

TPS22997 5.5-V, 10-A, 4-mΩ On-Resistance Load Switch with Adjustable Rise Time

1 Features

- Input operating voltage range (V_{IN}): 0.1 V–5.5 V
- Bias voltage range: 1.5 V–5.5 V
- Maximum continuous current: 10 A
- ON-Resistance (R_{ON}): 4 mΩ (typ.)
- Adjustable slew rate control
- Adjustable quick output discharge (QOD)
- Open drain Power Good (PG) signal
- Thermal shutdown
- Low power consumption:
 - ON state (I_Q): 10 µA (typ.)
 - OFF state (I_{SD}): 0.1 µA (typ.)
- Thermal shutdown
- Smart ON pin pulldown ($R_{PD,ON}$)
 - ON $\geq V_{IH}$ (I_{ON}): 25 nA (typ.)
 - ON $\leq V_{IL}$ ($R_{PD,ON}$): 500 kΩ (typ.)

2 Applications

- Solid state drive
- PC and notebooks
- Industrial PC
- Optical module

3 Description

The TPS22997 is a single-channel load switch that provides a configurable rise time to minimize inrush current. The device contains an N-channel MOSFET that can operate over an input voltage range of 0.1 V to 5.5 V and can support a maximum continuous current of 10 A.

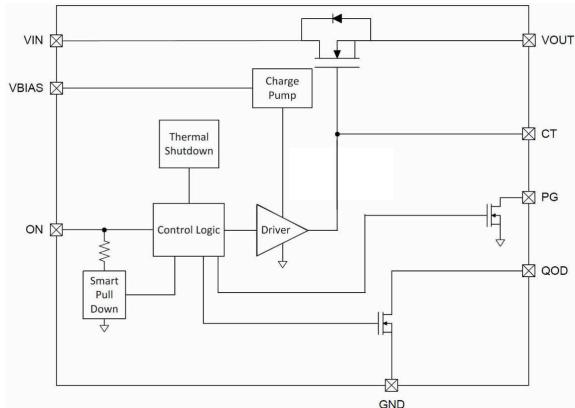
The switch is controlled by an enable pin (ON), which is capable of interfacing directly with low voltage GPIO signals ($V_{IH} = 0.8$ V). The TPS22997 device has an optional QOD pin for quick output discharge when switch is turned off, and the fall time (t_{FALL}) of the output can be adjusted through an external resistor. There is a Power Good (PG) signal on the device that indicates when the main MOSFET is fully turned on, which can be used to enable a downstream load. Integrated thermal shutdown ensures protection in high temperature environments.

The TPS22997 is available in a 1.5×2.0 mm, 0.5 mm pitch, 10-pin WQFN package (RYZ) and is characterized for operation over the free-air temperature range of -40°C to $+125^{\circ}\text{C}$.

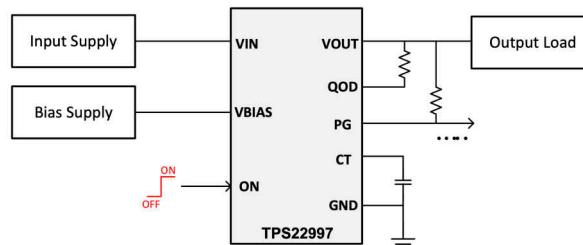
Device Information

Part Number	Package ⁽¹⁾	Body Size (Nom)
TPS22997	WQFN (10)	1.5 × 2.0 mm

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



TPS22997 Block Diagram



TPS22997 Typical Application

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4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

DATE	REVISION	NOTES
December 2022	*	Initial Release

5 Pin Configuration and Functions

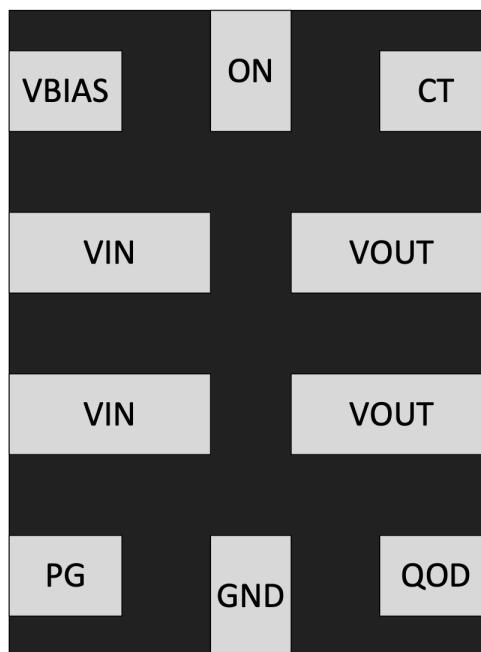


Figure 5-1. TPS22997 RYZ Package, 10-Pin WQFN (Top View)

Table 5-1. Pin Functions

PIN		I/O ⁽¹⁾	DESCRIPTION
NAME	NO.		
VBIAS	1	I	Device bias supply
VIN	2, 3	I	Switch input
PG	4	O	Open drain power good signal, asserted high when the output is full load ready
GND	5	-	Device ground
QOD	6	-	Quick output discharge pin
VOUT	7, 8	O	Switch output
CT	9	I	Timing pin, can control the slew rate of the output through a capacitor to GND
ON	10	I	Enable pin

(1) I = Input, O = Output

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
V_{IN}	Input Voltage	-0.3	6	V
V_{BIAS}	Bias Voltage	-0.3	6	V
V_{ON}, V_{PG}, V_{QOD}	Control Pin Voltage	-0.3	6	V
V_{CT}	CT Pin Voltage		15	V
I_{MAX}	Maximum Current		10	A
T_J	Junction temperature		Internally Limited	°C
T_{stg}	Storage temperature	-65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Rating* 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 Condition*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

6.2 ESD Ratings

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

(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.

6.3 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
V_{IN}	Input Voltage	0.1	5.5	5.5	V
V_{BIAS}	Bias Voltage	1.5	5.5	5.5	V
V_{IH}	ON Pin High Voltage Range	0.8	5.5	5.5	V
V_{IL}	ON Pin Low Voltage Range	0	0.35	0.35	V
V_{PG}, V_{QOD}	Control Pin Voltage	0	5.5	5.5	V
T_A	Ambient Temperature	-40	125	125	°C

6.4 Thermal Information

THERMAL METRIC		TPS22997	UNIT
		RYZ (WQFN)	
		10 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	83.7	°C/W
$R_{\theta JC(\text{top})}$	Junction-to-case (top) thermal resistance	73.9	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	18.2	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	2.0	°C/W
Υ_{JB}	Junction-to-board characterization parameter	18.1	°C/W

6.5 Electrical Characteristics (V_{BIAS} = 5 V)

over operating free-air temperature range (unless otherwise noted). Typical values are specified at 25°C and V_{IN} = 3.3V, V_{BIAS} = 5.5V.

PARAMETER		TEST CONDITIONS	T _A	MIN	TYP	MAX	UNIT
Power Consumption							
I _{SD,VBIAS}	V _{BIAS} Shutdown Current	ON = 0V	25°C	0.1			uA
			-40°C to 85°C		0.5		uA
			-40°C to 125°C		1		uA
I _{Q,VBIAS}	V _{BIAS} Quiescent Current	ON > V _{IH}	25°C	10			uA
			-40°C to 85°C		15		uA
			-40°C to 125°C		15		uA
I _{SD,VIN}	V _{IN} Shutdown Current	ON = 0V	25°C	0.1			uA
			-40°C to 85°C		1		uA
			-40°C to 125°C		7		uA
I _{ON}	ON pin leakage	ON = V _{BIAS}	-40°C to 125°C		0.1		uA
Performance							
R _{ON}	On-Resistance	VIN = 5V	25°C	4			mΩ
			-40°C to 85°C		6		mΩ
			-40°C to 125°C		7		mΩ
R _{ON}	On-Resistance	VIN = 3.3V	25°C	4			mΩ
			-40°C to 85°C		6		mΩ
			-40°C to 125°C		7		mΩ
R _{ON}	On-Resistance	VIN = 1.8V	25°C	4			mΩ
			-40°C to 85°C		6		mΩ
			-40°C to 125°C		7		mΩ
R _{ON}	On-Resistance	VIN = 1.2V	25°C	4			mΩ
			-40°C to 85°C		6		mΩ
			-40°C to 125°C		7		mΩ
R _{ON}	On-Resistance	VIN = 0.8V	25°C	4			mΩ
			-40°C to 85°C		6		mΩ
			-40°C to 125°C		7		mΩ
V _{OL,PG}	Power Good VOL	I _{PG} = 1mA	-40°C to 125°C		0.2		V
R _{PD,ON}	Smart Pull Down Resistance		25°C	500			kΩ
			-40°C to 125°C		700		kΩ
R _{QOD}	QOD Resistance		25°C	50			Ω
			-40°C to 125°C		75		Ω
Protection							
TSD	Thermal Shutdown		-	150	170	190	°C
TSD _{HYS}	Thermal Shutdown Hysteresis		-		20		°C

6.6 Electrical Characteristics (V_{BIAS} = 3.3 V)

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

PARAMETER		TEST CONDITIONS	T _A	MIN	TYP	MAX	UNIT
Power Consumption							
I _{SD,VBIAS}	V _{BIAS} Shutdown Current	ON = 0V	25°C	0.1			uA
			-40°C to 85°C		0.5		uA
			-40°C to 125°C		1		uA

6.6 Electrical Characteristics (V_{BIAS} = 3.3 V) (continued)

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

PARAMETER		TEST CONDITIONS	T _A	MIN	TYP	MAX	UNIT
I _{Q,VBIAS}	V _{BIAS} Quiescent Current	ON > V _{IH}	25°C		10		uA
			-40°C to 85°C		15		uA
			-40°C to 125°C		15		uA
I _{SD,VIN}	VIN Shutdown Current	ON = 0V	25°C		0.1		uA
			-40°C to 85°C		1		uA
			-40°C to 125°C		7		uA
I _{ON}	ON pin leakage	ON = V _{BIAS}	-40°C to 125°C		0.1		uA
Performance							
R _{ON}	On-Resistance	VIN = 3.3V	25°C		4		mΩ
			-40°C to 85°C		6		mΩ
			-40°C to 125°C		7		mΩ
R _{ON}	On-Resistance	VIN = 1.8V	25°C		4		mΩ
			-40°C to 85°C		6		mΩ
			-40°C to 125°C		7		mΩ
R _{ON}	On-Resistance	VIN = 1.2V	25°C		4		mΩ
			-40°C to 85°C		6		mΩ
			-40°C to 125°C		7		mΩ
R _{ON}	On-Resistance	VIN = 0.8V	25°C		4		mΩ
			-40°C to 85°C		6		mΩ
			-40°C to 125°C		7		mΩ
V _{OL,PG}	Power Good VOL	I _{PG} = 1mA	-40°C to 125°C		0.2		V
R _{PD,ON}	Smart Pull Down Resistance		25°C		500		kΩ
			-40°C to 125°C		700		kΩ
R _{QOD}	QOD Resistance		25°C		50		Ω
			-40°C to 125°C		100		Ω
Protection							
TSD	Thermal Shutdown		-	150	170	190	°C
TSD _{HYS}	Thermal Shutdown Hysteresis		-		20		°C

6.7 Electrical Characteristics (V_{BIAS} = 1.5 V)

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

PARAMETER		TEST CONDITIONS	T _A	MIN	TYP	MAX	UNIT
Power Consumption							
I _{SD,VBIAS}	V _{BIAS} Shutdown Current	ON = 0V	25°C		0.1		uA
			-40°C to 85°C		0.5		uA
			-40°C to 125°C		1		uA
I _{Q,VBIAS}	V _{BIAS} Quiescent Current	ON > V _{IH}	25°C		10		uA
			-40°C to 85°C		15		uA
			-40°C to 125°C		15		uA
I _{SD,VIN}	VIN Shutdown Current	ON = 0V	25°C		0.1		uA
			-40°C to 85°C		1		uA
			-40°C to 125°C		7		uA
I _{ON}	ON pin leakage	ON = V _{BIAS}	-40°C to 125°C		0.1		uA
Performance							

6.7 Electrical Characteristics (V_{BIAS} = 1.5 V) (continued)

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

PARAMETER		TEST CONDITIONS	T _A	MIN	TYP	MAX	UNIT
R _{ON}	On-Resistance	VIN = 1.5V	25°C		4.5		mΩ
			-40°C to 85°C		6		mΩ
			-40°C to 125°C		7		mΩ
R _{ON}	On-Resistance	VIN = 1.2V	25°C		4.5		mΩ
			-40°C to 85°C		6		mΩ
			-40°C to 125°C		7		mΩ
R _{ON}	On-Resistance	VIN = 0.8V	25°C		4.5		mΩ
			-40°C to 85°C		6		mΩ
			-40°C to 125°C		7		mΩ
V _{OL,PG}	Power Good VOL	I _{PG} = 1mA	-40°C to 125°C		0.2		V
R _{PD,ON}	Smart Pull Down Resistance		25°C		500		kΩ
			-40°C to 125°C		700		kΩ
R _{QOD}	QOD Resistance		25°C		55		Ω
			-40°C to 125°C		100		Ω
Protection							
TSD	Thermal Shutdown		-	150	170	190	°C
TSD _{HYS}	Thermal Shutdown Hysteresis		-	20			°C

6.8 Switching Characteristics (V_{BIAS} = 5 V)

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
VIN = 5V						
tON	Turn ON time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		1170		us
tRISE	Rise time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		819		us
tD	Delay time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		347		us
tFALL	Fall time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		2090		us
tOFF	Turn OFF time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		108		us
VIN = 3.3V						
tON	Turn ON time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		944		us
tRISE	Rise time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		567		us
tD	Delay time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		377		us
tFALL	Fall time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		2110		us
tOFF	Turn OFF time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		113		us
VIN = 1.8V						
tON	Turn ON time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		692		us
tRISE	Rise time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		327		us
tD	Delay time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		365		us
tFALL	Fall time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		2150		us
tOFF	Turn OFF time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		117		us
VIN = 1.2V						
tON	Turn ON time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		591		us
tRISE	Rise time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		227		us
tD	Delay time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		364		us
tFALL	Fall time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		2180		us

6.8 Switching Characteristics (V_{BIAS} = 5 V) (continued)

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t _{OFF} Turn OFF time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	120		us	
VIN = 0.8V						
t _{ON} Turn ON time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	523		us	
t _{RISE} Rise time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	159		us	
t _D Delay time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	365		us	
t _{FALL} Fall time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	2260		us	
t _{OFF} Turn OFF time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	129		us	

6.9 Switching Characteristics (V_{BIAS} = 3.3 V)

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
VIN = 3.3V						
t _{ON} Turn ON time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	898		us	
t _{RISE} Rise time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	563		us	
t _D Delay time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	336		us	
t _{FALL} Fall time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	2100		us	
t _{OFF} Turn OFF time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	108		us	
VIN = 1.8V						
t _{ON} Turn ON time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	708		us	
t _{RISE} Rise time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	331		us	
t _D Delay time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	377		us	
t _{FALL} Fall time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	2145		us	
t _{OFF} Turn OFF time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	113		us	
VIN = 1.2V						
t _{ON} Turn ON time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	605		us	
t _{RISE} Rise time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	231		us	
t _D Delay time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	375		us	
t _{FALL} Fall time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	2190		us	
t _{OFF} Turn OFF time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	119		us	
VIN = 0.8V						
t _{ON} Turn ON time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	536		us	
t _{RISE} Rise time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	162		us	
t _D Delay time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	373		us	
t _{FALL} Fall time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	2260		us	
t _{OFF} Turn OFF time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	126		us	

6.10 Switching Characteristics (V_{BIAS} = 1.5 V)

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
VIN = 1.5V						
t _{ON} Turn ON time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	620		us	
t _{RISE} Rise time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	281		us	
t _D Delay time		R _L = 100Ω, C _L = 10uF, CT = 1000pF	340		us	

6.10 Switching Characteristics (V_{BIAS} = 1.5 V) (continued)

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
tFALL	Fall time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		2150		us
tOFF	Turn OFF time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		111		us
V_{IN} = 1.2V						
tON	Turn ON time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		642		us
tRISE	Rise time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		237		us
tD	Delay time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		404		us
tFALL	Fall time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		2170		us
tOFF	Turn OFF time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		114		us
V_{IN} = 0.8V						
tON	Turn ON time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		535		us
tRISE	Rise time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		166		us
tD	Delay time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		368		us
tFALL	Fall time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		2245		us
tOFF	Turn OFF time	R _L = 100Ω, C _L = 10uF, CT = 1000pF		171		us

6.11 Typical Characteristics

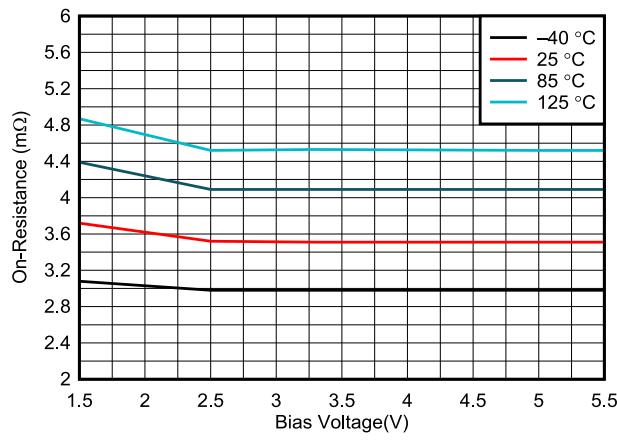


Figure 6-1. On-Resistance vs Bias Voltage

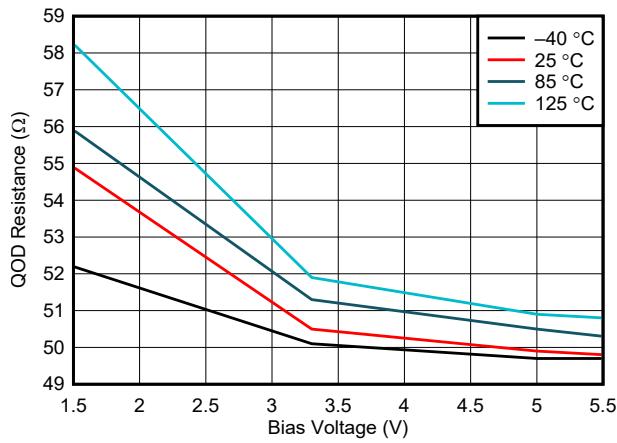


Figure 6-2. QOD-Resistance vs Bias Voltage

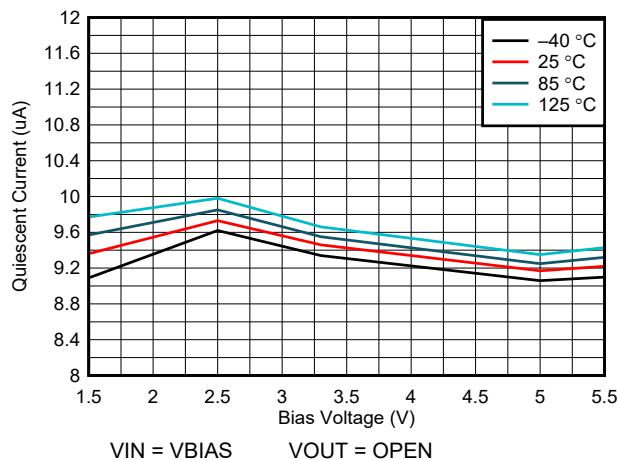


Figure 6-3. Quiescent Current vs Bias Voltage

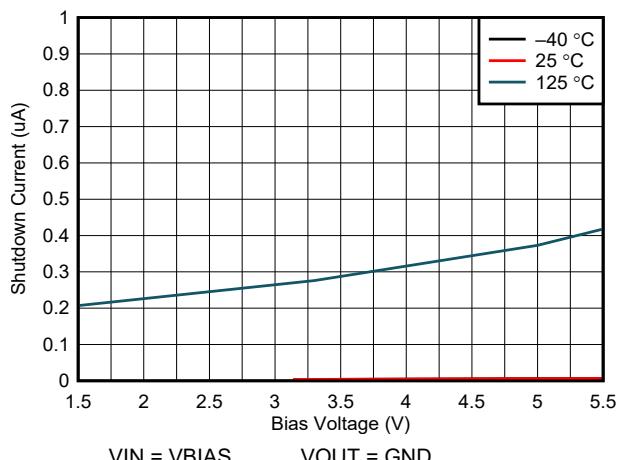


Figure 6-4. Shutdown Current vs Bias Voltage

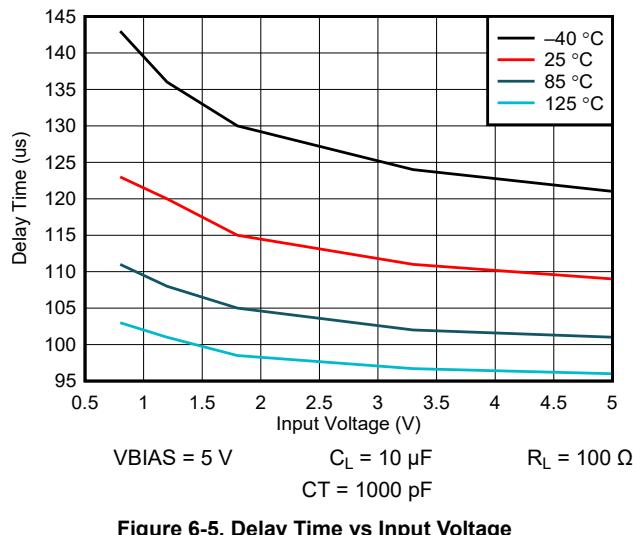


Figure 6-5. Delay Time vs Input Voltage

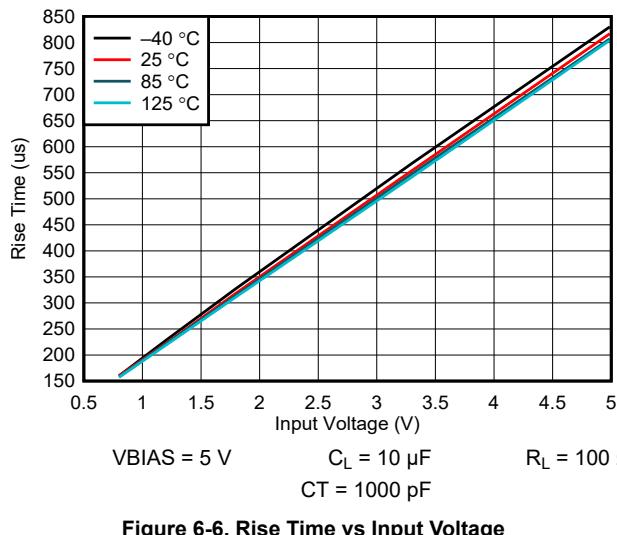


Figure 6-6. Rise Time vs Input Voltage

6.11 Typical Characteristics (continued)

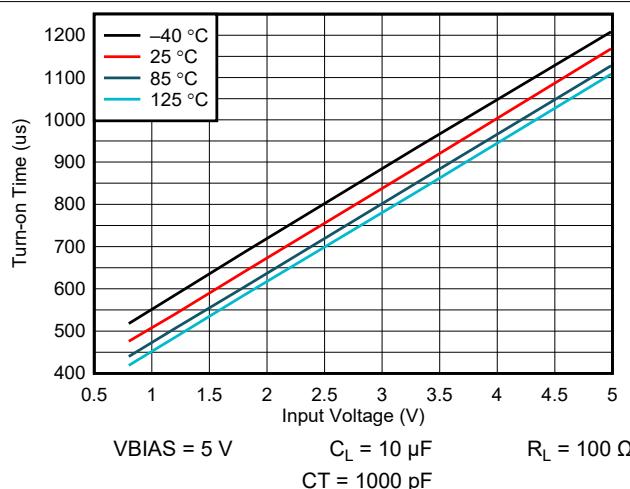


Figure 6-7. Turn-on Time vs Input Voltage

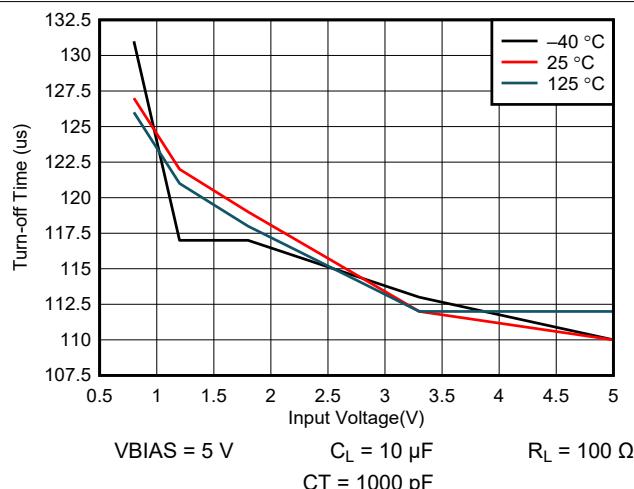


Figure 6-8. Turn-off Time vs Input Voltage

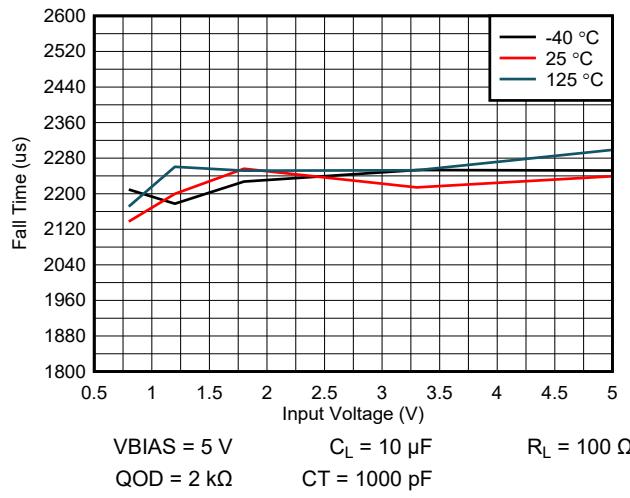


Figure 6-9. Fall Time vs Input Voltage

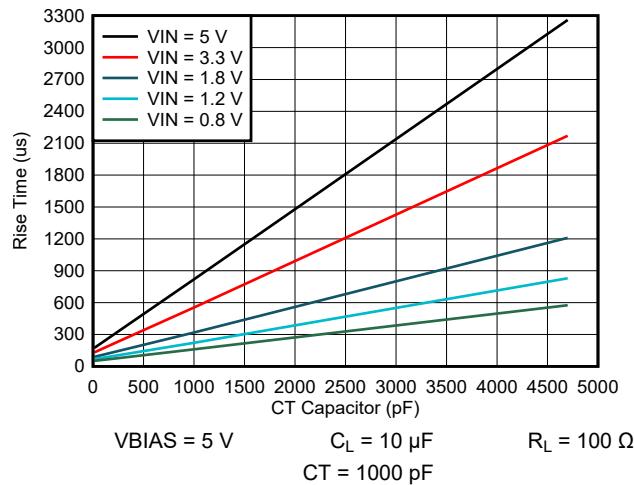


Figure 6-10. Rise Time vs CT Capacitor

7 Parameter Measurement Information

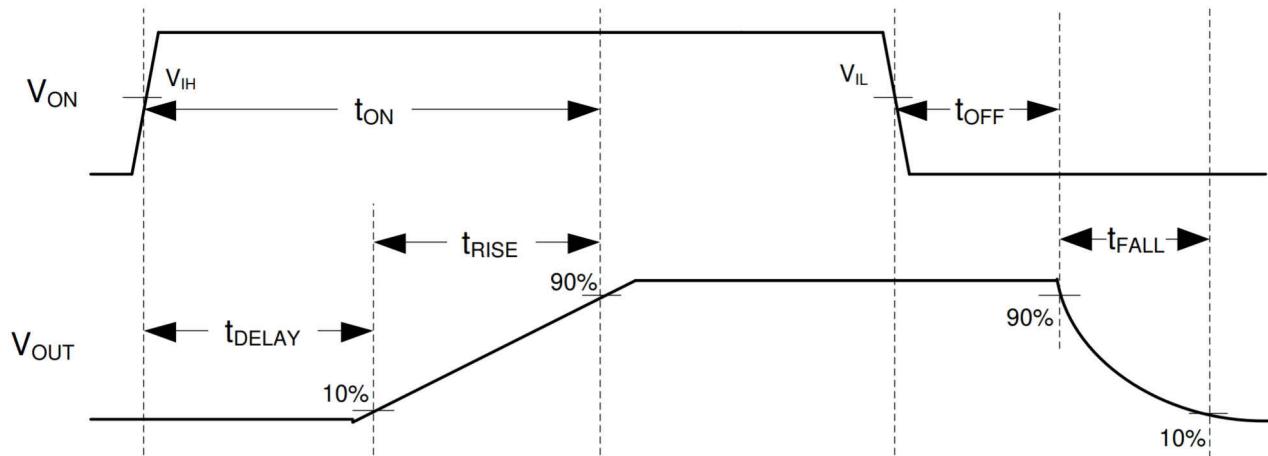


Figure 7-1. TPS22997 Timing Diagram

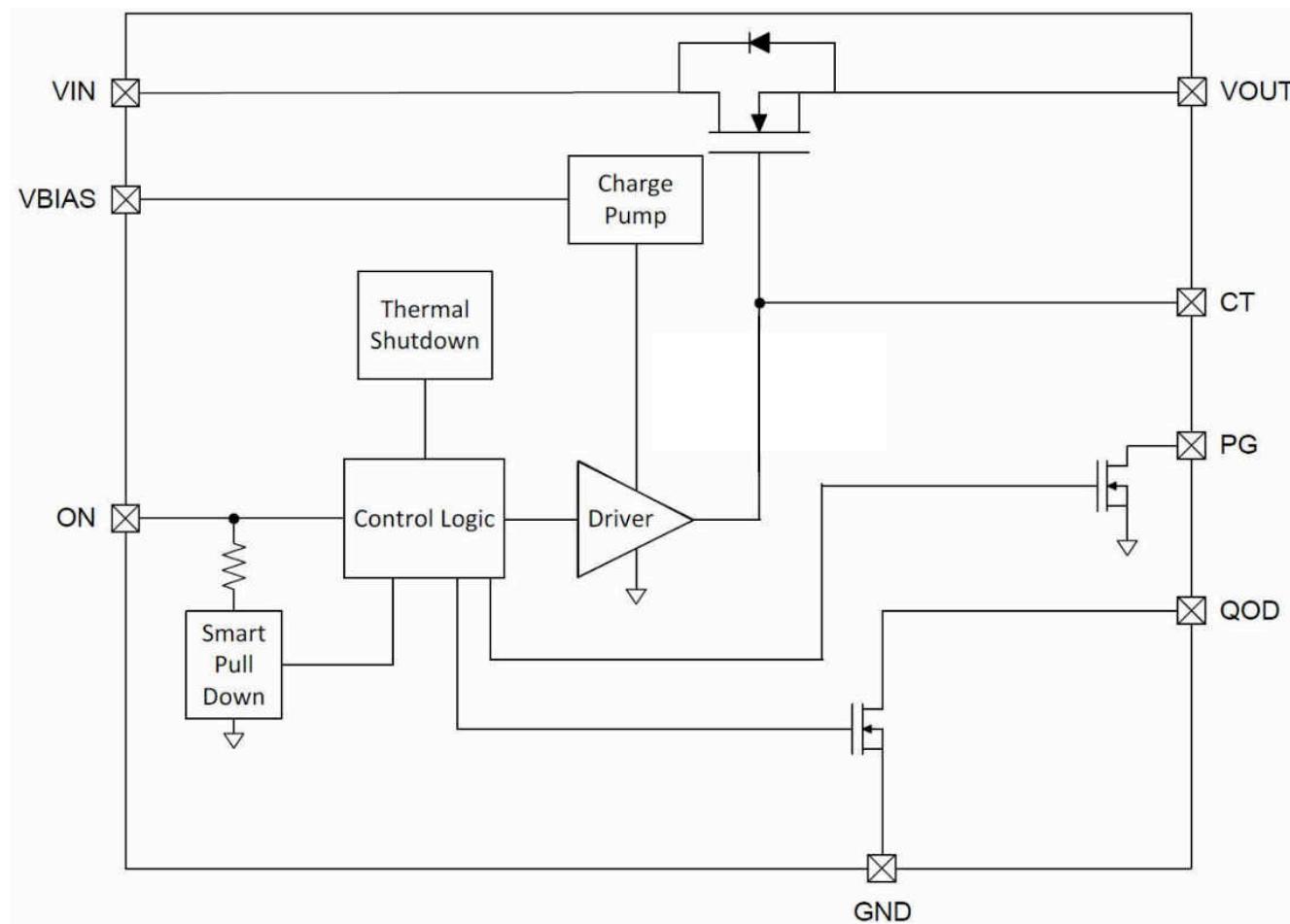
8 Detailed Description

8.1 Overview

The TPS22997 device is a single-channel load switch with a 4-mΩ power MOSFET designed to operate up to 10 A. The voltage range is 0.1 V to 5.5 V. A configurable rise time provides flexibility for power sequencing and minimizes inrush current for high capacitance loads.

The switch is controlled by an enable pin (ON), which is capable of interfacing directly with low voltage GPIO signals down to its V_{IH} level of 0.8 V. The TPS22997 device has an optional QOD pin for quick output discharge when switch is turned off, and the fall time (t_{FALL}) of the output can be adjusted through an external capacitor. There is a Power Good (PG) signal on the device that indicates when the main MOSFET is fully turned on and the on-resistance is at its final value.

8.2 Functional Block Diagram



8.3 Feature Description

8.3.1 ON and OFF Control

The ON pin controls the state of the switch. The ON pin is compatible with standard GPIO logic threshold so it can be used in a wide variety of applications. When the pin pull high, the device enables, and when it is low, the device disables.

8.3.2 Adjustable Slew Rate

A capacitor to GND on the CT pin sets the slew rate, and the higher the capacitance the lower the slew rate. The voltage on the CT pin can be as high as 15 V; therefore, the minimum voltage rating for the CT capacitor must be 30 V for optimal performance. Rise times for VBIAS = 5 V are shown below.

CT Capacitor	VIN = 5 V	VIN = 3.3 V	VIN = 1.8 V	VIN = 1.2 V	VIN = 0.8 V
0 pF	165 μ s	126 μ s	86 μ s	66 μ s	51 μ s
220 pF	309 μ s	221 μ s	137 μ s	99 μ s	74 μ s
1000 pF	819 μ s	554 μ s	319 μ s	222 μ s	160 μ s
4700 pF	3260 μ s	2170 μ s	1210 μ s	829 μ s	575 μ s

The following equation can be used to estimate the rise time for different VIN and CT capacitors at VBIAS = 5 V.

$$t_R = (0.1302 V_{IN} + 0.0063) \times CT + 27.797 V_{IN} + 30.54 \quad (1)$$

Where:

- t_R = Rise time in μ s
- V_{IN} = Input voltage in V
- CT = CT capacitance in pF

8.3.3 Adjustable Quick Output Discharge

The TPS22997 device includes a QOD feature that can be configured in one of three ways:

1. QOD pin shorted to VOUT pin. Using this method, the discharge rate after the switch becomes disabled is controlled with the value of the internal resistance RQOD. The value of this resistance is listed in the Electrical Characteristics table.
2. QOD pin connected to VOUT pin using an external resistor REXT. After the switch becomes disabled, the discharge rate is controlled by the value of the total resistance of the QOD.
3. QOD pin is unused and left floating. Using this method, there is no quick output discharge functionality, and the output remains floating after the switch is disabled.

Fall time is dependent on the strength of the configured pulldown resistance on the output.

8.3.4 Thermal Shutdown

When the device temperature reaches 150°C (typical), the device shuts itself off to prevent thermal damage. After it cools off by about 20°C, the device turns back on. If the device is kept in a thermally stressful environment, then the device oscillates between these two states until it can keep its temperature below the thermal shutdown point.

8.3.5 Power Good (PG) Signal

The TPS22997 device has a Power Good (PG) output signal to indicate the gate of the pass FET is driven high and the switch is on with the on-resistance close to its final value (full load ready). The signal is an active high and open drain output which can be connected to a voltage source through an external pullup resistor, R_{PU} . This voltage source can be VOUT from the TPS22997 device or another external voltage. VBIAS is required for PG to have a valid output.

8.4 Device Functional Modes

The below table summarizes the device functional modes:

ON	Fault Condition	VOUT State
L	N/A	Hi-Z
H	None	V_{IN} (through R_{ON})

ON	Fault Condition	VOUT State
X	Thermal shutdown	Hi-Z

9 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, as well as validating and testing their design implementation to confirm system functionality.

9.1 Application Information

This section highlights some of the design considerations when implementing this device in various applications.

9.2 Typical Application

This typical application demonstrates how to use the TPS22997 device to limit startup inrush current.

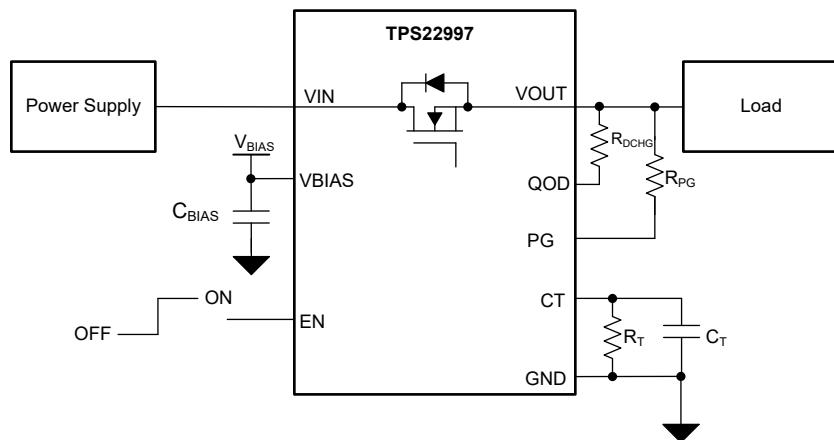


Figure 9-1. TPS22997 Basic Application

Table 9-1. Component Descriptions

PARAMETER	Purpose
C_{BIAS}	Stabilize the bias supply and filter out low frequency noise.
C_T	Adjustable rise time capacitor.
R_T	Optional C_T capacitor discharge resistor for cases when device is disabled before output has fully ramped up. Use a resistor $>10M\Omega$.
R_{DCHG}	Adjustable output discharge resistor.

9.2.1 Design Requirements

For this example, the values below are used as the design parameters.

Table 9-2. Design Parameters

PARAMETER	VALUE
V_{BIAS}	5.0 V
V_{IN}	5.0 V
Load capacitance	220 μ F
Maximum inrush current	1.5 A

9.2.2 Detailed Design Procedure

When the switch enables, the charge up the output capacitance from 0 V to the set value (1.8 V in this example). This charge arrives in the form of inrush current. Calculate inrush current using [Equation 2](#).

$$\text{Inrush Current} = C_L \times dVOUT/dt \quad (2)$$

Where:

- C_L is the output capacitance.
- $dVOUT$ is the change in $VOUT$ during the ramp up of the output voltage when device is enabled. Because rise time is 10% of $VOUT$ to 90% of $VOUT$, this is 80% of the VIN value.
- dt is the rise time in $VOUT$ during the ramp up of the output voltage when the device is enabled.

The TPS22997 offers an adjustable rise time for $VOUT$, allowing the user to control the inrush current during turn on. Calculate the appropriate rise time using the design requirements and the inrush current equation as shown below.

$$1.5 \text{ A} = 220 \mu\text{F} \times (5.0 \text{ V} \times 80\%) / dt \quad (3)$$

$$dt = 586 \text{ }\mu\text{s} \quad (4)$$

To ensure an inrush current of less than 1.5 A, a C_T setting that yields a rise time of more than 586 μ s must be chosen. By using a 1000pF capacitance, a rise time of 819 μ s is selected, limiting the inrush current to below 1.5 A.

9.2.3 Application Performance Plots

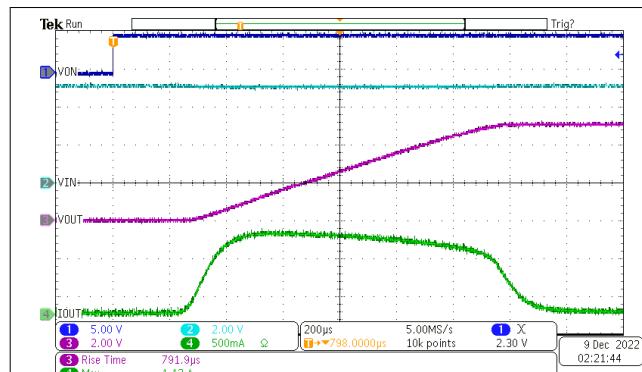


Figure 9-2. Inrush Current for $CL = 220 \mu\text{F}$ with $CT = 1000 \text{ pF}$

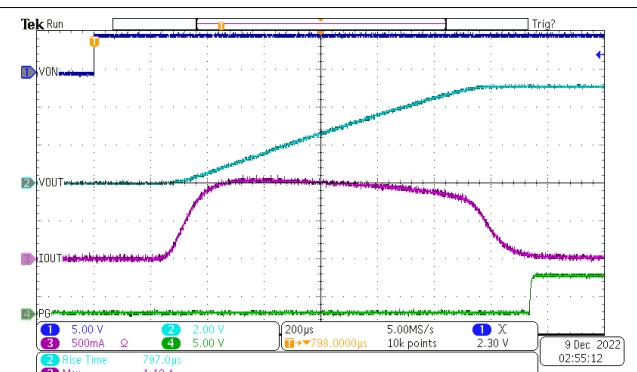


Figure 9-3. PG Pin Behavior with Inrush Current for $CL = 220 \mu\text{F}$ with $CT = 1000 \text{ pF}$

9.3 Power Supply Recommendations

The TPS22997 device is designed to operate with a VIN range of 0.1 V to 5.5 V. Regulate the VIN power supply well. The power supply must be able to withstand all transient load current steps. In most situations, using an input capacitance (C_{IN}) of 1 μ F is sufficient to prevent the supply voltage from dipping when the switch is turned on. In cases where the power supply is slow to respond to a large transient current or large load current step, additional bulk capacitance can be required on the input.

A capacitor (C_{BIAS}) is recommended to be placed as close to the device as possible to stabilize the supply and filter out low frequency noise.

9.4 Layout

9.4.1 Layout Guidelines

For best performance, all traces must be as short as possible. To be most effective, place the input and output capacitors close to the device to minimize the effects that parasitic trace inductances can have on normal operation. Using wide traces for VIN, VOUT, and GND helps minimize the parasitic electrical effects.

9.4.2 Layout Example

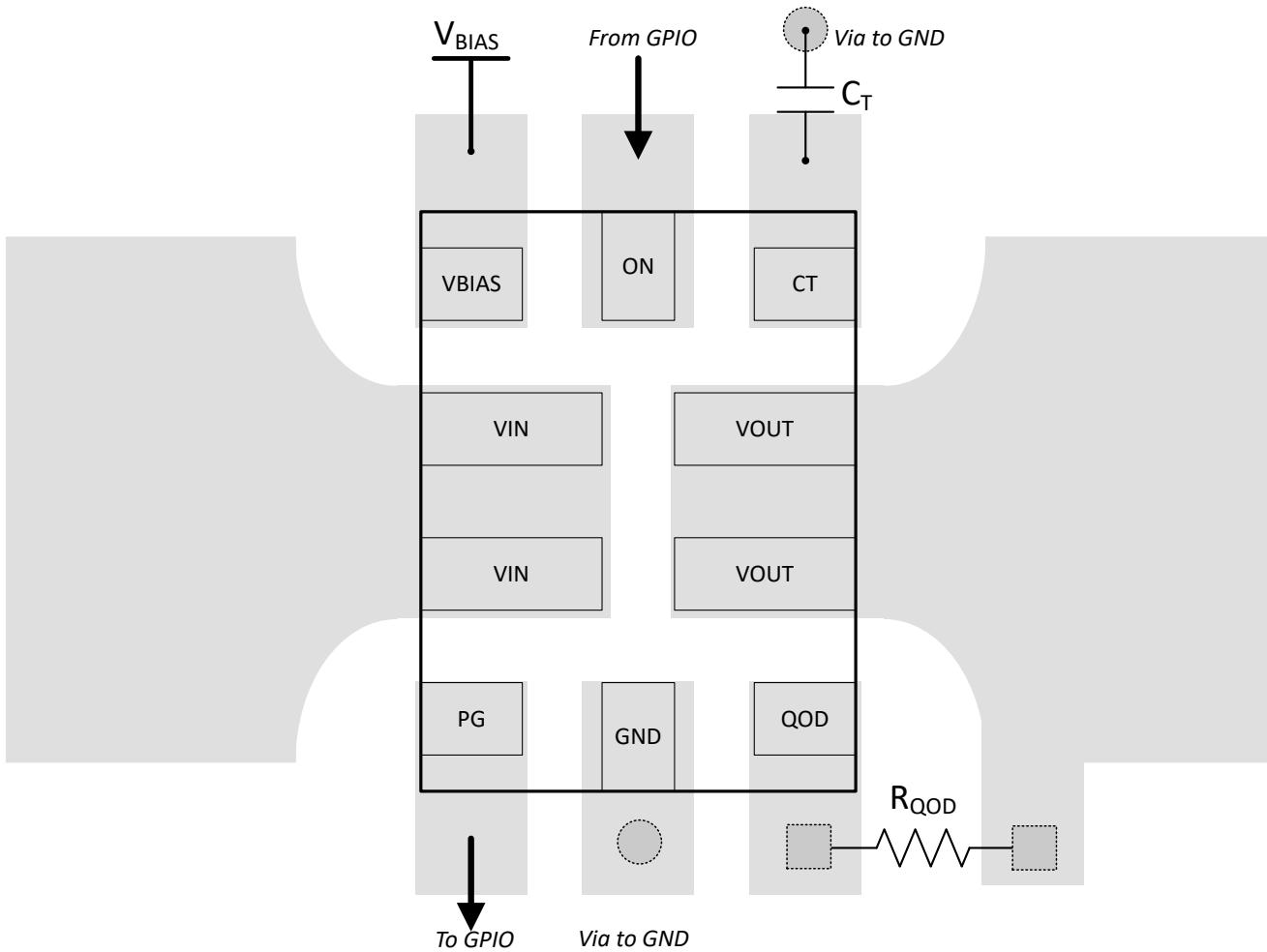


Figure 9-4. TPS22997 Layout Example

10 Device and Documentation Support

TI offers an extensive line of development tools. Tools and software to evaluate the performance of the device, generate code, and develop solutions are listed below.

10.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Subscribe to updates* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

10.2 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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10.3 Trademarks

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10.4 Electrostatic Discharge Caution



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.

10.5 Glossary

[TI Glossary](#)

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

11 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)
TPS22997RYZR	Active	Production	WQFN-HR (RYZ) 10	3000 LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	1O2
TPS22997RYZR.A	Active	Production	WQFN-HR (RYZ) 10	3000 LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	1O2

⁽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.

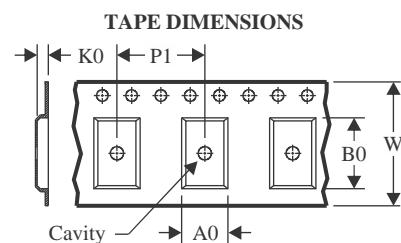
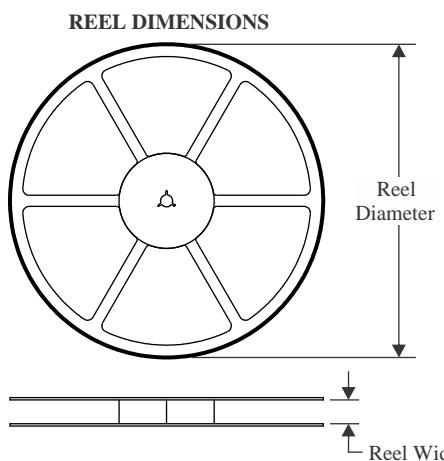
⁽⁵⁾ **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will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

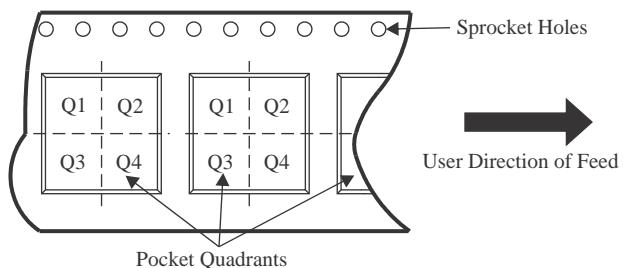
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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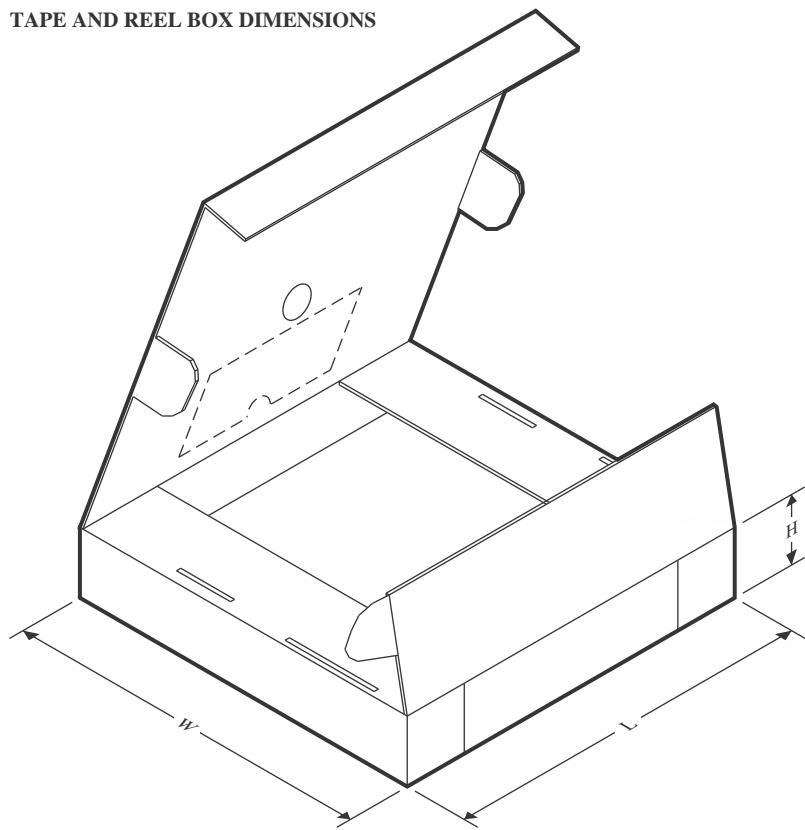
TAPE AND REEL INFORMATION


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
TPS22997RYZR	WQFN-HR	RYZ	10	3000	180.0	8.4	1.75	2.25	1.0	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)
TPS22997RYZR	WQFN-HR	RYZ	10	3000	210.0	185.0	35.0

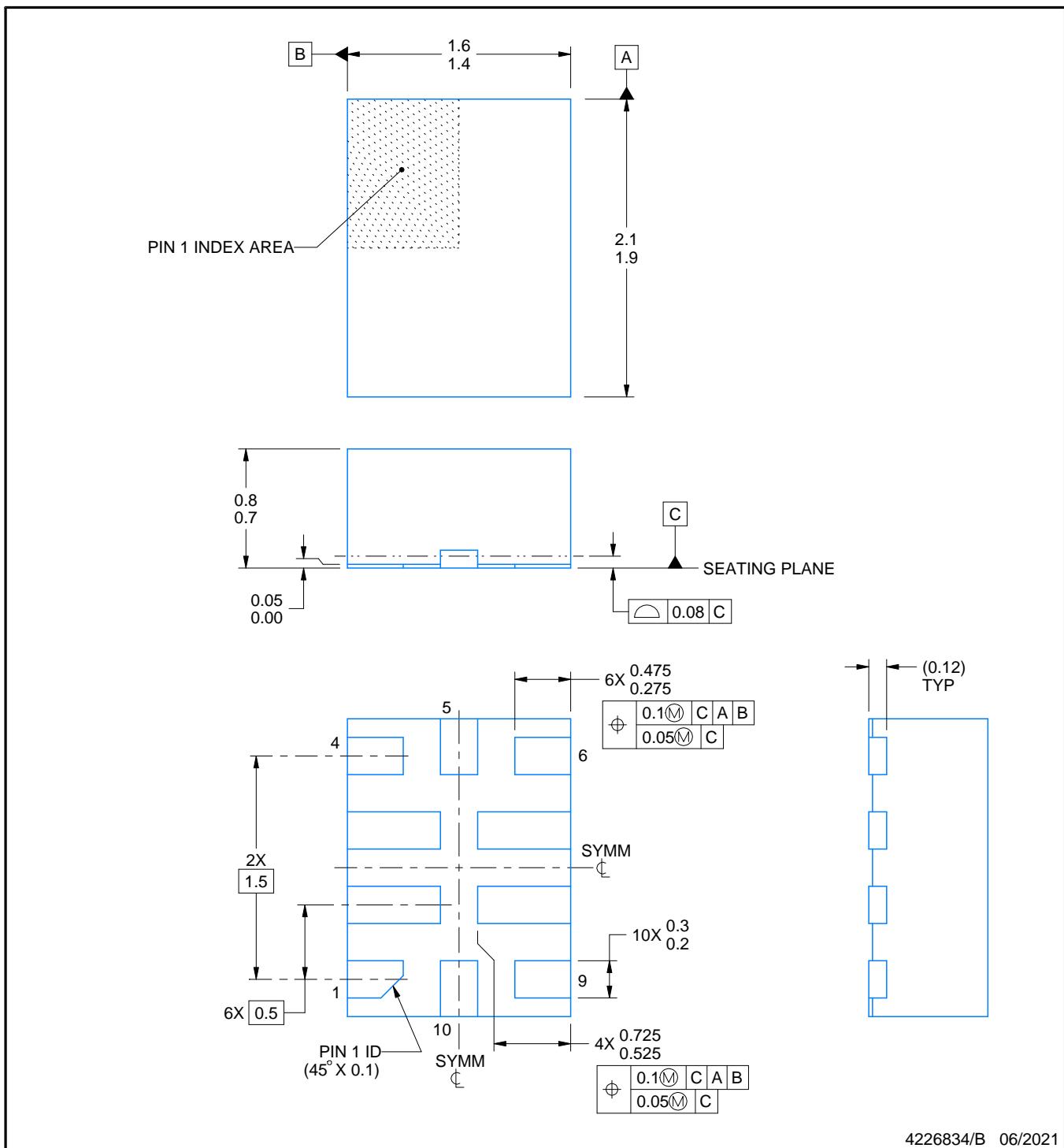
PACKAGE OUTLINE

RYZ0010A



WQFN-HR - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



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NOTES:

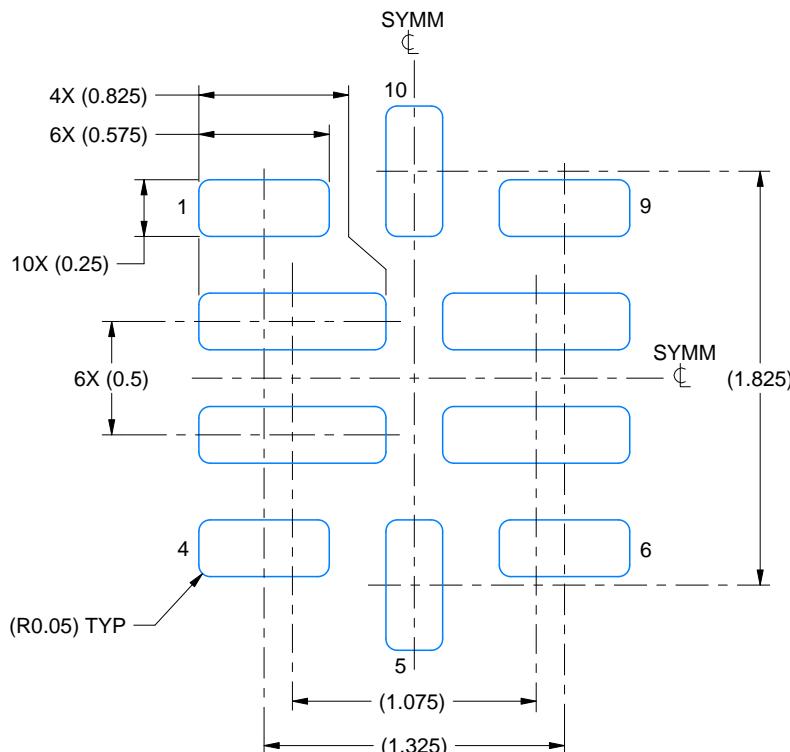
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.

EXAMPLE BOARD LAYOUT

RYZ0010A

WQFN-HR - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD

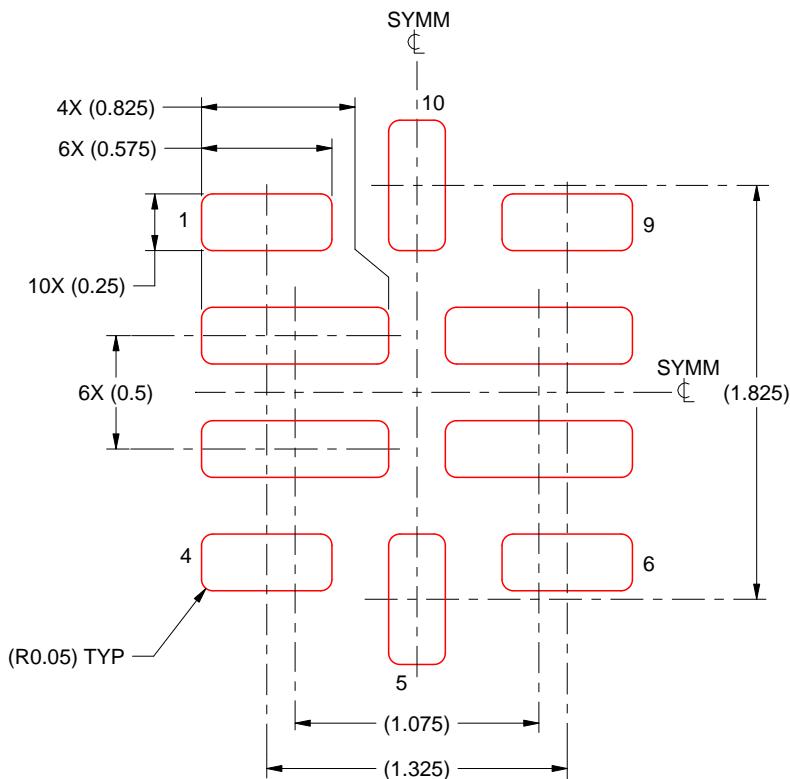


EXAMPLE STENCIL DESIGN

RYZ0010A

WQFN-HR - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



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NOTES: (continued)

5. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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