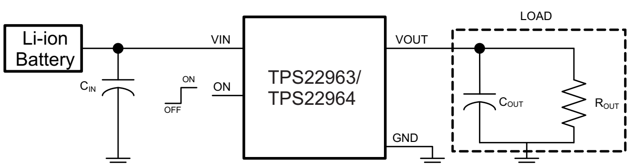
ULTRA-LOW ON-RESISTANCE, 3A LOAD SWITCH WITH REVERSE CURRENT PROTECTION AND CONTROLLED TURN-ON

Check for Samples: TPS22963 , TPS22964

FEATURES

- **Integrated N-Channel Load Switch**
- **Input Voltage Range: 1V to 5.5V**
- **Internal Pass-FET R_{DSON} = 8mΩ (typ)**
- **Ultra-low ON-Resistance**
  - **R_{ON} = 13mΩ (typ) at V_{IN} = 5V**
  - **R_{ON} = 14mΩ (typ) at V_{IN} = 3.3V**
  - **R_{ON} = 18mΩ (typ) at V_{IN} = 1.8V**
- **3A Maximum Continuous Switch Current**
- **Reverse Current Protection (when disabled)**
- **Low Shutdown Current (760nA)**
- **Low Threshold 1.3V GPIO Control Input**
- **Controlled Slew-rate to Avoid Inrush Current**
- **Six Terminal Wafer-Chip-Scale Package (Nominal Dimensions Shown - See Addendum for Details)**
  - **0.9mm x 1.4mm, 0.5mm Pitch, 0.5mm Height (YZP)**
- **ESD Performance Tested Per JESD 22**
  - **2KV Human-Body Model (A114-B, Class II)**
  - **500V Charged-Device Model (C101)**

TYPICAL APPLICATION



APPLICATIONS

- **Smartphones**
- **Notebook Computer and Ultrabook™**
- **Tablet PC Computer**
- **Solid State Drives (SSD)**
- **DTV/IP Set Top Box**
- **POS Terminals and Media Gateways**

DESCRIPTION

The TPS22963/64 is a small, ultra-low R_{ON} load switch with controlled turn on. The device contains a low R_{DSON} N-Channel MOSFET that can operate over an input voltage range of 1V to 5.5V and switch currents of up to 3A. An integrated charge pump biases the NMOS switch in order to achieve a low switch ON-Resistance. The switch is controlled by an on/off input (ON), which is capable of interfacing directly with low-voltage GPIO control signals. The rise time of the TPS22963/64 device is internally controlled in order to avoid inrush current.

The TPS22963/64 provides reverse current protection. When the power switch is disabled, the device will not allow the flow of current towards the input side of the switch. The reverse current protection feature is active only when the device is disabled so as to allow for intentional reverse current (when the switch is enabled) for some applications.

The TPS22963/64 is available in a small, space-saving 6-pin WCSP package and is characterized for operation over the free air temperature range of –40°C to 85°C.

Table 1. Feature List

	R_{ON} (typ) at 3.3 V	Rise Time (typ) at 3.3V(1)	Quick Output Discharge (QOD)(2)	Maximum Output Current	Enable
TPS22963C	14mΩ	715µs	No	3A	Active High
TPS22964C	14mΩ	715µs	Yes	3A	Active High

(1) Additional rise time options are possible. Contact factory for more information.
(2) This feature discharges the output of the switch to ground through a 273Ω resistor, preventing the output from floating (only in TPS22964C).

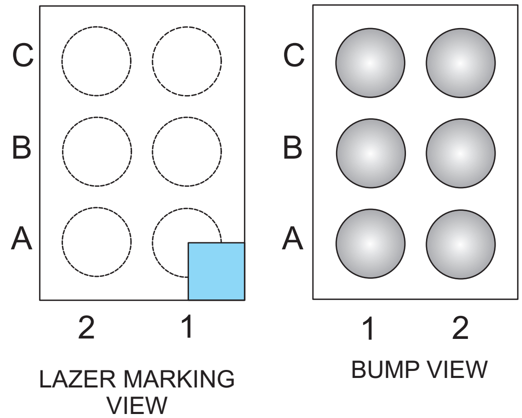
These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

ORDERING INFORMATION

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

DEVICE INFORMATION

YZP PACKAGE



Terminals Assignments (YZP Package)

C	GND	ON
B	VOUT	VIN
A	VOUT	VIN
	1	**2**

PIN DESCRIPTIONS

TPS22963/64	PIN 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. Use a bypass capacitor to ground (ceramic)

BLOCK DIAGRAM

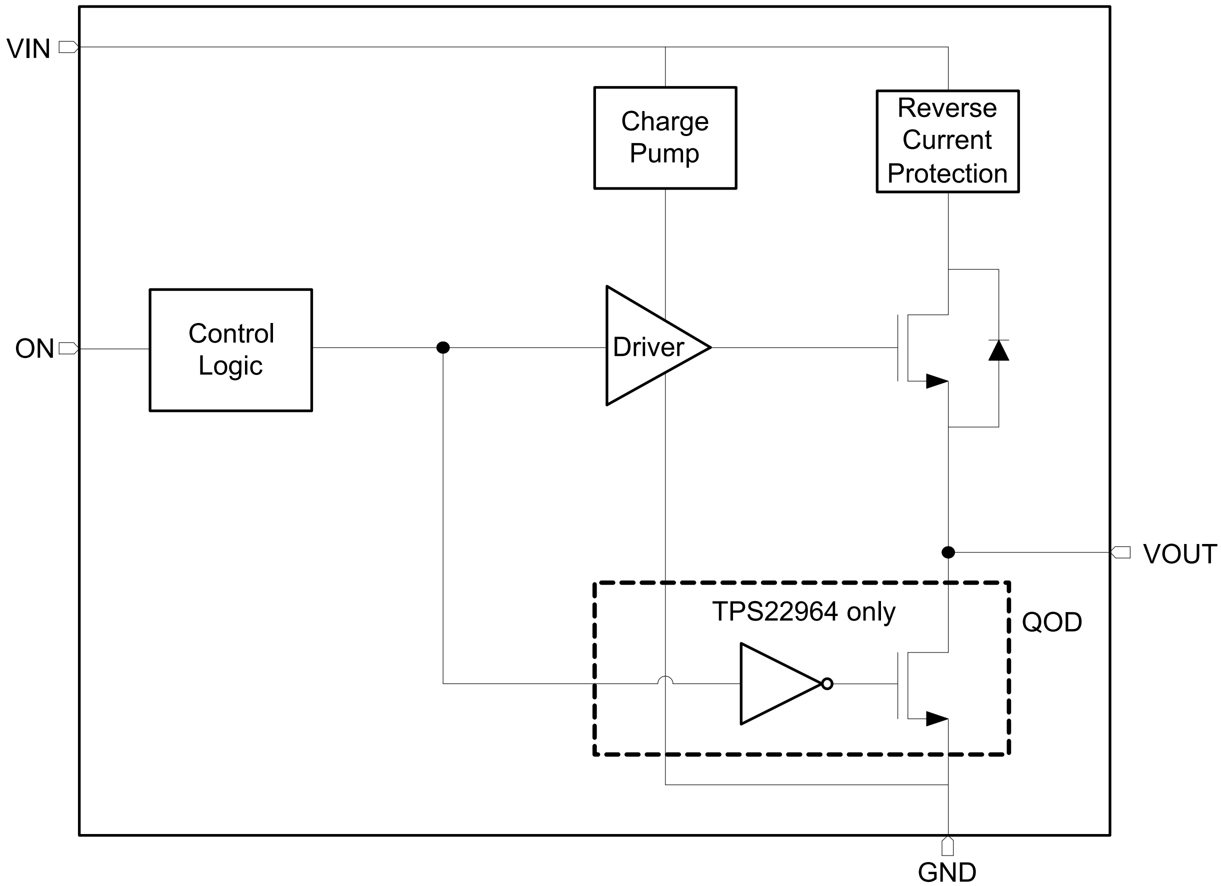


Table 2. FUNCTION TABLE

ON	VIN to VOUT	OUTPUT DISCHARGE[(1)(2)]
L	OFF	ACTIVE
H	ON	DISABLED

(1) This feature discharges the output of the switch to ground through a 273Ω resistor, preventing the output from floating.
(2) This feature is in the TPS22964 device only (not in the TPS22963).

ABSOLUTE MAXIMUM RATINGS

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

			VALUE	UNIT
V_{IN}	Input voltage range		–0.3 to 6	V
V_{OUT}	Output voltage range		–0.3 to 6	V
V_{ON}	ON pin voltage range		–0.3 to 6	V
I_{MAX}	Maximum continuous switch current		3	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 to 85	°C
T_J	Maximum junction temperature		125	°C
T_{STG}	Storage temperature range		–65 to 150	°C
T_{LEAD}	Maximum lead temperature (10s soldering time)		300	°C
ESD	Electrostatic discharge protection	Human-Body Model (HBM)	2000	V
		Charged Device Model (CDM)	500	

THERMAL INFORMATION

THERMAL METRIC[1]		TPS22963/TPS22964	UNITS
		YZP	
		6 PINS	
θ_{JA}	Junction-to-ambient thermal resistance[2]	132.0	°C/W
θ_{JCtop}	Junction-to-case (top) thermal resistance[3]	1.4	
θ_{JB}	Junction-to-board thermal resistance[4]	22.8	
ψ_{JT}	Junction-to-top characterization parameter[5]	5.7	
ψ_{JB}	Junction-to-board characterization parameter[6]	22.6	

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, SPRA953.
(2) The junction-to-ambient thermal resistance under natural convection is obtained in a simulation on a JEDEC-standard, high-K board, as specified in JESD51-7, in an environment described in JESD51-2a.
(3) The junction-to-case (top) thermal resistance is obtained by simulating a cold plate test on the package top. No specific JEDEC-standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.
(4) The junction-to-board thermal resistance is obtained by simulating in an environment with a ring cold plate fixture to control the PCB temperature, as described in JESD51-8.
(5) The junction-to-top characterization parameter, ψ_{JT}, estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining θ_{JA}, using a procedure described in JESD51-2a (sections 6 and 7).
(6) The junction-to-board characterization parameter, ψ_{JB}, estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining θ_{JA} , using a procedure described in JESD51-2a (sections 6 and 7).

RECOMMENDED OPERATING CONDITIONS

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

			MIN	TYP	MAX	UNIT
V_{IN}	Input voltage range		1		5.5	V
V_{OUT}	Output voltage range		0		5.5	V
$V_{IH, ON}$	High-level ON voltage	V_{IN} = 2.5V to 5.5V	1.3		5.5	V
		V_{IN} = 1V to 2.49V	1.1		5.5	
$V_{IL, ON}$	Low-level ON voltage	V_{IN} = 2.5V to 5.5V	0		0.6	V
		V_{IN} = 1V to 2.49V	0		0.4	
C_{IN}	Input capacitor			1[1]		µF

(1) Refer to the application section

ELECTRICAL CHARACTERISTICS

V_{IN} = 1V to 5.5V, T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
$I_{Q, VIN}$	Quiescent current	I_{OUT} = 0, V_{ON} = V_{IN} = 5V	Full		66.5	96	µA
		I_{OUT} = 0, V_{ON} = V_{IN} = 4.5V	Full		57	82	
		I_{OUT} = 0, V_{ON} = V_{IN} = 3.3V	Full		38	60	
		I_{OUT} = 0, V_{ON} = V_{IN} = 2.5V	Full		33.3	55	
		I_{OUT} = 0, V_{ON} = V_{IN} = 1.8V	Full		28.3	45	
		I_{OUT} = 0, V_{ON} = V_{IN} = 1.2V	Full		22.8	36	
		I_{OUT} = 0, V_{ON} = V_{IN} = 1.1V	Full		21.6	34	
		I_{OUT} = 0, V_{ON} = V_{IN} = 1V	Full		20.3	33	
$I_{SD, VIN}$	Shut down current	V_{ON} = 0, V_{IN} = 5V, V_{OUT} = 0V	Full		0.76	2	µA
		V_{ON} = 0, V_{IN} = 1V, V_{OUT} = 0V	Full		0.07	0.8	
R_{ON}	On-resistance	V_{IN} = 5V, I_{OUT} = –200mA	25˚C		13.3	21	mΩ
			Full			26	
		V_{IN} = 4.5V, I_{OUT} = –200mA	25˚C		13.3	21	mΩ
			Full			26	
		V_{IN} = 3.3V, I_{OUT} = –200mA	25˚C		13.8	22	mΩ
			Full			27	
		V_{IN} = 2.5V, I_{OUT} = –200mA	25˚C		15.4	24	mΩ
			Full			29	
		V_{IN} = 1.8V, I_{OUT} = –200mA	25˚C		18.2	28	mΩ
			Full			33	
		V_{IN} = 1.2V, I_{OUT} = –200mA	25˚C		25.6	37	mΩ
			Full			44	
		V_{IN} = 1.1V, I_{OUT} = –200mA	25˚C		28.7	41	mΩ
			Full			50	
		V_{IN} = 1V, I_{OUT} = –200mA	25°C		33.8	48	mΩ
			Full			60	
$V_{HYS, ON}$	ON pin hysteresis	V_{IN} = 5V	Full		115		mV
		V_{IN} = 4.5V	Full		105		
		V_{IN} = 3.3V	Full		80		
		V_{IN} = 2.5V	Full		65		
		V_{IN} = 1.8V	Full		50		
		V_{IN} = 1.2V	Full		35		
		V_{IN} = 1.1V	Full		30		
		V_{IN} = 1V	Full		30		
I_{ON}	ON pin leakage current	V_{ON} = 1.1V to 5.5V	Full			150	nA
$I_{RC, VIN}$	Reverse current when disabled	V_{IN} = V_{ON} = 0V, V_{OUT} = 5V	25°C		–0.02		µA
			85°C		–2.1		
R_{PD} (1)	Output pulldown resistance	V_{ON} = 0V, I_{OUT} = 2mA	Full		273	325	Ω

(1) Available in TPS22964 only.

SWITCHING CHARACTERISTICS

PARAMETER		TEST CONDITION	TPS22963/64	UNIT
			TYP	
V_{IN} = 5.0 V, T_A = 25°C (unless otherwise noted)				
t_{ON}	Turn-ON time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	928	µs
t_{OFF}	Turn-OFF time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	2.5	
t_R	VOUT rise time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	890	
t_F	VOUT fall time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	2.1	
t_D	Delay time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	561	
V_{IN} = 4.5 V, T_A = 25°C (unless otherwise noted)				
t_{ON}	Turn-ON time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	905	µs
t_{OFF}	Turn-OFF time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	2.6	
t_R	VOUT rise time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	859	
t_F	VOUT fall time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	2.1	
t_D	Delay time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	560	
V_{IN} = 3.3 V, T_A = 25°C (unless otherwise noted)				
t_{ON}	Turn-ON time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	836	µs
t_{OFF}	Turn-OFF time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	2.8	
t_R	VOUT rise time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	715	
t_F	VOUT fall time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	2	
t_D	Delay time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	553	
V_{IN} = 1.8 V, T_A = 25°C (unless otherwise noted)				
t_{ON}	Turn-ON time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	822	µs
t_{OFF}	Turn-OFF time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	2.8	
t_R	VOUT rise time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	651	
t_F	VOUT fall time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	2	
t_D	Delay time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	558	
V_{IN} = 1.2 V, T_A = 25°C (unless otherwise noted)				
t_{ON}	Turn-ON time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	852	µs
t_{OFF}	Turn-OFF time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	3.2	
t_R	VOUT rise time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	535	
t_F	VOUT fall time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	1.8	
t_D	Delay time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	594	
V_{IN} = 1.1 V, T_A = 25°C (unless otherwise noted)				
t_{ON}	Turn-ON time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	861	µs
t_{OFF}	Turn-OFF time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	3.5	
t_R	VOUT rise time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	518	
t_F	VOUT fall time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	1.9	
t_D	Delay time	R_{OUT} = 10Ω, C_{IN} = 1µF, C_{OUT} = 0.1µF	604	

PARAMETRIC MEASUREMENT INFORMATION

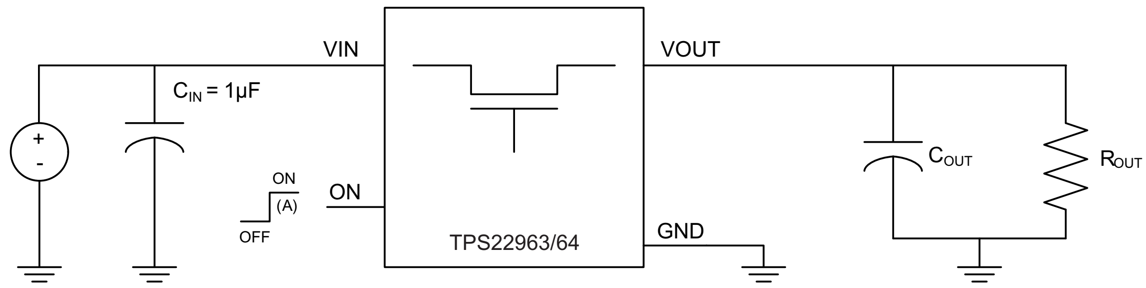
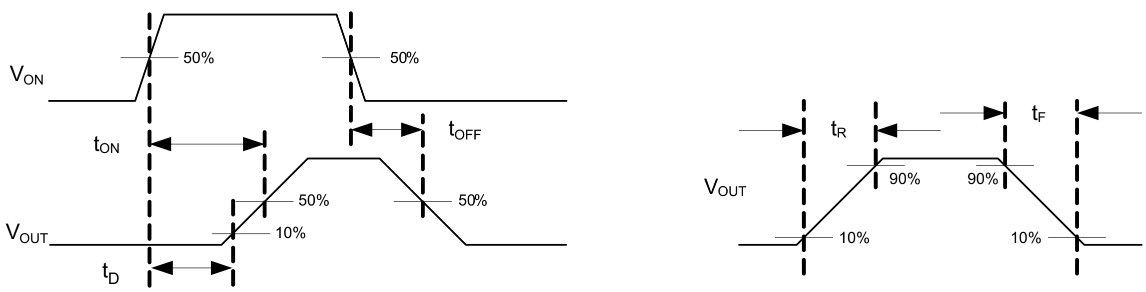


Figure 1. Test Circuit

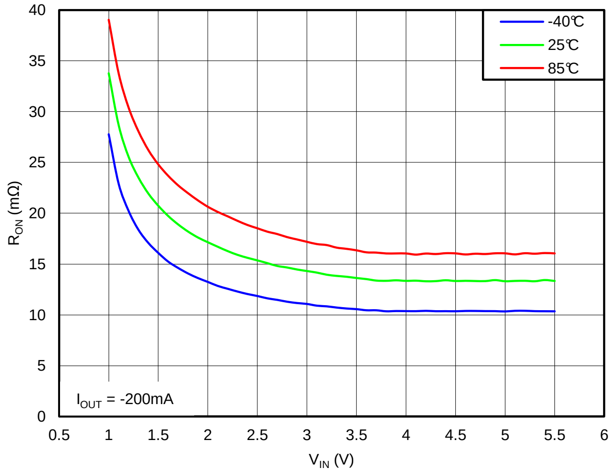


A. Rise and fall times of the control signal are 100 ns.

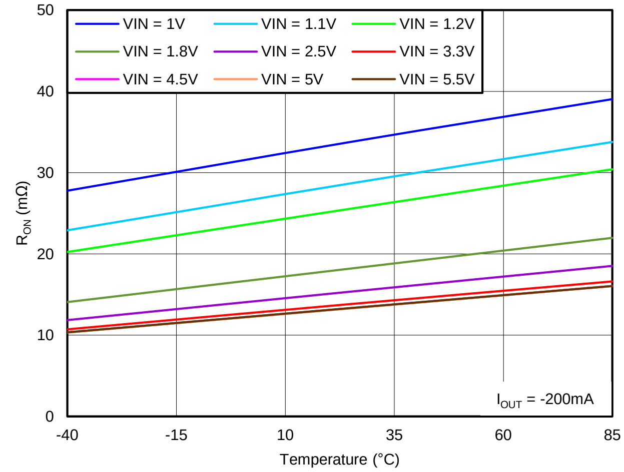
Figure 2. Timing Waveforms

TYPICAL ELECTRICAL CHARACTERISTICS

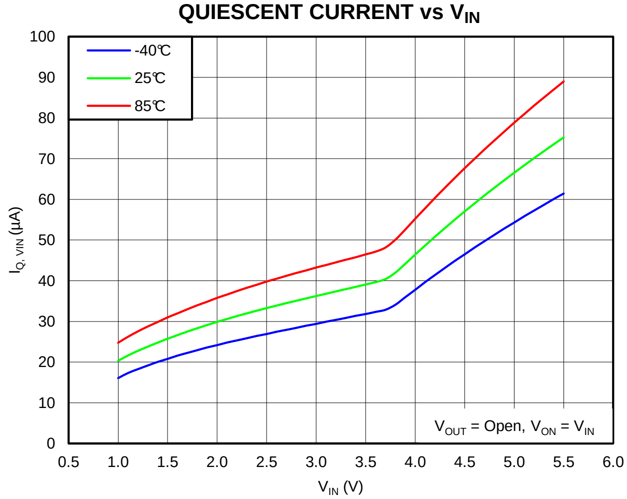
ON RESISTANCE vs V_{IN}



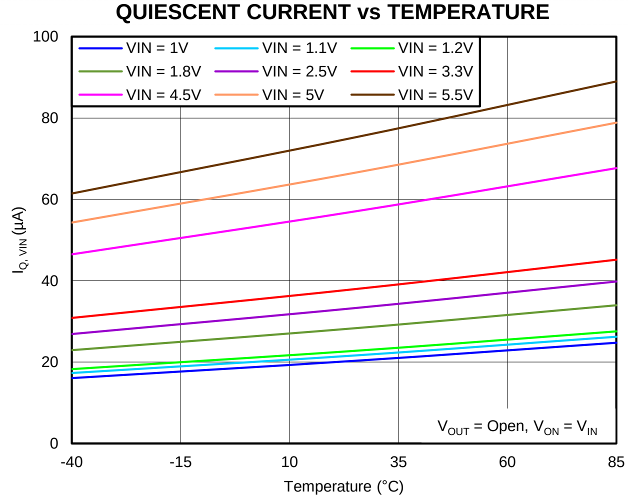
ON RESISTANCE vs TEMPERATURE



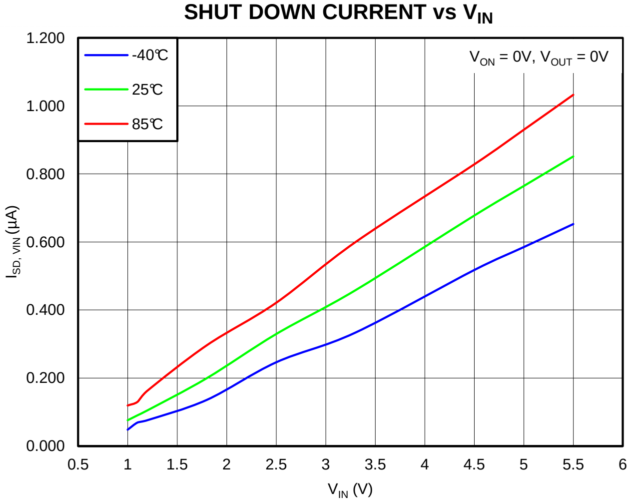
QUIESCENT CURRENT vs V_{IN}



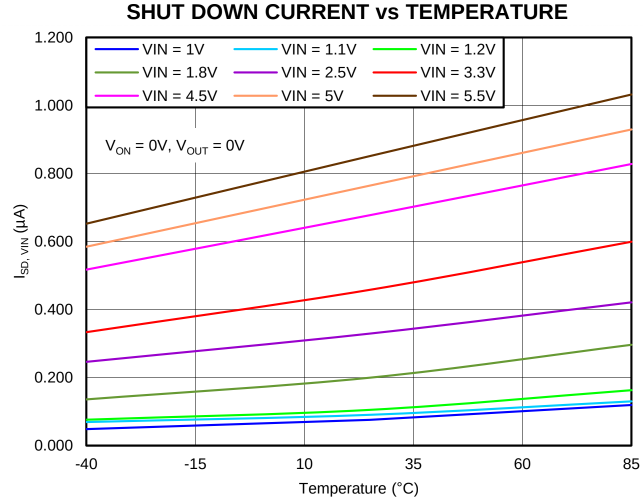
QUIESCENT CURRENT vs TEMPERATURE



SHUT DOWN CURRENT vs V_{IN}

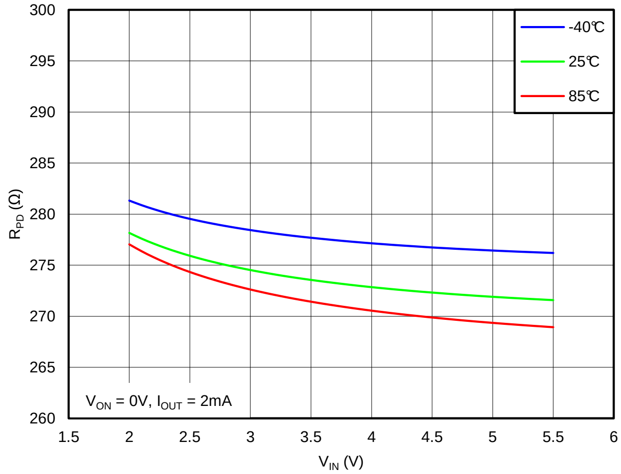


SHUT DOWN CURRENT vs TEMPERATURE

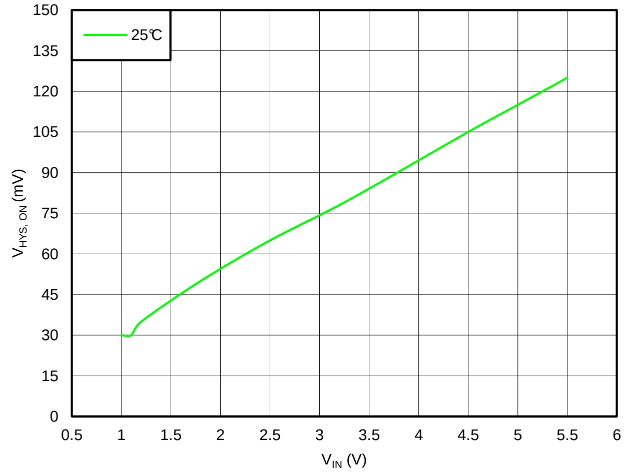


TYPICAL ELECTRICAL CHARACTERISTICS (continued)

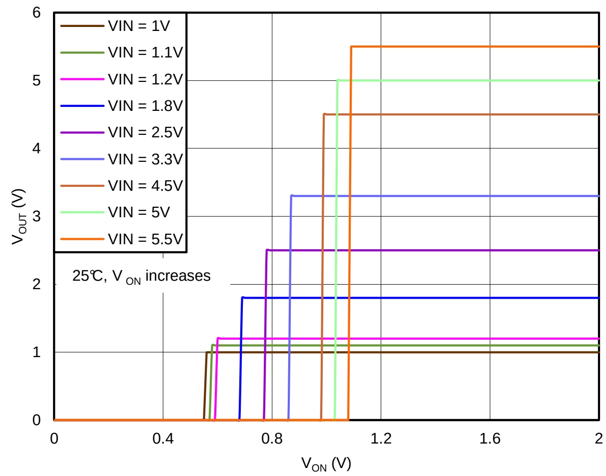
OUTPUT PULLDOWN RESISTANCE vs V_{IN}



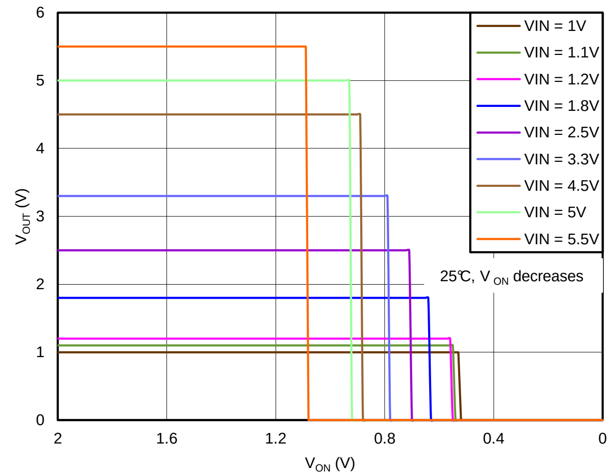
ON PIN HYSTERESIS vs V_{IN}



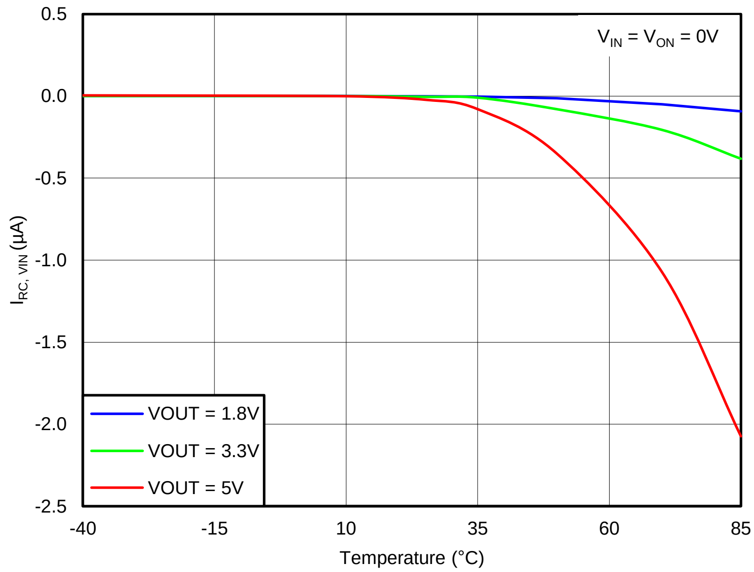
OUTPUT VOLTAGE vs V_{ON} RISING



OUTPUT VOLTAGE vs V_{ON} FALLING

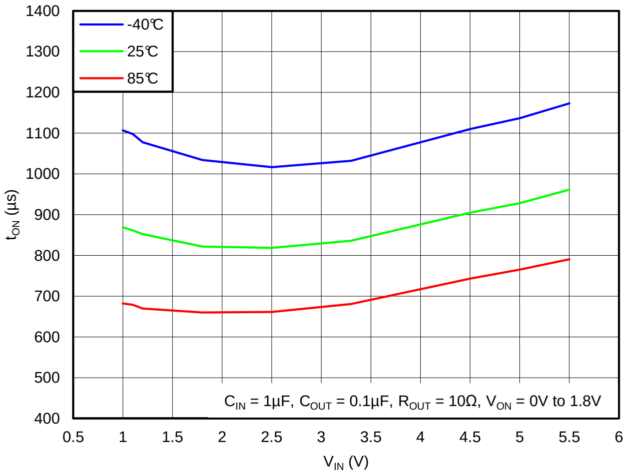


REVERSE CURRENT WHEN DISABLED vs TEMPERATURE

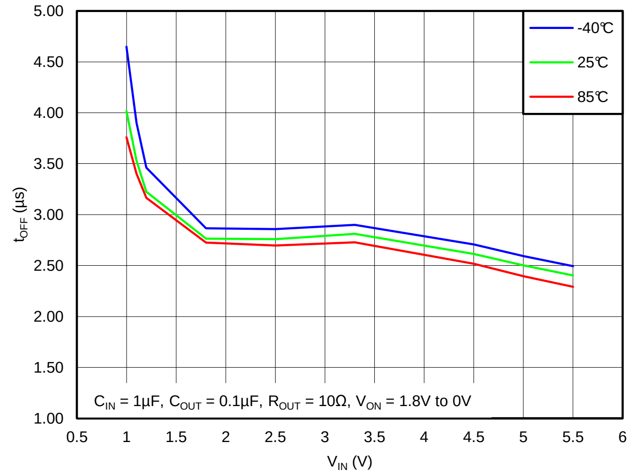


TYPICAL SWITCHING CHARACTERISTICS

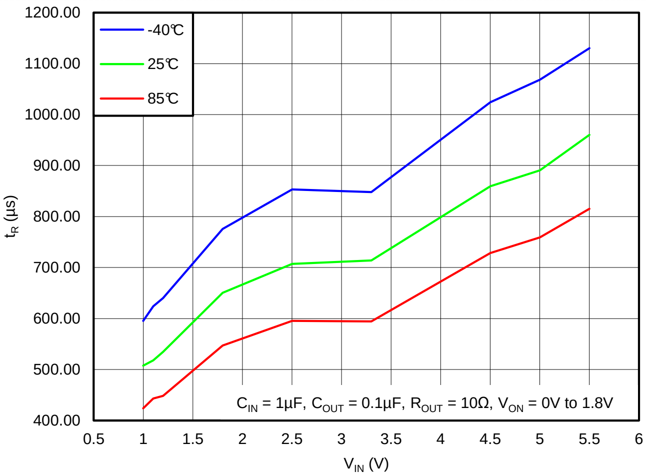
TURN-ON TIME vs V_{IN}



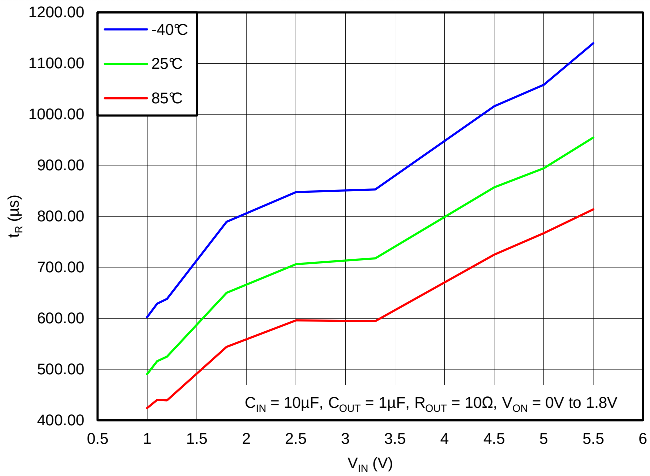
TURN-OFF TIME vs V_{IN}



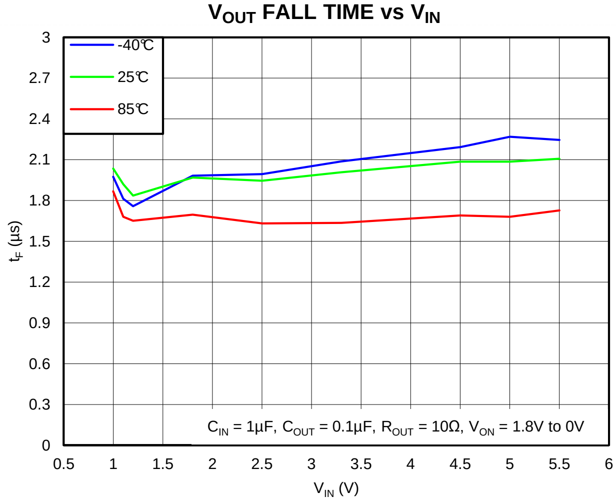
V_{OUT} RISE TIME vs V_{IN}



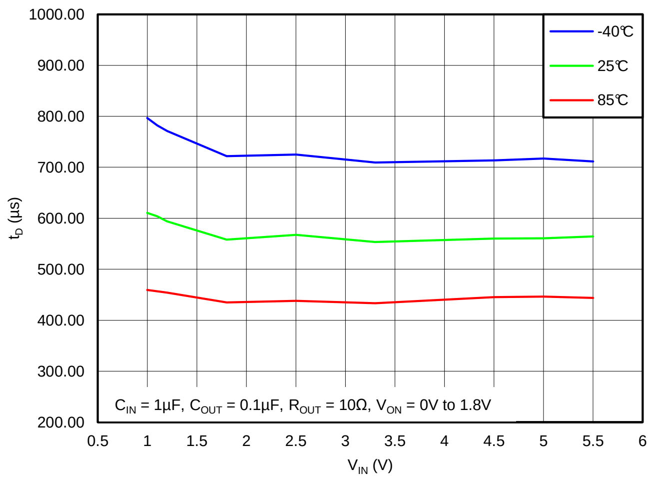
V_{OUT} RISE TIME vs V_{IN}



V_{OUT} FALL TIME vs V_{IN}

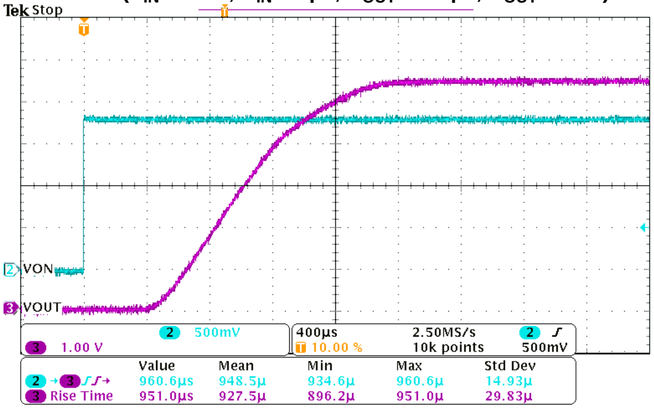


DELAY TIME vs V_{IN}

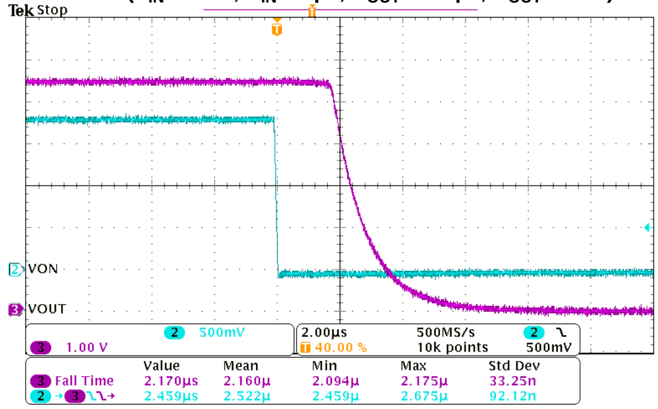


TYPICAL AC SCOPE CAPTURES @ T_A = 25ºC

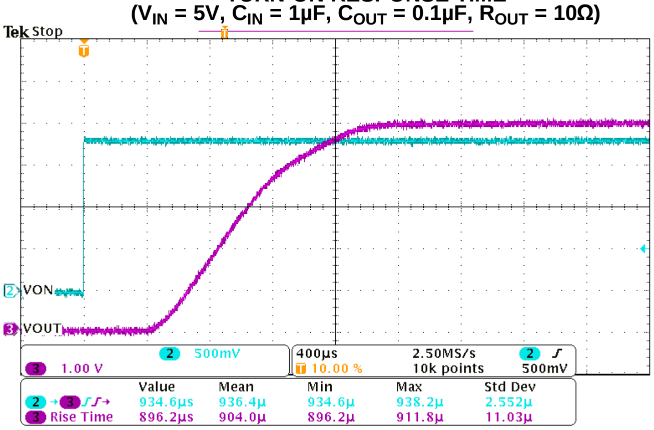
TURN-ON RESPONSE TIME
(V_{IN} = 5.5V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_{OUT} = 10Ω)



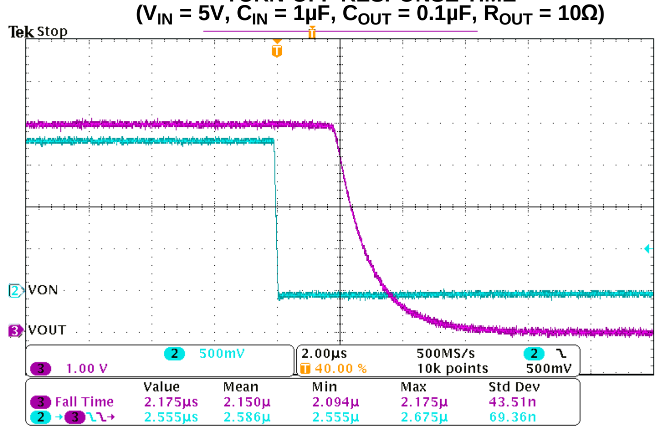
TURN-OFF RESPONSE TIME
(V_{IN} = 5.5V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_{OUT} = 10Ω)



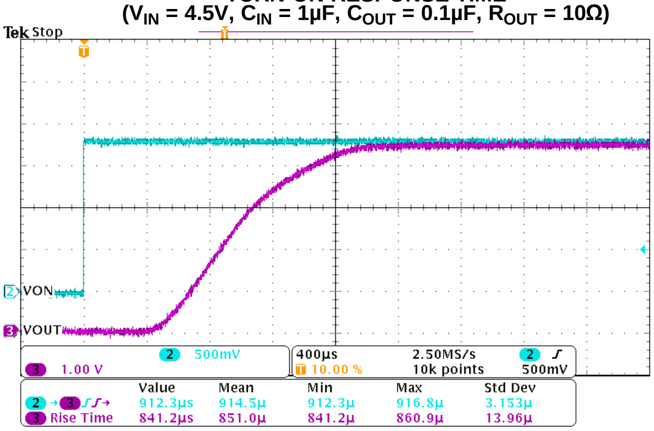
TURN-ON RESPONSE TIME
(V_{IN} = 5V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_{OUT} = 10Ω)



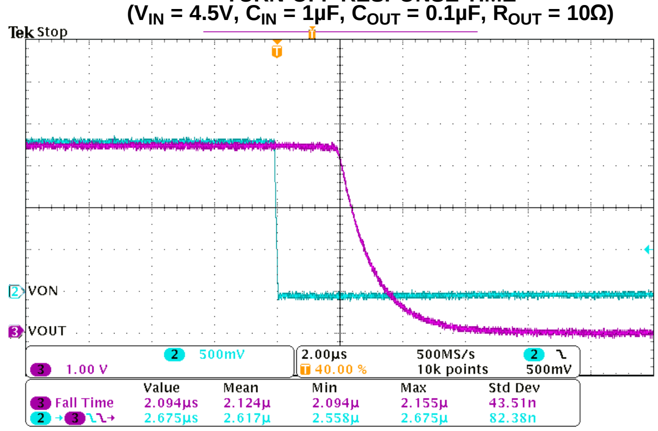
TURN-OFF RESPONSE TIME
(V_{IN} = 5V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_{OUT} = 10Ω)



TURN-ON RESPONSE TIME
(V_{IN} = 4.5V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_{OUT} = 10Ω)

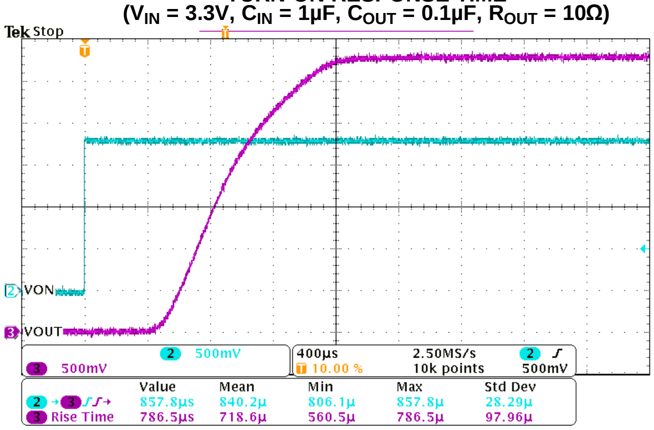


TURN-OFF RESPONSE TIME
(V_{IN} = 4.5V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_{OUT} = 10Ω)

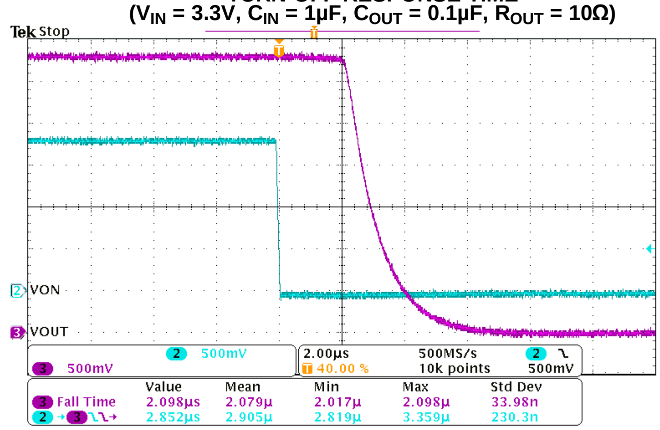


TYPICAL AC SCOPE CAPTURES @ T_A = 25ºC (continued)

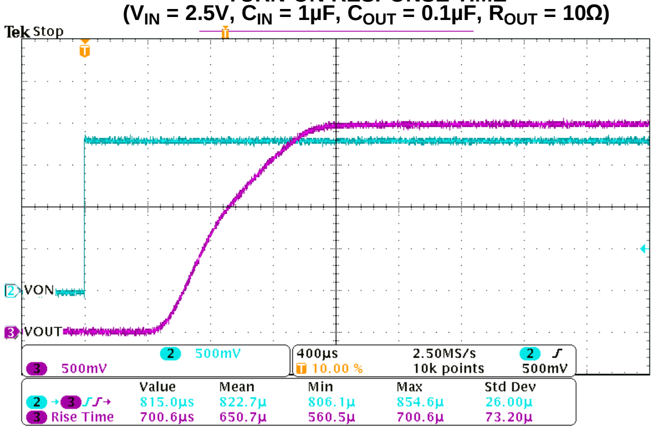
TURN-ON RESPONSE TIME
(V_{IN} = 3.3V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_{OUT} = 10Ω)



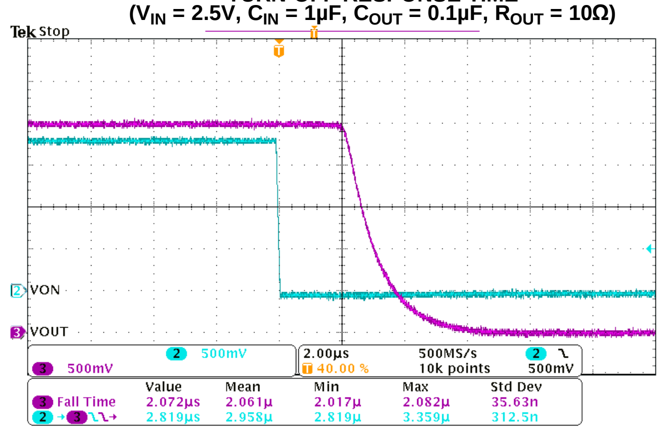
TURN-OFF RESPONSE TIME
(V_{IN} = 3.3V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_{OUT} = 10Ω)



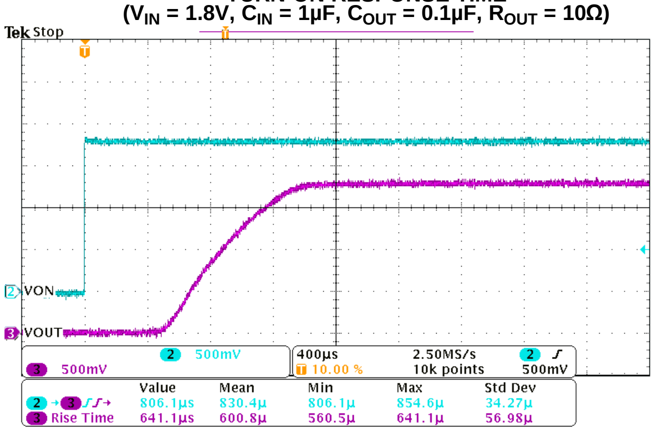
TURN-ON RESPONSE TIME
(V_{IN} = 2.5V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_{OUT} = 10Ω)



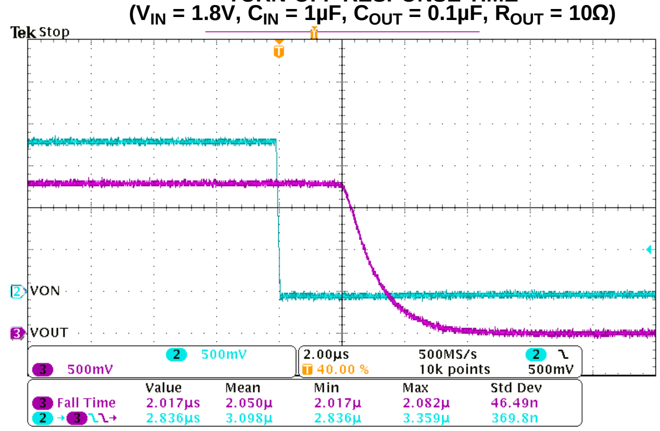
TURN-OFF RESPONSE TIME
(V_{IN} = 2.5V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_{OUT} = 10Ω)



TURN-ON RESPONSE TIME
(V_{IN} = 1.8V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_{OUT} = 10Ω)

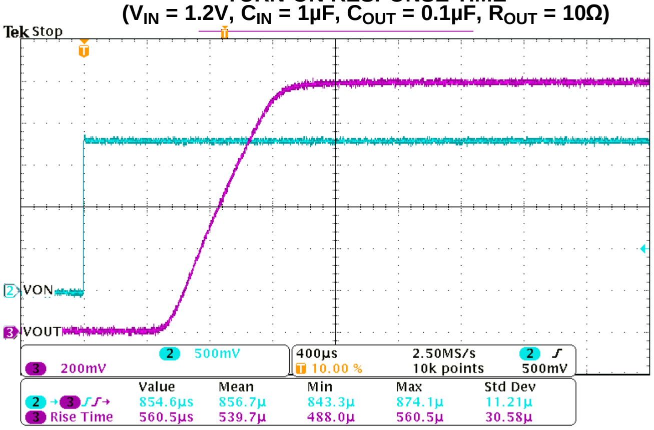


TURN-OFF RESPONSE TIME
(V_{IN} = 1.8V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_{OUT} = 10Ω)

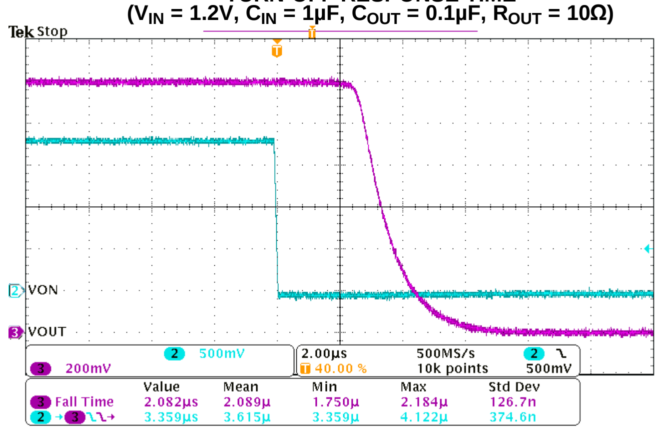


TYPICAL AC SCOPE CAPTURES @ T_A = 25ºC (continued)

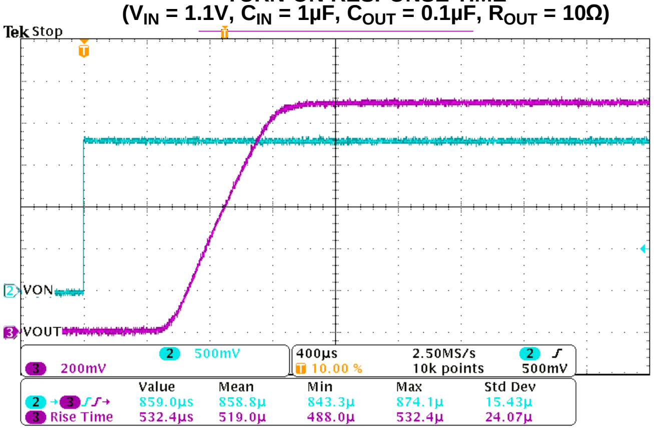
TURN-ON RESPONSE TIME
(V_{IN} = 1.2V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_{OUT} = 10Ω)



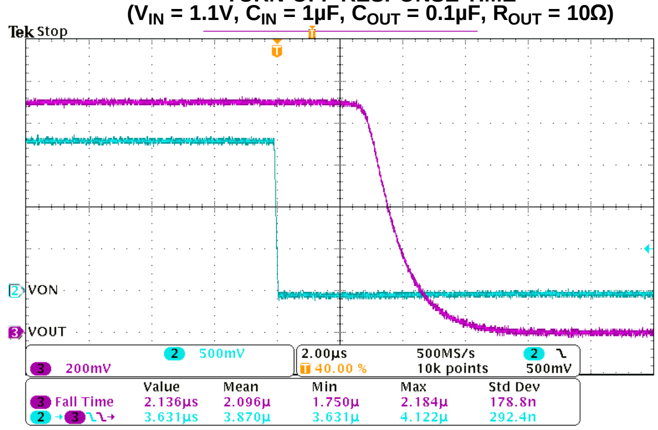
TURN-OFF RESPONSE TIME
(V_{IN} = 1.2V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_{OUT} = 10Ω)



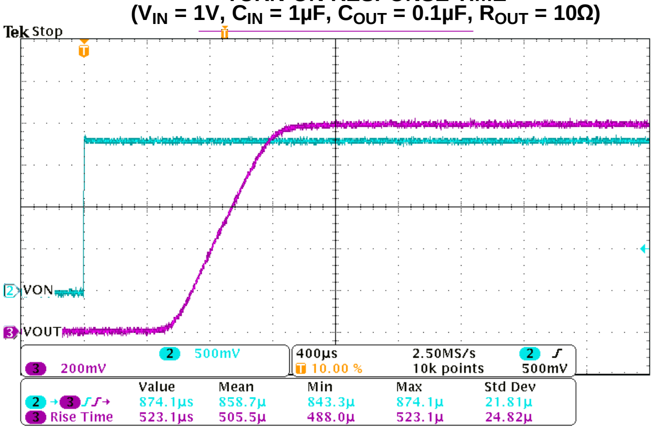
TURN-ON RESPONSE TIME
(V_{IN} = 1.1V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_{OUT} = 10Ω)



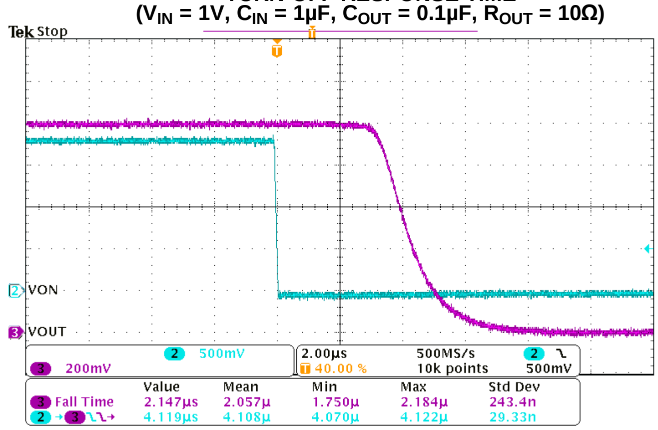
TURN-OFF RESPONSE TIME
(V_{IN} = 1.1V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_{OUT} = 10Ω)



TURN-ON RESPONSE TIME
(V_{IN} = 1V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_{OUT} = 10Ω)



TURN-OFF RESPONSE TIME
(V_{IN} = 1V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_{OUT} = 10Ω)



APPLICATION INFORMATION

TPS22963/64 is an ultra-low ON-resistance, 3A integrated load switch that is capable of interfacing directly with 1S battery in portable consumer devices such as smartphones, tablets etc. Its wide input voltage range (1V to 5.5V) makes it suitable to be used for lower voltage rails as well inside different end equipments to accomplish power sequencing, inrush current control and reducing leakage current in sub-systems that are in standby mode. Figure 3 shows the typical application circuit of TPS22963/64.

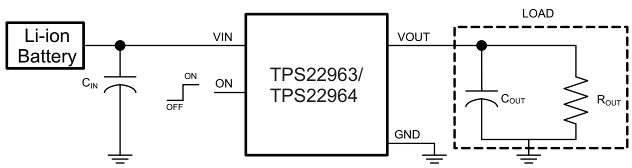


Figure 3. Typical Application circuit

Input Capacitor

It is recommended to place a capacitor (C_{IN}) between VIN and GND pins of TPS22963/64. This capacitor helps to limit the voltage drop on the input voltage supply when the switch turns ON into a discharged load capacitor. A 1µF ceramic capacitor that is placed close to the IC pins is usually sufficient. Higher values of C_{IN} can be used to further reduce the voltage drop in high current applications.

Output Capacitor

It is recommended to place a capacitor (C_{OUT}) between VOUT and GND pins of TPS22963/64. This capacitor acts as a low pass filter along with the switch ON-resistance to remove any voltage glitches coming from the input voltage source. It is generally recommended to have C_{IN} greater than C_{OUT} so that once the switch is turned ON, C_{OUT} can charge up to V_{IN} without V_{IN} dropping significantly. A 0.1µF ceramic capacitor that is placed close to the IC pins is usually sufficient.

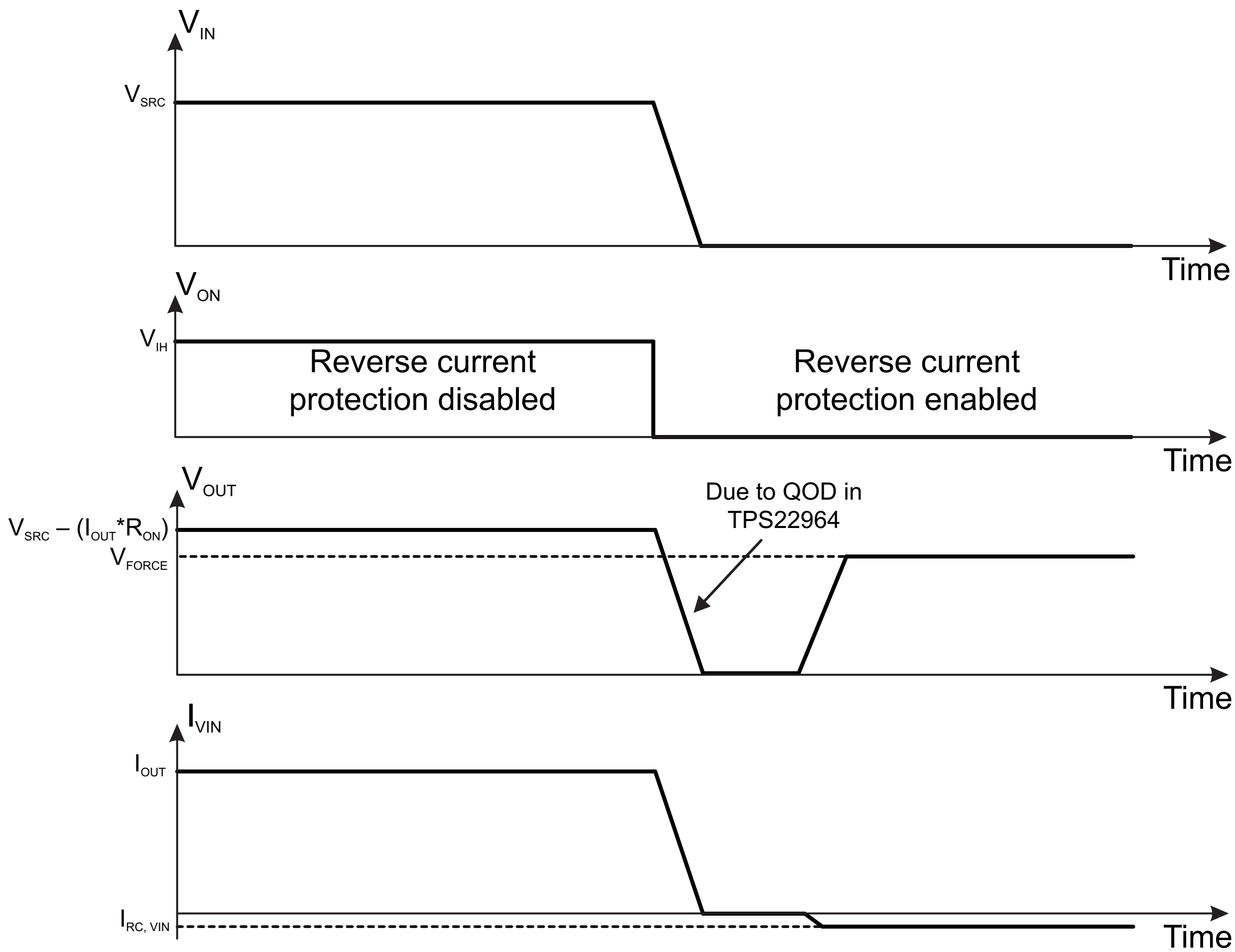
On/Off Control

The ON pin controls the state of the switch. It is an active “High” pin and has a low threshold making it capable of interfacing with low voltage GPIO control signals. It can be used with any microcontroller with 1.2V, 1.8V, 2.5V, 3.3V or 5.5V GPIOs. Applying V_{IH} on the ON pin will put the switch in the ON-state and V_{IL} will put the switch in the OFF-state.

Reverse Current Protection

The reverse current protection feature prevents the current to flow from VOUT to VIN when TPS22963/64 is disabled. This feature is particularly useful when the output of TPS22963/64 needs to be driven by another voltage source after TPS22963/64 is disabled (for example in a power multiplexer application). In order for this feature to work, TPS22963/64 has to be disabled and either of the following conditions shall be met: V_{IN} > 1V or V_{OUT} > 1V.

Figure 4 demonstrates the ideal behavior of reverse current protection circuit in TPS22963/64. After the device is disabled via the ON pin and VOUT is forced to an external voltage V_{FORCE}, a very small amount of current given by $I_{RC, VIN}$ will flow from VOUT to VIN. This will prevent any extra current loading on the voltage source supplying the V_{FORCE} voltage.



I_{VIN} = Current through VIN pin.

V_{SRC} = Input voltage applied to the device.

V_{FORCE} = External voltage source forced at VOUT pin of the device.

I_{OUT} = Output load current.

Figure 4. Reverse Current Protection

Board Layout and Thermal Considerations

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 operation. Using wide traces for VIN, VOUT and GND will help minimize the parasitic electrical effects.

For higher reliability, the maximum IC junction temperature, $T_{J(max)}$, should be restricted to 125˚C under normal operating conditions. Junction temperature is directly proportional to power dissipation in the device and the two are related by Equation 1.

$$T_J = T_A + \Theta_{JA} \times P_D \quad (1)$$

Where:

- T_J = Junction temperature of the device
- T_A = Ambient temperature
- P_D = Power dissipation inside the device
- Θ_{JA} = Junction to ambient thermal resistance. See Thermal Information section of the datasheet. This parameter is highly dependent on board layout.

Application Examples

Standby Power Reduction

Any end equipment that is being powered from the battery has a need to reduce current consumption in order to keep the battery charged for a longer time. TPS22963/64 helps to accomplish this by turning off the supply to the modules that are in standby state and hence significantly reduces the leakage current overhead of the standby modules.

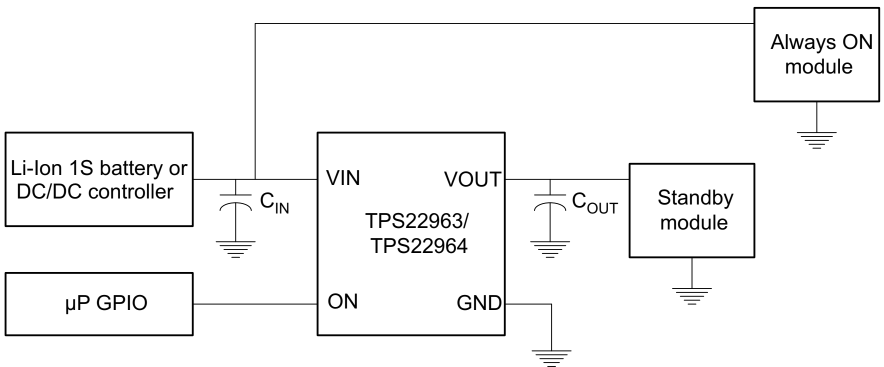


Figure 5. Standby Power Reduction

Power Supply Sequencing Without a GPIO Input

In many end equipments, there is a need to power up various modules in a pre-determined manner. TPS22963/64 can solve the problem of power sequencing without adding any complexity to the overall system.

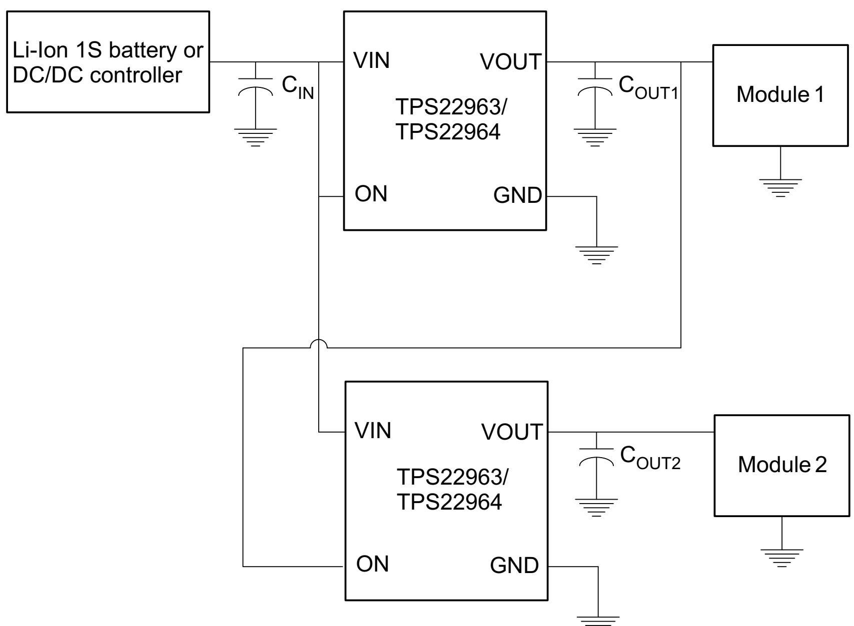


Figure 6. Power Supply Sequencing Without a GPIO Input

Power Multiplexer

The reverse current protection and no Quick Output Discharge (QOD) features of TPS22963 allow it to be used in a power multiplexer configuration as shown in Figure 7. Two TPS22963 devices can be used in a power multiplexer configuration with a suitable ON pin control circuit (Break before Make) such that either VIN1 or VIN2 is passed to the system. The reverse current protection feature does not allow current to flow from VOUT to VIN for the device that is in the OFF state.

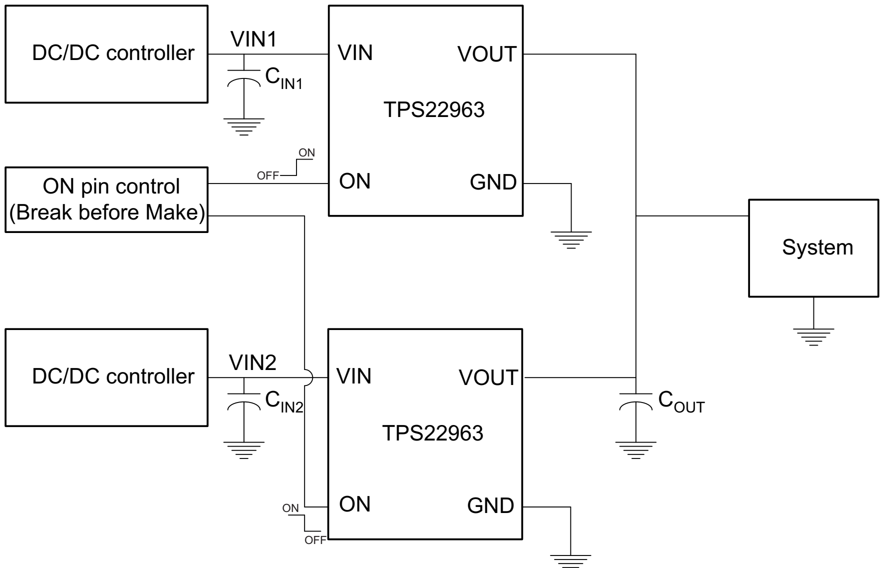


Figure 7. Power Multiplexer

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
TPS22963CYZPR	ACTIVE	DSBGA	YZP	6	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 85	BD	Samples
TPS22963CYZPT	ACTIVE	DSBGA	YZP	6	250	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 85	BD	Samples
TPS22964CYZPR	ACTIVE	DSBGA	YZP	6	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 85	DK	Samples
TPS22964CYZPT	ACTIVE	DSBGA	YZP	6	250	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 85	DK	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.

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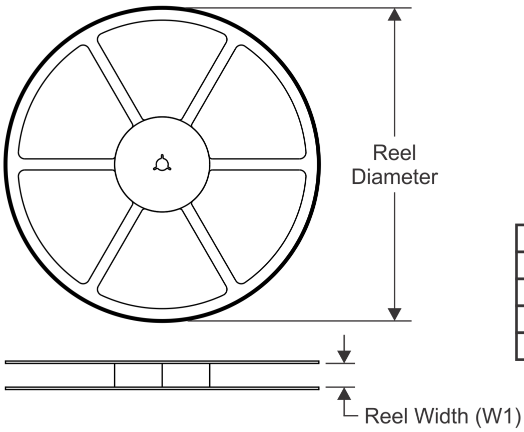
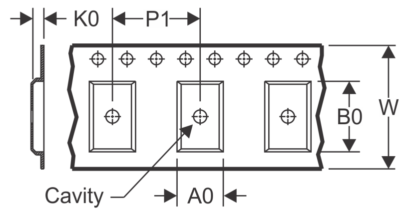
TAPE AND REEL INFORMATION

REEL DIMENSIONS

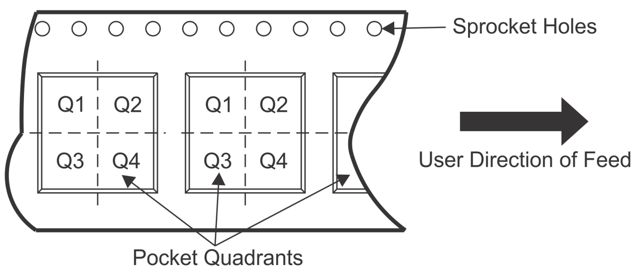


TAPE DIMENSIONS



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

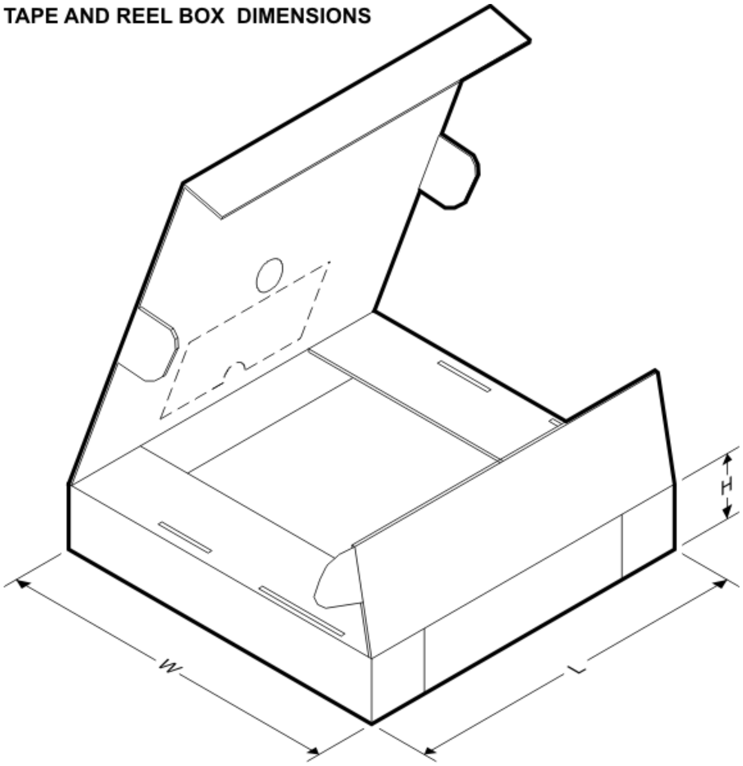
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TPS22964CYZPR	DSBGA	YZP	6	3000	180.0	8.4	1.04	1.54	0.56	4.0	8.0	Q1
TPS22964CYZPT	DSBGA	YZP	6	250	180.0	8.4	1.04	1.54	0.56	4.0	8.0	Q1

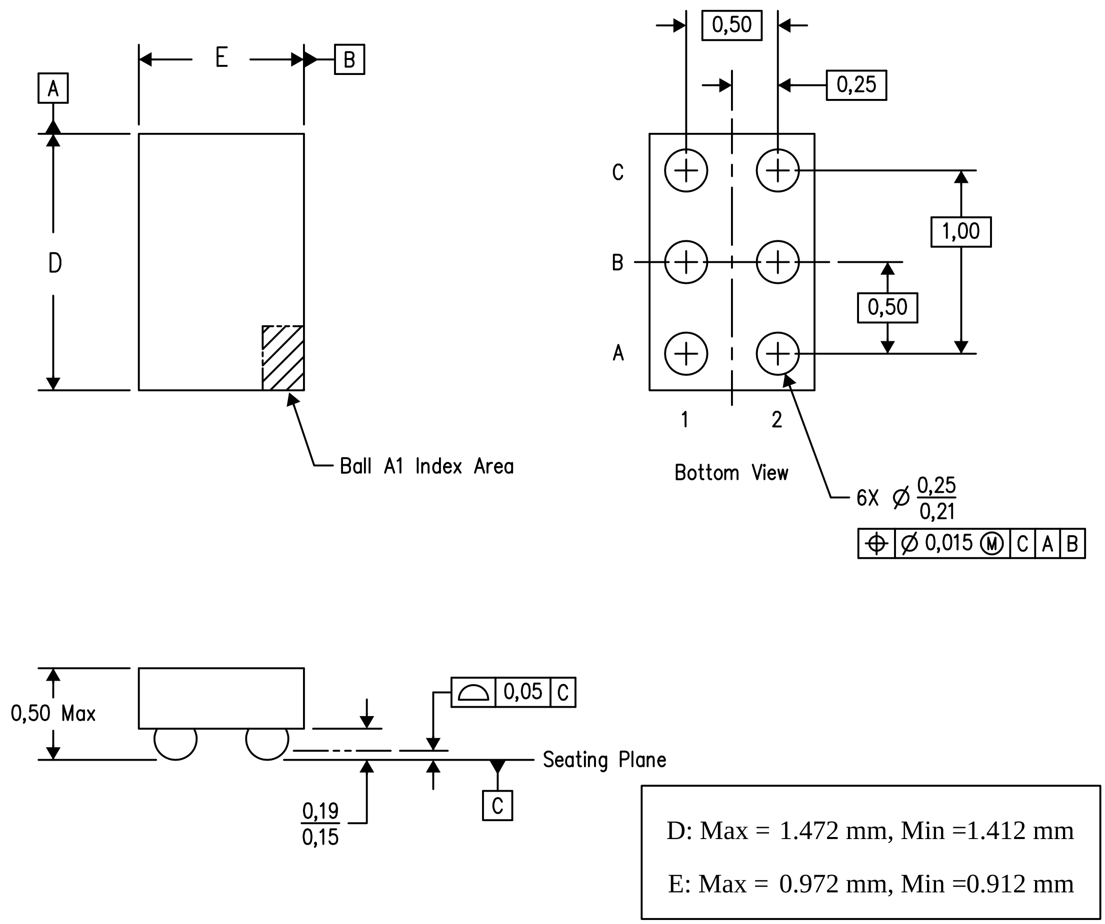
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS22964CYZPR	DSBGA	YZP	6	3000	182.0	182.0	17.0
TPS22964CYZPT	DSBGA	YZP	6	250	182.0	182.0	17.0

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



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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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