.5		µs
t_r	V_{OUT} rise time	R_L = 10 Ω, C_L = 0.1 µF, V_{IN} = 3.6V		6200		µs
t_f	V_{OUT} fall time	R_L = 10 Ω, C_L = 0.1 µF, V_{IN} = 3.6V		2		µs

SWITCHING CHARACTERISTICS

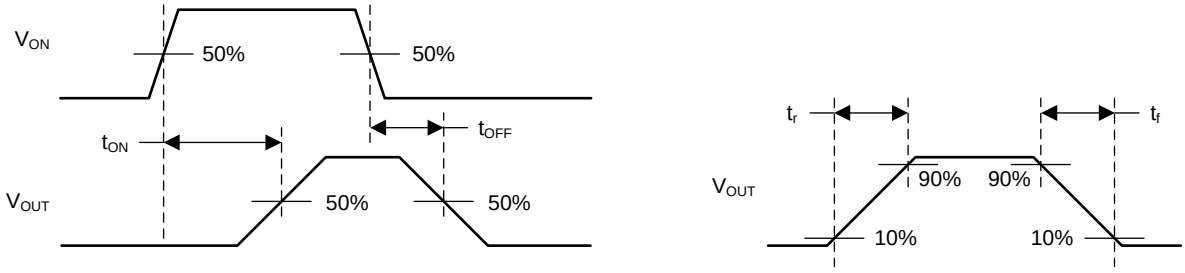
V_{IN} = 0.9 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{ON}	Turn-ON time	R_L = 10 Ω, C_L = 0.1 µF, V_{IN} = 0.9V		6300		µs
t_{OFF}	Turn-OFF time	R_L = 10 Ω, C_L = 0.1 µF, V_{IN} = 0.9V		12		µs
t_r	V_{OUT} rise time	R_L = 10 Ω, C_L = 0.1 µF, V_{IN} = 0.9V		3200		µs
t_f	V_{OUT} fall time	R_L = 10 Ω, C_L = 0.1 µF, V_{IN} = 0.9V		3		µs

PARAMETRIC MEASUREMENT INFORMATION



TEST CIRCUIT



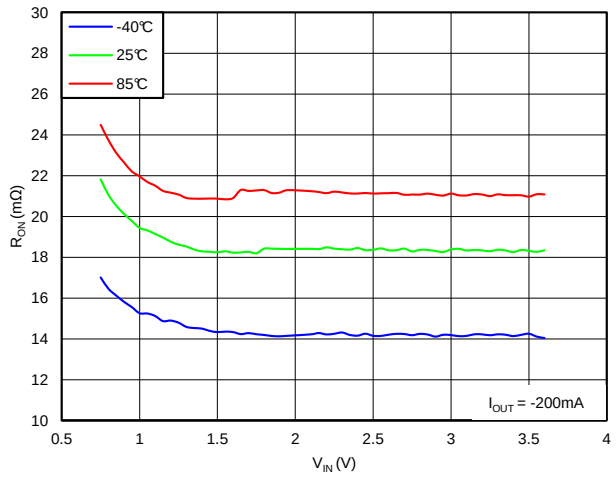
tON/tOFF WAVEFORMS

A. Rise and fall times of the control signal is 100ns

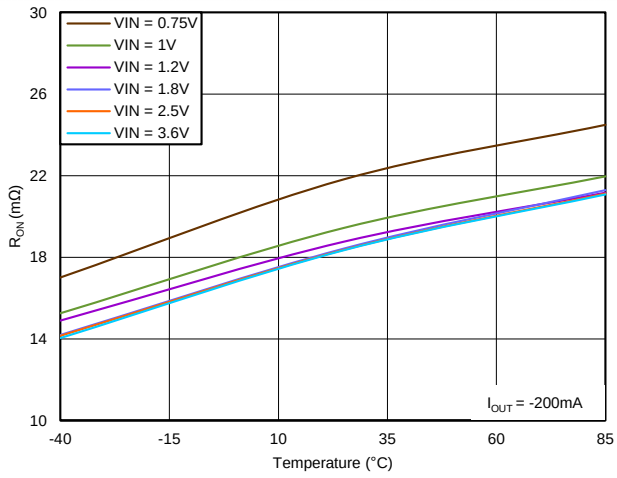
Figure 2. Test Circuit and t_{ON}/t_{OFF} Waveforms

TYPICAL CHARACTERISTICS

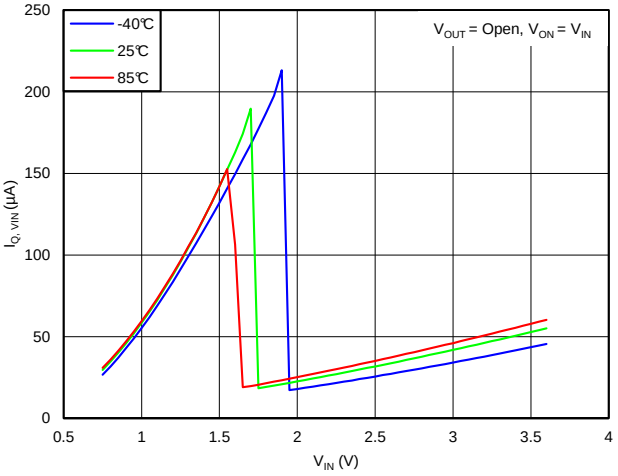
ON-STATE RESISTANCE vs INPUT VOLTAGE



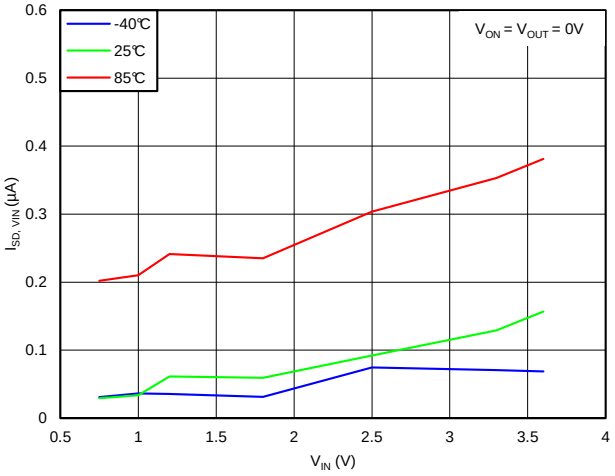
ON-STATE RESISTANCE vs TEMPERATURE



QUIESCENT CURRENT vs INPUT VOLTAGE

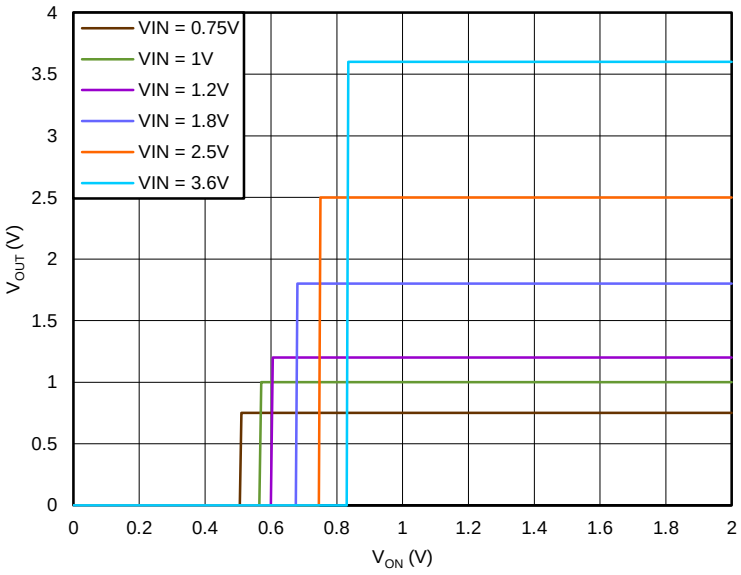


SHUTDOWN CURRENT vs INPUT VOLTAGE

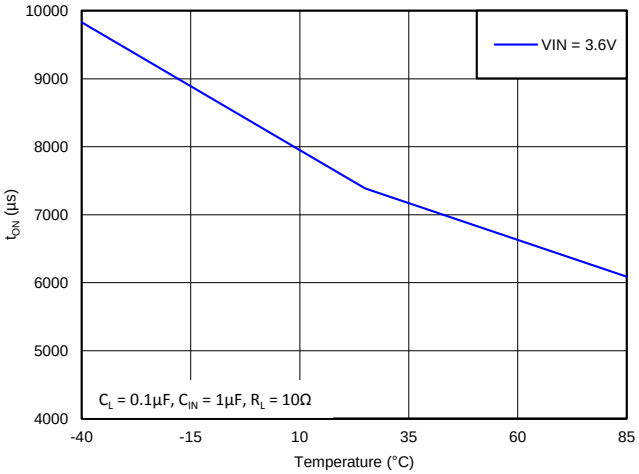


TYPICAL CHARACTERISTICS (continued)

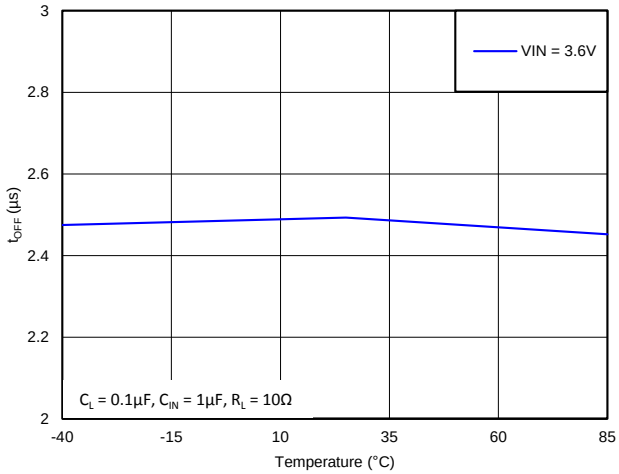
ON INPUT THRESHOLD



TURN-ON TIME vs TEMPERATURE
V_{IN} = 3.6 V, C_L = 0.1 µF, R_L = 10 Ω

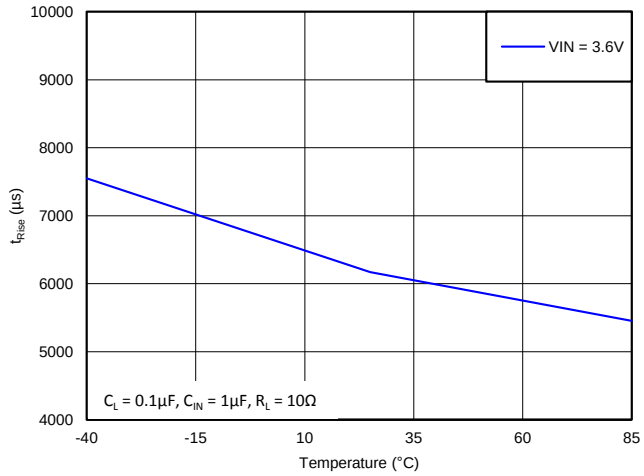


TURN-OFF TIME vs TEMPERATURE
V_{IN} = 3.6 V, C_L = 0.1 µF, R_L = 10 Ω

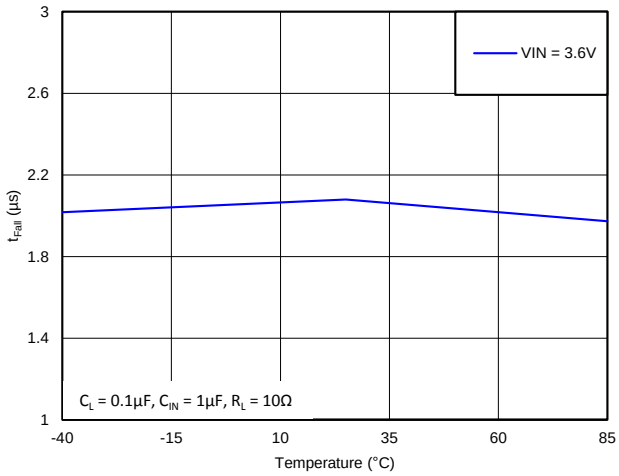


TYPICAL CHARACTERISTICS (continued)

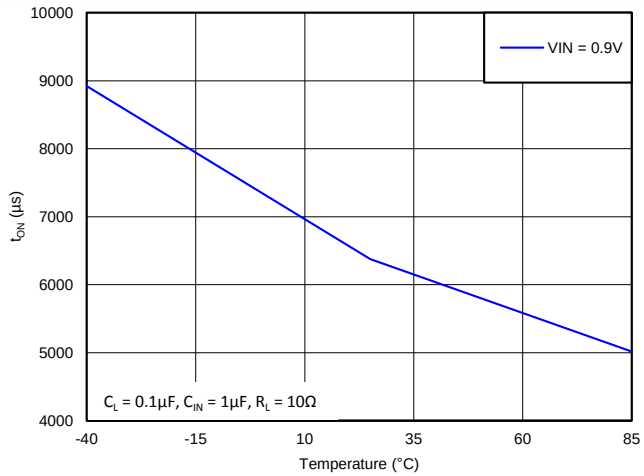
RISE TIME vs TEMPERATURE
V_{IN} = 3.6 V, C_L = 0.1 µF, R_L = 10 Ω



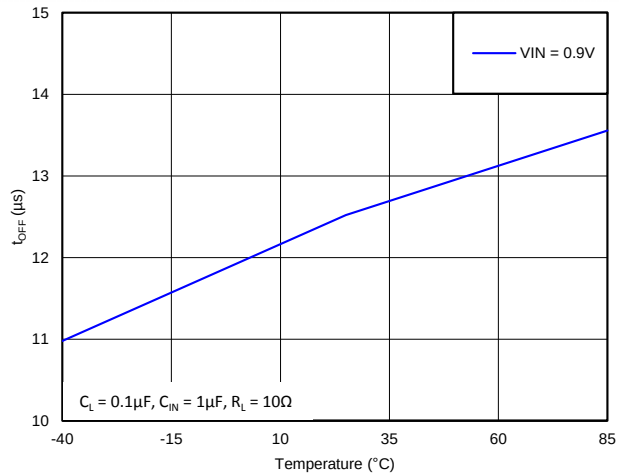
FALL TIME vs TEMPERATURE
V_{IN} = 3.6 V, C_L = 0.1 µF, R_L = 10 Ω



TURN-ON TIME vs TEMPERATURE
V_{IN} = 0.9 V, C_L = 0.1 µF, R_L = 10 Ω

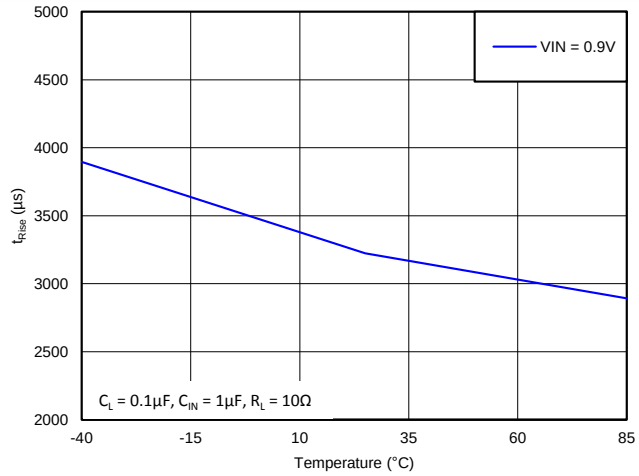


TURN-OFF TIME vs TEMPERATURE
V_{IN} = 0.9 V, C_L = 0.1 µF, R_L = 10 Ω

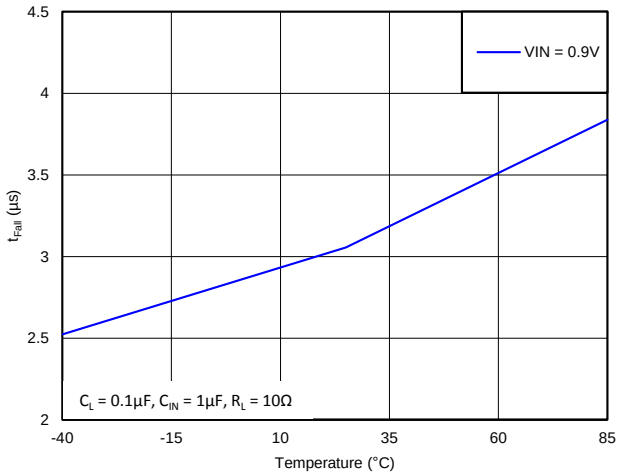


TYPICAL CHARACTERISTICS (continued)

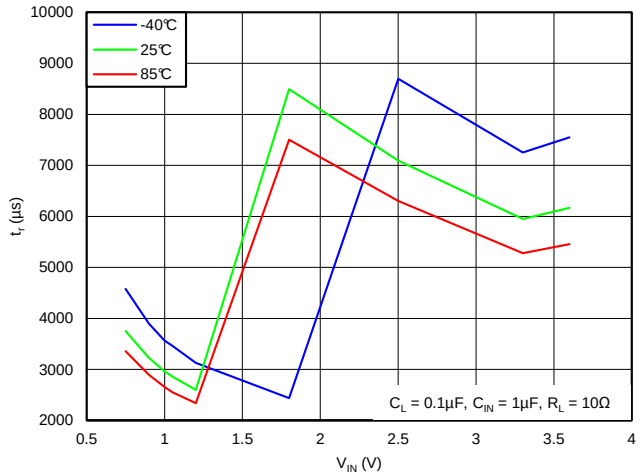
RISE TIME vs TEMPERATURE
V_{IN} = 0.9 V, C_L = 0.1 µF, R_L = 10 Ω



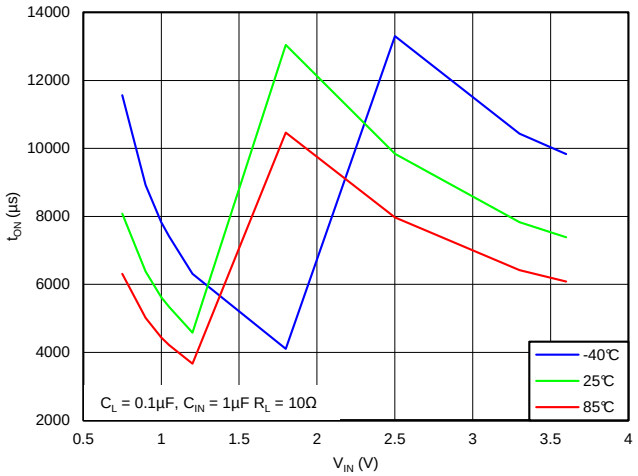
FALL TIME vs TEMPERATURE
V_{IN} = 0.9 V, C_L = 0.1 µF, R_L = 10 Ω



RISE TIME vs INPUT VOLTAGE
C_L = 0.1 µF, R_L = 10 Ω, V_{ON} = 1.8 V

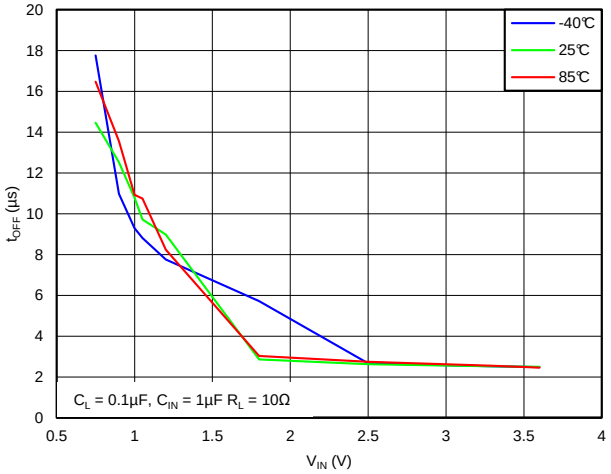


TURN-ON TIME vs INPUT VOLTAGE
C_L = 0.1 µF, R_L = 10 Ω, V_{ON} = 1.8 V

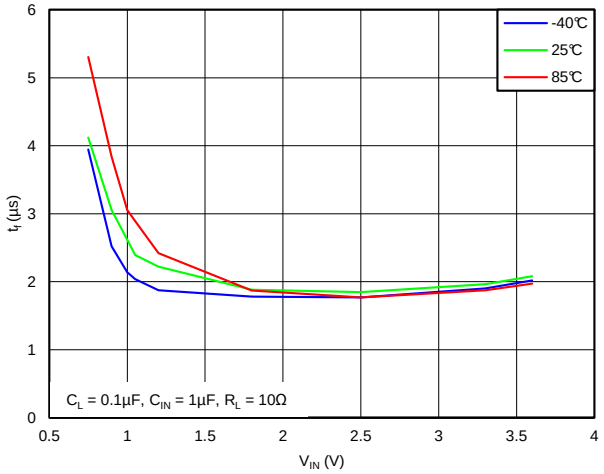


TYPICAL CHARACTERISTICS (continued)

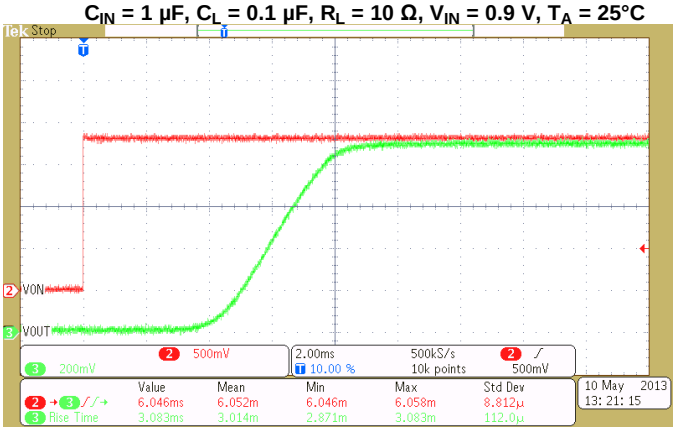
TURN-OFF TIME vs INPUT VOLTAGE
C_L = 0.1 µF, R_L = 10 Ω, V_{ON} = 1.8 V



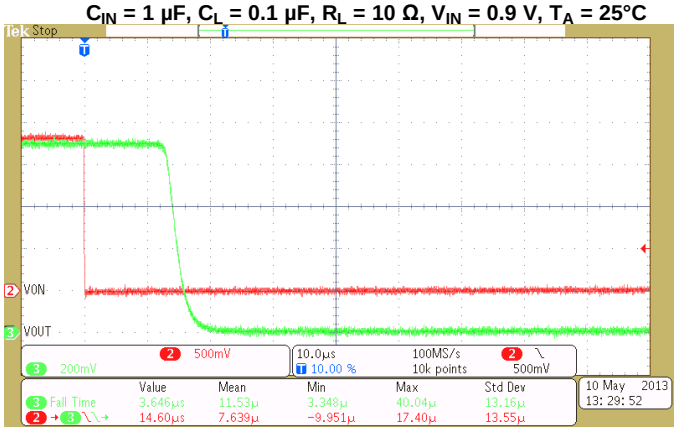
FALL TIME vs INPUT VOLTAGE
C_L = 0.1 µF, R_L = 10 Ω, V_{ON} = 1.8 V



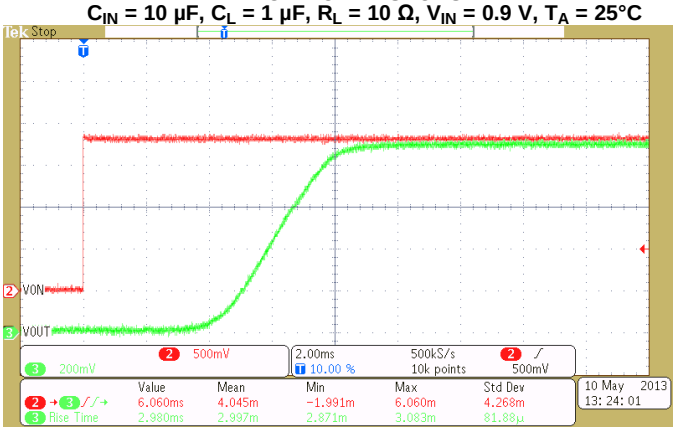
TURN-ON RESPONSE
C_{IN} = 1 µF, C_L = 0.1 µF, R_L = 10 Ω, V_{IN} = 0.9 V, T_A = 25°C



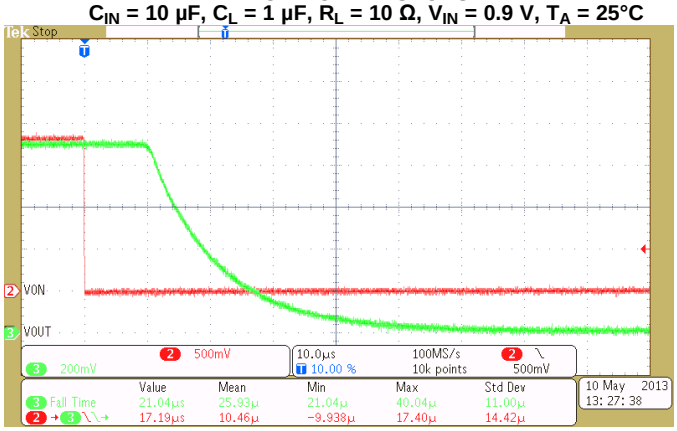
TURN-OFF RESPONSE
C_{IN} = 1 µF, C_L = 0.1 µF, R_L = 10 Ω, V_{IN} = 0.9 V, T_A = 25°C



TURN-ON RESPONSE
C_{IN} = 10 µF, C_L = 1 µF, R_L = 10 Ω, V_{IN} = 0.9 V, T_A = 25°C

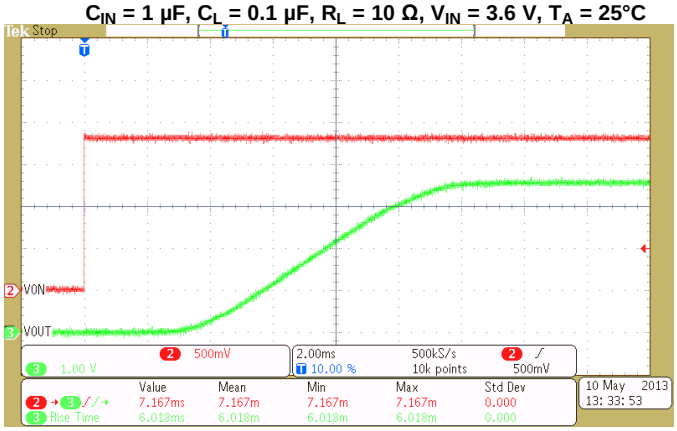


TURN-OFF RESPONSE
C_{IN} = 10 µF, C_L = 1 µF, R_L = 10 Ω, V_{IN} = 0.9 V, T_A = 25°C

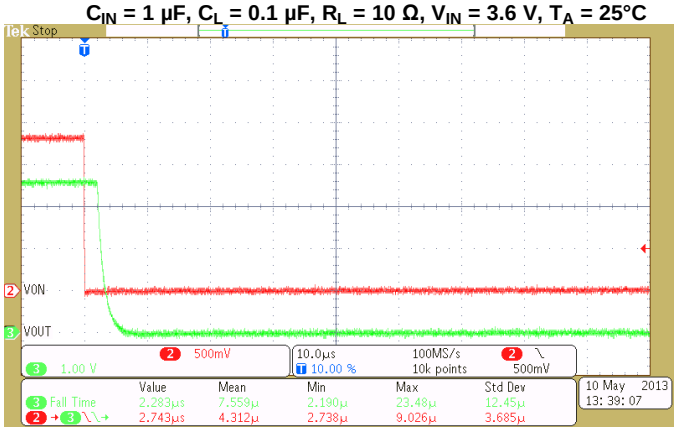


TYPICAL CHARACTERISTICS (continued)

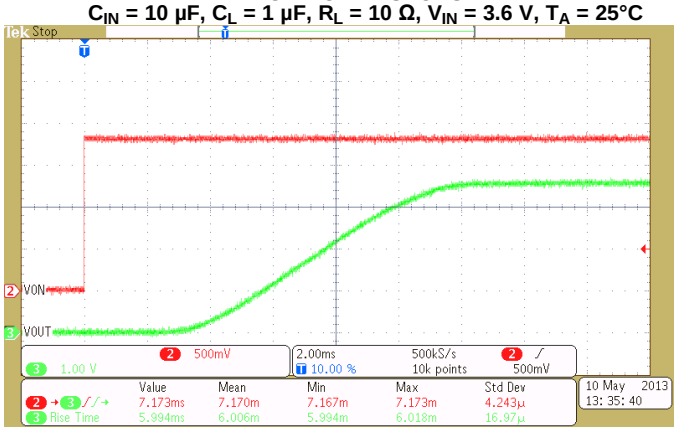
TURN-ON RESPONSE
C_{IN} = 1 µF, C_L = 0.1 µF, R_L = 10 Ω, V_{IN} = 3.6 V, T_A = 25°C



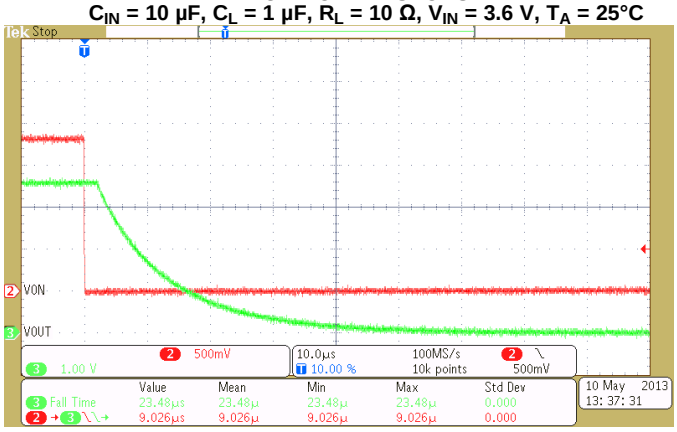
TURN-OFF RESPONSE
C_{IN} = 1 µF, C_L = 0.1 µF, R_L = 10 Ω, V_{IN} = 3.6 V, T_A = 25°C



TURN-ON RESPONSE
C_{IN} = 10 µF, C_L = 1 µF, R_L = 10 Ω, V_{IN} = 3.6 V, T_A = 25°C



TURN-OFF RESPONSE
C_{IN} = 10 µF, C_L = 1 µF, R_L = 10 Ω, V_{IN} = 3.6 V, T_A = 25°C



APPLICATION INFORMATION

ON/OFF Control

The ON pin controls the state of the switch. Asserting ON high enables the switch. ON is active high and has a low threshold, making it capable of interfacing with low-voltage signals. The ON pin is compatible with standard GPIO logic threshold. 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 inrush 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.

Output Capacitor

Due to the integrated body diode in the NMOS 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}. A C_{IN} to C_L ratio of 10 to 1 is recommended for minimizing V_{IN} dip caused by inrush currents during startup.

Output Pulldown

The output pulldown is active when the user is turning off the main pass FET. The pulldown discharges the output rail to approximately 10% of the rail, then the output pulldown is automatically disconnected to optimize the shutdown current.

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 helps 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)	Op Temp (°C)	Device Marking (4/5)	Samples
TPS22924DYZPR	ACTIVE	DSBGA	YZP	6	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 85	DL	Samples
TPS22924DYZPT	ACTIVE	DSBGA	YZP	6	250	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 85	DL	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

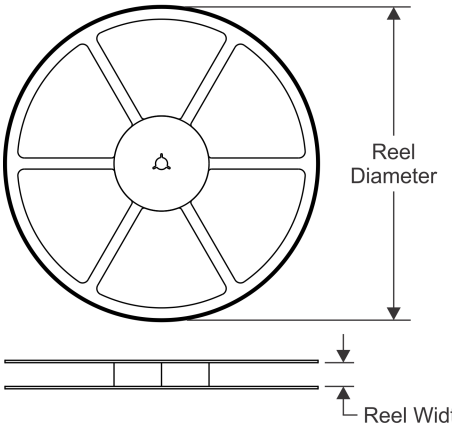
(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

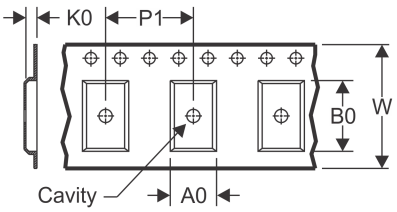
(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

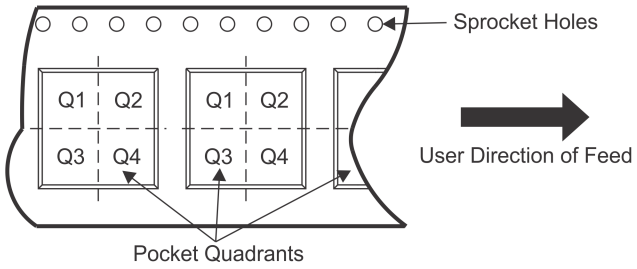


TAPE DIMENSIONS



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

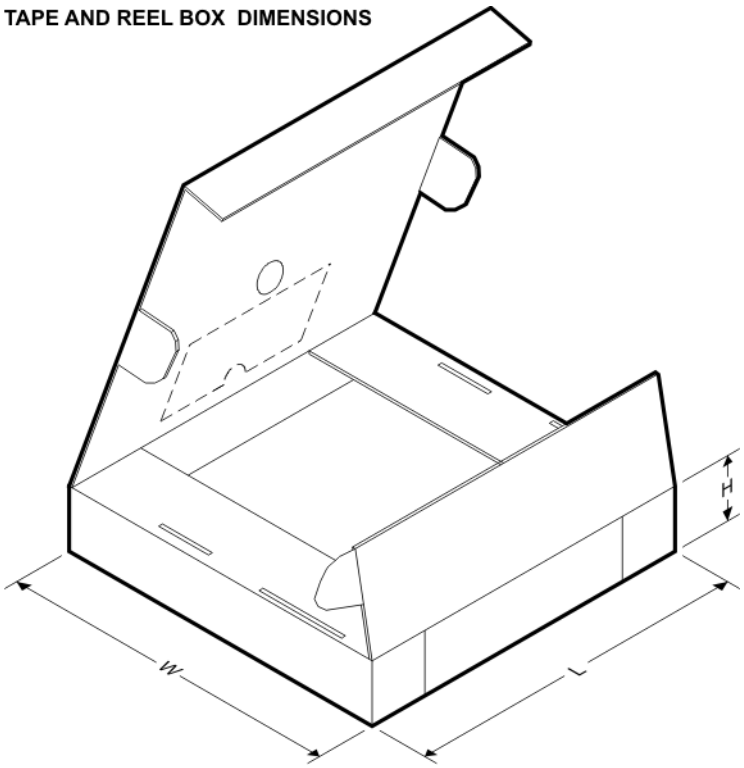
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TPS22924DYZPR	DSBGA	YZP	6	3000	178.0	9.2	1.02	1.52	0.63	4.0	8.0	Q1

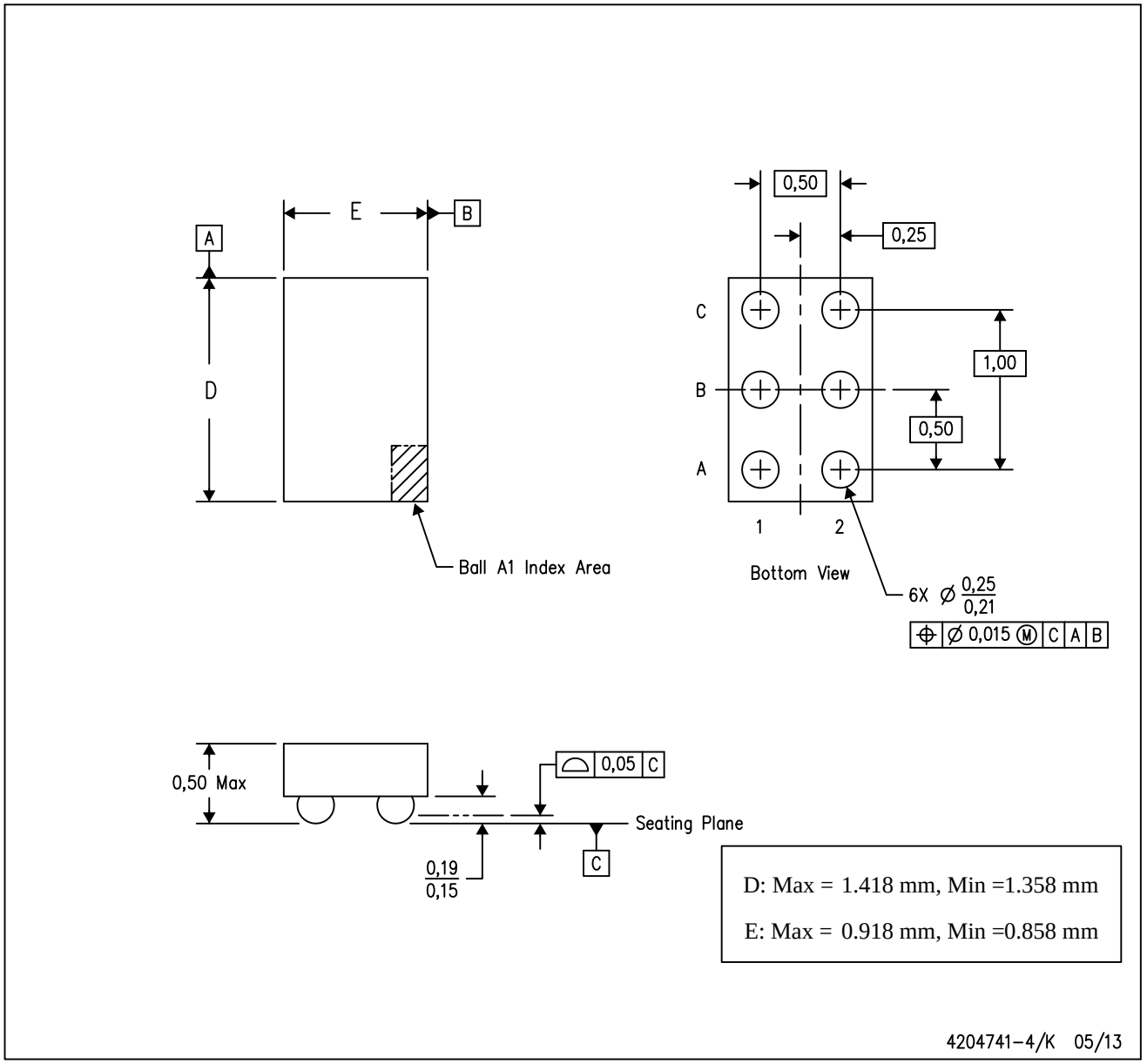
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS22924DYZPR	DSBGA	YZP	6	3000	220.0	220.0	35.0

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.

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