

3.3V TO 18V MUX with Overcurrent Limit

Check for Samples: [TPS22980](#)

FEATURES

- Powered From 3.3V
- 4.5V to 19.8V High Voltage Switch
- 3V to 3.6V Switch
- Adjustable Current Limit
- Thermal Shutdown
- Make Before Break Switch
- High Voltage Discharge Before Low Voltage Make
- Reverse Current Blocking

APPLICATIONS

- Notebook Computers
- Desktop Computers
- Power Management Systems

DESCRIPTION

The TPS22980 is a current-limited power mux providing a connection to a peripheral device from either a low voltage supply (3.0V up to 3.6V) or a high voltage supply (5V up to 18V). The desired output is selected by digital control signals.

The high voltage (VHV) and low voltage (V3P3) switch current limits are set with external resistance. Once the current limit is reached, the TPS22980 will control the switch to maintain the current at the limit.

When the high voltage supply is not present, the TPS22980 will maintain the connection to the output from the low voltage supply. When a high voltage line and high voltage enable signal is detected by the device, the high voltage switch will be turned on in conjunction with the low voltage switch until a reverse current is detected by the low voltage switch. The low voltage switch is then disabled allowing a seamless transition from a low voltage to a high voltage supply with minimal drop and shoot-through current.

To prevent current backflow during a transition from a VHV connection to a V3P3 connection, the TPS22980 will break the VHV connection and discharge the output to approximately 3.3V. Once the output reaches 3.3V the device will connect V3P3 switch. If a load is present, the output will transition to 0V before returning to 3.3V.

The TPS22980 is available in a 4mm x 4mm x 1mm QFN package.

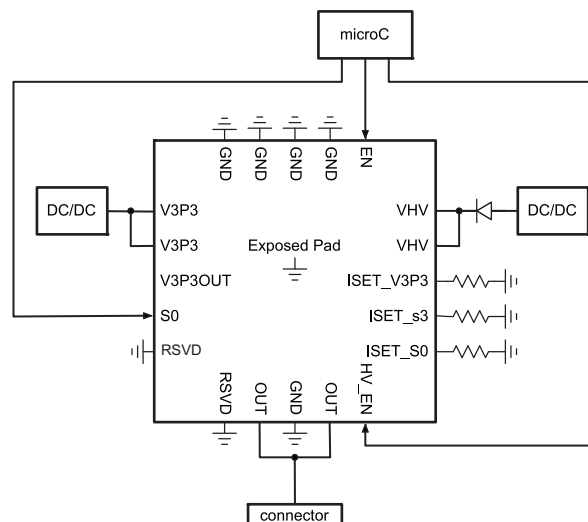


Figure 1. Typical Application



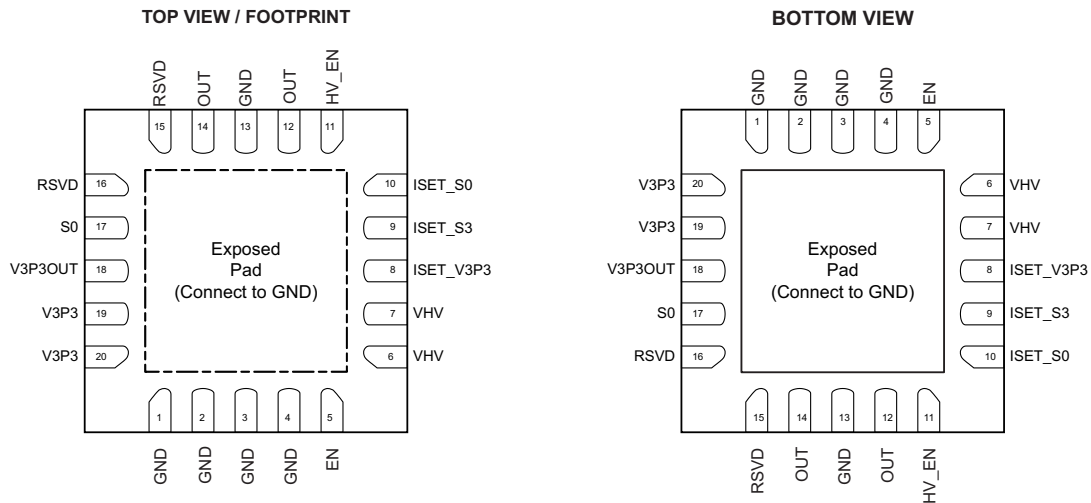
Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

TPS22980

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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.



Package Size: 4mm x 4mm x 1mm height, Pad Pitch: 0.5mm

PIN FUNCTIONS

PIN		DESCRIPTION
NO.	NAME	
1	GND	Device ground
2		
3		
4		
5	EN	Device Enable.
6	VHV	High voltage power supply input. Place a minimum of 0.1µF capacitor as close to this pin as possible.
7		
8	ISET_V3P3	Sets the current limit for V3P3. Place resistor between this pin and GND. See Equation 1 to calculate resistor value.
9	ISET_S3	Sets the current limit for VHV in S3 mode. Place resistor between this pin and GND. See Equation 1 to calculate resistor value.
10	ISET_S0	Sets the current limit for VHV in S0 mode. Place resistor between this pin and GND. See Equation 1 to calculate resistor value.
11	HV_EN	High voltage output enable.
12, 14	OUT	Power output. Place a minimum of 1µF capacitor as close to this pin as possible.
13	GND	Device ground.
15	RSVD	Reserved. Must Tie to GND.
16		
17	S0	When this pin is asserted, the device is put in S0 mode. Otherwise the device operates in S3 mode.
18	V3P3OUT	3.3V bypass output. Place a minimum of 0.1µF capacitor as close to this pin as possible.
19	V3P3	3.3V power supply input. Place a minimum of 0.1µF capacitor as close to this pin as possible.
20		
EP	GND	

ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range (unless otherwise noted)^{(1) (2)}

		VALUE	UNIT
V _I	Input voltage range on V3P3 (VDD) ⁽³⁾	–0.3 to 3.6	V
	Input voltage range on EN, HVEN, ISET_V3P3, ISET_S0, ISET_S3, S0 ⁽³⁾	–0.3 to V3P3+0.3	
	Input voltage range on VHV ⁽³⁾	–0.3 to 20	
	Output voltage range at OUT ⁽³⁾	–0.3 to 20	
	Output voltage range at V3P3OUT ⁽³⁾	–0.3 to V3P3+0.3	
T _A	Operating ambient temperature range	–40 to 85	°C
T _{J (MAX)}	Maximum operating junction temperature	110	°C
T _{stg}	Storage temperature range	–65 to 150	°C
ESD Rating	Charge Device Model (JESD 22 C101)	500	V
	Human Body Model (JESD 22 A114)	2	kV

- (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.
- (2) In applications where high power dissipation and/or poor package thermal resistance is present, the maximum ambient temperature may have to be de-rated. Maximum ambient temperature [T_{A(max)}] is dependent on the maximum operating junction temperature [T_{J(max)}], the maximum power dissipation of the device in the application [P_{D(max)}], and the junction-to-ambient thermal resistance of the part/package in the application (θ_{JA}), as given by the following equation: T_{A(max)} = T_{J(max)} – (θ_{JA} × P_{D(max)})
- (3) All voltage values are with respect to network ground terminal.

THERMAL INFORMATION

THERMAL METRIC ⁽¹⁾		TPS22980	UNITS
		RGP	
		16 PINS	
θ _{JA}	Junction-to-ambient thermal resistance	38.9	°C/W
θ _{JCtop}	Junction-to-case (top) thermal resistance	30.7	
θ _{JB}	Junction-to-board thermal resistance	11.5	
ψ _{JT}	Junction-to-top characterization parameter	0.4	
ψ _{JB}	Junction-to-board characterization parameter	11.4	
θ _{JCbot}	Junction-to-case (bottom) thermal resistance	2.2	

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

TPS22980

SLVSB61C –DECEMBER 2011–REVISED SEPTEMBER 2013

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RECOMMENDED OPERATING CONDITIONS

		MIN	MAX	UNIT
V _{3P3}	Supply voltage range	3.0	3.6	V
V _{HV}		4.5	19.8	V
I _{LIM3P3OUT}	V3P3OUT Switch current range	0	500	mA
V _{IH}	Input logic high	EN, HV_EN, S0		V3P3-0.6 V3P3
V _{IL}	Input logic low	EN, HV_EN, S0		0 0.6
R _{SET_V3P3}	3.3V switch current limit set resistance	25.3	402	kΩ
R _{SET_S0}	VHV switch current limit in S0 mode set resistance	25.3	402	kΩ
R _{SET_S3}	VHV switch current limit in S3 mode set resistance	25.3	402	kΩ

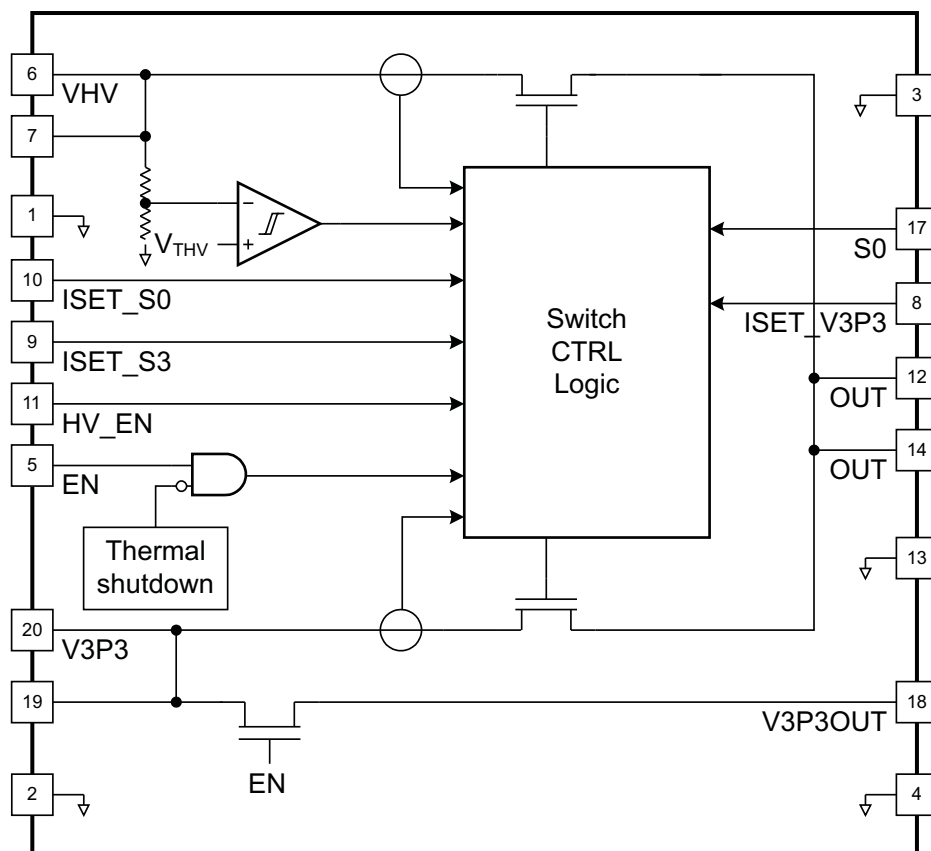
ELECTRICAL CHARACTERISTICS

Unless otherwise noted the specification applies over the V_{DD} range and operating junction temp $-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$. Typical values are for V_{3P3} = 3.3V, V_{HV} = 15V, and T_J = 25°C.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER SUPPLIES AND CURRENTS						
V _{3P3}	V3P3 Input voltage range		3	3.3	3.6	V
V _{HV}	VHV Input voltage range		4.5		19.8	V
I _{VHVACT}	Active quiescent current from VHV	HV_EN = 1, EN = 1			150	μA
I _{VHVSD}	Shutdown leakage current from VHV	HV_EN = 0, EN = 0 or 1			30	μA
I _{DDACT}	Active quiescent current from V3P3	EN = 1, HV_EN = 0			200	μA
I _{DDACTHV}	Active quiescent current from V3P3	EN = 1, HV_EN = 1			150	μA
I _{DDSD}	Shutdown Quiescent Current from V3P3	EN = 0, OUT = 0V			10	μA
I _{DIS}	OUT Discharge Current	EN = 1, V _{HV} = 5V HV_EN = 1 → 0	5		10	mA
I _{IN}	HV_EN, EN, S0, S3 Input pin leakage	V = 0 V			1	μA
		V = V3P3			1	μA
SWITCH AND RESISTANCE CHARACTERISTICS						
R _{SHV}	VHV Switch resistance	V _{HV} = 5 V to 18V, I _{VHV} = 1.5 A			250	mΩ
R _{S3P3}	V3P3 Switch resistance	V _{3P3} = 3.3 V, I _{V3P3} = 1.5 A			250	mΩ
R _{S3P3BYP}	V3P3 Bypass switch resistance	V _{3P3} = 3.3 V, I _{V3P3} = 500 mA			500	mΩ
R _{OUTDIS}	OUT Pulldown resistance when disabled	EN = 0	1.5	2.5	4	kΩ
VOLTAGE THESHOLDS						
V _{HVUVLO}	VHV Under voltage lockout	VHV Input Falling	3.6	4		V
		VHV Input Rising		4	4.3	
V _{3P3UVLO}	V3P3 Under voltage lockout	V3P3 Input Falling	1.8	2.25		V
		V3P3 Input Rising		2.25	2.5	
THERMAL SHUTDOWN						
T _{SD}	Shutdown Temperature		110	120	130	°C
T _{SDHYST}	Shutdown Hysteresis			10		°C

Unless otherwise noted the specification applies over the V_{DD} range and operating junction temp $-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$. Typical values are for $V_{3P3} = 3.3\text{V}$, $V_{HV} = 15\text{V}$, and $T_J = 25^{\circ}\text{C}$.

FUNCTIONAL BLOCK DIAGRAM



APPLICATION INFORMATION

CURRENT LIMIT

The TPS22980 provides current limiting in the power switches. Both the VHV supply current limit and the V3P3 supply current limit are adjustable by external resistors.

Figure 2 shows a simplified view of the TPS22980 current limit function. Both the VHV supply current limit and the V3P3 supply current limit are adjustable by external resistors.

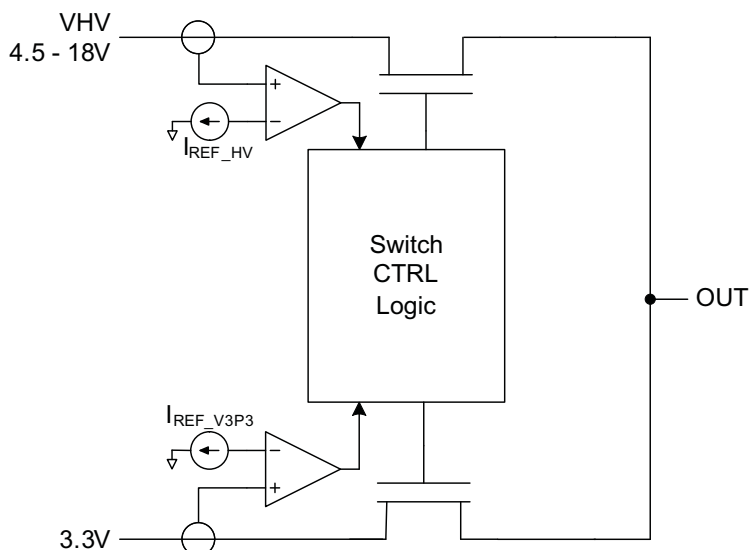


Figure 2. Simplified Current Limit Diagram

The current limit thresholds, I_{REF_HV} and I_{REF_V3P3} , are set with three external resistors as shown in Figure 3. When the TPS22980 is passes the V3P3 voltage, the current limit is set by R_{ISET_V3P3} . The VHV path has two modes that support two different current limits which are selected by the S0 pin. When S0 is asserted high, R_{ISET_S0} sets the current limit. When S0 is low, R_{ISET_S3} sets the current limit. This allows the system to have two separate VHV current limits for different modes such as active and sleep.

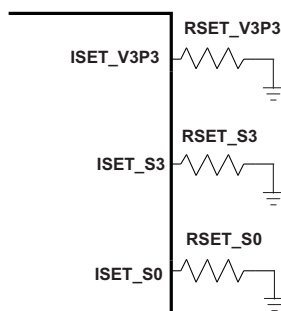


Figure 3. External R_{SET} Resistances to Set Current Limits

CURRENT LIMIT THRESHOLD

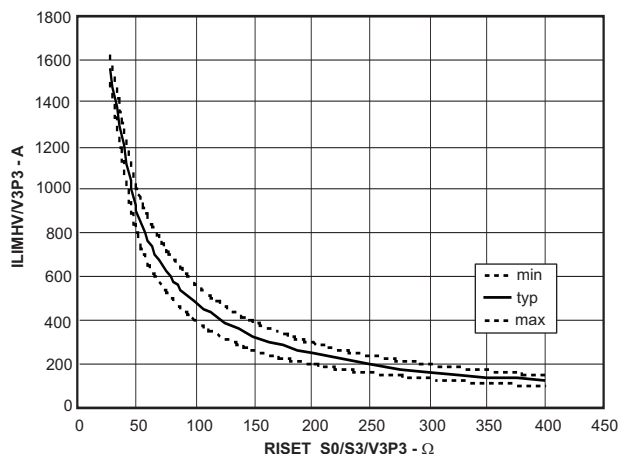


Figure 4. I_{LIM} vs R_{SET} for VHV and V3P3

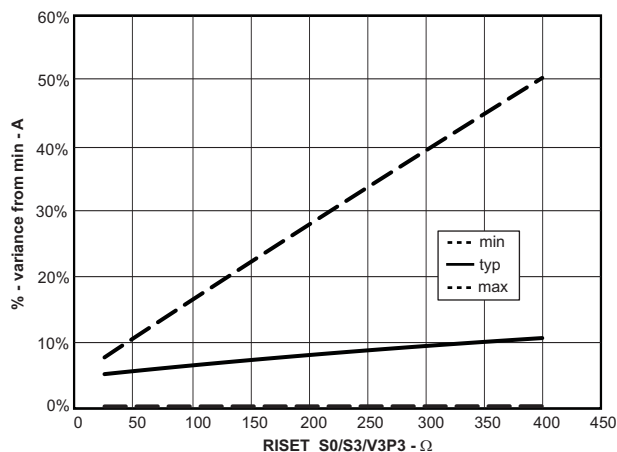


Figure 5. Percent Variance from min I_{LIM} vs R_{SET}

Figure 4 shows the minimum, typical, and maximum current limit for either supply versus its corresponding R_{SET} value. Equation 1 is used to determine the R_{SET} needed to set a minimum I_{LIM} for a given supply and mode. Figure 5 shows the approximate variation from the set minimum I_{LIM} value to the typical and maximum I_{LIM} values.

$$R_{SET} = \frac{40 \text{ k}\Omega \times \text{Amps}}{I_{LIMmin}} \quad (1)$$

where:

R_{SET} = external resistor used to set the current limit for V3P3, VHV (S0), or VHV (S3), and

I_{LIMmin} = current limit for V3P3, VHV (S0), or VHV (S3) set by the external R_{SET} resistor.

Each resistor is placed between the corresponding ISET pin and GND, as shown in Figure 3, providing a minimum current limit between 100mA and 1.5A.

TRANSITION DELAYS

Output transitions of the TPS22980 voltages are shown in Figure 6. When the device transitions from VHV to V3P3 at the output, the power switches both turn off until the output falls to near the V3P3 voltage. During this time, a discharge current ($IDIS$) pulls OUT down. If a load on the line is also pulling OUT down, the output can drop to 0V due to the switch off time of T3P3OFF. Figure 7 shows the voltage drop on the output during this transition with no output capacitance.

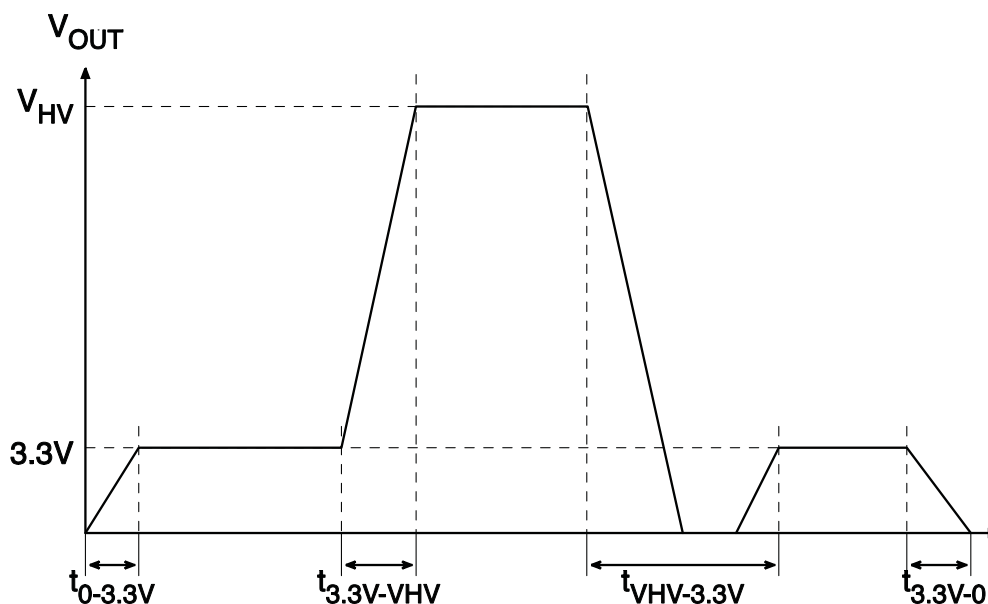


Figure 6. Allowable Voltage Transitions

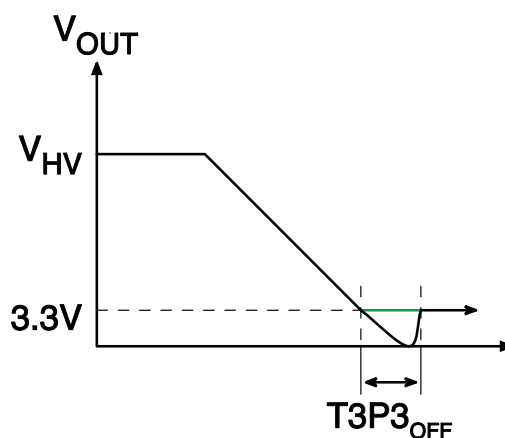


Figure 7. Voltage Drop During Transitions from VHV

DIGITAL CONTROL SIGNALS

The voltage at OUT is controlled by two digital logic input signals, EN and HV_EN. HV_EN controls the state of the VHV switch and EN controls the state of V3P3 switch. Table 1 lists the possible output states given the conditions of the digital logic signals. State PD indicates a pulldown resistance of R_{OUTDIS} to GND.

Table 1. Output State of OUT Given the States EN and HV_EN

EN	HV_EN	OUT
0	0	PD
0	1	PD
1	0	V3P3
1	1	VHV

Figure 8 shows possible combinations of EN and HV_EN controlling OUT of the TPS22980.

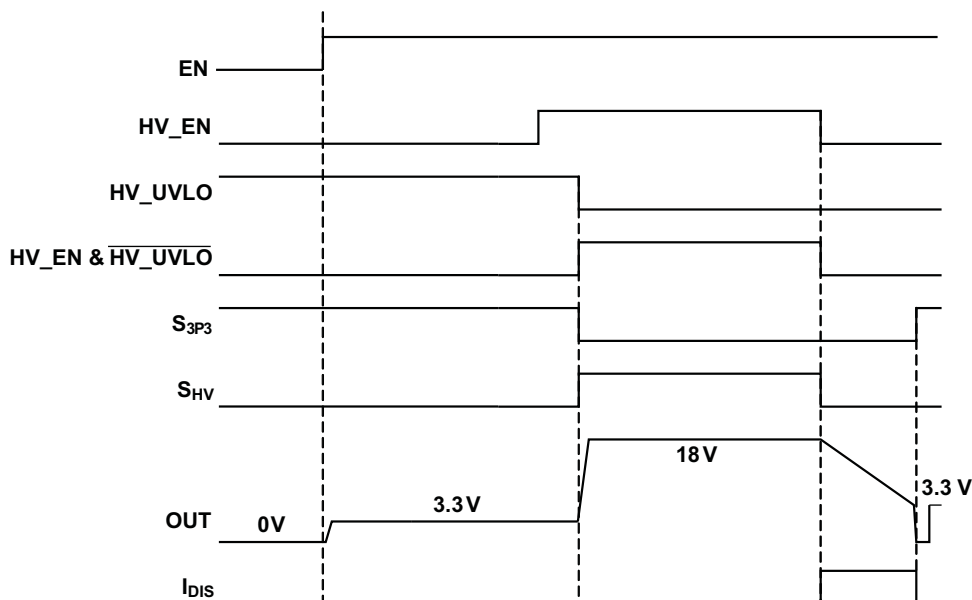


Figure 8. Logic Waveforms Displaying the Transition Between VHV and V3P3

OVER-CURRENT LIMIT AND SHORT CIRCUIT PROTECTION

When the load at OUT attempts to draw more current than the limit set by the external RSET resistors for the V3P3 switch and VHV switch (for both S0 and S3 modes), the device will operate in a constant current mode while lowering the output voltage. Figure 9 shows the delay, t_{LIM} , which occurs when an over-current fault is detected until the output current is lowered to $ILIMHV$ tolerances for VHV or $ILIM3V3$ tolerances for V3P3 as shown in Figure 4.

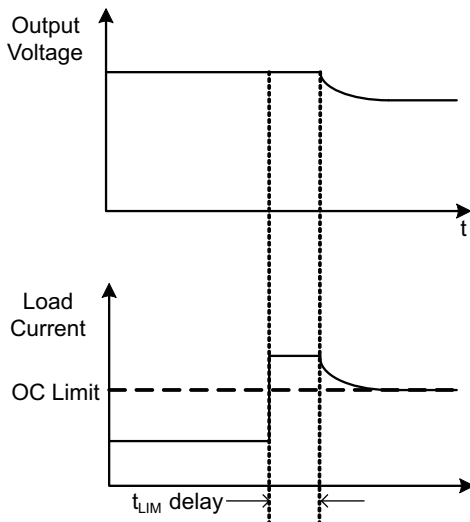


Figure 9. Overcurrent Output Response

All short circuit conditions are treated as over-current conditions. In the event of a short circuit, the device will limit the output current to the corresponding R_{SET} value and continue to do so until thermal shutdown is encountered or the short circuit condition is removed.

TPS22980

SLVSB61C –DECEMBER 2011–REVISED SEPTEMBER 2013

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Reverse Current Protection

Reverse current protection for the V3P3 supply to OUT triggers at I_{REV3P3} causing the V3P3 supply switch to open. When the HV_EN signal is not asserted and reverse current protection is triggered, a discharge current source is turned on to bring the output voltage to 3.3V nominal.

Thermal Shutdown

The device enters thermal shutdown when junction temperature reaches T_{SD} . The device will resume the previous state on power up once the junction temperature has dropped by 10°C. Connect thermal vias to the exposed GND pad underneath the device package for improved thermal diffusion.

UVLO

When the VHV rail reaches the under-voltage lockout threshold of $V_{HVVUVLO}$ while HV_EN is high, the device will switch back to V3P3. Once the UVLO condition has cleared, the device will switch to VHV again. When the V3P3 rail reaches the under-voltage lockout threshold of $V_{3P3UVLO}$, regardless of the states of any digital logic controls, the device will open all switches and enter a reset condition.

Input Inductive Bounce at Short Circuit

When the TPS22980 is operating at high currents and high input voltage on VHV, a short circuit condition can cause the input to exceed the maximum safe operating condition for VHV. When a significant inductance is present at the VHV input, sudden turn off of current through the device may produce a large enough inductive voltage bounce that exceeds the maximum safe operating condition and may damage the TPS22980. To prevent this, reduce any inductance at the input. Input capacitors, such as 4.7µF, can reduce the supply bounce and are recommended.

Single Point Failure Protection

The TPS22980 current limits are set by the R_{ISSET} resistances. Shorting one of these resistance would result in a single point failure that removes the current limiter for that particular input and mode. Without current limiting, an excessive current load may damage the TPS22980 and the system. To prevent a single point failure from occurring, the R_{ISSET} resistances can be divided into two series resistances each as shown in [Figure 10](#). Failure of a single resistance will not result in runaway current and damage.

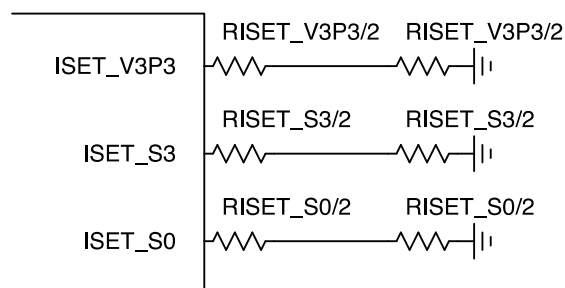


Figure 10. R_{ISSET} Division to Prevent Single Point Failure

REVISION HISTORY

Changes from Original (December 2011) to Revision A Page

- Changed Typical Application figure. [1](#)
 - Added bottom view pin out information. [2](#)
 - Updated Pin Functions Table. [2](#)
 - Added reverse current and thermal shutdown parameters to the ELECTRICAL CHARACTERISTICS table. [4](#)
 - Updated the APPLICATION INFORMATION section. [6](#)
-

Changes from Revision A (February 2012) to Revision B Page

- Changed bottom view pin out information. [2](#)
-

Changes from Revision B (April 2012) to Revision C Page

- Removed ordering information table. [2](#)
 - Added R_{OUTDIS} parameter to the Electrical Characteristics table. [4](#)
 - Updated the DIGITAL CONTROL SIGNALS section. [8](#)
-

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)
TPS22980RGPR	Active	Production	QFN (RGP) 20	3000 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	PS22980
TPS22980RGPR.A	Active	Production	QFN (RGP) 20	3000 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	PS22980
TPS22980RGPR.B	Active	Production	QFN (RGP) 20	3000 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	PS22980

⁽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



*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
TPS22980RGPR	QFN	RGP	20	3000	330.0	12.4	4.25	4.25	1.15	8.0	12.0	Q2

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS22980RGPR	QFN	RGP	20	3000	346.0	346.0	33.0

GENERIC PACKAGE VIEW

RGP 20

VQFN - 1 mm max height

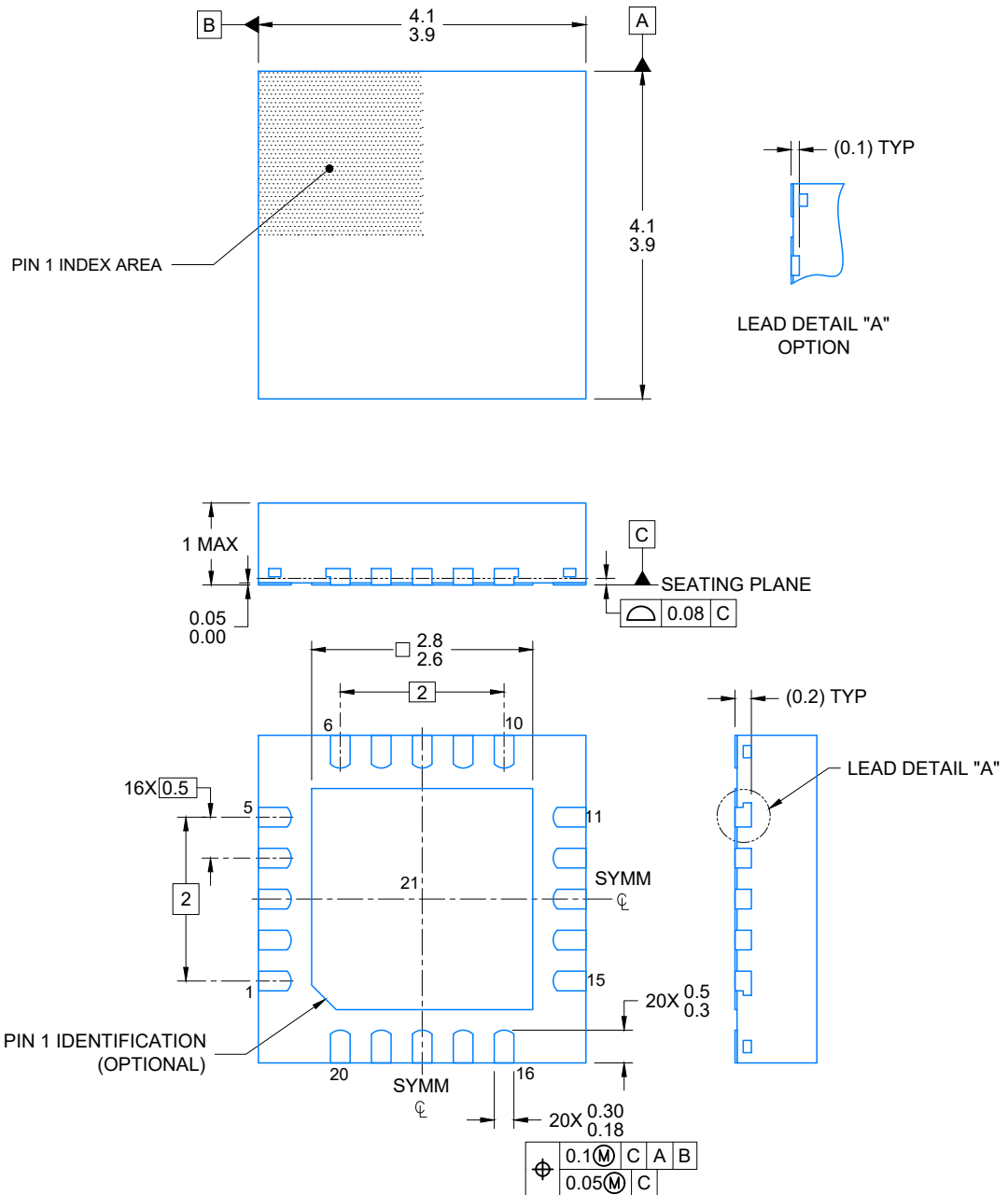
4 x 4, 0.5 mm pitch

VERY THIN QUAD FLATPACK



Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

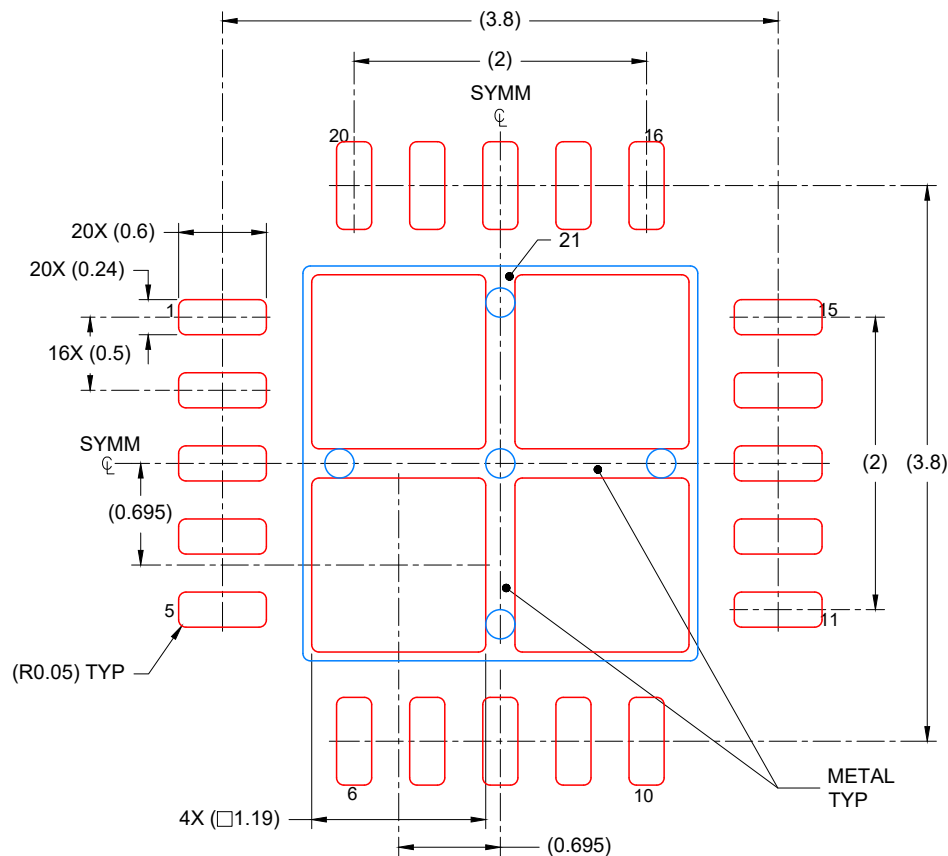
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NOTES:

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.
3. The package thermal pad must be soldered to the printed circuit board for optimal thermal and mechanical performance.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD
77% PRINTED COVERAGE BY AREA
SCALE: 20X

4219028/A 12/2018

NOTES: (continued)

6. 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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