Ultra-Small, Low on Resistance Load Switch with Controlled Turn-on

Check for Samples: TPS22912

FEATURES

- **Integrated Single Load Switch**
- **Ultra Small CSP-4 Package 0.9mm × 0.9mm, 0.5mm Pitch**
- **Input Voltage Range: 1.4-V to 5.5-V**
- **Low ON-Resistance**
  - **r_{ON} = 60-mΩ at VIN = 5-V**
  - **r_{ON} = 61-mΩ at VIN = 3.3-V**
  - **r_{ON} = 74-mΩ at VIN = 1.8-V**
  - **r_{ON} = 84-mΩ at VIN = 1.5-V**
- **2-A Maximum Continuous Switch Current**
- **Low Threshold Control Input**
- **Controlled Slew-rate Options**
- **Under-Voltage Lock Out**
- **Reverse Current Protection**

APPLICATIONS

- **Portable Industrial / Medical Equipment**
- **Portable Media Players**
- **Point of Sales Terminals**
- **GPS Navigation Devices**
- **Digital Cameras**
- **Portable Instrumentation**
- **Smartphones / Wireless Handsets**

DESCRIPTION

The TPS22912 is a small, low r_{ON} load switch with controlled turn-on and contains a P-channel MOSFET that can operate over an input voltage range of 1.4 V to 5.5 V. The switch is controlled by a high input (ON), which is capable of interfacing directly with low-voltage control signals.

The slew rate of the device is internally controlled in order to avoid inrush current. The TPS22912 family has various rise time options and is active high enable. (see Table 1).

The TPS22912 provides circuit breaker functionality by latching off the power switch during reverse voltage situations. An internal reverse voltage comparator disables the power switch when the output voltage (V_{OUT}) is higher than the input (V_{IN}). This process quickly (10µs typical) stops the flow of current towards the input side of the switch. Reverse current protection is always active, even when the device is disabled. Additionally, under-voltage lockout (UVLO) protection turns the switch off if the input voltage is too low.

The TPS22912 is available in a ultra-small, space-saving 4-pin CSP package and is characterized for operation over the free-air temperature range of –40°C to 85°C.

TYPICAL APPLICATION

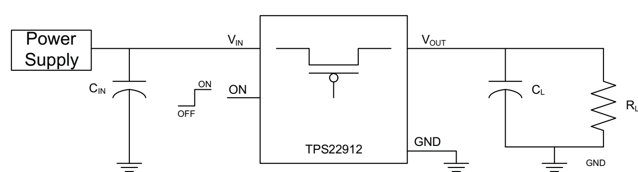


Table 1. Feature List

DEVICE	r_{ON} (typ) at 3.3 V	RISE TIME at 3.3V (typ)	QUICK OUTPUT DISCHARGE (1)	MAXIMUM OUTPUT CURRENT	ENABLE
TPS22912A (2)	61 mΩ	1 µs	No	2-A	Active High
TPS22912B (2)	61 mΩ	100 µs	No	2-A	Active High
TPS22912C	61 mΩ	1000 µs	No	2-A	Active High
TPS22912D (2)	61 mΩ	4500 µs	No	2-A	Active High

(1) This feature discharges the output of the switch to ground through a 150-Ω resistor, preventing the output from floating.
(2) Contact local sales/distributor or factory for availability.

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.

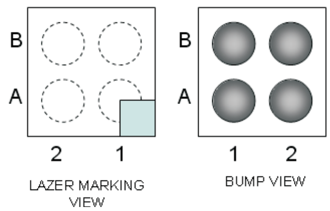
ORDERING INFORMATION

T_A	PACKAGE(1)		ORDERABLE PART NUMBER	TOP-SIDE MARKING/ STATUS(2)
–40°C to 85°C	YZV (0.5mm pitch)	Tape and Reel	TPS22912AYZVR	Contact factory for availability
–40°C to 85°C	YZV (0.5mm pitch)	Tape and Reel	TPS22912BYZVR	Contact factory for availability
–40°C to 85°C	YZV (0.5mm pitch)	Tape and Reel	TPS22912CYZVR	_ _ _ _ 78
–40°C to 85°C	YZV (0.5mm pitch)	Tape and Reel	TPS22912DYZVR	Contact factory for availability

(1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.
(2) Contact factory for details and availability for PREVIEW devices, minimum order quantities may apply.

DEVICE INFORMATION

YZV PACKAGE



TERMINAL ASSIGNMENTS

B	ON	GND
A	V_{IN}	V_{OUT}
	2	**1**

PIN FUNCTIONS

TPS22912 YZV	PIN NAME	DESCRIPTION
B1	GND	Ground
B2	ON	Switch control input, active high. Do not leave floating
A1	VOUT	Switch output
A2	VIN	Switch input. Use ceramic capacitor to GND for bypass.

BLOCK DIAGRAM

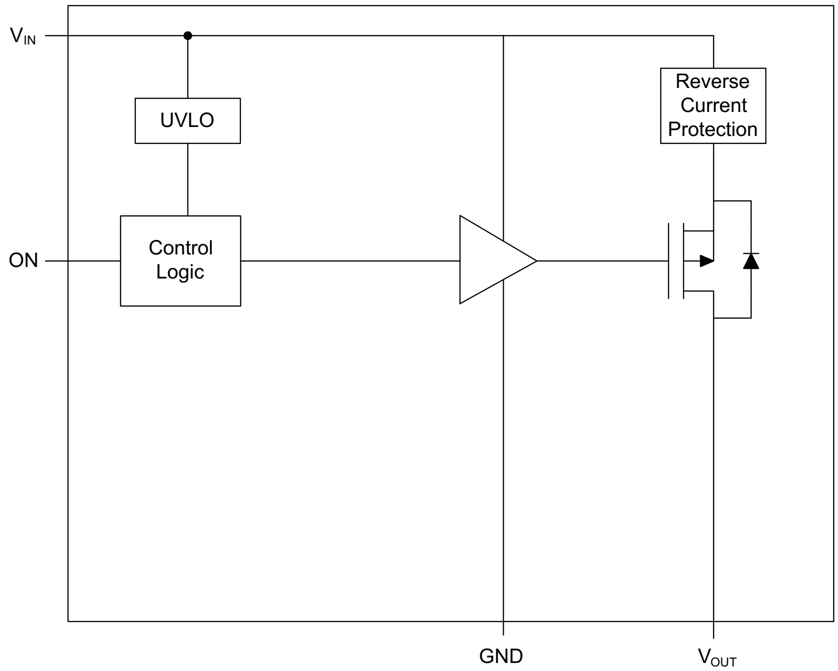


Table 2. FUNCTION TABLE

ON	VIN to VOUT
L	OFF
H	ON

ABSOLUTE MAXIMUM RATINGS

			VALUE	UNIT
V_{IN}	Input voltage range		–0.3 to 6	V
V_{OUT}	Output voltage range		–0.3 to 6	V
V_{ON}	Input voltage range		–0.3 to 6	V
I_{MAX}	Maximum continuous switch current		2	A
I_{PLS}	Maximum pulsed switch current, pulse ≤500 ms, 50% duty cycle		3	A
T_A	Operating free-air temperature range		–40 to 85	°C
T_J	Maximum junction temperature		125	°C
T_{STG}	Storage temperature range		–65 to 150	°C
T_{LEAD}	Maximum lead temperature (10-s soldering time)		300	°C
ESD	Electrostatic discharge protection	Human-Body Model (HBM) (VIN, VOUT, GND pins)	2000	V
		Charged-Device Model (CDM) (VIN, VOUT, ON, GND pins)	1000	

THERMAL INFORMATION

THERMAL METRIC[1]		TPS22912 CSP 4 PINS	UNITS
θ_{JA}	Junction-to-ambient thermal resistance	189.1	°C/W
θ_{JCtop}	Junction-to-case (top) thermal resistance	1.9	
θ_{JB}	Junction-to-board thermal resistance	36.8	
ψ_{JT}	Junction-to-top characterization parameter	11.3	
ψ_{JB}	Junction-to-board characterization parameter	36.8	
θ_{JCbot}	Junction-to-case (bottom) thermal resistance	N/A	

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

RECOMMENDED OPERATING CONDITIONS

			MIN	MAX	UNIT
V_{IN}	Input voltage range		1.4	5.5	V
V_{ON}	ON voltage range		0	5.5	V
V_{OUT}	Output voltage range (Note: V_{OUT} greater than V_{IN} will cause the reverse current protection of this device to trigger. See application section.)			V_{IN} [1]	
V_{IH}	High-level input voltage, ON	VIN = 3.61 V to 5.5 V	1.1	5.5	V
		VIN = 1.4 V to 3.6 V	1.1	5.5	V
V_{IL}	Low-level input voltage, ON	VIN = 3.61 V to 5.5 V		0.6	V
		VIN = 1.4 V to 3. 6V		0.4	V
C_{IN}	Input Capacitor		1 [1]		µF

(1) Refer to the application section.

ELECTRICAL CHARACTERISTICS

VIN = 1.4 V to 5.5 V, T_A = –40ºC to 85ºC (unless otherwise noted)

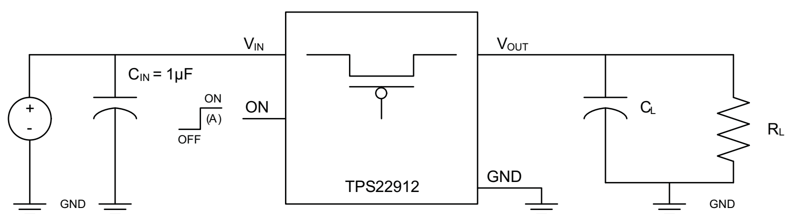
PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
I_{IN}	Quiescent current	I_{OUT} = 0, V_{ON} = V_{IN} = 5.25 V	Full		2	10	µA
		I_{OUT} = 0, V_{ON} = V_{IN} = 4.2 V			2	7.0	
		I_{OUT} = 0, V_{ON} = V_{IN} = 3.6 V			2	7.0	
		I_{OUT} = 0, V_{ON} = V_{IN} = 2.5 V			0.9	5	
		I_{OUT} = 0, V_{ON} = V_{IN} = 1.5 V			0.7	5	
$I_{IN(off)}$ (1)	Off supply current	R_L = 1 MΩ, V_{IN} = 5.25 V, V_{ON} = GND	Full		1.2	10	µA
		R_L = 1 MΩ, V_{IN} = 4.2 V, V_{ON} = GND			0.2	7.0	
		R_L = 1 MΩ, V_{IN} = 3.6 V, V_{ON} = GND			0.1	7.0	
		R_L = 1 MΩ, V_{IN} = 2.5 V, V_{ON} = GND			0.1	5	
		R_L = 1 MΩ, V_{IN} = 1.5 V, V_{ON} = GND			0.1	5	
$I_{IN(Leakage)}$	Leakage current	V_{OUT} = 0, V_{IN} = 5.25 V, V_{ON} = GND	Full		1.2	10	µA
		V_{OUT} = 0, V_{IN} = 4.2 V, V_{ON} = GND			0.2	7.0	
		V_{OUT} = 0, V_{IN} = 3.6 V, V_{ON} = GND			0.1	7.0	
		V_{OUT} = 0, V_{IN} = 2.5 V, V_{ON} = GND			0.1	5	
		V_{OUT} = 0, V_{IN} = 1.5 V, V_{ON} = GND			0.1	5	
r_{ON}	On-resistance	V_{IN} = 5.25 V, I_{OUT} = –200 mA	25°C		60	80	mΩ
			Full			110	
		V_{IN} = 5.0 V, I_{OUT} = –200 mA	25°C		60	80	
			Full			110	
		V_{IN} = 4.2 V, I_{OUT} = –200 mA	25°C		60	80	
			Full			110	
		V_{IN} = 3.3 V, I_{OUT} = –200 mA	25°C		60.7	80	
			Full			110	
		V_{IN} = 2.5 V, I_{OUT} = –200 mA	25°C		63.4	90	
			Full			120	
		V_{IN} = 1.8 V, I_{OUT} = –200 mA	25°C		74.2	100	
			Full			130	
		V_{IN} = 1.5 V, I_{OUT} = –200 mA	25°C		83.9	120	
			Full			150	
UVLO	Under voltage lockout	V_{IN} increasing, V_{ON} = 3.6 V, I_{OUT} = –100 mA	Full			1.2	V
		V_{IN} decreasing, V_{ON} = 3.6 V, I_{OUT} = –100 mA		0.50			
I_{ON}	ON input leakage current	V_{ON} = 1.4 V to 5.25 V or GND	Full			1	µA
V_{RCP}	Reverse Current Voltage Threshold	V_{OUT} > V_{IN}	25°C		54		mV
I_{RCP}(leak)	Reverse Current Protection Leakage after Reverse Current event	V_{OUT} – V_{IN} > V_{RCP}	25°C		0.3		µA
t_{DELAY}	Reverse Current Response Delay	V_{IN} = 5V			10		µs

(1) Verified by characterization, not production tested.

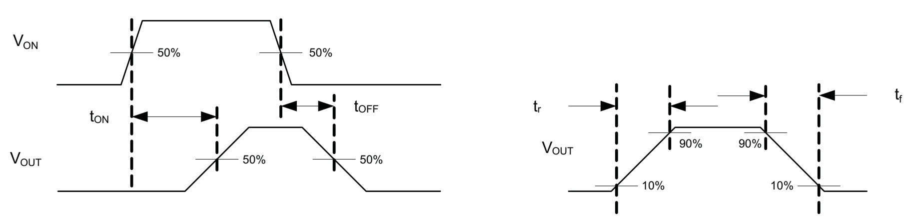
SWITCHING CHARACTERISTICS

PARAMETER		TEST CONDITION	TPS22912 TYP	UNIT
VIN = 5 V, T_A = 25ºC (unless otherwise noted)				
t_{ON}	Turn-ON time	R_L = 10 Ω, C_L = 0.1 µF	840	µs
t_{OFF}	Turn-OFF time	R_L = 10 Ω, C_L = 0.1 µF	6.6	
t_R	VOUT rise time	R_L = 10 Ω, C_L = 0.1 µF	912	
t_F	VOUT fall time	R_L = 10 Ω, C_L = 0.1 µF	3	
VIN = 3.3 V, T_A = 25ºC (unless otherwise noted)				
t_{ON}	Turn-ON time	R_L = 10 Ω, C_L = 0.1 µF	1147	µs
t_{OFF}	Turn-OFF time	R_L = 10 Ω, C_L = 0.1 µF	8.6	
t_R	VOUT rise time	R_L = 10 Ω, C_L = 0.1 µF	1030	
t_F	VOUT fall time	R_L = 10 Ω, C_L = 0.1 µF	3	
VIN = 1.5 V, T_A = 25ºC (unless otherwise noted)				
t_{ON}	Turn-ON time	R_L = 10 Ω, C_L = 0.1 µF	2513	µs
t_{OFF}	Turn-OFF time	R_L = 10 Ω, C_L = 0.1 µF	17.4	
t_R	VOUT rise time	R_L = 10 Ω, C_L = 0.1 µF	1970	
t_F	VOUT fall time	R_L = 10 Ω, C_L = 0.1 µF	6.5	

PARAMETRIC MEASUREMENT INFORMATION



TEST CIRCUIT



t_{ON}/t_{OFF} WAVEFORMS

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

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

Figure 1. Test Circuit and t_{ON}/t_{OFF} Waveforms

TYPICAL CHARACTERISTICS

ON-STATE RESISTANCE vs INPUT VOLTAGE

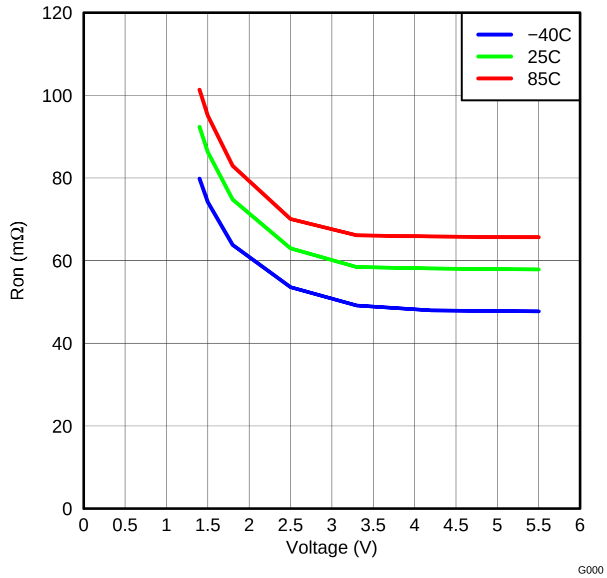


Figure 2.

ON INPUT THRESHOLD

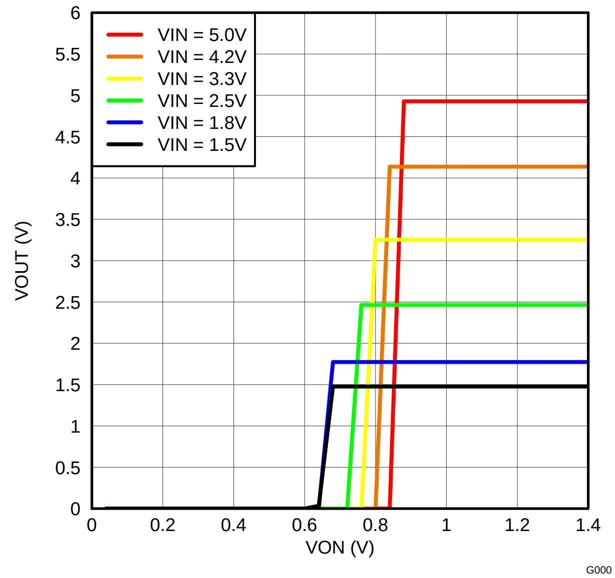


Figure 3.

INPUT CURRENT, QUIESCENT vs INPUT VOLTAGE

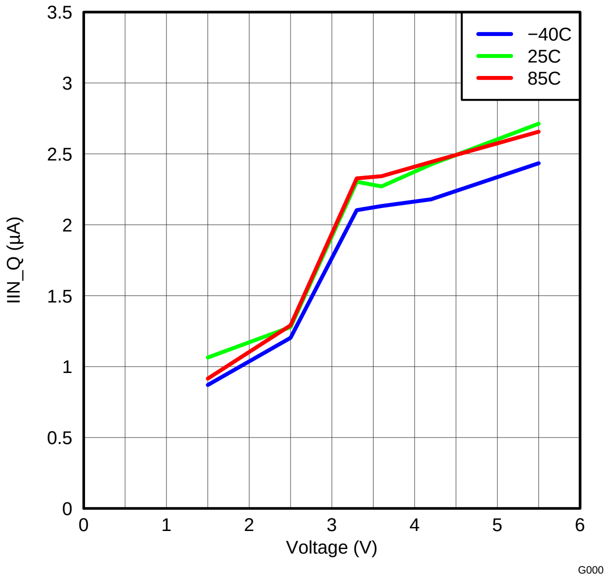


Figure 4.

INPUT CURRENT, LEAK vs INPUT VOLTAGE

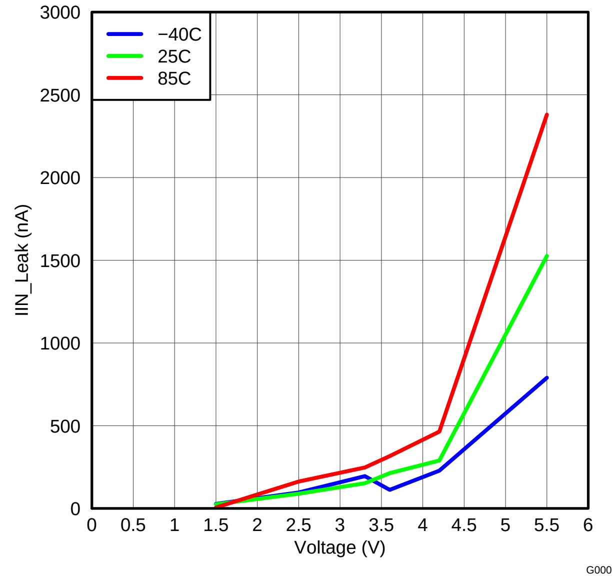


Figure 5.

TYPICAL CHARACTERISTICS (continued)

ON-STATE RESISTANCE vs TEMPERATURE

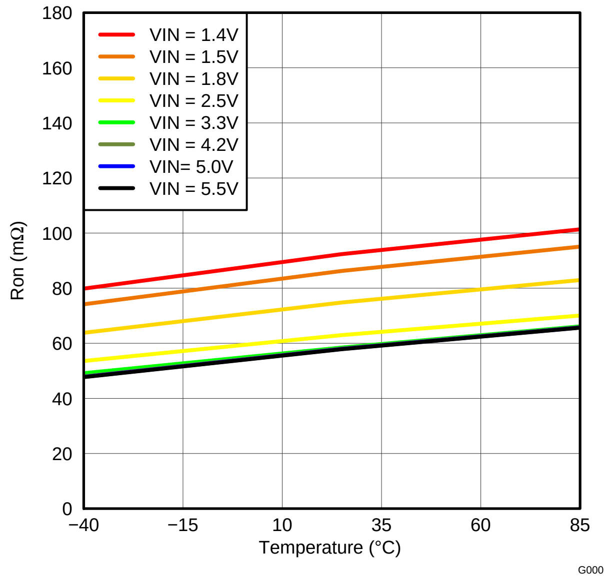


Figure 6.

INPUT CURRENT, OFF vs INPUT VOLTAGE

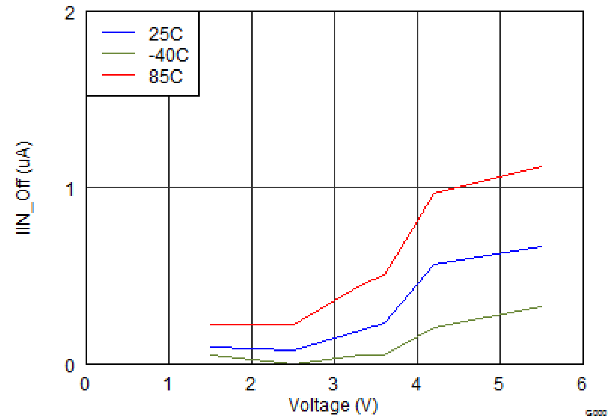


Figure 7.

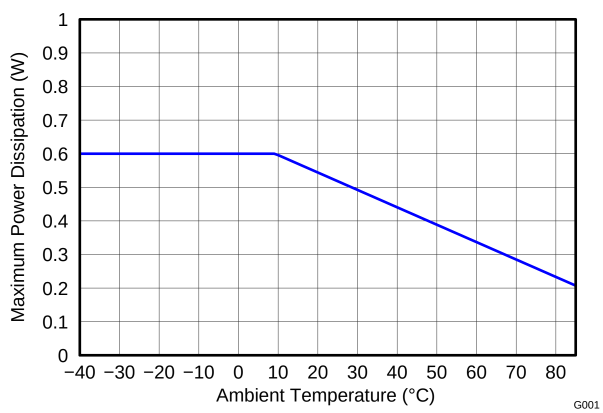


Figure 8. Allowable Power Dissipation

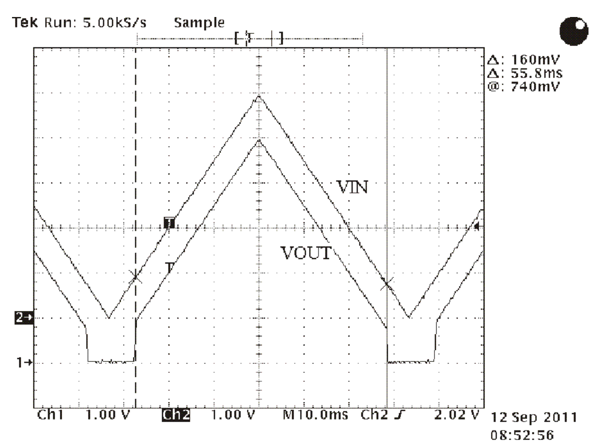


Figure 9. ULVO Response I_{OUT} = -100mA

TYPICAL CHARACTERISTICS (continued)

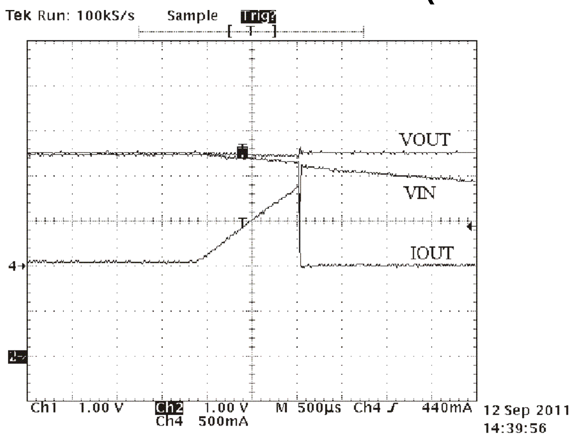


Figure 10. Reverse Current Protection V_{OUT} = 3.3V, V_{IN} = 3.3V Decreasing to 0V

TYPICAL AC CHARACTERISTICS FOR TPS22912C

RISE TIME vs TEMPERATURE

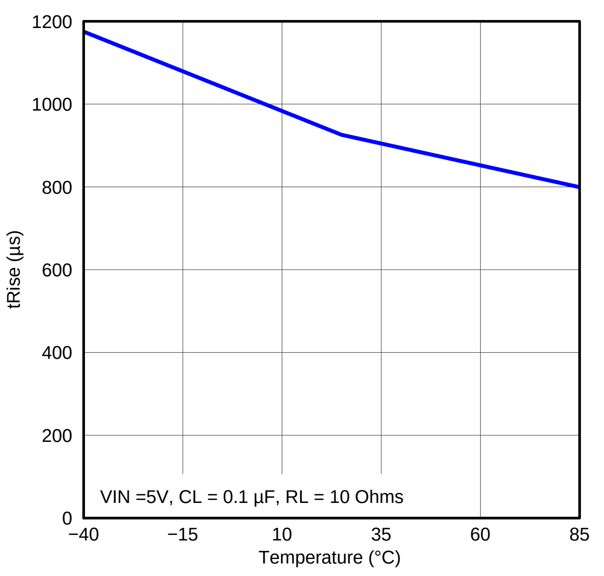


Figure 11.

FALL TIME vs TEMPERATURE

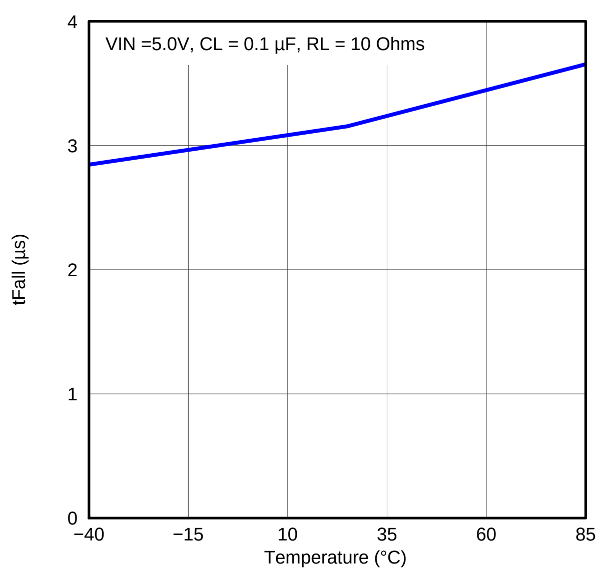


Figure 12.

TYPICAL CHARACTERISTICS (continued)

RISE TIME vs TEMPERATURE

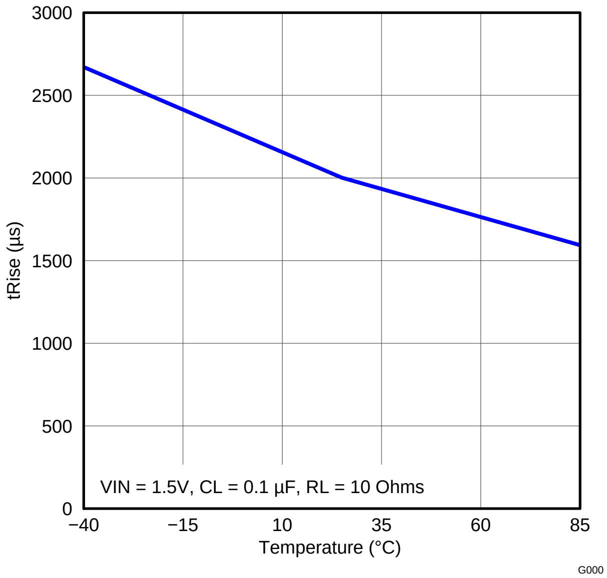


Figure 13.

FALL TIME vs TEMPERATURE

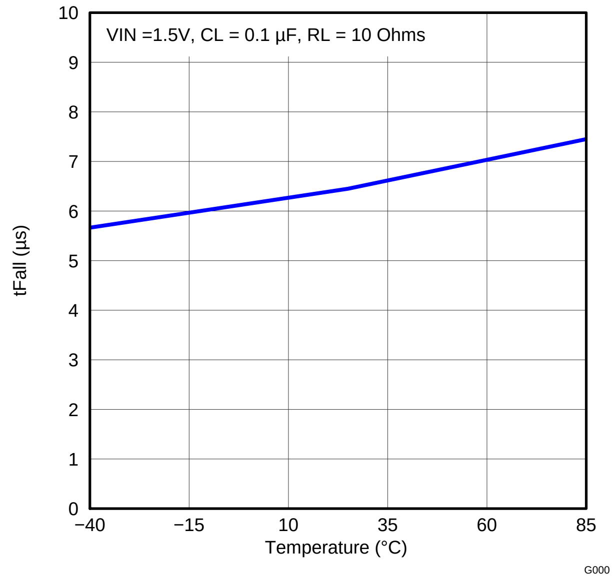


Figure 14.

TURN-ON TIME vs TEMPERATURE

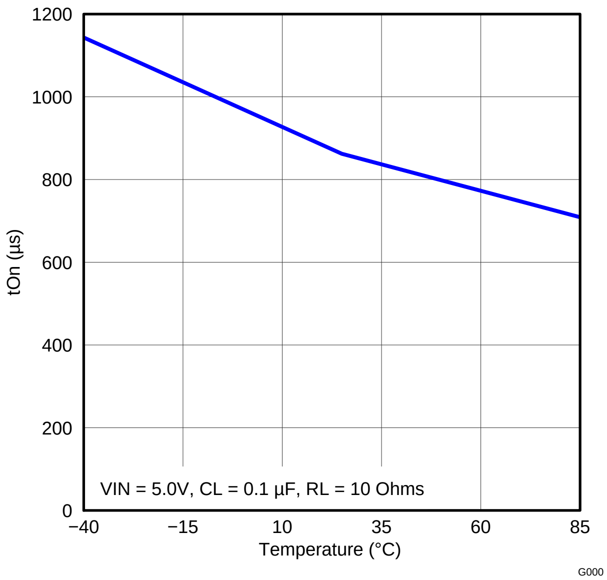


Figure 15.

TURN-OFF TIME vs TEMPERATURE

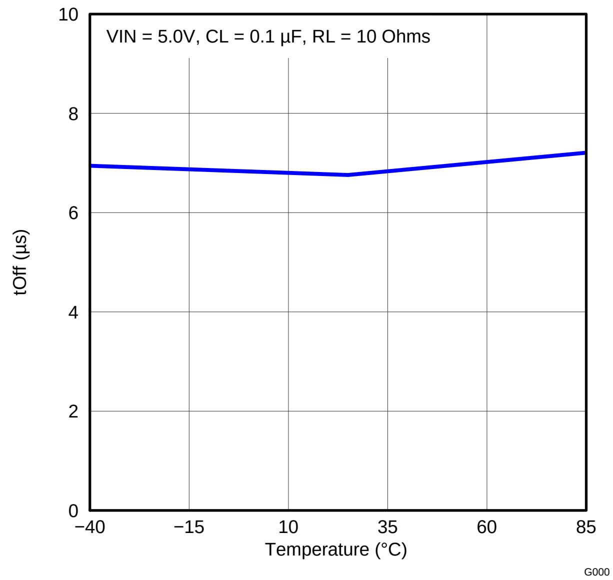


Figure 16.

TYPICAL CHARACTERISTICS (continued)

TURN-ON TIME vs TEMPERATURE

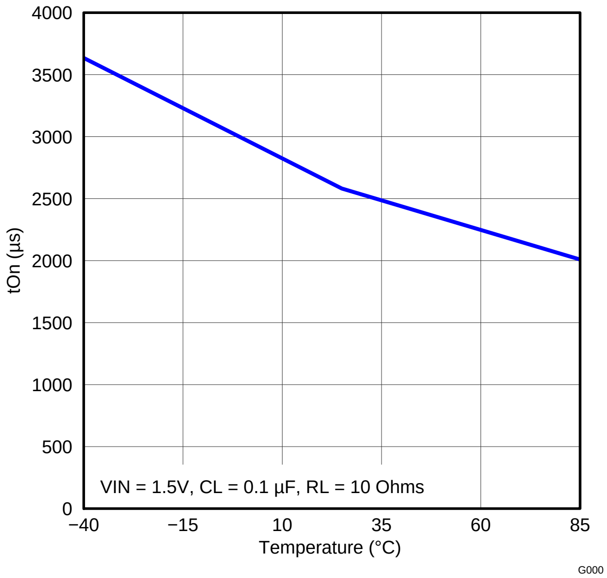


Figure 17.

TURN-OFF TIME vs TEMPERATURE

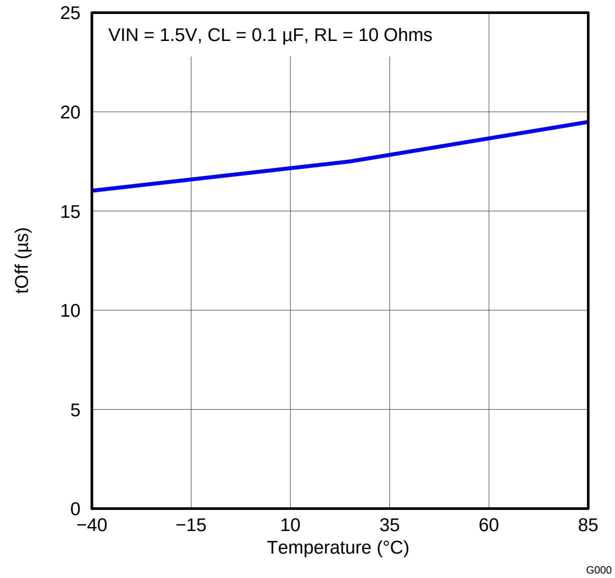


Figure 18.

RISE TIME vs INPUT VOLTAGE

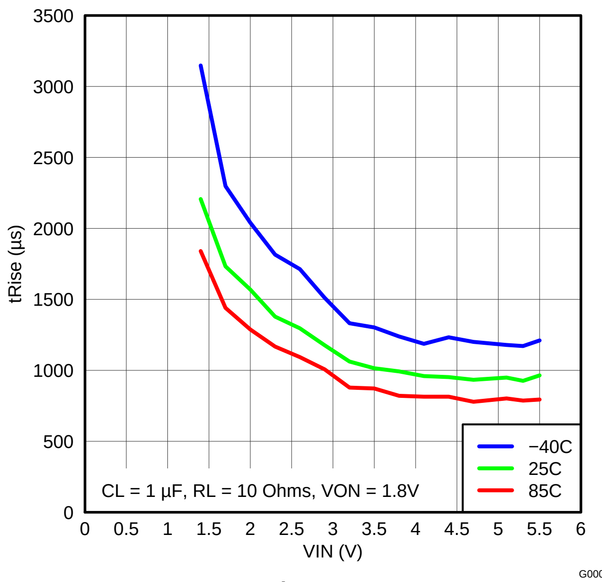


Figure 19.

TYPICAL CHARACTERISTICS (continued)

TURN-ON RESPONSE
V_{IN} = 5V, T_A = 25°C, C_{IN} = 1µF, C_L = 0.1µF, R_L = 10Ω

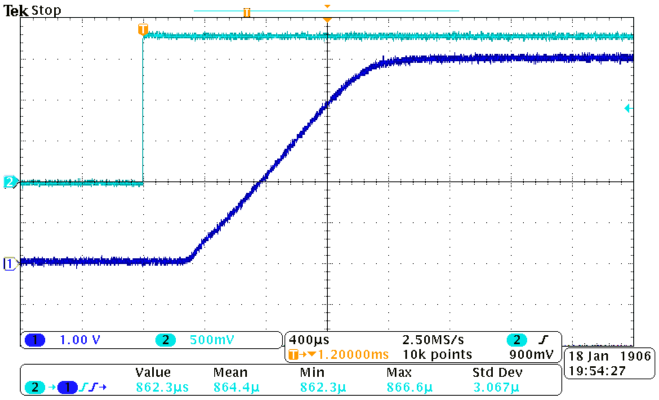


Figure 20.

TURN-OFF RESPONSE
V_{IN} = 5V, T_A = 25°C, C_{IN} = 1µF, C_L = 0.1µF, R_L = 10Ω

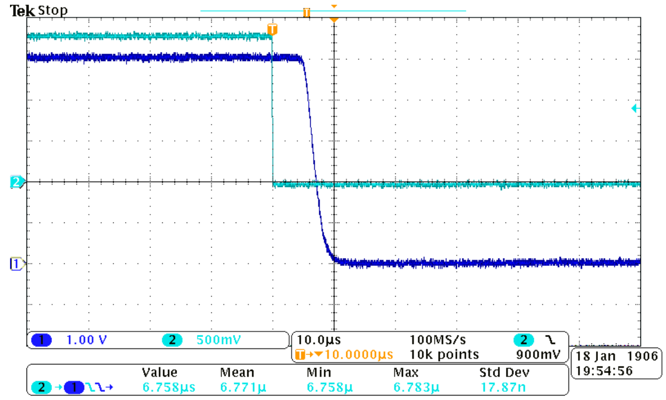


Figure 21.

TURN-ON RESPONSE TIME
V_{IN} = 5V, T_A = 25°C, C_{IN} =10µF, C_L = 1µF, R_L = 10Ω

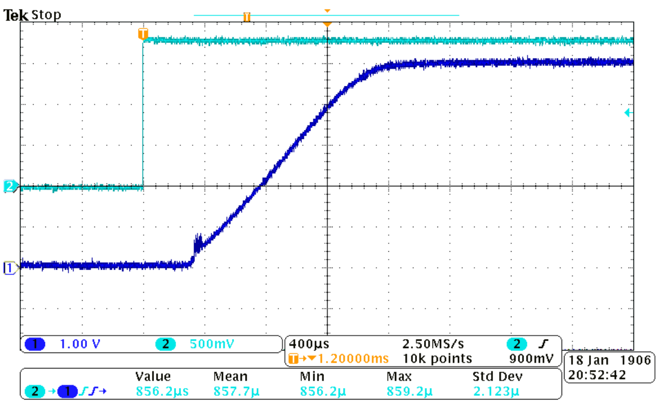


Figure 22.

TURN-OFF RESPONSE TIME
V_{IN} = 5V, T_A = 25°C, C_{IN} = 10µF, C_L = 1µF, R_L = 10Ω

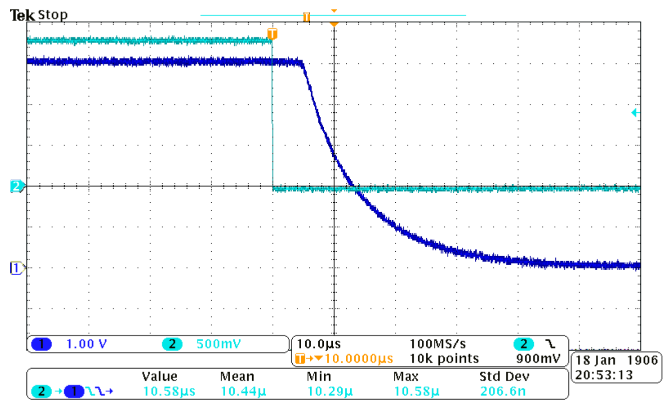


Figure 23.

TURN-ON RESPONSE TIME
V_{IN} = 1.5V, T_A = 25°C, C_{IN} = 1µF, C_L = 0.1µF, R_L = 10Ω

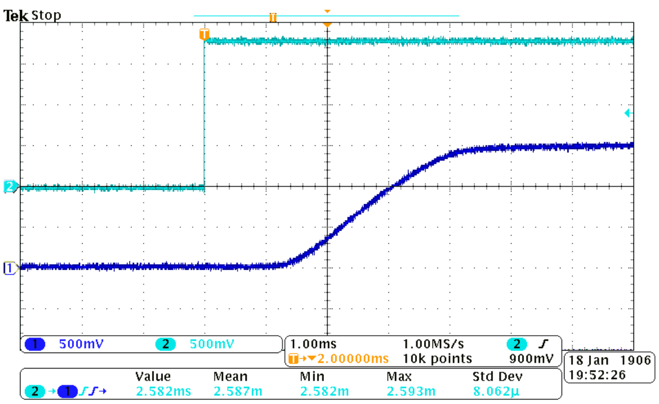


Figure 24.

TURN-OFF RESPONSE TIME
V_{IN} = 1.5V, T_A = 25°C, C_{IN} = 1µF, C_L = 0.1µF, R_L = 10Ω

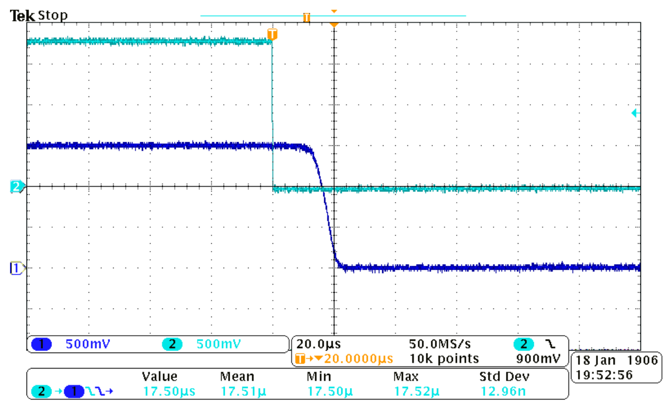


Figure 25.

TYPICAL CHARACTERISTICS (continued)

TURN-ON RESPONSE TIME

V_{IN} = 1.5V, T_A = 25°C, C_{IN} = 10µF, C_L = 1µF, R_L = 10Ω

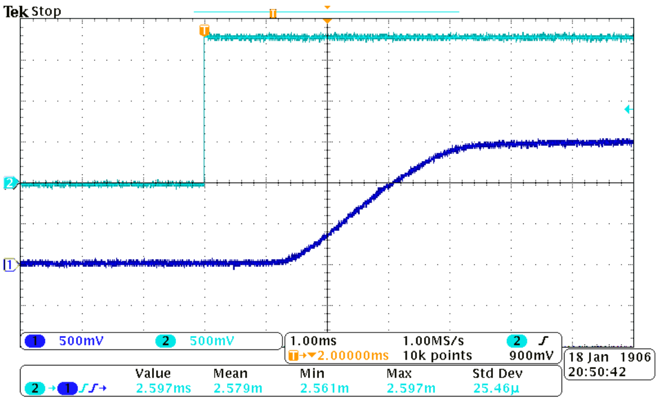


Figure 26.

TURN-OFF RESPONSE TIME

V_{IN} = 1.5V, T_A = 25°C, C_{IN} = 10µF, C_L = 1µF, R_L = 10Ω

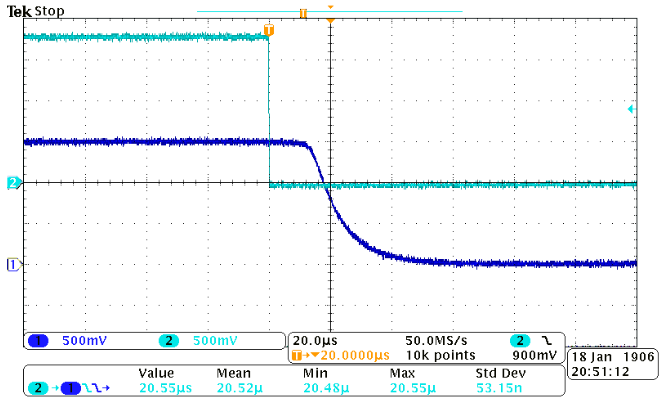


Figure 27.

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 the pin 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 GPIO.

Input Capacitor

To limit the voltage drop on the input supply caused by transient inrush currents, a capacitor needs to be placed between VIN 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

A C_{IN} to C_L ratio of 10 to 1 is recommended for minimizing V_{IN} dip caused by inrush currents during startup. Devices with faster rise times may require a larger ratio to minimize V_{IN} dip.

Under-Voltage Lockout

Under-voltage lockout protection turns off the switch if the input voltage is below the under-voltage lockout threshold. During under-voltage lockout (UVLO), if the voltage level at V_{OUT} exceeds the voltage level at V_{IN} by the Reverse Current Voltage Threshold (V_{RVP}), the body diode will be disengaged to prevent any current flow to V_{IN}. With the ON pin active, the input voltage rising above the under-voltage lockout threshold will cause a controlled turn-on of the switch to limit current over-shoot.

Reverse Current Protection

In a scenario where V_{OUT} is greater than V_{IN}, there is potential for reverse current to flow through the pass FET or the body diode. The TPS22912 monitors V_{IN} and V_{OUT} voltage levels. When the reverse current voltage threshold (V_{RCP}) is exceeded, the switch is disabled (within 10μs typ). Additionally, the body diode is disengaged so as to prevent any reverse current flow to V_{IN}. The FET, and the output (V_{OUT}), will resume normal operation when the reverse current scenario is no longer present. The peak instantaneous reverse current is the current it takes to trip the reverse current protection. After the reverse current protection has tripped due to the peak instantaneous reverse current, the DC (off-state) leakage current from V_{OUT} and V_{IN} is referred to as I_{RCP}(leak) (see figure below).

Use the following formula to calculate the amount of peak instantaneous reverse current for a particular application:

$$I_{RC} = \frac{V_{RCP}}{R_{ON(VIN)}}$$

Where,

I_{RC} is the amount of reverse current,

$R_{ON(VIN)}$ is the on-resistance at the VIN of the reverse current condition.

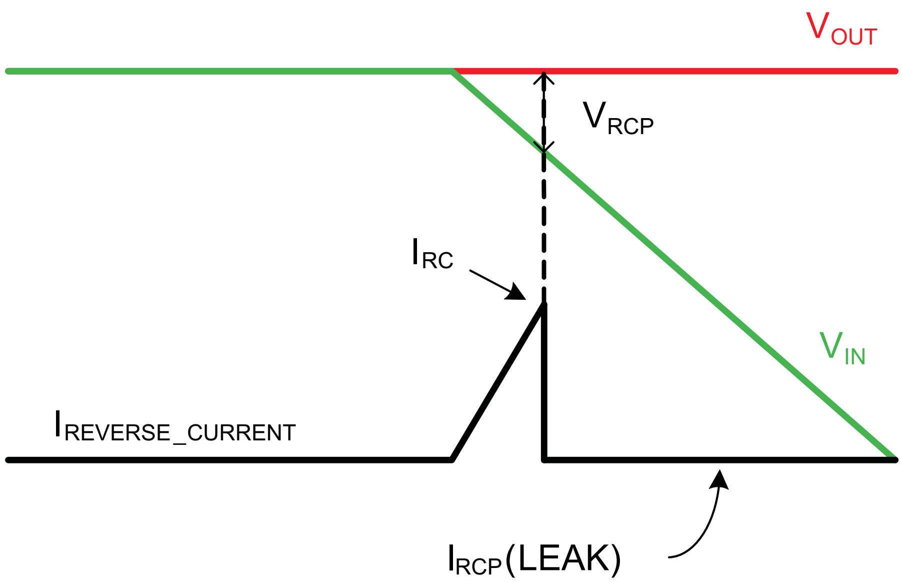


Figure 28. Reverse Current

Board Layout

For best performance, all traces should be as short as possible. The input and output capacitors should be placed close to the device to minimize the effects that parasitic trace inductances may have on normal operation. 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)	Samples (Requires Login)
TPS22912CYZVR	ACTIVE	DSBGA	YZV	4	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	
TPS22912CYZVT	ACTIVE	DSBGA	YZV	4	250	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.

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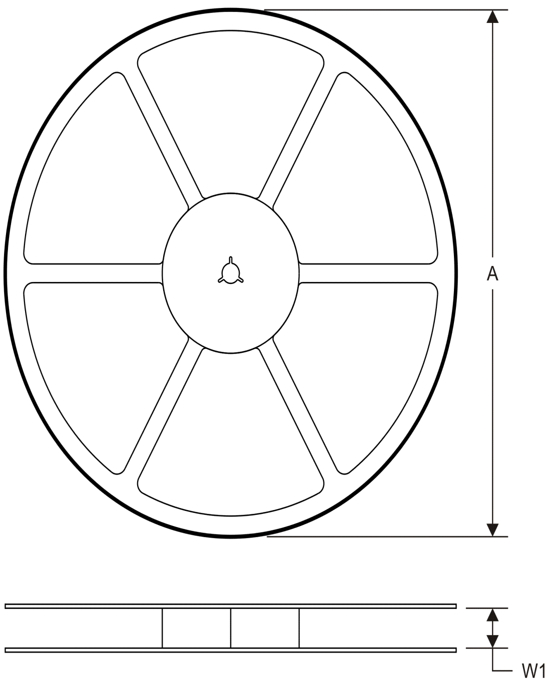
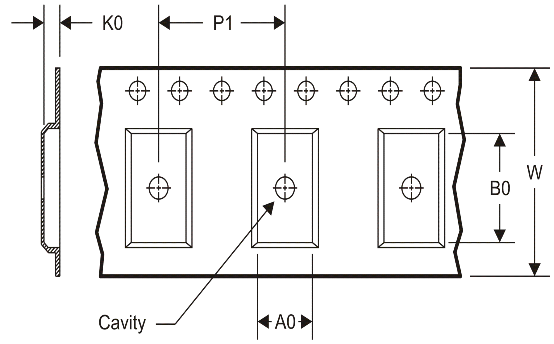
TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



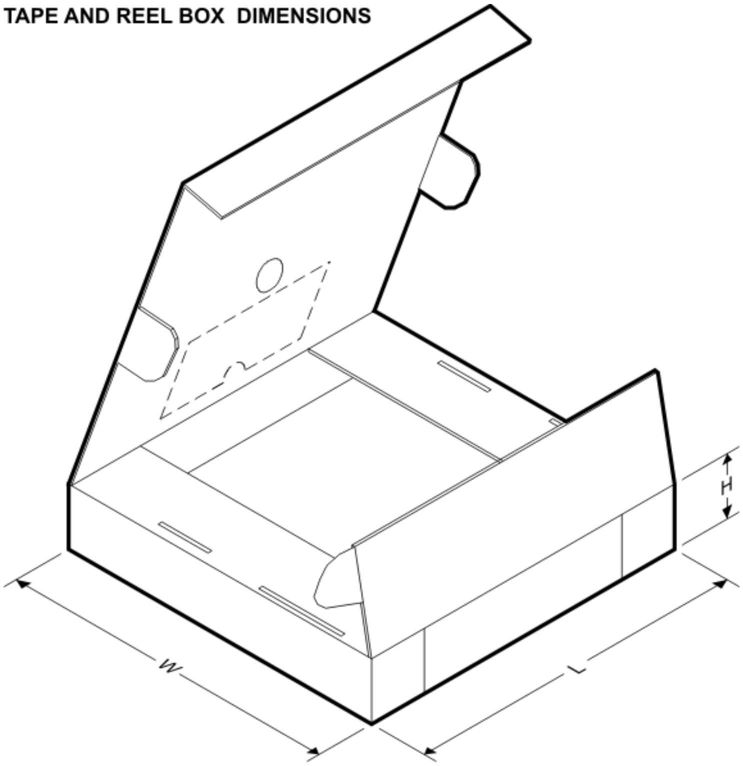
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

TAPE AND REEL INFORMATION

*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TPS22912CYZVR	DSBGA	YZV	4	3000	178.0	9.2	1.0	1.0	0.63	4.0	8.0	Q1
TPS22912CYZVT	DSBGA	YZV	4	250	178.0	9.2	1.0	1.0	0.63	4.0	8.0	Q1

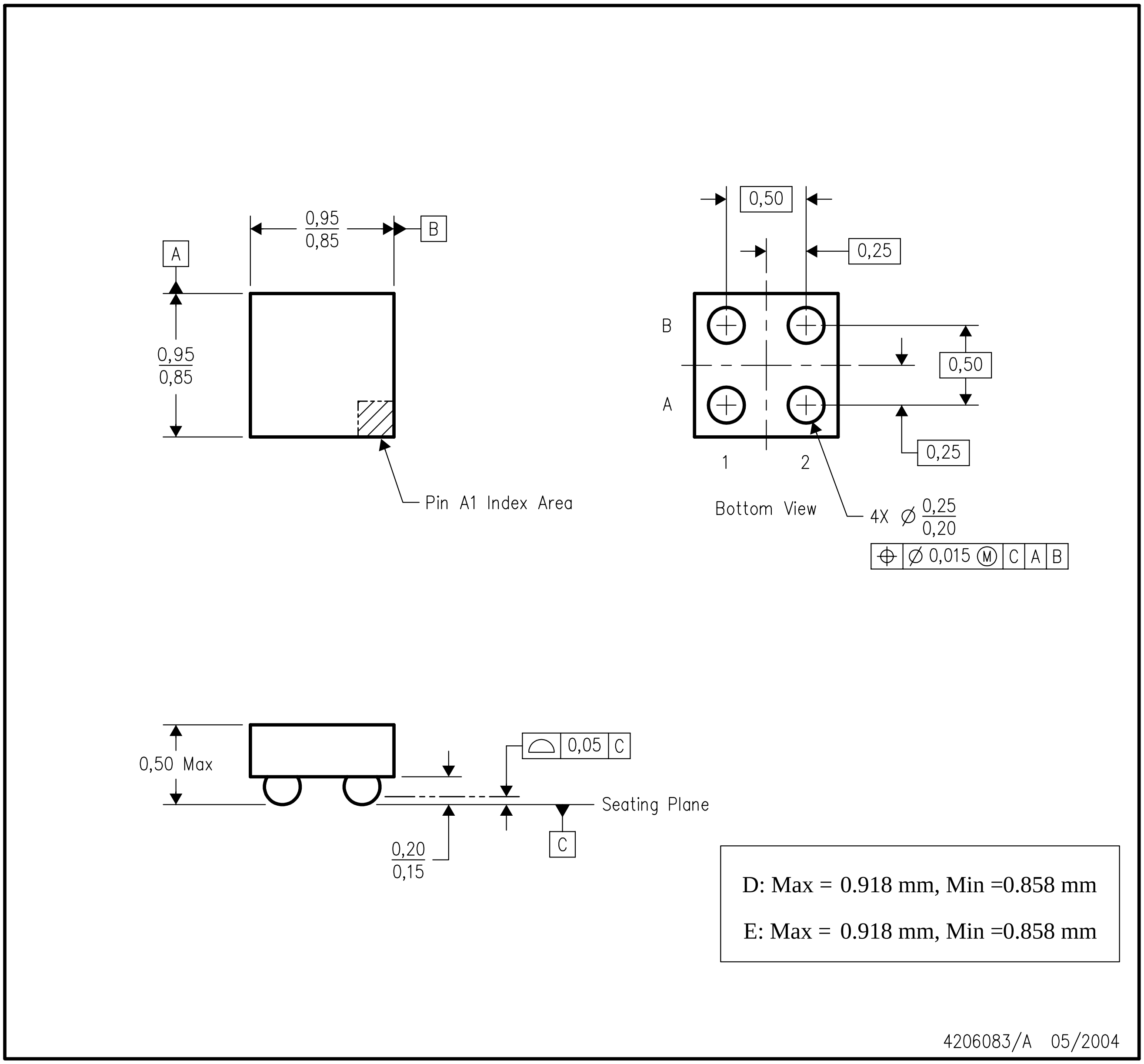
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS22912CYZVR	DSBGA	YZV	4	3000	220.0	220.0	35.0
TPS22912CYZVT	DSBGA	YZV	4	250	220.0	220.0	35.0

YZV (S-XBGA-N4) DIE-SIZE BALL GRID ARRAY



NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. NanoFree™ package configuration.
- D. This package contains lead-free balls. Refer to the 4 YEV package (drawing 4206082) for tin-lead (SnPb) balls.

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